Argonne National Laboratory-East

Site Environmental Report

for Calendar Year 2001

ANL-02/2

By N.W. Golchert and R.G. Kolzow

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ACM	Asbestos-Containing Material
AEA	Atomic Energy Act of 1954
ANL-E	Argonne National Laboratory-East
AOC	Area of Concern
APS	Advanced Photon Source
BAT	Best Available Technology
BCG	Biota Concentration Guide
BOD_5	Biochemical Oxygen Demand
CAA	Clean Air Act
CAAPP	Clean Air Act Permit Program
CAP-88	Clean Air Act Assessment Package-1988
CEDE	Committed Effective Dose Equivalent
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	*Code of Federal Regulations*
CLP	Contract Laboratory Program
CMT	Chemical Technology Division
COD	Chemical Oxygen Demand
COE	U.S. Army Corps of Engineers
CP-5	Chicago Pile-Five
CRMP	Cultural Resources Management Plan
CWA	Clean Water Act
D&D	Decontamination and Decommissioning
DCG	Derived Concentration Guide
DMR	Discharge Monitoring Report
DOE	U.S. Department of Energy
DOE-CH	U.S. Department of Energy, Chicago Operations Office
DOE-EML-QAP	U.S. Department of Energy, Environmental Measurements Laboratory, Quality Assurance Program
DOE-HQ	U.S. Department of Energy Headquarters
DPCHD	DuPage County Health Department
EA	Environmental Assessment
EH-24	U.S. Department of Energy, Office of Environment, Safety and Health
EIS	Environmental Impact Statement
EMS	Environmental Protection Data Management System
ENE	East-Northeast
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right to Know Act
EQO	The Office of ESH/QA Oversight
ERP	Environmental Remediation Program

ACRONYMS

ESA	Endangered Species Act
ESH	Environment, Safety and Health
ESH-AC	Environment, Safety and Health-Analytical Chemistry
FFCA	Federal Facility Compliance Act
FWS	U.S. Fish and Wildlife Service
FY	Fiscal Year
HSWA	Hazardous and Solid Waste Amendments
IAC	*Illinois Administrative Code*
ICRP	International Commission on Radiological Protection
IDNS	Illinois Department of Nuclear Safety
IDPH	Illinois Department of Public Health
IEPA	Illinois Environmental Protection Agency
IHPA	Illinois Historic Preservation Agency
IPNS	Intense Pulsed Neutron Source
ISM	Integrated Safety Management
LEPC	Local Emergency Planning Committee
LLW	Low-Level Radioactive Waste
MSDS	Material Safety Data Sheet
MW	Mixed Waste
MY	Model Year
NBL	New Brunswick Laboratory
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NFA	No Further Action
NHPA	National Historic Preservation Act
NIST	National Institute of Standards and Technology
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NRHP	National Register of Historical Places
O&M	Operation and Maintenance
OI	Opportunities for Improvement
P2/E2	Pollution Prevention and Energy Efficiency
PBT	Persistent, Bioaccumulative Toxic
PCB	Polychlorinated Biphenyl
PFS	Plant Facilities and Services
PQL	Practical Quantification Limit

PSTP	Proposed Site Treatment Plan
QA	Quality Assurance
RCRA	Resource Conservation and Recovery Act
RH-TRU	remote-handled transuranic waste
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SER	Site Environmental Report
SIP	Site Implementation Plan
SOP	Standard Operating Procedure
SSI	Site Screening Investigation
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
SWPPP	Storm Water Pollution Prevention Plan
TCA	1,1,1-trichloroethane
TDS	Total Dissolved Solids
TLD	Thermoluminescent Dosimeter
TOC	Total Organic Carbon
TOX	Total Organic Halogen
TRI	Toxic Release Inventory
TRU	Transuranic Waste
TSCA	Toxic Substances Control Act
TSS	Total Suspended Solids
UST	Underground Storage Tank
VOC	Volatile Organic Compound
WMO	Waste Management Operations
WM&P2	Waste Minimization and Pollution Prevention
WQS	Water Quality Standard
WTP	Wastewater Treatment Plant

This report discusses the accomplishments of the environmental protection program at Argonne National Laboratory-East (ANL-E) for calendar year 2001. The status of ANL-E environmental protection activities with respect to the various laws and regulations that govern waste handling and disposal is discussed, along with the progress of environmental corrective actions and restoration projects. To evaluate the effects of ANL-E operations on the environment, samples of environmental media collected on the site, at the site boundary, and off the ANL-E site were analyzed and compared with applicable guidelines and standards. A variety of radionuclides were measured in air, surface water, on-site groundwater, and bottom sediment samples. In addition, chemical constituents in surface water, groundwater, and ANL-E effluent water were analyzed. External penetrating radiation doses were measured, and the potential for radiation exposure to off-site population groups was estimated. Results are interpreted in terms of the origin of the radioactive and chemical substances (i.e., natural, fallout, ANL-E, and other) and are compared with applicable environmental quality standards. A U.S. Department of Energy dose calculation methodology, based on International Commission on Radiological Protection recommendations and the U.S. Environmental Protection Agency's CAP-88 (Clean Air Act Assessment Package-1988) computer code, was used in preparing this report.

This report summarizes the ongoing environmental protection program conducted by Argonne National Laboratory-East (ANL-E) in calendar year 2001. It includes descriptions of the site, ANL-E missions and programs, the status of compliance with environmental regulations, environmental protection and restoration activities, and the environmental surveillance program. The surveillance program conducts regular monitoring for radiation, radioactive materials, and nonradiological constituents on the ANL-E site and in the surrounding region. These activities document compliance with appropriate standards and permit limits, identify trends, provide information to the public, and contribute to a better understanding of ANL-E's impact on the environment. The surveillance program supports the ANL-E policy of protecting the public, employees, and the environment from harm that could be caused by ANL-E activities, and of reducing environmental impacts to the greatest degree practicable.

In 2001, ANL-E continued to implement its plan to complete all remedial actions at the site by the end of 2003. The plan is described in a document titled *Environmental Restoration Program (EM-40) Baseline for Argonne National Laboratory-East,* which was completed in early 1999.

Compliance Summary

Radionuclide emissions, the management of asbestos, and conventional air pollutants from ANL-E facilities are regulated under the Clean Air Act (CAA). A number of airborne radiological emission points at ANL-E are subject to National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations for radionuclide releases from U.S. Department of Energy (DOE) facilities (*Code of Federal Regulations*, Title 40, Part 61, Subpart H [40 CFR Part 61, Subpart H]). All such air emission sources were evaluated to ensure that these requirements are being addressed properly. The estimated hypothetical individual off-site dose from ANL-E activities required to be reported by U.S. Environmental Protection Agency (EPA) regulations in 2001 was 0.036 mrem/yr. This is 0.4% of the 10 mrem/yr standard. This dose does not include contributions from radon-220 and radon-222 emissions, as exempted in the regulations.

At ANL-E, asbestos-containing material (ACM) frequently is encountered during maintenance or renovation of existing facilities and equipment. Asbestos is removed and disposed of in strict accordance with NESHAP, Toxic Substances Control Act (TSCA), and Occupational Safety and Health Administration worker protection standards. Approximately 518 m^3 (18,300 ft^3) of ACM was removed and disposed of at off-site landfills in Illinois during 2001.

The ANL-E site contains several sources of conventional air pollutants. The steam plant and fuel dispensing facilities operate continuously and are the only significant sources of continuous air pollutants. The emergency generators at the Advanced Photon Source and the engine test facility are also significant sources, when operational. The IEPA issued the final ANL-E CAAPP permit in April 2001. All previous air operating permits (with the exception of the open burning permits) were incorporated into this sitewide permit for all emission sources and activities. The ANL-E Clean Air Act Permit (CAAPP) Title V Permit requires continuous opacity and sulfur dioxide monitoring of the steam plant smoke stack from Boiler No. 5, the only boiler equipped to burn coal. Low-sulfur coal was burned in Boiler No. 5 for four months during 2001, whereas natural gas was used as the fuel at that boiler for the other two months of the year. During the period coal was burned, which occurred during colder weather to supplement the other gas-fired boilers, one exceedance for opacity was observed.

The goals of the Clean Water Act are achieved primarily through the National Pollutant Discharge Elimination System (NPDES) permit program. The federal government has delegated implementation of the NPDES program to the State of Illinois. The renewal of the ANL-E NPDES permit, effective October 30, 1994, increased the number of monitored discharge points from 9 to 28. The permit was modified on August 24, 1995, to temporarily increase some discharge limits during the three-year compliance schedule imposed to achieve final limits. An application to renew the existing permit was submitted timely to the Illinois Environmental Protection Agency (IEPA) during December 1998. The IEPA did not act to review the permit renewal application in 2001, and, therefore, as provided for in the IEPA regulations, ANL-E continues to operate under the 1994 permit, as modified, until a renewal permit is issued. During 2001, seven exceedances of the NPDES permit limits were reported out of approximately 1,600 measurements.

ANL-E was granted interim status under the Resource Conservation and Recovery Act (RCRA) upon submitting a Part A Permit application in 1980. The IEPA issued a RCRA Part B Permit on September 30, 1997, which became effective on November 4, 1997. The permit addresses 25 hazardous waste treatment and storage facilities and establishes corrective action procedures and requirements for 49 Solid Waste Management Units (SWMUs) and 5 Areas of Concern (AOCs). Since the issuance of the permit, two additional SWMUs have been added to the permit. Following ANL-E remedial actions, the IEPA approved No Further Action requests for 30 SWMUs by the end of 2001. Five units had all planned remedial actions completed and are in long-term operations and maintenance mode.

ANL-E has prepared and implemented a sitewide underground storage tank (UST) compliance plan. The ANL-E site contains 18 USTs, which are in compliance with UST regulations.

The only TSCA-regulated compounds in significant quantities at ANL-E are polychlorinated biphenyls (PCBs) contained in electrical capacitors, power supplies, and small transformers. The ANL-E PCB Item Inventory Program was initiated in 1995 to identify all suspect PCB-containing items. All pole-mounted transformers and circuit breakers containing PCBs have been replaced or retrofilled with non-PCB oil. All removal and disposal activities were conducted by licensed contractors specializing in such operations. Radioactive PCB-contaminated sludge from the ANL-E wastewater treatment plant was characterized, containerized, and placed in storage during

1994. During 2001, 46,391 L (12,088 gal) of radioactive PCB-contaminated sludge and debris were shipped off site for disposal, leaving only 214 L (56 gal) in storage.

In 2001, most projects requiring National Environmental Policy Act (NEPA) review and submitted to DOE for assessment were determined to be categorical exclusions. One Environmental Assessment was prepared in 2001 for sitewide wetland management.

The ANL-E Environment, Safety and Health and Infrastructure Management Plan identifies funding needs for on-site rehabilitation projects, environmental restoration projects, and waste management activities. The rehabilitation projects concentrate on upgrading or replacing existing treatment facilities. ANL-E environmental restoration activities consist of projects that assess and clean up inactive waste sites. These include two inactive landfills, three French drains (i.e., dry wells used to dispose of liquid chemicals), two inactive wastewater treatment facilities, and a number of areas that may have been contaminated with small amounts of hazardous chemicals. This work is funded by the DOE Office of Environmental Management (EM) and conducted at ANL-E by the Environmental Remediation Program.

Ongoing compliance issues at ANL-E during 2001 were effluent concentrations of total dissolved solids (TDS) in excess of NPDES permit effluent limits; elevated levels of some routine indicator parameters in the groundwater at the sanitary landfill; and cleanup of environmental contamination caused by previous activities on the ANL-E site. These issues are not being driven by regulatory citations but can be best characterized as opportunities for improvement.

Environmental Surveillance Program

Airborne emissions of radioactive materials from ANL-E were monitored during 2001. The effective dose equivalents were estimated at the site perimeter, and to a hypothetical maximally exposed member of the public, with the EPA's CAP-88 (CAA Assessment Package-1988) computer code. The estimated maximum perimeter dose from airborne releases was 0.38 mrem/yr in the east direction, while the estimated maximum dose to a member of the public was 0.037 mrem/yr. This latter value is 0.04% of the DOE radiation protection standard of 100 mrem/yr for all pathways. If the contribution of radon-220 is excluded from reporting, as required by 40 CFR Part 61, Subpart H, the estimated dose to a maximally exposed member of the public would be 0.036 mrem/yr. The estimated population dose from releases to the approximately nine million people living within 80 km (50 mi) of the site was 2.41 person-rem.

Monitoring of particulates in ambient air was conducted for total alpha activity, total beta activity, strontium-90, isotopic thorium, isotopic uranium, and plutonium-239 at the ANL-E site perimeter and at off-site locations. No statistically significant difference was identified between samples collected at the ANL-E perimeter and samples collected off site. Monitoring was not conducted for hazardous chemical constituents in ambient air.

The only detectable radionuclides and chemical pollutants in surface water due to ANL-E releases were in Sawmill Creek, below the wastewater discharge point. At various times, measurable levels of hydrogen-3, strontium-90, plutonium-239, and americium-241 were detected. Of these radionuclides, the maximum annual release was 0.10 Ci of hydrogen-3. The other radionuclides were released at less than 0.001 Ci total. The hydrogen-3 was added to the wastewater as part of normal ANL-E operations. The dose to a hypothetical individual using water from Sawmill Creek as his or her sole source of drinking water would be 0.016 mrem/yr. However, no one uses this water for drinking, and dilution by the Des Plaines River reduces the concentrations of the measured radionuclides to levels below their respective detection limits downstream from ANL-E at Lemont. Sawmill Creek also is monitored for nonradiological constituents to demonstrate compliance with State of Illinois water quality standards. Iron and copper occasionally were detected above the standards.

Sediment samples were collected from Sawmill Creek, above, at, and below the point of wastewater treatment plant effluent discharge. Elevated levels of plutonium-239 (up to 0.742 pCi/g) and americium-241 (up to 0.165 pCi/g) were detected in the sediment below the outfall and are attributed to past ANL-E releases.

Dose rates from penetrating radiation (gamma-rays) were measured at 17 perimeter and on-site locations and at five off-site locations in 2001 using thermoluminescent dosimeters. The off-site results averaged 103 ± 6 mrem/yr, which is consistent with the long-term average. Above-background doses occurred at one perimeter location and were due to ANL-E operations. At the south fence, radiation from a temporary storage facility for radioactive waste resulted in an average dose of 128 ± 20 mrem/yr for 2001, although no one occupies this area. The estimated dose from penetrating radiation to the nearest resident south of the site was less than 0.01 mrem/yr.

The potential radiation doses to members of the public from all sources and pathways due to ANL-E operations during 2001 were estimated by combining the exposure from inhalation, ingestion, and direct radiation pathways. The inhalation pathway dominates. The highest estimated dose was approximately 0.063 mrem/yr to a hypothetical individual living east of the site, assuming he or she was outdoors at that location during the entire year, and drinking Sawmill Creek water. Estimated doses from other pathways were small by comparison. The doses from ANL-E operations are well within all applicable standards and are insignificant when compared with doses received by the public from natural radiation (≈300 mrem/yr) or other sources, for example, medical x-rays and consumer products (≈60 mrem/yr).

Radiological and chemical constituents in the groundwater were monitored in several areas of the ANL-E site in 2001. The former ANL-E domestic water supply is monitored by collecting quarterly samples from the three inactive supply wells. All results from water supply wells were less than the limits established by the Safe Drinking Water Act.

Ten monitoring wells screened in the glacial drift and two in the dolomite were sampled quarterly at the 317 and 319 Areas and analyzed for radiological, volatile organic, semivolatile, PCB, and pesticide and herbicide constituents. The major organic contaminants detected were acetone, benzene, trichloroethene, 1,1,1-trichloroethane, 1,1-dichloroethane, and 2-butanone. Measurable levels of hydrogen-3 and strontium-90 were present in several of the wells. Remediation continued in this area using phytoremediation and groundwater extraction to remove volatile organic compounds (VOCs) and hydrogen-3 from groundwater.

Three monitoring wells are screened in the glacial drift and one in the dolomite adjacent to the Chicago Pile-Five reactor. These wells were sampled quarterly, and samples were analyzed for selected radionuclides, metals, VOCs, semivolatile organic compounds (SVOCs), pesticides, herbicides, and PCBs. Measurable levels of hydrogen-3 and strontium-90 were detected regularly. Low levels of dichlorofluoromethane and trichlorofluoromethane were detected, in addition to a few inorganic constituents. All concentrations were well below any standard.

Twenty-six monitoring wells at the 800 Area sanitary landfill were sampled on a quarterly basis and analyzed for metals, cyanide, phenols, total organic carbon, total organic halogens, VOCs, SVOCs, PCBs, pesticides, herbicides, and hydrogen-3. As in previous years, levels above Illinois Class I Groundwater Quality Standards for chloride, chromium, iron, lead, manganese, nickel, sulfate, and TDS were found in some wells. Above-background levels of hydrogen-3 were detected in several of the wells, with concentrations up to 1,058 pCi/L. This is well below the standard of 20,000 pCi/L.

An extensive quality assurance program is maintained to cover all aspects of the environmental surveillance sampling and analysis programs. Approved documents are in place, along with supporting standard operating procedures. Newly collected data were compared with recent results and historical data to ensure that deviations from previous conditions were identified and evaluated promptly. Samples at all locations were collected using well-established and documented procedures to ensure consistency. Samples were analyzed by documented standard analytical procedures. Data quality was verified by a continuing program of analytical laboratory quality control, participation in interlaboratory cross-checks, and replicate sampling and analysis. Data were managed and tracked by a dedicated computerized data management system that assigns unique sample numbers, schedules collection and analysis, checks status, and prepares tables and information for the annual report.

ANL-E maintains a documented environmental management system that identifies responsibilities for environmental activities. ANL-E is committed to implementing that system as part of the overall Integrated Safety Management System.

1. INTRODUCTION

1.1. General

This annual report for calendar year 2001 of the Argonne National Laboratory-East (ANL-E) environmental protection program was prepared to inform the U.S. Department of Energy (DOE), environmental agencies, and the public about the levels of radioactive and chemical pollutants in the vicinity of ANL-E, and the amounts, if any, added to the environment by ANL-E operations. It also summarizes the compliance of ANL-E operations with applicable environmental laws and regulations and highlights significant accomplishments and issues related to environmental protection and environmental remediation. The report was prepared in accordance with the guidelines of DOE Orders 5400.1[1] and 231.1[2] and supplemental DOE guidance.

ANL-E conducts an environmental surveillance program on and near the site to determine the identity, magnitude, and origin of radioactive and chemical substances in the environment. The detection of any releases of such materials to the environment from ANL-E operations is of special interest, because one important function of this program is verification of the adequacy of the site's pollution control systems.

ANL-E is a DOE research and development laboratory with several principal objectives. It conducts a broad program of research in the basic energy and related sciences (i.e., physical, chemical, material, computer, nuclear, biomedical, and environmental) and serves as an important engineering center for the study of nuclear and nonnuclear energy sources. Energy-related research projects conducted during 2001 included safety studies for light-water reactors; high-temperature superconductivity experiments; development of electrochemical energy sources, including fuel cells and batteries for vehicles and for energy storage; evaluation of heat exchangers for the recovery of waste heat from engines; and studies to promote clean, efficient transportation.

Other areas of research are basic biological research, heavy-ion research into the properties of super-heavy elements, fundamental coal chemistry studies, the immobilization of radioactive waste products for safe disposal, fundamental studies of advanced computers, and the development of "chips" for the rapid assay of gene composition. Environmental research studies include the biological activity of energy-related mutagens and carcinogens, characterization and monitoring of energy-related pollutants, and new technologies for cleaning up environmental contaminants. A significant number of these laboratory studies requires the controlled use of radioactive and chemically toxic substances.

The principal radiological facilities at ANL-E are the Advanced Photon Source (APS); a superconducting heavy-ion linear accelerator (Argonne Tandem Linac Accelerating System [ATLAS]); a 22-MeV pulsed electron linac; several other charged-particle accelerators (principally of the Van de Graaff and Dynamitron types); a large fast neutron source (Intense Pulsed Neutron Source [IPNS]) in which high-energy protons strike a uranium target to produce neutrons; chemical and metallurgical laboratories; and several hot cells and laboratories designed for work with multicurie quantities of the actinide elements and with irradiated reactor fuel materials. The DOE New Brunswick Laboratory (NBL), a plutonium and uranium measurements and analytical chemistry laboratory, is located on the ANL-E site.

The principal nonnuclear activities at ANL-E in 2001 that could have measurable impacts on the environment include the use of a coal-fired boiler (No. 5), discharge of wastewater from various sources, and the cleanup of inactive waste disposal areas.

1.2. Description of Site

ANL-E occupies the central 607 ha (1,500 acres) of a 1,514-ha (3,740-acre) tract in DuPage County. The site is 43 km (27 mi) southwest of downtown Chicago and 39 km (24 mi) west of Lake Michigan. It is north of the Des Plaines River Valley, south of Interstate Highway 55 (I-55), and west of Illinois Highway 83. Figures 1.1 and 1.2 are maps of the site, the surrounding area, and sampling locations of the monitoring program. Much of the 907-ha (2,240-acre) Waterfall Glen Forest Preserve surrounding the site was part of the ANL-E site before it was deeded to the DuPage County Forest Preserve District in 1973 for use as a public recreational area, nature preserve, and demonstration forest. In this report, facilities are identified by the alphanumeric designations in Figure 1.1 to facilitate their location.

The terrain of ANL-E is gently rolling, partially wooded, former prairie and farmland. The grounds contain a number of small ponds and streams. The principal stream is Sawmill Creek, which runs through the site in a southerly direction and enters the Des Plaines River about 2.1 km (1.3 mi) southeast of the center of the site. The land is drained primarily by Sawmill Creek, although the extreme southern portion drains directly into the Des Plaines River, which flows along the southern boundary of the forest preserve. This river flows southwest until it joins the Kankakee River about 48 km (30 mi) southwest of ANL-E to form the Illinois River.

The largest topographical feature of the area is the Des Plaines River valley, which is about 1.6 km (1 mi) wide. This valley contains the river, the Chicago Sanitary and Ship Canal, and the Illinois and Michigan Canal. The elevation of the channel surface of these waterways is 180 m (578 ft) above sea level. The bluffs that form the southern border of the site rise from the river channel at slope angles of 15 to 60° and reach an average elevation of 200 m (650 ft) above sea level at the top. The land then slopes gradually upward and reaches the average site elevation of 220 m (725 ft) above sea level at 915 m (3,000 ft) from the bluffs. Several large ravines oriented in a north-south direction are located in the southern portion of the site. The bluffs and ravines generally are forested with mature deciduous trees. The remaining portion of the site changes in elevation by no more than 7.6 m (25 ft) in a horizontal distance of 150 m (500 ft).

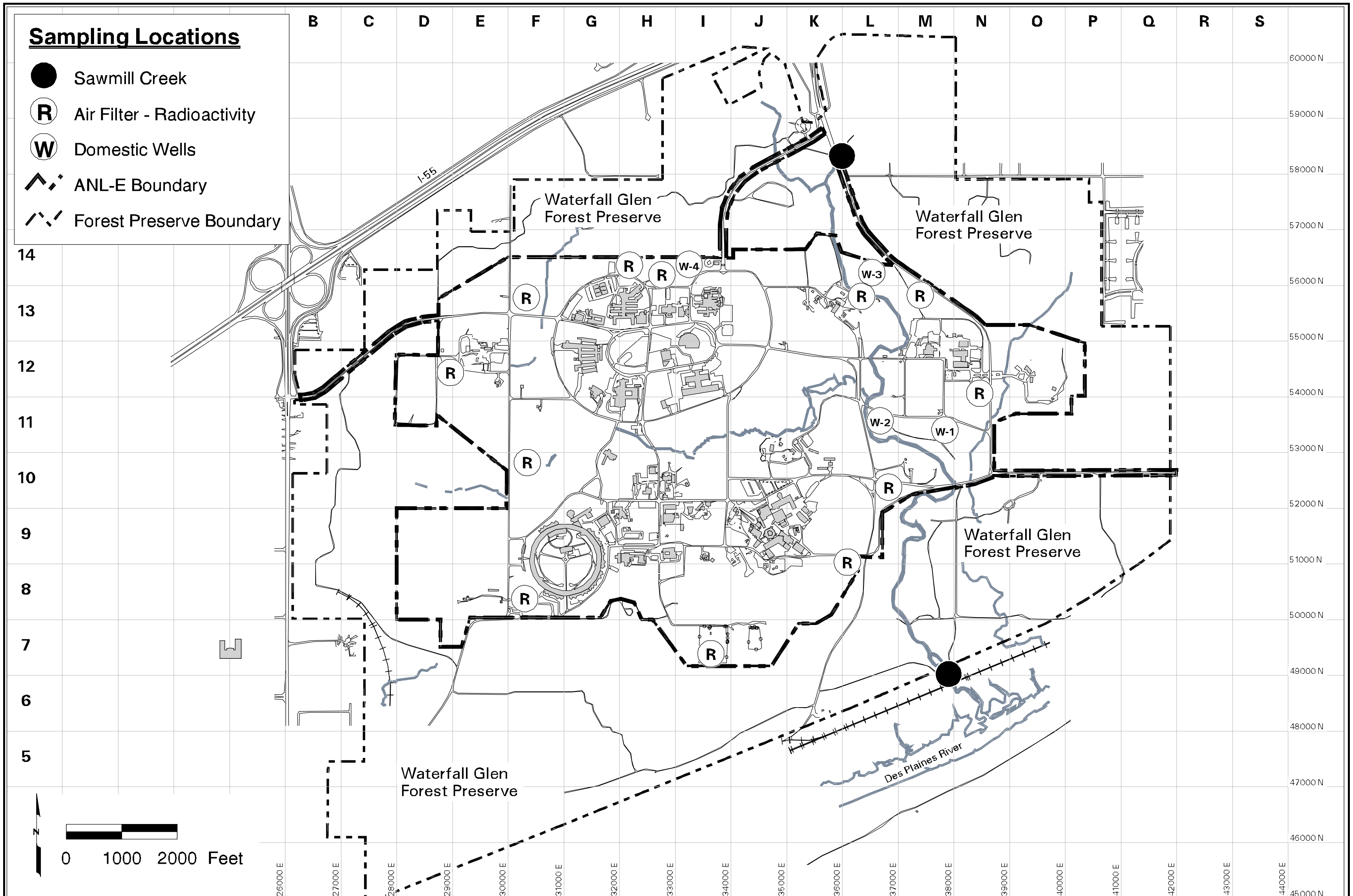


Figure 1.1 Sampling Locations at Argonne National Laboratory-East

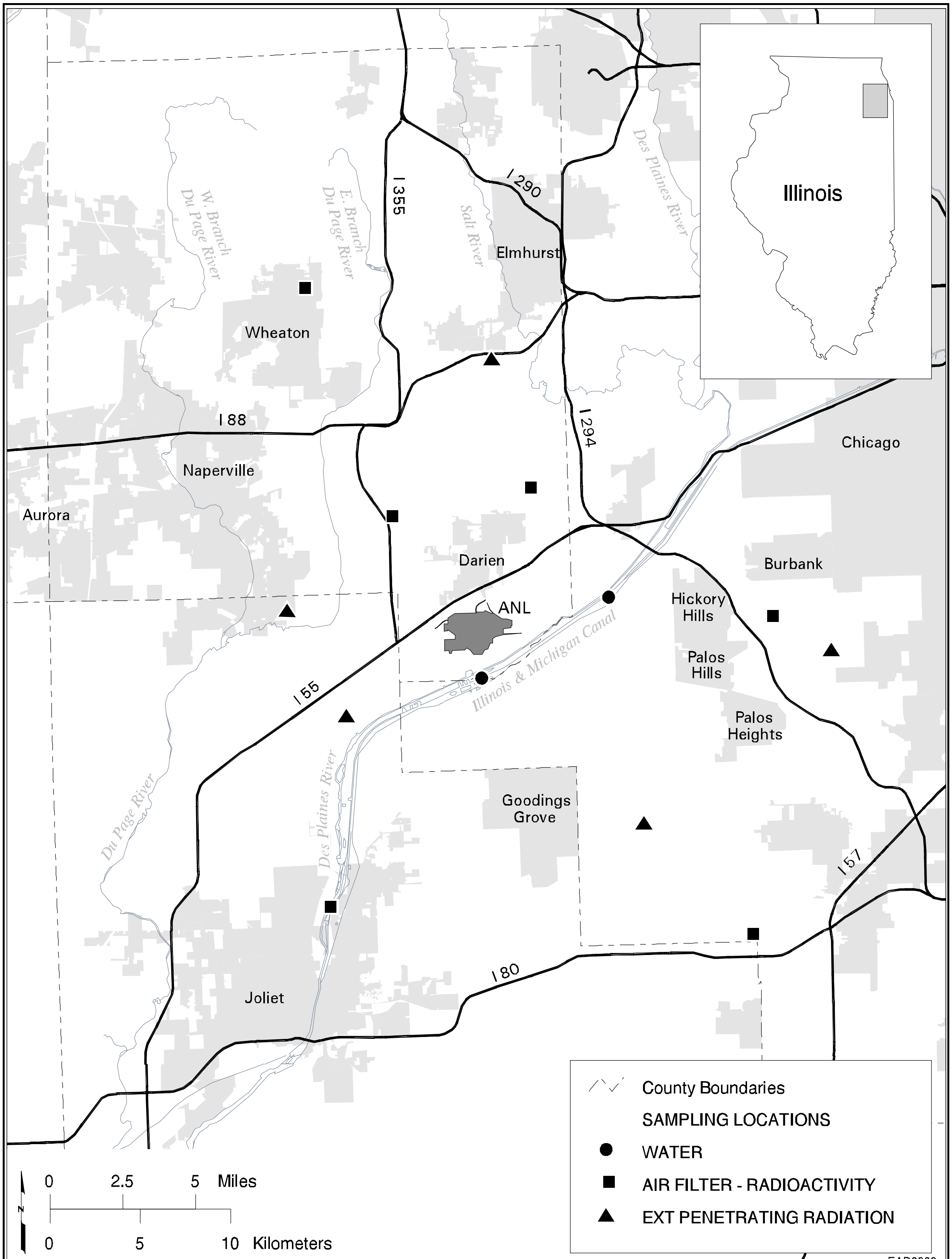


Figure 1.2 Sampling Locations near Argonne National Laboratory-East

1.3. Population

The area around ANL-E has experienced a large population growth in the past 30 years. Large areas of farmland have been converted into housing. Table 1.1 gives the directional and annular 80-km (50-mi) population distribution for the area, which is used to derive the population dose calculations presented later in this report. The population distribution, centered on the Chicago Pile-5 (CP-5) reactor (Location 9G in Figure 1.1), was prepared by the Risk Assessment and Safety Evaluation Group of the Environmental Assessment Division at ANL-E and represents projections on the basis of 2000 census data.

1.4. Climatology

The climate of the area is representative of the upper Mississippi Valley, as moderated by Lake Michigan. Summaries of the meteorological data collected on the site from 1950 to 1964 are available[3] and provide a historical sample of the climatic conditions. The most important meteorological parameters for the purposes of this report are wind direction, wind speed, temperature, and precipitation. The wind data are used to select air sampling locations and distances from sources and to calculate radiation doses from air emissions. Temperature and precipitation data are useful in interpreting some of the monitoring results. The 2001 data were obtained from the on-site ANL-E meteorological station. The 2001 average monthly and annual wind rose at the 60-m (200-ft) level is shown in Figure 1.3. The wind rose is a polar coordinate plot in which the lengths of the radii represent the percentage frequency of wind speeds in classes of 2.01 – 6 m/s (4.5 – 13.4 mph), 6.01 – 10 m/s (13.4 – 22.4 mph), and greater than 10.01 m/s (22.4 mph). The number in the center of the wind rose represents the percentage of observations of wind speed less than 2 m/s (4.5 mph) in all directions. The direction of the radii from the center represents the direction from which the wind blows. Sixteen radii are shown on each plot at 22.5° intervals; each radius represents the average wind speed for the direction covering 11.25° on either side of the radius. The annual average wind rose for 2001 is consistent with the long-term average wind direction, which usually varies from the west to south, but with a significant northeast component.

Table 1.2 gives 2001 precipitation and temperature data. The monthly precipitation data for 2001 show a few differences from the average. For example, February, August, and October were above the monthly average, while March and June were below the average. The annual total was 13% above the annual average for the ANL-E historic data and 7% above the O'Hare International Airport average. The temperatures were generally higher when compared with the long-term historical monthly average, but 22% higher than the long-term ANL-E monthly average.

TABLE 1.1

Population Distribution in the Vicinity of ANL-E, 2000

	Miles[a]									
Direction	0 – 1	1 – 2	2 – 3	3 – 4	4 – 5	5 – 10	10 – 20	20 – 30	30 – 40	40 – 50
N	0	1,269	3,646	6,190	9,651	46,597	183,061	353,821	222,737	309,159
NNE	0	611	4,112	5,971	6,169	40,711	302,525	492,536	102,273	1,094
NE	0	837	2,010	2,138	1,846	42,637	712,685	1,009,469	0	0
ENE	0	1,021	1,291	2,308	1,986	33,931	633,468	195,890	0	0
E	0	1,163	557	366	386	42,520	467,488	216,642	9,770	26,128
ESE	0	590	269	371	509	18,494	190,441	293,764	230,611	91,154
SE	0	309	271	459	947	25,059	131,937	120,187	34,557	17,023
SSE	0	451	400	1,014	1,327	18,433	42,321	9,904	14,172	15,963
S	0	628	2,302	2,148	1,221	8,181	31,084	4,436	36,505	36,639
SSW	0	529	2,329	2,645	1,001	18,156	89,111	12,221	20,350	7,739
SW	0	213	596	409	142	14,931	66,453	12,394	17,310	7,385
WSW	0	168	159	554	2,628	17,249	23,864	5,422	8,705	11,633
W	0	186	2,026	7,735	9,338	40,270	93,303	23,547	17,727	6,810
WNW	0	528	1,862	5,815	6,516	46,444	154,113	37,805	7,469	58,587
NW	0	711	2,317	7,057	7,769	45,993	83,324	123,290	23,881	19,530
NNW	0	1,088	2,628	5,961	9,457	34,008	217,040	263,590	172,437	122,112
Total	0	10,302	26,775	51,141	60,893	493,614	3,422,218	3,174,918	918,504	730,956
Cumulative total[b]	0	10,302	37,077	88,218	149,111	642,725	4,064,943	7,239,861	8,158,365	8,889,321

[a] To convert from miles to kilometers, multiply by 1.6.

[b] Cumulative total = the total of this sector plus the totals of all previous sectors.

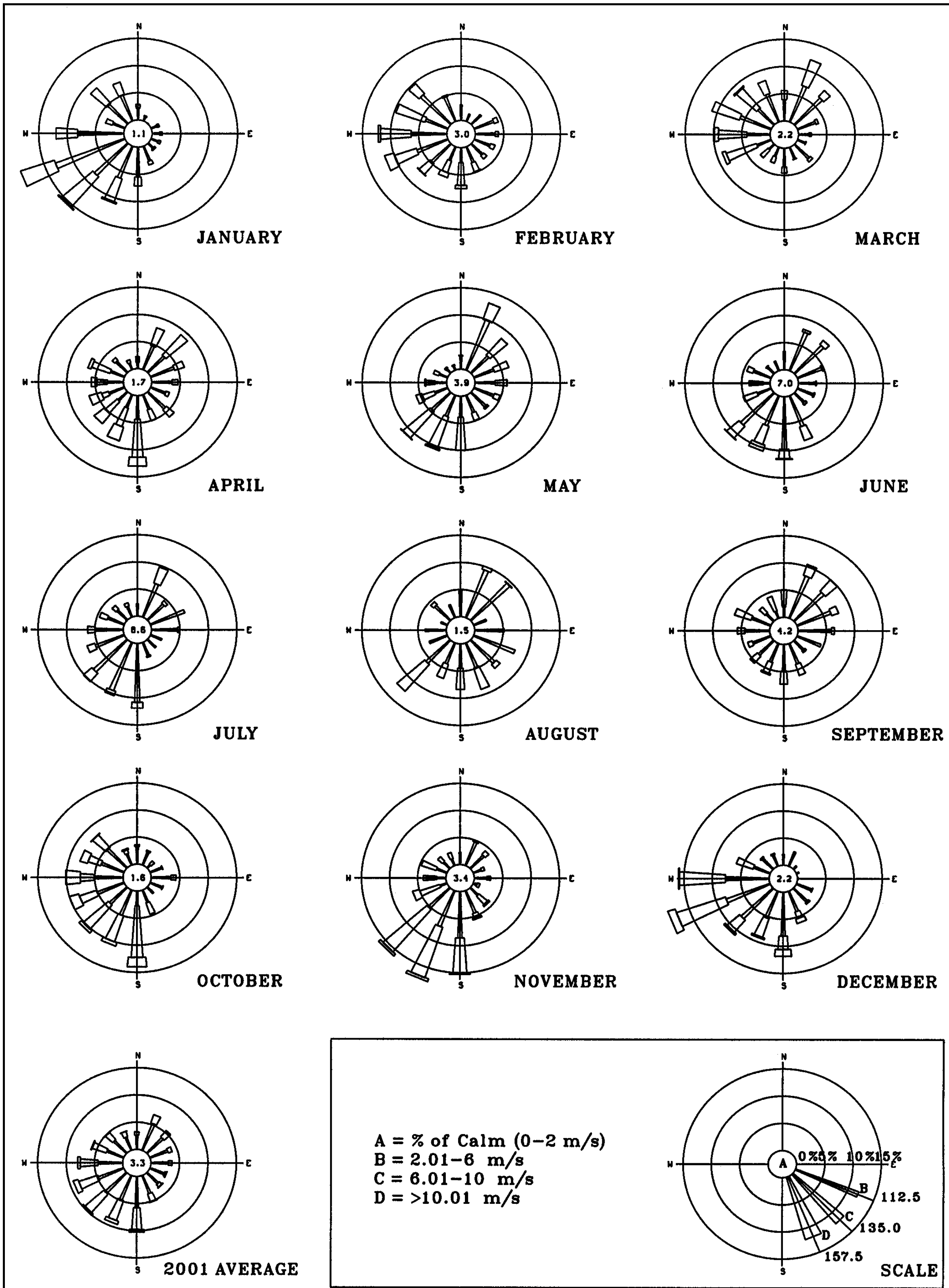


Figure 1.3 Monthly and Annual Wind Roses at Argonne National Laboratory-East, 2001

TABLE 1.2

ANL-E Weather Summary, 2001

	Precipitation (cm)				Temperature (°C)		
Month	ANL-E 2001	ANL-E Historical[a]	Historical[b]		ANL-E 2001	ANL-E Historical[a]	Historical[b]
January	3.51	3.61	4.06		– 4.0	– 5.9	– 5.9
February	7.67	3.38	3.33		– 1.9	– 3.7	– 3.3
March	3.00	5.56	6.58		1.3	0.6	2.2
April	7.05	9.14	9.30		11.7	8.3	9.3
May	8.13	7.82	8.00		16.2	14.5	15.1
June	5.30	9.47	10.36		20.5	19.7	20.3
July	11.32	10.97	9.22		23.2	21.7	22.8
August	11.21	8.71	8.97		21.5	20.9	22.2
September	9.78	7.14	8.51		16.6	16.8	18.2
October	17.04	6.58	5.79		11.0	11.4	11.9
November	3.93	4.37	5.23		9.3	2.9	4.3
December	2.74	3.20	5.33		0.8	– 4.2	– 2.4
Total	90.68	79.95	84.68	Monthly Average	10.5	8.6	9.6

[a] ANL-E data obtained from Reference 3.

[b] Data obtained from the National Oceanic and Atmospheric Administration for the weather station at O'Hare International Airport. The average is for the years 1951–1980.

1.5. Geology

The geology of the ANL-E area consists of about 30 m (100 ft) of glacial drift on top of nearly horizontal bedrock consisting of Niagaran and Alexandrian dolomite underlain by shale and older dolomites and sandstones of Ordovician and Cambrian age. The glacial drift sequence is composed of the Wadsworth and Lemont Formations. Both are dominated by fine-grained drift units but also contain sandy, gravelly, or silty interbeds. Niagaran and Alexandrian dolomite is approximately 60 m (200 ft) thick but has an irregular, eroded upper surface.

The southern boundary of ANL-E follows the bluff of a broad valley, which is now occupied by the Des Plaines River and the Chicago Sanitary and Ship Canal. This valley was carved by waters flowing out of the glacial Lake Michigan about 11,000 to 14,000 years ago. The soils on the site were derived from glacial drift over the past 12,000 years and are primarily of the Morley series, that is, moderately well-drained upland soils with a slope ranging from 2 to 20%. The surface layer is a dark grayish-brown silt loam, the subsoil is a brown silty clay, and the underlying material is a silty clay loam glacial drift. Morley soils have a relatively low organic content in the surface layer, moderately slow subsoil permeability, and a large water capacity. The remaining soils along creeks, intermittent streams, bottomlands, and a few small upland areas are of the Sawmill, Ashkum, Peotone, and Beecher series, which are generally poorly drained. They have a black to dark gray or brown silty clay loam surface layer, high organic matter content, and a large water capacity.

1.6. Seismicity

No tectonic features within 135 km (62 mi) of ANL-E are known to be seismically active. The longest inactive local feature is the Sandwich Fault. Smaller local features are the Des Plaines disturbance, a few faults in the Chicago area, and a fault of apparently Cambrian age.

Although a few minor earthquakes have occurred in northern Illinois, none have been positively associated with particular tectonic features. Most of the recent local seismic activity is believed to be caused by isostatic adjustments of the earth’s crust in response to glacial loading and unloading, rather than by motion along crustal plate boundaries.

Several areas of considerable seismic activity are located at moderate distances (i.e., hundreds of kilometers) from ANL-E. These areas include the New Madrid Fault zone (southeast Missouri) in the St. Louis area, the Wabash Valley Fault zone along the southern Illinois-Indiana border, and the Anna region of western Ohio. Although high-intensity earthquakes have occurred along the New Madrid Fault zone, their relationship to plate motions remains speculative at this time.

According to estimates, ground motions induced by near and distant seismic sources in northern Illinois are expected to be minimal. However, peak accelerations in the ANL-E area may exceed 10% of gravity (the approximate threshold of major damage) once in approximately 600 years, with an error range of -250 to +450 years.

1.7. Groundwater Hydrology

Two principal aquifers are used as water supplies in the vicinity of ANL-E. The upper aquifer is the Niagaran and Alexandrian dolomite, which is approximately 60 m (200 ft) thick in the ANL-E area and has a piezometric surface between 15 and 30 m (50 and 100 ft) below the ground surface for much of the site. The lower aquifer is Galesville sandstone, which lies between 150 and 450 m (500 and 1,500 ft) below the surface. Maquoketa shale separates the upper dolomite aquifer from the underlying sandstone aquifer. This shale retards the hydraulic connection between the two aquifers.

Up until 1997, most groundwater supplies in the ANL-E area were derived from the Niagaran, and to some extent, the Alexandrian dolomite bedrock. Dolomite well yields are variable, but many approach 3,028 L/min (800 gal/min). In DuPage County, groundwater pumpage over the past 100 years has led to severe overdraft; in northeastern Illinois, the piezometric surface has been lowered in areas of heavy pumping. Delivery of Lake Michigan water to the major suburban areas is expected to relieve this problem. ANL-E now obtains all its domestic water from the City of Chicago water system.

1.8. Water and Land Use

Sawmill Creek flows through the eastern portion of the site. This stream originates north of the site, flows through the property in a southerly direction, and discharges into the Des Plaines River. Two small streams, one originating on site and the other just off site, which enter the site from the western boundary, combine to form Freund Brook, which discharges into Sawmill Creek. Along the southern margin of the property, the terrain slopes abruptly downward forming forested bluffs. These bluffs are dissected by ravines containing intermittent streams that discharge some site drainage into the Des Plaines River. In addition to the streams, various ponds and cattail marshes are present on the site. A network of ditches and culverts transports surface runoff toward the smaller streams.

The greater portion of the ANL-E site is drained by Freund Brook. Two intermittent branches of Freund Brook flow from west to east, drain the interior portion of the site, and ultimately discharge into Sawmill Creek. The larger, south branch originates in a marsh adjacent to the western boundary line of the site. It traverses wooded terrain for a distance of about 2 km (1.5 mi) before discharging into the Lower Freund Pond. The upper Freund Brook branch originates within the central part of the site and also discharges into the Lower Freund Pond.

Residential and commercial development in the area have resulted in the collection and channeling of runoff water into Sawmill Creek. Treated sanitary and laboratory wastewater from ANL-E are combined and discharged into Sawmill Creek at location 7M in Figure 1.1. In 2001, this effluent averaged 3.3 million L/day (0.86 million gal/day), which is slightly higher than the averages for the last few years. The combined ANL-E effluent consisted of 56% laboratory wastewater and 44% sanitary wastewater. The water flow in Sawmill Creek upstream of the wastewater outfall averaged about 26 million L/day (7.0 million gal/day) during 2001.

Sawmill Creek and the Des Plaines River above Joliet, about 21 km (13 mi) southwest of ANL-E, receive very little recreational or industrial use. A few people fish in these waters downstream of ANL-E, and some duck hunting takes place on the Des Plaines River. Water from the Chicago Sanitary and Ship Canal is used by ANL-E for cooling towers and by others for industrial purposes, such as hydroelectric generators and condensers. ANL-E usage is approximately

1.1 million L/day (290,000 gal/day). The canal, which receives Chicago Metropolitan Sanitary District effluent water, is used for industrial transportation and some recreational boating. Near Joliet, the river and canal combine into one waterway, which continues until it joins the Kankakee River to form the Illinois River about 48 km (30 mi) southwest of ANL-E. The Dresden Nuclear Power Station complex is located at the confluence of the Kankakee, Des Plaines, and Illinois Rivers. This station uses water from the Kankakee River for cooling and discharges the water into the Illinois River. The first downstream location where water is used as a community water supply system is at Peoria, which is on the Illinois River about 240 km (150 mi) downstream of ANL-E. In the vicinity of ANL-E, only subsurface water (from both shallow and deep aquifers) and Lake Michigan water are used for drinking purposes.

The principal recreational area near ANL-E is the Waterfall Glen Forest Preserve, which surrounds the site (see Section 1.2 and Figure 1.1). The area is used for hiking, skiing, biking, and horseback riding. Sawmill Creek flows south through the eastern portion of the preserve on its way to the Des Plaines River. Several large forest preserves of the Forest Preserve District of Cook County are located east and southeast of ANL-E and the Des Plaines River. The preserves include the McGinnis and Saganashkee Sloughs (shown in Figure 1.2), as well as other smaller lakes. These areas are used for picnicking, boating, fishing, and hiking. A small park located in the eastern portion of the ANL-E site (Location 12-0 in Figure 1.1) is for the use of ANL-E and DOE employees. A local municipality has use of the park for athletic events. The park also contains a day-care center for children of ANL-E and DOE employees.

1.9. Vegetation

ANL-E lies within the Prairie Peninsula of the Oak-Hickory Forest Region. The Prairie Peninsula is a mosaic of oak forest, oak openings, and tall-grass prairie occurring in glaciated portions of Illinois, northwest Indiana, southern Wisconsin, and sections of other states. Much of the natural vegetation of this area has been modified by clearing and tillage. Forests in the ANL-E region, which are predominantly oak and hickory, are somewhat limited to slopes of shallow, ill-defined ravines or low morainal ridges. Gently rolling to flat intervening areas between ridges and ravines were predominantly occupied by prairie before their use for agriculture. The prevailing successional trend on these areas, in the absence of cultivation, is toward oak-hickory forest. Forest dominated by sugar maple, red oak, and basswood may occupy more pronounced slopes. Poorly drained areas, streamside communities, and floodplains may support forests dominated by silver maple, elm, and cottonwood. The vegetation communities are displayed in Figure 1.4.

Early photographs of the site indicate that most of the land that ANL-E now occupies was actively farmed. About 75% was plowed field and 25% was pasture, open oak woodlots, and oak

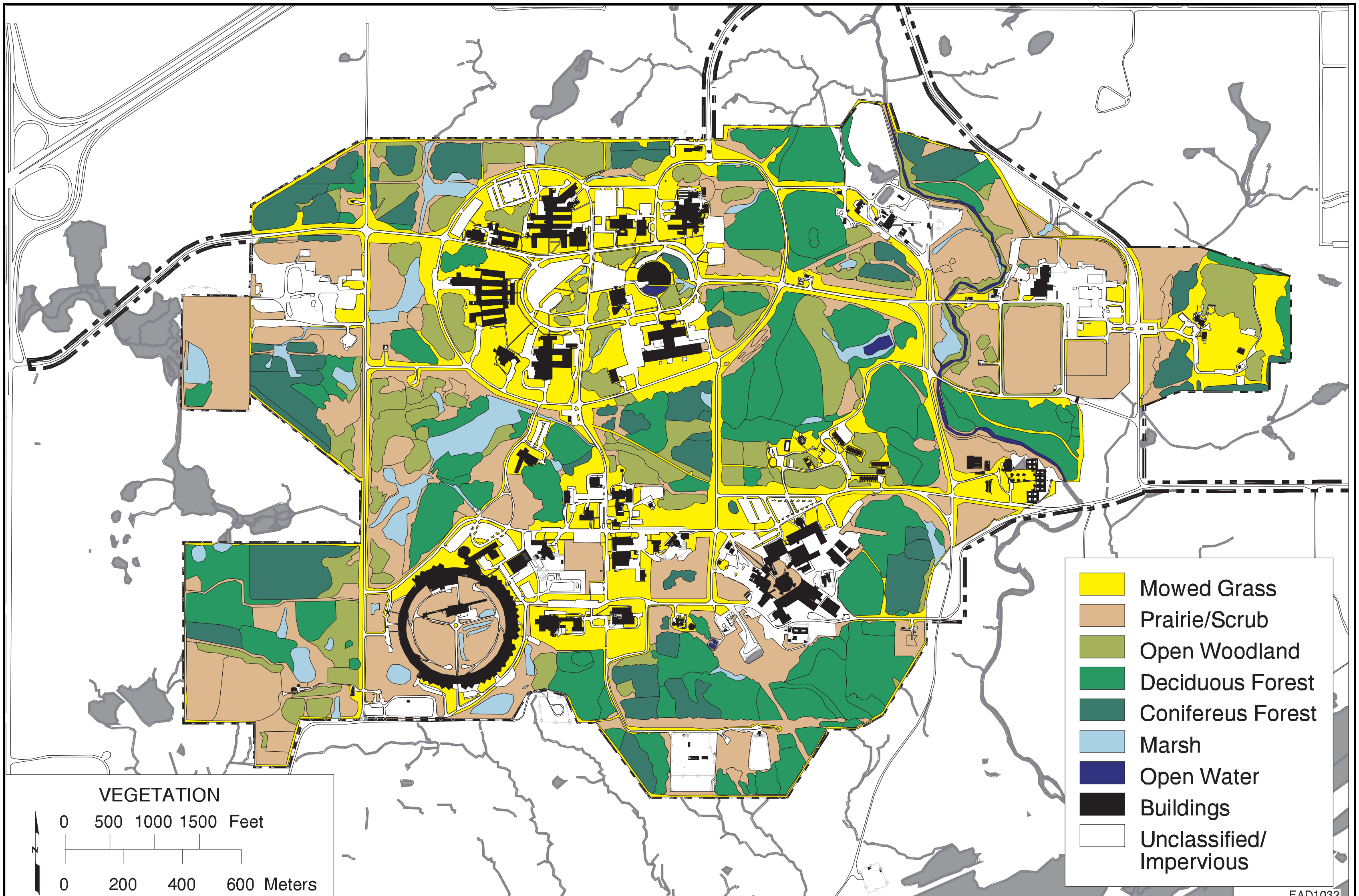


Figure 1.4 ANL-E Habitat

forests. Starting in 1953 and continuing for three seasons, some of the formerly cultivated fields were planted with jack, white, and red pine trees. Other fields are dominated by bluegrass.

The deciduous forests on the remainder of the site are dominated by various species of oak, generally as large, old, widely spaced trees, which often do not form a complete canopy. Their large low branches indicate that they probably matured in the open, rather than in a dense forest. Other upland tree species include hickory, hawthorn, cherry, and ash.

DOE and ANL-E belong to Chicago Wilderness, a partnership of more than 100 public and private organizations that have joined forces to protect, restore, and manage 81,000 ha (200,000 acres) of natural areas in the Chicago metropolitan region. Several activities are planned or are in progress to enhance oak woodland, savanna, wetland, and prairie habitats on the approximately 285 ha (700 acres) undeveloped at the ANL-E site.

1.10. Fauna

Terrestrial vertebrates that are commonly observed or likely to occur on the site include about 5 species of amphibians, 7 of reptiles, 40 of summer resident birds, and 25 of mammals. More than a hundred other bird species can be found in the area during migration or winter, but they do not nest on the site or in the surrounding region. An unusual species on the ANL-E site is the fallow deer, a European species that was introduced to the area by a private landowner prior to government acquisition of the property in 1947. A population of native white-tailed deer also inhabits the ANL-E site. The white-tailed and fallow deer populations are each maintained at a target density of 20 deer/mi^2 under an ongoing deer management program. Terrestrial invertebrate species and plants also reside on the ANL-E site.

Freund Brook crosses the center of the site. The gradient of the stream is relatively steep, and riffle habitat predominates. The substrate is coarse rock and gravel on a firm mud base. Primary production in the stream is limited by shading, but diatoms and some filamentous algae are common. Aquatic macrophytes include common arrowhead, pondweed, duckweed, and bulrush. Invertebrate fauna consist primarily of dipteran larvae, crayfish, caddisfly larvae, and midge larvae. Few fish are present because of low summer flows and high temperatures. Other aquatic habitats on the ANL-E site include beaver ponds, artificial ponds, ditches, and Sawmill Creek.

The biotic community of Sawmill Creek is relatively impoverished, which reflects the creek’s high silt load, steep gradient, and historic release of sewage effluent from the Marion Brook sewage treatment plant north of the site. The fauna consists primarily of blackflies, midges, isopods, flatworms, segmented worms, and creek chubs. A few species of minnows, sunfishes, and catfish are also present. Clean-water invertebrates, such as mayflies and stoneflies, are rare or absent. Fish species that have been recorded in ANL-E aquatic habitats include black bullhead, bluegill, creek chub, golden shiner, goldfish, green sunfish, largemouth bass, stoneroller, and orange-spotted sunfish.

The U.S. Fish and Wildlife Service (FWS) has rated the Des Plaines River system, including ANL-E streams, as "poor" in terms of the fish species present because of domestic and industrial pollution and stream modification.

1.11. Archaeology

ANL-E, which is located in the Illinois and Michigan Canal National Heritage Corridor, is situated in an area known to have a long and complex cultural history. All periods listed in the cultural chronology of Illinois, with the exception of the earliest period (Paleo-Indian), have been documented in the ANL-E area either by professional cultural resource investigators or through interviews of local artifact collectors by ANL-E staff. A variety of site types, including mounds, quarries, lithic workshops, and habitation sites, have been reported by amateurs within a 25-km (16-mi) radius.

Forty-six archaeological sites have been recorded at ANL-E. These sites include prehistoric chert quarries, special purpose camps, base camps, and historical farmsteads. The range of human occupation spans several time periods (Early Archaic through Mississippian Prehistoric to Historical). Three sites have been determined to be eligible for the National Register for Historic Places (NRHP); 20 sites have been determined to be ineligible; and 23 sites have not been evaluated for eligibility.

1.12. Endangered Species

No federal-listed threatened or endangered species are known to occur on the ANL-E site, and no critical habitat of federally listed species exists on the site. Three federal-listed endangered species are known to inhabit the Waterfall Glen Forest Preserve that surrounds the ANL-E property or are known to occur in the area.

The Hine's emerald dragonfly (*Somatochlora hineana*), federal and state listed as endangered, occurs in locations with calcareous seeps and wetlands along the Des Plaines River floodplain. Leafy prairie clover (*Dalea foliosa*), which is federal and state listed as endangered, is associated with dolomite prairie remnants of the Des Plaines River valley; two planted populations of this species occur in Waterfall Glen Forest Preserve. An unconfirmed capture of an Indiana bat (*Myotis sodalis*), which is federal and state listed as endangered, indicates that this species may occur in the area. The federal-listed threatened lakeside daisy (*Hymenarys acaulis var.glabra*) has a planted population in Waterfall Glen Forest Preserve. Additional state-listed species that occur in the area include the following:

- Endangered
  - Black-crowned night heron (*Nycticorax nycticorax*)
  - Osprey (*Pandion haliaetus*)
  - Shadbush (*Amelanchier interior*)

- Threatened
  - Brown creeper (*Certhia americana*)
  - Kirtland's snake (*Clonophis kirtlandi*)
  - Marsh speedwell (*Veronica scutellata*)
  - Pied-billed grebe (*Podilymbus podiceps*)
  - Red-shouldered hawk (*Buteo lineatus*)
  - River otter (*Lutra canadensis*)
  - Slender sandwort (*Arenaria patula*)
  - White lady's slipper (*Cypripedium candidum*)

Of these, Kirtland's snake, pied-billed grebe, black-crowned night heron, brown creeper, and red-shouldered hawk have been observed on ANL-E property.

2. COMPLIANCE SUMMARY

ANL-E is a government-owned, contractor-operated research and development facility that is subject to environmental statutes and regulations administered by the U.S. Environmental Protection Agency (EPA), the Illinois Environmental Protection Agency (IEPA), U.S. Army Corps of Engineers (COE), and the State Fire Marshal, as well as to numerous DOE Orders and Executive Orders. A detailed listing of applicable regulations is contained in DOE Order 5400.1,[1] which establishes DOE's policy concerning environmental compliance. The status of ANL-E during 2001 with regard to these authorities is discussed in this chapter.

To ensure compliance with both the letter and spirit of these requirements, ANL-E has made a commitment to comply with all applicable environmental requirements, as described in the following policy statement:

> The policy of Argonne National Laboratory is that its activities are to be conducted in such a manner that worker and public health and safety and protection of the environment are given the highest priority. The Laboratory will comply with all applicable federal and state health, safety, and environmental laws, regulations, and orders, so as to protect the health and safety of workers and the public and to minimize accidental damage to property.

2.1. Clean Air Act

The Clean Air Act (CAA) is a federal statute that sets emission limits for air pollutants and determines emission limits and operating criteria for certain hazardous air pollutants. The program for compliance with the requirements is implemented by individual states through a State Implementation Plan (SIP) that describes how that state will ensure compliance with the air quality standards for stationary sources.

A number of major changes to the CAA were made with the passage of the Clean Air Act Amendments of 1990. Under Title V of the Clean Air Act Amendments of 1990, ANL-E was required to submit a Clean Air Act Permit Program (CAAPP) application to the IEPA for a sitewide, federally enforceable operating permit to cover emissions of all regulated air pollutants at the facility. This permit supersedes the prior individual state air pollution control permits. All facilities designated as major emission sources for regulated air pollutants are subject to this requirement. ANL-E meets the definition of a major source because of potential emissions of oxides of nitrogen in excess of 22.68 t/yr (25 tons/yr) and sulfur dioxide in excess of 90.72 t/yr (100 tons/yr) at the Building 108 Central Heating Plant (see Table 2.4).

Facilities subject to Title V must characterize emissions of all regulated air pollutants, not only those that qualify them as major sources. In addition to oxides of nitrogen and sulfur dioxide, ANL-E also must evaluate emissions of carbon monoxide, particulates, volatile organic compounds (VOCs), hazardous air pollutants (a list of 188 chemicals, including radionuclides), and ozone-depleting substances. The air pollution control permit program requires that facilities pay annual fees on the basis of the total amount of regulated air pollutants (except carbon monoxide) they are allowed to emit.

Comments on the preliminary draft ANL-E CAAPP Permit were submitted to the IEPA prior to the January 19, 2001, deadline, and the final draft permit was sent out for public comment and for review by the EPA on February 14, 2001. A public hearing was not requested, and the finalized CAAPP permit was issued on April 3, 2001.

The ANL-E site contains a large number of air emission point sources. The vast majority are laboratory ventilation systems that are exempt from state permitting requirements, except for those systems emitting radionuclides. With the issuance of the ANL-E CAAPP Title V Permit on April 3, 2001, all previous operating permits, with two exceptions, were incorporated into this sitewide permit for all emission sources and activities. The open burning permits are renewed each year. In 2001, a construction permit was issued to expand the number of portable high-efficiency particulate air filters (HEPAs) from four to six. Operation is allowed under a special condition of the existing construction permit and will be incorporated when the ANL-E Title V Permit is renewed or reissued. The permitted air emission sources are listed in Table 2.14.

On July 26, 2001, a request by ANL-E for a permit revision was submitted to IEPA to change the service of two fuel storage tanks at Building 46. Following review by IEPA and EPA a revised CAAPP permit was issued on October 18, 2001.

2.1.1. National Emission Standards for Hazardous Air Pollutants

The National Emission Standards for Hazardous Air Pollutants (NESHAP) constitute a body of federal regulations that set forth emission limits and other requirements, such as monitoring, record keeping, and operational and reporting requirements, for activities generating emissions of certain hazardous air pollutants. The only standards affecting ANL-E operations are those for asbestos and radionuclides. By the end of 2001, the IEPA had issued a total of 21 air pollution control permits to ANL-E for NESHAP sources. The NESHAP sources are listed in Table 2.14. All ANL-E operating NESHAP Permits were incorporated into the sitewide ANL-E Title V permit.

2.1.1.1. Asbestos Emissions

Many buildings on the ANL-E site contain large amounts of asbestos-containing material (ACM), such as thermal system insulation around pipes and tanks, spray-applied surfacing material for fireproofing, floor tile, and asbestos-cement (Transite) panels. This material is removed as necessary during renovations or maintenance of equipment and facilities. The removal and disposal of this material are governed by the asbestos NESHAP.

ANL-E maintains an asbestos abatement program designed to ensure compliance with these and other regulatory requirements. In general, ACM is removed from buildings either by specially trained ANL-E crews (for small-scale, short-duration projects) or by outside contractors (for large-scale insulation removal projects). All removal work is performed in accordance with both NESHAP and Occupational Safety and Health Administration requirements governing worker safety at ACM removal sites.

Approximately 518 m^3 (18,300 ft^3) of ACM was removed from ANL-E buildings during 2001. The 99 small removal projects that were completed generated 31 m^3 (1,100 ft^3) of ACM waste; the remaining 488 m^3 (17,239 ft^3) generated resulted from 12 large removal projects. Large quantities of asbestos waste were generated from the demolition of five buildings in the East Area. Table 2.1 provides asbestos abatement information for the large removal projects. The IEPA was notified during December 2001, that no more than 71 m^3 (2,500 ft^3) of ACM waste is expected to be generated from small-scale projects during 2002.

A separate portion of the asbestos removal standards contains requirements for disposing of ACM. Off-site shipments are to be accompanied by completed shipping manifests. Asbestos disposal information is provided in Table 2.2. Until closure of the ANL-E landfill in September 1992, asbestos from small-scale projects was disposed of on site in a designated area of the 800 Area Landfill.

2.1.1.2. Radionuclide Emissions

The NESHAP standard for radionuclide emissions from DOE facilities (40 CFR Part 61, Subpart H) establishes the emission limits for the release of radionuclides other than radon to the air and the corresponding requirements for monitoring, reporting, and record keeping. A number of emission points at ANL-E are subject to these requirements and are operated in compliance with them. These points include ventilation systems for hot cell facilities for storage and handling of radioactive materials (Buildings 205 and 212), ventilation systems for particle accelerators (Building 375, IPNS facility, and the Building 411 APS linac), and several ventilation systems associated with the Building 350 New Brunswick Laboratory. In addition, many ventilation systems and fume hoods are used occasionally for processing small quantities of radioactive materials.

The amount of radioactive material released to the atmosphere from ANL-E emission sources is extremely small. The maximum off-site dose to a member of the general public for 2001 was 0.036 mrem, excluding radon-220 and radon-222, which is 0.4% of the 10 mrem/yr EPA

TABLE 2.1

Large-Scale Asbestos Abatement Projects DOE/IEPA Notification, 2001

Completion Date	Asbestos Abatement Contractor	Notification Quantity ft	Notification Quantity ft^2	Material	Building	Disposal Quantity (ft^3)	Landfill
02/09/01[a]	ANL-PFS-Waste Management	0	500	Floor Tile	335	24	Hanford[b]
03/16/01	Universal Asbestos Removal, Inc.	144	0	Steam Pipe Insulation	Outside	324	Streator[c]
04/07/01[a]	ANL PFS-Waste Management	0	986	Floor Tile	202	16	Hanford
05/21/01	Universal Asbestos Removal, Inc.	240	0	Steam Pipe Insulation	129	219	Streator
07/28/01	ANL PFS-Waste Management	275	270	Pipe Insulation Transite Panels	28[d]	300	Streator
09/20/01[a]	ANL PFS-Waste Management	0	1,000	Floor Tile	223	8	Streator
10/23/01	Environmental Cleansing Corp.	0	170	Transite Panels	26[d]	50	Streator
11/15/01	Environmental Cleansing Corp.	2,422	0	Pipe Insulation	Outside	1,600	Streator
11/21/01	Environmental Cleansing Corp.	2,225	28,900	Pipe Insulation Transite Panels	6[d]	2,180	Streator
12/11/01	Environmental Cleansing Corp.	2,378	40,794	Pipe Insulation Transite Panels, Floor Tile	5[d]	6,840	Streator
12/14/01[a]	ANL PFS-Waste Management	0	500	Floor Tile and Mastic	350	8	Hanford[e]
12/20/01	Environmental Cleansing Corp.	2,054	46,335	Pipe Insulation Transite Panels, Floor Tile	4[d]	5,670	Streator
				Total		17,239	

[a] Courtesy notification, nonfriable material removed intact.

[b] DOE Hanford Facility, Richland, WA.

[c] Streator Area Landfill, Streator, IL.

[d] Building demolished.

[e] Stored on site pending shipment to Hanford.

TABLE 2.2

Disposal of Asbestos-Containing Materials, 2001

Project Size	Landfill	Quantity (ft^3)	Total Quantity (ft^3)
Small-scale	Streator[a]	1,100	1,100
Large-scale (IEPA Notification)	Streator Hanford[b]	17,191 48[c]	17,239
	Total		18,339

[a] Streator Area Landfill, Streator, IL.

[b] DOE Hanford Facility, Richland, WA.

[c] 8 ft^3 pending shipment to Hanford.

standard. Section 4.6.1 contains a more detailed discussion of these emission points and compliance with the standard.

2.1.2. Conventional Air Pollutants

The ANL-E site contains a number of sources of conventional air pollutants, including a steam plant; gasoline, and ethanol/gasoline blend fuel-dispensing facilities; two alkali metal reaction booths; bulk chemical tanks; a dust collection system; the engine test facility; and fire training activities. These facilities are operated in compliance with applicable regulations and permit conditions. Table 2.14 gives the emission sources operating under the ANL-E CAAPP Title V Permit.

An annual compliance certification must be submitted each May 1 for the previous calendar year to the IEPA and EPA detailing any deviations from the permit and subsequent corrective actions. Three deviations were reported for 2001.

The first deviation involved the operation of the steam plant. The Title V Permit requires continuous opacity and sulfur dioxide monitoring of the smoke stack from Boiler No. 5, the only one of the five boilers at the steam plant equipped to burn coal. The permit requires submission of a quarterly report listing any exceedances beyond emission limits for this boiler (30% opacity averaged over 6 minutes and 0.82 kg [1.8 lb] of sulfur dioxide per million Btu averaged over a 1-hour period). Table 2.3 gives the hours that Boiler No. 5 operated on low-sulfur coal during 2001, as well as the amount of low-sulfur coal burned. On April 8, 2001, there were three six-minute opacity limit exceedance at Boiler No. 5 that were caused by unusually warm temperatures, which resulted in a very low steam demand. Verbal and written notifications were sent to the IEPA. Natural gas was used as the fuel in Boiler No. 5 for two months in 2001.

The second deviation involved an unpermitted bulking of mixed waste solvents at the Building 306 waste bulking sheds in April and May 2001. This action requires a permit change that will be submitted to the IEPA during 2002.

The third deviation involves noncompliance with the cold-cleaning rule, which began when the permit commenced in April 2001 and still continues. This deviation is being addressed by the preparation of a petition for an adjusted standard for submittal to the Illinois Pollution Control Board. The petition will request an adjusted standard to the cold-cleaning rule to allow the use of solvents exceeding the vapor pressure limits for research and development activities when no acceptable alternatives can be employed.

TABLE 2.3

Boiler No. 5 Operation, 2001

Month	Operated (hours)	Low-Sulfur Coal Burned (tons)
January	722	2,762.3
February	672	2,668.1
March	744	2,816.1
April	459	1,355.2
May	0	0
June	0	0
July	0	0
August	0	0
September	0	0
October	0	0
November	0	0
December	0	0
Total	2,597	9,601.7

Landfill gas monitoring is conducted quarterly at the 800 Area Landfill via 3 gas wells placed into the waste area and 10 gas wells at the perimeter of the landfill. In addition to the wells, ambient air is sampled in three nearby buildings and at three open-air locations to assess the presence of methane. The gas monitoring near the landfill determines whether or not methane is migrating from the landfill. Results indicate that methane is being generated; however, no migration of this compound has been noted.

Fuel-dispensing facilities include a commercial service station and the Building 46 Grounds and Transportation facility. Except for methanol and ethanol vapors from alternate fuel usage, these facilities have VOC emissions typical of any commercial gasoline service station.

Pursuant to *Illinois Administrative Code*, Title 35, Part 254 (35 IAC Part 254), ANL-E submits an emissions summary to the IEPA each May 1 for the previous year. The summary for 2001 is presented in Table 2.4.

TABLE 2.4

2001 Annual Emissions Report: Emissions Summary

Building No. and Source	CO[a]	NO_x	Particulate	SO_2	VOM	Lead	MC[b]	TCA[b]
46: Ethanol/Gasoline	–[c]	–	–	–	9.5	–	–	–
46: Methanol/Gasoline	–	–	–	–	0	–	–	–
46: 10,000 Gal Gasoline	–	–	–	–	12	–	–	–
108: Boiler 1	21,737	72,455	790	158	369	–	–	–
108: Boiler 2	0	0	0	0	0	–	–	–
108: Boiler 3	7,707	25,690	280	56	131	–	–	–
108: Boiler 4	4,193	13,976	152	30	71	–	–	–
108: Boiler 5 (coal-fired)	49,953	105,650	749	208,282	350	–	–	–
108: Boiler 5 (gas-fired)	5,916	8,605	215	43	100	–	–	–
108: Sulfuric Acid Tank[d]	–	–	–	–	–	–	–	–
200: Peak Shaving Generator	30	132	4	13	4	0	–	–
200: M-Wing Hot Cells (R)[e]	–	–	–	–	–	–	–	–
202: Peak Shaving Generator	0	0	0	0	0	–	–	–
206: Alkali Reaction Booth (R)[e]	–	–	<1	–	–	–	–	–
212: Alpha Gamma Hot Cell (R)[e]	–	–	–	–	–	–	–	–
212: Building Exhausts[d]	–	–	-	–	–	–	–	–
300: 8,000 Gal Gasoline	–	–	–	–	20.7	–	–	–
300: 10,000 Gal Gasoline	–	–	–	–	67.1	–	–	–
300: 6,000 Gal Gasoline	–	–	–	–	20.3	–	–	–
301: Hot Cell D&D Project (R)[e]	–	–	–	–	–	–	–	–
303: Mixed Waste Storage (R)[e]	–	–	–	–	–	–	–	–
306: Building Vents (R)[e]	–	–	–	<1	–	–	–	–
306: Bulking Sheds	–	–	36	–	329	–	8.5	2.7
306: Vial Crusher/Chemical Photooxidation Unit (R)[e]	–	–	–	–	0	–	–	–
308: Alkali Reaction Booth[d]	–	–	-	–	–	–	–	–
315: MACE Project (R)[e]	80	–	–	–	–	–	–	–
317: Lead Brick Cleaning (R)[e]	–	–	–	–	–	0	–	–
330: CP-5 D&D Project (R)[e]	–	–	–	–	–	–	–	–
331: Rad Waste Storage (R)[e]	–	–	–	–	–	–	–	–
350: NBL Pu/U Hoods (R)[e]	–	–	–	–	–	–	–	–
363: Central Shop Dust Collector[d]	–	–	-	–	–	–	–	–
368: Woodshop Dust Collector[d]	–	–	-	–	–	–	–	–
369: Salt Cake/Recov. Elec. Plant[d]	–	–	–	–	–	–	–	–
370: Alkali Reaction Booth[d]	–	–	-	–	–	–	–	–
375: Intense Pulsed Neutron Source (R)[e]	–	–	–	–	–	–	–	–
400: APS Facility (R)[e]	–	53	–	–	–	–	–	–
400: APS Generator Caterpillar (1 unit)	304	1,586	57	131	43	–	–	–
400: APS Generator Kohler (2 units)	2,926	3,948	154	811	140	–	–	–
595: Lab Wastewater Plant (R)[e]	–	–	–	–	58.6	–	0.2	0
Lab Rad Hoods (R)[e]	–	–	–	–	–	–	–	–
PCB Tank Cleanout	–	–	–	–	0	–	–	–
Torch Cut Lead-Based Paint[d]	–	–	-	–	–	–	–	–
Transportation Research Facility	1,120	4,119	292	266	343	–	–	–
WMO Portable HEPA - (4) (R)[e]	–	–	<1	–	–	–	–	–
Total (lb/yr)	93,965	236,214	2,730	209,790	2,068	0	8.7	2.7
Total (ton/yr)	46.98	118.11	1.36	104.90	1.03	0	0.04	0.0014
CAAPP Permit Limit (ton/yr)	(397.60)[f]	1,014.10	49.02	798.20	19.65	0.11	–	–

Footnotes continue on next page.

TABLE 2.4 (Cont.)

[a] Abbreviations: CO = carbon monoxide, HEPA = high-efficiency particulate air filter, MACE = melt attack and coolability experiment, NO_x = oxides of nitrogen, PCB = polychlorinated biphenyl, Pu = plutonium, SO_x = sulfur dioxide, U = uranium, and VOM = volatile organic material.

[b] MC = methylene chloride, TCA = 1,1,1-trichloroethane. These compounds are hazardous air pollutants (HAP) but are not classified as VOM.

[c] A hyphen indicates that the pollutant is not permitted from that particular unit (or it is classified as an insignificant activity); a zero means that the source is permitted for emissions of that pollutant but there were no emissions for the year.

[d] These sources have been designated as insignificant in the CAAPP.

[e] (R) = radionuclide source regulated by NESHAP (40 CFR Part 61 Subpart H).

[f] Not a permit limit, but is the maximum potential emission level for CO.

2.1.3. Clean Fuel Fleet Program

As mandated under the CAA and 35 IAC Part 241, the third annual Clean Fuel Fleet Program report was submitted to the IEPA on October 16, 2001, for vehicle acquisitions in Model Year (MY) 2001 (September 1, 2000–August 31, 2001). Four light-duty vehicles and one heavy-duty vehicle were reported. Total vehicle acquisitions were in compliance with the percentages required by the Clean Fuel Fleet Program.

2.2. Clean Water Act

The Clean Water Act (CWA) was established in 1977 as a major amendment to the Federal Water Pollution Control Act of 1972 and was modified substantially by the Water Quality Act of 1987. Section 101 of the CWA provides for the restoration and maintenance of water quality in all waters throughout the country, with the ultimate goal of “fishable and swimmable” water quality. The act established the National Pollutant Discharge Elimination System (NPDES) permitting system, which is the regulatory mechanism designed to achieve this goal. The authority to implement the NPDES program has been delegated to those states, including Illinois, that have developed a program substantially the same and at least as stringent as the federal NPDES program.

The 1987 amendments to the CWA significantly changed the thrust of regulatory activities. Greater emphasis is placed on monitoring and control of toxic constituents in wastewater, the permitting of outfalls composed entirely of storm water, and the imposition of regulations governing sewage sludge disposal. These changes in the NPDES program resulted in much stricter discharge limits in the 1990s and greatly expanded the number of chemical constituents monitored in the effluent.

2.2.1. Wastewater Discharge Permitting

The NPDES permitting process administered by the IEPA is the primary tool for enforcing the requirements of the NPDES program. Before wastewater can be discharged to any receiving stream, each wastewater discharge point (outfall) must be characterized and described in a permit application. The IEPA then issues a permit that, for each outfall, contains numeric limits or monitoring frequencies on certain pollutants likely to be present and sets forth a number of additional specific and general requirements, including sampling and analysis schedules and reporting and record keeping requirements. NPDES permits are effective for five years and must be renewed by the submission of a permit application at least 180 days prior to the expiration of the existing permit. Wastewater discharge at ANL-E is permitted by NPDES Permit No. IL 0034592. This permit was renewed during 1994 (effective October 30, 1994), was modified in 1995 (effective August 24, 1995), and was to expire on July 1, 1999. An application to renew the existing permit was submitted timely to the IEPA on December 28, 1998. As of the end of 2001, the IEPA was still in the process of reviewing the application to renew the permit; therefore, as provided for in the IEPA regulations, ANL-E continues to operate under the existing permit until the IEPA issues a renewal permit.

Wastewater at ANL-E is generated by a number of activities and consists of sanitary wastewater (from restrooms, cafeteria sinks and sinks in certain buildings and laboratories, and steam boiler blowdown), laboratory wastewater (from laboratory sinks and floor drains in most buildings), and storm water. Water softener regenerant from boiler house activities is discharged to the DuPage County sewer system. Cooling water and cooling tower blowdown are discharged into storm water ditches that are monitored as part of the NPDES permit. The current permit authorizes the release of wastewater from 40 separate outfalls, most of which discharge directly or indirectly into Sawmill Creek. Two of the outfalls are internal sampling points that combine to form the main wastewater outfall, Outfall 001. Table 2.5 lists these outfalls; Figure 2.1 shows their locations.

2.2.1.1. NPDES Permit Activities

Total dissolved solids (TDS) analyses results have historically demonstrated an annual cycle, culminating in periodic discharge limit violations occurring in the winter at Outfall 001. Investigations into the causes of the heightened TDS concentration during winter have focused on two sources of increased TDS contribution during the winter months: increased boiler activity with its associated increase in high TDS wastewater; and salt usage in the boiler house area that drains to the boiler house pond. To deal effectively with these problems, the boiler house equalization pond was routed to DuPage County for periodic discharge of up to 227,125 L/day (60,000 gal/day).

To accomplish this, ANL-E completed an application to DuPage County to allow the discharge of this wastewater under the existing permit with the county. An application was also sent

TABLE 2.5

Characterization of NPDES Outfalls at ANL-E, 2001

Outfall	Description	Average Flow[a]
001A	Sanitary Treatment Plant	0.375
001B	Laboratory Treatment Plant	0.502
001	Combined Outfall	0.877
003A	Swimming Pool	0.0
003B	300 Area (Condensate)	0.012
003C	Building 205 Footing Tile Drainage	0.008
003D&E	Steam Trench Drainage (Condensate)	0.006/0.002
003F	Building 201 Fire Pond Overflow Storm Water	<0.009
003G	North Building 201 Storm Sewer (Condensate)	0.023
003H	Building 212 Cooling Tower Blowdown	<0.001
003I	Buildings 200 and 211 Cooling Tower Blowdown	0.010
003J	Building 213 and Building 213 Parking Lot Storm Water	0.003
004	Building 203 Cooling Tower and Building 221 Footing Drainage and Storm Water	0.024
005A	Westgate Road Storm Water	Storm Water Only
005B	800 Area East Storm Water	Storm Water Only
005C	Building 200 West	0.016
005D	Storm Water	Storm Water Only
005E	Building 203 West Footing Drainage and Condensate	0.015
006	Cooling Tower Blowdown and Storm Water	0.025
007	Domestic Cooling Water for Compressor and Storm Water	0.011
008	Transportation and Grounds Storm Water	0.006
010	Coal Pile Runoff Emergency Overflow	Storm Water Only
101	North Fence Line Marsh Storm Discharge	Storm Water Only
102	100 Area Storm Water Discharge	Storm Water Only
103	Southeast 100 Area Storm Water	Storm Water Only
104	Northern East Area Storm Water Discharge	Storm Water Only
105A&B	Building 40 Storm Water Discharge	Storm Water Only
106A&B	Southern East Area Storm Water Discharge	Storm Water Only
108	Eastern 300 Area Storm Water and Cooling Water	0.018
110	Shooting Range Storm Water Discharge	Storm Water Only
111	319 Landfill and Northeast 317 Area	Storm Water Only
112A&B	Southern and Western 317 Area	Storm Water Only
113	Southern and Eastern 800 Area Landfill Storm Water Runoff	<0.021
114	Northern and Western 800 Area Landfill Storm Water Runoff	<0.001
115	314, 315, and 316 Cooling Water, Eastern and Southern APS Area	0.003
116	Water Treatment Plant and Storm Water	0.005

[a] Flow is measured in million gallons per day, except for outfalls with storm water only.

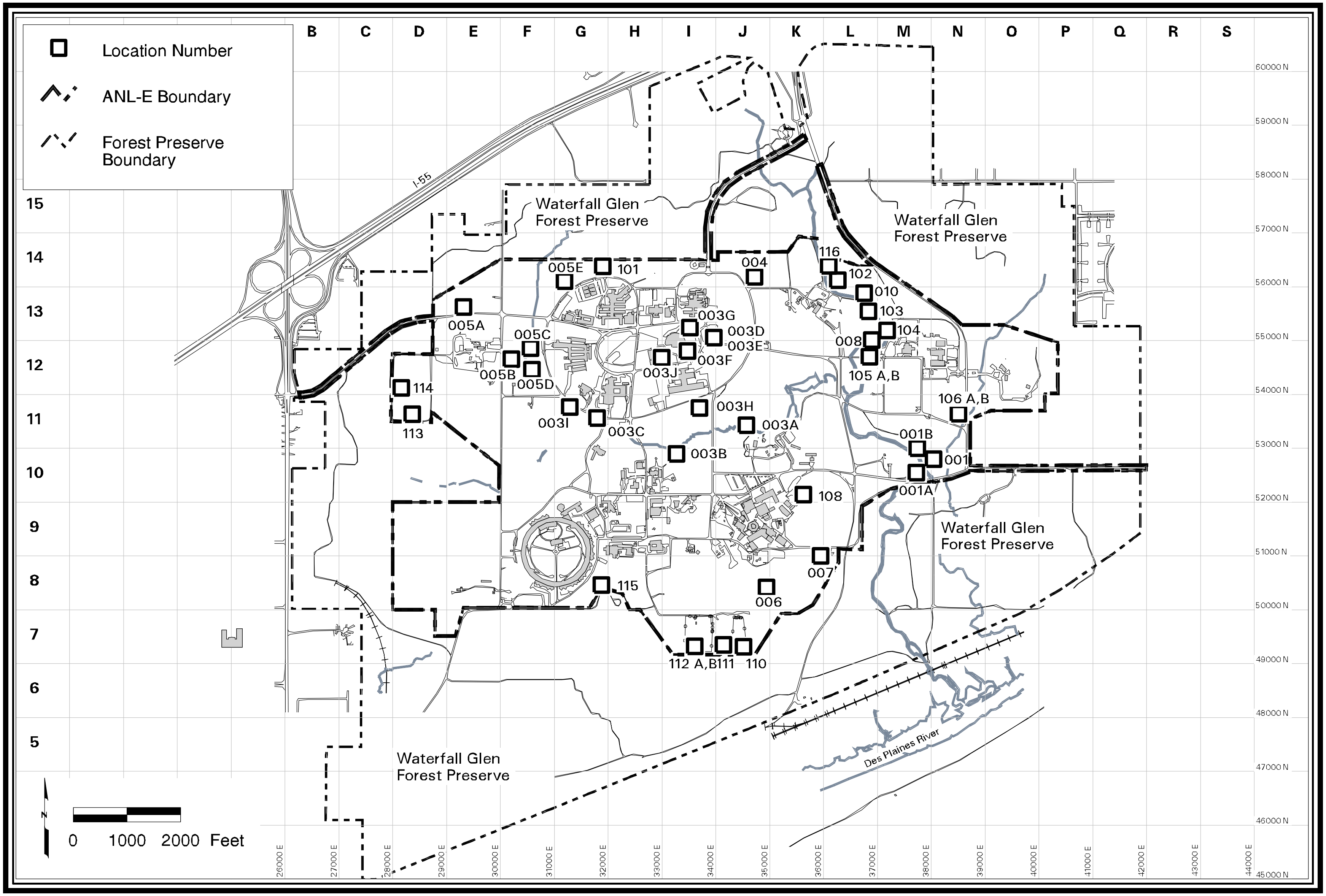


Figure 2.1 NPDES Permit Locations

to the IEPA. Historically, all wastewater in the equalization pond was directed to the sanitary wastewater treatment plant (SWTP). Redirection of the wastewater to the county would be considered a change requiring an NPDES permit modification.

2.2.1.2. Compliance with NPDES Permit

Wastewater is treated at ANL-E in two independent treatment systems, the sanitary system and the laboratory system. The sanitary wastewater collection and treatment system collects wastewater from sanitation facilities, the cafeteria, office buildings, and other portions of the site that do not contain radioactive or hazardous materials. This wastewater is treated in a biological wastewater treatment system consisting of primary clarifiers, trickling filters, final clarifiers, and slow sand filters. Wastewater generated by research-related activities, including those which utilize radioactive materials that could find their way into the sewer, flows to a series of retention tanks located in each building that are pumped to the laboratory wastewater sewer after radiological analysis and release certification. Treatment in the LWTP consists primarily of aeration, solids-contactor clarification, and pH adjustment. Additional steps can be added, including powder-activated carbon addition for organic removal, alum addition, and polymer addition or adjustment, if analysis demonstrates that any of these are required.

Figure 2.2 shows the two wastewater treatment systems that are located adjacent to each other. The volume of wastewater discharged from these facilities in 2001 averaged 1.4 million L/day (0.38 million gal/day) for the sanitary wastewater and 1.9 million L/day (0.50 million gal/day) for the laboratory process wastewater.

Results of the routine monitoring required by the NPDES permit are submitted monthly to the IEPA in a Discharge Monitoring Report (DMR). As required by the permit, any exceedance of permit limits or conditions is reported by telephone to the IEPA within 24 hours, and a written explanation of the exceedance is submitted with each DMR. During 2001, there were seven exceedances of NPDES permit limits out of approximately 1,600 measurements. All seven were exceedance of the TDS limit at Outfall 001, and all were attributed to road salt associated with snowmelt. Figure 2.3 presents the data for the total number of exceedances each year over the past 12 years.

The number of exceedances in 1999 and 2000 increased slightly because the provisional variance had expired, making the site subject to all the effluent limits in the 1994 permit. Efforts to reduce the number of violations by diverting high TDS wastewater streams to the DuPage County wastewater treatment system were completed late 2001.

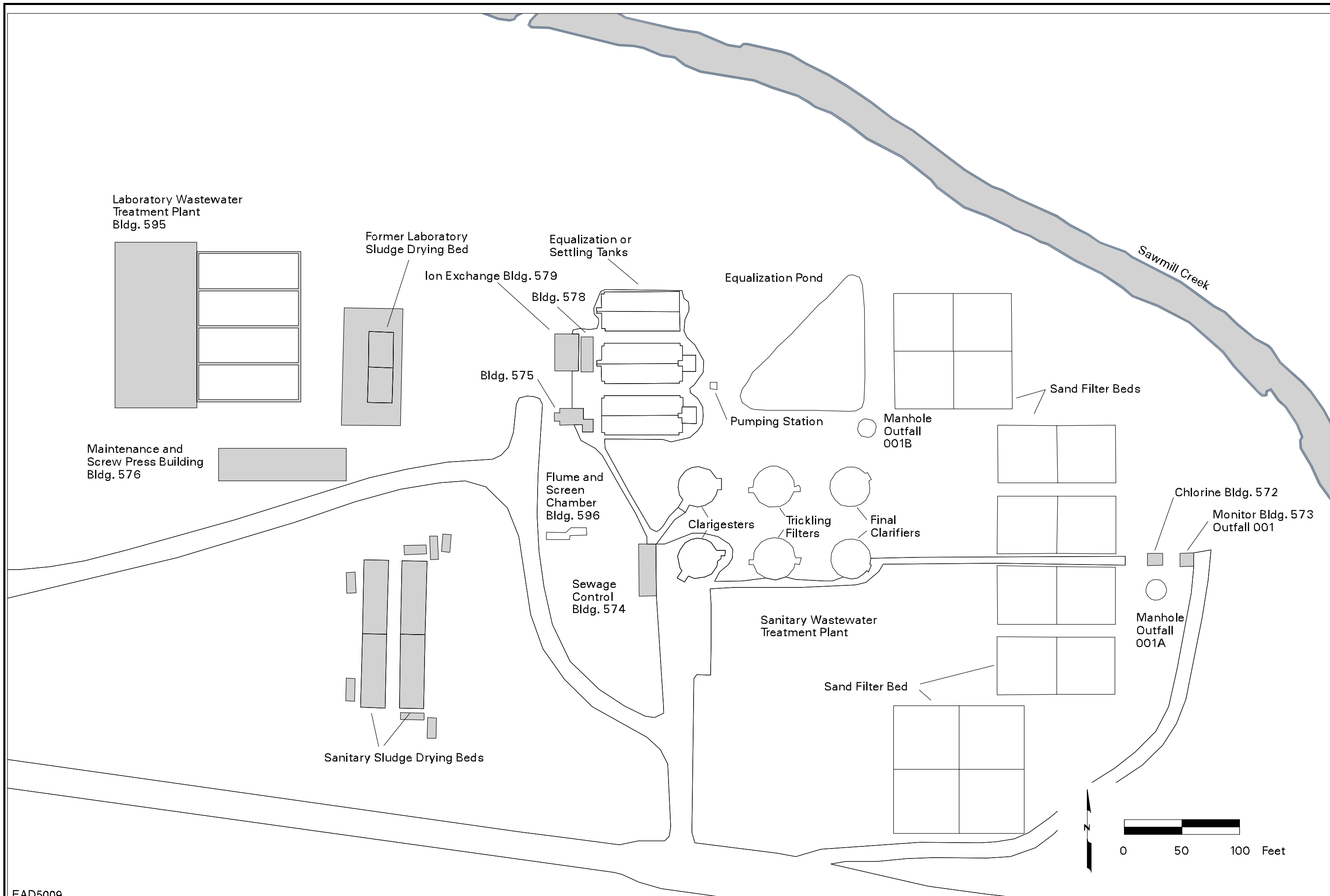


Figure 2.2 ANL-E Wastewater Treatment Plant

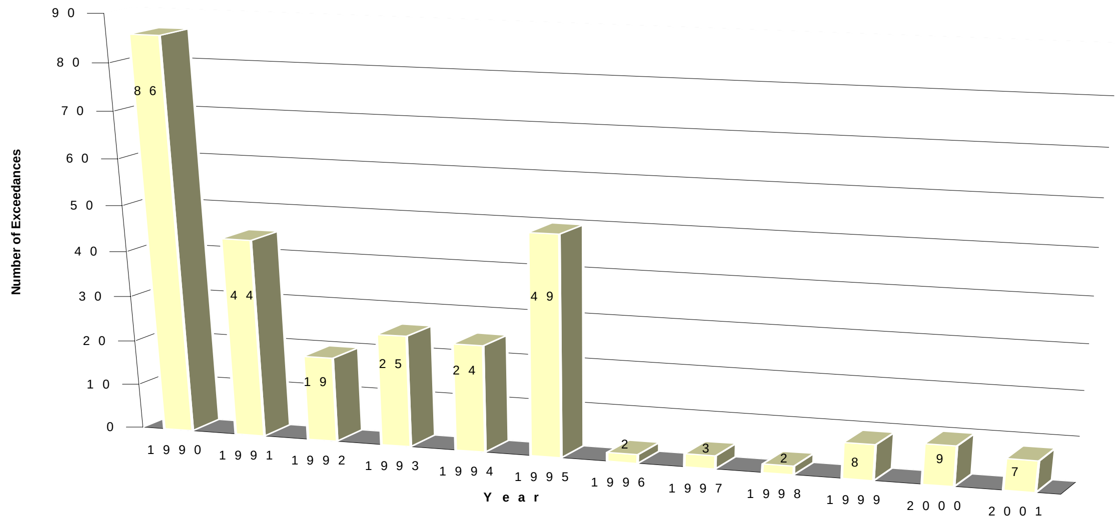


Figure 2.3 Total Number of NPDES Exceedances, 1990 to 2001

2.2.1.3. Priority Pollutant Analysis and Biological Toxicity Testing

The NPDES permit requires semiannual testing of Outfall 001B, the LWTP outfall, for all the priority pollutants — 124 metals and organic compounds identified by the IEPA as being of particular concern. During 2001, this sampling was conducted in June and December. Organic compound concentrations were very low. Chloroform (1 μg/L, 2 μg/L) was detected in both the June and December samples, as was bromodichloromethane (1 μg/L) and dibromochloromethane (1 μg/L, 2 μg/L), and bromoform (2 μg/L, 1 μg/L). It is suspected that the chloroform, dibromochloromethane, bromodichloromethane and bromoform result from the contact of chlorinated water with organic chemicals and residues from cooling tower biocide treatment chemicals. All semivolatile concentrations were below the detection limits. Low concentrations of copper (0.02 mg/L), mercury (0.0002 mg/L), phenols (0.022 mg/L), and zinc (0.062 mg/L) were detected at levels below the corresponding effluent limits (see Table 5.10). These findings are discussed further in Chapter 5.

In addition to the priority pollutant analysis, the permit requires annual biological toxicity testing of the combined effluent stream, Outfall 001. This testing was conducted June 18 through June 22, 2001. The data indicate that the effluent was not acutely toxic to either the fathead minnow or the water flea. Data from the past eight years suggest that cessation of chlorination of ANL-E effluent can be correlated with a beneficial effect on aquatic life in the receiving streams.

Special Condition No. 9 of the NPDES permit requires annual aquatic toxicity testing of Outfalls 003H, 003I, 003J, 004, 006, and 115 during the months of July and August. The samples were collected July 30 through August 3, 2001, and August 27 through 31, 2001. A review of the

July data indicates that Outfalls 003H and 004 exhibited no toxicity for either the water flea or the fathead minnow. This is generally consistent with the historical data, except for an occasional isolated instance of toxicity. Outfalls 003I, 006, and 115 were acutely toxic to the water flea but not to the fathead minnow. Outfall 003J was acutely toxic to both the water flea and fathead minnow. The results from the August samples were somewhat different. Outfalls 003H, 003I, 003J, 004, and 115 were free of toxic effects. Outfall 006 was toxic to the water flea but not to the fathead minnow.

The acute toxicity observed at these outfalls is believed to be related primarily to residual chlorine levels in the domestic water, some of which is discharged to the outfalls. Chlorine levels that are necessary to protect the water distribution system are high enough to cause measurable acute toxic effects in these tests. Another source of halogen compounds identified earlier is discharged cooling water containing water treatment chemicals used in various cooling towers throughout the site. Steps are being taken to redirect these nonstorm wastewater discharges into ANL-E's sewer systems to reduce the toxicity problems at these untreated outfalls.

2.2.1.4. Storm Water Regulations

In November 1990, the EPA promulgated regulations governing the permitting and discharge of storm water from industrial sites. The ANL-E site contains a large number of small-scale operations that are considered industrial activities under these regulations and, thus, are subject to these requirements. An extensive storm water characterization program was initiated in 1991, and a storm water permit application identifying 15 storm water outfalls was submitted to the IEPA in 1992.

The NPDES permit issued in October 1994 includes these 15 outfalls. In addition, the permit breaks up the watersheds for prior Outfalls 003 and 005 into smaller components and requires that their corresponding point-source discharges be analyzed and characterized for submission of a permit application, including characterization of industrial wastewater and storm water runoff discharged from these point sources. After 1994, three additional storm water outfall locations within the subdivided watersheds were identified as requiring characterization. Wastewater and storm water characterizations were completed in 1996 for the 18 outfalls identified within the subdivided watersheds. The characterization data include quantitative data; flow measurements; analyses for certain specified pollutants; and dates, durations, and precipitation volumes for monitored storm events. The resulting permit modification application was completed and submitted to the IEPA on September 18, 1996, and has been rolled into the permit renewal application, which the IEPA is presently reviewing.

The NPDES permit contains two special conditions requiring Storm Water Pollution Prevention Plans (SWPPPs) for the APS construction site (Special Condition No. 12) and for the remainder of the ANL-E site (Special Condition No. 11). Both of these plans were completed by the mandated date, May 1, 1995, which was 180 days after the effective date of the permit. These special conditions also require implementation of the plans by 365 days after the effective date of the permit; this was accomplished on November 1, 1995. With the completion of the APS construction project, that SWPPP was incorporated into the overall site plan in May 1997.

The same special conditions require ANL-E to inspect and report annually on the effectiveness of the sitewide SWPPP. In 2001, the annual inspection was completed and a report was submitted to the IEPA in December 2001. No major deficiencies were found. Changes to the plan will be required throughout the life of the permit, including any reissue or extension of the permit.

2.2.2. NPDES Inspections and Audits

The IEPA conducted a compliance inspection in May 2001. No major issues were determined.

2.2.3. General Effluent and Stream Quality Standards

In addition to specific NPDES permit conditions, ANL-E discharges are required to comply with general effluent limits contained in 35 IAC Part 304. Also, wastewater discharges must be of sufficient quality to ensure that Sawmill Creek complies with IEPA General Use Water Quality Standards found in 35 IAC Part 302, Subpart B. Chapter 5 of this report, which presents the results of the routine environmental monitoring program, also describes the general effluent limits and water quality standards applicable to the outfalls and discusses compliance with these standards.

2.2.4. Spill Prevention Control and Countermeasures Plan

ANL-E maintains a Spill Prevention Control and Countermeasures (SPCC) Plan as required by the CWA and EPA regulations at 40 CFR Part 112. This plan describes the actions to be taken in case of oil or oil product releases to navigable waters of the United States. Persons with specific duties and responsibilities in such situations are identified, as are reporting and record-keeping requirements mandated by the regulations. Regular training on implementation of this plan is conducted. No reportable spills occurred in 2001 that required activation of the SPCC Plan.

40 CFR 112.5 (b) requires that the plan undergo a complete review and evaluation at least once every three years. This was completed within the regulatory time frame, September 24, 2001. In addition, the same regulation requires that, within six months of the evaluation, changes to the plan identified by the evaluation will be completed and implemented. This will be accomplished by March 24, 2002.

2.2.5. Clean Water Action Plan

The Clean Water Action Plan Program, instituted in 1998, constitutes a voluntary commitment by federal agencies to work cooperatively to improve water quality in the United States. The approach is for federal agencies to form partnerships to identify watersheds with the most critical water quality problems. The goals of the plan are to establish initiatives to reduce public health threats, improve stewardship of natural resources, strengthen control of polluted runoff, and make water quality information more accessible to the public.

No formal plans related to this initiative have been established at ANL-E. However, ANL-E has worked with the IEPA to reduce or eliminate surface water discharges of regulated pollutants. Special focus has been on exceedances of NPDES permit parameter limits. Past upgrades to the ANL-E physical plant included acquisition of Lake Michigan water to replace dolomite well water as the source of domestic water. Lake Michigan water has a much lower TDS content than dolomite water, and the use of Lake Michigan water has reduced the amounts of TDS and copper that are discharged (water with lower TDS levels is less aggressive at dissolving copper from piping). The rehabilitation of the SWTP resulted in compliance with the ammonia-nitrogen limit. The upgrade of the LWTP also was completed, which gives ANL-E a number of options for treating various waste streams more effectively.

In 2001, ANL-E continued to reroute a number of sumps and drains from surface discharge to the Wastewater Treatment Plant (WTP). These reroutes are intended to prevent discharge of chlorinated water to the environment and to eliminate violations of permit limits and aquatic toxicity test failures. By the end of 2001, ANL-E had completed the steps necessary to begin directing some significant surface water discharges that contain boiler blowdown and road salt runoff to a county wastewater treatment plant. This action should reduce reoccurring TDS exceedances at the main outfall during the winter season. Projects to redirect the blowdown from cooling towers to the WTP to reduce TSS releases were implemented in 2001, at Buildings 200, 201, 363, and 377. The goal of ANL-E is to have zero NPDES permit related exceedances.

2.3. Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) and its implementing regulations are intended to ensure that facilities that treat, store, or dispose of hazardous waste do so in a way that protects human health and the environment. The Hazardous and Solid Waste Amendments of 1984 (HSWA) created a set of restrictions on land disposal of hazardous waste. In addition, the HSWA also require that releases of hazardous waste or hazardous constituents from any Solid Waste Management Unit (SWMU) at a RCRA-permitted facility be remediated, regardless of when the waste was placed in the unit or whether the unit originally was intended as a waste disposal unit. The RCRA program includes regulations governing management of underground storage tanks (USTs) containing hazardous materials or petroleum products. The IEPA has been authorized to administer most aspects of the RCRA program in Illinois. The IEPA issued a RCRA Part B Permit to ANL-E and DOE on September 30, 1997. The permit became effective on November 4, 1997.

The permit has been modified three times. First, on February 8, 1999, the IEPA issued a revised permit to include a Class 1 Modification to allow ANL-E to accept the ash from the incineration of ANL-E generated mixed waste at the DOE-owned Waste Experimental Reduction Facility in Idaho, in the event that it could not be disposed of otherwise. Second, on August 8, 2000, the IEPA issued a revised permit to include a Class 1 Modification to allow ANL-E to use Building 303 to store surplus chemicals, update the operating procedures for the Building 308 Alkali Metal Passivation Booth, and update the RCRA Contingency Plan. Third, on January 12, 2001, the IEPA issued a revised permit to include one Class 1 and one Class 2 Modification. These allowed ANL-E to (1) change the name of the DOE signatory authorized to sign documents related to the ANL-E RCRA Part B Permit, and (2) use an existing concrete pad at Building 331 to store solid radioactive and mixed waste.

2.3.1. Hazardous Waste Generation, Storage, Treatment, and Disposal

The nature of the research activities conducted at ANL-E results in the generation of small quantities of a large number of waste chemicals. Many of these materials are classified as hazardous waste under RCRA. ANL-E has 25 Hazardous Waste Management Units; these consist of 17 container storage units and 1 tank storage unit, and 4 miscellaneous treatment units and 3 tank chemical treatment units. Table 2.6 provides descriptions of all of the units. No RCRA closures were conducted in 2001. Figure 2.4 shows the locations of the major active hazardous waste treatment, storage, and disposal areas at ANL-E.

ANL-E prepares an annual Hazardous Waste Report. The report is submitted to the IEPA by March 1 of each year and describes the activity of the previous year. It is a summation of all RCRA waste activities, including generation, storage, treatment, and disposal. The report describing such activities during 2001 was submitted to the IEPA on February 26, 2002. The RCRA-permitted storage facilities, designed and operated in compliance with RCRA requirements, allow for accumulation and storage of waste pending off-site disposal. ANL-E's on-site permitted treatment facilities address a small number of hazardous wastes generated by ANL-E operations. Off-site treatment and disposal take place at approved hazardous waste treatment and disposal facilities. Hazardous wastes that were generated, treated, stored, disposed of, or recycled during 2001 are described in Table 2.7.

No hazardous waste treatability studies were conducted at ANL-E during 2001.

TABLE 2.6

Permitted Hazardous Waste Treatment and Storage Facilities, 2001

Description	Location	Purpose
Storage		
Concrete Storage Pad	317 Area[a] Building 331	Storage of solid radioactive waste and solid mixed waste (MW) in the form of steel-encased lead shielding containers and containerized solid MW.
Container Storage Area	Building 325C, East	Storage of liquid and solid bulk or lab-packed flammable and reactive hazardous waste and solid and liquid bulk polychlorinated biphenyls (PCBs) and miscellaneous PCB units.
	Building 325C, West	Storage of bulk and lab-packed liquid flammable hazardous waste.
	Building 303 Mixed Waste Storage Facility	Storage of containers of ignitable, corrosive, oxidizing, reactive, and solid hazardous, radiological, or MW.
	Building 331 Radioactive Waste Storage Facility	Storage of containers of flammable, toxic, corrosive, and oxidizing hazardous, radiological, and MW.
Dry Mixed Waste Storage Area	Building 374A	Storage of solid MW and radioactively contaminated lead bricks.
Mixed Waste Container Storage	Building 329	Storage of containers of bulk and lab-packed ignitable mixed waste or compatible waste.
Portable Storage Units (4)	Building 306	Storage of hazardous, radiological, or MW (3 of 4 units).
		Bulking operations to consolidate and reduce the volume of lab-packed waste in containers (1 of 4 units).
Hazardous Waste Storage Facility[b]	Building 307	Proposed storage facility for hazardous waste

TABLE 2.6 (Cont.)

Description	Location	Purpose
Tank Storage	Building 306	Storage of corrosive and toxic mixed waste and radiological liquid wastes (4,000 gal; currently not used).
Mixed Waste Storage	Building 306 - Storage Room A-142	Storage of ignitable MW.
	Building 306 - Storage Room A-150	Storage of solid and liquid MW.
	Building 306 - Storage Room C-131	Storage of ignitable, corrosive, and reactive hazardous waste.
	Building 306 - Storage Room C-157	Storage of corrosive and oxidizer MW.
	Building 306 - Storage Room D-001	Storage of solid MW containing toxic metal constituents.
Treatment		
Alkali Metal Passivation Booth	Building 206	Destruction of water reactive alkali metals possibly contaminated with radionuclides.
Alkali Metal Passivation Booth	Building 308	Destruction of water reactive alkali metals.
Chemical/Photooxidation Unit	Building 306	Treatment of ignitable liquid MW containing organic contaminants.
Dry Ice Pellet Decontamination Unit	317 Area	Treatment of solid MW having radionuclide and/or RCRA metal surface contamination.
Low-Level Waste (LLW) Neutralization/Precipitation System	Building 306	Treatment of aqueous, corrosive LLW, some of which is contaminated with heavy metals.
Mixed Waste Immobilization/ Macroencapsulation Unit	Building 306	Treatment of solid, semisolid, and organic liquid MW containing RCRA metals.
Transuranic (TRU) Neutralization/Precipitation Treatment Unit	Building 306	Treatment of corrosive, aqueous MW-containing TRU radionuclides and RCRA metals.

[a] This facility will be formally closed in 2002.

[b] This facility was proposed several years ago and a permit has been obtained. However, it has not yet been built.

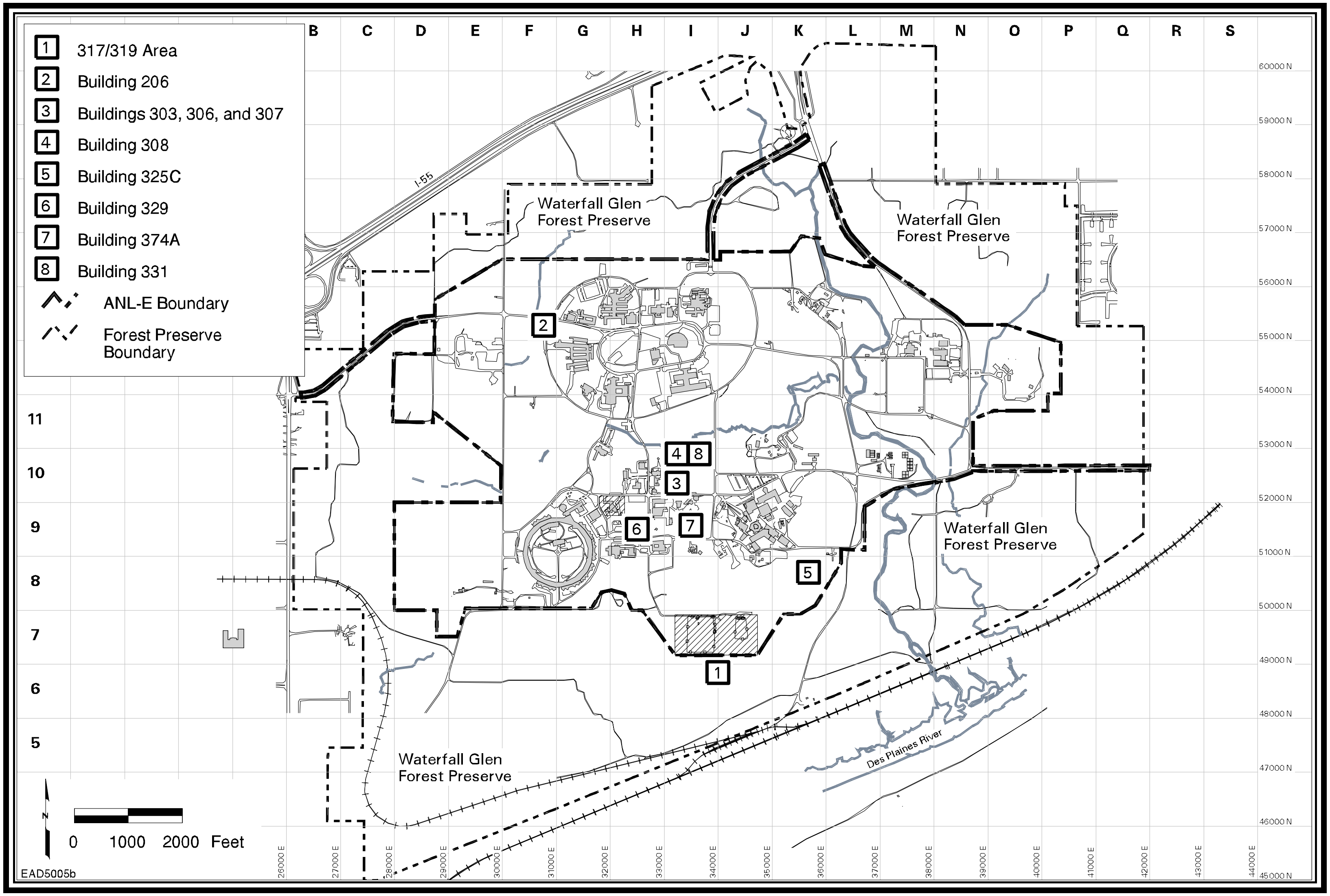


Figure 2.4 Major Treatment, Storage, and/or Disposal Areas at ANL-E

TABLE 2.7

Hazardous Waste Generation, Treatment, Disposal, or Recycle, 2001

Waste	Volume (gal)[a]	Weight (lb)
Generated and Disposed of or Recycled		
Acidic cleaning solutions	55	495
Aerosol cans	165	535
Alkaline cleaning solution	110	880
Aqueous solutions with lead	165	1,320
Brake cleaner fluid[b]	12	99
Bulked laboratory solvents	460	3,068
Cadmium-contaminated debris	90	360
Compressed gases	5	8
Compressed gases[b]	25	117
Cutting oils with lead and solvents	165	1,333
Diesel fuel-contaminated debris	305	1,220
Ethanol solutions with silver	275	2,489
Heavy metal-contaminated debris	30	120
Immersion cleaner fluid[b]	20	161
Kerosene	195	825
Labpacks of liquid chemicals	1,385	11,082
Labpacks of solid chemicals	766	3,063
Lead-contaminated debris	3,965	15,860
Mercury-contaminated debris	185	740
Methanol	1,400	9,500
Nickel-cadmium batteries[b]	110	1,210
Oil based paint waste	20	200
Plating wastes containing lead, alkaline	55	526
Solvent-containing debris	55	220
Sulfide-contaminated debris	30	120
Universal Hazardous Waste		
Mercury-containing lamps[b]	13,454	13,454
Lead acid batteries[b]	218	3,250

[a] In accordance with RCRA regulations, waste amounts are reported in units of gallons, regardless of the physical form of the waste.

[b] Recycled waste.

2.3.2. Mixed Waste Generation, Storage, Treatment, and Disposal

A small number of hazardous wastes that ANL-E generates also exhibit radioactivity, thereby making them "mixed waste." The hazardous component of mixed waste is governed by RCRA regulations, while the radioactive component is subject to regulation under the Atomic Energy Act of 1954 (AEA) as implemented by DOE Orders. Accordingly, facilities storing or disposing of mixed waste must comply with both DOE requirements and RCRA permitting and facility standards. ANL-E generates several types of mixed waste, including acids, solvents, and sludges contaminated with radionuclides. The RCRA Part B Permit provides for on-site treatment in five mixed waste treatment systems. These systems include neutralization of low-level waste (LLW) and transuranic (TRU) corrosive aqueous waste and the stabilization of sludge and soil. In addition, during 2001, some of the mixed waste was sent off site to Envirocare of Utah, Inc., a commercial treatment and disposal facility. Table 2.8 lists mixed waste generated, stored, treated on site, or shipped off site for disposal in 2001.

2.3.3. Federal Facility Compliance Act Activities

The Federal Facility Compliance Act of 1992 (FFCA) amended RCRA to clarify the application of its requirements and sanctions to federal facilities. The FFCA also requires that DOE prepare mixed waste treatment plans for DOE facilities that store or generate mixed waste. The Proposed Site Treatment Plan (PSTP) for mixed waste generated at ANL-E was submitted to the IEPA and the Illinois Department of Nuclear Safety (IDNS) in March 1995. Mixed waste at ANL-E has been managed in accordance with the PSTP as of October 1995. ANL-E's RCRA Part B Permit provides for on-site treatment of certain mixed waste as required by the PSTP.

During 2001, ANL-E completed the treatment milestones for waste streams that included acidic solutions with heavy metals, aqueous solutions with heavy metals, soil with heavy metals, TRU acids with heavy metals, and polychlorinated biphenyl (PCB) sludge and debris with heavy metals.

In 2002, ANL-E will be working on completing treatment of several lower-volume waste streams. The expectation is to complete treatment of all stored mixed waste by September 2004. Fourteen mixed waste streams will be treated under the PSTP; six will be treated by September 2002, six will be treated by September 2003, and the remaining two will be treated by September 2004.

TABLE 2.8

Mixed Waste Generation, Treatment, Storage, and Disposal, 2001

Waste	Volume (gal)	Weight (lb)
Generated		
MW acidic solutions	214	1,930
MW acidic solutions with heavy metals	189	1,701
MW alkali metals	0.1	1
MW aqueous solutions with heavy metals	29	264
MW elemental mercury	19	159
MW flammable liquids	28	195
MW metal scrap with cadmium	55	1,100
MW debris with chromium	7	177
MW debris with heavy metals	65	260
MW lead articles	295	26,548
MW sludge with heavy metals	495	4,950
MW uranyl nitrate	3	60
TRU acids with heavy metals	57	513
Shipped for Treatment/Disposal		
MW debris with chromium	3	75
MW debris with heavy metals	584	2,336
MW lead articles	7,473	672,570
MW metal scrap with cadmium	1,594	31,880
MW metal scrap with heavy metals	7	210
Treated		
MW acidic solutions with heavy metals (neutralized)	439	3,949
MW acidic solutions (neutralized)	105	945
MW aqueous solutions with heavy metals (neutralized)	11	99
MW soil with heavy metals	195	1,794
TRU acids with heavy metals	103	927
In Storage		
MW acidic solutions	110	986
MW acidic solutions with heavy metals	100	901
MW alkali metals	146	1,168
MW aqueous solutions with heavy metals	18	165

TABLE 2.8 (Cont.)

Waste	Volume (gal)	Weight (lb)
MW cyanide solution	15	128
MW elemental mercury	27	225
MW flammable liquids	28	195
MW uranyl nitrate	262	5,247
MW metal scrap with cadmium	2,070	41,401
MW metal scrap with heavy metals	133	3,982
MW debris with chromium	76	1,890
MW debris with heavy metals	2,332	9,326
MW debris with volatile organics	171	684
MW lead articles	4,643	417,867
MW sludges with heavy metals	3,192	31,927
TRU acids	57	513
TRU cadmium	138	9,913
TRU lead	230	20,690
TRU sludge	37	375

2.3.4. RCRA Inspections: Hazardous Waste

A RCRA Compliance Inspection was conducted by EPA Region V on September 18 and 19, 2001. EPA Region V reviewed pertinent documentation, such as inspection records, the contingency, waste analysis, and closure plans, and annual reports. All permitted storage areas and several satellite accumulation areas located in Buildings 200, 203, and 308 were inspected. The EPA determined that ANL-E provided an exemplary waste management program and is in compliance with RCRA regulations.

2.3.5. Underground Storage Tanks

The ANL-E site currently contains 18 USTs. Eight of the existing tanks are being used to store fuel oil for emergency generators. The on-site vehicle fueling and maintenance facilities (Building 46 and the on-site service station) use underground tanks to store diesel, gasoline, used oil, antifreeze, and ethanol/gasoline blend. The UST at Building 46 that was used to store a methanol/gasoline blend was converted to storing ethanol/gasoline fuel blend. An abandoned 3,785-L (1,000-gal) UST in the 800 Area that was used in the past to store gasoline was discovered during soil removal activities at Area of Concern F (AOC-F) (Contaminated Soil Near Building 827). The UST was removed in July 2001.

The Office of the Illinois State Fire Marshal conducted an UST inspection on April 16, 2001, resulting in two findings. A Certification Audit was subsequently performed on August 9, 2001. The Fire Marshal certified that all of the USTs were in compliance with regulations.

2.3.6. Corrective Action for Solid Waste Management Units

As mentioned previously, the HSWA require that any RCRA Part B Permit issued must include provisions for corrective action to address releases of hazardous constituents from any SWMU at the site, regardless of when waste was placed in the unit. Accordingly, the ANL-E Part B Permit issued in September 1997 contains procedures and requirements to govern the corrective action of such units. The Part B Permit identifies 49 SWMUs and 5 AOCs. During 2001, ANL-E submitted requests for No Further Action (NFA) for 4 SWMUs; the IEPA approved 5 ANL-E NFA requests, including one request made during 2000. These SWMUs are listed in Table 2.9. As of December 2001, the IEPA has approved NFA for 30 SWMUs. Planned remedial actions for five additional units have been completed, and the work has been approved by the IEPA; however since contamination remains at these units, a NFA designation has not yet been granted. The remediation program for the remaining units will continue under the authority of the Part B Permit. Chapter 3 of this report contains a summary of the characterization and remediation activities currently underway at a number of the SWMUs in accordance with IEPA-approved corrective action work plans.

2.4. Solid Waste Disposal

In September 1992, ANL-E ceased operation of its 800 Area sanitary landfill, which had begun operating in 1966. The original operating permit was issued by the IEPA in 1981 in accordance with 35 IAC Part 807. Supplemental permits addressing final elevations, a groundwater monitoring program, and closure/postclosure requirements, such as gas monitoring, were issued by the IEPA on April 24, 1992; September 15, 1992; January 11, 1995; November 20, 1997; August 25, 1998; September 16, 1998; June 16, 1999, and April 25, 2000. Ground Water Quality Standards of some routine indicator parameters have been consistently exceeded. Exceedances occur only in shallow, perched pockets of groundwater in the glacial drift that is not in direct communication with the deeper dolomite bedrock aquifer. To aid in the determination of the nature and extent of these exceedances, in 1999, additional groundwater monitoring wells were installed around the landfill. Hydrogen-3 has been noted in several wells at the 800 Landfill. The groundwater monitoring program is discussed in detail in Section 6.3.

ANL-E generates a large volume and variety of nonhazardous special wastes. Some otherwise special waste, such as sanitary sewage sludge, is certified to the IEPA as “nonspecial waste” pursuant to IEPA regulations. Table 2.10 gives the nonhazardous special and nonspecial

TABLE 2.9

No Further Action Requests and Approvals, 2001

SWMU Number	SWMU Name
5[a,b]	East Area Sewage Treatment Sand Filter Beds
19	East-Northeast 319 Landfill
134[a,b]	570 Area Laboratory Wastewater Sludge Drying Beds
136[a,b]	570 Area Sanitary Wastewater Sludge Drying Beds
146	A^2R^2 Reactor Excavation Fill
151[c]	Building 330 yard with materials for decommissioning
179[d]	Storm Sewers Cooling Tower Wastewater
180[a]	Scrap Disposal Staging Area East of 377 Cooling Towers
182[a]	Waste Oil Spread on Roads
AOC-F	Contaminated Soil near Building 827
AOC-H[d]	Contaminated Soil near Building 24

[a] IEPA approved NFA.

[b] NFA request submitted to IEPA in 2000.

[c] NFA granted for soil; further investigation of groundwater required.

[d] NFA approval expected in 2002.

wastes generated and disposed of during 2001. All nonhazardous special and nonspecial wastes generated at ANL-E in 2001 were disposed of at permitted off-site special waste landfills. The IEPA began requiring annual nonhazardous special waste reporting in 1991. The report is required to be submitted by February 1 of each year to describe the activity of the previous year. It is a summation of all manifested nonhazardous and polychlorinated biphenyls (PCBs) wastes.

ANL-E also periodically generates radioactive waste containing other regulated but nonhazardous materials, such as PCBs. Table 2.10 lists the quantities of such waste stored on site or disposed of off site.

2.5. National Environmental Policy Act

The National Environmental Policy Act of 1969 (NEPA) established a national environmental policy that promotes consideration of environmental factors in federal or federally

TABLE 2.10

Storage, Disposal, or Recycling of Special and Nonspecial Waste, 2001

Waste	Volume	Weight (lb)
Nonhazardous Special Waste Disposal		
Contaminated soil (remediation waste)	12,058 yd^3	24,116,000
Medical waste	198 ft^3	834
Nonhazardous liquid chemicals	4,275 gal	29,895
Nonhazardous solid chemicals	3,420 gal	14,298
Petroleum naptha[a] (parts washers)	1,189 gal	7,885
Used oil[a]	2,675 gal	19,260
Certified Nonspecial Waste Disposal		
Nonspecial fly ash	2,004 yd^3	1,693,000
Nonspecial laboratory sewage sludge	155 yd^3	310,000
Nonspecial sandblasting waste	15 yd^3	30,000
Nonspecial metal debris	30 yd^3	30,000
Toxic Substances Control Act (TSCA) Special Waste Disposal		
Asbestos	580 yd^3	590,000
PCBs	295 gal	1,997
Materials Recycled		
Fly ash (boiler house)[a]	484 yd^3	409,000
Sanitary sewage sludge[a]	82,000 gal	685,000
TSCA Mixed Waste Generated		
Radioactive PCB articles	10 gal	84
TSCA Mixed Waste in Storage		
Radioactive PCB sludge and debris	56 gal	496
Radioactive PCB articles	25 gal	220
TSCA Mixed Waste Disposed of		
Radioactive PCB sludge and debris	12,088 gal	107,065

[a] Recycled waste.

sponsored projects. NEPA requires that the environmental impacts of proposed actions with potentially significant effects be considered in an Environmental Assessment (EA) or Environmental Impact Statement (EIS). DOE has promulgated regulations in Title 10, Part 1021 of the *Code of Federal Regulations* (CFR) that list classes of actions that ordinarily require those levels of documentation or that are categorically excluded from further NEPA review. No EISs were prepared during 2001. One EA was prepared in 2001 for sitewide wetland management and includes the mitigation of Wetland C, which lost its wetland characteristics after the construction of the APS.

DOE conducted a NEPA Assessment in September 2001. No findings were identified but four Opportunities for Improvement (OIs) were noted. Corrective actions for the OIs are pending.

2.6. Safe Drinking Water Act

The Safe Drinking Water Act of 1974 (SDWA) established a program to ensure that public drinking water supplies are free of potentially harmful materials. This mandate is carried out through the institution of national drinking water quality standards, such as Maximum Contaminant Levels and Maximum Contaminant Level Goals, as well as through the imposition of wellhead protection requirements, monitoring requirements, treatment standards, and regulation of underground injection activities. The regulations implementing the SDWA in 40 CFR Parts 141–143 establish Primary and Secondary National Drinking Water Regulations that set forth requirements to protect human health (primary standards) and provide aesthetically acceptable water (secondary standards).

2.6.1. Applicability to ANL-E

In January 1997, ANL-E incorporated Lake Michigan water as its domestic source water, thereby replacing the dolomite groundwater that formerly constituted its source of drinking water. The Lake Michigan water is purchased from the DuPage County Water Commission. As such, ANL-E is now a customer rather than a supplier of water. Consequently, on January 23, 1997, the DuPage County Health Department (DPCHD) notified DOE that the federal and state monitoring requirements applicable to a “non-transient, non-community” public water supply, which ANL-E had been required to satisfy while operating the on-site water supply system, were no longer applicable. In addition, sampling, analysis, and reporting of the drinking water data to the DPCHD and the Illinois Department of Health (IDPH) were no longer required. Nevertheless, ANL-E voluntarily provides to on-site personnel the Consumer Confidence Report on drinking water quality that ANL-E receives as a customer of the DuPage County Water Commission.

2.6.2. Water Supply Monitoring

During 2001, ANL-E continued an informational monitoring program at the previously used dolomite domestic wells; quarterly samples were analyzed for radionuclides and VOCs. No radionuclides or VOCs were detected.

2.7. Federal Insecticide, Fungicide, and Rodenticide Act

During 2001, all exterior pesticides and herbicides at ANL-E were applied by a licensed contractor who provides the chemicals used and removes any unused portions. ANL-E coordinates the contractor's activities and ensures that the chemicals are EPA-approved, that they are used properly, and that any unused residue is removed from the site by the contractor.

In addition, routine applications of pesticides are performed within buildings, as needed. Indoor pesticide applications are provided by IDPH-licensed contractors under the direction of Plant Facilities and Services (PFS)-Custodial Services or Marriott management, depending on the building involved. The indoor applications involve EPA "Restricted Use" products.

In 2001, approximately 27,645 L (7,320 gal) of commercial-grade herbicide and 1,900 L (500 gal) of pesticide were applied throughout the ANL-E site. Fertilizer with weed control is included in the quantity of herbicide.

2.8. Comprehensive Environmental Response, Compensation and Liability Act

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) addresses the cleanup of hazardous waste disposal sites and the response to hazardous substance spills. Under CERCLA, the EPA collects site data regarding sites subject to CERCLA action through generation of a Preliminary Assessment (PA) report, followed up by a Site Screening Investigation (SSI). Sites then are ranked, on the basis of the data collected, according to their potential for affecting human health or causing environmental damage. The sites with the highest rankings are placed on the National Priority List (NPL) and are subject to mandatory cleanup actions. No ANL-E sites are included in the NPL.

On December 21, 1999, the EPA published interim guidance redefining "Federally permitted releases" under CERCLA. This action may have a significant impact on ANL-E with respect to what types of air emissions will need to be reported under Section 101(10)(H) of CERCLA. The guidance provides an extremely narrow definition of how CERCLA substances released to the air would be exempted from reporting as a federally permitted release. To date, the

EPA has announced it would hold implementation of the guidance in abeyance until the guidance is revised.

2.8.1. CERCLA Program at ANL-E

In early 1990, the EPA requested that DOE submit SSI reports for 6 of 13 ANL-E sites for which PA reports previously had been submitted. Upon further discussions between the EPA and DOE, one of the six sites was eliminated from consideration, and three adjacent units (317/319/East-Northeast [ENE]) were treated as a single site. As a result, three SSI reports were submitted to the EPA in January 1991. Table 2.11 lists the sites for which a PA report was submitted. As indicated in the table, these sites have either been cleaned up, are currently undergoing corrective action, or have been permitted.

2.8.2. CERCLA Remedial Actions

Remedial actions to clean up any release of hazardous materials from inactive waste sites follows one of two main routes. The first is through the CERCLA program (more commonly known as Superfund cleanup projects) and is generally used for abandoned sites. The second route is the RCRA corrective action process, which frequently is used for waste sites on active facilities. SWMUs are the units subject to RCRA corrective action. All but one of the sites described in the SSI reports (see Table 2.11) are on the ANL-E site, and most are included as SWMUs in the RCRA Part B Permit. The RCRA Part B Permit, effective November 4, 1997, contains procedures and requirements that govern the corrective action of these sites. Therefore, the remediation of the listed units, which are also SWMUs, will occur under the RCRA Program, not CERCLA. As of the end of 2001, corrective actions were underway or had been completed on all of the on-site units described in the CERCLA document, through the corrective action program, voluntary cleanup, or the RCRA closure process for permitted units. Sections 2.3.6 and 3.2 of this report contain a discussion of the RCRA corrective actions program. The cleanup of the CP-5 reactor was completed as part of the ANL-E D&D program under the oversight of DOE.

2.8.3. Emergency Planning and Community Right to Know Act (Superfund Amendments and Reauthorization Act, Title III)

Title III of the 1986 Superfund Amendments and Reauthorization Act (SARA) amendments to CERCLA is the Emergency Planning and Community Right to Know Act (EPCRA), a free-standing provision. EPCRA requires providing federal, state, and local emergency planning authorities information regarding the presence and storage of hazardous substances and their planned and unplanned environmental releases, including providing response to emergency situations

TABLE 2.11

List of Inactive Waste Disposal Sites at ANL-E
Described in Various CERCLA Reports

Site Name
On Current ANL-E Property
319 Area Landfill and French Drain[a,b,c]
800 Area Landfill and French Drain[a,b,c]
810 Area Paint Shop[d]
Compressed Gas Cylinder Disposal Area, 318 Area[a,b,c]
Decommissioned Reactor CP-5, Building 330[a,b]
French Drain, 317 Area[a,b,c]
Gasoline Spill, Gasoline Station[e]
Landfill East-Northeast of the 319 Area[a,b,c]
Liquid Waste Treatment Facility, Building 34[b,f]
Mixed Waste Storage, 317 Area[a,g]
Shock Treatment Facility, 317 Area[a,c]
Wastewater Holding Basin, Sewage Treatment Plant[b,g]
On Former ANL-E Property, Currently Waterfall Glen Forest Preserve
Reactive Waste Disposal, Underwriters Pond[h]

[a] SSI report submitted to the EPA in 1991.

[b] RCRA SWMU.

[c] RCRA corrective action completed.

[d] Contaminated soil removed.

[e] Remediation completed.

[f] Currently undergoing closure.

[g] Permitted under RCRA.

[h] Will be addressed in future investigations.

involving hazardous materials. Under EPCRA, ANL-E is required to submit reports pursuant to Sections 302, 304, 311, 312, and 313, which are discussed below.

Section 302 of SARA Title III, Planning Notification, requires that the State Emergency Response Commission be notified when an extremely hazardous substance is present at a facility in excess of the threshold planning quantity.

Section 304 of SARA Title III, Extremely Hazardous Substances Release Notification, requires that the Local Emergency Planning Committee (LEPC) and state emergency planning agencies be notified of accidental or unplanned releases of Section 302 hazardous substances to the environment. Also, the National Response Center is notified if the release exceeds the CERCLA Reportable Quantity for that particular hazardous substance. The procedures for notification are described in the ANL-E Comprehensive Emergency Management Plan. There were no incidents requiring notification during 2001.

Under SARA Title III, Section 311, Material Data Safety Sheet/Chemical Inventory, ANL-E is required to provide applicable emergency response agencies with Material Safety Data Sheets (MSDSs), or a list of MSDSs, for each hazardous chemical stored on site. In addition, pursuant to EPCRA Section 312, ANL-E is required to report certain information regarding inventories and the locations of hazardous chemicals to state and local emergency authorities upon request. Petroleum products need to be reported. However, chemicals used in research laboratories under the direct supervision of a technically qualified individual are exempt from reporting. The report on Section 312 information for 2001 was provided to DOE on February 28, 2002. Table 2.12 lists the hazardous chemicals reported. DOE conducted a Hazardous Chemical Inventory and Tracking Assessment on February 20 to 23, 2001. The assessment resulted in no findings but identified three OIs. Five corrective actions were developed in response to the OIs.

Section 313 of SARA Title III, Toxic Release Inventory (TRI) Reporting, requires facilities to prepare an annual report entitled “Toxic Chemical Release Inventory, Form R” if annual usage quantities of listed toxic chemicals exceed certain thresholds. ANL-E is not within the range of Standard Industrial Codes specified in the statute. ANL-E reports this information, however, because DOE, which is subject to Executive Order 12856, directs ANL-E to do so. Reports were filed from 1997 to 2000, because no listed chemicals usage exceeded reporting thresholds. However, new requirements regarding a class of TRI compounds called persistent, bioaccumulative toxics (PBTs) came into effect in 2000. ANL-E filed one report under Section 313 in 2001 (for activities in 2000) for polycyclic aromatic compounds which, as a PBT chemical, has a reporting threshold of 45 kg/yr (100 lb/yr) for manufacture, process, or otherwise used. This chemical was present in a seal coating compound that was applied to a number of building parking lots around the site.

TABLE 2.12

ANL-E, SARA, Title III, Section 312, Chemical List, 2001

	Physical Hazard			Health Hazard	
Compound	Fire	Pressure	Reactivity	Acute	Chronic
Ethanol/gasoline	X	-[a]	-	X	-
Aluminum sulfate	-	-	-	X	-
Chlorodifluoromethane	-	-	-	-	X
Diesel fuel/heating oil	X	-	-	-	-
Gasoline	X	-	-	-	-
Lubricating oils	X	-	-	-	-
Methanol/gasoline	X	-	-	-	-
NALCO 356 amine corrosion inhibitor	X	-	-	X	-
Sulfuric acid	-	-	-	X	-
Trichlorofluoromethane	-	-	-	-	X

[a] A hyphen indicates that the compound does not fall within the particular hazard class.

Effective in 2001, the reporting threshold for lead and lead compounds was reduced from 11,340 kg/yr (25,000 lb/yr) for manufacture/process, and 4,536 kg/yr (10,000 lb/yr) for otherwise used, to 45 kg/yr (100 lb/yr) for all categories. Preliminary information indicates that a report will be required for lead for 2001 (due July 1, 2002), and possibly also for lead compounds.

2.9. Toxic Substances Control Act

The Toxic Substances Control Act (TSCA) was enacted to require chemical manufacturers and processors to develop adequate data on the health and environmental effects of their chemical substances. The EPA has promulgated regulations to implement the provisions of TSCA. These regulations are found in CFR Title 40, Protection of the Environment, Chapter I: Environmental Protection Agency, Subchapter R - Toxic Substances Control Act. These regulations provide specific authorizations and prohibitions on the manufacturing, processing, and distribution in commerce of designated chemicals. The principal impact of these regulations at the ANL-E site concerns the handling of asbestos and PCBs. The asbestos management program is discussed in Section 2.1.1.1 of this report. Suspect PCB-containing items that are subject to this act are identified through the ANL-E PCB Item Inventory Program.

2.9.1. PCBs in Use at ANL-E

PCB items in use or in storage for reuse are tracked by the ANL-E PCB Item Inventory Program. All PCB items identified by the PCB Item Inventory Program have been labeled appropriately with a unique number for inventory and tracking purposes. These items are included in the ANL-E Annual PCB Report, which describes the location, quantity, manufacturer, and unique identification number for all PCBs on site. The PCBs in use at ANL-E are contained in capacitators and power supplies. Waste Management Operations (WMO) processes PCB-contaminated equipment and oil for disposal. The regulations governing the use and disposal of PCBs can be found in 40 CFR Part 761. The Annual PCB Report for 2001 was completed on June 29, 2001. This document is not submitted to regulatory agencies but is kept on file at ANL-E.

2.9.2. Disposal of PCBs

Disposal of PCBs from ANL-E operations includes materials lab-packed and bulked and aggregated solids shipped off site through WMO. This includes PCB-containing materials that also contain radioactive substances, known as TSCA mixed waste. Table 2.10 contains the amount of PCBs and PCB-contaminated materials and TSCA mixed waste in storage and shipped by ANL-E during 2001.

Several years ago, contamination from historical PCB spills resulted in the generation of sludge contaminated by both PCBs and low-level radioactivity from the building retention tanks and holding tanks at the laboratory WTP. During 2001, 46,391 L (12,088 gal) of PCB-contaminated sludge and debris was shipped off site for disposal, leaving only 214 L (56 gal) in storage.

2.10. Endangered Species Act

The Endangered Species Act of 1973 (ESA) is federal legislation designed to protect plant and animal resources from the adverse effects of development. Under the Act, the Secretaries of the Interior and Commerce are directed to establish programs to ensure the conservation of endangered or threatened species and the critical habitat of such species. The FWS has been delegated authority to implement the requirements of the ESA.

To comply with the ESA, federal agencies are required to assess the area of a proposed project to determine whether it contains any threatened or endangered species, or critical habitat of these species. If such species or habitat are found to exist, the FWS would be consulted.

At ANL-E, the applicable requirements of the ESA are identified and satisfied through the NEPA project review process. All proposed projects must provide a statement describing the potential impact to threatened or endangered species and critical habitat. This statement is included in the general Environmental Evaluation Notification Form. If the potential exists for an adverse impact, this impact will be assessed further and will be evaluated through the preparation of a more detailed NEPA document, such as an EA or EIS. Where appropriate, this information is shared with affected state and federal stakeholders, so that potential adverse impacts are assessed fully and any steps to minimize these impacts can be identified.

No federal-listed threatened or endangered species are known to occur on the ANL-E site, and no critical habitat of federal-listed species exists on the site. Three federal-listed endangered species are known to inhabit the Waterfall Glen Forest Preserve that surrounds the ANL-E property, or to occur elsewhere in the area.

The Hine’s emerald dragonfly (*Somatochlora hineana*), federal and state listed as endangered, occurs in locations with calcareous seeps and wetlands along the Des Plaines River floodplain. Leafy prairie clover (*Dalea foliosa*), which is federally and state listed as endangered, is associated with dolomite prairie remnants of the Des Plaines River valley; two planted populations of this species occur in Waterfall Glen Forest Preserve. An unconfirmed capture of an Indiana bat (*Myotis sodalis*), which is federal and state listed as endangered, indicates that this species may occur in the area. The federal-listed threatened lakeside daisy (*Hymenarys acaulis var. glabra*) has a planted population in Waterfall Glen Forest Preserve.

Although state-listed species that occur in the area are not covered by the ESA, the following state-listed species are evaluated in the NEPA process:

- Endangered
  - Black-crowned night heron (*Nycticorax nycticorax*)
  - Osprey (*pandion haliaetus*)
  - Shadbush (*Amelanchier interior)*

- Threatened
  - Brown creeper (*certhia americana*)
  - Kirtland’s snake (*Clonophis kirtlandi*)
  - Marsh speedwell (*Veronica scutellata*)
  - Pied-billed grebe (*Podilymbus podiceps*)
  - Red-shouldered hawk (*Buteo lineatus*)
  - River otter (*Lutra canadensis*)
  - Slender sandwort (*Arenaria patula*)
  - White lady’s slipper (*Cypripedium candidum*)

Of these, Kirtland's snake, pied-billed grebe, black-crowned night heron, red-shouldered hawk, and brown creeper have been observed on ANL-E property. Impacts to these species also would be assessed during the NEPA process.

2.11. National Historic Preservation Act

The National Historic Preservation Act (NHPA) requires federal agencies to assess the impact of proposed projects on historic or culturally important sites, structures, or objects within the sites of proposed projects. It further requires federal agencies to assess all sites, buildings, and objects on such sites to determine whether any qualify for inclusion in the NRHP. The Act also requires federal agencies to consult with the Illinois Historic Preservation Agency (IHPA) and the Advisory Council on Historic Preservation, as appropriate, when proposed actions would adversely affect properties that are eligible for listing on the NRHP.

The NHPA is implemented at ANL-E through the NEPA review process, as well as through the ANL-E digging permit process. All proposed actions must consider the potential impact to historic or culturally important artifacts and document this consideration on the Environmental Evaluation Notification Form. If the proposed site has not been surveyed for the presence of such artifacts, a cultural resources survey is conducted, and any artifacts found are documented and removed carefully. Prior to disturbing the soil, an ANL-E digging permit must be obtained from the PFS Division. This permit must be signed by the designated permit reviewer after verifying the location of nearby archaeological sites and documenting the fact that no significant cultural resources would be affected. DOE consults with the IHPA and the Advisory Council on Historic Preservation, as appropriate, if proposed actions would adversely affect properties eligible for listing on the NRHP.

In fall 2001, DOE entered into a programmatic agreement with the IHPA and the Advisory Council on Historic Preservation for management of cultural resources at ANL-E. This agreement streamlines compliance with the NHPA by allowing standard mitigation measures and by excluding from Section 106 review certain categories of activities that are unlikely to adversely affect historic structures.

Work on a Cultural Resources Management Plan (CRMP) that will replace the programmatic agreement is continuing. DOE expects to have a draft available for public review in late 2002 or early 2003.

Cultural resources include both historic structures and archaeological sites. Phase I archaeological surveys have been completed for the entire ANL-E facility, and 46 archaeological sites have been recorded. Of these, 23 sites have been tested to determine eligibility for inclusion on the NRHP. Three of the 23 sites tested potentially are eligible for the NRHP. The other 23 recorded sites have not yet been evaluated formally to determine whether they are eligible for inclusion under the NRHP. The assessment of the remaining sites will be performed as funding permits.

In fall 2001, Argonne completed a two-phased Sitewide Historic Property Inventory for ANL-E. The historic context portions of this inventory add significantly to the nuclear energy and nuclear science portions of the DOE cold war story. On the basis of inventory reports, DOE determined that two areas — the Main Campus Area and the Freund Estate Area — are eligible for listing on the NRHP as historic districts and that five buildings are individually eligible for listing on the NRHP.

The Main Campus district includes six scientific buildings: 200, 202, 203, 205, 206, and 211. These buildings were identified on the basis of their contribution in association with advancements in nuclear research and the development of nuclear power reactors (Criterion A) and for their engineering and design value as a unique specialized and cohesive scientific facility (Criterion C). The Freund Estate district includes five facilities: the former Freund Lodge (Building 600), the pool (603), bathhouse (604), pavilion (606), and tennis courts (616). All are eligible for listing under Criterion B, on the basis of their association with an important local personality, Erwin O. Freund.

Buildings 200 (M-Wing), 203, 205, 212, and 350 are the five buildings that are individually eligible for listing. Building 203 is significant because of its association with a Nobel Prize winner, Maria Goeppert-Mayer.

Prior to the fall 2001 inventory, DOE had already determined that four structures — Buildings 301, 315/316, 330, and 331 — are eligible for listing on the NRHP. D&D planning activities necessitated documenting the historical significance of the Building 301 hot cell facilities and the Argonne Thermal Source Reactor in Building 316, according to standards of the IHPA, through the preparation of Illinois Historical Architectural and Engineering Record reports. Preparation of these reports was required to mitigate the adverse effects to these structures caused by the D&D activities.

2.12. Floodplain Management

Federal policy on managing floodplains is contained in Executive Order 11988 (May 24, 1977). In addition, 10 CFR Part 1022 describes DOE's implementation of this Executive Order. The Executive Order requires federal facilities to avoid, to the extent possible, adverse impacts associated with the occupancy and modifications of floodplains. To construct a project in a floodplain, DOE must demonstrate that there is no reasonable alternative to the floodplain location.

The ANL-E site is located approximately 46 m (150 ft) above the nearest large body of water (Des Plaines River) and, thus, is not subject to major flooding. The 100- and 500-year floodplains are limited to low-lying areas near Sawmill Creek, Freund Brook, Wards Creek, and other small streams and associated wetlands and low-lying areas. No significant structures are located in the areas. To ensure that these areas are not adversely affected, new facility construction is not permitted within these areas, unless there is no practical alternative. Any impacts to floodplains are fully assessed in a floodplain assessment, and, as appropriate, documented in the NEPA documents prepared for a proposed project.

2.13. Protection of Wetlands

Federal policy on wetland protection is contained in Executive Order 11990 (May 24, 1977). In addition, 10 CFR Part 1022 describes DOE's implementation of this Executive Order. The Executive Order requires federal agencies to identify potential impacts to wetlands resulting from proposed activities and to minimize these impacts. Where impacts cannot be avoided, mitigating action must be taken by repairing the damage or replacing the wetlands with an equal or greater amount of a man-made wetland as much like the original wetland as possible.

Section 404 of the CWA establishes a program to regulate the discharge of dredged and fill material into waters of the United States, including wetlands. The COE administers this program. Activities regulated under this program include disturbance of wetlands for development projects, infrastructure improvements, and conversion of wetlands to uplands for farming and forestry. The COE uses a permit system to identify and enforce wetland mitigation efforts.

ANL-E completed a sitewide wetland delineation in 1993. All jurisdictional wetlands present on site were identified and mapped following the 1987 U.S. Army *Corps of Engineers Wetlands Delineation Manual*.[4] The delineation map shows the areal extent of all wetlands present at ANL-E down to 500 m^2 (1/8th acre). Thirty-five individual wetland areas were identified; their total area is approximately 18 ha (45 acres).

In February 1989, the COE issued a permit to DOE under Section 404 of the CWA, addressing the construction of the APS facility at ANL-E. The permit was required because construction of the APS involved the filling of three small wetland areas, known as Wetlands A, B, and E, which totaled 0.7 ha (1.8 acres) in size. Issuance of the permit was contingent upon approval of a mitigation plan submitted to the COE by DOE. The plan outlined procedures for the construction of a new wetland area, Wetland R, and also identified actions to be taken to avoid impacts to a fourth wetland, Wetland C, during APS construction activities.

During October 1996, the COE inspected Wetlands C and R and determined that they were no longer being managed in accordance with the original APS construction permit. The deficiencies noted were excessively dry soil conditions in Wetland C, caused by altered hydrology, and a poor quality biological community in Wetland R. In response to this finding, ANL-E prepared a management plan for Wetland R in January 1997 and began investigating the cause of the problems with Wetland C. The COE verbally agreed with these response actions. Implementation of the plan began in 1997.

Mitigative actions for Wetland R, as described in the 1997 management plan, involved improving the mix of vegetation through controlled burns, herbicide application, and planting of desirable plants. Controlled burns were completed in 1997, March 2000, and March 2001. Desirable native plants were then planted in these areas.

In 1998, the restoration of Wetland C was begun. In April 2000, the existing wetland was assessed to determine the current status and to identify alternate means of mitigating any damage incurred. This assessment determined that this area no longer meets the criteria for a wetland by virtue of the lack of appropriate hydrological conditions. The conditions no longer existed to maintain enough water in the soil to support a wetland ecology. In response to this finding, a mitigation plan for Wetland C was prepared and submitted to the COE. This plan recommended mitigating the loss of Wetland C by developing an equivalent area of wetland in a location more conducive to the proper conditions required to sustain a wetland ecology. The proposed location is several hundred feet north of the APS facility, adjacent to a large natural wetland area. The COE approved this mitigation plan on November 21, 2001.

An EA was completed in September 2001 for wetland management activities. This EA encompasses the Wetland C restoration and management activities. The IHPA concurred that the wetland restoration would not affect historic properties.

2.14. Wildlife Management and Related Monitoring

DOE manages the numbers of white-tailed and fallow deer at the site through an interagency agreement with the U.S. Department of Agriculture. DOE began the deer management program in 1995 to alleviate traffic safety hazards and ecological damage caused by extremely high deer densities. More than 600 deer were removed in the winter of 1995 to 1996, and more than 80 deer were removed the following winter to achieve target densities of 20 deer/mi^2 for each species. Smaller numbers of deer have been removed each year since 1997.

DOE lowered its target density for white-tailed deer to 15 deer/mi^2 in 2001 to better achieve its objectives of reducing deer and vehicle collisions, allowing oak trees to regenerate, and allowing deer-sensitive herbaceous species to recover.

DOE and the Forest Preserve District of DuPage County coordinate deer management efforts in order to preserve and enhance biodiversity at ANL-E and the surrounding Waterfall Glen Forest Preserve.

2.14.1. Deer Population Monitoring

The deer population is monitored frequently by spotlight survey to meet the requirements of Deer Population Control Permits and to aid in making deer management decisions. Thirty-one white-tailed deer were removed in the fall of 2001 to achieve a target density of 15 deer/mi^2. No fallow deer were removed in 2001.

2.14.2. Deer Health Monitoring

The health of the white-tailed deer herd is evaluated by assessing the deer that are removed each year for mean live and dressed weights and the amounts of fat stored in various organs. The health of the white-tailed deer herd has been improving since the deer management program began in 1995.

2.14.3. Deer Tissue Monitoring

Samples taken from the muscles of deer are analyzed periodically for radionuclides to verify that deer meat donated to charity does not pose a radiological health hazard. Samples sent to the IDNS radiochemistry laboratory in November 2000 were analyzed for gamma-ray-emitting radionuclides and hydrogen-3. Naturally occurring potassium-40 (at background levels) was the only gamma-ray-emitting radionuclide identified. Hydrogen-3 was not detected in any sample. No additional samples were collected in 2001.

2.14.4. Vegetation Damage

Woodland vegetation is monitored periodically to determine the effects of browsing by deer on woody vegetation and to assess forest health. This monitoring is conducted to meet conditions of Deer Population Control Permits and to help make deer and habitat management decisions. DOE changed its vegetation monitoring protocol in the fall of 2000 to better gauge overall forest health. The new protocol is an adapted form of the IIIinois ForestWatch Monitoring Manual issued by the Illinois Department of Natural Resources. It calls for fall surveys of woody vegetation and spring surveys of herbaceous vegetation and tree seedlings. Data collected in two sampling plots in 2000 and 2001 indicate that oak trees do not appear to be regenerating at ANL-E.

2.15. Current Issues and Actions

The purpose of this section is to summarize the most important issues related to environmental protection encountered during 2001. Table 2.13 lists all air and water effluent exceedances reported during 2001. Ongoing waste site remedial action work is described in Section 3.1.1. Exceedances of the NPDES wastewater discharge limits and Ground Water Quality Standards at the 800 Area Landfill Area are discussed in Chapters 5 and 6, respectively.

2.15.1. Clean Water Act - NPDES

As in previous years, ANL-E occasionally exceeded NPDES permit limits in 2001. The limit for TDS was exceeded seven times at Outfall 001 (the WTP discharge point). Boiler house blowdown and road salt runoff contribute to high TDS concentrations at Outfall 001 in the winter. The boiler house equalization pond collects runoff from salted roads in the boiler house area. To reduce winter concentrations of TDS, ANL-E obtained a construction permit from the IEPA to route the boiler house equalization pond to DuPage County for periodic discharge of up to 227,125 L/day (60,000 gal/d) (see Section 2.2.1.1) .

ANL-E has had occasional positive toxicity test results at several outfalls. These appear to be due to residual chlorine from discharge of chlorinated drinking water into these outfalls and from cooling tower blowdown that may contain antifouling agents. Many of these discharges have been redirected into the sewer system to be processed at the WTP.

TABLE 2.13

Summary of 2001 Air and Water Effluent Exceedances

Date	Source	Parameter	Assessment
January 16	001	TDS	Road salt associated with snowmelt
January 23	001	TDS	Road salt associated with snowmelt
February 6	001	TDS	Road salt associated with snowmelt
February 13	001	TDS	Road salt associated with snowmelt
February 20	001	TDS	Road salt associated with snowmelt
February 27	001	TDS	Road salt associated with snowmelt
March 20	001	TDS	Road salt associated with snowmelt
April 8	Boiler No. 5	Opacity	High ambient temperatures — low load
April	Bldg. 306	Air	Unpermitted bulking of mixed waste solvents
Ongoing	Sitewide	Air	Cold-cleaning rule Title V

2.15.2. Solid Waste Disposal

The IEPA-approved 800 Area sanitary landfill groundwater monitoring program continues to indicate that the Ground Water Quality Standards of some inorganic parameters consistently are being exceeded in several wells. The 1999 expansion of the groundwater monitoring well network is providing additional information about the nature of these exceedances. Additional information about the source and extent of these exceedances is needed before a plan of action to resolve the issue can be formulated. Hydrogen-3 has been detected in a number of wells north, east, and southwest of the landfill area. The groundwater monitoring program is discussed in detail in Section 6.3.

2.15.3. Remedial Actions

Remediation of waste management units is an ongoing compliance action. At current funding levels, the cleanup program will be completed in 2003. ANL-E currently is planning for a transition from active remediation to long-term operation, maintenance, and monitoring of these sites. These activities are described in detail in Section 3.1.1.

2.15.4. Environmental Monitoring and Surveillance Program

The U.S. Department of Energy (DOE) Office of Environment, Safety and Health Oversight (EH-24) performed an inspection of ANL-E on April 23 through 27, 2001. The primary purpose of the inspection was to assess the environmental monitoring and surveillance program structure and implementation to ensure that work activities at ANL-E do not adversely impact either the public or the environment. The inspection assessed the accuracy and adequacy of the methods and programs that quantify releases of contaminants to the environment and project their transport into the environment, including their resulting impact on the public and the environment. Specific areas of the monitoring program that were evaluated included liquid effluent monitoring and environmental surveillance, radiological air emissions, groundwater monitoring, and line management oversight.

The EH-24 inspection team consisted of five individuals who conducted a scoping visit on March 27 through 28, 2001. During the following month, the team developed an inspection plan on the basis of the initial contacts and visit, documents provided by ANL-E, and additional discussions. During the week of April 23 through 27, 2001, the team executed its inspection plan and generated its preliminary conclusions. Over the next few months, a draft EH-24 report was prepared by the team, reviewed by DOE-AAO and ANL-E staff, and a final report was issued in August 2001. No issues were identified. The team identified 14 Observations (OIs) and four positive attributes. Although observations do not require the development of action plans, ANL-E prepared plans to address 13 Observations (one Observation was a DOE responsibility) that were submitted to DOE and approved in December 2001. These commitments are currently being addressed.

2.16. Environmental Permits

Table 2.14 lists all the environmental permits in effect at the end of 2001. Other portions of this chapter discuss special requirements of these permits and compliance with those requirements. The monitoring results required by these permits are discussed in those sections, as well as in Chapters 5 and 6.

TABLE 2.14

ANL-E Environmental Permits in Effect December 31, 2001

Type	Subject of Permit	Building	Issued	Expiration Date[a]
Air	Title V-ANL-E	Sitewide	4/3/01	4/3/06
Air	ALEX Alkali Metal Scrubber[a]	370	Incorporated Title V	
Air	Alkali Metal Reaction Booth[a]	308	Incorporated Title V	
Air	APS Emergency Generators (3)	400	Incorporated Title V	
Air	Argonne Service Station	300	Incorporated Title V	
Air	Boiler No. 5 Low NO_x Gas Burner[b]	108	Incorporated Title V	
Air	Central Heating Plant	108	Incorporated Title V	
Air	Central Shops Dust Collector[a]	363	Incorporated Title V	
Air	Gasoline Dispensing Facility[c]	46	Incorporated Title V	
Air	Salt Cake/Recovery Electrodialysis Plant	369	Incorporated Title V	
Air	Sulfuric Acid Storage Tank[a]	108	Incorporated Title V	
Air	Torch Cutting (Welding) Fumes[a]	Sitewide	Incorporated Title V	
Air	Transportation Research Facility	376	Incorporated Title V	
Air	Wood Shop Dust Collector[a]	368	Incorporated Title V	
Air	Waste Bulking Sheds[a,d]	306	Incorporated Title V	
Air	Open-Burning Permit - Fire Dept.[a]	333	04/18/01	04/18/02
Air	Open Burning - Vegetation	Sitewide	01/29/01	01/29/02
NESHAP	Advanced Photon Source	400	Incorporated Title V	
NESHAP	Alkali Metal Reaction Booth	206	Incorporated Title V	
NESHAP	Alpha Gamma Hot Cell Facility	212	Incorporated Title V	
NESHAP	Building Exhausts[a,e]	212	Incorporated Title V	
NESHAP	Building Rehab - Phase 1[d]	306	Incorporated Title V	
NESHAP	Building Vents	306	Incorporated Title V	
NESHAP	Chemical Photooxid. Vial Crusher[f]	306	Incorporated Title V	
NESHAP	CP-5 D&D Project	330	Incorporated Title V	
NESHAP	Building 301 Hot Cell D&D Project	301	Incorporated Title V	
NESHAP	Intense Pulsed Neutron Source	375	Incorporated Title V	
NESHAP	Lab Wastewater Treatment Plant	575	Incorporated Title V	
NESHAP	Lead Brick Cleaning (carbon dioxide)	200/317	Incorporated Title V	
NESHAP	Melt Attack/Coolability Experiment	315	Incorporated Title V	
NESHAP	Mixed Waste Storage Facility	303	Incorporated Title V	
NESHAP	M-Wing Hot Cells	200	Incorporated Title V	
NESHAP	New Brunswick Lab Hoods	350	Incorporated Title V	
NESHAP	PCB Tank Cleanout[g]	Sitewide	Incorporated Title V	
NESHAP	Rad Hoods	Sitewide	Incorporated Title V	
NESHAP	Rad (TRU) Waste Storage Facility	331	Incorporated Title V	

TABLE 2.14 (Cont.)

Type	Subject of Permit	Building	Issued	Expiration Date[a]
NESHAP	WMO Portable HEPA Filters[g]	306	Incorporated Title V	
NESHAP	WMO HEPA Filter Systems (6)[h,i]	Sitewide	Incorporated Title V	
Hazardous Waste	RCRA Part B	Sitewide	09/30/97	11/04/07
Miscellaneous	Deer Population Control Permit	Sitewide	1/26/01	02/23/02
Miscellaneous	Nuisance Wildlife Control	Sitewide	01/01/01	01/31/02
Solid Waste	Landfill	800 Area	03/31/82	-[j]
Solid Waste	Landfill	800 Area	03/30/89	-
Solid Waste	Landfill	800 Area	04/12/89	-
Solid Waste	Landfill Groundwater Assessment	800 Area	09/30/91	-
Solid Waste	Landfill Leachate Characterization	800 Area	09/30/91	-
Solid Waste	Landfill Leachate Test Wells	800 Area	08/31/90	-
Solid Waste	Landfill Revised Closure Plan [k]	800 Area	04/24/92	-
Solid Waste	Landfill Supplemental Closure Plan	800 Area	09/15/92	-
Solid Waste	Landfill Supplemental Permit Groundwater	800 Area	04/19/94	-
Solid Waste	Landfill Supplemental Permit Groundwater	800 Area	01/11/95	-
Solid Waste	Landfill Supplemental Permit Groundwater	800 Area	11/20/97	-
Solid Waste	Landfill Supplemental Permit Groundwater	800 Area	08/25/98	-
Solid Waste	Landfill Supplemental Permit Groundwater	800 Area	06/16/99	-
Solid Waste	Landfill Supplemental Permit Groundwater	800 Area	4/25/00	-
Water	Lime Sludge Application - Land Application	Sitewide	10/30/98	10/31/02
Water	NPDES Permitted Outfalls[l]	Sitewide	10/31/94	07/01/99
Water	NPDES Storm Water Outfalls[l]	Sitewide	10/31/94	07/01/99

[a] These units have been designated as insignificant sources in the ANL-E Title V permit.

[b] Construction permit issued; operated under Central Heating Plant permit.

[c] Included ethanol/gasoline tank. In October 2001, methanol/gasoline tank converted to ethanol/gasoline storage.

[d] Construction permit issued; operated under Building 306 permit.

[e] Plasma spray booth added to permit 05/27/94.

[f] Vial crusher originally issued under Building 306 permit.

[g] Construction permit issued; operated under WMO HEPA permit.

Footnotes continue on next page.

TABLE 2.14 (Cont.)

[h] Construction permit added two portable HEPA filters to existing four filters.

[i] Construction permit originally issued October 15, 2001, used for operations until CAAPP Permit Renewal.

[j] A hyphen indicates superceded by the next permit.

[k] Includes gas monitoring program.

[l] Existing permit continues to be in effect while revised permit application is undergoing IEPA review.

3. ENVIRONMENTAL PROGRAM INFORMATION

3.1. Major Environmental Programs

DOE and ANL-E policies require that all operations be conducted in compliance with applicable environmental statutes, regulations, and standards, and that environmental obligations be carried out consistently across all operations and organizations. Protection of the environment and human health and safety always are given the highest priority. A number of programs and organizations exist at ANL-E to ensure compliance with these authorities and to monitor and minimize the impact of ANL-E operations on the environment.

During 2001, the site remediation program became part of the Plant Facilities and Services Division. The ANL-E Environmental Remediation Program (ERP) is responsible for achieving compliance with all applicable environmental requirements related to assessing and cleaning up releases of hazardous materials form inactive waste sites. The RCRA Part B Permit corrective action requirements makes up the primary regulatory vehicle, although several voluntary cleanup projects are included in the program.

3.1.1. Remedial Actions Progress in 2001

In 2001, ANL-E continued to implement its plan to complete all remedial actions at the site by the end of 2003. The plan is described in a document titled *Environmental Restoration Program (EM-40) Baseline for Argonne National Laboratory-East*[5] that was completed in early 1999.

As of the end of fiscal year 2001, out of the total number of SWMUs listed in the RCRA Part B Permit — 49 SWMUs and 5 AOCs — and the three voluntary cleanup projects, the ERP had completed remediation work on 42 SWMUs and AOCs and had received either a final NFA or No Further Remediation (NFR) (for long-term operation and maintenance [O&M] sites) acknowledgment on 35 sites.

In fiscal year 2001, the ERP worked on 17 sites, completing assessment or design work on 6, final cleanup fieldwork on 3, continued with remediation activities on 1 (the lime sludge project), and either completed a report requesting an NFA or conducted follow-on "project closeout" work on the remaining 6.

Table 3.1 lists each of the release sites worked on during the fiscal year, the scope of the work, and whether or not the work resulted in a request for NFA to the IEPA.

TABLE 3.1

Status of Release Sites, 2001

Site Name	Site Number	FY 2001 Work Scope	NFA Requested in FY 2001
ENE Landfill	SWMU No. 19	Completed remedial design, obtained IEPA approval and completed remediation fieldwork	Yes
317 Area Deep Vault	Release Site No. 743	Completed characterization of vault interior and exterior	No
317 Area North Vault	Release Site No. 747	Completed characterization of vault interior and exterior	No
Newly Identified Suspected Solid Waste Landfill	SWMU No. 744	Completed remedial design and submitted it to the IEPA	No
AOC-F Contaminated Soil near Bldg. 827	AOC-F	Completed remedial design, obtained IEPA approval, and completed remediation fieldwork	Yes
Freund Ponds	SWMU No. 7	Completed characterization plan and submitted it to the IEPA	No
Lime Sludge Pond	Former SWMU No. 8	Removed an additional 15,000 yd^3 of lime sludge from the lagoon	No
570 Area - Unlined Holding Basin	SWMU No. 133	Conducted project closeout work on the SWMU at the request of the IEPA; collecting several dozen samples. Prepared cost estimates for several alternatives to clean up the soil contaminated with arsenic and cesium-137.	No
Bldg. 34 Mixed Liquid Waste Treatment	SWMU No. 150	Completed the characterization report and a remedial design work plan and submitted it to the IEPA to address nickel contaminated groundwater in the area of former Bldg. 34.	No
Storm Sewers - Cooling Tower Wastewater	SWMU No. 179	Conducted a Tier 3 Ecological Affects Assessment and a human health risk assessment for submittal to the IEPA.	No[a]

TABLE 3.1

Status of Release Sites, 2001 (Cont.)

Site Name	Site Number	FY 2001 Work Scope	NFA Requested in FY 2001
Scrap Disposal Staging Area East of 377 Cooling Towers	SWMU No. 180	Completed remediation fieldwork and replanted the area with native wetland species.	Yes
Waste Oil Spread on Roads	SWMU No. 182	Completed additional characterization of roadside soils and completed and submitted a final report to the IEPA requesting NFA.	Yes
East Area Sewage Treatment Sand Filter Beds	SWMU No. 5	Conducted project closeout work on the SWMU at the request of the IEPA. Prepared and sent a letter addressing IEPA concerns.	No[a]
570 Area - Sanitary Wastewater Sludge Drying Beds	SWMU No. 136	Conducted project closeout work on the SWMU at the request of the IEPA. Prepared and sent a letter addressing IEPA concerns.	No[a]
A2R2 Reactor Excavation Fill	SWMU No. 146	Conducted project closeout work on the SWMU at the request of the IEPA. Prepared and sent a letter addressing IEPA concerns.	No[a]
Bldg. 330 Yard with Mixed Materials for Decommissioning	SWMU No. 151	Conducted project closeout work on the SWMU at the request of the IEPA. Prepared and sent a letter addressing IEPA concerns.	No[a]
AOC-H Contaminated Soil near Bldg. 24	AOC-H	Conducted project closeout work on the SWMU at the request of the IEPA. Prepared and sent a letter addressing IEPA concerns.	No[a]

[a] NFA requests for these units were submitted in 2000. Additional documentation in support of these requests was prepared in 2001.

As part of an ongoing effort to assess the efficacy of the long-term remedial actions within the 300 Area, specifically the 317 and 319 Areas of the site, the ERP conducted an exhaustive evaluation of the existing systems in the area and arrived at several recommendations for future work. The main recommendation was to accelerate the removal of residual soil contamination near the former 317 Area French Drain and to increase the amount of contaminated groundwater removed from the source area. Several enhancements to the existing remedial systems were devised to accomplish these objectives. DOE is currently reviewing the proposed actions.

The phytoremediation plantation in the 317 Area continued to mature and grow throughout the year. Tissue samples collected from the trees in the French drain area (SWMU No. 11) indicated that the trees in that area are taking up chlorinated organic compounds as they were expected to do. Information collected as part of the assessment of conditions in the 300 Area indicates that the trees could be made even more effective by reducing the amount of shallow groundwater. The shallow groundwater prevents the tree roots from penetrating to the desired depth since the roots stop growing when they reach water. The proposed enhancements discussed above include steps to reduce the amount of shallow groundwater.

Routine operations and monitoring of the two groundwater extraction systems south of the 317 and 319 Areas were carried out. Monitoring of these systems shows that they are generally operating as intended by preventing contaminated groundwater from leaving the site. On the western extent of the 317 area system, ANL-E discovered that the contaminant plume had apparently shifted westward and could be bypassing the westernmost extraction well. To remedy this, ANL-E plans to install additional wells in 2002 and fit them with extraction pumps to prevent this from occurring.

3.1.2. Environmental Monitoring Program Description

As required by DOE Orders 5400.1[1] and 231.1, ANL-E conducts a routine environmental monitoring program. This program is designed to determine the effect of ANL-E operations on the environment surrounding the site. This section describes this monitoring program. In 2001, a total of 2,005 samples were collected and 25,475 analyses were performed. A general description of the rationale for sampling for each media is presented. Greater detail is provided in the ANL-E Environmental Monitoring Plan.

3.1.2.1. Air Sampling

ANL-E conducts an air monitoring program for conventional and radioactive pollutants to assess the impact of ANL-E operations on the environment and the public health. Air monitoring is necessary since the NESHAP radiological inventory indicated that sufficient material is used in laboratory hood applications that a potential exists for releases. Monitoring is also conducted to estimate radiological releases that could occur if the high-efficiency particulate air filters failed. In addition, several major facilities have radiological airborne emissions because of the nature of the operation. Examples of these emissions are air activation products from APS and IPNS and hydrogen-3 from Alpha Gamma Hot Cell Facility. The air monitoring program consists of effluent monitoring and environmental surveillance of airborne contaminants. Effluent monitoring includes primarily continuous monitoring of airborne effluents (radionuclides and conventional pollutants) from stacks. Environmental surveillance includes continuous direct collection of airborne pollutants on filters at selected stations located around the perimeter of ANL-E, and off-site analysis of the collected particulate matter for radionuclides.

3.1.2.2. Water Sampling

Water samples are collected to determine what, if any, radionuclides or selected hazardous chemicals used or generated at ANL-E enter the environment by the water pathway. Surface water samples are collected from 28 NPDES outfalls, and from Sawmill Creek below the point at which ANL-E discharges its treated wastewater. The results of radiological analysis of water samples at these locations are compared with upstream and off-site results to determine the ANL-E contribution. The results of the chemical analyses are compared with the applicable IEPA stream quality standards to determine whether the site is degrading the quality of the creek. These results are discussed in more detail in Chapters 4 and 5.

Surface water samples are collected from Sawmill Creek and combined into a single weekly composite sample. A continuous sampling device has been installed at this location to improve sample collection representativeness. To provide control samples, Sawmill Creek is sampled upstream of ANL-E once a month. The Des Plaines River is sampled twice a month below, and monthly above, the mouth of Sawmill Creek to determine whether radionuclides in the creek are detectable in the river.

In addition to surface water, subsurface water samples also are collected at 51 locations. These samples are collected quarterly from monitoring wells located near areas that have the potential for adversely impacting groundwater. These areas are the 800 Area Landfill, the 317/319 waste management area, the ENE Landfill, the 570 Area, and the site of the inactive CP-5 reactor. Samples from the three on-site wells that formerly provided domestic water also are collected and analyzed for hazardous and radioactive constituents. The monitoring wells are purged, and samples are collected from the recharged well water. These samples are analyzed for both chemical and radiological constituents, as discussed in Chapter 6. Samples are collected quarterly from the wellheads of the three ANL-E wells that formally provided the domestic water supply. The water is pumped to the surface and collected in appropriate containers, depending on the required analysis.

At the time of sample collection for radiological analysis, the sampling location, time, date, and collector identification number are recorded on a label attached to the sample container. Upon return to the laboratory, the information is transferred to the Environmental Protection Data Management System (EMS). Each sample is assigned a unique number that accompanies it through all analyses. After the sample has been logged in, an aliquot is removed for hydrogen-3 analysis; 20 mL (1 oz) of concentrated nitric acid is added per gallon of water as a preservative, and the sample is filtered through Whatman No. 2 filter paper to remove any sediment present in the sample. Appropriate aliquots are then taken, depending on the analysis.

For nonradiological analysis, samples are collected and preserved using EPA-prescribed procedures. Cooling is used for organic analysis, and nitric acid is used to preserve samples to be analyzed for metals. Specific collection procedures are used for other components, and EPA methods are used. All samples are analyzed within the required holding period, or noncompliance is documented. The quality control requirements of either SW-846, *Test Methods for Evaluating Solid Waste: Physical and Chemical Methods*,[6] or the Contract Laboratory Program (CLP) must be met, or deviations are documented. All samples are assigned a unique number that serves as a reference source for each sample. When duplicate samples are obtained, unique numbers are assigned, and an indication that duplicates exist is entered in the data management system.

3.1.2.3. Bottom Sediment

Bottom sediment accumulates small amounts of radionuclides that may be present from time to time in a stream and, as a result, acts as an accumulator of the radionuclides that were present in the water. The sediment provides evidence of radionuclides in the surface water system. These samples are not routinely analyzed for chemical constituents. Bottom sediment samples are collected annually from Sawmill Creek above, at, and from several locations below the point at which ANL-E discharges its treated wastewater. Sediment is collected from each location with a stainless-steel scoop and is transferred to a glass bottle.

At the time of sample collection, the date, time, and sample collector identification are recorded on sample labels affixed to the sample container. Upon return to the laboratory, the information is transferred to the EMS. Each sample is assigned a unique number that accompanies it through the process.

Each sample is dried for several days at 110°C (230°F), ball milled, and sieved through a No. 70 mesh screen. The material that does not pass the No. 70 screen is discarded. A 100-g (4-oz) portion is taken for gamma-ray spectrometric measurement, and other appropriate aliquots are used for specific radiochemical analyses.

3.1.2.4. External Penetrating Radiation

Measurements of direct penetrating gamma radiation emanating from several sources within ANL-E are taken by using aluminum oxide thermoluminescent dosimeters (TLDs) provided by a commercial vendor. Each measurement is the average of two chips exposed in the same packet. Dosimeters are exposed at 17 locations at the site perimeter and on site and at five off-site locations. All dosimeters are changed quarterly. At the time of dosimeter collection, the date, time, and collector identification number are recorded on a preprinted label affixed to the container. Each sample is assigned a unique number that accompanies it through the process. After completion of the exposure period, the TLDs are mailed to the vendor for reading. When the dose information is provided to the on-site laboratory by the vendor, it is entered into the EMS.

3.1.2.5. Data Management

ANL-E manages the large amount of data assembled in the environmental monitoring program in a structured manner that allows a number of reports to be generated. Basic data management, including sample record keeping, is implemented with the EMS computerized record-keeping system. All sample and analytical data are maintained in the EMS for eventual output in formats required for either regulatory compliance reports or for annual reports. In addition, reports are provided for trend analysis, statistical analysis, and tracking.

The ANL-E–developed EMS is the basic data management tool; it generates sampling schedules, all other tracking and calculation routines, and the final analytical result tabulations. The EMS is set up for the radiological portion of the monitoring program and for nonradiological monitoring for groundwater and NPDES surface water effluents.

The starting point for effluent monitoring and environmental surveillance is establishing a set of sampling locations and a sample schedule. On the basis of regulatory parameters, pathway analysis, or professional judgment, sample locations for the various media are identified and entered into the EMS. For each sample location, nine categories of data are entered into the EMS: geographic code, location description, sampling frequency, sample type, exact sampling position, last date sampled, sampling priority (same location with multiple samples), size of sample to collect, and analytes.

Once the data are entered, the EMS is used to generate a sampling schedule. Every week a schedule for the next week is printed out, along with uniquely numbered preprinted labels for the sample containers. These items are provided to the staff who conduct the sampling in the field. Field data are entered into the EMS. At the time the samples are submitted to the analytical laboratory, chain of custody documents are generated. The EMS distributes sample data electronically (via diskette) to the Environment, Safety and Health (ESH) data management system and accepts back the analytical data (via diskette or e-mail).

As the laboratory results are compiled, the data are entered into the EMS. This permits up-to-date tracking of all samples currently in process. When the analysis for each sample is completed and the results electronically entered into the EMS, the completed final results sample card is retained in a file as an additional quality assurance (QA) measure.

Complete data sets for all samples are maintained by the EMS. When all results have been completed and entered into the EMS, a final result card is generated that lists all data related to each sample. The electronic files are backed up by the computer network server. The printed final result card is filed after review, then ultimately placed in DOE's archives in Chicago. Final results are thus available both on line via the network and in hard copy.

3.1.3. Waste Minimization and Pollution Prevention

During 2001, ANL-E continued efforts to enhance its past pollution prevention and waste minimization (P2/WM) accomplishments. ANL-E has a formal P2 Program that continues to develop and implement a comprehensive sitewide P2 Program plan in accordance with local, state, federal, DOE, and site-specific P2 regulations and requirements. The P2 Program performs tracking and trending of waste and pollution at ANL-E, and monitors the progress with regard to DOE P2/E2 Goals and P2 Performance Measures. ANL-E continues to maintain waste generation rates below the levels established by the DOE P2 and Energy Efficiency Leadership Goals.

For the second consecutive year, ANL-E received two prestigious national pollution prevention awards. It received the White House Closing the Circle Award for the Green Building design of the newly constructed Central Supply Facility. The same project was also recognized as a recipient of the DOE National Pollution Prevention Award. This project was managed by PFS-Facilities, Engineering, and Construction (FEC).

In keeping with its commitment to continuous improvement, ANL-E established and accomplished the following P2 initiatives during 2001:

- A Laboratorywide Pollution Prevention Awareness Training Program was introduced for all employees. This training program has allowed employees to learn about the basic information and tools needed to incorporate P2 into their daily work activities.

- The ANL-E Pollution Prevention Advisory Committee assumed the added role of performing routine assessments on processes and activities that generate large quantities of waste or difficult to manage waste streams.

- A formal guide was issued for integrating P2 components into the project/activity environmental review process.

- ANL-E's Affirmative Procurement (Green Purchasing) Program demonstrated continuous improvement in the amount of recycled-content products purchased at ANL-E.

- A Surplus Office Supply Exchange (SOS-X) program was launched. The SOS-X is a program developed to recycle and reuse surplus office supplies and furniture by promoting the availability or need of items via the ANL-E e-mail system.

- The Argonne Equipment and Materials Exchange (AEM-X) was implemented. The AEM-X is a program developed to recycle and reuse surplus equipment and materials by promoting the availability or need of items via the ANL-E e-mail system.

3.2. Environmental Support Programs

3.2.1. Self-Assessment

In line with the principles of Integrated Safety Management (ISM), line management is responsible for internal self-assessment. This process focuses on the activities of an individual organization and is intended to stimulate continuous improvement. The results are reported to those who have the authority and responsibility for the organization's performance. At the beginning of the calendar year, each organization develops an agenda of activities to be reviewed. A schedule was prepared, and assignments were made to manage the organization's self-assessment program. The ANL-E-wide results and conclusions of the assessment program are summarized by line management and submitted to the Director of EQO. The actual performance during the year is monitored by the line organization as well as by the oversight organization assisting senior management in fulfilling its oversight responsibilities.

3.2.2. Environmental Training Programs

ANL-E has a comprehensive environmental protection training program that includes mechanisms to identify, track, and document training requirements for every employee. Environmental protection training for ANL-E personnel is provided primarily by the EQO Training Section, although some training may be delivered by subject-matter experts from other organizations. Personnel training addresses various requirements, such as those contained in DOE Orders, or EPA or U.S. Department of Transportation regulations. Required training is identified by a Job Hazards Checklist form that is completed by every employee and is reviewed by each employee's supervisor.

Activities are managed through the Training Management System, an on-line computer-based system that tracks the training status of each employee. Environmental protection training courses and course descriptions are listed in the Training Course Catalog available from divisional training management system representatives, the EQO Training Section, or Human Resources.

3.2.3. Site Environmental Performance Measures Program

Effective June 1, 1995, the Prime Contract between DOE and The University of Chicago to operate ANL-E made provisions for a fee based on the performance of various research and operations activities, including ESH and Projects and Infrastructure Management performance. Performance objectives and supporting metrics have been developed as a part of the contract and for determination of the performance fee. At the end of the performance period, a rating (outstanding, excellent, good, or marginal) is assigned to each. The performance fee is based on these ratings.

For the period of the performance-based contract October 2000 to September 2001, the environmental measurements were included in two categories. One category was identified as the ES&H category, and the other as Projects and Infrastructure Management. The ratings of the measurements in these categories directly affected the performance-based fee. The environmental measurements included compliance with environmental permit conditions (excellent), compliance with air and water effluent limits (outstanding), compliance with environmental project schedule (outstanding), compliance with environmental project cost (outstanding), and waste minimization/pollution prevention (outstanding), for an overall rating of excellent. The overall rating of the Projects and Infrastructure Management categories, based on a roll-up of the individual performance ratings during the contract period, was outstanding.

3.2.4. Executive Order 13148 — Greening of the Government

On April 21, 2000, President Clinton signed Executive Order 13148, "Greening of the Government Through Leadership in Environmental Management." The new Executive Order incorporates directives from previous Executive Orders 12843, 12856, and 12969, as well as the Executive Memorandum of April 26, 1994, and also adds new requirements. The new Executive Order is applicable to all federal agencies, including DOE. The goals of the Executive Order are to develop and implement environmental management systems; ensure compliance with all environmental regulations; continue to conduct EPCRA Section 313 reporting; reduce the use of chemicals reportable under TRI reporting; reduce the procurement and use of toxic chemicals and hazardous substances; phase out the procurement of Class 1 Ozone Depleting Substances; and strive to promote environmentally and economically beneficial landscaping.

Attachment 1 of DOE Notice 450.4, dated June 1, 2001, assigns contractor responsibilities for the implementation of Executive Order 13148. A compliance action plan was prepared by ANL-E to address each of the eight contractor requirements and was submitted to DOE on July 25, 2001. The plan identifies the ANL-E status of each requirement relative to its the current programs. The major area requiring compliance is the section on environmental management systems. ANL-E committed to formally incorporating its environmental management system into its Integrated Safety Management Program. ANL-E will prepare an environmental management system program description document that will describe the processes for ensuring compliance with applicable environmental regulations, orders, and permits, along with environmental improvement initiatives that are consistent with the goals stipulated in Executive Order 13148. The environmental management system description document will be modeled after the guidance in ISO-14001 and is currently being drafted.

3.2.5. Ecological Restoration Program

DOE and ANL-E recognize the importance of enhancing and preserving biodiversity and have committed to supporting the Biodiversity Recovery Plan prepared by Chicago Wilderness partnership organizations. Ongoing ecological restoration activities include enhancing oak woodland, savanna, wetland, and prairie habitats in the undeveloped areas on the ANL-E site. Six acres of vacant land that was formerly occupied by Quonset huts has been converted to prairie. Controlled burns and hand clearing of invasive shrubs are restoring sunlight to oak woodlands so that native flowers and grasses can grow. The upland area around a site wetland has been planted with prairie species to cleanse water feeding the wetland. The area surrounding a man-made pond outside the main administrative building is being used to demonstrate the use of native plants for landscaping after invasive weedy plants were removed and replaced by native species.

ANL-E is implementing, where practical, Executive Order 13112 (Invasive Species) and Guidance for Presidential Memorandum on Environmentally and Economically Beneficial Landscape Practices on Federal Landscaped Grounds (Volume 60, *Federal Register*, page 40837).

3.3. Compliance with DOE Order 435.1

DOE Order 435.1 "Radioactive Waste Management,"[7] requires that an environmental monitoring and surveillance program be conducted to determine any releases or migration from LLW treatment, storage, or disposal sites. Compliance with these requirements is an integral part of the ANL-E sitewide monitoring and surveillance program. Waste management operations in general are covered by relying on the perimeter air monitoring network and monitoring of the liquid effluent streams and Sawmill Creek. The analytical results are presented in Chapter 4 of this report.

Of particular interest is monitoring of the waste management activities conducted in the 317 Area. These include air particulate monitoring for total alpha, total beta, and gamma-ray emitters and radiochemical determinations of plutonium, uranium, thorium, and strontium-90; direct radiation measurements with TLDs; surface water discharges for hydrogen-3 and gamma-ray emitters; and subsurface water samples at all the monitoring wells with analyses for hydrogen-3, strontium-90, and gamma-ray emitters, plus selected monitoring for VOCs. Direct radiation measurements are also conducted at other waste management areas; Building 306, Building 331, and the 398A Area. The results are presented in Chapters 4 and 6 of this report.

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

4.1. Description of Monitoring Program

The radioactivity of the environment around ANL-E in 2001 was determined by measuring radionuclide concentrations in air, surface water, subsurface water, and sediment, and by measuring the external penetrating radiation dose. Sample collections and measurements were made at the site perimeter and off site for comparative purposes. Some on-site results are also reported when they are useful in interpreting perimeter and off-site results.

Because radioactivity is primarily transported by air and water, the sample collection program concentrates on these media. In addition, samples of materials from the streambeds also are analyzed. The program follows the guidance provided in the DOE Environmental Regulatory Guide.[8] The results of radioactivity measurements are expressed in terms of pCi/L for water; fCi/m^3 and aCi/m^3 for air; and pCi/g and fCi/g for bottom sediment. Penetrating radiation measurements are reported in units of mrem/yr, and population dose is reported in units of person-rems.

DOE has provided guidance[9] for effective dose equivalent calculations for members of the public based on International Commission on Radiological Protection (ICRP) Publications 26 and 30.[10,11] Those procedures have been used in preparing this report. The methodology requires that three components be calculated: (1) the committed effective dose equivalent (CEDE) from all sources of ingestion, (2) the CEDE from inhalation, and (3) the direct effective dose equivalent from external radiation. These three components were summed for comparison with the DOE effective dose equivalent limits for environmental exposure. The guidance requires that sufficient data on exposure to radionuclide sources be available to ensure that at least 90% of the total CEDE is accounted for. The primary radiation dose limit for members of the public is 100 mrem/yr. The effective dose equivalents for members of the public from all routine DOE operations (natural background and medical exposures excluded) shall not exceed 100 mrem/yr and must adhere to the as-low-as-reasonably-achievable (ALARA) process or be as far below the limits as is practical, taking into account social, economic, technical, practical, and public policy considerations. Routine DOE operations are normally planned operations and exclude actual or potential accidental or unplanned releases.

The measured or calculated environmental radionuclide concentrations were converted to a 50-year CEDE with the use of the CEDE conversion factors[12] and were compared with the annual dose limits for uncontrolled areas. The CEDEs were calculated from the DOE Derived Concentration Guides (DCGs)[9] for members of the public on the basis of a radiation dose of 100 mrem/yr. The numerical values of the CEDE conversion factors used in this report are provided later in this chapter (Table 4.26). Occasionally, other standards are used, and their sources are identified in the text.

4.2. Air

The radioactive content of particles in the air was determined by collecting and analyzing air filter samples. The sampling locations are shown in Figures 1.1 and 1.2.

ANL-E uses continuously operating air samplers to collect samples for the measurement of concentrations of airborne particles contaminated by radionuclides. Currently, nonradiological air contaminants in ambient air are not monitored. Particle samplers are placed at 14 locations around the ANL-E perimeter and at six off-site locations, approximately 8 km (5 mi) from ANL-E, to determine the ambient or background concentrations.

Airborne particle samples for measurement of total alpha, total beta, and gamma-ray emitters are collected continuously at 12 perimeter locations and at five off-site locations on glass fiber filter media. Average flow rates on the air samplers are about 70 m^3/h (2,472 ft^3/h). Filters are changed weekly. The filters on perimeter samplers are changed by ANL-E staff, and the filters on off-site samplers are changed and mailed to ANL-E by cooperating local agencies. Additional samples of particles in air, used for radiochemical analysis of plutonium and other radionuclides, are collected at two perimeter locations and at one off-site location. These samples are collected on special filter media that are changed every 10 days by ANL-E staff. The sampling units are serviced every six months, and the flow meters are recalibrated annually.

At the time of sample collection, the date and time when sampling was begun and the date and time when the sample was collected are recorded on a label attached to the sample container. The samples are then transported to ANL-E where this information is then transferred to the EMS.

Each air filter sample collected for alpha, beta, and gamma-ray analysis is cut in half. Half of each sample for any calendar week is combined with all the other perimeter samples from that week and packaged for gamma-ray spectrometry. A similar package is prepared for the off-site filters for each week. A 5-cm (2-in.) circle is cut from the other half of the filter, mounted in a 5-cm (2-in.) low-lip stainless-steel planchet, and counted to determine alpha and beta activity. The remainder of the filter is saved.

The air filter samples collected for radiochemical analysis are composited by location for each month. After the addition of appropriate tracers, the samples are ashed, then sequentially analyzed for plutonium, thorium, uranium, and strontium, because these radionuclides are those most likely to be in the air due to ANL-E operations.

Stack monitoring is conducted continuously at five locations, that is, those emission points that have a probability of releasing measurable concentrations of radionuclides. The results of these measurements are used to estimate the annual off-site dose using the required EPA CAP-88 (Clean

Air Act Assessment Package-1988)[13] atmospheric dispersion computer code and dose conversion method.

Samples were collected at the site perimeter to determine whether a statistically significant difference exists between perimeter measurements and measurements taken from samples collected at various off-site locations. The off-site samples establish the local background concentrations of naturally occurring or ubiquitous man-made radionuclides, such as from nuclear weapons testing fallout. Higher levels of radioactivity in the air measured at the site perimeter may indicate radioactivity releases from ANL-E, provided that the perimeter samples are greater than the background samples by an amount greater than the relative error of the measurement. The relative error is a result of natural variation in background concentrations as well as sampling and measurement error. This relative error is typically 5 to 20% of the measurement value for most of the analyses, but approaches 100% at values near the detection limit of the instrument.

Table 4.1 summarizes the monthly total alpha and beta activities for the individual weekly sample analyses. These measurements were made in low-background gas-flow proportional counters, and the counting efficiencies used to convert counting rates to disintegration rates were those measured for a 0.30-MeV beta and a 5.5-MeV alpha on filter paper. The results were obtained by measuring the samples four days after they were collected to avoid counting the natural activity due to short-lived radon and thoron decay products. This activity is normally present in air and disappears within four days by radioactive decay. The average concentrations of gamma-ray emitters, as determined by gamma-ray spectrometry performed on composite weekly samples, are given in Table 4.2. The gamma-ray detector is a shielded germanium diode calibrated for each gamma-ray–emitting nuclide measured.

Comparison of perimeter to off-site alpha and beta concentrations over the past several years shows that the perimeter results are consistently lower. This was most pronounced this year, particularly during the summer months. An investigation of this difference showed that there was significantly less particulate material collected on the perimeter air filters. In addition, the off-site samples would occasionally not be changed on the weekly schedule and run for two weeks. These samples would have a significant amount of particulate material on the filter. The differences in concentration appear to be a function of the mass of material on the filter. This difference is probably related to the location of the air sampler. The perimeter samplers are sited in grassy, open areas, away from buildings, roads, and other sources of airborne particulate material. The off-site samplers are located within municipal complexes, within secured locations, and are typically exposed to higher levels of airborne particulate material, especially resuspended soil, which contains naturally occurring radionuclides.

The perimeter beta activity averaged 15 fCi/m^3, which is similar to the average value for the past five years. The gamma-ray emitters listed in Table 4.2 are those that have been present in the air for past years and are of natural origin. The beryllium-7 concentration increases in the

TABLE 4.1

Total Alpha and Beta Activities in Air Filter Samples, 2001
(concentrations in fCi/m^3)

Month	Location	No. of Samples	Alpha Activity Avg.	Alpha Activity Min.	Alpha Activity Max.	Beta Activity Avg.	Beta Activity Min.	Beta Activity Max.
January	Perimeter	57	1.0	0.3	2.2	20.7	10.3	34.6
	Off-Site	19	1.6	0.2	3.3	28.6	7.3	70.4
February	Perimeter	48	1.3	0.5	2.1	18.4	9.3	30.0
	Off-Site	14	2.4	0.4	9.4	27.5	7.1	104.4
March	Perimeter	48	1.1	0.1	2.7	14.5	7.2	22.6
	Off-Site	13	1.6	0.1	4.3	19.3	4.1	39.4
April	Perimeter	48	1.2	0.4	2.0	13.3	4.9	19.8
	Off-Site	12	2.2	0.3	4.1	19.0	2.9	35.9
May	Perimeter	40	0.9	0.1	2.5	11.6	3.7	23.6
	Off-Site	18	2.0	0.6	4.3	18.9	7.4	37.3
June	Perimeter	29	0.4	0.1	1.1	10.9	1.9	19.0
	Off-Site	16	2.5	0.5	12.7	22.6	6.0	51.6
July	Perimeter	40	0.5	0.1	1.4	12.9	5.2	21.9
	Off-Site	16	2.9	0.6	13.2	23.3	9.9	60.2
August	Perimeter	59	0.6	0.1	1.4	14.3	5.4	23.4
	Off-Site	20	2.5	0.6	6.2	25.0	4.8	63.6
September	Perimeter	47	0.7	0.1	1.3	11.8	1.9	19.9
	Off-Site	11	2.3	1.1	4.2	19.5	8.7	45.5
October	Perimeter	59	1.0	0.4	2.0	14.4	5.3	24.8
	Off-Site	19	2.8	1.0	6.2	21.0	5.0	62.2
November	Perimeter	44	1.4	0.5	2.7	18.4	7.0	34.1
	Off-Site	11	2.6	1.1	5.7	20.0	6.3	39.8
December	Perimeter	35	1.5	0.7	2.4	21.4	10.4	33.8
	Off-Site	13	2.7	0.6	9.0	19.8	2.7	62.6
Annual	Perimeter	554	1.0 ± 0.2	0.1	2.7	15.2 ± 2.3	1.9	34.6
summary	Off-Site	182	2.3 ± 0.3	0.1	13.2	22.0 ± 2.2	2.7	104.4

TABLE 4.2

Gamma-Ray Activity in Air Filter Samples, 2001
(concentrations in fCi/m^3)

Month	Location	Beryllium-7	Lead-210
January	Perimeter	33	18
	Off-Site	42	24
February	Perimeter	56	18
	Off-Site	72	24
March	Perimeter	64	14
	Off-Site	87	17
April	Perimeter	79	12
	Off-Site	91	13
May	Perimeter	77	10
	Off-Site	89	11
June	Perimeter	64	10
	Off-Site	101	13
July	Perimeter	71	12
	Off-Site	102	16
August	Perimeter	65	14
	Off-Site	78	18
September	Perimeter	66	12
	Off-Site	86	19
October	Perimeter	56	14
	Off-Site	62	14
November	Perimeter	47	19
	Off-Site	48	18
December	Perimeter	43	23
	Off-Site	32	18
Annual	Perimeter	60 ± 8	15 ± 2
Summary	Off-Site	74 ± 14	17 ± 2
Dose(mrem)	Perimeter	(0.00015)	(1.68)
	Off-Site	(0.00019)	(1.95)

spring, which indicates its stratospheric origin. The concentration of lead-210 in the air is due to the radioactive decay of gaseous radon-222 and is similar to the concentration last year. The annual average radiation measurements for the on-site samples were less than the off-site samples as discussed above.

The annual average alpha and beta activities since 1985 are displayed in Figure 4.1. The elevated beta activity in 1986 was due to fallout from the Chernobyl incident. If the radionuclides attributed to the Chernobyl incident are subtracted from the annual beta average of 40 fCi/m^3, the net would be 27 fCi/m^3, very similar to the averages of the other years. Figure 4.2 presents the annual average concentrations of the two major gamma-ray–emitting radionuclides in air. The annual average beryllium-7 concentrations have decreased regularly since 1987, reached a minimum in 1991, increased until 1996, and have now decreased. The changes in the beryllium-7 air concentrations have been observed worldwide by the DOE Environmental Laboratory's Surface Air Sampling Program and are attributed to changes in solar activity.[14]

Samples for radiochemical analyses were collected at perimeter locations 12N for the first eight months of the year and 7I (Figure 1.1) and off the site in Downers Grove (Figure 1.2). Sample collection at location 12N was discontinued because there was no longer any potential source of airborne radionuclides in this area. Collections were made on polystyrene filters. The total air volume filtered for the monthly samples was approximately 20,000 m^3 (700,000 ft^3). Samples were ignited at 600°C (1,100°F) to remove organic matter and were prepared for analysis by vigorous treatment with hot hydrochloric, hydrofluoric, and nitric acids.

Plutonium and thorium were separated on an ion-exchange column, and the uranium was extracted from the column effluent. Following the extraction, the aqueous phase was analyzed for radiostrontium by a standard radiochemical procedure. The separated plutonium, thorium, and uranium fractions were electrodeposited and measured by alpha spectrometry. The chemical recoveries were monitored by adding known amounts of plutonium-242, thorium-229, and uranium-236 tracers prior to ignition. Because spectrometry cannot distinguish between plutonium-239 and plutonium-240, when plutonium-239 is mentioned in this report, the alpha activity due to the plutonium-240 isotope is also included. The results are given in Table 4.3.

The strontium-90 concentrations have decreased over the past several years; consequently, during 2001, all of the results were less than the detection limit of 10 aCi/m^3, except for one result in April and one in August, which is attributed to D&D work in the area. Strontium-89 was not observed above the detection limit of 100 aCi/m^3. The plutonium-239 concentrations at all locations were similar to those of the last few years. The thorium and uranium concentrations were in the same range as in the past and are considered to be of natural origin. The amounts of thorium and uranium in a sample were proportional to the mass of inorganic material collected on the filter paper. The presence of most of these airborne elements can be attributed to the resuspension of soil.

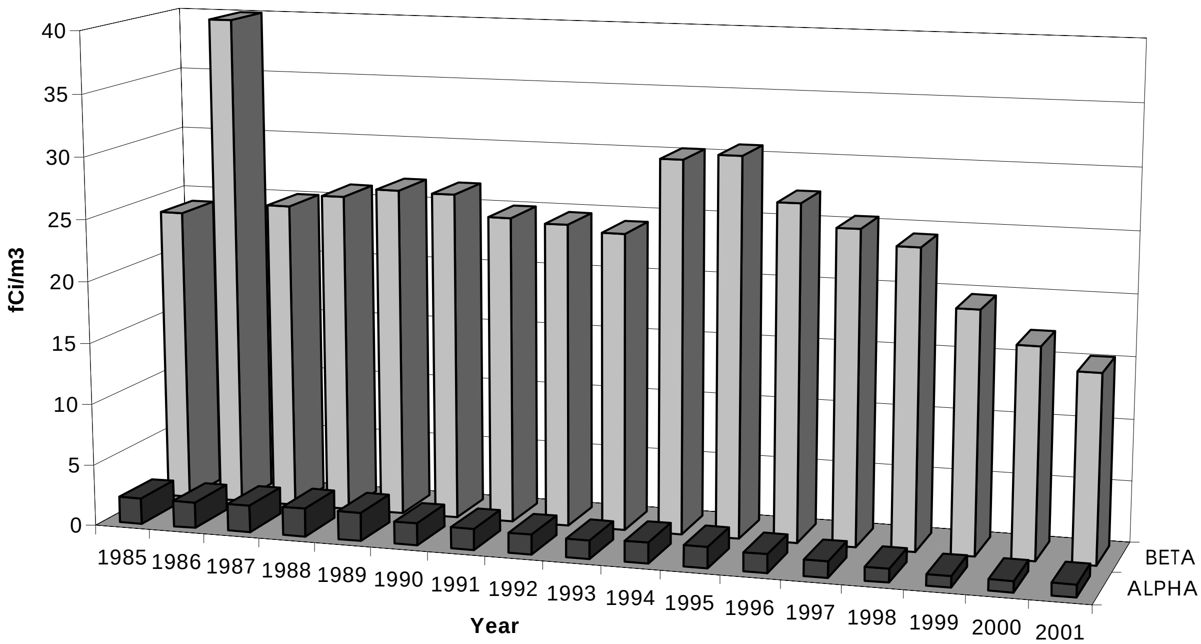


Figure 4.1 Comparison of Total Alpha and Beta Activities in Air Filter Samples

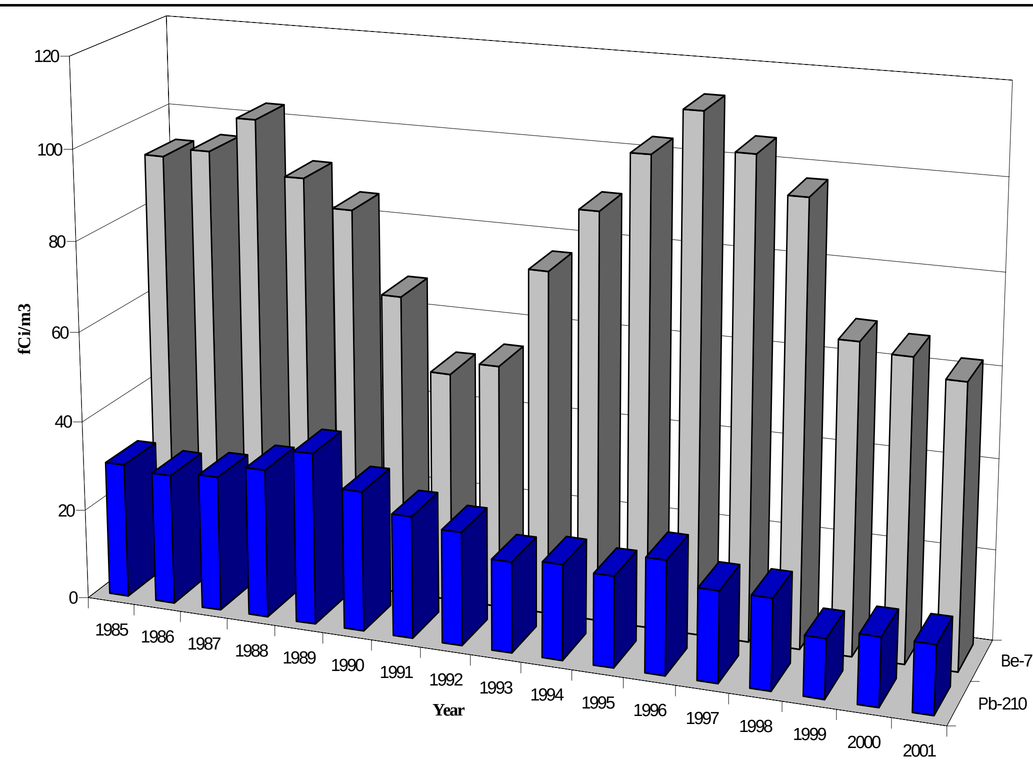


Figure 4.2 Comparison of Gamma-Ray Activity in Air Filter Samples

TABLE 4.3

Strontium, Thorium, Uranium, and Plutonium Concentrations
in Air Filter Samples, 2001
(Concentrations in aCi/m^3)

Month	Location[a]	Strontium-90	Thorium-228	Thorium-230	Thorium-232	Uranium-234	Uranium-238	Plutonium-239
January	7I	< 10	3 ± 2	4 ± 1	1 ± 1	16 ± 3	8 ± 2	0.5 ± 0.3
	12N	< 10	5 ± 2	6 ± 1	3 ± 1	18 ± 2	8 ± 1	0.5 ± 0.3
	Off-Site	< 10	3 ± 1	2 ± 1	1 ± 1	11 ± 2	3 ± 1	0.3 ± 0.2
February	7I	< 10	2 ± 1	3 ± 1	2 ± 1	12 ± 2	5 ± 1	0.5 ± 0.3
	12N	< 10	5 ± 2	6 ± 2	5 ± 1	15 ± 3	8 ± 2	0.2 ± 0.2
	Off-Site	< 10	2 ± 1	2 ± 1	1 ± 1	10 ± 2	4 ± 1	0.3 ± 0.2
March	7I	-[b]	3 ± 1	3 ± 1	2 ± 1	12 ± 3	4 ± 1	0.3 ± 0.2
	12N	< 10	6 ± 1	8 ± 1	4 ± 1	17 ± 2	9 ± 1	0.2 ± 0.1
	Off-Site	< 10	4 ± 1	4 ± 1	2 ± 1	13 ± 2	6 ± 1	0.3 ± 0.2
April	7I	13 ± 2	6 ± 1	6 ± 1	5 ± 1	15 ± 3	6 ± 2	0.5 ± 0.3
	12N	< 10	23 ± 4	26 ± 3	16 ± 3	45 ± 7	26 ± 5	0.6 ± 0.4
	Off-Site	< 10	3 ± 1	2 ± 1	1 ± 1	10 ± 2	4 ± 1	0.9 ± 0.3
May	7I	< 10	5 ± 2	5 ± 1	4 ± 1	16 ± 3	5 ± 2	0.5 ± 0.4
	12N	< 10	13 ± 2	13 ± 2	10 ± 2	24 ± 3	16 ± 3	0.3 ± 0.2
	Off-Site	< 10	2 ± 1	2 ± 1	1 ± 1	18 ± 3	8 ± 2	0.4 ± 0.3
June	7I	< 10	2 ± 1	4 ± 1	2 ± 1	12 ± 2	3 ± 1	0.5 ± 0.3
	12N	< 10	8 ± 2	9 ± 2	5 ± 1	14 ± 1	9 ± 1	0.4 ± 0.2
	Off-Site	< 10	1 ± 1	2 ± 1	< 1	8 ± 2	2 ± 1	0.4 ± 0.2
July	7I	< 10	3 ± 1	3 ± 1	3 ± 1	15 ± 3	4 ± 2	0.5 ± 0.3
	12N	< 10	13 ± 2	16 ± 2	10 ± 1	22 ± 3	18 ± 2	0.2 ± 0.3
	Off-Site	< 10	2 ± 1	2 ± 1	2 ± 1	8 ± 1	2 ± 1	0.3 ± 0.1
August	7I	28 ± 3	9 ± 3	9 ± 2	6 ± 2	16 ± 3	7 ± 2	0.4 ± 0.3
	12N	< 10	16 ± 3	18 ± 3	13 ± 3	31 ± 4	19 ± 3	0.7 ± 0.4
	Off-Site	< 10	< 1	1 ± 1	< 1	11 ± 2	2 ± 1	0.7 ± 0.4
September	7I	< 10	6 ± 2	6 ± 2	3 ± 1	15 ± 3	7 ± 2	0.6 ± 0.3
	12N	-	-	-	-	-	-	-
	Off-Site	< 10	1 ± 1	2 ± 1	1 ± 1	8 ± 2	2 ± 1	0.4 ± 0.2
October	7I	< 10	6 ± 2	7 ± 2	4 ± 1	17 ± 3	7 ± 2	0.5 ± 0.3
	12N	-	-	-	-	-	-	-
	Off-Site	< 10	3 ± 2	4 ± 1	2 ± 1	17 ± 3	6 ± 2	0.5 ± 0.2
November	7I	< 10	8 ± 2	6 ± 2	4 ± 1	16 ± 3	9 ± 2	0.6 ± 0.4
	12N	-	-	-	-	-	-	-
	Off-Site	< 10	2 ± 1	3 ± 1	2 ± 1	8 ± 2	3 ± 1	0.5 ± 0.2
December	7I	< 10	5 ± 2	7 ± 2	3 ± 1	16 ± 2	8 ± 2	0.2 ± 0.2
	12N	-	-	-	-	-	-	-
	Off-Site	< 10	1 ± 1	1 ± 1	< 1	8 ± 1	2 ± 1	0.4 ± 0.2
Annual Summary	7I	< 10	5 ± 5	5 ± 4	3 ± 3	15 ± 4	6 ± 4	0.5 ± 0.3
	12N	< 10	11 ± 15	13 ± 17	8 ± 11	23 ± 25	14 ± 16	0.4 ± 0.4
	Off-Site	< 10	2 ± 2	2 ± 2	1 ± 1	11 ± 8	4 ± 4	0.4 ± 0.4
Dose (mrem)	7I	< (0.00011)	(0.0120)	(0.0104)	(0.031)	(0.00074)	(0.00030)	(0.0012)
	12N	< (0.00011)	(0.0276)	(0.0251)	(0.082)	(0.00116)	(0.00069)	(0.0009)
	Off-Site	< (0.00011)	(0.0050)	(0.0044)	(0.013)	(0.00054)	(0.00018)	(0.0011)

[a] Perimeter locations are given in terms of the grid coordinates in Figure 1.1.

[b] A hyphen indicates that no samples were collected.

The major airborne effluents released at ANL-E during 2001 are listed by location in Table 4.4; Figure 4.3 shows the annual releases of the major sources since 1985. The radon-220 releases from Building 200, due to radioactive contamination from the “proof-of-breeding” program, have been greatly reduced. The hydrogen-3 emitted from Building 212 is from hydrogen-3 recovery studies, while short-lived neutron activation products are emitted from the IPNS and APS. In addition to the radionuclides listed in Table 4.4, several other fission products also were released in millicurie or smaller amounts. The quantities listed in Table 4.4 were measured by on-line stack monitors in the exhaust systems of the buildings, except those for Building 350.

Phytoremediation is being applied to the 317/319 Area to complete the cleanup of the groundwater in the area, which was contaminated in the past by the disposal of liquid wastes to the soil in French drains. Phytoremediation is a natural process by which woody and herbaceous plants extract pore water and entrained chemical substances from subsurface soil, degrade volatile organic constituents, and transpire water vapor to the atmosphere. The system consists of planting shallow-rooted willow and special deep-rooted poplar trees. A mixture of grasses and legumes are also planted around the trees to address shallow soil contamination and to prevent soil erosion. Approximately 800 trees were planted in the fall of 1999.

One of the major groundwater contaminants in the 317/319 Area is hydrogen-3, as tritiated water. The phytoremediation process will translocate the hydrogen-3 from the groundwater to the air as water vapor. Since the hydrogen-3 is released over an area of approximately 2 ha (5.5 acres), traditional point source monitoring for airborne hydrogen-3 water vapor is of little value to determine the quantity of hydrogen-3 released to the air. The annual inventory of hydrogen-3 released to the air can be estimated from the hydrogen-3 content of the groundwater and the extraction rate at which various aged trees remove groundwater. On the basis of the age and type of tree, estimates are available on the average consumption rate of groundwater per tree per month of the growing season. For this estimate, it is assumed that all of the groundwater that is extracted is transpired.

Quarterly monitoring is conducted at the 18 wells that are within the phytoremediation plantation. The average hydrogen-3 concentration for 2001 for all the wells was 1,093 pCi/L. The annual amount of hydrogen-3 released is then the product of the annual volume of water released for all 800 trees multiplied by the hydrogen-3 concentration in the groundwater. For 2001, the total hydrogen-3 released was 0.01 Ci. Applying the CAP-88 code,[13] an estimate of the annual dose to the maximally exposed individual was 0.0000001 mrem. This estimated dose is extremely small compared with the 10 mrem annual dose limit of NESHAP.

4.3. Surface Water

All water samples collected in the monitoring program were acidified to 0.1N with nitric acid and filtered immediately after collection. Total nonvolatile alpha and beta activities were

TABLE 4.4

Summary of Airborne Radioactive Emissions from ANL-E Facilities, 2001

Building	Nuclide	Half-Life	Amount Released (Ci)	Amount Released (Bq)
200	Radon-220	56 s	35.6	1.3×10^{12}
205	Hydrogen-3 (tritiated water [HTO])	12.3 yr	0.19	6.9×10^{9}
212 (Alpha Gamma Hot Cell Facility)	Hydrogen-3 (HTO)	12.3 yr	5.4	2.0×10^{11}
	Hydrogen-3 (tritiated hydrogen gas [HT])	12.3 yr	73.1	2.7×10^{12}
	Krypton-85	10.7 yr	13.2	4.9×10^{11}
	Radon-220	56 s	0.15	5.6×10^{9}
350 (NBL)	Uranium-234	2.4×10^{5} yr	8.8×10^{-8}	3.3×10^{-1}
	Uranium-238	4.5×10^{9} yr	8.8×10^{-8}	3.3×10^{-1}
	Plutonium-239	2.4×10^{4} yr	1.8×10^{-6}	6.7×10^{4}
	Plutonium-240	6.6×10^{4} yr	2.1×10^{-9}	7.8×10^{0}
375 (IPNS)	Carbon-11	20 m	1250.0	4.6×10^{13}
	Argon-41	1.8 h	81.0	3.0×10^{11}
411/415 (APS)	Carbon-11	20 m	0.10	3.7×10^{9}
	Nitrogen-13	10 m	6.56	2.4×10^{11}
	Oxygen-15	122 s	0.72	2.7×10^{10}

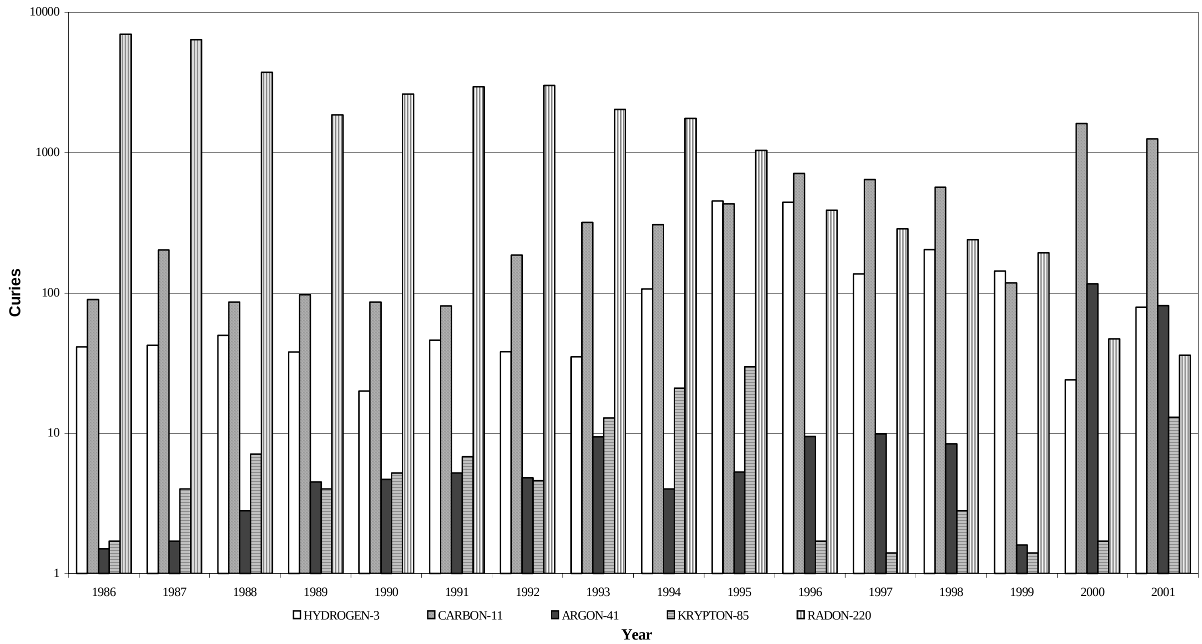


Figure 4.3 Selected Airborne Radionuclide Emissions

determined by counting the residue remaining after evaporation of the water and then applying counting efficiency corrections determined for plutonium-239 (for alpha activity) and thallium-204 (for beta activity) to obtain disintegration rates. Hydrogen-3 was measured from a separate aliquot; this activity does not appear in the results for total nonvolatile beta activity. Analyses for the radionuclides were performed by specific radiochemical separations followed by appropriate counting. One-liter aliquots were used for all analyses except for hydrogen-3 and the transuranium nuclides. Hydrogen-3 analyses were performed by liquid scintillation counting of 9 mL (0.03 oz) of a distilled sample in a nonhazardous cocktail. Analyses for transuranium nuclides were performed on 10-L (3-gal) samples with chemical separation methods followed by alpha spectrometry. Plutonium-236 was used to determine the yields of plutonium and neptunium, which were separated from the sample together. A group separation of a fraction containing the transplutonium elements was monitored for recovery with an americium-243 tracer. Isotopic uranium concentrations were determined by alpha spectrometry by using uranium-236 as an isotopic tracer.

Liquid wastewater from buildings or facilities that use or process radioactive materials is collected in retention tanks. When a tank is full, it is sampled and analyzed for alpha and beta radioactivity. If the radioactivity exceeds the release limits, the tank is processed by evaporation and the residue is disposed of as solid LLW. If the radioactivity is below the release limits, the wastewater is conveyed to the laboratory WTP in dedicated pipes to waste storage tanks. The release limits are based on the DCGs for plutonium-239 (0.03 pCi/mL) for alpha activity, and for strontium-90 (1.0 pCi/mL) for beta activity. These radionuclides were selected because of their potential for release and their conservative allowable limits in the environment. The effluent monitoring program documents that no liquid releases above the DCGs have occurred and reinforces demonstration of compliance with the use of best available technology (BAT) as required by DOE Order 5400.5.[9]

Another component of the radiological effluent monitoring program, which was instituted in 1999, is the radiological analysis of the main water treatment plant discharge (Outfall 001). Metals have been analyzed at this location for a number of years (see Table 5.10). The same radiological constituents that are determined in Sawmill Creek are also analyzed at this location. Samples are collected daily, and equal portions are combined for each week and analyzed to obtain an average weekly concentration. Table 4.5 gives the results for 2001. The results show that the radionuclides hydrogen-3 and strontium-90 detected in the effluent water can be attributed to ANL-E operations. The concentrations are very low and a small fraction of the DOE limits; these findings reinforce ANL-E compliance with DOE Order 5400.5 for use of BAT for releases of liquid effluents. To estimate the total annual quantity of each radionuclide released to the environment, the product of the annual average concentration and the annual volume of water discharged (1.19×10^9 L) is computed. These results are given in Table 4.6.

ANL-E wastewater is discharged into Sawmill Creek (Location 7M in Figure 1.1). The creek runs through the ANL-E grounds, drains surface water from much of the site, and flows into the Des Plaines River about 500 m (1,600 ft) downstream from the ANL-E wastewater outfall. Sawmill Creek was sampled upstream from the ANL-E site and downstream from the wastewater discharge point to determine whether radioactivity was added to the stream by ANL-E wastewater or surface drainage. The sampling locations are shown in Figure 1.1. Daily samples were collected below the wastewater outfall. Equal portions of the daily samples collected each week were combined and analyzed to obtain an average weekly concentration. Samples were collected upstream of the site once a month and were analyzed for the same radionuclides measured in the below-outfall samples.

Table 4.7 gives the annual summaries of the results obtained for Sawmill Creek. Comparison of the results and 95% confidence levels of the averages for the two sampling locations shows that the following radionuclides found in the creek water can be attributed to ANL-E operations: hydrogen-3, strontium-90, neptunium-237, plutonium-238, plutonium-239, americium-241, and curium-244 and/or californium-249. The concentrations of all these nuclides are low and at a small fraction of DOE concentration limits. In Sawmill Creek, below the ANL-E outfall, the annual average concentrations of most measured radionuclides were similar to recent annual averages. All the annual averages were well below the applicable DOE standards.

TABLE 4.5

Radionuclides in Effluents from the ANL-E Wastewater Treatment Plant, 2001

		Concentration (pCi/L)			Dose (mrem)		
Activity	No. of Samples	Avg.	Min.	Max.	Avg.	Min.	Max.
Alpha	52	0.9 ± 1.0	0.1	2.8	-[a]	-	-
Beta	52	11 ± 3	9	14	-	-	-
Hydrogen-3	52	< 100	< 100	164	< 0.0046	< 0.0046	0.0075
Strontium-90	52	0.53 ± 0.33	0.27	1.32	0.051	0.026	0.125
Cesium-137	52	< 2.0	< 2.0	< 2.0	< 0.07	< 0.07	< 0.07
Uranium-234	52	0.332 ± 0.276	0.119	0.806	0.063	0.023	0.153
Uranium-238	52	0.267 ± 0.222	0.120	0.482	0.045	0.020	0.081
Neptunium-237	52	< 0.0010	< 0.0010	0.0048	< 0.0028	< 0.0028	0.0136
Plutonium-238	52	< 0.0010	< 0.0010	0.0011	< 0.0028	< 0.0028	0.0031
Plutonium-239	52	< 0.0010	< 0.0010	0.0014	< 0.0031	< 0.0031	0.0043
Americium-241	52	0.0011 ± 0.0036	< 0.0010	0.0085	0.0035	< 0.0033	0.0280
Curium-242 and/or Californium-252	52	< 0.0010	< 0.0010	< 0.0010	< 0.0007	< 0.0007	< 0.0007
Curium-244 and/or Californium-249	52	< 0.0010	< 0.0010	0.0055	< 0.0034	< 0.0034	0.0185

[a] A hyphen indicates no CEDEs for alpha and beta.

On the basis of the results of the Storm Water Characterization Study (see Section 2.2.2), two perimeter surface water locations were identified that contained measurable levels of radionuclides. They were south of the 319 Area, Location 7J, and south of the 800 Area Landfill, Location 11D (see Figure 1.1). Samples were scheduled to be collected quarterly and analyzed for hydrogen-3, strontium-90, and gamma-ray emitters. The results are presented in Table 4.8.

TABLE 4.6

Total Radioactivity Released, 2001

Radionuclide	WTP Outfall (Ci)
Hydrogen-3	0.10
Strontium-90	0.0006
Plutonium-239	<0.0001
Americium-241	<0.0001
Total	0.10

The source of the radionuclides at Location 7J appears to be leachate from the 319 Area Landfill. A subsurface barrier wall and leachate collection system were constructed south of the 319 Landfill in November 1995 and became operational in 1996. Since the construction and operation of the leachate collection system, radionuclide concentrations in surface water at Location 7J have decreased substantially. The hydrogen-3 at Location 11D is probably also from the leachate; the decrease in the concentration from earlier years is due to the completion of the clay cap on the 800 Area Landfill in the fall of 1993.

One of the ANL-E waste management locations is within the 398A fenced area (Location 8J in Figure 1.1). Surface water drainage from this area is collected in a small pond at the south (downgradient) end of the 398A area. To evaluate whether any radionuclides are being transported by storm water flow through the 398A area, quarterly sampling is conducted from the 398A pond and analyzed for hydrogen-3 and gamma-ray–emitting radionuclides. All hydrogen-3 results were below the detection limit of 100 pCi/L and gamma-ray spectrometric analysis did not detect any radionuclides associated with ANL-E activities above the detection limit of 2 pCi/L.

Because Sawmill Creek empties into the Des Plaines River, data on the radioactivity in this river is important in assessing the contribution of ANL-E wastewater to environmental radioactivity. The Des Plaines River was sampled twice a month below and once a month above the mouth of Sawmill Creek to determine whether the radioactivity in the creek had any effect on the radioactivity in the river. Table 4.9 gives the annual summaries of the results obtained for these two locations. The average nonvolatile alpha, beta, and uranium concentrations in the river were very similar to past averages and remained in the normal range. Results were similar above and below the creek for all radionuclides, because the activity in Sawmill Creek was reduced by dilution to the point that it was not detectable in the Des Plaines River.

TABLE 4.7

Radionuclides in Sawmill Creek Water, 2001

			Concentration (pCi/L)			Dose (mrem)		
Activity	Location[a]	No. of Samples	Avg.	Min.	Max.	Avg.	Min.	Max.
Alpha	16K	11	1.3 ± 1.5	0.8	2.9	-[b]	-	-
(Nonvolatile)	7M	52	1.1 ± 1.3	0.1	2.9	-	-	-
Beta	16K	11	6 ± 4	4	11	-	-	-
(Nonvolatile)	7M	52	8 ± 5	4	16	-	-	-
Hydrogen-3	16K	11	< 100	< 100	< 100	< 0.0046	< 0.0046	< 0.0046
	7M	52	< 100	< 100	132	< 0.0046	< 0.0046	0.0061
Strontium-90	16K	11	< 0.25	< 0.25	0.29	< 0.024	< 0.024	0.027
	7M	52	0.36 ± 0.37	< 0.25	1.13	0.034	< 0.024	0.107
Cesium-137	16K	11	< 2.0	< 2.0	< 2.0	< 0.07	< 0.07	< 0.07
	7M	52	< 2.0	< 2.0	< 2.0	< 0.07	< 0.07	< 0.07
Uranium-234	16K	11	0.820 ± 0.754	0.351	1.545	0.156	0.067	0.294
	7M	52	0.552 ± 0.541	0.130	1.129	0.105	0.025	0.215
Uranium-238	16K	11	0.725 ± 0.564	0.284	1.095	0.122	0.048	0.184
	7M	52	0.492 ± 0.501	0.113	1.058	0.083	0.019	0.178
Neptunium-237	16K	11	< 0.0010	< 0.0010	< 0.0010	< 0.0028	< 0.0028	< 0.0028
	7M	52	< 0.0010	< 0.0010	0.0012	< 0.0028	< 0.0028	0.0034
Plutonium-238	16K	11	< 0.0010	< 0.0010	0.0010	< 0.0028	< 0.0028	0.0029
	7M	52	< 0.0010	< 0.0010	0.0018	< 0.0028	< 0.0028	0.0050
Plutonium-239	16K	11	< 0.0010	< 0.0010	< 0.0010	< 0.0031	< 0.0031	< 0.0031
	7M	52	< 0.0010	< 0.0010	0.0012	< 0.0031	< 0.0031	0.0039
Americium-241	16K	11	< 0.0010	< 0.0010	0.0026	< 0.0033	< 0.0033	0.0085
	7M	52	< 0.0010	< 0.0010	0.0032	< 0.0033	< 0.0033	0.0105
Curium-242 and/or	16K	11	< 0.0010	< 0.0010	< 0.0010	< 0.0007	< 0.0007	< 0.0007
Californium-252	7M	52	< 0.0010	< 0.0010	< 0.0010	< 0.0007	< 0.0007	< 0.0007
Curium-244 and/or	16K	11	< 0.0010	< 0.0010	< 0.0010	< 0.0034	< 0.0034	< 0.0034
Californium-249	7M	52	< 0.0010	< 0.0010	0.0033	< 0.0034	< 0.0034	0.0112

[a] Location 16K is upstream from the ANL-E site, and location 7M is downstream from the ANL-E wastewater outfall.

[b] A hyphen indicates no CEDEs for alpha and beta.

TABLE 4.8

Radionuclides in Storm Water Outfalls, 2001
(concentrations in pCi/L)

Date Collected	Location 7J Hydrogen-3	Location 7J Strontium-90	Location 7J Cesium-137	Location 11D Hydrogen-3
February 9	<100	0.42	<2	<100
May	Dry	Dry	Dry	Dry
September 19	<100	0.89	<2	131
October 25	104	1.29	<2	377

4.4. Bottom Sediment

The radioactive content of bottom sediment was measured in Sawmill Creek. A grab sample technique was used to obtain bottom sediments. After drying, grinding, and mixing, portions of each of the bottom sediment samples were analyzed by the same methods described in Section 4.2 for air filter residues. The plutonium and americium were separated from the same 10-g (0.35-oz) aliquot of sediment. Results are given in terms of the oven-dried (110°C [230°F]) weight.

A set of sediment samples was collected on November 28, 2001, from the Sawmill Creek bed, above, at the outfall, and at several locations below the point at which ANL-E discharges its treated wastewater (Location 7M in Figure 1.1). The results, as listed in Table 4.10, show that the concentrations in the samples collected above the 7M outfall are similar to those of the off-site samples collected in past years.[15] The plutonium, americium, and cesium-137 concentrations are elevated below the outfall, which indicates that their origin is in ANL-E wastewater. Plutonium results varied widely among locations and were strongly dependent on the retentiveness of the bottom material. The changes in concentrations of these nuclides with time and location indicate the dynamic nature of the sediment material in this area.

4.5. External Penetrating Radiation

Levels of external penetrating gamma radiation at and in the vicinity of the ANL-E site were measured with aluminum oxide TLD chips provided and read by a commercial vendor. Each measurement reported represents the average of two chips exposed in the same packet. Dosimeters were exposed at 17 locations at the site boundary and on the site. Readings were also taken at five off-site locations (Figure 1.2) for comparative purposes. Three locations were added to the network in 1999 to monitor radioactive waste management activities. They are east of Building 306

TABLE 4.9

Radionuclides in Des Plaines River Water, 2001

			Concentration (pCi/L)			Dose (mrem)		
Activity	Location[a]	No. of Samples	Avg.	Min.	Max.	Avg.	Min.	Max.
Alpha	A	11	1.3 ± 1.2	0.6	2.1	-[b]	-	-
(Nonvolatile)	B	23	1.2 ± 1.1	0.4	2.7	-	-	-
Beta	A	11	9 ± 5	7	13	-	-	-
(Nonvolatile)	B	23	10 ± 5	7	16	-	-	-
Hydrogen-3	A	11	< 100	< 100	< 100	< 0.0046	< 0.0046	< 0.0046
	B	23	< 100	< 100	139	< 0.0046	< 0.0046	0.0064
Strontium-90	A	11	< 0.25	< 0.25	0.31	< 0.024	< 0.024	0.029
	B	23	< 0.25	< 0.25	0.30	< 0.024	< 0.024	0.028
Uranium-234	A	11	0.628 ± 0.404	0.359	1.010	0.119	0.068	0.192
	B	23	0.591 ± 0.384	0.308	0.870	0.112	0.059	0.165
Uranium-238	A	11	0.541 ± 0.384	0.294	0.869	0.091	0.049	0.146
	B	23	0.520 ± 0.340	0.271	0.811	0.087	0.045	0.136
Neptunium-237	A	11	< 0.0010	< 0.0010	< 0.0010	< 0.0028	< 0.0028	< 0.0028
	B	11	< 0.0010	< 0.0010	< 0.0010	< 0.0028	< 0.0028	< 0.0028
Plutonium-238	A	11	< 0.0010	< 0.0010	0.0019	< 0.0028	< 0.0028	0.0052
	B	11	< 0.0010	< 0.0010	< 0.0010	< 0.0028	< 0.0028	< 0.0028
Plutonium-239	A	11	< 0.0010	< 0.0010	< 0.0010	< 0.0031	< 0.0031	< 0.0031
	B	11	< 0.0010	< 0.0010	< 0.0010	< 0.0031	< 0.0031	< 0.0031
Americium-241	A	11	< 0.0010	< 0.0010	0.0016	< 0.0033	< 0.0033	0.0054
	B	11	< 0.0010	< 0.0010	0.0010	< 0.0033	< 0.0033	0.0034
Curium-242 and/or	A	11	< 0.0010	< 0.0010	< 0.0010	< 0.0007	< 0.0007	< 0.0007
Californium-252	B	11	< 0.0010	< 0.0010	< 0.0010	< 0.0007	< 0.0007	< 0.0007
Curium-244 and/or	A	11	< 0.0010	< 0.0010	< 0.0010	< 0.0034	< 0.0034	< 0.0034
Californium-249	B	11	< 0.0010	< 0.0010	< 0.0010	< 0.0034	< 0.0034	< 0.0034

[a] Location A, near Willow Springs, is upstream; location B, near Lemont, is downstream from the mouth of Sawmill Creek. See Figure 1.2.

[b] A hyphen indicates no CEDEs for alpha and beta.

TABLE 4.10

Radionuclides in Bottom Sediment, 2001

Location	Concentration (pCi/g)					Concentration (fCi/g)		
	Potassium-40	Cesium-137	Radium-226	Thorium-228	Thorium-232	Plutonium-238	Plutonium-239	Americium-241
Sawmill Creek 25 m above outfall	9.57 ± 0.53	< 0.01	0.64 ± 0.06	0.40 ± 0.04	0.35 ± 0.08	0.1 ± 0.2	2.3 ± 0.8	1.2 ± 0.6
Sawmill Creek at outfall	16.83 ± 0.64	0.01 ± 0.03	0.98 ± 0.06	0.65 ± 0.04	0.56 ± 0.09	0.7 ± 0.4	11.2 ± 1.7	2.6 ± 0.8
Sawmill Creek 50 m below outfall	11.86 ± 0.57	0.46 ± 0.04	0.73 ± 0.06	0.55 ± 0.04	< 0.01	15.4 ± 2.0	742.1 ± 43.1	165.2 ± 12.4
Sawmill Creek 100 m below outfall	7.90 ± 0.50	0.07 ± 0.02	0.47 ± 0.05	0.35 ± 0.04	0.26 ± 0.07	0.2 ± 0.2	6.2 ± 1.2	2.0 ± 0.7
Sawmill Creek at Des Plaines River	19.58 ± 0.68	0.05 ± 0.03	1.14 ± 0.07	0.99 ± 0.05	0.81 ± 0.09	0.4 ± 0.4	4.5 ± 1.1	2.0 ± 0.7

(Location 9/10 I), south of Building 331 (Location 9 H/I), and next to the 398A radioactive waste storage area (Location 9J).

The results are summarized in Tables 4.11 and 4.12, and the site boundary and on-site readings are shown in Figure 4.4. Measurements were taken during the four successive exposure periods shown in the tables, and the results were calculated in terms of annual dose for ease in comparing measurements made for different elapsed times. The fourth quarter sets of TLDs were not returned promptly to the vendor for analysis but stored at ANL-E. As a result, the fourth quarter values were higher than those of the other quarters. The uncertainty of the averages given in the tables is the 95% confidence limit calculated from the standard deviation of the average.

The off-site results averaged 103 ± 6 mrem/yr and were similar to last year's off-site average of 99 ± 5 mrem/yr.[16] To compare boundary results for individual sampling periods, the standard deviation of the 20 individual off-site results is useful. This value is 10 mrem/yr; thus, individual results in the range of 103 ± 20 mrem/yr may be considered to be the average natural background with a 95% probability.

The site boundary at Location 7I had dose rates consistently above the average background. This was the result of radiation from ANL-E's 317 Area in the northern half of grid 7I. Waste was packaged and temporarily stored in this area before removal for permanent disposal off site. In 2001, the dose at this perimeter fence location was 128 ± 20 mrem/yr. Approximately 300 m (960 ft) south of the fence in grid 6I, the measured dose dropped to 114 ± 18 mrem/yr, which is within the normal background range.

TABLE 4.11

Environmental Penetrating Radiation at Off-Site Locations, 2001

	Dose Rate (mrem/yr) Period of Measurement				
Location	Jan. 16–April 6	April 6–July 5	July 5–Oct. 8	Oct. 8–Jan. 3	Average
Lemont	95	90	97	128	103 ± 17
Clarendon Hills	114	91	96	134	109 ± 19
Orland Park	103	94	74	119	97 ± 18
Woodridge	103	97	106	126	108 ± 12
Willow Springs	105	95	92	96	97 ± 5
Average	104 ± 6	93 ± 2	93 ± 10	120 ± 13	103 ± 6

TABLE 4.12

Environmental Penetrating Radiation at ANL-E, 2001

Location[a]	Dose Rate (mrem/yr) Period of Measurement				
	Jan. 16 – April 6	April 6 – July 5	July 5 – Oct. 8	Oct. 8 – Jan. 3	Average
14G - Boundary	119	105	112	145	120 ± 17
14I - Boundary	101	93	93	131	105 ± 18
14L - Boundary	99	94	108	149	112 ± 25
6I - 200 m N of Quarry Road	101	106	106	141	114 ± 18
7I - Center, Waste Storage Area Facility 317	259	502	508	502	443 ± 120
7I - Boundary	126	116	113	157	128 ± 20
8H - Boundary	111	93	98	126	107 ± 15
8H - 65 m S of Building 316	102	96	98	144	110 ± 22
8H - 200 m NW of Waste Storage Area (Heliport)	107	90	97	129	106 ± 17
8H - Boundary, Center, St. Patrick Cemetery	108	-[b]	112	145	122 ± 23
9H - 50 m SE of CP-5	98	95	99	132	106 ± 17
9 H/I - 50 m E of Building 331	614	438	438	427	479 ± 88
9/10 I - E of D306	155	146	160	458	230 ± 149
9/10 I - 65 m NE of Building 350, 230 m NE of Building 316	99	96	97	135	107 ± 19
9/10 EF - Boundary	113	103	107	140	116 ± 16
9J - 50 m W of 398A Area	474	441	624	812	587 ± 166
10/11 K - Lodging Facilities	90	93	89	137	102 ± 23

[a] See Figure 1.1.

[b] A hyphen indicates that the sample was lost.

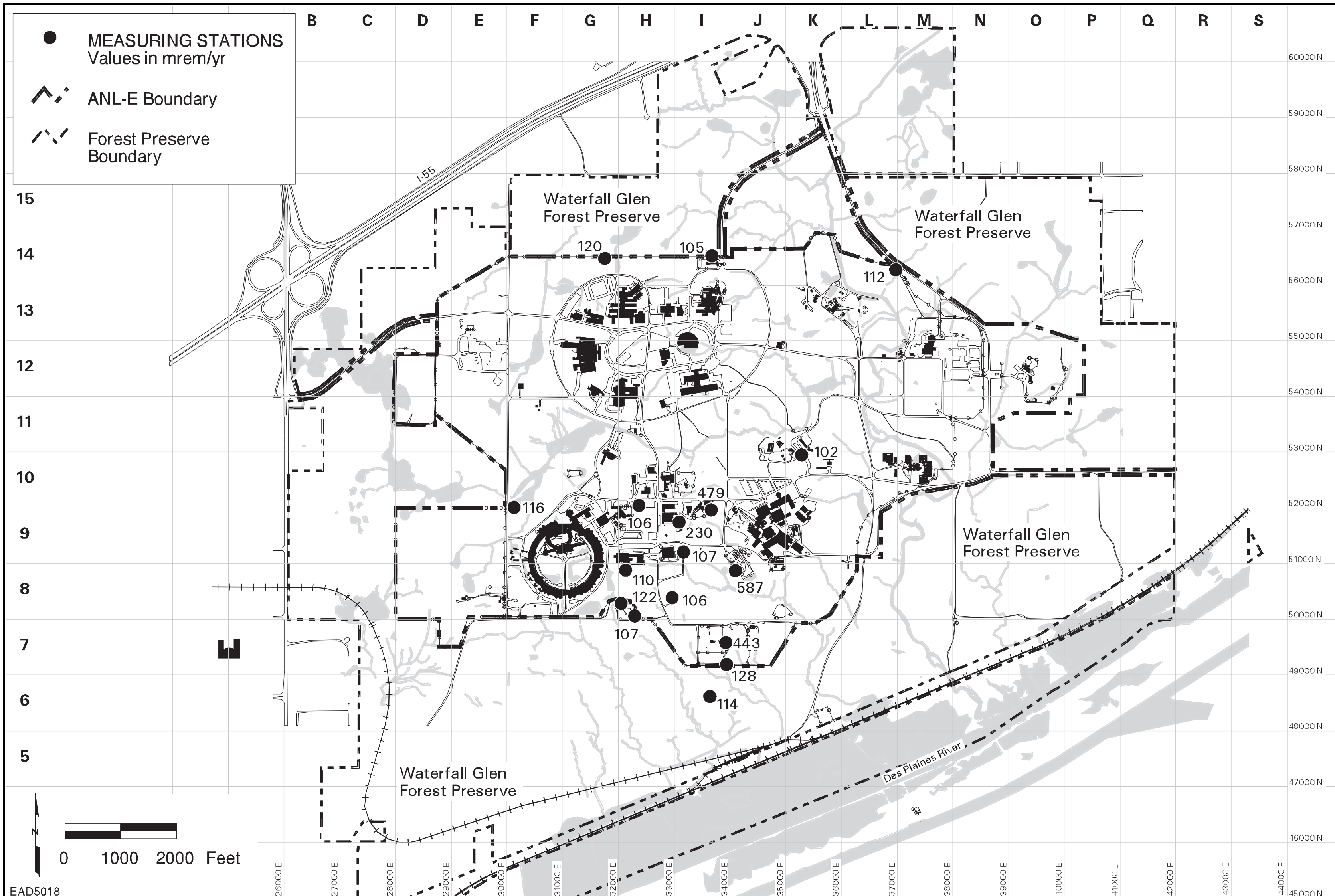


Figure 4.4 Penetrating Radiation Measurements at the ANL-E Site, 2001

In the past, an elevated on-site dose had been measured at Location 9H, next to the CP-5 reactor, where irradiated hardware from the reactor was stored. During the past few years, considerable cleanup of the CP-5 reactor yard has occurred as part of the CP-5 reactor D&D project. The dose at Location 9H decreased from about 1,200 mrem/yr in 1989 to 106 mrem/yr in 2001.

The three new locations were added to monitor radioactive waste facilities and areas. Significant movement of radioactive waste took place, principally waste from the D&D of the CP-5 reactor and the relocation of radioactive waste from the 317 Area to the 398A Area. Some waste is repacked in Building 306 (Location 9/10 I). Except for the fourth quarter, the dose from these operations was slightly above normal background levels. The elevated dose levels in the 398A Area (Location 9J) are from waste relocated from the 317 Area, historic waste, and D&D waste temporarily stored pending shipment. The Building 331 yard (Location 9 H/I) is being used as a staging area to load trucks for shipment off site. A number of radioactive waste shipments were made during 2001, as reflected by the elevated dose rates. The 398A area was also used as a staging area to load trucks for shipment off site.

4.6. Estimates of Potential Radiation Doses

The radiation doses at the site boundary and off the site that could have been received by the public from radioactive materials and radiation leaving the site were calculated. Calculations were performed for three exposure pathways—airborne, water, and direct radiation from external sources.

4.6.1. Airborne Pathway

DOE facilities with airborne releases of radioactive materials are subject to 40 CFR Part 61, Subpart H,[17] which requires the use of the EPA's CAP-88 code[13] to calculate the dose for radionuclides released to the air and to demonstrate compliance with the regulation. The dose limit applicable for 2001 for the air pathway is a 10-mrem/yr effective dose equivalent. The CAP-88 computer code uses a modified Gaussian plume equation to estimate both horizontal and vertical dispersion of radionuclides released to the air from stacks or area sources. For 2001, doses were calculated for hydrogen-3, carbon-11, nitrogen-13, oxygen-15, argon-41, krypton-85, radon-220 plus daughters, and a number of actinide radionuclides. The annual releases are those listed in Table 4.4; separate calculations were performed for each of the six release points. The wind speed and direction data shown in Figure 1.3 were used for these calculations. In the past, the wind stability classes had been determined by the temperature differences between the 10-m (33-ft) and 60-m (197-ft) levels. To improve the determination of stability levels, the categories were obtained from daytime measurements of solar radiation and nighttime measurements of the standard deviation of the horizontal wind speed. Doses were calculated for an area extending out to 80 km (50 mi) from

ANL-E. The population distribution of the 16 compass segments and 10 distance increments given in Table 1.1 was used. The dose rate was calculated at the midpoint of each interval and integrated over the entire area to give the annual population cumulative dose.

Distances from the specific facilities that exhaust radiological airborne emissions (see Table 4.4) to the fence line (perimeter) and nearest resident were determined in the 16 compass segments. Calculations also were performed to evaluate the major airborne pathways — ingestion, inhalation, and immersion — both at the point of maximum perimeter exposure and to the maximally exposed resident. The perimeter and resident doses and the maximum doses are listed, respectively, for releases from Buildings 200 (Tables 4.13 and 4.14), Building 205 (Tables 4.15 and 4.16), Building 212 (Tables 4.17 and 4.18), Building 350 (Tables 4.19 and 4.20), Building 375 (Tables 4.21 and 4.22), and Building 411 (Tables 4.23 and 4.24). The doses given in these tables are the committed whole body effective dose equivalents.

A significant D&D program was completed in 1995 for the M-Wing hot cells in Building 200, which constituted the source of the radon-220 emissions. Cleanup of the major source of the radon-220, cell M-1, resulted in a decrease of radon-220 emissions from 3,000 Ci in 1992 to 193 Ci in 1999. The radon-220 emissions were reduced further in 1999, to the present 35.6 Ci, because of the termination of the nuclear medical program that separates radium-224 from the thorium-228 parent and continued D&D of other cells.

The doses from each of the CAP-88 dose assessments were combined on the basis of the assumption that the CP-5 reactor is the central emission point for the site. The 16 compass directions from CP-5 were established for each perimeter and actual resident location. The six individual building assessments were then overlayed on the CP-5 grid, and the estimated dose was summed according to which values fell within the CP-5 segments. This approach provides an estimated dose to an actual individual and is not just the sum of the maximum doses from the individual building runs.

The highest perimeter dose was in the east direction, with a maximum value of 0.38 mrem/yr (Location 9L in Figure 1.1). Essentially all of this dose can be attributed to air immersion of carbon-11 from the IPNS facility. The maximum perimeter dose is less than that of last year and is due to decreased carbon-11 emissions from the IPNS as the result of reduced operational time. The programmatic need for continued operation of the facility will result in continued releases of carbon-11.

TABLE 4.13

Radiological Airborne Releases from Building 200, 2001

Direction	Distance to Perimeter (m)	Dose[a] (mrem/yr)	Distance to Nearest Resident (m)	Dose[a] (mrem/yr)
N	500	7.5×10^{-3}	1,000	2.1×10^{-3}
NNE	600	6.0×10^{-3}	1,100	1.9×10^{-3}
NE	750	3.4×10^{-3}	2,600	3.7×10^{-4}
ENE	1,700	7.3×10^{-4}	3,100	2.6×10^{-4}
E	2,400	5.2×10^{-4}	3,500	2.8×10^{-4}
ESE	2,200	4.3×10^{-4}	3,600	1.9×10^{-4}
SE	2,100	3.6×10^{-4}	4,000	1.2×10^{-4}
SSE	2,000	5.3×10^{-4}	4,000	1.7×10^{-4}
S	1,500	4.4×10^{-4}	4,000	9.0×10^{-5}
SSW	1,000	2.4×10^{-3}	2,500	5.0×10^{-4}
SW	800	5.0×10^{-3}	2,200	1.0×10^{-3}
WSW	1,100	1.5×10^{-3}	1,500	9.0×10^{-4}
W	750	2.7×10^{-3}	1,500	9.1×10^{-4}
WNW	800	1.8×10^{-3}	1,300	8.3×10^{-4}
NW	600	2.7×10^{-3}	1,100	1.0×10^{-3}
NNW	600	3.7×10^{-3}	800	2.2×10^{-3}

[a] Source term: radon-220 = 35.6 Ci (plus daughters).

TABLE 4.14

Maximum Perimeter and Individual Doses
from Building 200 Air Emissions, 2001
(dose in mrem/yr)

Pathway	Perimeter (500 m N)	Individual (800 m NNW)
Ingestion	1.1×10^{-14}	4.0×10^{-15}
Inhalation	7.5×10^{-3}	2.2×10^{-3}
Air immersion	5.2×10^{-5}	1.4×10^{-5}
Ground surface	3.6×10^{-6}	1.3×10^{-6}
Total	7.5×10^{-3}	2.2×10^{-3}
Radionuclide		
Thallium-208	4.5×10^{-5}	1.2×10^{-5}
Bismuth-212	8.9×10^{-4}	3.1×10^{-4}
Lead-212	4.5×10^{-3}	1.6×10^{-3}
Radon-220	2.1×10^{-3}	3.1×10^{-4}
Total	7.5×10^{-3}	2.2×10^{-3}

TABLE 4.15

Radiological Airborne Releases from Building 205, 2001

Direction	Distance to Perimeter (m)	Dose[a] (mrem/yr)	Distance to Nearest Resident (m)	Dose[a] (mrem/yr)
N	850	8.1×10^{-6}	1,300	3.9×10^{-6}
NNE	1,000	6.2×10^{-6}	2,100	1.8×10^{-6}
NE	1,200	4.2×10^{-6}	2,700	1.1×10^{-6}
ENE	2,400	1.3×10^{-6}	3,000	8.7×10^{-7}
E	2,200	1.9×10^{-6}	2,400	9.4×10^{-7}
ESE	2,000	1.6×10^{-6}	3,500	6.2×10^{-7}
SE	1,800	1.5×10^{-6}	3,900	4.2×10^{-7}
SSE	1,500	2.7×10^{-6}	4,000	5.4×10^{-7}
S	1,300	1.8×10^{-6}	3,900	3.1×10^{-7}
SSW	1,100	6.2×10^{-6}	2,400	1.7×10^{-6}
SW	900	1.4×10^{-5}	2,100	4.5×10^{-6}
WSW	1,100	4.6×10^{-6}	1,800	2.1×10^{-6}
W	1,300	3.0×10^{-6}	1,800	2.3×10^{-6}
WNW	1,100	3.6×10^{-6}	1,700	1.8×10^{-6}
NW	1,100	3.3×10^{-6}	1,500	2.0×10^{-6}
NNW	900	5.2×10^{-6}	1,500	2.2×10^{-6}

[a] Source term: hydrogen-3 = 0.19 Ci.

TABLE 4.16

Maximum Perimeter and Individual Doses from
Building 205 Air Emissions, 2001
(dose in mrem/yr)

Pathway	Perimeter (900 m SW)	Individual (2,100 m SW)
Ingestion	3.4×10^{-6}	1.1×10^{-6}
Inhalation	1.1×10^{-5}	3.4×10^{-6}
Air immersion	-[a]	-
Ground surface	-	-
Total	1.4×10^{-5}	4.5×10^{-6}
Radionuclide		
Hydrogen-3	1.4×10^{-5}	4.5×10^{-6}

[a] A hyphen indicates no exposure by this pathway.

TABLE 4.17

Radiological Airborne Releases from Building 212, 2001

Direction	Distance to Perimeter (m)	Dose[a] (mrem/yr)	Distance to Nearest Resident (m)	Dose[a] (mrem/yr)
N	800	3.1×10^{-3}	2,000	7.7×10^{-4}
NNE	1,000	2.3×10^{-3}	2,500	5.5×10^{-4}
NE	1,300	1.4×10^{-3}	2,000	7.1×10^{-4}
ENE	1,500	1.1×10^{-3}	2,500	4.7×10^{-4}
E	1,600	1.2×10^{-3}	2,800	5.1×10^{-4}
ESE	1,200	1.4×10^{-3}	2,500	4.4×10^{-4}
SE	1,400	8.5×10^{-4}	3,500	2.0×10^{-4}
SSE	1,400	1.2×10^{-3}	4,500	1.9×10^{-4}
S	1,500	5.2×10^{-4}	5,000	8.8×10^{-5}
SSW	1,600	1.3×10^{-3}	5,000	2.3×10^{-4}
SW	1,400	2.3×10^{-3}	2,400	1.1×10^{-3}
WSW	1,300	1.3×10^{-3}	2,300	5.4×10^{-4}
W	1,700	8.9×10^{-4}	2,200	6.2×10^{-4}
WNW	1,500	7.7×10^{-4}	2,000	5.2×10^{-4}
NW	1,300	8.9×10^{-4}	2,000	4.8×10^{-4}
NNW	1,000	1.6×10^{-3}	2,000	5.5×10^{-4}

[a] Source terms:
hydrogen-3 (HT) = 73.1 Ci
hydrogen-3 (HTO) = 5.4 Ci
krypton-85 = 13.2 Ci
radon-220 = 0.15 Ci.

TABLE 4.18

Maximum Perimeter and Individual Doses
from Building 212 Air Emissions, 2001
(dose in mrem/yr)

Pathway	Perimeter (800 m N)	Individual (2,400 m SW)
Ingestion	7.4×10^{-4}	2.6×10^{-4}
Inhalation	2.4×10^{-3}	8.5×10^{-4}
Air immersion	4.4×10^{-6}	1.6×10^{-6}
Ground surface	3.8×10^{-8}	1.0×10^{-8}
Total	3.1×10^{-3}	1.1×10^{-3}
Radionuclide		
Hydrogen-3	3.1×10^{-3}	1.1×10^{-3}
Krypton-85	6.5×10^{-6}	2.3×10^{-6}
Radon-220	2.2×10^{-6}	1.7×10^{-8}
Total	3.1×10^{-3}	1.1×10^{-3}

TABLE 4.19

Radiological Airborne Releases from Building 350, 2001

Direction	Distance to Perimeter (m)	Dose[a] (mrem/yr)	Distance to Nearest Resident (m)	Dose[a] (mrem/yr)
N	1,700	3.8×10^{-5}	2,200	2.7×10^{-5}
NNE	1,800	3.7×10^{-5}	3,200	1.6×10^{-5}
NE	2,200	2.4×10^{-5}	3,100	1.5×10^{-5}
ENE	2,000	2.7×10^{-5}	3,100	1.4×10^{-5}
E	1,700	4.3×10^{-5}	2,500	1.9×10^{-5}
ESE	900	7.6×10^{-5}	3,000	1.4×10^{-5}
SE	900	5.2×10^{-5}	3,000	1.2×10^{-5}
SSE	700	1.0×10^{-4}	2,700	1.7×10^{-5}
S	600	3.8×10^{-5}	2,700	8.1×10^{-6}
SSW	400	1.4×10^{-4}	2,500	2.6×10^{-5}
SW	600	1.6×10^{-4}	2,700	3.2×10^{-5}
WSW	800	7.7×10^{-5}	2,100	2.4×10^{-5}
W	900	4.6×10^{-5}	2,200	2.0×10^{-5}
WNW	1,000	3.3×10^{-5}	2,100	1.5×10^{-5}
NW	1,900	1.7×10^{-5}	2,400	1.3×10^{-5}
NNW	1,900	2.3×10^{-5}	2,200	1.9×10^{-5}

[a] Source terms: uranium-234 = 8.8×10^{-8} Ci
uranium-238 = 8.8×10^{-8} Ci
plutonium-239 = 1.8×10^{-6} Ci
plutonium-240 = 2.1×10^{-9} Ci

TABLE 4.20

Maximum Perimeter and Individual Doses
from Building 350 Air Emissions, 2001
(dose in mrem/yr)

Pathway	Perimeter (600 m SW)	Individual (2,700 m SW)
Ingestion	1.8×10^{-6}	3.6×10^{-7}
Inhalation	1.6×10^{-4}	3.2×10^{-5}
Air immersion	2.6×10^{-14}	5.1×10^{-15}
Ground surface	4.8×10^{-9}	9.8×10^{-10}
Total	1.6×10^{-4}	3.2×10^{-5}
Radionuclide		
Uranium-234	2.9×10^{-6}	5.8×10^{-7}
Uranium-238	2.6×10^{-6}	5.2×10^{-7}
Plutonium-239	1.6×10^{-4}	3.1×10^{-5}
Plutonium-240	1.8×10^{-7}	3.6×10^{-8}
Total	1.6×10^{-4}	3.2×10^{-5}

TABLE 4.21

Radiological Airborne Releases from Building 375 (IPNS), 2001

Direction	Distance to Perimeter (m)	Dose[a] (mrem/yr)	Distance to Nearest Resident (m)	Dose[a] (mrem/yr)
N	1,600	6.5×10^{-2}	3,200	1.8×10^{-2}
NNE	1,700	6.9×10^{-2}	3,100	2.0×10^{-2}
NE	1,700	6.1×10^{-2}	2,700	2.3×10^{-2}
ENE	1,500	6.4×10^{-2}	2,500	2.5×10^{-2}
E	600	3.7×10^{-1}	2,500	3.6×10^{-2}
ESE	600	2.9×10^{-1}	2,500	2.5×10^{-2}
SE	600	2.1×10^{-1}	2,500	1.8×10^{-2}
SSE	600	2.9×10^{-1}	3,000	1.7×10^{-2}
S	800	8.4×10^{-2}	3,000	8.8×10^{-3}
SSW	800	2.4×10^{-1}	3,500	1.7×10^{-2}
SW	800	3.2×10^{-1}	4,000	1.7×10^{-2}
WSW	1,500	6.4×10^{-2}	2,700	2.2×10^{-2}
W	2,200	3.6×10^{-2}	2,700	2.3×10^{-2}
WNW	1,500	4.6×10^{-2}	2,600	1.7×10^{-2}
NW	2,200	2.1×10^{-2}	2,500	1.6×10^{-2}
NNW	1,800	3.6×10^{-2}	2,200	2.5×10^{-2}

[a] Source terms: carbon-11 = 1250.0 Ci
argon-41 = 80.9 Ci.

TABLE 4.22

Maximum Perimeter and Individual Doses from
Building 375 (IPNS) Air Emissions, 2001
(dose in mrem/yr)

Pathway	Perimeter (600 m E)	Individual (2,400 m E)
Ingestion	-[a]	-
Inhalation	1.5×10^{-2}	1.4×10^{-3}
Air immersion	3.4×10^{-1}	3.3×10^{-2}
Ground surface	1.2×10^{-2}	1.4×10^{-3}
Total	3.7×10^{-1}	3.6×10^{-2}
Radionuclide		
Carbon-11	3.4×10^{-1}	3.2×10^{-2}
Argon-41	2.8×10^{-2}	3.2×10^{-3}
Total	3.7×10^{-1}	3.6×10^{-2}

[a] A hyphen indicates no exposure by this pathway.

TABLE 4.23

Radiological Airborne Releases from Building 411/415 (APS), 2001

Direction	Distance to Perimeter (m)	Dose[a] (mrem/yr)	Distance to Nearest Resident (m)	Dose[a] (mrem/yr)
N	1,500	3.1×10^{-4}	2,000	1.7×10^{-4}
NNE	1,600	3.0×10^{-4}	2,100	1.7×10^{-4}
NE	2,200	1.3×10^{-4}	3,100	6.3×10^{-5}
ENE	2,500	9.2×10^{-5}	3,300	4.9×10^{-5}
E	1,600	3.2×10^{-4}	3,400	6.3×10^{-5}
ESE	1,500	2.7×10^{-4}	3,500	4.5×10^{-5}
SE	400	2.4×10^{-3}	3,000	4.1×10^{-5}
SSE	400	3.3×10^{-3}	3,000	5.6×10^{-5}
S	350	1.8×10^{-3}	2,500	4.5×10^{-5}
SSW	400	4.3×10^{-3}	2,800	8.5×10^{-5}
SW	550	3.2×10^{-3}	3,000	8.7×10^{-5}
WSW	800	9.5×10^{-4}	1,400	3.2×10^{-4}
W	800	9.4×10^{-4}	1,500	2.8×10^{-4}
WNW	500	1.5×10^{-3}	1,400	2.3×10^{-4}
NW	350	2.3×10^{-3}	1,600	1.5×10^{-4}
NNW	1,500	2.1×10^{-4}	2,000	1.1×10^{-4}

[a] Source terms: carbon-11 = 0.10 Ci (estimated)
nitrogen-13 = 6.56 Ci (estimated)
oxygen-15 = 0.72 Ci (estimated).

TABLE 4.24

Maximum Perimeter and Individual Doses
from Building 411/415 (APS) Air Emissions, 2001
(dose in mrem/yr)

Pathway	Perimeter (400 m SSW)	Individual (1,400 m WSW)
Ingestion	-[a]	-
Inhalation	1.2×10^{-4}	9.4×10^{-6}
Air immersion	4.1×10^{-3}	3.0×10^{-4}
Ground surface	7.1×10^{-5}	6.3×10^{-6}
Total	4.3×10^{-3}	3.2×10^{-4}
Radionuclide		
Carbon-11	6.6×10^{-5}	5.7×10^{-6}
Nitrogen-13	3.9×10^{-3}	3.0×10^{-4}
Oxygen-15	2.7×10^{-4}	9.9×10^{-6}
Total	4.3×10^{-3}	3.2×10^{-4}

[a] A hyphen indicates no exposure by this pathway.

The full-time resident who would receive the largest annual dose (0.037 mrem/yr), if he or she were outdoors during the entire year, is located approximately 2.5 km (1.6 mi) east of the IPNS facility. The major contributor to the whole body dose is the air immersion dose from carbon-11 (0.036 mrem/yr). Releases of radon-220 plus daughters contribute less than one percent of the resident dose. If radon-220 plus daughters were excluded from the calculation, the NESHAP reportable dose to the maximally exposed individual would be 0.036 mrem/yr, essentially all from carbon-11 released by the IPNS.

The individual doses to the maximally exposed member of the public and the maximum fence line dose are shown in Figure 4.5. The decreases in individual and population doses from 1988 to 1999 are due in part to the decrease of radon-220 emissions as a result of the cleanup of the Building 200 M-Wing hot cells. The increase from 1999 to 2001 is principally due to increased emissions from the IPNS.

The population data in Table 1.1 were used to calculate the cumulative population dose from airborne radioactive effluents from ANL-E operations. The results are given in Table 4.25, along with the natural external radiation dose. The natural radiation dose listed is the product of the 80-km (50-mi) population and the natural radiation dose of 300 mrem/yr.[18] It is assumed that this dose is representative of the entire area within an 80-km (50-mi) radius. The population dose resulting from ANL-E operations since 1987 is shown in Figure 4.6.

TABLE 4.25

Population Dose within 80 km, 2001

Radionuclide	Person-rem
Hydrogen-3	0.14
Carbon-11	1.67
Nitrogen-13	<0.01
Oxygen-15	<0.01
Argon-41	0.49
Krypton-85	<0.01
Thallium-208	<0.01
Lead-212	0.08
Bismuth-212	<0.01
Radon-220	<0.01
Uranium-234	<0.01
Uranium-238	<0.01
Plutonium-239	<0.01
Plutonium-240	<0.01
Total	2.41
Natural	2.7×10^6

The potential radiation exposures by the inhalation pathways also were calculated by the methodology specified in DOE Order 5400.5.[9] The total quantity for each radionuclide inhaled, in microcuries (µCi), is calculated by multiplying the annual average air concentrations by the general public breathing rate of 8,400 m^3/yr.[19] This annual intake is then multiplied by the CEDE conversion factor for the appropriate lung retention class.[9] The CEDE conversion factors are in units of rem/µCi and this calculation gives the 50-year CEDE. Table 4.26 lists the applicable CEDE factors.

The calculated doses in Tables 4.1 and 4.2 were derived by using this procedure. Because they are all essentially at perimeter locations, these doses represent the fence-line values for those radionuclides measured. These doses are the same as the off-site measurements and represent the ambient dose for the

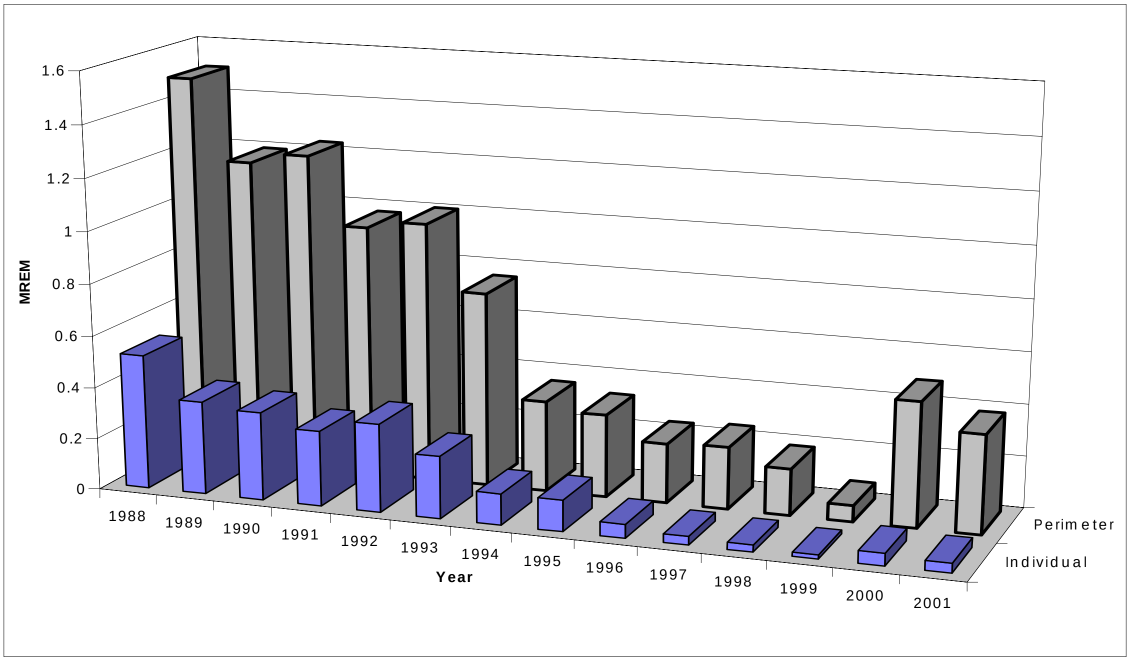


Figure 4.5 Individual and Perimeter Doses from Airborne Radioactive Emissions

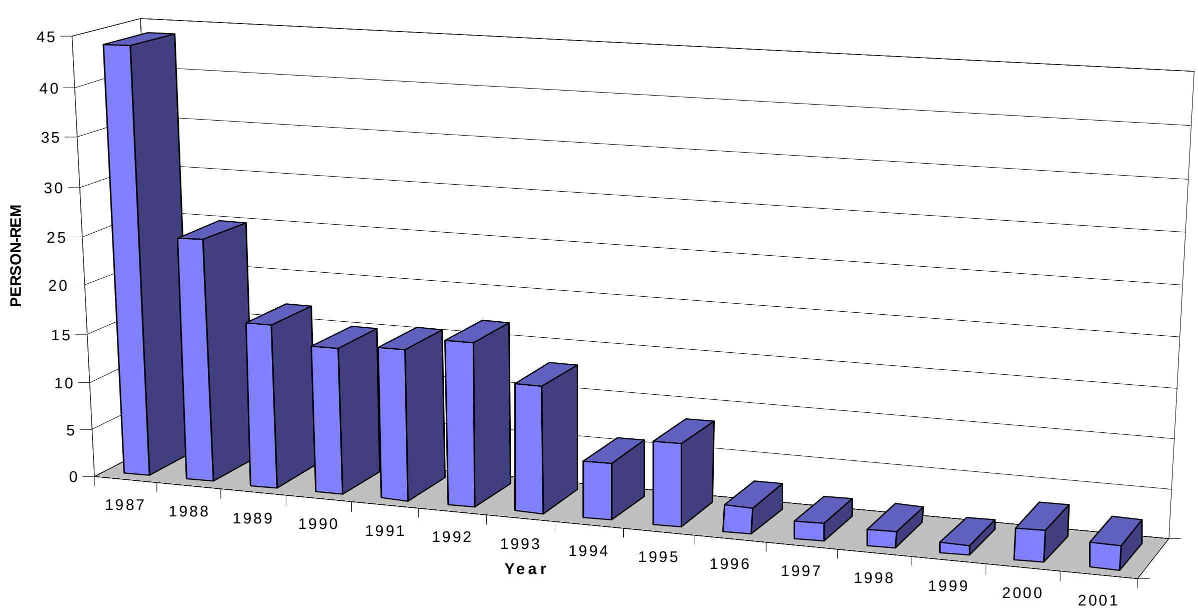


Figure 4.6 Population Dose from Airborne Radioactive Emissions

TABLE 4.26

50-Year Committed Effective Dose Equivalent (CEDE) Conversion Factors (rem/µCi)

Nuclide	Ingestion	Inhalation
Hydrogen-3	6.3×10^{-5}	9.6×10^{-5}
Beryllium-7	-[a]	2.7×10^{-4}
Carbon-11	-	8.0×10^{-6}
Strontium-90	0.13	1.32
Cesium-137	0.05	0.032
Lead-210	-	13.2
Radium-226	1.1	-
Thorium-228	-	310
Thorium-230	-	260
Thorium-232	-	1,100
Uranium-234	0.26	130
Uranium-235	0.25	120
Uranium-238	0.23	120
Neptunium-237	3.90	-
Plutonium-238	3.80	-
Plutonium-239	4.30	330
Americium-241	4.50	-
Curium-242	0.11	-
Curium-244	2.30	-
Californium-249	4.60	-
Californium-252	0.94	-

[a] A hyphen indicates value not required.

area from these nuclides. No doses were calculated for the total alpha and total beta measurements because the guidance does not provide CEDE conversion factors for such measurements.

An evaluation was conducted for potential sensitive receptors of ANL-E airborne releases. One example includes children at the Argonne Child Care Center (Location 120 in Figure 1.1). The airborne dose from ANL-E is estimated to be about 0.07 mrem/yr at this location. This assumes full-time, outdoor exposure. Assuming that the children are present about eight hours per day, five days per week, the actual dose is closer to 0.02 mrem/yr. Additional potential sensitive receptors are located at the Darien school on 91st St., west of Rt. 83. The estimated full-time, outdoor dose at this location is about 0.01 mrem/yr. Again, assuming that the children are only present at this location six hours per day, five days per week, and for 35 weeks a year, the actual dose is closer to 0.001 mrem/yr.

4.6.2. Water Pathway

Following the methodology outlined in DOE Order 5400.5,[9] the annual intake of radionuclides (in µCi) ingested with water is obtained by multiplying the concentration of radionuclides in microcuries per milliliter (µCi/mL) by the average annual water consumption of a member of the general public (7.3×10^5 mL). This annual intake is then multiplied by the CEDE conversion factor for ingestion (Table 4.26) to obtain the dose received in that year. This procedure was carried out for all radionuclides, and the individual results were summed to obtain the total ingestion dose.

The only significant location where radionuclides attributable to ANL-E operations could be found in off-site water was Sawmill Creek below the wastewater outfall (see Table 4.7). Although this water is not used for drinking purposes, the 50-year effective dose equivalent was calculated for a hypothetical individual ingesting water at the radionuclide concentrations measured at that location. Those radionuclides added to Sawmill Creek by ANL-E wastewater, their net concentrations in the creek, and the corresponding dose rates (if water at these concentrations was used as the sole water supply by an individual) are given in Table 4.27. The dose rates were all well below the standards for the general population. It should be emphasized that Sawmill Creek is not used for drinking, swimming, or boating. Inspection of the area shows that there are fish in the stream; however, they do not constitute a significant source of food for any individual. Figure 4.7 is a plot showing the estimated dose a hypothetical individual would receive if ingesting Sawmill Creek water since 1986.

As indicated in Table 4.7, occasional Sawmill Creek samples (fewer than 10%) contained traces of cesium-137, plutonium-238, curium-242 and 244, or californium-249 and 252; however, the averages were only slightly greater than the detection limit. The annual dose to an individual consuming water at these concentrations can be calculated with the same method used for those radionuclides more commonly found in creek water; this method of averaging, however, probably overestimates the true concentration. Annual doses range from 3×10^{-4} to 6×10^{-6} mrem/yr for these radionuclides.

DOE Order 5400.5[9] requires an evaluation of the dose to aquatic organisms from liquid effluents. The dose limit is 1 rad/day or 365 rad/yr. The location that could result in the highest dose to aquatic organisms is in Sawmill Creek downstream of the point where ANL-E discharges its treated wastewater. Inspection of the creek at this location indicates the presence of small bluegill and carp (about 100 g [4 oz] each). The aquatic dose assessment of these species was conducted using the DOE Technical Standard, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota." The assessment used the general screening approach, which compares maximum water and sediment radionuclide concentrations with biota concentration guides (BCGs).

TABLE 4.27

Radionuclide Concentrations and Dose Estimates for Sawmill Creek Water, 2001

Radionuclide	Total Released (Ci)	Net Avg. Concentration (pCi/L)	Dose (mrem)
Hydrogen-3	0.10	26	0.0012
Strontium-90	0.0006	0.16	0.0152
Plutonium-239	<0.0001	<0.0001	<0.0003
Americium-241	<0.0001	<0.0001	<0.0003
Total	0.10		0.016

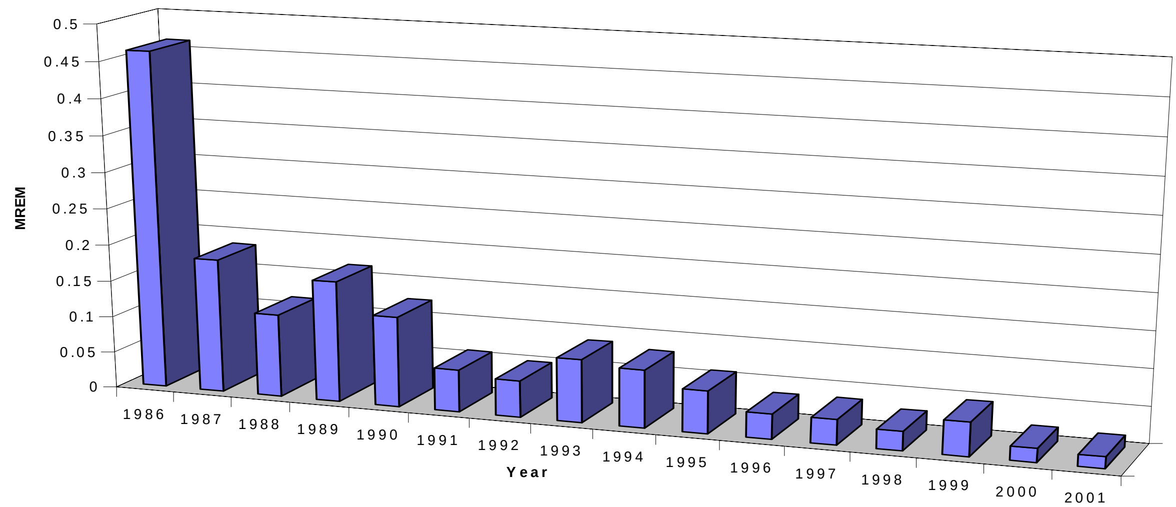


Figure 4.7 Comparison of Dose Estimate from Ingestion of Sawmill Creek Water

Maximum water concentrations for hydrogen-3, strontium-90, plutonium-239, and americium-241 were obtained from Table 4.7, while maximum sediment concentrations for cesium-137, plutonium-239, and americium-241 were obtained from Table 4.10. Summing the ratios of their respective BCGs for each radionuclide resulted in a dose estimate of 0.0041 rad/yr to aquatic biota. This is well below the 365 rad/yr limit in DOE Order 5400.5 and demonstrates compliance with the limit.

Sawmill Creek flows into the Des Plaines River. The flow rate of Sawmill Creek (see Section 1.6) is about 0.28 m^3/s (10 ft^3/s); the flow rate of the Des Plaines River in the vicinity of ANL-E is about 25 m^3/s (900 ft^3/s). Applying this ratio to the concentration of radionuclides in Sawmill Creek listed in Table 4.27, the dose to a hypothetical individual ingesting water from the Des Plaines River at Lemont would be about 0.0002 mrem/yr. Significant additional dilution occurs further downstream. Very few people, either directly or indirectly, use the Des Plaines River as a source of drinking water. If 100 people used Des Plaines River water at the hypothetical concentration at Lemont, the estimated population dose would be about 10^{-5} person-rem.

4.6.3. External Direct Radiation Pathway

The TLD measurements given in Section 4.5 were used to calculate the radiation dose from external sources. Above-background doses attributable to ANL-E operations were found at the southern boundary near the Waste Storage Facility (Location 7I).

At Location 7I, the fence-line dose from ANL-E was 128 ± 20 mrem/yr. Approximately 300 m (960 ft) south of the fence line (grid 6I), the measured dose was 114 ± 18 rem/yr, slightly higher than the off-site average (103 ± 6 mrem/yr). No individuals live in this area. The closest residents are about 1.6 km (1 mi) south of the fence line. At this distance, the calculated dose rate from the Waste Storage Facility would be 0.001 mrem/yr, if the energy of the radiation were that of a 0.66-MeV cesium-137 gamma ray, and approximately 0.003 mrem/yr, if the energy were that of a 1.33-MeV cobalt-60 gamma ray.

At the fence line, where higher doses were measured, the land is wooded and unoccupied. All of these dose calculations are based on full-time, outdoor exposure. Actual exposures to individuals would be substantially less because some of the individuals are indoors (which provides shielding) or away from their dwellings for part of the time. In addition to the permanent resident in the area, occasionally visitors may conduct activities around ANL-E that could result in exposure to radiation from this site. Examples of these activities could be cross-country skiing, horseback riding, or running in the fire lane next to the perimeter fence. If the individual spent 10 minutes per week adjacent to the 317 Area, the dose would be 0.002 mrem/yr at the 317 Area fence (Location 7I) from ANL-E operations.

4.6.4. Dose Summary

The total effective dose equivalent received by off-site residents during 2001 was a combination of the individual doses received through the separate pathways. Radionuclides that contributed through the air pathway are hydrogen-3, carbon-11, nitrogen-13, oxygen-15, argon-41, krypton-85, radon-220 (plus daughters), and actinides. The highest dose was approximately 0.037 mrem/yr to individuals living east of the site if they were outdoors at that location during the entire year. The total annual population dose to the entire area within an 80-km (50-mi) radius was 2.41 person-rem. The dose pathways are presented in Table 4.28 and are compared with the applicable standards.

To receive the maximum public dose, a hypothetical individual would need to live at the point of maximum air and direct radiation exposure and use only water from Sawmill Creek below the ANL-E wastewater discharge. This is a very conservative and unlikely situation. To put the maximum individual dose of 0.063 mrem/yr attributable to ANL-E operations into perspective, comparisons can be made with annual average doses from natural or accepted sources of radiation received by an average American who could be living anywhere in the United States. These values are listed in Table 4.29. These site related doses are in addition to the background doses. The magnitude of the doses received from ANL-E operations is insignificant compared with these sources. Therefore, the monitoring program results establish that the radioactive emissions from ANL-E are very low and do not endanger the health or safety of those living in the vicinity of the site.

TABLE 4.28

Summary of the Estimated Dose to a Hypothetical Individual, 2001 (mrem/yr)

Pathway	ANL-E Estimate	Applicable Standard
Air total	0.037	None
Water	0.016	4 (EPA)[a]
Direct radiation	0.010	25 (NRC)
Maximum dose	0.063	100 (DOE)

[a] The 4-mrem/yr EPA value is not an applicable standard since it applies to community water systems.[20] It is used here for illustrative purposes.

TABLE 4.29

Annual Average Dose Equivalent
in the U.S. Population[a]

Source	Dose (mrem)
Natural	
Radon	200
Internal (potassium-40 and radium-226)	39
Cosmic	28
Terrestrial	28
Medical	
Diagnostic X-rays	39
Nuclear medicine	14
Consumer Products	
Domestic water supplies, building materials, etc.	10
Occupational (medical radiology, industrial radiography, research, etc.)	1
Nuclear fuel cycle	<1
Fallout	<1
Other miscellaneous sources	<1
Total	360

[a] National Council on Radiation Protection and Measurements Report No. 93.[18]

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

The nonradiological monitoring program primarily involves the collection and analysis of surface water and groundwater samples from numerous locations throughout the site. Chapter 3 provides a detailed discussion of the environmental monitoring program. The amount of nonradiological pollutants released to the air from ANL-E is extremely small, except for the conventional air pollutants emitted from the boiler house while burning coal. This unit is equipped with dedicated monitoring equipment for sulfur dioxide and opacity while burning coal. Three opacity exceedances were noted during 2001 over a period of 2,597 hours of coal-burning operation of Boiler No. 5, the coal-burning boiler (see Section 2.1.2). No other air monitoring for nonradiological pollutants is performed.

Surface water samples for nonradiological chemical analyses are collected from NPDES-permitted outfalls and Sawmill Creek.[21] Analyses conducted on the samples from the NPDES outfalls vary, depending on the permit-mandated monitoring requirements for each outfall. The results of the analyses are compared with the permit limits for each outfall to determine whether they comply with the permit. In addition to being published in this report, the NPDES monitoring results are transmitted monthly to the IEPA in an official DMR.

In addition to the permit-required monitoring, other analyses are conducted on samples collected from the combined wastewater outfall (NPDES Outfall 001) to provide a more complete evaluation of the impact of the wastewater on the environment. Water samples from Sawmill Creek are also collected and analyzed for a number of inorganic constituents. The results of these additional analyses of the main outfall and receiving streams are then compared with IEPA General Effluent Standards and Stream Quality Standards listed in IAC, Title 35, Subtitle C, Chapter I.[22]

5.1. National Pollutant Discharge Elimination System Monitoring Results

5.1.1. Influent Monitoring

Since 1989, analyses of the laboratory wastewater influent have shown the presence of a variety of VOCs with variable concentrations. Although disposing of waste chemicals to the drain is not authorized, residual VOCs are released to the laboratory sewer from laboratory-related activities such as rinsing glassware. Also, VOCs are known to be discharged into the laboratory sewer from the 317/319 Lift Station, which pumps contaminated groundwater generated by ANL-E's RCRA corrective actions. The results of the analysis of laboratory wastewater influent are shown in Table 5.1.

TABLE 5.1

Laboratory Influent Wastewater, 2001
(concentrations in μg/L)

Month	Acetone	Chloroform	Bromodi-chloroethane	Dibromo-chloromethane	Bromoform
January	<1	1	1	1	<1
February	166	2	2	<1	<1
March	114	1	<1	<1	<1
April	11	2	3	5	3
May	2	2	1	1	2
June	19	2	2	2	2
July	34	1	2	3	3
August	7	2	2	2	<1
September	3	1	1	3	7
October	15	5	4	7	5
November	7	19	5	6	2
December	5	3	2	2	1
Average	35	3	2	3	3

The 2001 results for laboratory influent wastewater are quite similar to those from 1997 to 2000. Table 5.1 gives the 2001 results for the most common compounds detected. Bromoform, bromodichloromethane, chloroform, and dibromochloromethane are halomethanes that are produced as the result of contact of the chlorinated water supply with organic chemicals. Research activity may account for the presence of other volatiles.

As in 1999 and 2000, acetone was detected in 11 samples and levels ranged up to 166 μg/L, which is higher than the 2000 maximum value of 98 μg/L, and the yearly average was higher than the 1999 and 2000 averages (Figure 5.1). Infrequent trace levels of other chemicals, that is, 2-butanone, acetaldehyde, ethanol, and 2-methylpropanol, were also noted but not shown in Table 5.1. Overall, the number and levels of chemicals were less than those noted in previous years.

Figures 5.1 and 5.2 present comparisons of the 1992 through 2001 laboratory influent wastewater results for the two more common VOCs, that is, acetone and chloroform. The presence of acetone is likely due to laboratory activities such as rinsing glassware. Disposing of hazardous chemicals down laboratory drains is not authorized at ANL-E. ANL-E conducts a waste generator education program as part of its site safety awareness training program, in which proper handling and disposal of chemicals are explained. However, normal use of certain chemicals, such as acetone,

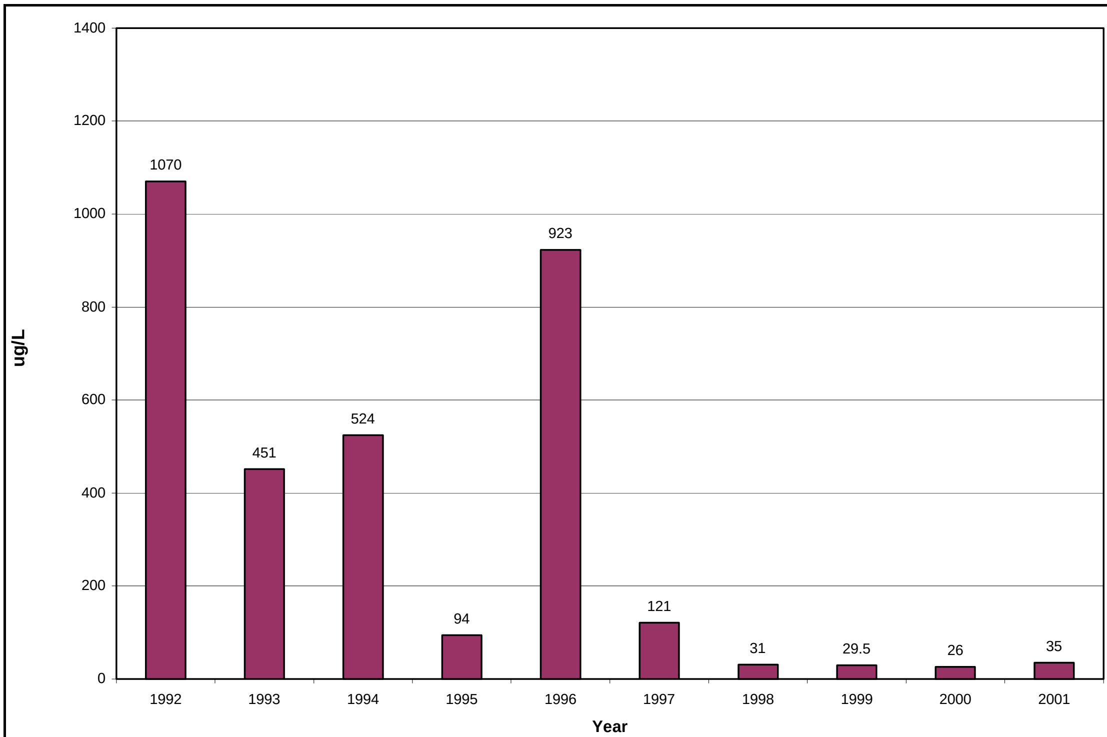


Figure 5.1 Average Acetone Levels in Laboratory Influent Wastewater, 1992 to 2001

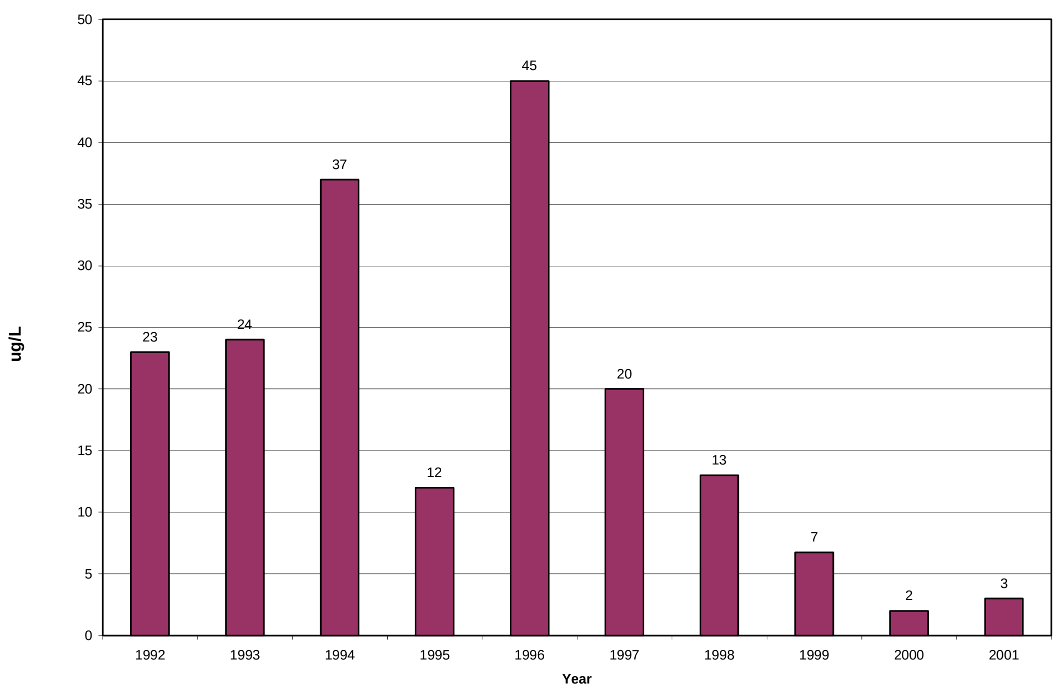


Figure 5.2 Average Chloroform Levels in Laboratory Influent Wastewater, 1992 to 2001

often results in the discharge of small amounts into the sewer. Although acetone levels were slightly elevated compared with 1999 and 2000, the decrease in influent concentrations of acetone and chloroform over the past several years shows the effectiveness of educational efforts related to waste disposal and pollution prevention.

5.1.2. Effluent Monitoring

Section 2.2 of Chapter 2 describes the outfalls on the ANL-E site. Table 2.5 contains a complete list of all the outfalls. In general, the outfalls fall into two groups: those that have some type of process wastewater discharge and those that contain only storm water runoff following a rain event. The sampling requirements of the process wastewater outfalls depend on the nature of the activity generating the wastewater. This section discusses those requirements and the results of the monitoring. The storm water outfalls are listed in the permit, but they do not require routine monitoring of the discharges.

Effluent samples are collected from ANL-E point-source discharges (outfalls) as specified by the NPDES permit. The permit specifies the frequency of sample collection and the specific parameters to be monitored for each individual outfall. Sample collection, preservation, holding times, and analytical methods are specified by the EPA as codified in 40 CFR Part 136, Tables 1B and 2.[23]

The NPDES outfall locations are shown in Figure 5.3. Outfalls 001A and 001B, the two internal monitoring points representing the effluent from the sanitary system and laboratory system, respectively, are both located at the WTP. Their flows combine to form Outfall 001, which also is located at the treatment facility. The combined stream flows through an outfall pipe that discharges into Sawmill Creek approximately 1,100 m (3,500 ft) south of the treatment plant.

In addition to the main wastewater outfalls, a small amount of process wastewater, primarily cooling tower blowdown and cooling water, is discharged directly to a number of small streams and ditches throughout the site. This wastewater does not contain significant amounts of contaminants and does not require treatment before discharge. These discharge points are included in the site NPDES permit as separate regulated outfalls.

5.1.2.1. Sample Collection

All samples are collected in specially cleaned and labeled bottles with appropriate preservatives added. Custody seals and chain of custody sheets also are used. All samples are analyzed within the required holding time. Samples are collected at locations 001A, 001B, and 001

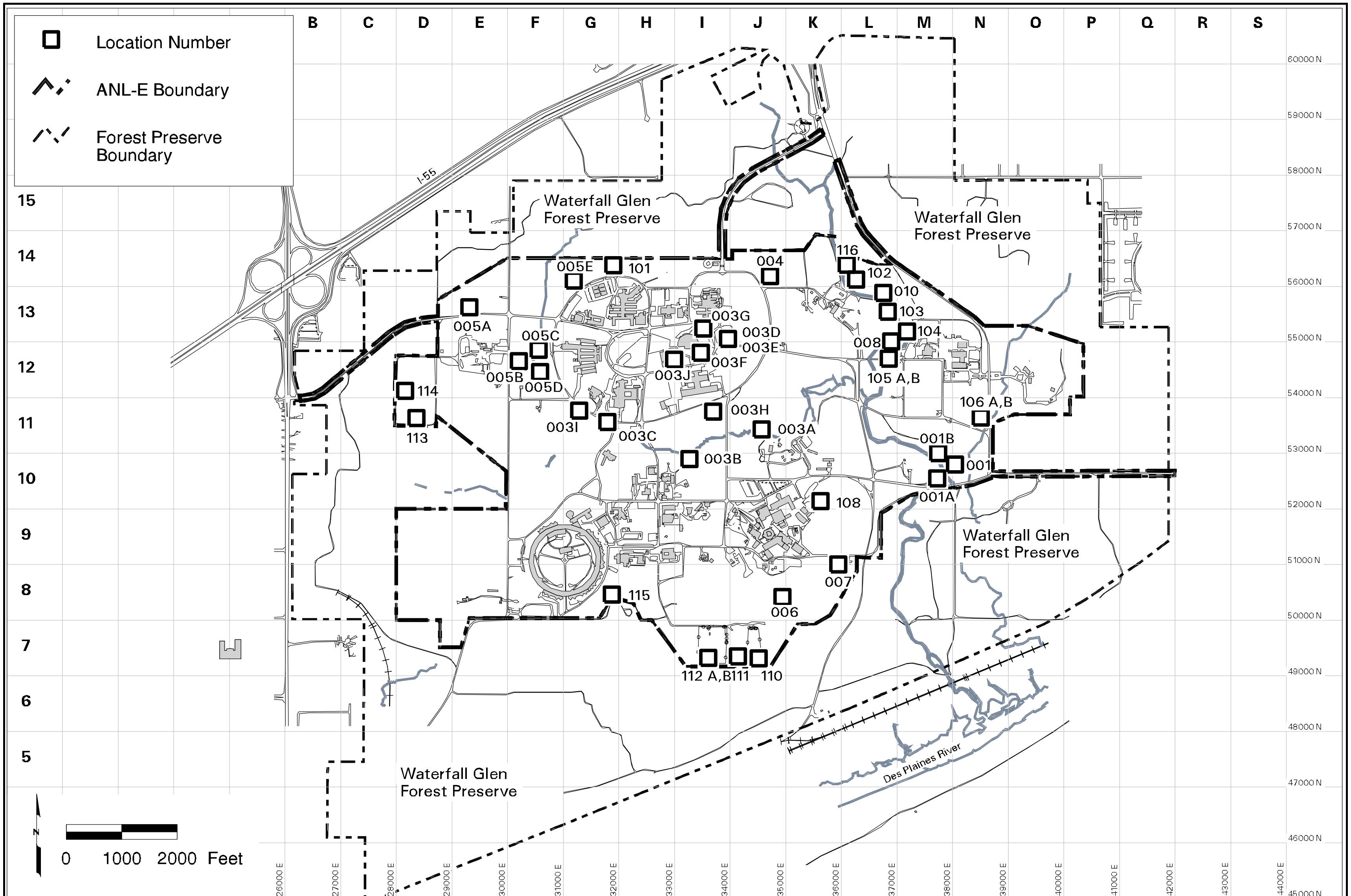


Figure 5.3 NPDES Outfall Locations

on a weekly basis, consistent with permit requirements. Similarly, samples are collected at the other locations in accordance with the NPDES permit.

5.1.2.2. Sample Analyses - NPDES

NPDES sample analyses were performed in accordance with standard operating procedures (SOPs) that were issued as controlled documents. These SOPs cite protocols that can be found in 40 CFR Part 136, "Test Procedures for the Analysis of Pollutants Under the Clean Water Act."[23] Six metal analyses were performed by using flame atomic absorption spectroscopy. Mercury was determined by cold vapor atomic absorption spectroscopy. Hexavalent chromium determination and chemical oxygen demand (COD) were performed by using a colorimetric technique. Five-day biochemical oxygen demand (BOD_5) was determined by using a dissolved oxygen probe. TSS, TDS, and oils and grease were determined gravimetrically. Sulfate determination was performed by using a turbidimetric technique; chloride was determined by titrimetry. Ammonia nitrogen was determined by distillation, followed by an ion-selective electrode measurement. VOC concentrations were determined by using a purge and trap sample pretreatment, followed by gas chromatography-mass spectroscopy detection. The PCB Aroclor-1260 concentrations were determined by solvent extraction, followed by gas chromatography-electron capture detection. Beta radioactivity was performed by using a gas flow proportional counting technique. Hydrogen-3 concentrations were determined by distillation, followed by a beta liquid scintillation counting technique.

NPDES Outfall 001B is sampled and analyzed semiannually for priority pollutant compounds. VOCs were determined by using a purge and trap sample pretreatment, followed by gas chromatography-mass spectroscopy detection. Semivolatile organic compounds (SVOCs) were determined by solvent extraction, followed by gas chromatography-mass spectroscopy detection. PCBs and pesticides were determined by solvent extraction, followed by gas chromatography-electron capture detection. Thirteen metals were determined by graphite furnace atomic absorption and flame atomic absorption spectroscopy. Cyanide and phenol were determined by distillation, followed by a spectrophotometric measurement.

NPDES Outfall 001 is sampled and analyzed annually during June for acute aquatic toxicity parameters. NPDES Outfalls 003H, 003I, 003J, 004, 006, and 115 are tested in July and August for acute aquatic toxicity. An off-site contract laboratory performs both the sample collection and analyses. The testing is performed by diluting a series of ANL-E effluent samples with Sawmill Creek receiving water, into which species of fish and invertebrates are introduced. Survival is measured over two to four days, and statistically significant mortality is reported as a function of effluent concentration.

5.1.2.3. Results

During 2001, approximately 99% of all NPDES analyses were in compliance with their applicable permit limits, as compared with 1991 through 2001, when rates ranged from 96 to 99%. Specific limit exceedances are discussed later in this section, as well as in Chapter 2. A discussion of the analytical results for each outfall follows.

5.1.2.4. Wastewater Treatment Facility Outfalls

Outfall 001A. This outfall consists of treated sanitary wastewater. Until fall of 2001, it also consisted of various wastewater streams from the boiler house area, including coal pile storm water runoff. These wastewater streams are now directed to the DuPage County system. The effectiveness of the sanitary wastewater treatment systems is evaluated by weekly monitoring for BOD_5, pH, and TSS. The limits for BOD_5 are a monthly average of 10 mg/L and a maximum value of 20 mg/L. The permit limits for TSS are a maximum concentration of 24 mg/L and a monthly average of 12 mg/L. The pH must range between values of 6 and 9. All samples collected and analyzed for these parameters during 2001 were within the permit limits.

The permit requires weekly monitoring for total chromium, copper, iron, lead, manganese, zinc, and oil and grease. Table 5.2 gives the effluent limits for these parameters and monitoring results. Two limits are listed; one is a maximum limit for any single sample, and the other is for the average of all samples collected during the month. The constituents in Table 5.2 are present in the

TABLE 5.2

Outfall 001A Effluent Limits and Monitoring Results, 2001
(concentrations in mg/L)

Constituent	Minimum	Average	Average Limit	Maximum	Maximum Limit
Chromium	-[a]	<0.015	1.0	<0.015	2.0
Copper	<0.010	0.020	0.50	0.027	1.0
Iron	0.061	0.105	2.0	0.167	4.0
Lead	-	<0.10	0.20	<0.10	0.40
Manganese	<0.015	<0.017	1.0	0.023	2.0
Zinc	0.064	0.098	1.0	0.143	2.0
Oil and grease	-	<5.0	15.0	<5.0	30.0

[a] A hyphen indicates no minimum values.

coal pile runoff that may have discharged to the sanitary sewage system prior to fall 2001. No limits were exceeded during 2001.

Outfall 001B. This outfall consists of processed wastewater from the laboratory wastewater system. The permit requires that weekly samples be collected and analyzed for BOD_5, TSS, mercury, pH, and COD.

The limits established for BOD_5 are a daily maximum of 20 mg/L and a 30-day average of 10 mg/L. The permit also contains BOD_5 mass loading limits of 52 kg/day (114 lb/day) as a daily maximum and 26 kg/day (57 lb/day) as a 30-day average. The mass loading represents the weight of material discharged per day and is a function of concentration and flow. The daily maximum concentration limit for TSS is 24 mg/L; the 30-day average is 12 mg/L. The TSS mass loading limits are 62 maximum and 31 average kg/day (136 and 68 lb/day), respectively. No exceedances of the TSS or BOD_5 mass loading and concentration limits were noted in 2001.

The daily maximum concentration limit for mercury is 6 µg/L; the 30-day average is 3 µg/L. The corresponding loading values are 0.02 kg/day (0.034 lb/day) and 0.01 kg/day (0.017 lb/day). No exceedances of the mercury loading and concentration limits were noted during 2001. The values obtained in 2001 ranged from less than 0.0001 mg/L to 0.0004 mg/L.

No concentration limits have been established for COD. The once-per-week grab samples give a rough indication of the organic and inorganic oxygen-consuming contents of this effluent stream. The values obtained in 2001 ranged from less than 10 to 31 mg/L.

A special condition at location 001B requires monitoring for the 124 priority pollutants listed in the permit during the months of June and December. The June sampling is to be conducted at the same time that aquatic toxicity testing of Outfall 001 is conducted. Samples were collected on June 19, 2001, and December 4, 2001, and analyzed within the required holding times.

Analysis of these samples indicated that very small amounts of a few chemicals were present. The results for SVOCs, PCBs, and pesticides were all less than the detection limits. The results for metals were similar to concentrations historically found in ANL-E–treated drinking water. Mercury was detected at a very low level in December (0.0002 mg/L), and phenols was detected at a low level in June (0.022 mg/L). The samples contained some VOCs at very low levels. The majority of compounds detected were halomethanes, which are found in chlorinated drinking water. Table 5.3 lists the concentrations of volatile organics identified in these samples. Currently, no permit limits or effluent standards are available for these compounds for comparison with these results.

Outfall 001. After the treatment processes, the effluents from both the laboratory and sanitary WTP are combined to form one point-source discharge. The combined effluent flows through a 1,100-m (3,500-ft) outfall pipe where it is eventually discharged into Sawmill Creek.

Samples of the combined effluent are collected weekly or monthly as grab samples or 24-hour composite samples as specified in the NPDES permit. The samples are analyzed for a variety of metals, ammonia nitrogen, chlorides, sulfates, TDS, pH, and beta radioactivity. The permit requires analysis of the combined effluent once a week for TDS, chloride, and sulfate. Table 5.4 gives the results, limits, and number of exceedances.

TABLE 5.3

Outfall 001B Effluent Priority Pollutant Monitoring Results, 2001
(concentrations in μg/L)

Compound	Concentration in June Sample	Concentration in December Sample
Bromodichloromethane	1	1
Bromoform	2	1
Chloroform	1	2
Dibromochloromethane	1	2

Two exceedances of the TDS limit were noted during January 2001. Four exceedances of the TDS limit were noted in February 2001, and one TDS exceedance occurred during March 2001. Elevated TDS levels occurred only during the 2001 heating season. They are believed to be related to the combination of reduced flows, increases in TDS concentrations from discharges from boiler blowdown, road salt, and cooling tower blowdown. For the past several years, chemical analysis for chloride has indicated a close relationship between TDS levels and chloride levels. Figure 5.4 shows the results of TDS and chloride analyses for 1995 through 2001. Elevated TDS levels prior to 1997 are attributed to high TDS levels (800 ppm) in ANL-E's domestic source water (i.e., groundwater, at that time).

TABLE 5.4

Outfall 001 Monitoring Results and Effluent Limits, 2001
(concentrations in mg/L)

Constituent	Minimum	Average	Maximum	Limit	Exceedances
Chloride	102	236	456	500	0
Copper	<0.010	0.016	0.022	0.051	0
TDS	508	725	1,203	1,000	7
Ammonia nitrogen	<0.4	<0.7	1.0	10.0 (November–March) 3.0 (April–October)	0

In 1997, Lake Michigan water, which is characterized by low TDS levels (200 to 400 ppm), became ANL-E's domestic source water. Figure 5.5 shows weekly TDS levels at Outfall 001; Figure 5.6 shows that average TDS levels at Outfall 001 have substantially decreased since the introduction of Lake Michigan water.

Copper levels have decreased since 1997. The changeover in the domestic water supply from groundwater to Lake Michigan water during 1997 appears to have played a role in reducing the amount of copper in the wastewater. Lake Michigan water causes less corrosion of domestic water distribution copper piping than the previously used groundwater source. The addition of this water source, combined with the proper balance of chemical treatment additives, has reduced copper concentrations in the discharge to below permit limits. Figure 5.7 shows the 1996 through 2001 monthly average copper levels at Outfall 001. No copper exceedances occurred during 2001.

The upgrade of the sanitary WTP, completed in 1996, has enhanced the treatment of ammonia nitrogen. Figure 5.8 shows a decrease in the monthly average ammonia nitrogen levels prior to and after the sanitary WTP upgrade. Improved mechanical operation of the trickling filters results in a more even dispersion of the wastewater. Also, dome covers on the trickling filters allow the trickling filters to hold a more constant temperature and aerobic conditions by providing a greater flow of air across the filter area. No ammonia nitrogen exceedances occurred during 2001.

The permit requires that a biological toxicity screening test be performed on wastewater from Outfall 001 in June of each year. The toxicity testing is run on two trophic levels of aquatic species for acute toxicity. The 2001 testing was conducted on samples collected June 18 through 22; the water flea (*Ceriodaphnia dubia*) and fathead minnow (*Pimephales promelas*) were used.

No toxicity was observed to the fathead minnow or to the water flea. The concentration of wastewater that produces 50% mortality in the test population (i.e., the LC_{50}) for both species is greater than 100%; that is, the pure, undiluted effluent is not toxic to these species. Table 5.5 summarizes the results of the toxicity tests for 2001. Table 5.6 summarizes the test results from 1991 to 2001.

The permit also requires that weekly pH, ammonia nitrogen, dissolved iron, manganese, and zinc measurements be made. Monthly monitoring for lead, hexavalent and trivalent chromium, and beta radioactivity is required. No exceedances of these parameters were noted in 2001. In addition to the outfalls at the WTP, a number of other outfalls are monitored. The sampling requirements and effluent limits for these outfalls are described in Table 5.7.

Special Condition No. 9 of the NPDES permit requires acute toxicity testing of the effluent from Outfalls 003H, 003I, 003J, 004, 006, and 115. The testing is performed on the fathead minnow

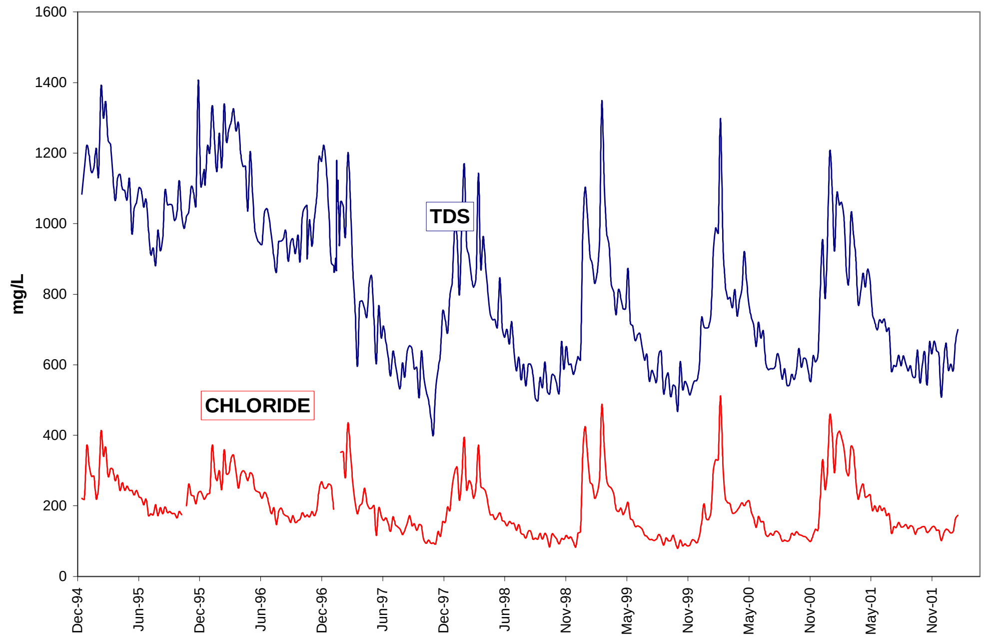


Figure 5.4 Total Dissolved Solids and Chloride in Outfall 001 Water, 1995 to 2001

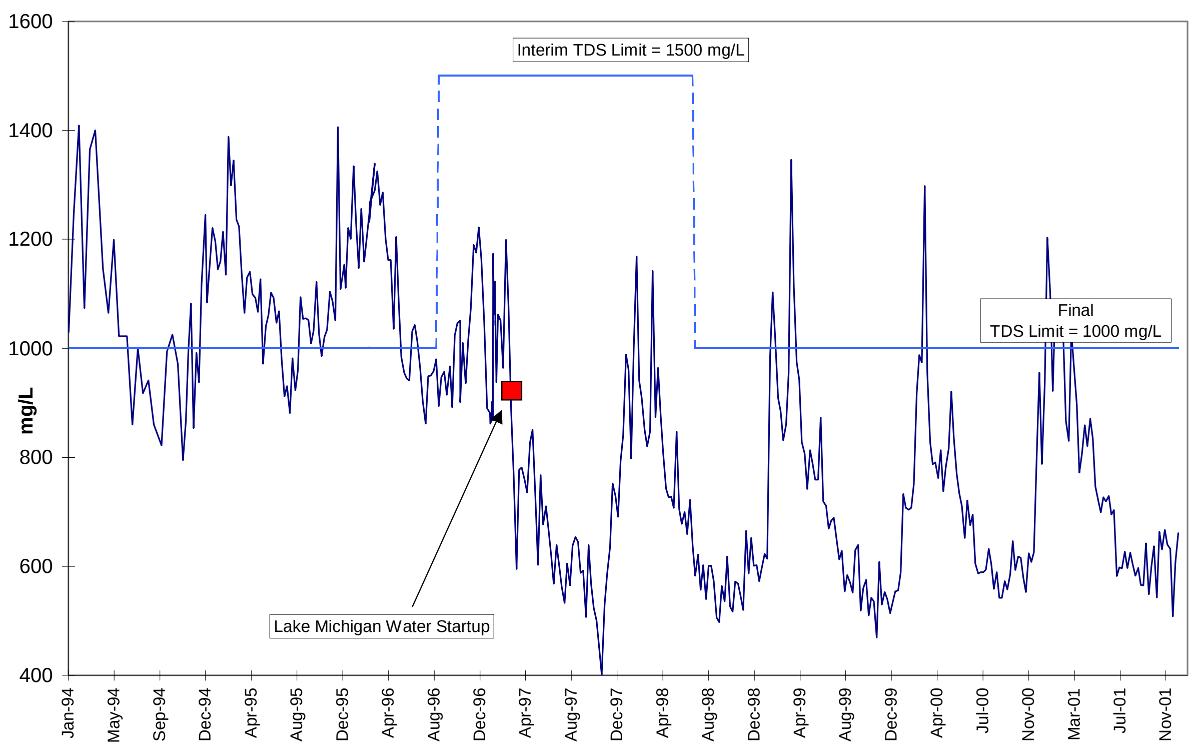


Figure 5.5 Total Dissolved Solids in NPDES Outfall 001

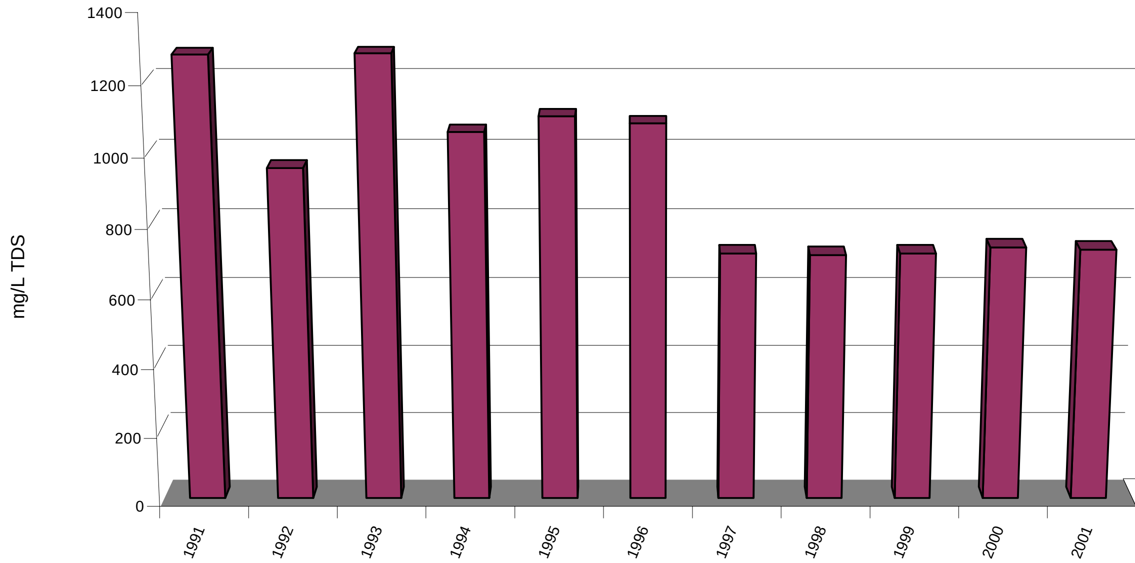


Figure 5.6 Average TDS Concentrations at NPDES Outfall 001, 1991 to 2001

and the water flea. The testing is performed during the months of July and August. These outfalls were sampled during the periods of July 30 to August 3 and August 27 to 31, 2001. The results are summarized in Tables 5.8 and 5.9. The results are discussed by month below.

July 2001 — Effluents from Outfalls 003H and 004 exhibited no acute toxicity. Outfall 003J was acutely toxic toward both the fathead minnow and the water flea. The toxicant at Outfall 003J appeared to be residual chlorine, on the basis of measured concentrations of 2.2 mg/L. Outfalls 003I, 006, and 115 were toxic toward the water flea but not fathead minnows. The toxicants at Outfalls 003I, 006, and 115 were unidentified.

August 2001 — Effluents from Outfalls 003H, 003I, 003J, 004, and 115 were not acutely toxic toward the water flea and fathead minnows. Outfall 006 was toxic to the water flea within a 48-hour LC_{50} of 59.6%. The toxicants were unidentified.

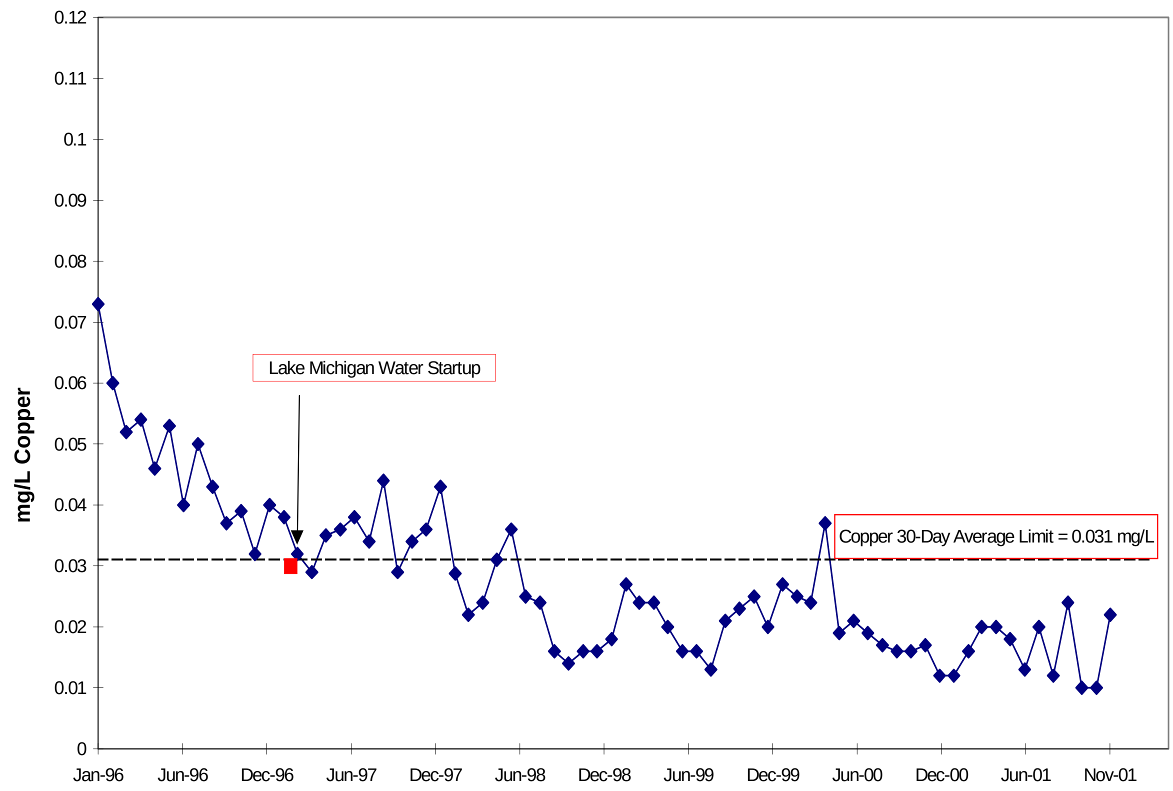


Figure 5.7 NPDES Outfall 001 30-Day Average Copper Results, 1996 to 2001

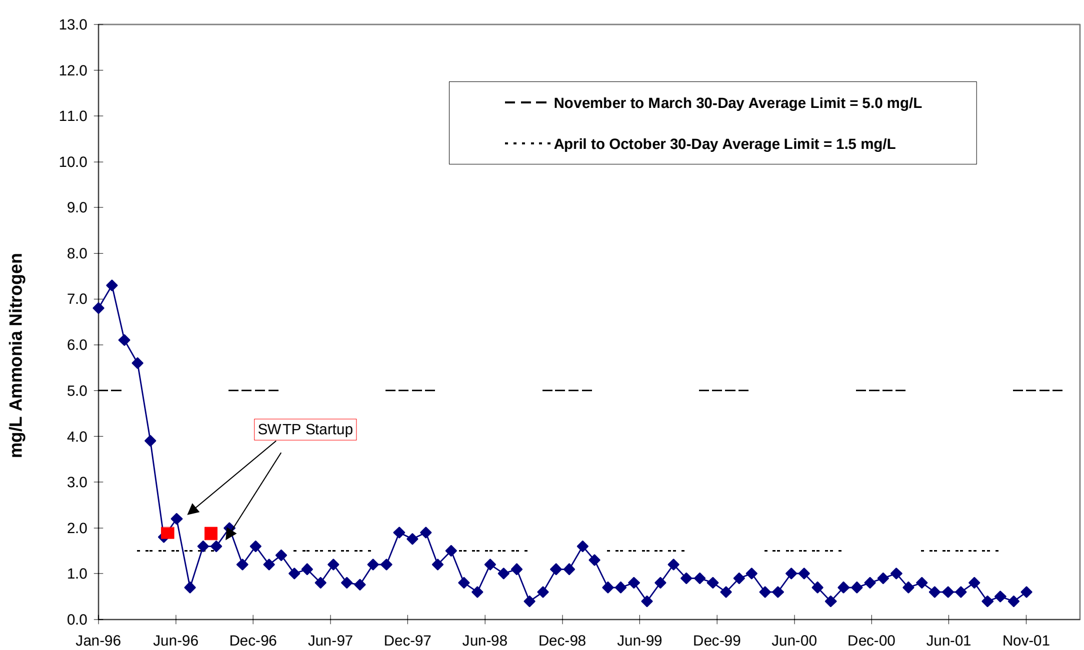


Figure 5.8 NPDES Outfall 001 30-Day Average Ammonia-Nitrogen Results, 1996 to 2001

TABLE 5.5

Outfall 001 Aquatic Toxicity Test Results, 2001

Test	End Point	96/48-Hour LC_{50} (%)
96-hour fathead minnow acute toxicity	Survival	>100.0
48-hour water flea acute toxicity	Survival	>100.0

TABLE 5.6

Outfall 001 Aquatic Toxicity Test Results, 1991 to 2001

Test	1991 (%)	1992 (%)	1993 (%)	1994 (%)	1995 (%)	1996 (%)	1997 (%)	1998 (%)	1999 (%)	2000 (%)	2001 (%)
Minnow, acute, LC_{50}	61.6	<6.2	100.0	100.0	>100	>100	>100	>100	>100	>100	>100
Water flea, acute, LC_{50}	17.1	35.4	100.0	100.0	>100	>100	>100	>100	>100	>100	>100
Minnow, chronic, survival, NOEC[a]	50.0	100.0	50.0	100.0	-[b]	-	-	-	-	-	-
Minnow, chronic, survival, LOEC[c]	100.0	100.0	100.0	100.0	-	-	-	-	-	-	-
Minnow, chronic, growth, NOEC	50.0	100.0	50.0	100.0	-	-	-	-	-	-	-
Water flea, chronic, survival, NOEC	50.0	50.0	50.0	100.0	-	-	-	-	-	-	-
Water flea, chronic, survival, LOEC	100.0	100.0	100.0	100.0	-	-	-	-	-	-	-
Water flea, chronic, reproduction, NOEC	50.0	50.0	25.0	100.0	-	-	-	-	-	-	-
Algal growth, LOEC	6.2	6.2	100.0	100.0	-	-	-	-	-	-	-
Algal growth, NOEC	3.1	<6.25	100.0	100.0	-	-	-	-	-	-	-

[a] NOEC = no observable effect concentration; the highest concentration of the effluent at which no adverse effect is observed.

[b] A hyphen indicates that no analysis was performed because of a change in the permit.

[c] LOEC = lowest observable effect concentration; the lowest concentration of the effluent at which an adverse effect is observed.

TABLE 5.7

Summary of Monitored NPDES Outfalls, 2001

Discharge Location	No. of Samples	Permit Constituent	Limit 30-Day Average	Limit Daily Maximum	No. Exceeding Limit
003A	0	Flow	None		0
		pH	6–9		0
		TSS	15	30	0
		TRC[a]	0.05		0
003B	12	Flow	None		0
		pH	6–9		0
		Temperature	<2.8°C rise		0
003C	12	Flow	None		0
		pH	6–9		0
003D	12	Flow	None		0
		pH	6–9		0
		Temperature	<2.8°C rise		0
003E	7	Flow	None		0
		pH	6–9		0
		Temperature	<2.8°C rise		0
003F	11	Flow	None		0
		pH	6–9		0
		Temperature	<2.8°C rise		0
		TDS	Monitor only		NA[b]
003G	12	Flow	None		0
		pH	6–9		0
		Temperature	<2.8°C rise		0
003H	12	Flow	None		0
		pH	6–9		0
		Temperature	<2.8°C rise		0
		TDS	Monitor only		NA

TABLE 5.7 (Cont.)

Discharge Location	No. of Samples	Permit Constituent	Limit 30-Day Average	Limit Daily Maximum	No. Exceeding Limit
003I	12	Flow	None		0
		pH	6–9		0
		Temperature	<2.8°C rise		0
		TDS	Monitor only		NA
		Oil and grease	Monitor only		NA
003J	12	Flow	None		0
		pH	6–9		0
		Temperature	<2.8°C rise		0
		TDS	Monitor only		NA
004	12	Flow	None		0
		pH	6–9		0
		TSS	15	30	0
005C	12	Flow	None		0
		pH	6–9		0
		Temperature	<2.8°C rise		0
		Oil and grease	Monitor only		NA
005E	12	Flow	None		0
		pH	6–9		0
006	12	Flow	None		0
		pH	6–9		0
		TSS	15	30	0
		TDS	Monitor only		NA
		Temperature	<2.8°C rise		0
007	12	Flow	None		0
	12	pH	6–9		0
	12	Temperature	<2.8°C rise		0
	36	TRC	0.05		0
	12	Oil and grease	Monitor only		NA
008	12	Flow	None		0
		pH	6–9		0
		VOC	Monitor only		NA

TABLE 5.7 (Cont.)

Discharge Location	No. of Samples	Permit Constituent	Limit: 30-Day Average	Limit: Daily Maximum	No. Exceeding Limit
010	0	Flow	None		0
		pH	6–9		0
		TSS	15	30	0
		Total iron	2	4	0
		Dissolved iron		1.0	0
		Lead		0.1	0
		Zinc		1.0	0
		Manganese		1.0	0
		Hexavalent chromium	0.011	0.016	0
		Trivalent chromium	0.519	2.0	0
		Copper	0.031	0.051	0
		Oil and grease	15	30	0
108	12	Flow	None		0
		pH	6–9		0
		Temperature	<2.8°C rise		0
111	2	Flow	None		0
		Hydrogen-3	Monitor only		NA
112A	2	Flow	None		0
		Hydrogen-3	Monitor only		NA
112B	2	Flow	None		0
		Hydrogen-3	Monitor only		NA
113	8	Flow	None		0
		Hydrogen-3	Monitor only		NA
		PCB 1260	Monitor only		NA
		Lead, copper, nickel, zinc	Monitor only		NA
114	7	Flow	None		0
		Hydrogen-3	Monitor only		NA
		PCB 1260	Monitor only		NA
		Lead, copper, nickel, zinc	Monitor only		NA

TABLE 5.7 (Cont.)

Discharge Location	No. of Samples	Permit Constituent	Limit: 30-Day Average	Limit: Daily Maximum	No. Exceeding Limit
115	12	Flow	None		0
		pH	6–9		0
		Temperature	<2.8°C rise		0
		TDS	Monitor only		NA
116	12	Flow	None		0
		pH	6–9		0
		TRC	0.05		0

[a] TRC = total residual chlorine.

[b] NA = not applicable.

TABLE 5.8

Acute Toxicity Results: Fathead Minnow, 2001

NPDES Outfall	96-Hour LC_{50} July 30–August 3, 2001 (%)	96-Hour LC_{50} August 27–31, 2001 (%)	Comments
003H	>100	>100	Not acutely toxic
003I	>100	>100	Not acutely toxic
003J	<20	>100	Acutely toxic (July)
004	>100	>100	Not acutely toxic
006	>100	>100	Not acutely toxic
115	>100	>100	Not acutely toxic

TABLE 5.9

Acute Toxicity Results: Water Flea, 2001

NPDES Outfall	48-Hour LC_{50} July 30–August 3, 2001 (%)	48-Hour LC_{50} August 27–31, 2001 (%)	Comments
003H	>100	>100	Not acutely toxic
003I	70.6	>100	Acutely toxic (July)
003J	<20	>100	Acutely toxic (July)
004	>100	>100	Not acutely toxic
006	40.1	59.6	Acutely toxic (July and August)
115	64.2	>100	Acutely toxic (July)

5.2. Additional Effluent Monitoring

To characterize the wastewater from the ANL-E site more fully, composite samples of the combined effluent from the WTP were collected each week and analyzed for the constituents shown in Table 5.10. The results were then compared with IEPA General Effluent Limits found in 35 IAC, Subtitle C, Part 304.[24]

5.2.1. Sample Collection

Samples for analysis of inorganic constituents were collected daily from Outfall 001 located at the WTP by using a refrigerated time-proportional sampler. A portion of the sample was transferred to a clean bottle, a security seal was affixed, and chain of custody was maintained. Five daily samples were composited on an equal volume basis to produce a weekly sample that was then analyzed.

5.2.2. Results

Fifteen metals were determined by inductively coupled plasma emission spectroscopy and graphite furnace atomic absorption spectroscopy. Mercury was analyzed using cold vapor atomic absorption spectroscopy, and fluoride was determined by a specific ion electrode. Table 5.10 gives the results for 2001. None of the annual average results exceeded General Effluent Limits.[24]

5.3. Sawmill Creek

Sawmill Creek is a small natural stream that is fed primarily by storm water runoff. During periods of low precipitation, the creek above ANL-E has a very low flow. At these times, a major portion of the water in Sawmill Creek south of the site consists of ANL-E wastewater and discharges to assorted storm drains. To determine the impact ANL-E wastewaters have on Sawmill Creek, samples of the creek downstream of all ANL-E discharge points were collected and analyzed. The results were then compared with IEPA General Use Water Quality Standards found in 35 IAC, Subtitle C, Part 302.[25]

5.3.1. Sample Collection

A time-proportional sampler was used to collect a daily sample at a point well downstream of the combined wastewater discharge point where thorough mixing of the ANL-E effluent and

TABLE 5.10

Chemical Constituents in Effluents from the ANL-E
Wastewater Treatment Plant, 2001

		Concentration (mg/L)			
Constituent	No. of Samples	Average	Minimum	Maximum	Limit
Arsenic	52	0.0028	< 0.0015	0.0030	0.25
Barium	52	0.0214	0.0137	0.0255	2.0
Beryllium	52			< 0.0002[a]	-[b]
Cadmium	52	0.0001	< 0.0001	0.0002	0.15
Chromium	52	0.0286	0.0240	0.0440	1.0
Cobalt	52	0.0183	<0.0160	0.0260	-
Copper	52	0.0165	< 0.0150	0.0247	0.5
Fluoride	52	0.8629	0.5560	1.1900	15.0
Iron	52	0.0442	< 0.0200	0.0972	2.0
Lead	52	< 0.0020	0.0020	0.0020	0.2
Manganese	52	0.0122	< 0.0100	0.0429	1.0
Mercury	52	0.0001	< 0.0001	0.0003	0.0005
Nickel	52	0.0246	< 0.0200	0.0400	1.0
Silver	52			< 0.0010	0.1
Thallium	52	0.0019	0.0018	0.0020	-
Vanadium	52	0.0301	0.0240	0.0320	-
Zinc	52	0.0664	0.0335	0.1972	1.0
pH (units)	51	NA[c]	7.02	8.09	6.0–9.0

[a] If all values are less than the detection limit for a constituent, only the detection limit value is given.

[b] A hyphen indicates no effluent limit for this constituent.

[c] NA = not applicable.

Sawmill Creek water is assured. Samples were collected in precleaned, labeled bottles and security seals were used. After pH measurement, the daily samples were acidified and then combined into equal volume weekly composites and analyzed for the same set of inorganic constituents as those in Table 5.10.

Fifteen metals were determined by inductively coupled plasma emission spectroscopy, flame atomic absorption spectroscopy, and graphite furnace atomic absorption spectroscopy. Mercury was analyzed with cold vapor atomic absorption spectroscopy. Fluoride was determined by a specific ion electrode.

5.3.2. Results

The results obtained for 2001 are shown in Table 5.11. None of the annual average results exceeded General Use Water Quality Standards.[25]

TABLE 5.11

Chemical Constituents in Sawmill Creek, Location 7M,[a] 2001

		Concentrations (mg/L)			
Constituent	No. of Samples	Average	Minimum	Maximum	Limit
Arsenic	52	0.0027	< 0.0015	0.0030	0.36[b]
Barium	52	0.0388	0.0207	0.0715	5.0
Beryllium	52			< 0.0002[c]	-[d]
Cadmium	52	0.0001	< 0.0001	0.0002	0.03[b]
Chromium	52	0.0282	0.0240	0.0440	3.6[b]
Cobalt	52	0.0181	<0.0160	0.0260	-
Copper	52	0.0154	0.0150	0.0170	0.041[b]
Fluoride	52	0.5001	0.2620	1.1660	1.4
Iron	52	0.0671	< 0.0200	0.1659	1.0
Lead	52	< 0.0020	0.0020	0.0020	0.3[b]
Manganese	52	0.0116	< 0.0100	0.0170	1.0
Mercury	52	0.0001	< 0.0001	0.0003	0.0026[b]
Nickel	52	0.0242	<0.0200	0.0400	1.0
Silver	52			< 0.0010[c]	0.005
Thallium	52	0.0019	0.0018	0.0020	-
Vanadium	52	0.0303	0.0240	0.0320	-
Zinc	52	0.0203	< 0.0080	0.0915	1.0
pH (units)	51	NA[e]	6.56	7.80	6.5–9.0

[a] Location 7M is 15 m (50 ft) downstream from the ANL-E wastewater outfall.

[b] The acute standard for the chemical constituent is listed.

[c] If all values are less than the detection limit for a constituent, only the detection limit is given.

[d] A hyphen indicates no effluent limit for this constituent.

[e] NA = not applicable.

6. GROUNDWATER PROTECTION

The groundwater below the ANL-E site is monitored through the collection and analysis of samples obtained from the former on-site water supply wells, from a series of groundwater monitoring wells located near several sites that have the potential for affecting groundwater, and other monitoring wells on and off the ANL-E site. Regulations establishing comprehensive water quality standards for the protection of groundwater have been enacted — IEPA Groundwater Quality Standards, 35 IAC, Subtitle F, Part 620.[26] In addition, demonstration of compliance with the groundwater protection requirements in DOE Order 5400.1,[1] as related to sitewide characterization studies and monitoring well requirements, is presented in this chapter. The permit for the 800 Area Landfill requires a groundwater monitoring program; the program was initiated in July 1992. Information generated by this program is also included in this report.

6.1. Former Potable Water System

Domestic water for ANL-E was supplied by four wells (see Section 1.7 and Table 6.1) until early 1997, when Lake Michigan water was obtained. The well locations are shown in Figure 1.1. Lake Michigan water was obtained to provide better quality drinking water. The dolomite water from the on-site wells had deteriorated in quality to where the TDS content of the supply water was approaching 800 mg/L, which made it difficult to consistently meet the 1,000-mg/L TDS discharge limit at NPDES Outfall 001. Lake Michigan water has a TDS of approximately 200 mg/L. In addition, Lake Michigan water is lower in bicarbonate, which makes it less corrosive on the piping system.

6.1.1. Informational Monitoring

Samples were collected quarterly at the wellhead, except for Well 2, which is no longer operational, and were analyzed to determine the presence of several types of radioactive constituents and VOCs in ANL-E groundwater. Samples from each well were tested for total alpha, total beta, hydrogen-3, and strontium-90. Samples also were analyzed annually for radium-226, radium-228, and isotopic uranium. Alpha and beta radioactivity were determined by a gas-flow–proportional counting technique. Hydrogen-3 was determined by distillation followed by a beta liquid scintillation counting technique. Strontium-90 was determined by ion-exchange separations followed by proportional counting. The results are presented in Table 6.2.

VOC samples were collected quarterly. Samples were analyzed for SDWA volatile compounds and quantified by EPA Method 524.2,[27] which includes purge and trap pretreatment, followed by gas chromatography-mass spectroscopy detection. The reporting limit is the Practical Quantification Limit (PQL), which is defined as 10 times the method detection limit.

TABLE 6.1

ANL-E Former Water Supply Wells

Well No.	Location	Well Elevation (m AMSL)[a]	Bedrock Elevation (m AMSL)	Well Depth (m bgs)[b]	Inner Diameter (m)	Year Drilled
1	Building 31	204.5	184.4	86.6	0.30	1948
2[c]	Building 32	202.4	183.2	91.4	0.30	1948
3	Building 163	210.0	182.9	96.9	0.30	1955
4	Building 264	218.2	181.4	103.6	0.36	1959

[a] AMSL = above mean sea level.

[b] bgs = below ground surface.

[c] Well not operational.

All radiological results were within their normal range of concentrations as compared with previous results. No VOCs were detected.

6.1.2. Dolomite Well Monitoring

Past analytical data were used to track the presence of hydrogen-3 in ANL-E domestic well 1 and at a lower concentration in well 2. It is speculated that the source of the hydrogen-3 was liquid waste placed in an unlined holding pond in the wastewater treatment area (Location 10M in Figure 1.1) in the 1950s. The hydrogen-3 as tritiated water appeared to have migrated through the glacial drift to the dolomite aquifer and was drawn into the wells. Well 1, which is about 200 m (650 ft) north of the wastewater treatment area, had higher hydrogen-3 concentrations than well 2, which is about 300 m (1,000 ft) from the treatment area. Although the normal subsurface water flow gradient is toward the south-southeast, the cone of depression created by pumping these wells while they are still in use would overpower the normal flow pattern.

With the conversion of local well water to Lake Michigan water in early 1997, the water table elevations began to recover. ANL-E was concerned that the direction of subsurface migration of radionuclides, particularly hydrogen-3, could change because of the lack of the influence of pumping. Since hydrogen-3 from the 570 Area Pond was already known to have migrated to the dolomite, a monitoring network of three ANL-E and seven forest preserve wells was established to monitor the magnitude and direction of hydrogen-3 movement in this area. The well locations are shown in Figure 6.l. Samples were collected quarterly and analyzed for hydrogen-3. Table 6.3 shows

TABLE 6.2

Radioactivity in ANL-E Former Water Supply Wells, 2001
(Concentrations in pCi/L)

Type of Activity	Location	No. of Samples	Average	Minimum	Maximum
Alpha	Well 1	4	3.3	1.9	5.0
	Well 3	4	2.8	1.2	7.1
	Well 4	4	3.4	1.9	6.3
Beta	Well 1	4	7.6	7.1	8.2
	Well 3	4	8.5	8.0	9.4
	Well 4	4	8.9	7.5	10.4
Hydrogen-3	Well 1	4	< 100	< 100	< 100
	Well 3	4	< 100	< 100	< 100
	Well 4	4	< 100	< 100	< 100
Strontium-90	Well 1	4	< 0.25	< 0.25	< 0.25
	Well 3	4	< 0.25	< 0.25	< 0.25
	Well 4	4	< 0.25	< 0.25	< 0.25
Radium-226	Well 1	1	-[a]	-	< 0.02
	Well 3	1	-	-	< 0.02
	Well 4	1	-	-	< 0.02
Radium-228	Well 1	1	-	-	< 0.02
	Well 3	1	-	-	< 0.02
	Well 4	1	-	-	< 0.02
Uranium-234	Well 1	1	-	-	0.88
	Well 3	1	-	-	0.19
	Well 4	1	-	-	0.20
Uranium-235	Well 1	1	-	-	0.02
	Well 3	1	-	-	< 0.01
	Well 4	1	-	-	< 0.01
Uranium-238	Well 1	1	-	-	0.49
	Well 3	1	-	-	0.11
	Well 4	1	-	-	0.07

[a] A hyphen indicates that for a single result, the value is placed in the maximum column.

the results for 2001. Hydrogen-3 results from well 570091D, which is directly below the 570 Pond, continue to show low concentrations of hydrogen-3. During the third quarter, HP11 and ANL20 had detectable levels of hydrogen-3.

6.2. Groundwater Monitoring at Waste Management Sites

ANL-E has occupied its current site since 1948. Since that time, waste generated by ANL-E was placed in a number of on-site disposal units; these ranged from ditches filled with construction and demolition debris during the 1950s, to a former sanitary landfill used for nonhazardous solid waste disposal until September 1992. Several of these units contain significant amounts of hazardous materials and, therefore, represent a potential threat to the environment. Groundwater below these sites is monitored routinely to assess the amount and nature of hazardous chemical releases from these units. Routinely monitored sites include the sanitary landfill in the 800 Area and the 317/319 Area, which consists of seven separate waste management units located within a small geographical area. The site of the CP-5 reactor is also monitored periodically to determine whether any radionuclides are being released from this unit.

6.2.1. 317 and 319 Areas

The 317 and 319 Areas contain seven separate current or former units that have been used in the past for handling or disposal of various types of waste. The 317 Area is currently an active radioactive waste processing and storage area. It consists of two in-ground (Deep Vault and North Vault) and one aboveground concrete structures used to store containers of dry radioactive or mixed (radioactive and chemically hazardous) waste. The Deep Vault was empty during 2001. The North Vault was emptied in May 2001 and has remained empty since. The area also contains a small building used for decontamination of metal objects, such as lead bricks, tools, metal objects, etc. In the past, the 317 Area was used for disposal of various liquid chemical wastes in a unit known as a French drain. The drain consisted of a shallow trench filled with gravel into which an unknown quantity of liquid wastes was poured. This unit was operational during the late 1950s. Because of these past disposal practices, there is a region of contaminated soil in the north half of the 317 Area. The contaminants are primarily VOCs such as cleaning solvents. The groundwater below this area also contains low concentrations of these chemicals. General features in the 317/319 Area are identified in Figure 6.2.

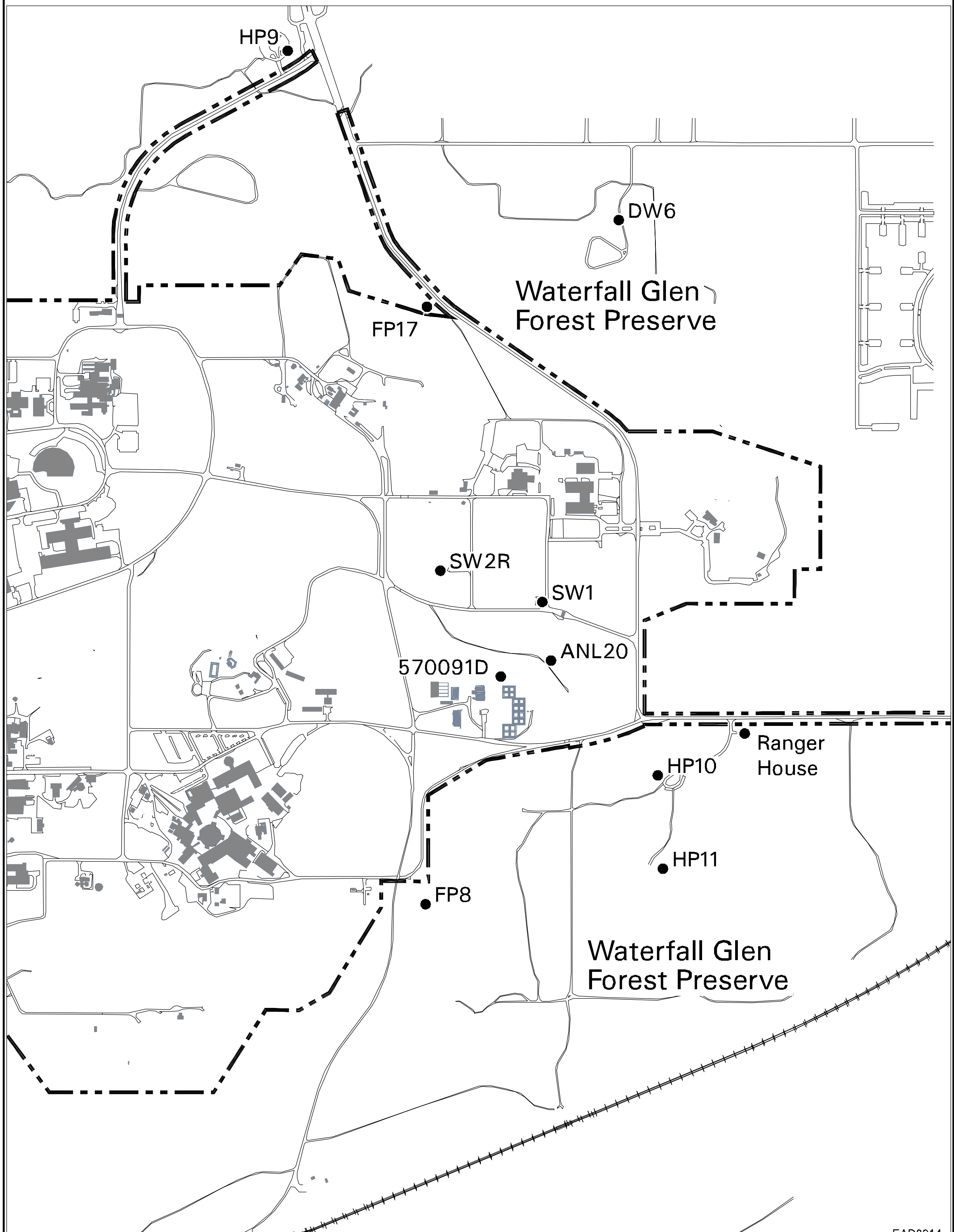


Figure 6.1 East Area/Forest Preserve Monitoring Wells

TABLE 6.3

Hydrogen-3 in Dolomite Wells, 2001
(Concentrations in pCi/L)

	Date Collected			
Well	January 25	May 8	August 21	November 5
Waterfall Glen				
DW 6	<100	<100	<100	<100
HP 9	<100	<100	<100	<100
HP 10	<100	<100	<100	<100
HP 11	<100	<100	114	<100
FP 8	<100	<100	<100	<100
FP 17	<100	<100	<100	<100
Ranger House	<100	<100	<100	<100
ANL-E				
5700910	<100	114	<100	104
ANL-20	<100	<100	111	<100
SW2R	<100	<100	<100	<100

The groundwater below the 317/319 Area exists in several shallow (3 to 16 m [10 to 50 ft]) sand and gravel layers within the glacial drift, as well as in the upper portions of the dolomite bedrock. There are no known consumers of this groundwater downgradient of the ANL-E site.

The 319 Area contains an inactive landfill that was used for disposal of a variety of solid wastes generated on site prior to 1969. It was not intended for disposal of radioactive waste; however, a small amount of radioactive material was detected during sampling activities completed several years ago. The only radionuclide found to be migrating from the landfill is hydrogen-3, although strontium-90 was noted one quarter in a well south of the 319 Area. The 319 waste burial area consists of two distinct segments: the waste mound, where the bulk of the waste was buried, and an adjacent burial trench, which contains a much smaller amount of mostly inert waste. This landfill also contains a French drain that was used for several years after the French drain in the 317 Area was closed. The presence of liquid chemical wastes from the French drain, as well as hydrogen-3 in the waste mound, have resulted in the generation of a plume of contaminated groundwater extending from the waste mound to the south, toward the Des Plaines River.

During late 1996, a series of small natural groundwater discharge points (groundwater seeps) was discovered approximately 183 m (600 ft) south of the 319 Area. Two of these seeps were found to contain low levels of three VOCs. These two seeps and one additional seep, which normally does not contain VOCs, were found to contain hydrogen-3 at concentrations below all applicable standards. Since their discovery, these seeps have been monitored on a regular basis (see Section 6.5). A characterization study was completed in 1998 to identify the source and

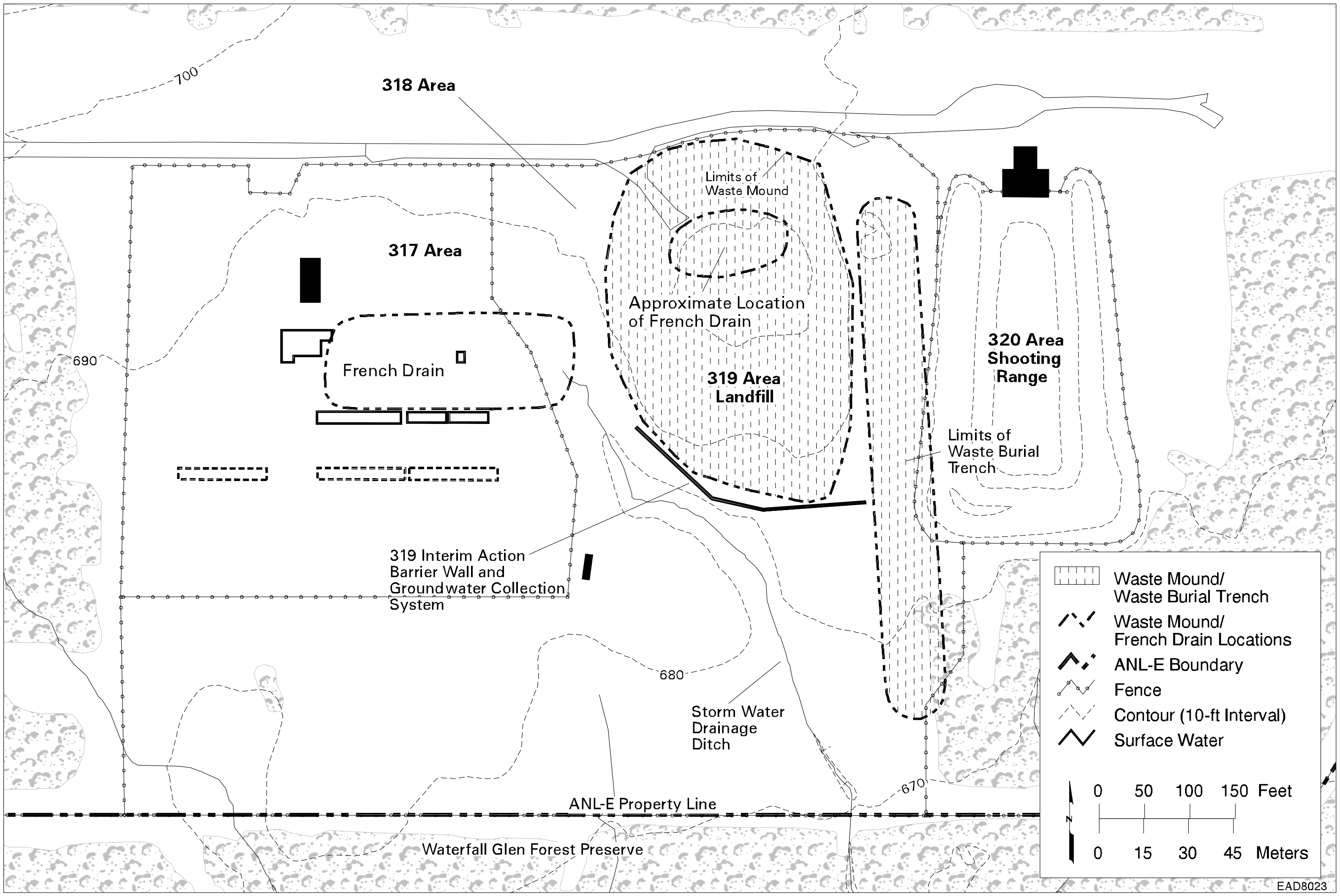


Figure 6.2 Locations of Components within the 317/319/ENE Area

migration pathways for the hydrogen-3 and VOCs. The hydrogen-3 appears to be emanating from the 319 Landfill and is likely an extension of the on-site hydrogen-3 plume, albeit at much lower concentrations than measured on site. The source of VOCs was not clearly discerned, though it is likely that they also emanated from some past waste disposal activities in the 319 or 317 Area. The known extent of contaminated groundwater covers much of the area from the 317 French Drain and 319 Landfill, southeast to the seeps.

Cleanup of the 317 and 319 Areas has been underway since the late 1980s. It is being carried out as a series of interrelated actions that will ultimately remove or contain the contaminants so that they will no longer migrate away from the waste disposal units. Several remedial actions are already in place and functioning as designed. These actions include a leachate and groundwater collection system for the 319 Landfill, demolition of four waste storage vaults contaminated with radioactive materials, sealing of an underground drainage sewer, installation of 13 groundwater extraction wells south of the 317 Area, construction of a concrete cover over a region containing buried compressed gas cylinders (318 Area), treating highly contaminated soil near the former French drain, and phytoremediation of residual soil and groundwater contamination. In addition, routine sampling and analysis of groundwater and surface water have continued.

During 2001, extensive remedial actions were begun on the 317 Area Deep Vault and North Vault. Work on the Deep Vault included removal of debris and shielding blocks and pressure-washing the walls and floor. Samples consisting of concrete surface, wall and floor core, and paint samples were collected and analyzed. The data were used to prepare a demolition plan.

Similar remediation work was conducted at the North Vault. However, since ANL-E has decided to continue storing waste in the vault, the North Vault will not be demolished.

In 1999, the IEPA approved the installation of a phytoremediation system in the 317 Area. Phytoremediation involves the use of green plants (trees, grasses, and flowering plants) to remove contaminated groundwater by evapotranspiration and to degrade contaminants in soil and groundwater. A dense planting of willow trees in the vicinity of the 317 French Drain and a larger planting of hybrid poplar trees downgradient of the 317 French Drain and the former 319 Landfill are in place and will be monitored over the next several years for their ability to remediate those areas.

The existing leachate and groundwater collection system at the 319 Landfill was upgraded during 1999. Four additional wells were installed, and equipment was purchased for converting the aboveground piping system to a belowground system. A composite cap was installed over the landfill mound.

The results of the required routine monitoring of the groundwater collection systems in the 317 and 319 Areas, the phytoremediation system, and the monitoring of the off-site groundwater seeps continue to be transmitted to the IEPA on a quarterly basis through the submittal of Quarterly Progress Reports. The results of this monitoring are too numerous to include in this report; however, the general conclusions are discussed below.

6.2.2. Groundwater Monitoring at the 317 and 319 Areas

Groundwater monitoring in the 317 and 319 Areas as part of the sitewide monitoring and surveillance program has been conducted since 1986. Wells 319011, 317021, and 319031 were installed in September 1986; well 317061 in August 1987; wells 317101 and 317111 in September 1988; and wells 319032 and 317052 were installed in June 1989. These wells were all completed in the glacial drift. Wells 317121D and 319131D were installed in November 1989 and reach the dolomite aquifer at about 20 m (64 ft) below the surface.

Wells 317101 and 317111 are upgradient of the 317 storage area, and well 319011 is upgradient of the 319 Area Landfill. A sand lens present at 5 to 8 m (15 to 25 ft) is monitored by wells 317052, 319031, 319032, and 317021. Groundwater in the dolomite bedrock aquifer is monitored at 317121D and 317131D. Table 6.4 lists well data for these areas. These wells are not used to monitor the progress of specific systems, but rather serve the 317/319 Area as a whole.

In addition to wells in this area, two manholes associated with the vault sewer system were monitored on a monthly basis. Figure 6.3 shows the locations of the manholes.

The remedial actions program collects groundwater data from an extensive network of wells located throughout the 317 and 319 Areas. These data are transmitted to the IEPA quarterly. For clarity, these other wells are not shown in Figure 6.3.

To monitor the performance of the various remedial actions constructed in the 317 and 319 Areas, samples are collected on a quarterly basis, and the results are transmitted to the IEPA each quarter. The purpose of this monitoring is to track the movement of contaminated groundwater and to determine the rate at which contaminant levels are decreasing. Monitoring results in 2001 indicate that the two groundwater collection systems south of the 319 Landfill and south of the 317 Area are effectively preventing off-site migration of contaminated groundwater. The analysis of groundwater samples for contaminants reveals that high concentrations of VOCs are present in groundwater in the immediate vicinity of the former 317 Area French Drain. Concentrations of up to 310,000 μg/L of several chlorinated VOCs were detected. However, at the ANL-E fence line, near the groundwater collection wells, the level of contamination is much lower; the highest concentration is less than 400 μg/L. This groundwater is being collected by the extraction system so that it does not migrate off site.

TABLE 6.4

Groundwater Monitoring Wells: 317 and 319 Areas

ID Number	Well Depth (m bgs)	Ground Elevation (m AMSL)	Monitoring Zone (m AMSL)	Well Type[a]	Date Drilled
319011	12.19	209.8	199.1–197.6	0.05/PVC	9/86
317021	12.19	209.2	198.5–197.0	0.05/PVC	9/86
319031	12.50	204.3	194.8–191.8	0.05/PVC	9/86
319032	7.62	204.3	198.2–196.7	0.05/PVC	8/89
317052	4.27	208.3	207.1–204.0	0.05/PVC	8/89
317061	12.19	207.5	196.9–195.3	0.05/PVC	7/87
317101	11.89	211.0	202.2–199.1	0.05/PVC	8/89
317111	11.89	210.3	201.4–198.4	0.05/PVC	8/89
317121D[b]	24.08	207.6	185.0–183.5	0.15/CS	9/88
319131D	21.03	203.5	184.0–182.5	0.15/CS	9/88

[a] Inner diameter (m)/well material (PVC = polyvinyl chloride, CS = carbon steel).

[b] Wells identified by a “D” are deeper wells monitoring the dolomite bedrock aquifer.

The phytoremediation system indicates that the trees are indeed taking up the organic materials and breaking them down within the trees. The effect of the trees on groundwater movement was also measured; however, the trees are so small, having only been in place for two growing seasons, that their effect was not great enough to be easily measured. Long-term monitoring of this system will determine its effectiveness at removing groundwater and degrading contaminants.

6.2.2.1. Sample Collection

The monitoring wells are sampled using the protocol listed in the *RCRA Ground-Water Monitoring Technical Enforcement Guidance Document*.[28] The volume of the water in the casing is determined by measuring the water depth from the surface and the depth to the bottom of the well. This latter measurement also determines whether siltation has occurred, which might restrict water movement in the screened area. For those wells in the glacial drift that do not recharge rapidly, the well is emptied and the volume of water removed is compared with the calculated volume. In most cases, these volumes are nearly identical. The well is then sampled, following recovery, by bailing with a dedicated Teflon bailer. The field parameters for these samples (pH, specific conductance, redox potential, and temperature) are measured statically. For those samples in the porous, saturated zone that recharges rapidly, three well volumes are purged using dedicated submersible pumps, while the field parameters are measured continuously. These parameters stabilize quickly in these wells.

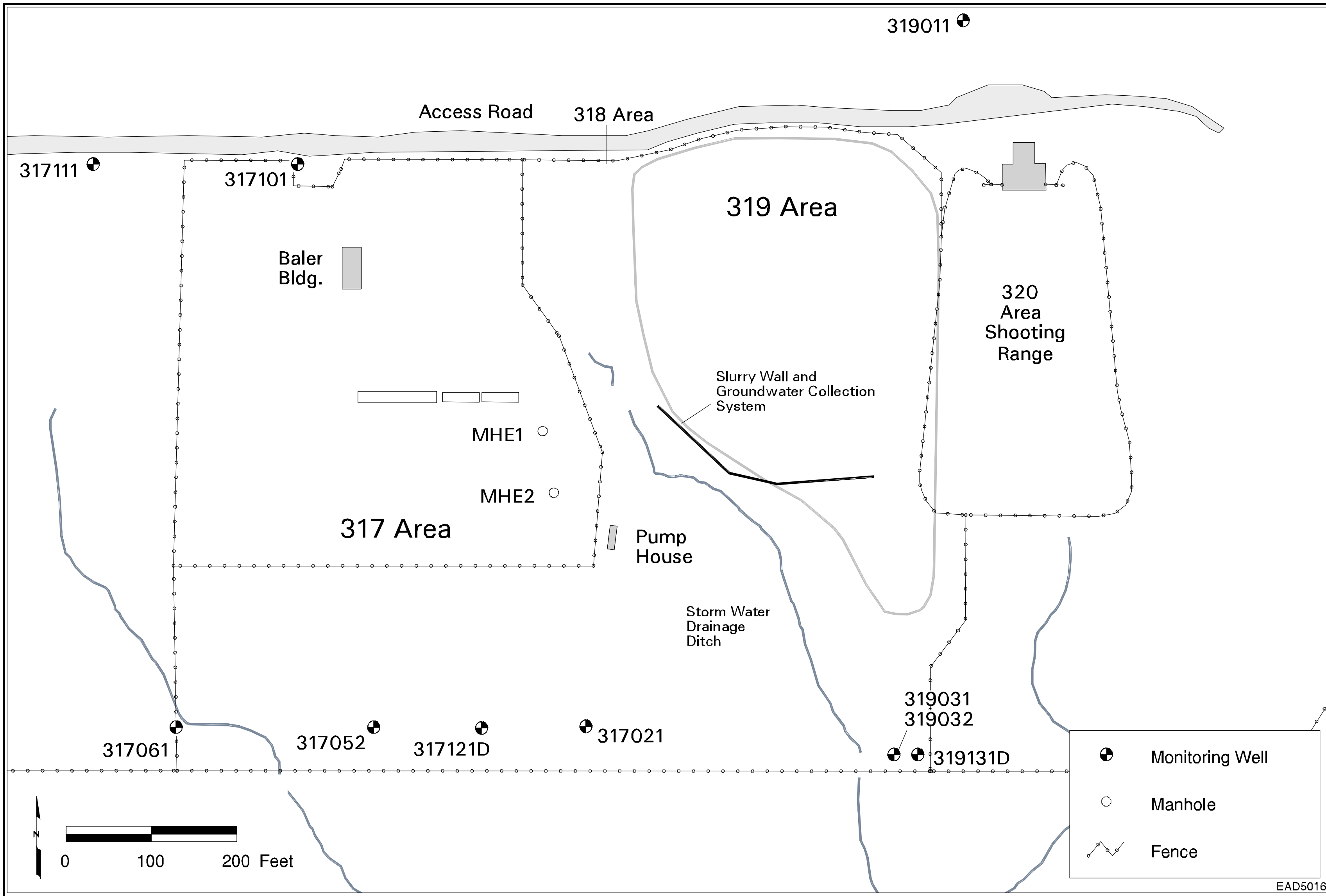


Figure 6.3 Monitoring and Characterization Wells in the 317 and 319 Areas, 2001

In the case of the dolomite wells, samples are collected as soon as these readings stabilize. Samples for VOCs, SVOCs, PCBs and pesticides, metals, nonmetals, and radioactivity are collected in that order. The samples are placed in precleaned bottles, labeled, and preserved.

During each sampling event, one well is selected for replicate sampling. An effort is made to vary this selection so that replicates are obtained at every well over time. In addition, a field blank is also obtained.

6.2.2.2. Sample Analyses - 317 and 319 Areas

The 317 and 319 Area groundwater chemical analyses were performed using SOPs written, reviewed, and issued as controlled documents by members of the Chemical Technology Division, ESH Analytical Chemistry (CMT/ESH-AC). These SOPs reference protocols in SW-846.[6] Fifteen metals were routinely measured using inductively coupled plasma atomic emission spectrometry and graphite furnace atomic absorption spectroscopy. Mercury was determined by cold vapor atomic absorption spectroscopy. Chloride was determined by titrimetry. VOCs were determined by using a purge and trap sample pretreatment followed by gas chromatography-mass spectroscopy detection. SVOCs were determined by solvent extraction followed by gas chromatography-mass spectrometry detection. PCBs and pesticides were determined by solvent extraction followed by gas chromatography-electron capture detection. In the case of organic compound analyses, efforts were made to identify compounds that were present but not included on the method list. This was accomplished, and standard solutions of these compounds were prepared and analyzed.

The 317 and 319 Area groundwater radiological analyses were performed using SOPs written, reviewed, and issued as controlled documents by members of CMT/ESH-AC. Cesium-137 was determined by gamma-ray spectrometry. Hydrogen-3 was determined by distillation followed by a beta liquid scintillation counting technique. Strontium-90 was determined by an ion-exchange separation followed by a proportional counting technique.

6.2.2.3. Results of Analyses

Descriptions of each well, the field parameters measured during sample collection, and the results of chemical and radiological analyses of samples from the wells in the 317 and 319 Areas are contained in Tables 6.5 through 6.14. All radiological and inorganic analytical results are shown in these tables. The analytical methods used for organic compounds could identify and quantify all the compounds contained in the CLP Target Compound List. However, the vast majority of these compounds were not detected in the samples. To simplify the format of these tables, those results less than the detection limit are not included. Only those constituents that were present in amounts

TABLE 6.5

Groundwater Monitoring Results, 300 Area Well 317021, 2001

		Date of Sampling			
Parameter	Unit	02/15/01	06/12/01	08/30/01	11/08/01
Water elevation[a]	m	200.92	199.32	198.87	200.14
Temperature	°C	8.5	12.9	12.6	11.8
pH	pH	7.54	7.63	6.41	7.33
Redox	mV	-25	-33	39	-14
Conductivity	µmhos/cm	824	1001	850	917
Chloride[b]	mg/L	27	63	36	28
Arsenic[b]	mg/L	< 0.0015	< 0.0030	< 0.0030	< 0.0030
Barium[b]	mg/L	0.0367	0.0420	0.0367	0.0399
Beryllium[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.0440	< 0.0240	< 0.0240	< 0.0240
Cobalt[b]	mg/L	< 0.0260	< 0.0160	< 0.0160	< 0.0160
Copper[b]	mg/L	< 0.0170	< 0.0150	< 0.0150	< 0.0150
Iron[b]	mg/L	< 0.0370	< 0.0200	< 0.0200	< 0.0200
Lead[b]	mg/L	< 0.0020	< 0.0020	< 0.0020	< 0.0020
Manganese[b]	mg/L	0.0958	< 0.0100	< 0.0100	< 0.0100
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.0400	< 0.0200	< 0.0200	< 0.0200
Silver[b]	mg/L	< 0.0005	< 0.0010	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0020	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.0240	< 0.0320	< 0.0320	< 0.0320
Zinc[b]	mg/L	< 0.0110	0.0224	0.0138	0.0105
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	< 100	174	< 100	168
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
1,1,1-Trichloroethane	µg/L	5	4	2	3
1,1-Dichloroethane	µg/L	2	2	< 1	1
Acetone	µg/L	< 1	4	< 1	< 1
Benzene	µg/L	9	< 1	< 1	< 1

[a] Well point elevation = 197.27 m (MSL); ground surface elevation = 209.17 m (MSL); casing material = PVC.

[b] Filtered sample.

TABLE 6.6

Groundwater Monitoring Results, 300 Area Well 317052, 2001

		Date of Sampling			
Parameter	Unit	02/15/01	06/07/01	08/30/01	11/09/01
Water elevation[a]	m	206.40	205.28	204.88	205.17
Temperature	°C	8.5	10.4	15.1	13.3
pH	pH	7.44	6.75	7.00	7.69
Redox	mV	-14	19	3	-29
Conductivity	µmhos/cm	851	940	952	884
Chloride[b]	mg/L	22	27	6	13
Arsenic[b]	mg/L	< 0.0015	< 0.0030	< 0.0030	< 0.0030
Barium[b]	mg/L	0.0333	0.0321	0.0310	0.0337
Beryllium[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.0440	< 0.0240	< 0.0240	< 0.0240
Cobalt[b]	mg/L	< 0.0260	< 0.0160	< 0.0160	< 0.0160
Copper[b]	mg/L	< 0.0170	< 0.0150	< 0.0150	< 0.0150
Iron[b]	mg/L	< 0.0370	< 0.0200	< 0.0200	0.1279
Lead[b]	mg/L	< 0.0020	< 0.0020	< 0.0020	< 0.0020
Manganese[b]	mg/L	< 0.0170	< 0.0100	< 0.0100	< 0.0100
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.02	< 0.02	< 0.02
Silver[b]	mg/L	< 0.0005	< 0.0010	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0020	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.0110	0.0108	< 0.0080	< 0.0080
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

[a] Well point elevation = 204.04 m (MSL); ground surface elevation = 208.32 m (MSL); casing material = PVC.

[b] Filtered sample.

TABLE 6.7

Groundwater Monitoring Results, 300 Area Well 317061, 2001

Parameter	Unit	Date of Sampling 02/06/01	06/07/01	08/29/01	11/08/01
Water elevation[a]	m	198.08	198.34	197.89	198.29
Temperature	°C	10.4	11.4	12.5	10.7
pH	pH	6.87	7.11	7.08	7.47
Redox	mV	-4	0	-1	-19
Conductivity	µmhos/cm	885	985	916	790
Chloride[b]	mg/L	6	10	9	4
Arsenic[b]	mg/L	0.0168	0.0183	0.0107	0.0157
Barium[b]	mg/L	0.0586	0.0578	0.0585	0.0639
Beryllium[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	0.0939	< 0.0200	< 0.0200	< 0.0200
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0273	0.0216	0.0215	0.0195
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.0400	< 0.0200	< 0.0200	0.0247
Silver[b]	mg/L	< 0.0005	< 0.0010	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0020	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.0110	0.0135	< 0.0080	< 0.0080
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

[a] Well point elevation = 195.35 m (MSL); ground surface elevation = 207.54 (MSL); casing material = PVC.

[b] Filtered sample.

TABLE 6.8

Groundwater Monitoring Results, 300 Area Well 317101, 2001

		Date of Sampling				
Parameter	Unit	02/15/01	02/15/01	06/07/01	08/29/01	11/08/01
Water elevation[a]	m	202.47	202.47	203.08	202.37	202.60
Temperature	°C	11.7	11.7	12.1	12.1	11.9
pH	pH	7.13	7.13	7.10	6.98	6.98
Redox	mV	1	1	0	7	6
Conductivity	µmhos/cm	3,130	3,130	2,870	2,210	3,350
Chloride[b]	mg/L	918	925	656	437	806
Arsenic[b]	mg/L	< 0.0015	< 0.0015	< 0.0030	< 0.0030	< 0.0030
Barium[b]	mg/L	0.1223	0.1271	0.1009	0.0874	0.1325
Beryllium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.017	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.037	< 0.037	< 0.020	< 0.020	< 0.020
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0329	0.0315	0.0159	0.0150	0.0420
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.02	< 0.02	< 0.02
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0010	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0018	< 0.0020	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.0110	< 0.0110	0.0091	< 0.0080	< 0.0080
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	132	< 100	< 100	< 100	142
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25

[a] Well point elevation = 198.66 m (MSL); ground surface elevation = 211.04 m (MSL); casing material = PVC.

[b] Filtered sample.

TABLE 6.9

Groundwater Monitoring Results, 300 Area Well 317111, 2001

Parameter	Unit	Date of Sampling				
		02/06/01	06/07/01	06/07/01	08/29/01	11/08/01
Water elevation[a]	m	199.81	200.90	200.90	199.77	199.98
Temperature	°C	10.0	11.4	11.4	12.2	11.0
pH	pH	6.85	7.08	7.08	6.58	7.15
Redox	mV	-2	2	2	26	-2
Conductivity	µmhos/cm	1,223	1,312	1,312	1,252	1,423
Chloride[b]	mg/L	244	225	244	212	187
Arsenic[b]	mg/L	< 0.0015	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Barium[b]	mg/L	0.0761	0.0789	0.0737	0.0832	0.0868
Beryllium[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	0.0795	< 0.0200	0.0211	< 0.0200	0.0575
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0443	0.1385	0.1471	0.0172	< 0.0100
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.02	< 0.02	< 0.02	< 0.02
Silver[b]	mg/L	< 0.0005	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0020	< 0.0020	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.032	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.008	< 0.008	< 0.008	< 0.008
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100	109
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
2-Butanone	µg/L	< 1	1	7	< 1	< 1
Acetone	µg/L	< 1	6	19	< 1	< 1
Methylene chloride	µg/L	< 1	2	< 1	< 1	< 1

[a] Well point elevation = 198.37 m (MSL); ground surface elevation = 210.25 m (MSL); casing material = PVC.

[b] Filtered sample.

TABLE 6.10

Groundwater Monitoring Results, 300 Area Well 317121D, 2001

		Date of Sampling			
Parameter	Unit	02/15/01	06/12/01	08/30/01	11/09/01
Water elevation[a]	m	186.45	186.45	186.42	186.43
Temperature	°C	9.9	14.1	13.9	10.8
pH	pH	9.99	7.84	7.78	9.97
Redox	mV	-164	-47	-36	-161
Conductivity	µmhos/cm	450	810	742	551
Chloride[b]	mg/L	44	51	46	44
Arsenic[b]	mg/L	< 0.0015	< 0.0030	< 0.0030	< 0.0030
Barium[b]	mg/L	0.0588	0.0442	0.0356	0.0539
Beryllium[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.037	< 0.020	< 0.020	< 0.020
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.017	< 0.010	< 0.010	< 0.010
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	0.0002
Nickel[b]	mg/L	< 0.04	< 0.02	< 0.02	< 0.02
Silver[b]	mg/L	< 0.0005	< 0.0010	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0020	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.008	< 0.008	< 0.008
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	169	< 100	146	270
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

[a] Well point elevation = 183.49 m (MSL); ground surface elevation = 207.57 m (MSL); casing material = steel.

[b] Filtered sample.

TABLE 6.11

Groundwater Monitoring Results, 300 Area Well 319011, 2001

Parameter	Unit	Date of Sampling 02/06/01	06/07/01	08/29/01	11/08/01
Water elevation[a]	m	199.40	201.49	200.79	201.09
Temperature	°C	9.7	12.5	12.4	10.9
pH	pH	6.90	7.32	7.08	7.21
Redox	mV	-4	-12	6	-10
Conductivity	µmhos/cm	971	971	945	1030
Chloride[b]	mg/L	35	47	44	41
Arsenic[b]	mg/L	< 0.0015	< 0.0030	< 0.0030	< 0.0030
Barium[b]	mg/L	0.0369	0.0343	0.0337	0.0401
Beryllium[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	0.0566	< 0.0200	0.0200	0.0252
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0220	0.0451	0.1291	0.0979
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.0400	< 0.0200	< 0.0200	0.0207
Silver[b]	mg/L	< 0.0005	< 0.0010	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0020	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.008	< 0.008	< 0.008
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

[a] Well point elevation = 197.60 m (MSL); ground surface elevation = 209.81m (MSL); casing material = PVC.

[b] Filtered sample.

TABLE 6.12

Groundwater Monitoring Results, 300 Area Well 319031, 2001

		Date of Sampling	
Parameter	Unit	06/11/01	11/08/01
Water elevation[a]	m	193.12	193.09
Temperature	°C	12.8	10.3
pH	pH	7.29	7.54
Redox	mV	-13	-25
Conductivity	µmhos/cm	965	1,062
Chloride[b]	mg/L	35	28
Arsenic[b]	mg/L	< 0.003	< 0.003
Barium[b]	mg/L	0.0497	0.0582
Beryllium[b]	mg/L	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015
Iron[b]	mg/L	< 0.020	0.129
Lead[b]	mg/L	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.01	< 0.01
Mercury[b]	mg/L	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.02	< 0.02
Silver[b]	mg/L	< 0.001	< 0.001
Thallium[b]	mg/L	< 0.002	< 0.002
Vanadium[b]	mg/L	< 0.032	< 0.032
Zinc[b]	mg/L	0.037	< 0.008
Cesium-137	pCi/L	< 2.0	< 2.0
Hydrogen-3	pCi/L	803	808
Strontium-90	pCi/L	0.33	0.27
1,1,1-Trichloroethane	µg/L	2	1
1,4-Dioxane	µg/L	8	< 8
Trichloroethene	µg/L	3	2

[a] Well point elevation = 191.78 m (MSL); ground surface elevation = 204.28 m (MSL); casing material = PVC.

[b] Filtered sample.

TABLE 6.13

Groundwater Monitoring Results, 300 Area Well 319032, 2001

		Date of Sampling				
Parameter	Unit	02/15/01	06/11/01	08/30/01	08/30/01	11/08/01
Water elevation[a]	m	197.75	197.82	197.23	197.23	197.56
Temperature	°C	10.0	11.2	11.3	11.3	11.1
pH	pH	7.32	7.13	6.96	6.96	7.39
Redox	mV	-8	-6	7	7	-17
Conductivity	µmhos/cm	875	966	895	895	1,031
Chloride[b]	mg/L	16	16	14	16	14
Arsenic[b]	mg/L	< 0.0015	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Barium[b]	mg/L	0.0638	0.0645	0.0670	0.0622	0.0735
Beryllium[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.037	< 0.020	< 0.020	< 0.020	< 0.020
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.017	< 0.010	< 0.010	< 0.010	< 0.010
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.02	< 0.02	< 0.02	< 0.02
Silver[b]	mg/L	< 0.0005	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0020	< 0.0020	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.032	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.0110	0.0112	0.0095	0.0105	< 0.0080
Americium-241	fCi/L	-[c]	-	< 0.001	-	-
Curium-242	fCi/L	-	-	< 0.001	-	-
Curium-244	fCi/L	-	-	< 0.001	-	-
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	285	292	247	247	280
Neptunium-237	fCi/L	-	-	< 0.001	-	-
Plutonium-238	fCi/L	-	-	< 0.001	-	-
Plutonium-239	fCi/L	-	-	< 0.001	-	-
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
1,4-Dioxane	µg/L	15	21	< 10	< 10	< 10

[a] Well point elevation = 196.66 m (MSL); ground surface elevation = 204.28 m (MSL); casing material = PVC.

[b] Filtered sample.

[c] A hyphen indicates that no samples were collected.

TABLE 6.14

Groundwater Monitoring Results, 300 Area Well 319131D, 2001

Parameter	Unit	Date of Sampling			
		02/15/01	06/11/01	08/30/01	11/08/01
Water elevation[a]	m	184.66	184.60	184.44	184.50
Temperature	°C	9.3	14.4	12.4	10.8
pH	pH	7.79	7.19	6.64	7.39
Redox	mV	-37	-8	22	-16
Conductivity	µmhos/cm	958	1,059	1,017	1,138
Chloride[b]	mg/L	52	53	56	50
Arsenic[b]	mg/L	< 0.0015	< 0.0030	< 0.0030	< 0.0030
Barium[b]	mg/L	0.0727	0.0669	0.0668	0.0677
Beryllium[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.0370	< 0.0200	< 0.0200	0.0217
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.017	< 0.010	< 0.010	< 0.010
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.02	< 0.02	< 0.02
Silver[b]	mg/L	< 0.0005	< 0.0010	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0020	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.008	< 0.008	< 0.008
Americium-241	fCi/L	-[c]	0.698	-	-
Curium-242	fCi/L	-	0.0343	-	-
Curium-244	fCi/L	-	0.0922	-	-
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	1153	608	1257	1068
Neptunium-237	fCi/L	-	0.1706	-	-
Plutonium-238	fCi/L	-	0.2747	-	-
Plutonium-239	fCi/L	-	0.8015	-	-
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

[a] Well bottom elevation = 182.88 m (MSL); ground surface elevation = 203.56 m (MSL); casing material = steel.

[b] Filtered sample.

[c] A hyphen indicates that no samples were collected.

great enough to quantify are shown. The detection limits for the organic compounds listed were typically 1 to 10 μg/L.

Field Parameters. The purging of wells to produce water representative of the groundwater being studied was followed by measuring the field parameters. For the wells reported in this study, temperature, pH, redox potential, and specific conductance remained fairly constant after two well volumes were removed. On the basis of this information, sampling was conducted after the removal of three well volumes. The field parameters listed in the tables are the final readings obtained at the time of sampling. Wells 319011, 317021, 317061, 317111, 319031, and 319131D usually dry up after one well volume is removed. Therefore, field parameters were measured on one well volume. Similar to past years, Well 319031 was dry during the first and third quarters. Conductivity was elevated in wells 317101 and 317111. This is probably related to the fact that chloride levels in these two wells exceeded the WQS (200 mg/L).

Inorganic Parameters. ANL-E chose a conservative approach for evaluating the monitoring results by selecting as the standard of comparison the Illinois Groundwater Quality Standards for Class I: Potable Resource Groundwater, 31 IAC, Section 620.410. The standards are presented in Tables 6.15 and 6.16. In 2001, all samples for metals analyses were field-filtered prior to preservation with acid (an IEPA requirement for the IEPA-approved groundwater monitoring program at the 800 Area Landfill, Section 6.3.2.3).

TABLE 6.15

Illinois Class I Groundwater Quality Standards: Inorganics (concentrations in mg/L, except radionuclides and pH)

Constituent	Standard
Antimony	0.006
Arsenic	0.05
Barium	2
Beryllium	0.004
Boron	2
Cadmium	0.005
Chloride	200
Chromium	0.1
Cobalt	1
Copper	0.65
Cyanide	0.2
Fluoride	4
Iron	5
Lead	0.0075
Manganese	0.15
Mercury	0.002
Nickel	0.1
Nitrate, as N	10
Radium-226	20 pCi/L
Radium-228	20 pCi/L
Selenium	0.05
Silver	0.05
Sulfate	400
Thallium	0.002
TDS	1,200
Zinc	5
pH	6.5–9.0

As noted in previous years, no elevated levels, with respect to the WQS for inorganics, were noted with the exception of pH at dolomite well 317121D and chloride at wells 317101 and 317111. Historically, elevated pH values at well 317121D have been reported. The pH changes drastically between the purging of two to five volumes of water. In each case, the last value obtained was recorded. Wells 317101 and 317111 exceeded the WQS for chloride each quarter. Chloride levels

TABLE 6.16

Illinois Class I Groundwater Quality Standards: Organics
(concentrations in mg/L)

Constituent	Standard	Constituent	Standard
Alachlor	0.002	1,1-Dichloroethene	0.007
Aldicarb	0.003	cis-1,2-Dichloroethylene	0.07
Atrazine	0.003	trans-1,2-Dichloroethylene	0.1
Benzene	0.005	1,2-Dichloropropane	0.005
Benzo(a)pyrene	0.0002	Ethylbenzene	0.7
Carbofuran	0.04	Methoxychlor	0.04
Carbon tetrachloride	0.005	Monochlorobenzene	0.1
Chlordane	0.002	Pentachlorophenol	0.001
Dalapon	0.2	Phenols	0.1
Dichloromethane	0.005	Picloram	0.5
Di(2-ethyhexyl)phthalate	0.006	PCBs (decachlorobiphenyl)	0.0005
Dinoseb	0.007	Simazine	0.004
Endothall	0.1	Styrene	0.1
Endrin	0.002	2,4-5-TP (Silvex)	0.05
Ethylene dibromide	0.00005	Tetrachloroethylene	0.005
Heptachlor	0.0004	Toluene	1
Heptachlor epoxide	0.0002	Toxaphene	0.003
Hexachlorocyclopentadiene	0.05	1,1,1-Trichloroethane	0.2
Lindane	0.0002	1,1,2-Trichloroethane	0.005
2,4-D	0.07	1,2,4-Trichlorobenzene	0.07
o-Dichlorobenzene	0.6	Trichloroethylene	0.005
p-Dichlorobenzene	0.075	Vinyl chloride	0.002
1,2-Dibromo-3-Chloropropane	0.0002	Xylenes	10
1,2-Dichloroethane	0.005		

ranged from 187 to 925 mg/L and may be due to road salt. Several wells had elevated levels of barium, iron, and manganese; however, they were considerably below the WQS. Barium concentrations ranged from less than 0.03 to 0.13 mg/L, iron concentrations ranged from less than 0.02 to 0.13 mg/L, and manganese concentrations ranged from less than 0.01 to 0.15 mg/L. The source of the elevated levels is unknown. Similar manganese concentrations have been measured at distances from the 317/319 Areas, that is, CP-5 reactor and 800 Landfill Areas. Elevated levels of barium and manganese have been reported in previous annual reports.[16]

Organic Parameters. No organic WQSs were exceeded in 2001. As in 2000, VOCs were detected in wells 317021, 319031, and 319032. Unlike 2000, they were also detected in well 317111 but not 319011 and 319131D. VOC concentrations were very low. Well 317021 continues to show persistent but very low VOC levels of the same contaminants as in previous years. Well 317111 showed acetone and 2-butanone only during the second quarter. The presence of acetone and 2-butanone may be due to laboratory contamination, since these VOCs were detected in the field control sample during the first three quarters. Methylene chloride was detected only during the second quarter at 2 µg/L. Historically, well 319031, although usually dry, contains organic constituents when water is present. 1,4-dioxane was the only VOC noted two quarters in well 319032. The reduction in frequency and concentration of VOCs appears to be a result of the extensive remedial actions in the 317 and 319 Areas completed during the last few years. It should be noted that monitoring conducted by the corrective actions group, which is not presented in this report, routinely detects much higher concentrations of VOCs than those described above; many results are well in excess of WQSs. These samples are collected near areas where waste was placed in the ground and where active remediation is being conducted. Higher concentrations at these locations are expected at this point in time.

Once during the year, the wells were sampled and analyzed for SVOCs, PCBs, pesticides, and herbicides. None of these parameters were found in 2001.

Figure 6.4 shows selected VOC results for well 317021 since 1988. The major components are 1,1,1-trichloroethane (TCA) and 1,1-dichloroethane (DCA); the latter can be a decomposition product of TCA. As shown in Figure 6.4, the concentrations roughly parallel each other, and the levels are consistent until 1991, at which time a trend of increasing, then decreasing concentrations can be observed. Since early 1998, the level of contamination has dropped dramatically. In 2001, trace levels of acetone and benzene were also found in this well but at levels well below the WQS and only during one quarter. The well is immediately below a former sewer line that was known to be contaminated. The sewer line was permanently closed in 1986 and sealed in 1997. A groundwater collection system in the vicinity of this well was installed in late 1997.

Manholes E1 and E2, in the 317 Area were sampled monthly and analyzed for VOCs. The results are presented in Table 6.17. Contributors of groundwater into manholes E1 and E2 include an average of 985 L/day (260 gal/day) from the 319 Area groundwater collection system, an average

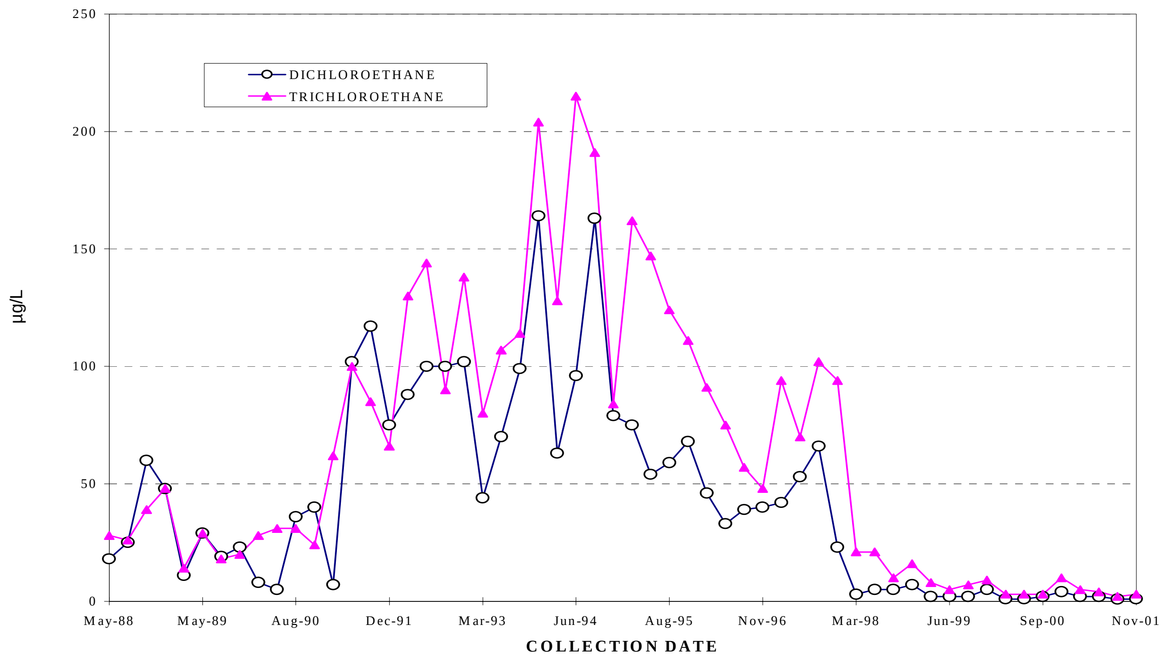


Figure 6.4 Concentration of 1,1-Dichloroethane and 1,1,1-Trichloroethane in Well 317021

of 24,465 L/day (6,461 gal/day) from the 317 Area groundwater collection system, and groundwater from existing 317 Area foundation drains around storage vaults.

Water from the 317 Area and 319 Area groundwater collection systems is pumped to Manhole 2E. Manhole 1E receives water from the 317 Area. Flows from the 319 Area collection system to Manhole 2E have decreased 72% (3,529 L/day to 985 L/day) since 1999. This decrease can be mainly attributed to a considerable drop in groundwater extraction rates due to the addition of the 319 Landfill Cap installed during summer 1999. The flows from the 317 Area groundwater collection system fluctuated over this time period; flows ranged from 29,840 L/day (7,880 gal/day) in 1999, 14,987 L/day (3,958 gal/day) in 2000, to 24,465 L/day (6,461 gal/day) in 2001. These flow rates appear to be due to seasonal precipitation fluctuations. For example, the flow rates during the first two quarters of 2001 represented over 63% of the total from the 317 Area.

In general, VOC concentrations in Manholes E1 and E2 decreased from levels noted in previous years (see Figure 6.5). The decrease is mainly associated with remediation activities in the 317 and 319 Areas. A soil remediation project in the 317 French Drain Area in 1998 resulted in the removal of approximately 80% of the VOCs from several locations within the 317 French Drain Area. As previously mentioned, the addition of the 319 Landfill Cap in summer of 1999 has decreased leachate production in this area and has resulted in a substantial decrease in the amount of water pumped to Manhole E2 from the 319 Area groundwater collection system. These activities probably account for the decrease in VOC concentrations in Manhole E2 from levels noted in 2000

TABLE 6.17

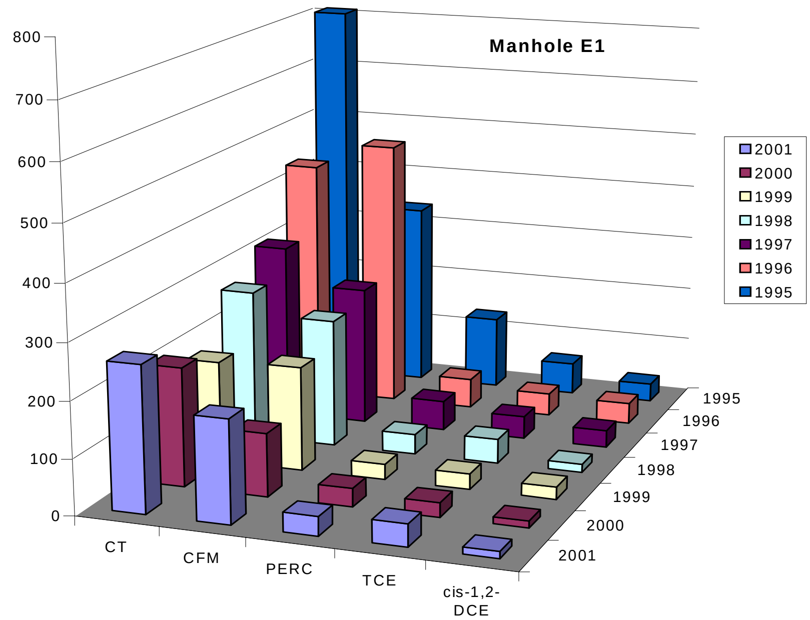
Volatile Organic Compounds in the 317 Area: Manholes E1 and E2, 2001
(Concentrations in μg/L)

	Chloroform		Tetra-chloroethene		Trichloro-ethene		cis-1,2-Dichloro-ethene		1,1-Dichloro-ethane		Carbon Tetrachloride		1,1,1-Trichloro-ethane	
Date Collected	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2
January 16	-*	7	-	5	-	12	-	5	-	30	-	15	-	76
February 16	446	60	58	12	103	22	27	10	8	30	519	71	20	7
March 5	488	47	53	18	78	19	22	37	6	6	803	120	15	9
April 19	42	13	16	5	20	18	4	3	47	51	64	19	106	128
May 14	36	7	8	4	17	21	4	3	41	56	65	18	118	170
June 14	121	2	23	3	22	14	10	3	26	29	212	9	78	94
July 23	179	5	48	4	60	15	14	5	18	28	252	6	44	81
August 6	239	73	32	16	52	30	19	12	27	42	229	64	62	98
September 11	112	5	80	8	21	20	8	5	26	52	278	9	66	137
October 11	184	5	29	4	38	18	15	4	32	47	227	11	71	110
November 20	54	2	9	1	14	10	5	2	33	36	62	2	62	69
December 5	123	6	22	3	18	12	9	2	28	37	165	11	56	77

*No Sample — Manhole inaccessible due to snow cover.

(see Figure 6.5). Compared to VOC concentrations in 2000 in Manhole E1, carbon tetrachloride, chloroform, and trichloroethene levels are slightly elevated. These increases, although slight, may be associated with the substantial increase of groundwater extraction from the 317 Area groundwater collection system. Figures 6.6 to 6.12 compare the major VOC concentrations in Manholes E1 and E2. The TCA and DCA levels in both manholes parallel each other (see Figures 6.11 and 6.12).

Radioactive Constituents. Samples collected quarterly from the monitoring wells in the 317 and 319 Areas were analyzed for hydrogen-3, strontium-90, and gamma-ray emitters. An annual sample for alpha emitters was collected from wells 317021, 319032, and 319131D. The results are presented in Tables 6.5 to 6.14. Evidence of possible off-site migration of radionuclides is noted by the low concentrations of hydrogen-3 and strontium-90 in wells located near the south perimeter fence in the 317 and 319 Areas. As in 2000, hydrogen-3 was detected in wells 317021 and 317121D, located south of the 317 Area and was also detected in wells 319031, 319032, and 319131D, which are located near the south 319 Area perimeter fence. The hydrogen-3 levels were well below the WQS (20,000 pCi/L) and ranged from less than 100 to 1,257 pCi/L. It was also detected one quarter at a very low level in upgradient well 317111, and two quarters in upgradient well 317101. The infrequent presence of hydrogen-3 in these upgradient wells may be due to a mounding effect of shallow groundwater from the 317 Area. As in 2000, strontium-90 was detected



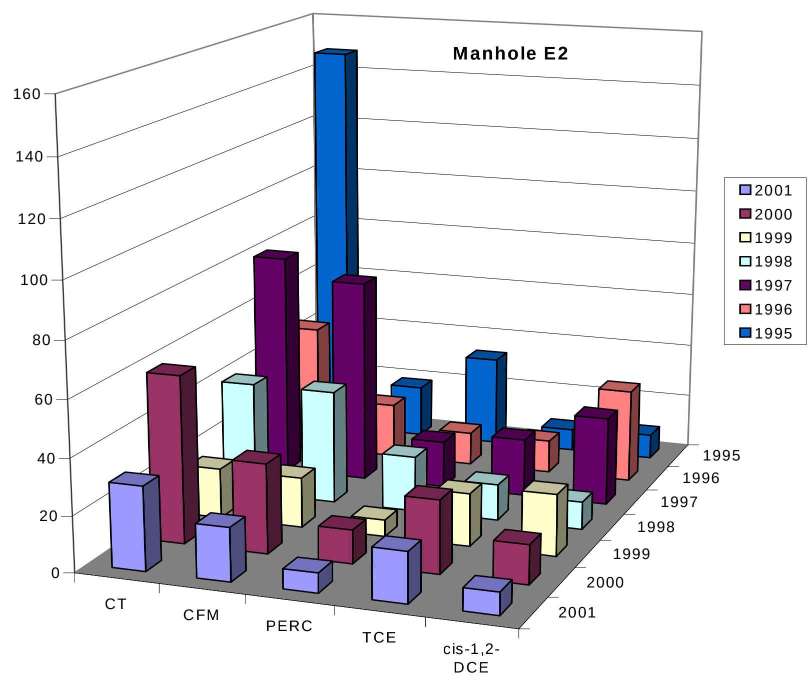


Figure 6.5 Manholes E1 and E2 Average Groundwater Concentrations, 1995 to 2001

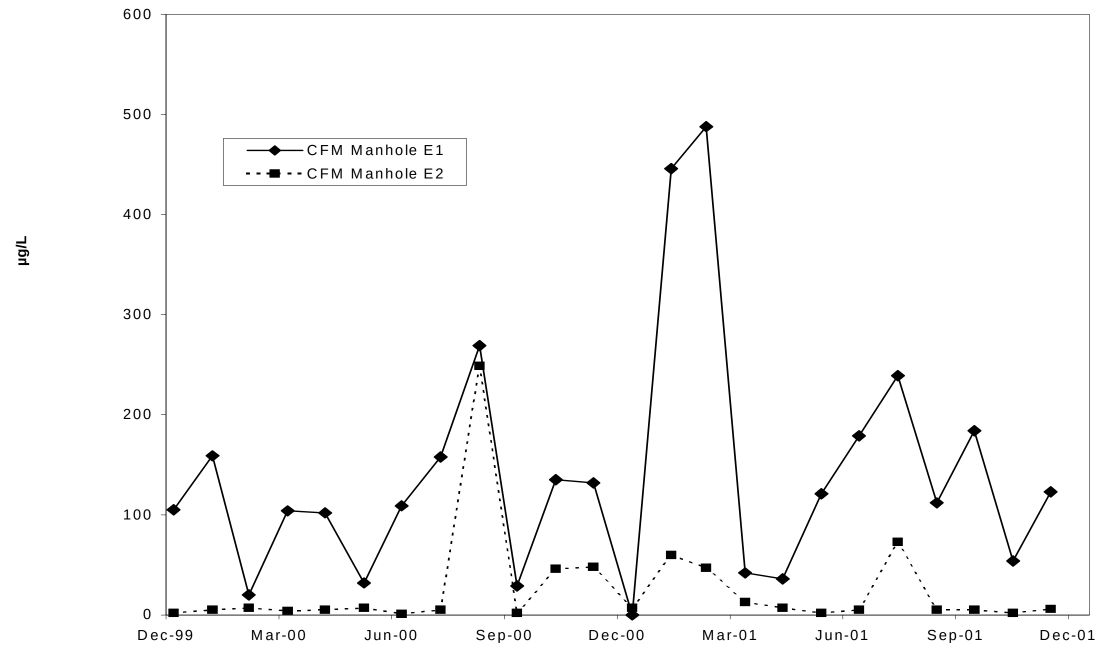


Figure 6.6 Manholes E1 and E2 Chloroform Levels, 2000 to 2001

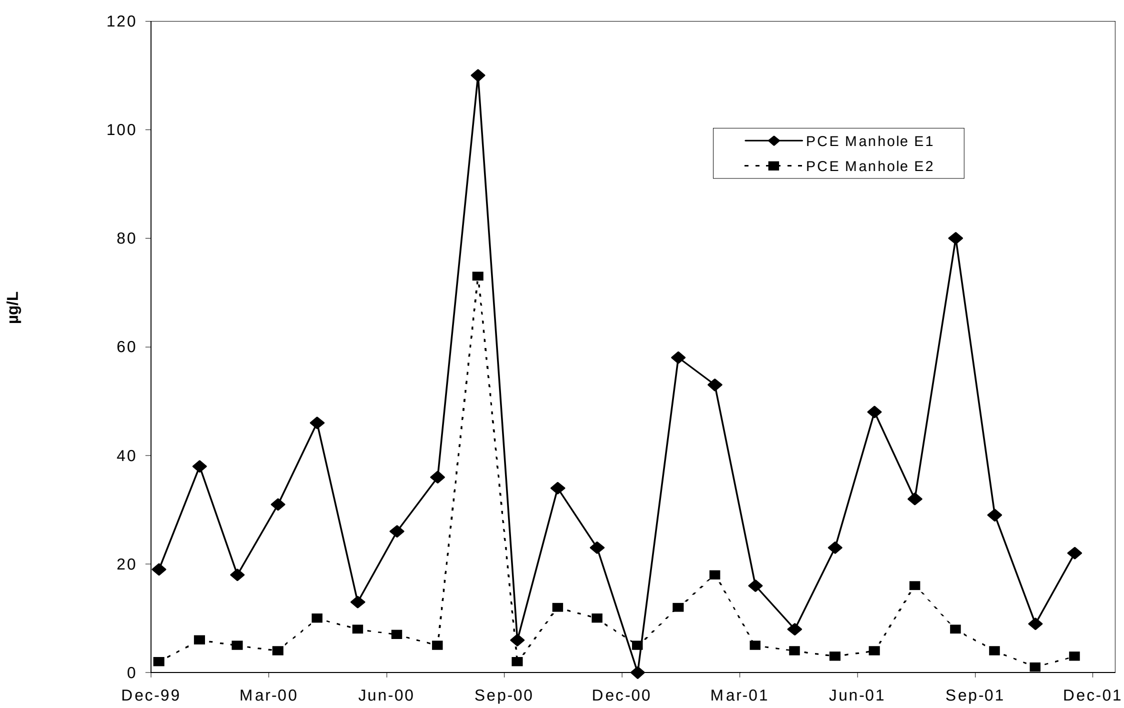


Figure 6.7 Manholes E1 and E2 Tetrachloroethene Levels, 2000 to 2001

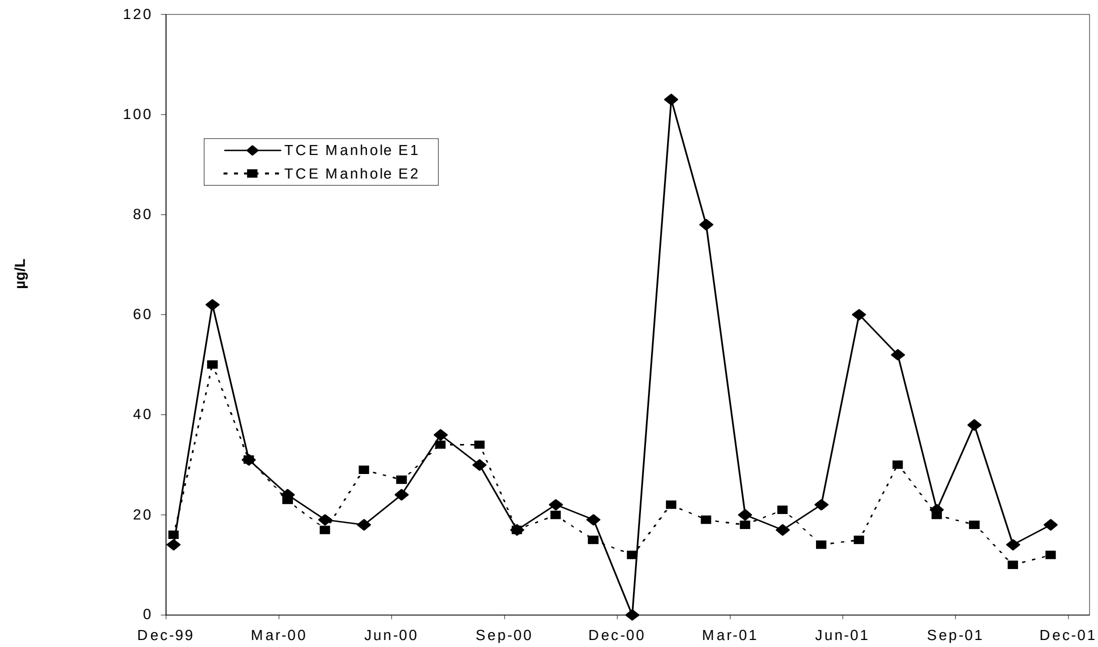


Figure 6.8 Manholes E1 and E2 Trichloroethene Levels, 2000 to 2001

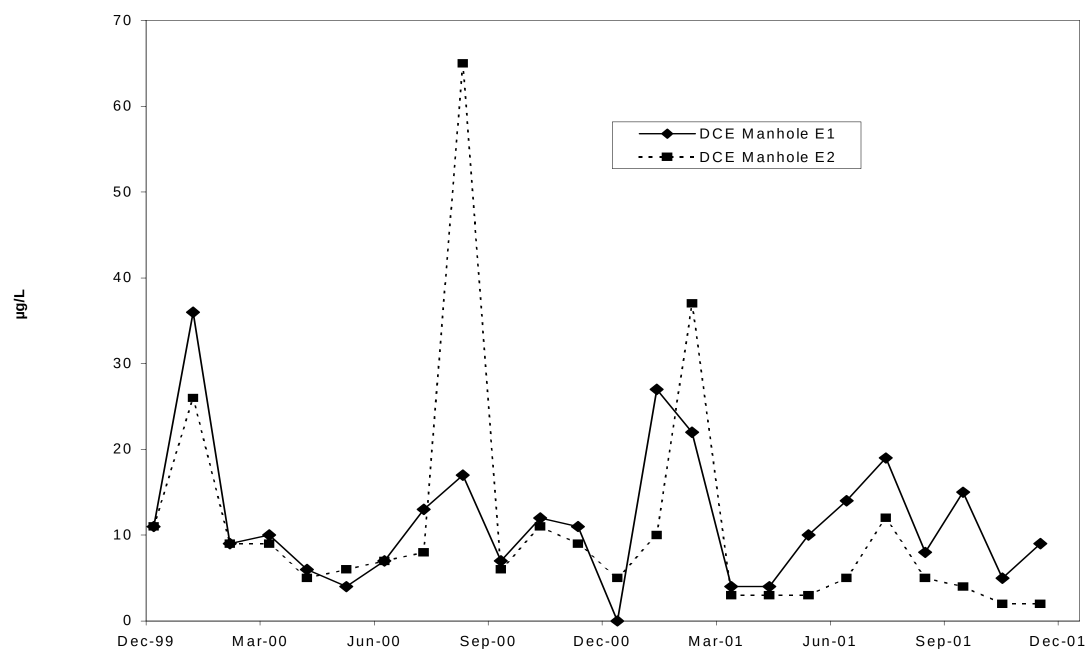


Figure 6.9 Manholes E1 and E2 cis-1,2-Dichloroethene Levels, 2000 to 2001

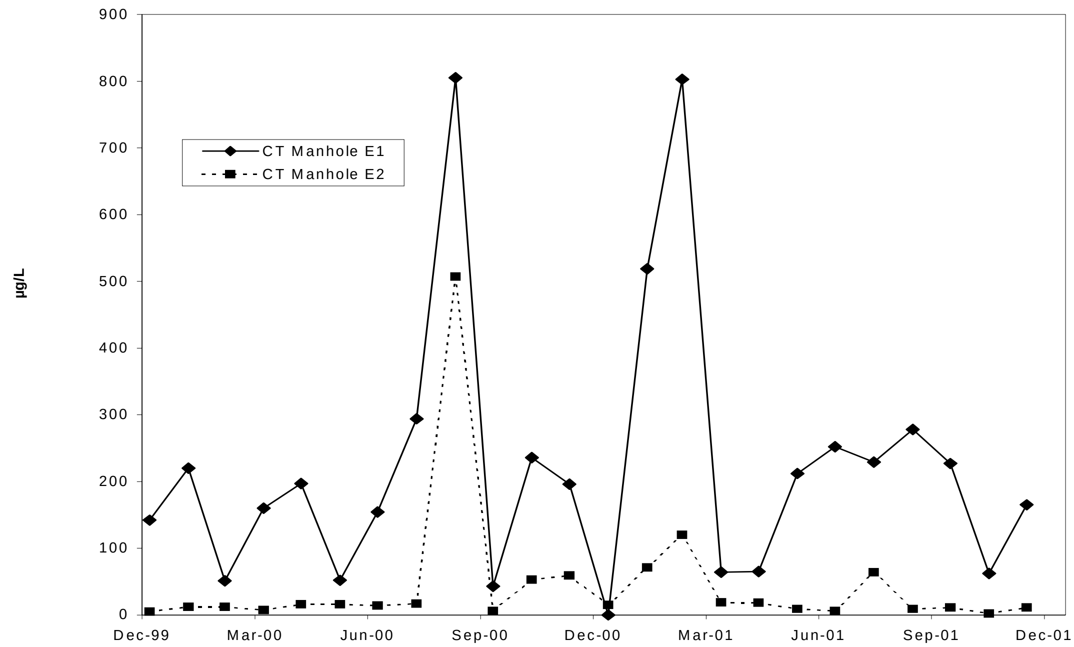


Figure 6.10 Manholes E1 and E2 Carbon Tetrachloride Levels, 2000 to 2001

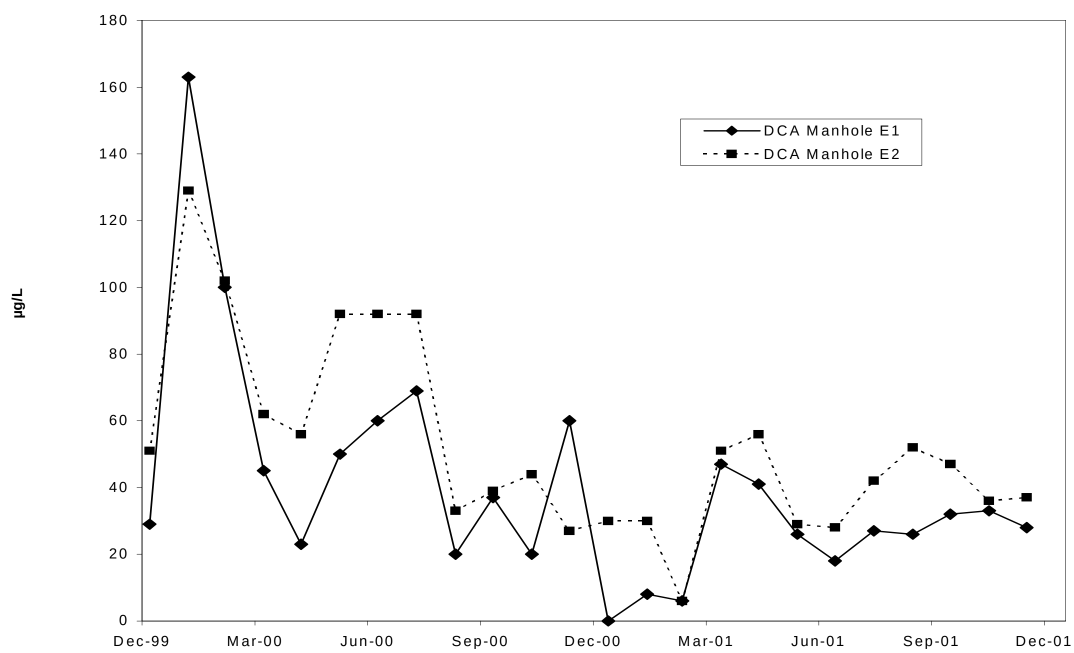


Figure 6.11 Manholes E1 and E2 1,1-Dichloroethane Levels, 2000 to 2001

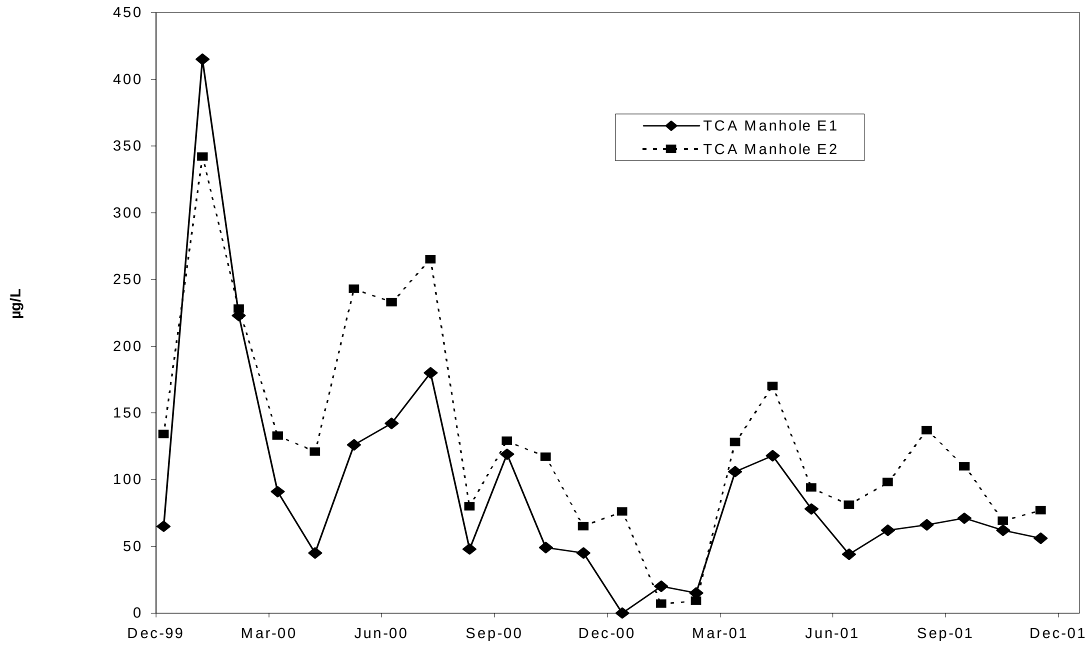


Figure 6.12 Manholes E1 and E2 1,1,1-Trichloroethane Levels, 2000 to 2001

only in well 319031, which is near the south perimeter fence. The strontium-90 level was well below the WQS (8 pCi/L).

Groundwater monitoring for the remedial actions in the 317 and 319 Areas for hydrogen-3 has identified two areas of elevated hydrogen-3. The first area is immediately under and south of the 319 Landfill. Groundwater concentrations as high as 47,400 pCi/L in this vicinity were measured in 2001. These concentrations appear to be decreasing slowly as a result of radioactive decay, as well as removal of contaminated groundwater and leachate by the extraction systems. Downgradient of the 319 Landfill, hydrogen-3 levels are much lower, ranging from about 4,700 pCi/L, 46 m (150 ft) south of the 319 Area, to nondetectable levels closer to the fence line. In the 317 Area, an area of elevated hydrogen-3 exists near the radioactive waste storage vaults. The levels of hydrogen-3 in this area are much lower than in the 319 Area, ranging from 3,500 to 7,000 pCi/L immediately south of the vaults, to 400 to 600 pCi/L at the fence line. All hydrogen-3 levels in the 317 Area monitoring wells are below the IEPA groundwater quality standards. In general, hydrogen-3 levels in the 317 Area appear to be decreasing; however, long-term monitoring of groundwater is needed to confirm this trend.

Water from the 317 Area and 319 Area groundwater collection systems is pumped to manhole 2E. Manhole 1E is connected to the footing drain system around the operating vaults. In addition to VOCs, the manhole water is analyzed for hydrogen-3 and gamma-ray–emitting radionuclides. Table 6.18 gives the hydrogen-3 results. Although the hydrogen-3 concentrations are relatively high, the volume is fairly low. Because hydrogen-3 concentrations are generally higher in manhole 2E, the source of the hydrogen-3 appears to be from the 319 Area groundwater pumping system. No gamma-ray–emitting radionuclides were detected in any samples.

TABLE 6.18

Hydrogen-3 Concentrations in Manhole Water Samples, 2001
(concentrations in pCi/L)

Date Collected	Manhole 1E	Manhole 2E
January 14	-[a]	4,282
February 9	2,063	5,931
March 7	2,687	34,570
April 13	1,369	1,423
May 10	1,394	1,302
June 16	1,572	1,481
July 13	2,121	2,570
August 3	2,119	2,761
September 14	1,766	2,807
October 24	2,030	2,523
November 13	1,322	1,292
December 8	1,177	1,114

[a] A hyphen indicates that no sample was collected.

6.3. Sanitary Landfill

The 800 Area is the site of the ANL-E sanitary landfill. The 8.8-ha (21.8-acre) landfill is located on the western edge of ANL-E property (Figure 1.1). The landfill has received waste since 1966 and was operated under IEPA Permit No. 1981-29-OP, which was issued on September 18, 1981. The landfill received general refuse, construction debris, boiler house ash, and other nonradioactive solid waste until September 1992. The landfill is now being closed pursuant to Permit No. 1992-002-SP and Supplemental Permit Nos. 1994-506-SP, 1997-295-SP, 1998-017-SP, 1999-107-SP, and 1999-476-SP.

6.3.1. French Drain

The landfill area was used for the disposal of certain types of liquid wastes from 1969 to 1978. The wastes were poured into a French drain that consisted of a corrugated steel pipe placed in a gravel-filled pit dug into an area previously filled with waste. The liquid waste was poured into the drain and allowed to permeate into the gravel, and thence into the soil and fill material. Available documentation indicates that 109,000 L (29,000 gal) of liquid waste was placed in this drain. Most of this material was used oil or used machining coolant (oil water emulsion). Some of the wastes disposed of in this manner would currently be defined as hazardous wastes. The presence of volatile and other toxic organic compounds has been confirmed by extensive characterization activities conducted at the landfill. Measurable amounts of these materials were identified in leachate but not in groundwater near the landfill.

6.3.2. Monitoring Studies

During October 1992, 15 stainless-steel wells, 800161 through 800203D, were installed around the landfill as part of the IEPA-approved closure plan. Wells 800172 and 800182 are consistently dry. The 13 active wells are required to be monitored as part of the IEPA-approved groundwater monitoring program, effective January 1995. These wells are set in five clusters; each cluster consists of a shallow, medium, and deep well (see Figure 6.13 and Table 6.19).

In late spring of 1999, an environmental remediation project was completed that resulted in the extension of the north portion of the landfill to cover some recently identified waste material. As part of this project, the landfill cap, perimeter road and fence were moved 15 m (50 ft) north, and monitoring wells 800161, 800162, and 800163D were also relocated. The sampling of the replacement wells — 800381, 800382, and 800383D — commenced in July 1999.

IEPA Supplemental Permit No. 1999-107-SP, effective June 16, 1999, provided for (1) the installation and addition of three new upgradient groundwater monitoring wells, 800271, 800272, and 800273D; and (2) the addition of 10 new downgradient groundwater monitoring wells (800281, 800291, 800301, 800311, 800321, 800331, 800341, 800351, 800361, and 800371). Sampling of these wells commenced in October 1999. Table 6.19 provides information on these wells, and Figure 6.13 shows their locations. Wells 800272 and 800311 have been dry since installation.

6.3.2.1. Sample Collection

The same procedure for well water sample collection previously described for the 300 Area was used for this area. Each well is sampled annually for semivolatiles, PCBs, pesticides, and herbicides. Also, during the second quarter, in accordance with the IEPA-approved groundwater monitoring plan, both filtered and unfiltered samples for numerous parameters (e.g., metals, chloride, sulfate) are required. Volatile organics are monitored each quarter, although only required by permit during the second quarter.

6.3.2.2. Sample Analyses - 800 Area

The 800 Area sample analyses were performed using SOPs written, reviewed, and issued as controlled documents by members of the PFS-Utilities Laboratory and CMT/ESH-AC. These SOPs reference protocols in SW-846.[6] Fifteen metals were routinely determined and analyzed by using inductively coupled plasma atomic emission spectroscopy and graphite furnace atomic absorption spectroscopy. Mercury was determined by cold vapor atomic absorption spectroscopy. VOCs were determined by using a purge and trap sample pretreatment, followed by gas chromatography-mass spectroscopy detection. SVOCs were determined by solvent extraction

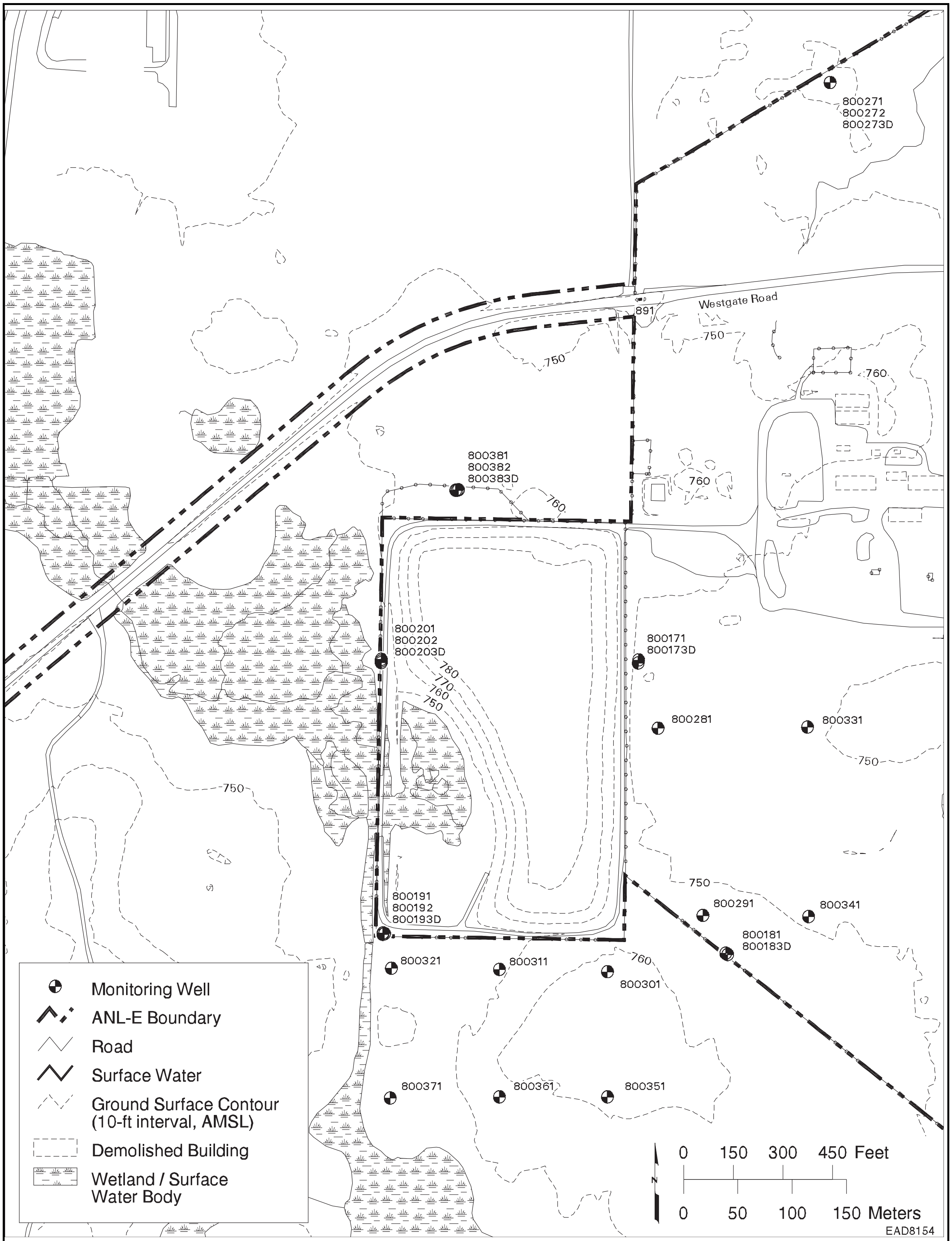


Figure 6.13 Active Monitoring Wells in the 800 Area Landfill

TABLE 6.19

Groundwater Monitoring Wells: 800 Area Landfill

ID Number[a]	Well Depth (m bgs)	Ground Elevation (m AMSL)	Monitoring Zone (m AMSL)	Well Type[b]	Date Drilled
800171	7.71	228.4	222.2–220.7	0.05/SS	10/92
800173D	39.08	228.4	192.4–189.3	0.05/SS	10/92
800181	11.01	230.5	221.0–219.5	0.05/SS	10/92
800183D	49.68	230.4	183.7–180.7	0.05/SS	10/92
800191	4.62	227.4	224.3–222.8	0.05/SS	10/92
800192	18.67	227.4	210.2–208.7	0.05/SS	10/92
800193D	45.48	227.4	185.0–181.9	0.05/SS	10/92
800201	10.74	227.9	218.7–217.2	0.05/SS	10/92
800202	18.52	227.9	210.9–209.4	0.05/SS	10/92
800203D	38.47	227.9	192.5–189.5	0.05/SS	9/92
800271	3.98	225.7	224.0–222.5	0.05/SS	8/99
800272	13.77	225.7	214.2–212.7	0.05/SS	8/99
800273D	36.72	225.7	192.8–189.7	0.05/SS	8/99
800281	3.98	227.7	226.2–224.6	0.05/SS	9/99
800291	7.34	230.5	225.5–224.0	0.05/SS	9/99
800301	7.04	232.6	227.7–226.2	0.05/SS	9/99
800311	12.85	227.5	218.5–215.4	0.05/SS	9/99
800321	3.67	228.0	227.4–225.9	0.05/SS	9/99
800331	5.20	228.0	225.2–223.7	0.05/SS	9/99
800341	3.67	230.0	228.6–227.1	0.05/SS	9/99
800351	11.63	232.8	225.2–222.2	0.05/SS	9/99
800361	7.04	227.6	222.8–221.3	0.05/SS	9/99
800371	9.79	227.6	220.0–218.5	0.05/SS	9/99
800381[c]	7.65	231.2	226.8–225.2	0.05/SS	6/99
800382[c]	19.89	231.2	214.5–213.0	0.05/SS	6/99
800383D[c]	44.38	231.3	190.0–188.5	0.05/SS	6/99

[a] Wells identified by a "D" are deeper wells monitoring the dolomite bedrock aquifer.

[b] Inner diameter (m)/well material (SS = stainless steel).

[c] Replacement wells used after July 1, 1999.

followed by gas chromatography-mass spectroscopy detection. PCBs and pesticides were determined by solvent extraction followed by gas chromatography-electron capture detection. In the case of organic compound analyses, efforts were made to identify compounds that were present but not included on the method list. This was accomplished, and standard solutions of these compounds were prepared and analyzed. TDS were determined gravimetrically. Sulfate determination was performed by using a turbidimetric technique, while chloride was determined by titrimetry. Ammonia nitrogen was determined by using distillation followed by an ion-selective electrode technique.

Some analyses were performed at an off-site contractor laboratory. SW-846[6] procedures were specified and used. Cyanide and phenol were determined by distillation followed by a spectrophotometric measurement. Total organic carbon (TOC) and total organic halogen (TOX) were determined by combustion techniques followed by infrared detection and coulometric titration, respectively. Chlorinated organic compounds and carbamate pesticides were analyzed by extractions followed by gas and liquid chromatography techniques, respectively.

The 800 Area groundwater radiological analyses were performed using SOPs written, reviewed, and issued as controlled documents by members of CMT/ESH-AC. Hydrogen-3 was determined by distillation followed by a beta liquid scintillation counting technique.

6.3.2.3. Results of Analyses

Descriptions of each well, field parameters measured during sample collection, and the results of chemical and radiological analysis of samples from the wells in the 800 Area are presented in Tables 6.20 to 6.43. All radiological and inorganic analysis results are shown in these tables. The analytical methods used for organic compounds could identify and quantify all the compounds contained in the CLP Target Compound List. However, the vast majority of these compounds were not detected in the samples. Only those constituents that were present in amounts great enough to quantify are shown. The detection limits for the organic compounds listed were typically 1 to 5 μg/L. Figures 6.14 to 6.27 show the trends for exceedances of the WQS for wells monitored as part of the IEPA-approved groundwater monitoring program for the sanitary landfill. Results represent filtered samples only because filtered samples were collected each quarter for the constituents presented.

ANL-E chose a conservative approach for evaluating the inorganic monitoring results by selecting as the standard of comparison the Illinois Groundwater Quality Standards for Class I: Potable Resource Groundwater, 35 IAC Part 620.410. The most common constituents at levels above the WQS (see Table 6.15) are chloride, iron, TDS, and manganese. This is consistent with results reported in prior years using the pre-IEPA–approved routine well monitoring network. In general, data for the shallow wells indicate exceedances of the manganese, TDS, sulfate, and chloride WQSs in a number of wells. These results are consistent with results reported in prior years. Chromium and

TABLE 6.20

Groundwater Monitoring Results, Sanitary Landfill Well 800381, 2001

		Date of Sampling			
Parameter	Unit	01/08/01	04/10/01	07/10/01	10/16/01
Water elevation[a]	m	227.36	229.08	227.44	227.07
Temperature	°C	11.5	9.8	11.7	12.4
pH	pH	7.09	6.78	6.89	6.84
Redox	mV	12	19	12	16
Conductivity	µmhos/cm	1,090	1,039	1,135	1,596
Chloride[b]	mg/L	60	60	56	41
Sulfate[b]	mg/L	404	323	409	398
TDS[b]	mg/L	1,242	1,126	1,352	1,277
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.0898	-	-
Barium[c]	mg/L	-	0.1963	-	-
Boron[c]	mg/L	-	0.3169	-	-
Cadmium[c]	mg/L	-	0.0006	-	-
Chromium[c]	mg/L	-	0.077	-	-
Cobalt[c]	mg/L	-	0.0336	-	-
Copper[c]	mg/L	-	0.1395	-	-
Iron[c]	mg/L	-	100.9	-	-
Lead[c]	mg/L	-	0.0666	-	-
Manganese[c]	mg/L	-	1.67	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-
Nickel[c]	mg/L	-	0.0998	-	-
Selenium[c]	mg/L	-	< 0.002	-	-
Silver[c]	mg/L	-	< 0.0005	-	-
Zinc[c]	mg/L	-	0.5916	-	-
Ammonia nitrogen[b]	mg/L	< 0.1	< 0.1	< 0.1	< 0.5
Arsenic[b]	mg/L	0.0120	0.0059	0.0033	< 0.0030
Barium[b]	mg/L	0.0394	0.0503	0.0352	0.0281
Beryllium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.017	< 0.015	< 0.015
Iron[b]	mg/L	0.8267	0.1018	0.1239	0.0864
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.1285	0.1209	0.8612	0.4578
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.02	< 0.02
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0018	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	0.0131	0.0116	< 0.008
Nitrate[c]	mg/L	-	< 0.1	-	-
Phenols[c]	mg/L	< 0.005	0.010	< 0.005	< 0.005
Cesium-137[c]	pCi/L	-	< 2.0	-	-
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	-	62	-	-
Fluoride[c]	mg/L	-	0.194	-	-
Sulfate[c]	mg/L	-	327	-	-
TOCs[c]	mg/L	3.4	3.5	3.4	4.1
TOCs[c]	mg/L	3.4	3.5	3.4	4.1
TOCs[c]	mg/L	3.3	3.5	3.5	4.0
TOCs[c]	mg/L	3.3	3.5	3.4	4.0
TOXs[c]	mg/L	0.029	0.027	0.022	0.036
TOXs[c]	mg/L	0.019	0.033	0.027	0.025
Acetone[c]	µg/L	< 1	< 1	5	< 1
Methylene chloride[c]	µg/L	< 1	< 1	1	< 1

[a] Well point elevation = 225.20 m (MSL); ground surface elevation = 232.00 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A hyphen indicates that no samples were collected.

TABLE 6.21

Groundwater Monitoring Results, Sanitary Landfill Well 800382, 2001

		Date of Sampling				
Parameter	Unit	01/08/01	04/10/01	07/10/01	07/10/01	10/16/01
Water elevation[a]	m	219.24	219.82	219.43	219.43	219.00
Temperature	°C	6.4	12.1	15.4	15.4	10.4
pH	pH	6.84	6.93	7.43	7.43	6.87
Redox	mV	22	3	-8	-8	9
Conductivity	µmhos/cm	1,005	922	1,022	1,022	985
Chloride[b]	mg/L	82	90	89	87	86
Sulfate[b]	mg/L	61	65	65	68	69
TDS[b]	mg/L	642	683	693	684	704
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	0.32	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.0089	-	-	-
Barium[c]	mg/L	-	0.2363	-	-	-
Boron[c]	mg/L	-	0.2166	-	-	-
Cadmium[c]	mg/L	-	0.0005	-	-	-
Chromium[c]	mg/L	-	0.0857	-	-	-
Cobalt[c]	mg/L	-	< 0.026	-	-	-
Copper[c]	mg/L	-	0.0722	-	-	-
Iron[c]	mg/L	-	64.56	-	-	-
Lead[c]	mg/L	-	0.037	-	-	-
Manganese[c]	mg/L	-	1.177	-	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-	-
Nickel[c]	mg/L	-	0.0863	-	-	-
Selenium[c]	mg/L	-	< 0.002	-	-	-
Silver[c]	mg/L	-	< 0.0005	-	-	-
Zinc[c]	mg/L	-	0.2057	-	-	-
Ammonia nitrogen[b]	mg/L	0.5	0.6	0.4	0.4	< 0.5
Arsenic[b]	mg/L	0.0024	0.0025	< 0.0030	< 0.0030	< 0.0030
Barium[b]	mg/L	0.1305	0.1229	0.1037	0.1008	0.0983
Beryllium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.017	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	0.0531	< 0.0370	0.1759	0.0382	1.4890
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.1109	0.1001	0.1056	0.0982	0.0919
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.02	< 0.02	< 0.02
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0010	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0018	< 0.0020	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.008	< 0.008	< 0.008
Nitrate[c]	mg/L	-	< 0.1	-	-	-
Phenols[c]	mg/L	0.0063	< 0.005	< 0.005	0.0067	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	-	91	-	-	-
Fluoride[c]	mg/L	-	0.23	-	-	-
Sulfate[c]	mg/L	-	67	-	-	-
TOCs[c]	mg/L	2.7	3.6	2.4	2.4	2.7
TOCs[c]	mg/L	2.6	4.0	2.4	2.4	2.8
TOCs[c]	mg/L	2.6	3.9	2.8	2.5	2.8
TOCs[c]	mg/L	2.7	3.6	2.5	2.6	2.7
TOXs[c]	mg/L	0.024	0.015	0.026	0.022	0.039
TOXs[c]	mg/L	0.026	0.014	0.024	0.033	0.018
Methylene chloride[c]	µg/L	< 1	< 1	1	1	< 1

[a] Well point elevation = 213.00 m (MSL); ground surface elevation = 232.10 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A hyphen indicates that no samples were collected.

TABLE 6.22

Groundwater Monitoring Results, Sanitary Landfill Well 800383D, 2001

		Date of Sampling				
Parameter	Unit	01/08/01	01/08/01	04/10/01	07/10/01	10/16/01
Water elevation[a]	m	192.65	192.65	193.04	192.98	192.92
Temperature	°C	9.7	9.7	11.6	12.8	11.3
pH	pH	6.76	6.76	7.21	7.28	7.08
Redox	mV	27	27	-3	-7	0
Conductivity	µmhos/cm	1,270	1,270	1,133	1,280	1,222
Chloride[b]	mg/L	119	117	124	132	135
Sulfate[b]	mg/L	140	138	140	167	159
TDS[b]	mg/L	845	848	837	914	935
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	-	0.0049	-	-
Barium[c]	mg/L	-	-	0.0833	-	-
Boron[c]	mg/L	-	-	0.1889	-	-
Cadmium[c]	mg/L	-	-	< 0.0001	-	-
Chromium[c]	mg/L	-	-	< 0.044	-	-
Cobalt[c]	mg/L	-	-	< 0.026	-	-
Copper[c]	mg/L	-	-	< 0.017	-	-
Iron[c]	mg/L	-	-	8.133	-	-
Lead[c]	mg/L	-	-	0.004	-	-
Manganese[c]	mg/L	-	-	0.2318	-	-
Mercury[c]	mg/L	-	-	< 0.0001	-	-
Nickel[c]	mg/L	-	-	< 0.04	-	-
Selenium[c]	mg/L	-	-	< 0.002	-	-
Silver[c]	mg/L	-	-	< 0.0005	-	-
Zinc[c]	mg/L	-	-	0.0372	-	-
Ammonia nitrogen[b]	mg/L	0.8	0.8	0.8	0.8	0.7
Arsenic[b]	mg/L	< 0.0015	0.0015	0.0015	< 0.0030	< 0.0030
Barium[b]	mg/L	0.0700	0.0712	0.0714	0.0600	0.0634
Beryllium[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.044	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.015	< 0.015
Iron[b]	mg/L	1.4540	1.3950	1.0640	0.5303	1.5540
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0532	0.0503	0.0496	0.0456	0.0480
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.04	< 0.02	< 0.02
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0018	< 0.0018	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.011	< 0.008	< 0.008
Nitrate[c]	mg/L	-	-	< 0.1	-	-
Phenols[c]	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	-	-	129	-	-
Fluoride[c]	mg/L	-	-	0.336	-	-
Sulfate[c]	mg/L	-	-	144	-	-
TOCs[c]	mg/L	1.4	1.3	1.6	1.4	1.5
TOCs[c]	mg/L	1.4	1.3	1.6	1.4	1.5
TOCs[c]	mg/L	1.3	1.3	1.6	1.4	1.5
TOCs[c]	mg/L	1.3	1.3	1.6	1.6	1.5
TOXs[c]	mg/L	0.019	< 0.010	0.030	0.018	0.018
TOXs[c]	mg/L	0.022	0.026	0.015	0.018	0.041
Acetone[c]	µg/L	<1	< 1	< 1	5	< 1
Methylene chloride[c]	µg/L	< 1	< 1	< 1	1	< 1

[a] Well point elevation = 188.50 m (MSL); ground surface elevation = 232.20 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A hyphen indicates that no samples were collected.

TABLE 6.23

Groundwater Monitoring Results, Sanitary Landfill Well 800171, 2001

		Date of Sampling			
Parameter	Unit	01/09/01	04/17/01	07/09/01	10/23/01
Water elevation[a]	m	225.94	226.66	225.51	227.17
Temperature	°C	10.4	10.8	12.1	13.2
pH	pH	6.90	7.02	6.83	6.81
Redox	mV	21	7	17	16
Conductivity	µmhos/cm	1,099	1,052	1,260	1,204
Chloride[b]	mg/L	16	14	17	12
Sulfate[b]	mg/L	175	173	119	121
Total Dissolved Solids[b]	mg/L	803	770	809	750
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.0196	-	-
Barium[c]	mg/L	-	0.7489	-	-
Boron[c]	mg/L	-	0.66	-	-
Cadmium[c]	mg/L	-	0.0012	-	-
Chromium[c]	mg/L	-	0.1531	-	-
Cobalt[c]	mg/L	-	0.0907	-	-
Copper[c]	mg/L	-	0.1899	-	-
Iron[c]	mg/L	-	214.7	-	-
Lead[c]	mg/L	-	0.0741	-	-
Manganese[c]	mg/L	-	4.102	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-
Nickel[c]	mg/L	-	0.2121	-	-
Selenium[c]	mg/L	-	< 0.002	-	-
Silver[c]	mg/L	-	< 0.0005	-	-
Zinc[c]	mg/L	-	0.5272	-	-
Ammonia nitrogen[b]	mg/L	< 0.1	< 0.1	< 0.1	< 0.1
Arsenic[b]	mg/L	< 0.0015	< 0.0015	< 0.0030	< 0.0030
Barium[b]	mg/L	0.0660	0.0554	0.0609	0.0599
Beryllium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.017	< 0.015	< 0.015
Iron[b]	mg/L	< 0.037	< 0.037	< 0.020	< 0.020
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.3097	0.2051	0.2399	0.1957
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.02	< 0.02
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0018	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.008	< 0.008
Nitrate[c]	mg/L	-	0.42	-	-
Phenols[c]	mg/L	< 0.005	< 0.005	< 0.005	< 0.005
Cesium-137[c]	pCi/L	-	< 2.0	-	-
Hydrogen-3[c]	pCi/L	110	< 100	< 100	< 100
Chloride[c]	mg/L	-	16	-	-
Fluoride[c]	mg/L	-	0.206	-	-
Sulfate[c]	mg/L	-	188	-	-
TOCs[c]	mg/L	2.5	2.7	2.1	2.6
TOCs[c]	mg/L	2.4	2.7	2.2	2.6
TOCs[c]	mg/L	2.3	2.7	2.2	2.7
TOCs[c]	mg/L	2.5	2.7	2.2	2.8
TOXs[c]	mg/L	0.015	0.028	0.016	0.021
TOXs[c]	mg/L	0.022	0.039	0.020	0.021
Chloroethane[c]	µg/L	< 1	< 1	1	< 1
Methylene chloride[c]	µg/L	< 1	< 1	1	< 1
Trichloroethlene[c]	µg/L	1	< 1	< 1	< 1

[a] Well point elevation = 220.71 m (MSL); ground surface elevation = 228.42 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A hyphen indicates that no samples were collected.

TABLE 6.24

Groundwater Monitoring Results, Sanitary Landfill Well 800173D, 2001

		Date of Sampling				
Parameter	Unit	01/09/01	04/17/01	07/09/01	10/22/01	10/23/01
Water elevation[a]	m	191.88	192.12	192.26	192.45	192.45
Temperature	°C	11.3	11.4	13.8	12.6	12.6
pH	pH	7.10	7.21	7.05	6.93	6.93
Redox	mV	10	-4	-	10	10
Conductivity	µmhos/cm	1,160	1,149	1,448	1,615	1,615
Chloride[b]	mg/L	137	132	197	247	241
Sulfate[b]	mg/L	85	98	139	140	140
TDS[b]	mg/L	828	900	1,029	977	907
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.0029	-	-	-
Barium[c]	mg/L	-	0.0781	-	-	-
Boron[c]	mg/L	-	0.1683	-	-	-
Cadmium[c]	mg/L	-	< 0.0001	-	-	-
Chromium[c]	mg/L	-	< 0.044	-	-	-
Cobalt[c]	mg/L	-	< 0.026	-	-	-
Copper[c]	mg/L	-	< 0.017	-	-	-
Iron[c]	mg/L	-	2.467	-	-	-
Lead[c]	mg/L	-	< 0.002	-	-	-
Manganese[c]	mg/L	-	0.0853	-	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-	-
Nickel[c]	mg/L	-	< 0.04	-	-	-
Selenium[c]	mg/L	-	< 0.002	-	-	-
Silver[c]	mg/L	-	< 0.0005	-	-	-
Zinc[c]	mg/L	-	0.0197	-	-	-
Ammonia nitrogen[b]	mg/L	0.8	0.9	1.0	1.0	1.0
Arsenic[b]	mg/L	0.0020	0.0024	< 0.0030	< 0.0030	< 0.0030
Barium[b]	mg/L	0.0817	0.0766	0.0825	0.0794	0.0865
Beryllium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.017	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	0.227	1.244	1.224	1.673	1.538
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0874	0.0662	0.0706	0.0693	0.0687
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.0400	< 0.0400	< 0.0200	0.0204	0.0210
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0010	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0018	< 0.0020	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.008	< 0.008	< 0.008
Nitrate[c]	mg/L	-	< 0.1	-	-	-
Phenols[c]	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	-	131	-	-	-
Fluoride[c]	mg/L	-	0.366	-	-	-
Sulfate[c]	mg/L	-	100	-	-	-
TOCs[c]	mg/L	2.7	2.4	3.4	5.4	5.4
TOCs[c]	mg/L	2.8	2.3	3.4	5.4	5.4
TOCs[c]	mg/L	2.7	2.4	3.3	5.5	5.5
TOCs[c]	mg/L	2.6	2.4	3.3	5.4	5.5
TOXs[c]	mg/L	0.024	0.027	0.016	0.120	0.021
TOXs[c]	mg/L	0.034	0.019	0.036	0.170	0.015
Methylene chloride	µg/L	< 1	< 1	1	< 1	< 1

[a] Well point elevation = 189.34 m (MSL); ground surface elevation = 228.42 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A hyphen indicates that no samples were collected.

TABLE 6.25

Groundwater Monitoring Results, Sanitary Landfill Well 800181, 2001

		Date of Sampling			
Parameter	Unit	01/17/01	04/18/01	07/09/01	10/29/01
Water elevation[a]	m	228.41	229.47	222.66	224.02
Temperature	°C	9.2	9.9	11.3	10.2
pH	pH	7.62	8.04	7.88	7.70
Redox	mV	-30	-51	-43	-34
Conductivity	µmhos/cm	967	624	878	1,293
Chloride[b]	mg/L	7	8	6	6
Sulfate[b]	mg/L	190	173	97	101
TDS[b]	mg/L	705	446	559	772
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.0201	-	-
Barium[c]	mg/L	-	0.6485	-	-
Boron[c]	mg/L	-	0.4274	-	-
Cadmium[c]	mg/L	-	0.0005	-	-
Chromium[c]	mg/L	-	0.1174	-	-
Cobalt[c]	mg/L	-	0.1092	-	-
Copper[c]	mg/L	-	0.119	-	-
Iron[c]	mg/L	-	140.2	-	-
Lead[c]	mg/L	-	0.0621	-	-
Manganese[c]	mg/L	-	3.366	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-
Nickel[c]	mg/L	-	0.1606	-	-
Selenium[c]	mg/L	-	< 0.002	-	-
Silver[c]	mg/L	-	< 0.0005	-	-
Zinc[c]	mg/L	-	0.3433	-	-
Ammonia nitrogen[b]	mg/L	< 0.1	< 0.1	< 0.1	< 0.5
Arsenic[b]	mg/L	0.0053	0.0045	0.0037	0.0048
Barium[b]	mg/L	0.0193	< 0.0180	0.0193	0.0314
Beryllium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.017	< 0.015	< 0.015
Iron[b]	mg/L	< 0.0370	0.0483	< 0.0200	< 0.0200
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.017	< 0.017	< 0.010	< 0.010
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.02	< 0.02
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0018	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.008	< 0.008
Nitrate[c]	mg/L	-	< 0.1	-	-
Phenols[c]	mg/L	0.005	< 0.005	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	-	9	-	-
Fluoride[c]	mg/L	-	0.256	-	-
Sulfate[c]	mg/L	-	169	-	-
TOCs[c]	mg/L	1.7	2.5	1.9	2.3
TOCs[c]	mg/L	1.7	2.5	1.9	2.4
TOCs[c]	mg/L	1.6	2.7	2.0	2.4
TOCs[c]	mg/L	1.7	2.6	1.9	2.4
TOXs[c]	mg/L	0.017	0.048	0.010	0.015
TOXs[c]	mg/L	0.014	0.029	< 0.010	0.027
Acetone	µg/L	< 1	2	< 1	< 1
Methylene chloride	µg/L	< 1	< 1	1	< 1

[a] Well point elevation = 219.52 m (MSL); ground surface elevation = 230.52 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A hyphen indicates that no samples were collected.

TABLE 6.26

Groundwater Monitoring Results, Sanitary Landfill Well 800183D, 2001

		Date of Sampling			
Parameter	Unit	01/17/01	04/18/01	07/09/01	10/29/01
Water elevation[a]	m	191.85	192.18	192.25	192.23
Temperature	°C	9.5	11.4	14.0	11.1
pH	pH	7.48	7.55	7.74	7.42
Redox	mV	-17	-25	-35	-18
Conductivity	µmhos/cm	1,132	1,134	1,247	1,323
Chloride[b]	mg/L	116	122	122	125
Sulfate[b]	mg/L	179	200	162	163
TDS[b]	mg/L	814	832	859	802
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.0018	-	-
Barium[c]	mg/L	-	0.0443	-	-
Boron[c]	mg/L	-	0.1683	-	-
Cadmium[c]	mg/L	-	< 0.0001	-	-
Chromium[c]	mg/L	-	< 0.044	-	-
Cobalt[c]	mg/L	-	< 0.026	-	-
Copper[c]	mg/L	-	< 0.017	-	-
Iron[c]	mg/L	-	0.7132	-	-
Lead[c]	mg/L	-	< 0.002	-	-
Manganese[c]	mg/L	-	< 0.017	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-
Nickel[c]	mg/L	-	< 0.04	-	-
Selenium[c]	mg/L	-	< 0.002	-	-
Silver[c]	mg/L	-	< 0.0005	-	-
Zinc[c]	mg/L	-	0.1449	-	-
Ammonia nitrogen[b]	mg/L	0.9	1.0	1.0	0.89
Arsenic[b]	mg/L	0.0083	< 0.0015	< 0.0030	< 0.0030
Barium[b]	mg/L	0.0448	0.0439	0.0454	0.0485
Beryllium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.017	< 0.015	< 0.015
Iron[b]	mg/L	0.4877	0.4522	0.5760	0.3827
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0189	< 0.0170	0.0125	0.0131
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.02	< 0.02
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0018	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.008	< 0.008
Nitrate[c]	mg/L	-	< 0.1	-	-
Phenols[c]	mg/L	0.042	< 0.005	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	-	119	-	-
Fluoride[c]	mg/L	-	0.352	-	-
Sulfate[c]	mg/L	-	204	-	-
TOCs[c]	mg/L	2.6	2.4	2.0	2.1
TOCs[c]	mg/L	2.6	2.3	2.1	2.2
TOCs[c]	mg/L	2.4	2.3	2.0	2.2
TOCs[c]	mg/L	2.6	2.3	2.1	2.2
TOXs[c]	mg/L	0.030	0.020	0.028	0.031
TOXs[c]	mg/L	0.038	0.018	0.025	0.021
Acetone[c]	µg/L	< 1	4	< 1	< 1

[a] Well point elevation = 180.69 m (MSL); ground surface elevation = 230.37 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A hyphen indicates that no samples were collected.

TABLE 6.27

Groundwater Monitoring Results, Sanitary Landfill Well 800191, 2001

		Date of Sampling				
Parameter	Unit	01/12/01	04/03/01	07/18/01	10/15/01	10/15/01
Water elevation[a]	m	225.41	224.91	224.76	225.91	225.91
Temperature	°C	9.8	8.2	11.3	12.4	12.4
pH	pH	7.04	6.56	6.57	6.67	6.67
Redox	mV	-28	37	21	23	23
Conductivity	µmhos/cm	1,733	1,226	1,420	1,650	1,650
Chloride[b]	mg/L	244	156	119	237	237
Sulfate[b]	mg/L	198	185	368	371	363
TDS[b]	mg/L	1,094	1,449	1,232	1,176	1,202
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.003	-	-	-
Barium[c]	mg/L	-	0.1944	-	-	-
Boron[c]	mg/L	-	0.1417	-	-	-
Cadmium[c]	mg/L	-	0.0003	-	-	-
Chromium[c]	mg/L	-	< 0.044	-	-	-
Cobalt[c]	mg/L	-	< 0.026	-	-	-
Copper[c]	mg/L	-	0.0226	-	-	-
Iron[c]	mg/L	-	32.03	-	-	-
Lead[c]	mg/L	-	0.0144	-	-	-
Manganese[c]	mg/L	-	1.91	-	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-	-
Nickel[c]	mg/L	-	< 0.04	-	-	-
Selenium[c]	mg/L	-	< 0.002	-	-	-
Silver[c]	mg/L	-	< 0.0005	-	-	-
Zinc[c]	mg/L	-	0.0799	-	-	-
Ammonia nitrogen[b]	mg/L	0.6	0.7	0.8	< 0.5	0.95
Arsenic[b]	mg/L	< 0.0015	< 0.0015	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0658	0.0695	0.0644	0.0621	0.0736
Beryllium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.017	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	0.4502	5.2380	2.1140	0.8933	0.7550
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	1.458	1.620	1.416	1.511	1.802
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.02	< 0.02	< 0.02
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0010	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0018	< 0.0020	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.008	< 0.008	< 0.008
Nitrate[c]	mg/L	-	< 0.1	-	-	-
Phenols[c]	mg/L	0.0120	0.0075	< 0.005	0.0061	< 0.010
Cesium-137[c]	pCi/L	-	< 2.0	-	-	-
Hydrogen-3[c]	pCi/L	201	< 100	128	122	< 100
Chloride[c]	mg/L	-	144	-	-	-
Fluoride[c]	mg/L	-	0.254	-	-	-
Sulfate[c]	mg/L	-	192	-	-	-
TOCs[c]	mg/L	5.3	7.3	5.8	5.5	5.6
TOCs[c]	mg/L	5.3	7.3	5.7	5.5	5.6
TOCs[c]	mg/L	5.6	7.4	5.8	5.4	5.6
TOCs[c]	mg/L	5.3	7.3	5.8	5.4	5.5
TOXs[c]	mg/L	0.032	0.032	0.027	0.022	0.021
TOXs[c]	mg/L	0.028	0.050	0.030	0.034	0.032

[a] Well point elevation = 222.77 m (MSL); ground surface elevation = 227.38 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A hyphen indicates that no samples were collected.

TABLE 6.28

Groundwater Monitoring Results, Sanitary Landfill Well 800192, 2001

		Date of Sampling			
Parameter	Unit	01/12/01	04/03/01	07/24/01	10/15/01
Water elevation[a]	m	219.43	220.68	218.42	220.08
Temperature	°C	10.2	12.2	14.3	11.4
pH	pH	6.98	6.71	6.70	6.88
Redox	mV	7	22	16	13
Conductivity	µmhos/cm	1,507	1,313	1,306	1,305
Chloride[b]	mg/L	81	81	86	86
Sulfate[b]	mg/L	109	104	330	329
TDS[b]	mg/L	1,038	1,115	1,196	1,120
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.0069	-	-
Barium[c]	mg/L	-	0.5445	-	-
Boron[c]	mg/L	-	0.0869	-	-
Cadmium[c]	mg/L	-	< 0.0001	-	-
Chromium[c]	mg/L	-	< 0.044	-	-
Cobalt[c]	mg/L	-	< 0.026	-	-
Copper[c]	mg/L	-	< 0.017	-	-
Iron[c]	mg/L	-	18.74	-	-
Lead[c]	mg/L	-	< 0.002	-	-
Manganese[c]	mg/L	-	0.192	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-
Nickel[c]	mg/L	-	< 0.04	-	-
Selenium[c]	mg/L	-	< 0.002	-	-
Silver[c]	mg/L	-	< 0.0005	-	-
Zinc[c]	mg/L	-	0.0222	-	-
Ammonia nitrogen[b]	mg/L	1.0	1.0	1.0	< 0.5
Arsenic[b]	mg/L	< 0.0015	< 0.0015	< 0.0030	< 0.0030
Barium[b]	mg/L	0.4798	0.3462	0.4102	0.4207
Beryllium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.017	< 0.015	< 0.015
Iron[b]	mg/L	11.880	6.700	< 0.020	3.063
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.2065	0.1283	0.1608	0.1625
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.02	< 0.02
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0018	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.008	< 0.008
Nitrate[c]	mg/L	-	< 0.1	-	-
Phenols[c]	mg/L	< 0.005	< 0.005	< 0.005	< 0.005
Cesium-137[c]	pCi/L	-	< 2.0	-	-
Hydrogen-3[c]	pCi/L	531	456	419	415
Chloride[c]	mg/L	-	80	-	-
Fluoride[c]	mg/L	-	0.246	-	-
Sulfate[c]	mg/L	-	102	-	-
TOCs[c]	mg/L	11.3	9.3	8.1	30.0
TOCs[c]	mg/L	11.2	9.3	8.1	30.0
TOCs[c]	mg/L	11.4	9.2	8.0	30.0
TOCs[c]	mg/L	11.4	9.2	8.0	30.0
TOXs[c]	mg/L	0.016	0.032	0.049	0.043
TOXs[c]	mg/L	0.030	0.049	0.028	0.035

[a] Well point elevation = 208.71 m (MSL); ground surface elevation = 227.38 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A hyphen indicates that no samples were collected.

TABLE 6.29

Groundwater Monitoring Results, Sanitary Landfill Well 800193D, 2001

		Date of Sampling				
Parameter	Unit	01/12/01	04/03/01	04/03/01	07/18/01	10/15/01
Water elevation[a]	m	191.92	191.85	191.85	192.15	192.18
Temperature	°C	10.6	11.6	11.6	13.0	11.4
pH	pH	7.13	6.96	6.96	6.83	7.14
Redox	mV	-2	8	8	7	-2
Conductivity	µmhos/cm	1,337	1,167	1,167	1,145	1,285
Chloride[b]	mg/L	130	116	115	164	149
Sulfate[b]	mg/L	177	177	173	154	159
TDS[b]	mg/L	877	902	896	1006	940
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	< 0.0015	< 0.0015	-	-
Barium[c]	mg/L	-	0.0571	0.0584	-	-
Boron[c]	mg/L	-	0.1699	0.1747	-	-
Cadmium[c]	mg/L	-	< 0.0001	< 0.0001	-	-
Chromium[c]	mg/L	-	< 0.044	< 0.044	-	-
Cobalt[c]	mg/L	-	< 0.026	< 0.026	-	-
Copper[c]	mg/L	-	< 0.017	< 0.017	-	-
Iron[c]	mg/L	-	1.216	1.306	-	-
Lead[c]	mg/L	-	< 0.002	< 0.002	-	-
Manganese[c]	mg/L	-	0.0215	0.0235	-	-
Mercury[c]	mg/L	-	< 0.0001	< 0.0001	-	-
Nickel[c]	mg/L	-	< 0.04	< 0.04	-	-
Selenium[c]	mg/L	-	< 0.002	< 0.002	-	-
Silver[c]	mg/L	-	< 0.0005	< 0.0005	-	-
Zinc[c]	mg/L	-	0.0968	0.0210	-	-
Ammonia nitrogen[b]	mg/L	0.8	0.9	0.9	0.9	0.72
Arsenic[b]	mg/L	< 0.0015	0.0024	0.0019	< 0.0030	< 0.0030
Barium[b]	mg/L	0.0636	0.0290	0.0471	0.0539	0.0617
Beryllium[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.044	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.015	< 0.015
Iron[b]	mg/L	0.7709	0.9404	0.8146	0.9848	0.9258
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0242	0.0232	0.0210	0.0212	0.0228
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.04	< 0.02	< 0.02
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0018	< 0.0018	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.011	< 0.008	< 0.008
Nitrate[c]	mg/L	-	< 0.1	< 0.1	-	-
Phenols[c]	mg/L	< 0.005	< 0.005	0.013	0.0058	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	-	119	116	-	-
Fluoride[c]	mg/L	-	0.350	0.346	-	-
Sulfate[c]	mg/L	-	173	169	-	-
TOCs[c]	mg/L	2.5	2.5	2.5	2.8	2.5
TOCs[c]	mg/L	2.5	2.4	2.4	2.8	2.5
TOCs[c]	mg/L	2.2	2.4	2.4	3.0	2.5
TOCs[c]	mg/L	2.4	2.1	2.4	2.7	2.4
TOXs[c]	mg/L	0.013	0.023	0.019	0.020	0.055
TOXs[c]	mg/L	0.017	0.013	0.026	0.019	0.025
Methylene chloride	µg/L	< 1	< 1	< 1	1	< 1

[a] Well point elevation = 181.91 m (MSL); ground surface elevation = 227.38 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A hyphen indicates that no samples were collected.

TABLE 6.30

Groundwater Monitoring Results, Sanitary Landfill Well 800201, 2001

		Date of Sampling			
Parameter	Unit	01/09/01	04/04/01	07/18/01	10/15/01
Water elevation[a]	m	223.66	224.47	223.40	223.60
Temperature	°C	9.3	11.1	13.9	10.4
pH	pH	7.24	7.02	6.98	6.84
Redox	mV	0	7	-7	14
Conductivity	µmhos/cm	1,085	995	978	1,017
Chloride[b]	mg/L	11	10	10	11
Sulfate[b]	mg/L	61	59	59	58
TDS[b]	mg/L	739	729	721	730
Cyanide (total)[c]	mg/L	0.019	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.026	-	-
Barium[c]	mg/L	-	0.4074	-	-
Boron[c]	mg/L	-	0.2202	-	-
Cadmium[c]	mg/L	-	0.0005	-	-
Chromium[c]	mg/L	-	0.0647	-	-
Cobalt[c]	mg/L	-	< 0.026	-	-
Copper[c]	mg/L	-	0.0709	-	-
Iron[c]	mg/L	-	65.8	-	-
Lead[c]	mg/L	-	0.0309	-	-
Manganese[c]	mg/L	-	2.378	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-
Nickel[c]	mg/L	-	0.0767	-	-
Selenium[c]	mg/L	-	< 0.002	-	-
Silver[c]	mg/L	-	< 0.0005	-	-
Zinc[c]	mg/L	-	0.2339	-	-
Ammonia nitrogen[b]	mg/L	4.0	4.5	5.0	3.07
Arsenic[b]	mg/L	0.0074	0.0037	0.0038	0.0040
Barium[b]	mg/L	0.2778	0.1817	0.2621	0.2273
Beryllium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.017	< 0.015	< 0.015
Iron[b]	mg/L	2.7540	1.9520	0.0865	0.7681
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.3876	0.1565	0.4514	0.4150
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.0400	0.0602	< 0.0200	0.0235
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0018	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.011	0.0083	0.0119
Nitrate[c]	mg/L	-	< 0.1	-	-
Phenols[c]	mg/L	< 0.005	0.0055	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	-	11	-	-
Fluoride[c]	mg/L	-	0.204	-	-
Sulfate[c]	mg/L	-	61	-	-
TOCs[c]	mg/L	27.4	27.1	26.0	28.0
TOCs[c]	mg/L	27.3	27.2	26.0	28.0
TOCs[c]	mg/L	27.5	27.1	26.0	28.0
TOCs[c]	mg/L	27.3	27.2	26.0	28.0
TOXs[c]	mg/L	< 0.010	0.017	0.014	0.020
TOXs[c]	mg/L	< 0.010	0.013	0.018	< 0.020
Acetone[c]	µg/L	< 1	< 1	4	< 1
Methylene chloride	µg/L	< 1	< 1	1	< 1

[a] Well point elevation = 217.20 m (MSL); ground surface elevation = 227.93 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A hyphen indicates that no samples were collected.

TABLE 6.31

Groundwater Monitoring Results, Sanitary Landfill Well 800202, 2001

		Date of Sampling			
Parameter	Unit	01/09/01	04/04/01	07/16/01	10/15/01
Water elevation[a]	m	217.71	218.14	217.94	217.67
Temperature	°C	9.0	11.1	13.0	10.8
pH	pH	7.33	6.88	7.06	7.27
Redox	mV	0	9	-4	-9
Conductivity	µmhos/cm	1,025	928	940	968
Chloride[b]	mg/L	18	18	19	20
Sulfate[b]	mg/L	69	70	69	71
TDS[b]	mg/L	649	643	657	650
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	< 0.0015	-	-
Barium[c]	mg/L	-	0.1925	-	-
Boron[c]	mg/L	-	0.0924	-	-
Cadmium[c]	mg/L	-	< 0.0001	-	-
Chromium[c]	mg/L	-	< 0.044	-	-
Cobalt[c]	mg/L	-	< 0.026	-	-
Copper[c]	mg/L	-	< 0.017	-	-
Iron[c]	mg/L	-	5.375	-	-
Lead[c]	mg/L	-	< 0.002	-	-
Manganese[c]	mg/L	-	0.117	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-
Nickel[c]	mg/L	-	< 0.04	-	-
Selenium[c]	mg/L	-	< 0.002	-	-
Silver[c]	mg/L	-	< 0.0005	-	-
Zinc[c]	mg/L	-	< 0.011	-	-
Ammonia nitrogen[b]	mg/L	3.00	3.50	2.50	1.68
Arsenic[b]	mg/L	0.0031	0.0027	< 0.003	< 0.003
Barium[b]	mg/L	0.1889	0.1431	0.1700	0.1731
Beryllium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.017	< 0.015	< 0.015
Iron[b]	mg/L	4.467	6.642	3.483	5.434
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.1291	0.1170	0.1265	0.1130
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.02	< 0.02
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0018	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.008	< 0.008
Nitrate[c]	mg/L	-	< 0.1	-	-
Phenols[c]	mg/L	< 0.005	< 0.005	0.021	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	-	20	-	-
Fluoride[c]	mg/L	-	0.25	-	-
Sulfate[c]	mg/L	-	70	-	-
TOCs[c]	mg/L	11.3	10.8	11.0	11.0
TOCs[c]	mg/L	10.7	11.0	11.0	11.0
TOCs[c]	mg/L	10.6	10.9	11.0	11.0\
TOCs[c]	mg/L	11.2	10.8	11.0	11.0
TOXs[c]	mg/L	< 0.010	< 0.010	0.018	0.013
TOXs[c]	mg/L	< 0.010	0.013	0.019	< 0.010
Acetone	µg/L	< 1	< 1	4	< 1
Methylene chloride	µg/L	< 1	< 1	1	< 1

[a] Well point elevation = 217.20 m (MSL); ground surface elevation = 227.93 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A hyphen indicates that no samples were collected.

TABLE 6.32

Groundwater Monitoring Results, Sanitary Landfill Well 800203D, 2001

		Date of Sampling			
Parameter	Unit	01/09/01	04/04/01	07/16/01	10/15/01
Water elevation[a]	m	191.90	192.16	192.18	192.22
Temperature	°C	8.5	11.2	13.5	11.3
pH	pH	7.00	6.98	7.33	6.97
Redox	mV	16	6	-21	7
Conductivity	µmhos/cm	1,014	964	986	1,045
Chloride[b]	mg/L	65	69	84	97
Sulfate[b]	mg/L	63	59	49	56
TDS[b]	mg/L	637	659	664	677
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.0022	-	-
Barium[c]	mg/L	-	0.11	-	-
Boron[c]	mg/L	-	0.1672	-	-
Cadmium[c]	mg/L	-	< 0.0001	-	-
Chromium[c]	mg/L	-	< 0.044	-	-
Cobalt[c]	mg/L	-	0.0561	-	-
Copper[c]	mg/L	-	< 0.017	-	-
Iron[c]	mg/L	-	1.109	-	-
Lead[c]	mg/L	-	< 0.002	-	-
Manganese[c]	mg/L	-	0.0406	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-
Nickel[c]	mg/L	-	< 0.04	-	-
Selenium[c]	mg/L	-	< 0.002	-	-
Silver[c]	mg/L	-	< 0.0005	-	-
Zinc[c]	mg/L	-	0.041	-	-
Ammonia nitrogen[b]	mg/L	1.5	2.0	2.5	1.54
Arsenic[b]	mg/L	0.0029	0.0036	< 0.0030	< 0.0030
Barium[b]	mg/L	0.1208	0.1229	0.1138	0.1128
Beryllium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.024	< 0.024
Cobalt[b]	mg/L	0.0963	0.0503	0.0685	0.0663
Copper[b]	mg/L	< 0.017	< 0.017	< 0.015	< 0.015
Iron[b]	mg/L	0.9548	0.8308	0.3744	0.7090
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0363	0.0428	0.0541	0.0467
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.02	< 0.02
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0018	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.008	< 0.008
Nitrate[c]	mg/L	-	< 0.1	-	-
Phenols[c]	mg/L	< 0.005	< 0.005	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	-	82	-	-
Fluoride[c]	mg/L	-	0.392	-	-
Sulfate[c]	mg/L	-	59	-	-
TOCs[c]	mg/L	4.5	4.5	4.5	5.2
TOCs[c]	mg/L	4.3	4.5	4.5	5.2
TOCs[c]	mg/L	4.4	4.5	4.5	5.2
TOCs[c]	mg/L	4.3	4.4	4.5	5.2
TOXs[c]	mg/L	0.020	< 0.010	0.023	0.024
TOXs[c]	mg/L	0.011	0.012	0.013	0.028
Acetone	µg/L	< 1	< 1	5	< 1
Methylene chloride	µg/L	< 1	< 1	1	< 1

[a] Well point elevation = 189.47 m (MSL); ground surface elevation = 227.93 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A hyphen indicates that no samples were collected.

TABLE 6.33

Groundwater Monitoring Results, Sanitary Landfill Well 800271, 2001

		Date of Sampling				
Parameter	Unit	01/12/01	01/12/01	04/17/01	07/16/01	10/23/01
Water elevation[a]	m	224.28	224.28	225.78	223.62	225.12
Temperature	°C	8.3	8.3	7.1	13.3	13.6
pH	pH	7.28	7.28	6.88	6.96	7.19
Redox	mV	-11	-11	12	-1	-5
Conductivity	µmhos/cm	671	671	580	670	681
Chloride[b]	mg/L	3	2	4	3	1
Sulfate[b]	mg/L	43	44	32	42	45
TDS[b]	mg/L	402	408	405	416	406
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	-	0.0019	-	-
Barium[c]	mg/L	-	-	0.1103	-	-
Boron[c]	mg/L	-	-	0.1632	-	-
Cadmium[c]	mg/L	-	-	0.0002	-	-
Chromium[c]	mg/L	-	-	< 0.044	-	-
Cobalt[c]	mg/L	-	-	< 0.026	-	-
Copper[c]	mg/L	-	-	0.0574	-	-
Iron[c]	mg/L	-	-	42.92	-	-
Lead[c]	mg/L	-	-	0.0212	-	-
Manganese[c]	mg/L	-	-	0.683	-	-
Mercury[c]	mg/L	-	-	< 0.0001	-	-
Nickel[c]	mg/L	-	-	0.051	-	-
Selenium[c]	mg/L	-	-	< 0.002	-	-
Silver[c]	mg/L	-	-	< 0.0005	-	-
Zinc[c]	mg/L	-	-	0.156	-	-
Ammonia nitrogen[b]	mg/L	< 0.1	< 0.1	< 0.1	0.9	< 0.1
Arsenic[b]	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0030	< 0.0030
Barium[b]	mg/L	< 0.0180	< 0.0180	< 0.0180	0.0167	0.0185
Beryllium[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.044	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.015	< 0.015
Iron[b]	mg/L	< 0.0370	0.0379	< 0.0370	< 0.0200	0.0888
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0327	0.0293	0.0184	0.0713	0.0149
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.04	< 0.02	< 0.02
Silver[b]	mg/L	0.0005	< 0.0005	< 0.0005	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0018	< 0.0018	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.011	< 0.008	< 0.008
Nitrate[c]	mg/L	-	-	< 0.1	-	-
Phenols[c]	mg/L	0.0067	< 0.005	< 0.005	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	135	< 100	108	< 100
Chloride[c]	mg/L	-	-	3	-	-
Fluoride[c]	mg/L	-	-	0.22	-	-
Sulfate[c]	mg/L	-	-	34	-	-
TOCs[c]	mg/L	1.3	1.2	1.3	1.5	1.3
TOCs[c]	mg/L	1.3	1.3	1.3	1.4	1.3
TOCs[c]	mg/L	1.3	1.3	1.3	1.4	1.2
TOCs[c]	mg/L	1.2	1.3	1.3	1.3	1.2
TOXs[c]	mg/L	< 0.010	< 0.010	0.015	< 0.010	0.011
TOXs[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Methylene chloride	µg/L	< 1	< 1	< 1	1	< 1

[a] Well point elevation = 191.84 m (MSL); ground surface elevation = 226.48 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A hyphen indicates that no samples were collected.

TABLE 6.34

Groundwater Monitoring Results, Sanitary Landfill Well 800273D, 2001

		Date of Sampling			
Parameter	Unit	01/12/01	04/17/01	07/16/01	10/23/01
Water elevation[a]	m	192.22	192.41	192.44	192.75
Temperature	°C	9.9	11.2	12.6	11.4
pH	pH	6.64	6.79	7.11	7.16
Redox	mV	25	16	-9	-3
Conductivity	µmhos/cm	1,122	1,003	1,175	1,315
Chloride[b]	mg/L	85	102	109	127
Sulfate[b]	mg/L	107	101	135	134
TDS[b]	mg/L	696	817	890	790
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.0034	-	-
Barium[c]	mg/L	-	0.0412	-	-
Boron[c]	mg/L	-	0.1695	-	-
Cadmium[c]	mg/L	-	< 0.0001	-	-
Chromium[c]	mg/L	-	< 0.044	-	-
Cobalt[c]	mg/L	-	< 0.026	-	-
Copper[c]	mg/L	-	< 0.017	-	-
Iron[c]	mg/L	-	1.337	-	-
Lead[c]	mg/L	-	< 0.002	-	-
Manganese[c]	mg/L	-	< 0.017	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-
Nickel[c]	mg/L	-	< 0.04	-	-
Selenium[c]	mg/L	-	< 0.002	-	-
Silver[c]	mg/L	-	< 0.0005	-	-
Zinc[c]	mg/L	-	< 0.011	-	-
Ammonia nitrogen[b]	mg/L	1.0	1.0	1.0	1.0
Arsenic[b]	mg/L	0.0031	0.0031	< 0.0030	< 0.0030
Barium[b]	mg/L	0.0452	0.0435	0.0477	0.0540
Beryllium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.017	< 0.015	< 0.015
Iron[b]	mg/L	0.9078	1.0930	0.4224	0.7872
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.0170	< 0.0170	0.0111	0.0112
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.02	< 0.02
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0018	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.008	< 0.008
Nitrate[c]	mg/L	-	< 0.1	-	-
Phenols[c]	mg/L	< 0.005	< 0.005	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	-	99	-	-
Fluoride[c]	mg/L	-	0.376	-	-
Sulfate[c]	mg/L	-	101	-	-
TOCs[c]	mg/L	1.2	1.4	1.3	1.4
TOCs[c]	mg/L	1.2	1.3	1.3	1.3
TOCs[c]	mg/L	1.2	1.3	1.3	1.2
TOCs[c]	mg/L	1.2	1.3	1.3	1.2
TOXs[c]	mg/L	0.019	0.040	0.026	< 0.010
TOXs[c]	mg/L	0.013	0.029	0.027	< 0.010

[a] Well point elevation = 189.70 m (MSL); ground surface elevation = 226.48 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A hyphen indicates that no samples were collected.

TABLE 6.35

Groundwater Monitoring Results, Sanitary Landfill Well 800281, 2001

		Date of Sampling				
Parameter	Unit	01/09/01	04/23/01	07/24/01	07/24/01	10/23/01
Water elevation[a]	m	226.36	227.23	225.56	225.56	227.00
Temperature	°C	8.3	7.7	12.4	12.4	13.3
pH	pH	7.21	6.78	6.55	6.55	7.07
Redox	mV	3	20	23	23	2
Conductivity	µmhos/cm	1,107	1,201	1,204	1,204	1,400
Chloride[b]	mg/L	141	102	89	92	90
Sulfate[b]	mg/L	73	117	103	94	109
TDS[b]	mg/L	1,093	981	975	970	901
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.0033	-	-	-
Barium[c]	mg/L	-	0.1958	-	-	-
Boron[c]	mg/L	-	0.3929	-	-	-
Cadmium[c]	mg/L	-	0.0004	-	-	-
Chromium[c]	mg/L	-	2.115	-	-	-
Cobalt[c]	mg/L	-	< 0.026	-	-	-
Copper[c]	mg/L	-	0.0579	-	-	-
Iron[c]	mg/L	-	24.03	-	-	-
Lead[c]	mg/L	-	0.0124	-	-	-
Manganese[c]	mg/L	-	1.798	-	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-	-
Nickel[c]	mg/L	-	0.2455	-	-	-
Selenium[c]	mg/L	-	< 0.002	-	-	-
Silver[c]	mg/L	-	< 0.0005	-	-	-
Zinc[c]	mg/L	-	0.082	-	-	-
Ammonia nitrogen[b]	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Arsenic[b]	mg/L	< 0.0015	< 0.0015	< 0.0030	< 0.0030	< 0.0030
Barium[b]	mg/L	0.1152	0.0837	0.0825	0.0948	0.1132
Beryllium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.017	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.0370	0.9035	< 0.0200	< 0.0200	0.0723
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	2.072	1.304	1.168	1.282	1.519
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	0.0519	0.2652	0.0344	0.0313	0.0491
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0010	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0018	< 0.0020	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.008	< 0.008	< 0.008
Nitrate[c]	mg/L	-	< 0.1	-	-	-
Phenols[c]	mg/L	< 0.005	0.0061	< 0.005	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	1058	434	440	377	346
Chloride[c]	mg/L	-	96	-	-	-
Fluoride[c]	mg/L	-	0.19	-	-	-
Sulfate[c]	mg/L	-	117	-	-	-
TOCs[c]	mg/L	5.0	2.7	3.2	3.3	3.0
TOCs[c]	mg/L	4.9	2.7	3.2	3.3	3.0
TOCs[c]	mg/L	4.9	2.8	3.1	3.1	3.0
TOCs[c]	mg/L	4.8	2.7	3.1	4.1	3.1
TOXs[c]	mg/L	0.168	0.054	0.036	0.027	0.095
TOXs[c]	mg/L	0.141	0.058	0.051	0.048	0.076
Acetone	µg/L	< 1	3	< 1	< 1	< 1

[a] Well point elevation = 224.60 m (MSL); ground surface elevation = 228.56 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A hyphen indicates that no samples were collected.

TABLE 6.36

Groundwater Monitoring Results, Sanitary Landfill Well 800291, 2001

		Date of Sampling				
Parameter	Unit	01/18/01	04/18/01	04/18/01	07/24/01	10/29/01
Water elevation[a]	m	227.95	228.64	228.64	227.32	228.75
Temperature	°C	9.4	8.9	8.9	11.0	10.9
pH	pH	7.18	7.02	7.02	7.10	7.37
Redox	mV	-4	16	16	-6	-15
Conductivity	µmhos/cm	1,074	1,157	1,157	1,136	1,294
Chloride[b]	mg/L	6	8	8	8	7
Sulfate[b]	mg/L	126	250	239	282	287
TDS[b]	mg/L	805	881	830	860	808
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.0109	0.0081	-	-
Barium[c]	mg/L	-	0.2180	0.1867	-	-
Boron[c]	mg/L	-	0.2302	0.1834	-	-
Cadmium[c]	mg/L	-	0.0003	0.0003	-	-
Chromium[c]	mg/L	-	0.0641	0.0516	-	-
Cobalt[c]	mg/L	-	0.0273	0.0267	-	-
Copper[c]	mg/L	-	0.0778	0.0524	-	-
Iron[c]	mg/L	-	67.05	53.68	-	-
Lead[c]	mg/L	-	0.0321	0.0261	-	-
Manganese[c]	mg/L	-	1.3470	0.9573	-	-
Mercury[c]	mg/L	-	< 0.0001	< 0.0001	-	-
Nickel[c]	mg/L	-	0.0749	0.0724	-	-
Selenium[c]	mg/L	-	< 0.002	< 0.002	-	-
Silver[c]	mg/L	-	< 0.0005	< 0.0005	-	-
Zinc[c]	mg/L	-	0.1741	0.1337	-	-
Ammonia nitrogen[b]	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.5
Arsenic[b]	mg/L	0.0018	< 0.0015	0.0016	< 0.0030	< 0.0030
Barium[b]	mg/L	0.0362	0.0277	0.0278	0.0249	0.0315
Beryllium[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.044	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.015	< 0.015
Iron[b]	mg/L	0.0654	< 0.0370	0.1291	< 0.0200	0.2834
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.1743	0.1690	0.1467	0.1486	0.1522
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.0400	< 0.0400	< 0.0400	0.0266	< 0.0200
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0018	< 0.0018	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.011	< 0.008	< 0.008
Nitrate[c]	mg/L	-	< 0.1	< 0.1	-	-
Phenols[c]	mg/L	0.0076	< 0.005	< 0.005	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100	104
Chloride[c]	mg/L	-	7	8	-	-
Fluoride[c]	mg/L	-	0.34	0.33	-	-
Sulfate[c]	mg/L	-	234	227	-	-
TOCs[c]	mg/L	2.0	2.0	2.1	2.3	1.8
TOCs[c]	mg/L	2.0	2.0	1.9	2.3	1.8
TOCs[c]	mg/L	1.9	2.0	1.9	2.2	1.8
TOCs[c]	mg/L	2.0	2.1	1.9	2.2	1.8
TOXs[c]	mg/L	0.018	0.013	0.041	< 0.010	0.015
TOXs[c]	mg/L	0.012	0.016	0.038	0.011	0.016

[a] Well point elevation = 223.97 m (MSL); ground surface elevation = 231.37 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A hyphen indicates that no samples were collected.

TABLE 6.37

Groundwater Monitoring Results, Sanitary Landfill Well 800301, 2001

		Date of Sampling			
Parameter	Unit	01/24/01	04/25/01	07/25/01	10/22/01
Water elevation[a]	m	227.10	231.89	228.97	222.40
Temperature	°C	5.6	8.8	10.6	11.0
pH	pH	7.17	7.00	7.00	7.06
Redox	mV	-6	5	-2	3
Conductivity	µmhos/cm	1,006	964	957	1,088
Chloride[b]	mg/L	6	8	7	6
Sulfate[b]	mg/L	97	152	154	157
TDS[b]	mg/L	781	680	692	668
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.0019	-	-
Barium[c]	mg/L	-	0.2019	-	-
Boron[c]	mg/L	-	0.2614	-	-
Cadmium[c]	mg/L	-	0.0003	-	-
Chromium[c]	mg/L	-	0.0528	-	-
Cobalt[c]	mg/L	-	0.0335	-	-
Copper[c]	mg/L	-	0.0913	-	-
Iron[c]	mg/L	-	76.97	-	-
Lead[c]	mg/L	-	0.0424	-	-
Manganese[c]	mg/L	-	1.445	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-
Nickel[c]	mg/L	-	0.0833	-	-
Selenium[c]	mg/L	-	< 0.002	-	-
Silver[c]	mg/L	-	< 0.0005	-	-
Zinc[c]	mg/L	-	0.1819	-	-
Ammonia nitrogen[b]	mg/L	< 0.1	< 0.1	< 0.1	< 0.1
Arsenic[b]	mg/L	0.0028	0.0029	0.0042	< 0.0030
Barium[b]	mg/L	0.0294	0.0210	0.0193	0.0237
Beryllium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.017	< 0.015	< 0.015
Iron[b]	mg/L	0.2668	0.2581	0.5254	0.0779
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.1528	0.0765	0.0722	0.0884
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.02	< 0.02
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0018	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.008	< 0.008
Nitrate[c]	mg/L	-	< 0.1	-	-
Phenols[c]	mg/L	< 0.005	0.047	0.020	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	-	7	-	-
Fluoride[c]	mg/L	-	0.258	-	-
Sulfate[c]	mg/L	-	155	-	-
TOCs[c]	mg/L	1.5	1.3	1.4	1.5
TOCs[c]	mg/L	1.5	1.4	1.5	1.5
TOCs[c]	mg/L	1.5	1.3	1.4	1.6
TOCs[c]	mg/L	1.4	1.3	1.5	1.5
TOXs[c]	mg/L	0.016	< 0.010	< 0.010	< 0.010
TOXs[c]	mg/L	0.026	< 0.010	< 0.010	< 0.010

[a] Well point elevation = 226.11 m (MSL); ground surface elevation = 233.42 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A hyphen indicates that no samples were collected.

TABLE 6.38

Groundwater Monitoring Results,
Sanitary Landfill Well 800321, 2001

		Date of Sampling
Parameter	Unit	04/25/01
Water elevation[a]	m	226.98
Temperature	°C	7.7
pH	pH	7.04
Redox	mV	7
Conductivity	µmhos/cm	2,190
Chloride[b]	mg/L	46
Sulfate[b]	mg/L	1,107
TDS[b]	mg/L	2,127
Cyanide (total)[c]	mg/L	< 0.01
Arsenic[c]	mg/L	0.0039
Barium[c]	mg/L	0.0667
Boron[c]	mg/L	0.1055
Cadmium[c]	mg/L	0.0002
Chromium[c]	mg/L	< 0.044
Cobalt[c]	mg/L	< 0.026
Copper[c]	mg/L	0.0433
Iron[c]	mg/L	18.97
Lead[c]	mg/L	0.0112
Manganese[c]	mg/L	0.5046
Mercury[c]	mg/L	< 0.0001
Nickel[c]	mg/L	< 0.04
Selenium[c]	mg/L	< 0.002
Silver[c]	mg/L	< 0.0005
Zinc[c]	mg/L	0.0776
Arsenic[b]	mg/L	< 0.0015
Barium[b]	mg/L	< 0.018
Beryllium[b]	mg/L	< 0.0001
Cadmium[b]	mg/L	< 0.0001
Chromium[b]	mg/L	< 0.044
Cobalt[b]	mg/L	< 0.026
Copper[b]	mg/L	< 0.017
Iron[b]	mg/L	< 0.037
Lead[b]	mg/L	< 0.002
Manganese[b]	mg/L	0.3057
Mercury[b]	mg/L	< 0.0001
Nickel[b]	mg/L	0.0436
Silver[b]	mg/L	< 0.0005
Thallium[b]	mg/L	< 0.0018
Vanadium[b]	mg/L	< 0.024
Zinc[b]	mg/L	0.0183
Nitrate[c]	mg/L	0.87
Phenols[c]	mg/L	< 0.005
Hydrogen-3[c]	pCi/L	< 100
Chloride[c]	mg/L	49
Fluoride[c]	mg/L	0.16
Sulfate[c]	mg/L	1,095
TOCs[c]	mg/L	1.7
TOCs[c]	mg/L	1.7
TOCs[c]	mg/L	1.7
TOCs[c]	mg/L	1.7
TOXs[c]	mg/L	0.019
TOXs[c]	mg/L	0.036

[a] Well point elevation = 225.90 m (MSL); ground surface elevation = 228.80 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

TABLE 6.39

Groundwater Monitoring Results, Sanitary Landfill Well 800331, 2001

		Date of Sampling			
Parameter	Unit	01/18/01	04/23/01	07/24/01	10/29/01
Water elevation[a]	m	226.10	227.40	225.41	227.12
Temperature	°C	8.0	8.5	12.2	11.9
pH	pH	7.02	7.20	7.18	7.30
Redox	mV	5	-5	-11	-12
Conductivity	µmhos/cm	1,014	975	975	1,149
Chloride[b]	mg/L	6	7	7	6
Sulfate[b]	mg/L	124	159	212	230
TDS[b]	mg/L	773	741	727	747
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.0043	-	-
Barium[c]	mg/L	-	0.1044	-	-
Boron[c]	mg/L	-	0.1403	-	-
Cadmium[c]	mg/L	-	0.0004	-	-
Chromium[c]	mg/L	-	0.1024	-	-
Cobalt[c]	mg/L	-	< 0.026	-	-
Copper[c]	mg/L	-	0.0649	-	-
Iron[c]	mg/L	-	41.77	-	-
Lead[c]	mg/L	-	0.0308	-	-
Manganese[c]	mg/L	-	0.6312	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-
Nickel[c]	mg/L	-	0.0855	-	-
Selenium[c]	mg/L	-	< 0.002	-	-
Silver[c]	mg/L	-	< 0.0005	-	-
Zinc[c]	mg/L	-	0.1544	-	-
Ammonia nitrogen[b]	mg/L	< 0.1	< 0.1	< 0.1	< 0.5
Arsenic[b]	mg/L	< 0.0015	< 0.0015	< 0.0030	< 0.0030
Barium[b]	mg/L	0.0516	0.0365	0.0359	0.0498
Beryllium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.016	< 0.016
Copper[b]	mg/L	< 0.0170	0.0193	< 0.0150	< 0.0150
Iron[b]	mg/L	< 0.037	< 0.037	< 0.020	< 0.020
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0384	0.1403	0.1233	0.0534
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.0400	< 0.0400	0.0209	< 0.0200
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0018	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.008	< 0.008
Nitrate[c]	mg/L	-	< 0.1	-	-
Phenols[c]	mg/L	< 0.005	< 0.005	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	117
Chloride[c]	mg/L	-	6	-	-
Fluoride[c]	mg/L	-	0.352	-	-
Sulfate[c]	mg/L	-	161	-	-
TOCs[c]	mg/L	1.5	1.5	1.6	1.4
TOCs[c]	mg/L	1.5	1.5	1.6	1.4
TOCs[c]	mg/L	1.4	1.4	1.5	1.3
TOCs[c]	mg/L	1.5	1.4	1.6	1.4
TOXs[c]	mg/L	< 0.010	0.011	< 0.010	0.012
TOXs[c]	mg/L	0.011	< 0.010	< 0.010	< 0.010

[a] Well point elevation = 223.66 m (MSL); ground surface elevation = 228.80 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A hyphen indicates that no samples were collected.

TABLE 6.40

Groundwater Monitoring Results, Sanitary Landfill Well 800341, 2001

		Date of Sampling			
Parameter	Unit	01/18/01	04/23/01	07/24/01	10/29/01
Water elevation[a]	m	229.80	229.92	228.02	229.68
Temperature	°C	7.2	7.6	12.4	12.5
pH	pH	7.35	7.34	6.88	7.21
Redox	mV	-14	-13	3	-7
Conductivity	µmhos/cm	1,071	1,064	1,095	1,294
Chloride[b]	mg/L	10	12	15	13
Sulfate[b]	mg/L	214	261	308	314
TDS[b]	mg/L	841	808	846	853
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.0061	-	-
Barium[c]	mg/L	-	0.1292	-	-
Boron[c]	mg/L	-	0.1427	-	-
Cadmium[c]	mg/L	-	0.0003	-	-
Chromium[c]	mg/L	-	0.0441	-	-
Cobalt[c]	mg/L	-	< 0.026	-	-
Copper[c]	mg/L	-	0.07	-	-
Iron[c]	mg/L	-	41.37	-	-
Lead[c]	mg/L	-	0.022	-	-
Manganese[c]	mg/L	-	0.85	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-
Nickel[c]	mg/L	-	0.0491	-	-
Selenium[c]	mg/L	-	< 0.002	-	-
Silver[c]	mg/L	-	< 0.0005	-	-
Zinc[c]	mg/L	-	0.1264	-	-
Ammonia nitrogen[b]	mg/L	< 0.1	< 0.1	< 0.1	< 0.5
Arsenic[b]	mg/L	< 0.0015	< 0.0015	< 0.003	< 0.003
Barium[b]	mg/L	0.0443	0.0372	0.0365	0.0479
Beryllium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.017	< 0.015	< 0.015
Iron[b]	mg/L	< 0.037	< 0.037	< 0.020	< 0.020
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.0170	0.0527	< 0.0100	0.0176
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.0400	< 0.0400	0.0209	< 0.0200
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0018	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.008	< 0.008
Nitrate[c]	mg/L	-	0.22	-	-
Phenols[c]	mg/L	< 0.005	< 0.005	< 0.005	0.0052
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	-	12	-	-
Fluoride[c]	mg/L	-	0.324	-	-
Sulfate[c]	mg/L	-	261	-	-
TOCs[c]	mg/L	2.3	2.4	2.7	2.5
TOCs[c]	mg/L	2.3	2.3	2.8	2.5
TOCs[c]	mg/L	2.3	2.4	2.7	2.5
TOCs[c]	mg/L	2.4	2.3	2.7	2.5
TOXs[c]	mg/L	0.016	0.017	0.013	0.028
TOXs[c]	mg/L	0.012	< 0.010	0.015	0.014

[a] Well point elevation = 227.03 m (MSL); ground surface elevation = 230.85 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A hyphen indicates that no samples were collected.

TABLE 6.41

Groundwater Monitoring Results, Sanitary Landfill Well 800351, 2001

Parameter	Unit	Date of Sampling 01/24/01	04/25/01	07/25/01	10/22/01
Water elevation[a]	m	226.15	229.19	227.14	226.13
Temperature	°C	9.9	9.7	10.6	10.4
pH	pH	7.49	7.20	6.97	7.24
Redox	mV	-22	-6	-1	-7
Conductivity	µmhos/cm	782	803	816	956
Chloride[b]	mg/L	3	3	4	4
Sulfate[b]	mg/L	27	49	52	61
TDS[b]	mg/L	558	557	556	558
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.0089	-	-
Barium[c]	mg/L	-	0.1899	-	-
Boron[c]	mg/L	-	0.2002	-	-
Cadmium[c]	mg/L	-	0.0002	-	-
Chromium[c]	mg/L	-	< 0.044	-	-
Cobalt[c]	mg/L	-	< 0.026	-	-
Copper[c]	mg/L	-	0.055	-	-
Iron[c]	mg/L	-	41.66	-	-
Lead[c]	mg/L	-	0.024	-	-
Manganese[c]	mg/L	-	0.7465	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-
Nickel[c]	mg/L	-	0.0462	-	-
Selenium[c]	mg/L	-	< 0.002	-	-
Silver[c]	mg/L	-	< 0.0005	-	-
Zinc[c]	mg/L	-	0.1263	-	-
Ammonia nitrogen[b]	mg/L	0.4	0.5	0.5	0.6
Arsenic[b]	mg/L	0.0022	< 0.0015	< 0.0030	< 0.0030
Barium[b]	mg/L	0.0977	0.0916	0.0654	0.0904
Beryllium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.017	< 0.015	< 0.015
Iron[b]	mg/L	< 0.0370	< 0.0370	0.0442	< 0.0200
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0318	0.0340	0.0236	0.0307
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.02	< 0.02
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0018	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.008	< 0.008
Nitrate[c]	mg/L	-	< 0.1	-	-
Phenols[c]	mg/L	< 0.005	< 0.005	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	-	4	-	-
Fluoride[c]	mg/L	-	0.338	-	-
Sulfate[c]	mg/L	-	48	-	-
TOCs[c]	mg/L	1.6	2.1	1.5	1.7
TOCs[c]	mg/L	1.6	1.9	1.6	1.6
TOCs[c]	mg/L	1.6	1.8	1.6	1.9
TOCs[c]	mg/L	1.6	1.9	1.6	1.7
TOXs[c]	mg/L	0.018	< 0.010	< 0.010	< 0.010
TOXs[c]	mg/L	0.022	< 0.010	< 0.010	< 0.010
Acetone	µg/L	< 1	3	< 1	< 1

[a] Well point elevation = 222.13 m (MSL); ground surface elevation = 233.64 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A hyphen indicates that no samples were collected.

TABLE 6.42

Groundwater Monitoring Results, Sanitary Landfill Well 800361, 2001

		Date of Sampling			
Parameter	Unit	01/24/01	04/25/01	07/25/01	10/22/01
Water elevation[a]	m	224.71	226.94	224.01	225.44
Temperature	°C	10.4	9.4	10.8	11.6
pH	pH	7.18	6.58	7.12	7.26
Redox	mV	-4	28	-10	-9
Conductivity	µmhos/cm	827	766	782	922
Chloride[b]	mg/L	9	10	12	10
Sulfate[b]	mg/L	99	132	163	147
TDS[b]	mg/L	607	558	597	586
Cyanide (Total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.0019	-	-
Barium[c]	mg/L	-	0.0796	-	-
Boron[c]	mg/L	-	0.0697	-	-
Cadmium[c]	mg/L	-	0.0001	-	-
Chromium[c]	mg/L	-	< 0.044	-	-
Cobalt[c]	mg/L	-	< 0.026	-	-
Copper[c]	mg/L	-	0.0292	-	-
Iron[c]	mg/L	-	13.1	-	-
Lead[c]	mg/L	-	0.0084	-	-
Manganese[c]	mg/L	-	0.289	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-
Nickel[c]	mg/L	-	< 0.04	-	-
Selenium[c]	mg/L	-	< 0.002	-	-
Silver[c]	mg/L	-	< 0.0005	-	-
Zinc[c]	mg/L	-	0.0619	-	-
Ammonia nitrogen[b]	mg/L	< 0.1	< 0.1	< 0.1	< 0.1
Arsenic[b]	mg/L	< 0.0015	< 0.0015	< 0.0030	< 0.0030
Barium[b]	mg/L	0.0343	0.0444	0.0223	0.0312
Beryllium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.017	< 0.015	< 0.015
Iron[b]	mg/L	< 0.037	0.044	0.0261	< 0.020
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.1205	0.0900	0.0815	0.0757
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.02	< 0.02
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0018	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.008	< 0.008
Nitrate[c]	mg/L	-	< 0.1	-	-
Phenols[c]	mg/L	< 0.005	< 0.005	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	107	107	156
Chloride[c]	mg/L	-	11	-	-
Fluoride[c]	mg/L	-	0.262	-	-
Sulfate[c]	mg/L	-	131	-	-
TOCs[c]	mg/L	1.5	1.5	1.6	1.5
TOCs[c]	mg/L	1.5	1.5	1.6	1.5
TOCs[c]	mg/L	1.5	1.5	1.6	1.5
TOCs[c]	mg/L	1.5	1.5	1.6	1.4
TOXs[c]	mg/L	0.010	0.016	0.012	< 0.010
TOXs[c]	mg/L	0.010	0.012	< 0.010	< 0.010

[a] Well bottom elevation = 221.21 m (MSL); ground surface elevation = 228.40 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A hyphen indicates that no samples were collected.

TABLE 6.43

Groundwater Monitoring Results, Sanitary Landfill Well 800371, 2001

		Date of Sampling			
Parameter	Unit	01/24/01	04/25/01	07/25/01	10/22/01
Water elevation[a]	m	219.23	219.19	219.27	219.40
Temperature	°C	10.1	11.1	11.1	10.8
pH	pH	7.08	7.20	7.21	7.33
Redox	mV	-2	-5	-14	-13
Conductivity	µmhos/cm	765	748	739	870
Chloride[b]	mg/L	3	4	4	3
Sulfate[b]	mg/L	19	37	63	66
TDS[b]	mg/L	543	538	537	523
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.0097	-	-
Barium[c]	mg/L	-	0.6391	-	-
Boron[c]	mg/L	-	0.825	-	-
Cadmium[c]	mg/L	-	0.0048	-	-
Chromium[c]	mg/L	-	0.1571	-	-
Cobalt[c]	mg/L	-	0.0944	-	-
Copper[c]	mg/L	-	0.4912	-	-
Iron[c]	mg/L	-	245.1	-	-
Lead[c]	mg/L	-	0.2325	-	-
Manganese[c]	mg/L	-	3.683	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-
Nickel[c]	mg/L	-	0.2477	-	-
Selenium[c]	mg/L	-	< 0.002	-	-
Silver[c]	mg/L	-	< 0.0005	-	-
Zinc[c]	mg/L	-	1.357	-	-
Ammonia nitrogen[b]	mg/L	1.0	1.0	0.9	1.0
Arsenic[b]	mg/L	< 0.0015	0.0028	< 0.0030	< 0.0030
Barium[b]	mg/L	0.0722	0.0968	0.0683	0.0661
Beryllium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.017	< 0.015	< 0.015
Iron[b]	mg/L	< 0.037	< 0.037	< 0.020	< 0.020
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0719	0.0685	0.0742	0.0789
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.02	< 0.02
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0018	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.008	< 0.008
Nitrate[c]	mg/L	-	< 0.1	-	-
Phenols[c]	mg/L	< 0.005	0.013	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	-	4	-	-
Fluoride[c]	mg/L	-	0.392	-	-
Sulfate[c]	mg/L	-	38	-	-
TOCs[c]	mg/L	1.7	1.8	1.7	2.1
TOCs[c]	mg/L	1.9	1.8	1.6	2.1
TOCs[c]	mg/L	2.0	2.1	1.6	2.2
TOCs[c]	mg/L	1.8	1.8	3.2	2.1
TOXs[c]	mg/L	< 0.010	< 0.010	0.013	< 0.010
TOXs[c]	mg/L	< 0.010	0.012	< 0.010	< 0.010

[a] Well point elevation = 218.46 m (MSL); ground surface elevation = 228.37 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A hyphen indicates that no samples were collected.

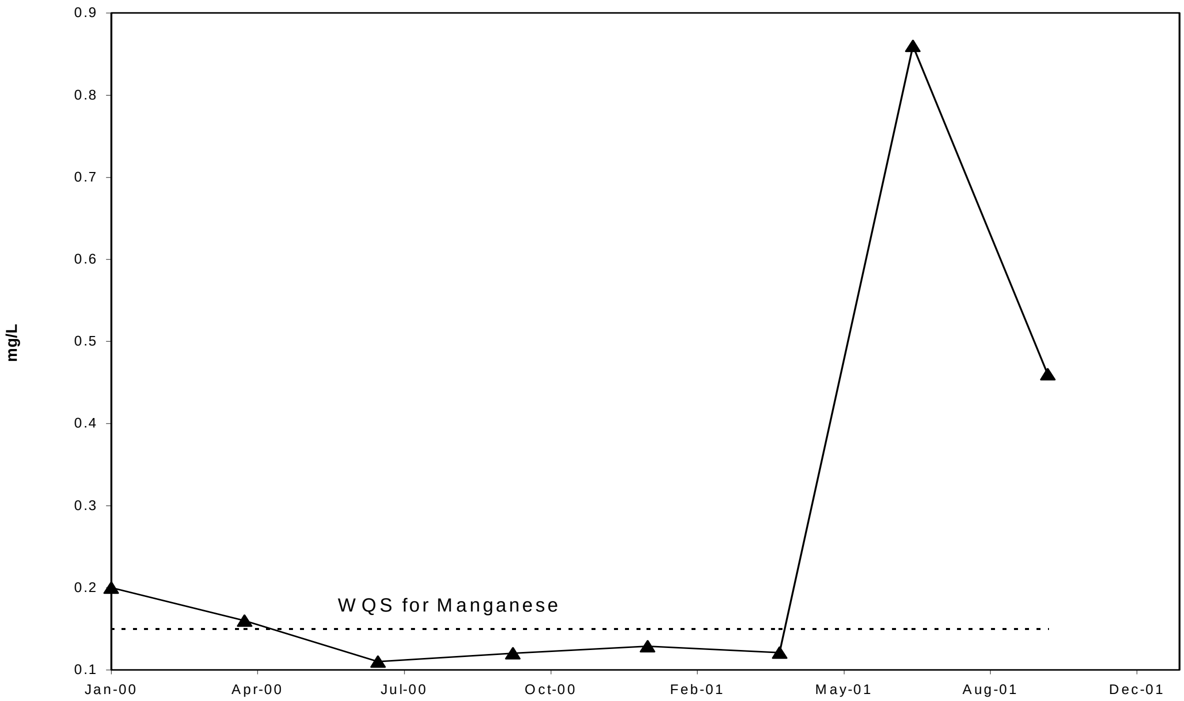


Figure 6.14 Well 800381 Manganese Results

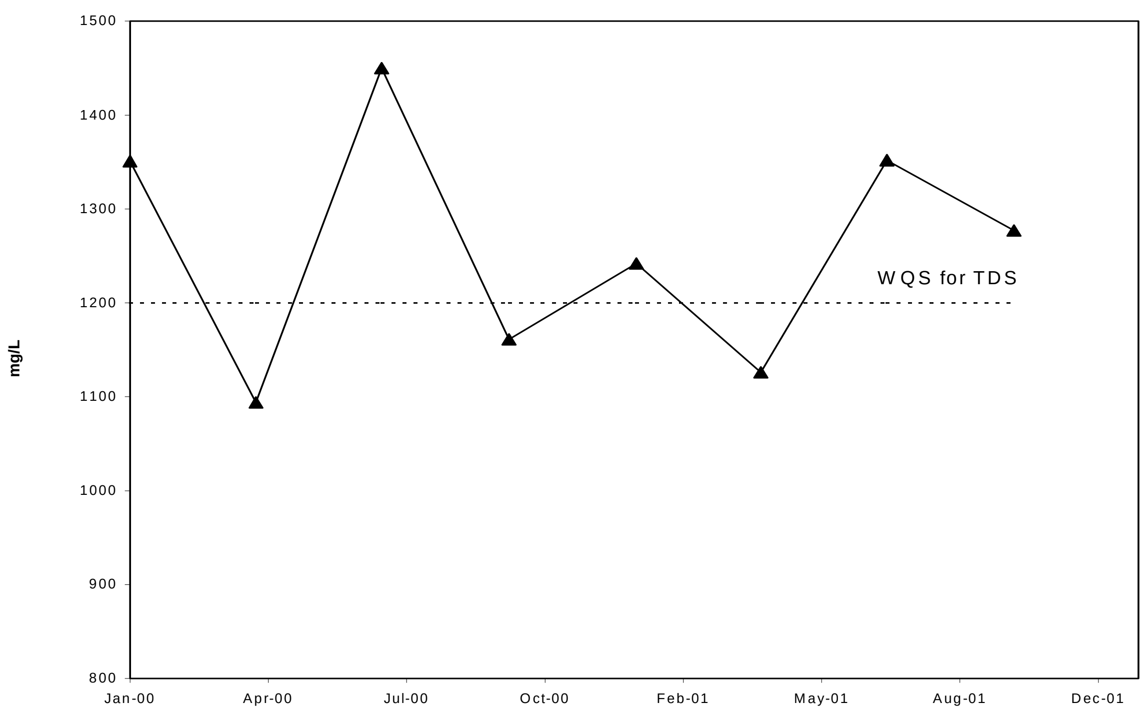


Figure 6.15 Well 800381 TDS Results

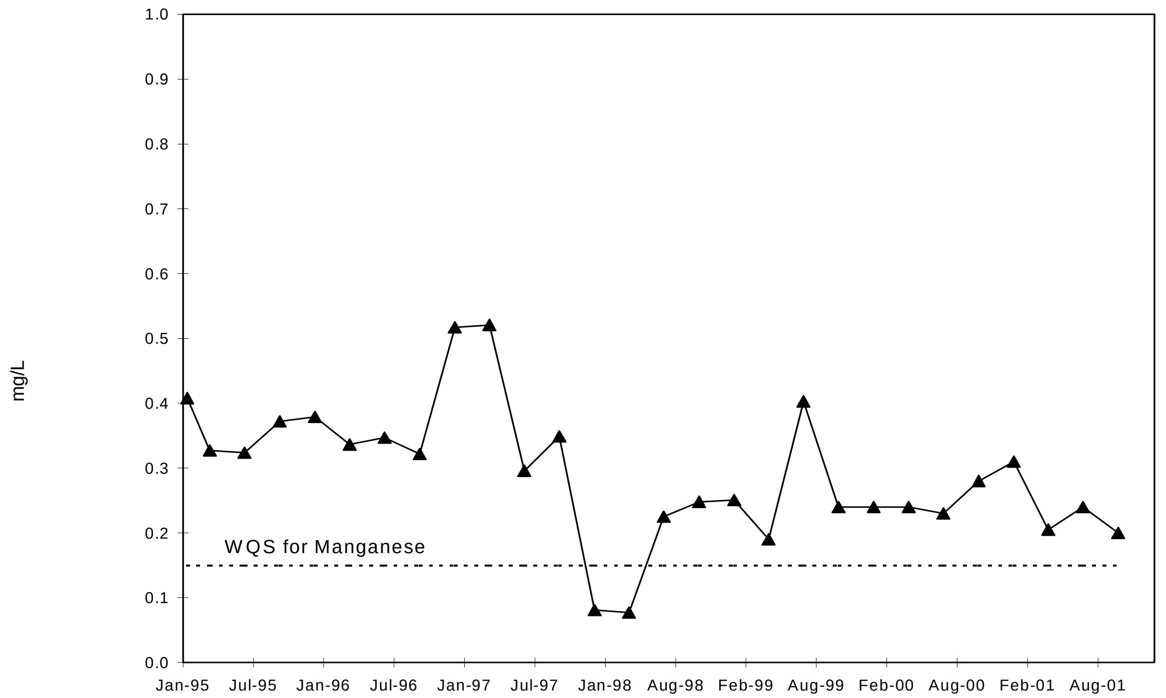


Figure 6.16 Well 800171 Manganese Results

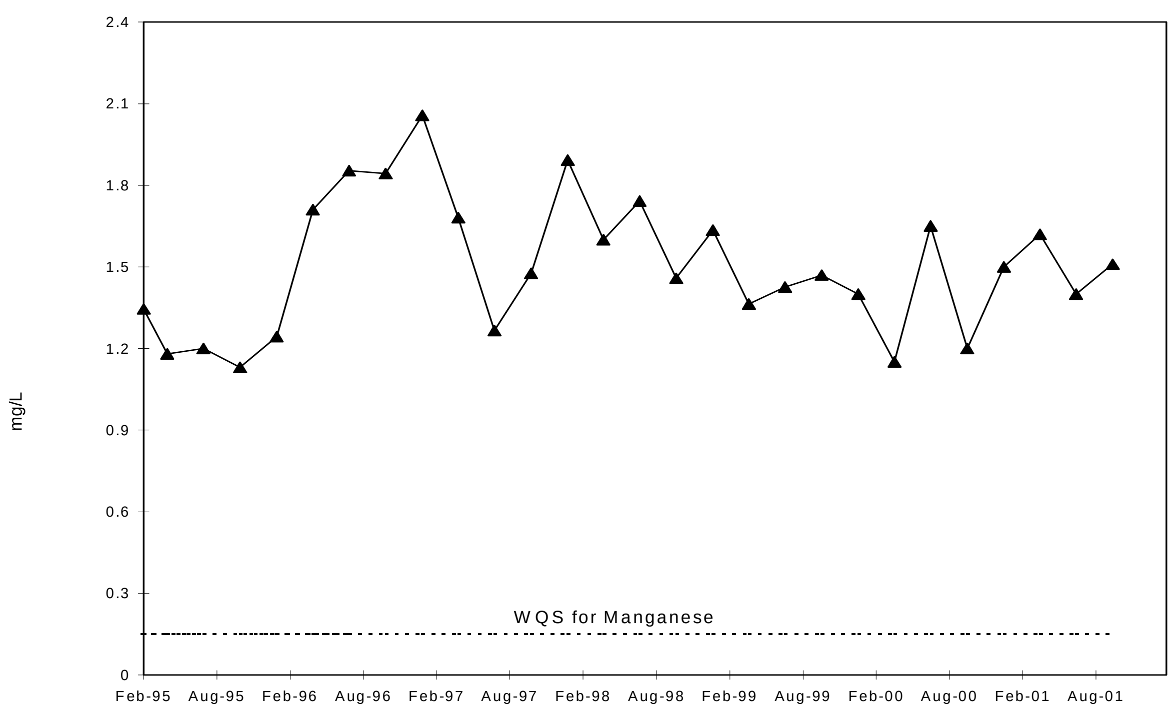


Figure 6.17 Well 800191 Manganese Results

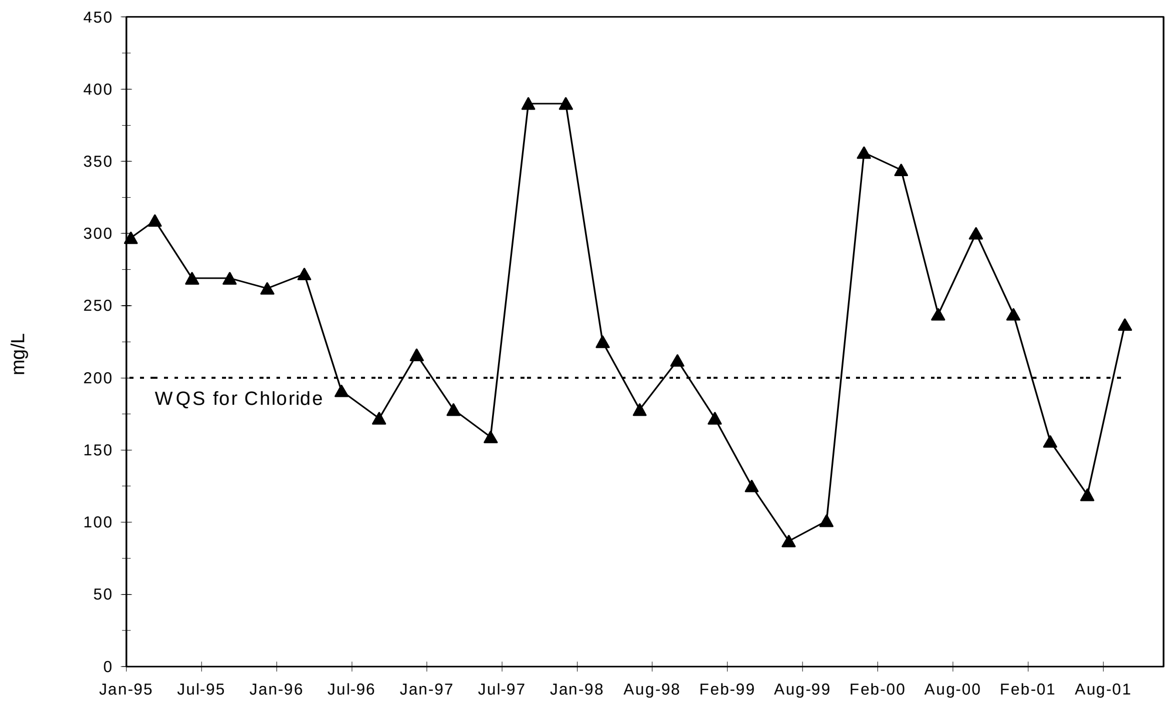


Figure 6.18 Well 800191 Chloride Results

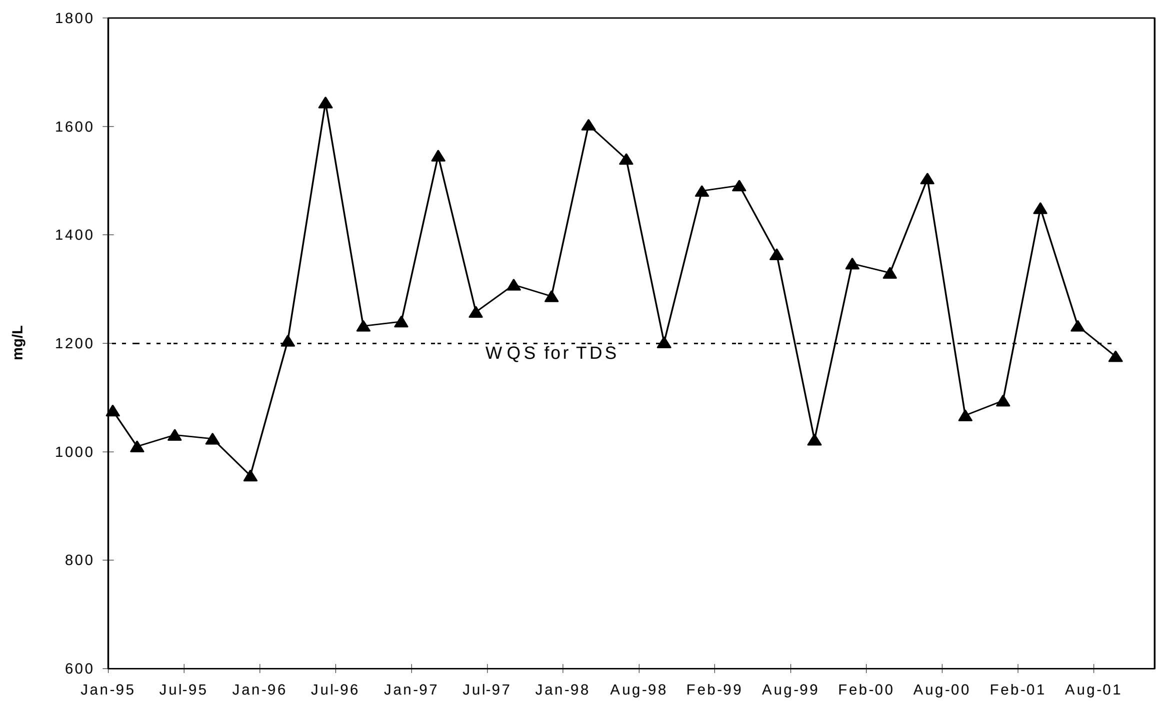


Figure 6.19 Well 800191 TDS Results

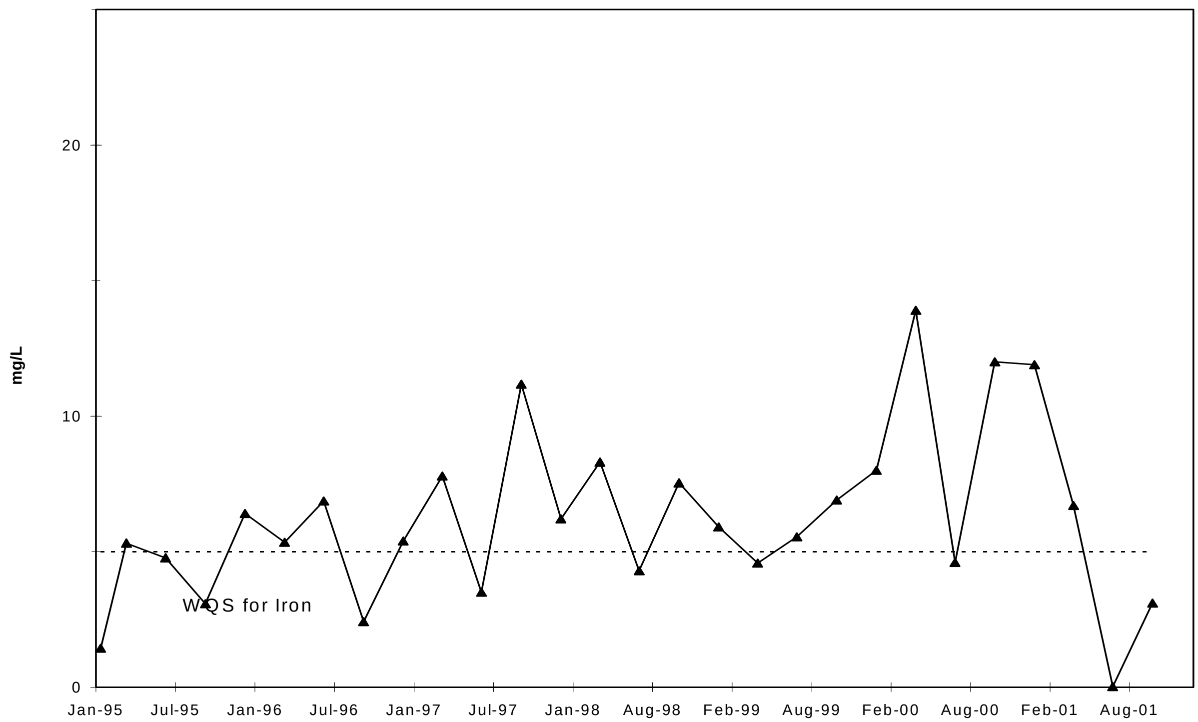


Figure 6.20 Well 800192 Iron Results

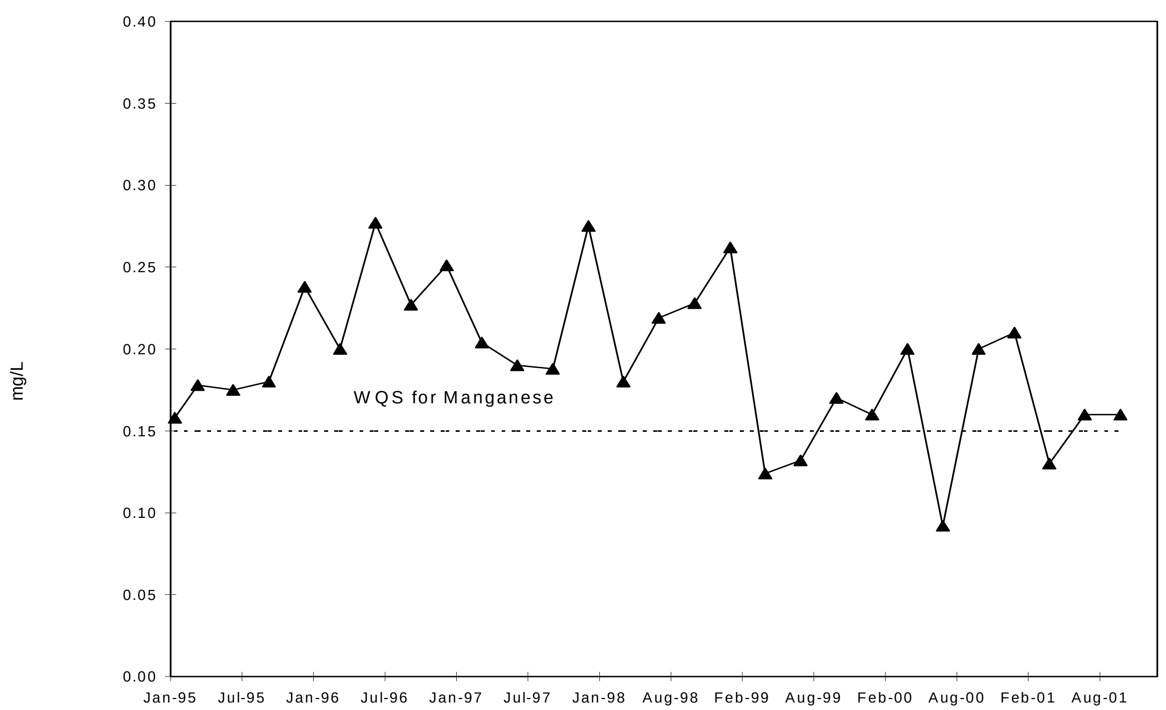


Figure 6.21 Well 800192 Manganese Results

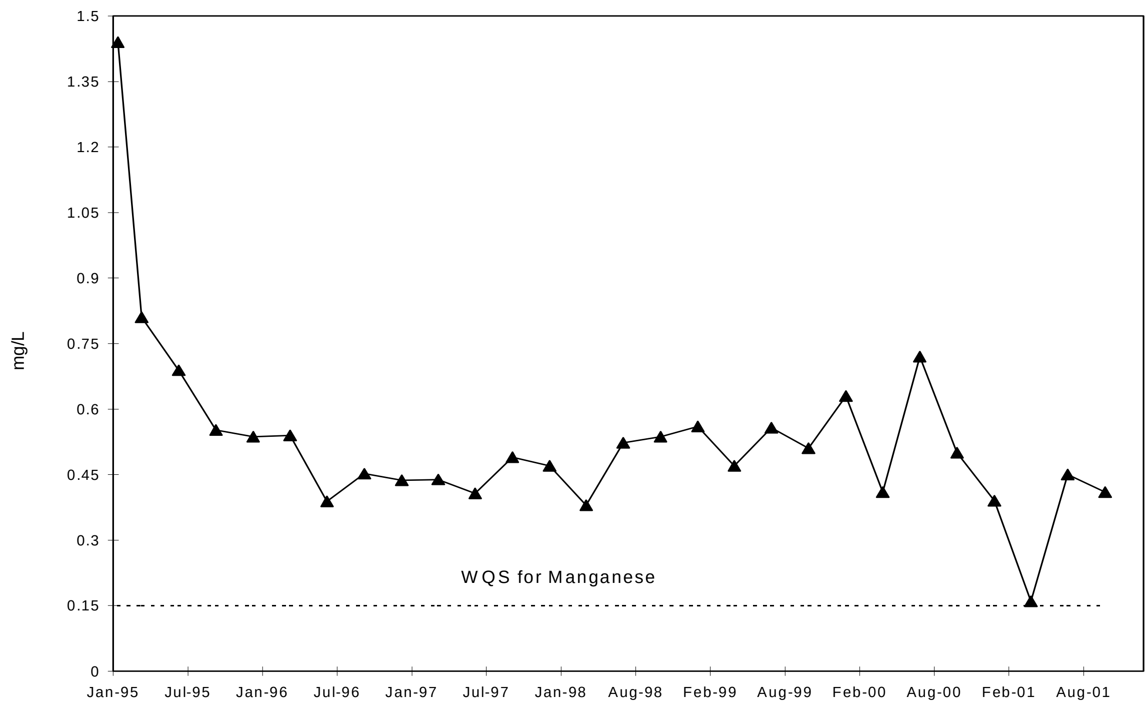


Figure 6.22 Well 800201 Manganese Results

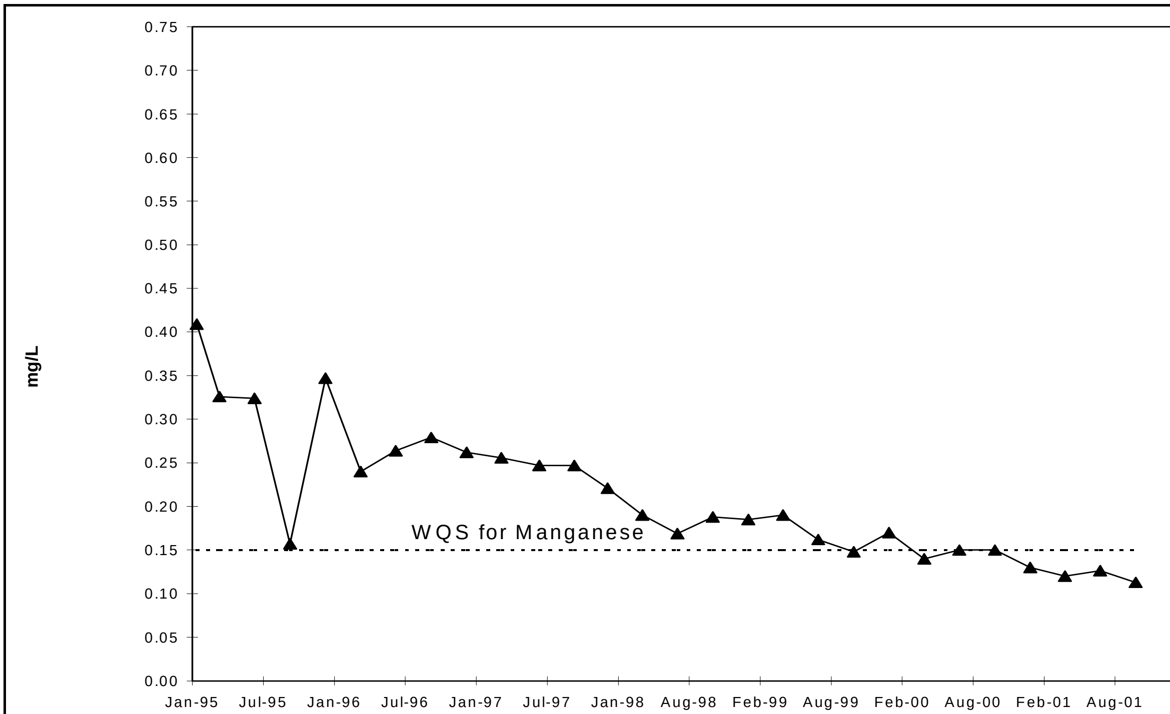


Figure 6.23 Well 800202 Manganese Results

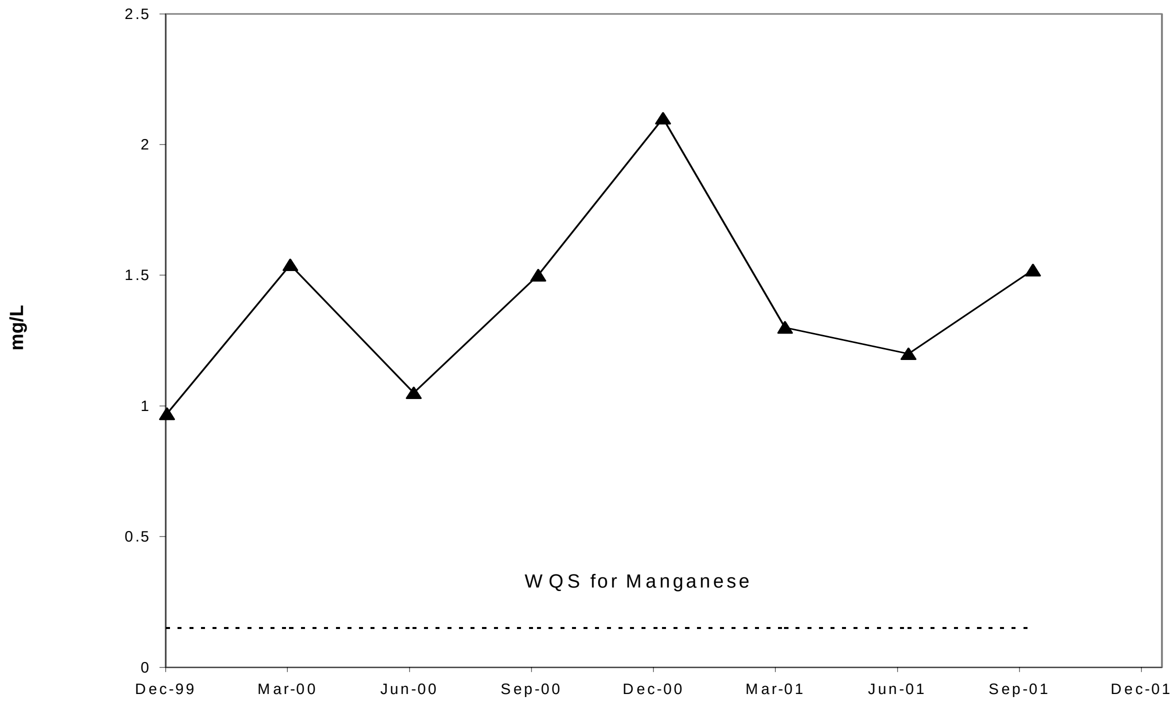


Figure 6.24 Well 800281 Manganese Results

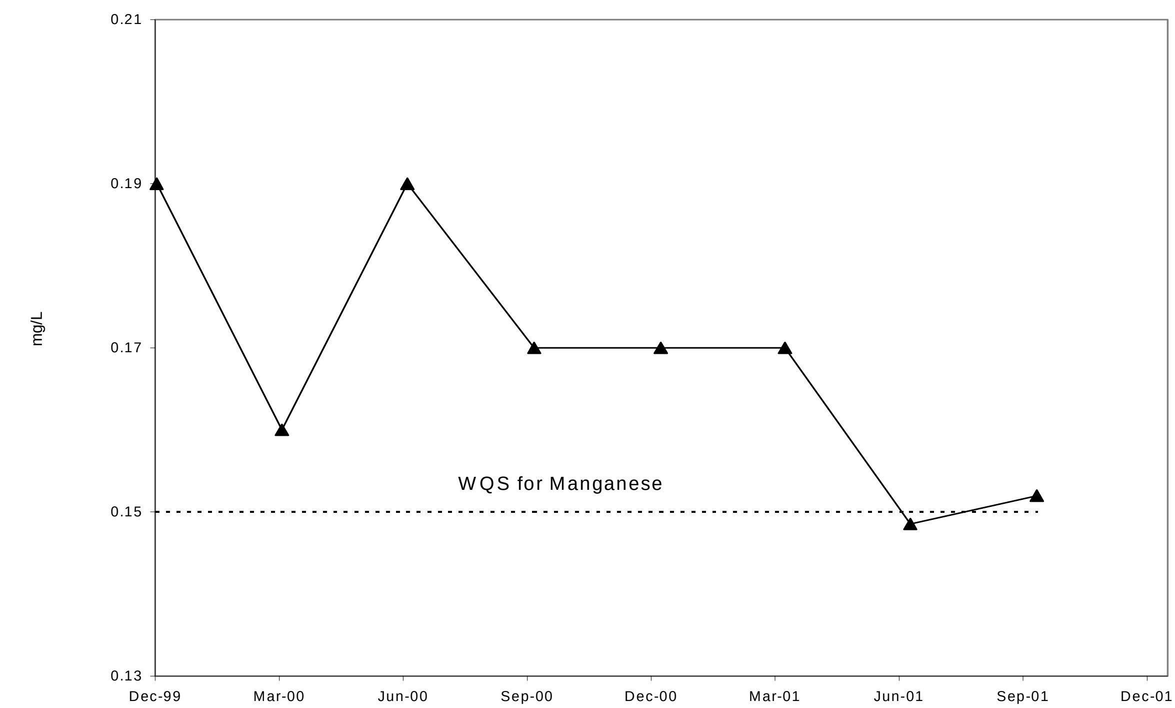


Figure 6.25 Well 800291 Manganese Results

nickel WQSs were exceeded in five shallow wells. The intermediate wells have fewer exceedances except for manganese, which exceeded the WQS in one of the three intermediate wells. The iron WQS was exceeded in two wells. The cyanide WQS was exceeded only one quarter in one intermediate well. Except for chloride only one quarter in one well, the results for the deep wells show no exceedances.

Field Parameters. Field parameters include such items as well and water depth information, pH, specific conductance, and temperature of water. These parameters are measured each quarter. No standards exist for comparative purposes, with the exception of pH. However, results are consistent from quarter to quarter and are similar to results obtained in previous years.

Filtered Routine Indicator Parameters. Filtered routine indicator parameters include ammonia nitrogen, arsenic, cadmium, chloride, iron, lead, manganese, mercury, sulfate, and TDS. These parameters are measured each quarter. Ammonia, arsenic, cadmium, lead, and mercury were all less than the WQS. As in 2000, sulfate exceeded the WQS (400 mg/L) in wells 800321 and 800381 during one and two quarters, respectively. Sulfate levels ranged from 323 to 1107 mg/L. Chloride exceeded the WQS (200 mg/L) in wells 800173D and 800191 one and two quarters, respectively, and the chloride levels ranged from 119 to 244 mg/L. TDS exceeded the WQS (1,200 mg/L) in wells 800191, 800321, and 800381, and the TDS levels ranged from 1,094 to 2,127 mg/L.

Iron concentrations exceeded the WQS (5 mg/L) at least once during the year in wells 800191, 800192, 800201, and 800202. Iron levels in these wells ranged from less than 0.02 to 12 mg/L.

Manganese concentrations exceeded the WQS (0.15 mg/L) during at least one quarter in wells 800171, 800191, 800192, 800201, 800281, 800291, 800321, and 800381. Manganese levels in these wells ranged from 0.09 to 2.1 mg/L. Manganese appears to be elevated over the entire 800 Landfill area, and similar concentrations have been measured in monitoring wells across the ANL-E site as well as several miles from the 800 Area Landfill.

Unfiltered Routine Indicator Parameters. These specific parameters include cyanide, phenols (total recoverable), TOC, and TOX and are measured each quarter. With the exception of cyanide, all measured unfiltered routine indicator parameters were less than the appropriate WQS values, where applicable. The cyanide WQS (0.2 mg/L) was exceeded in well 800382 during the third quarter.

Unfiltered Inorganic Parameters. These parameters are measured unfiltered only during the second quarter and include arsenic, barium, boron, cadmium, chloride, chromium, cobalt, copper, cyanide, fluoride, iron, lead, manganese, mercury, nickel, nitrate as nitrogen, selenium, silver, sulfate, and zinc. The results are similar to those noted in previous years.

Arsenic concentrations exceeded the WQS (0.050 mg/L) in only well 800381.

Sulfate concentrations exceeded the WQS (400 mg/L) only in well 800321.

Chromium and nickel concentrations exceeded the WQS (0.1 mg/L) in wells 800171, 800181, 800281, 800331, and 800371. Chromium levels ranged from 0.10 to 2.1 mg/L, and nickel levels ranged from 0.16 to 0.25 mg/L.

As in 2000, iron concentrations exceeded the WQS (5 mg/L) in wells 800271 (upgradient), 800171, 800181, 800191, 800192, 800201, 800202, 800281, 800291, 800301, 800321, 800331, 800341, 800351, 800361, 800371, 800381, 800382, and 800383D. The iron levels ranged from 5 to 214 mg/L. The iron exceedances are probably due to the requirement that these samples be unfiltered and result from iron in the soil particles suspended in the sample.

As in 2000, lead concentrations exceeded the WQS (0.0075 mg/L) in wells 800271 (upgradient), 800171, 800181, 800191, 800201, 800281, 800291, 800301, 800321, 800331, 800341, 800351, 800361, 800371, 800381, and 800382. Lead levels in these wells ranged from 0.0084 to 0.2325 mg/L. These elevated values are also likely to be the result of suspended soil particles in these samples.

As in 2000, manganese concentrations exceeded the WQS (0.15 mg/L) in wells 800271 (upgradient), 800171, 800181, 800191, 800192, 800201, 800281, 800291, 800301, 800321, 800331, 800341, 800351, 800361, 800371, 800381, 800382, and 800383D. Manganese levels in these wells ranged from 0.19 to 4.1 mg/L. Elevated manganese levels appear to be normal for this area.

Organic Parameters. Each well was sampled quarterly and analyzed for VOCs. VOCs were detected infrequently, that is, only during one quarter in 12 of the 14 wells where VOCs were determined at very low levels. Acetone and methylene chloride were the only VOCs noted in 13 of the 14 wells. However, the control sample for the first, third, and fourth quarters contained acetone at 9 µg/L and 11 µg/L, greater than the levels noted in the wells, that is, 1 to 5 µg/L. In addition, methylene chloride was noted in the third quarter control sample and methylene chloride was noted at very low levels only during the third quarter. Therefore, the presence of acetone and methylene chloride during these quarters is probably due to laboratory contamination. Acetone was noted during the second quarter in wells 800181, 800183D, 800281, and 800351; levels ranged from 2 to 4 µg/L. Chloroethane and trichloroethane were noted at a low level (1µg/L) and only during the third and first quarters, respectively, in well 800171. This shallow well is located east of the 800 Landfill area. The general groundwater flow direction in the shallow glacial drift, based on the water level elevations in the shallow series wells, is to the southeast with a minor component to the west.

Radioactive Constituents. Samples collected from the 800 Area sanitary landfill monitoring wells were also analyzed for hydrogen-3. The results are shown in Tables 6.20 to 6.43.

Although the disposal of radioactive materials was prohibited in the sanitary landfill, concentrations of hydrogen-3 were detected in wells 800171, 800281, 800291, and 800331 located east and southeast of the landfill, and wells 800191, 800192, and 800361 located south and at the southwest corner of the landfill area. Hydrogen-3 was also noted at very low levels for two quarters in upgradient well 800271. The presence of hydrogen-3 in this well is suspect and the results are probably due to laboratory error. Hydrogen-3 has been consistently noted in wells 800171, 800281, 800191, and 800192. Wells 800291, 800331, and 800361 were first monitored during 1999 and this is the first time hydrogen-3 has been detected in these wells, albeit at levels near detection (100 pCi/L). As previously mentioned, the general groundwater flow direction in the shallow glacial drift is to the southeast with a minor component to the west. Seasonal variations are known to exist as evidenced by the inconsistent presence of water in well 800321. Although hydrogen-3 was noted three quarters in well 800361 at very low levels, it has never been noted in wells immediately north (800301, 800321), west (800351), and east (800371) of this well. The wells in the southwest corner of the landfill area are adjacent to a stream that may be influencing subsurface water flow on the western side of the landfill area. For those wells with measurable levels of hydrogen-3, the samples were also analyzed for gamma-ray–emitting radionuclides. All results were below the detection limit.

6.4. CP-5 Reactor Area

The CP-5 reactor was an inactive research reactor located in Building 330 (see Figure 1.1). The CP-5 5-MW research reactor was used from 1954 until operations ceased in 1979. In addition to the reactor vessel, the CP-5 complex contained several large cooling towers and an outdoor equipment yard for storing equipment and supplies. The reactor and associated yard area have been decommissioned. A single exploratory monitoring well was installed in 1989 in the yard immediately behind the reactor building, just outside the reactor fuel storage area of the complex. Two new wells were installed as part of a full characterization study of this site, which took place during 1993. The three wells have been sampled quarterly since 1995 and analyzed for radionuclides, metals, VOCs, SVOCs, pesticides, herbicides, and PCBs. A deep well was installed during June 1997 to determine whether there had been any vertical migration of hydrogen-3 to the dolomite from the CP-5 reactor. Table 6.44 characterizes all wells in this area (see Figure 6.26 for locations). The results are shown in Tables 6.45 to 6.48 and are similar to those noted in previous years.

Well 330011 is installed in a relatively porous, saturated region of soil and as a result, recharges quickly. Purging the well by removing several well volumes of water does not lower the water level appreciably. The water has a higher conductivity and temperature than similar wells at other locations. The manganese WQS (0.15 mg/L) was exceeded each quarter, with levels ranging from 0.51 to 0.74 mg/L. Low levels of barium were noted each quarter; all levels were well below the WQS of 2 mg/L. As in past years, barium was detected each quarter in well 330021; all levels were considerably below the appropriate WQS. Iron was detected three quarters at levels well below the WQS (5 mg/L).

TABLE 6.44

Groundwater Monitoring Wells: 330 Area/CP-5 Reactor

ID Number	Well Depth (m bgs)	Ground Elevation (m AMSL)	Monitoring Zone (m AMSL)	Well Type[a]	Date Drilled
330011	6.1	227.10	224.2–221.1	0.05/PVC	8/89
330021	5.8	227.75	226.3–221.7	0.05/SS	9/93
330031	5.2	227.13	225.6–221.0	0.05/SS	9/93
330012D	41.5	227.13	191.7–185.6	0.05/SS	6/97

[a] Inner diameter (m)/well material (PVC = polyvinyl chloride, SS = stainless steel).

TABLE 6.45

Groundwater Monitoring Results, 300 Area Well 330011, 2001

Parameter	Unit	Date of Sampling 02/01/01	06/04/01	08/27/01	11/06/01
Water elevation[a]	m	225.15	224.78	224.38	224.95
Temperature	°C	11.7	13.5	18.6	17.1
pH	pH	7.09	6.84	6.88	7.06
Redox	mV	0	15	12	1
Conductivity	µmhos/cm	1,148	1,135	1,173	1,224
Chloride[b]	mg/L	100	87	162	131
Arsenic[b]	mg/L	< 0.0015	< 0.0030	< 0.0030	< 0.0030
Barium[b]	mg/L	0.0710	0.0646	0.0681	0.0659
Beryllium[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.037	< 0.020	< 0.020	< 0.020
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.6510	0.5324	0.7415	0.5056
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.02	< 0.02	< 0.02
Silver[b]	mg/L	< 0.0005	< 0.0010	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0020	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.008	< 0.008	< 0.008
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	1,292	1,362	992	1,514
Strontium-90	pCi/L	0.62	0.65	0.54	0.55
Dichlorofluoromethane	µg/L	< 1	< 1	2	1
Methylene chloride	µg/L	< 1	< 1	1	< 1

[a] Well point elevation = 221.00 m (MSL); ground surface elevation = 227.10 m (MSL); casing material = stainless steel.

[b] Filtered sample.

TABLE 6.46

Groundwater Monitoring Results, 300 Area Well 330021, 2001

Parameter	Unit	Date of Sampling 02/01/01	06/04/01	08/27/01	11/06/01
Water elevation[a]	m	227.38	225.28	225.36	226.38
Temperature	°C	8.3	10.2	14.4	13.3
pH	pH	7.51	7.21	7.14	7.24
Redox	mV	-29	-6	-4	-9
Conductivity	µmhos/cm	654	760	699	732
Chloride[b]	mg/L	4	5	6	4
Arsenic[b]	mg/L	< 0.0015	< 0.0030	< 0.0030	< 0.0030
Barium[b]	mg/L	0.0271	0.0239	0.0254	0.0284
Beryllium[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.0370	0.0592	0.1234	0.1101
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.017	< 0.010	< 0.010	< 0.010
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.0400	< 0.0200	< 0.0200	0.0206
Silver[b]	mg/L	< 0.0005	< 0.0010	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0020	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.008	< 0.008	< 0.008
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	136	178	138	193
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
Methylene chloride	µg/L	< 1	1	2	< 1

[a] Well point elevation = 221.95 m (MSL); ground surface elevation = 227.75 m (MSL); casing material = stainless steel.

[b] Filtered sample.

TABLE 6.47

Groundwater Monitoring Results, 300 Area Well 330031, 2001

		Date of Sampling			
Parameter	Unit	02/01/01	06/04/01	08/27/01	11/06/01
Water elevation[a]	m	227.13	225.92	224.98	226.44
Temperature	°C	9.6	10.6	13.9	13.7
pH	pH	7.05	7.18	7.05	7.05
Redox	mV	-2	-4	3	1
Conductivity	µmhos/cm	1,568	1,580	1,539	1,741
Chloride[b]	mg/L	219	185	202	206
Arsenic[b]	mg/L	< 0.0015	< 0.0030	< 0.0030	< 0.0030
Barium[b]	mg/L	0.0453	0.0349	0.0397	0.0428
Beryllium[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.037	< 0.020	< 0.020	0.061
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.1467	0.1321	0.0982	0.0642
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	0.7301	0.3790	0.4838	0.5788
Silver[b]	mg/L	< 0.0005	< 0.0010	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0020	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.0110	< 0.0080	0.0198	< 0.0080
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	188	254	273	304
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
Methylene chloride	µg/L	< 1	1	< 1	< 1

[a] Well point elevation = 221.95 m (MSL); ground surface elevation = 227.13 m (MSL); casing material = stainless steel.

[b] Filtered sample.

TABLE 6.48

Groundwater Monitoring Results, 300 Area Well 330012D, 2001

Parameter	Unit	Date of Sampling				
		02/01/01	06/04/01	08/27/01	11/06/01	11/06/01
Water elevation[a]	m	190.37	190.40	190.27	190.36	190.36
Temperature	°C	12.4	13.5	14.4	13.5	13.5
pH	pH	7.25	7.13	6.83	7.02	7.02
Redox	mV	-11	-1	15	3	3
Conductivity	µmhos/cm	1,022	1,074	1,055	1,105	1,105
Chloride[b]	mg/L	41	42	60	35	35
Arsenic[b]	mg/L	< 0.0015	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Barium[b]	mg/L	0.0613	0.0568	0.0581	0.0613	0.0594
Beryllium[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.026	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.017	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	0.2659	0.2685	0.0898	0.5695	0.5713
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0535	0.0445	0.0436	0.0336	0.0339
Mercury[b]	mg/L	< 0.0001	0.0002	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.0400	< 0.0200	< 0.0200	< 0.0200	0.0292
Silver[b]	mg/L	< 0.0005	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Thallium[b]	mg/L	< 0.0018	< 0.0020	< 0.0020	< 0.0020	< 0.0020
Vanadium[b]	mg/L	< 0.024	< 0.032	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.011	< 0.008	< 0.008	< 0.008	< 0.008
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	301	111	470	168	< 100
Strontium-90	pCi/L	0.39	< 0.25	< 0.25	< 0.25	< 0.25
Dichlorofluoromethane	µg/L	1	< 1	1	< 1	< 1
Methylene chloride	µg/L	< 1	1	1	< 1	< 1
Trichlorofluoromethane	µg/L	1	< 1	< 1	< 1	< 1

[a] Well point elevation = 185.65 m (MSL); ground surface elevation = 227.13 m (MSL); casing material = stainless steel.

[b] Filtered sample.

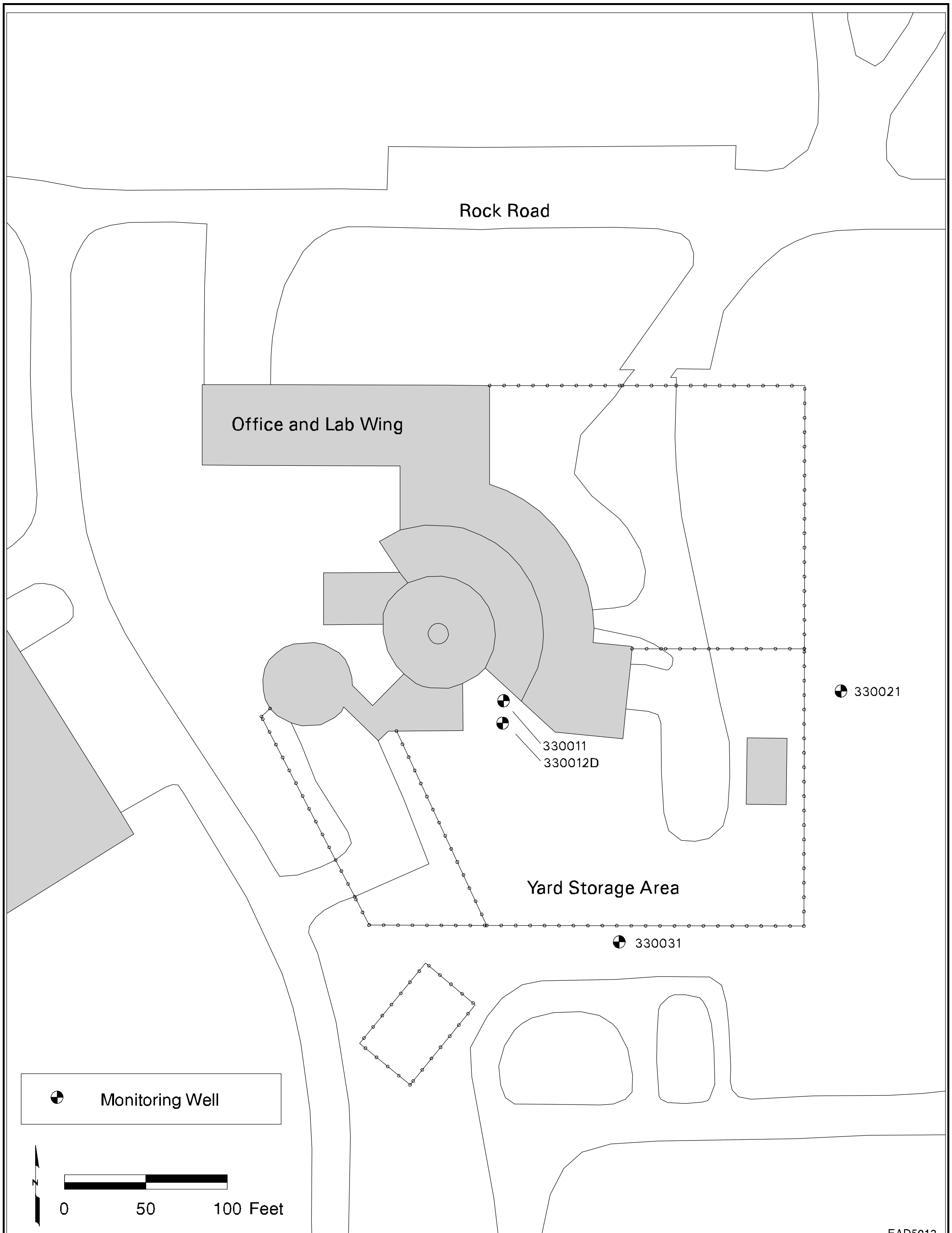


Figure 6.26 Active Monitoring Wells in the CP-5 Reactor Area

Low levels of manganese were noted each quarter in well 330031. Unlike previous years, no exceedances of the manganese WQS were noted. Manganese levels ranged from 0.06 to 0.15 mg/L. Nickel exceeded the WQS (0.10 mg/L) each quarter in well 330031 but levels were lower than those noted in 2000. Nickel levels ranged from 0.38 to 0.73 mg/L. The source of nickel is unknown. Chloride concentrations exceeded the WQS (200 mg/L) in three quarters, with chloride levels ranging from 185 to 219 mg/L. Barium and iron were detected at levels well below the WQS each quarter.

Barium, iron, and manganese were detected each quarter in well 330012D; all levels were considerably below the appropriate WQS.

As in past years, well 330011 contained low concentrations of dichlorofluoromethane; concentrations ranged from 1 to 2 μg/L. Well 330012D contained very low concentrations (1 μg/L) of dichlorofluoromethane and trichlorofluoromethane only during the first and third quarters. Methylene chloride was noted in each well in one or two quarters at a very low level (1 to 2 μg/L).

Radionuclide levels were similar to those noted in 2000 (see Figures 6.27 and 6.28). Hydrogen-3 was detected each quarter in each well. The levels of hydrogen-3 ranged from 111 to 1,514 pCi/L. These levels are well below the WQS (20,000 pCi/L). Similar to past years, strontium-90 was detected each quarter in well 330011 and one quarter in well 330012D, and the levels ranged from 0.39 to 0.65 pCi/L (Figure 6.28). These levels are well below the WQS (8 pCi/L).

The CP-5 was a heavy-water–moderated reactor. During its operational life, several incidents occurred that released small amounts of this heavy water containing high concentrations of hydrogen-3 to the environment. In addition, the normal operation released significant amounts of water vapor containing hydrogen-3 from the main ventilation system that may have condensed and fallen to the ground in the form of precipitation. These activities are believed to be responsible for the residual amounts of hydrogen-3 now found in the groundwater. The source of the strontium-90 is not known.

6.5. Monitoring of the Seeps South of the 300 Area

In spring 1996, during the RCRA Facility Investigation of the 317/319 Area, a series of groundwater seeps was discovered in a network of steeply eroded ravines in the Waterfall Glen Forest Preserve south and southeast of the 317 and 319 Areas. Three seeps (SP01, SP02, and SP04) are located about 200 m (600 ft) south of the 319 Area; two other seeps (SP03 and SP05) are located about 360 m (1,200 ft) south of the 317 Area and are considered clean background seeps. The locations are shown in Figure 6.29. The seeps are in ravines that are located in a pristine, heavily wooded section of the forest preserve. The ravines carry storm water drainage from the 317 and

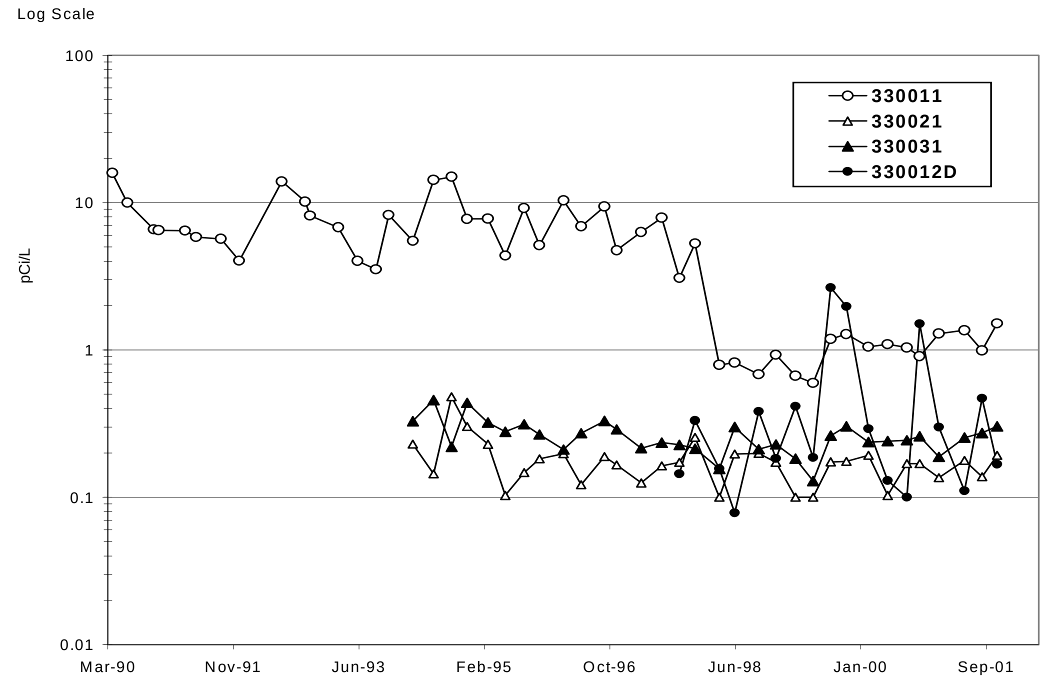


Figure 6.27 Hydrogen-3 Results in the CP-5 Monitoring Wells

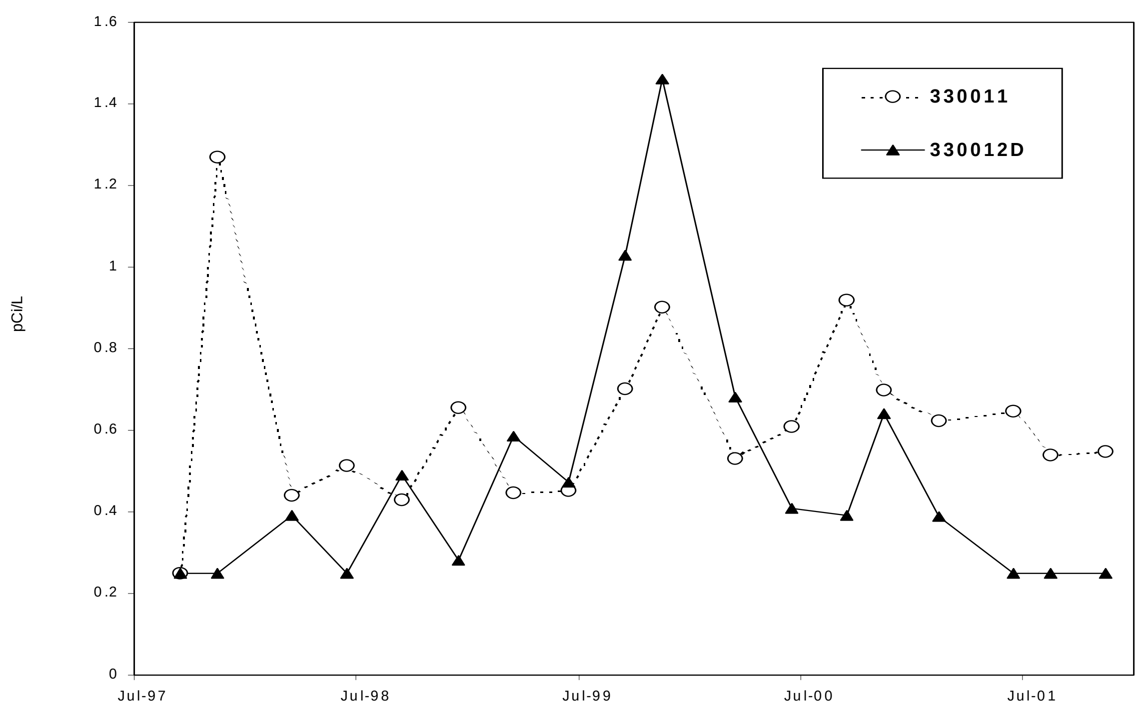


Figure 6.28 Strontium-90 Results in the CP-5 Monitoring Wells

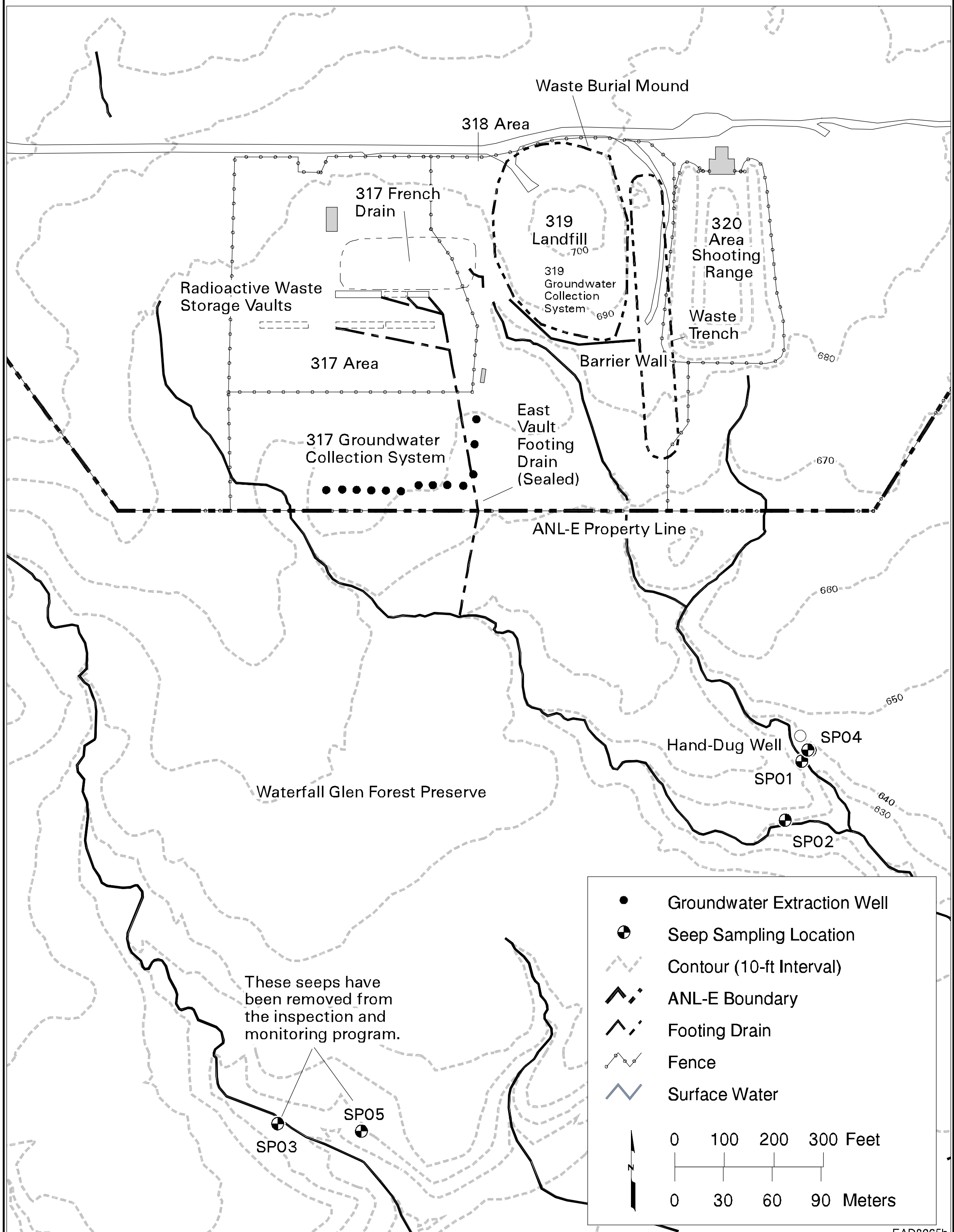


Figure 6.29 Seep Locations South of the 317/319 Area

319 Areas. Storm water flow has eroded the soil deep enough to expose a shallow sandy layer containing groundwater. Water emanating from the exposed sandy layer flows to the nearby ravine, where it forms a small rivulet in the bottom of the ravine. Approximately 30 m (100 ft) downstream of the seep area, the affected water from the seeps is no longer visible because it drains back into the soil in the bed of the ravine. During extended dry weather conditions, the flow disappears completely. The IEPA has designated this area as AOC-G — Off-Site Groundwater Seeps.

Samples were collected and analyzed for metals, VOCs, and selected radionuclides. Two groundwater seeps contained measurable levels of three VOCs — carbon tetrachloride, chloroform, and tetrachloroethene. Carbon tetrachloride and tetrachloroethene concentrations exceeded the Class I Groundwater Quality Standards. The other three seeps did not contain any quantifiable VOCs. Three of the five seeps, including the two containing the VOCs, were found to contain hydrogen-3 in measurable concentrations. Since the initial samples were collected, monthly samples were obtained through the end of 1997, and quarterly samples collected to the end of 1998. These results are summarized in the 1998 SER.[16]

During 2001, seeps SP01, SP02, and SP04 were sampled quarterly for VOCs and hydrogen-3. VOCs were noted in each seep each quarter. Seep SP04 showed the highest levels of all three VOCs (carbon tetrachloride, chloroform, and tetrachloroethene) each quarter. The data are presented in Table 6.45. The hydrogen-3 and VOC results are consistent with past data, which indicates a gradual decline in concentrations since measurements began in 1996.

Monitoring was also conducted quarterly at an artesian well located about 2,000 m (6,000 ft) southwest of the 317 Area (location 3E in Figure 1.1). All hydrogen-3 concentrations were less than the detection limit of 100 pCi/L. This finding suggests that any subsurface contaminant movement has not extended to this location and indicates a western limit to movement.

TABLE 6.49

Contaminant Concentrations in Seep Water, 2001

Site	Date Collected	Hydrogen-3 (pCi/L)	Carbon Tetrachloride (µg/L)	Chloroform (µg/L)	Tetrachloroethene (µg/L)
SP01	January 31	640	5	1	< 1
	May 15	633	7	1	< 1
	September 7	555	4	1	< 1
	November 2	645	6	2	< 1
SP02	January 31	1383	2	< 1	< 1
	May 15	340	2	< 1	< 1
	September 7	619	2	< 1	< 1
	November 2	626	2	< 1	< 1
SP04	January 31	418	221	22	6
	May 15	124	208	25	7
	September 7	117	145	54	7
	November 2	183	148	23	6

7. QUALITY ASSURANCE

QA plans exist for both radiological and nonradiological analyses; these QA documents were prepared in accordance with DOE Order 414.1[29] and discuss who is responsible for QA and for auditing analyses. Both documents are supplemented by operating manuals.

7.1. Sample Collection

Many factors enter into an overall QA program other than the analytical quality control. Representative sampling is of prime importance. Appropriate sampling protocols are followed for each type of sampling being conducted. Water samples are pretreated in a manner designed to maintain the integrity of the analytical constituent. For example, samples for trace radionuclide analyses are acidified immediately after collection to prevent hydrolytic loss of metal ions and are filtered to reduce leaching from suspended solids.

The monitoring wells are sampled using the protocols listed in the *RCRA Ground-Water Monitoring Technical Enforcement Guidance Document*.[28] The volume of water in the casing is determined by measuring the water depth from the surface and the depth to the bottom of the well. This latter measurement also determines whether siltation has occurred that might restrict water movement in the screened area. For those wells in the glacial drift that do not recharge rapidly, the well is emptied, and the volume removed is compared with the calculated volume. In most cases, these volumes are nearly identical. The well is then sampled by bailing with a Teflon bailer. If samples for parameters such as priority pollutants are collected, field parameters for these samples (pH, specific conductance, redox potential, and temperature) are measured per well volume while purging. For samples in the porous, saturated zone, which recharges rapidly, three well volumes are purged by using submersible pumps. If field parameters are measured, samples are collected as soon as these readings stabilize. All samples are placed in precleaned bottles, labeled, and preserved. All field measurement and sampling equipment is cleaned by field rinsing with Type II deionized water. The samples are transferred to the analytical laboratory via a computer floppy disk that generates a one-page list of all samples. This list acts as the chain of custody transfer document.

7.2. Radiochemical Analysis and Radioactivity Measurements

The documentation for radiological analyses is contained in the ESH-AC procedure manual. All nuclear instrumentation is calibrated with standard sources obtained from or traceable to the National Institute of Standards and Technology (NIST). The equipment is checked daily with secondary counting standards to ensure proper operation. Samples are periodically analyzed in duplicate or with the addition of known amounts of a radionuclide to check precision and accuracy. When a nuclide is not detected, the result is given as “less than” (<) the detection limit by the analytical method used. The detection limits are chosen so that the measurement uncertainty at the 95% confidence level is equal to the measured value. The air and water detection limits for all radionuclides for which measurements were made in 2001 are given in Table 7.1. The relative error in a result decreases with increasing concentration. At a concentration equal to twice the detection limit, the error is approximately 50% of the measured value; at 10 times the detection limit, the error is approximately 10% at the 95% confidence level.

Average values are accompanied by a plus-or-minus (±) limit value. Unless otherwise stated, this value is the standard error at the 95% confidence level calculated from the standard deviation of the average. The ± limit value is a measure of the range in the concentrations encountered at that location; it does not represent the conventional uncertainty in the average of repeated measurements on the same or identical samples. Because many of the variations observed in environmental radioactivity are not random but occur for specific reasons (e.g., seasonal variations), samples collected from the same location at different times are not replicates. The more random the variation in activity at a particular location, the closer the confidence limits will represent the actual distribution of values at that location. The averages and confidence limits should be interpreted with this in mind. When a ± value accompanies an individual result in this report, it represents the statistical counting error at the 95% confidence level.

TABLE 7.1

Air and Water Detection Limits

Nuclide or Activity	Air (fCi/m^3)	Water (pCi/L)
Americium-241	-[a]	0.001
Beryllium-7	5	-
Californium-249	-	0.001
Californium-252	-	0.001
Cesium-137	0.1	2
Curium-242	-	0.001
Curium-244	-	0.001
Hydrogen-3	-	100
Lead-210	1	-
Neptunium-237	-	0.001
Plutonium-238	0.0001	0.001
Plutonium-239	0.0001	0.001
Radium-226	-	0.02
Radium-228	-	0.02
Strontium-89	0.1	2
Strontium-90	0.01	0.25
Thorium-228	0.001	-
Thorium-230	0.001	-
Thorium-232	0.001	-
Uranium-234	0.001	0.01
Uranium-235	0.001	0.01
Uranium-238	0.001	0.01
Uranium - natural	0.02	0.2
Alpha	0.2	0.2
Beta	0.5	1

[a] A hyphen indicates that a value is not required.

ANL-E continues to participate in the DOE Environmental Measurements Laboratory Quality Assurance Program (DOE-EML-QAP), which consists of semiannual distribution of three different sample matrices containing various combinations of radionuclides that are analyzed. Table 7.2 summarizes the results for 2001. In the table, the EML value, which is the result of duplicate determinations by that laboratory, is compared with the average value obtained in the ANL-E laboratory. Information that will assist in judging the quality of the results includes

TABLE 7.2

Summary of DOE-EML-QAP Samples, 2001

Matrix	Constituent	Date	Unit	EML	ANL-E	Ratio	Comments
Air filter	Manganese-54	March	Bq/filter	6.52	6.30	0.97	Acceptable
		Sept.		81.15	82.0	1.01	Acceptable
	Cobalt-60	March		19.44	19.00	0.98	Acceptable
		Sept.		17.50	18.00	1.03	Acceptable
	Strontium-90	March		7.10	7.40	1.04	Acceptable
		Sept.		3.48	2.80	0.80	Acceptable
	Cesium-134	March		2.83	2.80	0.99	Acceptable
		Sept.		12.95	14.00	1.08	Acceptable
	Cesium-137	March		8.76	9.10	1.04	Acceptable
		Sept.		17.10	18.00	1.05	Acceptable
	Uranium-234	March		0.046	0.047	1.02	Acceptable
		Sept.		0.108	0.094	0.87	Warning
	Uranium-238	March		0.046	0.043	0.94	Acceptable
		Sept.		0.109	0.104	0.95	Acceptable
	Plutonium-238	March		0.215	0.210	0.98	Acceptable
		Sept.		0.071	0.072	1.01	Acceptable
	Plutonium-239	March		0.136	0.140	1.03	Acceptable
		Sept.		0.229	0.230	1.00	Acceptable
	Americium-241	March		0.486	0.490	1.01	Acceptable
		Sept.		0.088	0.079	0.90	Acceptable
Soil	Potassium-40	March	Bq/kg	468.0	485.0	1.04	Acceptable
		Sept.		623.0	685.0	1.10	Acceptable
	Strontium-90	March		69.0	66.0	0.96	Acceptable
		Sept.		30.60	29.00	0.95	Acceptable
	Cesium-137	March		1740.0	1874.0	1.08	Acceptable
		Sept.		612.0	665.0	1.09	Acceptable
	Uranium-234	March		43.6	52.0	1.19	Warning
		Sept.		92.2	90.0	0.98	Acceptable
	Uranium-238	March		46.1	51.0	1.11	Acceptable
		Sept.		98.3	91.0	0.92	Acceptable
	Plutonium-239	March		25.6	25.0	0.98	Acceptable
		Sept.		8.95	9.60	1.07	Acceptable
	Americium-241	March		14.80	14.00	0.95	Acceptable
		Sept.		4.43	4.50	1.02	Acceptable

TABLE 7.2 (Cont.)

Matrix	Constituent	Date	Unit	EML	ANL-E	Ratio	Comments
Water	Hydrogen-3	March	Bq/L	79.3	85.0	1.07	Acceptable
		Sept.		207.0	224.0	1.08	Acceptable
	Cobalt-60	March		98.2	99.0	1.01	Acceptable
		Sept.		209.0	209.0	1.00	Acceptable
	Strontium-90	March		4.40	4.20	0.96	Acceptable
		Sept.		3.73	3.60	0.96	Acceptable
	Cesium-137	March		73.0	72.0	0.99	Acceptable
		Sept.		45.1	45.0	1.00	Acceptable
	Uranium-234	March		1.04	0.98	0.94	Acceptable
		Sept.		1.17	1.20	1.03	Acceptable
	Uranium-238	March		1.04	1.00	0.96	Acceptable
		Sept.		1.17	1.30	1.11	Acceptable
	Plutonium-238	March		1.58	1.56	0.99	Acceptable
		Sept.		1.09	1.10	1.01	Acceptable
	Plutonium-239	March		1.64	1.64	1.00	Acceptable
		Sept.		1.63	1.70	1.04	Acceptable
	Americium-241	March		1.67	1.63	0.98	Acceptable
		Sept.		0.76	0.82	1.08	Acceptable

the fact that typical uncertainties for ANL-E's analyses are 2 to 50%, and that the uncertainties in the EML results are 1 to 30% (depending on the nuclide and the amount present). For most analyses for which the differences are large (> 20%), the concentrations were quite low and the differences were within the measurement uncertainties.

Overall, the ANL-E performance in the EML intercomparison studies on the three matrices resulted in over 96% (50 out of 52) of the analysis being in the DOE-EML-QAP acceptable range. Two samples analyzed for uranium-234 fell within the warning category. The ANL-E performance on these samples indicated that the reported results are accurate.

7.3. Chemical Analysis

The documentation for nonradiological analyses is contained in the ESH-AC Procedure Manual. All samples for NPDES and groundwater are collected and analyzed in accordance with EPA regulations found in 40 CFR Part 136,[23] EPA-600/4-84-017,[30] and SW-846.[6]

Standard reference materials traceable to the NIST exist for most inorganic analyses (see Table 7.3) and are replaced annually. Detection limits are determined with techniques listed in 40 CFR Part 136[23] and are given in Table 7.4. In general, the detection limit is the measure of the variability of a standard material measurement at 5 to 10 times the instrument detection limit as measured over an extended time period. Recovery of inorganic metals, as determined by “spiking” unknown solutions, must be within the range of 75 to 125%. The precision, as determined by analysis of duplicate samples, must be within 20%. These measurements must be taken for at least 10% of the samples. Comparison samples for organic constituents were formerly available from the EPA; they are now commercially available under the Cooperative Research and Development Agreement that exists between the EPA and commercial laboratories. In addition, standards are available that are certified by the American Association for Laboratory Accreditation, under a Memorandum of Understanding with the EPA. Many of these standards were used in this work. At least one standard mixture is analyzed each month; Tables 7.5 and 7.6 show the 2001 results for VOCs and SVOCs, respectively. The recoveries listed are those required by the respective methods.

7.4. NPDES Analytical Quality Assurance

ANL-E conducts the majority of the analyses required for inclusion in the DMR. These analyses are conducted in accordance with EPA-approved methods set out in 40 CFR Part 136.[23] To demonstrate the capabilities of the ANL-E laboratory for these analyses, the EPA requires that ANL-E participate in the DMR Quality Assurance program. An EPA-accredited provider sends a series of intercomparison samples to ANL-E annually, and the ensuing analytical results are submitted to the provider for review. The proficiency of the laboratory is determined by comparing the analytical results for the submitted samples with the provider values. The ANL-E laboratory has consistently performed very well on these tests. In 2001, all results were acceptable, with the exception of ammonia nitrogen. A corrective action statement was prepared and forwarded to the EPA provider and the IEPA.

TABLE 7.3

Standard Reference Materials Used for Inorganic Analysis

Constituent	Reference Material[a]
Antimony	SCP-140-051-511
Arsenic	SCP-140-051-331
Barium	SCP-140-051-561
Beryllium	SCP-140-051-041
Boron	SCP-140-050-051
Cadmium	SCP-140-051-481
Chromium	SCP-140-052-241
Cobalt	SCP-140-051-271
Copper	SCP-140-051-291
Iron	VHG-AFEN-100
Lead	SCP-140-051-821
Manganese	SCP-140-051-251
Mercury	SCP-140-051-801
Nickel	SCP-140-051-281
Selenium	SCP-140-051-341
Silver	SCP-140-051-471
Thallium	SCP-140-051-811
Vanadium	SCP-140-051-231
Zinc	SCP-140-051-301
Sulfate	NIST-SRM 3181
Chloride	NIST-SRM 3182
Fluoride	NIST-SRM 3183

[a] SCP = SCP Science, Inc; VHG = VHG Labs, Inc.; NIST-SRM = National Institute of Standards and Technology - Standard Reference Materials.

TABLE 7.4

Detection Limit for Metals Analysis, 2001

	Detection Limit (mg/L)	
Constituent	AA[a]	ICP[b]
Antimony	0.0030	NA[c]
Arsenic	0.0030	0.076
Barium	NA	0.010
Beryllium	0.0002	0.010
Boron	NA	0.016
Cadmium	0.0002	0.015
Chromium	0.015	0.024
Cobalt	NA	0.016
Copper	0.010	0.015
Hexavalent chromium[d]	0.006	NA
Iron	0.040	0.020
Lead	0.0020	0.086
Manganese	0.015	0.010
Mercury	0.0001	NA
Nickel	0.030	0.020
Selenium	0.0030	0.121
Silver	0.0010	NA
Thallium	0.0020	0.082
Vanadium	NA	0.032
Zinc	0.010	0.008

[a] AA = atomic absorption spectroscopy.

[b] ICP = inductively coupled plasma-atomic emission spectroscopy.

[c] NA = not analyzed.

[d] Colorimetric measurement.

TABLE 7.5

Quality Check Sample Results: Volatile Analyses, 2001

Constituent	Recovery[a] (%)	Quality Limit (%)
Benzene	101	73–126
Bromobenzene	105	76–133
Bromodichloromethane	92	50–140
Bromoform	73	57–156
Butylbenzene	105	71–125
sec-Butylbenzene	95	71–145
t-Butylbenzene	96	69–134
Carbon tetrachloride	91	86–118
Chlorobenzene	101	80–137
Chloroform	97	68–120
o-Chlorotoluene	101	81–146
p-Chlorotoluene	96	73–144
1,2-Dibromo-3-chloropropane	81	36–154
Dibromochloromethane	85	68–130
1,2-Dibromoethane	106	75–149
Dibromomethane	102	65–143
1,2-Dichlorobenzene	98	59–174
1,3-Dichlorobenzene	100	84–143
1,4-Dichlorobenzene	101	58–172
1,1-Dichloroethane	98	71–142
1,2-Dichloroethane	107	70–134
1,1-Dichloroethene	93	18–209
cis-1,2-Dichloroethene	104	85–124
trans-1,2-Dichloroethene	93	67–141
1,2-Dichloropropane	100	19–179
1,3-Dichloropropane	100	73–145
1,1-Dichloropropene	115	71–133
Ethyl benzene	105	84–130
Isopropylbenzene	104	70–144
4-Isopropyltoluene	112	72–140
Methylene chloride	99	D–197[b]
n-Propylbenzene	95	78–139
1,1,1,2-Tetrachloroethane	92	88–133
Tetrachloroethene	101	84–132
Toluene	98	81–130
1,1,1-Trichloroethane	90	68–149
1,1,2-Trichloroethane	100	70–133
Trichloroethene	98	91–135
1,2,3-Trichloropropane	102	50–158
1,2,4-Trimethylbenzene	99	80–144
1,3,5-Trimethylbenzene	99	76–142
o-Xylene	101	79–141
p-Xylene	100	74–138

[a] Average of two determinations.

[b] D denotes that the compound was detected.

TABLE 7.6

Quality Check Sample Results:
Semivolatile Analyses, 2001

Constituent	Recovery[a] (%)	Quality Limit (%)
2-Fluorophenol[b]	24.0	21–100
Phenol-d5[b]	21.6	10–94
Phenol	27.3	17–100
2-Chlorophenol	57.5	36–120
1,3-Dichlorobenzene	45.5	33–95
1,4-Dichlorobenzene	49.6	37–106
n-Nitroso-n-Propylamine	29.5	24–198
Nitrobenzene-d5[b]	61.4	35–114
1,2,4-Trichlorobenzene	60.5	57–129
4-Chloro-3-Methylphenol	72.6	41–128
2-Fluorobiphenyl[b]	69.9	43–116
2-Methylnaphthalene	76.4	45–113
Acenaphthene	78.4	47–145
2,4-Dinitrotoluene	80.7	48–127
2,4,6-Tribromophenol[b]	68.4	10–123
Pentachlorophenol	40.6	38–152
Pyrene	66.3	70–100
Terphenyl-d14[b]	95.2	33–141

[a] Average of three determinations.

[b] Required surrogates.

8. APPENDIX

8.1. References

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