

**ARGONNE NATIONAL LABORATORY-EAST  
SITE ENVIRONMENTAL REPORT FOR  
CALENDAR YEAR 1991**

by

**N. W. Golchert, T. L. Duffy, and L. P. Moos**



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**ARGONNE NATIONAL LABORATORY, ARGONNE, ILLINOIS**

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Environment and Waste Management Program

May 1992

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## ACRONYMS

1,2-DCE	cis-1,2-Dichloroethene
ACM	Asbestos-Containing Materials
ADS	Activity Data Sheets
ALARA	As Low As Reasonably Achievable
ANL	Argonne National Laboratory-East
APS	Advanced Photon Source
ASTM	American Society for Testing and Materials
ATLAS	Argonne Tandem Linac Accelerating System
BAT	Best Available Technology
BOD	Biochemical Oxygen Demand
CAA	Clean Air Act
CEDE	Committed Effective Dose Equivalent
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CIL	Compliancy Inquiry Letter
CLP	Contract Laboratory Program
COD	Chemical Oxygen Demand
CP-5	Chicago Pile-Five
CRADA	Cooperative Research and Development Agreement
CWA	Clean Water Act
CWDD	Continuous Wave Deuterium Demonstrator
CY	Calendar Year
D&D	Decontamination and Decommissioning
DCG	Derived Concentration Guides
DMR	Discharge Monitoring Report
DOE	U. S. Department of Energy
DOE-CH	U. S. Department of Energy - Chicago Field Office
EA	Environmental Assessment
EBWR	Experimental Boiling Water Reactor
EIS	Environmental Impact Statement
EML	Environmental Measurements Laboratory
EMS	Environmental Protection Data Management System
ENE	East-Northeast
EPA	United States Environmental Protection Agency
EPCRA	Emergency Planning and Community Right to Know
ESA	Endangered Species Act
ESH	Environment, Safety and Health
ESH/QA	Environment, Safety and Health/Quality Assurance
EWM	Environment and Waste Management Program
FEUL	Fossil Energy Users Laboratory
FIFRA	Federal Insecticide, Fungicide and Rodenticide Act
FWS	Fish and Wildlife Service
FY	Fiscal Year
GOCO	Government-Owned Contractor-Operated
HEPA	High-Efficiency Particulate
HRS	Hazard Ranking Scores
HSWA	Hazardous and Solid Waste Admendments
IAC	Illinois Administrative Code
ICRP	International Commission on Radiological Protection
IEPA	Illinois Environmental Protection Agency

IHOM	Industrial Hygiene Operating Manual
IPNS	Intense Pulsed Neutron Source
LEPC	Local Emergency Planning Committee
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goals
MHD	Magneto Hydrodynamics
MSDS	Material Safety Data Sheets
NBL	New Brunswick Laboratory
NCRP	National Commission on Radiation Protection and Measurements
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
OSHA	Occupational Safety and Health Administration
PA	Preliminary Assessment
PCB	Polychlorinated Biphenyls
PFS	Plant Facilities and Services
PRP	Potentially Responsible Party
QA	Quality Assurance
QAP	Quality Assurance Program
RCRA	Resources Conservation and Recovery Act
RFA	RCRA Facilities Assessment
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SI	Site Investigation
SIP	State Implementation Plan
SPCC	Spill Prevention Control and Countermeasures
SRM	Standard Reference Material
SSI	Site Screening Investigation
SWMU	Solid Waste Management Units
TCA	1,1,1-trichloroethane
TCE	Trichloroethene
TDS	Total Dissolved Solids
TLD	Thermoluminescent Dosimeter
TRU	Transuranic
TSCA	Toxic Substances Control Act
TSD	Treatment, Storage or Disposal
TSS	Total Suspended Solids
VOC	Volatile Organic Compounds
WMO	Waste Management Operations
WWTP	Waste Water Treatment Plant
ZPR	Zero Power Reactor

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**ABSTRACT**

This report discusses the results of the environmental protection program at Argonne National Laboratory-East (ANL) for 1991. To evaluate the effects of ANL operations on the environment, samples of environmental media collected on the site, at the site boundary, and off the ANL site were analyzed and compared to applicable guidelines and standards. A variety of radionuclides was measured in air, surface water, groundwater, soil, grass, and bottom sediment samples. In addition, chemical constituents in surface water, groundwater, and ANL effluent water were analyzed. External penetrating radiation doses were measured and the potential for radiation exposure to off-site population groups was estimated. The results of the surveillance program are interpreted in terms of the origin of the radioactive and chemical substances (natural, fallout, ANL, and other) and are compared with applicable environmental quality standards. A U. S. Department of Energy (DOE) dose calculation methodology, based on International Commission on Radiological Protection (ICRP) recommendations and the CAP-88 version of the EPA-AIRDOSE/RADRISK computer code, is used in this report. The status of ANL environmental protection activities with respect to the various laws and regulations which govern waste handling and disposal is discussed. This report also discusses progress being made on environmental corrective actions and restoration projects from past activities.

## EXECUTIVE SUMMARY

This report is a summary of the ongoing environmental protection program conducted by ANL in 1991. It includes descriptions of the site, the ANL 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 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's impact on the environment. The surveillance program supports the ANL policy to protect the public, employees, and the environment from harm that could be caused by ANL activities and to reduce environmental impacts to the greatest degree practicable.

### Compliance Summary

Radionuclide emissions, the disposal of asbestos, and conventional air pollutants from ANL facilities are regulated under the Clean Air Act. A number of airborne radiological emission points at ANL are subject to the NESHAP regulations for radionuclide releases from DOE facilities (40 CFR 61, Subpart H). All such air emission sources were evaluated to ensure that the requirements were being properly addressed. The ANL individual off site dose required to be reported by these EPA regulations was 0.0040 mrem/y in 1991. This is 0.04% of the 10 mrem/y standard.

At ANL, asbestos-containing material is frequently encountered during a renovation or demolition project. Asbestos is removed in strict accordance with the NESHAP regulations as well as with the much stricter OSHA worker protection standards. All asbestos waste material is sealed in special plastic bags and disposed of in a designated section of the ANL landfill. Approximately 62 m<sup>3</sup> (2197 ft<sup>3</sup>) of asbestos or asbestos-contaminated materials were disposed of during 1991 in the sanitary landfill.

The ANL site contains several sources of conventional air pollutants. The steam plant and fuel dispensing facilities operate continuously and represent the only significant sources of conventional air pollutants. The operating permit for the steam plant requires continuous opacity and sulfur dioxide monitoring of the smoke stack from Boiler No. 5, the only boiler equipped to burn coal. Coal was burned only during the first eight weeks of 1991 whereas natural gas was used as a fuel for the rest of the year. During the period coal was burned, no excursions were observed.

The regulatory mechanism designed to achieve the goals of the Clean Water Act is the National Pollutant Discharge Elimination System (NPDES). The authority to implement the NPDES program has been delegated to the State of Illinois. Nine surface water discharge points are regulated by the ANL NPDES permit which identifies the sampling locations, sampling frequency, constituents, and limits. In 1991, 96% of the measurements were in compliance with the permit requirements. The major source of the exceedances, 23 for total dissolved solids and chloride, were traced to the disposal of ion exchange regenerant solution into the wastewater treatment system. These exceedances were eliminated in August 1991 when the piping was completed to divert this effluent to the DuPage County sewer system. A total of 13 exceedances of the total suspended solids limit occurred during 1991 due to both soil erosion from precipitation run-off and operational problems. Other exceedances occurred at various outfalls and covered a number of parameters.

ANL was granted interim status under the Resources Conservation and Recovery Act (RCRA) by submitting a Part A permit application in 1980. In 1990, a Part B permit application was submitted to the IEPA. Twelve hazardous waste treatment and storage facilities were identified. The Part B permit application is currently under IEPA review.

ANL has prepared and implemented a Site-Wide Underground Storage Tank Compliance Plan. At present, 33 tanks have been removed over the past several years and 25 tanks remain for removal or upgrade in FY 1992 and FY 1993. Of the tanks removed, 15 were found to have some degree of exterior

contamination from leaks, spills, or overfills. All but one of these contaminated sites were successfully cleaned and filled. One site required a "dirty" closure due to its proximity to a building.

In 1986, ten potential Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) sites were identified. Under the Superfund Amendments and Reauthorization Act of 1986, a total of 15 PA reports were submitted. In late 1990, SSI reports were completed on two individual sites and one composite submittal of three locations (317/319/ENE). Characterization studies are at various stages for a number of the identified sites. For some sites, the regulatory vehicle, CERCLA, RCRA, or some combination, has not as yet been established.

The only Toxic Substances Control Act (TSCA) compounds in significant quantities at ANL are polychlorinated biphenyls (PCBs) contained in electrical capacitors, transformer oil, and PCB-contaminated soil and sludge. All pole-mounted transformers and circuit breakers containing PCBs were replaced or retrofilled with non-PCB oil. All removal and disposal activities were conducted by licensed contractors specializing in such operations. A sludge drying bed, servicing the ANL wastewater treatment plant, was found to be contaminated with PCBs of unknown origin. An extensive characterization study and appropriate remediation of this site is planned.

The DOE implementation of the National Environmental Policy Act (NEPA) regulations has been undergoing significant changes during 1991. This has resulted in the submission of a large number of NEPA project review documents to DOE for review and approval. Most of these were determined to be categorical exclusions although Environmental Assessments will be required for several projects. An EA for the construction of the Continuous Wave Deuterium Demonstrator (CWDD) was prepared in 1991. There are currently no other active projects at ANL for which an EIS is required.

The 1991 Five-Year Plan contained information of 181 separate projects. The on-site activities included 15 corrective action projects, 26 environmental restoration projects, and seven waste management activities. The

corrective action projects concentrate on upgrading or replacing existing treatment facilities. Environmental Restoration activities are projects which assess and clean up inactive waste sites. These include two inactive landfills, three French Drains, two inactive wastewater treatment facilities and a number of areas that may have been contaminated with small amounts of hazardous chemicals. A number of D&D projects for on-site nuclear facilities have been identified including clean up at the EBWR and CP-5 research reactors. The majority of the Waste Management projects involve improvements to existing treatment or storage facilities.

#### Environmental Surveillance Program

Airborne emissions of gaseous radioactive materials from ANL were monitored and the effective dose equivalents were estimated at the site perimeter and to the maximally-exposed member of the public. The CAP-88 version of the EPA/AIRDOSE-RAD RISK code was used. The estimated maximum perimeter dose was 0.97 mrem/y in the north direction, while the estimated maximum dose to a member of the public was 0.29 mrem/y. This is 0.29% of the DOE radiation protection standard of 100 mrem/y for all pathways. Approximately 99% of this estimated dose is due to the release of 2946 curies of radon-220 in 1991. If the radon-220 impact is excluded from reporting, as required in 40 CFR 61, Subpart H, the estimated dose to the maximally-exposed individual would be 0.0040 mrem/y. The estimated population dose from all releases to the approximately eight million people living within 50 miles of the site was 15.5 man-rem.

Air monitoring was also conducted at ANL for total alpha activity, total beta activity, hydrogen-3, strontium-90, isotopic thorium, isotopic uranium, and plutonium-239. No statistically significant difference was identified between samples collected at the ANL perimeter and samples collected off the site. Monitoring for chemically hazardous constituents in ambient air was not conducted.

The only source of radionuclides and chemical pollutants in surface water due to ANL releases was in Sawmill Creek below the waste water

discharge point. At various times, measurable levels of hydrogen-3, strontium-90, cesium-137, neptunium-237, plutonium-239, and americium-241 were detected. Of these radionuclides, the maximum annual release was 1.40 curies of hydrogen-3. The dose to a hypothetical individual using water from Sawmill Creek as his sole source of drinking water would be 0.058 mrem/y. However, no one uses this as drinking water and dilution by the Des Plaines River reduces the concentrations of the measured radionuclides to levels below their respective detection limits downstream from ANL at Lemont. Sawmill Creek is also monitored for nonradiological constituents to demonstrate compliance with State of Illinois water quality standards.

Surface soil and grass samples were collected at ten perimeter and ten off-site locations during 1991. The purpose of the sampling was to detect the possible buildup of radionuclides from the deposition of airborne emissions. The results indicate no statistically significant difference between the perimeter and off-site concentrations of potassium-40, cesium-137, radium-226, thorium-228, thorium-232, plutonium-238, plutonium-239, and americium-241.

Sediment samples were collected from Sawmill Creek, above, at, and below the point of waste water discharge. For comparison purposes, samples were also collected from the beds of ten off-site streams and ponds. The analysis of the off-site samples for selected radionuclides established their current ambient levels. Elevated levels of cobalt-60 (up to 1 pCi/g), cesium-137 (up to 0.95 pCi/g), plutonium-238 (up to 0.02 pCi/g), plutonium-239 (up to 0.49 pCi/g), and americium-241 (up to 0.08 pCi/g) were found in the sediment below the outfall and are attributed to past ANL releases.

Dose rates from penetrating radiation (gamma-rays) were measured at 14 perimeter and on-site locations, and at five off-site locations in 1991 using thermoluminescent dosimeters. The off-site results averaged  $78 \pm 6$  mrem/y, consistent with the long-term average. Above-background doses occurred at one perimeter location and were due to ANL operations. At the south fence, radiation from a temporary storage facility for radioactive waste resulted in an average net dose of 15 mrem/y for 1991. The estimated

dose from penetrating radiation to the nearest resident south of the site was < 0.01 mrem/y and the dose to the nearest resident north of the site was 0.02 mrem/y.

The potential radiation doses to members of the public from ANL operations during 1991 were estimated by combining the exposure from inhalation, ingestion, and direct radiation pathways. The pathway that dominates is the airborne releases. The highest estimated dose was about 0.29 mrem/y to individuals living 500 m north of the site if they were outdoors at that location during the entire year. Doses from other pathways were calculated and were small at this location. The magnitude of the doses from ANL operations are well within all applicable standards and are insignificant when compared to doses received by the public from natural radiation (~ 300 mrem/y) or other sources, e.g., medical x-rays and consumer products (~ 60 mrem/y).

Radiological and chemical constituents in the groundwater were monitored in several areas of the ANL site in 1991. The ANL domestic water supply is monitored by collecting quarterly samples from the four wells. All results were less than the limits established by the Safe Drinking Water Act except for elevated levels of TDS and turbidity.

Thirteen monitoring wells screened in the glacial till and two into the dolomite were sampled quarterly at the 317/319 Area and analyzed for radiological and volatile organic constituents. The major organic contaminants detected were perchloroethene, trichloroethene, 1,1-dichloroethane, 1,1,1-trichloroethane, cis-1,2-dichloroethene, carbon tetrachloride, and chloroform. Measurable levels of hydrogen-3, strontium-90, and cesium-137 were present in several of the wells. A characterization program statement of work has been prepared to assess the extent of the groundwater contamination.

Thirteen monitoring wells screened in the glacial till and two into the dolomite at the 800 Area sanitary landfill are sampled on a quarterly basis and analyzed for metals, volatile organic compounds, and hydrogen-3.

Elevated levels of iron, manganese, pH, arsenic, and hydrogen-3 were found in some wells. Significant levels of hydrogen-3, acetone, and other ketones were found in one of the dolomite wells. A work plan for a groundwater characterization program at this site is currently undergoing regulatory review.

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 the supporting standard operating procedures. Newly collected data were compared both with recent results and historical data to ensure that deviations from previous conditions were identified and promptly evaluated. 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 inter-laboratory cross-checks, and replicate sampling and analysis. Data were managed and tracked by a dedicated computerized data management system which assigns unique sample numbers, schedules collection and analysis, checks status, and prepares tables and information for the annual report.

## 1. INTRODUCTION

### 1.1. General

This annual report on the Argonne National Laboratory-East (ANL) environmental protection program provides the U. S. Department of Energy (DOE), environmental agencies, and the public with information on the levels of radioactive and chemical pollutants in the vicinity of ANL and on the amounts, if any, added to the environment by ANL operations. It also summarizes compliance of ANL operations with applicable environmental laws and regulations and highlights significant accomplishments and problems related to environmental protection. The report follows the guidelines given in DOE Order 5400.1.<sup>1</sup>

ANL conducts a continuing program of environmental surveillance on and near the site to determine the identity, magnitude, and origin of radioactive and chemical substances in the environment. The detection of any such materials released to the environment by operations of ANL is of special interest. One important function of the program is to verify the adequacy of ANL's pollution controls.

ANL is a DOE energy research and development laboratory with several principal objectives. It conducts a broad program of research in the basic energy and related sciences (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 1991 included: advanced reactor development; safety studies for light water and breeder reactors; component and material development for fission and fusion reactors; superconductivity advances and applications; improvements in the use of coal for power production (particularly high-sulfur coal); synchrotron radiation accelerator design; development of electrochemical energy sources, including fuel cells and batteries for vehicles and for energy storage; and evaluation of heat exchangers for the recovery of waste heat from engines.

Other areas of research are the use of superconducting magnets for improved nuclear particle accelerators, fundamental coal chemistry studies, the immobilization of radioactive waste products for safe disposal, medical radioisotope technology, carcinogenesis, and the biological effects of small amounts of radiation. Environmental research studies include biological activity of energy-related mutagens and carcinogens; characterization and monitoring of energy-related pollutants; and the effects of acid rain on vegetation, soil, and surface water quality. A significant number of these laboratory studies require the controlled use of radioactive and chemically toxic substances.

The principal nuclear facilities at ANL are: a 185 kW light-water cooled and moderated biological research reactor (JANUS), fueled with enriched uranium; a superconducting heavy ion linear accelerator (Argonne Tandem Linac Accelerating System, ATLAS); a 22 MeV pulsed electron Linac; a 60-in cyclotron; 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; cobalt-60 irradiation sources; chemical and metallurgical plutonium laboratories; and several hot cells and laboratories designed for work with multi-curie quantities of the actinide elements and with irradiated reactor fuel materials. The DOE New Brunswick Laboratory, a safeguards plutonium and uranium measurements and analytical chemistry laboratory, is located on the ANL site.

Two activities initiated in 1984 and continued in 1991 have some potential environmental impact: (1) management of radioactive contamination remaining from the proof-of-breeding in light-water reactors project, which involved the dissolution and analysis of irradiated thorium and uranium-233 dioxide fuel elements and (2) recovery of tritium from reactor irradiated ceramic lithium compounds. The shut down 5-MW heavy water enriched uranium research reactor (CP-5) and the Experimental Boiling Water Reactor (EBWR) are in various stages of decontamination and decommissioning.

The principal nonnuclear activities at ANL in 1991 that may have measurable impacts on the environment include the use of a coal-fired boiler

(No. 5), studies of the closed-loop heat exchanger for waste heat recovery, disposal of waste in the on-site sanitary landfill, disposal of water treatment chemicals, and use of large quantities of chlorine for water treatment. The boiler, designed to burn high-sulfur (3.5%) Illinois coal to produce steam for ANL use, is equipped with a slaked lime spray scrubber and bag collector to reduce sulfur dioxide and particulate emissions. The closed-loop heat exchanger studies involved the use of moderately large quantities of toxic or flammable organic compounds, such as toluene, Freon, biphenyl oxides, methyl pyridine, and trifluoroethanol. The landfill consists of an unlined area used for disposal of most of the solid, non-hazardous waste generated on-site. The treatment of the ANL drinking water results in the release of large quantities of dissolved solids and chloride to Sawmill Creek. These releases were eliminated in August 1991 with the diversion of this waste stream to the DuPage County treatment plant. Chlorine usage for waste water treatment was without incident. The major potential for environmental impact from these materials would be associated with any accidental releases caused by equipment malfunction. However, no such releases have occurred.

## 1.2. Description of Site

Argonne National Laboratory (Illinois site) occupies the central 688 hectares (1,700 acres) of a 1,514-hectare (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. The 826-hectare (2,040-acre) Waterfall Glen Forest Preserve surrounding the site is mostly former ANL property that was deeded to the DuPage County Forest Preserve District in 1973 for use as a public recreational area, nature preserve, and demonstration forest. Figure 1.1 contains numbers on the abscissa and letters on the ordinate. In this report, facilities are identified by the alpha-numeric designations in Figure 1.1 to facilitate their location.

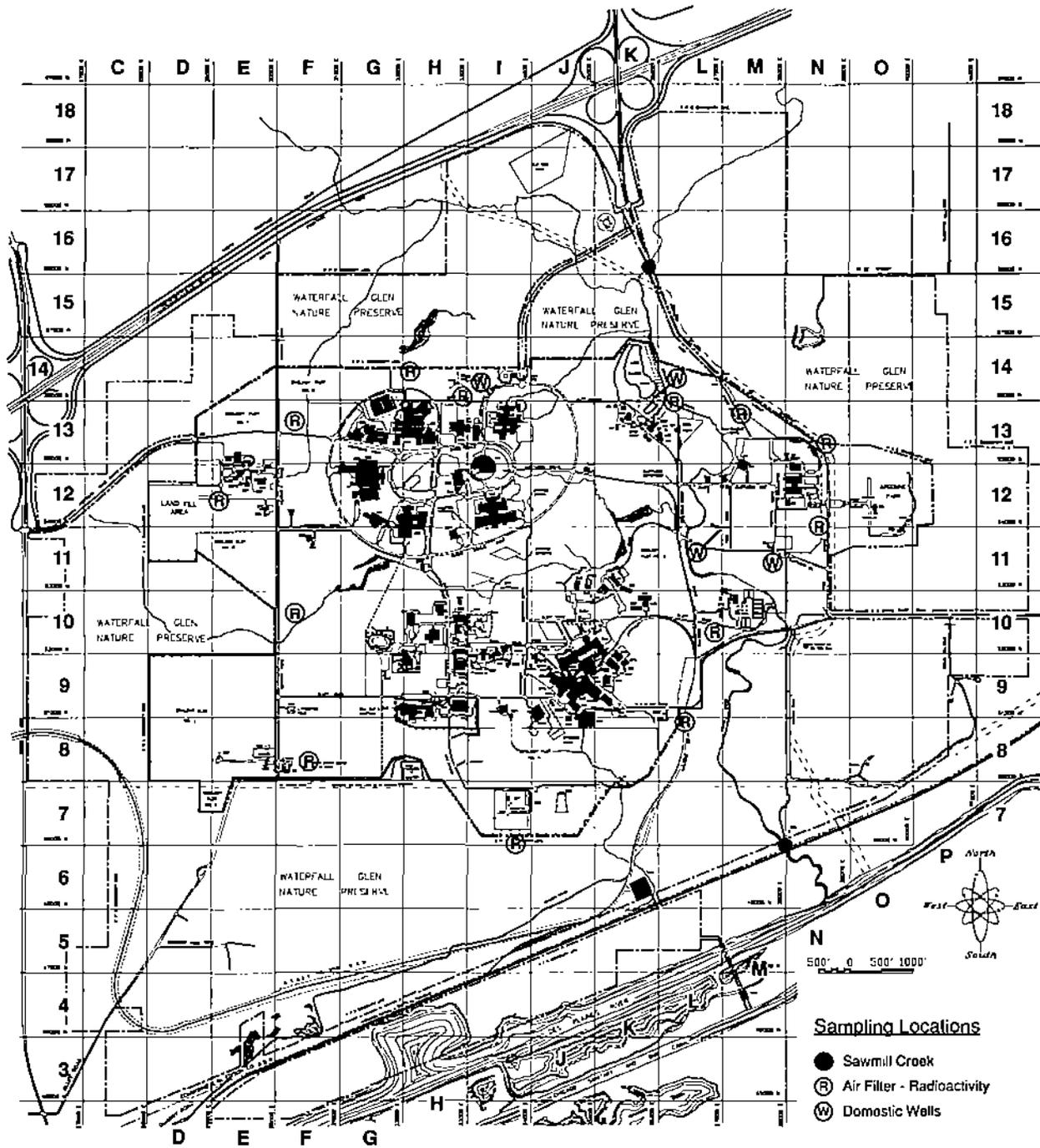


Figure 1.1 Sampling Locations at Argonne National Laboratory

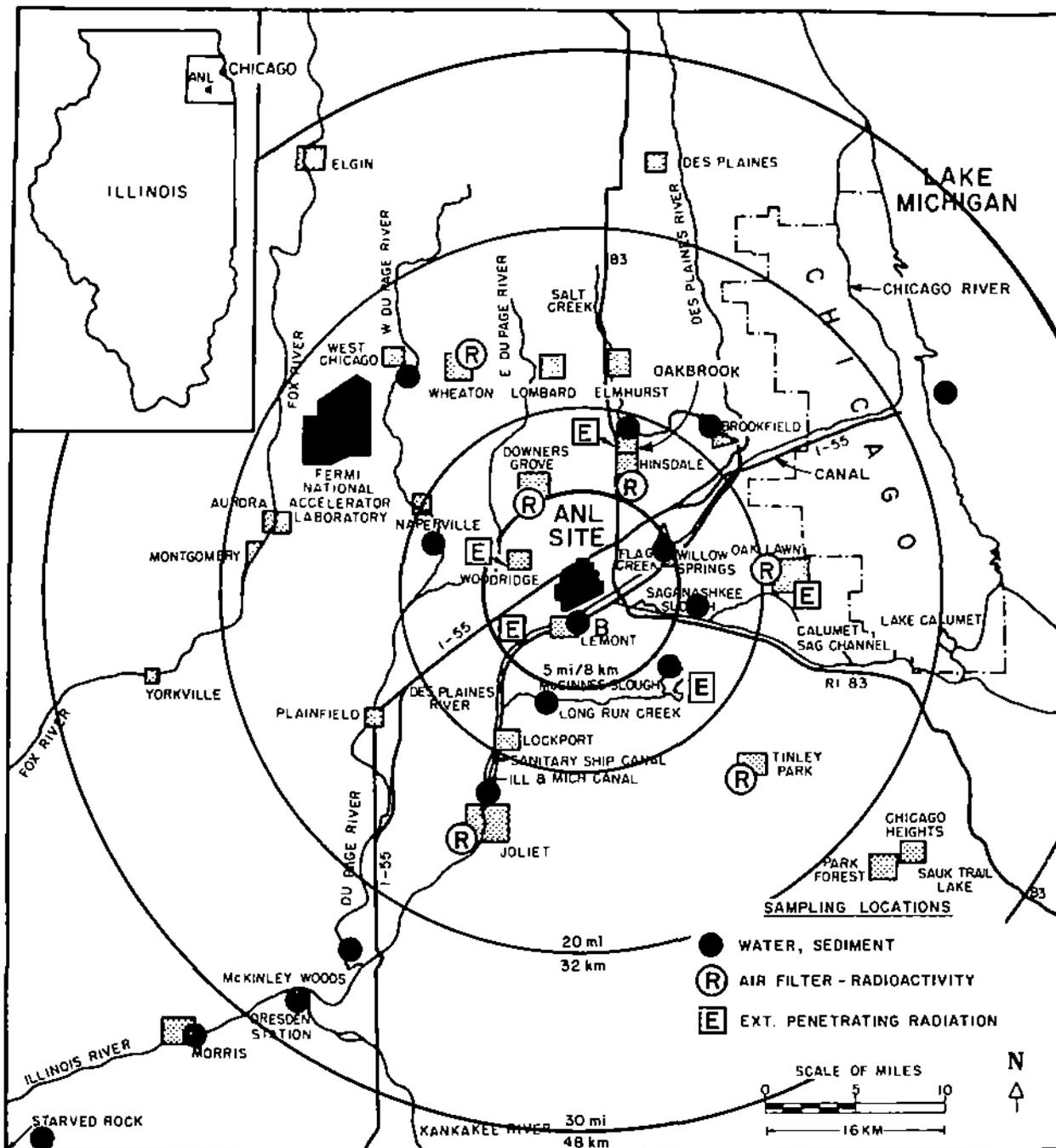


Figure 1.2 Sampling Locations Near Argonne National Laboratory

The terrain of ANL 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 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. Their presence extends the uninhabited area created by the ANL site and surrounding forest preserve about 1.6 km (1 mi) south of the site. The elevation of the channel surface 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°, reaching an average elevation of 200 m (650 ft) above sea level at the top. The land then slopes gradually upward reaching 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). The Chicago District Pipe Line Co. and the Atchison, Topeka, and Santa Fe Railroad have rights-of-way in the southern portion of the forest preserve. Additional information about the site is given in the 1982 draft Argonne Environmental Assessment.<sup>2</sup>

### 1.3. Population

The area around ANL has experienced a large population growth in the past 30 years. Large areas of farmland have been converted into housing. Table 1.1 presents directional and annular 80-km (50-mi) population distribution for the area, which is used for the population dose calculations

TABLE 1.1

## Population Distribution in the Vicinity of ANL, 1991

Direction	Population (individuals) at 0-5 Miles*					Population (thousands) at 5-50 Miles*				
	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
N	0	661	4199	5602	8783	44.7	172.1	336.7	187.5	221.3
NNE	0	22	3684	5925	5287	38.8	302.3	485.8	86.7	0
NE	0	737	2293	2431	1689	40.9	674.4	866.3	0	0
ENE	0	1117	2495	1460	1482	33.5	598.7	178.9	0	0
E	0	16	10	1	42	40.8	467.0	199.8	13.0	25.8
ESE	0	0	55	331	306	22.4	186.1	282.0	245.0	80.9
SE	0	2	219	425	198	19.8	103.2	114.2	28.6	12.2
SSE	0	72	401	221	1800	12.0	22.1	7.7	11.0	16.8
S	0	105	2298	921	860	3.7	23.4	2.0	35.3	35.0
SSW	0	33	3504	1229	759	14.7	89.8	10.8	17.6	7.1
SW	0	80	20	87	79	11.6	36.7	9.4	16.2	9.1
WSW	0	215	86	620	1646	4.8	7.6	3.7	8.0	7.2
W	0	779	1237	8338	9056	26.2	67.2	19.0	14.8	6.7
WNW	0	254	224	5867	4433	44.3	104.6	20.7	6.6	52.9
NW	0	552	2602	6979	6779	41.6	69.1	95.5	18.2	16.7
NNW	0	492	2774	4521	9390	33.4	188.5	225.2	130.6	96.5
Total	0	5137	26101	44958	52589	433.2	3112.8	2857.7	819.1	588.4
Cumulative Total**	0	5137	31238	76196	128785	561.9	3674.7	6532.4	7351.5	7939.9

\* To convert from miles to kilometers, multiply by 1.6.

\*\* Cumulative total = total of this sector plus totals of all previous sectors.

later in this report. The population distribution, centered on the CP-5 reactor (Location 9G in Figure 1.1), was prepared by the Geographic Data Systems Computing and Telecommunications Division at Oak Ridge National Laboratory and represents projections to 1991 based on the 1990 census data.

#### 1.4. Climatology

The climate of the area is representative of the upper Mississippi Valley, as moderated by Lake Michigan. Summaries of the meteorological data collected on the site from 1949 to 1964 are available<sup>3</sup> 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 1991 data were obtained from the on-site ANL meteorological station. The 1991 average monthly and annual wind roses are shown in Figure 1.3. The wind roses are polar coordinate plots 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 each 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 monthly wind roses indicate that the winds are variable, so that monitoring for airborne releases must be carried out in all directions from the site. For example, the dominant wind direction in January was from the southwest, while in June it is northeast. The annual average wind rose for 1991 is consistent with the long-term average wind direction, which usually varies from the west to south, but with a significant northeast component. Precipitation and temperature data for 1991 are shown in Table 1.2. The monthly precipitation data for 1991 showed marked differences from the

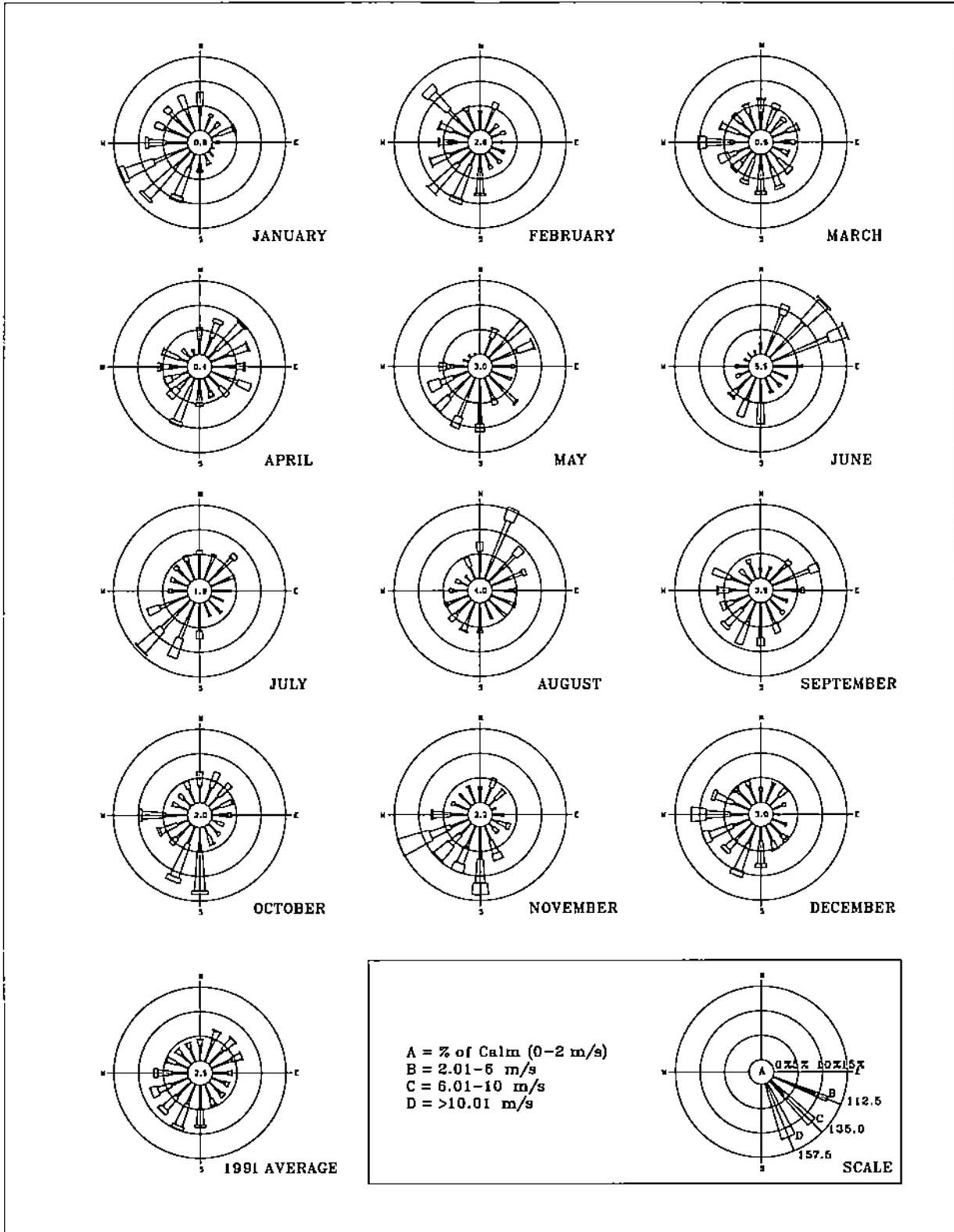


Figure 1.3 Monthly and Annual Wind Roses at Argonne National Laboratory, 1991

TABLE 1.2

## ANL Weather Summary, 1991

Month	Precipitation (cm)			Temperature (°C)		
	ANL 1991	ANL Historical Average**	Historical Average*	ANL 1991 Monthly Average	ANL Historical Average**	Historical Average*
January	3.77	3.61	4.06	-6.1	-5.9	-5.9
February	1.24	3.38	3.33	-0.7	-3.7	-3.3
March	12.07	5.56	6.58	4.6	0.6	2.2
April	12.85	9.14	9.30	11.3	8.3	9.3
May	12.47	7.82	8.00	18.8	14.5	15.1
June	2.64	9.47	10.36	22.9	19.7	20.3
July	0.84	10.97	9.22	23.9	21.7	22.8
August	3.36	8.71	8.97	23.1	20.9	22.2
September	5.69	7.14	8.51	17.6	16.8	18.2
October	22.38	6.58	5.79	11.2	11.4	11.9
November	9.08	4.37	5.23	1.6	2.9	4.3
December	3.51	3.20	5.33	-0.8	-4.2	-2.4
Total	89.90	79.95	84.68			

\*Data obtained from the National Oceanic and Atmospheric Administration (NOAA) for the weather station at O'Hare International Airport. The average for the years 1951-1980.

\*\*ANL data obtained from Reference 3.

average. For example, March, April, May, October, and November were above the average, while June, July, and August were below the average. The annual total was about 10% higher than the long-term average. Except for the spring being warmer than normal, the temperatures were similar to the long-term averages.

### 1.5. Geohydrology

The geology of the ANL area consists of about 30 m (100 ft) of glacial till overlying dolomite bedrock of Niagaran and Alexandrian dolomite from the Silurian age. Maquoketa shale of the Ordovician age and older dolomites and sandstones of Ordovician and Cambrian ages underlie these formations. The beds are nearly horizontal.

Two principal aquifers are used as water supplies in the vicinity of ANL. The upper aquifer is the Niagaran and Alexandrian dolomite, which is about 60 m (200 ft) thick in the ANL 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 hydraulic connection between the two aquifers.

The four domestic water supply wells now in use on the ANL site (see Figure 1.1) are drilled about 90 m (300 ft) deep terminating in the Niagaran dolomite. A well drilled in the Galesville sandstone 490 m (1,600 ft) deep has been taken out of service. The water level in the Niagaran dolomite has remained reasonably stable under ANL pumping, dropping about 3.7 m (12 ft) between 1960 and 1980. The aquifer appears to be adequate for future ANL use, but this ground water source is used throughout the area. Several small capacity water wells used for laboratory experiments, fire protection, and sanitary facilities also exist on the site, primarily in the 800 Area and meteorology complex.

## 1.6. Water and Land Use

The principal stream that drains the ANL site is Sawmill Creek. It carried effluent water continuously from a sewage treatment plant (Marion Brook Treatment Plant) located a few kilometers north of the site until October 27, 1986, when the plant was closed. Residential and commercial development in the area has resulted in the collection and channeling of runoff water into Sawmill Creek. Treated sanitary and laboratory wastewater from ANL are combined and discharged into Sawmill Creek at location 7M in Figure 1.1. This effluent averaged 3.4 million liters (0.91 million gallons) per day. The combined ANL effluent consisted of 40% laboratory wastewater and 60% sanitary wastewater but there were wide variations in both. The water flow in Sawmill Creek upstream of the wastewater outfall averaged about 22 million liters (5.8 million gallons) per day during 1991.

Sawmill Creek and the Des Plaines River above Joliet, about 21 km (13 mi) southwest of ANL, receive very little recreational or industrial use. A few people fish in these waters downstream of ANL and some duck hunting takes place on the Des Plaines River. Water from the Chicago Sanitary and Ship Canal is used by ANL for cooling towers and by others for industrial purposes, such as hydroelectric generators and condensers, and for irrigation at the state prison near Joliet. The ANL usage is about 0.4 million liters (100,000 gallons) per 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. 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 for drinking is at Alton, on the Mississippi River about 710 km (370 mi) downstream from ANL. At that location, water is used indirectly to replenish groundwater supplies by infiltration. In the vicinity of ANL, only subsurface water (from both shallow and deep aquifers) and Lake Michigan water are used for drinking purposes.

The principal recreational area near ANL is Waterfall Glen Forest Preserve, which surrounds the site (see Section 1.2 and Figure 1.1). The area is used for hiking, skiing, and equestrian sports. 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 Cook County Forest Preserve District are located east and southeast of ANL 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 site (Location 12-0 in Figure 1.1) is for the use of ANL and DOE employees only.

## 2. COMPLIANCE SUMMARY

Argonne National Laboratory-East is a government owned, contractor operated (GOCO) non-production facility which is subject to environmental regulations administered by the U. S. Environmental Protection Agency (EPA), the Illinois Environmental Protection Agency (IEPA), and the Illinois Department of Public Health, as well as numerous DOE Orders and Executive Orders. A detailed listing of applicable regulations is contained in DOE Order 5400.1, which establishes DOE's policy concerning environmental compliance. The status of ANL with regard to these regulations and orders is discussed in this Chapter. This chapter is divided into two parts, the 1991 whole year summary and the first quarter, 1992 summary. The latter section discusses important developments which occurred during the early part of 1992.

To insure compliance with both the letter and spirit of these regulations, ANL has made a commitment to comply with all applicable environmental regulations as described in the following policy statement revised during 1990.

"It is the policy of Argonne National Laboratory that its activities will be conducted in such a manner that worker and public safety, including protection of the environment, is given the highest priority. The Laboratory will comply with all applicable Federal and State environmental laws, regulations and orders."

### 2.1. Clean Air Act

The Clean Air Act (CAA) is a Federal statute that specifies National Ambient Air Quality Standards, sets emission limits for air pollutants and determines emission limits and operating criteria for a number of hazardous air pollutants. The program is implemented by individual states through a State Implementation Plan (SIP), which describes how that state will ensure compliance with the air quality standards for stationary sources. A number of major changes to the Clean Air Act were made with the passage of the

Clean Air Act Amendments of 1990. Many of these changes will have minimal impact on ANL. However, some changes, such as amendments to the hazardous pollutants regulations which expand the number of hazardous air pollutants from eight to 189, could have significant impact in the future.

The primary tool for enforcing most provisions of the CAA for point source emissions is the permitting process. The IEPA requires that all point sources of air emissions, except for those specifically excluded, apply for a construction permit (for proposed new sources) and/or operating permit (for existing or newly constructed sources). The permit, when issued, contains specific requirements necessary to ensure that the point source operates within the limits of the permit.

The ANL site contains a large number of air emission point sources. The vast majority are laboratory ventilation systems which are exempt from state permitting requirements, except for those systems emitting radionuclides. During 1990, a search for unpermitted emission points was conducted throughout the Laboratory. Approximately 35 emission points subject to permitting requirements had been identified. By the end of 1991, a total of 29 air permits were in place covering all 35 emission points. Section 2.15 contains a listing of the permits in effect at ANL.

#### 2.1.1. National Emission Standards for Hazardous Air Pollutants

The National Emission Standards for Hazardous Air Pollutants (NESHAP) are a body of federal regulations that set forth emission limits and other requirements, such as monitoring, record keeping, and operational requirements, for activities generating emissions of certain hazardous air pollutants. The standards for asbestos and radionuclides are the only standards affecting ANL operations.

#### 2.1.1.1. Asbestos Emissions

Many buildings on the ANL site contain large amounts of asbestos-containing materials (ACM) such as insulation around pipes and tanks, fire proofing and numerous other applications. This material is removed as necessary during renovations or repair of equipment and facilities. The removal and disposal of this material is governed by the asbestos NESHAP.

The standards for asbestos specify detailed requirements for removal and disposal of certain types of ACM. Until the November 1990 revisions, only friable (easily crushed) ACM was regulated. Now, however, many other types of ACM are regulated, including non-friable materials which have been, or could be reduced to a crumbly, pulverized or powder state through the process of removal or disposal. This change greatly increases the amount of material regulated by the NESHAP.

The standard describes accepted procedures for removal of ACM, including notification of the IEPA prior to removal of greater than certain amounts, work practices and procedures to be used and emission control procedures to be used. The use of specially trained individuals for removal of ACM is mandated.

ANL maintains an asbestos abatement program designed to assure compliance with these and other regulatory requirements. The removal of ACM at the Laboratory is done either by a specially trained Waste Management Operations (WMO) crew (used for small, short lead time jobs such as piping repairs) or by outside contractors specializing in ACM removal work (for large building renovation or major piping removal projects). All removal work is done in strict compliance with both the NESHAP requirements as well as the OSHA requirements governing worker safety at ACM removal sites. When ACM is encountered during a renovation or demolition project, it is carefully wetted or otherwise encapsulated and completely removed. The work area is sealed off using disposable glove bags or temporary plastic sheeting barriers, and high-efficiency particulate air (HEPA) filtration equipment is used to prevent emissions. Air is monitored in the vicinity of such work by ANL Industrial Hygiene personnel during the removal work as well as after

the work is completed in order to verify that adequate precautions have been taken to prevent the release of significant amounts of asbestos. Personal exposure air samples are collected. Asbestos fiber counts are analyzed using Phase Contrast Microscopy and selected samples are analyzed by Transmission Electron Microscopy.

The asbestos NESHAP standards require that the IEPA be notified before beginning large asbestos removal projects involving more than 80 m (260 ft) of pipe insulation or 15 m<sup>2</sup> (160 ft<sup>2</sup>) of other material. This written notification on a State form must be forwarded to the IEPA in a prescribed time limit. A total of 218 separate removal projects were completed which generated 62 cubic meters (2197 cubic feet) of ACM waste. These removal projects were all relatively small projects involving small amounts of piping or building material. One removal project generating 328 cubic feet was reported to the IEPA on September 13, 1991. Much of the material removed and disposed of as ACM is actually not regulated ACM, however, to insure consistency and to be conservative, all ACM is treated as if it were regulated. The revised NESHAP requires estimation of the total amount of ACM to be removed during renovation or demolition activities during each upcoming calendar year. If this amount exceeds the regulatory levels above, the IEPA must be notified. In late 1991, ANL made such a notification for activities planned for 1992. It is estimated that no more than 3500 cubic feet of ACM waste will be generated during 1992.

A separate portion of the standard contains requirements for waste disposal sites used for disposal of ACM. The acceptable disposal practice involves placing wetted waste materials into labeled, leakproof plastic bags for disposal in landfills. Off-site shipments are to be accompanied by completed shipping manifests. A specially designated portion of the ANL landfill is the primary disposal site for ACM generated on-site. The principal requirements applicable to the landfill relate to covering the ACM daily with at least 6 inches of non-asbestos-containing materials and maintenance of disposal records. To comply with this standard, the ACM is buried before the end of the work shift, normally immediately after it is placed in the landfill. The landfill operators maintain a record of all ACM placed in the landfill.

### 2.1.1.2. Radionuclide Emissions

The NESHAP standard for radionuclide emissions from DOE facilities (40 CFR 61, Subpart H) establishes the emission limits for release of radionuclides to the air and requirements for monitoring, reporting, and record keeping. This regulation was revised in late 1989, resulting in increased monitoring and reporting requirements. A number of emission points at ANL are subject to these requirements. These points include ventilation systems for hot cell facilities for storage and handling of radioactive materials (Buildings 200, 205, and 212), ventilation systems for currently operating and inactive reactors (Building 202, JANUS reactor and Building 330, inactive reactor CP-5), ventilation systems for particle accelerators (Building 211, cyclotron and Building 375, IPNS facility), and several ventilation systems associated with the New Brunswick Laboratory (Building 350). In addition, many small ventilation systems and fume hoods are occasionally used for processing of small quantities of radioactive materials. The radionuclide NESHAP requires that all air emission sources of radionuclides be evaluated to determine whether the magnitude of these emissions is above a threshold amount which would result in an effective dose equivalent to the maximally exposed individual of greater than 1% of the standard of 10 mrem/yr. Those sources with greater than this amount of emissions must be monitored in accordance with 40 CFR 61.93(b) and a report issued annually summarizing the emissions measured. Any emission point below this threshold must be measured occasionally to verify the low rate. At ANL, the major emission sources are continuously monitored to comply with this requirement. However, to satisfy the determination for monitoring requirements for the large number of smaller sources, all radionuclide air emission sources are being reevaluated. The emissions from the New Brunswick Laboratory are included with ANL emissions when calculating dose rates under NESHAP. Continuous monitors have been installed on these exhaust stacks to determine emission rates more accurately.

Routine continuous monitoring of the larger emission sources has indicated that the amount of radioactive material released to the atmosphere from these sources is extremely small, resulting in a very small incremental radiation dosage to the neighboring population. The calculated potential

maximum individual off-site dose to a member of the general public for 1991 was 0.0040 mrem (excluding radon-220), which is 0.04% of the 10 mrem per year EPA standard. Section 4.6.1. contains a more detailed discussion of these emission points and compliance with the standard.

IEPA regulations (incorporating by reference the Federal NESHAPs) require that all sources of hazardous pollutants subject to NESHAP apply for and receive an operating permit. This means that ANL must classify and permit all emission points for radionuclides. During 1990 and 1991, a survey of the most significant radionuclide-using facilities was conducted to identify nonpermitted emission points. Permit applications were prepared and submitted to the IEPA for these points. As shown in Section 2.15.1 of this chapter, all of these permits have already been issued. To complete this task, a detailed survey of fume hood usage, as well as sampling and analysis of exhaust points, will be required. This work was conducted in late 1991 and the permit application will be prepared in 1992. The application will identify 290 laboratory hoods in 12 buildings.

#### 2.1.2. Conventional Air Pollutants

The ANL site contains a number of sources of conventional air pollutants, including a steam plant, oil-fired boilers, gasoline and methanol fuel dispensing facilities, two alkali metal reaction booths, a small vapor degreaser, a number of bulk chemical tanks, a dust collection system, a medical equipment sterilization unit, fire training activities, and a research facility for combustion and power generation research (FEUL facility). These emission sources have either been granted operating permits by the IEPA or a permit has been applied for, as shown in Section 2.15. A survey of the majority of the site was conducted to identify unpermitted emission sources of conventional pollutants. Operating permit applications were then prepared and submitted to the IEPA.

The operating 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 excursions beyond emission limits

for this boiler [30% opacity averaged over six minutes and 1.8 lb sulfur dioxide (SO<sub>2</sub>) per million Btu averaged over a one-hour period]. In the last few years, the air pollution control equipment associated with Boiler No. 5 has experienced numerous breakdowns and failures, usually of short duration. The SO<sub>2</sub> scrubber was designed and built as a demonstration test unit in 1980; however, it has operated in recent years as an operations unit. Many of the components have reached the end of their useful life, resulting in frequent breakdowns and malfunctions. As a result, the air emissions frequently exceed the allowable amounts. These excursions have been reported to the IEPA as required. In April 1990, Boiler No. 5 was shut down. During 1991, the site steam requirements have been met using the four natural gas fired boilers. The steam plant underwent numerous corrective activities (i.e., equipment calibrating and rehabilitation) during 1991 to prevent future excursions while operating on coal. Boiler No. 5 started on coal again during January 1992 for eight weeks and no excursions were noted.

The fuel dispensing facilities are used to service vehicles associated with ANL only and, except for methanol vapors, have VOC emissions typical of any commercial gasoline service station. During October 1991, the methanol/gasoline dispensing facility permit was reissued to reflect the fact that all vapors were to be captured by the delivery vessel. The on-site Service Station permit had also been reissued during May 1991, reflecting the service station name change.

To comply with the new notification requirement of Section 609 of the Clean Air Act regulating future servicing of motor vehicle air conditioners, the on-site Service Station and Vehicle Maintenance Department submitted "small entity certifications" during December 1991. This certification states that fewer than 100 automobile air conditioners were serviced during 1990 and approved equipment will be purchased by January 1, 1993, which will be used to recover and recycle Freon.

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

The 1987 amendments to the CWA significantly changed the thrust of enforcement activities. Greater emphasis is now placed on monitoring and control of toxic constituents in wastewater, the permitting of outfalls composed entirely of stormwater, and the imposition of regulations governing sewage sludge disposal. These changes in the NPDES program resulted in much stricter discharge limits and greatly expanded the number of chemical constituents monitored in the effluent. The wastewater treatment facilities on the ANL site will be upgraded to comply with the changing requirements.

### 2.2.1. Liquid Effluent Discharge Permit

The primary tool for enforcing the requirements of the NPDES program is through the NPDES permitting process administered by the IEPA. 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 contains numeric limits on certain pollutants likely to be present and sets forth a number of specific and general requirements, including sampling and analysis schedules and reporting and record keeping requirements. Wastewater generation activities at ANL are covered by NPDES permit IL 0034592. This permit expires in January 1994.

Wastewater at ANL is generated by a number of activities and consists of sanitary wastewater (from restrooms, cafeteria sinks and sinks in certain buildings and laboratories, steam boiler blowdown, and drinking water filter backwash), laboratory wastewater (from laboratory sinks and floor drains in most buildings), and stormwater. Water softener regenerant is discharged to the DuPage County sewer system. Cooling water and cooling tower blowdown are currently discharged into stormwater ditches which are monitored as part of the NPDES permit. The current permit authorizes the release of wastewater from nine separate outfalls, most of which discharge directly or indirectly into Sawmill Creek. In addition, the permit requires monitoring of the wastewater at two internal sampling points that combine to form the main wastewater outfall, outfall 001. Table 2.1 described these outfalls, and the locations are shown in Figure 2.1. Two of these outfalls, 009 and 010, are used for emergency overflow discharge from the lime sludge pond and coal pile, respectively.

#### 2.2.1.1. Effluent Monitoring Results and Compliance Issues

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 1991, there were 44 exceedances of NPDES permit limits out of approximately 1000 measurements made. This represents a 96% compliance rate, compared to a 91% compliance rate in 1990.

The types of exceedances experienced were similar to recent years and a breakdown appears in Figure 2.2. About half (23) of the exceedances were of the total dissolved solids (TDS) and chloride limits at 001. The cause of these TDS and chloride exceedances was disposal of water softener regenerant solutions, as discussed below. The second largest category (13) is total suspended solids (TSS) exceedances at a number of outfalls, primarily outfalls 003, 004, 006, and 010. In addition, occasional exceedances (8) of pH, iron, zinc and manganese occurred. There are a number of different

TABLE 2.1

## Description of NPDES Outfalls at ANL

Outfall* Number	Description	Status	Average Flow (Million Gallons/Day)
001	Combined discharge of 001A and 001B - main site outfall (7M)	Active	0.8-1.2
001A	Sanitary wastewater treatment plant effluent	Active - internal sampling point	0.4-0.6
001B	Laboratory wastewater treatment plant effluent	Active - internal sampling point	0.4-0.6
003	Stormwater runoff, cooling water and cooling tower blow- down	Active	0.1-0.3
004	Cooling water, stormwater	Active	0-0.05
005	Cooling water and cooling tower blowdown, stormwater	Active	0-0.2
006	Canal water treatment plant wastewater, cooling tower drain- age, cooling water, stormwater	Active	0-0.12
007	Cooling water, stormwater	Active	0-0.01
008	Stormwater	Active	0-0.01
009	Lime sludge pond overflow	Emergency overflow	0
010	Coal pile runoff overflow	Emergency overflow	0

\*Locations are shown in Figure 2.1.

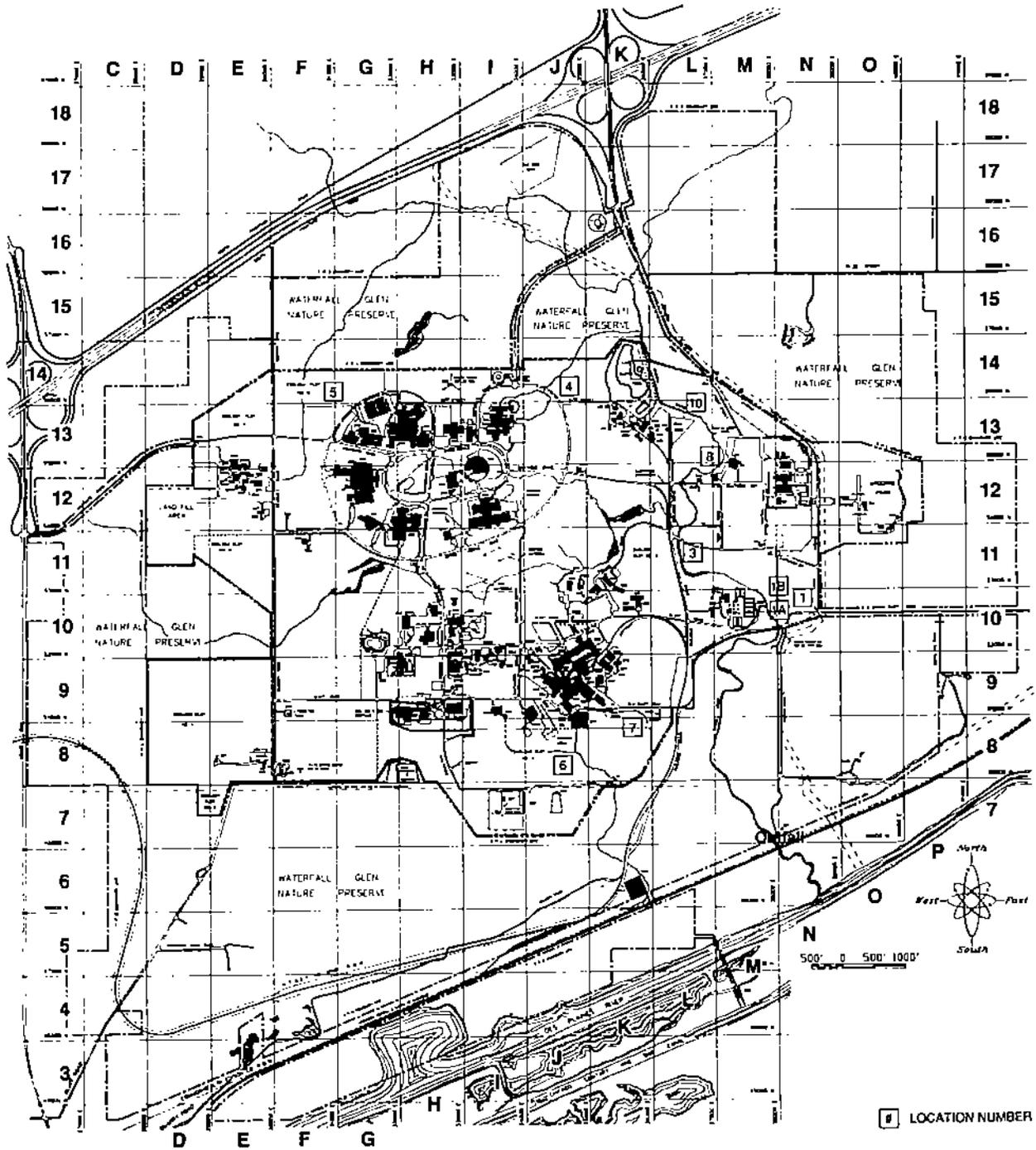
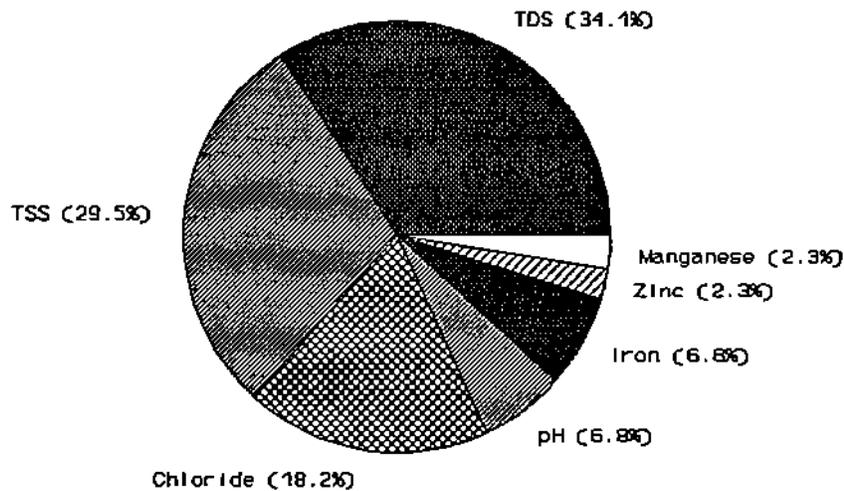


Figure 2.1 NPDES Permit Locations

reasons for these excursions. Chapter 5 discusses each outfall individually and presents the suspected reasons for permit exceedances.



**Figure 2.2** Distribution of NPDES Permit Exceedances, 1991

Since 1986, when a new ion-exchange water softening system was installed, ANL experienced numerous exceedances of limits for chlorides and total dissolved solids. These exceedances were the result of the disposal of water treatment system spent regenerant solutions (concentrated brine solution) into the laboratory wastewater treatment system. The laboratory wastewater treatment system was not designed to remove dissolved salts, and as a result, the salt passes directly through the system and is discharged into Sawmill Creek. To prevent these exceedances, a treatment plant for this brine solution was proposed to the IEPA and a compliance date of June 30, 1990, was inserted in the permit. However, as the design of the treatment plant advanced in early 1990, it was determined that due to the nature of the salts involved, very expensive materials would be required, and even with the system in place, there was a great likelihood that the TDS limits still would not be met. As an alternative, ANL proposed installing a sewer line to the DuPage County sewer system and pumping the spent brine to the DuPage County system. The IEPA approved this plan, and the pipe was constructed, and beginning August 23, 1991, the spent regenerant solution was

discharged to the DuPage County system. Since that date, no TDS or chloride exceedances have occurred.

The magnitude of the exceedances of TSS limits experienced during 1991 is thought to be caused by several factors, including erosion of soil from construction sites and drainage ditches, the siltation of several small on-site ponds which act as settling basins to remove solids from stormwater, and the operation of two small earthen sludge holding ponds which sometimes overflow following heavy rains, carrying solids into outfall 006. Due to the severity of the TSS exceedances, the IEPA placed ANL on the list of facilities in significant noncompliance. This will result in tighter scrutiny of the discharge monitoring reports and could result in enforcement action if the exceedances continue. Projects are in the planning stages to specifically reduce TSS discharges from the sludge lagoons and other sources by removal of accumulated sediments from three on-site ponds and site-wide erosion control. During September 1991, ANL requested that the IEPA modify the NPDES permit for the sludge holding pond overflow project which would divert flow to the ANL sanitary sewer system for further treatment before discharge to outfall 001A.

As a result of heavy rains, wastewater flowed from outfall 010, the coal storage pile stormwater emergency outfall, on three different occasions during 1991. Due to the composition and highly acidic nature of the high sulfur coal stored in this area, this discharge was out of compliance with several different limits, including pH, TSS, iron, zinc, and manganese. These three instances alone represent 25% of the total number of exceedances during the entire year.

To improve the level of compliance with permit limits, ANL is in the third year of an intensive effort of building additional wastewater treatment facilities or upgrading existing facilities. Projects to upgrade and refurbish the laboratory and sanitary wastewater treatment plant are scheduled for 1992 through 1995. These and other corrective action projects are described in the Environmental Restoration and Waste Management Five Year Plan for ANL and identified in Chapter 3.

### 2.2.1.2. Additional NPDES Monitoring

The current permit requires semiannual testing of outfall 001B, the laboratory wastewater treatment plant outfall, for all the priority pollutants (a list of 126 metals and organic compounds defined by the IEPA as being of particular concern). During 1991, this sampling was conducted in June and December. A number of volatile organic compounds were detected in these samples, at low concentration. The most significant of these are acetone (550  $\mu\text{g/L}$ ), methylene chloride (83  $\mu\text{g/L}$ ), and 1,1,1-trichloroethane (16  $\mu\text{g/L}$ ) in the June sample which were probably contributed by normal ANL operations. Barely detectable amounts (less than 5  $\mu\text{g/L}$ ) of several other volatile organics were also found, including chloroform, bromodichloromethane, dibromochloromethane, di-n-butylphthalate, and bis(2-ethylhexyl)-phthalate. The source of most of these materials is suspected to be from the contact of chlorinated water with organic chemicals in the laboratory, as well as the discharge of small amounts of chemicals from various research and support operations. Zinc was detected at low concentrations (27  $\mu\text{g/L}$ ), arsenic (3.1  $\mu\text{g/L}$ ), copper (20  $\mu\text{g/L}$ ) and phenol (6  $\mu\text{g/L}$ ). Chrysolite (asbestos) consisting of fibers of less than 10 millimicrons in length were detected in the December sample. The source of this material is unknown. 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 was done in September of 1991. Both the 1990 and the 1991 results on the 001 effluent exhibited acute toxicity to the fathead minnow and ceriodaphnia. This implies that there may be components in the effluent wastewater that effect aquatic life. Specific studies of these parameters may be required.

### 2.2.2. Stormwater Regulations

In November 1990, the EPA promulgated new regulations governing the permitting and discharge of stormwater from industrial sites. The ANL site contains a large number of small scale operations which are considered industrial activities by the new regulation, and thus, is subject to these

requirements. To satisfy the stormwater permit application information needs, an extensive stormwater characterization program began in 1991. This program measures stormwater flows and collects samples for chemical and radiological analysis. During 1991, 16 outfall points not included in the existing NPDES permit were monitored. This study will be discussed in next year's site environmental report. It is likely that this study will increase the number of permitted outfall points included in the NPDES permit.

#### 2.2.3. NPDES Inspections and Audits

In February 1991, the IEPA conducted a Compliance Inspection of NPDES outfalls and related facilities, as well as associated sampling and analysis and record keeping requirements. No problems were found.

#### 2.2.4. General Effluent and Stream Quality Standards

In addition to specific permit conditions, ANL discharges are required to comply with general effluent limits contained in 35 Illinois Administrative Code, Subtitle C, Chapter I, Part 304. Also, wastewater discharges must be of sufficient quality to insure that Sawmill Creek complies with the IEPA's General Use Water Quality Standards found in 35 Illinois Administrative Code, Subtitle C, Chapter I, 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. NPDES Analytical Quality Assurance

ANL conducts the majority of the analyses required for inclusion in the Discharge Monitoring Report. These analyses are conducted using EPA approved methods in 40 CFR 136. To demonstrate the capabilities of the ANL laboratory for these analyses, the IEPA requires the laboratory to participate in the DMR Quality Assurance program. The IEPA sends a series of control samples to ANL annually and the results of analyses of these samples are submitted to the IEPA and EPA for review. The proficiency of the

laboratory is determined by how close the analytical results for the submitted samples come to the actual values. The ANL laboratory has consistently performed very well on these tests, see Chapter 7.

#### 2.2.6. Spill Prevention Control and Countermeasures Plan

ANL maintains a Spill Prevention Control and Countermeasures (SPCC) plan as required by the Clean Water Act and EPA implementing regulations set forth in 40 CFR 112. This plan describes the actions to be taken in case of a spill or other accidental release into the environment. Persons with specific duties and responsibilities in such situations are identified, as are reporting and recordkeeping requirements mandated by the regulations. Effective use of this plan is ensured by regular training, including both classroom instruction and field exercises. This plan was revised and updated in 1989 and is scheduled for revision in 1992.

#### 2.3. Resource Conservation and Recovery Act

The extremely complex Resource Conservation and Recovery Act (RCRA) and its implementing regulations are intended to insure that hazardous wastes are disposed of in an environmentally safe manner and 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 wastes. In addition, HSWA also requires that releases of hazardous waste or hazardous constituents from any solid waste management unit located on the site of a RCRA permitted facility be cleaned up, regardless of when the waste was placed in the unit or if the unit was originally intended as a waste disposal unit. As discussed below, these RCRA corrective action provisions will have far reaching impact on ANL. The RCRA program includes regulations governing management of underground storage tanks containing hazardous materials or petroleum products. The IEPA has been authorized to administer most aspects of the RCRA program in Illinois.

### 2.3.1. Hazardous Waste Treatment and Disposal

Because of the nature of the research activities conducted at ANL, small quantities of a large number of waste chemicals are generated. Many of these materials are classified as hazardous waste under RCRA. A number of these wastes also exhibit significant levels of radioactivity, making them so-called mixed wastes. The hazardous components of mixed wastes are subject to RCRA regulations by IEPA, while the radioactive component is subject to DOE regulations under the Atomic Energy Act of 1954. Hazardous wastes are collected by the ANL Waste Management Operations (WMO) Department from individual generators and shipped off-site for disposal at an approved hazardous waste disposal facility. Small quantities of certain types of hazardous waste are treated on-site. To provide for on-site management of hazardous and mixed wastes before off-site shipment or on-site treatment, ANL operates several RCRA permitted storage facilities. These facilities, designed and operated in compliance with RCRA requirements, allow for accumulation and processing of waste and storage of waste pending identification of a disposal site. Several of the mixed wastes generated on-site do not have any approved disposal mechanism. As a result, some waste is being stored indefinitely until a disposal mechanism becomes available. A variety of facilities are used for these activities, including several buildings formerly used for research activities which have been converted to storage or treatment facilities. In addition to the storage areas, there are currently four active units used for treatment of small quantities of hazardous waste. Two of the units are used for treatment of water reactive alkali metals. The remaining two units, which are located in Building 306, are used for elementary neutralization of acidic or basic wastes. These four units are exempt from RCRA permitting requirements. Table 2.2 lists the on-site RCRA permitted storage and treatment units. The current Part A (interim status) application lists two units which are now inactive. These units, shown in Table 2.2, are the water reaction tank, used in the past for treatment of alkali metals and other water reactive materials, and the shock-sensitive treatment area, used for treatment of highly unstable or explosive materials. Both units are located in the 317 Area. These units are scheduled to undergo closure in accordance with IEPA requirements. They will then be removed from the permit.

TABLE 2.2

## Hazardous Waste Treatment and Storage Facilities

Description	Location	Purpose
<u>Current Interim Status Facilities</u>		
Waste Treatment and Storage	Building 306	Primary facility for treatment, accumulation, packaging and short term storage of hazardous and mixed waste
Container Storage Area	Building 325C	Storage of containers of waste
Mixed Waste Container Storage	Building 329	Storage of containers of mixed liquid wastes
Dry Mixed Waste Storage Area	Building 374A	Storage of containers or solid objects (e.g., lead bricks) containing hazardous or mixed waste materials
Alkali Metal Reaction Booth	Building 206	Destruction of water reactive alkali metals
Alkali Metal Reaction Booth	Building 308	Destruction of water reactive alkali metals, possibly contaminated with radio-nuclides
<u>Interim Status Facilities to be Closed</u>		
Water Reaction Tank	317 Area	Destruction of water reactive alkali metals and other reactive chemicals
Shock Sensitive Treatment Area	317 Area	Treatment (detonation) of extremely reactive, or shock-sensitive wastes
Neutralization Booth	Building 306	Elementary neutralization of acids and basic waste
High Bay Area	Building 306	Storage of containers of mixed wastes

### 2.3.2. Permit Status

ANL was granted interim status under RCRA after submitting a notification of Waste Handling Activities and a Part A application in 1980. In 1990, a new Part B permit application, one had previously been sent to the EPA but not acted upon, was prepared for submittal to the IEPA, since the IEPA has now been granted authority to administer the RCRA program. The application was submitted to the IEPA and EPA on December 21, 1990. Revisions to the permit application were submitted on June 17, 1991, and September 24, 1991, in response to IEPA and EPA comments. Besides being updated and prepared to comply with changes in RCRA and IEPA regulations, the application was modified to include information required to comply with the RCRA/HSWA corrective action provisions. A RCRA Facilities Assessment (RFA) was completed by the IEPA during summer 1991. The RFA is still undergoing review at IEPA and has not been finalized. The Part B permit is expected to be issued in late 1992. In the meantime, ANL will continue to abide by its Part A permit and the interim status standards found in 40 CFR 265 and 35 IAC Part 725.

### 2.3.3. Hazardous Waste Generation

ANL typically generates several thousand gallons of a wide variety of hazardous waste and mixed waste each year. The quantity of mixed wastes generated during 1991 was 12,440 liters (3287 gallons). Of that output, 530 liters (140 gallons) were shipped to an EPA-approved treatment facility. In 1991, 88,102 liters (23,256 gallons) of hazardous waste were shipped to a disposal site by an IEPA-permitted hazardous waste disposal company. In addition, small quantities of certain hazardous wastes were treated on the site in the permitted treatment units. These units render the waste non-hazardous and allow disposal in the normal refuse or in wastewater. During 1991, four liters (1 gallon) of waste were treated on site, primarily by thermal reaction in the alkali metal reaction booth.

#### 2.3.4. Facility Modifications

In an effort to bring the waste management facility into compliance with the more restrictive RCRA standards for a Part B-permitted Treatment Storage or Disposal (TSD) facility found in 40 CFR 264 and 35 IAC, Chapter I, Part 724, several parts of the waste handling system underwent major rehabilitation work. Many of the storage and work areas within Building 306 were modified by the installation of berms, sealing of floors and installation of improved ventilation systems. Improved safety equipment was installed, as were special cabinets for storage of flammable liquid wastes.

A new radioactive and hazardous waste storage building is also being planned. This project is scheduled for late 1992 or 1993. The Part A permit will be revised before construction of these facilities is begun. The Part B permit application will be revised to incorporate these facilities when the final design details are known.

#### 2.3.5. Mixed Waste Handling

The hazardous component of mixed waste is governed by RCRA regulations, while the radioactive component is subject to regulations under the Atomic Energy Act as supplemented by DOE Orders. Accordingly, facilities storing or disposing of mixed waste must comply with DOE requirements and RCRA permitting and facility standards. Argonne generates several types of mixed wastes, including acids or solvents contaminated with radionuclides. Mixed wastes are treated to remove the hazardous characteristic (e.g., by acid/base neutralization) before off-site disposal. Mixed wastes that cannot be rendered non-hazardous are stored pending future disposal. The Part B application addresses mixed waste management procedures.

#### 2.3.6. RCRA Inspections

A RCRA compliance inspection conducted by IEPA in February 1991 alleged one administrative violation, incomplete inspection records. A pre-enforcement conference letter was received in March 1991. The compliance problem raised in this letter was resolved successfully by April 1991.

### 2.3.7. Underground Storage Tanks

In response to underground storage tank regulations, ANL has prepared a Site-Wide Underground Tank Compliance Plan. The ANL site currently contains 25 existing underground storage tanks; 33 tanks have been removed over the last several years. The majority of these tanks are being used, or were used in the past, for storage of fuel oil for emergency generators or space heaters. The on-site vehicle maintenance facilities use underground gasoline and methanol tanks. The Compliance Plan sets out a two-phase program for removal of unused underground tanks and the replacement or upgrading of tanks that must remain in use.

The remainder of the tank removal and upgrade program is scheduled for 1992 and 1993. During this period, eight regulated underground tanks still in use will be removed and replaced and 11 will be upgraded to current technical requirements (secondary containment, corrosion protection, leak detection, double-walled piping, spill and overflow protection). Nine previous tank locations will be assessed for contamination.

### 2.3.8. Corrective Action for Solid Waste Management Units

As mentioned previously, the HSWA amendments added language to RCRA requiring that any Part B permit issued must include provisions for corrective actions for all releases of hazardous materials from any solid waste management unit (SWMU) at the site, regardless of when the waste was placed in the unit. When issued, the Part B permit will contain a compliance schedule which will govern the characterization and remediation of such units, if remediation is found to be necessary. The Part B permit submitted to the IEPA identified and provided information on 56 SWMUs, both active and inactive. The majority of these sites are believed to contain little or no residual contamination; however, a number may be required to undergo some type of corrective action. The process of conducting detailed characterization studies to determine if hazardous materials have been released from a number of these units was begun in 1989. A summary of the results of these investigations can be found in Chapter 6. Information developed by these studies was submitted to the IEPA with the Part B permit application.

#### 2.4. Solid Waste Disposal

Nonhazardous and nonradioactive solid waste generated on-site is disposed of in a sanitary landfill located in the 800 Area. This facility has been in operation since 1969. It received an operating permit from the IEPA in 1981. The operation of this facility is governed by IEPA regulations contained in 35 IAC, Subchapter I, Part 807. The IEPA, using the services of the DuPage County Department of Environmental Concerns, conducts monthly inspections of the landfill to insure compliance with these regulations. Except for a few minor problems related to several small leaks of leachate from the landfill, there were no major problems during 1991. Currently, leachate from under the landfill is not collected and analyzed on a routine basis but only when surface discharges are observed. It was discovered in late 1990 that large portions of the landfill have reached or exceeded the maximum permitted elevations. A supplemental permit application was prepared and submitted to the IEPA in early 1991 requesting that the final elevations be increased to allow continued use of the facility. Based on IEPA comments, a revised application was resubmitted to IEPA in December 1991.

The IEPA promulgated new regulations governing the construction and operation of sanitary landfills in September 1990. Under provisions of these regulations, existing landfills are allowed to operate under existing regulations as long as they initiate closure by September 1992. Operation beyond this time subjects landfills to much more stringent and costly requirements contained in the new regulations. Since the ANL landfill is already nearing its capacity, the decision was made to close it by the September 1992 deadline. In March 1991, ANL certified to the IEPA that it would initiate closure by September 1992. A revised closure plan was prepared and submitted to the IEPA in early 1991. Based on IEPA comments, a revised closure plan was resubmitted to IEPA in December 1991.

The IEPA required annual nonhazardous special waste reporting during 1991. The report is submitted by February 1 of each year and describes the activity of the previous year. It is a summation of all manifested nonhazardous and PCB wastes. Nonhazardous special waste includes such

materials as waste oils, PCB-contaminated oils, contaminated soil, sludges, etc. During 1991, 56,370 liters (14,895 gallons) of nonhazardous special waste were shipped offsite to approved recycling or disposal facilities. In addition, 77 cubic meters (101 cubic yards) of PCB containers and transformers were disposed of at an EPA-approved disposal facility.

## 2.5. National Environmental Policy Act

The National Environmental Policy Act (NEPA) of 1969 established a national environmental policy that promotes consideration of environmental factors in federal or federally-sponsored projects. NEPA procedurally forces review of the environmental impacts of a project. To ensure compliance with this policy, NEPA requires that projects with potentially significant impacts be carefully reviewed through the generation of either an Environmental Assessment (EA) or Environmental Impact Statement (EIS). This review process is designed to insure that all potential impacts are identified, all available options are considered, and all affected parties are informed and given opportunity to comment on a project.

The DOE implementation of NEPA has undergone significant change during recent years. The threshold at which projects are subject to NEPA review has been reduced to such an extent that virtually all activities are now required to undergo some sort of NEPA review and documentation. On the other hand, the list of Categorical Exclusions, which is a list of project types that normally do not require an EA or EIS, is being expanded to help streamline the process. The final rule is expected during 1992.

The ANL NEPA compliance program is designed to ensure that all activities under consideration are reviewed to determine any significant environmental impacts. This program subjects each proposed project to a careful consideration of potential impacts to air (dust, gaseous emissions), water (liquid effluents, wetland impacts), and soil (solid waste generation, construction activity), as well as impacts involving critical wildlife habitats, historic and cultural resources, radiation, noise, workers and other considerations. A questionnaire is completed for each project and is used as documentation of the review of potential impacts. This form (DOE/CH

Form 560) is submitted to DOE for review and determination of the proper level of NEPA documentation. Projects that exhibit potentially adverse impacts in any area are subject to further review, including, if necessary, preparation of one of the NEPA documents mentioned previously. Any EA or EIS prepared by ANL is reviewed by DOE according to the procedures specified in DOE Order 5440.1D and DOE/CH Order 5440.1C.

During 1991, 122 proposals were submitted to DOE for review. Most of them were relatively minor construction and maintenance operations with no significant impacts. The majority of these projects were determined by DOE to be categorical exclusions requiring no additional documentation. Proposals such as the construction of the CWDD accelerator were not clearly categorical exclusions and were required to submit Environmental Assessments to allow for a more detailed review of potential impacts. There are currently no active proposals at ANL which have been required to submit an Environmental Impact Statement.

## 2.6. Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) of 1974 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 (MCL) and Maximum Contaminant Level Goals (MCLG) as well as through imposition of well head protection requirements, monitoring requirements, treatment standards, and regulation of underground injection activities. The SDWA established Primary and Secondary National Drinking Water Regulations, which set forth requirements to protect human health (primary standards) and provide aesthetically acceptable water (secondary standards).

### 2.6.1. Applicability to ANL

The drinking water supply at ANL consists of four on-site wells that supply raw water to the water treatment plant. The treatment plant removes iron, softens the water by ion-exchange, and adds chlorine before pumping it to the site-wide distribution system. This system is classified as a non-

transient, non-community water supply, and as such is subject to the provisions of the National Primary Drinking Water regulations applicable to such systems. The Laboratory is subject to regulations under the State of Illinois program (77 IAC Part 900) as long as the program is at least as stringent as the EPA program (40 CFR Parts 141, 142, and 143). Otherwise, ANL is subject to these regulatory programs which establish a monitoring program, design, operation and maintenance requirements and secondary water quality standards.

#### 2.6.2. Monitoring Requirements

The primary drinking water standards establish certain monitoring and analytical requirements. Both Federal and state regulations apply to the ANL drinking water monitoring program. ANL samples each of the four wells quarterly and the treated water annually for radiological analyses. Chapter 6 of this report presents a detailed discussion of the results of the drinking water program. During 1991, ANL conducted an in-depth review of the drinking water monitoring program in order to assure full compliance with state and Federal monitoring requirements. To address noted deficiencies, samples were collected in November 1991 and all state and Federally-required analyses were conducted, and EPA-approved procedures were employed by a certified laboratory. Monitoring results were then reported within the specified time.

#### 2.7. Federal Insecticide, Fungicide and Rodenticide Act

The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) establishes a program to register pesticides, regulate their transportation and disposal, and determine standards for their use. Within ANL, all applications of pesticides are by licensed contractors who provide any pesticides used and remove any unused portions. Herbicides are rarely used, but when they are needed, a licensed contractor is brought in to apply them. In these situations, ANL ensures that the herbicide is EPA-approved, that it is used properly and any residue is disposed of in accordance with applicable regulations.

## 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 data regarding sites subject to CERCLA action through generation of a Preliminary Assessment (PA) report, followed up by a Site Investigation (SI). Based on the data collected, the sites are ranked according to their potential to cause human health impacts or environmental damage. The sites with the highest ranking are placed on the National Priority List (NPL) and are subject to mandatory cleanup actions, funded either by Potentially Responsible Parties (PRPs) or by the allocation of Superfund money to the project. Federal agencies are responsible for their own cleanup costs.

### 2.8.1. CERCLA Program at ANL

In the past, Federal facilities were allowed to develop and manage their own independent CERCLA program subject to EPA oversight. The DOE's CERCLA program was detailed in DOE Order 5480.14. This DOE Order has since been superceded by DOE Order 5400.4. Under the provisions of this Order, in July 1986, ANL submitted preliminary assessment (PA) reports to DOE for the seven inactive units on the current ANL site and one inactive unit located on land given to DuPage County in 1973 as shown in Table 2.3. Because of changes in the EPA CERCLA program brought about by the Superfund Amendments and Reauthorization Act (SARA) of 1986, the EPA is now required to publish a comprehensive inventory of Federal facility sites known as the Federal Agency Hazardous Waste Compliance Docket. These sites are ranked, using the Hazardous Ranking System (HRS), and placed on the NPL list if they score high enough. However, since they are Federal facilities, Superfund money is not available to support cleanup operations. In support of this effort, the EPA required submittal of PA reports for sites at ANL (as listed in Table 2.3). These reports were submitted in April 1988. Four sites not included in the original DOE submittal were included in the subsequent submission. In late 1990, ANL prepared and submitted one additional PA for a solvent disposal site used for a number of years by the ANL paint shop for disposal

TABLE 2.3

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

Site Name	DOE/CERCLA	EPA/SARA	EPA/SSI
<u>Waste Sites on Current ANL Property</u>			
800 Area Landfill and French Drain	X	X	X
319 Area Landfill and French Drain	X	X	X (1)
Landfill East-Northeast of the 319 Area	X	X	X (1)
Compressed Gas Cylinder Disposal Area, 318 Area	X	X	X (1)
French Drain, 317 Area	X	X	X (1)
Mixed Waste Storage Vaults, 317 Area		X	X (1)
Shock Treatment Facility, 317 Area	X	X	X (1)
Wastewater Holding Basin, Sewage Treatment Plant		X	
Liquid Waste Treatment Facility, Building 34	X	X	
Decommissioned Reactor CP-5, Building 330		X	X
Gasoline Spill, Gasoline Station		X	
<u>Waste Sites on Old ANL Property, Currently Waterfall Glen Forest Preserve</u>			
Reactive Waste Disposal, Underwriters Pond	X	X	

(1) All units located in the 317/319/ENE Area were described in a single Site Screening Investigation (SSI) report.

of waste paint solvents. The site in Waterfall Glen Forest Preserve is currently owned by DuPage County and thus is no longer part of a Federal facility subject to SARA. The PA for this site was submitted in an effort to inform the EPA of past ANL activities.

During early 1990, the EPA requested that ANL submit Site Screening Investigation (SSI) reports for six of the twelve sites. Upon further discussions between the EPA and DOE, one of the six sites was eliminated from consideration and the units (317/319/ENE) were treated as a single site due to their physical proximity. As a result, three SSI reports were completed by ANL and submitted to DOE in December 1990. They were subsequently transmitted to EPA in January 1991. Table 2.3 lists those sites for which a SSI was submitted.

#### 2.8.2. CERCLA Remedial Actions

Remedial actions to clean up any release of hazardous materials from these sites could occur in a number of different ways. Since all but one of the CERCLA sites are on the ANL site and are included as SWMUs in the RCRA Part B permit application, they may be subject to RCRA corrective actions and come under the authority of the IEPA. However, since several of the sites contain radiological contamination, over which RCRA has no authority, it is likely that the sites may be subject to a combined RCRA/CERCLA action.

Regardless of which regulatory vehicle is ultimately used to facilitate the cleanup of these sites, the DOE, through various initiatives put forth by the Secretary of Energy, has made the commitment to clean up voluntarily all such sites within the next 30 years, wherever possible returning them to unrestricted use. As a response to these commitments, ANL has requested funding for the characterization and remediation of all but two of these sites. The two remaining sites are the one off-site unit, which is no longer under the control of ANL or DOE, and a small gasoline spill which was completely cleaned up immediately after the spill occurred. Several of the characterization projects have already begun and will continue over the next few years.

### 2.8.3. Emergency Planning and Community Right to Know Act (EPCRA), SARA Title III

Title III of the 1986 SARA amendments to CERCLA created EPCRA as a freestanding provision for response to emergency situations involving hazardous materials and for making known to federal, state, and local emergency planning authorities information regarding the presence and storage of hazardous substances and their planned and unplanned environmental releases. Under EPCRA, ANL is required to provide an inventory of hazardous substances stored on the site, Material Safety Data Sheets (MSDS), and completed SARA data sheets (Tier I or II forms) for each hazardous substance stored in quantities above a certain threshold planning quantity (typically 10,000 lbs; but as low as one pound for certain compounds) to applicable emergency response agencies. However, all chemicals used in research laboratories, are exempt from reporting. In November 1987, an inventory and MSDS forms for nine chemicals were submitted to the Local Emergency Planning Committee (LEPC); in March 1988, Tier I reports providing additional information on these chemicals were submitted. In February 1989, Tier II report forms were completed and submitted to the LEPC. During March 1990 and March 1991, updated Tier II forms were submitted. These forms updated the previous listings and provided more information regarding the amount of material stored and the location of the material. Table 2.4 lists hazardous compounds reported under SARA Title III for 1991. ANL is not required to submit Section 313 reports.

Section 304 of SARA Title III requires that the LEPC and state emergency planning agencies be notified of accidental or unplanned releases of certain hazardous substances to the environment. The procedures for notification are described in the Argonne Comprehensive Emergency Management Plan. One incident during 1991 involving a mercury spill required notification of the LEPC and Illinois Emergency Management Agency.

TABLE 2.4

## Compounds Reported Under SARA Title III - 1991

Compound	Hazard Class				
	Fire	Sudden Release of Pressure	Reactive	Acute Health Hazard	Chronic Health Hazard
Diesel Fuel	X				
Gasoline	X				
Methanol/ Gasoline	X				
Chlorine		X		X	
Chlorofluoro- carbon 11		X			
Sodium Carbonate				X	
Sulfuric Acid				X	
Calcium Oxide				X	
Calcium Hydroxide				X	
Oils containing PCBs					X

## 2.9. Toxic Substances Control Act

The Toxic Substances Control Act (TSCA) of 1976 provides for testing of manufactured substances to determine toxic or otherwise harmful characteristics and regulation of the manufacture, distribution, use, and disposal of regulated substances. The only TSCA-regulated compounds in significant quantities at ANL are polychlorinated biphenyls (PCB) contained in electrical capacitors and transformer oil. Regulations governing PCB use and disposal are set forth in 40 CFR 761. These regulations provide detailed requirements for use and disposal of materials containing concentrations of PCBs above 50 ppm. Most of these regulations relate to PCBs contained in dielectric fluids within electrical equipment, such as transformers and capacitors.

### 2.9.1. PCBs in Use at ANL

The majority of PCBs at ANL were contained in a number of transformers, capacitors, and switches throughout the site. Starting in 1987, ANL began removing and disposing of all PCB and PCB-contaminated electrical equipment. All indoor units have been removed and transported off the site for proper disposal, and all outdoor units have been removed or retrofilled. During 1990, all pole mounted transformers and circuit breakers containing PCBs were replaced or retrofilled with non-PCB oil. All removal and disposal activities were conducted by licensed contractors specializing in such activities. Operation, removal, storage, and disposal of PCB-containing articles were conducted in compliance with applicable TSCA regulations.

During late 1989, it was discovered that a small sludge drying bed, servicing the laboratory wastewater treatment plant, was contaminated with PCBs of unknown origin. Concentrations of over 50 mg/kg were found in the sludge and over 300 mg/kg were found in the sand below the sludge. An extensive characterization study of this site during 1992 is being planned, to be followed by remediation of the PCB contaminated material.

During August 1991, the EPA conducted a compliance inspection of the PCB management program. No deficiencies were noted during the inspection.

## 2.10. Endangered Species Act

The Endangered Species Act (ESA) of 1973 is 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 insure the conservation of endangered or threatened species or critical habitat of such species. For ANL, the Fish and Wildlife Service has been delegated authority to conduct these consultations and enforce the ESA.

To comply with the ESA, Federal Agencies are required to make an assessment of the proposed project area to determine if any threatened or endangered species or critical habitat of these species exist. If no such species or habitat are present this fact is to be documented in a letter to the FWS. If such species or habitat are found to exist, the FWS is to be notified and a series of consultations and studies are then carried out to determine the extent of impact and any special actions which must be taken to minimize this impact.

At ANL, the provisions of the ESA are implemented 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 Project Environmental Evaluation Form. If there is potential adverse impact, this impact will be further assessed and evaluated through the preparation of a more detailed NEPA document, such as an EA or EIS.

Currently, no federally-listed endangered species are known to reside on ANL property. The northern Illinois region, including ANL, is considered in the range of several such species; however, no suitable habitat is known to exist on the site. A number of species listed by the State of Illinois as threatened state species are known to reside on the ANL site. Impacts to these species are also assessed during the NEPA process. No project at ANL has ever had to be stopped, delayed or modified as a result of potential impact to 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 site of the proposed projects. It further requires Federal agencies to assess all sites, buildings, and objects on the site to determine if any qualify for inclusion in the National Registry of Historic Places. The Act also establishes a procedure for archaeological investigation activities and a system of civil and criminal penalties for unlawfully damaging or removing such artifacts.

The NHPA is implemented at ANL through the NEPA review process, as well as through the internal digging permit process. All proposed actions must consider the potential impact to historic or culturally important artifacts and document this consideration in the Project Environmental Evaluation 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 carefully documented and removed. Prior to disturbing the soil, an ANL digging permit must be obtained from the PFS division. This permit must be signed by the Cultural Resources Officer at ANL prior to digging to document the fact that no significant cultural resources will be impacted. During 1991, progress was made toward the development of a site-wide cultural resource map. The map will aid project managers in the future planning of construction projects. In addition, an Argonne Cultural Resources Management Plan was initiated in 1991. The Plan is designed to establish policies and procedures for managing cultural resources on the Argonne site, provide guidance on regulatory compliance, and describe the distribution of cultural resources on the Argonne site.

ANL currently does not contain any sites, buildings or structures included in the National Register of Historic Places. It does, however, contain several facilities which represent historically important scientific or technical achievements, such as the first experimental boiling water reactor. If it is determined that such sites are suitable for listing, they will be investigated and submitted to the Department of the Interior for possible listing.

## 2.12. Flood Plain Management

Federal policy on managing flood plains is contained in Executive Order 11988 (May 24, 1977). This Executive Order requires Federal facilities to avoid to the extent possible adverse impacts associated with the occupancy and modifications of floodplains. A project proposed for construction in a floodplain must demonstrate that there is no reasonable alternative to the floodplain location.

The ANL site is located approximately 150 feet above the nearest large body of water (Des Plaines River) and thus is not subject to major flooding. A number of small areas, associated with Sawmill Creek and other small streams or low-lying areas, are subject to local flood conditions following extremely heavy precipitation. To insure that these areas are not adversely impacted, ANL has maintained a practice of not permitting new facility construction within these areas, unless there is no practical alternative. Any impact to flood plains are fully assessed and documented in the NEPA documents prepared for the proposed project.

## 2.13. Protection of Wetlands

Federal policy on wetland protection is contained in Executive Order 11990. In addition, 10 CFR Part 1022, describes DOE's implementation of this Executive Order. This Order requires Federal agencies to identify potential impacts to wetlands resulting from proposed activities and to minimize these impacts. Where impacts cannot be avoided, action must be taken to mitigate the damage 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. The current DOE policy is for no net decrease in the amount of wetland as a result of DOE activities.

Due to the topography and nature of the soil at ANL, the site contains a significant number of natural and man-made wetlands. These range from small stormwater ditches which are overgrown with cattails to natural depressions, beaver ponds and man-made ponds. The potential impact to these areas caused by a proposed action is described in the NEPA Project

hazardous waste management facilities were conducted or planned to comply with anticipated permit requirements.

The final major issue relates to the identification and clean-up of environmental contamination caused by previous activities on the ANL site. These activities come under the purview of the RCRA and CERCLA programs administered by the EPA and IEPA. The ANL site has a significant number of such sites which will probably require extensive remediation to remove residual contamination resulting from past activities. The Five Year Plan contains a number of projects, termed Environmental Restoration projects, to provide for characterization and remediation of the sites. Several characterization projects are ongoing, while others are planned for the next few years. Remedial actions are scheduled to begin within three years, depending on the results of the characterization studies.

#### 2.14.2. Regulatory Agency Interactions

The regulatory agency interactions with ANL during 1991 were primarily limited to normal written correspondence regarding permit requirements and related issues. A Compliance Inquiry Letter (CIL) was received for one alleged administrative non-compliance identified in the annual IEPA RCRA inspection. The alleged non-compliance issue raised in the CIL was successfully negotiated to the satisfaction of the IEPA, ANL and DOE. There are currently no ongoing outstanding compliance issues or agreements or pending enforcement actions against ANL.

The NPDES permit contains a compliance date of June 30, 1990, for construction of a treatment system to control chlorides in the wastewater discharge. This treatment plant was no longer considered a viable solution to the chloride and TDS exceedances. An alternative solution, to reroute the spent regenerant brines to the DuPage County sewer system, was proposed to the IEPA and was accepted. The necessary sewer line extension was constructed in early 1991 and was placed in service in August 1991. In November 1991, a request was made to the IEPA to remove the compliance date from the NPDES permit.

### 2.14.3. Tiger Team Assessment

To resolve the deficiencies identified by the Tiger Team and the ANL self assessment, an Action Plan was prepared in December 1990. This plan lists specific actions to be taken to resolve each Tiger Team finding and many of the self assessment findings. This document was approved by DOE Headquarters in early 1991. A number of the activities listed in the Action Plan were either ongoing actions or previously planned actions, many of which appear in the Five Year Plan. In addition, a series of new activities, not previously anticipated, were identified. These activities were started in 1991, contingent on additional funding provided by the DOE. When the original plan was written in 1990, 109 actions were scheduled to be completed in 1991. Seventy-four of those actions have been documented complete, 26 have been rescheduled and the other nine were in the process of being documented complete. An internal tracking system was developed to insure that the various commitments contained in the Action Plan are satisfied and the milestones are met.

One of the major needs identified by the Tiger Team was for an internal oversight group within ANL which could verify that appropriate regulations are being complied with and that adequate resources were available for ESH functions. This need was met with the establishment of a new position of Assistant Laboratory Director for ESH/QA Oversight. This individual reports directly to the Laboratory Director and is responsible for independent oversight of the various ESH activities and programs as well as ESH policy development and strategic planning. One of the principal responsibilities of this position is to serve as chairman of the ESH/QA Oversight Directorate. This committee will assist in the development of Laboratory policy and in the strategic planning functions of the Assistant Laboratory Director.

### 2.15. Environmental Permits

Table 2.5 lists all environmental permits in effect at the end of 1991. Table 2.6 lists all permits which were either renewed or granted for the first time during 1991. Other portions of this Chapter discuss special

Environmental Evaluation Form for the project. If the potential impact is thought to be significant, the DOE will require preparation of an EA or EIS. The APS project, currently under construction, required a U. S. Army Corps of Engineers 404 permit and extensive wetland mitigation activities since several small natural wetlands occupied the construction site and had to be replaced elsewhere. These actions were documented in the EA which was approved in early 1990.

#### 2.14. Current Issues and Actions

The purpose of this section is to summarize the most important issues related to environmental protection encountered during 1991. Since preceding sections of this chapter contain detailed discussions of specific issues related to each major piece of environmental regulations, discussions of specific issues will not be repeated in this section. Please refer to the appropriate section of this chapter for these details.

##### 2.14.1. Major Compliance Issues

The most significant ongoing issues encountered at ANL during 1991 involve compliance with existing NPDES wastewater discharge permit requirements. Exceedances were primarily the result of inadequate treatment to meet stringent limits. Corrective actions were taken or are underway or planned to upgrade or construct the necessary facilities. These projects are contained in the Five Year Plan, discussed in Chapter 3.

The acquisition of the necessary permits to conduct the various activities on site is a second major issue. The fume hoods and ventilation systems with the potential for emitting radionuclides require an air pollution control permit. A program of inspections and audits was begun in late 1990 and identified a number of unpermitted sources. Permit applications were prepared during 1991 and some IEPA air permits were issued. In addition, ANL submitted its RCRA Part B permit application to the EPA and IEPA in December 1990. This application is a major undertaking which will take several years to complete. Significant modification and upgrading of the

TABLE 2.5

ANL Environmental Permits in Effect on December 31, 1991

Permit Requirement	Source Name	Building	Date Issued	Expiration Date
Air	ALEX Alkali Metal Scrubber	370	12/5/91	12/3/96
Air	Alkali Booth	308	2/15/89	2/9/94
Air	Alkali Booth	206	6/19/89	5/31/94
Air	Argonne Service Station	300	4/23/91	1/7/96
Air	Central Shops Rotoclone Dust Collection System	363	3/12/91	3/7/96
Air	Coal/Oil Fired MHD (FEUL Facility)	146	3/30/90	3/27/95
Air	Gasoline Dispensing Facility	827	9/18/90	9/17/95
Air	Medical Department Steri-Vac Sterilizer	201	3/27/91	3/22/96
Air	Methanol/Gasoline Storage Tank	827	9/24/91	9/23/96
Air	Oil Fired Boilers	800 Area	11/1/91	10/29/96
Air	Open-Burning - Fire Training	Site-Wide	4/16/91	4/16/92
Air	Proton Decay Project Grieve Oven	366	8/8/91	8/6/96
Air	Steam Plant	108	7/26/90	8/1/92
Air	Sulfuric Acid Storage Tank	108	1/17/91	1/31/95
Air	Vapor Degreaser	363	3/13/90	3/9/95
Air	Wood Shop Rotoclone Dust Collection System	809	10/22/91	10/17/96
Air-Rad	Advanced Photon Source	400	1/17/90	-
Air-Rad	Advanced Photon Source	400	11/2/89	-
Air-Rad	Alpha-Gamma Hot Cell Facility	212	3/25/91	11/30/95
Air-Rad	Building 212 Exhausts	212	7/30/91	7/23/96
Air-Rad	Building 306 Vents and 317 Area	306	8/6/91	7/25/96
Air-Rad	Continuous Wave Deuterium Detector (CWDD)	369	5/9/91	4/30/95
Air-Rad	CP-5	330	5/10/91	1/31/95
Air-Rad	Cyclotron	211	5/10/91	1/31/95
Air-Rad	D&D HEPA Filtration System	331	3/25/91	12/31/94
Air-Rad	Intense Pulsed Neutron Source	375	3/25/91	11/30/95
Air-Rad	JANUS Reactor	202	5/10/91	11/30/95
Air-Rad	M-Wing Hot Cells	200	3/25/91	11/30/95
Air-Rad	NBL Plutonium & Uranium Hoods	350	4/25/91	4/19/96
Hazardous Waste	RCRA Part A Permit	Site-Wide	4/30/82	-
Miscellaneous	Clean/Replace Culverts	Site-Wide	-	-

TABLE 2.5 (Contd.)

Permit Requirement	Source Name	Building	Date Issued	Expiration Date
Solid Waste	Groundwater Monitoring Program Modification	800 Area	-	-
Solid Waste	Landfill	800 Area	3/31/89	-
Solid Waste	Landfill	800 Area	3/30/82	-
Solid Waste	Landfill	800 Area	4/12/89	-
Solid Waste	Landfill Groundwater Assessment	800 Area	9/30/91	-
Solid Waste	Landfill Leachate Characterization	800 Area	9/30/91	-
Solid Waste	Landfill Leachate Test Wells	800 Area	8/31/90	-
Solid Waste	Landfill Revised Closure Plan	800 Area	-	-
Water	APS Wetland	Site-Wide	11/22/88	-
Water	Boiler House WWTP	108	-	-
Water	DuPage County DEC Service Connection	Site-Wide	7/29/91	-
Water	DuPage Sewer Connection - Construction	Site-Wide	4/4/91	4/4/93
Water	Landfill Wetland	800 Area	5/20/81	-
Water	Lime Sludge Application - LPC	Site-Wide	10/23/89	10/4/94
Water	Lime Sludge Application - WPC	Site-Wide	12/31/90	12/31/93
Water	NPDES Permitted Outfalls	Site-Wide	6/7/89	1/15/94

TABLE 2.6

## ANL Environmental Permits Obtained During 1991

Permit Requirement	Source Name	Building	Date Issued	Expiration Date
Air	ALEX Alkali Metal Scrubber	370	12/5/91	12/3/96
Air	Argonne Service Station	300	4/23/91	1/7/96
Air	Central Shops Rotoclone Dust Collection System	363	3/12/91	3/7/96
Air	Medical Department Steri-Vac Sterilizer	201	3/27/91	3/22/96
Air	Methanol/Gasoline Storage Tank	827	9/24/91	9/23/96
Air	Oil Fired Boilers	800 Area	11/1/91	10/29/96
Air	Open-Burning - Fire Training	Site-Wide	4/16/91	4/16/92
Air	Proton Decay Project Grieve Oven	366	8/8/91	8/6/96
Air	Sulfuric Acid Storage Tank	108	1/17/91	1/31/95
Air	Wood Shop Rotoclone Dust Collection System	809	10/22/91	10/17/96
Air-Rad	Alpha-Gamma Hot Cell Facility	212	3/25/91	11/30/95
Air-Rad	Building 212 Exhsuts	212	7/30/91	7/23/96
Air-Rad	Building 306 Vents and 317 Area	306	8/6/91	7/25/96
Air-Rad	Continuous Wave Deuterium Detector (CWDD)	369	5/9/91	4/30/95
Air-Rad	CP-5	330	5/10/91	1/31/95
Air-Rad	Cyclotron	211	5/10/91	1/31/95
Air-Rad	D&D HEPA Filtration System	331	3/25/91	12/31/94
Air-Rad	Intense Pulsed Neutron Source	375	3/25/91	11/30/95
Air-Rad	JANUS Reactor	202	5/10/91	11/30/95
Air-Rad	M-Wing Hot Cells	200	3/25/91	11/30/95
Air-Rad	NBL Plutonium & Uranium Hoods	350	4/25/91	4/19/96
Solid Waste	Landfill Groundwater Assessment	800 Area	9/30/91	-
Solid Waste	Landfill Leachate Characterization	800 Area	9/30/91	-
Water	DuPage County DEC Service Connection	Site-Wide	7/29/91	-
Water	DuPage Sewer Connection - Construction	Site-Wide	4/4/91	4/4/93

requirements of these permits and compliance with those requirements. The results of monitoring required by these permits are discussed in those sections, as well as in Chapter 5. As mentioned in Section 2.1, a number of air pollution permit applications were submitted to the IEPA.

#### 2.16. Compliance Summary for the First Quarter of 1992

This section summarizes new regulatory compliance issues which developed from January 1, 1992 to April 1, 1992. It also reports on developments in compliance issues which were not resolved during 1991.

##### 2.16.1. Clean Air Act

Boiler No. 5 was placed into operation during the first quarter of 1992. Equipment calibration and needed repairs to the air pollution control equipment were made during 1991. A meeting was held with the IEPA to discuss the air operating permit applications for radionuclide-emitting fume hoods. IEPA comments on the ANL permit application plan were addressed and the projected date for completion is May 1992. The landfill has complied with the revised asbestos NESHAP and submitted historical records for asbestos disposal to the DOE.

##### 2.16.2. Clean Water Act

During the first quarter of 1992, one exceedance of TSS levels at outfall 006 was experienced as a result of soil erosion during a rain event. An NPDES inspection was conducted by the IEPA on February 18 and 19, 1992, and no deficiencies were found.

##### 2.16.3. Resource Conservation and Recovery Act

In January of 1992, the IEPA conducted a RCRA compliance inspection which identified one alleged non-compliance in an April 1992 CIL. The Laboratory transmitted its response to the CIL to DOE on April 17, 1992.

ANL submitted its 1991 nonhazardous special waste report to the IEPA in January 1992.

#### 2.16.4. National Environmental Policy Act

There were no significant developments regarding NEPA during the first quarter of 1992.

#### 2.16.5. Safe Drinking Water Act

Samples from the Argonne domestic wells were collected during February 1992. The samples were provided to an EPA-certified commercial laboratory and were analyzed for all constituents specified in the regulations and the required detection limits. The results were provided to the EPA, Illinois Department of Public Health, and DuPage County Health Department. The concentrations of all regulated constituents were less than the regulatory limit. In addition, in response to deficiencies noted during the 1991 DOE-CH environmental protection appraisal, in March 1992, Argonne posted a Safe Drinking Water Act User Information Notice throughout the site.

#### 2.16.6. Federal Insecticide, Fungicide and Rodenticide Act

There were no significant developments related to FIFRA during the first quarter of 1992.

#### 2.16.7. Toxic Substances Control Act

Extensive characterization of the laboratory wastewater treatment plant sludge drying bed, contaminated with PCBs, was completed in early 1992. Analysis of the results is progressing.

#### 2.16.8. Comprehensive Environmental Response, Compensation and Liability Act

ANL submitted revised Tier II forms containing information of the hazardous chemicals in use during 1991. Except for metallic sodium, the

list was the same as that submitted in 1991 for 1990. Metallic sodium was removed since the usage of this material was in research activities which are exempt from SARA notification requirements.

#### 2.16.9. Permits

There were no significant developments related to environmental permits during the first quarter of 1992.

### 3. ENVIRONMENTAL PROGRAM INFORMATION

It is the policy of the DOE and ANL to conduct all operations in compliance with applicable environmental statutes, regulations, and standards and to ensure that environmental obligations are carried out consistently across all operations and organizations. Protection of the environment and human health and safety are given the highest priority. At ANL, a number of programs and organizations exist to ensure compliance with these regulations and to monitor and minimize the impact ANL operations have on the environment. Each of these activities is discussed briefly in this chapter.

#### 3.1. Environmental Restoration and Waste Management Program

In 1989, the DOE established the goal of achieving compliance with applicable regulations and assessing and cleaning up releases of hazardous materials from inactive waste sites, returning all such sites to unrestricted use within 30 years. As a management tool to improve the achievement of this goal, the DOE established the Environmental Restoration and Waste Management Program. This program identifies specific needs and established a system for allocating funds to resolve the various deficiencies. Each of the DOE facilities has prepared a set of planning documents (Activity Data Sheets, or ADS) describing the activities necessary to bring that specific site into compliance and to identify and clean up inactive waste sites. These planning documents are contained in two reports which are updated and published annually, the Environmental Restoration and Waste Management Five Year Plan and the Site Specific Plan. Five Year Plan projects and activities are subdivided into three categories, namely, corrective activities (those actions necessary in the short term to bring a facility into compliance with environmental regulations), environmental restoration activities (those activities necessary to identify and clean up inactive waste sites and other sites potentially contaminated as a result of DOE activities) and waste management activities (activities designed to ensure that hazardous and radioactive wastes are stored and disposed of safely and the volume of waste is minimized).

The 1991 Five Year Plan contained information on 181 separate projects. The majority of these projects were proposed research and development or technology demonstration projects that were not directly related to ANL on-site activities. The on-site activities, described fully in the Site Specific Plan, included nine corrective activity projects, 17 environmental restoration projects, and five waste management activities. The titles of these projects are listed in Table 3.1. The Five Year Plan and the Site Specific Plan are both public documents available upon request from the DOE. Each type of project is discussed in more detail below.

#### 3.1.1. Corrective Actions

The corrective activity projects at ANL generally involve the construction of new or upgraded wastewater treatment facilities used for disposal of wastewater from the ANL. As discussed in Chapters 2 and 5, the site has experienced a number of violations of its NPDES wastewater discharge permit in recent years. The reason for many of these violations is the lack of appropriate treatment technology to comply with current effluent limits. These deficiencies will be resolved as these corrective action projects are completed. During 1991, design work on several facilities was started.

#### 3.1.2. Environmental Restoration Activities

Environmental Restoration Activities represent the projects designed to carry out the objective of assessing and cleaning up inactive waste sites. The ANL site contains a number of inactive waste sites used for disposal of waste during the early years of Laboratory operations. These sites include two inactive landfills, three French drains (which consisted of shallow pits used for disposal of liquid wastes), two inactive wastewater treatment facilities and a number of areas which may have been contaminated through the discharge of small amounts of hazardous chemicals. Several sites used from the 1940s through the 1970s for open burning of combustible waste and construction debris also exist. A series of ongoing and planned activities has been designed to foster the clean up of these sites.

TABLE 3.1

## Environmental Restoration and Waste Management Projects

ADS Number	Title
<u>Waste Management Operations</u>	
1300	Waste Management Operations, Defense Programs Waste
1301	Waste Management Operations, Non-Defense Programs Waste
1302	PCB Transformer Disposal
1303	Rehabilitation of Waste Management Building
1304	Waste Storage Facility Upgrade
<u>Corrective Actions</u>	
1305	Underground Storage Tank Upgrade and Replacement
1306	Sanitary Wastewater Treatment Plant Improvements
1307	Remedial Alternatives for the 800 Area Landfill
1308	Laboratory/Sanitary Sewage Collection System Rehabilitation
1309	Laboratory Wastewater Treatment Plant Improvements
1310	Wastewater Treatment Plant Modifications
1311	Canal Water Treatment Plant Rehabilitation
1313	Cooling Tower Blowdown Water Diversion
<u>Environmental Restoration</u>	
1400	Program Management
1401	800 Area Landfill
1402	East Area Sewage Treatment Plant
1403	570 Holding Pond
1404	Sawmill Creek
1405	317/319/ENE Area
1406	100 Area
1407	Outfall Area
1408	Site-Wide Well & Borehole Closure/Site-Wide Hydrogeological Study
1409	Solid Waste Management Unit Assessment
1410	Underground Storage Tanks Removal
1411	Lime Sludge Removal
<u>Decommissioning and Decontamination</u>	
1412	Experimental Boiling Water Reactor D&D
1413	CP-5 Reactor D&D
1414	Hot Cells D&D
1415	Juggernaut Reactor D&D
1416	Argonne Thermal Source Reactor D&D
1418	ZPR Facilities D&D

The Environmental Restoration projects at ANL are typically broken down into two phases, the characterization phase and the remediation phase. Several of the characterization projects were started in 1989 and 1990. Additional characterization is required before significant remediation can be undertaken. The results of some of this early characterization work is presented in Chapter 6. Following the characterization phase, projects designed to clean up and dispose of residual contamination found during characterization will commence.

In addition to the inactive waste site clean up projects, the Environmental Restoration section of the Five Year Plan also contains a number of Decontamination and Decommissioning (D&D) projects for on-site nuclear facilities. The ANL site contains several inactive nuclear reactors and hot cells used in the past for processing of radioactive materials. These facilities are either currently undergoing D&D or are scheduled for D&D in the next few years. The D&D operations will remove residual radiological contamination, dispose of radiologically contaminated materials and will return the facilities to unrestricted use status. The largest such activities are the D&D of the Experimental Boiling Water Reactor (EBWR) and the CP-5 research reactor.

Current technology is not adequate to process and dispose of properly many of the waste materials that may be generated by these activities. Much of the waste is a mixture of radioactive and chemically hazardous materials for which there are currently no recognized treatment or disposal process. The Five Year Plan contains a number of research and development projects designed to develop the necessary technologies and processes to dispose of these materials safely. Many of these projects will be carried out at ANL by several of the research divisions.

### 3.1.3. Waste Management

The projects included in this section of the Five Year Plan represent activities necessary to ensure that waste materials currently being generated are properly stored, treated and disposed. A primary motivation for the improvement in waste handling and disposal operation is the need to

upgrade such facilities to comply with increasingly stringent RCRA requirements as well as other state and federal regulations and DOE orders. The majority of the Waste Management projects involve improvements to existing treatment or storage facilities.

### 3.2. Pollution Prevention Program

ANL is developing a strong Pollution Prevention program. Increasing emphasis is being placed on the recycling of all types of waste, including paper, scrap metals, wood, waste oils, and solvents. Whenever possible, waste is sent to reprocessing facilities rather than disposal facilities, thus reducing the amount of waste.

As a result of new IEPA regulations governing operation of the on-site landfill, it is currently anticipated that the landfill will be closed in September 1992. To reduce the cost of off-site disposal, a renewed emphasis is being placed on recycling and waste reduction. The assistance of waste recycling and disposal experts is being sought to develop a site wide waste management program.

During late 1990, a draft Pollution Prevention and Waste Minimization Plan was prepared. This plan sets forth a formal program for performing waste minimization audits, identifying alternatives which generate less waste when new projects are proposed, setting waste reduction goals and documenting whether or not these goals are being met. Project-specific and Divisional waste minimization plans will be written, focusing on specific waste streams and operations. Full implementation of this plan is anticipated in late 1993.

### 3.3. Environmental Monitoring Program Description

As required by DOE Order 5400.1, ANL conducts a routine environmental monitoring program. This program is designed to determine the effect the operation of ANL is having on the environment surrounding the site. This section describes this monitoring program. A general description of the techniques used to sample each environmental medium is provided. This is

followed by the collection procedures, the sampling schedule and analytical techniques used.

### 3.3.1. Air Sampling

Continuously operating air samplers are used at ANL to measure the concentrations of airborne particulate radioactivity. There is currently no monitoring of non-radiological air contaminants in ambient air. Particulate samplers are placed at 15 locations around the ANL perimeter and at six off-site locations, approximately five miles from ANL to determine the ambient or background concentrations.

Airborne particulate samples for direct radiation measurement are collected continuously at 13 perimeter locations and at five off-site locations on glass fiber filter media. Average flow rates on the air samplers are about 70 m<sup>3</sup>/hr. Filters are changed weekly. The filters on perimeter samplers are changed by ANL staff and the filters on off-site samplers are changed and mailed to ANL by cooperating local agencies. The sampling units are serviced every six months and the flow meters are recalibrated annually.

Additional air samples, used for radiochemical analysis of plutonium and other radionuclides, are collected at two perimeter locations and one off-site location. These samples are collected on special filter media which are changed every ten days by ANL staff. The flow rate calibration and servicing schedule is the same as discussed above.

Stack monitoring is conducted continuously at those emission points that have a probability of releasing measurable radioactive effluents. The results of these measurements are used for calculating the theoretical annual off-site dose using the required CAP-88 version of the EPA-AIRDOSE atmospheric dispersion computer code and dose conversion.

At the time of sample collection, the date and time when sample collection began, the initial flow rate, the date and time when the sample was collected and final flow rate are recorded on a label attached to the sample

container. The samples are then transported to ANL where this information is then transferred to the ANL Environmental Protection computerized Data Management System (EMS).

Each air filter sample collected for direct measurement 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 two-inch circle is cut from the other half of the filter, mounted in a two-inch low-lip stainless steel planchet, and counted for alpha and for beta activity. The balance of the filter is saved.

The air filter samples collected for radiochemical analysis are composited by location for each month. After addition of the appropriate tracers, the samples are ashed, and then sequentially analyzed for plutonium, thorium, uranium, and strontium.

### 3.3.2. Water Sampling

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

In addition to surface water, subsurface water samples are also collected at approximately 32 locations. These samples are collected from monitoring wells located near sites which have the potential for adversely impacting groundwater. These sites are the 800 Area landfill, the 317/319 waste management area, and the site of the inactive CP-5 reactor. Samples

of the domestic water, which comes from four on-site wells, are also collected and analyzed for hazardous or radioactive constituents.

Surface water samples are collected from Sawmill Creek daily and manually composited into a single weekly composite sample. A continuous sampling device is being installed at this location to improve sample collection efficiency. To provide control samples, Sawmill Creek is sampled upstream of ANL once a month. The Des Plaines River is sampled twice a month below, and monthly above, the mouth of Sawmill Creek to determine if the radioactivity in the Creek had any effect on the activity in the River. Water samples are collected from remote locations in the spring and fall to serve as additional control samples.

Subsurface water samples are collected quarterly from the monitoring wells located in the 317/319 Area, 330 (CP-5), and the 800 Area Sanitary Landfill. The monitoring wells are purged and samples 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 well-heads of the four ANL wells used to provide the laboratory domestic water supply. The water is pumped to the surface and collected in one-gallon glass bottles.

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 EMS system. Each sample is assigned a unique number, which accompanies it through all analyses.

After the sample has been logged in, an aliquot is removed for tritium analysis, 20 mL of conc.  $\text{HNO}_3$  is added per gallon of water as a preservative, and the sample is filtered through Whatman #2 filter paper to remove sediment present in the sample. Appropriate aliquots are then taken depending on the analysis.

For nonradiological analysis, samples are collected and preserved using EPA prescribed procedures. Cooling is used for organic analysis and nitric

acid is used to preserve samples to be analyzed for metals. Specific collection procedures are used for other components and EPA methods are used. All samples are analyzed within the required holding period or noncompliance is documented. The quality control requirements of either SW-846 and/or CLP are met or deviations are documented. All samples are assigned a unique number which serves as a reference source for each sample. When duplicate samples are obtained, unique numbers are assigned and the indication that duplicates exist is noted in the data management system.

### 3.3.3. Bottom Sediment

Bottom sediment accumulates small amounts of radioactive materials which may be present from time to time in the stream and, as a result, acts as an integrator of radioactive material that was present in the water. It provides a historical record of radioactive materials in that surface water system. These samples are not routinely analyzed for chemical constituents.

Bottom sediment samples are collected annually from Sawmill Creek above, at, and several locations below the point at which ANL discharges its treated waste water. Periodically, sediment samples are collected from several on-site ponds and lagoons. Ten off-site bottom sediment samples are collected each year, five in the spring and five in the fall, from remote locations to serve as controls. One gallon of sediment is collected from each location with a stainless steel scoop and 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 system. Each sample is assigned a unique number which accompanies it through the process.

Each sample is dried for several days at 110°C, 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 portion is taken for gamma-ray spectrometric

measurement and other appropriate aliquots are used for specific radiochemical analyses.

#### 3.3.4. Soil

Soil accumulates small amounts of particulate matter and serves as an integrator of the deposition of airborne releases of radioactive materials. Although it should not be used as the primary measurement system for air monitoring, in many cases, it may be the only available avenue if insufficient air sampling occurred at the time of an incident. The ANL program is designed to provide samples for analysis to determine if any changes in concentrations have occurred over the year. No analysis for chemical constituents is carried out on these samples.

Each year soil from ten locations is collected at the site perimeter (five spring and five fall) and ten at remote locations (five spring and five fall). Sampling sites are selected in reasonably level areas that represent undisturbed soil. Two one-meter squares are marked off and soil samples are collected from the corners and center of each square. Samples are collected with a 10.4 cm-diameter coring tool to a depth of 5 cm. All ten cores are composited as a single sample. This procedure follows the ASTM Standard Method for Sampling Surface Soil for Radionuclides, C-998.

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

The entire sample is dried at 110°C for several days, ball milled, and sieved through a No. 70 mesh screen. The material that does not pass the No. 70 mesh screen is discarded. A 100 g portion is taken for gamma-ray spectrometric measurement and appropriate aliquots taken for radiochemical analysis. Because a known area of surface soil was collected, results are calculated in terms of concentration and deposition.

### 3.3.5. Vegetation

Grass samples are collected to determine the uptake of radionuclides from the soil by vegetation. This is done to monitor that part of the food chain pathway.

Grass samples are collected each year from ten perimeter and ten off-site at the same places as the soil samples. All the grass within one of the one-meter plots used for soil sampling is cut just above the soil surface and collected.

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

Grass samples are washed in water to remove surface dirt, dried at 110°C for several days, and ground. A 100 g aliquot is measured by gamma-ray spectrometry and appropriate aliquots taken for radiochemical analysis.

### 3.3.6. External Penetrating Radiation

Measurements of direct penetrating radiation emanating from several sources within ANL are made using calcium fluoride thermoluminescent dosimeter (TLD) chips. Each measurement is the average of four chips exposed in the same packet. All calcium fluoride packets are shielded with 1/16 inch copper foil to reduce or eliminate the beta and low-energy x-ray components. The response of the chips is determined with a U. S. National Institute of Standards and Technology (NIST) standard radium-226 source.

Dosimeters are exposed at approximately 14 locations at the site perimeter and on the site and at five locations off the site. 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. Upon return to the laboratory, the information is transferred to the EMS system. Each sample is assigned a unique number which accompanies it through the process.

The individual chips are read on an Eberline Model TLR-6 TLD reader. Control chips are read and their contribution subtracted from the values of the field chips. A set of chips irradiated with a radium-226 standard source is also read and these values are used to convert the individual field readings to dose.

## 4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

### 4.1. Description of Monitoring Program

The radioactivity of the environment around ANL was determined by measuring the concentrations of radioactive nuclides in naturally occurring materials and by measuring the external penetrating radiation dose. Sample collections and measurements were made at the site perimeter and off the site for comparative purposes. Some on-site results are also reported when they are useful in interpreting perimeter and off-site results.

Since radioactivity is primarily transported by air and water, the sample collection program concentrated on these media. In addition, samples of soil, plants, foodstuffs, and materials from the beds of lakes and streams also were analyzed. The program followed the guidance provided in the DOE Environmental<sup>4</sup> and Effluent<sup>5</sup> Surveillance Guides. About 1,715 samples were collected and approximately 4,123 analyses were performed. The results of radioactivity measurements are expressed in terms of picocuries per liter (pCi/L) for water; femtocuries per cubic meter (fCi/m<sup>3</sup>) and attocuries per cubic meter (aCi/m<sup>3</sup>) for air; and picocuries per gram (pCi/g), femtocuries per gram (fCi/g), and/or nanocuries per square meter (nCi/m<sup>2</sup>) for soil, bottom sediment, and vegetation. Penetrating radiation measurements are reported in units of millirem per year (mrem/y) and population dose in man-rem. Other units are defined in the text.

The DOE has provided guidance<sup>6</sup> for effective dose equivalent calculations for members of the public, based on ICRP-26 and ICRP-30.<sup>7</sup> Those procedures have been used in this report. The methodology requires three components to be calculated: (1) the committed effective dose equivalent from all sources of ingestion, (2) the committed effective dose equivalent from inhalation, and (3) direct effective dose equivalent from external radiation. These three components are 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 assure that at least 90% of the total committed effective dose equivalent is accounted for. The primary radiation dose limit for members

of the public is 100 mrem/y. The effective dose equivalents for members of the public from all routine DOE operations, natural background and medical exposures excluded, shall not exceed the values and shall be as low as reasonably achievable (ALARA), or 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, which exclude actual or potential accidental or unplanned releases.

The measured or calculated environmental radionuclide concentrations are converted to a 50-year committed effective dose equivalent with the use of the Committed Effective Dose Equivalent (CEDE) Factors<sup>8</sup> and compared to the annual dose limits for uncontrolled areas. The CEDE are calculated from the DOE Derived Concentration Guides (DCG)<sup>6</sup> for members of the public from ingested water and inhalation resulting in a radiation dose of 100 mrem/y. The numerical values of the CEDE factors used in this report are given in Table 4.32. Although the CEDE factors apply only to concentrations above natural levels, the calculated dose is sometimes given in this report for radioactivities that are primarily of natural origin for comparison purposes. Such values are enclosed in parentheses to indicate this. Occasionally, other standards are used, and their sources are identified in the text.

#### 4.2. Air

The radioactive content of particulate matter in the air was determined by collecting and analyzing air-filter samples. The sampling locations are shown in Figures 1.1 and 1.2. Separate collections were made for specific radiochemical analyses and for gross alpha, gross beta, and gamma-ray spectrometry. The latter measurements were made on samples collected continuously on laminated glass fiber filters (changed weekly) at 13 locations at the ANL site perimeter and at five off-site locations.

In the past, the perimeter air samplers were located within buildings, did not have flow control devices, and no particle size differentiation. Early in 1989, the ANL site was reviewed by a professional meteorologist, taking into account potential sources of airborne radiological emissions and

local meteorology, and 13 perimeter locations were identified for air samplers. These locations are identified in Figure 1.1. New PM-10 air samplers were procured, electrical power was provided to each location, and the new PM-10 units were installed. During November 1989, the new and existing air sampling systems were both operated and an analysis of the measured radioactivity on the collected air filters indicated no statistically significant difference in the overall averages and side-by-side comparisons of paired samplers. At the end of December 1989, use of the original system was terminated and the new PM-10 system began exclusive operation in January 1990.

Samples were collected at the site perimeter to determine if a statistically significant difference exists between perimeter measurements and measurements made on 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, providing 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.

The total alpha and beta activities in the individual weekly samples are summarized in Table 4.1. 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 radon decay products on filter paper. 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.

TABLE 4.1

Total Alpha and Beta Activities in Air-Filter Samples, 1991\*  
(Concentrations in fCi/m<sup>3</sup>)

Month	Location	No. of Samples	Alpha Activity			Beta Activity		
			Avg.	Min.	Max.	Avg.	Min.	Max.
January	Perimeter	50	1.9	0.9	2.4	39.7	28.9	51.1
	Off-Site	22	2.5	1.3	4.2	45.1	23.6	64.3
February	Perimeter	49	1.5	1.0	2.1	27.4	18.5	37.2
	Off-Site	20	1.7	0.9	2.3	29.9	19.7	40.3
March	Perimeter	46	1.5	0.5	2.6	25.7	14.4	39.7
	Off-Site	16	1.9	1.3	2.6	28.4	12.6	39.1
April	Perimeter	39	1.7	0.9	2.9	20.8	14.4	29.7
	Off-Site	16	1.9	1.5	2.5	23.0	15.2	27.7
May	Perimeter	57	1.4	0.6	3.7	16.6	7.9	25.5
	Off-Site	12	2.1	1.0	2.8	22.9	11.1	30.4
June	Perimeter	37	1.7	0.4	4.9	19.7	4.5	49.6
	Off-Site	9	2.2	1.0	4.2	27.5	18.1	45.3
July	Perimeter	59	1.9	0.3	3.4	22.2	2.2	37.4
	Off-Site	12	2.5	1.6	3.8	33.6	14.9	48.2
August	Perimeter	44	2.6	1.3	6.9	27.9	19.6	45.0
	Off-Site	8	2.5	1.5	3.6	33.8	25.1	41.3
September	Perimeter	46	1.3	0.3	2.1	20.4	14.1	28.8
	Off-Site	11	1.9	1.1	2.6	26.7	14.5	45.6
October	Perimeter	58	1.4	0.4	3.2	21.0	8.9	37.9
	Off-Site	14	1.5	0.7	2.4	23.7	9.9	37.3
November	Perimeter	46	1.3	0.9	3.1	26.0	15.5	47.3
	Off-Site	16	1.7	0.9	2.6	30.1	14.1	43.7
December	Perimeter	37	1.6	1.1	2.1	31.4	23.3	36.1
	Off-Site	16	2.4	1.3	4.2	35.6	25.3	46.9
Annual Summary	Perimeter	568	1.7 ± 0.2	0.3	6.9	24.9 ± 4.0	2.2	51.1
	Off-Site	172	2.1 ± 0.2	0.7	4.2	30.0 ± 4.0	9.9	64.3

\*These 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 the air and disappears within four days by radioactive decay.

TABLE 4.2

Gamma-Ray Activity in Air-Filter Samples, 1991  
(Concentrations in fCi/m<sup>3</sup>)

Month	Location	Beryllium-7	Lead-210
January	Perimeter	46	45
	Off-Site	44	54
February	Perimeter	63	31
	Off-Site	79	44
March	Perimeter	79	29
	Off-Site	101	38
April	Perimeter	70	23
	Off-Site	75	27
May	Perimeter	49	16
	Off-Site	77	24
June	Perimeter	55	17
	Off-Site	26	15
July	Perimeter	31	14
	Off-Site	71	38
August	Perimeter	63	26
	Off-Site	-	-
September	Perimeter	44	23
	Off-Site	41	36
October	Perimeter	44	25
	Off-Site	38	33
November	Perimeter	38	35
	Off-Site	47	58
December	Perimeter	37	36
	Off-Site	47	57
Annual Summary	Perimeter	51 ± 9	27 ± 6
	Off-Site	59 ± 15	39 ± 9
Dose(mrem)	Perimeter	(0.00013)	(2.95)
	Off-Site	(0.00015)	(4.29)

The alpha activity, principally due to naturally-occurring nuclides, averaged the same as in the past several years and was in its normal range. The perimeter beta activity averaged 25 fCi/m<sup>3</sup>, which is the same as 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 few years and are of natural origin. The beryllium-7 exhibits an increase in concentration in the spring, indicating its stratospheric origin. The lead-210 in air is due to the radioactive decay of gaseous radon-222 and is similar to last year. No airborne radionuclides from the accident at the Soviet nuclear power facility near Chernobyl were measurable in 1991.

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 average of 40 fCi/m<sup>3</sup>, the net would be 27 fCi/m<sup>3</sup>, very similar to the



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

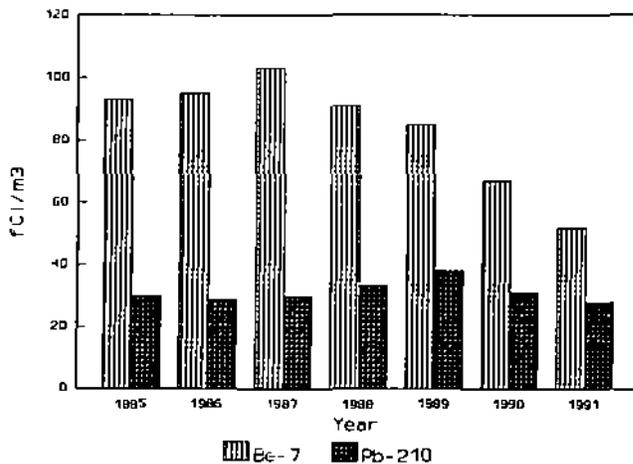


Figure 4.2 Comparison of Gamma-Ray Activity in Air-Filter Samples

averages of the other years. Figure 4.2 presents the annual average concentrations of the two major gamma-ray-emitting radionuclides in air. The beryllium-7 is about 50% lower than in past years. This downward trend in the beryllium-7 air concentrations has been observed worldwide by the DOE Environmental Laboratory's

Surface Air Sampling Program and is attributed to an increase in solar activity.<sup>9</sup>

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). The sampler at location 7I was unavailable until August due to building reconstruction. Collections were made on polystyrene filters. The total air volume filtered for the monthly samples was about 20,000 m<sup>3</sup> (700,000 ft<sup>3</sup>). Samples were ignited at 600°C (1080°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 anion 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. Since alpha spectrometry cannot distinguish between plutonium-239 and plutonium-240, it should be understood that 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 so that during 1991 most results were less than the detection limit of 10 aCi/m<sup>3</sup>. Strontium-89 was not observed above the detection limit of 100 aCi/m<sup>3</sup>. The plutonium-239 concentrations were about a factor of two lower, both on and off the site than last year.

The thorium and uranium concentrations are in the same range found 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 bulk of these elements in the air was due to resuspension of soil.

TABLE 4.3  
Strontium, Thorium, Uranium, and Plutonium Concentrations  
in Air-Filter Samples, 1991<sup>3</sup>  
(Concentrations in Attocuries/m<sup>3</sup>)

Month	Location*	Strontium-90	Thorium-228	Thorium-230	Thorium-232	Uranium-234	Uranium-238	Plutonium-239
January	7I	-	8 ± 1	8 ± 1	5 ± 1	14 ± 1	12 ± 1	0.4 ± 2.6
	12M	-	8 ± 1	8 ± 1	5 ± 1	14 ± 1	12 ± 1	0.4 ± 2.6
	Off-Site	-	7 ± 1	6 ± 1	4 ± 1	13 ± 1	11 ± 1	0.9 ± 1.1
February	7I	-	8 ± 1	7 ± 1	4 ± 1	10 ± 1	9 ± 1	0.6 ± 1.0
	12M	-	8 ± 1	7 ± 1	4 ± 1	10 ± 1	9 ± 1	0.6 ± 1.0
	Off-Site	-	7 ± 1	4 ± 1	2 ± 0	10 ± 1	7 ± 1	0.4 ± 2.8
March	7I	-	8 ± 1	7 ± 1	4 ± 1	10 ± 2	9 ± 2	0.7 ± 0.5
	12M	14 ± 5	10 ± 1	7 ± 1	4 ± 1	10 ± 2	9 ± 2	0.7 ± 0.5
	Off-Site	< 10	7 ± 1	5 ± 1	3 ± 1	9 ± 1	13 ± 1	0.3 ± 0.3
April	7I	-	8 ± 1	10 ± 1	5 ± 1	11 ± 1	11 ± 1	0.7 ± 0.4
	12M	< 10	9 ± 1	10 ± 1	5 ± 1	11 ± 1	11 ± 1	0.7 ± 0.4
	Off-Site	< 10	5 ± 1	3 ± 1	1 ± 0	7 ± 1	5 ± 1	0.5 ± 0.8
May	7I	-	8 ± 1	7 ± 1	4 ± 1	10 ± 2	9 ± 2	0.7 ± 0.5
	12M	12 ± 42	36 ± 6	37 ± 6	20 ± 4	47 ± 7	36 ± 6	0.7 ± 2.4
	Off-Site	12 ± 6	7 ± 1	5 ± 1	2 ± 0	8 ± 1	8 ± 1	0.3 ± 0.6
June	7I	-	8 ± 1	7 ± 1	4 ± 1	10 ± 2	9 ± 2	0.7 ± 0.5
	12M	24 ± 7	10 ± 2	10 ± 2	5 ± 1	13 ± 2	13 ± 2	0.2 ± 0.6
	Off-Site	13 ± 8	10 ± 1	8 ± 1	4 ± 1	11 ± 1	9 ± 1	0.3 ± 0.7
July	7I	-	8 ± 1	7 ± 1	4 ± 1	10 ± 2	9 ± 2	0.7 ± 0.5
	12M	32 ± 6	11 ± 1	10 ± 1	7 ± 1	13 ± 2	12 ± 1	0.3 ± 1.3
	Off-Site	12 ± 8	9 ± 1	8 ± 1	5 ± 1	12 ± 1	11 ± 1	0.8 ± 0.3
August	7I	-	-	-	-	-	-	-
	12M	41 ± 6	6 ± 1	5 ± 1	3 ± 1	9 ± 1	8 ± 1	1.2 ± 0.4
	Off-Site	12 ± 2	14 ± 1	11 ± 1	6 ± 1	13 ± 1	12 ± 1	0.5 ± 0.2
September	7I	< 10	46 ± 4	5 ± 1	3 ± 1	9 ± 2	6 ± 1	0.5 ± 0.3
	12M	< 10	50 ± 3	8 ± 1	4 ± 1	9 ± 2	8 ± 2	0.3 ± 0.3
	Off-Site	< 10	8 ± 1	3 ± 1	2 ± 1	6 ± 1	5 ± 1	0.2 ± 0.2
October	7I	< 10	9 ± 1	5 ± 1	2 ± 1	6 ± 1	5 ± 1	0.4 ± 0.3
	12M	< 10	39 ± 3	6 ± 1	3 ± 1	9 ± 1	7 ± 1	0.3 ± 0.2
	Off-Site	12 ± 2	9 ± 1	8 ± 1	4 ± 1	8 ± 1	8 ± 1	0.4 ± 0.2
November	7I	< 10	21 ± 3	6 ± 1	3 ± 1	9 ± 2	8 ± 2	0.5 ± 0.4
	12M	< 10	37 ± 3	9 ± 1	3 ± 1	6 ± 1	6 ± 1	0.1 ± 0.2
	Off-Site	10 ± 2	11 ± 2	9 ± 1	4 ± 1	10 ± 1	8 ± 1	0.8 ± 0.6
December	7I	< 10	15 ± 2	10 ± 2	5 ± 1	14 ± 3	11 ± 2	0.1 ± 0.5
	12M	< 10	35 ± 3	5 ± 1	4 ± 1	8 ± 1	8 ± 1	0.7 ± 0.3
	Off-Site	< 10	11 ± 1	4 ± 1	2 ± 1	7 ± 1	5 ± 1	0.3 ± 0.2
Annual Summary	7I	< 10	23 ± 52	7 ± 7	3 ± 4	9 ± 12	7 ± 9	0.4 ± 0.5
	12M	16 ± 27	22 ± 35	10 ± 19	6 ± 10	13 ± 24	12 ± 18	0.5 ± 0.7
	Off-Site	< 10	9 ± 6	6 ± 5	3 ± 3	9 ± 5	8 ± 6	0.5 ± 0.5
Dose (mrem)	7I	< (0.00004)	(0.0571)	(0.0134)	(0.030)	(0.00047)	(0.00037)	(0.0010)
	12M	(0.00018)	(0.0539)	(0.0205)	(0.055)	(0.00067)	(0.00058)	(0.0013)
	Off-Site	< (0.00009)	(0.0215)	(0.0122)	(0.035)	(0.00047)	(0.00042)	(0.0012)

\* Perimeter locations are given in terms of the grid coordinates in Figure 1.1

The major airborne effluents released at ANL during 1991 are listed by location in Table 4.4 and the annual releases of the major sources since 1986 are illustrated in Figure 4.3. The radon-220 released from Building 200 is due to radioactive contamination from the "proof-of-breeding" program and from nuclear medicine studies. Even though the CP-5 reactor ceased operations in 1977, hydrogen-3 continues to be emitted from Building 330. The hydrogen-3 emitted from Building 212 is from tritium recovery studies. In addition to the nuclides 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 for Building 350.

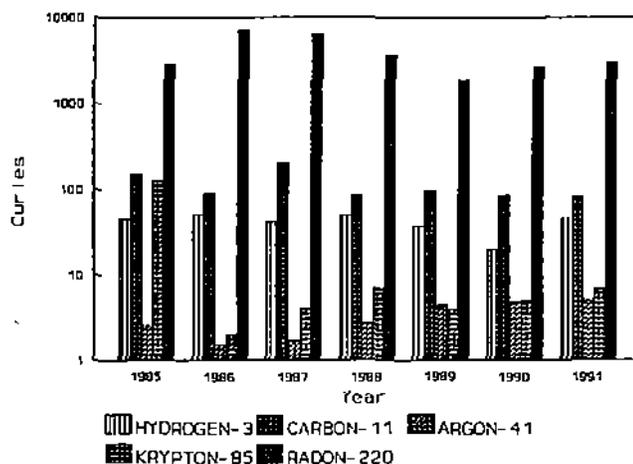


Figure 4.3 Selected Airborne Radionuclides Emissions

#### 4.3. Surface Water

All surface water samples collected in the monitoring program were acidified to 0.1N with  $\text{HNO}_3$  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 uranium-233 (for alpha activity) and thallium-204 (for beta activity) to obtain disintegration rates. Hydrogen-3 was measured from a separate aliquot, and this activity does not appear in the results for total nonvolatile beta activity. Uranium was measured with a laser fluorometer, and the results were calculated in terms of activity, with the assumption that the isotopic composition was that of natural uranium. Analyses for other 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

TABLE 4.4

Summary of Airborne Radioactive Emissions from ANL Facilities, 1991

Building	Nuclide	Half-Life	Amount Released (Curies/y)
200	Radon-220	56 s	2946
	Radon-222	3.82 d	0.26
202 (JANUS)	Argon-41	1.8 h	0.82
205	Hydrogen-3 (HTO)	12.3 y	17.4
211	Carbon-11	20 m	1.0
	Nitrogen-13	10 m	1.0
	Oxygen-15	122 s	7.5
	Fluorine-18	110 m	0.02
	Argon-41	1.8 h	0.07
212	Hydrogen-3 (HTO)	12.3 y	2.84
	Hydrogen-3 (HT)	12.3 y	18.9
	Krypton-85	10.7 y	6.80
	Antimony-125	2.71 y	0.00008
	Radon-220	56 s	0.06
330 (CP-5)	Hydrogen-3 (HTO)	12.3 y	6.88
375 (IPNS)	Carbon-11	20 m	80.8
	Argon-41	1.8 h	4.4
350 (NBL)	Uranium-234	$2.4 \times 10^5$ y	$5.9 \times 10^{-8}$
	Uranium-238	$4.5 \times 10^9$ y	$5.9 \times 10^{-8}$
	Plutonium-238	87.7 y	$3.06 \times 10^{-7}$
	Plutonium-239	$2.4 \times 10^4$	$3.35 \times 10^{-6}$
	Plutonium-240	$6.6 \times 10^4$	$8.06 \times 10^{-7}$
	Plutonium-241	14.4 y	$1.91 \times 10^{-4}$
	Plutonium-242	$3.76 \times 10^5$	$1.64 \times 10^{-9}$

nuclides. Hydrogen-3 analyses were performed by liquid scintillation counting of 9 mL of a distilled sample in a gel medium. Analyses for transuranium nuclides were performed on 10-liter samples with chemical separation methods followed by alpha spectrometry.<sup>10,11</sup> 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 americium-243 tracer.

Argonne wastewater is discharged into Sawmill Creek, which runs through the ANL grounds, drains surface water from much of the site, and flows into the Des Plaines River about 500 m (0.3 mi) downstream from the ANL wastewater outfall. Sawmill Creek was sampled upstream from the ANL site and downstream from the wastewater outfall to determine if radioactivity was added to the stream by ANL wastewater or surface drainage. The sampling locations are shown in Figure 1.1. Below the wastewater outfall, daily samples were collected by grab sampling. Equal portions of the daily samples collected each week were combined and analyzed to obtain an average weekly concentration. Upstream of the site, samples were collected once a month and were analyzed for the same radionuclides measured in the below-outfall samples.

Annual summaries of the results obtained for Sawmill Creek are given in Table 4.5. Comparison of the results and 95% confidence levels of the averages for the two sampling locations shows that the nuclides found in the creek water that can be attributed to ANL operations were strontium-90, neptunium-237, plutonium-239, americium-241, and occasionally hydrogen-3, cesium-137, plutonium-238, curium-242 and/or californium-252, and curium-244 and/or californium-249. The percentage of individual samples containing activity attributable to ANL was 16% for hydrogen-3, 61% for strontium-90, 14% for cesium-137, 88% for neptunium-237, 84% for plutonium-239, and 84% for americium-241. The concentrations of all these nuclides were low and a small fraction of the allowed DOE limits. If the concentrations of the radionuclides listed in Table 4.5 were increased by a factor of five, which approximates the effect of the dilution by Sawmill Creek on the ANL effluent water, the concentrations would still be below the DOE limits. This

TABLE 4.5

## Radionuclides in Sawmill Creek Water, 1991

Activity	Location*	No. of Samples	Concentrations in pCi/L			Dose (mrem)		
			Avg.	Min.	Max.	Avg.	Min.	Max.
Alpha (Nonvolatile)	16K	12	1.9 ± 1.0	1.1	2.8	-	-	-
	7M	51	1.5 ± 0.9	0.3	2.5	-	-	-
Beta (Nonvolatile)	16K	12	8 ± 5	5	13	-	-	-
	7M	51	11 ± 8	5	23	-	-	-
Hydrogen-3	16K	12	< 100	< 100	< 100	< 0.0050	< 0.0050	< 0.0050
	7M	51	179 ± 1501	< 100	5322	0.0089	< 0.0050	0.2661
Strontium-90	16K	12	< 0.25	< 0.25	0.34	< 0.025	< 0.025	0.034
	7M	51	0.33 ± 0.22	< 0.25	0.70	0.033	< 0.025	0.070
Cesium-137	16K	10	< 1.0	< 1.0	< 1.0	< 0.03	< 0.03	< 0.03
	7M	46	< 1.0	< 1.0	4.8	< 0.03	< 0.03	0.16
Uranium (Natural)	16K	12	1.7 ± 0.9	0.7	2.2	0.282	0.121	0.362
	7M	51	0.9 ± 1.0	0.2	1.7	0.148	0.035	0.284
Neptunium-237	16K	12	0.0012 ± 0.0018	< 0.0010	0.0031	0.0040	< 0.0033	0.0104
	7M	51	0.0029 ± 0.0055	< 0.0010	0.0192	0.0095	< 0.0033	0.0636
Plutonium-238	16K	12	< 0.0010	< 0.0010	< 0.0010	< 0.0025	< 0.0025	< 0.0025
	7M	51	0.0013 ± 0.0025	< 0.0010	0.0063	0.0033	< 0.0025	0.0157
Plutonium-239	16K	12	< 0.0010	< 0.0010	0.0018	< 0.0033	< 0.0033	0.0059
	7M	51	0.0063 ± 0.0178	< 0.0010	0.0561	0.0208	< 0.0033	0.1869
Americium-241	16K	10	< 0.0010	< 0.0010	0.0019	< 0.0033	< 0.0033	0.0065
	7M	51	0.0043 ± 0.0100	< 0.0010	0.0273	0.0142	< 0.0033	0.0909
Curium-242 and/or Californium-252	16K	10	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
	7M	51	< 0.0010	< 0.0010	0.0024	< 0.0010	< 0.0010	0.0024
Curium-244 and/or Californium-249	16K	10	< 0.0010	< 0.0010	0.0017	< 0.0033	< 0.0033	0.0056
	7M	51	< 0.0010	< 0.0010	0.0035	< 0.0033	< 0.0033	0.0116

\* Location 16K is upstream from the Argonne site and location 7M is downstream from the Argonne wastewater outfall.

demonstrates compliance with DOE Order 5400.5 for use of Best Available Technology (BAT) for release of liquid effluents.

Liquid wastewater from buildings or facilities that use or process radioactive materials are 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 disposed of as solid low-level radioactive waste. If the radioactivity is below the release limits, the wastewater is conveyed to the Laboratory wastewater treatment plant in dedicated pipes to waste storage tanks. These tanks are again sampled and analyzed for radioactivity and if below the release limits, discharged to the environment. The release limits are based on the DCGs of 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. This effluent monitoring program documents that no liquid releases above the DCGs have occurred and reinforces the demonstration of compliance with the use of BAT as required by DOE Order 5400.5.

At location 7M, below the ANL outfall, the annual average concentrations of most measured radionuclides were similar to the 1990 averages. All the annual averages were well below the applicable standards. The annual total radioactive effluent discharged to the creek in ANL wastewater can be estimated from the average net concentrations and the volume of water carried by the creek. These totals are collected in Table 4.6.

Because Sawmill Creek empties into the Des Plaines River, which in turn flows into the Illinois River, data on the radioactivity in the two rivers are important in assessing the contribution of ANL 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 if the radioactivity in the creek had any effect on the radioactivity in the river.

TABLE 4.6

## Total Radioactivity Released to Sawmill Creek, 1991

Radionuclide	Released (Ci)	Percent
Hydrogen-3	1.40	99.7
Strontium-90	$0.8 \times 10^{-3}$	0.1
Cesium-137	$3.0 \times 10^{-3}$	0.2
Neptunium-237	$1.6 \times 10^{-5}$	< 0.1
Plutonium-239	$4.8 \times 10^{-5}$	< 0.1
Americium-241	$2.9 \times 10^{-5}$	< 0.1
Total	1.40	

Table 4.7 presents 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. The average nonvolatile alpha and beta activities, 1.6 pCi/L and 9.1 pCi/L, respectively, of 24 off-site surface water samples collected in 1991 were similar to the levels found in previous years. The hydrogen-3 concentration in these surface water samples averaged 87 pCi/L.

The radioactivity levels in samples of Illinois River water, shown in Table 4.8, were similar to those found previously at these same locations. No radioactivity originating at ANL could be detected in the Des Plaines or Illinois rivers.

#### 4.4. Soil, Grass, and Bottom Sediment

The radioactive content of soil, grass, and bottom sediment was measured at the site perimeter and off the site. The purpose of the off-site sampling was to measure deposition for comparison with perimeter samples and with results obtained by other organizations for samples

TABLE 4.7

## Radionuclides in Des Plaines River Water, 1991

Activity	Location <sup>a</sup>	No. of Samples	Concentrations in pCi/L			Dose (mrem)		
			Avg.	Min.	Max.	Avg.	Min.	Max.
Alpha (Nonvolatile)	A	12	1.5 ± 1.3	0.7	2.5	-	-	-
	B	24	1.7 ± 1.1	0.8	2.9	-	-	-
Beta (Nonvolatile)	A	12	13 ± 13	7	23	-	-	-
	B	24	13 ± 12	5	25	-	-	-
Hydrogen-3	A	12	< 100	< 100	< 100	< 0.0050	< 0.0050	< 0.0050
	B	24	< 100	< 100	157	< 0.0050	< 0.0050	0.0078
Strontium-90	A	12	< 0.25	< 0.25	0.29	< 0.025	< 0.025	0.029
	B	24	< 0.25	< 0.25	0.30	< 0.025	< 0.025	0.030
Uranium (Natural)	A	12	1.0 ± 0.9	0.3	1.6	0.170	0.051	0.272
	B	24	1.0 ± 0.7	0.3	1.5	0.162	0.057	0.244
Neptunium-237	A	12	0.0011 ± 0.0017	< 0.0010	0.0028	0.0037	< 0.0033	0.0093
	B	12	0.0011 ± 0.0014	< 0.0010	0.0022	0.0036	< 0.0033	0.0072
Plutonium-238	A	12	< 0.0010	< 0.0010	0.0014	< 0.0025	< 0.0025	0.0036
	B	12	< 0.0010	< 0.0010	0.0028	< 0.0025	< 0.0025	0.0071
Plutonium-239	A	12	< 0.0010	< 0.0010	< 0.0010	< 0.0033	< 0.0033	< 0.0033
	B	12	< 0.0010	< 0.0010	0.0013	< 0.0033	< 0.0033	0.0042
Americium-241	A	10	< 0.0010	< 0.0010	0.0026	< 0.0033	< 0.0033	0.0086
	B	11	< 0.0010	< 0.0010	0.0029	< 0.0033	< 0.0033	0.0096
Curium-242 and/or Californium-252	A	10	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
	B	11	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Curium-244 and/or Californium-249	A	10	< 0.0010	< 0.0010	< 0.0010	< 0.0033	< 0.0033	< 0.0033
	B	11	< 0.0010	< 0.0010	0.0012	< 0.0033	< 0.0033	0.0040

<sup>a</sup> Location A, near Willow Springs, is upstream and location B, near Lemont, is downstream from the mouth of Sawmill Creek.  
See Figure 1.2

TABLE 4.8

## Radionuclides in Illinois River Water, 1991

(Concentrations in pCi/L)

Date Collected	Location	Alpha*	Beta*	Hydrogen-3	Uranium (natural)	Plutonium-239
April 24	Dresden Lock & Dam, IL	1.5 ± 0.3	3.9 ± 0.3	577 ± 99	1.1 ± 0.1	< 0.001
April 24	McKinley Woods Park, IL	1.3 ± 0.4	7.6 ± 0.4	< 100	1.1 ± 0.1	0.001 ± 0.001
April 24	Morris, IL	1.5 ± 0.3	5.5 ± 0.3	193 ± 95	1.1 ± 0.1	-
May 4	Starved Rock State Park, IL	0.8 ± 0.3	4.5 ± 0.3	118 ± 96	1.0 ± 0.1	-
May 4	Starved Rock State Park, IL	1.6 ± 0.4	6.2 ± 0.3	< 100	1.0 ± 0.1	-
November 14	Dresden Lock & Dam, IL	1.4 ± 0.4	8.4 ± 0.3	479 ± 98	0.9 ± 0.1	< 0.001
November 14	McKinley Woods Park, IL	0.9 ± 0.5	12.9 ± 0.4	< 100	0.8 ± 0.1	< 0.001
November 14	Morris, IL	1.2 ± 0.4	8.2 ± 0.3	< 100	0.9 ± 0.1	-
November 14	Starved Rock State Park, IL	1.0 ± 0.4	8.3 ± 0.3	243 ± 93	0.9 ± 0.1	-

\* Nonvolatile activity.

collected at large distances from nuclear installations. Such comparisons are useful in determining if the radioactivity of soil near ANL is normal. For this purpose, site-selection criteria and sample collection and sample preparation techniques recommended by the American Society for Testing and Materials (ASTM) were used.<sup>12</sup> Sites were selected in several directions and at various distances from ANL. Each site was selected on the basis that the soil appeared, or was known to have been, undisturbed for a number of years. Attempts were made to select open, level, grassy areas that were mowed at reasonable intervals. Public parks were selected when available.

Each soil sample consisted of ten cores, totaling 864 cm<sup>2</sup> (134 in<sup>2</sup>) in area by 5 cm (2 in) deep. Through 1976, samples had been collected down to 30 cm (12 in) to measure total deposition. The results of five years of sample collection at this depth has established the total deposition in the ANL environment. Reducing the sampling depth to 5 cm (2 in) will make the analysis more sensitive to changes in current deposition. The grass samples were obtained by collecting the grass from a 1 m<sup>2</sup> (10 ft<sup>2</sup>) area in the immediate vicinity of a soil sample. A grab sample technique was used to obtain bottom sediments from water bodies. After drying, grinding, and mixing, 100 g portions of each soil, bottom sediment, and grass 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 aliquot of soil. Results are given in terms of the oven-dried (110°C) weight.

The results for the gamma-ray emitting nuclides in soil are presented in Table 4.9. Intermediate half-life fission products reported in 1986 have decayed to below their detection limits and no evidence of Chernobyl fallout is apparent. The cesium-137 levels are similar to those found over the past several years and represent an accumulation from nuclear tests over a period of many years. The annual average concentrations for the perimeter and off-site samples were similar. The plutonium and americium concentrations are given in Table 4.10. The range and average concentrations of plutonium and americium in soil were similar at both perimeter and off-site sampling points. For fallout americium-241 in soil, about 10% is due to direct deposition, while about 90% is from the decay of the previously deposited plutonium-241. The americium-241/plutonium-239 ratio is

TABLE 4.9  
Gamma-Ray Emitting Radionuclides in Soil, 1991  
(Concentrations in pCi/g)

Date Collected	Location	Potassium-40	Cesium-137	Radium-226	Thorium-228	Thorium-232
<u>Perimeter*</u>						
April 22	10P	19.61 ± 0.79	0.60 ± 0.03	1.26 ± 0.07	1.01 ± 0.04	0.82 ± 0.10
April 22	14N	16.22 ± 0.73	0.58 ± 0.03	1.18 ± 0.07	1.05 ± 0.04	0.86 ± 0.09
April 22	4EF	17.24 ± 0.74	0.69 ± 0.03	1.53 ± 0.07	0.93 ± 0.04	0.82 ± 0.09
April 23	14E	18.79 ± 0.78	0.57 ± 0.03	1.42 ± 0.07	1.00 ± 0.04	0.81 ± 0.10
April 23	7EF	20.75 ± 0.78	0.69 ± 0.03	1.45 ± 0.07	0.99 ± 0.04	0.79 ± 0.09
May 1	7EF	17.51 ± 0.74	0.65 ± 0.03	1.22 ± 0.07	0.95 ± 0.04	0.79 ± 0.09
December 12	15H	12.72 ± 0.53	1.21 ± 0.04	0.97 ± 0.06	0.76 ± 0.04	0.68 ± 0.08
December 12	7H	15.93 ± 0.59	0.49 ± 0.03	1.16 ± 0.06	0.76 ± 0.04	0.74 ± 0.08
December 12	8G	18.40 ± 0.67	0.59 ± 0.03	1.21 ± 0.07	0.93 ± 0.04	0.75 ± 0.09
December 13	13D	16.37 ± 0.63	0.45 ± 0.03	1.45 ± 0.07	1.10 ± 0.04	1.03 ± 0.10
December 13	13N	16.54 ± 0.60	0.54 ± 0.03	1.34 ± 0.07	1.07 ± 0.04	0.94 ± 0.09
December 13	13O	16.10 ± 0.59	0.40 ± 0.03	1.39 ± 0.07	1.10 ± 0.04	0.93 ± 0.09
	Average	17.18 ± 4.57	0.62 ± 0.45	1.30 ± 0.35	0.97 ± 0.25	0.83 ± 0.21
<u>Off-site</u>						
April 24	Dresden Lock & Dam, IL	25.50 ± 0.81	0.81 ± 0.04	1.59 ± 0.07	1.29 ± 0.04	1.07 ± 0.10
April 24	McKinley Woods State Park, IL	21.55 ± 0.81	0.51 ± 0.03	1.38 ± 0.07	0.99 ± 0.04	0.84 ± 0.10
April 24	Morris, IL	16.11 ± 0.73	0.27 ± 0.03	1.67 ± 0.08	0.95 ± 0.04	0.79 ± 0.09
April 26	McCormick Woods, Brookfield, IL	20.18 ± 0.77	0.65 ± 0.03	1.57 ± 0.07	1.10 ± 0.04	0.87 ± 0.09
April 26	Bemis Woods, Western Springs, IL	20.41 ± 0.77	0.48 ± 0.03	1.97 ± 0.08	1.04 ± 0.04	0.87 ± 0.10
November 14	Channahon, IL	18.33 ± 0.61	0.73 ± 0.03	1.28 ± 0.06	1.09 ± 0.04	0.88 ± 0.09
November 14	Starved Rock State Park, IL	12.02 ± 0.52	0.67 ± 0.03	1.00 ± 0.06	0.70 ± 0.03	0.59 ± 0.08
November 14	Starved Rock State Park, IL	15.82 ± 0.58	0.25 ± 0.02	1.14 ± 0.06	1.12 ± 0.04	0.99 ± 0.09
December 17	Orland Park, IL	18.54 ± 0.62	0.49 ± 0.03	1.43 ± 0.07	0.95 ± 0.04	0.91 ± 0.09
December 17	Orland Park, IL	21.12 ± 0.72	1.36 ± 0.05	1.81 ± 0.08	0.97 ± 0.04	0.81 ± 0.10
December 18	Palos Hills, IL	15.87 ± 0.58	0.21 ± 0.02	1.93 ± 0.08	1.06 ± 0.04	0.80 ± 0.09
	Average	18.68 ± 8.13	0.59 ± 0.73	1.53 ± 0.70	1.02 ± 0.32	0.86 ± 0.27

\* The perimeter locations are given in terms of the grid coordinates in Figure 1.1

TABLE 4.10  
Transuranics in Soil, 1991

Date Collected	Location	Plutonium-238 (fCi/g)	Plutonium-238 (nCi/m <sup>2</sup> )	Plutonium-239 (fCi/g)	Plutonium-239 (nCi/m <sup>2</sup> )	Pu-238/Pu-239	Americium-241 (fCi/g)	Americium-241 (nCi/m <sup>2</sup> )	Am-241/Pu-239
<u>Perimeter*</u>									
April 22	10P	0.5 ± 0.5	0.028 ± 0.027	13.6 ± 1.8	0.745 ± 0.101	0.038	12.9 ± 2.2	0.704 ± 0.123	0.946
April 22	14W	0.8 ± 0.5	0.026 ± 0.020	15.1 ± 1.9	0.637 ± 0.079	0.040	4.1 ± 1.2	0.175 ± 0.051	0.274
April 22	46F	0.8 ± 0.8	0.043 ± 0.040	18.3 ± 2.6	0.929 ± 0.133	0.046	3.7 ± 1.1	0.189 ± 0.056	0.204
April 23	14E	0.6 ± 0.5	0.023 ± 0.018	16.0 ± 1.9	0.636 ± 0.075	0.035	9.4 ± 1.6	0.375 ± 0.063	0.589
April 23	7EF	1.0 ± 0.7	0.040 ± 0.031	17.6 ± 2.5	0.746 ± 0.107	0.054	6.0 ± 1.4	0.255 ± 0.060	0.342
May 1	7EF	0.4 ± 0.4	0.016 ± 0.017	17.0 ± 2.1	0.695 ± 0.086	0.023	6.9 ± 1.8	0.281 ± 0.072	0.405
December 12	15H	2.6 ± 1.2	0.097 ± 0.045	42.7 ± 4.6	1.558 ± 0.169	0.062	8.7 ± 2.2	0.317 ± 0.079	0.203
December 12	7N	< 0.1	< 0.01	14.1 ± 2.3	0.573 ± 0.094	-	8.2 ± 2.5	0.332 ± 0.102	0.580
December 12	8G	0.4 ± 0.7	0.019 ± 0.031	12.4 ± 2.1	0.568 ± 0.095	0.033	5.3 ± 1.9	0.242 ± 0.088	0.427
December 13	13D	0.8 ± 0.5	0.039 ± 0.023	12.1 ± 1.6	0.603 ± 0.081	0.065	4.6 ± 1.2	0.230 ± 0.059	0.381
December 13	13W	0.4 ± 0.4	0.019 ± 0.016	13.0 ± 1.8	0.585 ± 0.079	0.033	5.4 ± 1.2	0.243 ± 0.056	0.415
December 13	13D	1.4 ± 0.6	0.063 ± 0.026	10.9 ± 1.5	0.490 ± 0.067	0.129	4.9 ± 1.5	0.219 ± 0.068	0.448
	Average	0.8 ± 0.4	0.034 ± 0.016	16.9 ± 5.4	0.730 ± 0.181	0.046	6.7 ± 1.7	0.297 ± 0.090	0.434
<u>Off-site</u>									
April 24	Dresden Lock & Dam, IL	1.3 ± 1.0	0.075 ± 0.039	21.4 ± 3.6	0.831 ± 0.123	0.062	5.9 ± 1.4	0.231 ± 0.060	0.275
April 24	McKinley Woods State Park, IL	0.2 ± 0.5	0.009 ± 0.020	12.0 ± 1.9	0.526 ± 0.082	0.017	4.4 ± 1.2	0.192 ± 0.053	0.366
April 24	Morriss, IL	0.2 ± 0.6	0.010 ± 0.033	8.5 ± 1.7	0.488 ± 0.096	0.021	2.1 ± 0.9	0.126 ± 0.054	0.253
April 26	McCormick Woods, Brookfield, IL	0.2 ± 0.6	0.036 ± 0.028	18.6 ± 2.8	0.751 ± 0.104	0.013	6.5 ± 1.3	0.286 ± 0.056	0.353
April 26	Bemis Woods, Western Springs, IL	0.3 ± 0.5	0.012 ± 0.019	11.0 ± 1.8	0.418 ± 0.067	0.029	3.5 ± 1.1	0.135 ± 0.043	0.324
November 14	Channahon, IL	0.3 ± 0.5	0.011 ± 0.022	19.5 ± 2.1	0.888 ± 0.098	0.013	6.7 ± 2.6	0.306 ± 0.118	0.345
November 14	Starved Rock State Park, IL	0.6 ± 0.7	0.055 ± 0.040	18.0 ± 2.4	1.020 ± 0.135	0.035	7.4 ± 2.0	0.416 ± 0.113	0.408
November 14	Starved Rock State Park, IL	0.6 ± 0.4	0.031 ± 0.023	6.7 ± 1.3	0.381 ± 0.074	0.082	3.2 ± 1.0	0.182 ± 0.057	0.478
December 17	Orland Park, IL	1.0 ± 0.6	0.017 ± 0.028	16.2 ± 2.1	0.694 ± 0.101	0.065	5.2 ± 1.2	0.272 ± 0.064	0.324
December 17	Orland Park, IL	0.7 ± 0.5	0.033 ± 0.024	14.7 ± 1.9	0.713 ± 0.091	0.046	5.4 ± 1.4	0.263 ± 0.070	0.370
December 18	Palos Hills, IL	0.3 ± 0.4	0.010 ± 0.014	6.8 ± 1.3	0.236 ± 0.045	0.041	1.8 ± 0.8	0.061 ± 0.027	0.260
	Average	0.5 ± 0.3	0.025 ± 0.013	13.9 ± 3.5	0.631 ± 0.162	0.038	4.7 ± 1.3	0.225 ± 0.067	0.341

\* The perimeter locations are given in terms of the grid coordinates in Figure 1.1

consistent with the current estimated value for this ratio of 0.32 in fall-out derived material.<sup>13</sup>

The radionuclide concentrations measured in grass are listed in Table 4.11. The annual averages and concentration ranges were similar at the perimeter and off-site locations and were similar to those of previous years, indicating no contribution from ANL operations. In terms of deposition, the plutonium-239 concentration was a factor of about  $10^4$  less in the grass than in the soil from the same location.

Results of analyses of bottom sediment samples for gamma-ray emitters and transuranics are given in Table 4.12. The annual off-site averages were in the same range found in off-site samples collected in previous years. Plutonium results varied widely among locations and were strongly dependent on the retentiveness of the bottom material. A set of sediment samples was collected on July 18, 1991, from the Sawmill Creek bed, above, at the outfall, and at several locations below the point at which ANL discharges its treated waste water (location 7M in Figure 1.1). The results, as listed in Table 4.12, show that the concentrations in the sample above the 7M outfall are similar to those of the off-site samples. The plutonium, americium, and cesium-137 concentrations are elevated below the outfall, indicating that their origin is in ANL wastewater. In addition to the radionuclides listed in Table 4.12, cobalt-60, up to 1 pCi/g, was identified in the sediment below the outfall. The changes in concentrations of these nuclides with time and location indicate the dynamic nature of the sediment material in this area.

#### 4.5. External Penetrating Radiation

Levels of external penetrating radiation at and in the vicinity of the ANL site were measured with calcium fluoride thermoluminescent dosimeter (TLD) chips. Each measurement reported represents the average of four chips exposed in the same packet. All calcium fluoride packets were shielded with 1.6 mm (1/16 in) copper foil to reduce or eliminate the beta and low-energy X-ray components. The response of the chips was determined with a U. S. National Institute of Standards and Technology (NIST) standard radium-226

TABLE 4.11

## Radionuclides in Grass, 1991

Date Collected	Location	Potassium-40 (pCi/g)	Cesium-137 (fCi/g)	Plutonium-239 (fCi/g)	Deposited Plutonium-239 (nCi/m <sup>2</sup> )
<u>Perimeter*</u>					
April 22	10P	24.01 ± 0.89	< 10	0.3 ± 0.2	0.02 ± 0.01
April 22	14N	12.56 ± 0.59	< 10	0.2 ± 0.1	0.01 ± 0.01
April 22	4EF	13.37 ± 0.57	< 10	0.2 ± 0.1	0.01 ± 0.01
April 23	14E	17.54 ± 0.55	< 10	0.5 ± 0.1	0.05 ± 0.01
April 23	7EF	15.20 ± 0.52	< 10	0.3 ± 0.1	0.04 ± 0.01
May 1	7EF	15.24 ± 0.74	< 10	0.1 ± 0.1	0.02 ± 0.01
December 12	15H	1.50 ± 0.27	< 10	0.2 ± 0.1	0.03 ± 0.01
December 12	7M	0.88 ± 0.25	< 10	0.2 ± 0.1	0.84 ± 0.32
December 12	8G	1.67 ± 0.30	< 10	0.2 ± 0.1	0.04 ± 0.02
December 13	130	0.97 ± 0.27	< 10	0.1 ± 0.1	0.03 ± 0.01
December 13	13N	1.62 ± 0.30	< 10	0.1 ± 0.0	0.03 ± 0.01
	Average	9.51 ± 18.63	< 10	0.2 ± 0.2	0.10 ± 0.54
<u>Off-site</u>					
April 24	Dresden Lock & Dam, IL	23.76 ± 0.98	< 10	0.1 ± 0.1	0.01 ± 0.01
April 24	McKinley Woods State Park, IL	10.60 ± 0.57	< 10	0.5 ± 0.1	0.04 ± 0.01
April 24	Morris, IL	37.47 ± 0.92	< 10	0.2 ± 0.1	0.01 ± 0.01
April 26	McCormick Woods, Brookfield, IL	21.25 ± 0.52	< 10	< 0.1	0.02 ± 0.01
April 26	Bemis Woods, Western Springs, IL	25.23 ± 0.72	< 10	0.1 ± 0.1	0.02 ± 0.01
November 14	Channahon, IL	1.04 ± 0.26	< 10	11.1 ± 0.6	15.66 ± 0.80
November 14	Starved Rock State Park, IL	3.41 ± 0.31	< 10	0.9 ± 0.1	1.07 ± 0.16
November 14	Starved Rock State Park, IL	4.09 ± 0.37	< 10	0.1 ± 0.1	0.03 ± 0.02
December 17	Orland Park, IL	1.40 ± 0.27	< 10	0.1 ± 0.1	0.02 ± 0.01
December 17	Orland Park, IL	1.57 ± 0.29	< 10	0.2 ± 0.1	0.04 ± 0.02
December 18	Palos Hills, IL	1.85 ± 0.32	< 10	17.9 ± 0.8	3.64 ± 0.17
	Average	11.97 ± 28.45	< 10	2.8 ± 13.3	1.87 ± 10.48

\* The perimeter locations are given in terms of the grid coordinates in Figure 1.1

TABLE 4.12

## Radionuclides in Bottom Sediment, 1991

Date Collected	Location	Concentrations in pCi/g					Concentrations in fCi/g			
		Potassium-40	Cesium-137	Radium-226	Thorium-228	Thorium-232	Plutonium-238	Plutonium-239	Americium-241	
<u>Perimeter*</u>										
July 18	Sawmill Creek 25 M Above Outfall	7.94 ± 0.65	0.03 ± 0.02	0.62 ± 0.06	0.37 ± 0.03	0.40 ± 0.08	< 0.1	2.2 ± 0.7	1.7 ± 0.8	
July 18	Sawmill Creek At Outfall	9.50 ± 0.67	0.95 ± 0.04	1.02 ± 0.07	0.50 ± 0.04	0.67 ± 0.09	22.5 ± 2.6	487.3 ± 18.3	77.5 ± 7.1	
July 18	Sawmill Creek 50 M Below Outfall	12.26 ± 0.71	0.62 ± 0.03	1.10 ± 0.07	0.62 ± 0.04	0.63 ± 0.09	4.7 ± 1.1	61.7 ± 4.1	20.3 ± 2.5	
July 18	Sawmill Creek 100 M Below Outfall	11.99 ± 0.70	0.62 ± 0.03	1.15 ± 0.07	0.56 ± 0.04	0.63 ± 0.09	3.4 ± 1.1	38.1 ± 3.4	11.5 ± 1.8	
July 18	Sawmill Creek At Des Plaines River	13.86 ± 0.72	0.66 ± 0.04	0.87 ± 0.07	0.62 ± 0.04	0.47 ± 0.09	2.0 ± 0.8	26.1 ± 2.6	9.5 ± 1.6	
<u>Off-site</u>										
April 24	Illinois River Dresden Lock & Dam, IL	6.47 ± 0.61	0.09 ± 0.02	0.52 ± 0.06	0.23 ± 0.03	0.17 ± 0.08	0.3 ± 0.4	1.7 ± 0.7	1.7 ± 0.7	
April 24	Illinois River McKinley Woods State Park, IL	11.87 ± 0.69	0.09 ± 0.03	2.25 ± 0.08	1.01 ± 0.04	1.08 ± 0.10	1.2 ± 0.6	4.4 ± 1.1	2.2 ± 0.7	
April 24	Illinois River Morris, IL	13.45 ± 0.72	0.07 ± 0.02	0.65 ± 0.06	0.58 ± 0.04	0.48 ± 0.09	0.1 ± 0.3	1.7 ± 0.6	1.1 ± 0.5	
April 26	Salt Creek Bemis Woods, Western Springs, IL	12.52 ± 0.69	0.13 ± 0.03	1.47 ± 0.07	0.82 ± 0.04	0.81 ± 0.09	0.1 ± 0.4	5.7 ± 1.2	2.2 ± 0.6	
May 1	Des Plaines River McCormick Woods, Brookfield, IL	17.81 ± 0.77	0.52 ± 0.03	1.37 ± 0.07	0.99 ± 0.04	0.90 ± 0.10	1.3 ± 0.6	13.9 ± 1.8	5.4 ± 1.1	
May 1	Des Plaines River McCormick Woods, Brookfield, IL	16.93 ± 0.74	0.45 ± 0.03	1.31 ± 0.07	0.93 ± 0.04	0.74 ± 0.09	0.6 ± 0.5	12.0 ± 1.6	4.2 ± 1.0	
November 14	DuPage River Channahon, IL	12.30 ± 0.50	0.23 ± 0.02	1.44 ± 0.07	1.08 ± 0.04	1.09 ± 0.09	< 0.1	8.1 ± 1.5	2.8 ± 1.7	
November 14	Illinois River Starved Rock State Park, IL	12.23 ± 0.29	0.13 ± 0.01	1.18 ± 0.04	0.73 ± 0.02	0.59 ± 0.05	0.7 ± 0.5	2.7 ± 0.9	2.8 ± 1.5	
November 14	DuPage River Channahon, IL	13.11 ± 0.55	0.14 ± 0.02	1.46 ± 0.07	1.14 ± 0.04	1.05 ± 0.10	0.2 ± 0.5	4.7 ± 1.1	4.1 ± 1.4	
December 17	McGinnis Slough Orland Park, IL	18.17 ± 0.64	0.23 ± 0.02	1.24 ± 0.07	0.82 ± 0.04	0.66 ± 0.08	0.1 ± 0.4	7.9 ± 1.3	4.7 ± 3.4	
December 17	Saganashkee Slough Palos Hills, IL	18.11 ± 0.62	0.04 ± 0.02	0.83 ± 0.06	0.60 ± 0.03	0.57 ± 0.08	1.0 ± 0.6	2.6 ± 0.9	16.6 ± 6.5	
Average		13.91 ± 7.97	0.19 ± 0.35	1.25 ± 1.05	0.81 ± 0.59	0.74 ± 0.63	0.5 ± 1.1	5.9 ± 9.2	4.4 ± 9.6	

\* The perimeter locations are given in terms of the grid coordinates in Figure 1.1

source, and the results were calculated in terms of the air dose. Dosimeters were exposed at several locations at the site boundary and on the site. Readings were also taken at five off-site locations for comparison purposes. These locations are shown in Figure 1.2.

The results are summarized in Tables 4.13 and 4.14, and the site boundary and on-site readings are also shown in Figure 4.4. Measurements were made for 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 given in the tables for an average is the 95% confidence limit calculated from the standard deviation of the average.

TABLE 4.13

## Environmental Penetrating Radiation at Off-Site Locations, 1991

Location	Dose Rate (mrem/year)				Average
	Period of Measurement				
	1/15-4/16	4/16-7/16	7/16-10/8	10/8-1/14	
Lemont	79	85	83	76	81 ± 4
Oak Brook	82	83	85	73	81 ± 5
Oak Lawn	74	75	64	66	70 ± 5
Orland Park	78	80	76	76	78 ± 2
Woodridge	79	84	83	74	80 ± 4
Average	78 ± 2	81 ± 3	78 ± 7	73 ± 3	78 ± 6

The off-site results averaged  $78 \pm 6$  mrem/y and were similar to last year's off-site average of  $83 \pm 2$  mrem/y.<sup>14</sup> If the off-site locations provided an accurate sample of the radiation background in the area, then annual averages at the site in the range of  $78 \pm 6$  mrem/y may be considered normal with a 95% probability. To compare boundary results for individual sampling periods, the standard deviation of the 20 individual off-site results is useful. This value is 3 mrem/y, so individual results in the

TABLE 4.14

## Environmental Penetrating Radiation at ANL, 1991

Location*	Dose Rate (mrem/year)				Average
	Period of Measurement				
	1/15-4/16	4/16-7/16	7/16-10/8	10/8-1/15	
14G - Boundary	78	83	113	75	87 ± 17
14I - Boundary	78	81	81	76	79 ± 2
14L - Boundary	70	75	69	63	69 ± 5
6I - 200 m N of Quarry Road	80	85	80	83	82 ± 2
7I - Center, Waste Storage Area Facility 317	1390	1400	1470	1430	1423 ± 35
7I - Boundary	91	98	96	88	93 ± 4
8H - Boundary	77	81	71	74	76 ± 4
8H - 65 m S of Building 316	71	73	72	72	72 ± 1
8H - 200 m NW of Waste Storage Area (Heliport)	77	81	83	74	79 ± 4
8H - Boundary, Center, St. Patrick's Cemetery	81	81	76	80	80 ± 2
9H - 50 m SE of CP-5	922	853	872	849	874 ± 33
9I - 65 m NE of Building 350, 230 m NE of Building 316	70	69	67	62	67 ± 3
9/10EF - Boundary	73	84	82	88	82 ± 6
10/11K - Lodging Facilities	68	66	67	63	66 ± 2

\*See Figure 1.1.

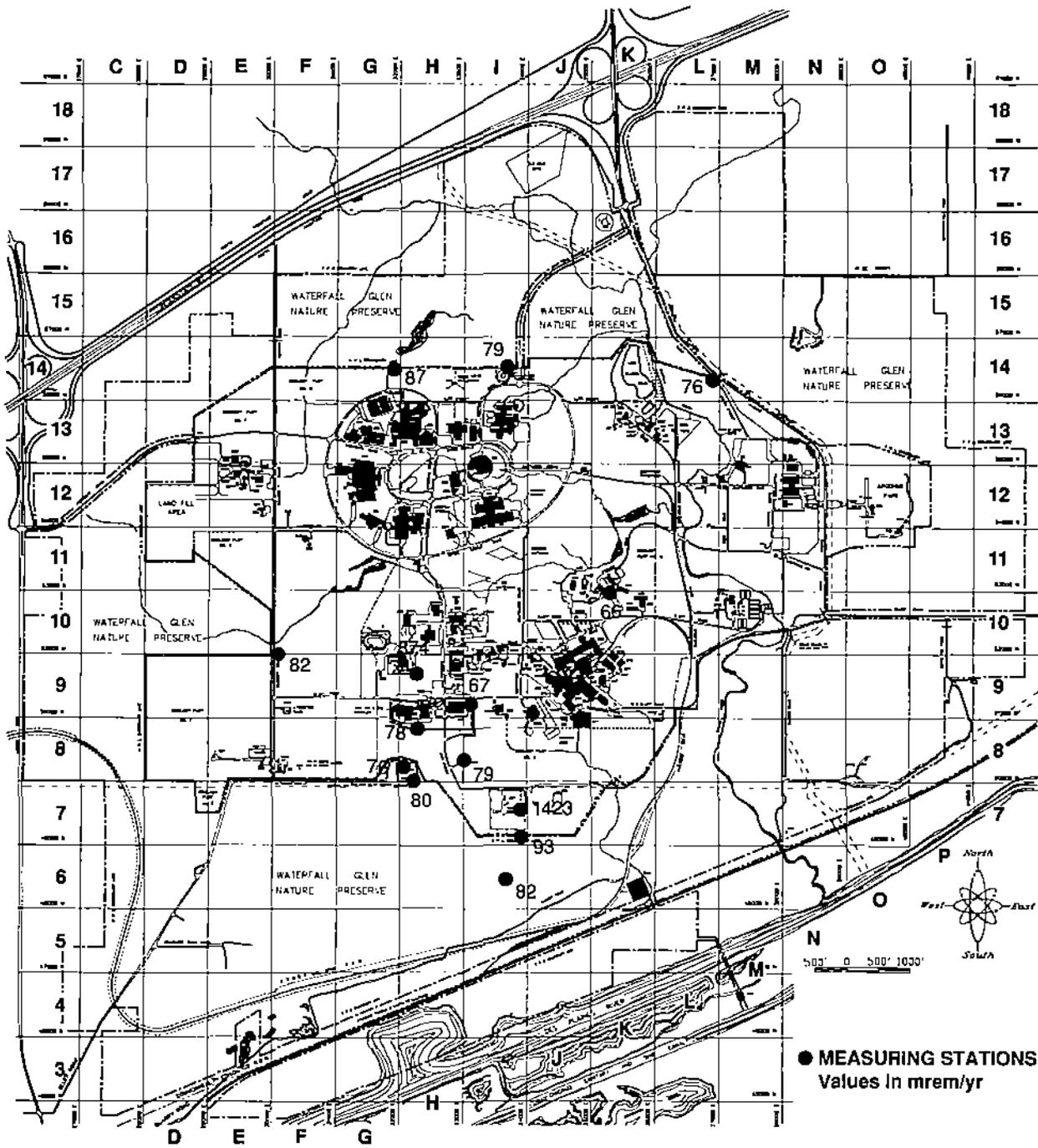


Figure 4.4 Penetrating Radiation Measurements at the ANL Site, 1991

range of  $78 \pm 6$  mrem/y may be considered to be the average natural background with a 95% probability.

In the past, two site boundary locations, 7I (south) and 14I (north), the dose rates were consistently above the average background. At 7I this was due to radiation from ANL's Radioactive Waste Storage Facility (317 Area) in the northern half of grid 7I. Waste is packaged and temporarily kept in this area before removal for permanent disposal off-site. The net above-background dose at this perimeter fence location was about 15 mrem/y, the lowest value since these measurements were conducted. In previous years, this value has ranged up to 865 mrem/y which was in 1985. About 300 m (0.2 mi) south of the fence in grid 6I, the measured dose dropped to  $82 \pm 2$  mrem/y, within the normal background range.

In the past, an elevated perimeter area was at Location 14I, at the north boundary. This dose was attributed to the use of cobalt-60 irradiation sources in Building 202. However, the irradiation program using the cobalt-60 source was terminated at the end of FY 1990 and not used at all during CY 1991. The perimeter dose at Location 14I,  $79 \pm 2$  mrem/y, was within the normal background range. An elevated on-site dose was measured at Location 9H, next to the CP-5 facility, where irradiated hardware from CP-5 is stored.

#### 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. These calculations were made for three exposure pathways, airborne, water, and direct radiation from external sources.

##### 4.6.1. Airborne Pathway

Guidance issued by the DOE<sup>6</sup> stipulates that DOE facilities with airborne releases of radioactive materials are subject to 40 CFR Part 61, Subpart H,<sup>15</sup> which requires the use of the CAP-88 version of the EPA-AIRDOSE/RAD RISK code

to calculate the dose for radionuclides released to the air and to demonstrate compliance with the regulation. The dose limit applicable for CY 1991 for the air pathway is 10 mrem/y effective dose equivalent. The EPA-AIRDOSE/RAD RISK 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 1991, 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 release rates are those listed in Table 4.4, and separate calculations were performed for each of the eight release points. The wind speed and direction data shown in Figure 1.3 were used for these calculations. Doses were calculated for an area extending out to 80 km (50 mi) from ANL. The upgraded population distribution of the 16 compass segments and ten 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 fenceline (perimeter) and nearest resident were determined in the 16 compass segments. The CAP-88 version of the EPA-AIRDOSE/RAD RISK computer code was used to calculate the dose at each of these locations. Calculations also were performed to evaluate the major airborne pathways; ingestion, inhalation, and immersion, both at the point of maximum perimeter exposure and to the maximally exposed resident. The perimeter and resident doses and the maximum doses are listed, respectively, for releases from Buildings 200 (Tables 4.15 and 4.16), Building 202 (Tables 4.17 and 4.18), Building 205 (Tables 4.19 and 4.20), Building 211 (Tables 4.21 and 4.22), Building 212 (Tables 4.23 and 4.24), Building 330 (Tables 4.25 and 4.26), Building 350 (Tables 4.27 and 4.28), and Building 375 (Tables 4.29 and 4.30). The doses given in these tables are the committed whole body effective dose equivalents.

The dominant contributor to the calculated doses was the radon-220 and daughters released from Building 200. This accounted for 99% of the off-site dose in 1991. The highest perimeter dose rates were in the north sector with a maximum dose of 0.97 mrem/y at a fenceline location north of

TABLE 4.15

## Radiological Airborne Releases from Building 200, 1991

Source Term: Radon-220 = 2946 Ci (plus daughters)  
 Radon-222 = 0.26 Ci (plus daughters)

Direction	Distance to Perimeter (m)	Dose (mrem/y)	Distance to Nearest Resident (m)	Dose (mrem/y)
N	500	0.97	1000	0.27
NNE	600	0.83	1100	0.27
NE	750	0.51	2600	0.06
ENE	1700	0.10	3100	0.04
E	2400	0.05	3500	0.03
ESE	2200	0.05	3600	0.02
SE	2100	0.04	4000	0.02
SSE	2000	0.06	4000	0.02
S	1500	0.06	4000	0.01
SSW	1000	0.21	2500	0.05
SW	800	0.57	2200	0.12
WSW	1100	0.21	1500	0.12
W	750	0.29	1500	0.08
WNW	800	0.22	1300	0.10
NW	600	0.45	1100	0.16
NNW	600	0.49	800	0.29

TABLE 4.16

Maximum Perimeter and Individual Doses from  
Building 200 Air Emissions, 1991

Dose (mrem/y)

Pathway	Perimeter (500 m N)	Individual (800 m NNW)
Ingestion	0.0001	< 0.0001
Inhalation	0.958	0.29
Air Immersion	0.007	0.0018
Ground Surface	0.0004	0.0002
Total	0.966	0.29
<u>Radionuclide</u>		
Polonium-210	0.0009	0.0003
Bismuth-210	< 0.0001	< 0.0001
Lead-210	0.0002	< 0.0001
Thallium-208	0.0058	0.0016
Bismuth-212	0.112	0.040
Lead-212	0.561	0.202
Polonium-216	< 0.0001	< 0.0001
Radon-220	0.286	0.048
Radon-222	0.0005	< 0.0001
Total	0.966	0.29

TABLE 4.17

## Radiological Airborne Releases from Building 202 (JANUS), 1991

Source Term: Argon-41 = 0.82 Ci

Direction	Distance to Perimeter (m)	Dose (mrem/y)	Distance to Nearest Resident (m)	Dose (mrem/y)
N	200	0.0001	1700	< 0.0001
NNE	250	0.0002	1800	< 0.0001
NE	350	0.0002	1500	< 0.0001
ENE	800	0.0002	2200	< 0.0001
E	1100	0.0001	2200	< 0.0001
ESE	1600	< 0.0001	2700	< 0.0001
SE	1600	< 0.0001	4000	< 0.0001
SSE	1700	< 0.0001	4000	< 0.0001
S	2100	< 0.0001	4000	< 0.0001
SSW	2200	< 0.0001	4000	< 0.0001
SW	2600	< 0.0001	3200	< 0.0001
WSW	2000	< 0.0001	2600	< 0.0001
W	1500	< 0.0001	2100	< 0.0001
WNW	1000	< 0.0001	1300	< 0.0001
NW	300	0.0001	1000	0.0001
NNW	250	0.0001	800	0.0001

TABLE 4.18

Maximum Perimeter and Individual Doses from  
Building 202 (JANUS) Air Emissions, 1991

Dose (mrem/y)

Pathway	Perimeter (350 m NE)	Individual (800 m NNW)
Ingestion	< 0.0001	< 0.0001
Inhalation	< 0.0001	< 0.0001
Air Immersion	0.0002	0.0001
Ground Surface	< 0.0001	< 0.0001
Total	0.0002	0.0001
<u>Radionuclide</u>		
Argon-41	0.0002	0.0001

TABLE 4.19

## Radiological Airborne Releases from Building 205, 1991

Source Term: Hydrogen-3 = 17.4 Ci

Direction	Distance to Perimeter (m)	Dose (mrem/y)	Distance to Nearest Resident (m)	Dose (mrem/y)
N	850	0.0010	1300	0.0005
NNE	1000	0.0009	2100	0.0003
NE	1200	0.0006	2700	0.0002
ENE	2400	0.0002	3000	0.0001
E	2200	0.0002	2400	< 0.0001
ESE	2000	0.0002	3500	< 0.0001
SE	1800	0.0002	3900	< 0.0001
SSE	1500	0.0003	4000	< 0.0001
S	1300	0.0002	3900	< 0.0001
SSW	1100	0.0006	2400	0.0002
SW	900	0.0014	2100	0.0004
WSW	1100	0.0006	1800	0.0003
W	1300	0.0003	1800	0.0002
WNW	1100	0.0004	1700	0.0002
NW	1100	0.0005	1500	0.0003
NNW	900	0.0007	1500	0.0003

TABLE 4.20

Maximum Perimeter and Individual Doses from  
Building 205 Air Emissions, 1991

Dose (mrem/y)

Pathway	Perimeter (900 m SW)	Individual (1300 m N)
Ingestion	0.0003	0.0001
Inhalation	0.0010	0.0004
Air Immersion	< 0.0001	< 0.0001
Ground Surface	< 0.0001	< 0.0001
Total	0.0014	0.0005
<u>Radionuclide</u>		
Hydrogen-3	0.0014	0.0005

TABLE 4.21

## Radiological Airborne Releases from Building 211, 1991

Source Term: Carbon-11 = 1.0 Ci  
 Nitrogen-13 = 1.0 Ci  
 Oxygen-15 = 7.5 Ci  
 Fluorine-18 = 0.02 Ci  
 Argon-41 = 0.07 Ci

Direction	Distance to Perimeter (m)	Dose (mrem/y)	Distance to Nearest Resident (m)	Dose (mrem/y)
N	800	0.0013	1300	0.0005
NNE	1000	0.0010	2700	0.0001
NE	1200	0.0006	2900	< 0.0001
ENE	2100	0.0001	3000	< 0.0001
E	2700	< 0.0001	3300	< 0.0001
ESE	1800	0.0001	3600	< 0.0001
SE	1800	0.0001	3600	< 0.0001
SSE	1800	0.0001	3600	< 0.0001
S	1300	0.0002	3300	< 0.0001
SSW	1500	0.0002	2400	< 0.0001
SW	700	0.0020	1900	0.0002
WSW	700	0.0015	2000	0.0002
W	1100	0.0004	1600	0.0002
WNW	1000	0.0004	1500	0.0002
NW	1000	0.0005	1300	0.0003
NNW	900	0.0007	1100	0.0004

TABLE 4.22

Maximum Perimeter and Individual Doses from  
Building 211 Air Emissions, 1991

Dose (mrem/y)

Pathway	Perimeter (700 m SW)	Individual (1300 m N)
Ingestion	< 0.0001	< 0.0001
Inhalation	< 0.0001	< 0.0001
Air Immersion	0.0020	0.0004
Ground Surface	< 0.0001	< 0.0001
Total	0.0020	0.0004
<u>Radionuclide</u>		
Carbon-11	0.0004	0.0001
Nitrogen-13	0.0003	< 0.0001
Oxygen-15	0.0012	0.0003
Fluorine-18	< 0.0001	< 0.0001
Argon-41	< 0.0001	< 0.0001
Total	0.0020	0.0004

TABLE 4.23

## Radiological Airborne Releases from Building 212, 1991

Source Term: Hydrogen-3 (HT) = 18.9 Ci  
 Hydrogen-3 (HTO) = 2.84 Ci  
 Krypton-85 = 6.80 Ci  
 Antimony-125 =  $8 \times 10^{-5}$  Ci  
 Radon-220 = 0.06 Ci

Direction	Distance to Perimeter (m)	Dose (mrem/y)	Distance to Nearest Resident (m)	Dose (mrem/y)
N	800	0.0014	2000	0.0004
NNE	1000	0.0012	2500	0.0003
NE	1300	0.0007	2000	0.0004
ENE	1500	0.0005	2500	0.0002
E	1600	0.0004	2800	0.0002
ESE	1200	0.0005	2500	0.0002
SE	1400	0.0004	3500	< 0.0001
SSE	1400	0.0004	4500	< 0.0001
S	1500	0.0002	5000	< 0.0001
SSW	1600	0.0004	5000	< 0.0001
SW	1400	0.0010	2400	0.0005
WSW	1300	0.0006	2300	0.0003
W	1700	0.0003	2200	0.0002
WNW	1500	0.0003	2000	0.0002
NW	1300	0.0005	2000	0.0003
NNW	1000	0.0007	2000	0.0003

TABLE 4.24

Maximum Perimeter and Individual Doses from  
Building 212 Air Emissions, 1991

Dose (mrem/y)

Pathway	Perimeter (800 m N)	Individual (2400 m SW)
Ingestion	0.0003	0.0001
Inhalation	0.0011	0.0004
Air Immersion	< 0.0001	< 0.0001
Ground Surface	< 0.0001	< 0.0001
Total	0.0014	0.0005
<u>Radionuclide</u>		
Hydrogen-3	0.0014	0.0005
Krypton-85	< 0.0001	< 0.0001
Antimony-125	< 0.0001	< 0.0001
Radon-220	< 0.0001	< 0.0001
Total	0.0014	0.0005

TABLE 4.25

## Radiological Airborne Releases from Building 330 (CP-5), 1991

Source Term: Hydrogen-3 (HTO) = 6.88 Ci

Direction	Distance to Perimeter (m)	Dose (mrem/y)	Distance to Nearest Resident (m)	Dose (mrem/y)
N	1500	0.0017	2000	0.0001
NNE	1800	0.0015	3300	< 0.0001
NE	2100	0.0011	2800	< 0.0001
ENE	2200	0.0008	3300	< 0.0001
E	1500	0.0013	3100	< 0.0001
ESE	1300	0.0014	3500	< 0.0001
SE	1200	0.0014	3500	< 0.0001
SSE	1000	0.0024	3500	< 0.0001
S	500	0.0036	3000	< 0.0001
SSW	700	0.0043	3500	< 0.0001
SW	900	0.0054	2400	0.0002
WSW	1400	0.0017	2000	0.0001
W	700	0.0034	2000	< 0.0001
WNW	700	0.0030	1900	< 0.0001
NW	1500	0.0012	2000	< 0.0001
NNW	1600	0.0011	1900	< 0.0001

TABLE 4.26

Maximum Perimeter and Individual Doses from  
Building 330 (CP-5) Air Emissions, 1991

Dose (mrem/y)

Pathway	Perimeter (900 m SW)	Individual (2400 m SW)
Ingestion	0.0012	< 0.0001
Inhalation	0.0041	0.0001
Air Immersion	< 0.0001	< 0.0001
Ground Surface	< 0.0001	< 0.0001
Total	0.0054	0.0001
<u>Radionuclide</u>		
Hydrogen-3	0.0054	0.0001

TABLE 4.27

## Radiological Airborne Releases from Building 350, 1991

Source Term: Uranium-234 =  $5.9 \times 10^{-8}$  Ci  
 Uranium-238 =  $5.9 \times 10^{-8}$  Ci  
 Plutonium-238 =  $3.06 \times 10^{-7}$  Ci  
 Plutonium-239 =  $3.35 \times 10^{-6}$  Ci  
 Plutonium-240 =  $8.06 \times 10^{-7}$  Ci  
 Plutonium-241 =  $1.91 \times 10^{-4}$  Ci  
 Plutonium-242 =  $1.64 \times 10^{-9}$  Ci

Direction	Distance to Perimeter (m)	Dose (mrem/y)	Distance to Nearest Resident (m)	Dose (mrem/y)
N	1700	0.0003	2200	0.0002
NNE	1800	0.0003	3200	0.0002
NE	2200	0.0002	3100	0.0002
ENE	2000	0.0003	3100	0.0001
E	1700	0.0003	2500	0.0002
ESE	900	0.0004	3000	0.0001
SE	900	0.0004	3000	0.0001
SSE	700	0.0006	2700	0.0002
S	600	0.0003	2700	< 0.0001
SSW	400	0.0005	2500	0.0002
SW	600	0.0007	2700	0.0002
WSW	800	0.0005	2100	0.0002
W	900	0.0004	2200	0.0002
WNW	1000	0.0003	2100	0.0001
NW	1900	0.0002	2400	0.0001
NNW	1900	0.0002	2200	0.0002

TABLE 4.28

Maximum Perimeter and Individual Doses from  
Building 350 Air Emissions, 1991

Dose (mrem/y)

Pathway	Perimeter (600 m SW)	Individual (2200 m N)
Ingestion	< 0.0001	< 0.0001
Inhalation	0.0007	0.0002
Air Immersion	< 0.0001	< 0.0001
Ground Surface	< 0.0001	< 0.0001
Total	0.0007	0.0002
<u>Radionuclide</u>		
Uranium-234	< 0.0001	< 0.0001
Uranium-238	< 0.0001	< 0.0001
Plutonium-238	0.0002	< 0.0001
Plutonium-239	0.0002	0.0001
Plutonium-240	< 0.0001	< 0.0001
Plutonium-241	0.0002	0.0001
Plutonium-242	< 0.0001	< 0.0001
Total	0.0007	0.0002

TABLE 4.29

## Radiological Airborne Releases from Building 375 (IPNS), 1991

Source Term: Carbon-11 = 80.8 Ci  
 Argon-41 = 4.4 Ci

Direction	Distance to Perimeter (m)	Dose (mrem/y)	Distance to Nearest Resident (m)	Dose (mrem/y)
N	1600	0.0069	3200	0.0020
NNE	1700	0.0073	3100	0.0026
NE	1700	0.0066	2700	0.0029
ENE	1500	0.0069	2500	0.0028
E	600	0.0270	2500	0.0027
ESE	600	0.0220	2500	0.0021
SE	600	0.0200	2500	0.0017
SSE	600	0.0260	3000	0.0015
S	800	0.0086	3000	0.0010
SSW	800	0.0160	3500	0.0012
SW	800	0.0280	4000	0.0018
WSW	1500	0.0068	2700	0.0024
W	2200	0.0026	2700	0.0016
WNW	1500	0.0042	2600	0.0016
NW	2200	0.0027	2500	0.0022
NNW	1800	0.0040	2200	0.0028

TABLE 4.30

Maximum Perimeter and Individual Doses from  
Building 375 Air Emissions, 1991

Dose (mrem/y)

Pathway	Perimeter (800 m SW)	Individual (2700 m NE)
Ingestion	< 0.0001	< 0.0001
Inhalation	0.0012	0.0001
Air Immersion	0.0261	0.0027
Ground Surface	0.0009	0.0001
Total	0.0282	0.0029
<u>Radionuclide</u>		
Carbon-11	0.0262	0.0027
Argon-41	0.0020	0.0002
Total	0.0282	0.0029

Building 203 (location 14H in Figure 1.1). The major contributor to this dose was inhalation of lead-212 (0.56 mrem/y) and the organs receiving the greatest dose were the lung and the bone. The releases from the other facilities are very minor contributors to the total dose.

The full-time resident who would receive the largest annual dose (0.29 mrem/y) is located approximately 0.8 km (0.5 mi) NNW of the site boundary. The major contributor to the whole body dose is the inhalation dose from lead-212 (0.20 mrem/y). If radon-220 and daughters were excluded from the calculation, as required by NESHAP,<sup>15</sup> the maximally exposed resident would receive a dose of 0.0040 mrem/y, primarily carbon-11 from the IPNS facility (Building 375).

The individual doses to the maximally exposed member of the public and the maximum fence-line dose is shown in Figure 4.5. The apparent increases in individual and population doses in 1987 and 1988 are due in part to the peak of the radon-220 emissions from the Proof-of-Breeding Program and also due to changes in the dispersion codes and input parameters.

The population data in Table 1.1 were used to calculate the cumulative population dose from gaseous radioactive effluents from ANL operations. The results are given in Table

4.31, together with the natural external radiation dose. The population dose since 1985 is shown in Figure 4.6. The natural radiation dose listed is the product of the 80-km (50-mi) population and the natural radiation dose of 300 mrem/y.<sup>16</sup> It is assumed that this dose is representative of the entire area within an 80-km (50-mi) radius.

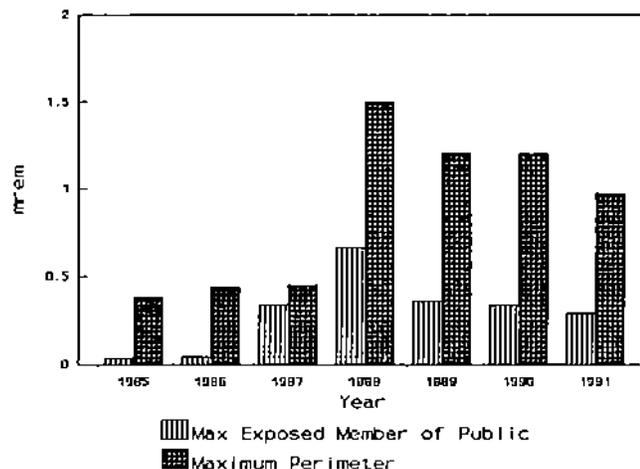


Figure 4.5 Individual and Perimeter Doses From Airborne Radioactive Emissions

TABLE 4.31

## 80 km Population Dose, 1991

Radionuclide	man-rems
Hydrogen-3	0.15
Carbon-11	0.23
Nitrogen-13	< 0.01
Oxygen-15	< 0.01
Argon-41	0.07
Krypton-85	< 0.01
Radon-220	< 0.01
Polonium-216	< 0.01
Lead-212	13.50
Bismuth-212	1.49
Thallium-208	< 0.01
Radon-222	< 0.01
Fluorine-18	< 0.01
Antimony-125	< 0.01
Lead-210	< 0.01
Bismuth-210	< 0.01
Polonium-210	0.02
Uranium-234	< 0.01
Uranium-238	< 0.01
Plutonium-238	0.02
Plutonium-239	0.03
Plutonium-240	< 0.01
Plutonium-241	0.03
Plutonium-242	< 0.01
Total	15.5
Natural	$2.4 \times 10^6$

The potential radiation exposures by the inhalation pathways also were calculated by the methodology specified in DOE Order 5400.5.<sup>6</sup> The total quantity for each radionuclide inhaled, in microcuries ( $\mu\text{Ci}$ ), is calculated by multiplying the annual average air concentrations by the general public breathing rate of  $8,400 \text{ m}^3/\text{y}$ .<sup>17</sup> This annual intake is then multiplied by the CEDE for the appropriate lung retention class.<sup>8</sup> Because the CEDE factors are in units of Rem per microcurie ( $\text{Rem}/\mu\text{Ci}$ ), this calculation gives the 50-year committed effective dose equivalent. The applicable CEDE factors are listed in Table 4.32.

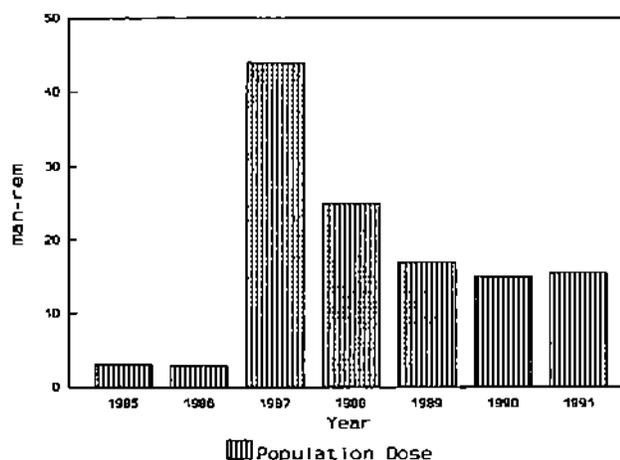


Figure 4.6 Population Dose From Airborne Radioactive Emissions

The calculated doses in Tables 4.2 and 4.3 were obtained using this procedure. Because they are all essentially at perimeter locations, these doses represent the fence-line values for those radionuclides measured. In most cases, these doses also are the same as the off-site measurements and represent the ambient dose for the area from these nuclides. No doses are calculated for the total alpha and total beta measurements since the guidance does not provide CEDE factors for such measurements.

#### 4.6.2. Water Pathway

Following the methodology outlined in DOE Order 5400.5, the annual intake of radionuclides (in  $\mu\text{Ci}$ ) ingested with water is obtained by multiplying the concentration of radionuclides in microcuries per milliliter ( $\mu\text{Ci}/\text{mL}$ ) by the average annual water consumption of a member of the general public ( $7.3 \times 10^5 \text{ mL}$ ). This annual intake is then multiplied by the CEDE factor for ingestion (Table 4.32) to obtain the dose received in that year. This procedure is carried out for all radionuclides and the individual results are summed to obtain the total ingestion dose.

TABLE 4.32

50-Year Committed Effective Dose Equivalent (CEDE) Factors  
(Rem/ $\mu$ Ci)

Nuclide	Ingestion	Inhalation
Hydrogen-3	$6.3 \times 10^{-5}$	$6.3 \times 10^{-5}$
Beryllium-7	-	$2.7 \times 10^{-4}$
Carbon-11	-	$8.0 \times 10^{-6}$
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	-	1100
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	-

The only location where radionuclides attributable to ANL operations could be found in off-site water was Sawmill Creek below the waste-water outfall, see Table 4.5. 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 waste water, their net concentrations in the creek and the corresponding dose rates (if water at these concentrations were used as the sole water supply by an individual) are given in Table 4.33. 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 there are fish in the stream, but they do not constitute a significant source of food for any individual. Figure 4.7 is a plot of the ingested estimated dose an individual would receive if ingesting Sawmill Creek water.

TABLE 4.33

Radionuclide Concentrations and Dose Estimates  
for Sawmill Creek Water, 1991

Radionuclide	Total Released (millicuries)	Net Avg Conc (pCi/L)	Dose (mrem)
Hydrogen-3	1400	151	0.0069
Strontium-90	0.8	0.09	0.0085
Cesium-137	3.0	0.32	0.012
Neptunium-237	0.016	0.0017	0.0048
Plutonium-239	0.048	0.0052	0.016
Americium-241	0.029	0.0031	0.010
Sum			0.058

As indicated in Table 4.5, occasional Sawmill Creek samples (fewer than ten percent) contained traces of plutonium-238, curium-242,244, or californium-249,252, but 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, but the method of averaging probably overestimates the true concentration. Annual doses range from  $3 \times 10^{-3}$  to  $6 \times 10^{-5}$  mrem/y for these radionuclides.

DOE Order 5400.5<sup>6</sup> requires that an evaluation be made of the dose to aquatic organisms from liquid effluents. The dose limit is one rad/day or 365 rad/y. 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. Based on inspection of the creek at this location, small bluegill and carp (about 100 g each) have been observed. Using the annual average concentrations of the radionuclides listed in Table 4.5, a dose can be estimated. The sum of the exposure from these radionuclides is estimated to be about  $3 \times 10^{-6}$  rad/y, well within the DOE standard, and therefore demonstrating compliance with that portion of the Order.

The EPA has established drinking water standards based on a maximum dose of 4 mrem/y for man-made beta particle and photon-emitting radionuclides.<sup>18</sup> The EPA standard is  $2 \times 10^4$  pCi/L for hydrogen-3, 8 pCi/L for strontium-90, and 200 pCi/L for cesium-137. The net concentrations in Table 4.33 correspond to 0.0008% (hydrogen-3), 1.1% (strontium-90), and 0.16% (cesium-137) of the EPA standards. No specific EPA standards exist for the transuranic nuclides.

Sawmill Creek flows into the Des Plaines River. The flow rate of Sawmill Creek (see Section 1.6) is about 10 cfs, while the flow rate of the Des Plaines River in the vicinity of ANL is about 900 cfs. Applying this ratio to the concentration of radionuclides in Sawmill Creek listed in Table 4.33, the dose to a hypothetical individual ingesting water from the Des

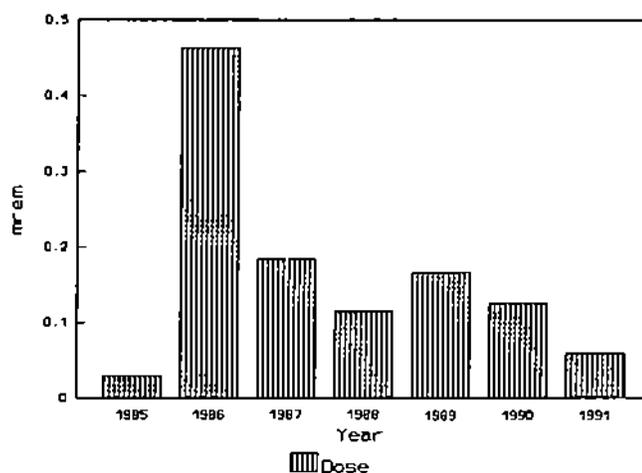


Figure 4.7 Comparison of Dose Estimates From Ingestion of Sawmill Creek Water

Plaines River at Lemont would be about 0.0005 mrem/y. 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  $10^{-4}$  man-rem.

#### 4.6.3. External Direct Radiation Pathway

The TLD measurements given in Section 4.6 were used to calculate the radiation dose from external sources. Above-normal fenceline doses attributable to ANL operations were found at the southern boundary near the Waste Storage Facility (Location 7I).

At Location 7I, the net fenceline dose from ANL was about 15 mrem/y. Approximately 300 m (0.3 mi) south of the fenceline (grid 6I), the measured dose was  $82 \pm 6$  mrem/y, the same as the normal range of the off-site average ( $78 \pm 6$  mrem/y). No individuals live in this area. The closest residents are about 1.6 km (1 mi) south of the fenceline. At this distance, the calculated dose rate from the Waste Storage Facility was 0.003 mrem/y, if the energy of the radiation were that of 0.66 MeV cesium-137 gamma-ray, and about 0.01 mrem/y if the energy were that of 1.33 MeV cobalt-60 gamma-ray.

At the fenceline, 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, since some of the individuals are indoors (which provides shielding) or away from their dwellings for some of the time.

In addition to the permanent residences in the area, occasionally visitors may conduct activities around ANL that could result in exposure to radiation from these sites. 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 ten minutes per week in these areas, the dose would be 0.01 mrem/y at the 317 Area fence (location 7I).

#### 4.6.4. Dose Summary

The total effective dose equivalent received by off-site residents during 1991 was a combination of the individual doses received through the separate pathways that contributed to exposure: hydrogen-3, carbon-11, nitrogen-13, oxygen-15, argon-41, krypton-85, radon-220 (plus daughters), and actinides through the airborne pathway. The highest dose was about 0.29 mrem/y to individuals living north 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 is 15 man-rem.

To put the maximum individual dose of 0.29 mrem/y attributable to ANL operations into perspective, comparisons can be made to annual average doses received by the public from natural or accepted sources of radiation. These values are listed in Table 4.34. It is obvious that the magnitude of the doses received from ANL operations is insignificant compared with these sources. Therefore, the monitoring program results establish that the radioactive emissions from ANL are very low and do not endanger the health or safety of those living in the vicinity of the site.

TABLE 4.34

Annual Average Dose Equivalent  
in the U. S. Population\*

Source	Dose (mrem)
Natural Sources	
Radon	200
Internal ( $^{40}\text{K}$ and $^{226}\text{Ra}$ )	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

\*NCRP Report No. 93.<sup>16</sup>

## 5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

The nonradiological monitoring program involves the collection and analysis of surface water and groundwater samples from numerous locations throughout the site. The release of nonradiological pollutants to the air from ANL is extremely small, except for the boiler house, which is equipped with dedicated monitoring equipment. As a result, the ambient air is not routinely monitored. Chapter 3 discusses the entire environmental monitoring program in more detail.

Surface water samples for nonradiological chemical analyses are collected from NPDES permitted outfalls, Sawmill Creek, and the Des Plaines River. 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. Besides being published in this report, the NPDES monitoring results are transmitted monthly to the IEPA in an official Discharge Monitoring Report (DMR). A summary of exceedances of permit limits during 1991 appears in Table 5.1.

TABLE 5.1

NPDES Permit Limit Exceedances, 1991		
Outfall	Parameter	Number of Exceedances
001	Total Dissolved Solids	15
	Chloride	8
001B	Total Suspended Solids	1
003	Total Suspended Solids	4
004	Total Suspended Solids	3
006	Total Suspended Solids	2
010	pH	3
	Total Suspended Solids	3
	Iron	3
	Zinc	1
	Manganese	1

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. Samples of water from Sawmill Creek and the Des Plaines River 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 the IAC, Title 35, Subtitle C, Chapter I.<sup>19</sup>

### 5.1. National Pollutant Discharge Elimination System Monitoring Results

Wastewater is processed at ANL in two independent treatment systems, the sanitary system and the laboratory system. The sanitary wastewater collection and treatment system collects wastewater from lavatories, the cafeteria, office buildings, and other portions of the site which do not contain radioactive or hazardous materials. This wastewater is treated in a biological wastewater treatment system consisting of primary clarifiers, trickling filters, final clarifiers, and slow sand filters. Wastewater generated by research-related activities, such as laboratories and experimental equipment, flows to a series of retention tanks located in each building. When a retention tank is full, a sample is collected and analyzed for radioactivity. If the wastewater is found to be below the release limits for discharge, it is pumped to the laboratory wastewater collection system, which directs the flow to the laboratory wastewater treatment system. This system consists of a series of concrete holding tanks which collect the wastewater prior to discharge. As with the retention tanks, once a holding tank is full, it is sampled and analyzed for radioactivity. If the level of radioactivity is below ANL discharge criteria, which were selected to ensure compliance with DOE Orders, it is pumped to a lined equalization basin, slowly combined with the sanitary waste stream, chlorinated, and discharged to Sawmill Creek. If either a retention tank or holding tank is found to contain unacceptable levels of radioactivity, the wastewater is pumped into portable tanks, treated by evaporation in Building 306 and the residue is disposed of as radioactive waste. Figure 5.1 shows the two wastewater treatment systems that are located adjacent to each

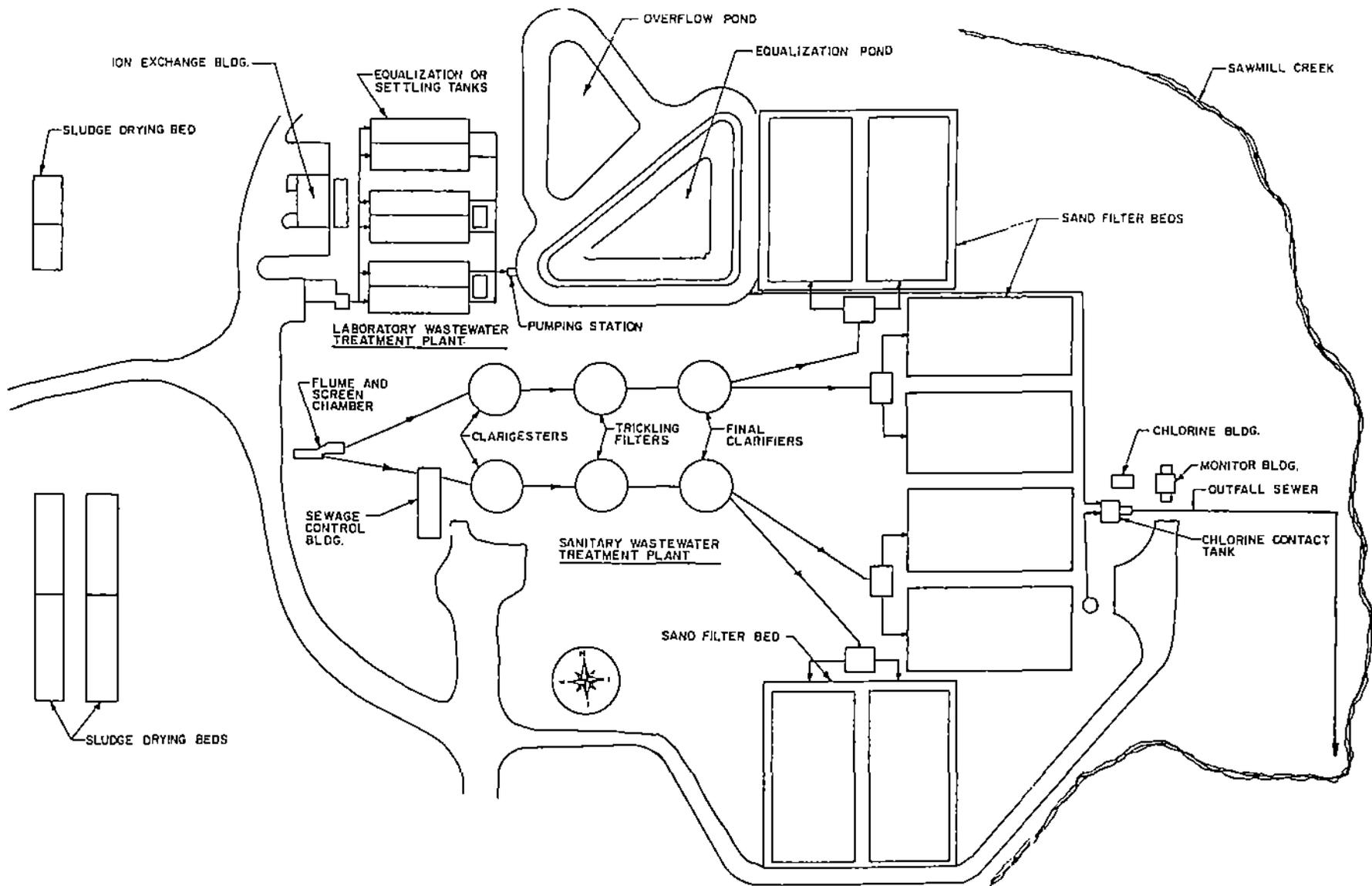


Figure 5.1 ANL Sewage Treatment Plant

other. The volume of wastewater discharged from these facilities averaged 3.4 million liters per day (0.91 million gallons per day) and was composed of 60% sanitary wastewater and 40% laboratory process wastewater.

These two systems process the vast majority of wastewater generated by ANL. However, 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. However, these discharge points are included in the site NPDES permit as separate regulated outfalls.

ANL processed wastewater discharges are regulated by NPDES Permit No. IL 0034592.<sup>20</sup> As discussed in Section 2.2.1., this permit was renewed on July 7, 1989, and expires on January 15, 1994. Nine surface water discharge points (outfalls) and two internal monitoring points are included in this permit. The analyses required and the frequency of analysis for each point are specified in the permit. The analytical methods required for NPDES monitoring are listed in Table 1B of 40 CFR Part 136.<sup>21</sup> Sample collection, preservation, and holding times are also mandated by requirements stipulated in Table 2 of 40 CFR Part 136.<sup>21</sup>

The NPDES outfall locations are shown in Figure 5.2. To improve the clarity of this figure, the outfall numbers are shown without the leading zeroes. Thus, outfall 001A is shown as 1A. 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 wastewater treatment facility. Their flows combine to form outfall 001 which is also located at the treatment facility. The combined stream flows through an outfall pipe which discharges into Sawmill Creek approximately 1100 meters (3500 feet) south of the treatment plant.

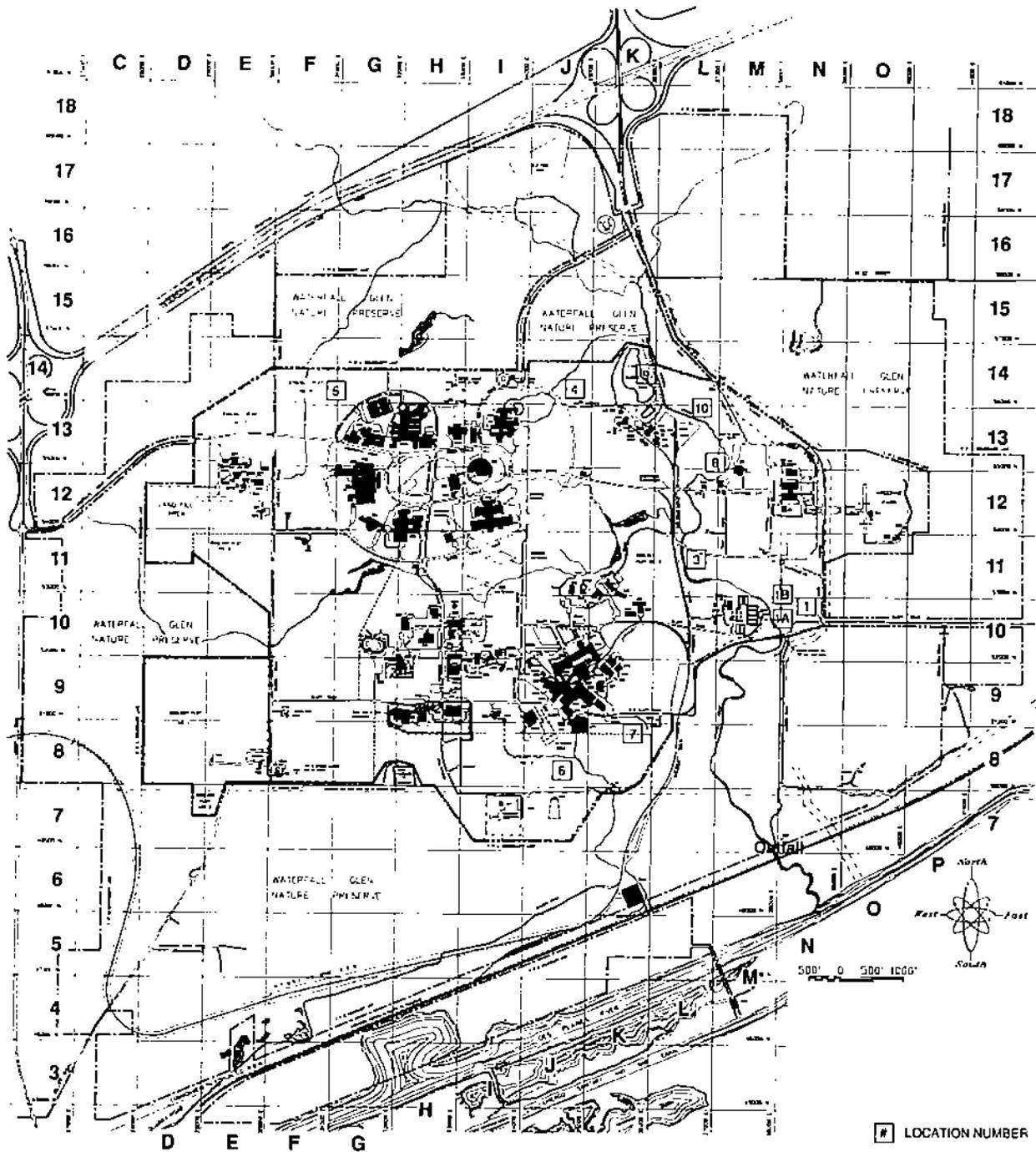


Figure 5.2 NPDES Outfall Locations

### 5.1.1. Sample Collection

NPDES samples are collected by ANL's Environment and Waste Management Program (EWM) personnel, with the exception of samples from locations 001A and 001B, which are collected by Plant Facilities and Services Division (PFS) personnel. All samples are collected using specially cleaned and labelled bottles with appropriate preservatives added. Custody seals and chain-of-custody sheets are also used. All samples are analyzed within the required holding time. Samples are collected at locations 001A and 001B on a weekly basis and at 001 twice per month. Samples are collected at the other locations on a monthly basis.

### 5.1.2. Results

During 1991, approximately 96% of all NPDES analyses were in compliance with their applicable permit limits as compared to a 1990 rate of 91%. 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.

#### Outfall 001A

This outfall is composed 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 Biochemical Oxygen Demand (BOD), pH, and total suspended solids. The limits for five-day BOD are a monthly average of 10 mg/L with a maximum value of 20 mg/L. The permit limits for total suspended solids 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. There were no exceedances of any of these limits at outfall 001A.

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

the coal pile runoff. All samples collected and analyzed for these parameters were within the permit limits during 1991. The average shown in the table is the annual average for each constituent.

TABLE 5.2

Outfall 001A Effluent Limits and Monitoring Results, 1991  
(Concentrations in mg/L)

Constituent	Minimum	Average	Average Limit	Maximum	Maximum Limit
Chromium	< 0.02	< 0.02	1.00	0.10	2.00
Copper	0.02	0.06	0.50	0.23	1.00
Iron	0.20	0.5	2.00	1.50	4.00
Lead	-	< 0.10	0.20	-	0.40
Manganese	< 0.02	0.03	1.00	0.17	2.00
Zinc	0.03	0.09	1.00	0.23	2.00
Oil & Grease	< 5	< 5	15.0	11.0	30.0

Outfall 001B

This outfall consists of processed wastewater from the laboratory wastewater treatment system. The permit requires that weekly samples be collected and analyzed for BOD, Total Suspended Solids (TSS), mercury, and Chemical Oxygen Demand (COD).

The limits established for BOD are a daily maximum of 20 mg/L with a 30-day average of 10 mg/L. The permit also contain mass loading limits of 114 lbs/day as a daily maximum and 57 lbs/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 limit for TSS is 24 mg/L with a 30-day average of 12 mg/L. The mass loading limits are 136 and 68 lbs/day, respectively. There was one violation of concentration limit for TSS at this location in 1991.

The daily maximum concentration limit for mercury is 6  $\mu\text{g/L}$  and the 30-day average is 3  $\mu\text{g/L}$ . The corresponding loading values are 0.034 lbs/day and 0.017 lbs/day. There were no exceedances in 1991 of either limit.

There are no concentration limits established for COD. The once-per-week grab samples give a rough indication of the organic content of this stream. The values obtained in 1991 ranged from 10 mg/L to 100 mg/L.

There is a special condition for location 001B that requires the monitoring for the 126 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. In addition to the typical list of priority pollutants, fibrous asbestos and 2,3,7,8-tetrachlorodibenzo-p-dioxin (commonly called dioxin) are to be determined. Samples were collected on June 19, 1991, and December 12, 1991, 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 semivolatile organic compounds, PCBs and pesticides were all less than the detection limits. The results for metals were similar to concentrations found in ANL treated drinking water. The samples contained several volatile organic compounds at very low levels. The majority of compounds found are halomethanes. The concentrations of volatile organics identified in these samples are contained in Table 5.3. While there are currently no permit limits or effluent standards for these compounds with which to compare these results, the concentrations found are believed to be of little concern because they are below acceptable standards for drinking water supplies, where such standards exist.

Results for the June sample for asbestos showed 4.8 million structures/L of less than 10 micrometers in length (chrysotile). The December sample indicated a concentration of asbestos structures of 130.2 million structures/L, all of which were less than 10  $\mu\text{m}$  in length. The June sample had trace levels of Alpha-BHC, aldrin and 4,4,-DDT while the December sample had nondetectable levels of these compounds. Neither of the samples had detectable levels of dioxin.

TABLE 5.3

Outfall 001B Volatile Organic Carbon Monitoring Results, 1991  
(Concentrations in  $\mu\text{g/L}$ )

Compound	Concentration in June Sample	Concentration in December Sample
Acetone	550	78
Bromodichloromethane	4	< 1
Chloroform	4	4
Dibromochloromethane	< 1	5
Methylene Chloride	83	12
1,1,1 Trichloroethane	16	< 1

The laboratory wastewater treatment system consists of six 69,000 gallon equalization or settling (holding) tanks (see Figure 5.1) which are pumped to a lined equalization pond before being discharged to Sawmill Creek. During 1989, a study was performed to determine the levels of volatile organic compounds in the influent to these tanks and to determine the variability of this concentration. A number of different volatile organics were found to be present from time to time, with the concentration varying greatly throughout the day. Maximum levels were found to occur in the late afternoon. As a follow-up to this study, each month one influent sample is obtained at about 1300 hours and analyzed for volatile organic compounds. The results for the most common compounds found are shown in Table 5.4. In addition to these compounds, most samples contained very low concentrations of bromodichloromethane, chlorodibromomethane, and, in some cases, bromoform. These halomethanes, at the levels found, including some of the chloroform results, are thought to be due to the contact of the chlorinated supply water with organic chemicals. Chloroform levels above approximately 10  $\mu\text{g/L}$  are probably due to other causes.

TABLE 5.4

Volatile Organic Compounds in Laboratory Wastewater, 1991  
(Concentrations in  $\mu\text{g/L}$ )

Month	Acetone	Chloroform	Methylene Chloride	1,1,1-Tri-chloroethane
January	852	< 5	80	2
February	8280	< 5	3	< 1
March	340	< 5	207	< 1
April	< 10	< 5	< 5	8
May	< 10	10	1340	< 1
June	< 10	< 5	< 5	2
July	6580	551	938	< 1
August	158	< 5	< 5	< 1
September	55	< 5	< 5	< 1
October	< 10	< 5	< 5	< 1
November	4955	< 5	696	2
December	121	14	< 5	1

Acetone was found in the influent in every sample but four. The levels found ranged to 8280  $\mu\text{g/L}$ . Methylene chloride was found in about half of the samples and ranged to 1340  $\mu\text{g/L}$ . Samples obtained in January, May, July, and November had elevated levels of several other chemicals, i.e., ethyl ether, tetrahydrofuran, and di-limonene, frequently used in the laboratory. D-limonene is a natural constituent of citrus fruit and is used as a surfactant and as an odor reductant.

#### Outfall 001

The treated wastewater streams from the two treatment systems are combined and samples for analysis of most of the permit parameters are collected from a manhole downstream of the chlorine contact chamber. This combined effluent then flows through the outfall sewer to Sawmill Creek. The effluent travels through this sewer for approximately 20 minutes before

being discharged. The time the chlorinated wastewater resides within this sewer pipe, before mixing with Sawmill Creek, increases the effectiveness of the chlorine added at the treatment plant. The samples used for determination of fecal coliform bacteria are collected at the outlet of this pipe. The disinfection of ANL wastewater resulted in no exceedances of fecal coliform limits.

The disposal of water softener brine solutions results in an effluent with high levels of TDS and chloride. The permit requires analysis of the combined effluent twice per month for TDS, chloride, and sulfate. The results, limits, and number of exceedances are collected in Table 5.5. The limit for TDS was exceeded in every sample collected in 1991 until the spent brine solution was diverted to the DuPage County sewerage system on August 23, 1991. There have been no exceedances since that date. In 1991, exceedances above the chloride limit occurred on occasion, but none since the diversion. Levels for sulfate have never been exceeded. Figure 5.3 shows the results of TDS and chloride analyses for 1991.

TABLE 5.5

Outfall 001 Monitoring Results and Effluent Limits, 1991  
(Concentrations in mg/L)

Constituent	Minimum	Average	Maximum	Limit	Exceedances
Total Dissolved Solids	750	1272	1753	1045	15
Sulfates	164	211	292	575	0
Chlorides	116	414	669	550	8

The permit requires that a biological toxicity screening test be performed at location 001 in June of each year. The toxicity testing is run on at least three trophic levels of aquatic species for both chronic and acute toxicity. The 1991 testing was conducted during the period September 11-20, 1991. The testing was performed using a water flea, Ceriodaphnia dubia, a

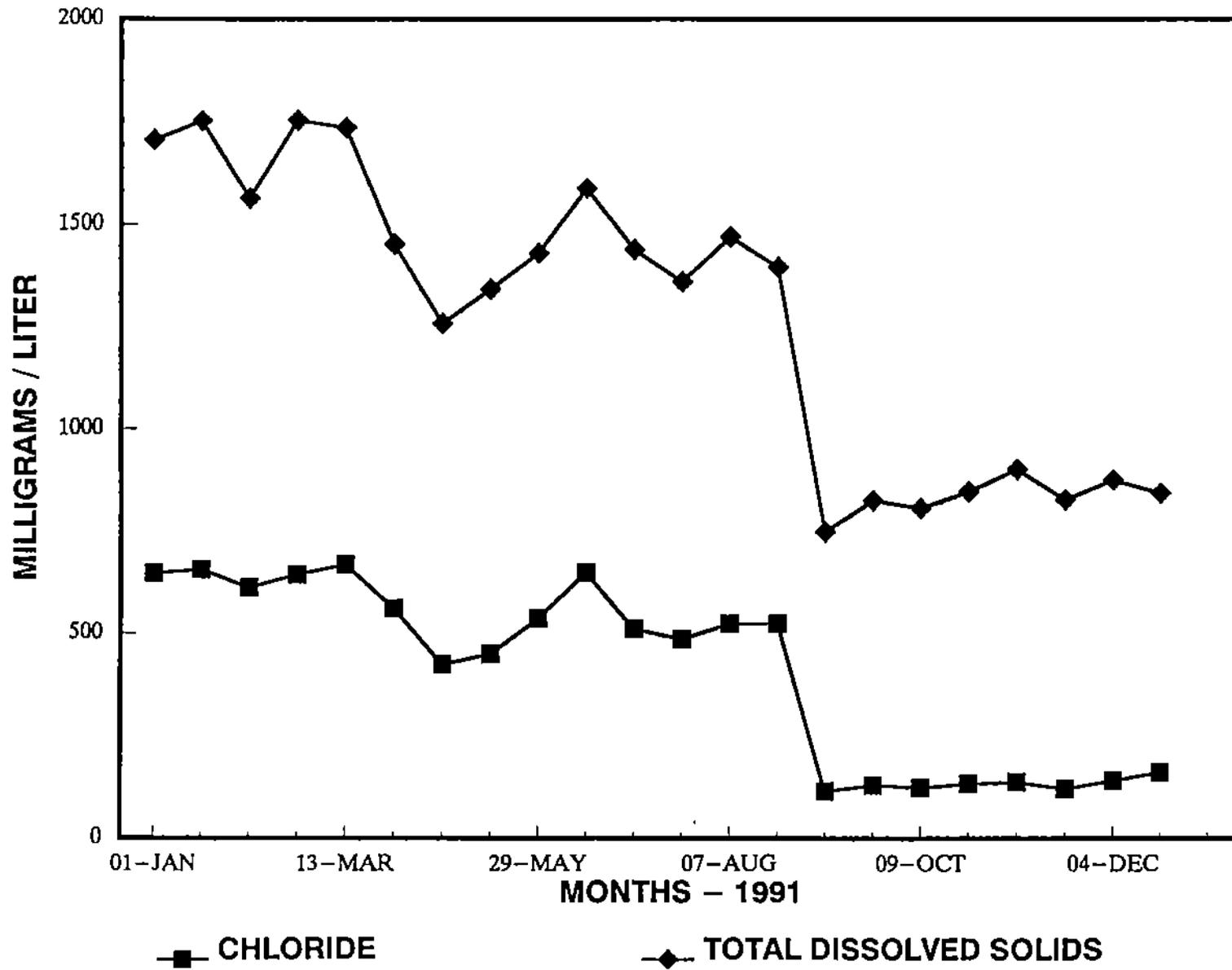


Figure 5.3 Total Dissolved Solids and Chloride in Outfall 001 Water, 1991

fathead minnow, Pimephales promelas, and a green alga, Selenastrum capricornutum. The EPA protocol, as modified by the IEPA, was used for this test.

The testing was complicated by the collection and analysis of a receiving water sample after a substantial rain event. When this receiving water was utilized for the acute test, total mortality was demonstrated for Ceriodaphnia at dilutions of 25, 50, and 100%. When the chronic test was repeated using laboratory grade water as diluent, 100% survival was demonstrated at 25 and 50% dilutions. The tests indicate that somewhat greater toxicity was demonstrated in this study as compared to the 1990 study.

The permit also requires that weekly pH measurements be made. There were no exceedances of the pH limits of 6-9 units during 1991.

#### Outfall 003

This outfall is the discharge point from a series of small man-made ponds and is composed primarily of stormwater, with small amounts of process wastewater, such as cooling tower blowdown. It is sampled monthly and analyzed for pH, TSS, and temperature. Permit limits exist for TSS (15 mg/L average and 30 mg/L maximum), pH (between 6 and 9 pH units) and temperature (less than 5°F temp. rise). During 1991, there were four exceedances of TSS limits. These and past TSS exceedances are probably due to excessive siltation that has occurred over the years. Plans are being developed to dredge the excess sediment from these ponds to improve the effluent TSS levels. No other limits were exceeded. For the outfalls 003 through 009, the number of samples collected, permit constituents, and limits are collected in Table 5.6.

#### Outfall 004

Outfall 004 consists primarily of stormwater with small amounts of cooling water from Building 202. The sampling requirements and effluent limits are in Table 5.6. There were three exceedances of TSS limits in 1991. This outfall has a history of frequent TSS exceedances. Most of the exceedances are thought to be caused by erosion of soil from the surrounding

TABLE 5.6

NPDES Effluent Summary, Outfalls 003 to 009, 1991

Discharge Location	Number of Samples Collected	Permit Constituent	Limit		Number Exceeding Limit
			30-Day Average	Daily Maximum	
003	12	Flow		None	0
		pH		6-9	0
		TSS	15	30	4
		Temperature	< 2.8°C	Rise	0
004	12	Flow		None	0
		pH		6-9	0
		TSS	15	30	3
		Temperature	< 2.8°C	Rise	0
005	12	Flow		None	0
		pH		6-9	0
		Temperature	< 2.8°C	Rise	0
		Oil & Grease	15	30	0
006	12	Flow		None	0
		pH		6-9	0
		TSS	15	30	2
		Zinc	1.0	2.0	0
007	7	Flow		None	0
		pH		6-9	0
		Temperature	< 2.8°C	Rise	0
008	0	Flow		None	0
		pH		6-9	0
009	0	Flow		None	0
		pH		6-9	0
		TSS	15	30	0

area during heavy precipitation. Corrections of soil erosion problems throughout the site are currently being developed.

#### Outfall 005

This outfall consists of stormwater and process wastewater from the Building 206 cooling system and the 800 Area, which includes vehicle and other maintenance areas. The permit requirements include monthly sampling and analysis for oil and grease, pH, and temperature. Limits of 15 mg/L average and 30 mg/L maximum exist for oil and grease. The pH and TSS limits are the same as for outfall 003. There were no exceedances in 1991.

#### Outfall 006

This outfall consists of stormwater, cooling tower blowdown and overflow from settling ponds used at the Canal Water Treatment Plant. The permit requires monthly sampling for pH, TSS, and temperature. The limits are in Table 5.6. In 1991, there were two exceedances of the TSS limit.

#### Outfall 007

Outfall 007 consists of stormwater and Building 360 cooling water. It is to be sampled monthly and analyzed for pH and temperature. The effluent limits are collected in Table 5.6. Samples were obtained from February through May and from October through December. The stream was dry from June through September and was frozen solid in January. There were no exceedances at this location.

#### Outfall 008

Outfall 008 consists of uncontaminated stormwater runoff from the East Area. The only permit limit that applies at this point is pH. There is normally no flow from this outfall. An attempt to sample this point is made each month. If water is found to be flowing, a sample is collected and analyzed. During 1991, no samples were collected.

### Outfall 009

This outfall is an emergency overflow for an inactive lime sludge lagoon near the water treatment plant. This lagoon has not been used since 1986. Accumulated rainwater is periodically pumped to the sanitary wastewater treatment system to prevent overflow of the alkaline water. In the event that an extremely heavy storm occurs, rainwater could flow out of this outlet. The permit contains limits for pH and TSS, as shown in Table 5.6. The permit requires monitoring monthly, when discharge is occurring. There was no such discharge during 1991.

### Outfall 010

This location is an emergency overflow point for the diked coal pile storage area. It discharges only under conditions of heavy rain and prevents flooding of the coal pile area. This outfall is sampled once per month when flow occurs. Analyses are performed for pH, total suspended solids, iron, lead, zinc, manganese, total chromium, copper, and oil and grease. The permit limits for these parameters are shown in Table 5.7.

Flow occurred at this site during April, May, and October 1991. As required, samples were collected and analyzed. The results are shown in Table 5.7. The iron, total suspended solid and pH results exceeded the limits in all three samples. The zinc and manganese results exceeded the monthly averages in the October sample.

## 5.2. Additional Effluent Monitoring

To characterize the wastewater from the ANL site more fully, composite samples of the combined effluent are collected each week and analyzed for the constituents shown in Table 5.8. The results are then compared to the IEPA General Effluent limits found in 35 IAC, Subtitle C, Part 304.<sup>22</sup>

TABLE 5.7

Outfall 010 Effluent Limits and Monitoring Results, 1991  
(Concentrations are mg/L, except for pH)

Constituent	April Results	May Results	October Results	Average Limit	Maximum Limit
Chromium	< 0.02	< 0.02	< 0.02	1.0	2.0
Copper	< 0.02	0.04	0.18	0.5	1.0
Iron	7.8	8.6	190	2.0	4.0
Lead	< 0.1	< 0.1	< 0.1	0.2	0.4
Manganese	0.43	0.48	1.01	1.0	2.0
Oil & Grease	< 5	< 5	< 5	15	30
pH	5.9	5.7	2.7	6-9	6-9
TSS	108	93	73	15	30
Zinc	0.3	0.5	1.5	1.0	2.0

TABLE 5.8

Chemical Constituents in Effluents From ANL Wastewater Treatment Plant, 1991  
(Concentrations in mg/L)

Constituent	No. of Samples	Avg.	Concentration		Limit
			Min.	Max.	
Arsenic	51	-	-	< 0.004	0.25
Barium	51	0.054	0.013	0.200	2.0
Beryllium*	51	-	-	< 0.20	-
Cadmium	51	0.0004	< 0.0002	0.0010	0.15
Chromium	51	0.003	< 0.003	0.020	1.0
Cobalt	51	0.020	< 0.015	0.032	-
Copper	51	0.046	0.027	0.118	0.5
Fluoride	9	0.312	0.224	0.384	15.0
Iron	51	0.4	0.2	1.1	2.0
Lead	50	0.005	< 0.001	0.037	0.2
Manganese	51	0.029	< 0.015	0.083	1.0
Mercury*	52	0.1	< 0.1	0.3	0.5
Nickel	51	0.032	< 0.020	0.043	1.0
Silver	51	0.0010	< 0.0002	0.0039	0.1
Thallium	51	-	-	< 0.004	-
Vanadium	51	-	-	< 0.003	-
Zinc	51	0.072	0.50	0.124	1.0
pH (Units)	247	-	7.1	8.2	6.0-9.0

\*Units =  $\mu\text{g/L}$

### 5.2.1. Sample Collection

Samples for analysis of inorganic constituents are collected daily from outfall 001 located at the Waste Water Treatment Plant using a refrigerated time proportional sampler. A portion of the sample is transferred to a specially cleaned bottle, a security seal is affixed and chain-of-custody is maintained. Five daily samples are composited on an equal volume basis to produce a weekly sample, which is then analyzed.

### 5.2.2. Results

The results for 1991 appear in Table 5.8. The values are similar to results reported in previous years. The only constituents found in significant concentrations were mercury and silver. Elevated levels of mercury were seen occasionally and were probably due to residual mercury contamination in the laboratory sewage collection system. Silver has been detected on occasion at very low levels. Its presence is thought to be caused by discharges from several film processing operations. Both constituents were well below the General Effluent Limits.<sup>22</sup>

## 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 has a very low flow. At these times, a major portion of the water in Sawmill Creek south of the site consists of ANL wastewater and discharges to assorted storm drains. To determine the impact ANL wastewaters have on Sawmill Creek, samples of the creek downstream of all ANL discharge points are collected and analyzed. The results are then compared to the IEPA Water Quality Standards.<sup>23</sup>

### 5.3.1. Sample Collection

Grab samples are collected daily at a point well downstream of the combined wastewater discharge point where thorough mixing of the ANL effluent and Sawmill Creek water is assured. Samples are collected in

precleaned, labelled bottles and security seals are used. After pH measurement, the daily samples are acidified and then combined into equal volume weekly composites.

#### 5.3.2. Results

The results obtained are shown in Table 5.9. Two constituents, copper and iron were above Water Quality Standards on at least one occasion. The annual average concentrations for copper and iron were above the standards as well.

#### 5.4. Des Plaines River

Based on previous sampling results, it was determined that mercury would be the only element likely to have a measurable impact on the Des Plaines River. The effect of Sawmill Creek on the levels of mercury in the Des Plaines River was evaluated by collecting samples in the river at Willow Springs (upstream of ANL) and at Lemont (downstream of ANL). All of the samples analyzed showed that the total mercury concentration was less than the detection limit of 0.1  $\mu\text{g/L}$ .

TABLE 5.9

Chemical Constituents in Sawmill Creek, Location 7M,\* 1991  
(Concentrations in mg/L)

Constituent	No. of Samples	Avg.	Concentration Min.	Max.	Limit
Arsenic	51	-	-	< 0.004	1.0
Barium	51	0.056	0.015	0.107	5.0
Beryllium**	51	-	-	< 0.2	-
Cadmium	51	0.0011	< 0.0002	0.0115	0.05
Chromium	51	0.004	< 0.003	0.020	1.0
Cobalt	51	-	-	< 0.015	-
Copper	51	0.030	< 0.005	0.128	0.02
Fluoride	10	0.218	0.146	0.360	1.4
Iron	51	1.0	0.2	4.6	1.0
Lead	50	0.008	< 0.001	0.100	0.1
Manganese	51	0.053	< 0.015	0.163	1.0
Mercury**	52	0.1	< 0.1	0.2	0.5
Nickel	51	0.025	< 0.020	0.044	1.0
Silver	51	0.0006	< 0.0002	0.0024	0.005
Thallium	51	-	-	< 0.004	-
Vanadium	51	-	-	< 0.003	-
Zinc	51	0.051	0.019	0.107	1.0
pH (Units)	242	8.0	7.2	8.5	6.5-9.0

\*Location 7M is 15 m (50 ft) downstream from the ANL wastewater outfall.

\*\*Units =  $\mu\text{g/L}$ .

## 6. GROUNDWATER PROTECTION

The groundwater below the ANL site is monitored through the collection and analysis of samples obtained from the on-site water supply wells and from a series of groundwater monitoring wells located near several sites which have the potential for causing groundwater impact. Except for the drinking water, there are no limits or other numeric criteria to evaluate groundwater quality. To determine if an adverse impact to the groundwater has occurred, concentration data is compared against data from control samples collected in areas known to be uncontaminated.

### 6.1. Potable Water System

The ANL domestic water is supplied by four wells. The wells are described in Section 1.5 and their locations are shown in Figure 1.1. According to the National Primary Drinking Water Regulations, Argonne's system is classified as a non-transient, non-community water system,<sup>18</sup> since it regularly serves at least 25 of the same persons over six months of the year. This designation determines the parameters to be monitored and the frequency of monitoring. Monitoring of the ANL domestic water supply is conducted to demonstrate compliance with applicable regulations and to obtain information on the concentrations of other constituents.

#### 6.1.1. Regulatory Required Monitoring

The primary regulations that apply to ANL are the Illinois Department of Public Health, Drinking Water System Code.<sup>24</sup> These regulations identify the inorganic (900.50) and organic (900.65) constituents that require monitoring and set the State limits. In addition, ANL must also demonstrate compliance with Section 141.40 of the National Primary Drinking Water Regulations<sup>18</sup> by conducting the Special Monitoring for Organic Chemicals.

Samples were collected on November 20, 1991, from each of the four ANL domestic wells and a treated tap water sample in Building 128. The samples were analyzed for nitrate/nitrite, metals, volatile organic compounds, pesticides, and herbicides by a commercial laboratory which is certified to

conduct Safe Drinking Water Act analyses. The samples were analyzed for the constituents specified in the regulations by approved methods which allowed the minimum detectable limit of 0.0005 mg/L to be met for the organic chemicals. The results were provided to the DuPage County Health Department, the Illinois Department of Public Health, and the Drinking Water Section of the EPA.

The analytical results are summarized on the following tables. Each table includes the regulated constituents by group, the regulatory limits, and the results for each of the five ANL locations. Table 6.1 sets forth the required State of Illinois inorganic chemicals. All results are below the respective State MCL limits. Table 6.2 contains the required State of Illinois organic chemicals. All results are below the respective State MCL limits. The optional organic compounds listed in Table 6.3 require analysis only if the Illinois Department of Public Health determines that the system is vulnerable to contamination by any of these chemicals. No such determination has been made by the Department with respect to the ANL system. Selected analyses of compounds on this list were performed to determine if any were present. All analyzed constituents were below the maximum contaminant level. Table 6.4 contains the chemicals listed in 40 CFR 141.40 of the National Primary Drinking Water Regulations identified for special monitoring of organic chemicals. All concentrations were below the analytical detection limits using the required EPA methods.

Based on the information provided in these tables, all the State and Federal required analyses have been conducted, all concentrations were below the MCLs, the EPA-approved procedures were used by a certified laboratory, and the monitoring results were reported within the specified time. Therefore, ANL is in compliance with all applicable Drinking Water regulations.

#### 6.1.2. Informational Monitoring

Samples were collected quarterly at the wellhead. These samples were analyzed for several types of radioactive constituents to determine their presence in the ANL drinking water. Samples from each well were tested for total alpha, total beta, and hydrogen-3. The results are presented in Table

TABLE 6.1

## State of Illinois - Required Inorganic Chemicals - 900.50

Chemical	State Limit (MCL)	ANL Results (mg/L)				Tap
		Well #1	Well #2	Well #3	Well #4	
Nitrate	10 mg/L	< 0.1	< 0.1	< 0.1	< 0.1	0.58
Nitrite	1 mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Barium	5 mg/L	0.054	0.090	0.061	0.054	0.067
Cadmium	0.005 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Chromium	0.1 mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Mercury	0.002 mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Selenium	0.05 mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002

TABLE 6.2

## State of Illinois - Required Organic Chemicals - 900.65

	Maximum Contaminant Level	ANL Results (mg/L)				Tap
		Well #1	Well #2	Well #3	Well #4	
A) Benzene	0.005 mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
B) Carbon Tetrachloride	0.005 mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
C) 1,2-Dichloroethane	0.005 mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0001	< 0.0002
D) Trichloroethylene	0.005 mg/L	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003
E) Para-dichlorobenzene	0.075 mg/L	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003
F) 1,1-Dichloroethylene	0.007 mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
G) 1,1,1-Trichloroethane	0.20 mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
H) Vinyl Chloride	0.002 mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
I) cis 1,2-Dichloroethylene	0.07 mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
J) 1,2-Dichloropropane	0.005 mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
K) Ethylbenzene	0.7 mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
L) Monochlorobenzene	0.1 mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
M) o-Dichlorobenzene	0.6 mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
N) Styrene	0.005 mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
O) Tetrachloroethylene	0.005 mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
P) Toluene	2 mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Q) trans-1,2-Dichloroethylene	0.1 mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
R) p-Xylene	10 mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
m-Xylene		< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
o-Xylene		< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003

TABLE 6.3

State of Illinois - Optional Organic Chemicals - 900.65  
Pesticides/Herbicides

	Maximum Contaminant Level	ANL Results (mg/L)				Tap
		Well #1	Well #2	Well #3	Well #4	
A) Alachlor	0.002 mg/L	*				
B) Aldicarb	0.01 mg/L	*				
C) Aldicarb Sulfone	0.04 mg/L	*				
D) Aldicarb Sulfoxide	0.01 mg/L	*				
E) Atrazine	0.003 mg/L	*				
F) Carborfuran	0.04 mg/L	*				
G) Chlordane	0.002 mg/L	*				
H) Dibromochloropropane	0.0002 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
I) 2,4-D	0.07 mg/L	< 0.00045	< 0.00045	< 0.00045	< 0.00045	< 0.00045
J) Ethylene Dibromide	0.00005 mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
K) Heptachlor	0.0004 mg/L	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
L) Heptachlor Epoxide	0.0002 mg/L	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
M) Lindane	0.0002 mg/L	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
N) Methoxychlor	0.4 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
O) PCBs	0.0005 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
P) Pentachlorophenol	0.2 mg/L					
Q) Toxaphene	0.005 mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
R) 2,4,5-TP (Silvex)	0.05 mg/L	< 0.00045	< 0.00045	< 0.00045	< 0.00045	< 0.00045

\* No certified laboratory in the State of Illinois is currently routinely performing these analyses.

TABLE 6.4

National Primary Drinking Water Regulations 141.40  
Special Monitoring for Organic Chemicals

Federal Chemical Name	ANL Results (mg/L)				Tap
	Well #1	Well #2	Well #3	Well #4	
(1) Chloroform	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
(2) Bromodichloromethane	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
(3) Chlorodibromomethane	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
(4) Bromoform	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
(5) trans-1,2,-Dichloroethylene	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(6) Chlorobenzene	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(7) m-Dichlorobenzene	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(8) Dichloromethane	< 0.0006	< 0.0006	< 0.0006	< 0.0006	< 0.0006
(9) cis-1,2-Dichloroethylene	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
(10) o-Dichlorobenzene	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(11) Dibromomethane	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
(12) 1,1-Dichloropropene	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(13) Tetrachloroethylene	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(14) Toluene	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(15) p-Xylene	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
(16) o-Xylene	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003
(17) m-Xylene	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
(18) 1,1-Dichloroethane	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(19) 1,2-Dichloropropane	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
(20) 1,1,2,2-Tetrachloroethane	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
(21) Ethylbenzene	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(22) 1,3-Dichloropropane	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
(23) Styrene	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
(24) Chloromethane	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
(25) Bromomethane	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(26) 1,2,3-Trichloropropane	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004
(27) 1,1,1,2-Tetrachloroethane	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
(28) Chloroethane	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(29) 1,1,2-Trichloroethane	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003
(30) 2,2-Dichloropropane	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(31) o-Chlorotoluene	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
(32) p-Chlorotoluene	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
(33) Bromobenzene	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(34) 1,3-Dichloropropene	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(35) Ethylene Dibromide (EDB)	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
(36) 1,2-Dibromo-3-chloropropane (DBCP)	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005

6.5. Since ANL is a "non-transient, non-community" water system, the following EPA limits are established for the nuclides measured in Table 6.5:

Gross Alpha Particle Activity = 15 pCi/L  
Gross Beta Particle Activity = 50 pCi/L  
Hydrogen-3 =  $2 \times 10^4$  pCi/L

Well #1 was removed from service in 1990 and the system was not operated during 1991, however, one sample was collected in November 1991 and the results are in Table 6.5.

## 6.2. Groundwater Monitoring at Waste Management Sites

ANL has occupied its current site since 1948. Since that time, waste generated by the Laboratory has been placed in a number of on-site disposal units ranging from ditches filled with construction and demolition debris during the 1950s to a modern sanitary landfill currently used for nonhazardous solid waste disposal. 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. The sites which are routinely monitored are the sanitary landfill in the 800 Area and the 317/319 Area, which consists of eight separate waste management units located within a small geographical area. The site of an inactive experimental reactor, CP-5, is also monitored periodically to determine if any releases of radionuclides occurred from this unit.

### 6.2.1. 317/319 Area

Management of waste has been conducted in eight separate units within the 317 and 319 Areas. The 317 Area is currently used as a temporary storage area for radioactive waste before it is shipped off-site for disposal. The area also contains two RCRA permitted units which are scheduled to undergo closure in the near future. The 319 Area is an inactive landfill adjacent to the 317 Area. In addition to these units, a second landfill site, the ENE landfill, is located to the east-northeast of the 319 Area.

TABLE 6.5

Radioactivity in ANL Domestic Wells, 1991  
(Concentrations in pCi/L)

Type of Activity	Location	No. of Samples	Avg.	Min.	Max.
Alpha (nonvolatile)	Well #1	1	-	-	2.3
	Well #2	3	4.7	3.2	6.2
	Well #3	4	2.9	2.2	4.3
	Well #4	4	3.5	2.7	4.2
Beta (nonvolatile)	Well #1	1	-	-	10.5
	Well #2	3	10.4	9.9	11.4
	Well #3	4	7.4	6.4	8.5
	Well #4	4	9.6	6.9	12.0
Hydrogen-3	Well #1	1	-	-	119
	Well #2	3	< 100	< 100	160
	Well #3	4	< 100	< 100	< 100
	Well #4	4	< 100	< 100	< 100

This unit was used in the late 1940s and early 1950s for the disposal of primarily construction debris from several sites, including the University of Chicago's Manhattan Project. A sketch of the 317/319 Area is shown in Figure 6.1.

The most significant units in this area in terms of groundwater impact are an inactive French drain (dry well) in the 317 area and the landfill and French drain in the 319 Area. The 317 Area French drain operated until the mid 1950s and was used for disposal of unknown amounts of liquid chemical wastes. The landfill at 319 was operated from the mid-1950s until 1968 when the sanitary landfill in the 800 Area was put into use. The French drain, similar to the one in the 317 Area, was operated until 1968. Small quantities of a wide variety of liquid wastes, including heavy metals, solvents and waste oil, some containing PBCs, were poured into this drain.

The 317 Area contains six vaults used for temporary storage of solid radioactive waste. Water from footing drains and/or sumps is collected and discharged into a sewer system nearby. This sewer system, which was designed to drain off-site, was permanently closed in 1986 after it was discovered that the water contained very small amounts of several radionuclides. Water collecting in the sewer system is periodically pumped out into portable tanks, transported to the Waste Management Building and analyzed for radioactivity before release to the laboratory sewage collection system.

The 319 Area currently consists of a mound created by waste fill activities. The waste consisted of noncombustible refuse, demolition and construction debris. In addition, suspect waste (material which was not known to be contaminated but which had the potential for hidden radioactive contamination which could not be confirmed by direct measurement, such as the inside of long pipes or ductwork) was also placed in this unit. The landfill consisted of a number of trenches, 3 to 5 m (10 to 15 ft) deep, which were filled with waste material. When the trenches were filled with waste, they were covered with soil. A recent geophysical survey has identified at least three of these trenches.

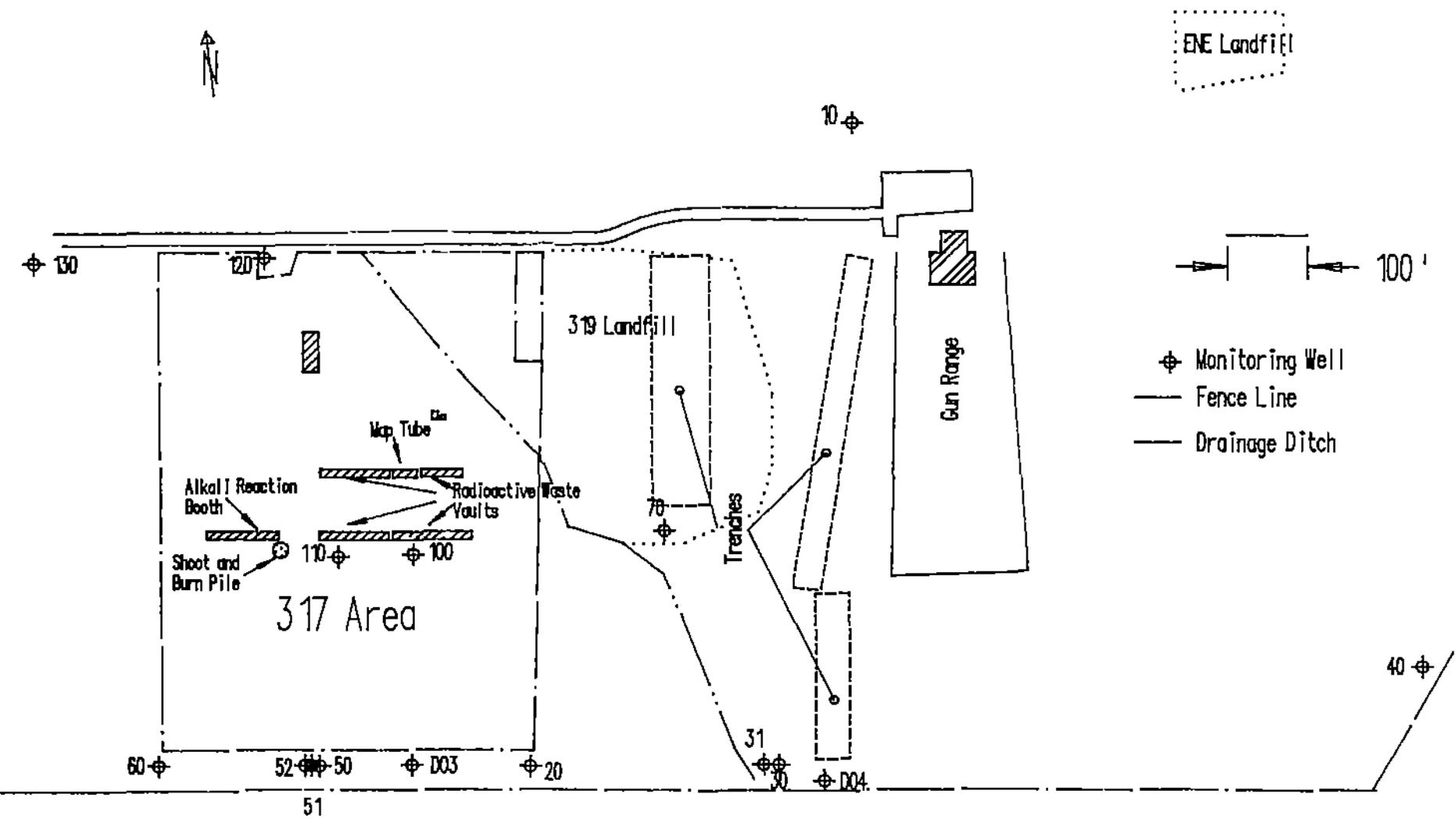


Figure 6.1 Location of Components Within the 317/319/ENE Area

The French drain in the 319 Area was constructed in the late 1950s in an area of the fill material by placing a corrugated steel pipe vertically into a gravel-filled excavation and backfilling around the pipe. Waste liquids were poured into the pit and flowed into the pipe.

The ENE landfill is believed to consist primarily of construction debris, and other noncombustible rubbish, such as metal turnings and empty steel drums. The waste was placed in a natural ravine and covered with soil.

#### 6.2.2. Groundwater Monitoring at the 317/319 Area

Groundwater monitoring in the 317/319 Area has been conducted since 1986. The location of the wells is shown in Figure 6.2. Wells 300010, 300020, 300030, and 300040 were installed in September 1986; 300050 and 300060 in August 1987; 300070, 300100, and 300110 in July 1988; 300120 and 300130 in September 1988; and wells 300031, 300051, and 300052 were installed in June 1989. These wells were all completed in the glacial till. In addition, wells 300D03 and 300D04 were installed in November 1989 and reach the dolomite aquifer at about 25 m (80 ft) below the surface.

Wells 300120 and 300130 are upgradient of the 317 storage area and well 300010 is upgradient of the 319 landfill area. A sand lens present at 5-8 m (15-25 ft) was recently discovered and wells 300051, 300052 and 300031 were placed at this depth. This layer is also intercepted by wells 300100, 300110, and 300120.

##### 6.2.2.1. Sample Collection

The monitoring wells are sampled using the protocol listed in the RCRA Groundwater Monitoring Technical Enforcement Guidance Document.<sup>25</sup> 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 that might restrict water movement in the screen area. For those wells in the glacial till that do not recharge rapidly, the well is emptied and the volume removed compared

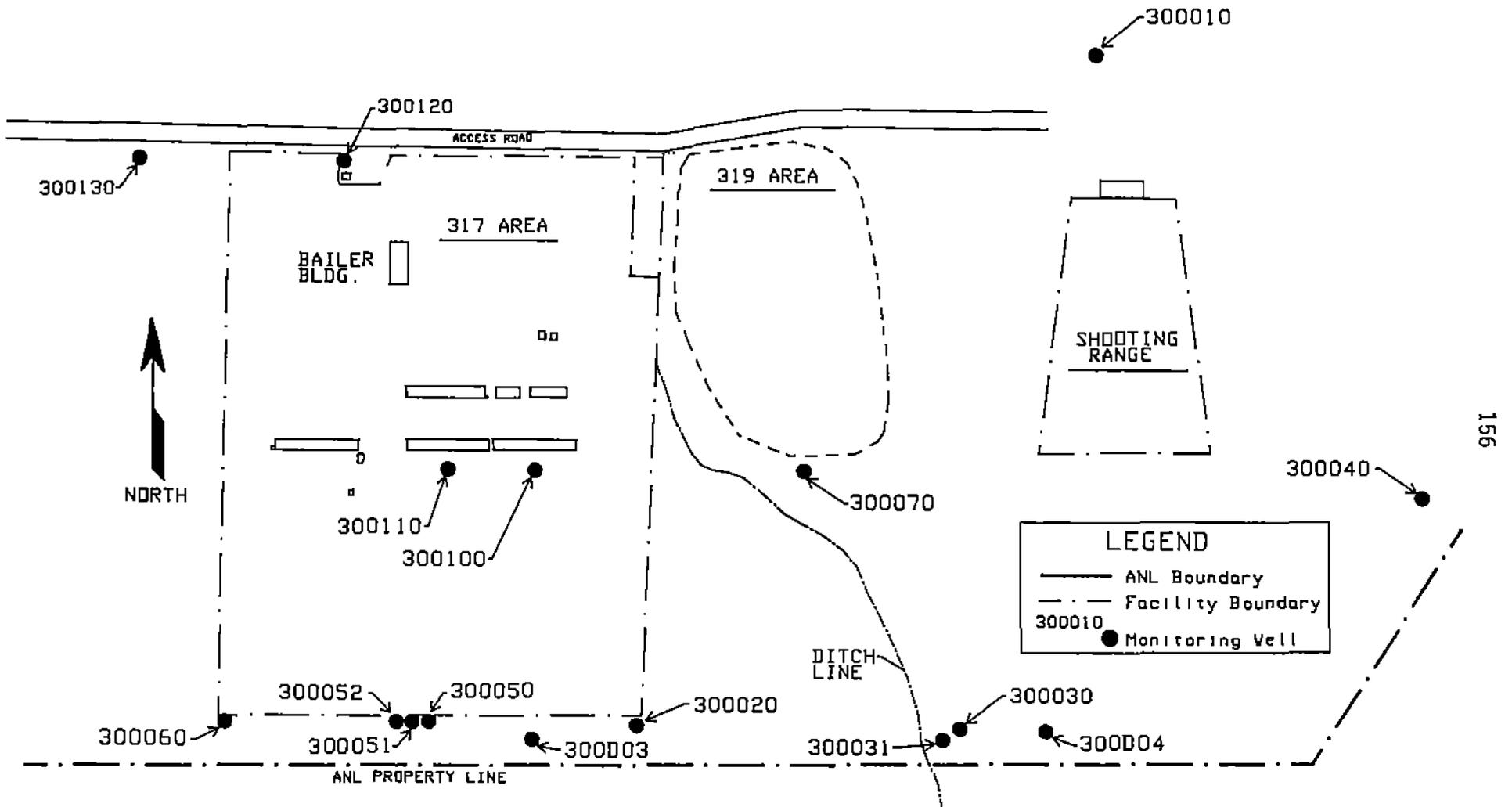


Figure 6.2 Monitoring Well Locations in the 317 and 319 Areas

to the calculated volume. After approximately 24 hours, the water level is remeasured, and the refill volume is compared to the original volume. In most cases these volumes are nearly identical. The well is then sampled by bailing with a 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 which recharge rapidly, three well volumes are purged 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 volatile organics, semivolatile organics, PCB/pesticides, metals, and radioactivity are collected in that order. The samples are placed in precleaned bottles, labelled, and preserved.

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

#### 6.2.2.2. Sample Analysis

Metal analyses were performed using methods listed in the Statement of Work for Inorganic Analysis No. 787 or No. 788 of the EPA Contract Laboratory Program. The volatile organic analyses were performed using capillary column methods in SW-846. Analyses for semivolatile and PCB/pesticides were performed using the Organic Statement of Work No. 288 of the EPA Contract Laboratory Program. All samples were analyzed within the required holding times or this deficiency was noted. In the case of volatile organic analysis, an effort was made to identify compounds which are present, but are not included on the method list. In many cases, this was successfully accomplished and standard solutions of these compounds were prepared and analyzed.

#### 6.2.2.3 Results of Analyses

The description of each well, a listing of field parameters measured during sample collection, and the results of chemical and radiological

analyses of samples from the wells in the 317/319 Area are contained in Tables 6.6 through 6.17. All radiological and inorganic analyses results are shown in these tables. The analysis methods used for organic compounds will 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, these negative results are not included. Only those constituents which were present in amounts great enough to quantify are shown. The detection limits for the organic compounds listed were typically 5 to 10  $\mu\text{g/L}$ .

### Field Results

The purging of wells to produce water representative of the groundwater being studied is followed by measuring the field parameters. For a normal well, the temperature and specific conductance do not change after one well volume is removed. The pH is somewhat variable through 3-5 well volumes but the final pH is about their average. The redox potential changes radically after two well volumes are removed and then becomes constant. This is the situation for the wells reported in this study. On the basis of this information, sampling is conducted after the removal of three well volumes. The parameters listed in the tables are the final readings obtained at the time of sampling.

### Inorganic Results

None of the inorganic results were above ambient levels, except for several samples from wells 300030, 300031, 300052, and 300120, which had elevated lead and/or chromium concentrations. Wells 300052, 300100, 300110, and 300120 are located in the same layer of water. The levels of lead range from 5.0  $\mu\text{g/L}$  to 23  $\mu\text{g/L}$ , while the levels in the other wells are less than 10  $\mu\text{g/L}$ . The levels of chromium in these same wells range from 5 to 23  $\mu\text{g/L}$  while the levels in the other wells are less than 10  $\mu\text{g/L}$ . There are elevated levels of iron in several wells but the significance of these levels is not known. The source of the elevated chromium and lead levels is unknown. Elevated levels of lead were reported in the last annual report.<sup>14</sup> The levels of most constituents were elevated in samples collected in the

TABLE 6.6

## Groundwater Monitoring Results, 300 Area Well #300010, 1991

		Well Point Elevation			m(MSL)
		Ground Surface Elevation			196.950
		Casing Material:			209.81
					PVC
Constituent	Units	03/22/91	05/15/91	09/11/91	12/06/91
Water Elevation	m	200.42	201.45	198.27	197.66
Temperature	°C	12.3	11.3	12.8	10.0
pH	pH	6.99	6.86	6.85	6.49
Redox	mV	116	-44	-34	-18
Conductivity	µmhos/cm	831	320	860	823
Arsenic	mg/L	< 0.0040	< 0.0040	0.0040	-
Barium	mg/L	0.0244	0.0347	0.0584	-
Beryllium	µg/L	< 0.2	< 0.2	< 0.2	-
Cadmium	mg/L	< 0.0002	0.0004	0.0006	-
Chloride	mg/L	21	24	26	-
Chromium	mg/L	< 0.003	0.007	0.007	-
Cobalt	mg/L	< 0.015	0.015	0.032	-
Copper	mg/L	0.005	0.006	0.032	-
Iron	mg/L	0.1	0.1	9.8	-
Lead	mg/L	0.001	0.002	0.008	-
Manganese	mg/L	0.095	0.093	0.822	-
Mercury	µg/L	< 0.1	< 0.1	< 0.1	-
Nickel	mg/L	< 0.020	0.022	0.041	-
Silver	mg/L	< 0.0002	< 0.0002	< 0.0002	-
Thallium	mg/L	< 0.004	< 0.004	< 0.004	-
Vanadium	mg/L	< 0.003	< 0.003	0.007	-
Zinc	mg/L	0.017	0.016	0.053	-
Cesium-137	pCi/L	< 1	< 1	< 1	1
Hydrogen-3	nCi/L	0.182	< 0.100	< 0.100	0.107
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

TABLE 6.7

## Groundwater Monitoring Results, 300 Area Well #300020, 1991

						m(MSL)
						Well Point Elevation
						Ground Surface Elevation
						Casing Material:
Constituent	Units	03/22/91	05/15/91	09/11/91	12/10/91	
Water Elevation	m	203.21	202.88	200.15	199.80	
Temperature	°C	11.2	10.1	10.9	10.0	
pH	pH	7.16	7.42	6.95	7.06	
Redox	mV	86	-74	-38	-118	
Conductivity	µmhos/cm	567	558	591	544	
Arsenic	mg/L	< 0.0040	< 0.0040	< 0.0040	< 0.0040	
Barium	mg/L	0.0414	0.0333	0.0545	0.0365	
Beryllium	µg/L	< 0.2	0.2	< 0.2	< 0.2	
Cadmium	mg/L	< 0.0002	0.0004	0.0002	0.0005	
Chloride	mg/L	11	14	15	10	
Chromium	mg/L	< 0.003	0.005	0.005	< 0.003	
Cobalt	mg/L	< 0.015	< 0.015	< 0.015	< 0.015	
Copper	mg/L	0.005	-	0.018	0.015	
Iron	mg/L	0.1	0.2	5.4	0.3	
Lead	mg/L	0.005	< 0.001	0.006	0.002	
Manganese	mg/L	< 0.015	< 0.015	0.118	< 0.015	
Mercury	µg/L	< 0.1	< 0.1	< 0.1	< 0.1	
Nickel	mg/L	< 0.020	< 0.020	0.033	< 0.020	
Silver	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	
Thallium	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	
Vanadium	mg/L	< 0.003	< 0.003	0.005	< 0.003	
Zinc	mg/L	0.014	0.015	0.042	0.019	
Cesium-137	pCi/L	< 1	< 1	< 1	< 1	
Hydrogen-3	nCi/L	0.187	0.136	0.166	0.133	
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25	
1,1,1-Trichloroethane	µg/L	62	100	85	66	
1,1-Dichloroethane	µg/L	7	102	117	75	
1,1-Dichloroethene	µg/L	-	-	11	-	
1,2-Dichloroethane	µg/L	11	17	17	10	
Carbon Tetrachloride	µg/L	10	8	6	6	
Chloroform	µg/L	3	5	4	2	
Tetrachloroethene	µg/L	1	1	-	-	

TABLE 6.8

## Groundwater Monitoring Results, 300 Area Well #300030, 1991

		Well Point Elevation	m(MSL)
		Ground Surface Elevation	192.08
		Casing Material:	204.28
			PVC
Constituent	Units	03/21/91	05/14/91
Water Elevation	m	193.20	193.13
Temperature	°C	10.8	10.4
pH	pH	6.70	6.77
Redox	mV	101	-80
Conductivity	µmhos/cm	711	662
Arsenic	mg/L	< 0.0040	< 0.0040
Barium	mg/L	0.1584	0.3551
Beryllium	µg/L	0.6	0.8
Cadmium	mg/L	0.0004	0.0007
Chloride	mg/L	30	24
Chromium	mg/L	0.018	0.022
Cobalt	mg/L	0.054	0.093
Copper	mg/L	0.057	0.079
Iron	mg/L	29.0	52.6
Lead	mg/L	0.026	0.026
Manganese	mg/L	0.772	1.562
Mercury	µg/L	< 0.1	< 0.1
Nickel	mg/L	0.081	0.136
Silver	mg/L	< 0.0002	< 0.0002
Thallium	mg/L	< 0.004	< 0.004
Vanadium	mg/L	0.025	0.020
Zinc	mg/L	0.123	0.212
Cesium-137	pCi/L	< 1	< 1
Hydrogen-3	nCi/L	1.302	1.034
Strontium-90	pCi/L	0.48	0.50
1,1,1-Trichloroethane	µg/L	4	4
1,1-Dichloroethane	µg/L	1	1
Trichloroethene	µg/L	5	4

TABLE 6.9

## Groundwater Monitoring Results, 300 Area Well #300031, 1991

		Well Point Elevation		m(MSL)
		Ground Surface Elevation		195.82
		Casing Material:		204.28
				PVC
Constituent	Units	03/21/91	05/14/91	09/10/91
Water Elevation	m	198.27	197.98	197.20
Temperature	°C	10.8	10.3	11.6
pH	pH	6.50	6.76	6.98
Redox	mV	107	-77	-38
Conductivity	µmhos/cm	760	723	794
Arsenic	mg/L	0.0053	0.0061	0.0042
Barium	mg/L	0.2161	0.3417	0.1986
Beryllium	µg/L	0.8	1.1	0.6
Cadmium	mg/L	0.0002	0.0004	0.0012
Chloride	mg/L	30	30	31
Chromium	mg/L	0.009	0.015	0.010
Cobalt	mg/L	0.036	0.042	0.028
Copper	mg/L	0.056	0.032	0.038
Iron	mg/L	16.9	24.6	10.8
Lead	mg/L	0.016	0.021	0.014
Manganese	mg/L	0.519	0.638	0.343
Mercury	µg/L	< 0.1	< 0.1	< 0.1
Nickel	mg/L	0.049	0.060	0.052
Silver	mg/L	< 0.0002	0.0002	< 0.0002
Thallium	mg/L	< 0.004	< 0.004	< 0.004
Vanadium	mg/L	0.012	0.015	0.011
Zinc	mg/L	0.080	0.104	0.092
Cesium-137	pCi/L	< 1	< 1	< 1
Hydrogen-3	nCi/L	1.130	1.015	0.985
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25
Bis(2-Ethylhexyl) Phthalate	µg/L	-	-	79
Butyl Benzyl Phthalate	µg/L	-	-	0.7
Di-N-Butyl Phthalate	µg/L	-	-	2
Diethyl Phthalate	µg/L	-	-	0.6

TABLE 6.10

## Groundwater Monitoring Results, 300 Area Well #300052, 1991

Constituent	Units	Well Point Elevation				m(MSL)
		03/21/91	05/14/91	09/10/91	12/06/91	203.70
						208.32
						PVC
Water Elevation	m	206.52	205.58	204.44	206.03	
Temperature	°C	8.3	9.8	14.8	10.8	
pH	pH	7.56	7.04	7.26	7.54	
Redox	mV	55	-46	-39	-69	
Conductivity	µmhos/cm	478	503	577	486	
Arsenic	mg/L	< 0.0040	< 0.0040	0.0051	< 0.0040	
Barium	mg/L	0.0597	0.0897	0.9610	0.0425	
Beryllium	µg/L	< 0.2	0.3	3.9	< 0.2	
Cadmium	mg/L	0.0002	0.0004	0.0075	0.0009	
Chloride	mg/L	1	2	1	1	
Chromium	mg/L	0.007	0.015	0.084	0.007	
Cobalt	mg/L	< 0.015	0.016	0.214	< 0.015	
Copper	mg/L	0.027	0.026	0.231	0.018	
Iron	mg/L	13.2	19.9	280.0	9.3	
Lead	mg/L	0.013	0.008	0.233	0.005	
Manganese	mg/L	0.092	0.162	7.010	0.073	
Mercury	µg/L	< 0.1	< 0.1	< 0.1	< 0.1	
Nickel	mg/L	0.031	0.036	0.328	< 0.020	
Silver	mg/L	< 0.0002	< 0.0002	< 0.0002	0.0003	
Thallium	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	
Vanadium	mg/L	0.008	0.007	0.100	0.008	
Zinc	mg/L	0.060	0.087	0.756	0.037	
Cesium-137	pCi/L	< 1	< 1	< 1	< 1	
Hydrogen-3	nCi/L	0.11	< 0.100	< 0.100	< 0.100	
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25	
Bis(2-Ethylhexyl) Phthalate	µg/L	9	-	-	-	
Di-N-Butyl Phthalate	µg/L	7	-	-	-	
Acetone	µg/L	-	-	-	16	

TABLE 6.11

## Groundwater Monitoring Results, 300 Area Well #300060, 1991

							m(MSL)
							Well Point Elevation
							Ground Surface Elevation
							Casing Material:
							PVC
Constituent	Units	03/22/91	03/22/91	05/15/91	09/11/91	12/10/91	
Water Elevation	m	201.51	201.51	201.34	198.63	198.84	
Temperature	°C	11.1	11.1	10.6	11.3	10.2	
pH	pH	7.93	7.93	7.63	7.35	7.50	
Redox	mV	54	54	-87	-36	-29	
Conductivity	µmhos/cm	473	473	561	599	502	
Arsenic	mg/L	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	
Barium	mg/L	0.0678	0.0602	0.0458	0.0703	0.0690	
Beryllium	µg/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	
Cadmium	mg/L	0.0002	< 0.0002	0.0003	-	0.0003	
Chloride	mg/L	57	60	57	59	51	
Chromium	mg/L	< 0.003	< 0.003	0.005	0.004	< 0.003	
Cobalt	mg/L	< 0.015	< 0.015	< 0.015	< 0.015	0.016	
Copper	mg/L	0.013	0.008	< 0.005	0.014	0.007	
Iron	mg/L	0.2	0.3	0.4	1.3	0.1	
Lead	mg/L	0.001	0.003	0.004	< 0.001	0.001	
Manganese	mg/L	0.027	0.024	0.030	0.040	0.022	
Mercury	µg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	
Nickel	mg/L	0.023	0.028	< 0.020	0.030	< 0.020	
Silver	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	
Thallium	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	
Vanadium	mg/L	< 0.003	< 0.003	< 0.003	0.004	< 0.003	
Zinc	mg/L	0.023	0.013	0.015	0.033	0.012	
Cesium-137	pCi/L	< 1	-	< 1	< 1	< 1	
Hydrogen-3	nCi/L	0.212	-	0.160	< 0.100	0.157	
Strontium-90	pCi/L	< 0.25	-	< 0.25	< 0.25	< 0.25	
Bis(2-Ethylhexyl) Phthalate	µg/L	-	-	4	-	-	
Di-N-Butyl Phthalate	µg/L	-	-	2	-	-	

TABLE 6.12

## Groundwater Monitoring Results, 300 Area Well #300100, 1991

Constituent	Units	03/21/91	05/14/91	09/10/91	12/03/91	Well Point Elevation	m(MSL)
						198.88	
						Ground Surface Elevation	208.14
						Casing Material:	PVC
Water Elevation	m	205.23	204.83	202.48	204.90		
Temperature	°C	10.2	10.7	13.0	11.8		
pH	pH	6.94	7.01	6.82	6.88		
Redox	mV	77	-46	-25	-23		
Conductivity	µmhos/cm	482	582	683	515		
Arsenic	mg/L	< 0.0040	< 0.0040	0.0198	< 0.0040		
Barium	mg/L	0.0437	0.2251	0.9170	0.0602		
Beryllium	µg/L	0.3	< 0.2	3.8	< 0.2		
Cadmium	mg/L	0.0002	0.0004	0.0049	0.0004		
Chloride	mg/L	24	28	22	14		
Chromium	mg/L	0.006	0.007	0.074	0.003		
Cobalt	mg/L	< 0.015	< 0.015	0.286	< 0.015		
Copper	mg/L	0.019	0.019	0.411	0.006		
Iron	mg/L	8.0	7.1	380.1	2.8		
Lead	mg/L	0.007	0.005	0.321	0.004		
Manganese	mg/L	0.128	0.108	7.370	0.044		
Mercury	µg/L	< 0.1	< 0.1	< 0.1	< 0.1		
Nickel	mg/L	0.031	0.026	0.494	0.026		
Silver	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002		
Thallium	mg/L	< 0.004	< 0.004	< 0.004	< 0.004		
Vanadium	mg/L	0.008	0.004	0.079	0.005		
Zinc	mg/L	0.044	0.038	1.165	0.021		
Cesium-137	pCi/L	< 1	< 1	1	< 1		
Hydrogen-3	nCi/L	0.264	0.781	1.174	0.266		
Strontium-90	pCi/L	8.70	16.45	17.64	8.54		
Bis(2-Ethylhexyl) Phthalate	µg/L	-	-	110	-		
Butyl Benzyl Phthalate	µg/L	-	-	0.7	-		
Di-N-Butyl Phthalate	µg/L	-	-	2	-		
Diethyl Phthalate	µg/L	-	-	0.6	-		
Pyrene	µg/L	-	-	0.3	-		
1,1,1-Trichloroethane	µg/L	-	1	-	-		
Carbon Tetrachloride	µg/L	-	2	-	1		
Chloroform	µg/L	1	1	1	2		
Tetrachloroethane	µg/L	-	1	-	-		
Trichloroethene	µg/L	26	32	37	34		
Cis-1,2-Dichloroethene	µg/L	8	26	14	13		
Trans-1,2 Dichloroethene	µg/L	-	1	-	-		

TABLE 6.13

## Groundwater Monitoring Results, 300 Area Well #300110, 1991

Constituent	Units	Well Point Elevation				m(MSL)
		03/21/91	05/14/91	09/10/91	12/03/91	199.16
						208.14
						PVC
Water Elevation	m	205.23	204.37	201.37	204.23	
Temperature	°C	9.3	10.4	14.8	12.3	
pH	pH	6.92	6.93	7.08	6.86	
Redox	mV	73	-44	-30	-31	
Conductivity	µmhos/cm	524	531	623	544	
Arsenic	mg/L	0.0043	< 0.0040	0.0104	< 0.0040	
Barium	mg/L	0.0454	0.0713	0.1636	0.0617	
Beryllium	µg/L	0.3	0.2	0.8	< 0.2	
Cadmium	mg/L	0.0002	0.0005	0.0010	0.0006	
Chloride	mg/L	7	5	15	6	
Chromium	mg/L	0.009	0.009	0.026	0.005	
Cobalt	mg/L	0.022	0.019	0.051	< 0.015	
Copper	mg/L	0.029	0.028	0.072	0.015	
Iron	mg/L	12.0	7.7	48.7	7.8	
Lead	mg/L	0.014	0.010	0.052	0.009	
Manganese	mg/L	0.283	0.130	1.042	0.163	
Mercury	µg/L	< 0.1	< 0.1	< 0.1	< 0.1	
Nickel	mg/L	0.035	0.032	0.094	0.079	
Silver	mg/L	< 0.0002	0.0002	0.0002	< 0.0002	
Thallium	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	
Vanadium	mg/L	0.012	0.006	0.034	0.008	
Zinc	mg/L	0.066	0.063	0.185	0.038	
Cesium-137	pCi/L	< 1	1	< 1	< 1	
Hydrogen-3	nCi/L	0.161	0.117	0.291	< 0.100	
Strontium-90	pCi/L	1.00	0.30	< 0.25	0.52	
Bis(2-Ethylhexyl) Phthalate	µg/L	-	3	-	-	
Di-N-Butyl Phthalate	µg/L	-	0.5	-	-	
1,1,1-Trichloroethane	µg/L	-	1	5	1	
1,1-Dichloroethane	µg/L	-	1	9	-	
1,2-Dichloroethane	µg/L	-	-	2	-	
Tetrachloroethene	µg/L	1	-	1	-	
Trichloroethene	µg/L	-	-	1	-	

TABLE 6.14

## Groundwater Monitoring Results, 300 Area Well #300120, 1991

Constituent	Units	Date			
		03/21/91	05/14/91	09/10/91	12/03/91
		Well Point Elevation			
		Ground Surface Elevation			
		Casing Material:			
		m(MSL)			
		198.66			
		211.04			
		PVC			
Constituent	Units	03/21/91	05/14/91	09/10/91	12/03/91
Water Elevation	m	204.95	205.44	202.45	202.09
Temperature	°C	12.2	12.2	12.5	10.9
pH	pH	6.71	6.82	6.82	6.62
Redox	mV	82	-46	-23	-16
Conductivity	µmhos/cm	1477	1280	1219	463
Arsenic	mg/L	0.0161	0.0128	0.0097	0.0051
Barium	mg/L	0.1665	0.1573	0.1215	0.1292
Beryllium	µg/L	0.7	0.7	0.5	0.2
Cadmium	mg/L	0.0004	0.0011	0.0011	0.0011
Chloride	mg/L	337	266	228	337
Chromium	mg/L	0.021	0.025	0.015	0.008
Cobalt	mg/L	0.051	0.044	0.032	0.032
Copper	mg/L	0.060	0.073	0.039	0.047
Iron	mg/L	39.9	40.1	21.2	12.7
Lead	mg/L	0.027	0.024	0.018	0.012
Manganese	mg/L	0.719	0.848	0.518	0.356
Mercury	µg/L	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	0.086	0.086	0.064	0.054
Silver	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Thallium	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Vanadium	mg/L	0.025	0.024	0.020	0.012
Zinc	mg/L	0.153	0.123	0.084	0.062
Cesium-137	pCi/L	< 1	< 1	< 1	< 1
Hydrogen-3	nCi/L	0.144	0.129	< 0.100	0.137
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
Bis(2-Ethylhexyl) Phthalate	µg/L	5	-	-	-
Di-N-Butyl Phthalate	µg/L	3	-	-	-

TABLE 6.15

## Groundwater Monitoring Results, 300 Area Well #300130, 1991

Constituent	Units	03/22/91	05/15/91	09/11/91	09/11/91	12/06/91	12/06/91	Well Point Elevation	m(MSL)
								200.72	
								Ground Surface Elevation	213.02
								Casing Material:	PVC
Water Elevation	m	207.14	208.31	203.79	203.79	205.07	205.07		
Temperature	°C	11.3	11.0	11.5	11.5	11.9	11.9		
pH	pH	6.89	6.97	6.95	6.95	6.73	6.73		
Redox	mV	71	-34	-29	-29	-115	-115		
Conductivity	µmhos/cm	764	741	734	734	817	817		
Arsenic	mg/L	< 0.0040	< 0.0040	0.0081	0.0100	< 0.0040	< 0.0040		
Barium	mg/L	0.0729	0.0695	0.1326	0.1660	0.0818	0.0852		
Beryllium	µg/L	< 0.2	< 0.2	0.5	0.5	< 0.2	< 0.2		
Cadmium	mg/L	< 0.0002	0.0002	0.0004	0.0009	0.0007	0.0005		
Chloride	mg/L	91	91	81	81	74	76		
Chromium	mg/L	< 0.003	0.009	0.033	0.020	< 0.003	< 0.003		
Cobalt	mg/L	< 0.015	< 0.015	0.025	0.039	0.017	0.020		
Copper	mg/L	0.005	0.005	0.037	0.061	0.010	0.009		
Iron	mg/L	0.7	0.6	17.4	37.7	1.0	1.3		
Lead	mg/L	0.002	0.003	0.019	0.024	0.002	0.002		
Manganese	mg/L	0.049	0.041	0.434	0.694	0.053	0.064		
Mercury	µg/L	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1		
Nickel	mg/L	0.021	< 0.020	0.050	0.078	< 0.020	< 0.020		
Silver	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002		
Thallium	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004		
Vanadium	mg/L	< 0.003	< 0.003	0.018	0.019	< 0.003	< 0.003		
Zinc	mg/L	0.012	0.021	0.087	0.133	0.017	0.019		
Cesium-137	pCi/L	< 1	< 1	< 1	-	< 1	-		
Hydrogen-3	nCi/L	0.132	< 0.100	< 0.100	-	< 0.100	-		
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	-	< 0.25	-		
Di-N-Butyl Phthalate	µg/L	3	-	-	-	-	-		

TABLE 6.16

## Groundwater Monitoring Results, 300 Area Well #300D03, 1991

Constituent	UNITS					Well Point Elevation	m(MSL)
		03/21/91	05/14/91	09/10/91	12/06/91	183.17	183.17
						Ground Surface Elevation	207.57
						Casing Material:	STEEL
Water Elevation	m	184.46	186.45	189.22	186.34		
Temperature	°C	11.4	11.2	12.3	9.9		
pH	pH	11.13	11.11	10.12	11.13		
Redox	mV	-2	-134	-64	-136		
Conductivity	µmhos/cm	844	880	379	730		
Heptachlor Epoxide	µg/L	-	0.0070	-	-		
Arsenic	mg/L	< 0.0040	< 0.0040	< 0.0040	< 0.0040		
Barium	mg/L	0.0554	0.2556	0.0467	0.1177		
Beryllium	µg/L	< 0.2	< 0.2	< 0.2	< 0.2		
Cadmium	mg/L	< 0.0002	0.0002	0.0005	0.0002		
Chloride	mg/L	33	43	39	26		
Chromium	mg/L	0.004	0.009	0.006	0.004		
Cobalt	mg/L	< 0.015	< 0.015	< 0.015	< 0.015		
Copper	mg/L	0.011	< 0.005	0.006	0.005		
Iron	mg/L	4.2	1.8	1.0	3.0		
Lead	mg/L	0.003	0.002	0.002	0.003		
Manganese	mg/L	0.034	< 0.015	< 0.015	0.025		
Mercury	µg/L	< 0.1	< 0.1	< 0.1	< 0.1		
Nickel	mg/L	0.024	< 0.020	< 0.020	0.027		
Silver	mg/L	< 0.0002	0.0003	< 0.0002	< 0.0002		
Thallium	mg/L	< 0.004	< 0.004	< 0.004	< 0.004		
Vanadium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003		
Zinc	mg/L	0.018	0.021	< 0.005	0.011		
Cesium-137	pCi/L	< 1	< 1	< 1	< 1		
Hydrogen-3	nCi/L	0.212	0.105	0.136	0.137		
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25		
Bis(2-Ethylhexyl) Phthalate	µg/L	-	4	-	-		
Di-N-Butyl Phthalate	µg/L	-	0.6	-	-		
Diethyl Phthalate	µg/L	-	1	-	-		
2-Butanone	µg/L	4	3	-	-		
Acetone	µg/L	24	14	13	32		

TABLE 6.17

## Groundwater Monitoring Results, 300 Area Well #300D04, 1991

Constituent	Units	Well Point Elevation		
		03/21/91	05/14/91	09/10/91
				m(MSL)
				182.06
				Ground Surface Elevation
				203.56
				Casing Material:
				STEEL
Constituent	Units	03/21/91	05/14/91	09/10/91
Water Elevation	m	184.93	184.98	184.29
Temperature	°C	11.4	11.2	11.8
pH	pH	9.94	9.35	6.99
Redox	mV	48	-107	-42
Conductivity	µmhos/cm	323	317	765
Arsenic	mg/L	< 0.0040	< 0.0040	< 0.0040
Barium	mg/L	0.0498	0.0589	0.0807
Beryllium	µg/L	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	0.0002	0.0005	0.0016
Chloride	mg/L	30	36	44
Chromium	mg/L	0.031	0.012	0.008
Cobalt	mg/L	< 0.015	< 0.015	0.015
Copper	mg/L	0.008	< 0.005	0.007
Iron	mg/L	0.8	0.7	0.6
Lead	mg/L	0.002	0.010	0.004
Manganese	mg/L	< 0.015	< 0.015	< 0.015
Mercury	µg/L	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.020	< 0.020	< 0.020
Silver	mg/L	< 0.0002	< 0.0002	0.0002
Thallium	mg/L	< 0.004	< 0.004	0.004
Vanadium	mg/L	< 0.003	< 0.003	0.005
Zinc	mg/L	0.099	0.153	0.011
Cesium-137	pCi/L	< 1	< 1	< 1
Hydrogen-3	nCi/L	0.798	0.806	1.344
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25
Butyl Benzyl Phthalate	µg/L	1	-	-
Di-N-Butyl Phthalate	µg/L	6	-	-
Acetone	µg/L	-	-	15

third quarter of the year. A period of drought preceded this period as can be seen by the much lower water levels in the wells in the third quarter. Elevated levels in these samples probably represent increased siltation due to the low water levels. The results obtained for the dolomite well samples are within the normal range for water of this type with the exception of chromium which is slightly elevated. The chloride levels are in the range of 26 to 44 mg/L, which are similar to the chloride concentrations in the four drinking water wells.

### Organic Results

Each well was sampled quarterly and analyzed for volatile organic compounds. Once during the year the wells were sampled and analyzed for semivolatile organic compounds, polychlorinated biphenyls (PCBs) and pesticides and herbicides. When results exceeding the required detection limits were obtained for these analyses, the sampling and analysis were repeated. Volatile organic compounds were detected in wells 300020, 300030, 300052, 300100, 300110, 300003 and 300004. The levels of volatile organics are persistent and appear to be indicative of different sources of contamination.

The results for well 300020 are shown in Figure 6.3. The major components are 1,1,1-trichloroethane (TCA) and 1,1-dichloroethane, which can be a decomposition product of TCA. As can be seen, the concentrations roughly parallel each other and the levels found are remarkably constant until 1991 at which time a substantial increase is seen. The previous consistency would indicate that this well is sampling a large area of contaminated water which is unaffected by seasonal water level changes. The large increase in the summer and fall of 1991 clearly is related to a period of intense drought and could be related to restricted flow of normal dilution water. Trace levels of chloroform and carbon tetrachloride were also found in this well. The well is immediately below the plugged sewer line previously discussed and this sewer line is known to be contaminated with these two compounds, but not the other constituents found in this well.

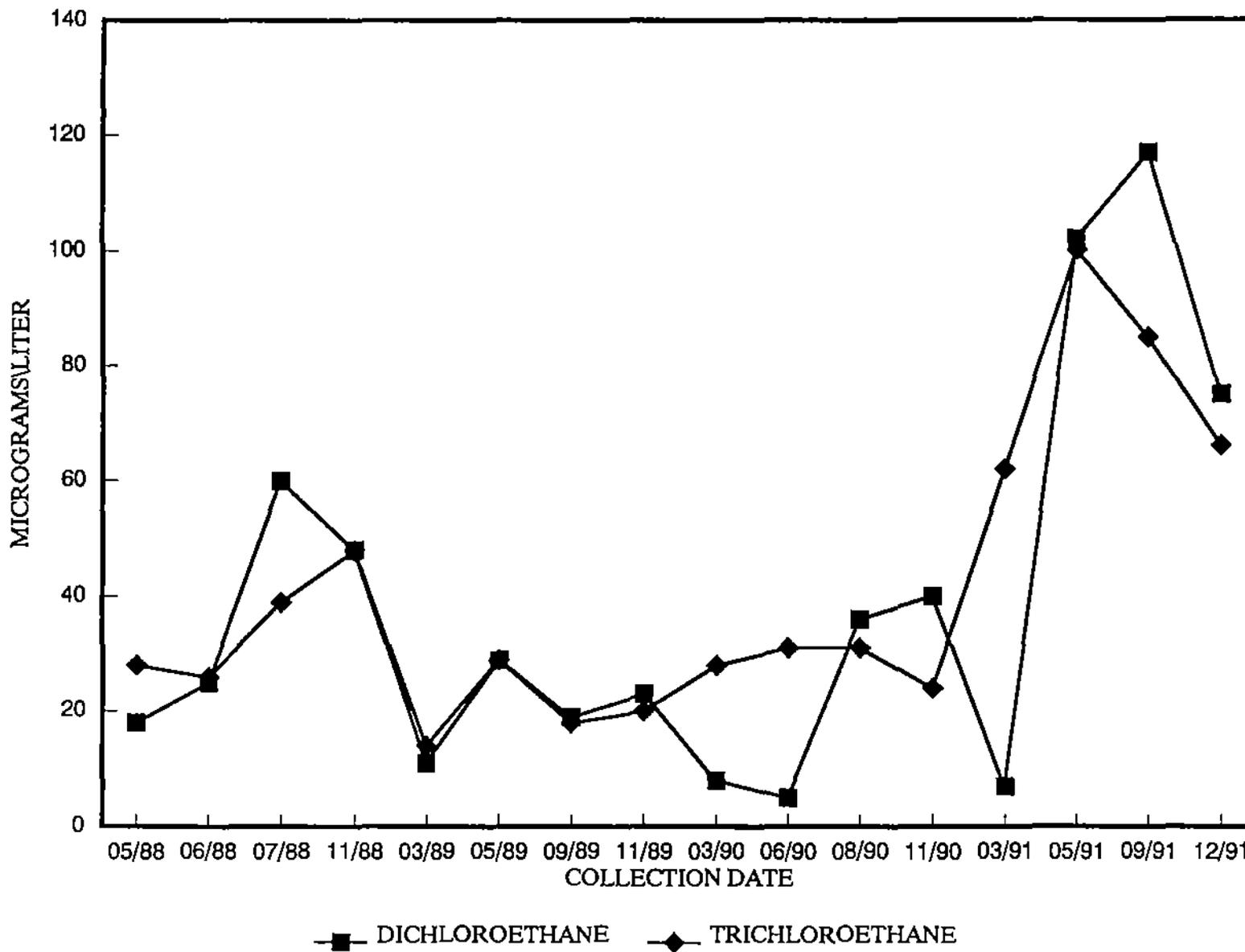


Figure 6.3 Concentrations of 1,1-Dichloroethane and 1,1,1-Trichloroethane in Well #300020

Wells 300100 and 300110 are adjacent to the storage vaults and are close to one another. The chemical characteristics are quite dissimilar. The principal volatile organic compounds found in well 300100 are trichloroethene (TCE) and cis-1,2-dichloroethene (1,2-DCE). The results obtained from the beginning of sampling until the end of 1991 are shown in Figure 6.4. When TCE breaks down in the presence of soil bacteria, the cis isomer of 1,2-DCE is produced almost exclusively. Indeed, only trace amounts of the trans isomer are seen in these samples and one can assume that the TCE is the parent of the 1,2-DCE. The fact that they are both present in these samples at relatively stable concentrations indicates that there may be ongoing release of TCE into the groundwater, such as from highly contaminated soil. The half life for the conversion indicated is about 30 days. The end product of this conversion is vinyl chloride which has a half life of 26,000 days. Vinyl chloride has never been detected in these samples. Chloroform, carbon tetrachloride, and tetrachloroethene are occasionally found in trace amounts in this well. In contrast, the levels and variety of volatile organics found in well 300110 are quite variable. In the initial samples obtained in 1988, very high amounts of 1,1,1-trichloroethane and 1,1-dichloroethane (170 and 160  $\mu\text{g/L}$ , respectively) were found. In subsequent samples, values for 1,1-dichloroethane have ranged from 1  $\mu\text{g/L}$  to 186  $\mu\text{g/L}$  and values for 1,1,1-trichloroethane have ranged from 1  $\mu\text{g/L}$  to 31  $\mu\text{g/L}$ . Trichloroethene, tetrachloroethene and 1,2-dichloroethane have also been detected on occasion.

Samples obtained in 1991 from dolomite well 300D03 have contained acetone and 2-butanone on a consistent basis. Other studies conducted at the 319 Area, discussed in Section 6.5., indicate that ketones are able to move through the glacial till at a much higher rate than other organics. Their presence in the dolomite aquifer indicates that the waste chemicals placed in the French drain may be moving through the glacial till, into the dolomite aquifer.

Samples were obtained from well 300030 in the first two quarters of 1991. Trichloroethene, 1,1,1-trichloroethane and 1,1-dichloroethane were detected in both samples. This well is frequently dry but it contains organic constituents when water is present.

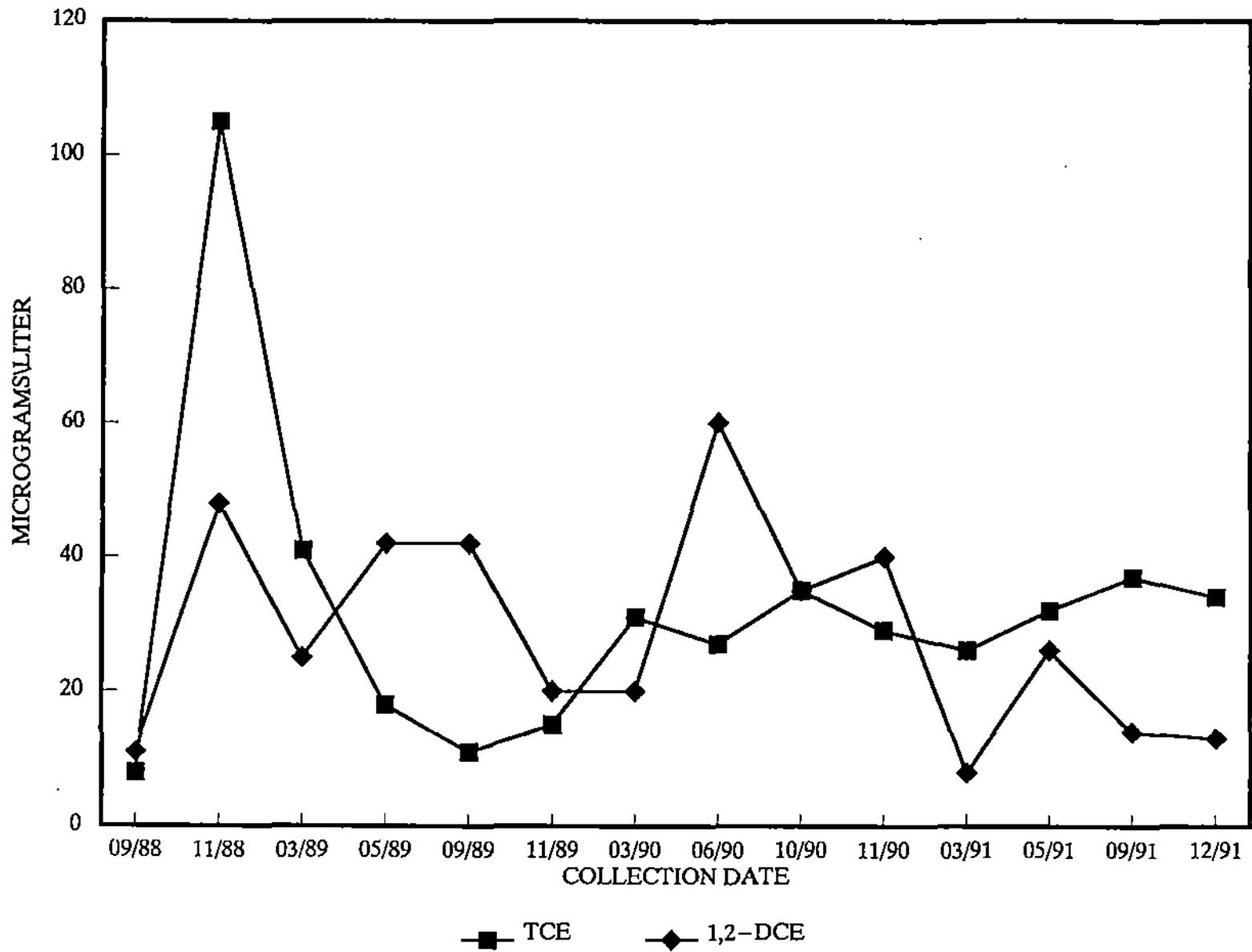


Figure 6.4 Concentrations of Trichloroethene and cis-1,2-Dichloroethane in Well #300100

Polychlorinated biphenyl compounds were reported in several of the wells in 1990. These wells were resampled in 1991 and no PCBs were indicated. This confirms previous sampling results.

Semivolatile organics and pesticides/herbicides, with the exception of several phthalates, were not detected in any of the wells. The phthalates were found in most of the samples and the blanks. Their presence may be due to Laboratory procedural problems.

### Radioactive Constituents

Samples collected quarterly from the monitoring wells in the 317 and 319 Areas were analyzed for hydrogen-3, strontium-90, and for gamma-ray emitters. The results are presented in Tables 6.6 to 6.17. The only evidence of possible migration of radionuclides off the site is the low concentrations of hydrogen-3 in wells 300030, 300031, and 300D04, which are located near the south perimeter fence. A small amount of strontium-90 was also detected in well 30030. These monitoring wells are directly below a small drainage swale from the 319 Area that has contained water intermittently with measurable concentrations of hydrogen-3 and strontium-90. Well 300100 contains measurable levels of hydrogen-3, strontium-90, cesium-137, while well 300110 contains strontium-90. These wells are next to facilities that have stored radioactive materials in the past. All concentrations are well below any applicable standards.

### 6.3 Sanitary Landfill

The 800 Area is the site of ANL's sanitary landfill. The 21.8-acre landfill is located on the western edge of ANL property (Figure 1.1). The landfill has received waste since 1966 and operates under IEPA permit No. 1981-29-0P which was issued on September 17, 1981. The landfill currently receives general refuse, construction debris, boiler house ash, and other nonradioactive solid waste.

### 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 which 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. There is documentation available that indicates that 29,000 gallons of liquid waste were placed in this drain. Many of the wastes disposed of in this manner are now defined as hazardous wastes. The presence of volatile and other toxic organic compounds has been confirmed by soil gas surveys conducted at the landfill. Measurable amounts of these materials were identified in soil vapors and in shallow groundwater of the landfill. These findings are discussed further in Section 6.5.

### 6.3.2. Monitoring Studies

In 1979, an investigation was conducted to determine the subsurface characteristics of the site and to place monitoring wells around the landfill (see Figure 6.5). The topography and initial studies indicated that water flow was primarily southerly. Wells 800010 and 800050 were located outside the landfill and were meant to measure water entering and leaving the landfill. Wells 800020, 800030, and 800040 were placed at the perimeter of the landfill. In April 1980, a more comprehensive study was initiated to develop information required for the State of Illinois operating permit.<sup>22</sup> Three additional wells were placed at the perimeter to improve coverage as well as to measure vertical movement. Well 800060 was placed in the eastern section to sample any water flowing out of the landfill in a southeasterly direction. Wells 800070 and 800071 were located along the southern boundary and were nested. In September 1986, six new wells were installed. Wells 800010, 800020, and 800040 were suspected of being poorly sealed and were removed and replaced by 800012, 800022 and 800042. The replacement wells were located within 2 m (6 ft) of the original wells. In addition, wells 800080, 800090, and 800100 were constructed to improve peripheral coverage. In November 1987, additional wells were added to provide sampling at a deeper level. Well 800120, which is next to 800060, and well 800130, which

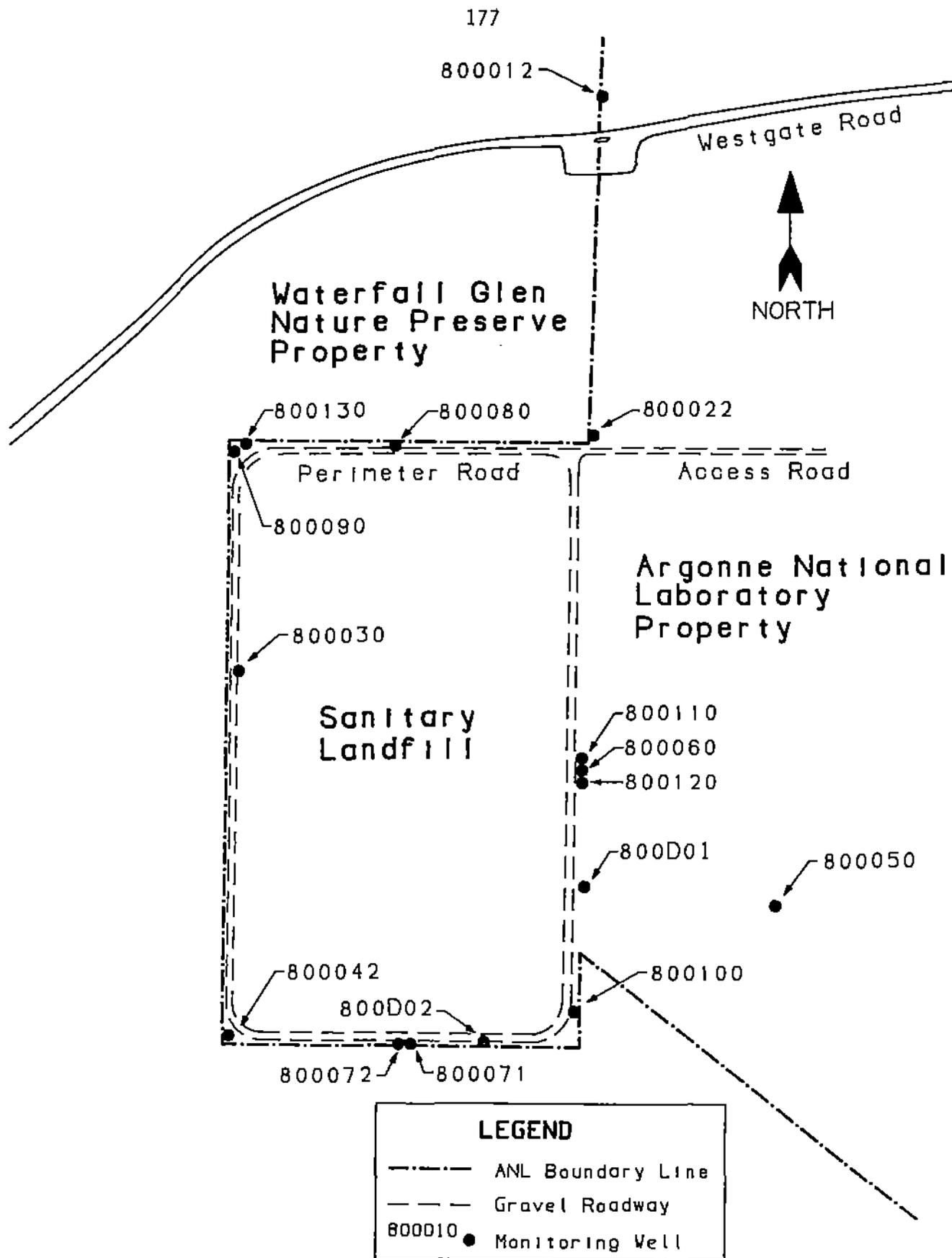


Figure 6.5 Monitoring Well Locations for Landfill in the 800 Area

is next to 800090, were both installed to a depth of 24 m (80 ft). Finally, in September 1989, two wells (800D01 and 800D02) were placed into the dolomite at a depth of 45 m (140 ft).

#### 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. Previous water level measurements have indicated that a perched water layer exists at a depth of about 6 m (20 ft) on the north to about 7.6 m (25 ft) on the south. Wells 800012 through 800100 sample this layer. Wells 800120 and 800130, which are at a depth of 24 m (80 ft), exhibit very different characteristics. Well 800130 has an abundant supply of water [casing volume of about 100 L (27 gal)] while well 800120 is usually dry. It is not known if there is a water layer at this depth or if well 800130 is in a local body of water. The dolomite wells are at a depth of about 45 m (140 ft), and both have an abundant supply of water.

#### 6.3.2.2 Results of Analyses

A description of each well, a listing of field parameters measured during sample collection, and the results of chemical and radiological analysis of samples from the wells in the 800 Area are contained in Tables 6.18 to 6.29. All radiological and inorganic analysis results are shown in these tables. The analysis methods used for organic compounds will 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, these negative results are not included. Only those constituents which were present in amounts great enough to quantify are shown. The detection limits for the organic compounds listed were typically 5 to 10  $\mu\text{g/L}$ .

##### Inorganic Constituents

With the exception of three wells, the inorganic constituents were typical of groundwater in this region. Significant levels of arsenic were

TABLE 6.18

## Groundwater Monitoring Results, Sanitary Landfill Perimeter Well #800012, 1991

Constituent	Units	04/19/91	06/26/91	09/26/91	09/26/91	Well Point Elevation
						m(MSL)
						219.99
						Ground Surface Elevation
						227.69
						Casing Material:
						PVC
Constituent	Units	04/19/91	06/26/91	09/26/91	09/26/91	12/17/91
Water Elevation	m	226.95	225.67	224.56	224.56	226.95
Temperature	°C	10.5	13.7	14.2	14.2	12.7
pH	pH	6.90	6.60	7.21	7.21	6.87
Redox	mV	31	-59	68	68	-10
Conductivity	µmhos/cm	2002	2080	1934	1934	1656
Arsenic	mg/L	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040
Barium	mg/L	0.2002	0.1466	0.1646	0.1676	0.1347
Beryllium	µg/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	0.0015	0.0006	0.0004	0.0006	0.0004
Chloride	mg/L	653	537	534	537	487
Chromium	mg/L	0.006	< 0.003	< 0.003	< 0.003	0.003
Cobalt	mg/L	0.031	0.015	0.022	0.019	0.019
Copper	mg/L	0.017	0.010	0.012	0.015	0.013
Iron	mg/L	2.2	0.8	0.8	1.1	0.6
Lead	mg/L	0.006	< 0.001	< 0.001	< 0.001	< 0.001
Manganese	mg/L	0.990	0.361	0.348	0.365	0.260
Mercury	µg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	0.032	0.026	0.031	0.035	0.027
Silver	mg/L	0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Thallium	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Vanadium	mg/L	< 0.003	0.003	< 0.003	< 0.003	< 0.003
Zinc	mg/L	0.028	0.042	0.014	0.028	0.024
Cesium-137	pCi/L	-	< 1	-	-	-
Hydrogen-3	nCi/L	0.126	0.105	< 0.100	0.106	< 0.100
Strontium-90	pCi/L	-	< 0.25	-	-	-
Bis(2-Ethylhexyl) Phthalate	µg/L	29	-	-	-	-
Di-N-Butyl Phthalate	µg/L	2	-	-	-	-
Isophorone	µg/L	0.9	-	-	-	-

TABLE 6.19

## Groundwater Monitoring Results, Sanitary Landfill Perimeter Well #800022, 1991

Constituent	Units	Well Point Elevation				m(MSL)
		04/19/91	06/26/91	09/26/91	12/17/91	214.70
						Ground Surface Elevation
						230.83
						Casing Material:
						PVC
Constituent	Units	04/19/91	06/26/91	09/26/91	12/17/91	12/17/91
Water Elevation	m	217.84	225.32	224.25	225.34	225.34
Temperature	°C	11.5	13.0	11.9	11.7	11.7
pH	pH	6.36	6.83	6.79	6.84	6.84
Redox	mV	-67	-70	-110	-54	-54
Conductivity	µmhos/cm	1414	676	667	643	643
Arsenic	mg/L	< 0.0040	< 0.0040	0.0051	< 0.0040	< 0.0040
Barium	mg/L	0.2279	0.4035	1.4650	0.6068	0.5361
Beryllium	µg/L	< 0.2	< 0.2	0.3	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	0.0004	0.0013	0.0004	0.0006
Chloride	mg/L	20	17	17	16	15
Chromium	mg/L	< 0.003	0.004	0.010	< 0.003	< 0.003
Cobalt	mg/L	0.015	0.015	0.023	0.021	< 0.015
Copper	mg/L	0.013	0.006	0.028	0.016	0.014
Iron	mg/L	0.6	0.4	15.4	1.3	1.5
Lead	mg/L	0.001	0.003	0.008	0.002	0.003
Manganese	mg/L	0.511	0.424	0.974	0.477	0.483
Mercury	µg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.020	< 0.020	0.040	0.028	0.027
Silver	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Thallium	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Vanadium	mg/L	< 0.003	< 0.003	0.019	< 0.003	< 0.003
Zinc	mg/L	0.029	0.032	0.054	0.027	0.028
Cesium-137	pCi/L	-	< 1	-	-	-
Hydrogen-3	nCi/L	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
Strontium-90	pCi/L	-	< 0.250	-	-	-
Bis(2-Ethylhexyl) Phthalate	µg/L	-	-	260	-	-
Di-N-Butyl Phthalate	µg/L	-	-	56	-	-
Diethyl Phthalate	µg/L	-	-	1	-	-

TABLE 6.20

Groundwater Monitoring Results, Sanitary Landfill Perimeter Well #800030, 1991

Constituent	Units	Well Point Elevation				m(MSL)
		4/18/91	06/25/91	09/25/91	12/16/91	217.51
						226.77
						Casing Material: PVC
Water Elevation	m	224.43	224.06	222.98	216.91	
Temperature	°C	10.1	11.5	12.0	11.4	
pH	pH	6.67	6.57	6.33	6.52	
Redox	mV	-107	-156	-141	-42	
Conductivity	µmhos/cm	1054	1060	1205	1341	
Gamma-BHC (Lindane)	µg/L	-	0.0500	-	-	
Arsenic	mg/L	0.0178	0.0103	0.0127	0.0122	
Barium	mg/L	0.4324	0.3445	0.4731	0.3743	
Beryllium	µg/L	0.4	0.3	0.4	0.3	
Cadmium	mg/L	0.0002	0.0004	0.0005	0.0007	
Chloride	mg/L	12	9	17	25	
Chromium	mg/L	0.014	0.010	0.012	0.011	
Cobalt	mg/L	0.052	0.036	0.047	0.055	
Copper	mg/L	0.036	0.029	0.041	0.034	
Iron	mg/L	32.7	26.0	32.7	25.1	
Lead	mg/L	0.015	0.010	0.012	0.009	
Manganese	mg/L	0.540	0.457	0.586	0.521	
Mercury	µg/L	< 0.1	< 0.1	< 0.1	< 0.1	
Nickel	mg/L	0.073	0.056	0.075	0.076	
Silver	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	
Thallium	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	
Vanadium	mg/L	0.015	0.015	0.017	0.012	
Zinc	mg/L	0.069	0.093	0.077	0.059	
Cesium-137	pCi/L	-	< 1	-	-	
Hydrogen-3	nCi/L	< 0.100	< 0.100	< 0.100	< 0.100	
Strontium-90	pCi/L	-	< 0.25	-	-	
Bis(2-Ethylhexyl) Phthalate	µg/L	-	7	-	-	
Di-N-Butyl Phthalate	µg/L	-	6	-	-	

TABLE 6.21

Groundwater Monitoring Results, Sanitary Landfill Perimeter Well #800042, 1991

Constituent	Units	Well Point Elevation		
		05/02/91	07/03/91	10/10/91
				m(MSL)
				219.48
				Ground Surface Elevation
				227.23
				Casing Material:
				PVC
Constituent	Units	05/02/91	07/03/91	10/10/91
Water Elevation	m	225.58	225.32	224.16
Temperature	°C	9.9	11.4	12.4
pH	pH	6.82	6.69	6.40
Redox	mV	-83	-152	-610
Conductivity	µmhos/cm	1017	1062	1100
Arsenic	mg/L	< 0.0040	< 0.0040	< 0.0040
Barium	mg/L	0.4065	0.4572	0.3751
Beryllium	µg/L	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	0.0002	0.0008	0.0002
Chloride	mg/L	157	141	117
Chromium	mg/L	< 0.003	0.008	0.005
Cobalt	mg/L	0.026	0.022	0.022
Copper	mg/L	0.016	0.029	0.015
Iron	mg/L	0.4	6.4	0.8
Lead	mg/L	0.016	0.006	< 0.001
Manganese	mg/L	0.087	0.283	0.041
Mercury	µg/L	< 0.1	< 0.1	< 0.1
Nickel	mg/L	0.034	0.030	0.031
Silver	mg/L	< 0.0002	< 0.0002	< 0.0002
Thallium	mg/L	< 0.004	< 0.004	< 0.004
Vanadium	mg/L	< 0.003	< 0.003	< 0.003
Zinc	mg/L	0.044	0.083	0.049
Cesium-137	pCi/L	-	< 1	-
Hydrogen-3	nCi/L	< 0.100	< 0.100	< 0.100
Strontium-90	pCi/L	-	< 0.25	-

TABLE 6.22

## Groundwater Monitoring Results, Sanitary Landfill Perimeter Well #800060, 1991

		Well Point Elevation				m(MSL)
		Ground Surface Elevation				213.71
		Casing Material:				PVC
Constituent	Units	04/19/91	06/26/91	09/26/91	12/17/91	
Water Elevation	m	217.84	217.60	216.38	217.15	
Temperature	°C	11.5	14.1	11.7	10.6	
pH	pH	6.36	6.26	5.81	6.26	
Redox	mV	-67	-138	-182	-42	
Conductivity	µmhos/cm	1414	1413	1398	695	
Arsenic	mg/L	< 0.0040	< 0.0040	< 0.0040	< 0.0040	
Barium	mg/L	0.2048	0.2022	0.2177	0.1748	
Beryllium	µg/L	< 0.2	< 0.2	< 0.2	< 0.2	
Cadmium	mg/L	0.0003	0.0004	0.0006	0.0004	
Chloride	mg/L	225	234	225	175	
Chromium	mg/L	< 0.003	0.006	0.003	< 0.003	
Cobalt	mg/L	0.030	0.025	0.029	0.029	
Copper	mg/L	0.011	0.008	0.026	0.011	
Iron	mg/L	4.1	3.8	4.3	3.6	
Lead	mg/L	0.002	0.002	0.003	0.002	
Manganese	mg/L	0.807	0.856	0.912	0.911	
Mercury	µg/L	< 0.1	< 0.1	< 0.1	< 0.1	
Nickel	mg/L	0.039	0.029	0.043	0.045	
Silver	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	
Thallium	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	
Vanadium	mg/L	< 0.003	< 0.003	0.004	< 0.003	
Zinc	mg/L	0.026	0.029	0.045	0.025	
Cesium-137	pCi/L	-	< 1	-	-	
Hydrogen-3	nCi/L	0.619	0.614	0.851	0.629	
Strontium-90	pCi/L	-	< 0.25	-	-	
1,4-Dioxane	µg/L	1	2	-	-	
Acetone	µg/L	-	6	-	-	
Ethyl Ether	µg/L	20	21	5	4	
Tetrahydrofuran	µg/L	-	-	18	12	

TABLE 6.23

Groundwater Monitoring Results, Sanitary Landfill Perimeter Well #800071, 1991

		Well Point Elevation	m(MSL)		
		Ground Surface Elevation	219.61		
		Casing Material:	227.81		
			PVC		
Constituent	Units	06/26/91	09/26/91	12/17/91	
Water Elevation	m	224.22	221.73	222.53	
Temperature	°C	13.5	11.2	11.1	
pH	pH	6.82	7.66	6.91	
Redox	mV	-162	-8	-30	
Conductivity	µmhos/cm	780	979	380	
Arsenic	mg/L	< 0.0040	< 0.0040	< 0.0040	
Barium	mg/L	0.1163	0.1540	0.0889	
Beryllium	µg/L	< 0.2	< 0.2	< 0.2	
Cadmium	mg/L	0.0006	0.0004	0.0003	
Chloride	mg/L	31	61	36	
Chromium	mg/L	0.004	0.004	0.006	
Cobalt	mg/L	0.015	0.017	< 0.015	
Copper	mg/L	0.022	0.010	0.022	
Iron	mg/L	3.0	2.5	3.3	
Lead	mg/L	0.002	0.002	0.004	
Manganese	mg/L	0.279	0.328	0.239	
Mercury	µg/L	< 0.1	< 0.1	< 0.1	
Nickel	mg/L	< 0.020	0.026	0.022	
Silver	mg/L	< 0.0002	< 0.0002	< 0.0002	
Thallium	mg/L	< 0.004	< 0.004	< 0.004	
Vanadium	mg/L	< 0.003	< 0.003	< 0.003	
Zinc	mg/L	0.044	0.026	0.049	
Cesium-137	pCi/L	< 1	-	-	
Hydrogen-3	nCi/L	0.895	2.403	0.756	
Strontium-90	pCi/L	< 0.25	-	-	
4-Methylphenol	µg/L	-	4.	-	
Benzo(A)Anthracene	µg/L	-	0.9	-	
Benzo(A)Pyrene	µg/L	-	0.7	-	
Benzo(K)Flouranthene	µg/L	-	0.6	-	
Bis(2-Ethylhexyl) Phthalate	µg/L	-	19	-	
Butyl Benzyl Phthalate	µg/L	-	1	-	
Chrysene	µg/L	-	0.8	-	
Di-N-Butyl Phthalate	µg/L	-	3	-	
Diethyl Phthalate	µg/L	-	1	-	
Flouranthene	µg/L	-	0.4	-	
Phenanthrene	µg/L	-	0.4	-	
Pyrene	µg/L	-	0.4	-	

TABLE 6.24

Groundwater Monitoring Results, Sanitary Landfill Perimeter Well #800080, 1991

						m(MSL)
						222.23
						231.53
						PVC
Constituent	Units	04/19/91	06/26/91	09/26/91	12/17/91	
Water Elevation	m	229.85	227.33	225.52	226.35	
Temperature	°C	9.3	14.6	11.5	10.9	
pH	pH	6.75	6.30	7.08	6.73	
Redox	mV	-117	-152	-17	-53	
Conductivity	µmhos/cm	1179	1330	1119	495	
Arsenic	mg/L	0.0040	< 0.0040	< 0.0040	0.0047	
Barium	mg/L	0.0926	0.0958	0.0837	0.0512	
Beryllium	µg/L	< 0.2	< 0.2	< 0.2	< 0.2	
Cadmium	mg/L	< 0.0002	0.0005	0.0004	0.0010	
Chloride	mg/L	104	100	91	74	
Chromium	mg/L	< 0.003	0.007	0.004	0.005	
Cobalt	mg/L	0.032	0.024	0.025	0.027	
Copper	mg/L	0.010	0.009	0.023	0.024	
Iron	mg/L	0.3	0.2	2.2	4.7	
Lead	mg/L	0.001	< 0.001	0.003	0.008	
Manganese	mg/L	0.340	0.341	0.249	0.314	
Mercury	µg/L	< 0.1	< 0.1	< 0.1	< 0.1	
Nickel	mg/L	0.046	0.031	0.068	0.038	
Silver	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	
Thallium	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	
Vanadium	mg/L	< 0.003	< 0.003	< 0.003	0.004	
Zinc	mg/L	0.036	0.037	0.050	0.051	
Cesium-137	pCi/L	-	< 1	-	-	
Hydrogen-3	nCi/L	0.123	0.116	0.184	0.139	
Strontium-90	pCi/L	-	< 0.25	-	-	

TABLE 6.25

## Groundwater Monitoring Results, Sanitary Landfill Perimeter Well #800090, 1991

Constituent	Units	Date				m(MSL)
		04/18/91	06/25/91	09/26/91	12/16/91	
Water Elevation	m	227.91	226.73	224.99	227.46	223.79
Temperature	°C	10.2	12.6	12.1	12.1	230.00
pH	pH	6.64	6.44	6.93	6.53	PVC
Redox	mV	-124	-155	-73	-152	
Conductivity	µmhos/cm	1157	1273	1352	1205	
Arsenic	mg/L	0.0490	0.0235	0.0316	0.0315	
Barium	mg/L	0.5006	0.3663	0.4558	0.3529	
Beryllium	µg/L	1.5	0.8	0.7	1.0	
Cadmium	mg/L	0.0006	0.0008	0.0010	0.0009	
Chloride	mg/L	95	121	126	112	
Chromium	mg/L	0.040	0.020	0.023	0.025	
Cobalt	mg/L	0.092	0.056	0.078	0.065	
Copper	mg/L	0.114	0.082	0.075	0.087	
Iron	mg/L	81.2	58.3	67.2	77.5	
Lead	mg/L	0.076	0.038	0.040	0.048	
Manganese	mg/L	2.170	1.716	2.860	3.380	
Mercury	µg/L	< 0.1	< 0.1	< 0.1	< 0.1	
Nickel	mg/L	0.129	0.109	0.129	0.116	
Silver	mg/L	0.0003	< 0.0002	< 0.0002	< 0.0002	
Thallium	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	
Vanadium	mg/L	0.047	0.033	0.038	0.038	
Zinc	mg/L	0.220	0.183	0.185	0.163	
Hydrogen-3	nCi/L	0.460	0.376	0.552	0.429	
Bis(2-Ethylhexyl) Phthalate	µg/L	28	-	20	-	
Butyl Benzyl Phthalate	µg/L	-	-	1	-	
Di-N-Butyl Phthalate	µg/L	1	-	3	-	
Diethyl Phthalate	µg/L	-	-	0.8	-	
1,4-Dioxane	µg/L	2	1	-	-	
Ethyl Ether	µg/L	20	20	4	4	

TABLE 6.26

Groundwater Monitoring Results, Sanitary Landfill Perimeter Well #800100, 1991

Constituent	Units	Date				Well Point Elevation	m(MSL)
		06/25/91	06/25/91	09/25/91	12/16/91	222.28	229.15
							PVC
Water Elevation	m	227.53	227.53	226.24	228.55		
Temperature	°C	11.8	11.8	13.8	11.8		
pH	pH	6.80	6.80	6.45	6.97		
Redox	mV	-102	-102	-155	-104		
Conductivity	µmhos/cm	716	716	749	733		
Arsenic	mg/L	< 0.0040	0.0041	< 0.0040	0.0048		
Barium	mg/L	0.0745	0.0792	0.0874	0.0823		
Beryllium	µg/L	< 0.2	< 0.2	< 0.2	< 0.2		
Cadmium	mg/L	0.0003	0.0002	0.0010	0.0002		
Chloride	mg/L	5	6	6	4		
Chromium	mg/L	0.004	0.004	0.006	0.005		
Cobalt	mg/L	< 0.015	< 0.015	0.017	< 0.015		
Copper	mg/L	0.018	0.017	0.019	0.014		
Iron	mg/L	4.9	4.7	6.0	4.1		
Lead	mg/L	0.002	0.003	0.003	0.004		
Manganese	mg/L	0.182	0.177	0.176	0.145		
Mercury	µg/L	< 0.1	< 0.1	< 0.1	< 0.1		
Nickel	mg/L	0.020	0.025	0.025	< 0.020		
Silver	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002		
Thallium	mg/L	< 0.004	< 0.004	< 0.004	< 0.004		
Vanadium	mg/L	0.004	0.005	0.008	< 0.003		
Zinc	mg/L	0.042	0.039	0.039	0.020		
Cesium-137	pCi/L	< 1	< 1	-	-		
Hydrogen-3	nCi/L	< 0.100	< 0.100	< 0.100	0.103		
Strontium-90	pCi/L	< 0.25	-	-	-		
Bis(2-Ethylhexyl) Phthalate	µg/L	17	11	-	-		
Di-N-Butyl Phthalate	µg/L	3	1	-	-		

TABLE 6.27

Groundwater Monitoring Results, Sanitary Landfill Perimeter Well #800130, 1991

				m(MSL)
		Well Point Elevation		222.28
		Ground Surface Elevation		229.15
		Casing Material:		PVC
Constituent	Units	04/18/91	06/25/91	09/25/91
Water Elevation	m	226.95	216.85	216.85
Temperature	°C	10.5	11.8	11.1
pH	pH	6.9	6.69	6.57
Redox	mV	31	-174	-190
Conductivity	µmhos/cm	2020	706	710
Arsenic	mg/L	0.0071	0.0052	0.0065
Barium	mg/L	0.2570	0.1988	0.2753
Beryllium	µg/L	< 0.2	< 0.2	0.2
Cadmium	mg/L	< 0.0002	0.0002	0.0009
Chloride	mg/L	35	30	29
Chromium	mg/L	< 0.003	< 0.003	0.014
Cobalt	mg/L	0.024	< 0.015	< 0.015
Copper	mg/L	0.010	0.040	0.007
Iron	mg/L	9.8	7.4	11.0
Lead	mg/L	0.001	< 0.001	0.001
Manganese	mg/L	0.151	0.059	0.064
Mercury	µg/L	< 0.1	< 0.1	< 0.1
Nickel	mg/L	0.026	0.024	0.026
Silver	mg/L	< 0.0002	< 0.0002	< 0.0002
Thallium	mg/L	< 0.004	< 0.004	< 0.004
Vanadium	mg/L	< 0.003	0.004	< 0.003
Zinc	mg/L	0.015	0.057	0.009
Cesium-137	pCi/L	-	< 1	-
Hydrogen-3	nCi/L	0.153	< 0.100	< 0.100
Strontium-90	pCi/L	-	< 0.25	-
Bis(2-Ethylhexyl) Phthalate	µg/L	-	31	-
Di-N-Butyl Phthalate	µg/L	-	3	-

TABLE 6.28

Groundwater Monitoring Results, Sanitary Landfill Perimeter Well #800D01, 1991

Constituent	Units	Well Point Elevation		m(MSL)
		04/18/91	04/18/91	183.13
				Ground Surface Elevation
				229.53
				Casing Material:
				Steel
Constituent	Units	04/18/91	04/18/91	06/25/91
Water Elevation	m	224.43	224.43	192.25
Temperature	°C	10.1	10.1	12.0
pH	pH	6.67	6.67	9.05
Redox	mV	-107	-107	-140
Conductivity	µmhos/cm	1054	1054	497
Arsenic	mg/L	< 0.0040	< 0.0040	< 0.0040
Barium	mg/L	0.0037	0.0026	< 0.0025
Beryllium	µg/L	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002
Chloride	mg/L	67	71	66
Chromium	mg/L	< 0.003	< 0.0030	0.003
Cobalt	mg/L	< 0.015	0.015	< 0.015
Copper	mg/L	0.008	0.005	0.005
Iron	mg/L	3.8	3.7	3.2
Lead	mg/L	< 0.001	< 0.001	0.001
Manganese	mg/L	0.070	0.071	0.066
Mercury	µg/L	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.020	< 0.020	< 0.020
Silver	mg/L	0.0002	0.0002	< 0.0002
Thallium	mg/L	< 0.004	< 0.004	< 0.004
Vanadium	mg/L	< 0.003	< 0.003	< 0.003
Zinc	mg/L	0.006	0.007	0.010
Hydrogen-3	nCi/L	< 0.100	< 0.100	< 0.100
Bis(2-Ethylhexyl) Phthalate	µg/L	142	0.7	-
1,1,1-Trichloroethane	µg/L	1	1	-
2-Butanone	µg/L	1	1	-
Acetone	µg/L	4	4	8

TABLE 6.29

Groundwater Monitoring Results, Sanitary Landfill Perimeter Well #800D02, 1991

		Well Point Elevation	m(MSL)
		Ground Surface Elevation	227.81
		Casing Material:	Steel
Constituent	Units	06/26/91	09/25/91
Water Elevation	m	191.17	190.71
Temperature	°C	12.6	11.2
pH	pH	7.27	6.78
Redox	mV	-273	-152
Conductivity	µmhos/cm	650	780
Arsenic	mg/L	< 0.0040	< 0.0040
Barium	mg/L	0.0248	0.0281
Beryllium	µg/L	< 0.2	< 0.2
Cadmium	mg/L	0.0002	0.0002
Chloride	mg/L	66	76
Chromium	mg/L	< 0.003	0.005
Cobalt	mg/L	< 0.015	0.020
Copper	mg/L	< 0.005	0.012
Iron	mg/L	16.1	14.4
Lead	mg/L	< 0.001	0.002
Manganese	mg/L	0.072	0.063
Mercury	µg/L	< 0.1	< 0.1
Nickel	mg/L	< 0.020	0.030
Silver	mg/L	< 0.0002	< 0.0002
Thallium	mg/L	< 0.004	< 0.004
Vanadium	mg/L	< 0.003	< 0.003
Zinc	mg/L	0.011	0.019
Cesium-137	pCi/L	< 1	-
Hydrogen-3	nCi/L	< 0.100	< 0.100
Strontium-90	pCi/L	< 0.25	-

detected in wells 800030, 800090, and 800130 and a lesser amount was detected in 800100. In previous years arsenic had been consistently found in 800030. The presence of arsenic in the other wells was noted in the previous report. The levels of most of the inorganic constituents in wells 800030 and 800090 are greater than the concentrations in the other wells. Chromium, copper, and lead are of particular note. The levels in well 800090 are 3-10 times higher than levels in 800030 for these elements. The chloride concentrations are elevated in wells 800012, 800042, and 800060 where the levels vary from 200 mg/L to 600 mg/L. All of the other wells are less than 100 mg/L. The inorganic results for dolomite wells 800001 and 800002 were all within normal ranges.

#### Organic Constituents

All of the monitoring wells with sufficient recharge rates were sampled quarterly and analyzed for volatile organic compounds. In addition, annual samples were collected from each of these wells and analyzed for semi-volatile organic compounds, PCBs, and pesticides and herbicides. All of the constituents were below the limit of detection except those noted below. 1,4-Dioxane and diethyl ether were tentatively identified in wells 800060 and 800090 and acetone and tetrahydrofuran were tentatively identified in well 800060. Varying amounts of several phthalates were found in some wells. These materials are frequently found in waters as well as in background samples. The sample collected from 800071 in September 1991 contained several polynuclear aromatic hydrocarbons. The levels were low but methylphenol was also found which could indicate that coal residues were the source. The presence of these residues in this landfill is known. Follow-up samples will be obtained.

Acetone and 2-butanone were detected in samples from 800001. In 1990, the concentrations ranged from 53 to 66  $\mu\text{g/L}$  for acetone and from 14 to 17  $\mu\text{g/L}$  for 2-butanone. Results for 1991 are much lower, acetone ranging from 4-8  $\mu\text{g/L}$  and 2-butanone at 1.0  $\mu\text{g/L}$ . The magnitude of the results is probably less important than the continued presence of these substances.

## Radioactive Constituents

Samples collected from the 800 Area sanitary landfill monitoring wells were also analyzed for hydrogen-3. The results are shown in Tables 6.18 to 6.29. Although the disposal of radioactive materials is prohibited in the sanitary landfill, very low concentrations of hydrogen-3 were detected, probably due to inadvertent disposal of radioactivity in the ANL trash. However, the presence of hydrogen-3 as tritiated water allows information to be obtained on the subsurface water flow pathway in the sanitary landfill area. The data indicate that the principal direction of subsurface water flow is to the south-southeast, with a small component to the northwest. This is consistent with the estimated subsurface water flow based on water level measurements and general flow patterns in the area.

### 6.4. CP-5 Reactor Area

The CP-5 reactor is an inactive research reactor located in Building 330 (See Figure 1.1 for location). CP-5 was a 5 megawatt research reactor which was used from 1954 until operations were ceased in 1977. In addition to the reactor vessel itself, the CP-5 complex contained several large cooling towers and an outdoor equipment yard used for storage of equipment and supplies. The reactor and associated yard area is in the process of being decommissioned. There are currently plans to begin a full characterization of this site, starting in 1993. As a preliminary step to this study, a single exploratory monitoring well was installed in the yard, immediately behind the reactor building, just outside the reactor fuel storage area of the complex. This well was sampled quarterly and analyzed for radionuclides, metals, and volatile organic compounds. The results are shown in Table 6.30. In addition, a sample collected in September was also examined for semivolatiles, pesticides, herbicides and polychlorinated biphenyls.

This well 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 than similar wells at other locations. This

TABLE 6.30

## Groundwater Monitoring Results, 300 Area Well #330010, 1991

Constituent	Units	Well Point Elevation					m(MSL)
		03/22/91	05/14/91	05/14/91	09/10/91	12/06/91	215.7
							222.56
							Steel
Water Elevation	m	220.70	220.57	220.57	220.07	219.75	
Temperature	°C	12.3	14.1	14.1	19.0	15.7	
pH	pH	6.59	6.74	6.74	6.96	6.68	
Redox	mV	36	-50	-50	-51	-45	
Conductivity	µmhos/cm	1451	1568	1568	981	1054	
Arsenic	mg/L	0.0050	0.0041	0.0069	0.0072	< 0.0040	
Barium	mg/L	0.0975	0.1360	0.1421	0.1301	0.1282	
Beryllium	µg/L	0.4	0.3	0.6	0.6	0.2	
Cadmium	mg/L	0.0010	0.0004	0.0005	0.0008	0.0006	
Chloride	mg/L	207	275	271	112	59	
Chromium	mg/L	0.008	0.012	0.019	0.017	0.006	
Cobalt	mg/L	0.034	0.030	0.044	0.033	0.024	
Copper	mg/L	0.024	0.016	0.029	0.034	0.018	
Iron	mg/L	13.2	13.3	28.4	31.4	9.0	
Lead	mg/L	0.008	0.008	0.018	0.016	0.008	
Manganese	mg/L	1.262	1.253	1.463	1.071	1.050	
Mercury	µg/L	< 0.1	0.1	< 0.1	< 0.1	< 0.1	
Nickel	mg/L	0.053	0.060	0.088	0.070	0.040	
Silver	mg/L	< 0.0002	< 0.0002	0.0003	< 0.0002	< 0.0002	
Thallium	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	
Vanadium	mg/L	0.010	0.008	0.016	0.018	0.008	
Zinc	mg/L	0.057	0.044	0.088	0.099	0.035	
Cesium-137	pCi/L	< 1	< 1	-	< 1	< 1	
Hydrogen-3	nCi/L	6.453	5.839	-	5.682	4.034	
Strontium-90	pCi/L	1.62	1.56	-	0.73	1.02	
Bis(2-Ethylhexyl) Phthalate	µg/L	-	-	-	160	-	
Bis(2-Ethylhexyl) Phthalate	µg/L	-	-	-	38	-	
Di-N-Butyl Phthalate	µg/L	-	-	-	9	-	
Di-N-Butyl Phthalate	µg/L	-	-	-	8	-	
Diethyl Phthalate	µg/L	-	-	-	0.4	-	
Diethyl Phthalate	µg/L	-	-	-	0.4	-	
Acetone	µg/L	30	-	-	-	-	
Trichlorofluoromethane	µg/L	25	18	15	20	16	

observation is consistent with high chloride concentrations also observed in this well. Other wells on-site have been found to contain high chloride concentrations; however, most of these were located near roadways which are routinely salted during the winter for ice removal. The area around this well is not subject to these same activities. Relatively high concentrations of iron and manganese were also found. Arsenic levels ranged from < 4.0 to 7.2  $\mu\text{g/L}$ . Though these results are low, it is unusual to find any arsenic in groundwater in this area.

There were no volatile organic compounds identified in the samples studied in 1990. All of the samples collected and analyzed in 1991 contained trichlorofluoromethane at levels ranging from 15 to 25  $\mu\text{g/L}$ , which is well above the detection limit of 10  $\mu\text{g/L}$ . In addition the sample collected in March 1991 contained acetone. The sample collected in September 1991 contained the usual array of phthalates.

The levels of hydrogen-3 ranged from 4.0 to 6.5 nCi/L and the levels of strontium-90 ranged from 0.7 to 1.6 pCi/L. All values for cesium-137 were below the detection limit of 1.0 pCi/L. CP-5 was a heavy water-moderated reactor. During its operation life, several incidents occurred which 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 which may have condensed and fallen to the ground in the form of precipitation. These activities are believed to be responsible for the residual amounts of hydrogen-3 now found in the groundwater. The source of the strontium-90 is not known.

It is of interest to note that the levels of chloride and radioactivity were seen to decrease significantly during the first three quarters, stabilizing during the final quarter. This could be the result of the well purging and sampling activities pulling less contaminated water into the area around the well, diluting the constituents originally present in the soil and pore water. The additional characterization activities planned for 1993 will define the extent of this contamination.

## 6.5. Site Characterization Activities

Historical information about waste disposal activities on the ANL site, as well as groundwater monitoring results, indicate that several sites are either currently releasing small amounts of hazardous materials to the environment or have the potential to do so in the future. As a first step to stopping these releases and cleaning up any residual contamination, a series of site characterization projects is underway. To date, these projects have focused on the most significant sites, the 800 Area landfill and the 317/319 Areas. The studies are in the preliminary stages, and thus the information available is currently incomplete and may not accurately represent the actual conditions at these sites. Characterization activities are currently scheduled to extend beyond 1994.

### 6.5.1. 800 Area Landfill Characterization

The characterization activities at the landfill have thus far been limited to the collection of a series of soil gas and shallow groundwater samples from in and near the fill material. The results of this analysis have shown that significant amounts of volatile organic compounds are present in the fill material and leachate. A large number of compounds have been detected, most of which are listed on the log of wastes poured into the old French drain in the north end of the site. It appears that volatile organics are present throughout most of the fill material. The distribution of these chemicals throughout the fill was found to be highly variable, indicating the possibility of multiple sources within the waste.

In addition to volatile organics, a number of semivolatile organics have also been identified including benzoic acid, phenol and several substituted phenols, a number of phthalates and several polynuclear aromatic hydrocarbons. The concentration of these compounds was generally lower than the volatile organics.

One sampling point, near the site of the French drain, yielded a sample containing significant amounts (over 109  $\mu\text{g/L}$  total) of two different PCBs, Aroclor 1254 and Aroclor 1260. The sample contained a small amount of

floating oil, indicating that the source of PCB was probably the disposal of PCB-containing waste oils. One monitoring well, 800090, has shown measurable amounts of the PCB Aroclor 1254 on at least one occasion.

Additional characterization activities planned for 1992 and beyond will more completely define the nature and amount of contaminants present in the fill material. A detailed hydrogeological study will be conducted to identify the location, direction of movement and velocity of groundwater below the landfill and to determine the potential for migration of these chemicals off-site. The magnitude of any existing groundwater contamination will also be determined. Remedial actions necessary to clean up or contain the hazardous constituents in the landfill and groundwater will then be selected and implemented.

#### 6.5.2. 317/319 Area Characterization

A similar study was conducted in the 317/319 Area involving the collection of soil gas and shallow groundwater samples. The data generated by this study indicates that two distinct areas of highly contaminated soil exist, one near the site of the French drain in the 317 Area and the other in the 319 Area landfill. A larger number of organic compounds were identified in the 317 Area, some at very high concentrations (over 100,000  $\mu\text{g/L}$ ). A relatively small area of highly contaminated soil was found to exist, just north of the vaults used for storage of radioactive wastes. Significant, but much lower concentrations of volatile organics were found several hundred feet from the vault area, indicating that movement of the contamination through the soil is occurring. This is consistent with the results of the monitoring well sampling discussed in this chapter. Samples of shallow groundwater [less than 3 m (10 ft) deep] collected on Forest Preserve property south of the ANL fence line indicate that low levels of several ketones have moved off-site. The depth and extent of groundwater contamination is not fully defined at this time.

The 319 Area, which contained a similar French drain, was also found to contain a large number of organic compounds, although the concentrations were much lower than in the 317 Area. The French drain in this area was

much deeper than the one in the 317 area. Since the techniques used in this preliminary investigation were limited to a depth of approximately 3 m (10 ft) below the surface, they may not have been able to detect contamination located deep within the 319 waste pile.

One sample recovered from the 319 area was found to contain relatively high concentrations of two PCBs, Aroclor 1254 and Aroclor 1260 (220  $\mu\text{g}/\text{L}$  total). A floating oil layer was encountered at this point, indicating the PCBs were the result of disposal of PCB-containing waste oils.

Additional characterization activities planned for 1992 and beyond will better define the nature and extent of soil and groundwater contamination and will determine if hazardous materials have migrated into underlying aquifers. A detailed hydrogeological study will be conducted to define the location, direction of movement and velocity of groundwater below the 317/319 Area. Remedial actions necessary to clean up or contain the hazardous constituents in this area will then be selected and implemented.

## 7. QUALITY ASSURANCE

Quality Assurance (QA) plans exist for both radiological (H 0030-0003-QA-00) and non-radiological (H 0030-0002-QA-01) analyses. Both QA documents were prepared in accordance with ANSI/ASMC NQA-1 and meet the requirements of ANL QA documents.<sup>27,28</sup> The plans discuss responsibilities and auditability. Both documents are supplemented by operating manuals.

### 7.1. Radiochemical Analysis and Radioactivity Measurements

All nuclear instrumentation is calibrated with standard sources obtained from the National Institute of Standards and Technology (NIST), if possible. If NIST standards are not available for particular nuclides, NIST traceable standards from the Amersham Corporation are used. The equipment is usually 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 was not detected, the result is given as "less than" (<) the detection limit by the analytical method used. The detection limits were 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 are given in Table 7.1. The relative error in a result decreases with increasing concentration. At a concentration equal to twice the detection limit, the error is about 50% of the measured value and at ten times the detection limit, the error is about 10%.

Average values are usually 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. Since 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

TABLE 7.1

## Detection Limits

Nuclide or Activity	Air (fCi/m <sup>3</sup> )	Water (pCi/L)
Americium-241	-	0.001
Beryllium-7	5	-
Californium-249	-	0.001
Californium-252	-	0.001
Cesium-137	0.1	1
Curium-242	-	0.001
Curium-244	-	0.001
Hydrogen-3	100	100
Lead-210	1	-
Neptunium-237	-	0.001
Plutonium-238	0.0003	0.001
Plutonium-239	0.0003	0.001
Radium-226	-	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	0.0003	0.01
Uranium-235	0.0003	0.01
Uranium-238	0.0003	0.01
Uranium - natural	0.02	0.2
Alpha	0.2	0.2
Beta	0.5	1

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 plus-or-minus value accompanies an individual result in this report, it represents the statistical counting error at the 95% confidence level.

Standard and intercomparison samples distributed by the Quality Assurance Branch of the EPA are analyzed regularly. Results of ANL's participation in the EPA program during 1991 are given in Table 7.2. In the table, the comparison is made between the EPA value, which is the quantity added to the sample by that laboratory, is compared with the value obtained in the ANL laboratory. Certain information may assist in judging the quality of the results, including the fact that typical uncertainties for the ANL analyses are 2% to 50%, depending on the concentration and the nuclide, and the uncertainties in the EPA results are 2% to 5% (ANL estimate).

In addition, participation continued in the DOE Environmental Measurements Laboratory Quality Assurance Program (DOE-EML-QAP), a semi-annual distribution of four different sample matrices containing various combinations of radionuclides that are analyzed. Results for 1991 are summarized in Table 7.3. 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 laboratory. Information that will assist in judging the quality of the results includes the fact that typical uncertainties for ANL'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.

## 7.2. Chemical Analysis

The documentation for nonradiological analyses is contained in an Industrial Hygiene Operating Manual (IHOM), which includes a sampling and analysis plan, as well as individual analytical and collection procedures.

TABLE 7.2

## Summary of EPA Samples, 1991

Type of Sample	Analysis	Number Analyzed	Average Difference from Added (%)
Air Filter	Total Alpha	2	20
	Total Beta	2	6
	Strontium-90	2	3
	Cesium-137	2	9
Milk	Potassium-40	2	3
	Strontium-89	2	8
	Strontium-90	2	10
	Iodine-131	2	3
	Cesium-137	2	1
Water	Hydrogen-3	3	3
	Cobalt-60	3	2
	Zinc-65	3	3
	Strontium-89	3	7
	Strontium-90	3	15
	Ruthenium-106	3	3
	Iodine-131	2	3
	Cesium-134	4	8
	Cesium-137	4	6
	Barium-133	3	5
	Radium-226	1	15
	Radium-228	1	15
	Total Uranium	3	16
	Plutonium-239	2	5

TABLE 7.3

Summary of DOE-EML-QAP Samples, 1991

Radionuclide	Percent Difference From EML Value			
	Air Filters	Soil	Vegetation	Water
Hydrogen-3	-	-	-	1 (2)
Beryllium-7	2 (2)	-	-	-
Potassium-40	-	12 (2)	24 (2)	-
Manganese-54	9 (2)	-	-	7 (2)
Cobalt-57	9 (2)	-	-	6 (2)
Cobalt-60	3 (2)	-	-	4 (2)
Strontium-90	23 (2)	25 (2)	22 (1)	4 (2)
Cesium-137	10 (2)	6 (2)	15 (2)	8 (2)
Cerium-144	10 (2)	-	-	8 (1)
Uranium-234	8 (2)	26 (2)	-	6 (2)
Uranium-238	11 (2)	38 (2)	-	5 (2)
Plutonium-238	-	24 (1)	18 (1)	-
Plutonium-239	8 (2)	2 (1)	0 (1)	12 (2)
Americium-241	15 (2)	8 (1)	10 (1)	20 (2)

Note: The value in parentheses is the number of samples.

All samples for NPDES and groundwater are collected and analyzed in accordance with EPA regulations found in EPA-600/4-84-017,<sup>29</sup> SW-846,<sup>30</sup> and 40 CFR Part 136.<sup>21</sup>

Standard Reference Materials (SRM), traceable to the NIST, exist for most inorganic analyses (see Table 7.4). These are replaced annually. Detection limits are determined with techniques listed in Report SW-846.<sup>30</sup> In general, the detection limit is the measure of the variability ( $\sigma$ ) of a standard material measurement at 5-10 times the instrument detection limit as measured over an extended time period. Recovery of inorganic metals, as determined by "spiking" unknown solutions, must be in the range of 75% to 125%. The precision, as determined by analysis of duplicate samples, must be within 20%. These measurements must be made on at least 10% of the samples. Comparison samples for organic constituents were formerly available from the EPA, but are now commercially available under the Cooperative Research and Development Agreement (CRADA) which exists between the EPA and commercial laboratories. Many of these standards are used in this work. At least one standard mixture is analyzed each month and the results for 1991 are shown in Table 7.5. The recoveries listed are those developed by the manufacturer and are at the 95% confidence interval.

Argonne participates in the EPA Discharge Monitoring Report Quality Assurance Program. Results for 1991 are listed in Table 7.6. All results were acceptable except for the COD value. Corrective action was taken to resolve the problem.

TABLE 7.4

## NIST-SRM Used for Inorganic Analysis

NIST-SRM	Contents
3103	Arsenic
3104	Barium
3105	Beryllium
3108	Cadmium
3112	Chromium
3113	Cobalt
3114	Copper
3126	Iron
3128	Lead
3132	Manganese
3133	Mercury
3136	Nickel
3149	Selenium
3151	Silver
3165	Vanadium
3168	Zinc
3181	Sulfate
3182	Chloride
3183	Fluoride

TABLE 7.5

EPA Quality Check Sample Results, 1991

Compound	Percent Recovery	Percent Quality Limits
Benzene	100.0	73-126
Bromobenzene	104.3	76-133
Bromodichloromethane	113.5	101-138
Bromoform	93.5	57-156
Butylbenzene	106.0	71-125
sec-Butylbenzene	108.5	71-145
t-Butylbenzene	107.4	69-134
Carbon Tetrachloride	88.0	86-118
Chlorobenzene	96.5	80-137
Chloroform	96.0	68-120
o-Chlorotoluene	124.0	81-146
p-Chlorotoluene	104.4	73-144
1,2-Dibromo-3-chloropropane	98.0	36-154
Dibromochloromethane	111.8	68-130
1,2-Dibromomethane	93.6	75-149
Dibromomethane	38.6	65-143
1,2-Dichlorobenzene	91.0	59-174
1,3-Dichlorobenzene	103.0	84-143
1,4-Dichlorobenzene	110.4	58-172
1,1-Dichloroethane	95.0	71-142
1,2-Dichloroethane	99.5	70-134
1,1-Dichloroethene	102.0	18-209
cis-1,2-Dichloroethene	121.8	85-124
trans-1,2-Dichloroethene	99.0	67-141
1,2-Dichloropropane	100.0	19-179
1,3-Dichloropropane	111.9	73-145
1,1-Dichloropropane	106.5	71-133
Ethyl Benzene	107.8	84-130
Isopropylbenzene	100.0	70-144
4-Isopropyltoluene	105.0	72-140
Methylene Chloride	109.6	D-197
n-Propylbenzene	104.0	78-139
1,1,1,2-Tetrachloroethane	89.0	88-133
Tetrachloroethene	109.9	84-132
Toluene	97.1	81-130
1,1,1-Trichloroethane	90.6	68-149
1,1,2-Trichloroethane	108.3	70-133
Trichloroethene	104.4	91-135
1,2,3-Trichloropropane	72.8	50-158
1,2,4-Trimethylbenzene	109.0	80-144
1,3,5-Trimethylbenzene	100.0	76-142
o-Xylene	119.0	79-141
p-Xylene	114.7	74-138

Note: D denotes the compound was detected.

TABLE 7.6

## Summary of EPA Nonradiological Samples, 1991

Constituent	Average Difference From Reference Value (%)
Chromium	-7
Copper	+3
Iron	+0.7
Lead	-14
Manganese	+2
Mercury	-4
pH	-0.1 unit
Zinc	+5
Total Suspended Solids	-22
Oil and Grease	-21
Chemical Oxygen Demand	27

## 8. APPENDIX

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