

Argonne National Laboratory-East



Site Environmental Report for Calendar Year 2000



ANL-01/2

By N.W. Golchert, R.G. Kolzow, and L.P. Moos

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**ARGONNE NATIONAL LABORATORY-EAST
SITE ENVIRONMENTAL REPORT
FOR CALENDAR YEAR 2000**

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**N.W. Golchert, R.G. Kolzow, and L.P. Moos
The Office of ESH/QA Oversight**

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**ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue
Argonne, Illinois 60439**

Preceding Report in This Series: ANL-00/2

This Site Environmental Report (SER) was prepared by the Office of ESH/QA Oversight (EQO) at Argonne National Laboratory-East (ANL-E) for the U.S. Department of Energy (DOE). The results of the environmental monitoring program and an assessment of the impact of site operations on the environment and the public are presented in this publication. This SER and those for recent years are available on the Internet at <http://www.anl.gov/ESH/anleser/2000>.



The majority of the figures and tables were prepared by Jennifer Tucker of the Data Management Team. Some figures, however, were prepared by Jim Kuiper of the Ecological and Geographical Sciences Section of ANL-E's Environmental Assessment Division. Sample collection and field measurements were conducted under the direction of Ronald Kolzow of the Monitoring and Surveillance Group by:

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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
BOD₅	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	<i>Code of Federal Regulations</i>
CLP	Contract Laboratory Program
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
EIS	Environmental Impact Statement
EMS	Environmental Protection Data Management System
ENE	East-Northeast
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right to Know Act
EQO	The Office of ESH/QA Oversight
ESA	Endangered Species Act
ESH	Environment, Safety and Health
ESH-ASCH	Environment, Safety and Health/Analytical Services, Chemical Laboratory
ESH-ASRL	Environment, Safety and Health/Analytical Services, Radiochemistry Laboratory
FFCA	Federal Facility Compliance Act

ACRONYMS

FWS	U.S. Fish and Wildlife Service
FY	Fiscal Year
HSWA	Hazardous and Solid Waste Amendments
IAC	<i>Illinois Administrative Code</i>
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
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 results of the environmental protection program at Argonne National Laboratory-East (ANL-E) for calendar year 2000. 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. 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.

This report summarizes the ongoing environmental protection program conducted by Argonne National Laboratory-East (ANL-E) in calendar year 2000. 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 2000, 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 2000 was 0.046 mrem/yr. This is 0.5% of the 10 mrem/yr standard. This dose does not include contributions from radon-220 and radon-222 emissions, as stipulated 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 79 m³ (2,800 ft³) of ACM was removed and disposed of at off-site landfills in Illinois during 2000.

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 air pollution control operating permit for the steam plant requires continuous opacity and sulfur dioxide monitoring of the smoke stack from

EXECUTIVE SUMMARY

Boiler No. 5, the only boiler equipped to burn coal. Low-sulfur coal was burned in Boiler No. 5 for four months during 2000, whereas natural gas was used as the fuel at that boiler for the other eight months of the year. During the period coal was burned, which occurred during colder weather to supplement the other gas-fired boilers, no exceedance for opacity was observed.

During 2000, a preliminary draft of the ANL-E Clean Air Act Permit Program (CAAPP) permit was issued. The final permit was issued in April 2001.

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 increase temporarily until July 1, 1999, some discharge limits during the three-year compliance schedule imposed to achieve final limits. During 2000, nine exceedances of the NPDES permit limits were reported out of approximately 1,600 measurements. 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 2000, 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.

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 3 Areas of Concern (AOCs). Since the issuance of the permit, two additional SWMUs have been added to the permit.

ANL-E has prepared and implemented a sitewide underground storage tank (UST) compliance plan. Thirty-nine tanks have been removed over the past several years. 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 suppliers, and small transformers. 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. PCB-contaminated sludge from the ANL-E wastewater treatment plant was characterized, containerized, and stored during 1994. Most of this sludge was shipped off site for disposal in 2000; the remainder was shipped in early 2001. The ANL-E PCB Item Inventory Program was initiated in 1995 to identify all suspect PCB-containing items.

DOE implementation of National Environmental Policy Act (NEPA) requirements has undergone significant changes since 1992. In 2000, most projects requiring NEPA review submitted to DOE for assessment were determined to be categorical exclusions. One Environmental Assessment (EA) addendum addressing the site-wide Remediation Program, was completed in 2000. One EA was completed for the decontamination and decommissioning of Building 301.

The ANL-E Environmental 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.

Ongoing compliance issues at ANL-E during 2000 were effluent concentrations of total dissolved solids (TDS) and total suspended solids 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.

Environmental Surveillance Program

Airborne emissions of radioactive materials from ANL-E were monitored during 2000. 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 was 0.48 mrem/yr in the east direction, while the estimated maximum dose to a member of the public was 0.047 mrem/yr. This latter value is 0.05% 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 hypothetical maximally exposed individual would be 0.046 mrem/yr. The estimated population dose from releases to the approximately eight million people living within 80 km (50 mi) of the site was 3.15 person-rem.

Ambient air monitoring 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

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levels of hydrogen-3, strontium-90, plutonium-239, and americium-241 were detected. Of these radionuclides, the maximum annual release was 0.12 Ci of hydrogen-3. 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 0.019 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 0.013 pCi/g) and americium-241 (up to 0.004 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 2000 using thermoluminescent dosimeters. The off-site results averaged 99 ± 5 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 114 ± 21 mrem/yr for 2000, although no one occupies this area. The estimated dose from penetrating radiation to the nearest resident south of the site was < 0.01 mrem/yr.

The potential radiation doses to members of the public from ANL-E operations during 2000 were estimated by combining the exposure from inhalation, ingestion, and direct radiation pathways. The inhalation pathway dominates. The highest estimated dose was approximately 0.076 mrem/yr to a hypothetical individual living east of the site, if he or she were 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 2000. 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, except for elevated levels of TDS.

Ten monitoring wells screened in the glacial till 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, carbon tetrachloride, trichloroethene, 1,1,1-trichloroethane, 1,1-dichloroethane, and tetrachloro-

ethene. Measurable levels of hydrogen-3 and strontium-90 were present in several of the wells. Remediation continued in this area using phytoremediation to remove volatile organic compounds (VOCs) and hydrogen-3 from groundwater.

Three monitoring wells are screened in the glacial till 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 metals.

Thirteen 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 and herbicides, and hydrogen-3. An additional 13 wells were added under a Supplemental Permit issued June 16, 1999. Levels above Illinois Class I Groundwater Quality Standards for chloride, iron, lead, manganese, and TDS were found in some wells. Above-background levels of hydrogen-3 were detected in several of the wells, with concentrations up to 1,200 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. INTRODUCTION

1.1. General

This annual report for calendar year 2000 on 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 problems related to environmental protection and environmental remediation. The report was prepared in accordance with the guidelines of DOE Orders 5400.1¹ and 231.1² 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 2000 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 require 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

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multicurie quantities of the actinide elements and with irradiated reactor fuel materials. The DOE New Brunswick Laboratory (NBL), a safeguards plutonium and uranium measurements and analytical chemistry laboratory, is located on the ANL-E site.

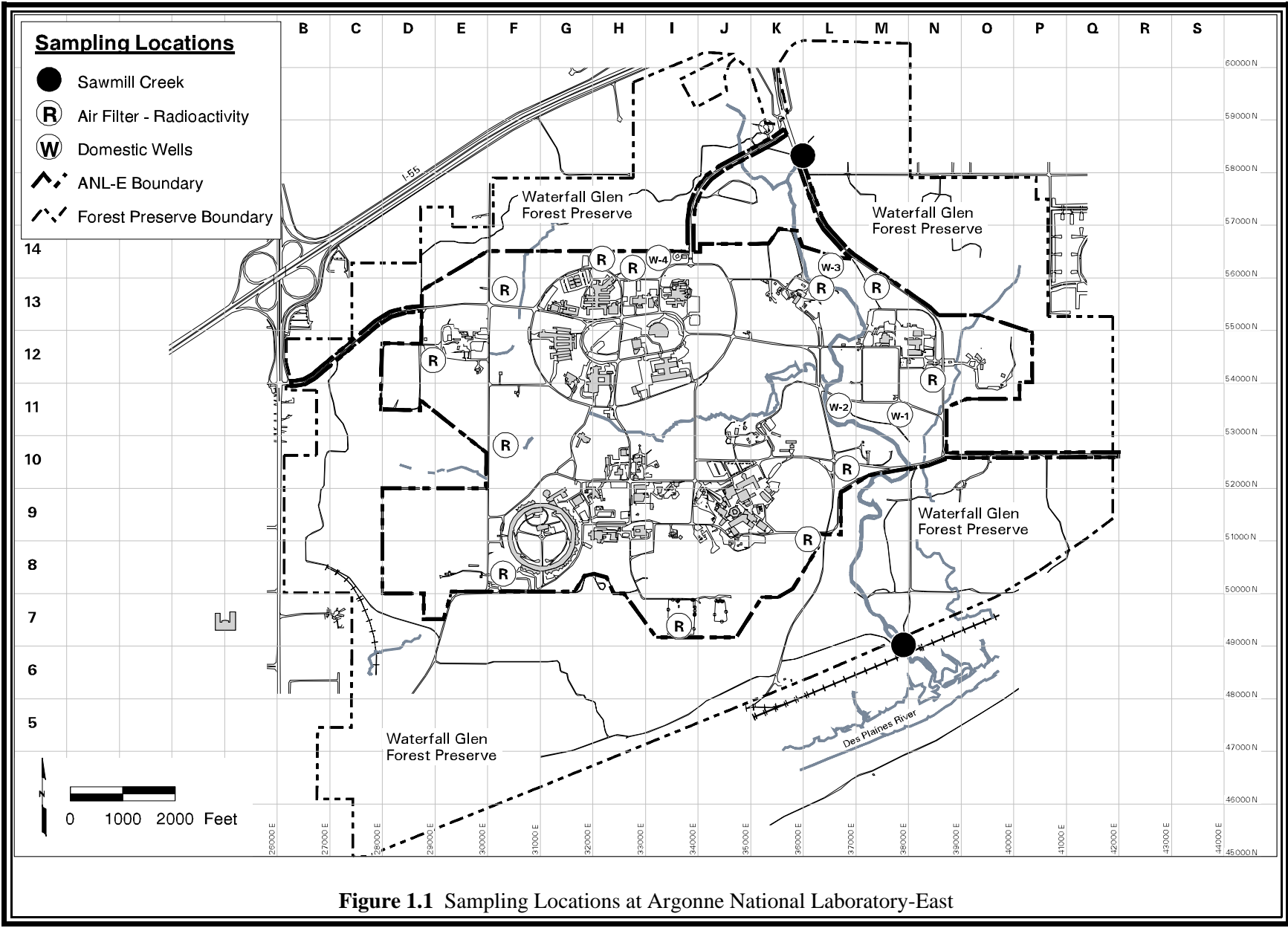
The principal nonnuclear activities at ANL-E in 2000 that could have measurable impacts on the environment include the use of a coal-fired boiler (No. 5), discharge of wastewater from various sources, and the cleanup of inactive waste disposal areas.

1.2. Description of Site

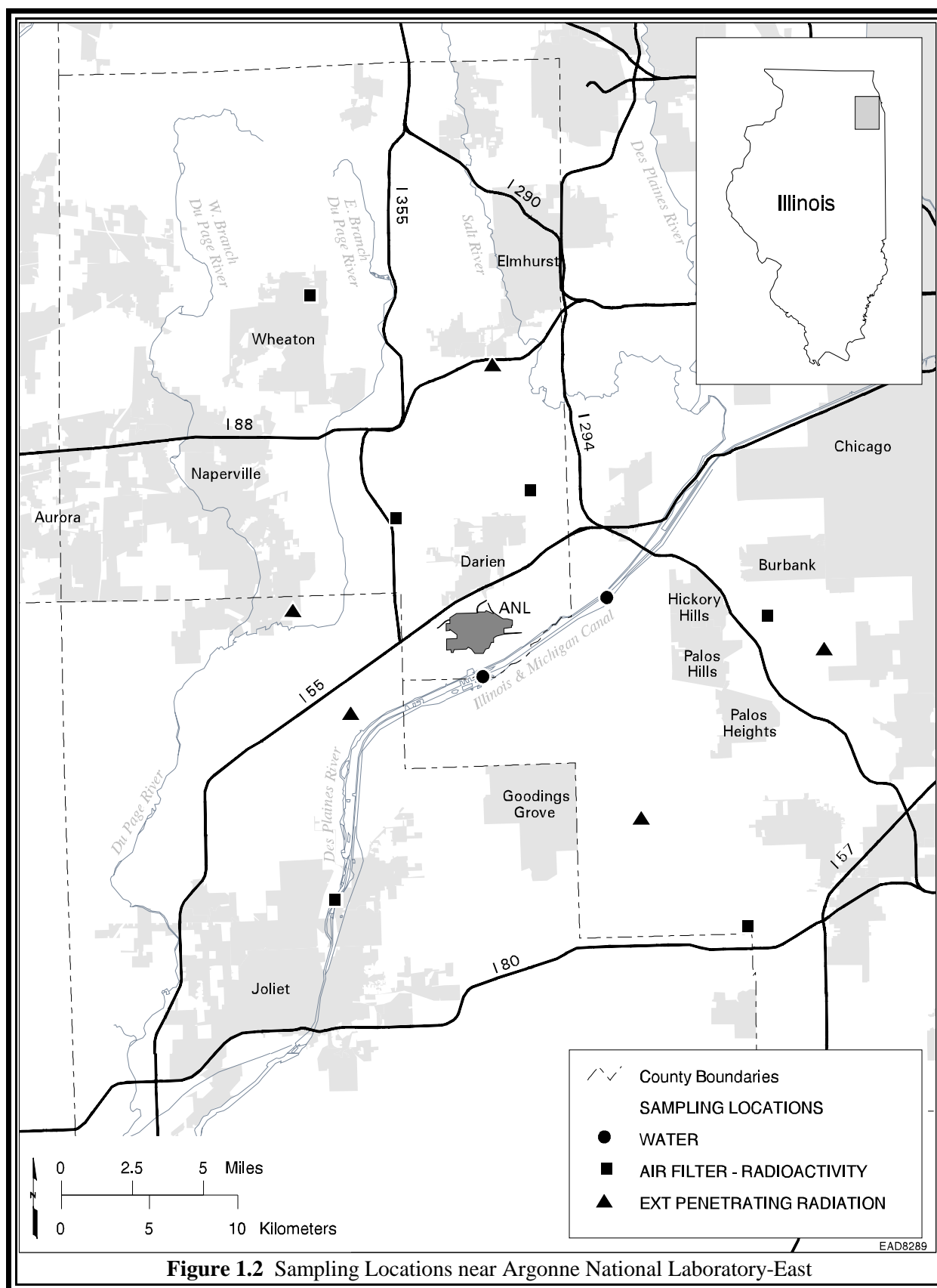
ANL-E occupies the central 607 ha (1,500 acres) of a 1,514-ha (3,740-acre) tract in DuPage County. The site is 43 km (27 mi) southwest of downtown Chicago and 39 km (24 mi) west of Lake Michigan. It is north of the Des Plaines River Valley, south of Interstate Highway 55 (I-55), and west of Illinois 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).



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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 to 1997, on the basis of 1990 census data. This projection will be updated when the new 2000 census data are available.

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 available³ 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 2000 data were obtained from the on-site ANL-E meteorological station. The 2000 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 2000 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 2000 precipitation and temperature data. The monthly precipitation data for 2000 show a few differences from the average. For example, May, June, September, and November were above the monthly average, while March was below the average. The annual total was 28% above the annual average for the ANL-E historic data and 21% above the O'Hare average. The temperatures are generally similar when compared with the long-term historical monthly average, but 13% higher than the long-term ANL-E monthly average.

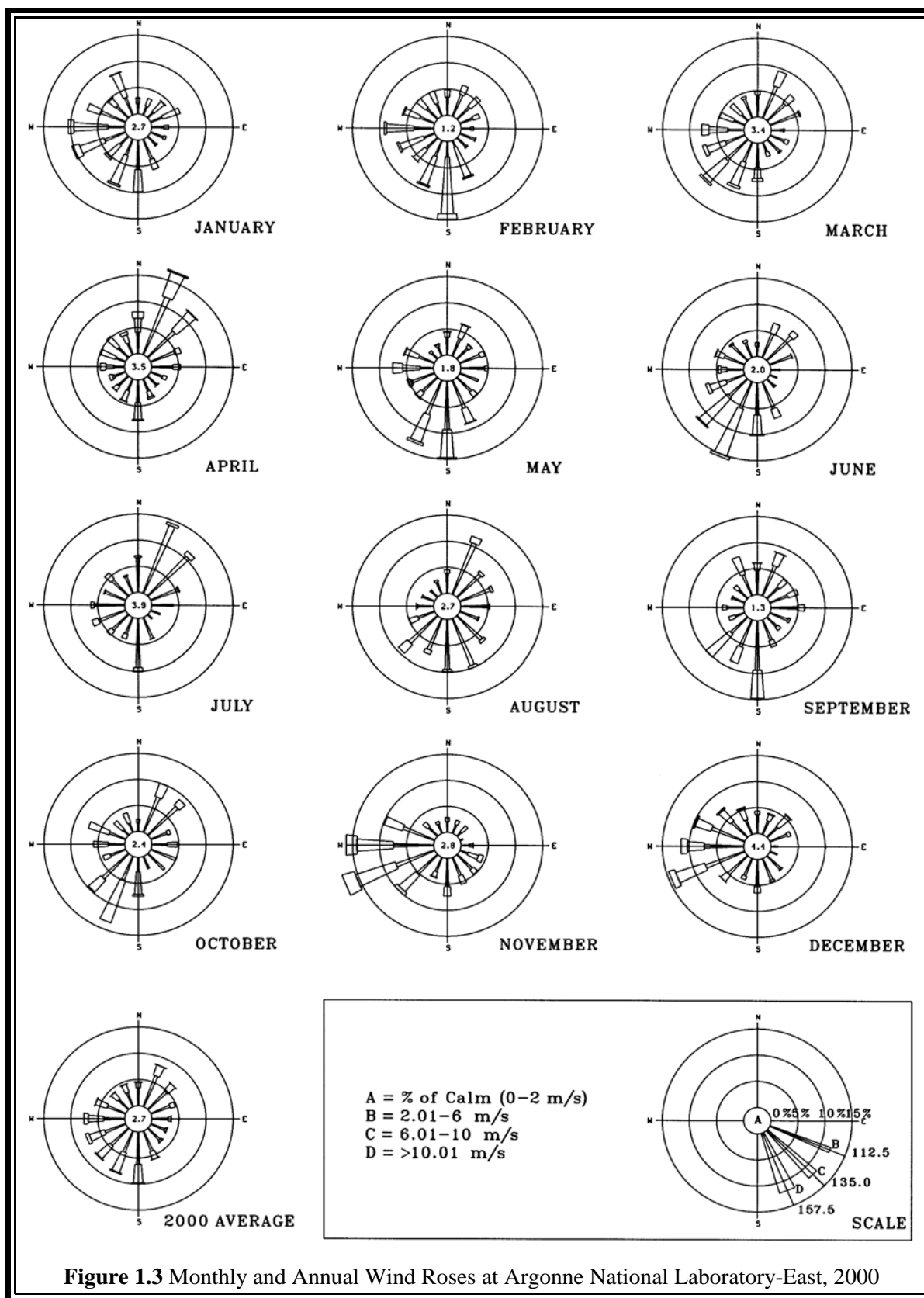
TABLE 1.1

Population Distribution in the Vicinity of ANL-E, 1997

Direction	Miles ^a									
	0 – 1	1 – 2	2 – 3	3 – 4	4 – 5	5 – 10	10 – 20	20 – 30	30 – 40	40 – 50
N	0	1,120	2,884	6,245	8,613	46,331	174,570	345,014	212,982	261,504
NNE	0	898	3,573	6,846	7,168	44,197	287,496	463,950	95,266	2,047
NE	0	748	2,203	2,255	2,125	42,131	642,743	930,802	0	0
ENE	0	333	1,057	1,615	1,989	33,508	569,089	180,886	0	0
E	0	335	985	954	462	41,692	463,141	206,619	9,217	26,320
ESE	0	373	882	1,161	541	19,213	199,976	291,723	230,482	87,179
SE	0	468	900	1,192	1,109	22,696	131,492	120,061	34,063	17,926
SSE	0	521	900	937	1,418	14,904	40,179	12,562	11,807	15,974
S	0	543	900	1,007	1,275	6,807	28,223	6,226	36,775	37,107
SSW	0	497	740	898	1,063	18,028	91,686	17,430	16,371	6,348
SW	0	353	594	637	647	9,521	48,150	11,398	16,652	6,793
WSW	0	333	394	984	2,742	9,950	11,068	5,649	8,196	14,320
W	0	370	2,964	7,810	9,200	30,181	65,457	20,082	16,193	5,718
WNW	0	1,022	3,573	7,777	6,817	52,201	138,763	34,280	8,780	53,815
NW	0	1,361	2,793	7,075	8,755	46,680	83,890	101,417	24,562	17,492
NNW	0	1,361	2,756	5,798	9,150	40,435	200,789	268,137	144,672	113,070
Total	0	10,636	28,098	53,191	63,074	478,475	3,176,712	3,016,236	866,018	665,613
Cumulative total ^b	0	10,636	38,734	91,925	154,999	633,474	3,810,186	6,826,422	7,692,440	8,358,053

^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.



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TABLE 1.2

ANL-E Weather Summary, 2000

Month	Precipitation (cm)			Temperature (°C)		
	ANL-E 2000	ANL-E Historical ^a	Historical ^b	ANL-E 2000	ANL-E Historical ^a	Historical ^b
January	3.20	3.61	4.06	- 4.2	- 5.9	- 5.9
February	2.22	3.38	3.33	1.5	- 3.7	- 3.3
March	2.64	5.56	6.58	6.8	0.6	2.2
April	10.74	9.14	9.30	8.9	8.3	9.3
May	21.34	7.82	8.00	16.7	14.5	15.1
June	15.00	9.47	10.36	19.6	19.7	20.3
July	11.50	10.97	9.22	21.4	21.7	22.8
August	6.99	8.71	8.97	21.9	20.9	22.2
September	12.32	7.14	8.51	17.2	16.8	18.2
October	4.24	6.58	5.79	13.3	11.4	11.9
November	7.87	4.37	5.23	2.2	2.9	4.3
December	<u>4.52</u>	<u>3.20</u>	<u>5.33</u>	<u>- 8.4</u>	<u>- 4.2</u>	<u>- 2.4</u>
Total	102.58	79.95	84.68	Monthly Average	9.7	8.6

^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 till 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 till 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 till. 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.

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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. With the acquisition of Lake Michigan water in 1997, the recovery of the dolomite water table at ANL-E was measured. Delivery of Lake Michigan water to the major suburban areas is expected to relieve this problem. ANL-E now obtains all its 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 2000, this effluent averaged 3.1 million L/day (0.81 million gal/day), which is slightly higher than the averages for the last few years. The combined ANL-E effluent consisted of 51% laboratory wastewater and 49% sanitary wastewater. The water flow in Sawmill Creek upstream of the wastewater outfall averaged about 28 million L/day (7.5 million gal/day) during 2000.

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

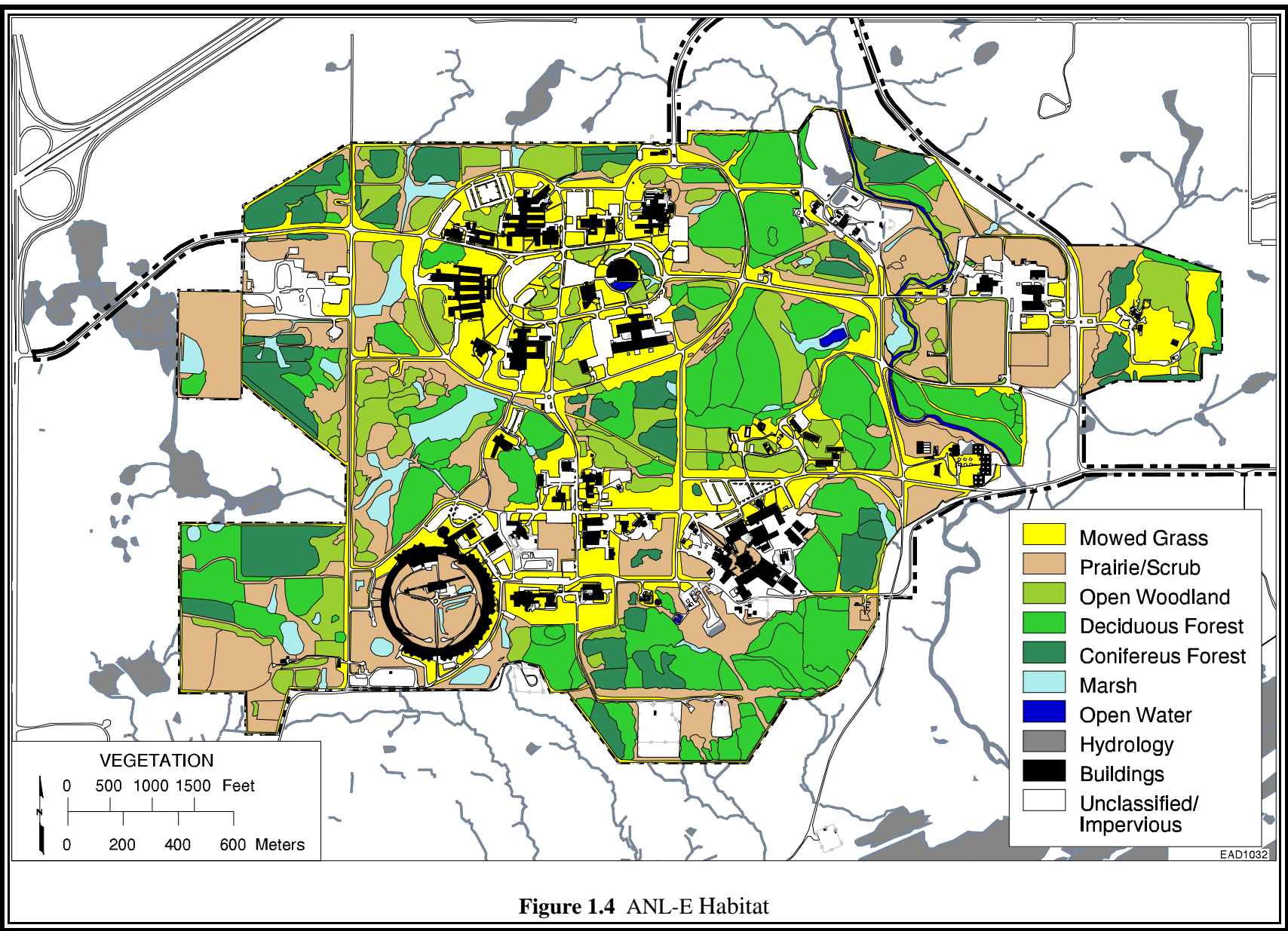
industrial purposes, such as hydroelectric generators and condensers. ANL-E usage is approximately 1.1 million L/day (290,000 gal/day). The canal, which receives Chicago Metropolitan Sanitary District effluent water, is used for industrial transportation and some recreational boating. Near Joliet, the 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



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/mi² 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

1. INTRODUCTION

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 federally 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 federally 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*), federally 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 federally and state listed as endangered, indicates that this species may occur in the area. The federally threatened lakeside daisy (*Hymenarum 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.

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2. COMPLIANCE SUMMARY



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 2000 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 will supersede 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

2. COMPLIANCE SUMMARY

(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.

When the IEPA acknowledges a CAAPP application as timely and complete, the applicant receives an application shield. The application shield allows the applicant to continue to operate in accordance with existing permits, until the IEPA issues the final permit. The ANL-E CAAPP application was submitted to the IEPA on September 19, 1995; the IEPA issued a Notice of Completeness on October 26, 1995. The Notice of Completeness also means that current air pollution control permits for operations that remain unchanged do not need to be renewed. Exceptions to this are the open burning permits used for fire training and ecological management, which must be renewed annually.

On November 28, 2000, the IEPA issued a preliminary draft CAAPP permit to ANL-E for review and comment, with comments to be submitted by December 19, 2000. ANL-E requested and was granted additional review time, with formal response to be submitted to the IEPA before January 19, 2001. The IEPA stated its intent to publish the final draft for public comment and possible public hearing in early 2001, with the final permit expected to be issued in 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. By the end of 2000, a total of 21 individual air pollution control permits were in place, covering all known emission points. Section 2.16 contains a list (Table 2.14) of all of the air pollution control permits at ANL-E. The list in Table 2.14 also includes the CAAPP permit which was still pending at the end of 2000. No IEPA air emissions inspection was conducted in 2000.

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 2000, the IEPA had issued a total of 26 air pollution control permits to ANL-E for NESHAP sources. The NESHAP permits are listed in Table 2.14.

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 79 m³ (2,784 ft³) of ACM was removed from ANL-E buildings during 2000. The 120 small removal projects that were completed generated 36 m³ (1,282 ft³) of ACM waste; the remaining 43 m³ (1,502 ft³) generated resulted from 15 large removal projects. Table 2.1 provides asbestos abatement information for the large removal projects. The IEPA was notified during December 2000 that no more than 100 m³ (3,500 ft³) of ACM waste is expected to be generated from small-scale projects during 2001.

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.

2. COMPLIANCE SUMMARY

TABLE 2.1

Asbestos Abatement Projects DOE/IEPA Notification, 2000

Completion Date	Asbestos Abatement Contractor	Notification Quantity			Material	Building	Disposal Quantity (ft ³)	Landfill
		ft	ft ²	ft ³				
01/12/00	National Surface Cleaning, Inc.	265	- ^a	60	Pipe insulation	211	202	Hanford ^b
01/21/00	ANL PFS-Waste Management	135	170	-	Pipe insulation, ventilation duct insulation	206	240	Streator ^c
01/27/00	ANL PFS-Waste Management	-	420	-	Floor tile and mastic	330	16	Hanford
03/17/00	ANL PFS-Waste Management	-	520	-	Floor tile	223	32	Streator
03/25/00	ANL PFS-Waste Management	-	430	-	Floor tile	620	16	Streator
05/06/00 ^d	ANL PFS-Waste Management	-	1,200	-	Carpet mastic	202	128	Streator
07/08/00	ANL PFS-Waste Management	390	-	-	Pipe insulation	202	24	Streator
07/12/00	ANL PFS-Waste Management	-	700	-	Floor tile and mastic	203	36	Streator
08/12/00 ^d	ANL PFS-Waste Management	-	610	-	Floor tile	212	32	Streator
09/18/00	Insul-Control, Inc.	600	-	-	Pipe insulation	46, outside	89	Streator
09/25/00	M&O Environmental Management	50	195	-	Pipe insulation, gaskets, ventilation duct insulation	362	294	Streator
10/20/00	LVI Environmental Services, Inc.	-	530	-	Floor and tile mastic	211	36 ^e	Hanford
10/25/00 ^d	ANL PFS-Waste Management	-	200	-	Floor tile	202	32 ^e	Hanford
12/09/00 ^d	ANL PFS-Waste Management	-	2,330	-	Floor tile	202	104	Streator
12/15/00	ANL PFS-Waste Management	-	1,400	-	Transite	116	220 ^f	Streator
Total							1,501	

^a A hyphen indicates that the quantity was not measured in this unit.

^b DOE Hanford Facility, Richland, WA.

^c Streator Area Landfill, Streator, IL.

^d Courtesy notification, nonfriable material removed intact.

^e Stored on site pending shipment to Hanford.

^f Material stored on site until project is complete; removal stopped because of winter weather.

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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 2000 was 0.046 mrem, which, excluding radon-220 and radon-222, is 0.5% of the 10 mrem/yr EPA 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, methanol/gasoline blend, and ethanol/gasoline blend fuel-dispensing facilities; two alkali metal reaction booths; bulk chemical tanks; a dust collection system; the engine test facility; a medical equipment sterilization unit; and fire training activities. These facilities are operated in compliance with applicable regulations and permit conditions. Table 2.14 gives the emission sources that have been granted individual operating air pollution control permits by the IEPA.

The operating air pollution control permit for the steam plant requires continuous opacity and sulfur dioxide monitoring of the smoke stack from Boiler No. 5, the only one of the five boilers 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 2000, as well as the amount of low-sulfur coal burned. There were no permit exceedances in 2000.

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 in the waste area determines the levels of methane, carbon dioxide, nitrogen, and oxygen generated by the landfill. The perimeter gas wells are monitored to determine 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.

TABLE 2.2

Disposal of Asbestos-Containing Materials, 2000		
Project Size	Landfill	Quantity (ft ³)
Small-scale	Streator ^a	1,258
	Hanford ^b	24
Large-scale	Streator	1,215
	Hanford	286
Total		2,783

^a Streator Area Landfill, Streator, IL.

^b DOE Hanford Facility, Richland, WA.

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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 2000 is presented in Table 2.4.

2.1.3. Clean Fuel Fleet Program

As mandated under the CAA and 35 IAC Part 241, the second annual Clean Fuel Fleet Program report was submitted to the IEPA on October 25, 2000, for vehicle acquisitions in Model Year (MY) 2000 (September 1, 1999–August 31, 2000). Fifteen light-duty vehicles and two-heavy duty vehicles were reported. On August 29, 2000, ANL-E received a 2.46 light-duty vehicle credit approval for overcompliance in MY 1999. These credits can be put toward future compliance requirements. September 1, 2000, marked the beginning of MY 2001; certified light-duty acquisition requirements increased from 50 to 70% for the model year (heavy-duty vehicle acquisitions remain at 50%).

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.

TABLE 2.3

Boiler No. 5 Operation, 2000		
Month	Operated (hours)	Low-Sulfur Coal Burned (tons)
January	720	2,147
February	336	1,053
March	264	943
April	0	0
May	0	0
June	0	0
July	0	0
August	0	0
September	0	0
October	0	0
November	0	0
December	744	2,770
Total	2,064	6,913

2. COMPLIANCE SUMMARY

TABLE 2.4

2000 Annual Emissions Report: Emissions Summary

Building No. and Source	CO ^a	NO _x	Particulate	SO ₂	VOM	Lead
46: Ethanol/Gasoline	0	0	0	0	6	0
46: Methanol/Gasoline	0	0	0	0	0	0
46: 10,000 Gal Gasoline	0	0	0	0	9	0
108: Boiler 1	23,451	78,171	853	171	398	0
108: Boiler 2	0	0	0	0	0	0
108: Boiler 3	12,393	41,310	451	90	210	0
108: Boiler 4	3,000	10,001	109	22	51	0
108: Boiler 5 (coal-fired)	40,342	85,324	605	167,406	282	0
108: Boiler 5 (gas-fired) ^b	6,643	9,663	242	48	113	0
108: Sulfuric Acid Tank ^b	0	0	- ^c	0	0	0
200: M-Wing Hot Cells (R)	0	0	0	0	0	0
201: Ethylene Oxide Sterilizer	0	0	0	0	2	0
206: Alkali Reaction Booth (R) ^d	0	0	<1	0	0	0
212: Alpha Gamma Hot Cell (R)	0	0	0	0	0	0
212: Building Exhausts ^b	0	0	-	0	0	0
300: 8,000 Gal Gasoline	0	0	0	0	20	0
300: 10,000 Gal Gasoline	0	0	0	0	65	0
300: 6,000 Gal Gasoline	0	0	0	0	20	0
301: Hot Cell D&D Project	0	0	0	0	0	0
303: Mixed Waste Storage (R)	0	0	0	0	0	0
306: Building Vents (R)	0	0	0	<1	0	0
306: Bulking Sheds	0	0	0	0	114	0
306: Vial Crusher/Chemical Photooxidation Unit	0	0	0	0	0	0
308: Alkali Reaction Booth ^b	0	0	-	0	0	0
315: MACE Project (R)	0	0	0	0	0	0
317: Lead Brick Cleaning (R)	0	0	0	0	0	0
330: CP-5 D&D Project (R)	0	0	0	0	0	0
331: Rad Waste Storage (R)	0	0	0	0	0	0
350: NBL Pu/U Hoods (R)	0	0	0	0	0	0
363: Central Shop Dust Collector ^b	0	0	-	0	0	0
368: Woodshop Dust Collector ^b	0	0	-	0	0	0
369: Salt Cake/Recov. Elec. Plant ^b	0	0	0	0	0	0
370: Alkali Reaction Booth ^b	0	0	-	0	0	0
375: Intense Pulsed Neutron Source (R)	0	0	0	0	0	0
400: APS Facility (R)	0	55	0	0	0	0
400: APS Generator Caterpillar (1 unit)	269	1,400	50	116	38	0
400: APS Generator Kohler (2 units)	2,098	2,831	110	581	100	0
595: Lab Wastewater Plant (R)	0	0	0	0	41	0
Lab Rad Hoods (R)	0	0	0	0	0	0
PCB Tank Cleanout	0	0	0	0	0	0
Torch Cut Lead-Based Paint ^b	0	0	-	0	0	0
Transportation Research Facility	1,992	3,340	236	221	324	0
WMO Portable HEPA - (4) (R)	0	0	<1	0	0	0
Total (lb/yr)	90,188	232,095	2,656	168,655	1,793	0
Total (ton/yr)	45.09	116.05	1.33	84.33	0.90	0

^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 These sources have been designated as insignificant in the CAAPP application.

^c A hyphen indicates no emissions for this parameter.

^d (R) = radionuclide source regulated by NESHAP (40 CFR Part 61 Subpart H).

2. COMPLIANCE SUMMARY

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. Liquid Effluent Discharge Permit

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 2000, the IEPA had not acted 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. Compliance with NPDES Permit

Wastewater is processed 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

2. COMPLIANCE SUMMARY

TABLE 2.5

Characterization of NPDES Outfalls at ANL-E, 2000

Outfall	Description	Average Flow ^a
001A	Sanitary Treatment Plant	0.40
001B	Laboratory Treatment Plant	0.42
001	Combined Outfall	0.82
003A	Swimming Pool	0.0
003B	300 Area (Condensate)	0.033
003C	Building 205 Footing Tile Drainage	0.006
003D&E	Steam Trench Drainage (Condensate)	0.008/0.002
003F	Building 201 Fire Pond Overflow Storm Water	0.003
003G	North Building 201 Storm Sewer (Condensate)	0.023
003H	Building 212 Cooling Tower Blowdown	0.003
003I	Buildings 200 and 211 Cooling Tower Blowdown	0.015
003J	Building 213 and Building 213 Parking Lot Storm Water	0.005
004	Building 203 Cooling Tower and Building 221 Footing Drainage and Storm Water	0.021
005A	Westgate Road Storm Water	Storm Water Only
005B	800 Area East Storm Water	Storm Water Only
005C	Building 200 West	0.007
005D	Storm Water	Storm Water Only
005E	Building 203 West Footing Drainage and Condensate	0.026
006	Cooling Tower Blowdown and Storm Water	0.047
007	Domestic Cooling Water for Compressor and Storm Water	0.005
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	0.029
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	0.015
114	Northern and Western 800 Area Landfill Storm Water Runoff	0.013
115	314, 315, and 316 Cooling Water, Eastern and Southern APS Area	0.007
116	Water Treatment Plant and Storm Water	0.008

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

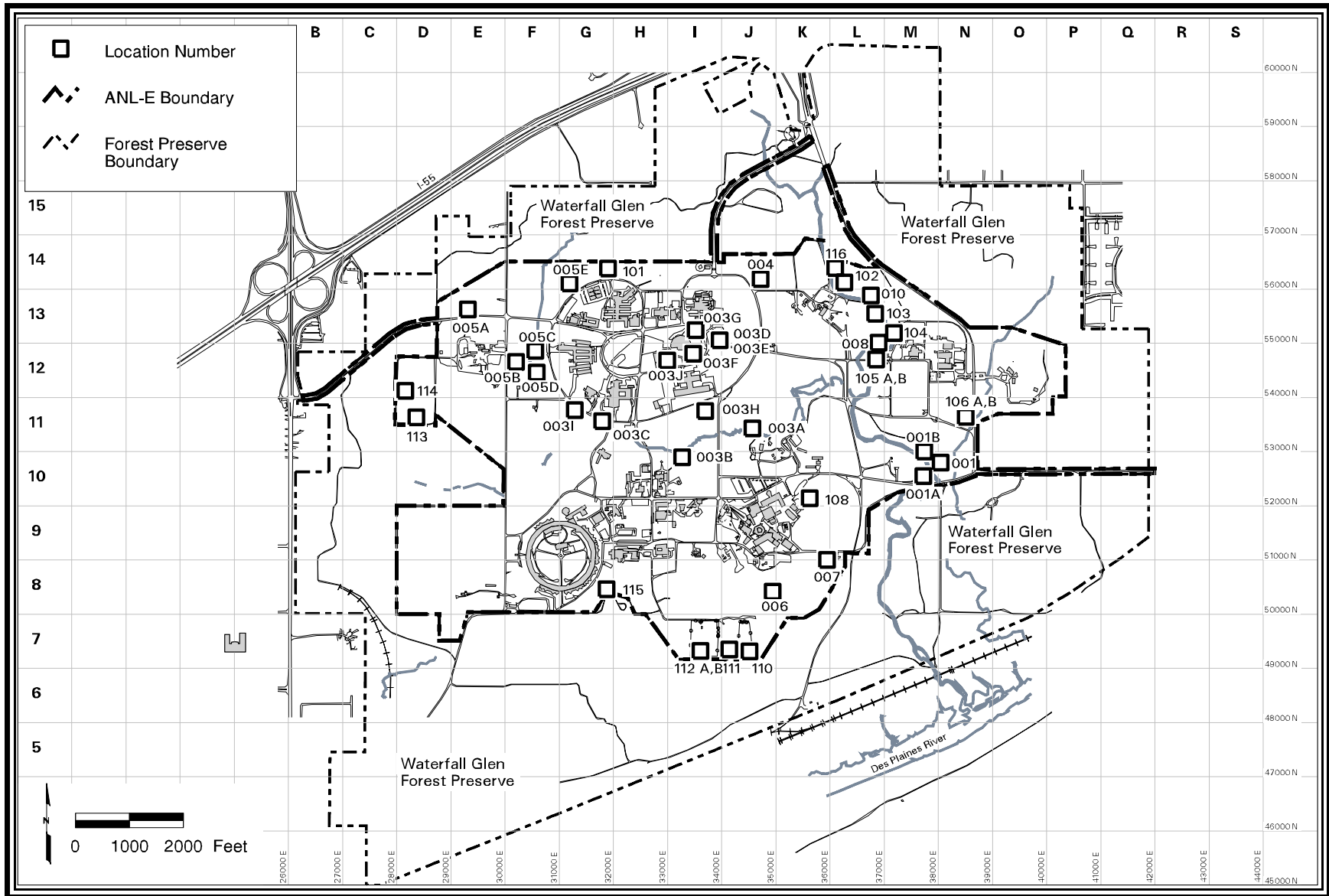


Figure 2.1 NPDES Permit Locations

2. COMPLIANCE SUMMARY

wastewater treatment system consisting of primary clarifiers, trickling filters, final clarifiers, and slow sand filters. Wastewater generated by research-related activities, which utilize radioactive materials that could find their way into the sewer, flows to a series of retention tanks located in each building and subsequently discharges to the laboratory wastewater sewer after radiological analysis. Treatment in the laboratory wastewater treatment plant (WTP) consists primarily of aeration, solids-contact 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, which are located adjacent to each other. The volume of wastewater discharged from these facilities in 2000 averaged 1.5 million L/day (0.40 million gal/day) for the sanitary wastewater and 1.6 million L/day (0.42 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 2000, there were seven exceedances of NPDES permit limits out of approximately 1,600 measurements. Total dissolved solids (TDS) and total suspended solids (TSS) permit limits are the more persistent exceedances. The TSS limit was exceeded three times at Outfall 006 in February, March, and October. These exceedances probably were caused by sediment associated with snowmelt runoff, sediment runoff from an upstream construction project, and cooling tower drainage, respectively. The one exceedance of the TDS limit and the one exceedance of the chloride limit in February at Outfall 001 were due to road salt associated with snowmelt. Sediment contained in snowmelt runoff resulted in a TSS exceedance at Outfall 004 in February. The copper limit was exceeded at Outfall 001 in April; the cause was not determined.

An unpermitted release of asphalt paving seal coating material (containing coal tar constituents) occurred at Outfall 003H during an unexpected rainstorm during the sealing operation in August. An unpermitted release of ethylene glycol at Outfall 003C occurred in December. This release was caused by the failure of a pressure relief valve on a closed-loop heating system for Building 205. Also in December, an inadvertent release of paint residue into permitted Outfall 007 occurred. The spill occurred while a technician was cleaning paint residue from a nearly empty bucket. The paint materials were determined not to be an environmental hazard. The IEPA was notified following each of these release incidents. In all cases, the spills were cleaned up as soon as possible, with only small amounts reaching the outfalls. These releases were minor in nature and required no remedial action after the initial cleanup.

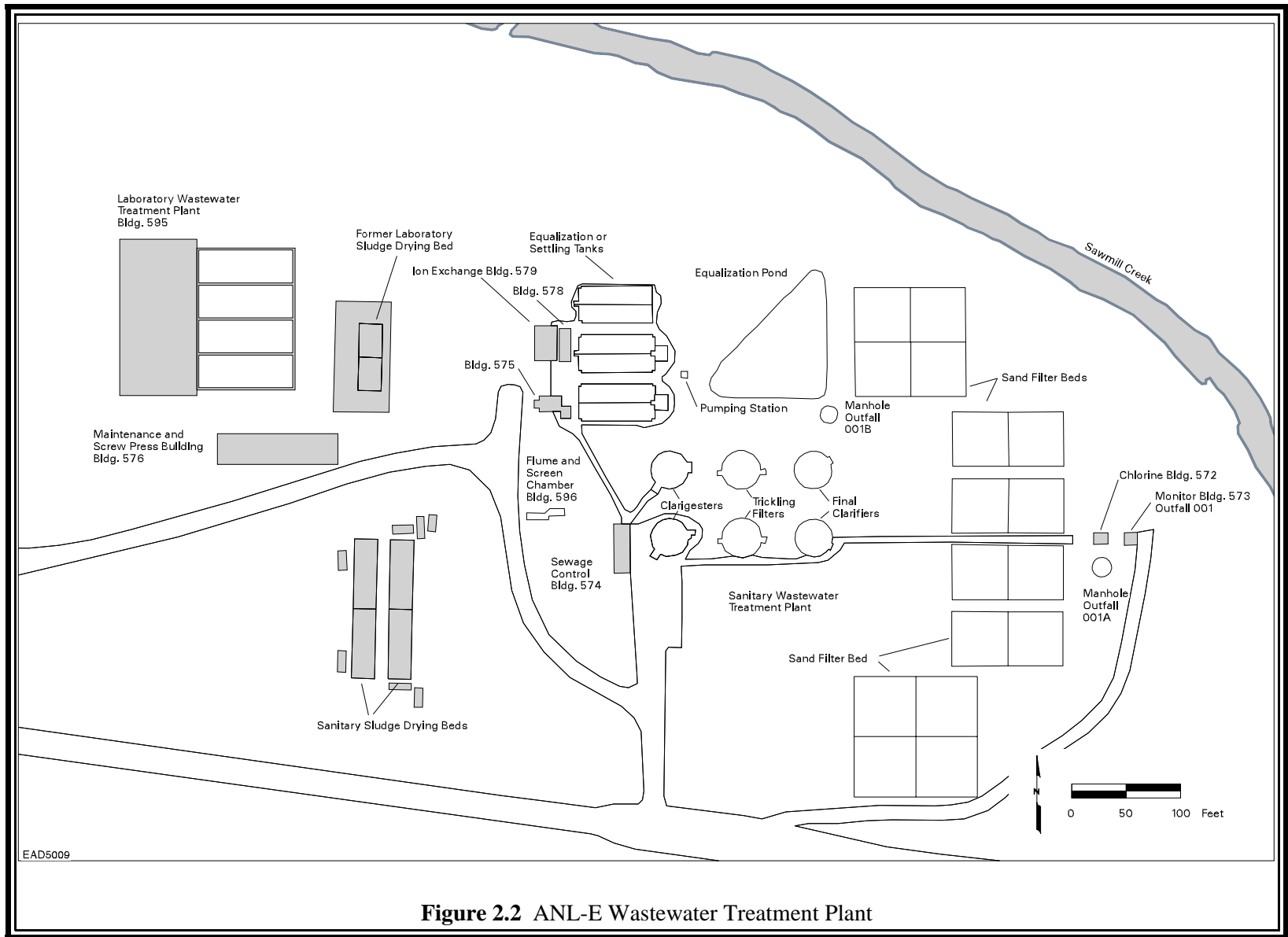
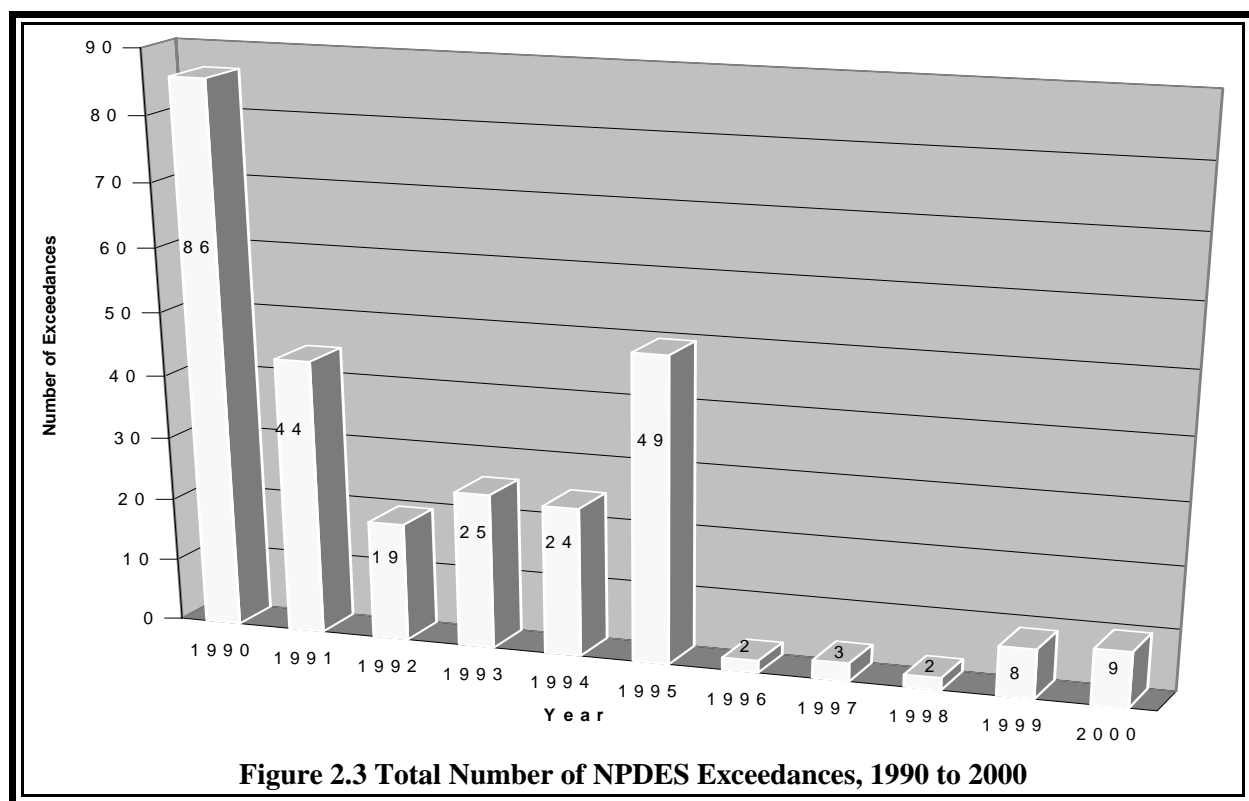


Figure 2.2 ANL-E Wastewater Treatment Plant

2. COMPLIANCE SUMMARY

Figure 2.3 presents the data for the total number of each type of exceedance over the past 11 years. In general, the total number of exceedances per year has declined steadily. The exception is 1995, when the number of exceedances increased. This increase can be attributed to the renewal of the NPDES Permit, effective October 30, 1994, which placed more restrictive limits on ANL-E discharges and increased the number of analyses required each year by approximately 600. The more restrictive limits for copper, TDS, and ammonia nitrogen resulted in a substantial increase in the number of exceedances during 1995, prior to issuance of the modified permit. The permit modification gave ANL-E a provisional variance from the existing limits for copper, TDS, and ammonia nitrogen, and included a compliance schedule to bring these discharges under their respective limits. ANL-E met the compliance schedule through the upgrade of the sanitary and laboratory wastewater treatment facilities and the incorporation of Lake Michigan water as the ANL-E source water. As required by the compliance schedule, by July 1, 1998, ANL-E achieved compliance with the restrictive discharge permit limits set forth in the October 30, 1994 permit.

The number of exceedances in 1999 and 2000 increased slightly because provisional variance expired in 1999, making the site subject to all the effluent limits in the 1994 permit. Efforts are underway to reduce the number of violations by diverting high TDS and TSS wastewater streams to the DuPage County wastewater treatment system and making other improvements to on-site wastewater collection systems.



2. COMPLIANCE SUMMARY

2.2.1.2. Priority Pollutant Analysis and Biological Toxicity Testing

The NPDES permit requires semiannual testing of Outfall 001B, the laboratory WTP outfall, for all the priority pollutants — 124 metals and organic compounds identified by the IEPA as being of particular concern. During 2000, this sampling was conducted in June and December. Organic compound concentrations were very low. Chloroform (1 µg/L) was detected in both the June and December samples, as was bromodichloromethane (1 µg/L) and dibromochloromethane (1 µg/L). Bromoform (2 µg/L) was noted in the June sample. It is suspected that the sources of chloroform, dibromochloromethane, bromoform, and bromodichloromethane are the result of 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 (0.013 mg/L), cadmium (0.0003 mg/L), and zinc (0.146 mg/L) were detected. 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 12 through June 16, 2000. The data indicate that the effluent was not acutely toxic to either the fathead minnow or the water flea. Data from the past seven 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 10 through 14, 2000, and August 21 through 25, 2000. A review of the July data indicates that Outfalls 003H, 003I, 003J, and 006 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. Outfall 004 was slightly acutely toxic to the fathead minnow but not to the water flea. Outfall 115 was acutely toxic to the water flea but not to the fathead minnow. The results from the August samples were somewhat different. Outfalls 003H, 003I, and 004 were free of toxic effects. Outfall 003J, however, was toxic to the fathead minnow but not to the water flea, and Outfalls 006 and 115 were 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. Steps are being taken to redirect the discharges of domestic water into the sanitary sewer system to reduce the toxicity problem at these outfalls. Another source of toxicity identified in the past is related to water treatment chemicals used in various cooling towers around the site. These chemicals are being replaced with less toxic materials.

2.2.2. Storm Water Regulations

In November 1990, the EPA promulgated new 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 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 application was completed and submitted to the IEPA on September 18, 1996. The IEPA is expected to include these 18 outfalls in the NPDES permit when it is reissued.

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.

The same special conditions require ANL-E to inspect and report annually on the effectiveness of the sitewide SWPPP. In 2000, the annual inspection was completed and a report submitted to the IEPA in December 2000. 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.

2.2.3. NPDES Inspections and Audits

The IEPA conducted a compliance inspection in April 2000. No major issues were determined. An internal audit of the NPDES Program was conducted in June 2000. No major issues were identified.

2. COMPLIANCE SUMMARY

2.2.4. 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.

2.2.5. Spill Prevention Control and Countermeasures Plan

ANL-E maintains a Spill Prevention Control and Countermeasures plan as required by the CWA and the EPA regulations in 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. This plan is updated every three years and was updated last in 1998. The unplanned discharge of asphalt sealing material that occurred in August 2000 was reported to the IEPA and discussed in the ANL-E toxic release inventory (TRI) report for 2000.

2.2.6. 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 parameters 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 Sanitary Wastewater Treatment Plant resulted in compliance with the ammonia-nitrogen limit. The upgrade of the Laboratory Wastewater Treatment Plant also was completed, which gives ANL-E a number of options for treating various waste streams more effectively.

In 2000, ANL-E rerouted a number of sumps and drains from surface discharge to the 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. Future plans include directing some significant surface water discharges that contain road salt runoff to a county wastewater treatment plant. This project, which should be completed in 2001 or 2002, should reduce reoccurring TDS exceedances at the main outfall during the winter season. As funding allows, other projects to redirect the blowdown from cooling towers to the WTP to reduce TSS releases will be planned and implemented. 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.

In August 2000, the IEPA issued a permit modification. The modification allows ANL-E to use Building 303 to store surplus chemicals for recycling or reuse. The modification also included updated operating procedures for the Building 308 Alkali Metal Passivation Booth, which is a permitted treatment unit.

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 2000. Figure 2.4 shows the locations of the major active hazardous waste treatment, storage, and disposal areas at ANL-E.

2. COMPLIANCE SUMMARY

TABLE 2.6

Permitted Hazardous Waste Treatment and Storage Facilities, 2000

Description	Location	Purpose
<i>Storage</i>		
Concrete Storage Pad	317 Area	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 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 ^a	Building 307	Proposed storage facility for hazardous waste

2. COMPLIANCE SUMMARY

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.
<i>Treatment</i>		
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 was proposed several years ago and a permit has been obtained. However, it has not yet been built.

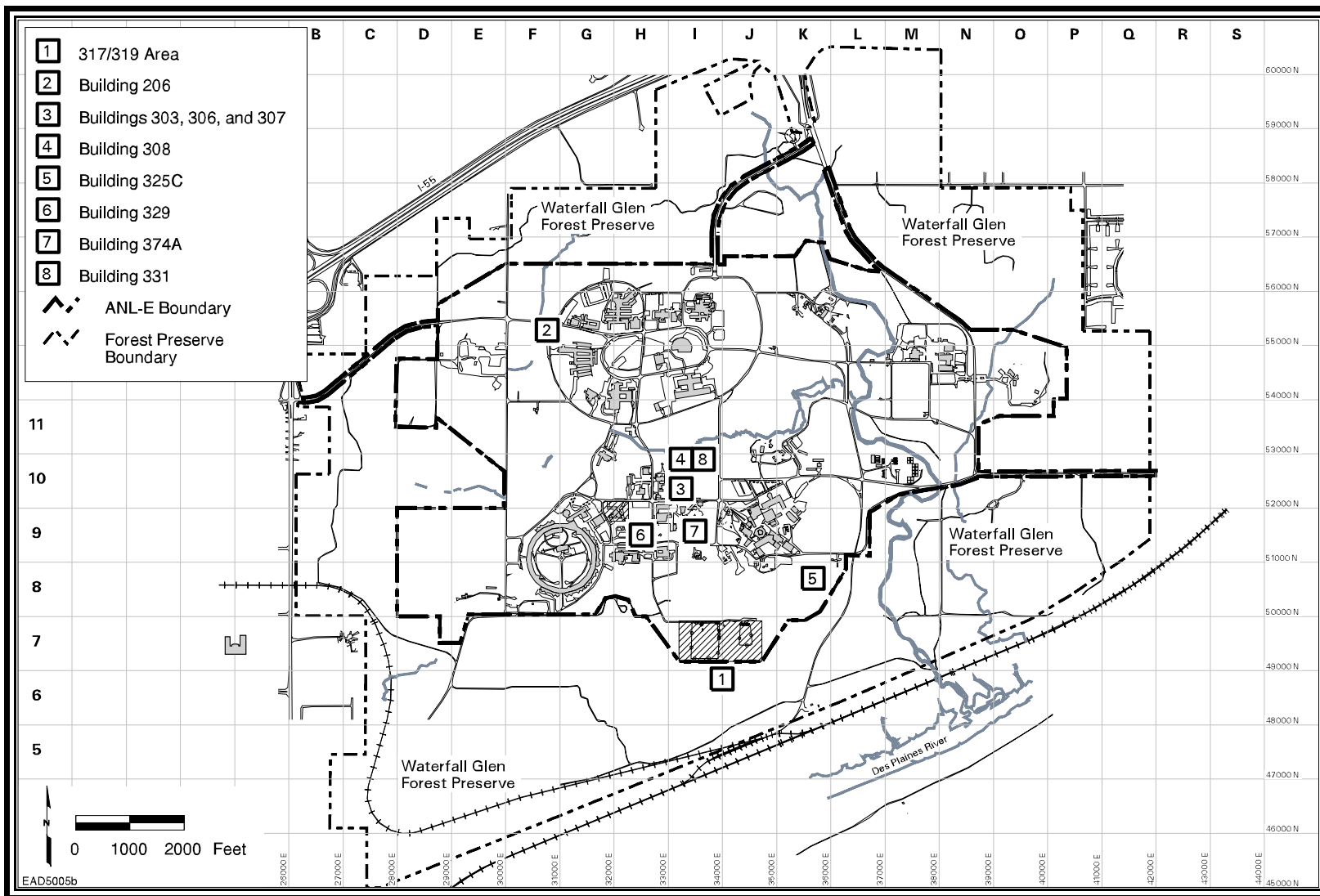


Figure 2.4 Major Treatment, Storage, and/or Disposal Areas at ANL-E

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 1999 was submitted to the IEPA on March 3, 2000. The RCRA-permitted storage facilities, designed and operated in compliance with RCRA requirements, allow for accumulation and storage of waste pending on-site or 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 2000 are described in Table 2.7.

No hazardous waste treatability studies were conducted at ANL-E during 2000.

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

A small number of hazardous waste that ANL-E generates also exhibit radioactivity, thereby making them "mixed waste." The hazardous component of mixed waste is subject to RCRA regulation by the IEPA, while the radioactive component is subject to DOE regulation under the Atomic Energy Act of 1954 (AEA). ANL-E generates several types of mixed waste, including acids, solvents, and sludges contaminated with radionuclides. Off-site treatment options for mixed waste are extremely limited. 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, some of the mixed waste was sent to two off-site commercial treatment facilities during 2000, Envirocare of Utah Inc., Clive, Utah, and Allied Technology Group of Richland, Washington. Table 2.8 lists mixed wastes generated, stored, treated on site, or shipped off site for disposal in 2000.

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.

2. COMPLIANCE SUMMARY

TABLE 2.7

Hazardous Waste Generation, Treatment, Disposal, or Recycle, 2000		
Waste	Volume (gal) ^a	Weight (lb)
<i>Generated and Disposed of or Recycled</i>		
Acidic solutions with lead	440	3,828
Aerosol cans	600	300
Beryllium-containing debris	55	275
Brake cleaner fluid ^b	9	75
Bulked laboratory solvents	440	3,080
Compressed gases	40	200
Compressed gases ^b	6	32
Cutting oils with lead and solvents	165	1,188
Ethanol solutions with silver	275	2,300
Fuel-containing debris	30	120
Heavy metal-containing debris	30	120
Immersion cleaner fluid ^b	18	142
Labpacks of liquid chemicals	1,202	9,614
Labpacks of solid chemicals	540	2,156
Lead acid batteries ^b	110	2,250
Lead-contaminated debris	195	780
Mercury-contaminated debris	55	275
Plating wastes containing lead, alkaline	330	3,003
Solvent-containing debris	55	275
Used soils with lead	55	396
Used oils with solvents	615	4,428
Waste flammable solids	30	90
Wastes containing elemental mercury	55	495
Wastes containing elemental lead	30	600
Wastes containing phosphoric acid solution	55	495
Water contaminated with benzene	385	3,219
<i>Treated</i>		
Alkali metals (passivation)	1.3	10.4
<i>Universal Hazardous Waste</i>		
Mercury-containing lamps ^b	12,395	12,395

^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. COMPLIANCE SUMMARY

TABLE 2.8

Mixed Waste Generation, Treatment, Storage, and Disposal, 2000

Waste	Volume (gal)	Weight (lb)
<i>Generated</i>		
Acidic solutions	306	1,836
Acidic solutions with heavy metals	117	1,053
Alkali metals	215	1,720
Aqueous solutions with heavy metals	3	25
Flammable liquids	64	448
Metal scrap with cadmium	185	3,700
MW debris with chromium	56	1,400
MW debris with heavy metals	52	208
MW debris with volatile organics	30	120
MW lead articles	1,624	146,160
MW sludge with heavy metals	1,220	12,200
MW soil with heavy metals	74	681
RMW flammable liquids	64	448
RMW alkali metals	215	1,720
RMW acidic solutions with heavy metals	117	1,053
RMW acidic solutions	306	1,836
RMW aqueous solutions with heavy metals	3	25
RMW soil with heavy metals	74	681
RMW lead articles	1,624	146,160
RMW metal scrap with cadmium	185	3,700
RMW debris with chromium	56	1,400
RMW debris with heavy metals	52	208
RMW debris with volatile organics	30	120
RMW inorganic nitrates	0	0
RMW sludges with heavy metals	1,220	12,200
TRU acids with heavy metals	125	1,125
TRU-contaminated lead	0	0

2. COMPLIANCE SUMMARY

TABLE 2.8 (Cont.)

Waste	Volume (gal)	Weight (lb)
<i>Shipped for Treatment/Disposal</i>		
RMW metal scrap with cadmium	2,905	58,100
RMW metal scrap with heavy metals	9	270
RMW debris with chromium	42	1,050
RMW debris with heavy metals	272	1,088
RMW lead articles	16,364	1,472,760
RMW flammable liquids	146	1,022
RMW aqueous solutions with organics	19	158
<i>Treated</i>		
Acidic solutions (neutralized)	303	2,727
Aqueous solutions with heavy metals (neutralized)	522	4,364
RMW acidic solutions with heavy metals (neutralized)	0	0
RMW acidic solutions (neutralized)	303	2,727
RMW aqueous solutions with heavy metals (neutralized)	522	4,364
RMW elemental mercury (amalgamated)	0	0
RMW aqueous solutions with halogenated solvents	0	0
<i>In Storage</i>		
Acidic solutions	65	585
Acidic solutions with heavy metals	222	1,998
Alkali metals	216	1,728
Aqueous solutions with heavy metals	3	25
Cyanide solution	20	168
Elemental mercury	64	6,336
Flammable liquids	64	448
Inorganic nitrates	176	3,520
Metal scrap with cadmium	716	14,320
Metal scrap with heavy metals	156	4,680
MW debris with chromium	30	750
MW debris with heavy metals	1,406	5,624
MW debris with volatile organics	171	684
MW lead articles	5,421	487,890
MW sludges with heavy metals	1,561	23,415
MW soil with heavy metals	249	2,291

2. COMPLIANCE SUMMARY

TABLE 2.8 (Cont.)

Waste	Volume (gal)	Weight (lb)
TRU acids	137	1,233
TRU cadmium	135	9,720
TRU lead	60	5,640
TRU sludge	135	1,350
RMW flammable liquids	64	448
RMW alkali metals	216	1,728
RMW acidic solutions	65	585
RMW acidic solutions with heavy metals	222	1,998
RMW aqueous solutions with heavy metals	3	25
RMW elemental mercury	64	6,336
RMW sludges with heavy metals	1,561	23,415
RMW soil with heavy metals	249	2,291
RMW lead articles	5,421	487,890
RMW cyanide solution	20	168
RMW aqueous solutions with organics	0	0
RMW metal scrap with cadmium	716	14,320
RMW metal scrap with heavy metals	156	4,680
RMW debris with heavy metals	1,406	5,624
RMW debris with chromium	30	750
RMW debris with volatile organics	171	684
RMW inorganic nitrates	176	3,520
TRU acids	137	1,233
TRU lead	60	5,640
TRU cadmium	135	9,720
TRU sludge	135	1,350

During 2000, ANL-E completed the treatment milestone for the organic solvents waste stream; therefore, this waste stream was deleted from the PSTP. ANL-E concentrated its fiscal year (FY) 2000 mixed waste treatment efforts on the three largest waste streams — inorganic solids with cadmium, lead shielding, and stored lead waste. ANL-E shipped 77%, 84%, and 90% of these wastes, respectively, to the Envirocare of Utah, Inc., facility for treatment and disposal. Consequently, ANL-E reduced the total inventory of mixed waste from 120 m³ (4,220 ft³) in October 1999 to 31 m³ (1,102 ft³) in October 2000.

2. COMPLIANCE SUMMARY

2.3.4. RCRA Inspections: Hazardous Waste

The EPA conducted a RCRA Compliance Inspection on September 13, 2000. No significant issues were identified.

2.3.5. Underground Storage Tanks

The ANL-E site currently contains 18 USTs, all of which are in compliance with UST regulations; 39 tanks have been removed. Eight of the existing tanks are being used for storage of 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 methanol/gasoline blend. Ethanol/gasoline fuel blend is stored in an aboveground tank. The leak detection system for five USTs and associated piping at Building 46 were replaced in December 2000.

2.3.6. Corrective Action for Solid Waste Management Units

As mentioned previously, the HSWA requires 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 five Areas of Concern (AOCs). During 2000, IEPA approved ANL-E requests that No Further Action (NFA) is necessary for the 25 SWMUs listed in Table 2.9. 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

2. COMPLIANCE SUMMARY

TABLE 2.9

No Further Action Determinations in 2000

SWMU Number or AOC	SWMU Name
1	Facility 318 Compressed Gas Cylinder Burial Area
2	319 Area Landfill
6	Fossil Energy User's Lab (FEUL) Settling Pond
9	Building 108 Equalization Pond
11	317 Area French Drain
12	318 Area Map Tube Vault
18	319 Area French Drain
21	Laboratory Sewer
132	Sanitary Sewers
137	Canal Water Treatment Plant Settling Ponds
138	East Area Sanitary Sewers
142	East Area Burn Pit
148	South of 381 Ravines Filled with Trash
152	Waste Oil Storage Areas
170	Waste Oil Storage Areas
175	Boiler House Spent Sorbent Silo
176	Scrap Metal Storage Area - West of Building 827
177	Boiler House Ash Silo
178	360 Area Fenced Low-Level Radioactive Waste Staging Area
694	Building 108B-Baghouse Unit
725	Central Boiler House Ash Loader
736	800 Area Non-PCB Transformer Storage Pad
745	Building 214 Sump
AOC-B	800 Area Landfill Wetland Area
AOC-G	Off-Site Groundwater Seeps (South of 317/319/ENE Area)

2. COMPLIANCE SUMMARY

of some routine indicator parameters have been consistently exceeded. Exceedances occur only in shallow, perched pockets of groundwater in the glacial till 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 wastes generated and disposed of during 2000. All nonhazardous special and nonspecial wastes generated at ANL-E in 2000 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 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 10 *Code of Federal Regulations* (CFR) Part 1021 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 2000. One EA addendum was written for the sitewide remediation work. This was required to address changes in the project work scope, which the IEPA is overseeing. An EA was completed for the decontamination and decommissioning (D&D) of Building 301.

2. COMPLIANCE SUMMARY

TABLE 2.10

Storage, Disposal, or Recycling of Special and Nonspecial Waste, 2000

Waste	Volume	Weight (lb)
<i>Nonhazardous Special Waste Disposal</i>		
Contaminated soil (remediation waste)	13,425 yd ³	26,844,000
Medical waste	211 ft ³	1,091
Nonhazardous liquid chemicals	2,595 gal	18,047
Nonhazardous solid chemicals	2,455 gal	9,927
Petroleum naptha ^a (parts washers)	984 gal	6,576
Used oil ^a	3,145 gal	22,640
Antifreeze ^a	600 gal	5,203
<i>Certified Nonspecial Waste Disposal</i>		
Nonspecial fly ash	526 yd ³	526,000
Nonspecial laboratory sewage sludge	90 yd ³	180,000
<i>Toxic Substances Control Act (TSCA) Special Waste Disposal</i>		
Asbestos	240 yd ³	270,000
PCBs	675 gal	3,700
<i>Materials Recycled</i>		
Fly ash (boiler house)	1,563 yd ³	1,563,000
Sanitary sewage sludge	22,667 gal	240,000
<i>(TSCA) Mixed Waste in Storage</i>		
Radioactive PCB sludge and debris	966	8,095
Radioactive PCB articles	5	42
<i>TSCA Mixed Waste Disposed of</i>		
Radioactive PCB sludge and debris	17,380	145,754

^a Recycled waste.

2. COMPLIANCE SUMMARY

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 has been required to satisfy while operating the on-site water supply system, no longer are applicable. In addition, sampling, analysis, and reporting of the drinking water data to the DPCHD and the Illinois Department of Health (IDPH) are 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 2000, 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 2000, all exterior pesticides and herbicides were applied by licensed contractors who provide the chemicals used and who remove 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 2000, approximately 14,200 L (3,760 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. Since submittal of these reports, the EPA has taken no action on these sites.

2. COMPLIANCE SUMMARY

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^c

Compressed Gas Cylinder Disposal Area, 318 Area^{a,b,c}

Decommissioned Reactor CP-5, Building 330^{a,b,c}

French Drain, 317 Area^{a,b,c}

Gasoline Spill, Gasoline Station^c

Landfill East-Northeast of the 319 Area^{a,b}

Liquid Waste Treatment Facility, Building 34^b

Mixed Waste Storage, 317 Area^{a,d}

Shock Treatment Facility, 317 Area^{a,c}

Wastewater Holding Basin, Sewage Treatment Plant^b

On Former ANL-E Property,

Currently Waterfall Glen Forest Preserve

Reactive Waste Disposal, Underwriters Pond

^a SSI report submitted to the EPA in 1991.

^b RCRA SWMU.

^c Remediation has been initiated or completed.

^d This unit consists of six separate vaults being remediated under the ANL-E remedial actions project.

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 2000, corrective actions were underway or had been completed on all but one of the units described in the CERCLA document. Remedial actions for the remaining unit, the landfill east-northeast of the 319 Area is planned for 2001. 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 involving hazardous materials. Under EPCRA, ANL-E may be 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 notification to the State Emergency Response Commission 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. The procedures for notification are described in the Argonne Comprehensive Emergency Management Plan.

One incident in 2000 required notification to the Illinois Emergency Management Agency and other agencies. On October 26, 2000, during decontamination operations at a former cyclotron

2. COMPLIANCE SUMMARY

facility in Building 211, two small (20-mL [0.68 oz] capacity) sealed glass vials were broken open so that the liquid contents could be treated and prepared for disposal. After opening the vials, it was discovered that a small amount of radon gas had been released. A preliminary estimate of the quantity that was released was approximately 0.5 curies. On the basis of this amount, which exceeded the CERCLA reportable quantity of 0.1 curies, a report was submitted to the necessary emergency response agencies. No response was necessary as a result of these notifications (except for filing written reports). After further investigation, it was found that a more accurate estimate of the amount of radon released was approximately 0.008 curie, well below the reportable quantity of 0.1 curie.

Under EPCRA 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 2000 was provided to DOE on February 22, 2001. Table 2.12 lists the hazardous chemicals reported.

Section 313 of EPCRA, 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 and participates in the EPA 33/50 program, directs ANL-E to do so. No report has been filed since 1997, because no listed chemicals usage exceeded reporting thresholds. However, new requirements regarding a class of compounds called persistent, bioaccumulative toxics (PBTs) came into effect in 2000. As of the end of 2000, it was anticipated that one Form R report for PBT compounds will be submitted in 2001. Changes in reporting thresholds for lead and lead compounds, which became effective in December 2000, may require submission of Form R reports for lead in 2001.

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

2. COMPLIANCE SUMMARY

TABLE 2.12

ANL-E, SARA, Title III, Section 312, Chemical List, 2000

Compound	Physical Hazard			Health Hazard	
	Fire	Pressure	Reactivity	Acute	Chronic
Sodium hydroxide	- ^a	-	X	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.

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. Of these specially regulated substances, only asbestos and PCBs are found at the ANL-E site. The asbestos management program is discussed in Section 2.1.1.1 of this report. Suspect PCB-containing items which 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 capacitors 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 2000 was completed on May 31, 2000. This document is not submitted to regulatory agencies but is kept on file at ANL-E.

2. COMPLIANCE SUMMARY

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 2000.

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 2000, 66,700 L (17,380 gal) of PCB-contaminated sludge and debris was shipped off site for disposal, leaving only 3,700 L (966 gal) in storage.

2.10. Endangered Species

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 federally 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 federally 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*), federally 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 federally and state listed as endangered, indicates that this species may occur in the area.

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. No project at ANL-E has ever had to be stopped, delayed, or modified as a result of a potential impact to an endangered species.

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.

2. COMPLIANCE SUMMARY

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 will 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.

A draft Cultural Resources Management Plan (CRMP) was prepared in 1998 to fulfill DOE's responsibilities under the NHPA. This draft CRMP describes the management of cultural resources at ANL-E pursuant to the NHPA and identifies a strategy for stewardship of cultural resources. DOE is currently reviewing the draft plan.

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 done as funding permits.

A sitewide inventory of all building structures was begun in 1998 to identify those buildings that may have housed activities of historic significance. Such buildings potentially may be eligible for listing on the NRHP. Prior to the start of the inventory, DOE had already determined that four structures — Buildings 301, 315/316, 330, and 331 — are eligible for listing on the NRHP. D&D activities associated with the CP-5 reactor necessitated documenting the historical significance of 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 (IL HAER) 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 EO 11990 (May 24, 1977). In addition, 10 CFR Part 1022 describes DOE's implementation of this EO. The EO 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.

Because of its topography and the nature of the soil at ANL-E, the site contains a significant number of natural and man-made wetlands. These range from small storm water ditches overgrown with cattails to natural depressions, beaver ponds, and man-made ponds. Potential impacts to those areas from proposed actions are assessed in wetlands assessments and NEPA documentation as appropriate.

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 m² (1/8th acre). The findings were documented in an accompanying report that describes in detail the soil, vegetation, and hydrology of each wetland area delineated on the map. Thirty-five individual wetland areas were identified; their total area is approximately 18 ha (45 acres). The wetland areas also were digitized onto a computer-aided design file to provide

2. COMPLIANCE SUMMARY

ANL-E engineers with scale maps for planning and designing projects. This delineation also is useful for determining project impacts under NEPA review. The site wetlands map will be updated as needed to reflect significant changes in wetland boundaries that may occur over time.

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 construction of the APS facility, Wetland R was constructed and actions were taken to avoid Wetland C, in accordance with the plan.

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 restoration of the proper mix of vegetation through controlled burns, herbicide application, and planting of desirable plants. A controlled burn was completed in 1997. In March 2000, another burn was performed. Undesirable plants that were not killed by the burn were later removed by herbicide application and by manual removal. Desirable plants were reintroduced by transplanting rootstock or planting seeds. Preparations were made in late 2000 for an additional burn of Wetland R and burns of other wetland and woodland areas on site that were planned for early 2001.

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 has not yet acted on this mitigation plan.

In the summer of 2000, DOE requested that an EA be prepared for wetland management work. The EA was drafted in November 2000 and should be completed in the summer of 2001. This EA encompasses the Wetland C restoration activities as well as other related wetland management activities planned for the future. The related activities include the enlargement of on-site wetlands to provide advanced compensatory mitigation for modifications to existing wetlands that may result from future construction activities.

2.14. Wildlife Management and Related Monitoring

DOE manages the site white-tailed and fallow deer herds through an interagency agreement with the U.S. Department of Agriculture. Each species is managed to a target density of 20 deer/mi². 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 – 1996, and more than 80 deer were removed the following winter. Smaller numbers of deer have been removed each year since 1997. 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 four white-tailed deer were removed starting in November 2000 to achieve a target density of 20 deer/mi². No fallow deer were removed in 2000.

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

2. COMPLIANCE SUMMARY

radionuclides and hydrogen-3. Naturally occurring potassium-40 was the only gamma-ray-emitting radionuclide identified above detection limits. Hydrogen-3 was not detected in any sample.

2.14.4. Vegetation Damage

Vegetation is monitored periodically to determine the effects of browsing by deer on woody vegetation. This monitoring is conducted to meet conditions of Deer Population Control Permits and to help make deer management decisions. Horizontal vegetation densities and tree species richness at ANL-E are compared with previous ANL-E data and with data from Herrick Lake Forest Preserve, which has had a lower density of deer than ANL-E. Data collected in 1993 and 1997 indicated very heavy or extremely heavy adverse effects on ANL-E vegetation. Data for 2000 show improved tree species richness.

2.15. Current Issues and Actions

The purpose of this section is to summarize the most important issues related to environmental protection encountered during 2000. Table 2.13 lists all water effluent exceedances reported during 2000. 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 Air Act

A review of the preliminary draft CAAPP (Title V) permit received in November 2000 indicates that this permit will impose new requirements on ANL-E. Along with additional record keeping and coverage of some operations that were previously not subject to permitting, an annual compliance certification will be required. This certification, to be sent to both the EPA and IEPA, must signify whether all activities covered by the permit were in continuous or intermittent compliance, or whether there were any cases of noncompliance.

2.15.2. Clean Water Act - NPDES

As in previous years, ANL-E occasionally exceeded NPDES permit limits in 2000. The limits for TDS and chloride and copper were each exceeded once at Outfall 001 (the WTP discharge point), and the limit for TSS was exceeded three times at Outfall 006 and once at Outfall 004. Boiler house blowdown and road salt runoff contribute to high TDS and chloride concentrations at Outfall 001 in the winter. The boiler house equalization pond collects runoff from salted roads

2. COMPLIANCE SUMMARY

TABLE 2.13

Summary of 2000 NPDES Effluent Limit Exceedances

Month	Location of Exceedance	Parameter	Assessment
February 9	004	TSS	Sediment associated with snowmelt runoff
February 9	006	TSS	Sediment associated with snowmelt runoff
February 29	001	TDS	Road salt content in snowmelt
February 29	001	Chloride	Road salt content in snowmelt
March 7	006	TSS	Erosion runoff from bare areas
April 18	001	Copper	Unknown
October 12	006	TSS	Cooling tower drainage

in the boiler house area. ANL-E plans to reduce winter concentrations of TDS and chloride by pumping boiler house blowdown and equalization pond discharges to the DuPage County sewer system. ANL-E is addressing high TSS concentrations by improving erosion control efforts and by redirecting cooling tower blowdown from direct discharge through NPDES outfalls into the sewer system to be processed at the wastewater treatment plant.

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. These discharges are being redirected, as funding allows, into the sewer system to be processed at the WTP.

2.15.3. 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.

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2.15.4. Remedial Actions

Remediation of waste management units is an ongoing compliance issue. 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.

2.16. Environmental Permits

Table 2.14 lists all the environmental permits in effect at the end of 2000. 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.

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TABLE 2.14

ANL-E Environmental Permits in Effect December 31, 2000

Type	Subject of Permit	Building	Issued	Expiration Date ^a
Air	ALEX Alkali Metal Scrubber ^b	370	12/05/91	12/03/96
Air	Alkali Metal Reaction Booth ^b	308	02/15/89	11/18/98
Air	APS Emergency Generators (3)	400	05/16/94	03/15/99
Air	Argonne Service Station	300	01/09/91	10/04/00
Air	Boiler No. 5 Low NO _x Gas Burner ^c	108	06/21/96	12/28/98
Air	Central Heating Plant	108	12/28/93	12/28/98
Air	Central Shops Dust Collector ^b	363	03/12/91	01/08/01
Air	Ethylene Oxide Sterilizer	201	03/27/91	01/08/01
Air	Gasoline Dispensing Facility ^d	46	02/01/93	05/22/00
Air	Hazardous Waste Storage Facility ^e	307	05/24/95	04/26/00
Air	Methanol/Gasoline Storage Tank	46	09/24/91	09/23/96
Air	Open-Burning Permit - Fire Dept. ^b	333	04/18/00	04/18/01
Air	Open Burning - Vegetation	Sitewide	01/30/00	01/29/01
Air	Paint Spray Booth ^{e,f}	306	07/03/95	06/27/00
Air	Salt Cake/Recovery Electrodialysis Plant	369	08/10/98	08/10/03
Air	Sulfuric Acid Storage Tank ^b	108	01/17/91	12/01/99
Air	Title V (CAAPP)	Sitewide	Pending	- ^g
Air	Torch Cutting (Welding) Fumes ^b	Sitewide	07/20/95	07/20/00
Air	Transportation Research Facility	376	07/25/96	07/25/01
Air	Wood Shop Dust Collector ^b	368	12/16/93	10/17/96
Air	Waste Bulking Sheds ^b	306	06/14/94	07/25/96
Hazardous Waste	RCRA Part B	Sitewide	09/30/97	11/04/07
Miscellaneous	Deer Population Control Permit	Sitewide	11/27/00	02/28/01
Miscellaneous	Nuisance Wildlife Control	Sitewide	01/01/01	01/31/02
NESHAP	Advanced Photon Source	400	12/21/93	07/26/98
NESHAP	Alkali Metal Reaction Booth	206	06/09/93	06/09/97
NESHAP	Alpha Gamma Hot Cell Facility	212	03/25/91	08/09/00
NESHAP	Building Exhausts ^{b,h}	212	07/30/91	07/23/96
NESHAP	Building Rehab - Phase 1 ⁱ	306	03/13/95	07/25/96
NESHAP	Building Vents	306	08/06/91	07/25/96
NESHAP	Chemical Photooxid. Vial Crusher ^j	306	01/06/99	01/06/04
NESHAP	Continuous Wave Deuterium Demonstration ^e	369	05/09/91	12/28/99
NESHAP	CP-5 D&D Project ^e	330	05/10/91	12/08/96

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TABLE 2.14 (Cont.)

Type	Source	Building	Issued	Expiration Date ^a
NESHAP	Cyclotron ^e	211	05/10/91	12/01/99
NESHAP	D&D HEPA Filter System ^e	317	05/10/94	05/10/99
NESHAP	French Drain Soil Vapor Extraction ^e	317 Area	05/08/97	05/08/02
NESHAP	Building 301 Hot Cell D&D Project	301	01/05/99	01/05/04
NESHAP	Intense Pulsed Neutron Source	375	03/25/91	08/09/00
NESHAP	Janus D&D Project ^e	202	06/12/96	06/12/01
NESHAP	Lab Wastewater Treatment Plant	575	08/29/95	08/29/00
NESHAP	Lead Brick Cleaning (carbon dioxide)	200/317	06/20/95	06/19/00
NESHAP	Melt Attack/Coolability Experiment	315	03/22/96	03/22/01
NESHAP	Mixed Waste Storage Facility	303	05/18/95	04/26/00
NESHAP	M-Wing Hot Cells	200	03/25/91	08/09/00
NESHAP	New Brunswick Lab Hoods	350	04/25/91	04/19/96
NESHAP	PCB Tank Cleanout ^j	Sitewide	08/16/95	09/28/99
NESHAP	Rad Hoods	Sitewide	07/09/92	07/09/97
NESHAP	Rad (TRU) Waste Storage Facility	331	05/18/95	04/26/00
NESHAP	WMO HEPA Filter Systems (4)	Sitewide	09/28/94	09/28/99
NESHAP	WMO Portable HEPA Filters ^k	306	06/04/97	-
Solid Waste	Landfill	800 Area	03/31/82	-
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	800 Area	04/24/92 ^l	-
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 ^m	Sitewide	10/31/94	07/01/99
Water	NPDES Storm Water Outfalls ^m	Sitewide	10/31/94	07/01/99

Footnotes on next page

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TABLE 2.14 (Cont.)

- ^a The expiration dates on NESHAP and air pollution permits are no longer valid (except for open burning), since the Notice of Completeness for the CAAPP application was received (see Section 2.1).
- ^b These units have been designated as insignificant sources in the ANL-E Title V permit application.
- ^c Construction permit issued; operated under Central Heating Plant permit.
- ^d Includes ethanol/gasoline tank.
- ^e Inactive.
- ^f Permit originally issued for Building 815.
- ^g A hyphen indicates no expiration date.
- ^h Plasma spray booth added to permit 05/27/94.
- ⁱ Construction permit issued; operated under Building 306 permit.
- ^j Vial crusher originally issued under Building 306 permit.
- ^k Construction permit issued; operated under WMO HEPA permit.
- ^l Revised September 15, 1992, and October 22, 1992.
- ^m Existing permit continues to be in effect while revised permit application is undergoing IEPA review.

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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 2000, the site remediation, environmental compliance, and environmental monitoring programs were within the Environment, Safety and Health (ESH) Division. (The ESH Division has subsequently been eliminated because of a Laboratory reorganization.) The ANL-E Remedial Actions Project is responsible for achieving compliance with all applicable environmental authorities related to assessing and cleaning up releases of hazardous materials from inactive waste sites. The corrective action requirements specified in the RCRA Part B Permit compose the primary regulatory vehicle. The environmental compliance and environmental monitoring programs are responsible for the actions conducted at ANL-E to ensure the safety of the public; protection of the environment; and compliance with applicable federal, state, and local environmental regulations and DOE orders.

3.1.1. Remedial Actions Progress in 2000

In 2000, 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.

In FY 2000, several remedial actions were completed. ANL-E worked on 35 SWMUs during the year and completed closure on 24 of the units. The 24 SWMUs for which closure was completed can be divided into various groupings: SWMUs requiring removal of contaminated soils; those requiring assessment of soil; those requiring assessment of soil and groundwater; and those requiring completion of written reports.

The eight soil removal SWMUs included a waste oil storage yard, a former waste burn pit, a former wastewater sump pit, and similar units. The work at these SWMUs included the removal of contaminated soil by excavation, transport of the contaminated soil to an off-site landfill, and backfilling and restoration of the excavated area. Following the completion of fieldwork activities, a final report describing the work was prepared and submitted to the IEPA, along with a NFA request for each SWMU.

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The next set of SWMUs for which work was conducted were the soil assessment SWMUs. Few data were available concerning the concentrations of any contaminants in the soil for these SWMUs. The work conducted at these SWMUs focused mainly on collecting sufficient information to justify either a recommendation for NFA or to design a corrective action for the SWMU. This set of six SWMUs included recycled materials storage areas, storm water ravines, gravel roads, and similar small areas. The work at these SWMUs included preparing a sampling and analysis work plan, followed by completion of the work and final reporting of the results of the work. With the exception of one unit, all work on these SWMUs was completed and a NFA request submitted for IEPA approval.

The seven soil and groundwater assessment SWMUs constituted the next set of SWMUs for which work was performed. This set of SWMUs included those for which ANL-E had some information with respect to soil or groundwater contamination from prior studies. At these SWMUs, ANL-E installed groundwater monitoring wells and completed several soil borings to characterize the areas for potential groundwater and soil contamination. Because of the known nature of the soil and groundwater conditions at the site, ANL-E employed specialized technology to sample the groundwater to represent aquifer conditions better than conventional sampling. Conventional sampling techniques tend to mobilize microscopic soil particles found in the silts and clays into the groundwater sample. These particles in turn contain naturally occurring metals that dissolve during the laboratory analysis process, thereby increasing the concentration of metals. This tends to skew the results of the groundwater analysis. The specialized sampling technology, known as MicroPurge[®] sampling, collects the groundwater from the well without disturbing the clay and silt particles in the soil, thus reflecting more natural conditions in the groundwater. This work included SWMUs such as old sludge drying beds, an old waste burial pit, material storage yards, and similar sites. The work at these SWMUs included preparing a work plan, followed by completion of the soil boring and well installation work, followed by two rounds of sampling, and a final report of the results of the work. All planned work on these SWMUs was completed, and a NFA request submitted for IEPA approval.

Another minor set of SWMUs for which actions occurred included those for which ANL-E had sufficient information to recommend NFA, but the proper recommendation reports had not been written. This set included three SWMUs, one of which was a former radioactive waste storage structure. This work included tabulating data and comparing the results with the current set of IEPA cleanup objectives.

Other work included gathering additional information to design corrective actions for SWMUs scheduled for closure in future fiscal years. This included characterization work on three SWMUs, including a solid waste burial area and a former underground storage tank release site. Several operation and maintenance (O&M) activities were continued.

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The phytoremediation plantation in the 317 Area continued to mature and grow throughout the year. The plantation had a mortality rate of about 10%, which was expected. About 80 new trees were planted at locations where prior trees had died. Tissue samples collected from the trees in the French drain area (SWMU No. 11) indicated that the trees were taking up chlorinated organic compounds as they were planted to do. It is still too early to evaluate the success of the phytoremediation plantation, since this was only the first full growing season for the trees. ANL-E estimates that it will take another two to three growing seasons before the trees are fully mature and the success of the system can be evaluated.

Routine O&M of the two groundwater extraction systems south of the 317 and 319 Areas were carried out. Monitoring of these systems shows that they are operating as intended by preventing contaminated groundwater from leaving the site.

3.1.2. Environmental Monitoring Program Description

As required by DOE Orders 5400.1¹ 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 2000, a total of 1,964 samples were collected and 28,722 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.

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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, the wastewater outfall, 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, 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.

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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-846⁶ 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 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

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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 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

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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 2000, ANL-E received two prestigious pollution prevention awards. In June, ANL-E received the White House Closing the Circle Award for the Laboratory's Affirmative Procurement Program. In October, ANL-E received the DOE 2000 Pollution Prevention Award for the Laboratory's Affirmative Procurement Program.

ANL-E has a formal Waste Minimization and Pollution Prevention (WM&P2) Program. The program's long-term strategy is identified in the ANL-E WM&P2 Strategic Plan. In addition, ANL-E is in the process of developing a Pollution Prevention Program Plan that identifies short-term (five-year cycle) pollution prevention goals and describes the strategies that will be employed to achieve those goals. DOE established new Pollution Prevention and Energy Efficiency (P2/E2) Leadership Goals in December 1999, that ANL-E and other DOE facilities are to achieve by 2005.

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 that year. A schedule is prepared, and assignments are made to manage the organization's self-assessment program. The ANL-E-wide results and conclusions of the assessment program are summarized annually 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 the oversight organization assisting senior management in fulfilling its oversight responsibilities.

During 2000, ANL-E underwent an external verification of its ISM system by an independent team sponsored by the DOE Chicago Operations Office (CH). The team declared that the ANL-E ISM system is being implemented and noted specific strengths in its report. In general, the team documented that ANL-E is integrating safety considerations at the work level. The team identified 11 opportunities for improvement, which ANL-E evaluated for further action. The actions

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planned will promote improvements in the ISM system and are being tracked to completion as part of a Prime Contract performance measure. These actions reflect opportunities for improvement in the ANL-E environmental programs as well as in other operations.

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 ESH 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 ESH 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. Each performance expectation is weighted. 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 1999 to September 2000, 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 (good), 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.

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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 EO incorporates directives from previous EOs 12843, 12856, and 12969, as well as the Executive Memorandum of April 26, 1994, and also adds new requirements. The new EO is applicable to all federal agencies, including DOE. The goals of the EO 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.

ANL-E has formed a focus group to inform the ANL-E community about the implementation of the new EO. Efforts in 2000 have been on monitoring activities at the agency level and meeting with ANL-E managers to inform them of the EO requirements. A major component of the EO requires contractors to establish environmental management systems at their sites. Members of the ANL-E focus group have visited other sites to learn how they are approaching the development of an environmental management system.

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 have been removed and replaced by native species.

ANL-E is implementing, where practical, EO 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).

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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 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.

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4.1. Description of Monitoring Program

The radioactivity of the environment around ANL-E in 2000 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/m³ and aCi/m³ 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-rem.

DOE has provided guidance⁹ 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 factors¹² 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.

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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 m³/h (2,472 ft³/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

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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.

The alpha activity, principally due to naturally occurring nuclides, averaged the same as in the past several years and was within its normal range. The perimeter beta activity averaged 17 fCi/m³, 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 the past five years and are of natural origin. The beryllium-7 concentration increases in the 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. All annual average radiation measurements for the on-site samples were less than the off-site samples.

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/m³, the net would be 27 fCi/m³, 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 started to decrease. The changes in the beryllium-7 air

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TABLE 4.1

Total Alpha and Beta Activities in Air Filter Samples, 2000
(concentrations in fCi/m³)

Month	Location	No. of Samples	Alpha Activity			Beta Activity		
			Avg.	Min.	Max.	Avg.	Min.	Max.
January	Perimeter	33	0.8	0.3	1.6	23.2	9.9	38.9
	Off-Site	16	1.6	0.7	3.5	30.9	22.6	46.5
February	Perimeter	48	0.7	0.1	1.4	21.4	7.3	34.2
	Off-Site	17	1.1	0.2	2.8	23.2	5.4	34.2
March	Perimeter	60	0.8	0.2	2.0	15.1	8.2	24.8
	Off-Site	14	1.0	0.2	2.7	13.1	0.4	32.3
April	Perimeter	42	0.9	0.2	1.6	13.6	2.9	24.9
	Off-Site	15	1.4	0.5	4.2	19.7	11.7	53.7
May	Perimeter	57	0.6	0.1	1.0	12.3	6.1	18.8
	Off-Site	20	0.9	0.1	1.7	14.5	8.2	21.6
June	Perimeter	44	0.6	0.1	1.4	9.7	5.2	15.9
	Off-Site	10	0.7	0.3	1.3	13.0	7.2	18.0
July	Perimeter	46	0.6	0.1	1.5	12.0	5.4	21.0
	Off-Site	15	0.7	0.1	1.3	13.8	6.7	24.6
August	Perimeter	60	0.6	0.1	1.4	15.7	6.0	36.5
	Off-Site	20	1.0	0.2	2.3	19.3	8.4	39.8
September	Perimeter	48	0.7	0.2	1.3	13.3	6.8	26.0
	Off-Site	15	1.0	0.1	2.0	14.3	4.8	23.4
October	Perimeter	48	1.2	0.3	2.7	23.1	12.0	43.0
	Off-Site	15	1.6	0.8	3.5	27.1	13.7	54.1
November	Perimeter	60	1.1	0.3	1.9	19.4	9.0	33.3
	Off-Site	12	1.8	0.6	4.3	24.3	11.8	58.3
December	Perimeter	33	1.6	0.6	2.7	23.7	10.7	39.8
	Off-Site	14	2.2	0.4	6.3	26.0	10.3	60.8
Annual summary	Perimeter	579	0.9 ± 0.2	0.1	2.7	16.9 ± 3.2	2.9	43.0
	Off-Site	183	1.3 ± 0.3	0.1	6.3	19.9 ± 4.0	0.4	60.8

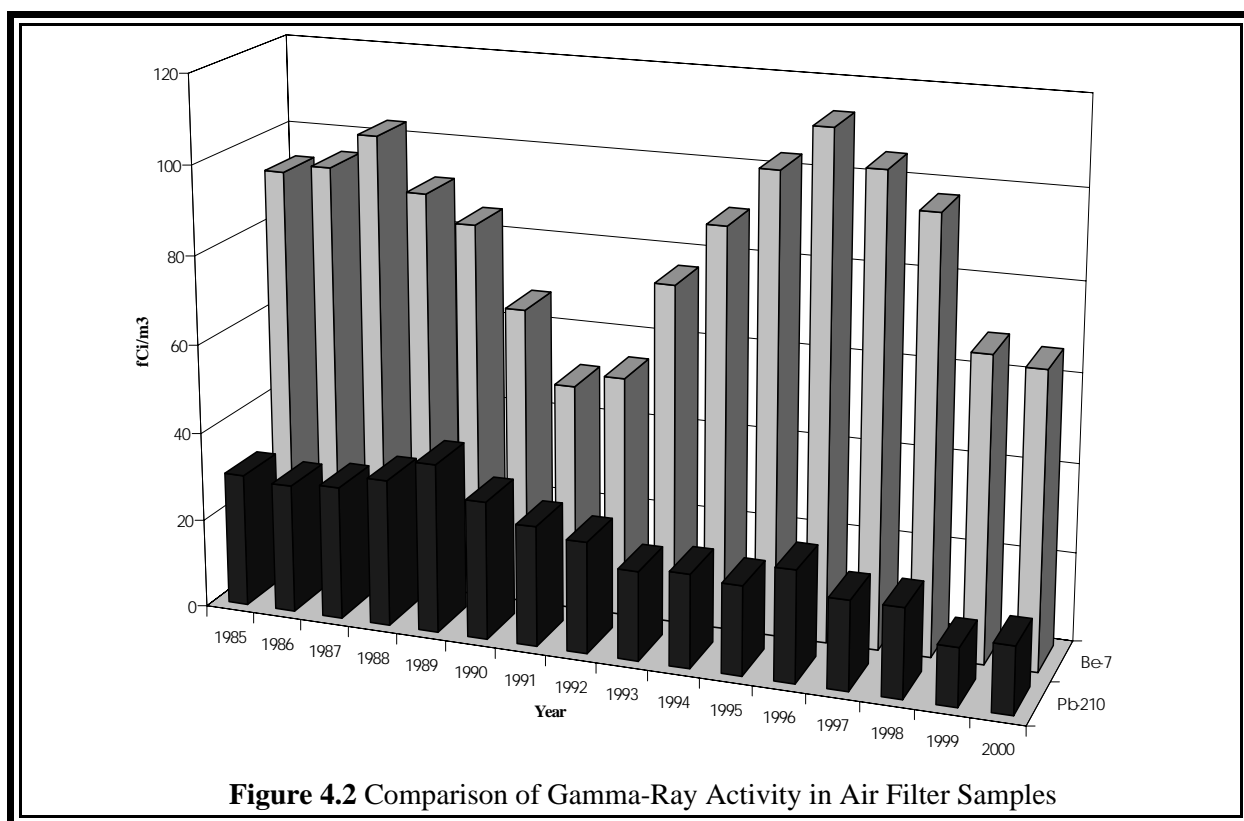
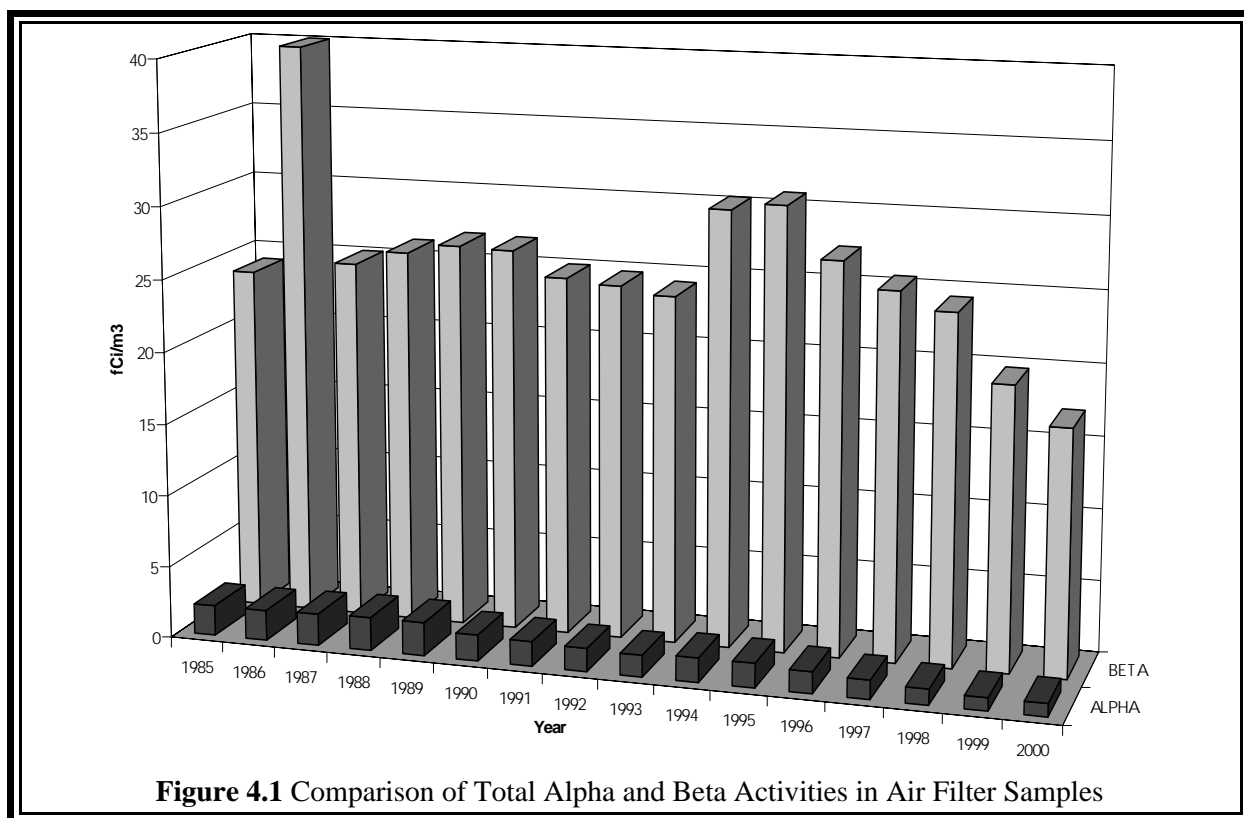
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TABLE 4.2

Gamma-Ray Activity in Air Filter Samples, 2000
(concentrations in fCi/m³)

Month	Location	Beryllium-7	Lead-210
January	Perimeter	46	23
	Off-Site	55	24
February	Perimeter	57	19
	Off-Site	91	20
March	Perimeter	95	12
	Off-Site	57	10
April	Perimeter	83	10
	Off-Site	80	13
May	Perimeter	68	9
	Off-Site	64	9
June	Perimeter	53	7
	Off-Site	57	8
July	Perimeter	55	9
	Off-Site	60	10
August	Perimeter	64	14
	Off-Site	84	24
September	Perimeter	60	11
	Off-Site	50	10
October	Perimeter	54	19
	Off-Site	59	20
November	Perimeter	38	17
	Off-Site	43	20
December	Perimeter	38	20
	Off-Site	41	19
Annual Summary	Perimeter	59 ± 10	14 ± 3
	Off-Site	62 ± 9	15 ± 3
Dose(mrem)	Perimeter	(0.00015)	(1.62)
	Off-Site	(0.00016)	(1.77)

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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 and 7I (Figure 1.1) and off the site in Downers Grove (Figure 1.2). Collections were made on polystyrene filters. The total air volume filtered for the monthly samples was approximately 20,000 m³ (700,000 ft³). 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 2000, all of the results were less than the detection limit of 10 aCi/m³, except for one result in July. Strontium-89 was not observed above the detection limit of 100 aCi/m³. 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. The annual average concentrations for the two on-site locations were somewhat higher than the background location. The samples collected on the eastern edge of the site at Location 12N were significantly higher than the samples collected at Location 7I on the southern part of the site; however, the uncertainty in the annual averages is significant.

The major airborne effluents released at ANL-E during 2000 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.

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TABLE 4.3

Strontium, Thorium, Uranium, and Plutonium Concentrations
in Air Filter Samples, 2000
(Concentrations in aCi/m³)

Month	Location ^a	Strontium-90	Thorium-228	Thorium-230	Thorium-232	Uranium-234	Uranium-238	Plutonium-239
January	7I	< 10	6 ± 2	4 ± 1	3 ± 1	6 ± 1	5 ± 1	0.8 ± 0.5
	12N	< 10	11 ± 2	13 ± 2	9 ± 2	13 ± 1	13 ± 1	0.4 ± 0.4
	Off-Site	< 10	4 ± 1	4 ± 1	2 ± 1	5 ± 1	5 ± 1	2.6 ± 0.8
February	7I	< 10	4 ± 2	3 ± 1	2 ± 1	6 ± 2	5 ± 1	0.4 ± 0.3
	12N	< 10	6 ± 1	9 ± 2	6 ± 1	9 ± 2	9 ± 2	0.1 ± 0.2
	Off-Site	< 10	3 ± 1	4 ± 1	3 ± 1	5 ± 1	5 ± 1	0.3 ± 0.3
March	7I	< 10	4 ± 1	5 ± 1	3 ± 1	5 ± 1	5 ± 1	0.1 ± 0.2
	12N	< 10	6 ± 1	6 ± 1	4 ± 1	6 ± 1	6 ± 1	< 0.1
	Off-Site	< 10	< 1	1 ± 1	< 1	2 ± 1	2 ± 1	0.4 ± 0.3
April	7I	< 10	7 ± 2	7 ± 2	5 ± 1	8 ± 2	7 ± 2	0.4 ± 0.4
	12N	< 10	13 ± 2	17 ± 2	11 ± 2	16 ± 2	15 ± 2	0.5 ± 0.3
	Off-Site	< 10	3 ± 1	4 ± 1	3 ± 1	4 ± 1	5 ± 1	0.3 ± 0.3
May	7I	< 10	5 ± 2	6 ± 2	6 ± 2	6 ± 2	6 ± 1	0.4 ± 0.3
	12N	< 10	23 ± 4	27 ± 4	18 ± 3	23 ± 3	25 ± 3	0.7 ± 0.4
	Off-Site	< 10	5 ± 2	5 ± 1	2 ± 1	4 ± 2	5 ± 2	0.2 ± 0.2
June	7I	< 10	6 ± 1	6 ± 1	3 ± 1	6 ± 2	5 ± 2	0.4 ± 0.5
	12N	< 10	9 ± 2	10 ± 2	8 ± 2	9 ± 1	10 ± 1	0.1 ± 0.2
	Off-Site	< 10	2 ± 1	3 ± 1	1 ± 1	2 ± 1	2 ± 1	0.3 ± 0.2
July	7I	< 10	3 ± 1	2 ± 1	1 ± 1	2 ± 1	3 ± 1	0.7 ± 0.3
	12N	11 ± 1	13 ± 2	15 ± 2	11 ± 2	13 ± 2	13 ± 2	0.9 ± 0.3
	Off-Site	< 10	3 ± 1	2 ± 1	2 ± 1	2 ± 1	3 ± 1	0.2 ± 0.1
August	7I	< 10	1 ± 1	2 ± 1	2 ± 1	2 ± 1	2 ± 1	0.3 ± 0.3
	12N	< 10	7 ± 2	10 ± 1	6 ± 1	9 ± 2	10 ± 2	0.3 ± 0.2
	Off-Site	< 10	2 ± 1	2 ± 1	< 1	2 ± 1	2 ± 1	0.2 ± 0.2
September	7I	< 10	2 ± 2	2 ± 1	2 ± 1	13 ± 2	3 ± 1	0.7 ± 0.4
	12N	< 10	5 ± 2	5 ± 1	4 ± 1	10 ± 2	7 ± 1	0.3 ± 0.2
	Off-Site	< 10	< 1	1 ± 1	< 1	2 ± 1	3 ± 1	< 0.1
October	7I	< 10	3 ± 2	3 ± 1	2 ± 1	14 ± 3	5 ± 1	0.6 ± 0.3
	12N	< 10	7 ± 1	8 ± 1	5 ± 1	13 ± 2	9 ± 2	0.5 ± 0.3
	Off-Site	< 10	< 1	2 ± 1	< 1	9 ± 2	2 ± 1	0.2 ± 0.2
November	7I	< 10	3 ± 2	3 ± 1	2 ± 1	16 ± 3	3 ± 1	0.5 ± 0.3
	12N	< 10	10 ± 2	10 ± 2	7 ± 1	16 ± 3	10 ± 2	0.6 ± 0.3
	Off-Site	< 10	2 ± 1	2 ± 1	1 ± 1	10 ± 2	3 ± 1	0.2 ± 0.2
December	7I	< 10	5 ± 2	6 ± 2	4 ± 1	51 ± 6	43 ± 5	0.3 ± 0.2
	12N	< 10	22 ± 3	26 ± 3	16 ± 2	9 ± 1	4 ± 1	3.4 ± 0.5
	Off-Site	< 10	2 ± 1	2 ± 1	< 1	8 ± 2	3 ± 1	0.2 ± 0.1
Annual Summary	7I	< 10	4 ± 4	4 ± 4	3 ± 3	11 ± 30	8 ± 25	0.5 ± 0.4
	12N	< 10	11 ± 13	13 ± 16	9 ± 10	12 ± 10	11 ± 12	0.7 ± 2.0
	Off-Site	< 10	2 ± 3	3 ± 3	1 ± 2	5 ± 6	3 ± 3	0.4 ± 1.5
Dose (mrem)	7I	< (0.00011)	(0.0102)	(0.0081)	(0.028)	(0.00056)	(0.00038)	(0.0012)
	12N	< (0.00011)	(0.0272)	(0.0259)	(0.087)	(0.00060)	(0.00054)	(0.0016)
	Off-Site	< (0.00011)	(0.0054)	(0.0053)	(0.015)	(0.00023)	(0.00016)	(0.0011)

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

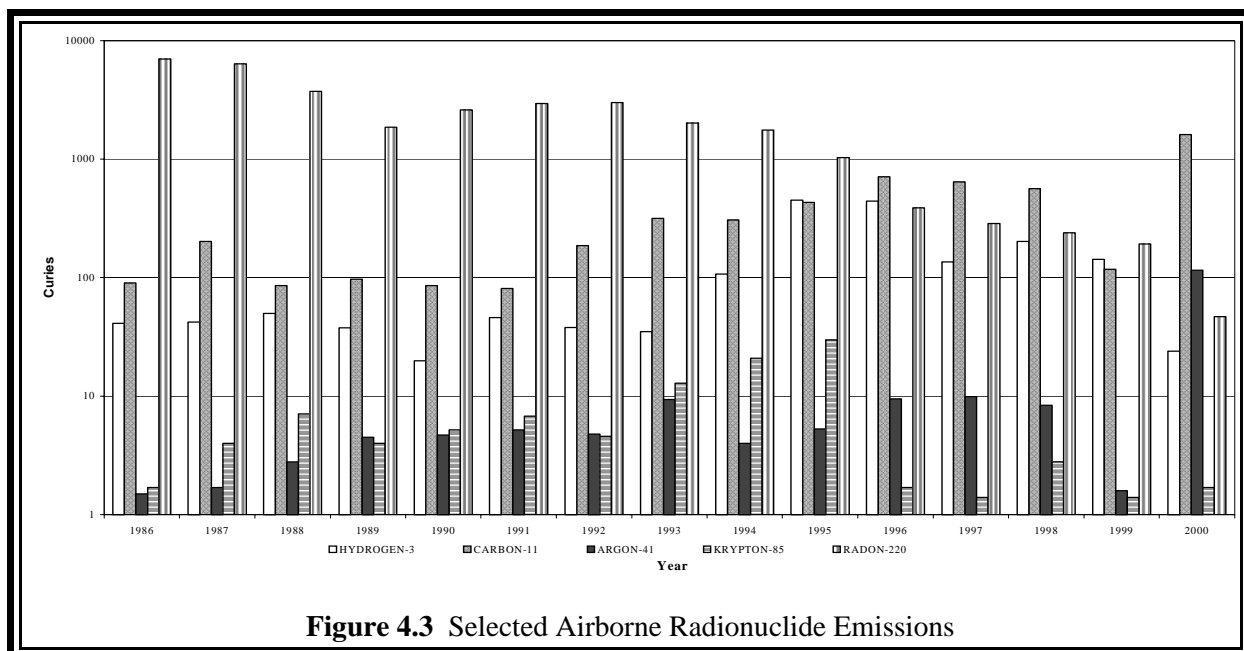
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TABLE 4.4

Summary of Airborne Radioactive Emissions from ANL-E Facilities, 2000

Building	Nuclide	Half-Life	Amount Released (Ci)	Amount Released (Bq)
200	Radon-220	56 s	46.7	1.7×10^{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	10.2	3.8×10^{11}
	Hydrogen-3 (tritiated hydrogen gas [HT])	12.3 yr	119.3	4.4×10^{12}
	Krypton-85	10.7 yr	4.6	1.7×10^{11}
	Radon-220	56 s	0.15	5.6×10^9
350 (NBL)	Uranium-234	2.4×10^5 yr	4.2×10^{-7}	1.5×10^{-1}
	Uranium-238	4.5×10^9 yr	4.2×10^{-7}	1.5×10^{-1}
	Plutonium-238	87.7 yr	9.1×10^{-9}	3.3×10^1
	Plutonium-239	2.4×10^4 yr	2.7×10^{-6}	9.8×10^4
	Plutonium-240	6.6×10^4 yr	9.2×10^{-9}	3.3×10^1
	Plutonium-241	14.4 yr	4.7×10^{-7}	1.7×10^4
	Plutonium-242	3.76×10^5 yr	7.6×10^{-11}	2.8×10^{-2}
	Plutonium-244	8.0×10^7 yr	3.9×10^{-15}	1.4×10^{-5}
375 (IPNS)	Carbon-11	20 m	1610.5	5.9×10^{13}
	Argon-41	1.8 h	115.7	4.2×10^{11}
411/415 (APS)	Carbon-11	20 m	0.06	2.2×10^9
	Nitrogen-13	10 m	3.47	1.3×10^{11}
	Oxygen-15	122 s	0.38	1.4×10^{10}

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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 popular 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 2000 for all the wells was 1,814 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 2000, the total

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hydrogen-3 released was 0.008 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 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 2000. The results show that the radionuclides

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TABLE 4.5

Radionuclides in Effluents from the ANL-E Wastewater Treatment Plant, 2000

Activity	No. of Samples	Concentrations in pCi/L			Dose (mrem)		
		Avg.	Min.	Max.	Avg.	Min.	Max.
Alpha	52	0.6 ± 0.9	< 0.1	2.7	- ^a	-	-
Beta	52	14 ± 6	9	22	-	-	-
Hydrogen-3	52	104 ± 86	< 100	283	0.0048	< 0.0046	0.0130
Strontium-90	52	0.66 ± 0.59	0.30	2.25	0.063	0.029	0.214
Cesium-137	52	< 2.0	< 2.0	< 2.0	< 0.08	< 0.08	< 0.08
Uranium-234	52	0.251 ± 0.298	0.051	0.712	0.048	0.010	0.135
Uranium-238	52	0.210 ± 0.262	0.069	0.617	0.035	0.012	0.104
Neptunium-237	52	< 0.0010	< 0.0010	0.0012	< 0.0028	< 0.0028	0.0033
Plutonium-238	52	< 0.0010	< 0.0010	0.0054	< 0.0028	< 0.0028	0.0150
Plutonium-239	52	< 0.0010	< 0.0010	0.0011	< 0.0031	< 0.0031	0.0034
Americium-241	52	< 0.0010	< 0.0010	0.0035	< 0.0033	< 0.0033	0.0116
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	0.0019	< 0.0034	< 0.0034	0.0064

^a A hyphen indicates no CEDEs for alpha and beta.

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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 (1.12×10^9 L) is computed. These results are given in Table 4.6.

TABLE 4.6

Total Radioactivity Released, 2000

Radionuclide	WTP Outfall (Ci)
Hydrogen-3	0.116
Strontium-90	0.0007
Plutonium-239	<0.0001
Americium-241	<0.0001
Total	0.12

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: strontium-90 and americium-241; and occasionally hydrogen-3, neptunium-237, plutonium-238, plutonium-239, 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 standards.

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.

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TABLE 4.7

Radionuclides in Sawmill Creek Water, 2000

Activity	Location ^a	No. of Samples	Concentrations in pCi/L			Dose (mrem)		
			Avg.	Min.	Max.	Avg.	Min.	Max.
Alpha	16K	12	1.4 ± 1.2	0.4	2.5	- ^b	-	-
(Nonvolatile)	7M	51	1.0 ± 0.9	0.3	2.7	-	-	-
Beta	16K	12	9 ± 10	5	19	-	-	-
(Nonvolatile)	7M	51	11 ± 8	5	21	-	-	-
Hydrogen-3	16K	12	< 100	< 100	< 100	< 0.0046	< 0.0046	< 0.0046
	7M	51	< 100	< 100	133	< 0.0046	< 0.0046	0.0061
Strontium-90	16K	12	< 0.25	< 0.25	0.34	< 0.024	< 0.024	0.033
	7M	51	0.39 ± 0.37	< 0.25	1.13	0.037	< 0.024	0.108
Cesium-137	16K	12	< 2.0	< 2.0	< 2.0	< 0.08	< 0.08	< 0.08
	7M	51	< 2.0	< 2.0	< 2.0	< 0.08	< 0.08	< 0.08
Uranium-234	16K	12	0.782 ± 0.617	0.334	1.297	0.149	0.063	0.246
	7M	51	0.463 ± 0.369	0.113	0.907	0.088	0.021	0.172
Uranium-238	16K	12	0.710 ± 0.591	0.278	1.193	0.119	0.047	0.200
	7M	51	0.414 ± 0.354	0.109	0.863	0.070	0.018	0.145
Neptunium-237	16K	12	< 0.0010	< 0.0010	< 0.0010	< 0.0028	< 0.0028	< 0.0028
	7M	51	< 0.0010	< 0.0010	0.0011	< 0.0028	< 0.0028	0.0031
Plutonium-238	16K	12	< 0.0010	< 0.0010	0.0014	< 0.0028	< 0.0028	0.0039
	7M	51	< 0.0010	< 0.0010	0.0037	< 0.0028	< 0.0028	0.0103
Plutonium-239	16K	12	< 0.0010	< 0.0010	< 0.0010	< 0.0031	< 0.0031	< 0.0031
	7M	51	< 0.0010	< 0.0010	0.0016	< 0.0031	< 0.0031	0.0049
Americium-241	16K	12	< 0.0010	< 0.0010	0.0055	< 0.0033	< 0.0033	0.0182
	7M	51	0.0011 ± 0.0027	< 0.0010	0.0072	0.0036	< 0.0033	0.0235
Curium-242 and/or	16K	12	< 0.0010	< 0.0010	0.0022	< 0.0007	< 0.0007	0.0015
Californium-252	7M	51	< 0.0010	< 0.0010	0.0015	< 0.0007	< 0.0007	0.0011
Curium-244 and/or	16K	12	< 0.0010	< 0.0010	0.0024	< 0.0034	< 0.0034	0.0080
Californium-249	7M	51	< 0.0010	< 0.0010	0.0017	< 0.0034	< 0.0034	0.0057

^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.

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TABLE 4.8

Radionuclides in Storm Water Outfalls, 2000
(concentrations in pCi/L)

Date Collected	Location 7J Hydrogen-3	Location 7J Strontium-90	Location 7J Cesium-137	Location 11D Hydrogen-3
February 22	202	0.49	<2	890
April 20	198	0.80	<2	209
July 10	108	0.79	<2	<100
November 9	Dry	Dry	Dry	<100

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 1 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 quite 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.

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TABLE 4.9

Radionuclides in Des Plaines River Water, 2000

Activity	Location ^a	No. of Samples	Concentrations in pCi/L			Dose (mrem)		
			Avg.	Min.	Max.	Avg.	Min.	Max.
Alpha (Nonvolatile)	A	12	1.3 ± 2.4	0.6	4.5	- ^b	-	-
	B	24	1.1 ± 1.1	0.3	2.4	-	-	-
Beta (Nonvolatile)	A	12	14 ± 9	8	22	-	-	-
	B	24	16 ± 12	8	30	-	-	-
Hydrogen-3	A	12	< 100	< 100	< 100	< 0.0046	< 0.0046	< 0.0046
	B	24	< 100	< 100	116	< 0.0046	< 0.0046	0.0053
Strontium-90	A	12	< 0.25	< 0.25	0.32	< 0.024	< 0.024	0.030
	B	24	< 0.25	< 0.25	0.39	< 0.024	< 0.024	0.037
Uranium-234	A	12	0.526 ± 0.618	0.292	1.335	0.100	0.056	0.254
	B	24	0.462 ± 0.255	0.252	0.699	0.088	0.048	0.133
Uranium-238	A	12	0.436 ± 0.468	0.214	1.014	0.073	0.036	0.170
	B	24	0.399 ± 0.257	0.191	0.602	0.067	0.032	0.101
Neptunium-237	A	12	< 0.0010	< 0.0010	< 0.0010	< 0.0028	< 0.0028	< 0.0028
	B	12	< 0.0010	< 0.0010	0.0015	< 0.0028	< 0.0028	0.0042
Plutonium-238	A	12	< 0.0010	< 0.0010	0.0017	< 0.0028	< 0.0028	0.0048
	B	12	< 0.0010	< 0.0010	0.0030	< 0.0028	< 0.0028	0.0084
Plutonium-239	A	12	< 0.0010	< 0.0010	< 0.0010	< 0.0031	< 0.0031	< 0.0031
	B	12	< 0.0010	< 0.0010	0.0014	< 0.0031	< 0.0031	0.0043
Americium-241	A	12	< 0.0010	< 0.0010	0.0011	< 0.0033	< 0.0033	0.0036
	B	12	< 0.0010	< 0.0010	< 0.0010	< 0.0033	< 0.0033	< 0.0033
Curium-242 and/or Californium-252	A	12	< 0.0010	< 0.0010	0.0017	< 0.0007	< 0.0007	0.0011
	B	12	< 0.0010	< 0.0010	0.0015	< 0.0007	< 0.0007	0.0010
Curium-244 and/or Californium-249	A	12	< 0.0010	< 0.0010	< 0.0010	< 0.0034	< 0.0034	< 0.0034
	B	12	< 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.

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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 soil. Results are given in terms of the oven-dried (110°C [230°F]) weight.

A set of sediment samples was collected on December 1, 2000, 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. This was evidenced by the 2000 results, which are at least a factor of 10 less than the 1999 results.

4.5. External Penetrating Radiation

Levels of external penetrating 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 (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 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 99 ± 5 mrem/yr and were significantly higher than last year's off-site average of 80 ± 4 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,

TABLE 4.10**Radionuclides in Bottom Sediment, 2000**

Location	Concentrations (pCi/g)					Concentrations (fCi/g)		
	Potassium-40	Cesium-137	Radium-226	Thorium-228	Thorium-232	Plutonium-238	Plutonium-239	Americium-241
Sawmill Creek 25 m above outfall	8.22 ± 0.47	0.01 ± 0.02	0.48 ± 0.05	0.40 ± 0.04	0.28 ± 0.07	2.0 ± 0.9	2.7 ± 1.1	0.6 ± 0.4
Sawmill Creek at outfall	9.15 ± 0.48	0.14 ± 0.02	0.43 ± 0.05	0.39 ± 0.04	0.34 ± 0.07	1.1 ± 0.6	12.8 ± 2.1	4.5 ± 1.2
Sawmill Creek 50 m below outfall	8.12 ± 0.46	0.12 ± 0.02	0.51 ± 0.05	0.37 ± 0.04	0.27 ± 0.07	0.7 ± 0.5	6.8 ± 1.6	1.7 ± 0.7
Sawmill Creek 100 m below outfall	10.35 ± 0.54	0.10 ± 0.03	0.74 ± 0.06	0.55 ± 0.04	0.47 ± 0.08	0.3 ± 0.3	10.4 ± 1.8	2.0 ± 0.7
Sawmill Creek at Des Plaines River	16.56 ± 0.66	0.12 ± 0.03	1.15 ± 0.07	0.95 ± 0.05	0.60 ± 0.09	0.1 ± 0.2	8.7 ± 1.7	3.0 ± 0.8

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TABLE 4.11

Environmental Penetrating Radiation at Off-Site Locations, 2000

Location	Dose Rate (mrem/yr) Period of Measurement				Average
	Jan. 6 – April 4	April 4 – July 6	July 6 – Oct. 1	Oct. 1 – Jan. 16	
Lemont	87	92	105	90	94 ± 8
Oak Brook	103	97	132	92	106 ± 17
Orland Park	100	89	104	91	96 ± 7
Woodridge	111	98	109	97	104 ± 7
Willow Springs	94	97	100	82	93 ± 8
Average	99 ± 8	95 ± 3	110 ± 11	90 ± 5	99 ± 5

individual results in the range of 99 ± 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 is packaged and temporarily stored in this area before removal for permanent disposal off site. In 2000, the dose at this perimeter fence location was 114 ± 21 mrem/yr. Approximately 300 m (960 ft) south of the fence in grid 6I, the measured dose dropped to 104 ± 8 mrem/yr, which is within the normal background range.

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 CP-5 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 179 mrem/yr in 2000. The cleanup of the yard was completed in 1994; the residual dose is from sources in the building, which is currently undergoing D&D, and the use of the yard to stage radioactive waste from the D&D, pending shipment off site. This waste was totally removed from the yard by early summer, and during the second half of the year, the dose was at background levels.

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. Although some waste is repacked in Building 306 (Location 9/10 I), except for the first quarter, the dose from these

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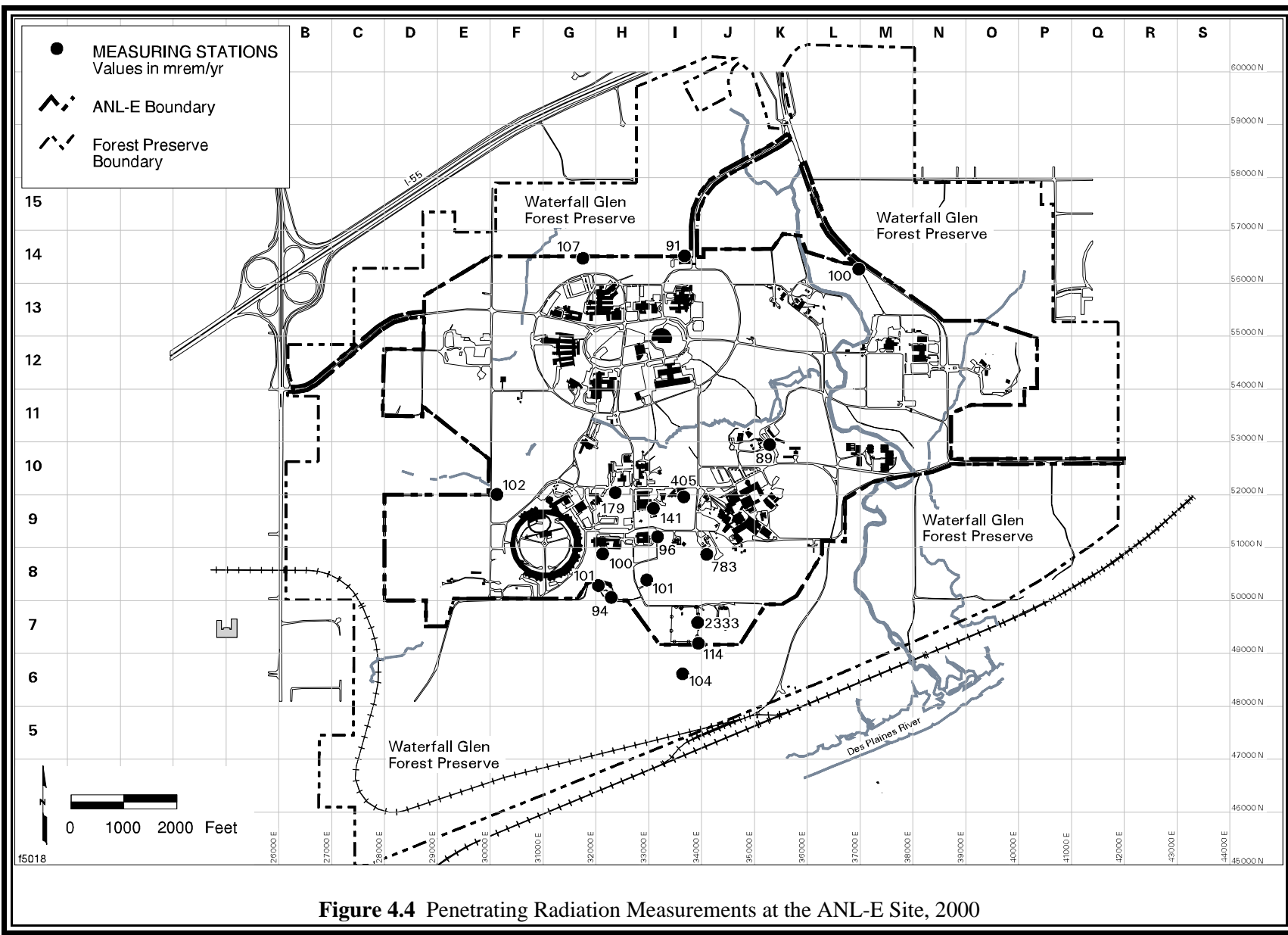
TABLE 4.12

Environmental Penetrating Radiation at ANL-E, 2000

Location ^a	Dose Rate (mrem/yr) Period of Measurement				Average
	Jan. 6 – April 4	April 4 – July 6	July 6 – Oct. 1	Oct. 1 – Jan. 16	
14G - Boundary	108	104	112	105	107 ± 4
14I - Boundary	96	92	88	89	91 ± 3
14L - Boundary	98	96	109	96	100 ± 6
6I - 200 m N of Quarry Road	112	99	101	- ^b	104 ± 8
7I - Center, Waste Storage Area Facility 317	3,384	2,888	2,028	1,030	2,333 ± 1,013
7I - Boundary	137	126	105	90	114 ± 21
8H - Boundary	94	97	96	89	94 ± 4
8H - 65 m S of Building 316	100	106	103	90	100 ± 7
8H - 200 m NW of Waste Storage Area (Heliport)	102	105	95	-	101 ± 6
8H - Boundary, Center, St. Patrick Cemetery	99	102	106	97	101 ± 4
9H - 50 m SE of CP-5	208	323	90	97	179 ± 108
9 H/I - 50 m E of Building 331	396	461	388	377	405 ± 37
9/10 I - E of D306	260	103	107	96	141 ± 78
9/10 I - 65 m NE of Building 350, 230 m NE of Building 316	96	102	97	90	96 ± 5
9/10 EF - Boundary	95	108	109	98	102 ± 7
9J - 50 m W of 398A Area	636	405	1,541	550	783 ± 504
10/11 K - Loading Facilities	85	95	94	82	89 ± 6

^a See Figure 1.1.

^b A hyphen indicates that the sample was lost.



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operations could not be distinguished from 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 2000, as reflected by the elevated dose rates. The 398A area was also used as a staging area to load trucks for shipment off site. A substantial number of shipments were conducted from 398A in the third quarter of the year.

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 code¹³ to calculate the dose for radionuclides released to the air and to demonstrate compliance with the regulation. The dose limit applicable for 2000 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 2000, 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

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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 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, was completed in 1995. This has 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, to 47 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. An accidental release of 0.008 Ci of radon-222 occurred in December 2000 from Building 211 during the opening of sealed solutions of radium-226.

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 0.48 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 about eight times higher than last year and is due to increased carbon-11 emissions from the IPNS. These increased emissions are due to changes in the exhaust air system, which reduced the holdup time. The programmatic need for continued operation of the facility will result in continued releases of carbon-11.

The full-time resident who would receive the largest annual dose (0.047 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 (0.046 mrem/yr). Releases of radon-220 plus daughters contribute about 2% 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 0.046 mrem/yr, essentially all from carbon-11 released by the IPNS. The maximum resident dose is about 11 times higher than last year.

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TABLE 4.13

Radiological Airborne Releases from Building 200, 2000

Direction	Distance to Perimeter (m)	Dose ^a (mrem/yr)	Distance to Nearest Resident (m)	Dose ^a (mrem/yr)
N	500	9.9×10^{-3}	1,000	2.8×10^{-3}
NNE	600	7.8×10^{-3}	1,100	2.5×10^{-3}
NE	750	4.5×10^{-3}	2,600	4.8×10^{-4}
ENE	1,700	9.6×10^{-4}	3,100	3.4×10^{-4}
E	2,400	6.8×10^{-4}	3,500	3.7×10^{-4}
ESE	2,200	5.7×10^{-4}	3,600	2.5×10^{-4}
SE	2,100	4.7×10^{-4}	4,000	1.6×10^{-4}
SSE	2,000	6.9×10^{-4}	4,000	2.2×10^{-4}
S	1,500	5.8×10^{-4}	4,000	1.2×10^{-4}
SSW	1,000	3.1×10^{-3}	2,500	6.6×10^{-4}
SW	800	6.6×10^{-3}	2,200	1.3×10^{-3}
WSW	1,100	2.0×10^{-3}	1,500	1.2×10^{-3}
W	750	3.5×10^{-3}	1,500	1.2×10^{-3}
WNW	800	2.3×10^{-3}	1,300	1.1×10^{-3}
NW	600	3.6×10^{-3}	1,100	1.3×10^{-3}
NNW	600	4.9×10^{-3}	800	2.9×10^{-3}

^a Source term: radon-220 = 46.7 Ci (plus daughters).

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TABLE 4.14

Maximum Perimeter and Individual Doses
from Building 200 Air Emissions, 2000
(dose in mrem/yr)

Pathway	Perimeter (500 m N)	Individual (800 m NNW)
Ingestion	1.4×10^{-14}	5.3×10^{-15}
Inhalation	9.8×10^{-3}	2.9×10^{-3}
Air immersion	6.8×10^{-5}	1.8×10^{-5}
Ground surface	4.8×10^{-6}	1.8×10^{-6}
Total	9.9×10^{-3}	2.9×10^{-3}
Radionuclide		
Thallium-208	5.9×10^{-5}	1.5×10^{-5}
Bismuth-212	1.2×10^{-3}	4.1×10^{-4}
Lead-212	5.9×10^{-3}	2.1×10^{-3}
Radon-220	2.8×10^{-3}	4.0×10^{-4}
Total	9.9×10^{-3}	2.9×10^{-3}

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TABLE 4.15

Radiological Airborne Releases from Building 205, 2000

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.

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TABLE 4.16

Maximum Perimeter and Individual Doses from
Building 205 Air Emissions, 2000
(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.

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TABLE 4.17

Radiological Airborne Releases from Building 212, 2000

Direction	Distance to Perimeter (m)	Dose ^a (mrem/yr)	Distance to Nearest Resident (m)	Dose ^a (mrem/yr)
N	800	5.2×10^{-3}	2,000	1.3×10^{-3}
NNE	1,000	3.8×10^{-3}	2,500	9.0×10^{-4}
NE	1,300	2.3×10^{-3}	2,000	1.2×10^{-3}
ENE	1,500	1.8×10^{-3}	2,500	7.8×10^{-4}
E	1,600	2.0×10^{-3}	2,800	8.4×10^{-4}
ESE	1,200	2.4×10^{-3}	2,500	7.2×10^{-4}
SE	1,400	1.4×10^{-3}	3,500	3.3×10^{-4}
SSE	1,400	1.9×10^{-3}	4,500	3.1×10^{-4}
S	1,500	8.5×10^{-4}	5,000	1.4×10^{-4}
SSW	1,600	2.7×10^{-3}	5,000	3.8×10^{-4}
SW	1,400	3.8×10^{-3}	2,400	1.8×10^{-3}
WSW	1,300	2.2×10^{-3}	2,300	8.9×10^{-4}
W	1,700	1.5×10^{-3}	2,200	1.0×10^{-3}
WNW	1,500	1.3×10^{-3}	2,000	8.5×10^{-4}
NW	1,300	1.5×10^{-3}	2,000	7.8×10^{-4}
NNW	1,000	2.6×10^{-3}	2,000	9.0×10^{-4}

^a Source terms: hydrogen-3 (HT) = 119.3 Ci
hydrogen-3 (HTO) = 10.2 Ci
krypton-85 = 4.6 Ci
radon-220 = 0.15 Ci.

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TABLE 4.18

Maximum Perimeter and Individual Doses
from Building 212 Air Emissions, 2000
(dose in mrem/yr)

Pathway	Perimeter (800 m N)	Individual (2,400 m SW)
Ingestion	1.2×10^{-3}	4.4×10^{-4}
Inhalation	3.9×10^{-3}	1.4×10^{-3}
Air immersion	1.5×10^{-6}	5.4×10^{-7}
Ground surface	3.8×10^{-8}	1.0×10^{-8}
Total	5.2×10^{-3}	1.8×10^{-3}
Radionuclide		
Hydrogen-3	5.2×10^{-3}	1.8×10^{-3}
Krypton-85	2.3×10^{-6}	8.1×10^{-7}
Radon-220	2.2×10^{-6}	1.7×10^{-8}
Total	5.2×10^{-3}	1.8×10^{-3}

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TABLE 4.19

Radiological Airborne Releases from Building 350, 2000

Direction	Distance to Perimeter (m)	Dose ^a (mrem/yr)	Distance to Nearest Resident (m)	Dose ^a (mrem/yr)
N	1,700	6.2×10^{-5}	2,200	4.3×10^{-5}
NNE	1,800	6.0×10^{-5}	3,200	2.6×10^{-5}
NE	2,200	4.0×10^{-5}	3,100	2.4×10^{-5}
ENE	2,000	4.4×10^{-5}	3,100	2.3×10^{-5}
E	1,700	6.9×10^{-5}	2,500	3.1×10^{-5}
ESE	900	1.2×10^{-4}	3,000	2.3×10^{-5}
SE	900	8.4×10^{-5}	3,000	2.0×10^{-5}
SSE	700	1.6×10^{-4}	2,700	2.8×10^{-5}
S	600	6.1×10^{-5}	2,700	1.3×10^{-5}
SSW	400	2.3×10^{-4}	2,500	4.2×10^{-5}
SW	600	2.6×10^{-4}	2,700	5.2×10^{-5}
WSW	800	1.2×10^{-4}	2,100	3.9×10^{-5}
W	900	7.5×10^{-5}	2,200	3.2×10^{-5}
WNW	1,000	5.4×10^{-5}	2,100	2.5×10^{-5}
NW	1,900	2.8×10^{-5}	2,400	2.1×10^{-5}
NNW	1,900	3.8×10^{-5}	2,200	3.1×10^{-5}

^a Source terms: uranium-234 = 4.2×10^{-7} Ci
 uranium-238 = 4.2×10^{-7} Ci
 plutonium-238 = 9.1×10^{-9} Ci
 plutonium-239 = 2.7×10^{-6} Ci
 plutonium-240 = 9.2×10^{-9} Ci
 plutonium-241 = 4.7×10^{-7} Ci
 plutonium-242 = 7.6×10^{-11} Ci
 plutonium-244 = 3.9×10^{-15} Ci.

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TABLE 4.20

Maximum Perimeter and Individual Doses
from Building 350 Air Emissions, 2000
(dose in mrem/yr)

Pathway	Perimeter (600 m SW)	Individual (2,700 m SW)
Ingestion	2.8×10^{-6}	5.7×10^{-7}
Inhalation	2.6×10^{-4}	5.1×10^{-5}
Air immersion	5.0×10^{-14}	1.0×10^{-14}
Ground surface	9.7×10^{-9}	2.0×10^{-9}
Total	2.6×10^{-4}	5.2×10^{-5}
Radionuclide		
Uranium-234	1.4×10^{-5}	2.8×10^{-6}
Uranium-238	1.2×10^{-5}	2.5×10^{-6}
Plutonium-238	7.3×10^{-7}	1.4×10^{-7}
Plutonium-239	2.3×10^{-4}	4.6×10^{-5}
Plutonium-240	8.0×10^{-7}	1.6×10^{-7}
Plutonium-241	2.1×10^{-7}	1.2×10^{-7}
Plutonium-242	6.2×10^{-9}	1.2×10^{-9}
Plutonium-244	3.2×10^{-13}	6.3×10^{-14}
Total	2.6×10^{-4}	5.2×10^{-5}

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TABLE 4.21

Radiological Airborne Releases from Building 375 (IPNS), 2000

Direction	Distance to Perimeter (m)	Dose ^a (mrem/yr)	Distance to Nearest Resident (m)	Dose ^a (mrem/yr)
N	1,600	8.5×10^{-2}	3,200	2.4×10^{-2}
NNE	1,700	8.9×10^{-2}	3,100	2.7×10^{-2}
NE	1,700	7.9×10^{-2}	2,700	3.1×10^{-2}
ENE	1,500	8.3×10^{-2}	2,500	3.2×10^{-2}
E	600	4.8×10^{-1}	2,500	4.6×10^{-2}
ESE	600	3.8×10^{-1}	2,500	3.2×10^{-2}
SE	600	2.7×10^{-1}	2,500	2.3×10^{-2}
SSE	600	3.8×10^{-1}	3,000	2.2×10^{-2}
S	800	1.1×10^{-1}	3,000	1.1×10^{-2}
SSW	800	3.2×10^{-1}	3,500	2.2×10^{-2}
SW	800	4.1×10^{-1}	4,000	2.2×10^{-2}
WSW	1,500	8.3×10^{-2}	2,700	2.9×10^{-2}
W	2,200	4.7×10^{-2}	2,700	3.0×10^{-2}
WNW	1,500	6.0×10^{-2}	2,600	2.3×10^{-2}
NW	2,200	2.7×10^{-2}	2,500	2.1×10^{-2}
NNW	1,800	4.7×10^{-2}	2,200	3.2×10^{-2}

^a Source terms: carbon-11 = 1610.5 Ci
argon-41 = 115.7 Ci.

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TABLE 4.22

Maximum Perimeter and Individual Doses from
Building 375 (IPNS) Air Emissions, 2000
(dose in mrem/yr)

Pathway	Perimeter (600 m E)	Individual (2,400 m E)
Ingestion	- ^a	-
Inhalation	2.0×10^{-2}	1.8×10^{-3}
Air immersion	4.5×10^{-1}	4.3×10^{-2}
Ground surface	1.6×10^{-2}	1.8×10^{-3}
Total	4.8×10^{-1}	4.6×10^{-2}
Radionuclide		
Carbon-11	4.4×10^{-1}	4.2×10^{-2}
Argon-41	4.0×10^{-2}	4.6×10^{-3}
Total	4.8×10^{-1}	4.6×10^{-2}

^a A hyphen indicates no exposure by this pathway.

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TABLE 4.23

Radiological Airborne Releases from Building 411/415 (APS), 2000

Direction	Distance to Perimeter (m)	Dose ^a (mrem/yr)	Distance to Nearest Resident (m)	Dose ^a (mrem/yr)
N	1,500	1.7×10^{-4}	2,000	9.1×10^{-5}
NNE	1,600	1.6×10^{-4}	2,100	9.0×10^{-5}
NE	2,200	7.1×10^{-5}	3,100	3.3×10^{-5}
ENE	2,500	4.9×10^{-5}	3,300	2.6×10^{-5}
E	1,600	1.7×10^{-4}	3,400	3.4×10^{-5}
ESE	1,500	1.4×10^{-4}	3,500	2.4×10^{-5}
SE	400	1.3×10^{-3}	3,000	2.2×10^{-5}
SSE	400	1.8×10^{-3}	3,000	3.0×10^{-5}
S	350	9.5×10^{-4}	2,500	2.4×10^{-5}
SSW	400	2.3×10^{-3}	2,800	4.5×10^{-5}
SW	550	1.7×10^{-3}	3,000	4.6×10^{-5}
WSW	800	5.1×10^{-4}	1,400	1.7×10^{-4}
W	800	5.0×10^{-4}	1,500	1.5×10^{-4}
WNW	500	7.8×10^{-4}	1,400	1.2×10^{-4}
NW	350	1.2×10^{-3}	1,600	8.1×10^{-5}
NNW	1,500	1.1×10^{-4}	2,000	6.0×10^{-5}

^a Source terms: carbon-11 = 0.06 Ci (estimated)
nitrogen-13 = 3.47 Ci (estimated)
oxygen-15 = 0.38 Ci (estimated).

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TABLE 4.24

Maximum Perimeter and Individual Doses
from Building 411/415 (APS) Air Emissions, 2000
(dose in mrem/yr)

Pathway	Perimeter (400 m SSW)	Individual (1,400 m WSW)
Ingestion	- ^a	-
Inhalation	6.5×10^{-5}	5.0×10^{-6}
Air immersion	2.2×10^{-3}	1.6×10^{-4}
Ground surface	3.8×10^{-5}	3.4×10^{-6}
Total	2.3×10^{-3}	1.7×10^{-4}
Radionuclide		
Carbon-11	4.0×10^{-5}	3.5×10^{-6}
Nitrogen-13	2.1×10^{-3}	1.6×10^{-4}
Oxygen-15	1.4×10^{-4}	5.2×10^{-6}
Total	2.3×10^{-3}	1.7×10^{-4}

^a A hyphen indicates no exposure by this pathway.

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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 2000 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 gaseous 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.

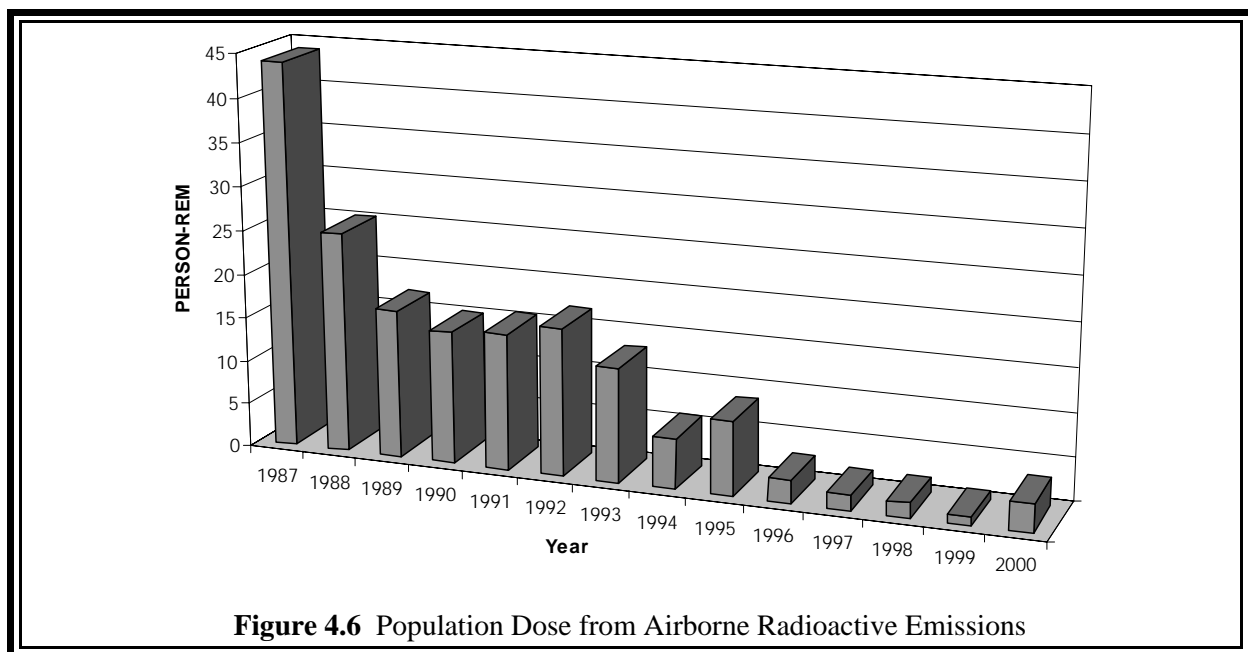
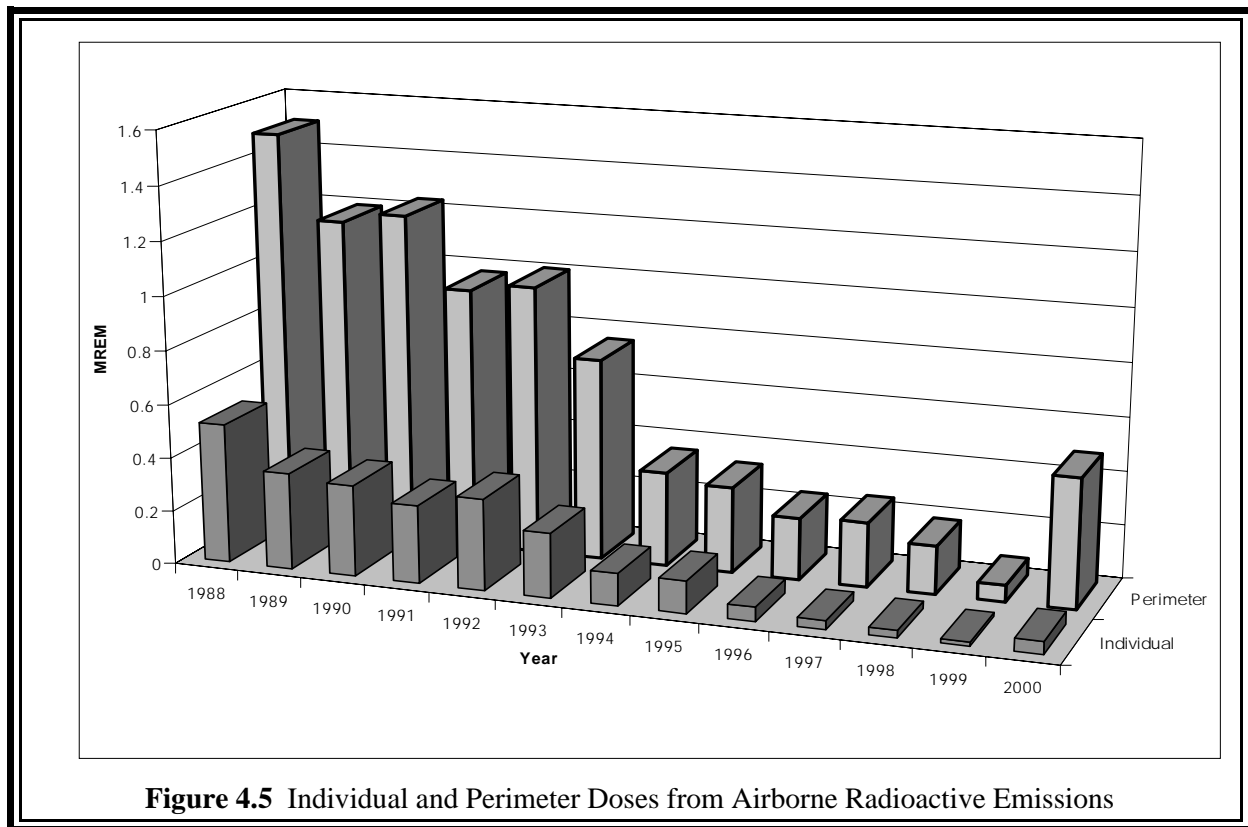
The potential radiation exposures by the inhalation pathways also were calculated by the methodology specified in DOE Order 5400.5.⁹ The total quantity for each radionuclide inhaled, in microcuries (μCi), is calculated by multiplying the annual average air concentrations by the general public breathing 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 Because the CEDE conversion factors are in units of $\text{rem}/\mu\text{Ci}$, this calculation gives the 50-year CEDE. Table 4.26 lists the applicable CEDE factors.

The calculated doses in Tables 4.2 and 4.3 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 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.

TABLE 4.25

Population Dose within 80 km, 2000	
Radionuclide	Person-rem
Hydrogen-3	0.04
Carbon-11	1.89
Nitrogen-13	<0.01
Oxygen-15	<0.01
Argon-41	0.64
Krypton-85	<0.01
Thallium-208	<0.01
Lead-212	0.52
Bismuth-212	<0.01
Radon-220	<0.01
Uranium-234	<0.01
Uranium-238	<0.01
Plutonium-238	<0.01
Plutonium-239	0.01
Plutonium-240	<0.01
Plutonium-241	<0.01
Plutonium-242	<0.01
Plutonium-244	<0.01
Total	3.15
Natural	2.5×10^6

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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 0.08 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 ($\mu\text{Ci/mL}$) 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

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.

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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.

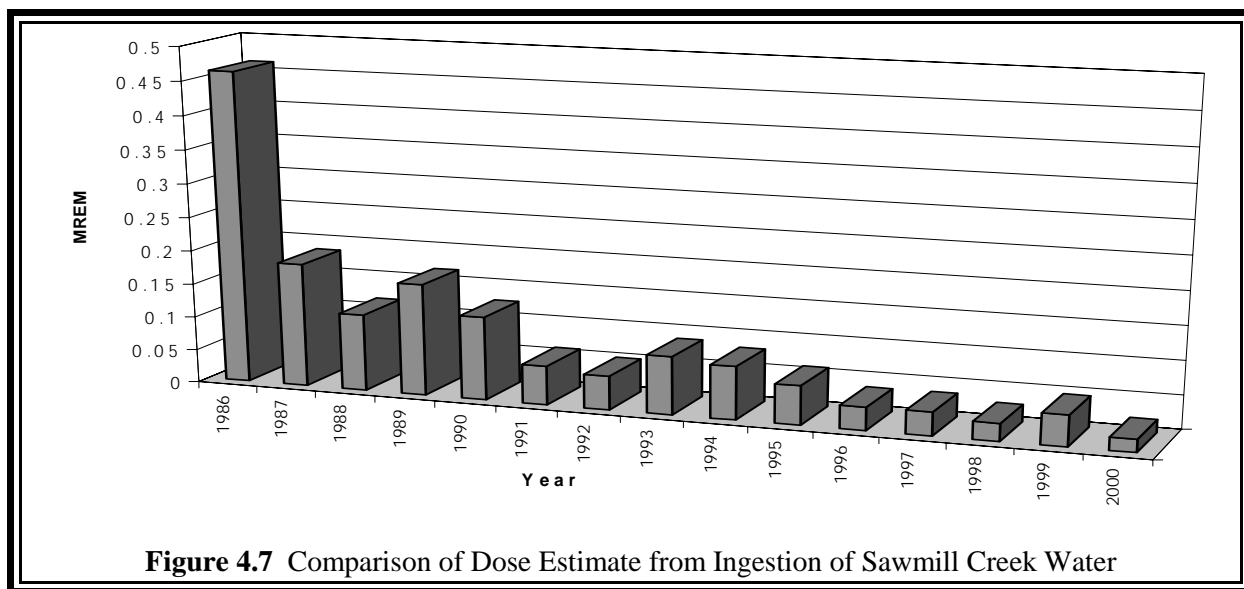
DOE Order 5400.5⁹ requires an evaluation of the dose to aquatic organisms from liquid effluents. The dose limit is 1 rad/day or 365 rad/yr. The location that could result in the highest dose to aquatic organisms is in Sawmill Creek downstream of the point where ANL-E discharges its treated wastewater. 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). 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,

TABLE 4.27

Radionuclide Concentrations and Dose Estimates
for Sawmill Creek Water, 2000

Radionuclide	Total Released (Ci)	Net Avg. Concentration (pCi/L)	Dose (mrem)
Hydrogen-3	0.116	23	0.0011
Strontium-90	0.0007	0.18	0.0171
Plutonium-239	<0.0001	<0.0001	<0.0003
Americium-241	<0.0001	<0.0001	<0.0003
Total	0.12		0.0188

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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 0.004 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 m³/s (10 ft³/s); the flow rate of the Des Plaines River in the vicinity of ANL-E is about 25 m³/s (900 ft³/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 114 ± 21 mrem/yr. Approximately 300 m (960 ft) south of the fence line (grid 6I), the measured dose was 104 ± 8 rem/yr, slightly higher than the off-site average (99 ± 5 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

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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 2000 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 0.047 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 3.15 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 0.076 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.

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TABLE 4.28

Summary of the Estimated Dose to a Hypothetical Individual, 2000 (mrem/yr)

Pathway	ANL-E Estimate	Applicable Standard
Air total	0.047	None
Water	0.019	4 (EPA) ^a
Direct radiation	0.010	None
Maximum dose	0.076	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.

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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

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The nonradiological monitoring program involves the collection and analysis of surface water and groundwater samples from numerous locations throughout the site. 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. No exceedances were noted during 2000 over a period of 2,064 hours of coal-burning operation of Boiler No. 5, the coal-burning boiler. Chapter 3 provides a detailed discussion of the environmental monitoring program.

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, it appears that some limited quantities of VOCs are, in fact, finding their way to the laboratory drain through laboratory sinks located throughout the site. 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.

The 2000 results for laboratory influent wastewater are quite similar to those from 1997 to 1999. Table 5.1 gives the 2000 results for the most common compounds detected. Bromoform, bromodichloromethane, chloroform, and dibromochloromethane are halomethanes that are produced

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TABLE 5.1

Laboratory Influent Wastewater, 2000
(concentrations in $\mu\text{g/L}$)

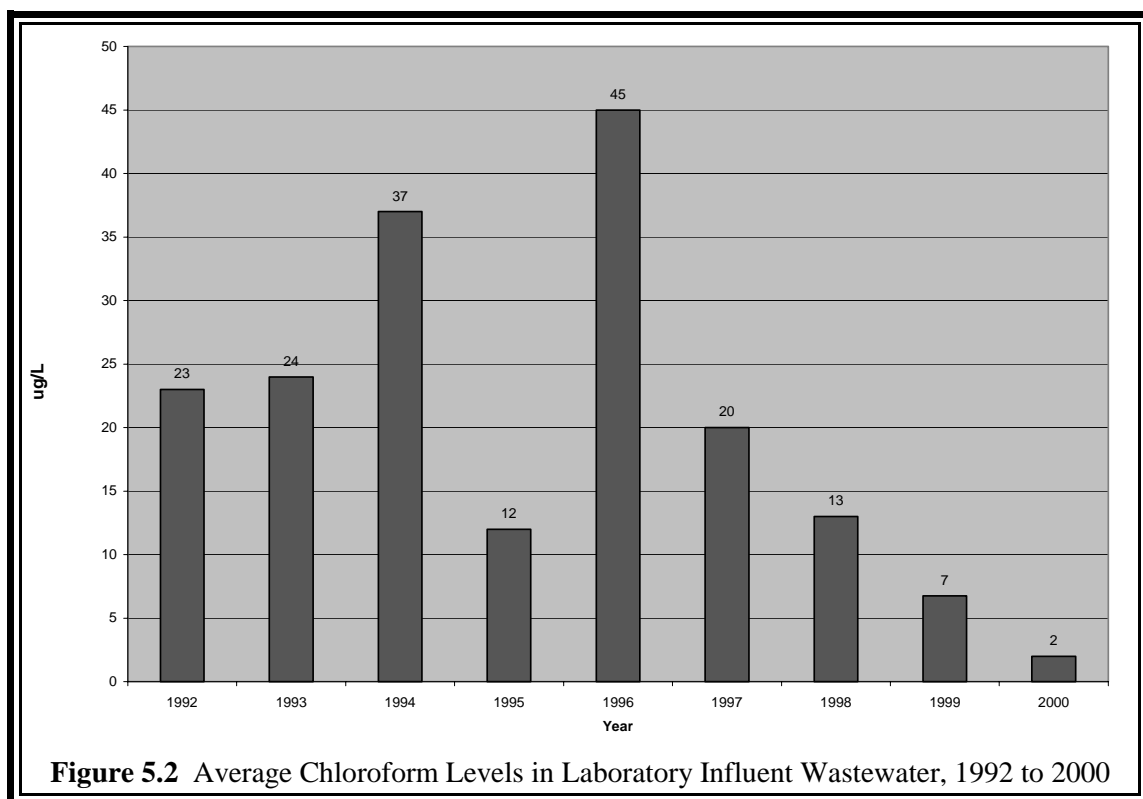
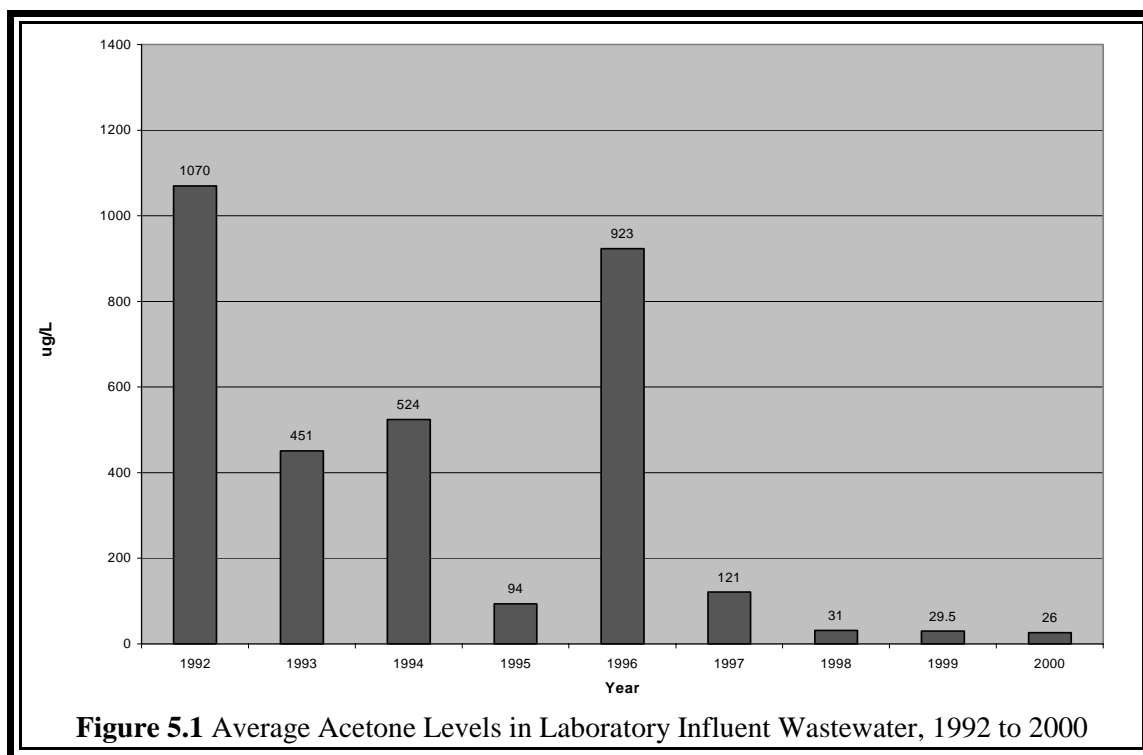
Month	Acetone	Chloroform	Bromodi- chloroethane	Dibromo- chloromethane	Bromoform
January	9	2	2	1	<1
February	9	1	2	1	<1
March	96	4	3	2	<1
April	25	1	1	3	9
May	8	6	1	2	2
June	98	1	1	2	2
July	5	2	7	2	1
August	12	1	1	2	3
September	9	2	2	2	2
October	7	1	1	2	3
November	<1	3	1	2	3
December	8	1	2	1	<1

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, acetone was detected in 11 samples and levels ranged up to 98 $\mu\text{g/L}$, which is lower than the 1999 maximum value of 168 $\mu\text{g/L}$, and the yearly average was lower than the 1999 average (Figure 5.1). Infrequent trace levels of other chemicals, that is, 2-butanone, tetrahydrofuran, 1,1-dichloroethane, 1,1,1-trichloroethane, acetaldehyde, ethanol, and propanol were also noted. 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 2000 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, often results in the discharge of small amounts into the sewer. The sharp decrease in influent concentrations of acetone and chloroform in the last five years shows the effectiveness of educational efforts related to waste disposal and pollution prevention.

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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.

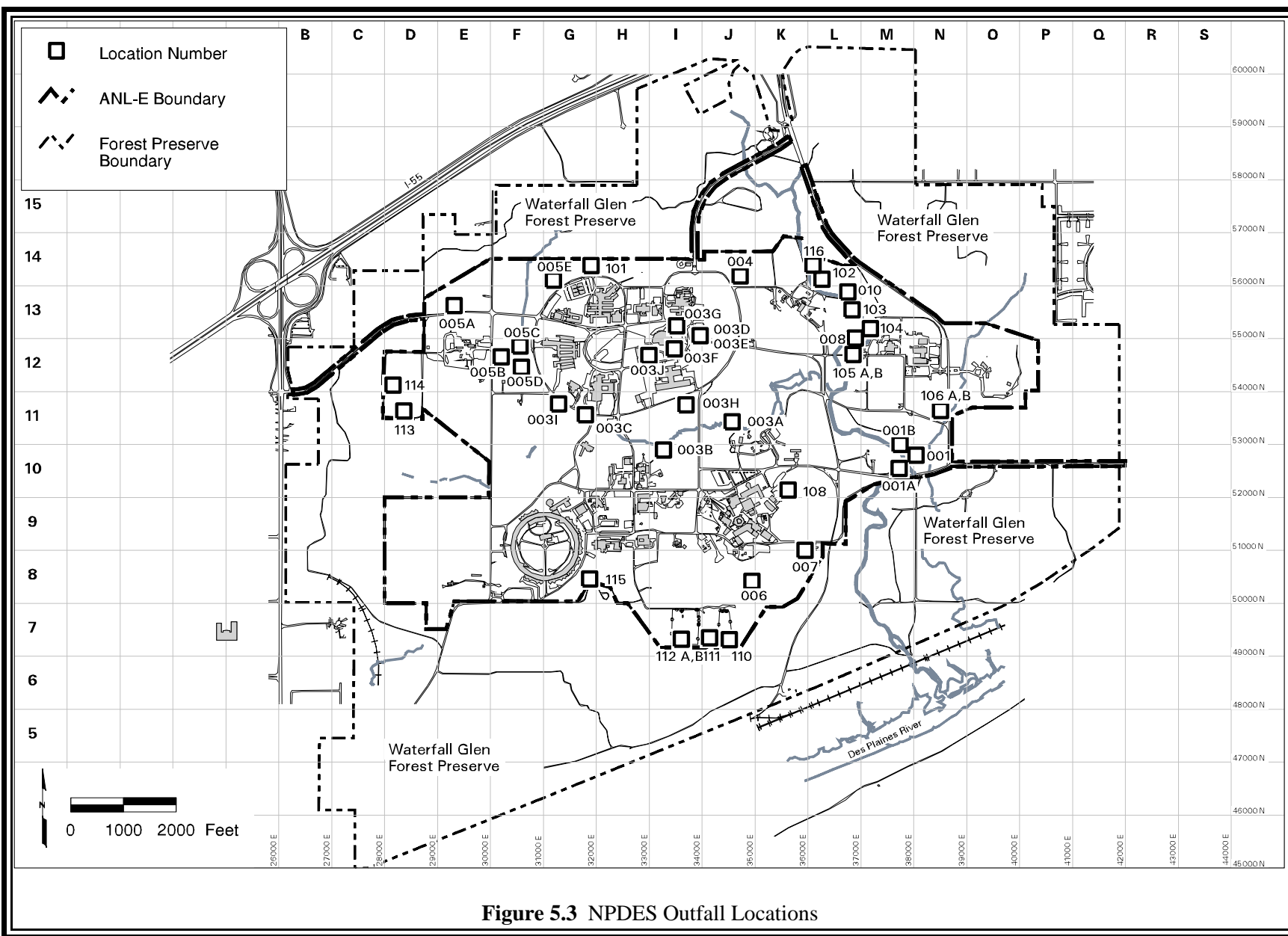
Effluent samples are collected from ANL-E point-source discharges (outfalls) as specified by the NPDES permit. The permit specifies the frequency of sample collection and the specific parameters to be monitored for each individual outfall. Sample collection, preservation, holding times, and analytical 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 on a weekly basis, consistent with permit requirements. Similarly, samples are collected at the other locations in accordance with the NPDES permit.



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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 (BOD₅) 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 2000, approximately 99% of all NPDES analyses were in compliance with their applicable permit limits, as compared with 1991 through 1999, when rates ranged from 96 to 99%.

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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. Outfalls

Outfalls 001, 001A, and 001B are located at the ANL-E wastewater treatment facility.

Outfall 001A. This outfall consists of treated sanitary wastewater and various wastewater streams from the boiler house area, including coal pile storm water runoff. The effectiveness of the sanitary wastewater treatment systems is evaluated by weekly monitoring for BOD₅, pH, and TSS. The limits for BOD₅ 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 2000 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 coal pile runoff that may discharge to the sanitary sewage system. No limits were exceeded during 2000.

TABLE 5.2

Outfall 001A Effluent Limits and Monitoring Results, 2000
(concentrations in mg/L)

Constituent	Minimum	Average	Average Limit	Maximum	Maximum Limit
Chromium	- ^a	<0.015	1.0	<0.015	2.0
Copper	0.011	0.030	0.50	0.105	1.0
Iron	<0.04	0.132	2.0	0.303	4.0
Lead	-	<0.10	0.20	<0.10	0.40
Manganese	<0.015	0.020	1.0	0.049	2.0
Zinc	0.053	0.136	1.0	0.274	2.0
Oil and grease	-	<5.0	15.0	<5.0	30.0

^a A hyphen indicates no minimum values.

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Outfall 001B. This outfall consists of processed wastewater from the laboratory wastewater system. The permit requires that weekly samples be collected and analyzed for BOD₅, TSS, mercury, pH, and COD.

The limits established for BOD₅ are a daily maximum of 20 mg/L and a 30-day average of 10 mg/L. The permit also contains BOD₅ 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 BOD₅ mass loading and concentration limits were noted in 2000.

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 2000.

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 2000 ranged from less than 10 to 19 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 12, 2000, and December 5, 2000, 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. 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.

TABLE 5.3

Outfall 001B Effluent Priority Pollutant Monitoring
Results, 2000
(concentrations in µg/L)

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

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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.

Two exceedances were noted during February 2000; one was of the TDS limit and the other was of the chloride limit. Elevated TDS levels occurred only during the 2000 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 2000. 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).

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; average TDS levels at Outfall 001 have substantially decreased since the introduction of Lake Michigan water.

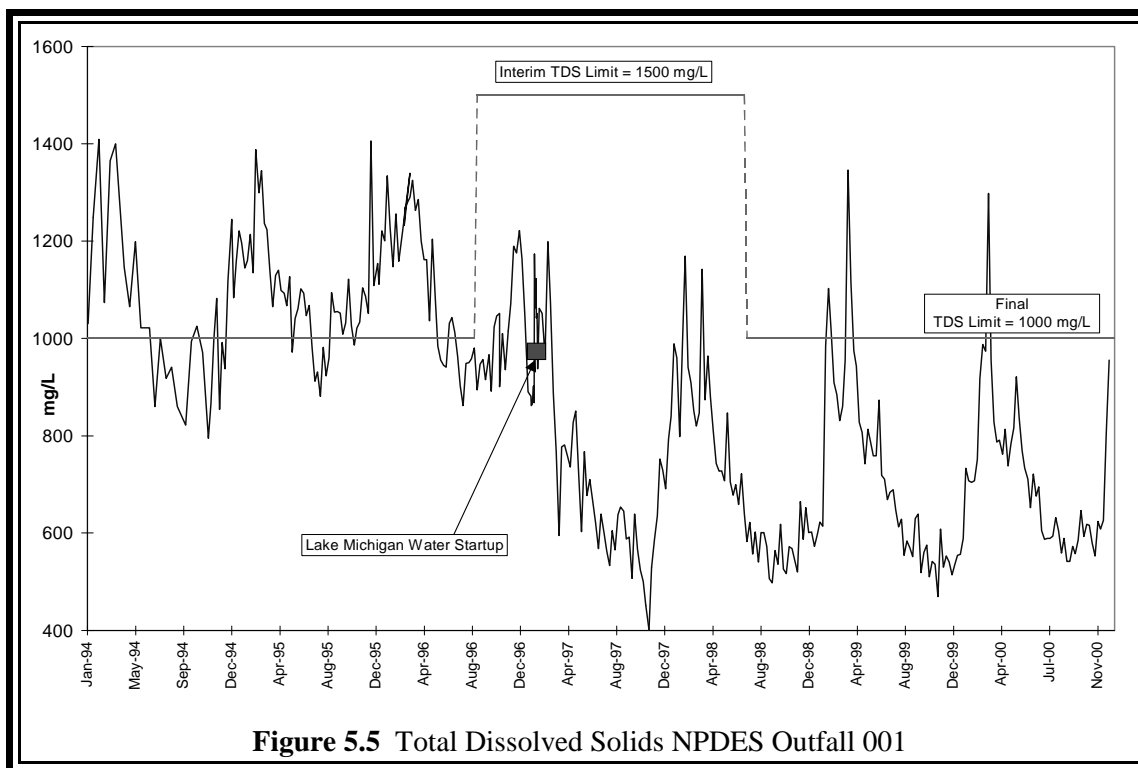
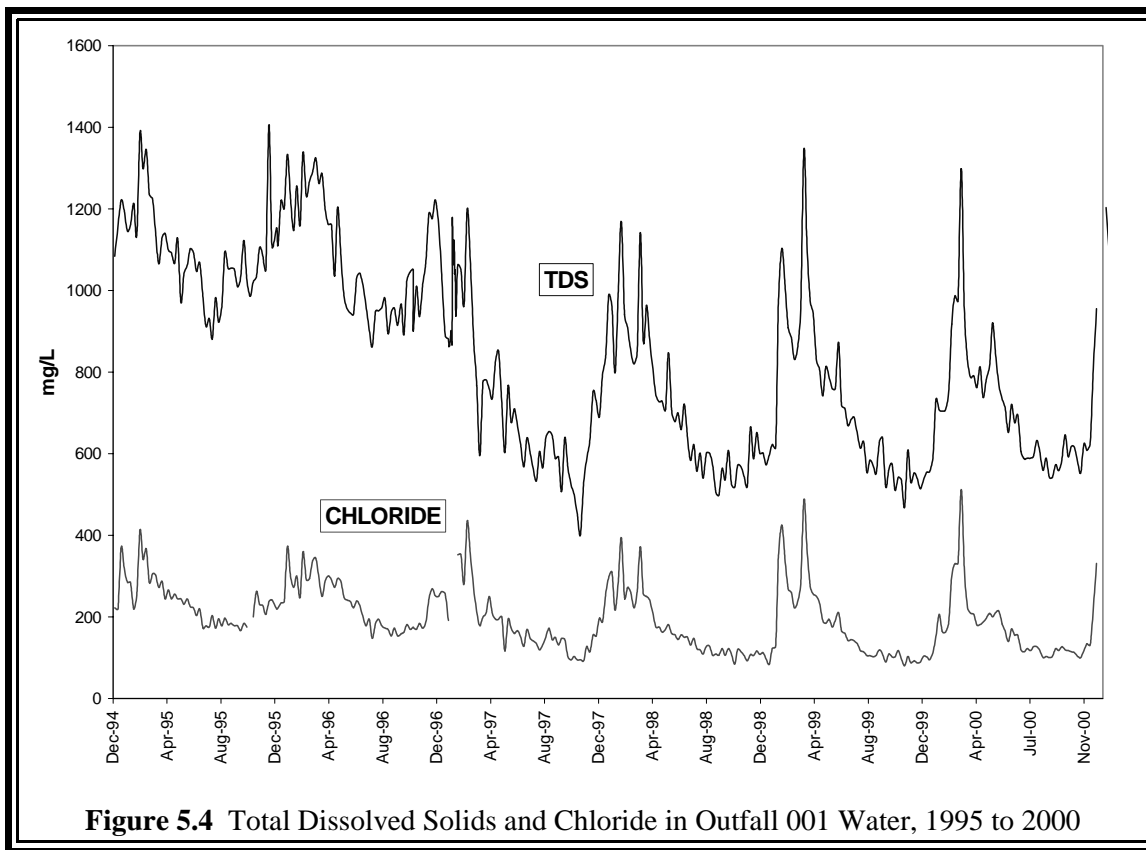
Copper levels have decreased since 1997. The changeover in the domestic water supply from groundwater to Lake Michigan water during 1997 appears to have played a role in reducing the amount of copper in the wastewater. Lake Michigan water causes less corrosion of domestic water distribution copper piping than the previously used groundwater source. The addition of this water source, combined with the proper balance of chemical treatment additives, has reduced copper

TABLE 5.4

Outfall 001 Monitoring Results and Effluent Limits, 2000
(concentrations in mg/L)

Constituent	Minimum	Average	Maximum	Limit	Exceedances
Chloride	100	174	512	500	1
Copper	<0.010	0.021	0.062	0.051	1
TDS	542	731	1,298	1,000	1
Ammonia nitrogen	0.2	0.8	1.5	10.0 (November–March) 3.0 (April–October)	0

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concentrations in the discharge to below permit limits. Figure 5.6 shows the 1996 through 2000 monthly average copper levels at Outfall 001. One copper exceedance occurred during April 2000, the cause of which is unknown.

The upgrade of the sanitary WTP, completed in 1996, has enhanced the treatment of ammonia nitrogen. Figure 5.7 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 2000.

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 2000 testing was conducted on samples collected June 12 through 16; the water flea (*Ceriodaphnia dubia*) and fathead minnow (*Pimephales promelas*) were used.

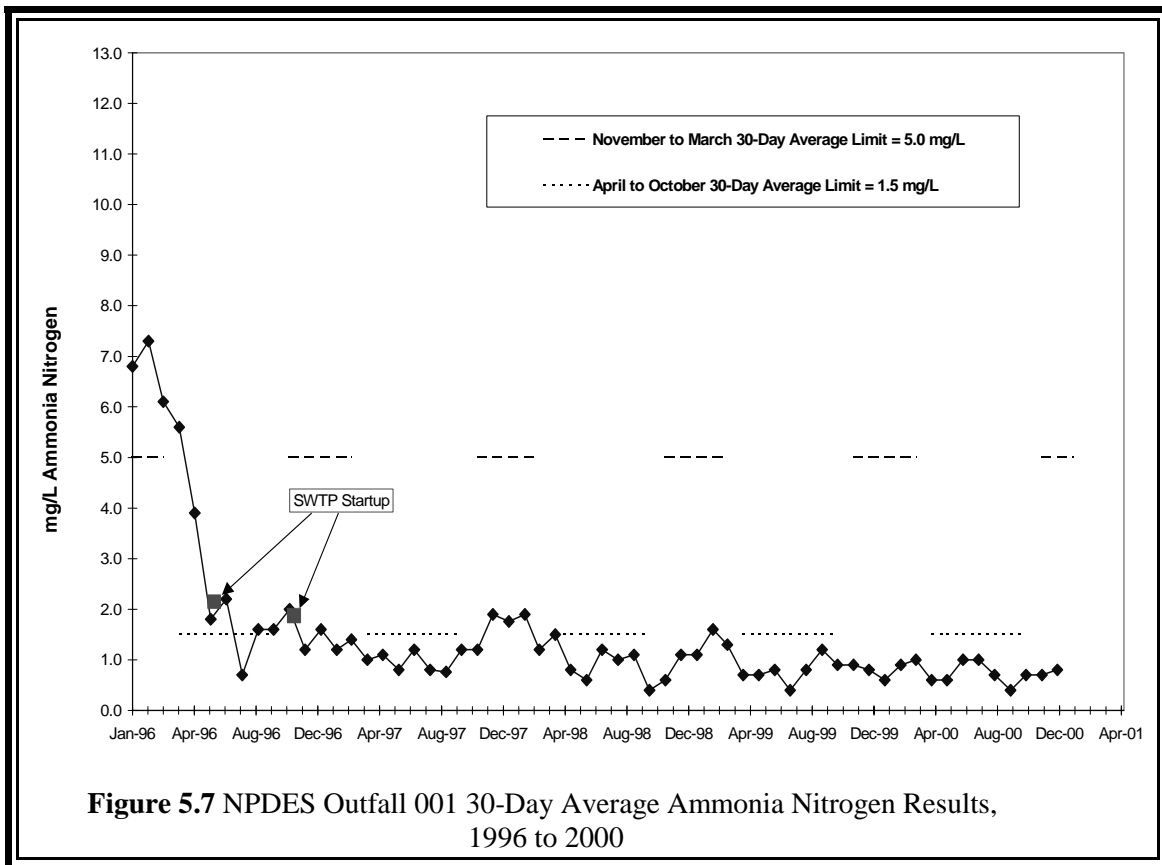
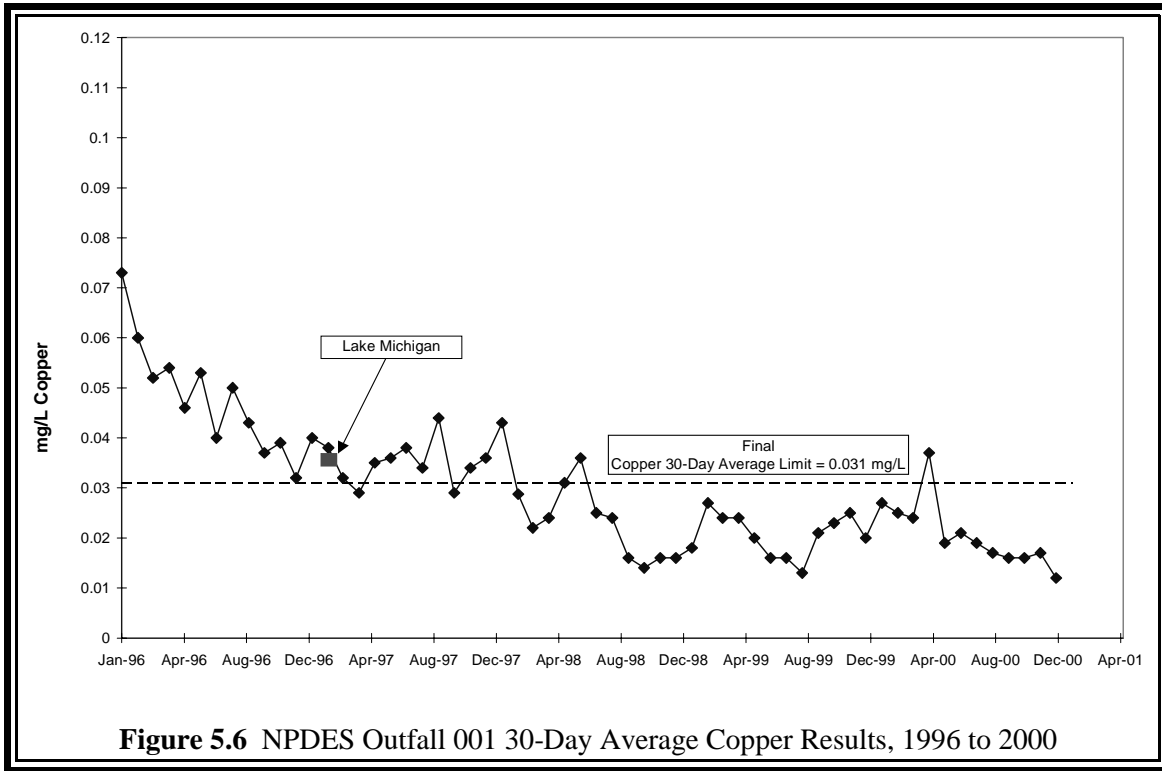
No toxicity was observed to the fathead minnow or to the water flea. The concentration of wastewater that produces 50% mortality in the test population (i.e., the LC_{50}) for both species is greater than 100%; that is, the pure, undiluted effluent is not toxic to these species. Table 5.5 summarizes the results of the toxicity tests for 2000. Table 5.6 summarizes the test results from 1991 to 2000.

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 2000. In addition to the outfalls at the WTP, a number of other outfalls are monitored.

Outfall 003A. This potential discharge is located approximately 25 m (75 ft) north of the swimming pool and is a vitrified clay pipe that was originally used as the discharge point for all the swimming pool activities (filter backwash, draining, and overflow). Table 5.7 presents the sampling requirements and effluent limits.

By July 1995, discharge of chlorinated water from Outfall 003A had been completely eliminated by installation of a sump collection system that captures all the flow and discharges into the sanitary drain system.

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TABLE 5.5

Outfall 001 Aquatic Toxicity Test Results, 2000

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 2000

Test	1991 (%)	1992 (%)	1993 (%)	1994 (%)	1995 (%)	1996 (%)	1997 (%)	1998 (%)	1999 (%)	2000 (%)
Minnow, acute, LC ₅₀	61.6	<6.2	100.0	100.0	>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
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.

Outfall 003B. This outfall is located approximately 150 m (500 ft) northeast of Building 308 and is composed of storm water runoff and condensate from the buildings in the watershed of the outfall. The discharge point is a 1-m (3-ft) concrete pipe to a tributary brook flowing north to the Freund Brook. Table 5.7 gives the sampling requirements and effluent limits. No exceedances occurred during 2000.

Outfall 003C. The discharge from this outfall is made up of footing tile drainage and storm water runoff. The discharge point is a 0.65-m (2-ft) concrete pipe discharging into Freund Brook approximately 50 m (150 ft) upstream of the gas station, south of Building 205. The sampling requirements and effluent limits are given in Table 5.7. No exceedance of the NPDES Permit limits

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TABLE 5.7

Summary of Monitored NPDES Outfalls, 2000

Discharge Location	No. of Samples	Permit Constituent	Limit		No. Exceeding Limit
			30-Day Average	Daily Maximum	
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	9	Flow	None		0
		pH	6 – 9		0
		Temperature	<2.8°C rise		0
003F	10	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

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TABLE 5.7 (Cont.)

Discharge Location	No. of Samples	Permit Constituent	Limit		No. Exceeding Limit
			30-Day Average	Daily Maximum	
003I ^c	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	1
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	3
		TDS	Monitor only		NA
		Temperature	<2.8°C rise		0
007	5	Flow	None		0
	5	pH	6 – 9		0
	5	Temperature	<2.8°C rise		0
	27	TRC	0.05		0
	5	Oil and grease	Monitor only		NA
008	11	Flow	None		0
		pH	6 – 9		0
		VOC	Monitor only		NA

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TABLE 5.7 (Cont.)

Discharge Location	No. of Samples	Permit Constituent	Limit		No. Exceeding Limit
			30-Day Average	Daily Maximum	
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	5	Flow	None		0
		Hydrogen-3	Monitor only		NA
		PCB 1260	Monitor only		NA
		Lead, copper, nickel, zinc	Monitor only		NA
114	5	Flow	None		0
		Hydrogen-3	Monitor only		NA
		PCB 1260	Monitor only		NA
		Lead, copper, nickel, zinc	Monitor only		NA

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

TABLE 5.7 (Cont.)

Discharge Location	No. of Samples	Permit Constituent	Limit		No. Exceeding Limit
			30-Day Average	Daily Maximum	
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.

^c An unpermitted discharge occurred at Outfall 003I due to a break in a chiller water line.

occurred during 2000. One unpermitted discharge of about 114 L (30 gal) of 50% ethylene glycol occurred in December because of a break in a chiller water line. Verbal notification was given to the IEPA; no further action was required.

Outfalls 003D and 003E. These two discharge points are from the steam trench around Inner Circle Drive and discharge into the north fork of Freund Brook approximately 150 m (500 ft) east of the intersection of Inner Circle Drive and Eastwood Extension. Table 5.7 gives the sampling requirements and effluent limits. No exceedances occurred during 2000.

Outfall 003F. This outfall is intended to discharge excess water from the fire pond during storm events. Building 201 discharges cooling tower water to the fire pond; the rate is generally insufficient to result in a discharge at this outfall. When the rate is sufficient, the discharge is through a cement raceway to the south fork of the north branch of Freund Brook. Table 5.7 gives the sampling requirements and effluent limits. No exceedances occurred during 2000.

Outfall 003G. Footing tile drainage from the Inner Circle steam trench is pumped to the storm sewer passing around the northeastern portion of Building 201 and discharges into the northern fork of the southern branch of Freund Brook. Condensate leaks in the steam trench produce discharge on a regular basis to the storm sewer. Table 5.7 gives the sampling requirements and effluent limits. No exceedances occurred during 2000.

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

Outfall 003H. This discharge originates from the footing tile drainage around Building 212 and storm water collected from around Buildings 212 and 214 and their associated parking lots. The cooling tower located on the south roof of Building 212 discharges into the tile drainage system and is the source of the industrial discharge. Table 5.7 gives the sampling requirements and effluent limits. No exceedances of the NPDES permit limits occurred during 2000. One unpermitted discharge of seal coating material occurred in August 2000.

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 and the water flea. The testing is performed on a biannual basis during the months of July and August. These outfalls were sampled during the periods of July 10 to 14 and August 21 to 25, 2000. Unlike 1999, the 2000 test results for Outfall 003H showed no toxicity. The results are summarized in Tables 5.8 and 5.9.

Outfall 003I. This outfall collects storm water from Buildings 200 and 211 and the western portion of Building 205 areas and also accumulates cooling tower discharge from the cooling tower located behind Building 200. Table 5.7 gives the sampling requirements and effluent limits. One unpermitted discharge occurred in July due to a break in a chiller water line. Results of acute toxicity tests for Outfall 003I are presented in Tables 5.8 and 5.9. Outfall 003I was not acutely toxic to the fathead minnow or water flea.

Outfall 003J. This outfall collects storm water from the Building 213 area and parking lot. The storm water passes through a storm sewer around Building 201. Cooling tower blowdown is the industrial discharge to this system. The sampling requirements and effluent limits are given in Table 5.7. No exceedances were noted during 2000. Results of acute toxicity tests for Outfall 003J are presented in Tables 5.8 and 5.9. The August results indicate that Outfall 003J was acutely toxic to the fathead minnow and the water flea. High residual chlorine values (0.77 to 1.57 mg/L) associated with chlorinated cooling water were noted in the daily composite samples taken at this location.

Outfall 004. This outfall discharges storm water from the Buildings 202, 203, and 221 areas and cooling water from Building 221. The discharge is to a drainage ditch and sewer system that pass around the northeastern portion of Outer Circle Drive and to a ditch leading north to the fence line, east of the Visitor's Center. Table 5.7 gives the sampling requirements and effluent limits. One exceedance was noted during 2000. This was probably due to excessive runoff from snow melt. Results of acute toxicity tests for Outfall 004 are presented in Tables 5.8 and 5.9. Outfall 004 was not acutely toxic to the fathead minnow or water flea.

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

TABLE 5.8

Acute Toxicity Results: Fathead Minnow, 2000

NPDES Outfall	96-Hour LC ₅₀ July 10 – 14, 2000 (%)	96-Hour LC ₅₀ August 21 – 25, 2000 (%)	Comments
003H	>100	>100	Not acutely toxic
003I	>100	>100	Not acutely toxic
003J	>100	40.4	Acutely toxic (August)
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, 2000

NPDES Outfall	48-Hour LC ₅₀ July 10 – 14, 2000 (%)	48-Hour LC ₅₀ August 21 – 25, 2000 (%)	Comments
003H	>100	>100	Not acutely toxic
003I	>100	>100	Not acutely toxic
003J	>100	<20	Acutely toxic (August)
004	>100	>100	Not acutely toxic
006	>100	30.1	Acutely toxic (August)
115	29.1	<20	Acutely toxic

Outfall 005A. This is a storm water only outfall. This outfall discharges runoff from the northwestern portion of the 800 Area. The flow passes under Westgate Road, east of the West Gate, and flows toward the northwestern fence line. No effluent standards apply and no monitoring is performed at this outfall.

Outfall 005B. This is a storm water only outfall. The outfall for this watershed discharges runoff collected from the major portion of the 800 Area. The flow is collected from the parking lots and roadways and flows by storm sewers to the east, where it is discharged to the marsh located on the eastern side of Kearney Road. No effluent standards apply and no monitoring is performed at this outfall.

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Outfall 005C. This outfall collects storm water from the northern side and the loading dock area of Building 200. The Building 200 once-through cooling water systems discharge to this outfall, which passes through sewers to the west of the loading dock and to the wetland area west of Building 200. The sampling requirements and effluent limits are given in Table 5.7. No exceedances occurred during 2000.

Outfall 005D. This is a storm water only discharge. The Building 200 M-Wing loading dock area storm water runoff is collected in a storm sewer and passes west to a beaver pond located west of Building 200. The discharge is through a 1-m (3-ft) corrugated pipe into the pond. No effluent standards apply and no monitoring is performed at this outfall.

Outfall 005E. This outfall discharges footing tile drainage from the west sides of Buildings 203 and 208. It also discharges storm water collected from the same area. The industrial discharge arises from cup drains and compressors discharging into the footing tile sumps. The sampling requirements and effluent limits are given in Table 5.7. No exceedances occurred during 2000.

Outfall 006. Cooling towers at Building 350 and the 377 Area discharge into the drainage ditch that flows south of the Canal Water Treatment Plant, bends south, and flows to the south fence line. The permit requires monthly sampling for pH, TSS, and temperature. The limits are given in Table 5.7. Three exceedances of the TSS limit occurred in 2000. The exceedances were due to suspended solids associated with snow melt runoff (February), storm water runoff from an upstream construction project (March), and cooling tower drainage with high concentrations of suspended solids (October). The 377 Area cooling tower discharge will be rerouted to the laboratory sewer system during 2001. Results of acute toxicity tests for Outfall 006 are presented in Tables 5.8 and 5.9. Outfall 006 was acutely toxic to the water flea during the August test. As in 1998 and 1999, it was not acutely toxic to the fathead minnow.

Outfall 007. The watershed for Outfall 007 includes the southeastern section of the 300 Area and extends from Building 370 east to Building 366 and north to Building 367. Water is collected in catchment basins and conveyed toward the southeast to a point approximately 30 m (100 ft) southeast of Building 366, where it is discharged into a ditch on the south side of Old Bluff Road. This ditch runs along the roadside for 15 m (50 ft), at which point it turns south and runs to the fence line where it is discharged to the forest preserve. The once-through cooling water of compressors is the industrial component of this outfall. Table 5.7 gives the sampling requirements and effluent limits. No exceedances occurred during 2000.

Outfall 008. The watershed for this outfall includes the area around the new Vehicle Maintenance and Grounds Building 46. Runoff is collected in storm water grates and catchments and conveyed through sewers to the discharge point in Sawmill Creek, which is located directly west of Building 24. Industrial activity in this small watershed involves operations associated with the

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

maintenance of all facility vehicles; grounds, maintenance, and storage of the equipment associated with these activities; and fueling for the vehicles. Five VOCs are monitored once a month. Low levels (less than 1 to 57 µg/L) of tetrachloroethylene are consistently noted at this outfall. A characterization study was performed in this area, and a recommendation of NFA was submitted to the IEPA during October 2000. The only NPDES limit that applies at this point is pH. No exceedances were noted during 2000.

Outfall 010. This outfall is for the coal pile storage area runoff collection system overflow line. The collection system consists of a trench on the north and west sides of the coal pile; a sump is located at the extreme southern end of the western trench line. The overflow line comes into use only when the runoff reaches the level at which the trench system would overflow; the line was put into place to ensure against flooded conditions in the coal yard. During normal operations, the water is pumped to the equalization basin located in the western part of the 100 Area. The industrial activity associated with this outfall is solely the coal pile operation. The berm and trench system in place to collect runoff has been improved to eliminate discharge from the outfall.

This outfall is sampled once per day when flow occurs. Analyses are performed for pH, TSS, TDS, iron, lead, zinc, manganese, trivalent and hexavalent chromium, copper, and oil and grease. No flow occurred at this site during 2000.

Outfall 101. This is a storm water only discharge. The drainage to this outfall is through ditches along the streets and storm sewer from the parking lot north of Building 203 to a marsh located between Outer Circle Drive and the ANL-E fence line; the storm sewer consist of a 0.65-m (2-ft) corrugated metal pipe with a Palmer-Bowlus flume. The drainage then discharges on the other side of the fence line into the forest preserve. The sources of storm water runoff to the outfall are the Building 203 parking lot and loading dock and the excess equipment storage area on the north side of Outer Circle Drive. No effluent standards apply and no monitoring is performed at this outfall.

Outfall 102. This is a storm water only discharge. This watershed includes portions of the 100 Area. Large amounts of paved areas are associated with the industrial activities for the production of steam such as those areas associated with the water treatment plant, the lime sludge pond, and the tarmac around the boiler house. The contributing runoff flows are collected from storm water inlet grates and catch basins, through storm sewers to a discharge point consisting of a 0.30-m (1-ft) corrugated metal pipe extending out of the bank of Sawmill Creek. No effluent standards apply and no monitoring is performed at this outfall.

Outfall 103. This is a storm water only discharge. The watershed for Outfall 103 includes the southern and southeastern extreme portions of the 100 Area and the area south of the coal pile. These areas drain into a storm sewer that runs due east of the coal pile toward Sawmill Creek. The outfall is located at the outlet of a 0.35-m (1.2-ft) corrugated metal pipe culvert located approximately 50 m (150 ft) from the creek. Activities that are industrial in nature take place in and

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around the utilities area and consist of boiler house steam generation, storage of plastic and metal, loading dock activities, a flue gas scrubber and cooling pond (no longer in use), steam condensate return storage (two tanks), and the southern access road to the coal pile storage area. No effluent standards apply and no monitoring is performed at this outfall.

Outfall 104. This is a storm water only discharge. This outfall includes the buildings and parking areas remaining in the East Area, excluding Buildings 40 and 46. Buildings 4, 5, and 6 and their smaller attendant buildings are included. The area is served by a number of roadways leading to and from these buildings; contributing storm grate inlets are located on the roadways and parking areas. No effluent standards apply and no monitoring is performed at this outfall.

Outfalls 105A and 105B. These are storm water only discharges. Two discharge points are located within this watershed. The contributing sources of storm water for this watershed include runoff from the Building 40 area, elevated water tower tanks, and scrub vegetation areas on the west side of Tech Road. Industrial activity within this watershed includes receiving, loading, parking and storage areas, and oil-containing transformers. No effluent standards apply and no monitoring is performed at this outfall.

Outfalls 106A and 106B. These are storm water only discharges. The watershed for these outfalls encompasses the largest portion of the East Area, most of which is now demolished and the buildings razed. A portion of the eastern end of the Shipping and Receiving Area is part of this watershed, that is, Building 33, which has electrical transformers located outside of it, and a portion of Argonne Park. Like Outfall 105 above, this watershed is served by two distinct outfalls. The industrial activities within this watershed involve the receiving and shipping areas and associated loading dock and the transformer area. No effluent standards apply and no monitoring is performed at this outfall.

Outfall 108. This watershed encompasses a portion of the 300 Area. The drainage area includes the parking areas north of Building 360, the buildings in and around Building 360, excluding Buildings 370 and 390 and the southern and western ends of the 300 Area, and the paved parking and loading dock areas in and around the eastern portions of the 300 Area (surrounding Building 363). Ongoing industrial activities in this watershed are shipping and receiving, a metals reclamation dumpster (Building 363), loading dock activities, and numerous outdoor equipment storage areas. Table 5.7 gives the sampling requirements and effluent limits. No exceedances occurred during 2000.

Outfall 110. This is a storm water only discharge. The watershed for this outfall includes the 320 Area shooting range (inactive since March 1993) and the area just south of the range. No other industrial activities take place within this watershed at present. Past industrial activity involved use of the shooting range for practice by the security force. No effluent standards apply and no monitoring is performed at this outfall.

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Outfall 111. This outfall is located on the south fence line of the site due south of the old, closed 319 Area Landfill, between the watershed for Outfall 110 and the watershed for Outfalls 112A and 112B. This watershed encompasses the 319 Area Landfill, the 318 Area (landfill area for compressed gases), and portions of the 317 Area, primarily the paved area. In addition, the roadways for access to these areas drain to this outfall through a small ditch running along the southern extreme of the 319 Area Landfill, turning south to the fence line, and then to the outfall location, which is a 0.65-m (2-ft) corrugated metal pipe culvert that passes under the fence and discharges into the forest preserve. Industrial activities within this watershed consist of 317 Area radioactive waste storage and remediation activities, the 319 Area Landfill, and associated roadways for access. This outfall is sampled semiannually for flow and hydrogen-3 and has no permit limits. Hydrogen-3 was noted at a level of 294 pCi/L during February 2000.

Outfalls 112A and 112B. The contributing sources of storm water within this watershed receive runoff from the southern and western sections of the 317 Area radioactive waste storage. Runoff flow is generally toward the south in sheet flow from the source areas; the eastern portions consolidate at the fence line at the southeastern corner of the 317 Area and pass under the fence through rough concrete fill. The western and central portions of the drainage area sheet flow consolidate in the same manner and pass under the fence through the same material, approximately 50 m (150 ft) to the west. Both flows discharge into large gullies in the forest preserve and form one flow approximately 100 m (328 ft) south of the ANL-E fence line. Industrial activity within this watershed consists of 317 Area radioactive waste storage and handling and remediation activities, and the associated roadways for access. These outfalls are sampled semiannually for flow and hydrogen-3 and have no permit limits. Hydrogen-3 levels of 246 pCi/L and 301 pCi/L were noted in February at Outfalls 112A and 112B, respectively.

Outfall 113. This outfall is the discharge point for runoff from the eastern, southern, and southwestern sections of the closed 800 Area Landfill. The outfall is located in a ditch on the extreme southern end of the landfill, approximately 50 m (150 ft) from the southwestern corner of the landfill fence line. This discharge flows under the fence in the ditch and empties into the creek that flows south from the wetland marsh west of the site. The marsh is the headwaters of one leg of the Freund Brook system that runs through the middle of the ANL-E site and discharges into Sawmill Creek. Industrial activity within this watershed is limited to the landfill. This outfall was sampled monthly when discharging and has no permit limits. Flow occurred during five months in 2000.

Outfall 114. This outfall is the discharge point for runoff coming from the northern and northwestern sections of the closed 800 Area Landfill. The outfall is located in a ditch on the extreme western side of the landfill, approximately halfway between the northern and southern boundaries of the landfill. The flow proceeds along the western edge of the landfill where water is added from the marsh. The flow eventually combines with the ditch from the Outfall 113 flow and then passes into the creek that flows south from the wetland marsh west of the ANL-E site. Industrial

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

activity within this watershed is limited to the landfill. This outfall was sampled monthly when discharging and has no permit limits. Flow occurred during five months in 2000.

Outfall 115. This watershed encompasses the APS site and the southern areas around the Building 314, 315, and 316 complex. The APS flow drains into ditches that discharge through a cement culvert into a collection pond located on the southeastern portion of the APS site. The 0.65-m (2-ft) sewer conduit from the Building 314, 315, and 316 complex discharges into the same collection pond approximately 10 m (30 ft) east of the ditch culvert. The flow from this pond discharges south through a culvert into another pond, flows through this pond, and discharges through a 1-m (3-ft) corrugated metal pipe culvert under the south fence line into the forest preserve. Industrial activities within the watershed involve the APS; all roadways associated with APS; loading docks in the APS buildings; and the Building 314, 315, and 316 complex storage, loading areas, and cooling water discharges. Table 5.7 gives the sampling requirements and effluent limits. No exceedances occurred during 2000.

Results of acute toxicity tests for Outfall 115 are presented in Tables 5.8 and Table 5.9. Outfall 115 was acutely toxic to the water flea during the July and August tests. The toxicity appears to come from discharges from the Building 314-315 complex. Domestic chlorinated water from the Building 314 cooling tower, a Building 314 air compressor, and Building 315 footing drains was discharged through Outfall 115. The cooling tower and air compressor discharges have been rerouted to the laboratory sewer system. Additional Building 315 floor drain discharges are scheduled for rerouting during 2001.

Outfall 116. The watershed for this outfall contains sections of the domestic water treatment plant, including the garage and storage area, the area around Well 5, and the associated access roads for the domestic water treatment plant. Flow is conducted through storm water sewers and discharged at the outfall, which is a 0.25-m (0.82-ft) vitrified clay pipe with a cement raceway into Sawmill Creek. Industrial activities for this watershed include parking, loading, and materials storage around the domestic water treatment plant; domestic water treatment plant operation, including bulk chemical storage (brine tank) and transformers (Building 129); outdoor equipment storage area and four flammable materials storage cabinets (Building 130); outdoor materials storage (Buildings 107 and 163); well operation and maintenance (Building 160); and the associated roadways for these activities. Table 5.7 gives the sampling requirements and effluent limits. No exceedances occurred during 2000.

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

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

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 2000. 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 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.

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TABLE 5.10

Chemical Constituents in Effluents from the ANL-E
Wastewater Treatment Plant, 2000

Constituent	No. of Samples	Concentrations (mg/L)			
		Average	Minimum	Maximum	Limit
Arsenic	52	< 0.0030	< 0.0030	0.0032	0.25
Barium	51	0.0203	< 0.0180	0.0253	2.0
Beryllium	52			< 0.0001 ^a	- ^b
Cadmium	52	< 0.0001	< 0.0001	0.0004	0.15
Chromium	51			< 0.0440	1.0
Cobalt	51			< 0.0260	-
Copper	51	0.0195	< 0.0170	0.0366	0.5
Fluoride	52	0.8905	0.6300	1.1020	15.0
Iron	51	0.0678	< 0.0370	0.5042	2.0
Lead	52			< 0.0020	0.2
Manganese	51			< 0.0170	1.0
Mercury	52	< 0.0001	< 0.0001	0.0002	0.0005
Nickel	51			< 0.0400	1.0
Silver	52	< 0.0007	< 0.0005	0.0041	0.1
Thallium	52			< 0.0015	-
Vanadium	51			< 0.0240	-
Zinc	51	0.1260	0.0747	0.2490	1.0
pH (units)	52	NA ^c	6.93	7.75	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.

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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 are shown in Table 5.11. None of the annual average results exceeded General Use Water Quality Standards.²⁶ The maximum concentration for silver exceeded the WQS one time in March. The cause is unknown.

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TABLE 5.11

Chemical Constituents in Sawmill Creek, Location 7M,^a 2000

Constituent	No. of Samples	Concentrations (mg/L)			
		Average	Minimum	Maximum	Limit
Arsenic	51			< 0.0030 ^b	0.36 ^c
Barium	49	0.0404	0.0227	0.0788	5.0
Beryllium	51			< 0.0001	- ^d
Cadmium	51	< 0.0001	< 0.0001	0.0020	0.03 ^c
Chromium	49			< 0.0440	3.6 ^c
Cobalt	49			< 0.0260	-
Copper	49	< 0.0178	< 0.0170	0.0329	0.041 ^c
Fluoride	51	0.4785	0.2140	0.9560	1.4
Iron	49	0.1904	0.0370	0.6185	1.0
Lead	51	< 0.0022	< 0.0020	0.0044	0.3 ^c
Manganese	49	< 0.0398	< 0.0170	0.3214	1.0
Mercury	51	< 0.0001	< 0.0001	0.0003	0.0026 ^c
Nickel	49			< 0.0400	1.0
Silver	51	< 0.0016	< 0.0005	0.0522	0.005
Thallium	51			< 0.0015	-
Vanadium	49			< 0.0240	-
Zinc	49	0.0825	0.0110	0.3460	1.0
pH (units)	50	NA ^e	6.87	8.01	6.5–9.0

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

^b If all values are less than the detection limit for a constituent, only the detection limit is given.

^c The acute standard for the chemical constituent is listed.

^d A hyphen indicates no effluent limit for this constituent.

^e NA = not applicable.

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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. Regulatory-Required Monitoring

The supplier of the domestic water is responsible for conducting any regulatory agency-required monitoring. ANL-E water is provided by the DuPage Water Commission, which is responsible for any monitoring. Therefore, ANL-E did not conduct any required monitoring in 2000. Water quality analyses are supplied to ANL-E by the DuPage Water Commission on a regular basis. All parameters are within acceptable regulatory limits.

6.1.2. 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

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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	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.

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 detection limit is the Practical Quantification Limit (PQL), which is defined as 10 times the method detection limit.

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

6.1.3. 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 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.

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TABLE 6.2

Radioactivity in ANL-E Former Water Supply Wells, 2000
(concentrations in pCi/L)

Type of Activity	Location	No. of Samples	Average	Minimum	Maximum
Alpha	Well 1	4	4.2	3.4	6.4
	Well 3	4	2.3	1.7	3.0
	Well 4	4	4.4	2.8	6.2
Beta	Well 1	4	9.4	8.6	9.9
	Well 3	4	10.4	9.1	11.1
	Well 4	4	11.0	9.4	12.3
Hydrogen-3	Well 1	4	< 100	< 100	115
	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	-	0.60
	Well 3	1	-	-	0.73
	Well 4	1	-	-	1.25
Radium-228	Well 1	1	-	-	0.50
	Well 3	1	-	-	0.71
	Well 4	1	-	-	0.76
Uranium-234	Well 1	1	-	-	0.65
	Well 3	1	-	-	0.19
	Well 4	1	-	-	0.20
Uranium-238	Well 1	1	-	-	0.64
	Well 3	1	-	-	0.10
	Well 4	1	-	-	0.08

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

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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 6.1. Samples were collected quarterly and analyzed for hydrogen-3. Table 6.3 shows the results for 2000. Hydrogen-3 results from well 570091D, which is directly below the 570 Pond, continue to show low concentrations of hydrogen-3. None of the other wells had detectable levels of hydrogen-3. This sampling network is now part of the monitoring program.

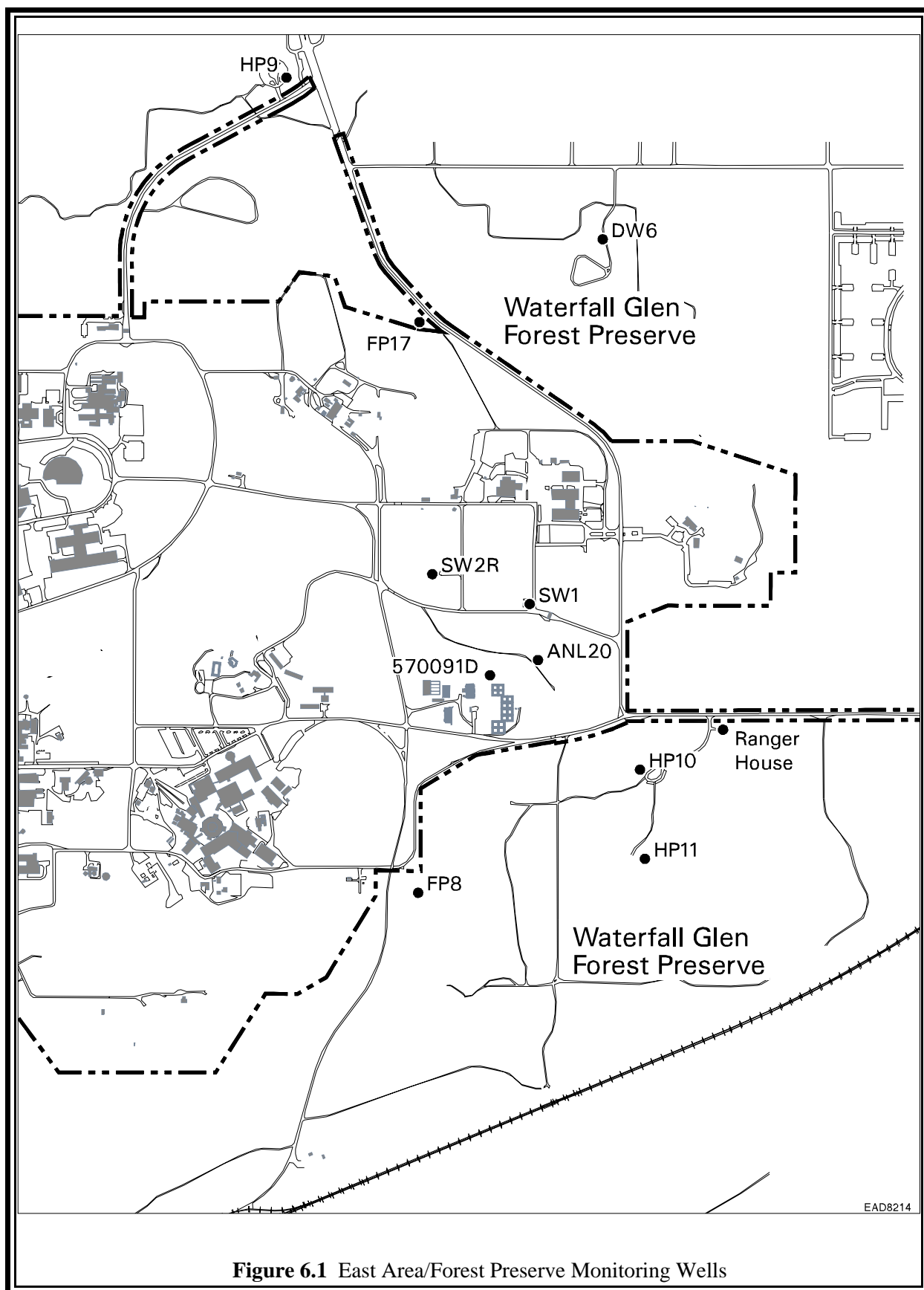
6.2. Groundwater Monitoring at Waste Management Sites

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 and one aboveground concrete structures used for storage of containers of dry radioactive or mixed (radioactive and chemically hazardous) waste. It 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 northern 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.

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TABLE 6.3

Hydrogen-3 in Dolomite Wells, 2000
(concentrations in pCi/L)

Well	Date Collected			
	February 16	May 31	July 28	October 17
Waterfall Glen				
DW 6	<100	<100	<100	<100
HP 9	<100	<100	<100	<100
HP 10	<100	<100	<100	<100
HP 11	<100	<100	<100	<100
FP 8	<100	<100	<100	<100
FP 17	<100	<100	<100	<100
Ranger House	<100	<100	<100	<100
ANL-E				
570091D	<100	<100	<100	117
ANL-20	<100	<100	<100	<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 migration

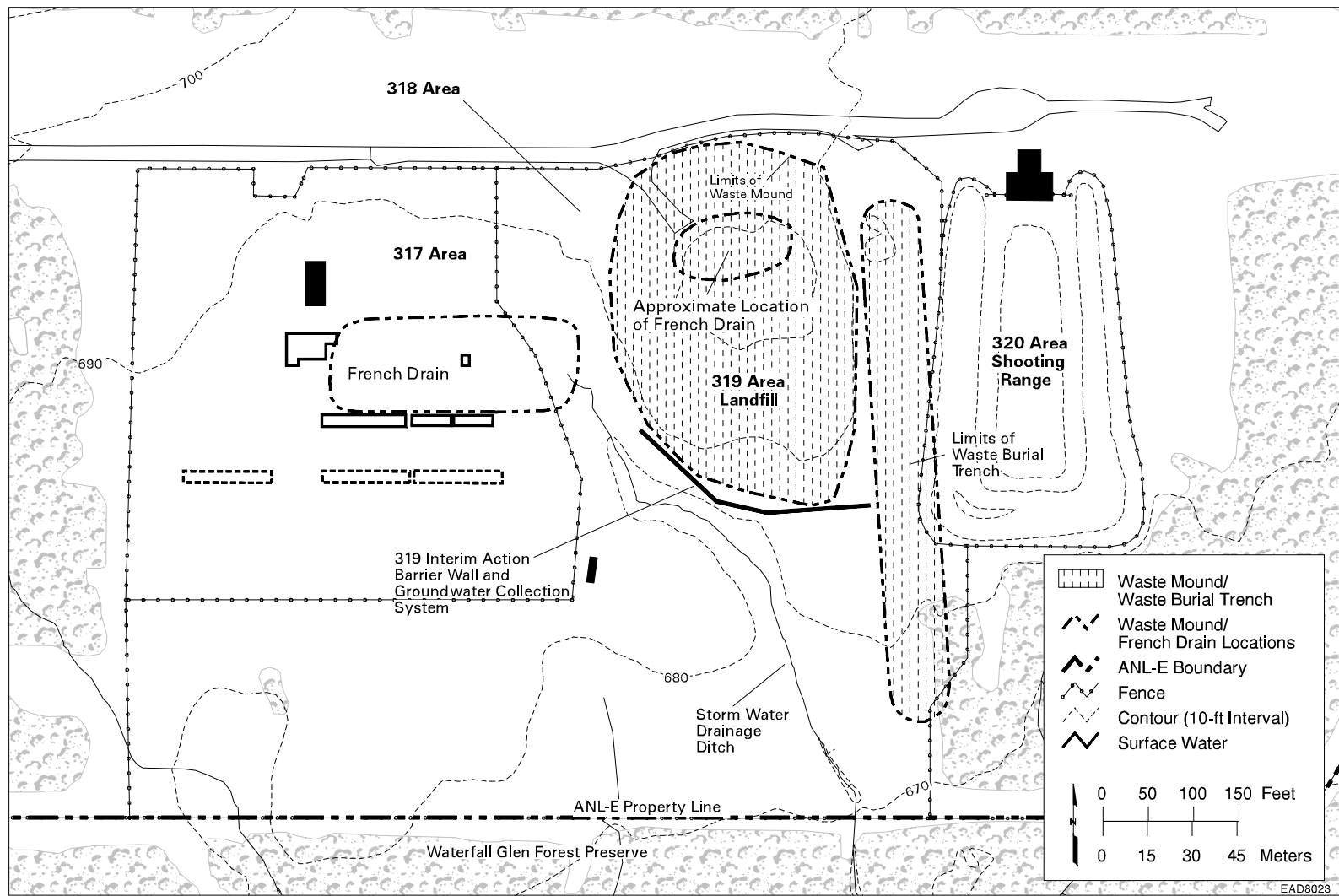


Figure 6.2 Locations of Components within the 317/319/ENE Area

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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, removal 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), and treating highly contaminated soil near the former French drain. In addition, routine sampling and analysis of groundwater and surface water have continued.

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 routine O&M 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 also summarized in this report.

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

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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.

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, an extensive groundwater monitoring network was installed. 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 2000 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 140,000 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.

In 1999, a phytoremediation system was installed in the 317/319 Area. This system utilizes a variety of specially selected trees to remove contaminated groundwater from the shallow soil and to stimulate the natural biodegradation of organic contaminants in soil and groundwater. Monitoring of this system in 2000 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 one growing season, 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.

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TABLE 6.4

Groundwater Monitoring Wells: 317 and 319 Areas

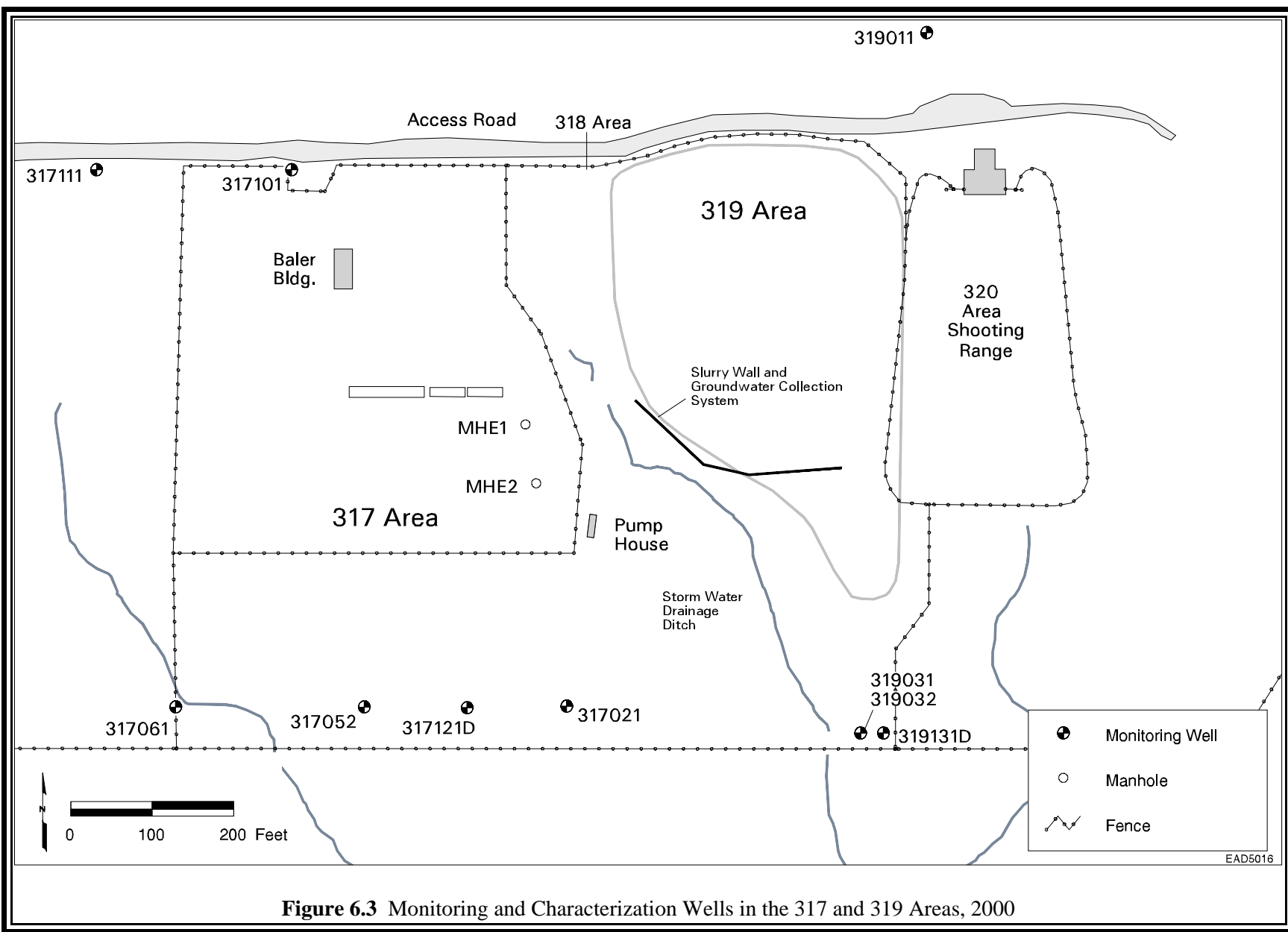
ID Number	Well Depth (m bgs)	Ground Elevation (m AMSL)	Monitoring Zone (m AMSL)	Well Type ^a	Date Drilled
319011	12.19	209.8	199.1 – 197.6	0.05/PVC	9/86
317021	12.19	209.2	198.5 – 197.0	0.05/PVC	9/86
319031	12.50	204.3	194.8 – 191.8	0.05/PVC	9/86
319032	7.62	204.3	198.2 – 196.7	0.05/PVC	8/89
317052	4.27	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.

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. 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.



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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 ESH-Analytical Services, Chemistry Laboratory (ESH-ASCH). These SOPs reference protocols in SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*.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 spectrometry 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 ESH-Analytical Services, Radiochemistry Laboratory (ESH-ASRC). 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 great enough to quantify are shown. The detection limits for the organic compounds listed were typically 1 to 5 µg/L.

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TABLE 6.5

Groundwater Monitoring Results, 300 Area Well 317021, 2000

Parameter	Unit	Date of Sampling			
		03/14/00	06/27/00	09/13/00	11/21/00
Water elevation ^a	m	198.87	199.83	200.55	199.09
Temperature	°C	11.0	11.8	12.2	9.3
pH	pH	7.26	7.56	7.16	7.87
Redox	mV	-14	-30	14	-41
Conductivity	µmhos/cm	800	770	770	917
Chloride ^b	mg/L	15	19	16	34
Arsenic ^b	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium ^b	mg/L	0.0342	0.0369	0.0352	0.0390
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	< 0.0370	< 0.0370	0.0571	0.0681
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
Americium-241	fCi/L	- ^c	-	-	< 1.0
Curium-242	fCi/L	-	-	-	< 1.0
Curium-244	fCi/L	-	-	-	< 1.0
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	< 100	147	103	< 100
Neptunium-237	fCi/L	-	-	-	< 1.0
Plutonium-238	fCi/L	-	-	-	< 1.0
Plutonium-239	fCi/L	-	-	-	< 1.0
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
1,1,1-Trichloroethane	µg/L	33	3	3	10
1,1-Dichloroethane	µg/L	11	1	2	4
Trichloroethene	µg/L	< 1	< 1	< 1	1

^a Well bottom elevation = 197.27 m mean sea level (MSL); Ground surface elevation = 209.17 m (MSL); casing material = PVC.

^b Filtered sample.

^c A hyphen indicates that no samples were collected.

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TABLE 6.6

Groundwater Monitoring Results, 300 Area Well 317052, 2000

Parameter	Unit	Date of Sampling				
		03/14/00	06/27/00	09/13/00	11/21/00	11/21/00
Water elevation ^a	m	204.75	205.67	204.93	205.00	205.00
Temperature	°C	8.7	11.9	14.6	11.0	11.0
pH	pH	7.90	7.78	7.65	7.64	7.64
Redox	mV	-47	-42	-34	-33	-33
Conductivity	µmhos/cm	749	735	845	882	882
Chloride ^b	mg/L	3	3	15	26	26
Arsenic ^b	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Barium ^b	mg/L	0.0236	0.0326	0.0355	0.0335	0.0329
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	< 100	< 100	< 100	144	134
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Acetone	µg/L	< 1	< 1	9	< 1	< 1

^a Well bottom elevation = 204.04 m (MSL); ground surface elevation = 208.32 m (MSL); casing material = PVC.

^b Filtered sample.

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TABLE 6.7

Groundwater Monitoring Results, 300 Area Well 317061, 2000

Parameter	Unit	Date of Sampling			
		06/27/00	06/27/00	09/13/00	11/16/00
Water elevation ^a	m	198.88	198.88	198.01	197.97
Temperature	°C	11.3	11.3	11.8	10.5
pH	pH	7.47	7.47	7.15	7.30
Redox	mV	-22	-22	-5	-5
Conductivity	µmhos/cm	876	876	970	985
Chloride ^b	mg/L	14	10	10	6
Arsenic ^b	mg/L	0.0169	0.0172	0.0192	0.0179
Barium ^b	mg/L	0.0585	0.0600	0.0619	0.0615
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	0.0506	< 0.0370	0.0377	< 0.0370
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.0444	0.0477	0.0415	0.0342
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	0.0006	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	0.012	< 0.011	< 0.011
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 bottom elevation = 195.35 m (MSL); ground surface elevation = 207.54 m (MSL); casing material = PVC.

^b Filtered sample.

6. GROUNDWATER PROTECTION

TABLE 6.8

Groundwater Monitoring Results, 300 Area Well 317101, 2000

Parameter	Unit	Date of Sampling			
		03/14/00	06/26/00	09/12/00	11/16/00
Water elevation ^a	m	201.86	202.73	202.38	202.31
Temperature	°C	12.0	12.9	12.8	11.5
pH	pH	6.54	7.07	6.92	6.85
Redox	mV	25	3	6	17
Conductivity	µmhos/cm	2,540	2,620	2,410	2,790
Chloride ^b	mg/L	431	656	512	619
Arsenic ^b	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium ^b	mg/L	0.0734	0.1055	0.0899	0.1082
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	< 0.037	< 0.037	< 0.037	< 0.037
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.0358	0.0197	0.0335	0.0331
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	0.0009	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
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 bottom elevation = 198.66 m (MSL); ground surface elevation = 211.04 m (MSL); casing material = PVC.

^b Filtered sample.

6. GROUNDWATER PROTECTION

TABLE 6.9

Groundwater Monitoring Results, 300 Area Well 317111, 2000

Parameter	Unit	Date of Sampling			
		03/14/00	06/26/00	09/12/00	11/16/00
Water elevation ^a	m	201.96	200.33	199.74	199.69
Temperature	°C	11.5	12.0	11.9	10.3
pH	pH	6.41	7.16	6.60	7.36
Redox	mV	33	-8	23	-9
Conductivity	µmhos/cm	1,913	1,267	1,370	1,640
Chloride ^b	mg/L	362	212	237	331
Arsenic ^b	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium ^b	mg/L	0.1177	0.0799	0.0833	0.1111
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	< 0.0370	< 0.0370	< 0.0370	0.0533
Lead ^b	mg/L	< 0.002	< 0.0020	< 0.002	< 0.002
Manganese ^b	mg/L	< 0.0170	0.0387	< 0.0170	0.0204
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
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 bottom elevation = 198.37 m (MSL); ground surface elevation = 210.25 m (MSL); casing material = PVC.

^b Filtered sample.

6. GROUNDWATER PROTECTION

TABLE 6.10

Groundwater Monitoring Results, 300 Area Well 317121D, 2000

Parameter	Unit	Date of Sampling			
		03/14/00	06/27/00	09/13/00	11/21/00
Water elevation ^a	m	186.38	186.35	186.41	188.48
Temperature	°C	11.1	11.7	12.3	9.4
pH	pH	10.63	9.45	8.99	9.17
Redox	mV	-197	-129	-100	-113
Conductivity	µmhos/cm	664	695	470	550
Chloride ^b	mg/L	43	39	42	49
Arsenic ^b	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium ^b	mg/L	0.0548	< 0.01	0.0784	0.0674
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	< 0.037	< 0.037	< 0.037	< 0.037
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	117	145	120	160
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

^a Well bottom elevation = 183.49 m (MSL); ground surface elevation = 207.57 m (MSL); casing material = steel.

^b Filtered sample.

6. GROUNDWATER PROTECTION

TABLE 6.11

Groundwater Monitoring Results, 300 Area Well 319011, 2000

Parameter	Unit	Date of Sampling			
		03/14/00	06/26/00	09/07/00	11/16/00
Water elevation ^a	m	198.44	200.20	199.17	198.92
Temperature	°C	11.5	12.1	12.3	9.9
pH	pH	7.40	7.80	6.86	7.44
Redox	mV	-14	-41	12	-14
Conductivity	μmhos/cm	1,051	925	1,051	1,080
Chloride ^b	mg/L	35	39	41	35
Arsenic ^b	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium ^b	mg/L	0.0362	0.0374	0.0400	0.0389
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	< 0.0370	< 0.0370	< 0.0370	0.0379
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.0213	< 0.0170	< 0.0170	0.0456
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	< 100	< 100	< 100	103
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
Acetone	μg/L	3	< 1	< 1	< 1

^a Well bottom elevation = 197.60 m (MSL); ground surface elevation = 209.81 m (MSL); casing material = PVC.

^b Filtered sample.

6. GROUNDWATER PROTECTION

TABLE 6.12

Groundwater Monitoring Results,
300 Area Well 319031, 2000

Parameter	Unit	Date of Sampling
		06/26/00
Water elevation ^a	m	193.13
Temperature	°C	15.6
pH	pH	7.21
Redox	mV	-11
Conductivity	µmhos/cm	829
Chloride ^b	mg/L	26
Arsenic ^b	mg/L	< 0.003
Barium ^b	mg/L	0.0514
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	< 0.017
Mercury ^b	mg/L	< 0.0001
Nickel ^b	mg/L	< 0.04
Silver ^b	mg/L	< 0.0005
Thallium ^b	mg/L	< 0.0015
Vanadium ^b	mg/L	< 0.024
Zinc ^b	mg/L	0.0934
Cesium-137	pCi/L	< 2.0
Hydrogen-3	pCi/L	743
Strontium-90	pCi/L	0.31
1,1,1-Trichloroethane	µg/L	2
Trichloroethene	µg/L	4

^a Well bottom elevation = 191.78 m (MSL); ground surface elevation = 204.28 m (MSL); casing material = PVC.

^b Filtered sample.

6. GROUNDWATER PROTECTION

TABLE 6.13

Groundwater Monitoring Results, 300 Area Well 319032, 2000

Parameter	Unit	Date of Sampling			
		03/14/00	06/26/00	09/07/00	11/21/00
Water elevation ^a	m	197.09	198.28	197.83	197.25
Temperature	°C	11.5	12.0	12.2	9.2
pH	pH	6.96	7.33	6.60	6.99
Redox	mV	6	-14	22	3
Conductivity	µmhos/cm	1,060	872	965	952
Chloride ^b	mg/L	15	14	16	13
Arsenic ^b	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium ^b	mg/L	0.0672	0.0677	0.0652	0.0649
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	< 0.037	< 0.037	< 0.037	< 0.037
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	0.0006	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
Americium-241	fCi/L	- ^c	-	< 1.0	-
Curium-242	fCi/L	-	-	< 1.0	-
Curium-244	fCi/L	-	-	< 1.0	-
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	436	401	376	422
Neptunium-237	fCi/L	-	-	< 1.0	-
Plutonium-238	fCi/L	-	-	1.7	-
Plutonium-239	fCi/L	-	-	< 1.0	-
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
Dichlorofluoromethane	µg/L	< 1	< 1	4	< 1
Trichlorofluoromethane	µg/L	< 1	< 1	1	< 1

^a Well bottom elevation = 196.66 m (MSL); ground surface elevation = 204.28 m (MSL); casing material = PVC.

^b Filtered samples.

^c A hyphen indicates that no samples were collected.

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TABLE 6.14

Groundwater Monitoring Results, 300 Area Well 319131D, 2000

Parameter	Unit	Date of Sampling			
		03/14/00	06/26/00	09/07/00	11/21/00
Water elevation ^a	m	184.30	184.75	184.47	184.47
Temperature	°C	11.2	11.9	12.3	7.5
pH	pH	7.40	7.27	6.51	7.49
Redox	mV	-15	-28	29	-14
Conductivity	µmhos/cm	1,078	948	1,056	1,105
Chloride ^b	mg/L	51	47	43	49
Arsenic ^b	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium ^b	mg/L	0.0690	0.0758	0.0722	0.0740
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	< 0.037	0.102	< 0.037	< 0.037
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	< 0.0170	0.1057	< 0.0170	< 0.0170
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.0400	< 0.0400	0.0675	< 0.0400
Silver ^b	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
Americium-241	fCi/L	- ^c	< 1.0	-	-
Curium-242	fCi/L	-	< 1.0	-	-
Curium-244	fCi/L	-	< 1.0	-	-
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	1330	1221	1206	1238
Neptunium-237	fCi/L	-	< 1.0	-	-
Plutonium-238	fCi/L	-	< 1.0	-	-
Plutonium-239	fCi/L	-	< 1.0	-	-
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
Acetone	µg/L	3	< 1	< 1	< 1
Carbon Tetrachloride	µg/L	< 1	< 1	< 1	1

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

^b Filtered samples.

^c A hyphen indicates that no samples were collected.

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. As in past years, Well 319031 was dry during the first, third and fourth 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 2000, 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).

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 ranged from 212 to 656 mg/L and may be due to road salt. Several wells had elevated levels of barium and manganese; however, they were

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

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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-ethylhexyl)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		

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considerably below the WQS. Barium concentrations ranged from less than 0.01 to 0.12 mg/L, and manganese concentrations ranged from less than 0.017 to 0.11 mg/L. The source of the elevated barium and manganese levels is unknown. Elevated levels of barium and manganese have been reported in previous annual reports.¹⁶

Organic Parameters. Each well was sampled quarterly and analyzed for VOCs. Similar to 1999, VOCs were detected in five wells — 317021, 319011, 319031, 319032, and 319131D. The VOC acetone was also detected only one quarter at a very low level in wells 317052, 319011, and 319131D. The presence of acetone may very well be due to laboratory contamination, since each quarter it was detected in the field control sample at levels of 7 to 8 µg/L. VOC concentrations in other wells were very low. Well 317021 showed persistent but very low VOC levels of the same contaminants as in previous years. Well 319031, although usually dry, contains organic constituents when water is present. VOCs were noted only one quarter in well 319032. Carbon tetrachloride was detected only one quarter in well 319131D. No organic WQSs were exceeded. The reduction in the frequency and concentration of VOCs may be due to the extensive remedial actions in the 317 and 319 Areas completed during the last few years.

Once during the year, the wells were sampled and analyzed for SVOCs, PCBs, pesticides, and herbicides. None of these parameters were found in 2000.

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; 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 is seen. Since early 1998 the level of contamination has dropped dramatically. In 2000, a trace level of trichloroethene was also found in this well but at a level 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 1,128 L/day (298 gal/day) from the 319 Area groundwater collection system, an average of 14,987 L/day (3,958 gal/day) from the 317 Area groundwater collection system, and groundwater from existing 317 Area foundation drains around storage vaults.

These amounts represent a substantial decrease in flow from 1999 from the 319 and 317 Area groundwater collection systems of 68% and 50%, respectively. This decrease can be attributed to (1) rainfall fluctuation; (2) early snows during late November and December 2000; and (3) in the case of the 319 Area system, a considerable drop in groundwater extraction rates due to the addition of the 319 Landfill Cap installed during late summer 1999.

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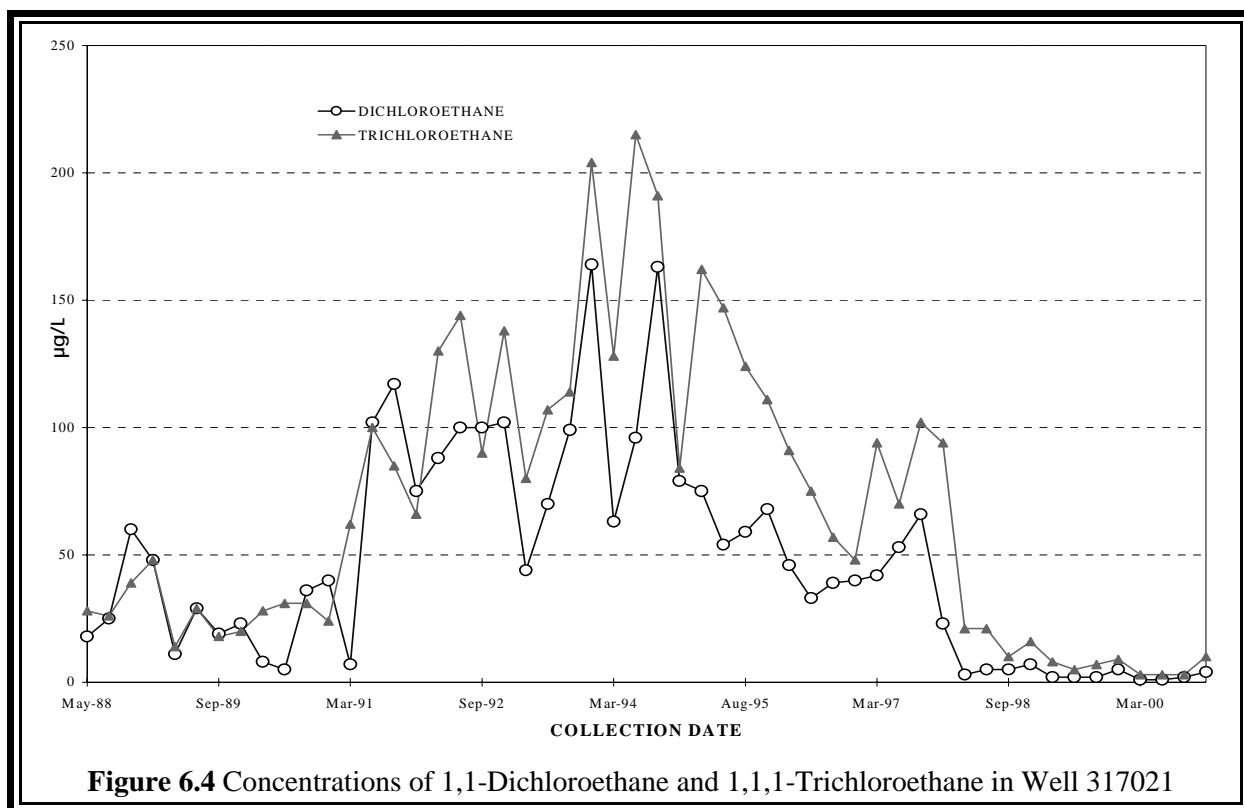


TABLE 6.17

Volatile Organic Compounds in the 317 Area: Manholes E1 and E2, 2000
(concentrations in µg/L)

Date Collected	Chloroform		Tetra-chloroethene		Trichloro-ethene		cis-1,2-Dichloro-ethene		1,1-Dichloro-ethane		Carbon Tetrachloride		1,1,1-Trichloro-ethane	
	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2
January 14	105	2	19	2	14	16	11	11	29	51	142	5	65	134
February 9	159	5	38	6	62	50	36	26	163	129	220	12	415	342
March 7	20	7	18	5	31	31	9	9	100	102	51	12	223	228
April 13	104	4	31	4	24	23	10	9	45	62	160	7	91	133
May 10	102	5	46	10	19	17	6	5	23	56	197	16	45	121
June 16	32	7	13	8	18	29	4	6	50	92	52	16	126	243
July 13	109	< 1	26	7	24	27	7	7	60	92	154	14	142	233
August 3	158	5	36	5	36	34	13	8	69	92	294	17	180	265
September 14	269	249	110	73	30	34	17	65	20	33	805	507	48	80
October 24	29	2	6	2	17	17	7	6	37	39	43	6	119	129
November 13	135	46	34	12	22	20	12	11	20	44	236	53	49	117
December 8	132	48	23	10	19	15	11	9	20	27	196	59	45	65

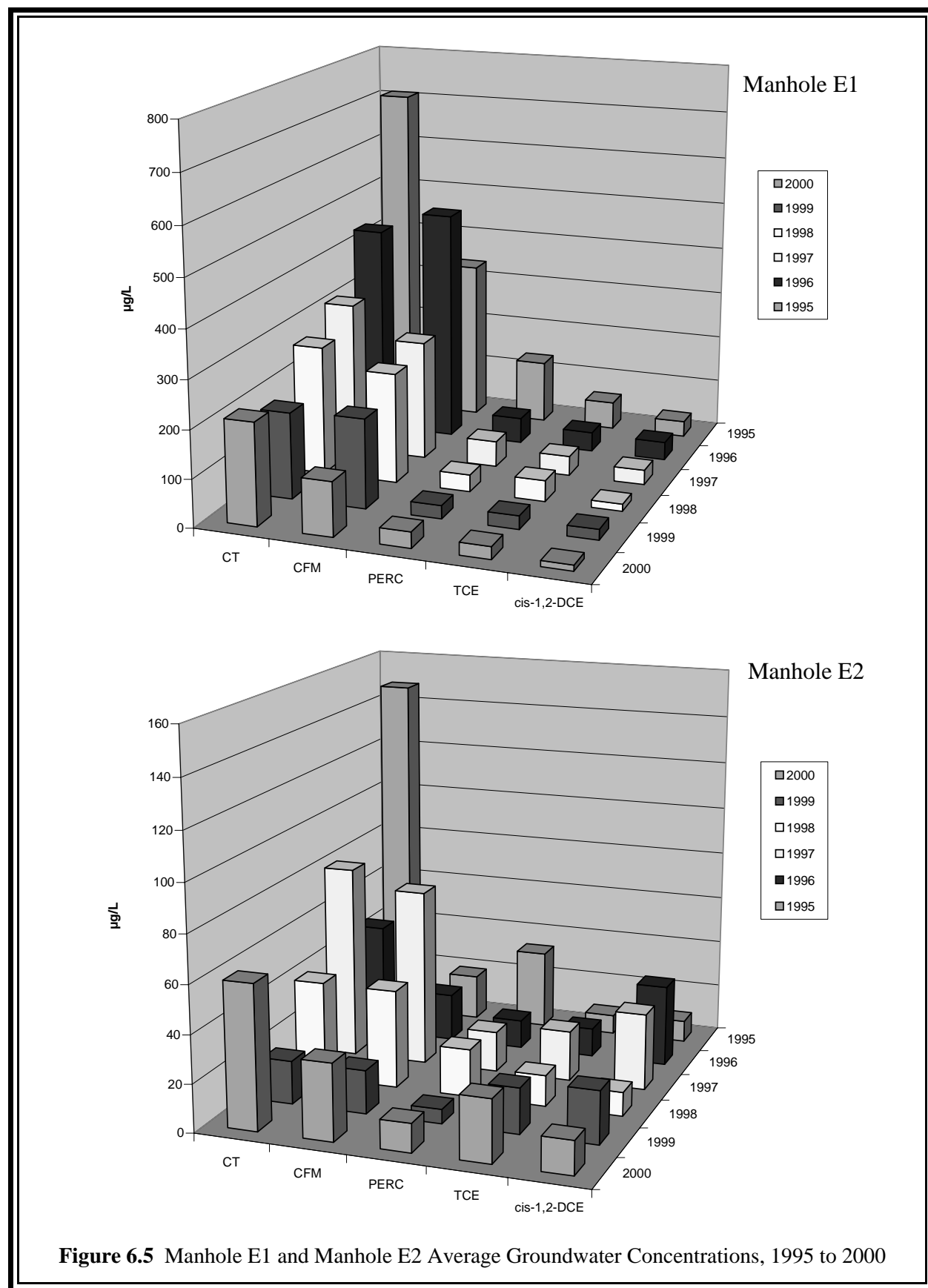
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In general, volatile constituent concentrations from manhole E1 decreased from levels noted in previous years (see Figure 6.5). This decrease is probably associated with the soil treatment remediation project in 1998, which resulted in the removal of approximately 80% of the VOCs from several locations within the 317 French Drain area. The increase in volatile constituent concentrations from manhole E2 (see Figures 6.6 to 6.12) from levels noted in previous years is probably associated with the substantial decrease in groundwater extraction from both the 317 and 319 Areas, which has resulted in a reduction in dilution. Remediation activities in the 317 and 319 Areas have resulted in manhole E2 receiving additional groundwater flows from these areas. Starting in October 1997, as part of the 317 Area remediation project, 317 Area groundwater was pumped at a rate of over 4,542 L/day (1,200 gal/day) to manhole E2, increasing to 29,840 L/day (7,880 gal/day) in 1999, and decreasing by 50% to 14,987 L (3,958 gal/day) in 2000.

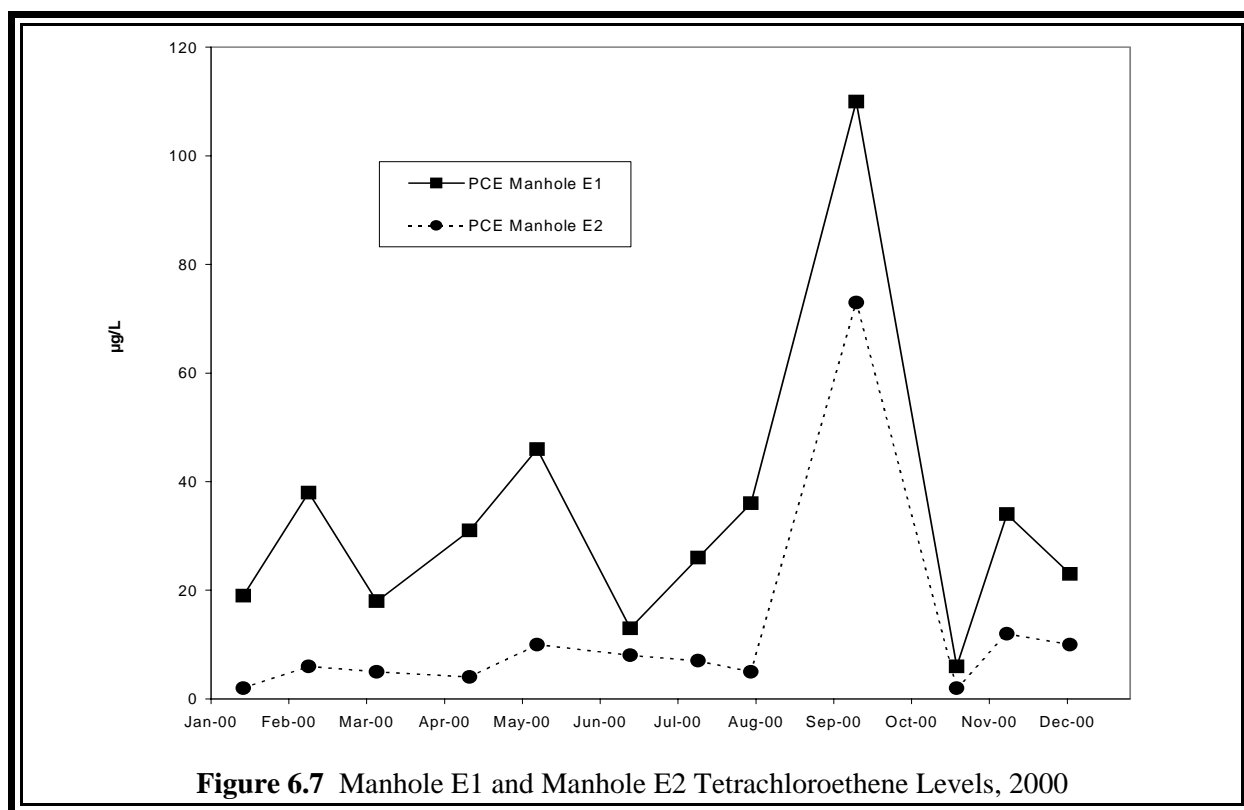
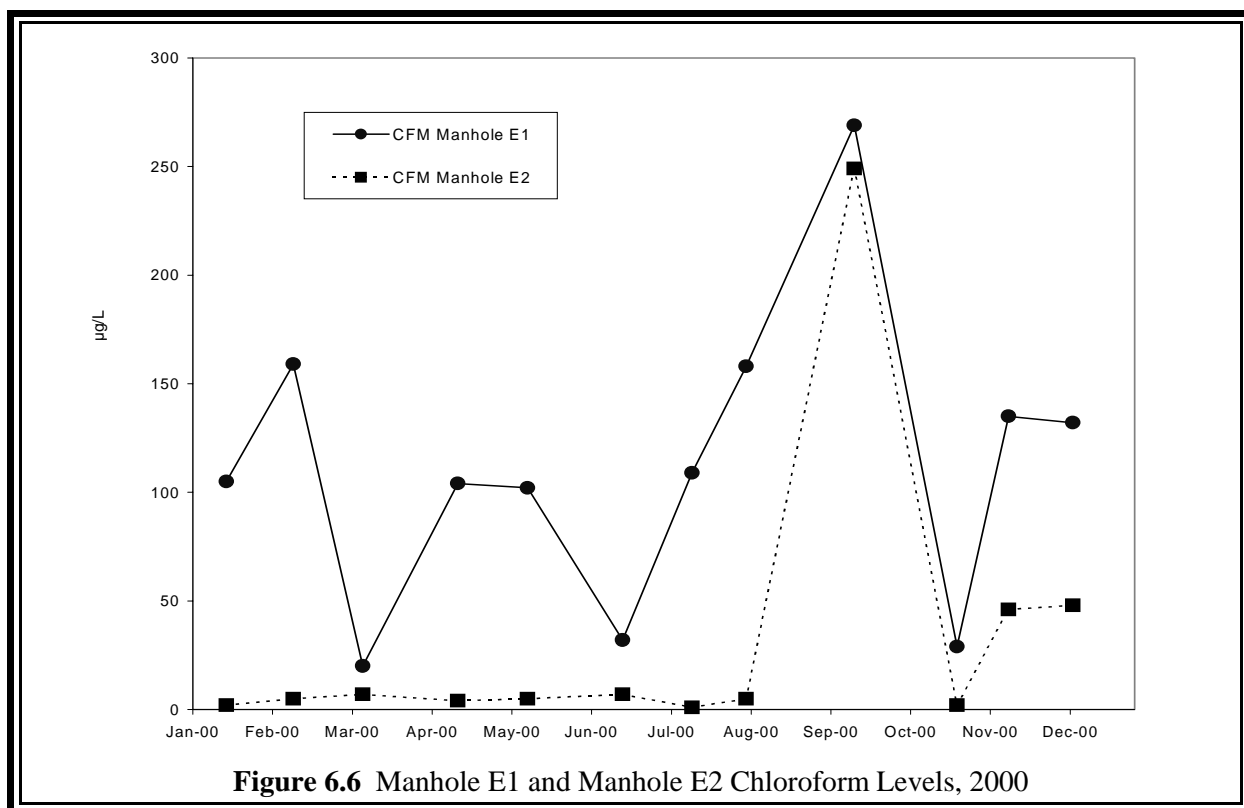
Radioactive Constituents. Samples collected quarterly from the monitoring wells in the 317 and 319 Areas were analyzed for hydrogen-3, strontium-90, and gamma-ray emitters. An annual sample for alpha emitters was collected from wells 317021, 319032, and 319131D. The results are presented in Tables 6.5 to 6.14. Radionuclides were detected in fewer wells than in 1999. 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. Hydrogen-3 was detected in wells 317021, 317052, and 317121D, located south of the 317 Area. As in 1999, hydrogen-3 was also detected in wells 319011, 319031, 319032, and 319131D, which (except for well 319011) 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 1,330 pCi/L. It was also detected one quarter in upgradient well 319011. The infrequent presence of hydrogen-3 in this upgradient well may be due to a mounding effect of shallow groundwater from the 319 Landfill Area. Strontium-90 was detected 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 40,000 to 200,000 pCi/L in this vicinity were measured in 2000. 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 8,000 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 6,000 to 15,000 pCi/L immediately south of the vaults, to 300 to 400 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.

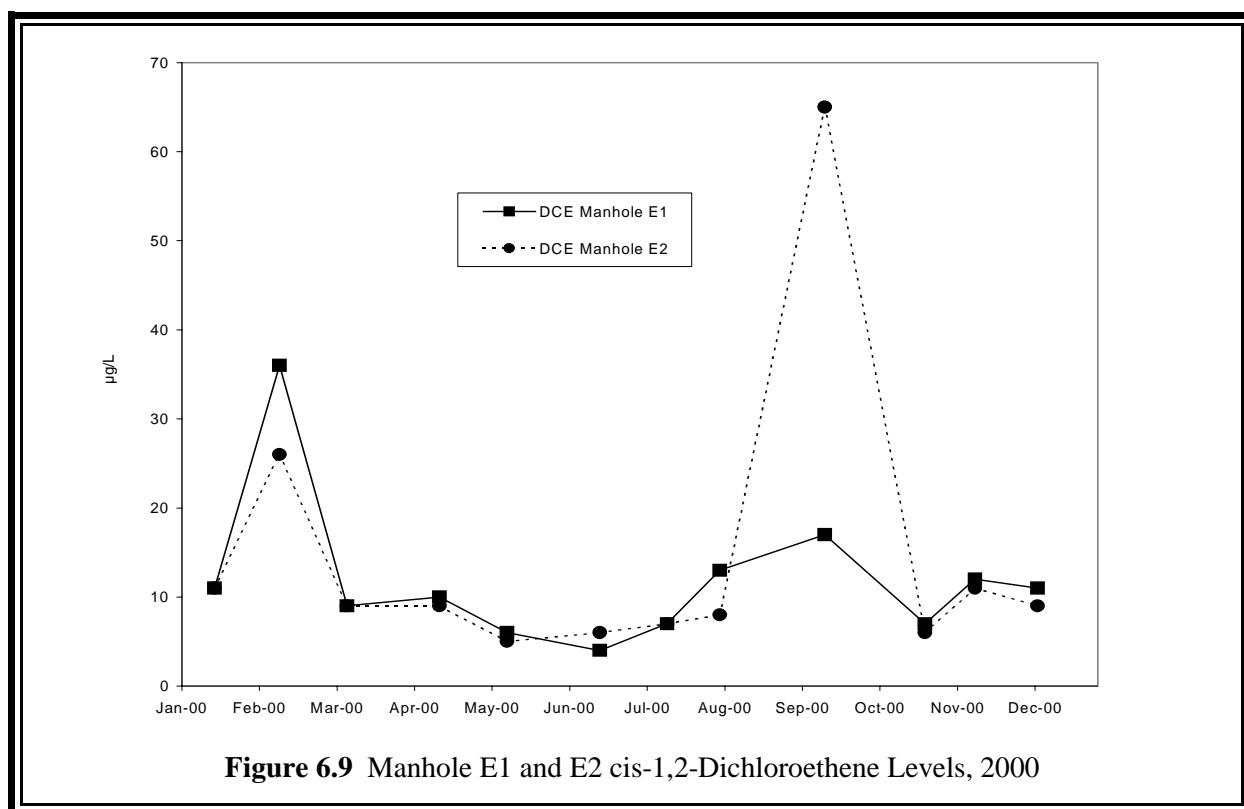
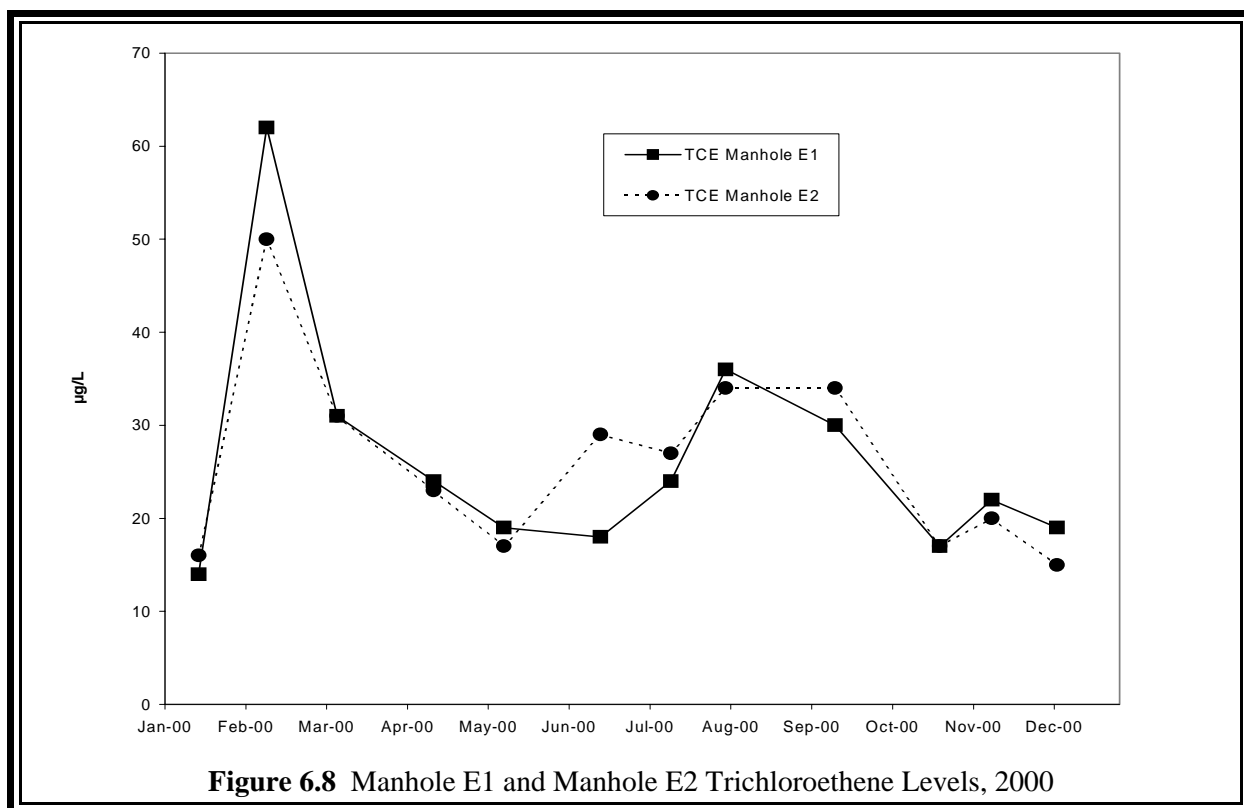
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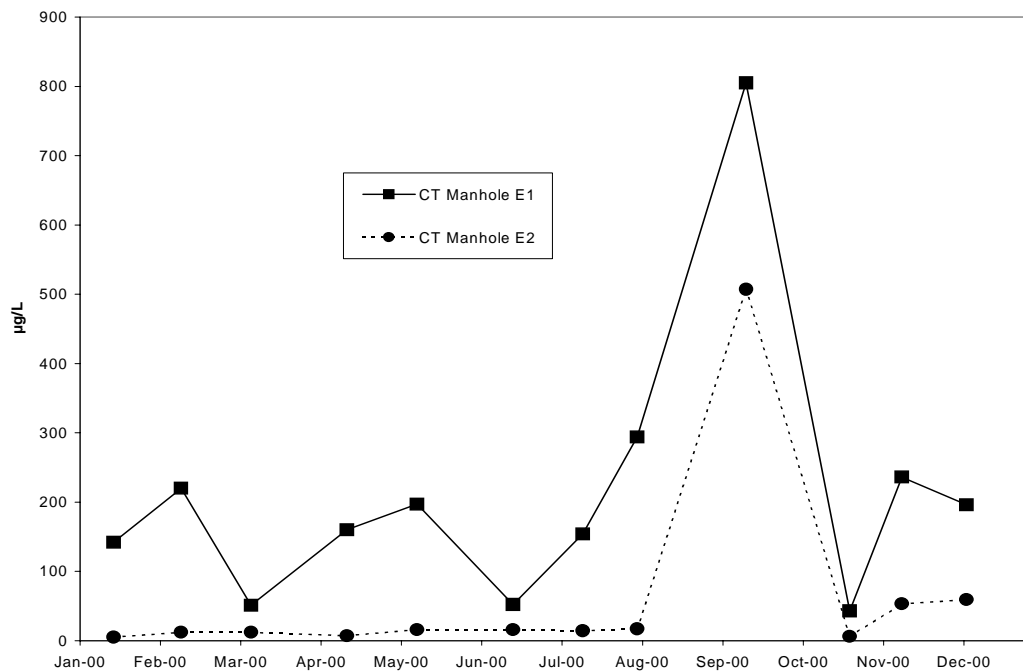


Figure 6.10 Manhole E1 and Manhole E2 Carbon Tetrachloride Levels, 2000

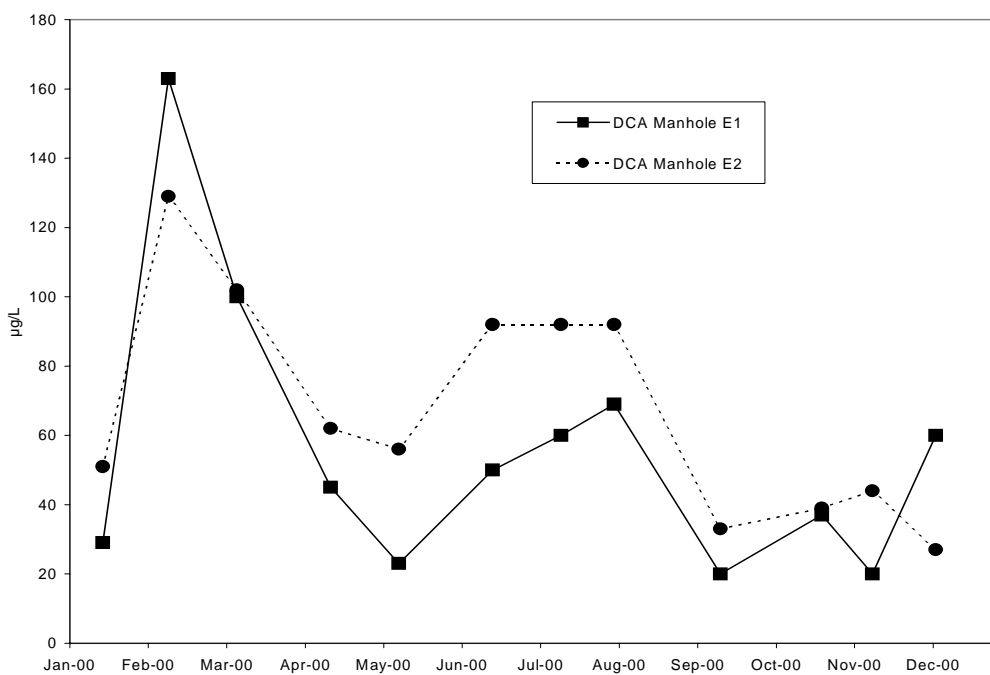
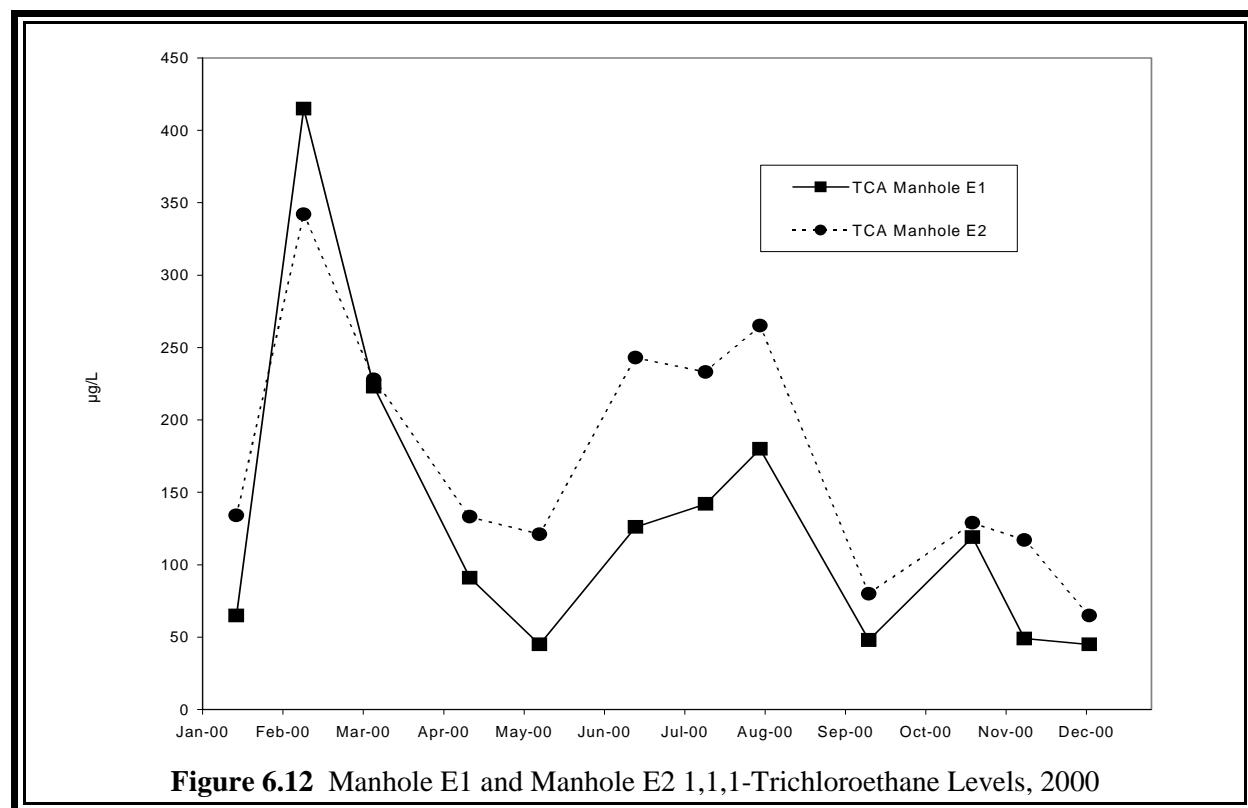


Figure 6.11 Manhole E1 and Manhole E2 1,1-Dichloroethane Levels, 2000

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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.

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.

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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.

TABLE 6.18

Hydrogen-3 Concentrations in Manhole
Water Samples, 2000
(concentrations in pCi/L)

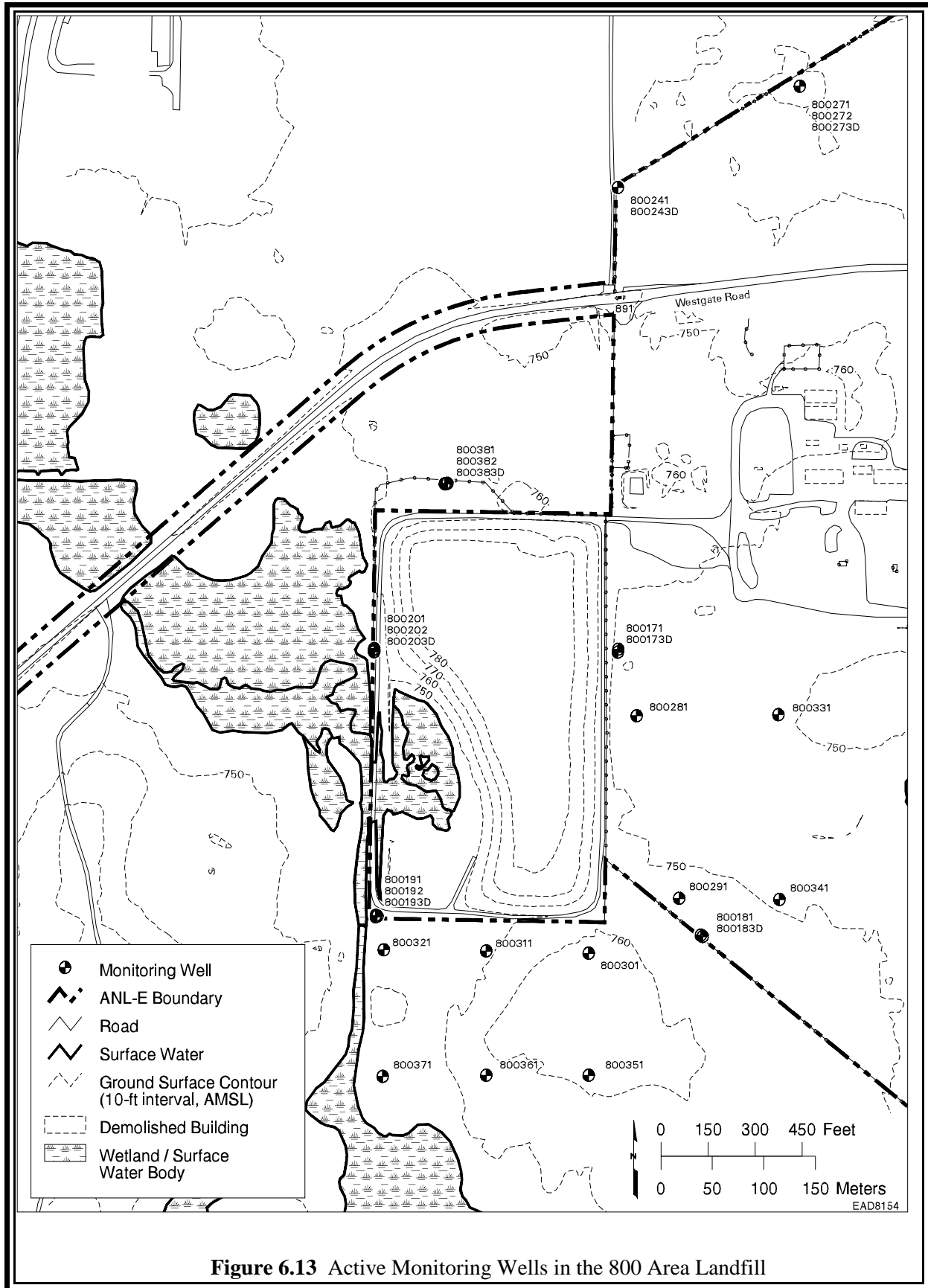
Date Collected	Manhole 1E	Manhole 2E
January 14	11,850	16,120
February 9	21,510	25,340
March 7	8,550	8,766
April 13	8,843	9,212
May 10	2,448	3,303
June 16	2,251	2,939
July 13	2,437	2,803
August 3	2,875	3,476
September 14	1,807	29,820
October 24	3,002	3,193
November 13	2,679	3,550
December 8	3,515	3,708

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). Wells 800241 and 800243D, installed during 1995, were formally incorporated into the 800 Area Landfill Groundwater Monitoring Program by IEPA Supplemental Permit No. 1998-017-SP, effective August 25, 1998. Review of the analytical data from these wells indicated that they were not appropriate for use as upgradient wells for the shallow and deep series wells. IEPA Supplemental Permit No. 1999-476-SP, effective April 25, 2000, provided for the removal of wells 800241 and 800243D from the 800 groundwater monitoring program. These two wells were sampled only one quarter in 2000.

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

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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
800241	4.90	226.1	224.3 – 221.3	0.05/SS	3/95
800243D	35.50	226.1	193.9 – 190.8	0.05/SS	4/95
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.

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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 ESH-ASCH, PFS-Utilities Laboratory, and ESH-ASRC. 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 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-846⁶ 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 ESH-ASRL. 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 6.45. 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. The intermediate wells have fewer exceedances except for manganese, which exceeded the WQS in two of the three intermediate wells. The iron WQS was exceeded in two wells. Chromium and nickel WQSs were exceeded in one intermediate well. The TDS WQS was exceeded only one quarter in one intermediate 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.

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TABLE 6.20

Groundwater Monitoring Results, Sanitary Landfill Well 800381, 2000

Parameter	Unit	Date of Sampling				
		01/17/00	04/18/00	04/18/00	07/18/00	10/25/00
Water elevation ^a	m	226.49	226.73	226.73	228.79	227.20
Temperature	°C	9.4	10.5	10.5	12.2	13.6
pH	pH	6.82	6.78	6.78	6.15	6.92
Redox	mV	15	17	17	42	7
Conductivity	µmhos/cm	1,660	1,567	1,567	1,511	1,526
Chloride ^b	mg/L	70	52	45	66	61
Sulfate ^b	mg/L	432	400	408	400	399
TDS ^b	mg/L	1,351	1,094	1,022	1,450	1,161
Cyanide (total) ^c	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic ^c	mg/L	^d	0.1582	0.1301	-	-
Barium ^c	mg/L	-	0.3805	0.2763	-	-
Boron ^c	mg/L	-	0.8185	0.5396	-	-
Cadmium ^c	mg/L	-	0.0023	0.0014	-	-
Chromium ^c	mg/L	-	0.1883	0.1229	-	-
Cobalt ^c	mg/L	-	0.1242	0.0795	-	-
Copper ^c	mg/L	-	0.5568	0.3213	-	-
Iron ^c	mg/L	-	324.5	213.3	-	-
Lead ^c	mg/L	-	0.2039	0.1282	-	-
Manganese ^c	mg/L	-	5.693	3.787	-	-
Mercury ^c	mg/L	-	< 0.0001	< 0.0001	-	-
Nickel ^c	mg/L	-	0.2897	0.1848	-	-
Selenium ^c	mg/L	-	0.002	< 0.002	-	-
Silver ^c	mg/L	-	0.0010	0.0008	-	-
Zinc ^c	mg/L	-	0.5939	0.3903	-	-
Ammonia nitrogen ^b	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	-
Arsenic ^b	mg/L	0.0078	0.0059	0.0065	< 0.0030	0.0096
Barium ^b	mg/L	0.0493	0.0530	0.0410	0.0549	0.0395
Beryllium ^b	mg/L	< 0.0001	< 0.0001	0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	0.0495	0.2132	0.1836	0.5524	0.5797
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.1950	0.1606	0.1251	0.1120	0.1180
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	0.0223	< 0.011
Nitrate ^c	mg/L	-	< 0.1	< 0.1	-	-
Phenols ^c	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	0.0054
Cesium-137 ^c	pCi/L	-	< 2.0	-	-	-
Hydrogen-3 ^c	pCi/L	< 100	< 100	< 100	< 100	< 100
Chloride ^c	mg/L	-	49	52	-	-
Fluoride ^c	mg/L	-	0.176	0.184	-	-
Sulfate ^c	mg/L	-	404	412	-	-
TOCs ^c	mg/L	4.3	2.4	2.1	3.6	3.6
TOCs ^c	mg/L	4.5	2.3	2.1	3.5	3.5
TOCs ^c	mg/L	4.4	2.3	2.1	3.5	3.6
TOCs ^c	mg/L	4.4	2.3	2.1	3.5	3.5
TOXs ^c	mg/L	0.045	0.024	0.042	0.021	0.019
TOXs ^c	mg/L	0.036	0.018	0.037	0.033	0.020

^a Well bottom 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.

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TABLE 6.21

Groundwater Monitoring Results, Sanitary Landfill Well 800382, 2000

Parameter	Unit	Date of Sampling			
		01/17/00	04/18/00	07/18/00	10/25/00
Water elevation ^a	m	218.58	218.32	219.48	219.09
Temperature	°C	8.3	11.4	11.8	11.3
pH	pH	6.55	6.81	6.36	7.00
Redox	mV	29	13	32	1
Conductivity	µmhos/cm	1,035	995	902	910
Chloride ^b	mg/L	79	76	76	79
Sulfate ^b	mg/L	67	69	55	56
TDS ^b	mg/L	605	675	745	622
Cyanide (total) ^c	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic ^c	mg/L	- ^d	0.0202	-	-
Barium ^c	mg/L	-	0.3697	-	-
Boron ^c	mg/L	-	0.4904	-	-
Cadmium ^c	mg/L	-	0.0023	-	-
Chromium ^c	mg/L	-	0.3333	-	-
Cobalt ^c	mg/L	-	0.0666	-	-
Copper ^c	mg/L	-	0.178	-	-
Iron ^c	mg/L	-	185.6	-	-
Lead ^c	mg/L	-	0.101	-	-
Manganese ^c	mg/L	-	3.635	-	-
Mercury ^c	mg/L	-	< 0.0001	-	-
Nickel ^c	mg/L	-	0.3009	-	-
Selenium ^c	mg/L	-	< 0.002	-	-
Silver ^c	mg/L	-	0.0012	-	-
Zinc ^c	mg/L	-	0.4743	-	-
Ammonia nitrogen ^b	mg/L	0.4	0.2	0.1	0.3
Arsenic ^b	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium ^b	mg/L	0.1126	0.1187	0.0983	0.1158
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	0.0516	0.1377	< 0.0370	0.9807
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.0913	0.0903	0.0759	0.1098
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
Nitrate ^c	mg/L	-	< 0.1	-	-
Phenols ^c	mg/L	< 0.005	< 0.005	< 0.005	0.0069
Hydrogen-3 ^c	pCi/L	< 100	< 100	< 100	< 100
Chloride ^c	mg/L	-	76	-	-
Fluoride ^c	mg/L	-	0.206	-	-
Sulfate ^c	mg/L	-	65	-	-
TOCs ^c	mg/L	3.4	1.9	2.6	2.8
TOCs ^c	mg/L	3.4	1.8	2.6	2.9
TOCs ^c	mg/L	3.4	1.8	2.5	2.9
TOCs ^c	mg/L	3.5	1.8	2.6	2.9
TOXs ^c	mg/L	0.012	0.022	0.019	0.056
TOXs ^c	mg/L	0.038	0.027	0.011	0.018

^a Well bottom 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.

6. GROUNDWATER PROTECTION

TABLE 6.22

Groundwater Monitoring Results, Sanitary Landfill Well 800383D, 2000

Parameter	Unit	Date of Sampling			
		01/17/00	04/18/00	07/18/00	10/25/00
Water elevation ^a	m	192.66	192.74	193.07	192.72
Temperature	°C	10.0	11.4	12.9	11.5
pH	pH	6.95	6.46	6.92	6.98
Redox	mV	7	36	12	1
Conductivity	µmhos/cm	1,296	1,285	1,157	1,156
Chloride ^b	mg/L	140	127	131	126
Sulfate ^b	mg/L	149	148	137	131
TDS ^b	mg/L	805	920	954	910
Cyanide (total) ^c	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic ^c	mg/L	- ^d	0.0097	-	-
Barium ^c	mg/L	-	0.0918	-	-
Boron ^c	mg/L	-	0.2028	-	-
Cadmium ^c	mg/L	-	0.0001	-	-
Chromium ^c	mg/L	-	< 0.044	-	-
Cobalt ^c	mg/L	-	< 0.026	-	-
Copper ^c	mg/L	-	0.0171	-	-
Iron ^c	mg/L	-	12.98	-	-
Lead ^c	mg/L	-	0.0068	-	-
Manganese ^c	mg/L	-	0.3014	-	-
Mercury ^c	mg/L	-	< 0.0001	-	-
Nickel ^c	mg/L	-	< 0.04	-	-
Selenium ^c	mg/L	-	< 0.002	-	-
Silver ^c	mg/L	-	0.0009	-	-
Zinc ^c	mg/L	-	0.0479	-	-
Ammonia nitrogen ^b	mg/L	0.7	0.6	0.6	0.7
Arsenic ^b	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium ^b	mg/L	0.0729	0.0719	0.0672	0.0723
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	1.064	1.203	1.332	1.691
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.063	0.0585	0.0542	0.0523
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
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	-	132	-	-
Fluoride ^c	mg/L	-	0.302	-	-
Sulfate ^c	mg/L	-	146	-	-
TOCs ^c	mg/L	2.0	1.0	1.5	1.4
TOCs ^c	mg/L	1.8	< 1.0	1.5	1.4
TOCs ^c	mg/L	1.7	1.0	1.4	1.4
TOCs ^c	mg/L	1.8	< 1.0	1.5	1.3
TOXs ^c	mg/L	0.014	0.047	0.013	0.017
TOXs ^c	mg/L	0.019	0.044	< 0.010	0.014
Chlorobenzene ^c	mg/L	2	< 1	< 1	< 1

^a Well bottom 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.

6. GROUNDWATER PROTECTION

TABLE 6.23

Groundwater Monitoring Results, Sanitary Landfill Well 800171, 2000

Parameter	Unit	Date of Sampling			
		01/11/00	04/12/00	07/11/00	10/11/00
Water elevation ^a	m	225.91	225.64	226.82	225.71
Temperature	°C	10.9	11.1	13.7	12.7
pH	pH	7.57	7.31	6.81	6.83
Redox	mV	-61	3	12	14
Conductivity	µmhos/cm	1,304	1,156	983	1,222
Chloride ^b	mg/L	22	22	12	18
Sulfate ^b	mg/L	188	188	186	177
TDS ^b	mg/L	891	860	720	804
Cyanide (total) ^c	mg/L	< 0.005	< 0.010	0.044	< 0.010
Arsenic ^c	mg/L	- ^d	< 0.003	-	-
Barium ^c	mg/L	-	0.0993	-	-
Boron ^c	mg/L	-	0.1328	-	-
Cadmium ^c	mg/L	-	0.0002	-	-
Chromium ^c	mg/L	-	< 0.044	-	-
Cobalt ^c	mg/L	-	< 0.026	-	-
Copper ^c	mg/L	-	< 0.0170	-	-
Iron ^c	mg/L	-	6.071	-	-
Lead ^c	mg/L	-	0.0051	-	-
Manganese ^c	mg/L	-	0.4173	-	-
Mercury ^c	mg/L	-	< 0.0001	-	-
Nickel ^c	mg/L	-	< 0.04	-	-
Selenium ^c	mg/L	-	< 0.002	-	-
Silver ^c	mg/L	-	0.0009	-	-
Zinc ^c	mg/L	-	0.0511	-	-
Ammonia nitrogen ^b	mg/L	< 0.1	< 0.1	< 0.1	-
Arsenic ^b	mg/L	< 0.003	< 0.003	0.0036	< 0.003
Barium ^b	mg/L	0.0630	0.0607	0.0494	0.0576
Beryllium ^b	mg/L	< 0.0001	0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	0.0624	0.1321	< 0.037	< 0.037
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.2371	0.2442	0.2304	0.2826
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	0.0466	0.0656	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
Nitrate ^c	mg/L	-	< 0.1	-	-
Phenols ^c	mg/L	< 0.005	< 0.005	0.006	< 0.005
Cesium-137 ^c	pCi/L	-	< 2.0	-	-
Hydrogen-3 ^c	pCi/L	< 100	109	< 100	124
Chloride ^c	mg/L	-	21	-	-
Fluoride ^c	mg/L	-	0.118	-	-
Sulfate ^c	mg/L	-	191	-	-
TOCs ^c	mg/L	3.1	2.7	3.1	2.3
TOCs ^c	mg/L	3.2	2.6	3.0	2.4
TOCs ^c	mg/L	3.2	2.7	2.9	2.4
TOCs ^c	mg/L	3.2	2.6	3.1	2.4
TOXs ^c	mg/L	0.029	0.025	0.017	0.017
TOXs ^c	mg/L	0.011	0.021	0.015	0.018
Chloroethane ^c	µg/L	< 1	< 1	< 1	1
Trichloroethene ^c	µg/L	1	1	< 1	1

^a Well bottom 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.

6. GROUNDWATER PROTECTION

TABLE 6.24

Groundwater Monitoring Results, Sanitary Landfill Well 800173D, 2000

Parameter	Unit	Date of Sampling			
		01/11/00	04/12/00	07/11/00	10/11/00
Water elevation ^a	m	192.14	191.85	192.32	191.97
Temperature	°C	10.6	10.8	13.0	12.3
pH	pH	7.88	7.16	6.86	7.14
Redox	mV	-39	-1	9	-4
Conductivity	µmhos/cm	1,303	1,150	1,148	1,283
Chloride ^b	mg/L	153	134	150	141
Sulfate ^b	mg/L	90	88	101	94
TDS ^b	mg/L	818	829	969	864
Cyanide (total) ^c	mg/L	< 0.005	< 0.01	< 0.01	< 0.01
Arsenic ^c	mg/L	- ^d	0.0049	-	-
Barium ^c	mg/L	-	0.0832	-	-
Boron ^c	mg/L	-	0.1732	-	-
Cadmium ^c	mg/L	-	0.0005	-	-
Chromium ^c	mg/L	-	< 0.044	-	-
Cobalt ^c	mg/L	-	< 0.026	-	-
Copper ^c	mg/L	-	< 0.017	-	-
Iron ^c	mg/L	-	2.852	-	-
Lead ^c	mg/L	-	< 0.002	-	-
Manganese ^c	mg/L	-	0.0724	-	-
Mercury ^c	mg/L	-	< 0.0001	-	-
Nickel ^c	mg/L	-	< 0.04	-	-
Selenium ^c	mg/L	-	< 0.002	-	-
Silver ^c	mg/L	-	0.0007	-	-
Zinc ^c	mg/L	-	0.147	-	-
Ammonia nitrogen ^b	mg/L	0.6	0.7	0.7	0.7
Arsenic ^b	mg/L	0.0038	< 0.003	0.004	< 0.003
Barium ^b	mg/L	0.0865	0.0798	0.0860	0.0764
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	1.762	1.630	2.455	1.103
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.0800	0.0816	0.0718	0.0696
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
Nitrate ^c	mg/L	-	< 0.1	-	-
Phenols ^c	mg/L	< 0.005	< 0.005	0.006	< 0.005
Hydrogen-3 ^c	pCi/L	< 100	< 100	< 100	< 100
Chloride ^c	mg/L	-	153	-	-
Fluoride ^c	mg/L	-	0.332	-	-
Sulfate ^c	mg/L	-	94	-	-
TOCs ^c	mg/L	3.4	3.0	2.4	2.2
TOCs ^c	mg/L	3.2	2.4	2.5	2.3
TOCs ^c	mg/L	3.0	2.9	2.5	2.2
TOCs ^c	mg/L	3.4	1.6	2.5	2.3
TOXs ^c	mg/L	0.011	0.029	0.025	0.040
TOXs ^c	mg/L	0.022	0.021	0.027	0.021

^a Well bottom 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.

6. GROUNDWATER PROTECTION

TABLE 6.25

Groundwater Monitoring Results, Sanitary Landfill Well 800181, 2000

Parameter	Unit	Date of Sampling				
		01/11/00	04/12/00	07/11/00	07/11/00	10/10/00
Water elevation ^a	m	220.75	221.46	228.92	228.92	221.01
Temperature	°C	9.1	10.4	11.4	11.4	10.2
pH	pH	7.38	6.99	6.80	6.80	6.94
Redox	mV	-23	7	18	18	5
Conductivity	µmhos/cm	1,170	1,051	788	788	1,060
Chloride ^b	mg/L	5	6	4	2	7
Sulfate ^b	mg/L	208	192	206	202	196
TDS ^b	mg/L	796	901	606	608	696
Cyanide (total) ^c	mg/L	< 0.005	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic ^c	mg/L	- ^d	0.0101	-	-	-
Barium ^c	mg/L	-	0.2787	-	-	-
Boron ^c	mg/L	-	0.1365	-	-	-
Cadmium ^c	mg/L	-	0.0002	-	-	-
Chromium ^c	mg/L	-	< 0.044	-	-	-
Cobalt ^c	mg/L	-	< 0.026	-	-	-
Copper ^c	mg/L	-	0.0298	-	-	-
Iron ^c	mg/L	-	29.23	-	-	-
Lead ^c	mg/L	-	0.0143	-	-	-
Manganese ^c	mg/L	-	0.8267	-	-	-
Mercury ^c	mg/L	-	< 0.0001	-	-	-
Nickel ^c	mg/L	-	< 0.04	-	-	-
Selenium ^c	mg/L	-	< 0.002	-	-	-
Silver ^c	mg/L	-	0.0008	-	-	-
Zinc ^c	mg/L	-	0.0895	-	-	-
Ammonia nitrogen ^b	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	-
Arsenic ^b	mg/L	< 0.0030	0.0031	0.0084	0.0076	0.0049
Barium ^b	mg/L	0.0851	0.0557	< 0.0180	< 0.0180	0.0339
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	0.0010	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	0.0209	< 0.011	< 0.011	< 0.011	< 0.011
Nitrate ^c	mg/L	-	< 0.1	-	-	-
Phenols ^c	mg/L	< 0.005	< 0.005	0.006	< 0.005	0.014
Hydrogen-3 ^c	pCi/L	< 100	< 100	< 100	< 100	< 100
Chloride ^c	mg/L	-	5	-	-	-
Fluoride ^c	mg/L	-	0.238	-	-	-
Sulfate ^c	mg/L	-	200	-	-	-
TOCs ^c	mg/L	1.8	1.9	2.2	2.1	1.9
TOCs ^c	mg/L	1.7	1.9	2.2	2.1	1.9
TOCs ^c	mg/L	1.7	2.0	2.2	2.2	2.0
TOCs ^c	mg/L	1.7	1.9	2.2	2.3	1.9
TOXs ^c	mg/L	< 0.010	0.029	< 0.010	< 0.010	0.016
TOXs ^c	mg/L	< 0.010	0.012	0.013	< 0.010	< 0.010

^a Well bottom 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.

6. GROUNDWATER PROTECTION

TABLE 6.26

Groundwater Monitoring Results, Sanitary Landfill Well 800183D, 2000

Parameter	Unit	Date of Sampling				
		01/11/00	01/11/00	4/12/00	07/11/00	10/10/00
Water elevation ^a	m	192.11	192.11	191.85	192.31	192.00
Temperature	°C	9.1	9.1	10.7	12.0	11.4
pH	pH	7.43	7.43	7.24	6.73	7.06
Redox	mV	-16	-16	6	27	0
Conductivity	µmhos/cm	1,254	1,254	1,109	1,091	1,257
Chloride ^b	mg/L	111	111	106	95	116
Sulfate ^b	mg/L	188	192	192	202	196
TDS ^b	mg/L	789	794	799	858	844
Cyanide (total) ^c	mg/L	< 0.005	< 0.005	< 0.010	< 0.010	< 0.010
Arsenic ^c	mg/L	- ^d	-	< 0.003	-	-
Barium ^c	mg/L	-	-	0.0432	-	-
Boron ^c	mg/L	-	-	0.1919	-	-
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	-	-	0.997	-	-
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	-	-	0.0008	-	-
Zinc ^c	mg/L	-	-	0.098	-	-
Ammonia nitrogen ^b	mg/L	0.7	0.7	0.9	0.8	0.8
Arsenic ^b	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Barium ^b	mg/L	0.0482	0.0497	0.0455	0.0425	0.0433
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	0.8101	0.6793	0.5186	0.3617	0.7599
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	0.0011	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011
Nitrate ^c	mg/L	-	-	< 0.1	-	-
Phenols ^c	mg/L	< 0.005	< 0.005	0.006	0.009	0.011
Hydrogen-3 ^c	pCi/L	< 100	< 100	< 100	< 100	< 100
Chloride ^c	mg/L	-	-	104	-	-
Fluoride ^c	mg/L	-	-	0.32	-	-
Sulfate ^c	mg/L	-	-	196	-	-
TOCs ^c	mg/L	2.6	2.4	2.3	2.0	2.2
TOCs ^c	mg/L	2.5	2.4	2.1	2.1	2.2
TOCs ^c	mg/L	2.4	2.4	2.2	2.0	2.3
TOCs ^c	mg/L	2.4	2.4	2.2	2.0	2.3
TOXs ^c	mg/L	0.017	0.016	0.012	0.022	0.018
TOXs ^c	mg/L	0.017	0.025	0.015	0.018	0.010
Carbon disulfide ^c	µg/L	3	1	< 1	< 1	< 1

^a Well bottom 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.

6. GROUNDWATER PROTECTION

TABLE 6.27

Groundwater Monitoring Results, Sanitary Landfill Well 800191, 2000

Parameter	Unit	Date of Sampling			
		01/10/00	04/13/00	07/11/00	10/25/00
Water elevation ^a	m	225.00	224.97	225.90	224.73
Temperature	°C	9.6	12.3	12.0	13.2
pH	pH	6.88	6.62	6.95	6.72
Redox	mV	17	20	7	26
Conductivity	µmhos/cm	2,080	1,874	1,745	1,520
Chloride ^b	mg/L	356	344	244	300
Sulfate ^b	mg/L	200	204	186	153
TDS ^b	mg/L	1,347	1,330	1,504	1,067
Cyanide (total) ^c	mg/L	< 0.005	< 0.01	< 0.01	< 0.01
Arsenic ^c	mg/L	- ^d	0.0071	-	-
Barium ^c	mg/L	-	0.2093	-	-
Boron ^c	mg/L	-	0.1629	-	-
Cadmium ^c	mg/L	-	0.0004	-	-
Chromium ^c	mg/L	-	< 0.044	-	-
Cobalt ^c	mg/L	-	< 0.026	-	-
Copper ^c	mg/L	-	0.0304	-	-
Iron ^c	mg/L	-	33.86	-	-
Lead ^c	mg/L	-	0.016	-	-
Manganese ^c	mg/L	-	1.486	-	-
Mercury ^c	mg/L	-	< 0.0001	-	-
Nickel ^c	mg/L	-	< 0.04	-	-
Selenium ^c	mg/L	-	< 0.002	-	-
Silver ^c	mg/L	-	0.0014	-	-
Zinc ^c	mg/L	-	0.0782	-	-
Ammonia nitrogen ^b	mg/L	0.6	0.4	0.4	0.5
Arsenic ^b	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium ^b	mg/L	0.0805	0.0732	0.0739	0.0670
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	0.0002	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	2.9880	2.0290	1.9600	0.8547
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	1.404	1.147	1.647	1.217
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
Nitrate ^c	mg/L	-	< 0.1	-	-
Phenols ^c	mg/L	< 0.005	0.008	0.010	0.005
Cesium-137 ^c	pCi/L	-	< 2.0	-	-
Hydrogen-3 ^c	pCi/L	126	111	119	< 100
Chloride ^c	mg/L	-	331	-	-
Fluoride ^c	mg/L	-	0.216	-	-
Sulfate ^c	mg/L	-	196	-	-
TOCs ^c	mg/L	9.1	7.6	6.9	6.7
TOCs ^c	mg/L	8.6	7.7	6.9	6.6
TOCs ^c	mg/L	9.1	7.8	7.0	6.6
TOCs ^c	mg/L	9.5	7.5	6.8	6.7
TOXs ^c	mg/L	0.035	0.190	0.055	0.038
TOXs ^c	mg/L	0.049	0.058	0.041	0.064

^a Well bottom 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.

6. GROUNDWATER PROTECTION

TABLE 6.28

Groundwater Monitoring Results, Sanitary Landfill Well 800192, 2000

Parameter	Unit	Date of Sampling			
		01/10/00	04/13/00	07/11/00	10/25/00
Water elevation ^a	m	221.06	221.13	221.63	220.17
Temperature	°C	9.7	12.1	13.1	11.9
pH	pH	7.20	6.61	7.13	6.65
Redox	mV	2	24	-4	35
Conductivity	µmhos/cm	1,472	1,290	1,289	1,338
Chloride ^b	mg/L	125	75	81	156
Sulfate ^b	mg/L	112	110	121	90
TDS ^b	mg/L	1,011	1,045	1,268	1,043
Cyanide (total) ^c	mg/L	< 0.005	< 0.01	< 0.01	< 0.01
Arsenic ^c	mg/L	- ^d	0.0051	-	-
Barium ^c	mg/L	-	0.4531	-	-
Boron ^c	mg/L	-	0.081	-	-
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	-	14.34	-	-
Lead ^c	mg/L	-	< 0.002	-	-
Manganese ^c	mg/L	-	0.1883	-	-
Mercury ^c	mg/L	-	< 0.0001	-	-
Nickel ^c	mg/L	-	< 0.04	-	-
Selenium ^c	mg/L	-	< 0.002	-	-
Silver ^c	mg/L	-	0.001	-	-
Zinc ^c	mg/L	-	0.0163	-	-
Ammonia nitrogen ^b	mg/L	0.9	1.0	0.6	1.0
Arsenic ^b	mg/L	< 0.003	0.0033	< 0.003	< 0.003
Barium ^b	mg/L	0.4382	0.4434	0.3728	0.4516
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	7.019	13.930	4.643	11.990
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.1627	0.1991	0.0920	0.2030
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
Nitrate ^c	mg/L	-	< 0.1	-	-
Phenols ^c	mg/L	< 0.005	0.010	< 0.005	0.0081
Cesium-137 ^c	pCi/L	-	< 2.0	-	-
Hydrogen-3 ^c	pCi/L	346	483	435	404
Chloride ^c	mg/L	-	69	-	-
Fluoride ^c	mg/L	-	0.194	-	-
Sulfate ^c	mg/L	-	110	-	-
TOCs ^c	mg/L	9.7	9.3	8.2	9.4
TOCs ^c	mg/L	9.7	9.1	8.2	9.4
TOCs ^c	mg/L	9.6	9.2	8.2	9.5
TOCs ^c	mg/L	9.5	9.2	8.1	9.4
TOXs ^c	mg/L	0.018	0.016	0.029	0.024
TOXs ^c	mg/L	0.015	0.011	0.017	0.021

^a Well bottom 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.

6. GROUNDWATER PROTECTION

TABLE 6.29

Groundwater Monitoring Results, Sanitary Landfill Well 800193D, 2000

Parameter	Unit	Date of Sampling			
		01/10/00	04/13/00	07/11/00	10/25/00
Water elevation ^a	m	192.27	191.90	192.30	191.98
Temperature	°C	9.6	12.4	11.8	11.6
pH	pH	7.01	6.72	7.03	6.87
Redox	mV	7	20	-1	8
Conductivity	µmhos/cm	1,155	1,130	1,132	1,205
Chloride ^b	mg/L	107	94	101	149
Sulfate ^b	mg/L	192	183	176	172
TDS ^b	mg/L	845	843	995	856
Cyanide (total) ^c	mg/L	< 0.005	< 0.01	< 0.01	< 0.01
Arsenic ^c	mg/L	- ^d	< 0.003	-	-
Barium ^c	mg/L	-	0.0543	-	-
Boron ^c	mg/L	-	0.1735	-	-
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	-	1.225	-	-
Lead ^c	mg/L	-	< 0.002	-	-
Manganese ^c	mg/L	-	0.0223	-	-
Mercury ^c	mg/L	-	< 0.0001	-	-
Nickel ^c	mg/L	-	< 0.04	-	-
Selenium ^c	mg/L	-	< 0.002	-	-
Silver ^c	mg/L	-	0.0008	-	-
Zinc ^c	mg/L	-	0.0363	-	-
Ammonia nitrogen ^b	mg/L	0.5	0.7	0.7	0.6
Arsenic ^b	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium ^b	mg/L	0.0584	0.0574	0.0574	0.0626
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	0.8576	1.0490	0.4672	1.0120
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.0274	0.0214	0.0249	0.0213
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	0.0006	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
Nitrate ^c	mg/L	-	< 0.1	-	-
Phenols ^c	mg/L	< 0.005	< 0.005	0.008	0.006
Hydrogen-3 ^c	pCi/L	< 100	< 100	< 100	< 100
Chloride ^c	mg/L	-	97	-	-
Fluoride ^c	mg/L	-	0.314	-	-
Sulfate ^c	mg/L	-	175	-	-
TOCs ^c	mg/L	2.6	2.3	2.8	2.8
TOCs ^c	mg/L	2.6	2.2	2.8	2.6
TOCs ^c	mg/L	2.6	2.3	2.9	2.7
TOCs ^c	mg/L	2.6	2.2	2.8	2.7
TOXs ^c	mg/L	0.025	0.015	0.039	0.025
TOXs ^c	mg/L	0.022	< 0.010	0.039	< 0.010

^a Well bottom 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.

6. GROUNDWATER PROTECTION

TABLE 6.30

Groundwater Monitoring Results, Sanitary Landfill Well 800201, 2000

Parameter	Unit	Date of Sampling				
		01/10/00	04/17/00	07/11/00	10/19/00	10/19/00
Water elevation ^a	m	223.24	223.32	224.37	223.69	223.69
Temperature	°C	10.2	10.1	11.9	11.0	11.0
pH	pH	7.17	6.54	7.14	7.12	7.12
Redox	mV	-1	30	-5	-4	-4
Conductivity	µmhos/cm	1,111	1,097	962	1,109	1,109
Chloride ^b	mg/L	9	9	10	8	9
Sulfate ^b	mg/L	66	67	76	67	67
TDS ^b	mg/L	759	763	759	740	747
Cyanide (total) ^c	mg/L	< 0.005	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic ^c	mg/L	- ^d	0.0212	-	-	-
Barium ^c	mg/L	-	0.3065	-	-	-
Boron ^c	mg/L	-	0.1133	-	-	-
Cadmium ^c	mg/L	-	0.0003	-	-	-
Chromium ^c	mg/L	-	0.0856	-	-	-
Cobalt ^c	mg/L	-	< 0.026	-	-	-
Copper ^c	mg/L	-	0.0215	-	-	-
Iron ^c	mg/L	-	21.17	-	-	-
Lead ^c	mg/L	-	0.0144	-	-	-
Manganese ^c	mg/L	-	1.013	-	-	-
Mercury ^c	mg/L	-	< 0.0001	-	-	-
Nickel ^c	mg/L	-	0.0508	-	-	-
Selenium ^c	mg/L	-	< 0.002	-	-	-
Silver ^c	mg/L	-	< 0.0005	-	-	-
Zinc ^c	mg/L	-	0.0975	-	-	-
Ammonia nitrogen ^b	mg/L	2.0	0.5	2.0	3.5	3.5
Arsenic ^b	mg/L	< 0.003	< 0.003	0.0031	0.0075	0.0073
Barium ^b	mg/L	0.2443	0.2139	0.2066	0.2776	0.2573
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	0.5346	0.1303	0.0874	2.6590	1.6330
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.6308	0.4120	0.7153	0.4961	0.5161
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	0.0135	< 0.011	< 0.011	< 0.011	< 0.011
Nitrate ^c	mg/L	-	1.9	-	-	-
Phenols ^c	mg/L	< 0.005	0.025	< 0.005	0.014	0.022
Hydrogen-3 ^c	pCi/L	< 100	< 100	< 100	< 100	< 100
Chloride ^c	mg/L	-	9	-	-	-
Fluoride ^c	mg/L	-	0.152	-	-	-
Sulfate ^c	mg/L	-	65	-	-	-
TOCs ^c	mg/L	31.7	20.0	28.9	27.4	27.6
TOCs ^c	mg/L	31.5	20.2	29.0	27.7	27.7
TOCs ^c	mg/L	31.2	20.3	28.9	27.6	27.6
TOCs ^c	mg/L	31.5	20.0	29.0	27.9	27.4
TOXs ^c	mg/L	< 0.01	< 0.01	0.016	< 0.02	< 0.02
TOXs ^c	mg/L	< 0.01	< 0.01	0.011	< 0.02	< 0.02
Acetone ^c	µg/L	< 1	< 1	< 1	3	4

^a Well bottom 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.

6. GROUNDWATER PROTECTION

TABLE 6.31

Groundwater Monitoring Results, Sanitary Landfill Well 800202, 2000

Parameter	Unit	Date of Sampling			
		01/10/00	04/17/00	07/11/00	10/25/00
Water elevation ^a	m	217.56	217.25	218.13	217.72
Temperature	°C	10.0	10.5	12.3	12.4
pH	pH	7.39	6.67	7.23	6.94
Redox	mV	-14	21	-11	5
Conductivity	µmhos/cm	1,084	1,031	918	940
Chloride ^b	mg/L	15	15	16	15
Sulfate ^b	mg/L	75	74	70	46
TDS ^b	mg/L	688	683	689	660
Cyanide (total) ^c	mg/L	< 0.005	< 0.01	< 0.01	< 0.01
Arsenic ^c	mg/L	- ^d	0.0101	-	-
Barium ^c	mg/L	-	0.1984	-	-
Boron ^c	mg/L	-	0.0986	-	-
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	-	6.869	-	-
Lead ^c	mg/L	-	< 0.002	-	-
Manganese ^c	mg/L	-	0.1496	-	-
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	-	0.0172	-	-
Ammonia nitrogen ^b	mg/L	1.5	2.5	1.5	2.5
Arsenic ^b	mg/L	0.0080	0.0059	0.0067	0.0034
Barium ^b	mg/L	0.2118	0.2070	0.1650	0.1754
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	6.52	5.551	5.161	4.823
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.1697	0.1359	0.1466	0.1467
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
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	-	14	-	-
Fluoride ^c	mg/L	-	0.196	-	-
Sulfate ^c	mg/L	-	73	-	-
TOCs ^c	mg/L	15.5	11.7	12.5	11.5
TOCs ^c	mg/L	15.3	11.4	12.2	11.2
TOCs ^c	mg/L	16.2	11.4	12.5	11.5
TOCs ^c	mg/L	15.6	11.4	12.5	11.5
TOXs ^c	mg/L	0.010	0.021	< 0.010	0.014
TOXs ^c	mg/L	< 0.010	0.016	0.013	0.010

^a Well bottom elevation = 209.41 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.

6. GROUNDWATER PROTECTION

TABLE 6.32

Groundwater Monitoring Results, Sanitary Landfill Well 800203D, 2000

Parameter	Unit	Date of Sampling			
		01/10/00	04/17/00	07/11/00	10/25/00
Water elevation ^a	m	192.34	191.99	192.37	192.06
Temperature	°C	10.5	10.5	13.0	11.6
pH	pH	7.31	6.44	7.32	6.96
Redox	mV	-6	34	-16	6
Conductivity	µmhos/cm	1,019	1,045	980	927
Chloride ^b	mg/L	41	51	56	61
Sulfate ^b	mg/L	70	158	63	26
TDS ^b	mg/L	620	641	656	634
Cyanide (total) ^c	mg/L	< 0.005	< 0.01	< 0.01	< 0.01
Arsenic ^c	mg/L	- ^d	< 0.003	-	-
Barium ^c	mg/L	-	0.1015	-	-
Boron ^c	mg/L	-	0.2011	-	-
Cadmium ^c	mg/L	-	< 0.0001	-	-
Chromium ^c	mg/L	-	< 0.044	-	-
Cobalt ^c	mg/L	-	0.0813	-	-
Copper ^c	mg/L	-	< 0.017	-	-
Iron ^c	mg/L	-	0.1326	-	-
Lead ^c	mg/L	-	< 0.002	-	-
Manganese ^c	mg/L	-	0.0282	-	-
Mercury ^c	mg/L	-	< 0.0001	-	-
Nickel ^c	mg/L	-	< 0.04	-	-
Selenium ^c	mg/L	-	< 0.002	-	-
Silver ^c	mg/L	-	0.0011	-	-
Zinc ^c	mg/L	-	0.0207	-	-
Ammonia nitrogen ^b	mg/L	1.0	0.7	1.5	1.5
Arsenic ^b	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium ^b	mg/L	0.1175	0.1106	0.1145	0.1133
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	0.0390	0.0456	0.0532	0.0685
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	0.4186	0.5305	0.4456	0.4281
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.0279	0.0274	0.0472	0.0379
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
Nitrate ^c	mg/L	-	< 0.1	-	-
Phenols ^c	mg/L	0.010	0.008	0.005	< 0.005
Hydrogen-3 ^c	pCi/L	< 100	< 100	< 100	< 100
Chloride ^c	mg/L	-	56	-	-
Fluoride ^c	mg/L	-	0.336	-	-
Sulfate ^c	mg/L	-	161	-	-
TOCs ^c	mg/L	4.6	3.0	4.6	4.5
TOCs ^c	mg/L	4.4	3.0	4.6	4.6
TOCs ^c	mg/L	4.6	3.0	4.6	4.5
TOCs ^c	mg/L	4.8	3.0	4.6	4.6
TOXs ^c	mg/L	0.015	0.024	0.018	0.016
TOXs ^c	mg/L	< 0.010	< 0.010	0.027	0.019

^a Well bottom 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.

6. GROUNDWATER PROTECTION

TABLE 6.33

Groundwater Monitoring Results, Sanitary Landfill
Well 800241, 2000

Parameter	Unit	Date of Sampling	
		01/17/00	05/01/00
Water elevation ^a	m	224.13	224.80
Temperature	°C	7.6	9.4
pH	pH	7.32	6.63
Redox	mV	0	24
Conductivity	µmhos/cm	1,357	1,440
Chloride ^b	mg/L	200	350
Sulfate ^b	mg/L	157	161
TDS ^b	mg/L	800	1,089
Cyanide (total) ^c	mg/L	< 0.01	< 0.01
Arsenic ^c	mg/L	- ^d	< 0.004
Barium ^c	mg/L	-	0.1961
Boron ^c	mg/L	-	0.1783
Cadmium ^c	mg/L	-	< 0.0002
Chromium ^c	mg/L	-	2.376
Cobalt ^c	mg/L	-	0.0309
Copper ^c	mg/L	-	0.0601
Iron ^c	mg/L	-	62.4
Lead ^c	mg/L	-	< 0.1
Manganese ^c	mg/L	-	1.348
Mercury ^c	mg/L	-	< 0.0001
Nickel ^c	mg/L	-	0.7202
Selenium ^c	mg/L	-	< 0.005
Silver ^c	mg/L	-	< 0.02
Zinc ^c	mg/L	-	0.1813
Ammonia nitrogen ^b	mg/L	< 0.1	< 0.1
Arsenic ^b	mg/L	< 0.003	< 0.003
Barium ^b	mg/L	0.0419	0.0574
Beryllium ^b	mg/L	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017
Iron ^b	mg/L	0.2419	0.3674
Lead ^b	mg/L	< 0.002	< 0.002
Manganese ^b	mg/L	0.1753	0.2775
Mercury ^b	mg/L	< 0.0001	< 0.0001
Nickel ^b	mg/L	0.2358	0.2705
Silver ^b	mg/L	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011
Nitrate ^c	mg/L	-	0.29
Phenols ^c	mg/L	0.068	< 0.01
Hydrogen-3 ^c	pCi/L	< 100	< 100
Chloride ^c	mg/L	-	312
Fluoride ^c	mg/L	-	0.18
Sulfate ^c	mg/L	-	157
TOCs ^c	mg/L	1.9	1.5
TOCs ^c	mg/L	1.8	1.4
TOCs ^c	mg/L	1.9	1.5
TOCs ^c	mg/L	1.9	1.5
TOXs ^c	mg/L	0.070	0.022
TOXs ^c	mg/L	0.092	0.021

^a Well bottom elevation = 221.15 m (MSL); ground surface elevation = 226.10 m (MSL); casing material = stainless steel.

^b Filtered sample.

^c Unfiltered sample.

^d A hyphen indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.34

Groundwater Monitoring Results, Sanitary Landfill
Well 800243D, 2000

Parameter	Unit	Date of Sampling	
		01/17/00	05/01/00
Water elevation ^a	m	191.62	191.76
Temperature	°C	9.7	11.1
pH	pH	6.90	6.46
Redox	mV	9	20
Conductivity	µmhos/cm	713	622
Chloride ^b	mg/L	13	9
Sulfate ^b	mg/L	159	42
TDS ^b	mg/L	446	455
Cyanide (total) ^c	mg/L	< 0.01	< 0.01
Arsenic ^c	mg/L	- ^d	< 0.004
Barium ^c	mg/L	-	0.1848
Boron ^c	mg/L	-	0.2327
Cadmium ^c	mg/L	-	< 0.0002
Chromium ^c	mg/L	-	< 0.044
Cobalt ^c	mg/L	-	< 0.026
Copper ^c	mg/L	-	< 0.017
Iron ^c	mg/L	-	12.7
Lead ^c	mg/L	-	< 0.1
Manganese ^c	mg/L	-	0.9938
Mercury ^c	mg/L	-	< 0.0001
Nickel ^c	mg/L	-	< 0.04
Selenium ^c	mg/L	-	< 0.005
Silver ^c	mg/L	-	< 0.02
Zinc ^c	mg/L	-	0.0485
Ammonia nitrogen ^b	mg/L	0.4	0.2
Arsenic ^b	mg/L	< 0.003	< 0.003
Barium ^b	mg/L	0.1298	0.1447
Beryllium ^b	mg/L	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017
Iron ^b	mg/L	0.4099	0.2878
Lead ^b	mg/L	< 0.002	< 0.002
Manganese ^b	mg/L	0.4577	0.4504
Mercury ^b	mg/L	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011
Nitrate ^c	mg/L	-	< 0.1
Phenols ^c	mg/L	< 0.005	< 0.01
Hydrogen-3 ^c	pCi/L	< 100	< 100
Chloride ^c	mg/L	-	10
Fluoride ^c	mg/L	-	0.386
Sulfate ^c	mg/L	-	39
TOCs ^c	mg/L	2.0	1.5
TOCs ^c	mg/L	2.0	1.5
TOCs ^c	mg/L	2.1	1.4
TOCs ^c	mg/L	2.0	1.6
TOXs ^c	mg/L	0.014	< 0.01
TOXs ^c	mg/L	0.011	< 0.01
Toluene ^c	µg/L	1	< 1

^a Well bottom elevation = 190.56 m (MSL); ground surface elevation = 226.10 m (MSL); casing material = stainless steel.

^b Filtered sample.

^c Unfiltered sample.

^d A hyphen indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.35

Groundwater Monitoring Results, Sanitary Landfill Well 800271, 2000

Parameter	Unit	Date of Sampling			
		01/17/00	04/25/00	07/18/00	10/19/00
Water elevation ^a	m	223.26	225.32	224.74	224.03
Temperature	°C	6.0	8.6	14.2	14.0
pH	pH	7.20	7.53	7.01	6.98
Redox	mV	-5	-26	-1	18
Conductivity	µmhos/cm	678	660	578	667
Chloride ^b	mg/L	3	1	2	2
Sulfate ^b	mg/L	47	45	33	43
TDS ^b	mg/L	421	403	414	428
Cyanide (total) ^c	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic ^c	mg/L	- ^d	0.0034	-	-
Barium ^c	mg/L	-	0.1794	-	-
Boron ^c	mg/L	-	0.3784	-	-
Cadmium ^c	mg/L	-	0.0007	-	-
Chromium ^c	mg/L	-	0.0925	-	-
Cobalt ^c	mg/L	-	0.0653	-	-
Copper ^c	mg/L	-	0.1818	-	-
Iron ^c	mg/L	-	154	-	-
Lead ^c	mg/L	-	0.0625	-	-
Manganese ^c	mg/L	-	1.85	-	-
Mercury ^c	mg/L	-	< 0.0001	-	-
Nickel ^c	mg/L	-	0.1593	-	-
Selenium ^c	mg/L	-	0.0023	-	-
Silver ^c	mg/L	-	0.0014	-	-
Zinc ^c	mg/L	-	0.442	-	-
Ammonia nitrogen ^b	mg/L	< 0.1	< 0.1	< 0.1	< 0.1
Arsenic ^b	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium ^b	mg/L	0.0202	< 0.0180	0.0195	0.0193
Beryllium ^b	mg/L	< 0.0001	0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	< 0.037	< 0.037	0.0445	< 0.037
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.0214	< 0.017	0.0387	0.0516
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
Nitrate ^c	mg/L	-	0.14	-	-
Phenols ^c	mg/L	< 0.005	0.007	< 0.005	< 0.005
Hydrogen-3 ^c	pCi/L	< 100	< 100	< 100	< 100
Chloride ^c	mg/L	-	2	-	-
Fluoride ^c	mg/L	-	0.206	-	-
Sulfate ^c	mg/L	-	44	-	-
TOCs ^c	mg/L	2.4	< 1.0	1.6	1.7
TOCs ^c	mg/L	2.4	< 1.0	1.6	1.6
TOCs ^c	mg/L	2.3	< 1.0	1.6	1.5
TOCs ^c	mg/L	2.4	< 1.0	1.6	1.5
TOXs ^c	mg/L	0.012	< 0.01	0.016	< 0.01
TOXs ^c	mg/L	< 0.01	< 0.01	0.017	< 0.01
Acetone ^c	µg/L	< 1	< 1	< 1	3
Methylene chloride ^c	µg/L	< 1	< 1	< 1	2

^a Well bottom elevation = 222.50 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.

6. GROUNDWATER PROTECTION

TABLE 6.36

Groundwater Monitoring Results, Sanitary Landfill Well 800273D, 2000

Parameter	Unit	Date of Sampling			
		01/17/00	04/25/00	07/18/00	10/19/00
Water elevation ^a	m	192.25	192.23	192.60	192.30
Temperature	°C	9.8	11.2	12.8	11.3
pH	pH	7.04	7.23	6.83	7.66
Redox	mV	10	-7	4	-30
Conductivity	µmhos/cm	1,156	1,125	1,063	1,150
Chloride ^b	mg/L	107	97	109	92
Sulfate ^b	mg/L	114	113	100	91
TDS ^b	mg/L	722	744	847	814
Cyanide (total) ^c	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic ^c	mg/L	- ^d	0.0047	-	-
Barium ^c	mg/L	-	0.0532	-	-
Boron ^c	mg/L	-	0.172	-	-
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	-	4.26	-	-
Lead ^c	mg/L	-	< 0.002	-	-
Manganese ^c	mg/L	-	0.0724	-	-
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	-	0.0249	-	-
Ammonia nitrogen ^b	mg/L	0.7	0.6	0.8	0.6
Arsenic ^b	mg/L	< 0.003	0.0035	< 0.003	< 0.003
Barium ^b	mg/L	0.0491	0.0497	0.0507	0.0474
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	0.3262	1.053	1.333	1.140
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.0179	< 0.017	< 0.017	< 0.017
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
Nitrate ^c	mg/L	-	< 0.1	-	-
Phenols ^c	mg/L	< 0.005	< 0.005	< 0.005	0.006
Hydrogen-3 ^c	pCi/L	< 100	< 100	< 100	< 100
Chloride ^c	mg/L	-	97	-	-
Fluoride ^c	mg/L	-	0.306	-	-
Sulfate ^c	mg/L	-	112	-	-
TOCs ^c	mg/L	1.9	< 1.0	1.2	1.3
TOCs ^c	mg/L	2.0	< 1.0	1.2	1.2
TOCs ^c	mg/L	2.1	< 1.0	1.2	1.5
TOCs ^c	mg/L	2.0	< 1.0	1.3	1.2
TOXs ^c	mg/L	0.036	0.035	0.012	0.018
TOXs ^c	mg/L	0.022	0.036	0.015	0.020

^a Well bottom 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.

6. GROUNDWATER PROTECTION

TABLE 6.37

Groundwater Monitoring Results, Sanitary Landfill Well 800281, 2000

Parameter	Unit	Date of Sampling			
		01/24/00	04/25/00	07/19/00	10/11/00
Water elevation ^a	m	224.90	226.87	226.05	225.87
Temperature	°C	8.8	8.4	11.7	13.0
pH	pH	6.39	6.33	6.21	6.70
Redox	mV	35	42	36	15
Conductivity	µmhos/cm	1,648	1,728	1,370	1,513
Chloride ^b	mg/L	120	167	104	94
Sulfate ^b	mg/L	80	137	125	118
TDS ^b	mg/L	1,051	1,108	1,044	1,039
Cyanide (total) ^c	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic ^c	mg/L	- ^d	< 0.003	-	-
Barium ^c	mg/L	-	0.2042	-	-
Boron ^c	mg/L	-	0.5155	-	-
Cadmium ^c	mg/L	-	0.0005	-	-
Chromium ^c	mg/L	-	0.0481	-	-
Cobalt ^c	mg/L	-	< 0.026	-	-
Copper ^c	mg/L	-	0.0423	-	-
Iron ^c	mg/L	-	27.5	-	-
Lead ^c	mg/L	-	0.0124	-	-
Manganese ^c	mg/L	-	1.993	-	-
Mercury ^c	mg/L	-	< 0.0001	-	-
Nickel ^c	mg/L	-	0.0567	-	-
Selenium ^c	mg/L	-	< 0.002	-	-
Silver ^c	mg/L	-	0.0009	-	-
Zinc ^c	mg/L	-	0.0919	-	-
Ammonia nitrogen ^b	mg/L	< 0.1	< 0.1	< 0.1	< 0.1
Arsenic ^b	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium ^b	mg/L	0.1662	0.1016	0.0985	0.0982
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	0.2012	< 0.037	1.525	0.1605
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.9733	1.538	1.050	1.475
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.0400	0.1112	0.4547	0.1595
Silver ^b	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	0.023	< 0.011
Nitrate ^c	mg/L	-	< 0.1	-	-
Phenols ^c	mg/L	< 0.005	< 0.005	< 0.005	0.008
Hydrogen-3 ^c	pCi/L	657	1,218	584	562
Chloride ^c	mg/L	-	162	-	-
Fluoride ^c	mg/L	-	0.114	-	-
Sulfate ^c	mg/L	-	133	-	-
TOCs ^c	mg/L	3.9	3.1	2.6	2.9
TOCs ^c	mg/L	2.9	3.1	2.6	3.0
TOCs ^c	mg/L	4.7	3.1	2.7	3.0
TOCs ^c	mg/L	4.6	3.1	2.6	3.1
TOXs ^c	mg/L	0.075	0.100	0.033	0.094
TOXs ^c	mg/L	0.079	0.110	0.039	0.096
Methylene chloride ^c	µg/L	< 1	< 1	< 1	11

^a Well bottom 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.

6. GROUNDWATER PROTECTION

TABLE 6.38

Groundwater Monitoring Results, Sanitary Landfill Well 800291, 2000

Parameter	Unit	Date of Sampling			
		01/24/00	05/03/00	07/19/00	10/10/00
Water elevation ^a	m	225.94	228.26	228.50	227.54
Temperature	°C	10.7	10.0	11.2	11.1
pH	pH	7.84	7.19	7.40	7.09
Redox	mV	-40	-5	-21	0
Conductivity	μmhos/cm	1,120	999	1,079	1,238
Chloride ^b	mg/L	6	6	8	8
Sulfate ^b	mg/L	137	135	234	223
TDS ^b	mg/L	765	772	853	843
Cyanide (total) ^c	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic ^c	mg/L	^d	0.0096	-	-
Barium ^c	mg/L	-	0.1664	-	-
Boron ^c	mg/L	-	0.1588	-	-
Cadmium ^c	mg/L	-	0.0003	-	-
Chromium ^c	mg/L	-	0.0529	-	-
Cobalt ^c	mg/L	-	< 0.026	-	-
Copper ^c	mg/L	-	0.0966	-	-
Iron ^c	mg/L	-	53.3	-	-
Lead ^c	mg/L	-	0.0239	-	-
Manganese ^c	mg/L	-	1.013	-	-
Mercury ^c	mg/L	-	< 0.0001	-	-
Nickel ^c	mg/L	-	0.0732	-	-
Selenium ^c	mg/L	-	< 0.002	-	-
Silver ^c	mg/L	-	0.0011	-	-
Zinc ^c	mg/L	-	0.157	-	-
Ammonia nitrogen ^b	mg/L	< 0.1	< 0.1	< 0.1	< 0.1
Arsenic ^b	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium ^b	mg/L	0.0372	0.0354	0.0351	0.0396
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	< 0.037	0.0455	0.0493	0.1454
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.1896	0.1595	0.1918	0.1718
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	0.0008	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
Nitrate ^c	mg/L	-	< 0.1	-	-
Phenols ^c	mg/L	0.013	< 0.005	< 0.005	0.020
Hydrogen-3 ^c	pCi/L	< 100	< 100	< 100	< 100
Chloride ^c	mg/L	-	6	-	-
Fluoride ^c	mg/L	-	0.266	-	-
Sulfate ^c	mg/L	-	137	-	-
TOCs ^c	mg/L	3.1	2.0	1.9	2.0
TOCs ^c	mg/L	2.8	1.9	1.9	1.9
TOCs ^c	mg/L	2.4	1.9	1.9	2.0
TOCs ^c	mg/L	3.0	1.9	1.9	2.0
TOXs ^c	mg/L	< 0.01	< 0.01	0.011	< 0.01
TOXs ^c	mg/L	< 0.01	0.012	0.01	< 0.01

^a Well bottom 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.

6. GROUNDWATER PROTECTION

TABLE 6.39

Groundwater Monitoring Results, Sanitary Landfill Well 800301, 2000

Parameter	Unit	Date of Sampling			
		01/24/00	05/02/00	07/24/00	10/04/00
Water elevation ^a	m	226.40	226.12	230.26	228.47
Temperature	°C	9.3	9.9	10.1	10.6
pH	pH	7.27	6.53	6.44	6.69
Redox	mV	-11	37	28	18
Conductivity	µmhos/cm	1,043	981	1,018	1,120
Chloride ^b	mg/L	6	7	5	6
Sulfate ^b	mg/L	108	104	93	100
TDS ^b	mg/L	682	717	834	719
Cyanide (total) ^c	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic ^c	mg/L	- ^d	0.0434	-	-
Barium ^c	mg/L	-	0.3853	-	-
Boron ^c	mg/L	-	0.5901	-	-
Cadmium ^c	mg/L	-	0.0016	-	-
Chromium ^c	mg/L	-	0.1253	-	-
Cobalt ^c	mg/L	-	0.1045	-	-
Copper ^c	mg/L	-	0.3345	-	-
Iron ^c	mg/L	-	254	-	-
Lead ^c	mg/L	-	0.1476	-	-
Manganese ^c	mg/L	-	6.373	-	-
Mercury ^c	mg/L	-	< 0.0001	-	-
Nickel ^c	mg/L	-	0.222	-	-
Selenium ^c	mg/L	-	< 0.002	-	-
Silver ^c	mg/L	-	0.001	-	-
Zinc ^c	mg/L	-	0.575	-	-
Ammonia nitrogen ^b	mg/L	0.1	< 0.1	< 0.1	< 0.1
Arsenic ^b	mg/L	0.0036	0.003	< 0.003	0.0063
Barium ^b	mg/L	0.0344	0.0345	0.0274	0.0246
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	0.0009	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	< 0.037	< 0.037	0.1938	0.5849
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.1295	0.1189	0.196	0.0982
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	0.0008	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
Nitrate ^c	mg/L	-	< 0.1	-	-
Phenols ^c	mg/L	< 0.005	0.012	0.012	0.010
Hydrogen-3 ^c	pCi/L	< 100	< 100	< 100	< 100
Chloride ^c	mg/L	-	7	-	-
Fluoride ^c	mg/L	-	0.216	-	-
Sulfate ^c	mg/L	-	104	-	-
TOCs ^c	mg/L	2.4	1.5	1.3	2.0
TOCs ^c	mg/L	1.9	1.5	1.4	1.7
TOCs ^c	mg/L	2.5	1.5	1.3	2.0
TOCs ^c	mg/L	2.4	1.5	1.4	2.0
TOXs ^c	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
TOXs ^c	mg/L	< 0.01	< 0.01	0.01	< 0.01

^a Well bottom 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.

6. GROUNDWATER PROTECTION

TABLE 6.40

Groundwater Monitoring Results, Sanitary Landfill Well 800321, 2000

Parameter	Unit	Date of Sampling		
		05/04/00	07/24/00	10/04/00
Water elevation ^a	m	226.65	226.45	224.84
Temperature	°C	9.6	12.8	13.0
pH	pH	7.07	6.44	6.65
Redox	mV	4	40	28
Conductivity	µmhos/cm	1,723	2,470	2,830
Chloride ^b	mg/L	32	32	39
Sulfate ^b	mg/L	677	712	580
TDS ^b	mg/L	1,746	1,764	2,867
Cyanide (total) ^c	mg/L	< 0.01	< 0.01	< 0.01
Arsenic ^c	mg/L	0.008	- ^d	-
Barium ^c	mg/L	0.0892	-	-
Boron ^c	mg/L	0.1702	-	-
Cadmium ^c	mg/L	0.0007	-	-
Chromium ^c	mg/L	0.0937	-	-
Cobalt ^c	mg/L	< 0.026	-	-
Copper ^c	mg/L	0.1905	-	-
Iron ^c	mg/L	54.5	-	-
Lead ^c	mg/L	0.0356	-	-
Manganese ^c	mg/L	1.228	-	-
Mercury ^c	mg/L	< 0.0001	-	-
Nickel ^c	mg/L	0.0971	-	-
Selenium ^c	mg/L	0.0139	-	-
Silver ^c	mg/L	0.0008	-	-
Zinc ^c	mg/L	0.1171	-	-
Ammonia nitrogen ^b	mg/L	< 0.1	< 0.1	-
Arsenic ^b	mg/L	< 0.003	< 0.003	< 0.003
Barium ^b	mg/L	< 0.018	< 0.018	< 0.018
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	0.0001	< 0.0001	0.0002
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	0.0421	< 0.017	0.075
Iron ^b	mg/L	< 0.037	< 0.037	< 0.037
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.6194	0.7116	1.618
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	0.0319	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	0.0162
Nitrate ^c	mg/L	3.2	-	-
Phenols ^c	mg/L	0.005	0.014	< 0.005
Hydrogen-3 ^c	pCi/L	< 100	< 100	< 100
Chloride ^c	mg/L	31	-	-
Fluoride ^c	mg/L	0.11	-	-
Sulfate ^c	mg/L	873	-	-
TOCs ^c	mg/L	2.5	2.4	2.7
TOCs ^c	mg/L	2.5	2.5	2.5
TOCs ^c	mg/L	2.5	2.4	2.6
TOCs ^c	mg/L	2.6	2.4	2.6
TOXs ^c	mg/L	0.013	0.019	0.023
TOXs ^c	mg/L	0.028	0.011	0.011

^a Well bottom elevation = 224.33 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.

6. GROUNDWATER PROTECTION

TABLE 6.41

Groundwater Monitoring Results, Sanitary Landfill Well 800331, 2000

Parameter	Unit	Date of Sampling				
		01/24/00	01/24/00	04/25/00	07/19/00	10/11/00
Water elevation ^a	m	224.84	224.84	226.94	226.74	226.09
Temperature	°C	7.1	7.1	8.5	11.6	12.3
pH	pH	7.75	7.75	7.33	6.99	6.85
Redox	mV	-28	-28	-3	4	12
Conductivity	µmhos/cm	1,104	1,104	1,171	1,009	1,169
Chloride ^b	mg/L	8	7	7	7	6
Sulfate ^b	mg/L	135	142	140	128	133
TDS ^b	mg/L	755	728	843	809	822
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	-	-	0.0644	-	-
Boron ^c	mg/L	-	-	0.0698	-	-
Cadmium ^c	mg/L	-	-	0.0003	-	-
Chromium ^c	mg/L	-	-	0.0447	-	-
Cobalt ^c	mg/L	-	-	< 0.026	-	-
Copper ^c	mg/L	-	-	0.0179	-	-
Iron ^c	mg/L	-	-	4.64	-	-
Lead ^c	mg/L	-	-	0.0078	-	-
Manganese ^c	mg/L	-	-	0.1576	-	-
Mercury ^c	mg/L	-	-	< 0.0001	-	-
Nickel ^c	mg/L	-	-	< 0.04	-	-
Selenium ^c	mg/L	-	-	< 0.002	-	-
Silver ^c	mg/L	-	-	0.0063	-	-
Zinc ^c	mg/L	-	-	0.0348	-	-
Ammonia nitrogen ^b	mg/L	0.1	< 0.1	< 0.1	< 0.1	< 0.1
Arsenic ^b	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Barium ^b	mg/L	0.0613	0.0727	0.0635	0.0539	0.0552
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.0783	0.0285	0.0458	0.207	0.2777
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	0.0006	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	0.0147	< 0.011	0.0292	< 0.011
Nitrate ^c	mg/L	-	-	1.1	-	-
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	-	-	6	-	-
Fluoride ^c	mg/L	-	-	0.272	-	-
Sulfate ^c	mg/L	-	-	142	-	-
TOCs ^c	mg/L	2.2	2.2	1.1	1.6	1.5
TOCs ^c	mg/L	2.1	2.2	1.1	1.6	1.5
TOCs ^c	mg/L	2.0	2.2	1.1	1.6	1.4
TOCs ^c	mg/L	2.1	2.2	1.1	1.6	1.5
TOXs ^c	mg/L	< 0.01	< 0.01	0.014	< 0.01	< 0.01
TOXs ^c	mg/L	< 0.01	< 0.01	0.012	< 0.01	0.015
Trichlorofluoromethane ^c	µg/L	1	< 1	< 1	< 1	< 1

^a Well bottom 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.

6. GROUNDWATER PROTECTION

TABLE 6.42

Groundwater Monitoring Results, Sanitary Landfill Well 800341, 2000

Parameter	Unit	Date of Sampling		
		04/25/00	07/19/00	10/10/00
Water elevation ^a	m	229.78	228.52	228.53
Temperature	°C	8.0	14.1	13.2
pH	pH	7.40	7.11	6.90
Redox	mV	-15	-8	11
Conductivity	µmhos/cm	1,114	1,059	1,265
Chloride ^b	mg/L	10	11	12
Sulfate ^b	mg/L	246	234	221
TDS ^b	mg/L	806	836	893
Cyanide (Total) ^c	mg/L	< 0.01	< 0.01	< 0.01
Arsenic ^c	mg/L	< 0.003	- ^d	-
Barium ^c	mg/L	0.0582	-	-
Boron ^c	mg/L	0.0644	-	-
Cadmium ^c	mg/L	0.0001	-	-
Chromium ^c	mg/L	< 0.044	-	-
Cobalt ^c	mg/L	< 0.026	-	-
Copper ^c	mg/L	0.0289	-	-
Iron ^c	mg/L	6.78	-	-
Lead ^c	mg/L	0.004	-	-
Manganese ^c	mg/L	0.1226	-	-
Mercury ^c	mg/L	< 0.0001	-	-
Nickel ^c	mg/L	< 0.04	-	-
Selenium ^c	mg/L	< 0.002	-	-
Silver ^c	mg/L	0.001	-	-
Zinc ^c	mg/L	0.0497	-	-
Ammonia nitrogen ^b	mg/L	< 0.1	0.2	< 0.1
Arsenic ^b	mg/L	< 0.003	< 0.003	< 0.003
Barium ^b	mg/L	0.0503	0.0417	0.0485
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	< 0.037	< 0.037	< 0.037
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.0328	0.0396	< 0.0170
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	0.0255	< 0.011
Nitrate ^c	mg/L	0.57	-	-
Phenols ^c	mg/L	0.008	< 0.005	0.024
Hydrogen-3 ^c	pCi/L	< 100	< 100	< 100
Chloride ^c	mg/L	10	-	-
Fluoride ^c	mg/L	0.294	-	-
Sulfate ^c	mg/L	237	-	-
TOCs ^c	mg/L	1.7	2.8	2.3
TOCs ^c	mg/L	1.7	2.8	2.4
TOCs ^c	mg/L	1.7	2.8	2.4
TOCs ^c	mg/L	1.7	2.8	2.4
TOXs ^c	mg/L	0.019	< 0.01	0.011
TOXs ^c	mg/L	0.019	0.014	0.012
Acetone ^c	µg/L	< 1	3	< 1

^a Well bottom 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.

6. GROUNDWATER PROTECTION

TABLE 6.43

Groundwater Monitoring Results, Sanitary Landfill Well 800351, 2000

Parameter	Unit	Date of Sampling				
		01/24/00	05/02/00	05/02/00	07/24/00	10/04/00
Water elevation ^a	m	225.14	224.99	224.99	228.11	226.89
Temperature	°C	9.1	10.8	10.8	10.5	10.3
pH	pH	7.82	7.18	7.18	7.58	6.81
Redox	mV	-39	-1	-1	-28	14
Conductivity	µmhos/cm	779	786	786	779	850
Chloride ^b	mg/L	8	6	5	3	4
Sulfate ^b	mg/L	29	29	29	27	25
TDS ^b	mg/L	465	507	556	544	528
Cyanide (total) ^c	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic ^c	mg/L	- ^d	0.0311	0.0239	-	-
Barium ^c	mg/L	-	0.4182	0.3405	-	-
Boron ^c	mg/L	-	0.6073	0.4238	-	-
Cadmium ^c	mg/L	-	0.0013	0.0009	-	-
Chromium ^c	mg/L	-	0.1636	0.1158	-	-
Cobalt ^c	mg/L	-	0.1045	0.0598	-	-
Copper ^c	mg/L	-	0.2453	0.1433	-	-
Iron ^c	mg/L	-	251	148	-	-
Lead ^c	mg/L	-	0.1261	0.0731	-	-
Manganese ^c	mg/L	-	5.218	2.552	-	-
Mercury ^c	mg/L	-	< 0.0001	< 0.0001	-	-
Nickel ^c	mg/L	-	0.2519	0.1555	-	-
Selenium ^c	mg/L	-	< 0.002	< 0.002	-	-
Silver ^c	mg/L	-	0.0012	0.0011	-	-
Zinc ^c	mg/L	-	0.5474	0.3336	-	-
Ammonia nitrogen ^b	mg/L	0.4	0.4	0.4	0.3	0.3
Arsenic ^b	mg/L	0.0062	< 0.003	0.0036	< 0.003	< 0.003
Barium ^b	mg/L	0.1051	0.0884	0.094	0.084	0.0875
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.0450	0.0378	0.0271	0.0239	0.0319
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	0.0008	0.0008	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	0.016	< 0.011	< 0.011	< 0.011	< 0.011
Nitrate ^c	mg/L	-	< 0.1	< 0.1	-	-
Phenols ^c	mg/L	0.012	0.016	0.010	0.007	0.018
Hydrogen-3 ^c	pCi/L	< 100	< 100	< 100	< 100	< 100
Chloride ^c	mg/L	-	5	5	-	-
Fluoride ^c	mg/L	-	0.320	0.336	-	-
Sulfate ^c	mg/L	-	29	29	-	-
TOCs ^c	mg/L	3.0	2.2	1.9	1.5	1.8
TOCs ^c	mg/L	2.9	2.3	2.0	1.6	1.8
TOCs ^c	mg/L	3.2	2.1	1.9	1.5	1.9
TOCs ^c	mg/L	3.1	2.2	1.8	1.5	1.7
TOXs ^c	mg/L	0.012	< 0.01	< 0.01	< 0.01	< 0.01
TOXs ^c	mg/L	0.013	< 0.01	< 0.01	0.01	< 0.01
Acetone ^c	µg/L	6	< 1	< 1	< 1	< 1

^a Well bottom 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.

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TABLE 6.44

Groundwater Monitoring Results, Sanitary Landfill Well 800361, 2000

Parameter	Unit	Date of Sampling				
		01/26/00	05/03/00	07/24/00	07/24/00	10/03/00
Water elevation ^a	m	222.14	226.15	225.78	225.78	223.69
Temperature	°C	7.8	10.4	10.7	10.7	11.8
pH	pH	6.42	6.69	7.25	7.25	6.42
Redox	mV	20	22	0	0	46
Conductivity	µmhos/cm	900	804	768	768	894
Chloride ^b	mg/L	12	11	10	10	10
Sulfate ^b	mg/L	109	106	100	97	96
TDS ^b	mg/L	619	708	588	603	580
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	-	0.0545	-	-	-
Boron ^c	mg/L	-	0.0644	-	-	-
Cadmium ^c	mg/L	-	0.0002	-	-	-
Chromium ^c	mg/L	-	< 0.044	-	-	-
Cobalt ^c	mg/L	-	< 0.026	-	-	-
Copper ^c	mg/L	-	0.032	-	-	-
Iron ^c	mg/L	-	7.19	-	-	-
Lead ^c	mg/L	-	0.0041	-	-	-
Manganese ^c	mg/L	-	0.2839	-	-	-
Mercury ^c	mg/L	-	< 0.0001	-	-	-
Nickel ^c	mg/L	-	< 0.04	-	-	-
Selenium ^c	mg/L	-	< 0.002	-	-	-
Silver ^c	mg/L	-	0.0011	-	-	-
Zinc ^c	mg/L	-	0.0716	-	-	-
Ammonia nitrogen ^b	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Arsenic ^b	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Barium ^b	mg/L	0.0532	0.0246	0.0293	0.0314	0.0272
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	0.0703	< 0.037	0.1902	0.209	< 0.037
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.1494	0.137	0.1068	0.1097	0.0857
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	0.0009	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011
Nitrate ^c	mg/L	-	0.15	-	-	-
Phenols ^c	mg/L	< 0.005	0.049	< 0.005	< 0.005	< 0.005
Hydrogen-3 ^c	pCi/L	< 100	< 100	< 100	< 100	113
Chloride ^c	mg/L	-	12	-	-	-
Fluoride ^c	mg/L	-	0.192	-	-	-
Sulfate ^c	mg/L	-	108	-	-	-
TOCs ^c	mg/L	2.0	1.6	1.5	1.4	1.7
TOCs ^c	mg/L	1.9	1.6	1.4	1.4	1.7
TOCs ^c	mg/L	1.5	1.6	1.4	1.4	1.7
TOCs ^c	mg/L	1.8	1.6	1.5	1.5	1.9
TOXs ^c	mg/L	0.013	0.017	< 0.01	0.01	< 0.01
TOXs ^c	mg/L	0.011	0.016	< 0.01	0.01	0.01
Acetone ^c	µg/L	< 1	< 1	< 1	< 1	5

^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.

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TABLE 6.45

Groundwater Monitoring Results, Sanitary Landfill Well 800371, 2000

Parameter	Unit	Date of Sampling				
		01/26/00	05/03/00	07/24/00	10/03/00	10/03/00
Water elevation ^a	m	219.16	219.23	219.29	219.36	219.36
Temperature	°C	7.5	11.3	12.7	11.3	11.3
pH	pH	6.39	6.74	7.14	7.25	7.25
Redox	mV	40	18	8	-12	-12
Conductivity	µmhos/cm	1,087	822	796	880	880
Chloride ^b	mg/L	9	12	5	4	5
Sulfate ^b	mg/L	21	20	19	19	19
TDS ^b	mg/L	717	743	580	580	591
Cyanide (total) ^c	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic ^c	mg/L	- ^d	0.0115	-	-	-
Barium ^c	mg/L	-	0.4656	-	-	-
Boron ^c	mg/L	-	0.5354	-	-	-
Cadmium ^c	mg/L	-	0.0026	-	-	-
Chromium ^c	mg/L	-	0.1652	-	-	-
Cobalt ^c	mg/L	-	0.0799	-	-	-
Copper ^c	mg/L	-	0.3536	-	-	-
Iron ^c	mg/L	-	210	-	-	-
Lead ^c	mg/L	-	0.1151	-	-	-
Manganese ^c	mg/L	-	5.129	-	-	-
Mercury ^c	mg/L	-	< 0.0001	-	-	-
Nickel ^c	mg/L	-	0.2471	-	-	-
Selenium ^c	mg/L	-	< 0.002	-	-	-
Silver ^c	mg/L	-	< 0.0005	-	-	-
Zinc ^c	mg/L	-	0.5915	-	-	-
Ammonia nitrogen ^b	mg/L	1.0	0.9	0.8	0.8	0.8
Arsenic ^b	mg/L	< 0.003	0.0045	< 0.003	0.0048	< 0.003
Barium ^b	mg/L	0.0693	0.0635	0.0755	0.0675	0.0792
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	< 0.037	< 0.037	< 0.037	< 0.037	0.0613
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.1078	0.0525	0.0885	0.0487	0.066
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	0.0012	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011
Nitrate ^c	mg/L	-	< 0.1	-	-	-
Phenols ^c	mg/L	0.008	0.044	< 0.005	0.017	0.01
Hydrogen-3 ^c	pCi/L	< 100	< 100	< 100	< 100	< 100
Chloride ^c	mg/L	-	10	-	-	-
Fluoride ^c	mg/L	-	0.318	-	-	-
Sulfate ^c	mg/L	-	20	-	-	-
TOCs ^c	mg/L	2.8	2.1	1.6	2.4	2.0
TOCs ^c	mg/L	2.8	2.1	1.6	2.3	2.0
TOCs ^c	mg/L	2.9	2.1	1.5	2.4	2.2
TOCs ^c	mg/L	2.9	2.2	1.6	2.4	2.1
TOXs ^c	mg/L	0.011	< 0.01	< 0.01	< 0.01	< 0.01
TOXs ^c	mg/L	< 0.01	0.013	< 0.01	< 0.01	< 0.01
Acetone ^c	µg/L	< 1	< 1	< 1	6	6

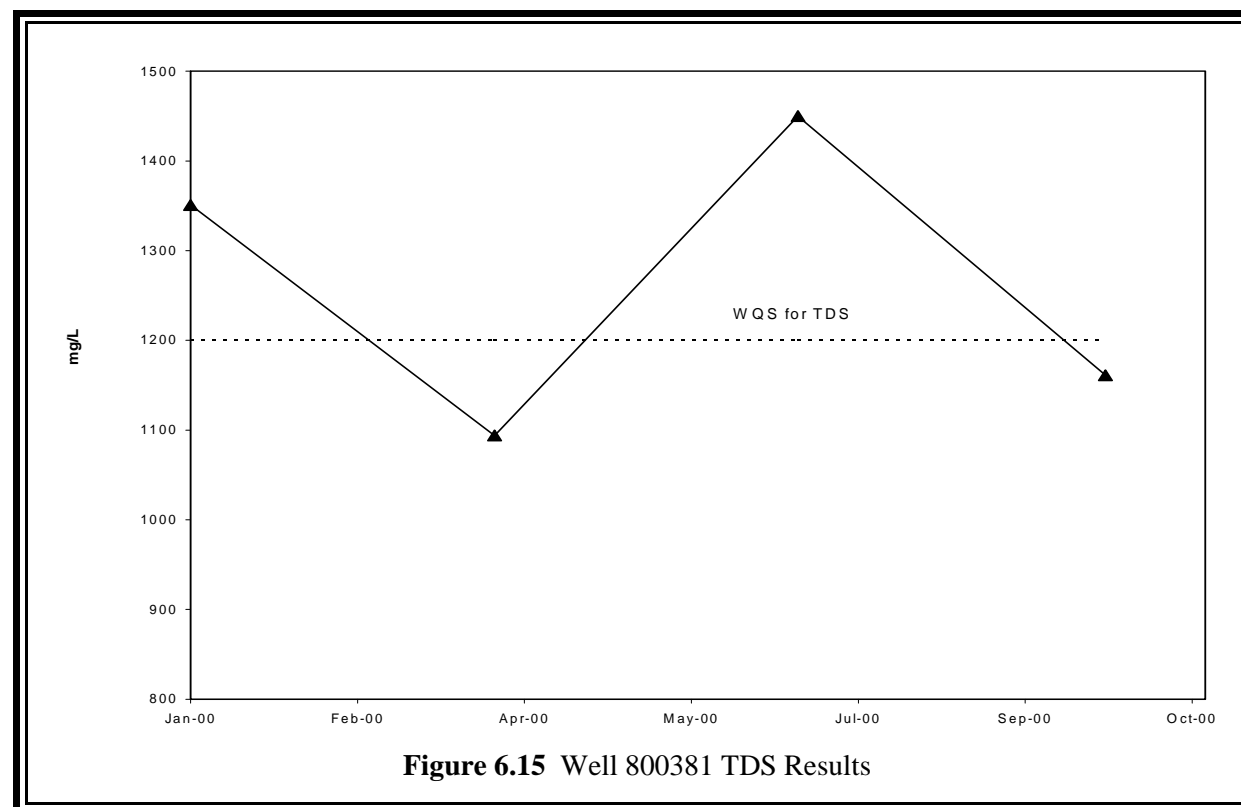
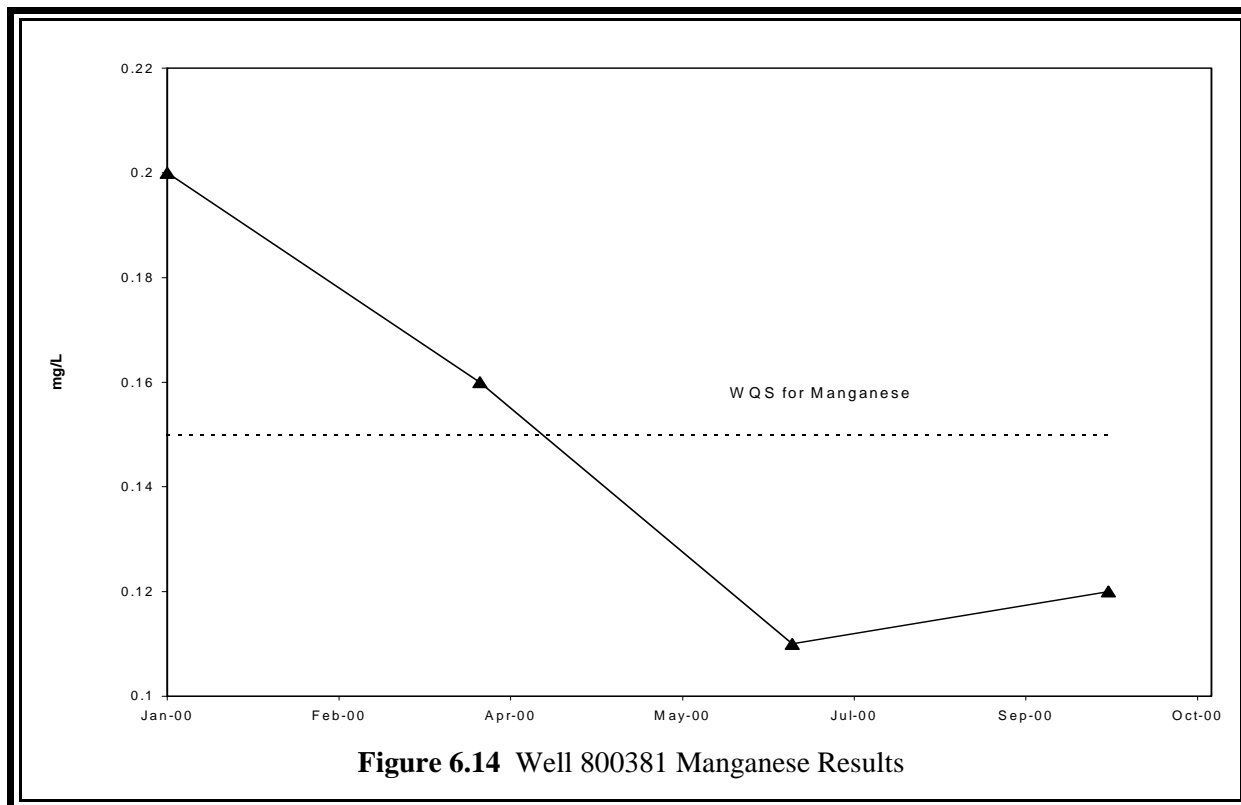
^a Well bottom elevation = 218.46 m (MSL); ground surface elevation = 228.37 m (MSL); casing material = stainless steel.

^b Filtered sample.

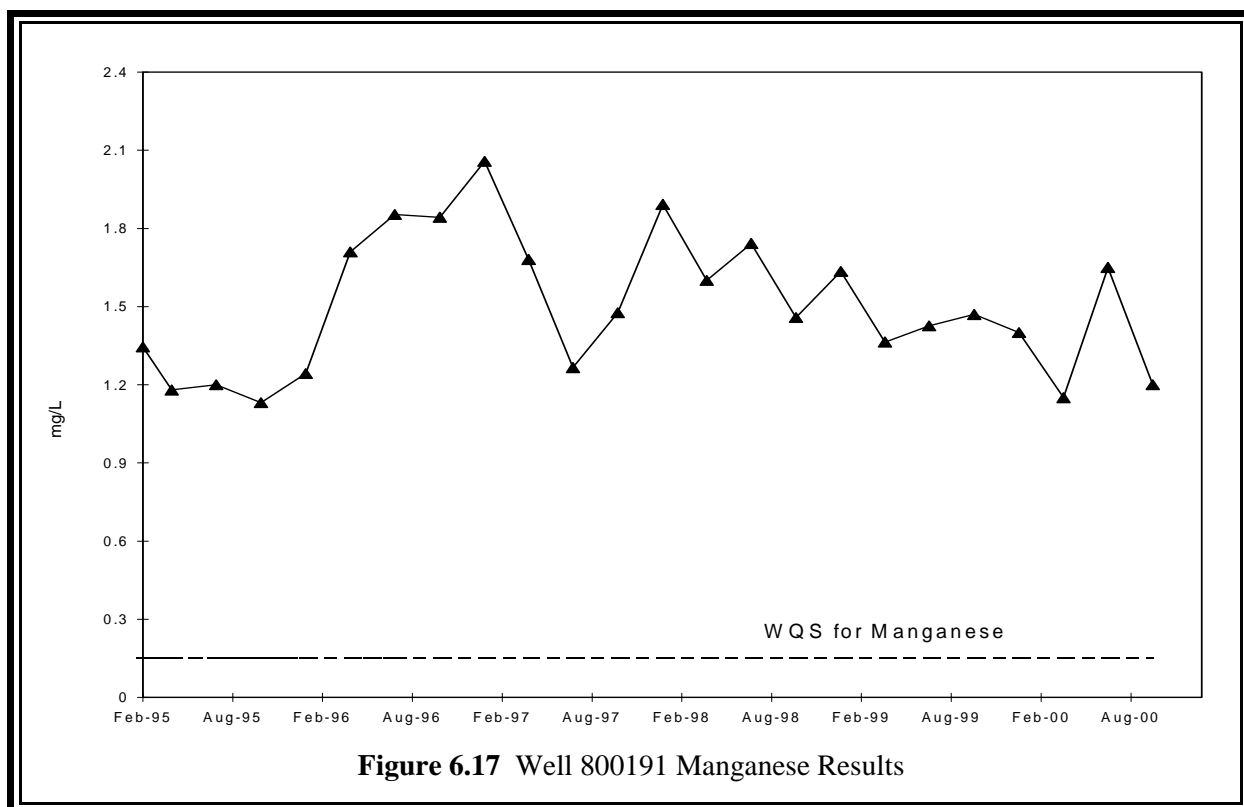
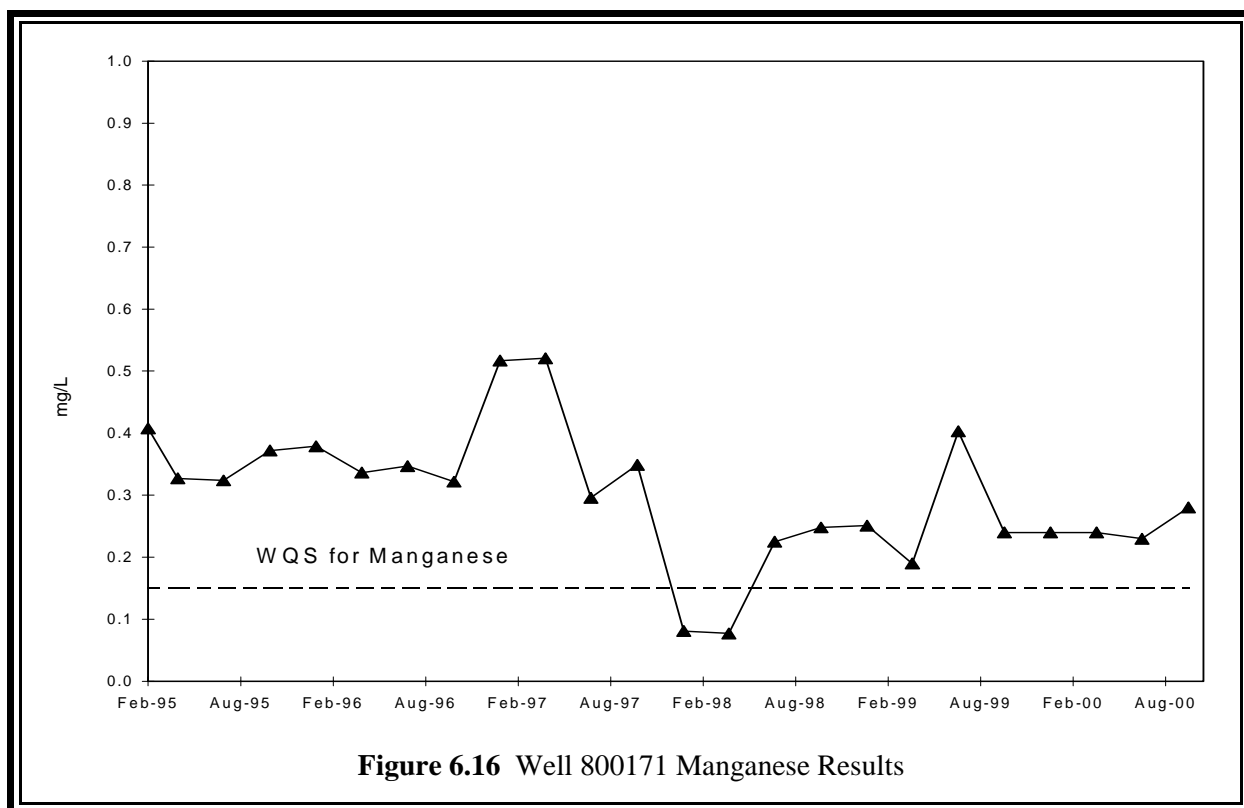
^c Unfiltered sample.

^d A hyphen indicates that no samples were collected.

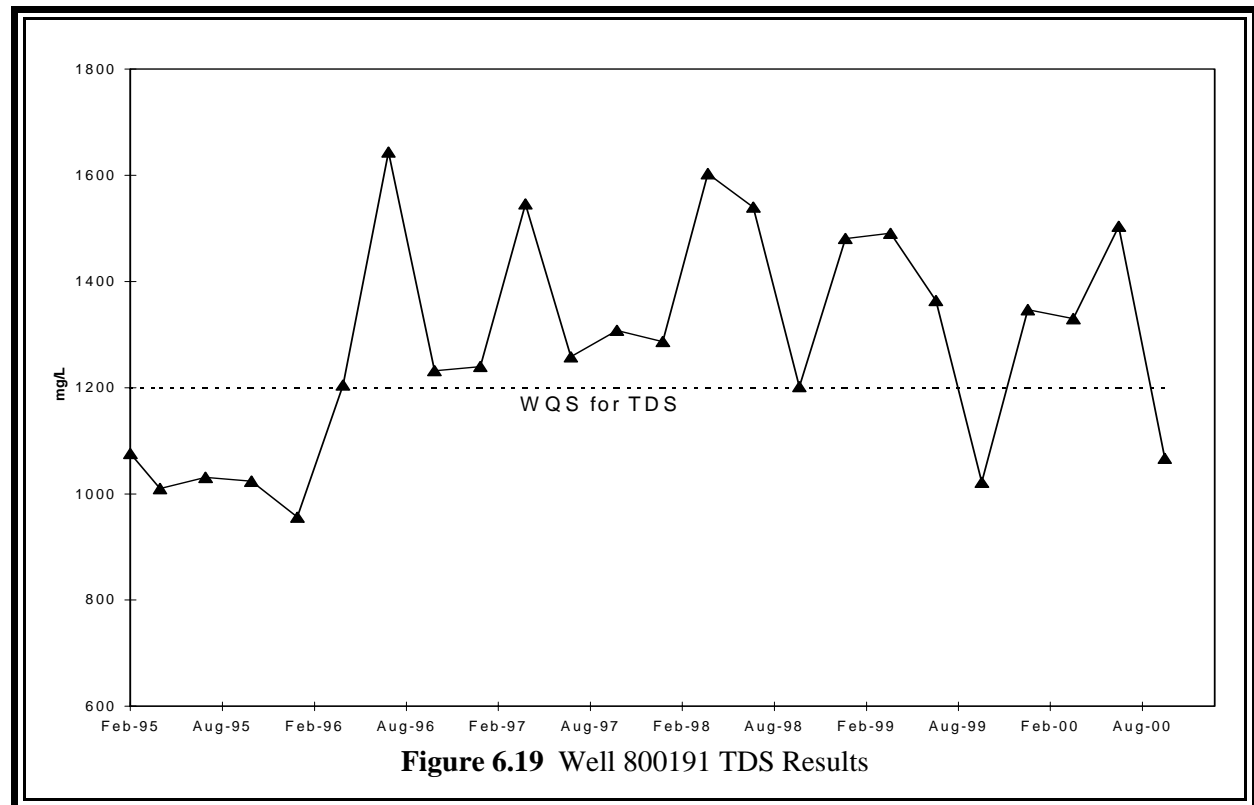
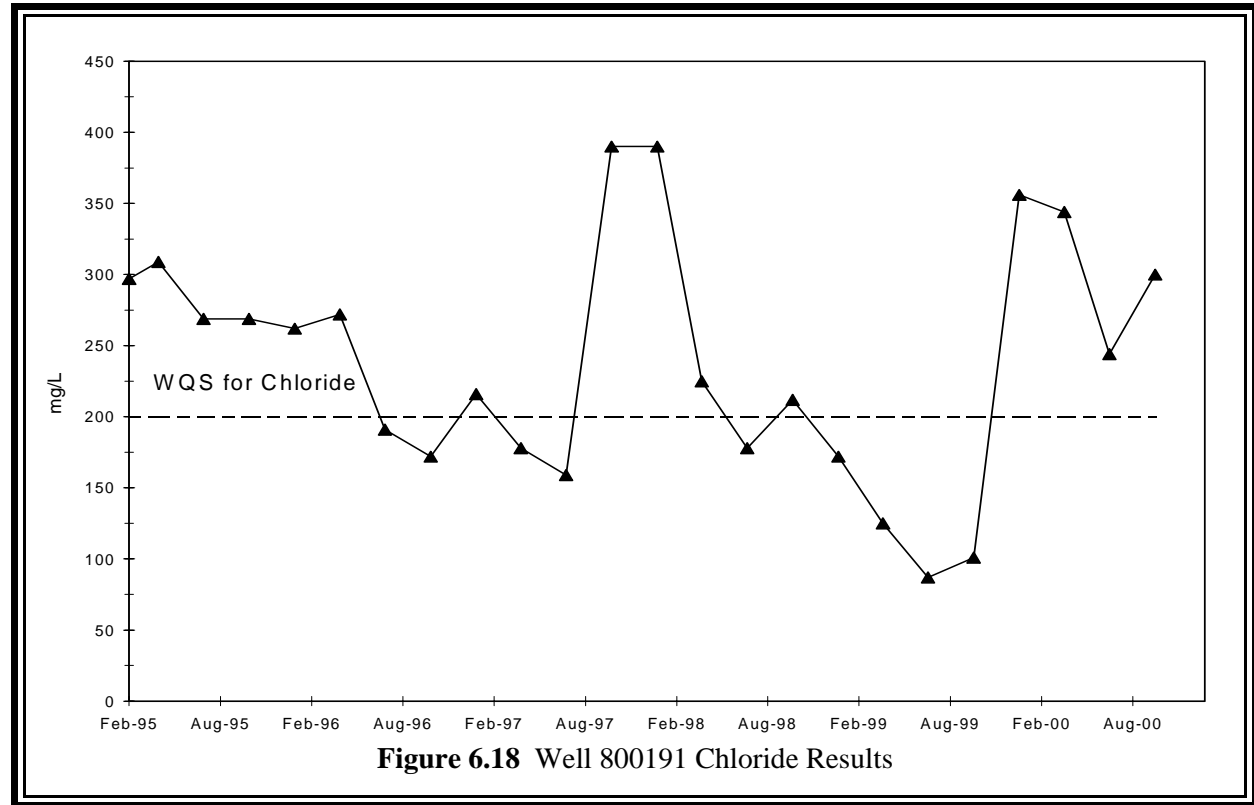
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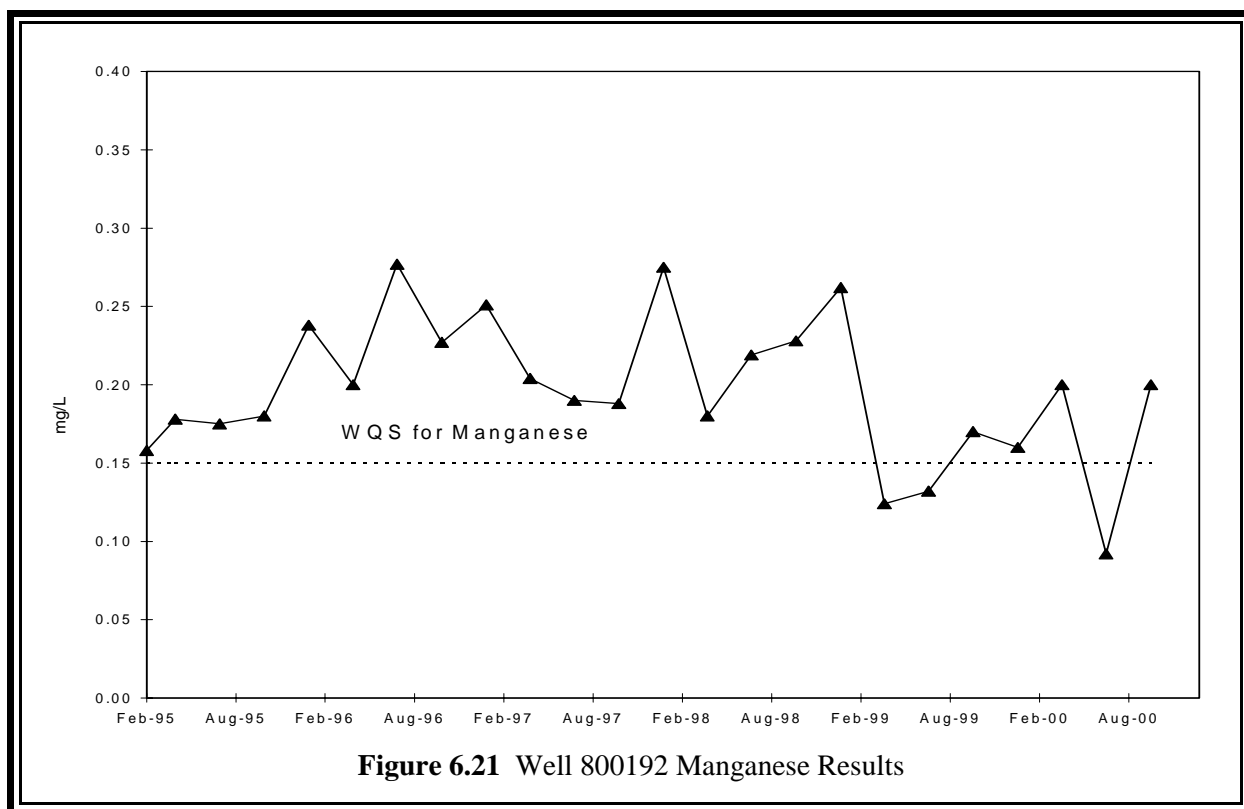
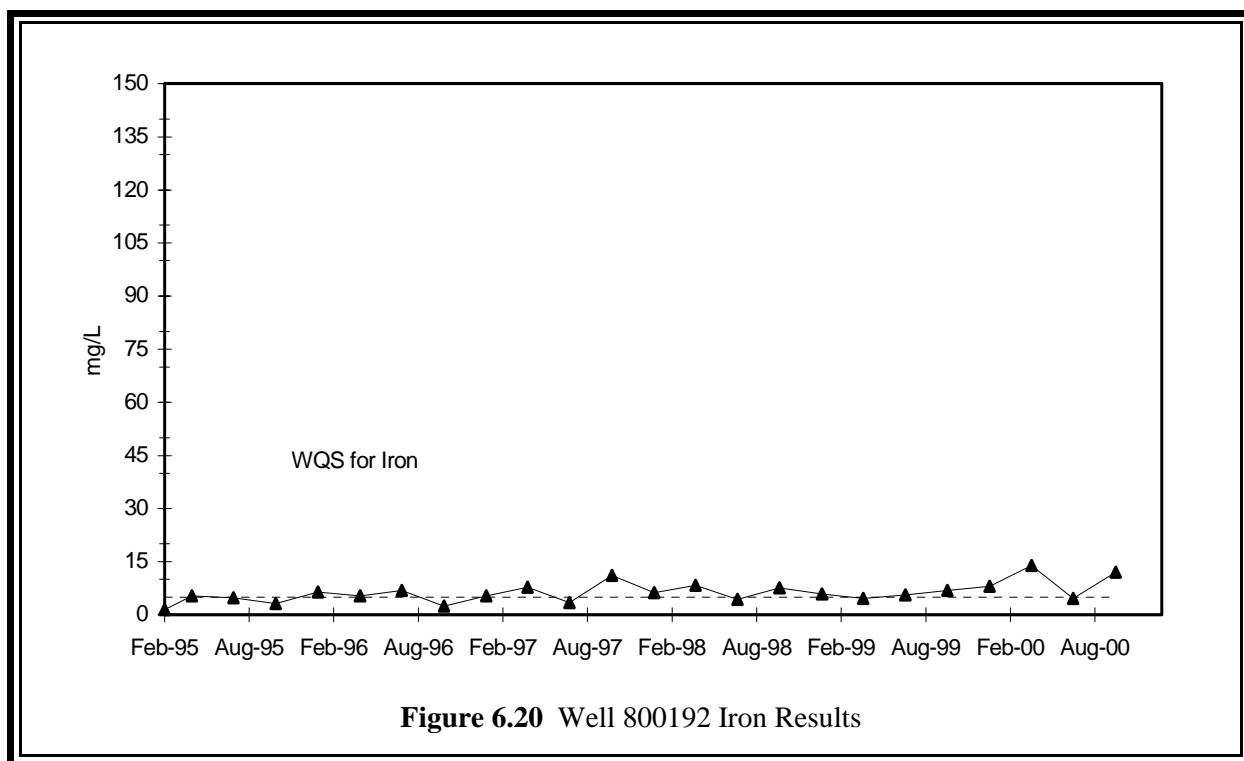


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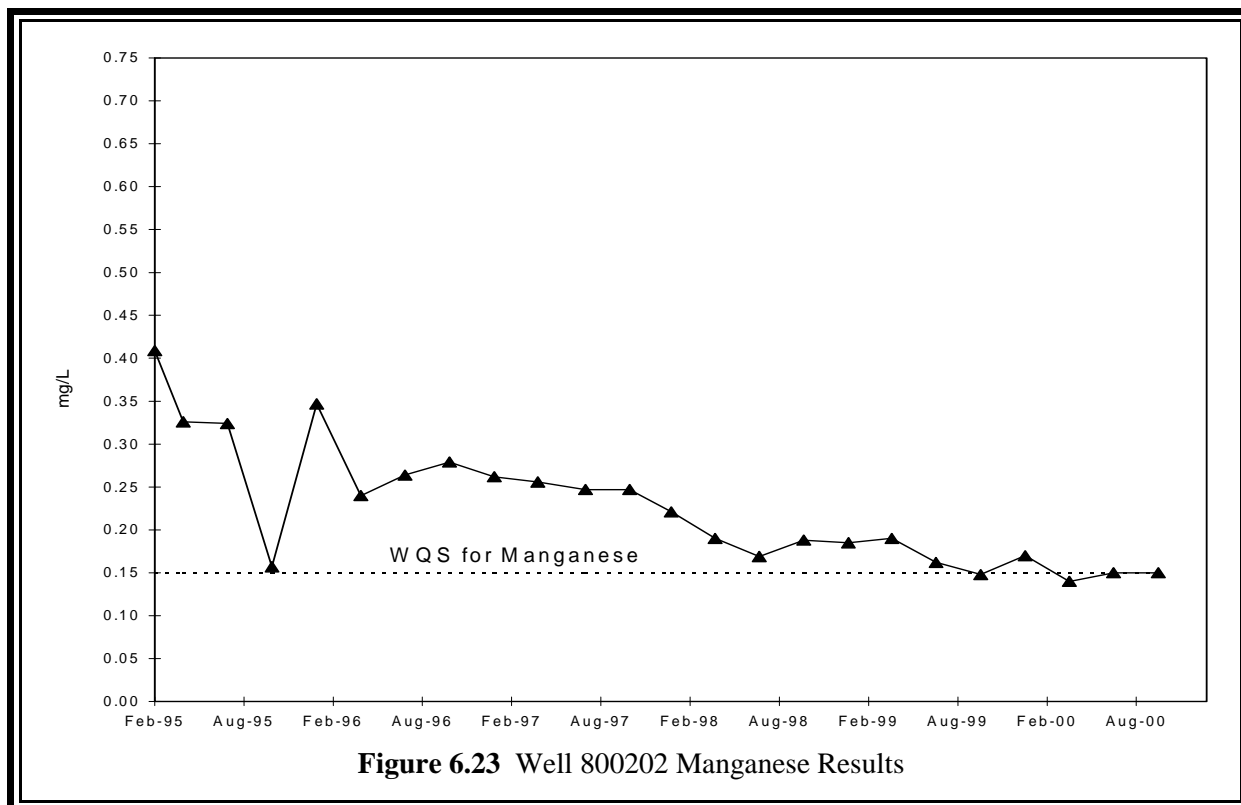
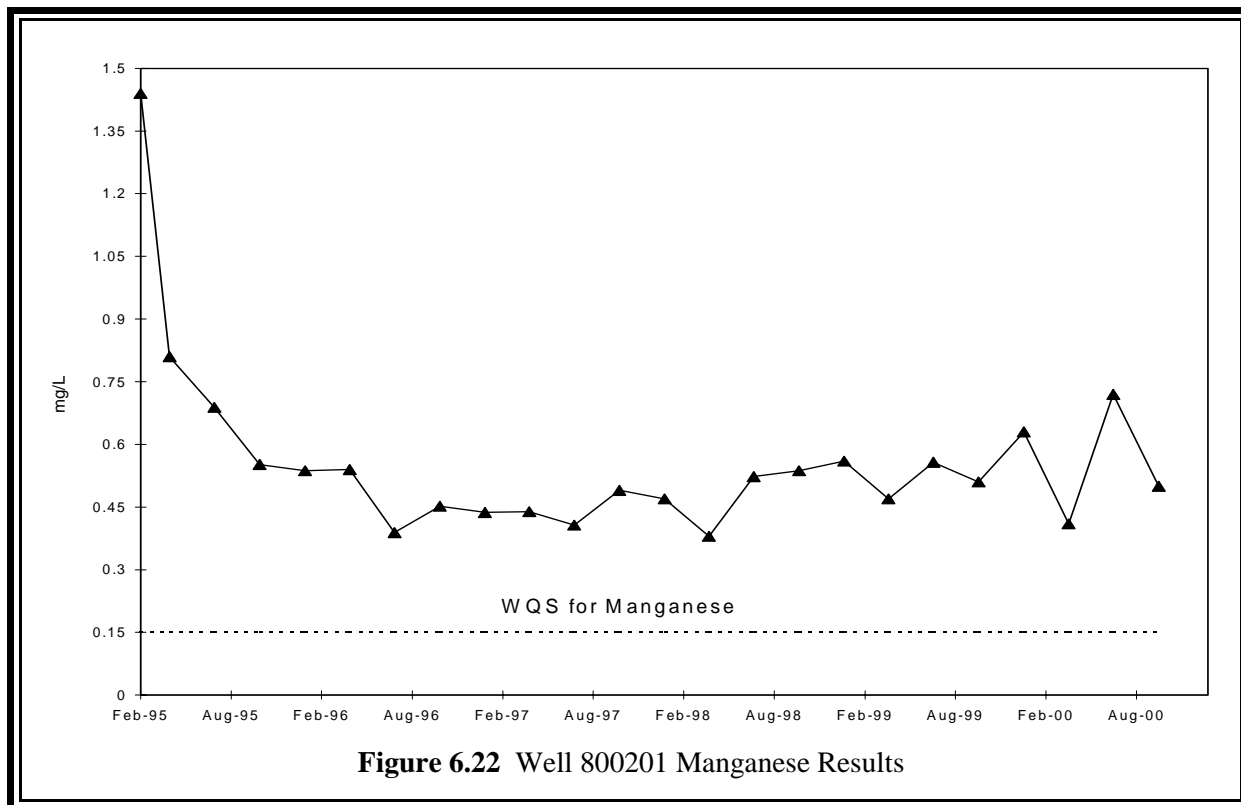


6. GROUNDWATER PROTECTION





6. GROUNDWATER PROTECTION



6. GROUNDWATER PROTECTION

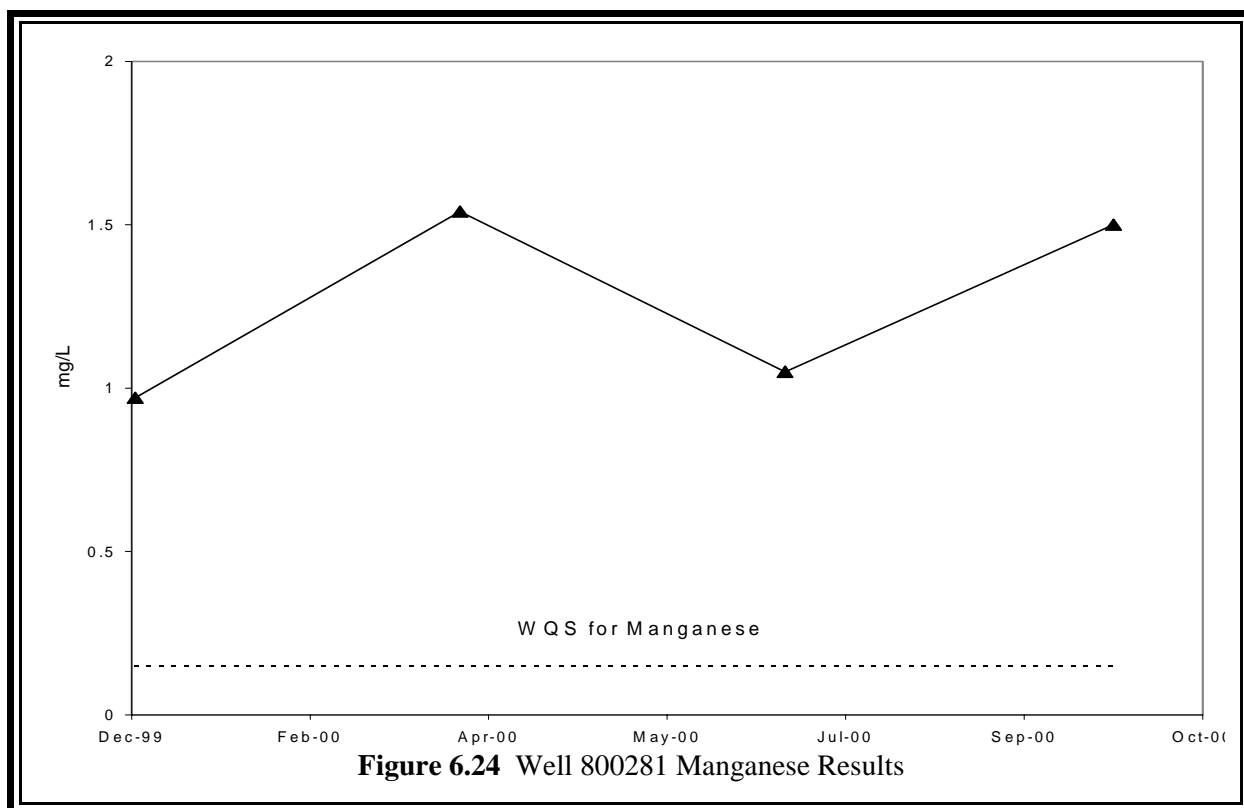


Figure 6.24 Well 800281 Manganese Results

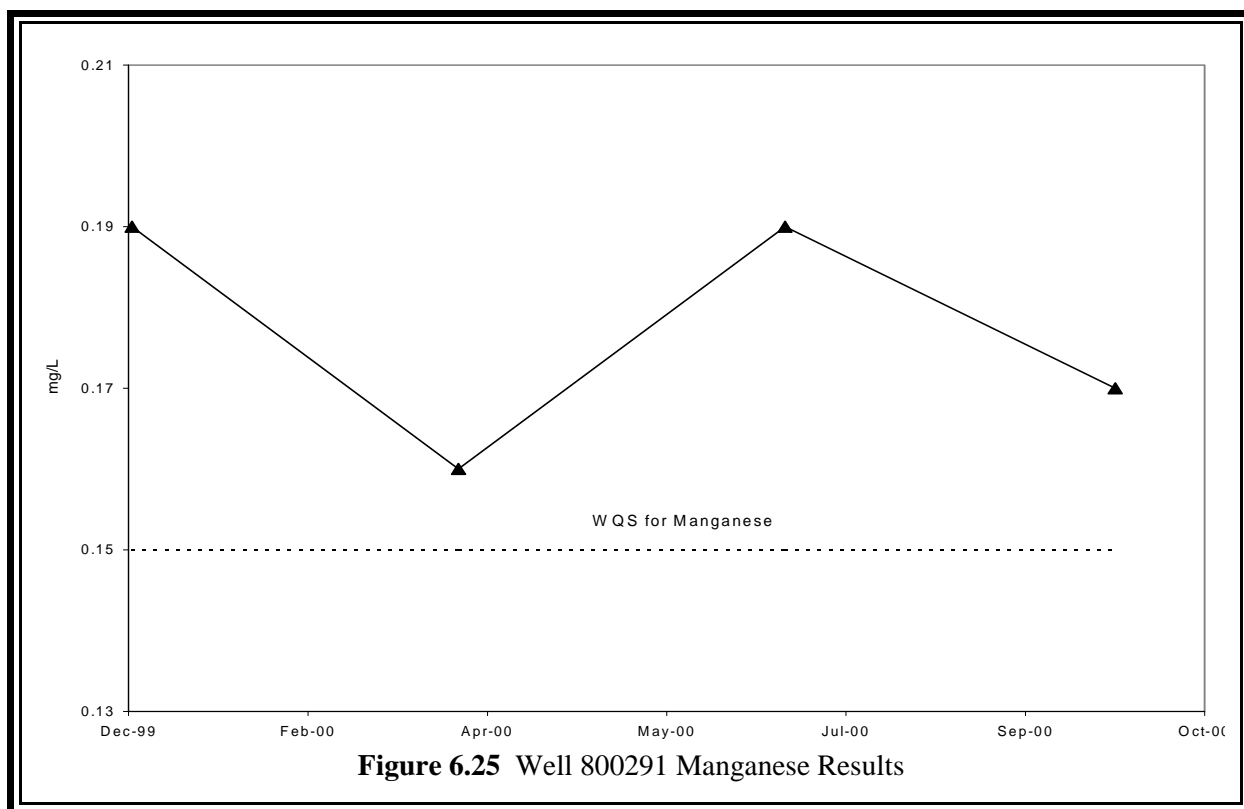
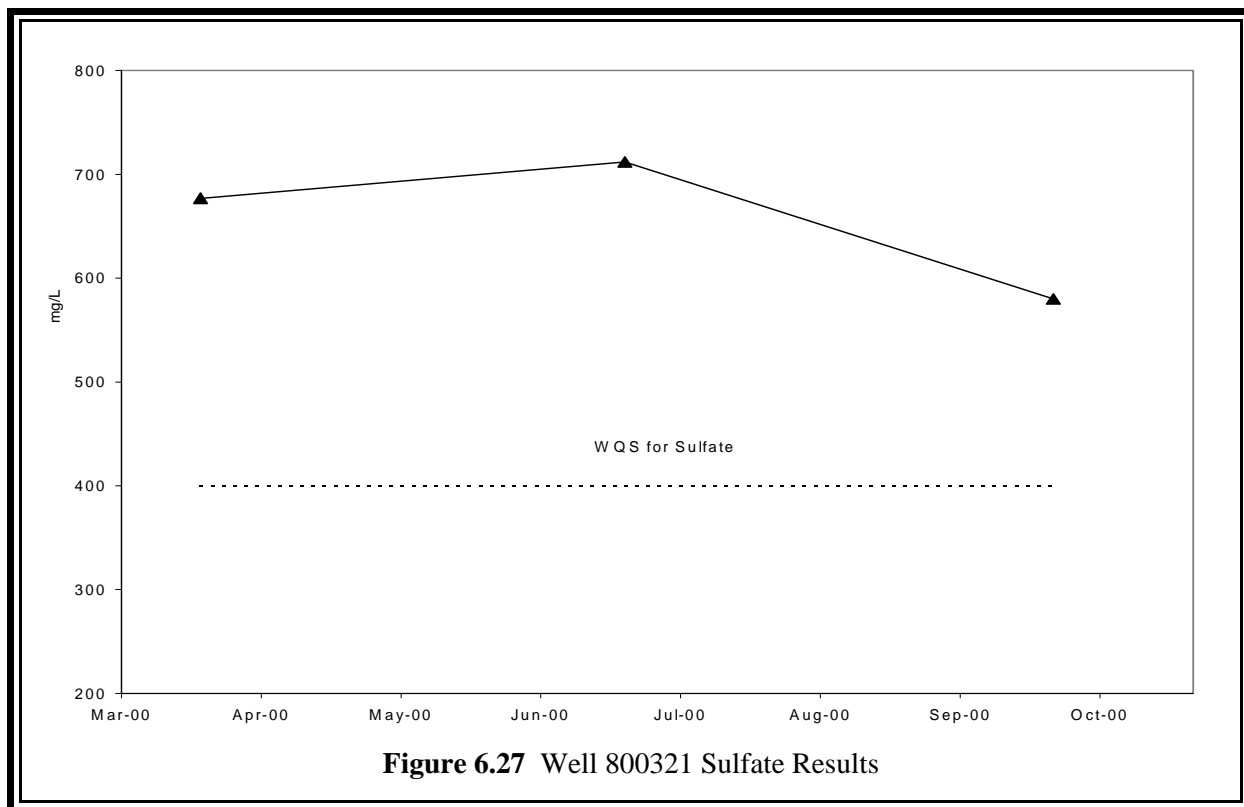
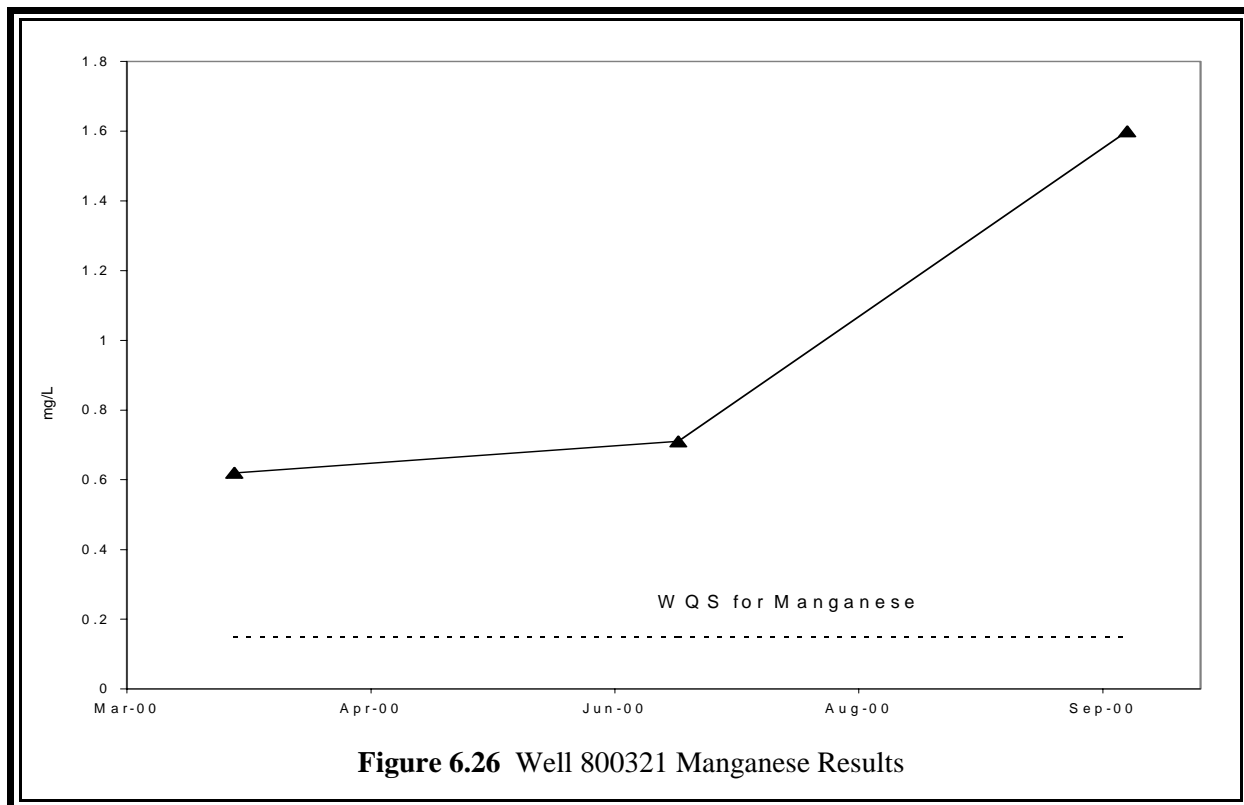


Figure 6.25 Well 800291 Manganese Results

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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. Sulfate exceeded the WQS (400 mg/L) in wells 800381 and 800321 during one quarter and three quarters, respectively. Sulfate levels ranged from 432 to 712 mg/L. Chloride exceeded the WQS (200 mg/L) in well 800191 each quarter, and the chloride levels ranged from 244 to 356 mg/L. TDS exceeded the WQS (1,200 mg/L) in wells 800191, 800192, 800321, and 800381, and the TDS levels ranged from 1,268 to 2,867 mg/L.

Iron concentrations exceeded the WQS (5 mg/L) at least once during the year in wells 800192 and 800202. Iron levels in these wells ranged from 5 to 139 mg/L.

Manganese concentrations exceeded the WQS (0.15 mg/L) during at least one quarter in wells 800171, 800191, 800192, 800201, 800202, 800241, 800243D, 800281, 800291, 800301, 800331, and 800381. Manganese levels in these wells ranged from 0.16 to 1.65 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. All measured unfiltered routine indicator parameters were less than the appropriate WQS values, where applicable.

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.

Arsenic concentrations and chloride concentrations exceeded the WQS (0.050 mg/L and 200 mg/L, respectively) in only one well each, well 800381 and 800191, respectively.

Sulfate concentrations exceeded the WQS (400 mg/L) in wells 800321 and 800381. Sulfate levels in these wells ranged from 432 to 712 mg/L.

Chromium and nickel concentrations exceeded the WQS (0.1 mg/L) in wells 800271 (upgradient), 800301, 800351, 800371, 800381, and 800382. Chromium levels ranged from 0.13 to 0.33 mg/L, and nickel levels ranged from 0.16 to 0.30 mg/L.

Iron concentrations exceeded the WQS (5 mg/L) in wells 800271 (upgradient), 800171, 800181, 800191, 800192, 800201, 800202, 800281, 800291, 800301, 800321, 800341, 800351, 800361, 800371, 800381, 800382, and 800383D. The iron levels ranged from 6 to 339 mg/L. The

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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.

Lead concentrations exceeded the WQS (0.0075 mg/L) in wells 800271 (upgradient), 800181, 800191, 800201, 800281, 800291, 800301, 800321, 800331, 800351, 800371, 800381, and 800382. Lead levels in these wells ranged from 0.0078 to 0.2039 mg/L. These elevated values are also likely to be the result of suspended soil particles in these samples.

Manganese concentrations exceeded the WQS (0.15 mg/L) in wells 800271 (upgradient), 800171, 800181, 800191, 800192, 800201, 800281, 800291, 800301, 800321, 800331, 800351, 800361, 800371, 800381, 800382, and 800383D. Manganese levels in these wells ranged from 0.19 to 6.4 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 10 of the 12 wells where VOCs were determined at very low levels. Acetone was the only VOC noted in six of the wells. However, the corresponding control sample for the sampling period contained acetone at levels greater than those noted in the wells. Therefore, the presence of acetone is probably due to laboratory contamination. With the exception of methylene chloride in well 800281 during the fourth quarter, all VOC levels were below the corresponding PQL. The PQL is the lowest concentration that can be reliably achieved within specific limits of precision and accuracy during routine operating conditions. VOCs were noted two quarters in well 800183D and three quarters in well 800171. These wells (one dolomite and one shallow well) are located east and southeast of the 800 Landfill Area. The general groundwater flow direction in the shallow glacial till, based on the water level elevations in the shallow series wells, is to the southeast with a minor component to the west. Groundwater flow in the dolomite (i.e., deep series) is primarily to the east and southeast. Although some seasonal variation exists, the flow pattern is very consistent from quarter to quarter.

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 6.45. Although the disposal of radioactive materials was prohibited in the sanitary landfill, very low concentrations of hydrogen-3 were detected in wells 800171 and 800281, located east of the landfill, and wells 800191 and 800192, located in the southwest corner of the landfill area. Hydrogen-3 has been consistently noted in these four wells from 1997 (well 800281 was first monitored during 1999). The presence of hydrogen-3 as tritiated water allows information to be obtained on the subsurface water flow pathway in the 800 Landfill area. As mentioned previously, the data indicate that the principal direction of subsurface water flow is to the southeast. 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 6.46 characterizes all wells in this area (see Figure 6.28 for locations). The results are shown in Tables 6.47 to 6.50 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 0.16 to 0.89 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 two quarters at levels well below the WQS (5 mg/L).

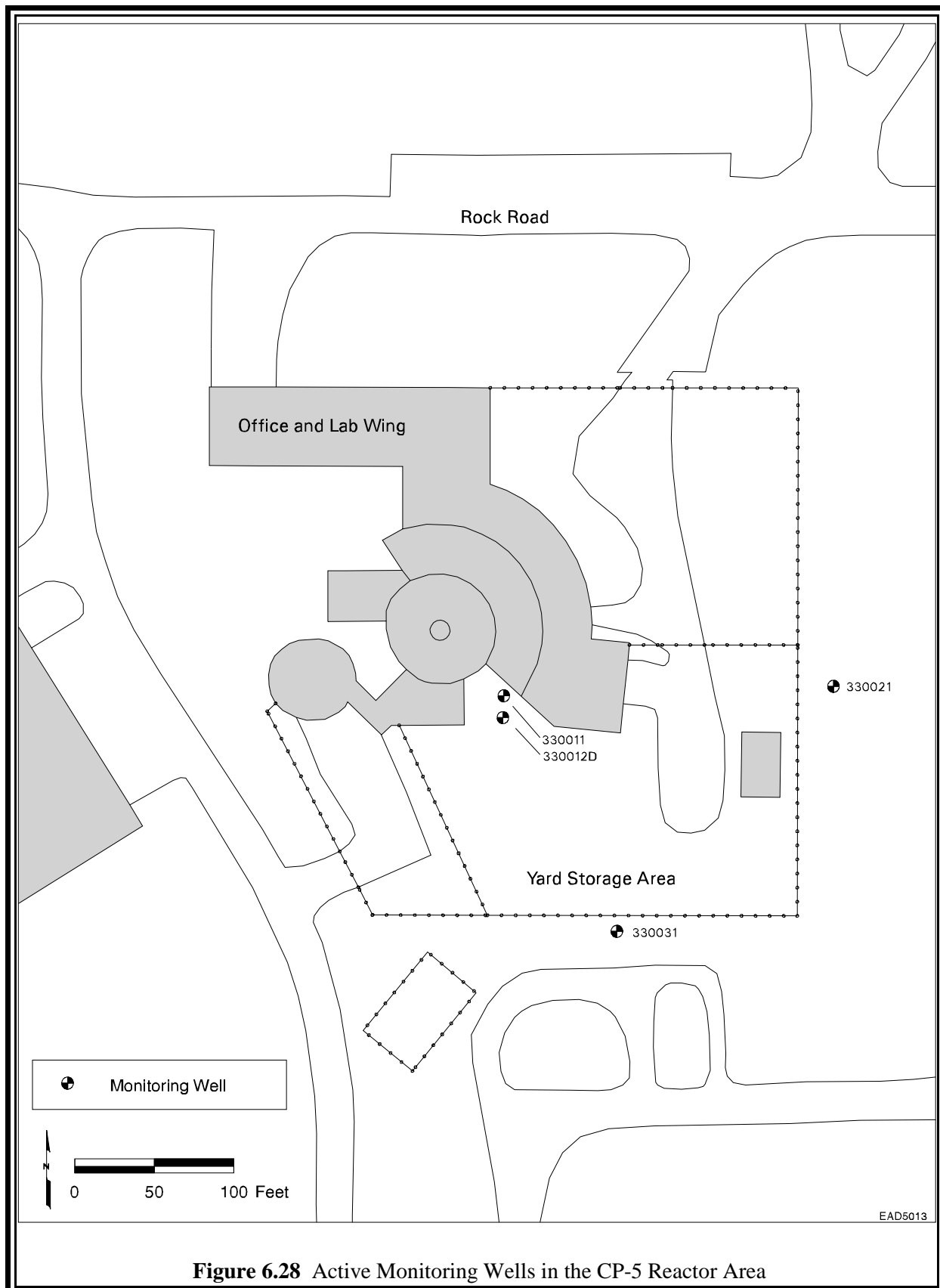
TABLE 6.46

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).

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TABLE 6.47

Groundwater Monitoring Results, 300 Area Well 330011, 2000

Parameter	Unit	Date of Sampling				
		02/29/00	02/29/00	06/26/00	09/06/00	11/15/00
Water elevation ^a	m	225.03	225.03	225.10	224.26	224.48
Temperature	°C	15.2	15.2	17.1	19.9	17.9
pH	pH	7.05	7.05	6.48	6.63	6.98
Redox	mV	-7	-7	28	22	14
Conductivity	µmhos/cm	1,022	1,022	1,013	2,170	1,275
Chloride ^b	mg/L	26	21	96	365	200
Arsenic ^b	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Barium ^b	mg/L	0.0607	0.0629	0.0744	0.1080	0.0897
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	0.0001	0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.1651	0.2458	0.5612	0.5060	0.8924
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	1,050	951	1,093	1,040	906
Strontium-90	pCi/L	0.53	0.56	0.61	0.92	0.70
Dichlorofluoromethane	µg/L	1	1	1	< 1	2

^a Well bottom elevation = 221.00 m (MSL); ground surface elevation = 227.10 m (MSL); casing material = stainless steel.

^b Filtered sample.

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TABLE 6.48

Groundwater Monitoring Results, 300 Area Well 330021, 2000

Parameter	Unit	Date of Sampling			
		02/29/00	06/26/00	09/06/00	11/15/00
Water elevation ^a	m	225.44	227.39	225.11	226.44
Temperature	°C	10.0	13.1	15.2	12.6
pH	pH	7.23	6.90	6.85	7.23
Redox	mV	-16	5	16	-7
Conductivity	µmhos/cm	725	686	752	686
Chloride ^b	mg/L	5	3	4	4
Arsenic ^b	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium ^b	mg/L	0.0230	0.0377	0.0286	0.0340
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	< 0.0370	< 0.0370	0.0550	0.3374
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	< 0.017	< 0.017	< 0.017	0.034
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	0.0006	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.0110	< 0.0110	0.0341	< 0.0110
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	193	103	169	169
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

^a Well bottom elevation = 221.95 m (MSL); ground surface elevation = 227.75 m (MSL); casing material = stainless steel.

^b Filtered sample.

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TABLE 6.49

Groundwater Monitoring Results, 300 Area Well 330031, 2000

Parameter	Unit	Date of Sampling			
		02/29/00	06/26/00	09/06/00	11/15/00
Water elevation ^a	m	225.81	227.02	225.47	226.79
Temperature	°C	9.6	11.8	15.9	13.2
pH	pH	7.13	7.15	6.94	6.92
Redox	mV	-10	-7	3	14
Conductivity	µmhos/cm	1,722	1,414	1,770	1,165
Chloride ^b	mg/L	254	214	236	246
Arsenic ^b	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium ^b	mg/L	0.0410	0.0493	0.0502	0.0539
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.0260	< 0.0260	0.0265	< 0.0260
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	< 0.0370	3.1350	3.8410	0.4126
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.0742	0.2260	0.5096	0.3220
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	0.6515	1.2110	1.7820	0.7128
Silver ^b	mg/L	< 0.0005	0.0006	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.0110	< 0.0110	0.0214	< 0.0110
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	237	241	244	259
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
Acetone	µg/L	< 1	2	< 1	< 1

^a Well bottom elevation = 221.95 m (MSL); ground surface elevation = 227.13 m (MSL); casing material = stainless steel.

^b Filtered sample.

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TABLE 6.50

Groundwater Monitoring Results, 300 Area Well 330012D, 2000

Parameter	Unit	Date of Sampling			
		02/29/00	06/26/00	09/06/00	11/15/00
Water elevation ^a	m	190.21	190.32	190.17	190.15
Temperature	°C	13.7	14.1	13.1	12.5
pH	pH	6.52	6.60	6.39	6.95
Redox	mV	22	45	54	11
Conductivity	µmhos/cm	1,064	965	1,102	860
Chloride ^b	mg/L	40	37	81	105
Arsenic ^b	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium ^b	mg/L	0.0507	0.0612	0.0548	0.0695
Beryllium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium ^b	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt ^b	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper ^b	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron ^b	mg/L	< 0.0370	< 0.0370	< 0.0370	0.0525
Lead ^b	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese ^b	mg/L	0.0748	0.1275	0.1283	0.0618
Mercury ^b	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel ^b	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver ^b	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium ^b	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium ^b	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc ^b	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	292	130	< 100	1,509
Strontium-90	pCi/L	0.68	0.41	0.39	0.64
Dichlorofluoromethane	µg/L	2	1	1	2
Trichlorofluoromethane	µg/L	2	1	1	1

^a Well bottom elevation = 185.65 m (MSL); ground surface elevation = 227.13 m (MSL); casing material = stainless steel.

^b Filtered sample.

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Manganese exceeded the WQS (0.15 mg/L) three quarters in well 330031. Manganese levels ranged from 0.07 to 0.51 mg/L. Similar manganese concentrations have been measured at distances from the CP-5 reactor (see Section 6.3.2.3). Nickel exceeded the WQS (0.10 mg/L) each quarter in well 330031. Nickel levels ranged from 0.65 to 1.78 mg/L. The source of nickel is unknown. Chloride concentrations exceeded the WQS (200 mg/L) each quarter, with chloride levels ranging from 214 to 254 mg/L. Barium and iron were detected at levels well below the WQS each quarter.

Barium and manganese were detected each quarter in well 330012D; all levels were considerably below the appropriate WQS. Iron was detected one quarter at a level well below the WQS (5 mg/L).

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 of dichlorofluoromethane and trichlorofluoromethane each quarter; concentrations ranged from 1 to 2 µg/L.

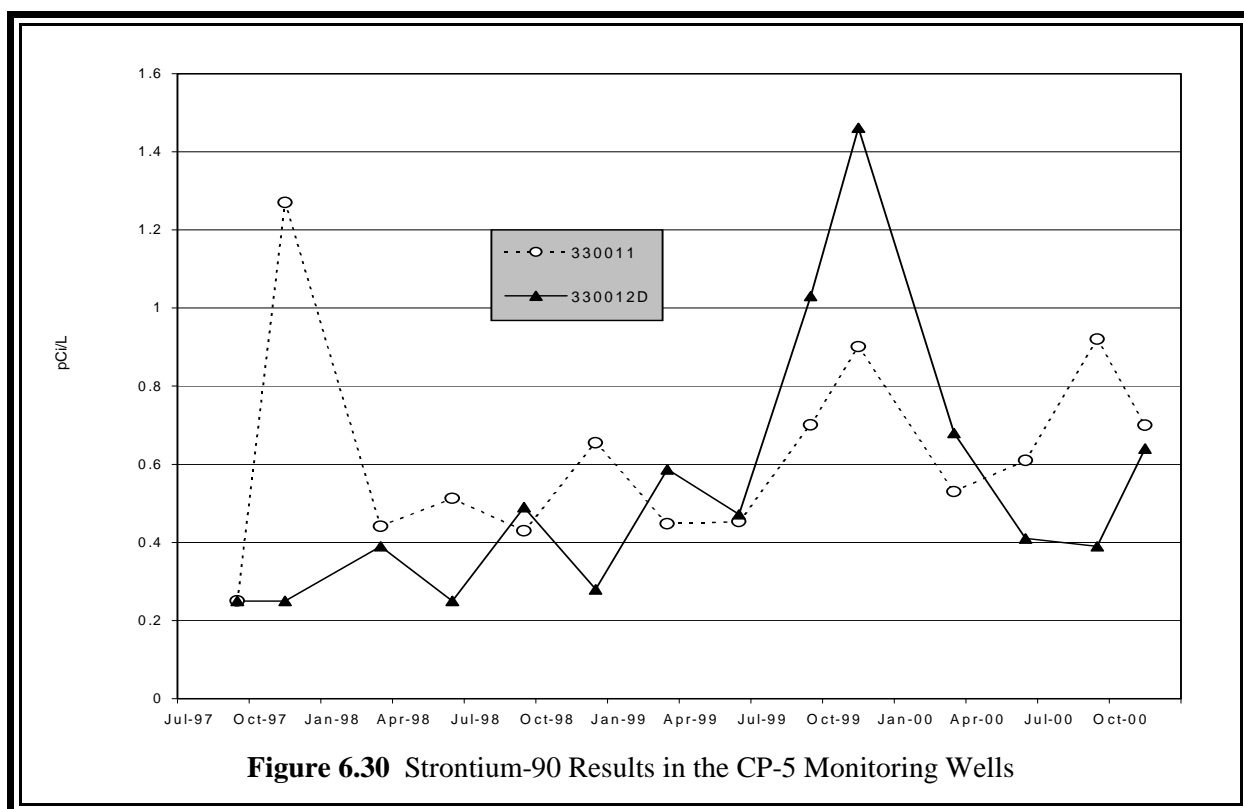
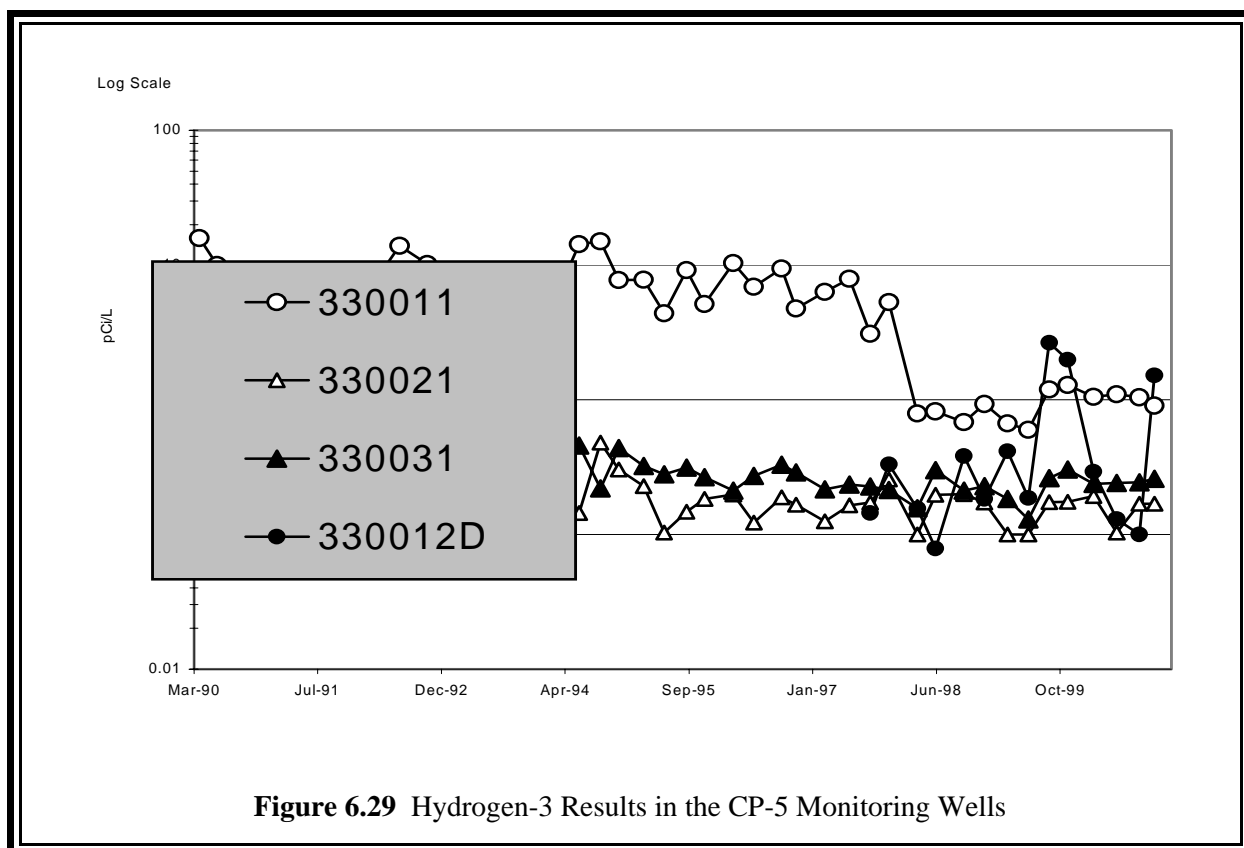
Radionuclide levels were similar to those noted in 1999 (see Figures 6.29 and 6.30). Unlike previous years, hydrogen-3 was detected each quarter in wells 330011, 330021, and 330031. The levels of hydrogen-3 ranged from 103 to 1,050 pCi/L. Hydrogen-3 was also detected three quarters in samples from 330012D at levels of less than 100 to 1,509 pCi/L. These levels are well below the WQS (20,000 pCi/L). The increase in the hydrogen-3 concentration during the last quarter is being investigated. Similar to past years, strontium-90 was detected in wells 330011 and 330012D, and the levels ranged from 0.39 to 0.92 pCi/L (Figure 6.30). 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. All the hydrogen-3 monitoring results for the CP-5 wells are plotted in Figure 6.29. 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

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6. GROUNDWATER PROTECTION

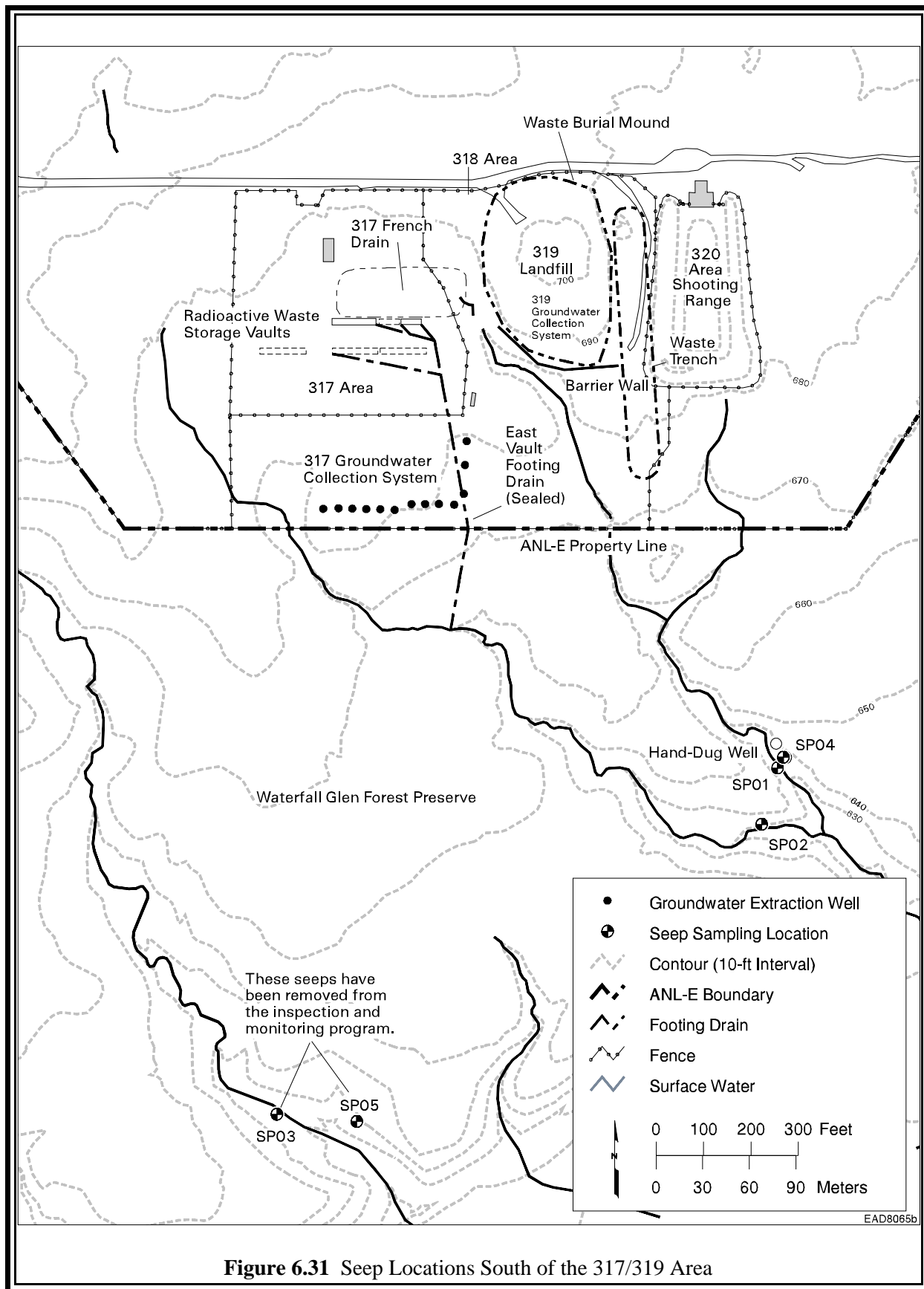
about 360 m (1,200 ft) south of the 317 Area and are considered clean background seeps. The locations are shown in Figure 6.31. The seeps are in ravines that are located in a pristine, heavily wooded section of the forest preserve. The ravines carry storm water drainage from the 317 and 319 Areas. Stormwater 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 2000, attempts were made to sample the three seeps quarterly. Seep SP04 was dry during the first quarter. The data are presented in Table 6.51. 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.

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TABLE 6.51

Contaminant Concentrations in Seep Water, 2000

Site	Date Collected	Hydrogen-3 (pCi/L)	Carbon Tetrachloride (µg/L)	Chloroform (µg/L)	Tetrachloroethene (µg/L)
SP01	March 21	706	5	2	< 1
	June 7	1,425	6	2	< 1
	August 21	1,178	8	2	< 1
	November 3	1,120	7	2	< 1
SP02	March 21	1,998	1	< 1	< 1
	June 7	1,124	1	< 1	< 1
	August 21	625	3	< 1	< 1
	November 3	1,348	2	< 1	< 1
SP04	March 21	Dry	Dry	Dry	Dry
	June 7	1,043	179	18	7
	August 21	435	301	28	9
	November 3	323	194	23	6

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7. QUALITY ASSURANCE



7. QUALITY ASSURANCE

QA plans exist for both radiological and nonradiological analyses; these QA documents were prepared in accordance with DOE Order 414.1²⁹ 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 till 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

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 2000 are given in Table 7.1. The relative error

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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 (\pm) 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 \pm 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 \pm value accompanies an individual result in this report, it represents the statistical counting error at the 95% confidence level.

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 2000. 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 7.1

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	-	0.1
Radium-228	-	0.1
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.

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TABLE 7.2

Summary of DOE-EML-QAP Samples, 2000

Matrix	Constituent	Date	Unit	EML	ANL-E	Ratio	Comments
Air filter	Manganese-54	March	Bq/filter	27.20	28.50	1.05	Acceptable
		Sept.		43.20	46.00	1.06	Acceptable
	Cobalt-57	March		5.31	5.44	1.02	Acceptable
		Sept.		14.55	15.00	1.03	Acceptable
	Cobalt-60	March		5.32	6.60	1.24	Warning
		Sept.		8.43	9.00	1.07	Acceptable
	Strontium-90	March		0.242	0.230	0.95	Acceptable
		Sept.		1.640	1.400	0.85	Acceptable
	Cesium-137	March		6.10	6.53	1.07	Acceptable
		Sept.		7.41	8.00	1.08	Acceptable
	Uranium-234	March		0.062	0.060	0.97	Acceptable
		Sept.		0.041	0.040	0.98	Acceptable
	Uranium-238	March		0.062	0.070	1.13	Acceptable
		Sept.		0.041	0.040	0.98	Acceptable
	Plutonium-238	March		0.080	0.080	1.00	Acceptable
		Sept.		0.045	0.050	1.11	Acceptable
	Plutonium-239	March		0.089	0.090	1.01	Acceptable
		Sept.		0.074	0.080	1.08	Acceptable
	Americium-241	March		0.088	0.080	0.91	Acceptable
		Sept.		0.032	0.040	1.25	Acceptable
Soil	Potassium-40	March	Bq/kg	811.0	904.0	1.12	Acceptable
		Sept.		713.0	761.0	1.07	Acceptable
	Strontium-90	March		20.2	18.9	0.94	Acceptable
		Sept.		50.4	47.0	0.93	Acceptable
	Cesium-137	March		339.2	396.0	1.17	Acceptable
		Sept.		1020.0	1070.0	1.05	Acceptable
	Uranium-234	March		111.0	111.0	1.00	Acceptable
		Sept.		157.0	135.0	0.86	Acceptable
	Uranium-238	March		114.0	115.0	1.01	Acceptable
		Sept.		163.0	137.0	0.84	Acceptable
	Plutonium-239	March		7.00	7.57	1.08	Acceptable
		Sept.		16.80	18.00	1.07	Acceptable
	Americium-241	March		3.36	3.40	1.01	Acceptable
		Sept.		9.00	8.27	1.09	Acceptable

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TABLE 7.2 (Cont.)

Matrix	Constituent	Date	Unit	EML	ANL-E	Ratio	Comments
Water	Hydrogen-3	March	Bq/L	79.4	84.9	1.07	Acceptable
		Sept.		91.3	110.0	1.20	Acceptable
	Cobalt-60	March		48.9	49.7	1.02	Acceptable
		Sept.		73.7	74.0	1.00	Acceptable
	Strontium-90	March		3.39	3.40	1.00	Acceptable
		Sept.		4.53	4.20	0.93	Acceptable
	Cesium-137	March		103.0	108.0	1.05	Acceptable
		Sept.		67.0	65.0	0.97	Acceptable
	Uranium-234	March		0.482	0.510	1.06	Acceptable
		Sept.		0.481	0.460	0.96	Acceptable
	Uranium-238	March		0.492	0.520	1.06	Acceptable
		Sept.		0.368	0.360	0.98	Acceptable
	Plutonium-238	March		0.944	0.950	1.01	Acceptable
		Sept.		0.786	0.770	0.98	Acceptable
	Plutonium-239	March		0.918	0.920	1.00	Acceptable
		Sept.		0.591	0.600	1.02	Acceptable
	Americium-241	March		1.950	2.000	1.03	Acceptable
		Sept.		1.190	1.280	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 98% (51 out of 52) of the analysis being in the DOE-EML-QAP acceptable range. One sample analyzed by gamma-ray spectrometry 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-ASCH 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 136²³ 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 2000 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 EPA for review. The proficiency of the laboratory is determined by comparing the analytical results for the submitted samples with the EPA values. The ANL-E laboratory has consistently performed very well on these tests. In 2000, all results were acceptable.

7. QUALITY ASSURANCE

TABLE 7.3

Standard Reference Materials Used for Inorganic Analysis	
Constituent	Reference Material ^a
Antimony	HPS-10002-2
Arsenic	HPS-10003-1
Barium	HPS-10004-1
Beryllium	HPS-10005-1
Boron	HPS-10007-4
Cadmium	HPS-10008-1
Chromium	HPS-100012-1
Cobalt	HPS-100013-1
Copper	HPS-100014-1
Iron	HPS-100026-1
Lead	HPS-100028-1
Manganese	HPS-100032-1
Mercury	HPS-100033-1
Nickel	HPS-100036-1
Selenium	HPS-100049-1
Silver	HPS-100051-1
Thallium	HPS-100058-1
Vanadium	HPS-100065-1
Zinc	HPS-100068-1
Sulfate	NIST-SRM 3181
Chloride	NIST-SRM 3182
Fluoride	NIST-SRM 3183

^a HPS = High Purity Standards, Inc.; NIST-SRM = National Institute of Standards and Technology - Standard Reference Materials.

TABLE 7.4

Detection Limit for Metals Analysis, 2000		
Constituent	Detection Limit (mg/L)	
	AA ^a	ICP ^b
Antimony	0.0030	NA ^c
Arsenic	0.0030	0.124
Barium	NA	0.012
Beryllium	0.0001	0.018
Boron	NA	0.024
Cadmium	0.0001	0.013
Chromium	0.015	0.011
Cobalt	NA	0.011
Copper	0.010	0.020
Hexavalent chromium ^d	0.006	NA
Iron	0.040	0.014
Lead	0.0020	0.072
Manganese	0.015	0.013
Mercury	0.0001	NA
Nickel	0.030	0.026
Selenium	0.0020	0.118
Silver	0.0005	NA
Thallium	0.0015	0.068
Vanadium	NA	0.025
Zinc	0.010	0.017

^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, 2000

Constituent	Recovery ^a (%)	Quality Limit (%)
Benzene	106	73 – 126
Bromobenzene	96	76 – 133
Bromodichloromethane	101	101 – 138
Bromoform	71	57 – 156
Butylbenzene	86	71 – 125
sec-Butylbenzene	109	71 – 145
t-Butylbenzene	108	69 – 134
Carbon tetrachloride	86	86 – 118
Chlorobenzene	103	80 – 137
Chloroform	111	68 – 120
o-Chlorotoluene	93	81 – 146
p-Chlorotoluene	97	73 – 144
1,2-Dibromo-3-chloropropane	78	36 – 154
Dibromochloromethane	88	68 – 130
1,2-Dibromoethane	108	75 – 149
Dibromomethane	94	65 – 143
1,2-Dichlorobenzene	104	59 – 174
1,3-Dichlorobenzene	101	84 – 143
1,4-Dichlorobenzene	100	58 – 172
1,1-Dichloroethane	111	71 – 142
1,2-Dichloroethane	98	70 – 134
1,1-Dichloroethene	99	18 – 209
cis-1,2-Dichloroethene	110	85 – 124
trans-1,2-Dichloroethene	98	67 – 141
1,2-Dichloropropane	102	19 – 179
1,3-Dichloropropane	101	73 – 145
1,1-Dichloropropene	95	71 – 133
Ethyl benzene	101	84 – 130
Isopropylbenzene	117	70 – 144
4-Isopropyltoluene	101	72 – 140 ^b
Methylene chloride	110	D – 197 ^b
n-Propylbenzene	103	78 – 139
1,1,1,2-Tetrachloroethane	90	88 – 133
Tetrachloroethene	103	84 – 132
Toluene	115	81 – 130
1,1,1-Trichloroethane	98	68 – 149
1,1,2-Trichloroethane	102	70 – 133
Trichloroethene	107	91 – 135
1,2,3-Trichloropropane	98	50 – 158
1,2,4-Trimethylbenzene	100	80 – 144
1,3,5-Trimethylbenzene	102	76 – 142
o-Xylene	90	79 – 141
p-Xylene	99	74 – 138

^a Average of two determinations.^b D denotes that the compound was detected.

7. QUALITY ASSURANCE

TABLE 7.6

Quality Check Sample Results:
Semivolatile Analyses, 2000

Constituent	Recovery ^a (%)	Quality Limit (%)
2-Fluorophenol ^b	33.8	21 – 100
Phenol-d5 ^b	26.4	10 – 94
Phenol	24.0	17 – 100
2-Chlorophenol	56.8	36 – 120
1,3-Dichlorobenzene	43.5	33 – 95
1,4-Dichlorobenzene	47.4	37 – 106
n-Nitroso-n-Propylamine	32.6	24 – 198
Nitrobenzene-d5 ^b	67.2	35 – 114
1,2,4-Trichlorobenzene	65.8	57 – 129
4-Chloro-3-Methylphenol	86.2	41 – 128
2-Fluorobiphenyl ^b	71.3	43 – 116
2-Methylnaphthalene	95.6	45 – 113
Acenaphthene	83.8	47 – 145
2,4-Dinitrotoluene	95.1	48 – 127
2,4,6-Tribromophenol ^b	80.6	10 – 123
Pentachlorophenol	60.8	38 – 152
Pyrene	66.3	70 – 100
Terphenyl-d14 ^b	89.9	33 – 141

^a Average of three determinations.

^b Required surrogates.

8. APPENDIX



8. APPENDIX

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8. APPENDIX

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