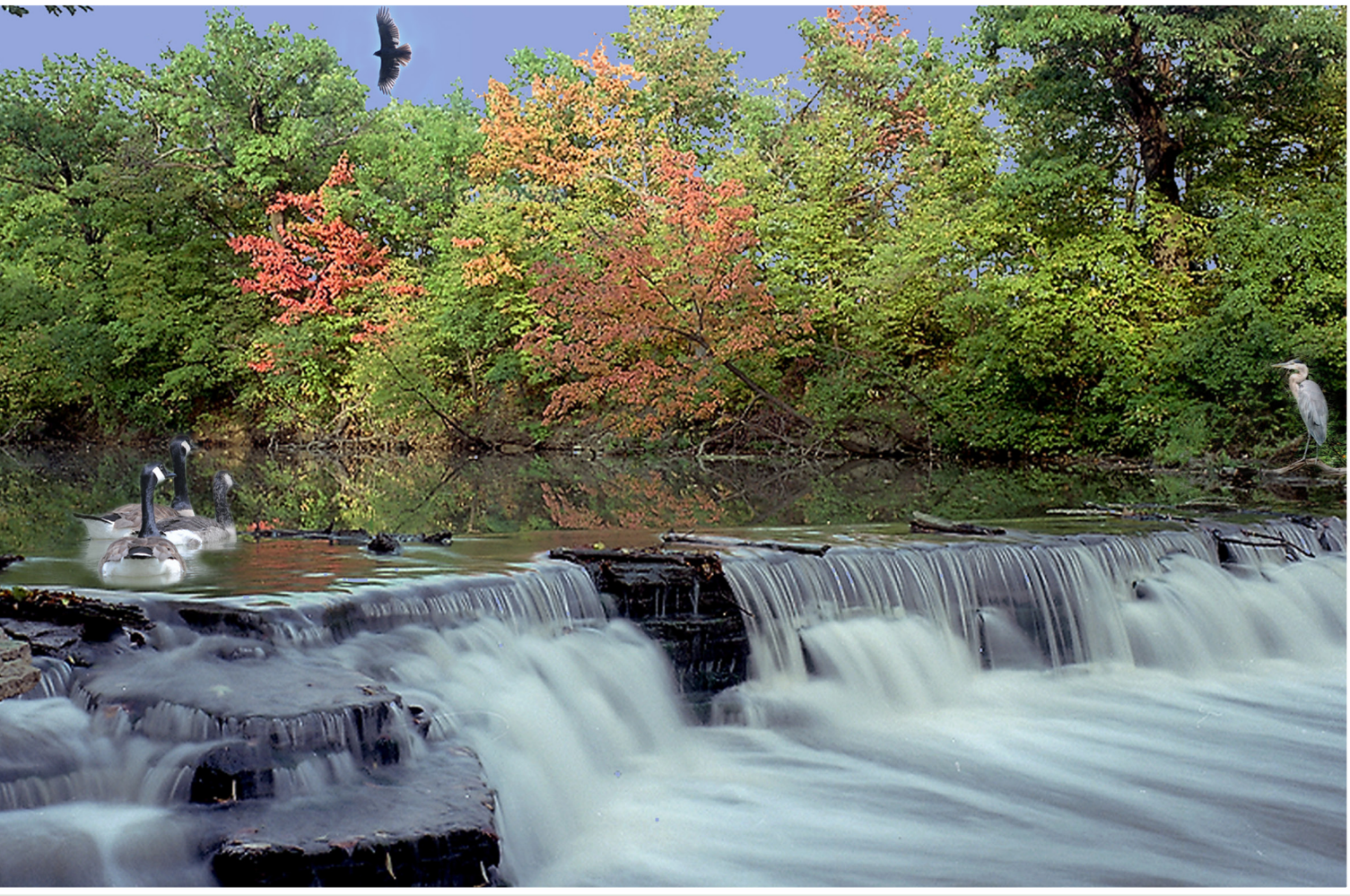
Argonne NATIONAL LABORATORY

ANL-09/02

Site Environmental Report

for Calendar Year 2008

Environment, Safety, and Health/Quality Assurance Division



About Argonne National Laboratory
Argonne is a U.S. Department of Energy laboratory managed by UChicago Argonne, LLC under contract DE-AC02-06CH11357. The Laboratory's main facility is outside Chicago, at 9700 South Cass Avenue, Argonne, Illinois 60439. For information about Argonne, see www.anl.gov.

Availability of This Report
This report is available, at no cost, at http://www.osti.gov/bridge. It is also available on paper to the U.S. Department of Energy and its contractors, for a processing fee, from:

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
phone (865) 576-8401
fax (865) 576-5728
reports@adonis.osti.gov

ANL-09/02

Argonne National Laboratory Site Environmental Report for Calendar Year 2008

Preceding Report in This Series: ANL-08/05

by
N.W. Golchert, T.M. Davis, and L.P. Moos
Environment, Safety, and Health/Quality Assurance Division
Argonne National Laboratory

September 2009

A NOTE FROM THE AUTHORS

This Site Environmental Report (SER) was prepared by the Environment, Safety, and Health/Quality Assurance (ESQ) Division at Argonne National Laboratory (Argonne) for the U.S. Department of Energy (DOE). The results of the environmental monitoring program and an assessment of the impact of site operations on the environment and the public are presented in this publication. This SER and those for recent years are available on the Internet at http://www.anl.gov/ESH/anleser/.

The majority of the figures and tables were prepared by Jennifer Tucker of the Data Management Team. Some figures, however, were prepared by Amanda Hollingsworth of the Ecological and Geographical Sciences Section of Argonne's Environmental Science Division (EVS). Sample collection and field measurements were conducted, under the direction of Larry Moos of the Environmental Monitoring and Surveillance Group, by:

Tony Fracaro
Jennifer Gomez
Rob Piorkowski
Jennifer Tucker

The members of the Environmental Monitoring and Surveillance Group are shown in the photograph at the beginning of Chapter 1.

The analytical separations and measurements were conducted by the ESQ Analytical Services Group by:

Gerald Baudino
Tim Branch
Theresa Davis
Alan Demkovich
Robert Froom
Gary Griffin
Jim Riha
Mary Salisbury
Denise Seeman
Anil Thakkar
Bettylou Wahl
Jianhua Zhang

Most members of the ESQ Analytical Services Group are shown in the photograph at the beginning of Chapter 7. Gerald Baudino provided most of the data in Chapter 7.

A NOTE FROM THE AUTHORS

The following staff made informational contributions to this report:

Greg Barrett
John Daum
Gary Griffin
Jim Heine
Devin Hodge
Rob Hrabak
Mark Kamiya
Gregg Kulma
Susan Lorenz
Bill Luck
Tim Martin
Geoff Pierce
Rob Piorkowski
Earl Powell
Bob Utesch
Robert Van Lonkhuyzen
Gary Winner

Members of the ESQ Environmental Compliance Group are shown in the photograph at the beginning of Chapter 2.

Support to prepare this report was provided by Terri Schneider (ESQ). Editorial and document preparation services were provided by Linda Graf, Pat Hollopeter, and Lorenza Salinas of the Business and Technical Communications Group of Argonne's Technical Services Division (TSD).

This report was printed by TSD's Print and Business Services Group under the direction of Gary Weidner by:

John Schneider
Mike Vaught

All the photos in this report were taken by George Joch of TSD's Visual Arts Group. Cindi Andersen, a contractor for TSD's Visual Arts Group, prepared the cover.

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

ACHP	Advisory Council for Historic Preservation
ACM	Asbestos-Containing Material
AEA	Atomic Energy Act of 1954
ALARA	As Low As Reasonably Achievable
ALD	Associate Laboratory Director
AOC	Area of Concern
APES	Argonne Property Excess System
APS	Advanced Photon Source
Argonne	Argonne National Laboratory
ATLAS	Argonne Tandem Linac Accelerating System
BAT	Best Available Technology
BCG	Biota Concentration Guide
BOD_5	Biochemical Oxygen Demand
CAA	Clean Air Act
CAAPP	Clean Air Act Permit Program
CAP-88	Clean Air Act Assessment Package-1988
CARB	California Air Resources Board
CCA	Compliance Commitment Agreement
CEDE	Committed Effective Dose Equivalent
CEMP	Comprehensive Emergency Management Plan
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
CLP	Contract Laboratory Program
COA	Compliance, Oversight, and Assessments
COD	Chemical Oxygen Demand
COE	U.S. Army Corps of Engineers
CP-5	Chicago Pile-Five
CRMP	Cultural Resources Management Plan
CWA	Clean Water Act
D&D	Decontamination and Decommissioning
DCA	1,1-Dichloroethane
DMR	Discharge Monitoring Report
DOE	U.S. Department of Energy
DOE-ASO	DOE Argonne Site Office
EA	Environmental Assessment
EHS	Extremely Hazardous Substance
EIS	Environmental Impact Statement
EMS	Environmental Management System
ENE	East-Northeast
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EPC	Environmental Planning and Compliance

EPCRA	Emergency Planning and Community Right to Know Act
ESA	Endangered Species Act of 1973
ESH	Environment, Safety, and Health
ESQ	Environment, Safety, and Health/Quality Assurance
ESQ-AS	ESQ, Analytical Services
FFCA	Federal Facility Compliance Act of 1992
FMS	Facilities Management and Services
FY	Fiscal Year
GMZ	Groundwater Management Zone
GQS	Groundwater Quality Standard
GRO	Groundwater Remediation Objective
HAP	Hazardous Air Pollutant
HSWA	Hazardous and Solid Waste Amendments of 1984
IAC	*Illinois Administrative Code*
ICRP	International Commission on Radiological Protection
IDPH	Illinois Department of Public Health
IEPA	Illinois Environmental Protection Agency
IHPA	Illinois Historic Preservation Agency
IPNS	Intense Pulsed Neutron Source
ISMS	Integrated Safety Management System
ISO	International Organization for Standardization
LEPC	Local Emergency Planning Committee
LLW	Low-Level Radioactive Waste
LMS	Laboratory Management System
LTS	Long-Term Stewardship
LWTP	Laboratory Wastewater Treatment Plant
MAPEP	Mixed Analyte Performance Evaluation Program
MSDS	Material Safety Data Sheet
MW	Mixed Waste
MY	Model Year
NBL	New Brunswick Laboratory
NEPA	National Environmental Policy Act of 1969
NESHAP	National Emission Standards for Hazardous Air Pollutants
NFA	No Further Action
NHPA	National Historic Preservation Act of 1966
NIST	National Institute of Standards and Technology
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List

NRC	National Response Center
NRHP	*National Register of Historic Places*
P2	Pollution Prevention
PA	Programmatic Agreement
PBT	Persistent, Bioaccumulative Toxic
PCB	Polychlorinated Biphenyl
POL	Policy
PPOA	Pollution Prevention Opportunity Assessment
PQL	Practical Quantitation Limit
PROC	Procedure
PSTP	Proposed Site Treatment Plan
PVC	Polyvinyl Chloride
QA	Quality Assurance
QC	Quality Control
R&D	Research and Development
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RQ	Reportable Quantity
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act of 1974
SER	Site Environmental Report
SERC	State Emergency Response Commission
SHPO	State Historic Preservation Office
SIP	State Implementation Plan
SOP	Standard Operating Procedure
SPCC	Spill Prevention Control and Countermeasures
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
SWPPP	Stormwater Pollution Prevention Plan
SWTP	Sanitary Wastewater Treatment Plant
TCA	1,1,1-Trichloroethane
TCE	Trichloroethene
TCS	Theory and Computing Sciences
TDS	Total Dissolved Solids
THM	Trihalomethanes
TLD	Thermoluminescent Dosimeter
TOC	Total Organic Carbon
TOX	Total Organic Halogens
TRC	Total Residual Chlorine
TRI	Toxic Release Inventory
TRU	Transuranic Waste

TSCA	Toxic Substances Control Act
TSD	Technical Services Division
TSS	Total Suspended Solids
USFWS	U.S. Fish and Wildlife Service
UST	Underground Storage Tank
VOC	Volatile Organic Compound
VOM	Volatile Organic Matter
WM	Waste Minimization
WMO	Waste Management Operations
WQS	Water Quality Standard
WTP	Wastewater Treatment Plant
ZPR	Zero Power Reactor

ABSTRACT

This report discusses the status and the accomplishments of the environmental protection program at Argonne National Laboratory for calendar year 2008. The status of Argonne environmental protection activities with respect to compliance with the various laws and regulations is discussed, along with the progress of environmental corrective actions and restoration projects. To evaluate the effects of Argonne operations on the environment, samples of environmental media collected on the site, at the site boundary, and off the Argonne site were analyzed and compared with applicable guidelines and standards. A variety of radionuclides were measured in air, surface water, on-site groundwater, and bottom sediment samples. In addition, chemical constituents in surface water, groundwater, and Argonne effluent water were analyzed. External penetrating radiation doses were measured, and the potential for radiation exposure to off-site population groups was estimated. Results are interpreted in terms of the origin of the radioactive and chemical substances (i.e., natural, fallout, Argonne, and other) and are compared with applicable environmental quality standards. A U.S. Department of Energy dose calculation methodology, based on International Commission on Radiological Protection recommendations and the U.S. Environmental Protection Agency's CAP-88 Version 3 (Clean Air Act Assessment Package-1988) computer code, was used in preparing this report.

ABSTRACT

This report summarizes the ongoing environmental protection program activities conducted by Argonne National Laboratory (Argonne) in calendar year 2008. It includes descriptions of the site, Argonne missions and programs, the status of compliance with environmental regulations, environmental protection and restoration activities, and the environmental surveillance program. Members of the surveillance program regularly conduct monitoring for radiation, radioactive materials, and nonradiological constituents on the Argonne 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 Argonne's impact on the environment. The surveillance program supports the Argonne policy of protecting the public, employees, and the environment from harm that may result from Argonne activities and reducing environmental impacts to the greatest degree practicable.

Executive Orders 13148 and 13423 and U.S. Department of Energy (DOE) Order 450.1A require that an Environmental Management System (EMS) be implemented at Argonne. In December 2005, the DOE Argonne Site Office (DOE-ASO) manager certified that the EMS had been implemented. Part of the implementation of the EMS was the integration of the EMS into the Integrated Safety Management System (ISMS).

Compliance Summary

Radionuclide emissions, the management of asbestos, and discharge of conventional air pollutants from Argonne facilities are regulated under the Clean Air Act (CAA). A number of airborne radiological emission points at Argonne are subject to National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations for radionuclide releases from DOE facilities (Title 40 of the *Code of Federal Regulations*, Part 61, Subpart H [40 CFR Part 61, Subpart H]). All such air emission sources were evaluated to ensure that these requirements are being addressed properly. The estimated dose to the maximally exposed off-site individual for 2008 was 0.0034 mrem/yr. This is 0.03% of the 10-mrem/yr standard. This dose is approximately 10 times lower than that in 2007 due to the termination of the operation of the Intense Pulsed Neutron Source (IPNS) facility. This dose does not include contributions from radon-220 and radon-222 emissions, which are exempted in the regulations.

At Argonne, asbestos-containing material (ACM) frequently is encountered during maintenance or renovation of existing facilities and equipment. Asbestos is removed and disposed of in strict accordance with NESHAP and Occupational Safety and Health Administration worker protection standards. Approximately 85.5 m^3 (3,020 ft^3) of ACM was removed and disposed of at off-site landfills in Illinois during 2008.

The Argonne site contains sources of conventional air pollutants, including a steam plant, gasoline and ethanol/gasoline blend fuel-dispensing facilities, a dust-collection system, an engine test facility, a surface treatment facility for etching research equipment, a number of diesel generators, and a wastewater treatment plant. The Illinois Environmental Protection Agency (IEPA) issued the final Argonne Clean Air Act Permit Program (CAAPP) Title V permit in April 2001 and renewed it in October 2006. All previous air operating permits (with the

exception of the open burning permits) were incorporated into this sitewide permit for all emission sources and activities. The Argonne CAAPP Title V permit requires continuous opacity and sulfur dioxide monitoring of the steam plant smoke stack from Boiler No. 5, the only boiler equipped to burn coal. Low-sulfur coal was burned in Boiler No. 5 for four months during 2008. During the period coal was burned, no exceedances were recorded.

The goals of the Clean Water Act (CWA) are achieved primarily through the National Pollutant Discharge Elimination System (NPDES) permit program. The federal government has delegated implementation of the NPDES program to the State of Illinois. The IEPA reissued the current permit effective September 1, 2005. During 2008, 12 exceedances of NPDES permit limits were reported out of approximately 1,800 measurements.

The IEPA issued a Resource Conservation and Recovery Act (RCRA) Part B permit on September 30, 1997, which became effective on November 4, 1997. The permit addresses 24 hazardous waste treatment and storage facilities and establishes corrective action procedures and requirements for 49 Solid Waste Management Units (SWMUs) and 3 Areas of Concern (AOCs). Since the issuance of the permit, three additional AOCs have been added to the permit. By September 30, 2003, all planned remediation work was completed. However, ongoing activities are being conducted at five SWMUs, and two new AOC units were identified in recent years and are undergoing investigation. These five SWMUs require monitoring as part of the Argonne Long-Term Stewardship (LTS) Program.

Argonne has prepared and implemented a sitewide underground storage tank (UST) compliance plan. The Argonne site contains 12 USTs, which are in compliance with UST regulations.

The only Toxic Substances Control Act (TSCA)-regulated compounds present in significant quantities at Argonne are polychlorinated biphenyls (PCBs) contained in large and small electrical capacitors, power supplies, and small transformers. The Argonne PCB Item Inventory Program was initiated in 1995 to identify all suspect PCB-containing items. All pole-mounted transformers and circuit breakers containing PCBs have been replaced or retrofilled with non-PCB oil. All removal and disposal activities were conducted by licensed contractors specializing in such operations.

In 2008, all projects requiring National Environmental Policy Act (NEPA) assessment were determined to be Categorical Exclusions.

Environmental Surveillance Program

Airborne emissions of radioactive materials from Argonne were monitored during 2008. The effective dose equivalents were estimated at the site perimeter and to a hypothetical maximally exposed member of the public by using the U.S. Environmental Protection Agency's CAP-88 (CAA Assessment Package-1988) Version 3.0 computer code. The estimated maximum perimeter dose from airborne releases was 0.030 mrem/yr in the north-northeast direction, while the estimated maximum dose to a member of the public was 0.013 mrem/yr. If the contribution

of radon-220 is excluded from reporting, as required by 40 CFR Part 61, Subpart H, the estimated dose to a maximally exposed member of the public would be 0.0034 mrem/yr. The estimated population dose from releases to the approximately nine million people living within 80 km (50 mi) of the site was 0.31 person-rem.

Monitoring of radioactivity associated with particulates in ambient air was conducted for total alpha activity, total beta activity, and gamma-ray emitters at the Argonne site perimeter and at off-site locations. No statistically significant difference was identified between samples collected at the Argonne perimeter and samples collected off-site. Monitoring was not conducted for hazardous chemical constituents in ambient air.

The only detectable radionuclides in surface water due to Argonne releases were in Sawmill Creek below the wastewater discharge point. At various times, measurable levels of hydrogen-3, strontium-90, plutonium-239, and americium-241 were detected. Of these radionuclides, the maximum annual release was 0.11 Ci of hydrogen-3. The amount of other radionuclides released totaled less than 0.001 Ci. The hydrogen-3 was added to the wastewater as part of normal Argonne operations. The dose to a hypothetical individual using water from Sawmill Creek as his or her sole source of drinking water would be 0.012 mrem/yr. However, no one uses this water for drinking, and dilution by the Des Plaines River reduces the concentrations of the measured radionuclides to levels below their respective detection limits downstream from Argonne at Lemont. Sawmill Creek also is monitored for nonradiological constituents to demonstrate compliance with State of Illinois water quality standards. No parameters were detected above the limits established by the standards.

Sediment samples were collected from Sawmill Creek above, at, and below the point of wastewater treatment plant effluent discharge. Slightly above background levels of plutonium-239 (up to 0.14 pCi/g) and americium-241 (up to 0.04 pCi/g) were detected in the sediment below the outfall and are attributed to past Argonne releases.

Dose rates from penetrating radiation (gamma rays) were measured at 17 perimeter and on-site locations and at 5 off-site locations in 2008 by using thermoluminescent dosimeters. The off-site results averaged 97 ± 15 mrem/yr, which is similar to the long-term average dose rate. The estimated dose rate from penetrating radiation to the nearest resident south of the site was less than 0.01 mrem/yr.

The potential radiation doses to members of the public from all sources and pathways due to Argonne operations during 2008 were estimated by combining the exposures from inhalation, ingestion, and direct radiation pathways. The inhalation pathway would be primary. The highest estimated dose was approximately 0.026 mrem/yr to a hypothetical individual living east of the site, assuming that he or she was outdoors at that location during the entire year and drinking Sawmill Creek water. Estimated doses from other pathways were not significant by comparison. The doses from Argonne operations are well within all applicable standards and are insignificant when compared with doses received by the public from natural radiation (≈300 mrem/yr) or other sources, for example, medical x-rays and consumer products (≈60 mrem/yr).

Radiological and chemical constituents in the groundwater were monitored in several areas of the Argonne site in 2008. The former Argonne domestic water supply is monitored by collecting quarterly samples from the two operating inactive supply wells. All results from water supply wells were less than the limits established by the Safe Drinking Water Act (SDWA).

Eight monitoring wells screened in glacial drift and two in dolomite were sampled quarterly at the 317 and 319 Areas and analyzed for radiological, volatile organic, semivolatile organic, PCB, pesticide, and herbicide constituents. The major organic contaminants detected were 1,4-dioxane; 1,1,1-trichloroethane; trichloroethene; and 1,1-dichloroethane. Measurable levels of hydrogen-3 were present in several of the wells.

Argonne conducts an LTS program to operate and monitor environmental cleanup actions implemented in recent years. This program focuses primarily on several former waste management units in the 317, 319, and East-Northeast (ENE) areas at the extreme southern end of the site. Remedial actions managed by this program include inspection and maintenance of two landfill caps, operation and maintenance of two groundwater collection systems, a phytoremediation system, and a groundwater monitoring program. Monitoring of these systems indicates that significant contamination of groundwater exists below two of the waste units. High concentrations of volatile organic compounds (VOCs) are present in and downgradient of a former chemical waste disposal unit (French drain) in the 317 Area. Measurable levels of hydrogen-3 are found under the 319 Area Landfill, though these concentrations are currently much lower than in previous years. Very low concentrations of several VOCs are routinely found in several small off-site groundwater seeps in the Waterfall Glen Forest Preserve. Ongoing remedial actions should continue to reduce the concentrations of these contaminants in coming years. A Groundwater Management Zone (GMZ) has been established around the 317/319 Area to facilitate the remediation of contaminated groundwater. Monitoring of the GMZ perimeter wells indicates that the groundwater plume has not migrated beyond the original boundaries. Monitoring of the landfill in the ENE Area indicates that hazardous materials in the waste are not being released to the groundwater.

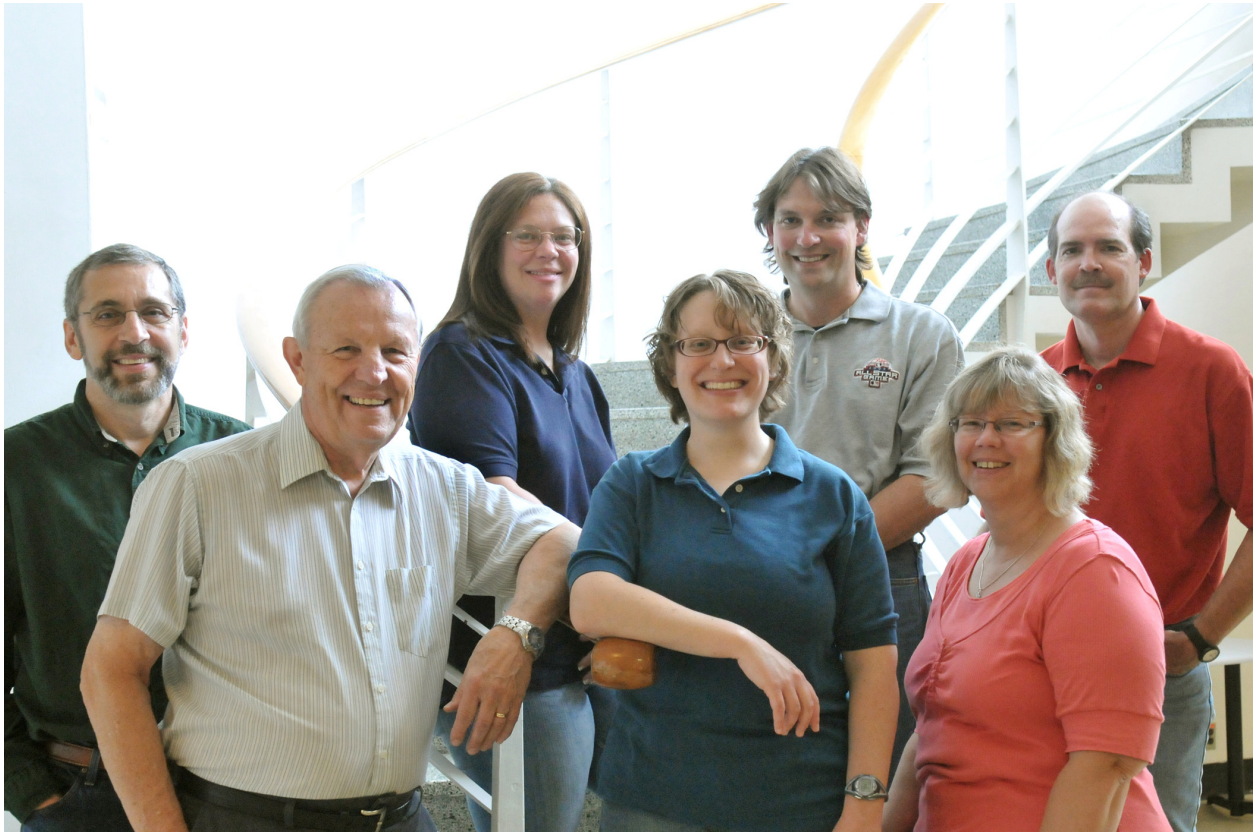
Twenty-one monitoring wells at the 800 Area Landfill were sampled on a quarterly basis and analyzed for hydrogen-3, metals, cyanide, phenols, total organic carbon (TOC), total organic halogens (TOX), and VOCs, and annually for semivolatile organic compounds (SVOCs), PCBs, pesticides, and herbicides. As in previous years, levels exceeding background concentrations for ammonia, chloride, iron, lead, manganese, sulfate, TOC, and total dissolved solids were found in some wells. Above-background levels of hydrogen-3 were detected in several of the wells, with concentrations up to 245 pCi/L.

Nine monitoring wells are screened in the glacial drift and one in the dolomite adjacent to the Chicago Pile-Five (CP-5) reactor. These wells were sampled quarterly, and samples were analyzed for selected radionuclides and metals. Elevated levels of hydrogen-3 and strontium-90 were detected regularly; however, these concentrations are localized and not migrating.

An extensive quality assurance program is maintained to cover all aspects of the environmental surveillance sampling and analysis programs. Approved documents are in place, along with supporting standard operating procedures. Newly collected data were compared with

recent results and historical data to ensure that deviations from previous conditions were identified and evaluated promptly. Samples at all locations were collected by using well-established and documented procedures to ensure consistency. Samples were analyzed by means of documented standard analytical procedures. Data quality was verified by a continuing program of analytical laboratory quality control, participation in interlaboratory cross-checks, and replicate sampling and analysis. Data were managed and tracked by a dedicated computerized data management system that assigns unique sample numbers, schedules collection and analysis, checks status, and prepares tables and information for this annual report.

1. INTRODUCTION



1. INTRODUCTION

1.1. General

This annual report for calendar year 2008 of the Argonne National Laboratory (Argonne) environmental protection program was prepared to inform the U.S. Department of Energy (DOE), environmental agencies, and the public about the levels of radioactive and chemical pollutants in the vicinity of Argonne and the amounts, if any, added to the environment by Argonne operations. It also summarizes the compliance of Argonne operations with applicable environmental laws and regulations and highlights significant accomplishments and issues related to environmental protection and remediation. The report was prepared in accordance with the guidelines of DOE Orders 450.1A[1] and 231.1A[2] and supplemental DOE guidance.

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

Argonne is a DOE research and development (R&D) laboratory with several principal objectives. Argonne conducts a broad program of research in the basic energy and related sciences (i.e., physical, chemical, material, computer, nuclear, biomedical, and environmental) and serves as an important engineering center for the study of nuclear and non-nuclear energy sources. Energy-related research projects conducted during 2008 included safety studies for light-water reactors; high-temperature superconductivity experiments; development of electrochemical energy sources, including fuel cells and batteries for vehicles and energy storage; engineered nanomaterials; and studies to promote clean, efficient transportation.

Other R&D areas include basic biological research, heavy-ion research into the properties of super-heavy elements, the immobilization of radioactive waste products for safe disposal, fundamental studies of advanced computers, and the development of advanced computing technologies. Environmental research studies include the biological activity of energy-related mutagens and carcinogens, characterization and monitoring of energy-related pollutants, and new technologies for cleaning up environmental contaminants. A significant number of these laboratory studies require the controlled use of radioactive and chemically toxic substances.

The principal radiological facilities at Argonne are the Advanced Photon Source (APS), a superconducting heavy-ion linear accelerator (Argonne Tandem Linac Accelerating System [ATLAS]), a 22-MeV pulsed electron linac, several other charged-particle accelerators (principally of the Van de Graaff and Dynamitron types), chemical and metallurgical laboratories, and several hot cells and laboratories designed for work with multicurie quantities of the actinide elements and with irradiated reactor fuel materials. The DOE New Brunswick Laboratory (NBL), a plutonium and uranium measurements and analytical chemistry laboratory, is located on the Argonne site. The University of Chicago's Howard J. Ricketts Regional Biocontainment Laboratory, a state-of-the-art biocontainment facility intended to study infectious diseases, was constructed in 2008 but will be not operational until 2009.

The principal non-nuclear activities at Argonne in 2008 that could have measurable impacts on the environment include the use of a coal-fired boiler (No. 5) and the discharge of wastewater from various sources.

1.2. Description of Site

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

The terrain of Argonne 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 Argonne to form the Illinois River.

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

1.3. Population

The area around Argonne has experienced significant population growth in the past 40 years as large areas of farmland have been converted into housing. Table 1.1 gives the directional and annular 80-km (50-mi) population distribution for the area, which is used to derive the population dose calculations presented later in this report. The population distribution,

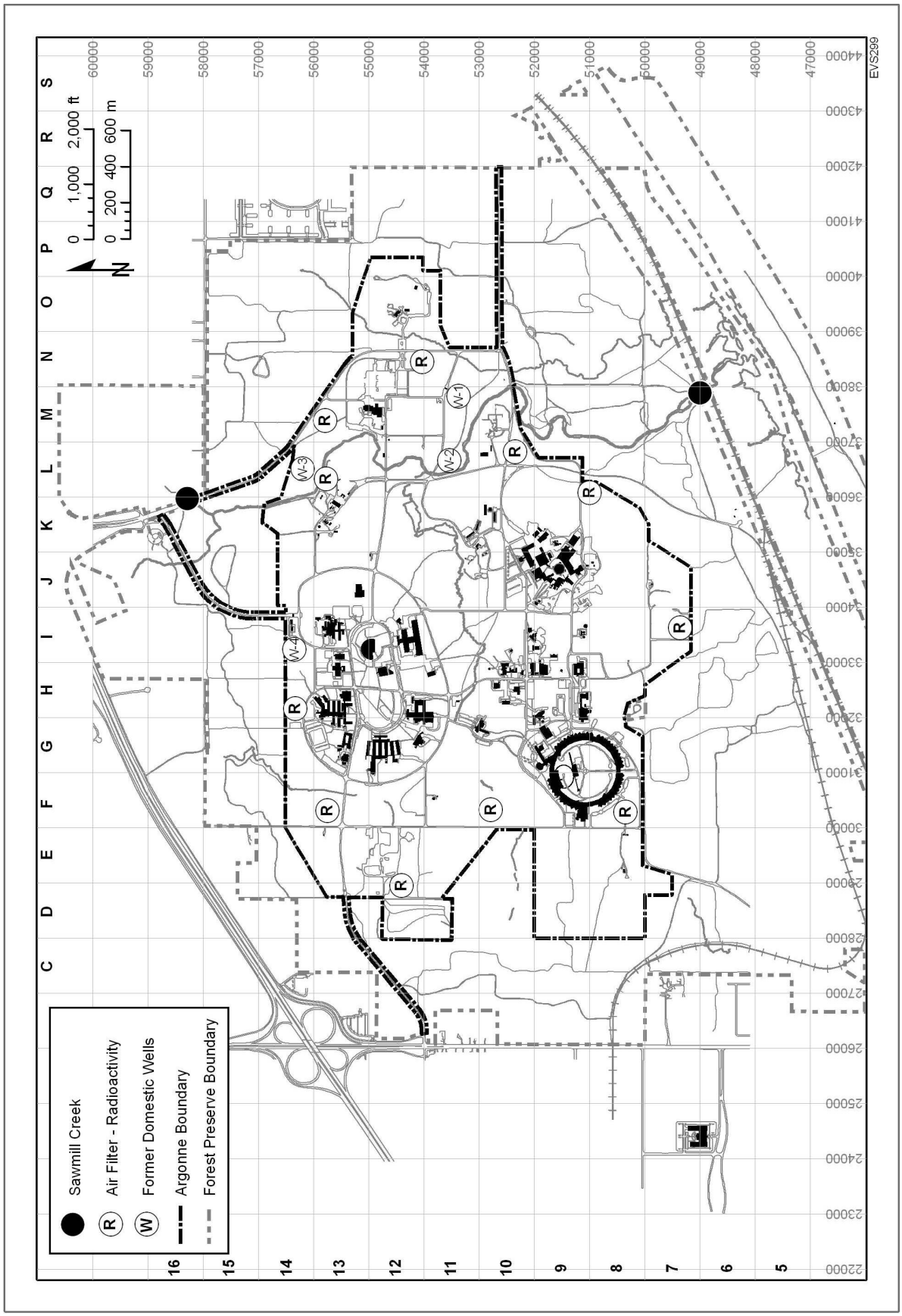


FIGURE 1.1 Sampling Locations at Argonne National Laboratory

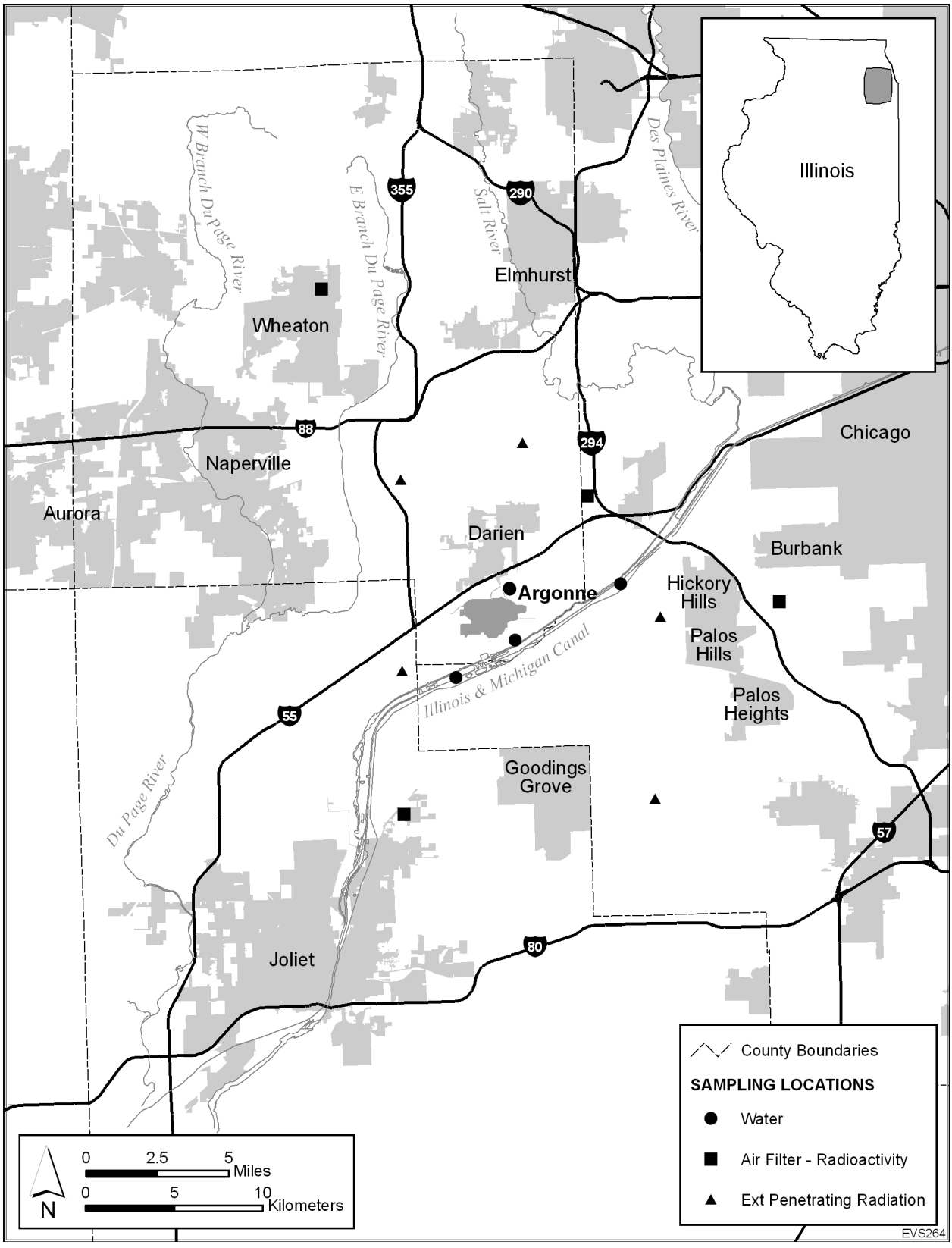


FIGURE 1.2 Sampling Locations near Argonne National Laboratory

TABLE 1.1

Population Distribution in the Vicinity of Argonne, 2005

	Miles[a]									
Direction	0–1	1–2	2–3	3–4	4–5	5–10	10–20	20–30	30–40	40–50
N	0	1,260	3,745	6,359	9,913	47,865	187,957	350,601	235,346	314,363
NNE	0	585	4,226	6,133	6,337	41,311	30,0391	488,056	106,733	1,177
NE	0	816	2,064	2,198	1,876	42,287	706,197	958,769	0	0
ENE	0	1,005	1,307	2,349	1,974	33,622	618,433	190,117	0	0
E	0	1,069	554	363	383	42,134	463,231	215,304	9,899	27,578
ESE	0	424	267	368	505	18,327	188,712	294,596	224,205	95,839
SE	0	193	269	456	939	23,793	111,879	101,003	32,401	17,261
SSE	0	406	396	1,004	1,448	10,466	43,222	1,873	13,635	16,443
S	0	582	2,280	2,129	1,399	9,998	37,982	3,641	36,598	37,792
SSW	0	484	2,307	2,621	1,047	22,183	108,907	14,750	16,781	7,838
SW	0	173	590	342	10	18,024	81,243	14,503	18,929	7,564
WSW	0	129	127	559	3,112	21,066	29,434	7,213	9,429	11,717
W	0	147	567	7,818	10,530	46,610	100,304	30,268	19,165	7,087
WNW	0	500	863	2,973	4,708	46,580	162,138	44,204	8,317	62,884
NW	0	687	2,377	7,248	7,979	47,247	86,635	130,674	27,822	21,825
NNW	0	1,074	2,700	6,124	9,714	34,933	222,946	267,024	183,404	138,432
Total	0	9,534	24,639	49,044	61,874	506,446	3,449,611	3,112,596	942,664	767,800
Cumulative totals[b]	0	9,534	34,173	83,217	145,091	651,537	4,101,148	7,213,744	8,156,408	8,924,208

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

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

centered on the Intense Pulsed Neutron Source (IPNS) (Location 9J in Figure 1.1), was prepared by the Risk Assessment and Safety Evaluation Group of the Environmental Science Division at Argonne and represents projections to 2005 on the basis of 2000 census data.

1.4. Climatology

The climate of the area is representative of the upper Mississippi Valley, as moderated by Lake Michigan. The most important meteorological parameters for the purposes of this report are wind direction, wind speed, temperature, and precipitation. Historic wind data were used to select air sampling locations. Data from the current year were used to calculate radiation doses from air emissions. Temperature and precipitation data are useful in interpreting some of the monitoring results. The 2008 data were obtained from the on-site Argonne meteorological station. The annual average wind rose for 2008 is consistent with the long-term average wind direction, which usually varies from the west to south, but with a significant northeast component.

Table 1.2 gives 2008 precipitation and temperature data. The monthly precipitation data for 2008 show differences from the Argonne historical average primarily in September and December. The annual total was 35% above the annual average for the Argonne data. The

TABLE 1.2

Argonne Weather Summary, 2008

	Precipitation (cm)			Temperature (°C)	
Month	Argonne 2008	Argonne Historical[a]		Argonne 2008	Argonne Historical[a]
January	8.51	4.29		–4.3	–4.7
February	7.49	4.19		–5.2	–1.9
March	5.23	6.05		1.4	3.1
April	8.33	8.34		9.8	9.4
May	12.67	9.69		13.9	14.0
June	12.34	8.52		21.7	20.7
July	11.65	10.55		23.1	23.1
August	6.60	10.34		22.1	22.1
September	27.37	8.28		18.9	18.2
October	5.40	8.07		11.4	11.4
November	3.05	8.87		3.8	4.4
December	14.66	4.58		–5.3	–2.9
Total	123.30	91.77	Monthly Average	9.3	10.0

[a] Averages were obtained from the Argonne meteorological tower by using data from the last 25 years (1983–2007).

2008 annual monthly average was 7% lower than the long-term annual average. The climatology information was provided by the Atmospheric and Climate Research Section of the Environmental Science Division.

1.5. Geology

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

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

1.6. Seismicity

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

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

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

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

1.7. Groundwater Hydrology

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

Up until 1997, most groundwater supplies in the Argonne area were derived from the Niagaran, and to some extent, the Alexandrian dolomite bedrock. Dolomite well yields are variable, but many approach 3,028 L/min (800 gal/min). In DuPage County, groundwater pumpage over the past 100 years has led to severe overdraft; in northeastern Illinois, the piezometric surface has been lowered in areas of heavy pumping. Delivery of Lake Michigan water to the nearby suburban areas, which began in 1992, is expected to relieve this overdraft problem. Argonne now obtains all of its domestic water from the DuPage Water Commission, which obtains potable water from the City of Chicago water system.

1.8. Water and Land Use

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

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

Residential and commercial development in the area have resulted in the collection and channeling of runoff water into Sawmill Creek. Treated sanitary and laboratory wastewater from Argonne are combined and discharged into Sawmill Creek at location 7M in Figure 1.1. In 2008, this effluent averaged 2.86 million L/day (0.76 million gal/day), which is similar to the averages for the last few years. The combined Argonne effluent consisted of 61% laboratory wastewater and 39% sanitary wastewater. The water flow in Sawmill Creek upstream of the wastewater outfall averaged about 50 million L/day (13.2 million gal/day) during 2008.

Sawmill Creek and the Des Plaines River upstream of Joliet, about 21 km (13 mi) southwest of Argonne, receive very little recreational or industrial use. A few people fish in these waters downstream of Argonne, and some duck hunting takes place on the Des Plaines River. Water from the Chicago Sanitary and Ship Canal is used by Argonne for cooling tower makeup water and by others for industrial purposes, such as hydroelectric generators and condensers. Argonne usage is approximately 1.7 million L/day (0.45 million gal/day). The canal, which receives Chicago Metropolitan Sanitary District effluent water, is used for industrial transportation and some recreational boating. Near Joliet, the river and canal combine into one waterway, which continues until it joins the Kankakee River to form the Illinois River about 48 km (30 mi) southwest of Argonne. 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 river water is used as a community water supply is at Peoria, which is on the Illinois River about 240 km (150 mi) downstream of Argonne. In the vicinity of Argonne, only subsurface water (from both shallow and deep aquifers) and Lake Michigan water are used for drinking purposes.

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

1.9. Vegetation

Argonne lies within the Prairie Peninsula of the Oak-Hickory Forest Region. The Prairie Peninsula is a mosaic of oak forest, oak openings, and tall-grass prairie occurring in glaciated portions of Illinois, northwestern Indiana, southern Wisconsin, and sections of other states. Much of the natural vegetation of this area has been modified by clearing and tillage. Forests in the Argonne region, which are predominantly oak and hickory, are somewhat limited to slopes of shallow, ill-defined ravines or low morainal ridges. Gently rolling to flat intervening areas

between ridges and ravines were predominantly occupied by prairie before their use for agriculture. The prevailing successional trend in these areas, in the absence of cultivation, is toward oak-hickory forest. Forest dominated by red oak and basswood may occupy more pronounced slopes. Poorly drained areas, streamside communities, and floodplains may support forests dominated by silver maple, elm, and cottonwood. Figure 1.3 shows the vegetation communities.

Early photographs of the site indicate that most of the land that Argonne now occupies was actively farmed. About 75% was plowed field and 25% was pasture, open oak woodlots, and oak forests. Starting in 1953 and continuing for three seasons, some of the formerly cultivated fields were planted with jack, white, and red pine trees. Other fields are dominated by bluegrass.

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

DOE and Argonne are members of the Chicago Wilderness Coalition, a partnership of more than 170 public and private organizations that have joined forces to protect, restore, and manage 81,000 ha (200,000 acres) of natural areas in the Chicago metropolitan region. Several activities are planned or are in progress to enhance oak woodland, savanna, wetland, and prairie habitats on the approximately 285 ha (700 acres) that remain undeveloped at the Argonne site.

1.10. Fauna

Terrestrial vertebrates that are commonly observed or likely to occur on the site include about 5 species of amphibians, 7 of reptiles, 40 of summer resident birds, and 25 of mammals. More than 100 other bird species can be found in the area during migration or winter; however, they do not nest on the site or in the surrounding region. An unusual species on the Argonne site is the fallow deer, a European species that was introduced to the area by a private landowner prior to government acquisition of the property in 1947. A population of native white-tailed deer also inhabits the Argonne site. The white-tailed and fallow deer populations are each maintained at a target density of 15 deer/mi^2 under an ongoing deer management program.

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

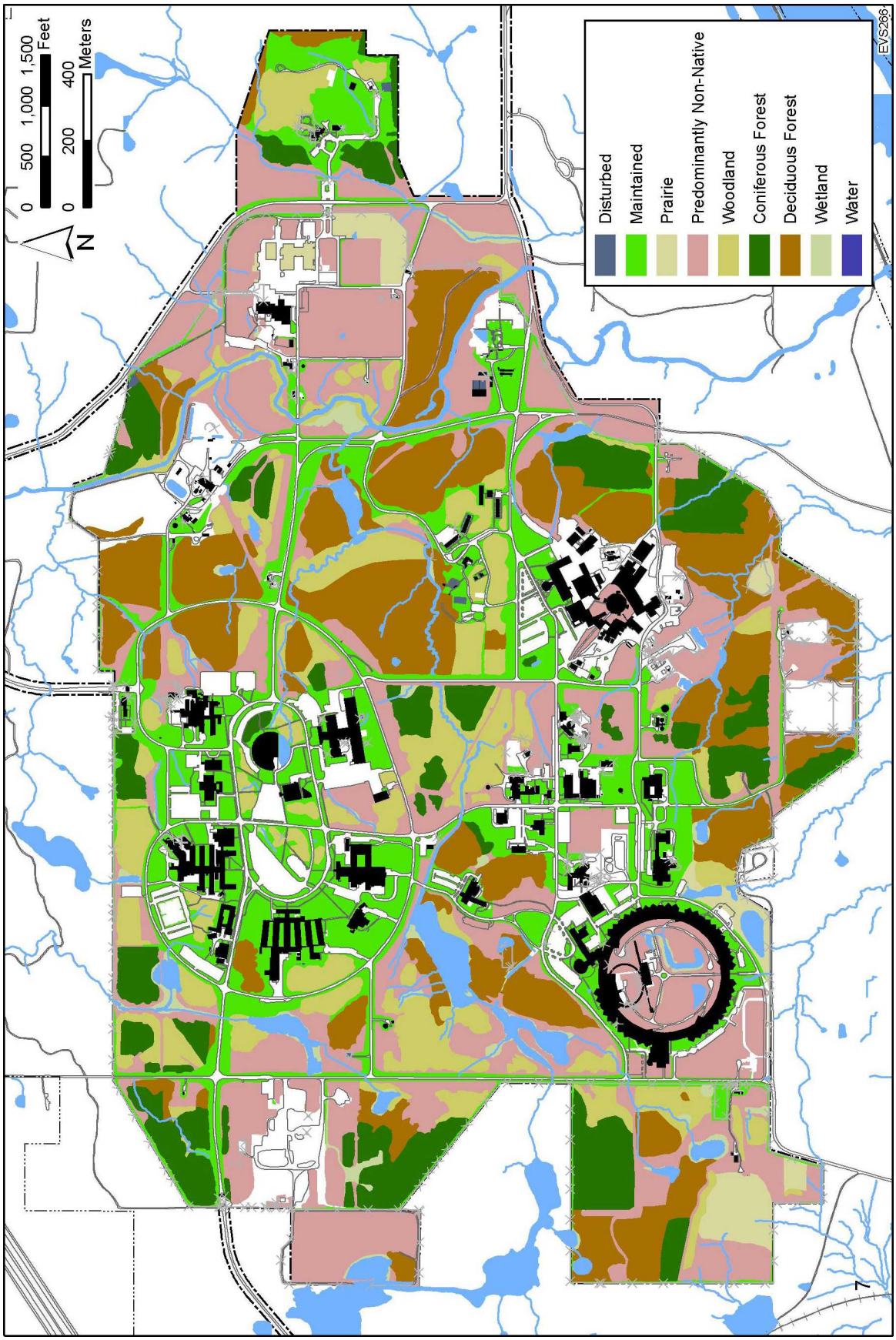


FIGURE 1.3 Argonne Vegetation Communities

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

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

1.11. Cultural Resources

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

Forty-six archaeological sites have been recorded at Argonne. These sites include prehistoric chert quarries, special-purpose camps, base camps, and historical farmsteads. The range of human occupation spans several time periods (Early Archaic through Mississippian Prehistoric to Historical). Four sites have been determined to be eligible for the *National Register of Historic Places* (NRHP); 21 sites have been determined to be ineligible; and 21 sites have not been evaluated for eligibility.

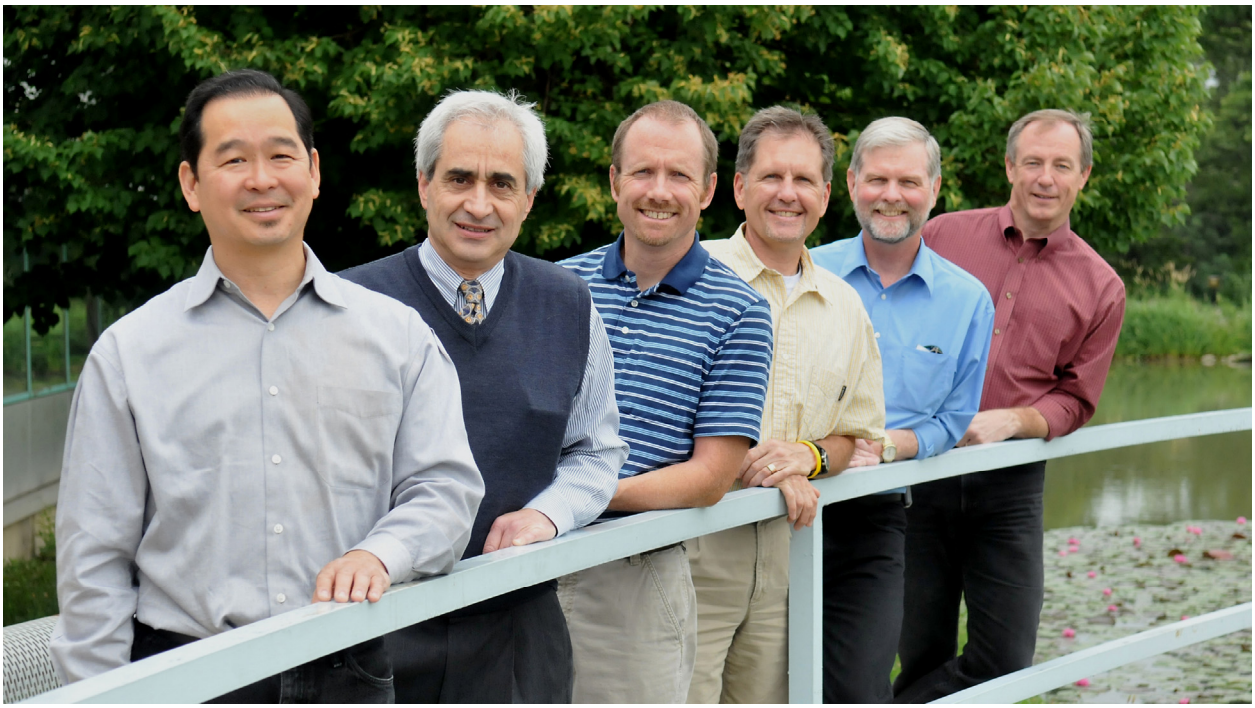
Cultural resources also include historic structures. Historic property surveys over the past several years identified two areas at Argonne, the 200 Area campus and the 300 Area reactor development buildings, which are eligible for listing on the NRHP as historic districts, as well as several buildings that are individually eligible for listing on the NRHP.

1.12. Endangered Species

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

The Hine's emerald dragonfly (*Somatochlora hineana*), federally and state listed as endangered, occurs in locations with calcareous seeps and wetlands along the Des Plaines River floodplain. Leafy prairie clover (*Dalea foliosa*), which is federally and state listed as endangered, is associated with dolomite prairie remnants of the Des Plaines River Valley; two planted populations of this species occur in Waterfall Glen Forest Preserve. An unconfirmed capture of an Indiana bat (*Myotis sodalis*), which is federally and state listed as endangered, indicates that this species may occur in the area. The federally listed threatened lakeside daisy (*Hymenoxys herbasea*) has a planted population in Waterfall Glen Forest Preserve. Additional state-listed species that occur in the area are identified in Section 2.10.

2. COMPLIANCE SUMMARY



2. COMPLIANCE SUMMARY

Argonne is a U.S. government-owned, contractor-operated R&D facility that is subject to environmental statutes and regulations administered by the U.S. Environmental Protection Agency (EPA), the Illinois Environmental Protection Agency (IEPA), the U.S. Army Corps of Engineers (COE), and the State Fire Marshal, as well as to numerous DOE Orders and Executive Orders (EOs). The status of Argonne during 2008 with regard to these authorities is discussed in this chapter.

The Atomic Energy Act of 1954 (AEA) was promulgated to assure the proper management of radioactive materials. Under the act, DOE regulates the control of radioactive materials under its authority. Sections of the act authorize DOE to set radiation protection standards for itself and its contractors. Accordingly, DOE promulgated a series of regulations (e.g., Title 10 of the *Code of Federal Regulations*, Parts 820, 830, and 835 [10 CFR Parts 820, 830, and 835], and DOE Orders 435.1, 450.1A, and 5400.5) to protect public health and the environment from potential risks associated with radioactive materials. This Site Environmental Report (SER) is used to document compliance with these regulations and orders.

Argonne has made a commitment to comply with all applicable environmental requirements, as described in the following statement in Section 3 of the Environmental Protection Policy (Laboratory Management System Policy 2 [LMS-POL-2]):

> Argonne activities (including experiments, facility operations, construction activities, and other activities) must be conducted in an environmentally safe and sound manner consistent with Argonne permit conditions. Argonne is committed to:
>
> - Continuous environmental improvement;
> - Implementation of the environmental objectives and targets process;
> - Pollution prevention and waste minimization; and
> - Compliance with all applicable requirements.

2.1. Clean Air Act

The Clean Air Act (CAA) is a federal statute that addresses the emission of regulated air pollutants, which includes criteria pollutants (carbon monoxide, sulfur dioxide, lead, nitrogen dioxide, particulate matter, and ozone), hazardous air pollutants (HAPs), and ozone-depleting substances. The program for compliance with the requirements of the CAA is implemented by individual states through a State Implementation Plan (SIP) that describes how that state will ensure compliance with the air quality standards for stationary sources.

Under Title V of the Clean Air Act Amendments of 1990, Argonne submitted a Clean Air Act Permit Program (CAAPP) application to the IEPA for a sitewide, federally enforceable

operating permit to cover emissions of all regulated air pollutants at the facility. The finalized CAAPP (Title V) permit was issued on April 3, 2001. This permit supersedes the prior individual state air pollution control permits, with two exceptions for prior open-burning permits. The open-burning permits are renewed each year. Argonne meets the definition of a major source because of potential emissions of oxides of nitrogen in excess of 90.72 t/yr (100 tons/yr), carbon monoxide in excess of 90.72 t/yr (100 tons/yr), or sulfur dioxide in excess of 90.72 t/yr (100 tons/yr) at the Building 108 central heating plant.

The CAAPP permit renewal application was submitted to the IEPA on April 15, 2005. The final permit was approved and became effective October 17, 2006. One outstanding permit issue involved the delay of the California Air Resources Board (CARB) to certify Stage II vapor recovery equipment for use on E85 dispensing facilities. Argonne agreed to have such CARB-certified equipment installed within 180 days of it becoming commercially available in Illinois. As of the end of 2008, such equipment was not yet available for installation.

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

The Argonne site contains a large number of air emission point sources. The vast majority are laboratory ventilation systems used for bench-scale research activities. These activities are categorized as insignificant, except in cases involving the emission of radionuclides. In 2008, a construction permit was issued for the evaluation of three types of biomass fuel to be tested with coal in the beginning of 2009 in Boiler No. 5. Also, a notification was sent to the IEPA and EPA, as required by the CAAPP permit, for the use of urea in fuel testing at the Transportation Research Facility.

2.1.1. National Emission Standards for Hazardous Air Pollutants

The National Emission Standards for Hazardous Air Pollutants (NESHAP) constitute a body of federal regulations that set forth emission limits and other requirements, such as monitoring, recordkeeping, and operational and reporting requirements, for activities generating emissions of certain HAPs. The only standards affecting Argonne operations are those for asbestos and radionuclides. By the time of the issuance of the sitewide Argonne Title V permit, the IEPA had issued a total of 23 air pollution control permits to Argonne for NESHAP sources. All Argonne operating NESHAP permits were incorporated into the sitewide Argonne Title V permit.

2.1.1.1. Asbestos Emissions

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

Argonne maintains an asbestos abatement program designed to ensure compliance with these and other regulatory requirements. ACM is removed from buildings either by Argonne personnel or outside contractors licensed by the Illinois Department of Public Health (IDPH). All removal work is performed in accordance with both NESHAP and Occupational Safety and Health Administration requirements governing worker safety at ACM removal sites.

Approximately 85.5 m^3 (3,020 ft^3) of ACM was generated from Argonne asbestos removal projects during 2008. The 81 small removal projects that were completed generated 24.7 m^3 (874 ft^3) of ACM waste. Eight large removal projects generated the remaining 60.8 m^3 (2,146 ft^3) of ACM waste. Table 2.1 provides asbestos abatement information for the large removal projects. The IEPA was notified during December 2008 that no more than 34 m^3 (1,200 ft^3) of ACM waste is expected to be generated from small-scale projects during 2009. A separate portion of the asbestos removal standards contains requirements for disposing of ACM. Off-site shipments are to be accompanied by completed shipping manifests.

2.1.1.2. Radionuclide Emissions

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

The amount of radioactive material released to the atmosphere from Argonne emission sources is extremely small, thereby contributing little to the off-site dose. The maximum off-site dose to a member of the general public for 2008 was 0.0034 mrem, which is less than 0.03% of the 10 mrem/yr EPA standard. Section 4.7.1 and the 2008 NESHAP report contain more detailed discussions of these emission points and compliance with the standard.

2.1.2. Conventional Air Pollutants

The Argonne site contains a number of sources of conventional air pollutants, including a steam plant, gasoline and ethanol/gasoline blend fuel-dispensing facilities, a dust collection

TABLE 2.1

Asbestos Abatement Projects
DOE/IEPA Notification,
January–December 2008

Completion Date	Asbestos Abatement Contractor	Notification Quantity ft	Notification Quantity ft^2	Notification Quantity ft^3	Material	Building	Disposal Quantity (ft^3)	Landfill
4/7/2008	Argonne Waste Management	0	1,390	0	Floor tile and mastic	212	64	Environtech, Morris, IL
5/24/2008	Argonne Waste Management	0	280	0	Pipe insulation	40	102	Energy Solutions,[a] Clive, UT
5/31/2008	Argonne Waste Management	9,370	125	0	Floor tile and mastic, pipe insulation	301	1,487	Environtech, Morris, IL
9/15/2008	Argonne Waste Management	0	975	0	Floor tile and mastic	362	40	Environtech, Morris, IL
9/20/2008	Argonne Waste Management	0	625	0	Floor tile and mastic	208	60	Environtech, Morris, IL
9/24/2008	Argonne Waste Management	0	2,970	0	Floor tile and mastic	951	301	Environtech, Morris, IL
10/11/2008	Argonne Waste Management	0	710	0	Floor tile and mastic[b]	40	32	Environtech,[c] Morris, IL
10/28/2008	Environmental Cleansing Corporation	260	0	0	Pipe insulation	40	60	Environtech, Morris, IL

[a] On-site pending shipment to Energy Solutions.

[b] Courtesy notification, nonfriable material.

[c] On-site pending shipment to Environtech.

system, an engine test facility, a surface treatment facility for etching research equipment, a number of diesel generators, and a wastewater treatment plant (WTP). These facilities are operated and the associated activities are conducted in compliance with applicable regulations and permit conditions.

The Title V permit requires continuous opacity and sulfur dioxide monitoring of the smoke stack from Boiler No. 5, the only one of the five boilers at the steam plant that is equipped to burn coal. The permit requires submission of a quarterly report listing any exceedances beyond emission limits for this boiler (30% opacity averaged over 6 min or 0.82 kg [1.8 lb] of sulfur dioxide per million Btu averaged over a 1-hour period). Table 2.2 gives the hours that Boiler No. 5 operated on low-sulfur coal during 2008, as well as the amount of low-sulfur coal burned. There were no exceedances at Boiler No. 5 in 2008.

An annual compliance certification must be submitted to the IEPA and EPA each May 1 for the previous calendar year, detailing any deviations from the Title V permit and subsequent corrective actions. During 2008, there were no deviations identified regarding compliance with the Title V permit.

Landfill gas monitoring is conducted quarterly at the 800 Area Landfill via 4 gas wells placed into the waste area and 10 gas wells at the perimeter of the landfill. Figure 2.1 shows their locations. In addition to the wells, ambient air is sampled in two nearby buildings and at three open-air locations to assess the presence of methane. The gas monitoring near the landfill provides information on whether methane is migrating from the landfill. In 2008, no methane was detected above action levels in the landfill perimeter gas sampling wells.

TABLE 2.2

Boiler No. 5 Operation, 2008

Month	Operated (hours)	Low-Sulfur Coal Burned (tons)
January	744.0	2,637.0
February	592.3	2,317.1
March	709.5	2,452.8
April	365.0	1,110.7
May	0	0
June	0	0
July	0	0
August	0	0
September	0	0
October	0	0
November	0	0
December	0	0
Total	2,411	8,518

A fuel-dispensing facility is at Building 46, Grounds and Transportation. Except for ethanol vapors from alternate-fuel usage, this facility has VOC emissions typical of any commercial gasoline service station.

Pursuant to *Illinois Administrative Code*, Title 35, Part 254 (35 IAC Part 254), Argonne submits an emissions report to the IEPA each May 1 for the previous year. The summary for 2008 is presented in Table 2.3.

2.1.3. Clean Fuel Fleet Program

Although reporting requirements for the Clean Fuel Fleet Program are still in effect under the CAA and 35 IAC Part 241, the IEPA indicated that it no longer wanted reports to be filed for model year (MY) 2008 (September 1, 2007–August 31, 2008) vehicles because all current MY vehicles meet clean fuel fleet standards. Because the requirements are still in effect, in lieu of a report, Argonne submitted a letter to the IEPA on September 16, 2008, certifying that all vehicles acquired in MY 2008 meet federal emission standards.

2.2. Clean Water Act

The Clean Water Act (CWA) was established in 1977 as a major amendment to the Federal Water Pollution Control Act of 1972 and was modified substantially by the Water

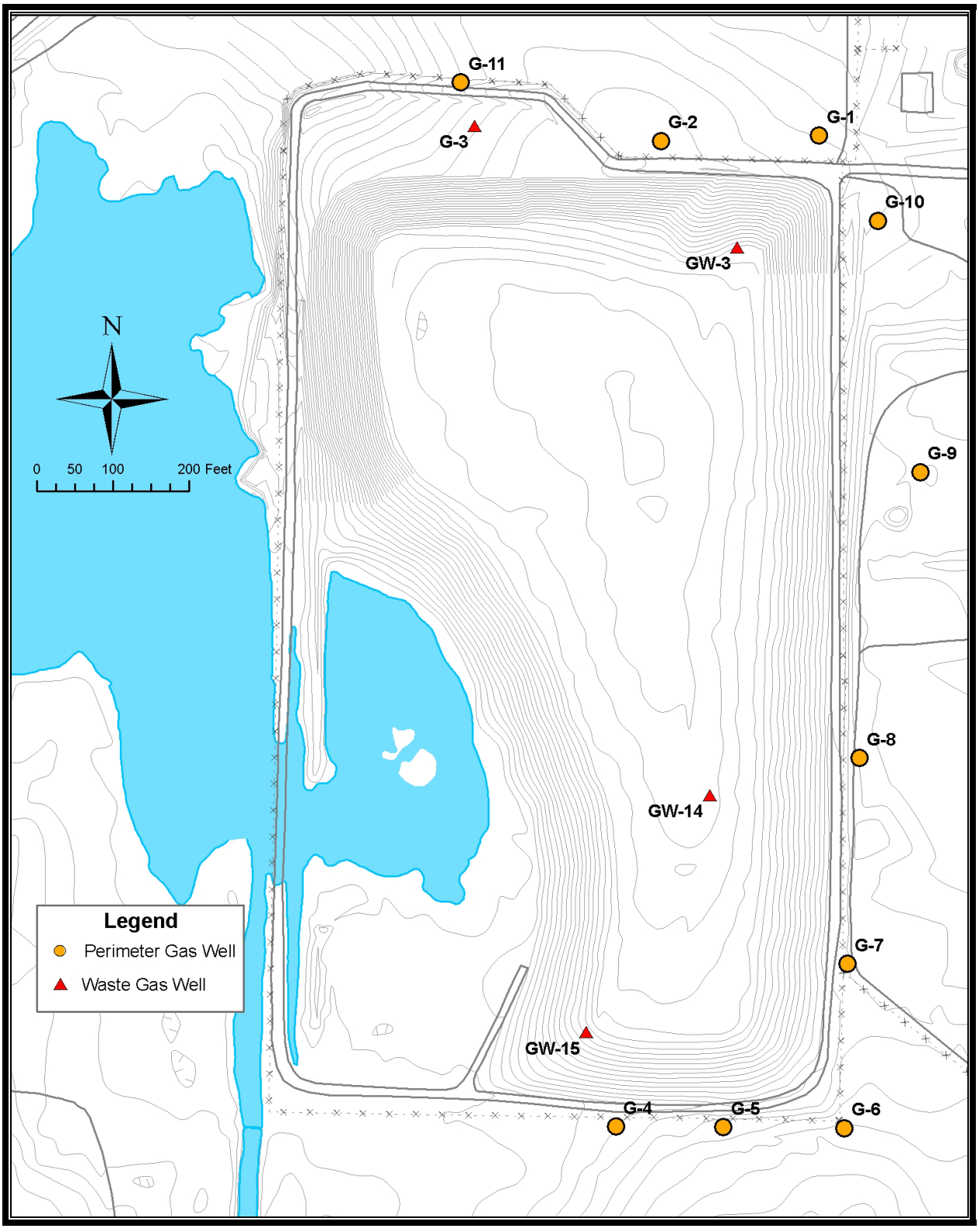


FIGURE 2.1 800 Area Landfill Gas Monitoring Wells

TABLE 2.3

2008 Annual Emissions Report: Emissions Summary,
Argonne CAAPP Permit No. 95090195[a]

Building No. and Source	CO	NO_x	PM/PM_{10}	$PM_{2.5}$[b]	SO_2	VOM	HAP[c]	NH_3[b]	CO_2[d]	CH_4[d]	N_2O[d]
108: Boiler 1 (gas-fired)	21,574	25,684	1,952	488	154	1,413	–[e]	119	30,820,639	591	565
108: Boiler 2 (gas-fired)	0	0	0	0	0	0	–	0	0	0	0
108: Boiler 3 (gas-fired)	14,747	17,556	1,334	334	105	966	–	86	21,067,488	404	386
108: Boiler 4 (gas-fired)	15,211	18,108	1,376	344	109	996	–	89	21,729,835	416	398
108: Boiler 5 (gas-fired)	2,654	3,855	240	60	19.0	174	–	15	3,791,372	73	70
108: Boiler 5 (coal-fired)	20,418	93,677	2,702	273	214,527	310	11,505	4.8	40,969,656	511	341
400: APS generator (Caterpillar)	315	1,642	58	58	136	44	–	<1	17,741	<1	<1
400: APS generators – Kohler (2)	414	2,152	76	76	178	69	–	1	29,900	<1	<1
200: Peak shaving generator	0	0	0	0	0	0	–	0	0	0	0
202: Peak shaving generator	0	0	0	0	0	0	–	0	0	0	0
Transportation research facility	27,154	12,854	765	472	690	2,071	–	15.8	253,400	–	–
PCB tank cleanout	–	–	–	–	–	0	–	–	–	–	–
208: Surface preparation facility	–	–	–	–	–		<0.1	–			
46: Ethanol/gasoline storage	–	–	–	–	–	1.3	–	–	–	–	–
46: 10,000-gal gasoline storage	–	–	–	–	–	9.8	–	–	–	–	–
					–	–	–	–	–	–	–
370: Alkali reaction booth[f]	–	–	–	–	–	–	–	–	–	–	–
308: Alkali reaction booth[f]	–	–	–	–	–	–	–	–	–	–	–
363: Central Shop dust collector[f]	–	–	–	–	–	–	–	–	–	–	–
212: Building exhausts[f]	–	–	–	–	–	–	–	–	–	–	–
368: Woodshop dust collector[f]	–	–	–	–	–	–	–	–	–	–	–
108: Sulfuric acid storage[f]	–	–	–	–	–	–	–	–	–	–	–
Torch cut Pb-based paint[f]	–	–	–	–	–	–	–	–	–	–	–
206: Alkali reaction booth (R)[g]	–		1	–	–	–	–	–	–	–	–
306: Building vents (R)	–		<1	–	–	–	–	–	–	–	–
306: Vial crusher/chemical photooxidation unit (R)	–	–	–	–	–	0	–	–	–	–	–

TABLE 2.3 (Cont.)

Building No. and Source	CO	NO_x	PM/PM_{10}	$PM_{2.5}$[b]	SO_2	VOM	HAP[c]	NH_3[b]	CO_2[d]	CH_4[d]	N_2O[d]
306: Waste bulking sheds (R)	–	–	32.2	32.2	–	68.4	2.3	–	–	–	–
375: IPNS (R)	–	–	–	–	–	–	–	–	–	–	–
200: M-Wing hot cells (R)	–	–	–	–	–	–	–	–	–	–	–
400: APS facility (R)	–	67	–	–	–	–	–	–	–	–	–
212: Alpha gamma hot cell (R)	–	–	–	–	–	–	–	–	–	–	–
330: CP-5 D&D Project (R)	–	–	–	–	–	–	–	–	–	–	–
350: NBL Pu/U Hoods (R)	–	–	–	–	–	–	–	–	–	–	–
Lab rad hoods (R)	–	–	–	–	–	–	–	–	–	–	–
WMO Portable HEPA – (6) (R)		–	<1	<1	–	–	–	–	–	–	–
303: Mixed waste storage (R)	–	–	–	–	–	–	–	–	–	–	–
331: Rad waste facility (R)	–	–	–	–	–	–	–	–	–	–	–
595: Lab wastewater plant (R)	–	–	–	–	–	109	–	–	–	–	–
315: MACE project (R)	170	–	–	–	–	–	–	–	–	–	–
301: Hot Cell D&D project (R)	–	–	–	–	–	–	–	–	–	–	–
Total (lb/yr)	102,658	175,595	8,537	2,136	215,918	6,231	11,507	331	118,680,032	1,995	1,760
Total (ton/yr)	51.3289	87.7973	4.2683	1.0681	107.9592	3.1155	5.7534	0.1655	59,340.0158	0.9974	0.8799
CAAPP Permit Limit (ton/yr)	(237.60)[h]	395.20	65.93	–	332.20	21.53	10.00	–	–	–	–

[a] Abbreviations: APS = Advanced Photo Source; CAAPP = Clean Air Act Permit Program; CO = carbon monoxide; CP-5 = Chicago Pile-Five; D&D = decontamination and decommissioning; HAP = hazardous air pollutant; HEPA = high-efficiency particulate air; MACE = melt attack and coolability experiment; N_2O = nitrous oxide; NBL = New Brunswick Laboratory; NH_3 = ammonia; NO_x = oxides of nitrogen; Pb = lead; PCB = polychlorinated biphenyl; PM = particulate matter; PM_{10} = particulate matter less than 10 microns; $PM_{2.5}$ = particulate matter less than 2.5 microns; Pu = plutonium; SO_2 = sulfur dioxide; U = uranium; VOM = volatile organic matter; WMO = Waste Management Operations.

[b] As of 2003, emissions of $PM_{2.5}$ and a precursor, ammonia (NH_3), must be included in the Annual Emission Report.

[c] HAPs not included in VOM or particulates (hydrogen chloride, hydrogen fluoride, methyl chloroform, and methylene chloride).

[d] As of 2007, greenhouse gas emissions (CO_2, CH_4, and N_2O) are included in the Annual Emission Report per IEPA request.

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

[f] These sources designated as insignificant in the CAAPP permit.

[g] (R) = Radionuclide source – radionuclides except radon regulated by NESHAP (40 CFR 61, Subpart H).

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

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

2.2.1. Wastewater Discharge Permitting

The NPDES permitting process administered by the IEPA is the primary tool for enforcing the requirements of the NPDES program. Before wastewater can be discharged to any receiving stream, each wastewater discharge point (outfall) must be characterized and described in a permit application. The IEPA then issues a permit that, for each outfall, contains numeric limits and monitoring frequencies on certain pollutants likely to be present and sets forth a number of additional specific and general requirements, including sampling and analysis schedules and reporting and recordkeeping requirements. NPDES permits are effective for 5 years and must be renewed by the submission of a permit application at least 180 days prior to the expiration of the existing permit.

Wastewater discharge at Argonne is permitted by NPDES Permit No. IL 0034592. The IEPA issued a renewal permit effective September 1, 2005. The September 1, 2005, NPDES permit placed additional limits for total residual chlorine (TRC) at Outfalls H03, J03, 004, E05, 006, and 025; total suspended solids (TSS) at Outfalls B03, D03, E03, and H03; and total dissolved solids (TDS) at Outfalls H03, J03, 006, and 025. The current permit was modified on April 24, 2007, which added Outfall 028. The permit expires August 31, 2010.

Wastewater at Argonne is generated by a number of activities and consists of sanitary wastewater (from restrooms, cafeteria sinks, and sinks in certain buildings and laboratories), laboratory wastewater (from laboratory sinks and other industrial wastewater sewers), and stormwater. Water softener regenerant from boiler house activities can be discharged into the DuPage County sewer system or the Argonne laboratory sewer system. Cooling water and cooling tower blowdown are generally sent to the laboratory wastewater sewer, although a small volume is still discharged into stormwater ditches that are monitored as part of the NPDES permit. The permit authorizes the release of wastewater from 43 separate outfalls, most of which discharge directly or indirectly into Sawmill Creek. Two of the outfalls are internal sampling points that combine to form the main wastewater outfall, Outfall 001. Table 2.4 lists these outfalls, and Figure 2.2 shows the outfall locations.

2.2.1.1. NPDES Permit Activities

TDS and chloride analytical results historically have demonstrated an annual cycle, culminating in periodic discharge limit violations occurring in the winter at Outfall 001.

TABLE 2.4

Characterization of NPDES Outfalls at Argonne, 2008[a]

Outfall Number	Description	Average 2008 Flow[b]
A01	Sanitary Treatment Plant	0.294
B01	Laboratory Treatment Plant	0.463
001	Combined outfall	0.758
B03	300 Area (condensate) and groundwater	0.013
C03	Building 205 footing tile drainage	0.024
D03/E03	Steam trench drainage (condensate)	0.026
F03	Building 201 fire pond overflow stormwater	Stormwater only
G03	North Building 201 storm sewer (condensate)	0.016
H03	Building 212 cooling tower blowdown	0.0[c]
I03	Buildings 200 and 211 cooling tower blowdown	Stormwater only
J03	Building 213 and Building 213 parking lot stormwater	0.0[c]
K03	Stormwater, APS	Stormwater only
L03	Stormwater, APS	Stormwater only
M03	Stormwater, APS	Stormwater only
N03	Stormwater, 212 East	Stormwater only
004	Building 203 cooling tower and Building 221 footing drainage and stormwater	0.042
A05	Westgate Road stormwater	Stormwater only
B05	800 Area east stormwater	Stormwater only
C05	Building 200 West	0.015
D05	Stormwater	Stormwater only
E05	Building 203 west footing drainage and condensate	0.003
006	Cooling tower blowdown and stormwater	0.074
007	Domestic cooling water for compressor and stormwater	0.031
008	Transportation and grounds stormwater	Stormwater only
011	North fence line marsh storm discharge	Stormwater only
012	100 Area stormwater discharge	Stormwater only
013	Southeast 100 Area stormwater	Stormwater only
014	Northern East Area stormwater discharge	Stormwater only
A15, B15	Building 40 stormwater discharge	Stormwater only
A16, B16	Southern East Area stormwater discharge	Stormwater only
018	Eastern 300 Area stormwater and cooling water	Stormwater only
020	Shooting range stormwater discharge	Stormwater only
021	319 Landfill and Northeast 317 Area	Stormwater only
A22	Southern 317 Area	Stormwater only
B22	Western 317 Area	Stormwater only
023	Southern and Eastern 800 Area Landfill stormwater runoff	Stormwater only
025	Buildings 314, 315, and 316 cooling water, eastern and southern APS area	0.001
026	Water Treatment Plant area stormwater	Stormwater only
027	CNM fire suppression system water and stormwater	Stormwater only
028	Stormwater from HTRL building area	Stormwater only

[a] Abbreviations: APS = Advanced Photon Source; CNM = Center for Nanoscale Materials; HTRL = Howard T. Ricketts Laboratory.

[b] Flow is measured in million gallons per day, except for outfalls with stormwater only.

[c] All process wastewater discharged to these outfalls was redirected to the laboratory sewer. There was no recordable wastewater flow in 2008.

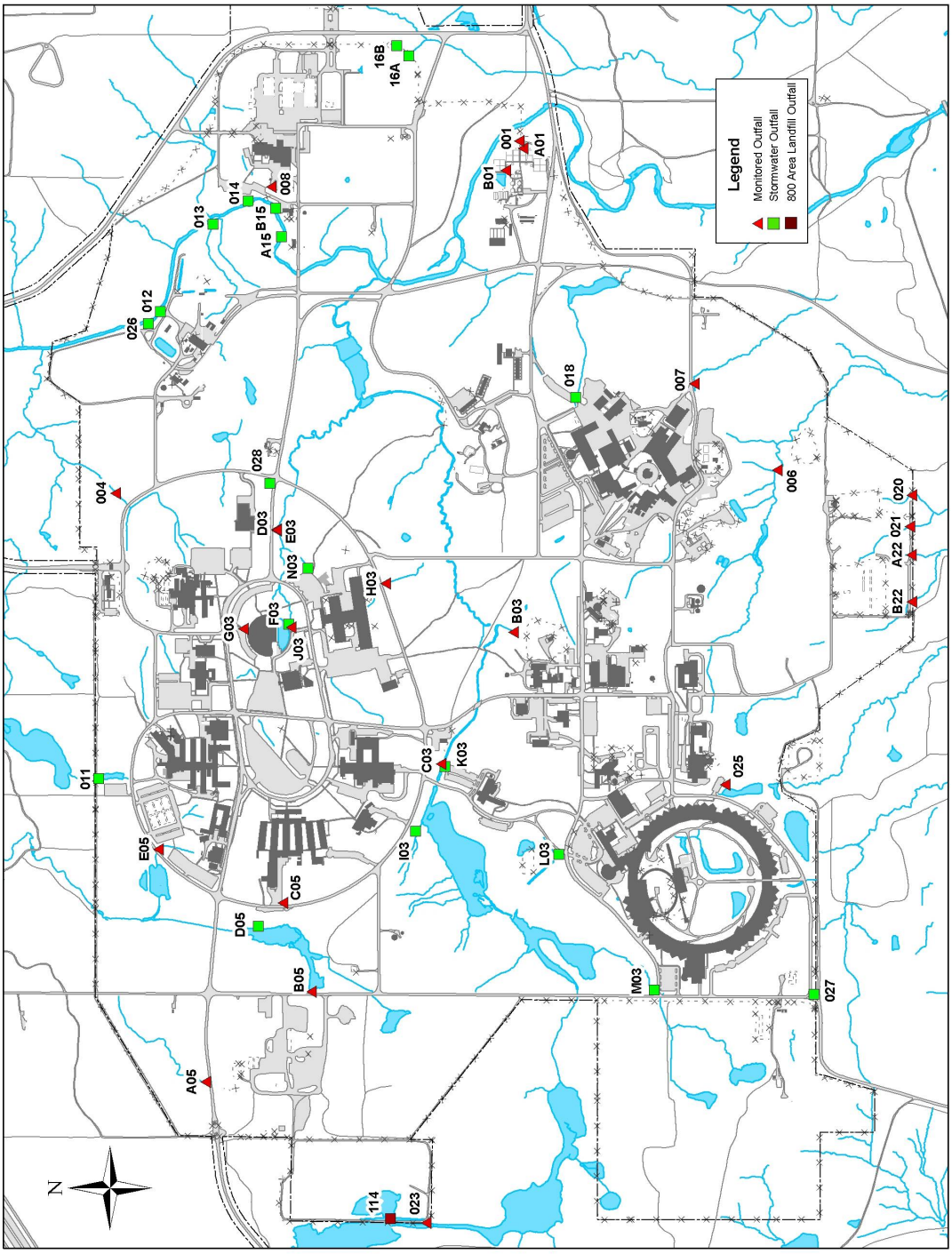


FIGURE 2.2 NPDES Outfall Locations

Investigations into the causes of the heightened TDS and chloride concentrations have focused on four sources that occur during the winter months: (1) increased boiler activity with its associated increase in high TDS wastewater (i.e., boiler blowdown), (2) road salt usage in the boiler house area that drains to the boiler house pond, (3) salt-contaminated cooling water originating from the Sanitary and Ship Canal, and (4) road salt used sitewide for melting snow.

To deal effectively with the boiler house area problems, the boiler house equalization pond was routed to DuPage County for periodic discharge of up to 215,517 L/day (57,000 gal/day). To accomplish this, in 2001, Argonne was granted a permit to discharge this wastewater to DuPage County under the existing permit with the county. Redirection of the equalization pond wastewater to DuPage County is done as needed only during the heating season in late fall and winter.

In 2007, Argonne submitted an application to modify the NPDES permit (IL 0034592) and requested the following revisions:

1. Recharacterization of the Outfall H03 and Outfall J03 discharges as stormwater only;

2. Addition of the estimated discharges for the Theory and Computing Sciences (TCS) Building for which construction was being planned;

3. Addition of Fire Protection Test and System Flush Water discharges; and

4. Recharacterization of Outfall E03 as stormwater only.

This modification package was submitted to the IEPA on August 13, 2007. To date, this modification request has not yet been approved by the IEPA.

2.2.1.2. Compliance with NPDES Permit

Wastewater is treated at Argonne in two independent treatment systems, the sanitary system and the laboratory system. The sanitary wastewater collection and treatment system collects wastewater from sanitation facilities, the cafeteria, office buildings, some small industrial discharges that cannot be routed to the laboratory sewer, and other portions of the site that do not contain radioactive or hazardous materials. This wastewater is treated in a biological wastewater treatment system consisting of primary clarifiers, trickling filters, secondary clarifiers, and slow sand filters. Wastewater generated during research-related activities, including those that utilize radioactive materials, generally flows to a series of retention tanks located in each building and is pumped to the laboratory wastewater sewer after radiological analysis and release certification. Treatment in the Laboratory Wastewater Treatment Plant (LWTP) consists of aeration, solids-contactor clarification, and pH adjustment. Additional steps can be added, including powdered-activated carbon addition for organic removal, alum addition, and polymer addition or adjustment, if analysis demonstrates that any of these are required.

Figure 2.3 shows the two wastewater treatment systems that are located adjacent to each other. The volume of wastewater discharged from these facilities in 2008 averaged 1.10 million L/day (0.29 million gal/day) for the sanitary wastewater and 1.74 million L/day (0.46 million gal/day) for the laboratory process wastewater.

Results of the routine monitoring required by the NPDES permit are submitted monthly to the IEPA in a Discharge Monitoring Report (DMR). As required by the permit, any exceedance of permit limits or conditions is reported by telephone to the IEPA within 24 hours, and a written explanation of the exceedance is submitted with each DMR. During 2008, there were 12 exceedances of NPDES permit limits out of approximately 1,800 measurements.

All but one of the exceedances that were reported in 2008 occurred at Outfall 001, the combined wastewater discharge. There were eight exceedances of TDS limits and three exceedances of chloride limits at this outfall. All of the exceedances occurred during the winter or early spring months and are the direct or indirect result of the use of road salt after heavy snows that occurred in early 2008. One TDS exceedance was reported at Outfall 006 in June of 2008. While the cause of this exceedance is not clear, it is possibly related to leaching of residual road salt from parking lots and roadways in the Outfall 006 watershed.

The effect of road salt usage on wastewater discharge permit exceedances has been a major issue since the permit was modified in 2005. The majority of the exceedances experienced since 2005 have been caused by high levels of TDS and chloride during winter months. These exceedances resulted in a Notice of Violation (NOV) from the IEPA in 2006 and a Compliance Commitment Agreement (CCA) later that year. As a result of the CCA, Argonne completed two studies into the sources of high TDS and chloride discharges and made a number of changes to reduce the amount of TDS and chloride discharged to outfalls that had TDS limits. The changes included rerouting a number of cooling tower discharges and building sumps from storm drains to the sewer system and modifying the snow management practices to reduce the use of salt on site. These changes removed all process wastewater from Outfalls J03 and H03, which had experienced numerous exceedances in recent years. In 2007, the IEPA agreed to treat these two outfalls as stormwater-only outfalls, which are not monitored for TDS. As a result of these changes, the number of exceedances was reduced from 23 in 2007 to 12 in 2008.

In September 2008, the IEPA changed its approach to general use water quality standards (35 IAC Part 302 Subpart A) for TDS and eliminated TDS as a water quality parameter. Therefore, the next renewal of the permit will no longer have TDS limits included. However, until the permit is modified, Argonne will continue monitoring for TDS and reporting exceedances if they occur.

Figure 2.4 presents the data for the total number of permit limit exceedances each year over the past 9 years. The increases in the number of exceedances in 2005 through 2007, compared with previous years, reflects the more restrictive discharge limits in the renewed permit issued in September 2005.

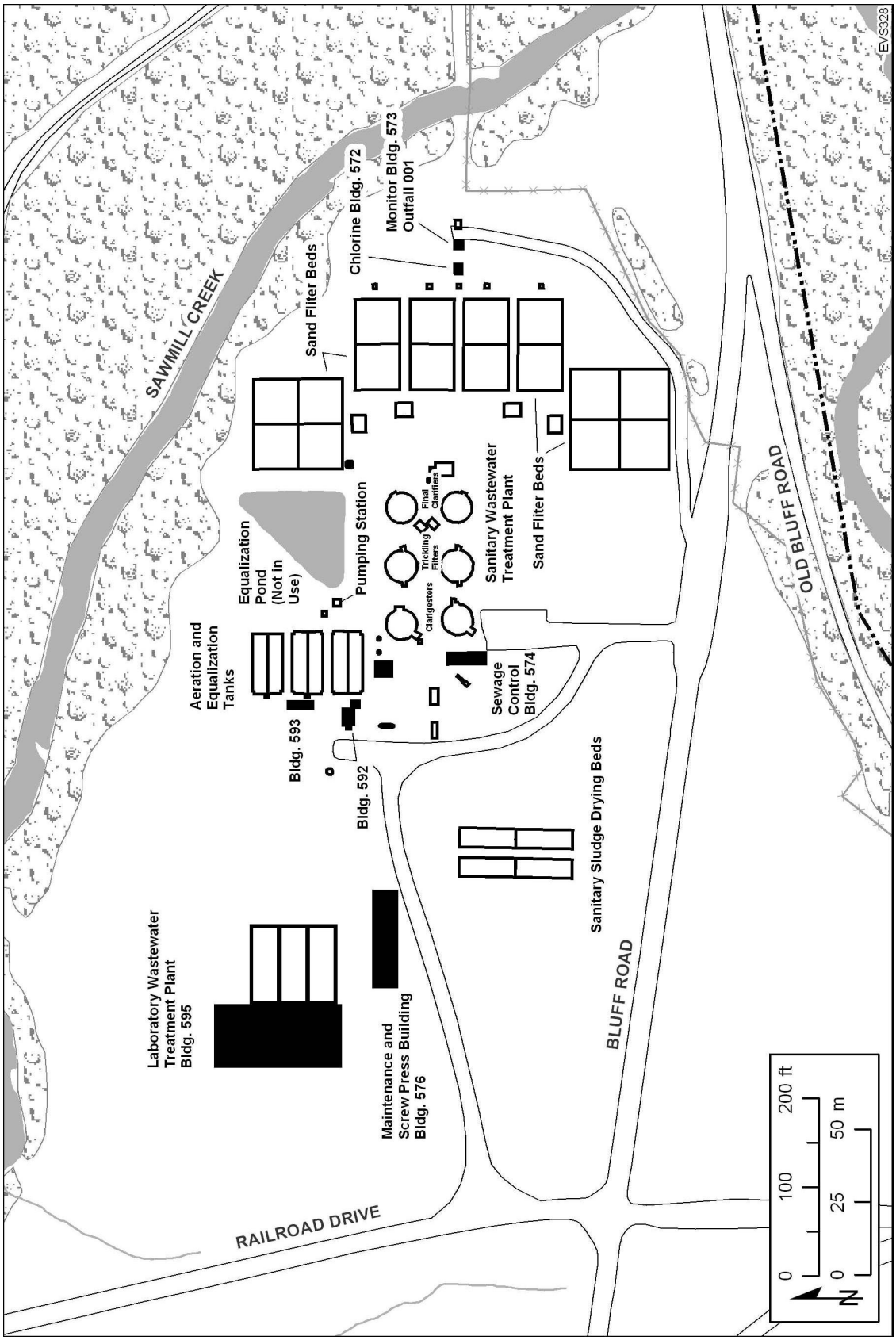


FIGURE 2.3 Argonne Wastewater Treatment Plant

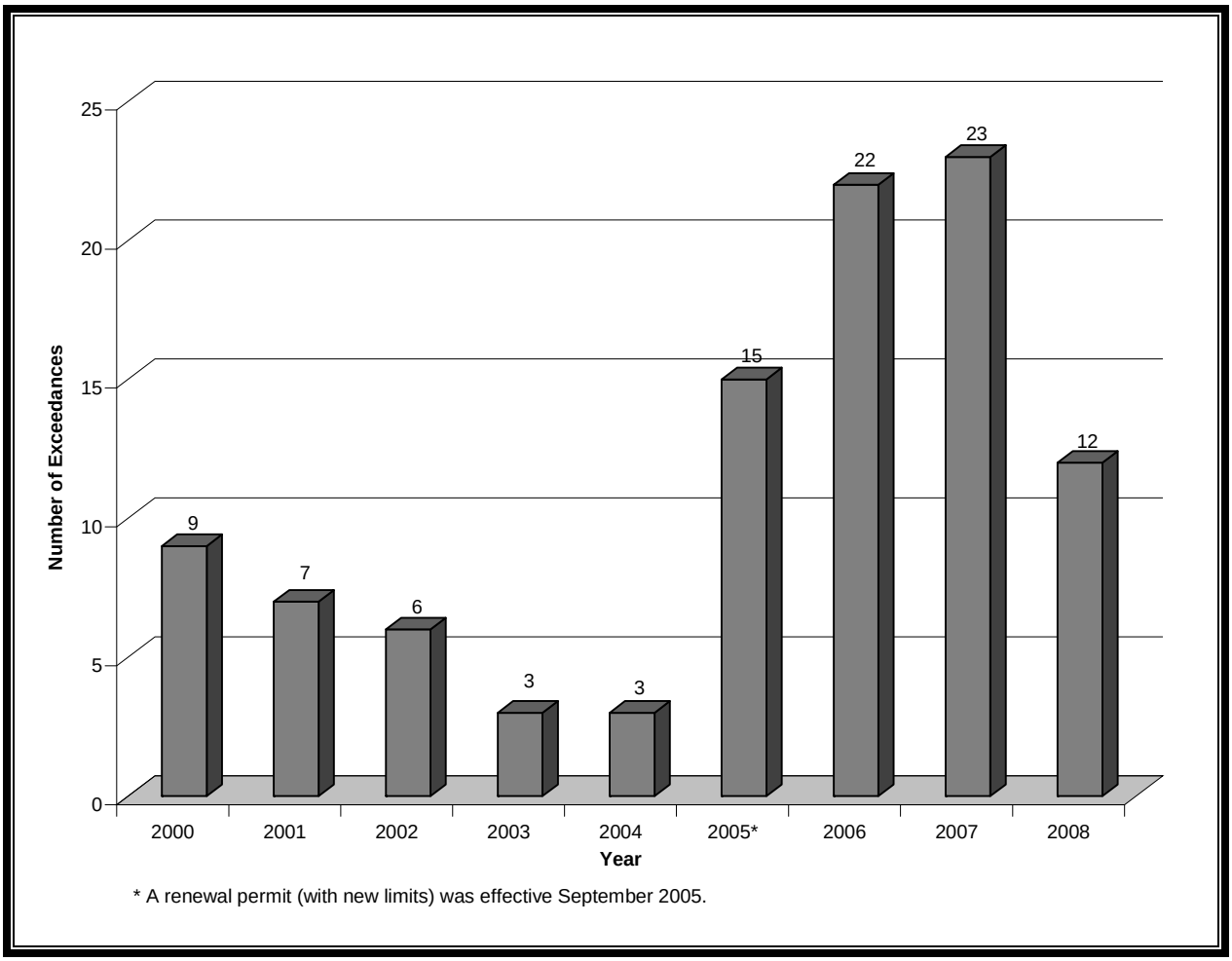


FIGURE 2.4 Total Number of NPDES Exceedances, 2000 to 2008

2.2.1.3. Priority Pollutant Analysis and Biological Toxicity Testing

The NPDES permit requires semiannual testing of Outfall B01 (the LWTP outfall) and annually at Outfall 021 for all the priority pollutants — 124 metals and organic compounds identified by the IEPA as being of particular concern. During 2008, the Outfall B01 sampling was conducted in June and December. In the June sample, all of the inorganic results were below the analytical detection limits. The organic constituents present above analytical detection limits were all trihalomethane (THM) compounds that are by-products of the chlorination of potable water purchased from the DuPage Water Commission. The compounds detected in June were dichlorobromomethane (1 μg/L), bromoform (4 μg/L), chloroform (0.9 μg/L), and chlorodibromomethane (2 μg/L). In the December sample, the only constituent present above analytical detection limits was chloroform (estimated at 0.5 μg/L). The limit on total THM is 80 μg/L.

Outfall 021 is sampled annually and analyzed for the priority pollutant list of constituents. The 2008 sample was collected on June 13, 2008. None of the 124 compounds measured by this

test were detected above the analytical detection limits. Total phenols at a concentration of 0.0056 µg/L were detected in the sample. This parameter is not considered a priority pollutant.

In addition to the priority pollutant analysis, the permit requires annual biological toxicity testing of the combined effluent stream, Outfall 001. This testing was conducted June 17–18, 2008. The data indicate that the effluent was not acutely toxic to either the fathead minnow or the water flea.

2.2.1.4. Stormwater Regulations

In November 1990, the EPA promulgated regulations governing the permitting and discharge of stormwater from industrial sites. The Argonne site contains a large number of small-scale operations that are considered industrial activities under these regulations and, thus, are subject to these requirements. An extensive stormwater characterization and permitting program was initiated in 1991 and continues as required by the present NPDES permit; Argonne's NPDES permit includes both industrial and stormwater discharges to surface water.

The NPDES permit was reissued on April 24, 2007. As a portion of the effective permit, there are special conditions that include a number of requirements that Argonne must fulfill, including monitoring, reporting, and investigations. One of these requirements, Special Condition 9, requires Argonne to maintain its existing Stormwater Pollution Prevention Plan (SWPPP), as well as to modify it as necessary to ensure compliance with all provisions of the regulations regarding stormwater. The SWPPP was revised and published in October 2007, and the revision was communicated to affected personnel. Special Condition 9 continues to require Argonne to inspect and report annually on the effectiveness of the sitewide SWPPP. Argonne's annual SWPPP assessment consists of physical walkthroughs of each building on site to identify any potential pollutant sources and/or conditions that may lead to industrial discharges into Argonne's outfalls. Outfall watersheds are also inspected to verify that no changes have occurred that may affect the permitted discharges at the outfalls. Finally, SWPPP "best management practices" are evaluated to ensure that potential surface water pollution sources remain under good institutional control. For 2008, the annual inspection was completed, and a report was submitted to the IEPA in December 2008. The 2008 SWPPP assessment identified three minor best management practice effectiveness issues, or findings, involving improper storage of material at several buildings and inadequate storm drain topography at one location. These findings will be addressed during the first part of 2009. Improved best management practices include housekeeping practices related to sitewide snow management, snow removal modifications, and reduced salt usage.

During 2008, a spill of sulfuric acid occurred due to a leak from the bulk acid storage tank near the boiler house. The spill was contained and cleaned up before any of the acid entered the stormwater collection system. There was no discharge to surface water. Four other minor spills of fluids from vehicles occurred in 2008. They were all cleaned up with no impact to surface water.

Also during 2008, the construction of the TCS Building in the north-central part of the site was begun. An NPDES stormwater construction permit was obtained prior to the start of construction, and a stormwater pollution plan was prepared. During construction, the required erosion control precautions were put in place and inspected every 7 days and within 24 hours of a rainfall event of 1.3 cm (0.5 in.) or more. No major deficiencies were noted in 2008, and no permit exceedances were caused by erosion in the construction area. Construction will be complete in 2009. Also, an NPDES stormwater construction permit was obtained for the decontamination and decommissioning (D&D) of Building 301.

2.2.2. Spill Prevention Control and Countermeasures Plan

Argonne maintains a Spill Prevention Control and Countermeasures (SPCC) Plan as required by the CWA and EPA regulations at 40 CFR Part 112. This plan describes the planning, design features, and response measures that are in place to prevent oil or oil products from being released to navigable waters of the United States. Persons with specific duties and responsibilities in such situations are identified, as are reporting and recordkeeping requirements mandated by the regulations. Regular training is conducted on implementation of this plan. No reportable spills occurred in 2008 that required activation of the SPCC Plan.

The SPCC Plan was revised in 2004 to address some of the changes to applicable regulations proposed by the EPA. These regulations were finalized in December 2008; the deadline for full compliance with the new requirements is January 14, 2010. During 2008, the 2004 version of the SPCC Plan was revised to incorporate enhancements identified during an investigation into a sulfuric acid leak that occurred in 2008. The enhancements include procedures for testing water retained in secondary containment structures to ensure that a spill has not occurred before the water discharges.

2.2.3. General Effluent and Stream Quality Standards

In addition to specific NPDES permit conditions, Argonne discharges are monitored to determine if they conform to the general effluent limits contained in 35 IAC Part 304. Also, samples are collected to determine if Sawmill Creek meets IEPA General Use Water Quality Standards (WQSs) found in 35 IAC Part 302, Subpart B. Both the wastewater and Sawmill Creek were found to be in conformance with these standards. Chapter 5 of this report, which presents the results of the routine environmental monitoring program, describes the general effluent limits and WQSs and discusses conformance with these limits.

2.3. Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) and its implementing regulations are intended to ensure that facilities that generate, treat, store, or dispose of hazardous waste do so in a way that protects human health and the environment. The Hazardous and Solid Waste

Amendments of 1984 (HSWA) created a set of restrictions on land disposal of hazardous waste. In addition, the HSWA also require that releases of hazardous waste or hazardous constituents from any Solid Waste Management Unit (SWMU) at a RCRA-permitted facility be remediated, regardless of when the waste was placed in the unit or whether the unit originally was intended as a waste disposal unit. The RCRA program also includes regulations governing the management of underground storage tanks (USTs) containing hazardous materials or petroleum products. The IEPA has been authorized to administer most aspects of the RCRA program in Illinois. The IEPA issued a RCRA Part B permit to Argonne and DOE on September 30, 1997. The permit became effective on November 4, 1997. The permit has been modified eight times. Argonne submitted an application to renew the permit in October 2007. The IEPA is currently reviewing the application.

The Argonne remediation program was designed to achieve compliance with all applicable environmental requirements related to assessing and cleaning up releases of hazardous materials from inactive waste sites. The corrective action portion of the RCRA Part B permit provides the primary regulatory vehicle. This program was completed on September 30, 2003. However, seven SWMUs could not be remediated to No Further Action (NFA) status. The long-term monitoring of these inactive waste sites has been incorporated into the Argonne Long-Term Stewardship (LTS) Program. Quarterly reports are transmitted to the IEPA for these inactive sites. The LTS Program is described in greater detail in Chapter 6.

Also, one new SWMU and one new Area of Concern (AOC) have been identified since the remediation was completed. Argonne sent a notice about SWMU No. 746 (Building 300 Floor Drains) to DOE in July 2004. The IEPA added this SWMU to the Argonne corrective action program in March 2005. Argonne sent a notice about AOC-J (lead in soil near water towers) to DOE in November 2004. The IEPA added this AOC to the Argonne corrective action program in February 2005. The new SWMU and AOC are being investigated by Argonne's Facilities Management and Services (FMS) Division.

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

The nature of the research activities conducted at Argonne results in the generation of small quantities of a large number of waste chemicals. Many of these materials are classified as hazardous waste under RCRA. Argonne has 18 Hazardous Waste Management Units: 12 container storage units, 1 tank storage unit, 3 miscellaneous treatment units, and 2 tank chemical treatment units. Table 2.5 provides descriptions of these units. Figure 2.5 shows the locations of the major active hazardous waste treatment, storage, and disposal areas at Argonne.

Argonne prepares an annual Hazardous Waste Report. The report is submitted to the IEPA by March 1 of each year and describes the activity of the previous year. It is a summation of all RCRA waste activities, including generation, storage, and treatment. The report describing such activities during 2008 was submitted to the IEPA. The RCRA-permitted storage facilities, designed and operated in compliance with RCRA requirements, allow for accumulation and storage of waste pending off-site disposal. Argonne's on-site permitted treatment facilities address a small number of hazardous wastes generated by Argonne operations. Off-site treatment

TABLE 2.5

Permitted Hazardous Waste Treatment and Storage Facilities, 2008

Description	Location	Purpose
Storage		
Concrete Storage Pad	Building 331	Storage of solid radioactive waste and solid mixed waste (MW) in the form of steel-encased lead shielding containers and containerized solid MW.
Container Storage Area	Building 303 Mixed Waste Storage Facility	Storage of containers of ignitable, corrosive, oxidizing, reactive, solid hazardous, radiological, or MW.
	Building 331 Radioactive Waste Storage Facility	Storage of containers of flammable, toxic, corrosive, oxidizing hazardous, radiological, or MW.
Portable Storage Units (4)	Building 306	Storage of hazardous, radiological, or MW (3 of 4 units).
		Bulking operations to consolidate and reduce the volume of lab-packed waste in containers (1 of 4 units).
Tank Storage	Building 306	Storage of corrosive and toxic mixed waste and radiological liquid wastes (4,000 gal; currently not used).
Mixed Waste Storage	Building 306 – Storage Room A-142	Storage of ignitable MW.
	Building 306 – Storage Room A-150	Storage of solid and liquid MW.
	Building 306 – Storage Room C-131	Storage of ignitable, corrosive, and reactive hazardous waste.
	Building 306 – Storage Room C-157	Storage of corrosive and oxidizer MW.
	Building 306 – Storage Room D-001	Storage of solid MW containing toxic metal constituents.
Treatment		
Alkali Metal Passivation Booth	Building 206	Destruction of water reactive alkali metals possibly contaminated with radionuclides.
Alkali Metal Passivation Booth	Building 308	Destruction of water reactive alkali metals.

TABLE 2.5 (Cont.)

Description	Location	Purpose
Treatment (Cont.)		
Chemical/Photooxidation Unit[a]	Building 306	Treatment of ignitable liquid MW containing organic contaminants.
Metal Precipitation System	Building 306	Treatment of aqueous, corrosive LLW, some of which is contaminated with heavy metals.
Mixed Waste Immobilization/ Macroencapsulation Unit	Building 306	Treatment of solid, semisolid, and organic liquid MW containing RCRA metals.

[a] Not in use.

and disposal take place at approved hazardous waste treatment and disposal facilities. Hazardous and nonhazardous wastes that were shipped during 2008 are described in Table 2.6.

2.3.2. Hazardous Waste Treatability Studies

The IEPA requires that Argonne submit a report by March 15 of each year that estimates the number of hazardous waste treatability studies and the amount of waste expected to be used in the studies during the current year. No treatability studies were conducted during 2008.

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

The hazardous component of mixed waste is governed by RCRA regulations, while the radioactive component is subject to regulation under the AEA as implemented by DOE Orders. Accordingly, facilities storing or disposing of mixed waste must comply with both DOE requirements and RCRA permitting and facility standards. Argonne generates several types of mixed waste, including acids, solvents, and debris contaminated with radionuclides. The RCRA Part B permit provides for on-site treatment in four mixed waste treatment systems. These systems include

TABLE 2.6

Non-Rad Waste Shipped in 2008[a]

Category	Weight (lb)
Hazardous solids	8,390
Hazardous liquids	22,119
Hazardous gas cylinders	170
PCB ballasts	732
PCB liquids	34
Lead-acid batteries (recycle)	6,999
Lightbulbs (recycle)	2,869
Potentially infectious waste	322
Other batteries (recycle)	1,392
Lead scrap (recycle)	2,065
Asbestos	276,000
Nonhazardous liquids	56,512
Nonhazardous oil (recycle)	13,895
Nonhazardous solvent (recycle)	1,574
Nonhazardous gas cylinders	51
Nonhazardous solids	9,021
Total	402,145

[a] Abbreviations: PCB = polychlorinated biphenyl.

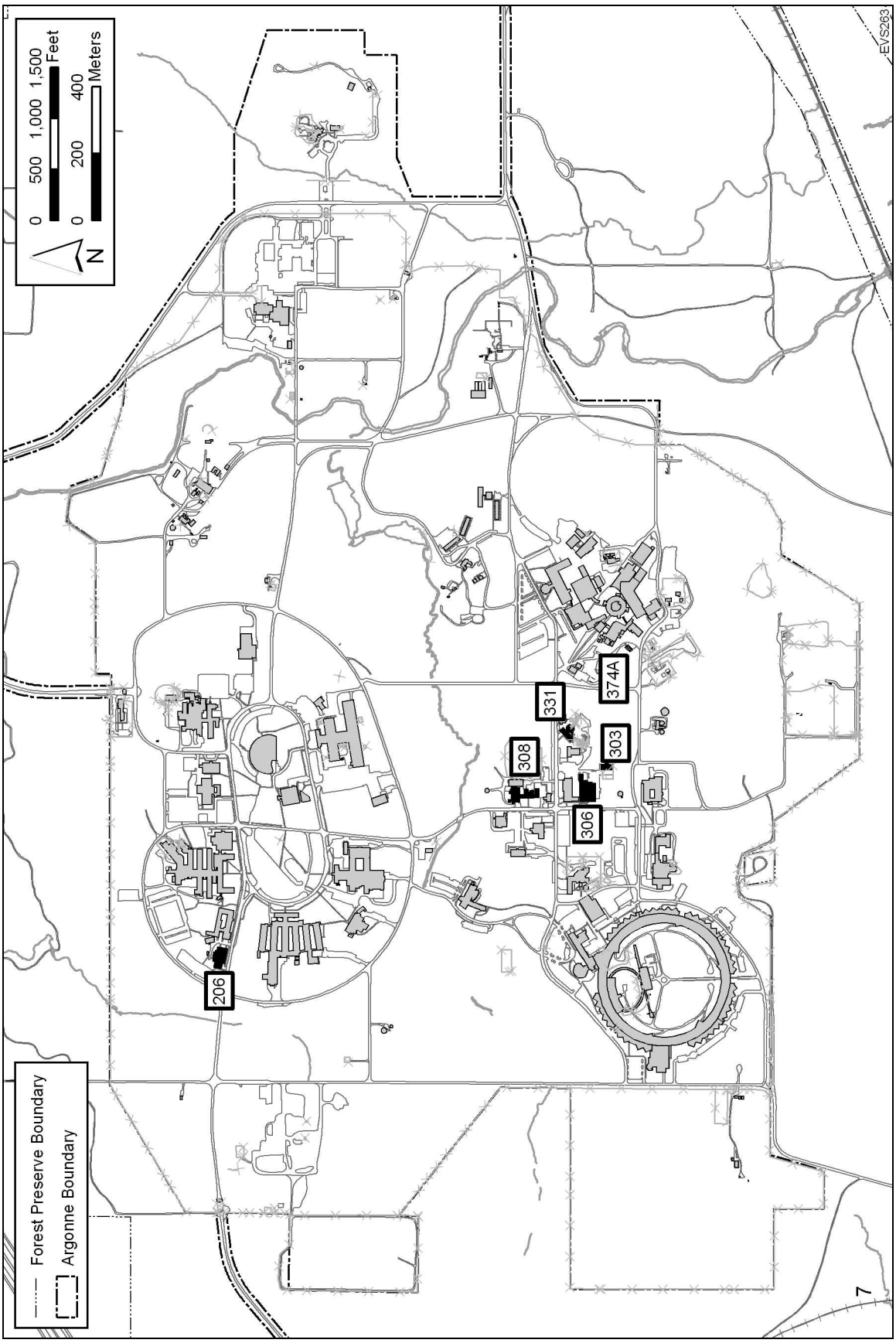


FIGURE 2.5 Major Treatment, Storage, and/or Disposal Areas at Argonne

neutralization of low-level radioactive waste (LLW) and the stabilization of sludge and soil. In addition, during 2008, some of the mixed waste was sent off-site to Energy Solutions and Perma-fix, out-of-state commercial treatment and disposal facilities. Mixed wastes that were generated and disposed of during 2008 are described in Table 2.7.

2.3.4. Federal Facility Compliance Act Activities

The Federal Facility Compliance Act of 1992 (FFCA) amended RCRA to clarify the application of its requirements and sanctions to federal facilities. The FFCA also requires that DOE prepare mixed-waste treatment plans for DOE facilities that store or generate mixed waste. The Proposed Site Treatment Plan (PSTP) for mixed waste generated at Argonne was submitted to the IEPA and the Illinois Department of Nuclear Safety (IDNS) in March 1995. Argonne's RCRA Part B permit provides for on-site treatment of certain mixed waste as required by the PSTP. During 2008, Argonne met the established treatment target dates. An update to the PSTP was provided to DOE with the treatment target dates for the remaining mixed waste storage. The schedule shows mixed waste governed by the plan, all of which will be treated by the end of 2009.

2.3.5. Underground Storage Tanks

The Argonne site currently contains 12 USTs. Six of the existing tanks are being used to store fuel oil for emergency generators. The on-site maintenance facility (Building 46) uses underground tanks to store diesel, gasoline, used oil, antifreeze, and an ethanol/gasoline blend. On August 28, 2006, the Illinois State Fire Marshal certified that the USTs at Argonne are in compliance with the regulations. Argonne compliance staff conducted compliance assessments in July and August 2008. In April 2008, Argonne removed a 2,271-L (600-gal) diesel fuel UST. The IEPA required that sampling be conducted; Argonne plans to conduct the sampling in 2009.

2.4. Solid Waste Disposal

In September 1992, Argonne ceased operation of its 800 Area Landfill, which had begun operating in 1966. The landfill was closed in 1992. On March 25, 2003, the IEPA determined that the postclosure care of the 800 Area Landfill, which includes groundwater monitoring, would be carried out under the corrective action provisions (Section V) of Argonne's RCRA Part B permit.

Groundwater Quality Standards of some routine indicator parameters have been consistently exceeded, such as TDS, iron, chloride, sulfate, and manganese. Exceedances occur primarily in shallow, perched pockets of groundwater in the glacial drift that are not in direct communication with the deeper dolomite bedrock aquifer. Hydrogen-3 has been measured in several wells at the 800 Area Landfill at concentrations ranging from <100 to 245 pCi/L. The 800 Area Landfill groundwater monitoring program is discussed in detail in Section 6.5.

TABLE 2.7

Mixed Waste Generation and Disposal, 2008[a]

Category	Volume (ft^3)
Radioactive Mixed Waste Generated	
Mixed waste debris	118.39
Corrosive wastewater with metals	16.47
Corrosive wastewater without metals	9.74
Inorganic nitrates	0.02
Mixed wastewater with metals	0.01
Organic solvents	2.17
PCB articles	9.34
Potentially infectious waste	322
TRU corrosives	3.83
PCB sludge and debris	14.705
Reactive compounds	0.27
Lead shielding	88.09
Scintillation vials	0.0021
Total	585.0371
Radioactive Mixed Waste Shipped	
Mixed waste debris	112.7435
Corrosive wastewater with metals	66.39
Corrosive wastewater without metals	39.084
Wastewater with metals	10.967
Scintillation vials	2.002
Organic solvents	57.532
Retention tank sludge	7.35
Soil with metals	0.571
Inorganic solids with chromium	0.018
General mixed waste debris	327.364
Inorganic solids with chromium	0.134
Combustible solids with metals	16
Combustible solids with organics	24.161
Lead shielding	125.43
PPE contaminated with lead	0.668
Stored lead waste	7.986
Reactive alkali metals	34.311
Elemental mercury	10.83
Reactive compounds	0.13
Inorganic nitrates	2.706
PCB sludge and debris	37.431
PCB articles	2.005
Total	885.8135

[a] Abbreviations: PCB = polychlorinated biphenyl; PPE = personal protective equipment; TRU = transuranic waste.

Argonne generates a large volume and variety of nonhazardous special wastes. Some special waste, such as sanitary sewage sludge, is certified by the IEPA as "nonspecial waste" pursuant to IEPA regulations. Table 2.6 gives the nonhazardous special and nonspecial wastes shipped during 2008. All nonhazardous special and nonspecial wastes generated at Argonne in 2008 were disposed of at permitted off-site special waste landfills. The IEPA began requiring annual nonhazardous special waste reporting in 1991. The report is required to be submitted by February 1 of each year to describe the activity of the previous year. It is a summation of all manifested nonhazardous and polychlorinated biphenyl (PCB) wastes shipped out of state.

2.5. National Environmental Policy Act

The National Environmental Policy Act of 1969 (NEPA) established a national environmental policy that promotes consideration of environmental impacts in federal or federally sponsored projects. NEPA requires that the environmental impacts of proposed actions with potentially significant effects be considered in an Environmental Assessment (EA) or Environmental Impact Statement (EIS). DOE has promulgated regulations at 10 CFR Part 1021 that list classes of actions that ordinarily require those levels of documentation or that are categorically excluded from further NEPA review. No EISs or EAs were prepared during 2008.

2.6. Safe Drinking Water Act

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

2.6.1. Applicability to Argonne

In January 1997, Argonne incorporated Lake Michigan water as its domestic source water, thereby replacing the dolomite groundwater that formerly constituted its source of drinking water. Because the Lake Michigan water is purchased from the DuPage County Water Commission, Argonne is now a customer, rather than a supplier of water. Consequently, on January 23, 1997, the DuPage County Health Department notified DOE that the federal and state monitoring requirements applicable to a "non-transient, non-community" public water supply were no longer applicable. Nevertheless, Argonne voluntarily provides to on-site personnel the Consumer Confidence Report on drinking water quality that Argonne receives as a customer of the DuPage County Water Commission. The annual report indicates that all measured contaminants meet the drinking water standards.

2.6.2. Water Supply Monitoring

During 2008, Argonne continued an informational monitoring program at three previously used dolomite domestic wells that are still operational; quarterly samples were analyzed for radionuclides and VOCs. No radionuclides or VOCs above drinking water standards were detected.

2.7. Federal Insecticide, Fungicide, and Rodenticide Act

During 2008, all EPA Restricted-Use pesticides and herbicides at Argonne were applied by an IDPH licensed contractor who provides the chemicals used and removes any unused portions. Argonne coordinates the contractor's activities and ensures that the chemicals are EPA-approved, that they are used properly, and that any unused chemicals are removed from the site by the contractor.

In 2008, approximately 59,170 L (15,571 gal) of commercial-grade herbicide was applied throughout the Argonne site. Fertilizer with weed control is included in the quantity of herbicide.

Also in 2008, gypsy moth habitats were sprayed. Several stands of oak trees at Argonne and in the surrounding forest preserves and communities are at risk due to gypsy moths. The risk is severe but difficult to predict. Without effective treatment, Argonne could lose 50 or more mature trees.

2.8. Comprehensive Environmental Response, Compensation, and Liability Act

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) addresses the cleanup of hazardous waste disposal sites and the response to hazardous substance spills. Under CERCLA, the EPA collects site data regarding sites subject to CERCLA action through generation of a Preliminary Assessment report, followed by a Site Screening Investigation. Sites then are ranked, on the basis of the data collected, according to their potential for affecting human health or causing environmental damage. The sites with the highest rankings are placed on the National Priority List (NPL) and are subject to mandatory cleanup actions. No Argonne sites are included in the NPL.

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

Title III of the 1986 Superfund Amendments and Reauthorization Act (SARA) amendments to CERCLA is the Emergency Planning and Community Right to Know Act (EPCRA), a freestanding provision. EPCRA requires providing federal, state, and local emergency planning authorities information regarding the presence and storage of hazardous

substances and their planned and unplanned environmental releases, including providing for responses to emergency situations involving hazardous materials. Under EPCRA, Argonne submitted reports pursuant to Sections 302, 304, 311, 312, and 313, which are discussed in the following paragraphs. Table 2.8 gives Argonne's status in regard to EPCRA.

Section 302 of SARA Title III, Planning Notification, addresses notifying and updating the Local Emergency Planning Committee (LEPC) and the State Emergency Response Commission (SERC) as to the presence of extremely hazardous substances (EHSs) at Argonne, including laboratory usage, that exceed any extremely hazardous substance (EHS) threshold planning quantity. The Section 302 information for 2008 was transmitted to the LEPC and SERC during June, October, and December of 2008.

Section 304 of SARA Title III, Extremely Hazardous Substances Release Notification, requires that the LEPC and state emergency management agencies be notified of accidental or unplanned releases of Section 302 hazardous substances to the environment. Also, the National Response Center (NRC) is notified if a release exceeds the CERCLA Reportable Quantity (RQ) for that particular hazardous substance. The procedures for notification are described in the Argonne Emergency Management Plan Implementing Procedures. On January 29, 2008, a sulfuric acid spill from a leaking flange at the storage tank outside Building 108 (Boiler House) resulted in a notification to the LEPC, SERC, and NRC. During the incident, the spill was thought to constitute an RQ release; subsequent investigation determined that the amount released was not an RQ.

Under SARA Title III, Section 311, Material Data Safety Sheet (MSDS)/Chemical Inventory, Argonne is required to provide applicable emergency response agencies with MSDSs, or a list of MSDSs, for each hazardous chemical stored on-site. The 2008 information was transmitted to the LEPC and SERC during June and October of 2008.

Pursuant to EPCRA Section 312, Argonne is required to report certain information regarding inventories and the locations of hazardous chemicals to state and local emergency authorities upon request. Chemicals used in research laboratories under the direct supervision of a technically qualified individual are exempt from reporting. The report on Section 312 (Tier 2) information for 2008 was provided to the SERC, LEPC, and Argonne Fire Department during February 2009. Table 2.9 lists the hazardous chemicals reported.

TABLE 2.8

Status of EPCRA Reporting, 2008

EPCRA Section	Description of Reporting	Status
Section 302	Planning notification	Required
Section 304	Extremely hazardous substance release notification	Required
Section 311–312	Material Safety Data Sheet chemical inventory	Required
Section 313	Toxic Release Inventory reporting	Required

TABLE 2.9

SARA, Title III, Section 312, Chemical List, 2008

CAS No.	Name	Hazard[a]
NA[b]	Lead/acid batteries	A,C,R
7664-93-9	Sulfuric acid	A,C,R
75-69-4	Trichlorofluoromethane	A,C
75-45-6	Chlorodifluoromethane	P,A,C
306-83-2	Dichlorotrifluoroethane	A,C
811-97-2	Tetrafluoroethane	P,A,C
8006-61-9	Gasoline	F,A,C
NA	E85 Fuel	F,A,C
68476-30-2	Diesel Fuel #2	F,A,C
10043-01-3	Aluminum sulfate	A,C
10043-52-4	Calcium chloride (pellets)	A,C
10043-52-4	Calcium chloride solution	A,C
7881-52-9	Sodium hypochlorite	A,C
7699-45-8	Zinc bromide	A,C,R
7647-14-5	Rock salt (sodium chloride)	A,C
24307-26-4	Mepiquat chloride	A,C
245735-90-4	Mepiquat pentaborate	A,C
10043-35-3	Boric acid	A,C
14464-46-1	Sand	A,C

[a] Hazard: A = Acute; C = Chronic; F = Fire; P = Pressure; R = Reactive.

[b] NA = no CAS No.

Section 313 of SARA Title III, Toxic Release Inventory (TRI) Reporting, requires certain facilities to prepare an annual report entitled “Toxic Chemical Release Inventory, Form R,” if annual usage of listed toxic chemicals exceeds certain thresholds. Argonne is not within the range of Standard Industry Classification (SIC) and North American Industry Classification System (NAICS) Codes specified in 40 CFR Part 372. Argonne reports this information, however, because DOE, which is subject to EO 13148, “Greening the Government through Leadership in Environmental Management” (April 21, 2000), directs Argonne to do so. No reports were filed from 1997 to 2000, because no listed chemicals were used in amounts that exceeded reporting thresholds. However, new requirements regarding a class of TRI compounds called persistent, bioaccumulative toxics (PBTs) came into effect in 2000. As a result, Argonne filed one report under Section 313 in 2008 for activities in 2007 for lead and lead compounds. Use of lead included machining of various types of lead articles in excess of the 45-kg (100-lb) reporting threshold. Lead compounds were included due to conversion of lead in coal to lead oxide. Under TRI, the lead oxide is categorized as having been “manufactured,” and it was reported since it exceeded the 45-kg (100-lb) threshold.

2.9. Toxic Substances Control Act

The Toxic Substances Control Act (TSCA) was enacted to require chemical manufacturers and processors to develop adequate data on the health and environmental effects of their chemical substances. The EPA has promulgated regulations to implement the provisions of TSCA. These regulations are found in CFR Title 40, "Protection of the Environment, Chapter I: Environmental Protection Agency, Subchapter R – Toxic Substances Control Act." These regulations provide specific authorizations and prohibitions on the manufacturing, processing, and distribution in commerce of designated chemicals. The principal impact of these regulations at the Argonne site concerns the handling of asbestos and PCBs. Suspect PCB-containing items that are subject to this act are identified through the Argonne PCB Item Inventory Program. Argonne has developed procedures to deal with the import/export of TSCA materials by relying on U.S. Customs Service processes.

2.9.1. PCBs in Use at Argonne

PCB items in use or in storage for reuse are tracked by the Argonne PCB Item Inventory Program. All PCB items identified by the PCB Item Inventory Program have been labeled appropriately with a unique number for inventory and tracking purposes. These items are included in the Argonne Annual PCB Report, which describes the location, quantity, manufacturer, and unique identification number for all PCBs on-site. This report is not submitted to regulatory agencies but is kept on file at Argonne. The Annual PCB Report for 2008 was completed on April 21, 2009. The PCBs in use at Argonne are contained in capacitors and power supplies. Waste Management Operations (WMO) processes PCB-contaminated equipment and oil for disposal. The regulations governing the use and disposal of PCBs can be found in 40 CFR Part 761.

2.9.2. Disposal of PCBs

Disposal of PCBs from Argonne operations includes materials lab-packed and bulked and aggregated solids shipped off-site through WMO. This includes PCB-containing materials that also contain radioactive substances, the combination of which is known as TSCA mixed waste. Table 2.6 contains the amount of PCBs and PCB-contaminated materials shipped by Argonne during 2008.

2.10. Endangered Species Act

The Endangered Species Act of 1973 (ESA) is federal legislation designed to protect plant and animal resources from the adverse effects of human activities. To comply with the ESA, federal agencies are required to assess the area affected by a proposed project to determine whether it contains any threatened or endangered species, or critical habitat of such species.

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

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

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

Although state-listed species that occur in the area are not covered by the ESA, the following state-listed species can be found on the Argonne site or within the vicinity of Argonne:

- Endangered
  - Black-crowned night heron (*Nycticorax nycticorax)*
  - Eastern massasauga (*Sistrurus catenatus catenatus*)
  - Prairie bush clover (*Lespedeza leptostachya*)
  - Quillwort (*Isoetes butleri*)
  - Tennessee milkvetch (*Astragalus tennesseensis*)
  - Tuckerman's sedge (*Carex tuckermanii*)
  - Yellow-crowned night heron (*Nyctanassa violacea*)

- Threatened
  - Blanding's turtle (*Emydoidea blandingii*)
  - Buffalo clover (*Trifolium reflexum*)
  - Henslow's sparrow (*Ammodramus henslowii*)
  - Kirtland's snake (*Clonophis kirtlandi*)
  - Marsh speedwell (*Veronica scutellata*)
  - Shadbush (*Amelanchier interior*)
  - Slender sandwort (*Minuartia patula*)
  - White lady's slipper (*Cypripedium candidum*)

Of these, the black-crowned night heron and the Kirtland's snake have been observed on Argonne property. Impacts on these species also would be assessed during the NEPA process.

2.11. National Historic Preservation Act

The National Historic Preservation Act of 1966 (NHPA), as amended, requires federal agencies to assess the impact of proposed projects on historic or culturally important sites, structures, or objects within the area of potential effect for a proposed project. It further requires federal agencies to assess all archaeological sites, historic buildings, and objects on such sites to determine whether any qualify for inclusion in the NRHP. The act also requires federal agencies to consult with the State Historic Preservation Office (SHPO) and the Advisory Council for Historic Preservation (ACHP), as appropriate, when determining if proposed actions would adversely affect properties that are eligible for listing on the NRHP.

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

Argonne's compliance procedures for satisfying the NHPA and DOE requirements are outlined in a Cultural Resources Management Plan (CRMP), which was approved by the IHPA and ACHP in October 2006. The CRMP replaces a Programmatic Agreement (PA) signed in 2002 among Argonne, the ACHP, and the IHPA, which defined Argonne's procedures for management of cultural resources. The acceptance of the CRMP nullifies the PA as the guiding document for the management of cultural resources at Argonne. The 5-year update of the CRMP is scheduled for 2011.

Cultural resources include both archaeological sites and historic structures. Roughly 191 ha (473 acres) of the Argonne site have been examined through Phase I Archaeological surveys for the presence of cultural resources. It was previously determined that the roughly 63 ha (155 acres) immediately surrounding the buildings in the 200 Area are not expected to contain intact resources as a result of past earthmoving activities. There are approximately 348 ha (861 acres) that require examination for the presence of cultural resources on the Argonne site. Past surveys have identified 46 archaeological sites on Argonne-managed property. Three of the sites have been determined eligible for listing on the NRHP. Twenty-two sites have been

determined ineligible for listing on the NRHP. The remaining 21 sites have yet to be evaluated for listing.

In 2001, Argonne completed an evaluation of all structures built prior to 1989 for potential listing on the NRHP. The survey identified the Building 200 M-Wing Caves and Buildings 203, 205, 212, 315/316, and 350 as individually eligible for listing on the NRHP. The evaluation also identified two historic districts — the Main Campus District (Buildings 200, 202, 203, 205, 208, and 211) and the Freund Estate District (Buildings 600 and 604 and properties 603 [pool], 606 [pavilion], and 616 [tennis courts]). Separate NHPA evaluations generally conducted as part of D&D efforts have also found the Chicago Pile-5 Reactor (CP-5); the Argonne Thermal Source Reactor, Building 301; the Physics and Metallurgy Hot Laboratory; the High Voltage Electron Microscopy Facility; the Alpha-Gamma Hot Cell Facility; and Zero Power Reactors (ZPR) VI and IX eligible for listing on the NRHP.

Compliance activities associated with the NHPA have resulted in the documentation of several properties prior to removal. Building 301, CP-5, ZPRs VI and IX, and the Argonne Thermal Source Reactor have all been documented to Illinois Historic American Engineering Record standards. The documentation reports are on file with the Illinois State Archives. Archaeological excavations of several farmsteads and prehistoric sites occurred prior to the construction of the APS during the early 1990s. In 2003, site 11-DU-201, a mid-nineteenth century farmstead, was partially excavated, which resulted in the site being determined ineligible for listing on the NRHP.

As stated above, all cultural resource reviews and mitigation work are performed in consultation with the IHPA and the ACHP as required in the Argonne CRMP. The primary 2008 compliance activity at Argonne was the implementation of Argonne's CRMP. In addition, archaeological field surveys were conducted prior to the installation of an underground communication line and prior to installation of new power lines for the TCS Building. No new cultural resources were identified during these investigations.

2.12. Floodplain Management

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

The Argonne site is located approximately 46 m (150 ft) above the nearest large body of water (Des Plaines River); thus, it is not subject to major flooding. The 100- and 500-year floodplains are limited to low-lying areas of the site near Sawmill Creek, Freund Brook, Wards Creek, and other small streams and associated wetlands and low-lying areas. These areas are delineated in Argonne's site development plan and are contained within areas designated as

conservation use, not intended for development. No significant structures are located in these areas, although an existing pumping station for securing canal water as a cooling tower feedstock is situated in the floodplain of the Des Plaines River south of the site. To ensure that these areas are not adversely affected, new facility construction is not permitted within these areas, unless there is no practical alternative. Any impacts on floodplains would be fully assessed in a floodplain assessment, and, as appropriate, documented in the NEPA documents prepared for a proposed project.

2.13. Protection of Wetlands

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

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

Argonne completed a sitewide wetland delineation in 1993. All wetlands present on-site were identified and mapped following the 1987 *Corps of Engineers Wetlands Delineation Manual*.[3] The delineation map shows the areal extent of all wetlands present at Argonne down to 500 m^2 (1/8th acre). Thirty-five individual wetland areas were identified; their total area is approximately 20 ha (50 acres). The larger wetlands are illustrated in Figure 1.3.

In February 1989, the COE issued a permit to DOE under Section 404 of the CWA, addressing the construction of the APS facility at Argonne. The permit was required because construction of the APS involved the filling of three small wetland areas, known as Wetlands A, B, and E, which totaled 0.7 ha (1.8 acres) in size. Issuance of the permit was contingent upon approval of a mitigation plan submitted to the COE by DOE. The plan outlined procedures for the construction of a new wetland area, Wetland R, and also identified actions to be taken to avoid impacts on a fourth wetland, Wetland C, just under 0.4 ha (1 acre), during APS construction activities.

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

cause of the problems with Wetland C. The COE verbally agreed with these response actions. Implementation of the plan began in 1997.

Mitigative actions for Wetland R, as described in the 1997 management plan, involved improving the mix of vegetation through controlled burns, herbicide application, and planting of desirable plants. Controlled burns were completed in 1997, 2000, 2001, 2002, 2005, and 2008. In September 2007, the COE visited the site to see the two compliance wetlands. On the basis of its observations and feedback, a jurisdictional determination for the failed wetland and an approval request for Wetland R were prepared. This information was sent to the COE in June 2008.

Argonne's wetland management strategy, as described in a September 2001 DOE EA, included creating advanced compensatory mitigation. The advanced compensatory mitigation is similar to a wetland "bank" and is to be used to offset wetland losses at Argonne.

Argonne restored several acres of high-quality wetland in the 400 Area by disabling a drainage tile network installed when the land had been farmed. Depending on the COE's response, Argonne may or may not need to continue the mitigation but could continue the development of the advanced compensatory mitigation as described by the EA. Vegetative monitoring data show improving vegetation quality in the advanced compensatory mitigation wetland but still not meeting COE standards. A proposed upgrade to the APS facility involves an expansion to the north through existing wetlands, which could require new mitigation and loss of the wetland bank.

2.14. Land Management and Habitat Restoration

Land management and habitat restoration has been an area of interest. The retention of scarce habitat types and their need for preservation and husbandry from encroachment by development as well as protection from invasive species is now increasingly prevalent in the Chicago region.

As documented in the 2007 *Ten Year Site Plan,* the land use plan for undeveloped areas is based on the tailored need for mitigation, environmental restoration, and diversification of landscape forms and materials through the increased presence of cost-saving native species and reduction or elimination of non-native or potentially invasive plant species. Numerous initiatives have been established to return selected localities within Argonne's boundaries to more viable and self-sustaining habitat types, such as prairie and savannah, that formerly existed in this region, as well as to combat invasive species in remaining areas of high-quality habitat. Additional efforts have sought to increase floristic diversity and use of native plant materials within the developed areas of the site while reducing traditional costs for landscaping maintenance.

Projects have been coordinated with environmental compliance activities related to wetlands mitigation, which complement the committee's efforts to date. Major issues include the control of invasive species and the management of areas that have not been addressed adequately

in past practices. Argonne expects that DOE will continue its high level of interest, as evidenced in performance contract measures.

Significant achievements in 2008 include a decrease in the buckthorn footprint, an increase in prairie acreage, and implementation of an oak tree health plan.

2.15. Wildlife Management and Related Monitoring

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

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

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

2.16. Current Issues and Actions

The purpose of this section is to summarize the most important issues related to environmental protection encountered during 2008. Table 2.10 lists all water effluent exceedances reported during 2008. Exceedances of the NPDES wastewater discharge limits and Ground Water Quality Standards at the 800 Area Landfill are discussed in Chapters 5 and 6, respectively.

2.16.1. Clean Water Act — NPDES

As in previous years, Argonne exceeded some NPDES permit limits in 2008 (see Table 2.10). In past years, the TDS concentration was the most persistent exceedance of the NPDES permit limits. Investigations regarding cause and corrective actions were completed and are discussed in Chapter 5.

In the past, Argonne has had occasional positive toxicity test results at several outfalls. These appear to be due to residual chlorine from the discharge of chlorinated drinking water into these outfalls and from cooling tower blowdown that may contain antifouling agents. Many of

TABLE 2.10

Summary of 2008 Water Effluent Exceedances

Date	Outfall	Parameter	Assessment
January 1	001	Chloride	Road salt associated with melting snow
January 8	001	TDS	Road salt associated with melting snow
February 5	001	TDS	Road salt associated with melting snow
February 12	001	TDS	Road salt associated with melting snow
February 12	001	Chloride	Road salt associated with melting snow
February 14[a]	006	TDS	Road salt associated with melting snow
February 19	001	TDS	Road salt associated with melting snow
February 19	001	Chloride	Road salt associated with melting snow
March 4	001	TDS	Road salt associated with melting snow
March 11	001	TDS	Road salt associated with melting snow
March 25	001	TDS	Road salt associated with melting snow
April 1	001	TDS	Road salt associated with melting snow
June 19	006	TDS	Unknown

[a] Not reported to state, exempt from reporting due to snowmelt.

these discharges have been redirected into the sewer system to be processed at the WTP. No toxicity has been found during the last three years of testing.

2.16.2. 800 Area Groundwater Monitoring

The IEPA-approved 800 Area Landfill groundwater monitoring program continues to indicate that the Ground Water Quality Standards of some inorganic parameters, such as TDS, iron, and manganese, consistently are being exceeded in several wells. The groundwater monitoring program is discussed in detail in Section 6.5.

2.16.3. Long-Term Stewardship Activities

Remediation of waste management units was completed in 2003. During 2004, the long-term operation, maintenance, and monitoring of these sites, which constitutes Argonne's LTS Program, were incorporated, in their entirety, into Argonne's environmental monitoring and surveillance program. Ongoing activities during 2008 are summarized in Chapter 6.

2.16.4. CP-5 Monitoring

Elevated levels of hydrogen-3 in CP-5 Monitoring Well 330031R (up to 45,000 pCi/L) were measured in quarterly groundwater samples after the original well was removed and the well replaced with a new well screened at a lower depth. Although the hydrogen-3 concentrations

are decreasing, expanded monitoring activities in this area determined that the hydrogen-3 distribution was localized.

2.17. Environmental Permits

Table 2.11 lists all the environmental permits in effect at the end of 2008. Other portions of this chapter discuss special requirements of these permits and compliance with those requirements.

2.18. IEPA/DOE Inspections/Appraisals

Various inspections and appraisals were conducted during 2008. A short description of each is included in Table 2.12.

TABLE 2.11

Environmental Permits in Effect, 2008

Permit Name	Permit ID	Status	Start Date	End Date
B-203 CARIBU Project Construction Permit	05120055	Effective	3/20/2006	–[a]
CAAPP (Title V) Permit	95090195	Effective	10/17/2006	10/17/2011
NPDES Wastewater Discharge Permit	IL0034592	Effective	9/1/2005	8/31/2010
Open Burn Permit – Fire Training	B0801035	Effective	4/18/2008	4/18/2009
Open Burn Permit – Vegetative Control	B0809136	Effective	12/11/2008	12/11/2009
RCRA Part B Permit	IL3890008946	Effective	9/30/1997	–
USDA Soil Permit	P330-09-00006	Effective	1/8/2009	1/8/2012
Wastewater Discharge Permit to DuPage County	18965	Effective	7/29/1991	–
Wastewater Treatment Plant Land Application Permit	2004-SC-1419	Effective	8/12/2004	7/31/2009
Nuisance Wildlife Control Permit	Argonne/Group Class C Permit	Effective	1/30/2009	1/31/2010
Boiler No. 5 Stoker Replacement Project	07040001	Effective (construction)	7/12/2007	–
Howard T. Ricketts Laboratory Construction Project	2006-EN-6007	Effective (construction)	1/12/2006	–

[a] A dash indicates that the permit continues to be in effect until it is renewed.

TABLE 2.12

IEPA/DOE Environmental Compliance Inspections/Appraisals, 2008

Agency	Type	Date
IEPA	RCRA Inspection	August 20, 2008
IEPA	NPDES CWA Inspection	October 23–24, 2008
DOE-ASO	Environmental Stewardship Functional Area Review	March 6, 2008
DOE-ASO	NEPA Functional Area Review	November 25, 2008
Argonne COA and DOE-ASO	EMS conformance with ISO 14001:2004(E) and DOE 0 450.1A Internal Assessment	November 18, 2008
Argonne COA and DOE-ASO	LMS Environmental Processes Spot Audit	December 19, 2008
Argonne COA and DOE-ASO	Environmental Surveillance Program • Housekeeping Inspections – 3 • Environmental Walkthrough – 39	Various

3. ENVIRONMENTAL MANAGEMENT SYSTEM

3. ENVIRONMENTAL MANAGEMENT SYSTEM

The Environmental Management System (EMS) is a management tool that describes how Argonne consistently monitors and manages the effects its operations or processes may have on the environment and continually improves its environmental stewardship performance. The EMS is required by DOE Order 450.1A, which has been incorporated into the UChicago Argonne, LLC, prime contract for the operation of Argonne.

The UChicago Argonne, LLC, Board of Governors, the Laboratory Directorate, and the Laboratory Management Council are committed to ensuring that environment, safety, and health (ESH) considerations are integrated into the performance of all work. Implicit in this commitment is support to continually improve and maintain an EMS in compliance with DOE Order 450.1A. The Argonne overall policy for ESH is documented in the LMS-POL-2, and it is available to Argonne employees and to the public on the Argonne public website.

A supporting document to the Environmental Protection Policy is the EMS Description Document. In 2008, the EMS document was revised and restructured to address the 17 elements found in International Organization for Standardization (ISO) 14001:2004. It is linked to a number of Argonne-wide LMS procedures (PROCs). The process for the establishment of significant environmental aspects is described in this document. The EMS must be validated by a qualified party outside of the Argonne EMS every three years. The initial certification of the Argonne EMS must be declared completed by June 30, 2009.

3.1. EMS Components

3.1.1. Environmental Aspects and Impacts

Argonne evaluates its operations, identifies aspects of its operations that can impact the environment, and determines which of those impacts are significant. When operations have an environmental aspect, Argonne implements the EMS to minimize or eliminate any potential adverse impact.

The environmental aspects addressed in the EMS are air emissions, water effluents, drinking water, waste management, pollution prevention/waste minimization, floodplain/wetlands, pesticide management, cultural resources management, PCB management, TSCA chemical management, UST management, EPCRA reporting, and long-term stewardship. Regulatory responsibilities as well as organizational roles and responsibilities are delineated in the EMS description document to address the management of the aspects and impacts. On the basis of a scoring methodology in Appendix A of the EMS, four aspects have been identified as being significant: regulated air emissions, wastewater discharges, waste generation, and pollution prevention/waste minimization.

3.1.2. Performance Measures

Argonne establishes performance measures to drive improvements and ultimately, environmental performance. Focus is on the environmental aspects that can have a significant impact, address stakeholder concerns, address progress on meeting sustainable practices goals, and align the commitments made in the environmental policy. Performance measures are developed each fiscal year.

3.1.3. Objectives and Targets

Another mechanism to improve environmental performance is the annual establishment of EMS Objectives and Targets. Objectives describe Argonne's goals for environmental performance. The objectives are a set of measurable or qualitative goals concerning how Argonne will address each significant environmental aspect. Targets are specific, and measureable interim steps are taken to obtain objectives. Targets are documentable actions with due dates. All organizations are encouraged to establish and implement environmental targets where applicable to individual programs.

Objectives and targets are established in a top-down manner. The procedure used to describe this process in LMS-PROC-12 (Setting and Meeting Environmental Management System Objectives and Targets) and the current objectives and targets are collected each year on the ANL-777 form.

In 2008, Argonne's EMS objectives included:

1. Obtain ISO-14001 certification,
2. Improve sustainable practices,
3. Improve ecological stewardship,
4. Achieve full compliance with applicable environmental regulations, and
5. Enhance pollution prevention/waste minimization activities.

For 2008, Argonne established 23 targets. In addition to several core activities, a set of targets was established to encourage line management to increase its participation in the process.

All objectives and targets established for fiscal year (FY) 2008 were completed by their due dates.

3.1.4. Incorporation of New Environmental Requirements

LMS-PROC-61, "DOE Directives Processing Procedure" defines the procedure for processing environmental draft and final DOE Orders or other directives and incorporating them into the documentation hierarchy. Once issued to Argonne, these DOE Orders and directives become part of the prime operating contract. Argonne has established a procedure to formalize the process that it follows to identify applicable environmental laws and regulations (LMS-PROC-55) not addressed by DOE Orders.

A number of sources of information are reviewed to identify new or changing regulations, including:

- Monitoring *Federal Register* notices, DOE Web sites, and newsletters;
- Attending workshops and seminars; and
- Participating in professional organizations and conferences.

Identification of new requirements will be communicated to managers and supervisors by subject matter experts. Evaluations are conducted to determine the impact of the proposed and final regulations.

In addition to new or revised DOE Orders and regulations that prescribe requirements, Argonne uses other sources to identify opportunities for environmental improvement. These include lessons-learned reports, interaction with other DOE sites, participation in forums, Occurrence Reporting Processing System reports, assessments by stakeholders, monitoring changes in environmental regulations, and feedback from public interest groups and others.

3.2. Environmental Organization Structure and Roles

The roles and responsibilities in implementing EMS flow from the DOE to UChicago Argonne, LLC, to the Argonne Laboratory Director, the Laboratory Directorate and Management Council, to the individual Associate Laboratory Directors (ALDs), to the Division Directors, and to the Argonne workers along the line management structure.

The line organization appoints a number of individuals with environmental responsibilities to provide advice and guidance to them. Each ALD is supported by an ESH/Quality Assurance (QA) representative. The environmental responsibilities of the ESH/QA representative include the following: interfaces with division ESH/QA coordinators on environmental issues; interfaces with Environment, Safety, Health/Quality Assurance (ESQ) staff on environmental issues; serves as a participant and point of contact for assessments; and maintains cognizance of ALD activities in order to ensure environmental protection support when needed. Each ALD also appoints a NEPA owner to oversee and implement the NEPA program in his/her area of responsibility. Division/department environmental compliance

representatives (ECRs) are also appointed. The ECRs report to the organization management and serve as the primary point of contact on matters related to environmental protection. Other division staff also assist the line in maintaining a safe environment, such as the ESH coordinators, health physicists, health physics technicians, and QA representatives.

3.3. EMS Support Organizations and Programs

3.3.1. Environmental Planning and Compliance

The Environmental Planning and Compliance (EPC) group serves as the primary support organization dealing with the implementation of environmental regulations. The staff is knowledgeable in federal, state, and local regulations and DOE Orders. The EPC responsibilities include providing expert assistance, supported by the Argonne Legal Department, in the planning, designing, implementing, and permitting of operations to ensure that the environmental requirements are met; providing prompt reporting to management and regulators of any noncompliances; developing and administering the Argonne NEPA program; administering, reviewing, and consulting on the permitting process; functioning as a technical resource on environmental issues/regulations; conducting environmental reviews of projects; conducting compliance assessments for major program areas; maintaining an environmental compliance Web site; and supporting oversight activities by participating in audits.

3.3.2. Environmental Monitoring and Surveillance

The Environmental Monitoring and Surveillance group is responsible for monitoring the effects, if any, of Argonne activities on the public and the environment. Environmental monitoring consists of two major activities: effluent monitoring and environmental surveillance. Effluent monitoring includes collecting and analyzing samples or measuring liquid and gaseous releases for the purpose of characterizing and quantifying contaminants, assessing radiation exposure to the public, providing information used to control effluent releases, and demonstrating compliance with applicable standards and permit conditions. Environmental surveillance includes collecting and analyzing samples or directly measuring contamination in air, surface water, groundwater, and sediment from the Argonne site and its environs and assessing radiation exposure of members of the public and assessing the effects, if any, on the local environment. The information generated by the monitoring program is the basis for reports to various federal and state agencies to satisfy permit and regulatory requirement.

3.3.3. Analytical Support

The Analytical Services group is responsible for providing radiological and chemical analysis to support the environmental monitoring, bioassay, industrial hygiene, and health physics programs. This dedicated on-site laboratory provides quality analytical data needed by

programs to satisfy their regulatory and internal needs. The analytical program is supported by a rigorous QA program, including participation in environmental industrial hygiene, radiobioassay, and performance evaluation programs. The analytical program is accredited by the DOE Laboratory Accreditation Program (DOE-LAP) and the American Industrial Hygiene Association (AIHA).

3.3.4. Training

The Training group is responsible for developing training modules, conducting training, and administrating the Training Management System, which is used to determine the training needs of each worker based on the worker's responsibilities/activities and the hazards each employee may encounter in the workplace. Argonne has developed a comprehensive environmental training program to train staff, visitors, and contractors to ensure that they are competent to carry out their environmental responsibilities. The environmental training program includes general environmental awareness, regulatory compliance training, and specific courses for managers, internal assessors, and operations personnel.

3.3.5. Waste Management Operations

The WMO Department is responsible for the safe collection, treatment, storage, and disposal of all regulated waste generated at Argonne. This includes hazardous waste, special waste, LLW, mixed waste (MW), and transuranic waste (TRU). Argonne activities do not generate or involve the use of any high-level radioactive waste. WMO is also responsible for compliance with the RCRA Part B permit, the DOE requirements for radioactive waste management, and all other applicable regulations.

3.3.6. Pollution Prevention and Waste Minimization

Argonne implements a sitewide Pollution Prevention/Waste Minimization (P2/WM) Program in accordance with DOE Order 450.1A and site-specific P2 performance measures. The P2 program tracks the generation of waste and recyclable material at Argonne and monitors the progress with regard to performance measures.

Argonne management fosters a work environment that promotes the development and implementation of P2 activities. Argonne management has established a P2 policy statement and a requirement that all new project reviews include the use of a P2 review checklist. In addition, Argonne uses the Integrated Safety Management Systems (ISMSs) to promote and institutionalize P2 strategies across the Argonne site.

Historically, those involved in the Argonne P2 program have identified, developed, and performed Pollution Prevention Opportunity Assessments (PPOAs). PPOAs are reviews of programs, projects, and activities to determine what changes can be made to reduce or eliminate pollution. During 2008, PPOAs resulted in the following determinations:

- Hard hats with a 1 or 2 in the recycle triangle can be recycled after the support web is removed.
- Unleaded egress tape can be used in place of lead-containing egress tape.
- Used welding rods can be recycled.
- Unneeded computers/scientific equipment cannot be provided to schools.
- The quantity of boxes purchased by FMS could potentially decrease by 35 to 40%.
- Polyvinyl chloride (PVC) cannot be recycled.
- Approximately 1,179 kg (2,600 lb) of lead and 0.8 kg (1.8 lb) of mercury are unnecessary to Nuclear Engineering programs or program development.
- E-signatures can be used for approvals.
- E-access, not hard copy distribution, can be used for work planning/control documents.
- Insulation can be installed on the recirculating chilled water pipes in Building 205.

Argonne's comprehensive solid waste recycling program effectively recycles/reduces a wide range of materials. Table 3.1 presents a summary of the results for 2008.

TABLE 3.1

Recycled Materials, 2008

Material	Amount Recycled (tons)
Mixed office paper	288
Aluminum (70%), steel (10%), glass (10%), plastic (5%), Styrofoam (5%)	35
Asphalt, concrete, construction debris	117
Scrap metal	222
Computer components (PCs)	13
Computer monitors	23
Toner cartridges	3
Batteries	1
Engine lubricating oils	5
Fluorescent lightbulbs	2
Lead/acid batteries	3
Transparencies	0.1
Athletic shoes	0.2

Many of the recycling activities result in significant savings for Argonne. For example, Argonne received approximately $31,000 for the mixed office paper and scrap metal. The other material that is recycled represents a cost avoidance for Argonne; that is, Argonne does not pay for disposal of the material.

Argonne continues to utilize programs, such as the Argonne Property Excess System (APES), which allows employees and contractors to minimize waste and reuse available materials. The APES program was developed to assist Argonne employees in recycling and reusing surplus equipment, supplies, and materials by promoting the availability or need for items via the Argonne e-mail system. Also, the Argonne Chemical Exchange System is being revised so that surplus chemicals can be used rather than purchasing new chemicals.

3.3.7. Energy Conservation

In 2008, in response to DOE's Transformational Energy Action Management (TEAM) initiative, the FMS Division formed an Energy Programs Office aimed at conserving energy, cutting water consumption, and driving down costs.

The FY 2008 Energy Report summarizes some of Argonne's accomplishments toward these goals. Some of these projects include sitewide replacement of building exit sign fixtures with more energy-efficient models (expected energy reduction per year: 61,883 kWh); Building 366 lighting upgrade project (expected energy reduction per year: 210,240 kWh); Building 203 condensate return project (expected potable water reduction per year: 23 million L [5.6 million gal]); Boiler House Variable-Frequency Drive (VFD) installation project (expected energy reduction per year: 125,808 kWh); and Sustainable Building Design-Building 216 Scanning Electron Microscope and Microscopy (SAMM) project (includes preferred parking established for high-efficiency vehicles, bike storage, use of white reflective roofing membrane to reflect direct sunlight, operable office windows that face north providing comfortable indirect lighting, and light-operated motion sensor faucets).

3.3.8. Fire Department

The Fire Department provides primary support in the handling of environmental emergencies such as response to hazardous material spills and specialized training in spill prevention and cleanup.

3.3.9. Emergency Management

The Emergency Management group is responsible for maintaining the requirements of the Comprehensive Emergency Management Plan (CEMP). The CEMP identifies potential environmental concerns and impacts of issues resulting in or contributing to operational emergencies as defined in DOE Order 151.1A.

3.3.10. Committees

Identification, implementation, and conformance with environmental regulations/ requirements are also assisted through Argonne-wide and division-level committees. The members of committees come from various Argonne organizations, and the representation allows for development of processes and procedures that are appropriate for Argonne environmental concerns and can be applied across the diverse Argonne organizations. Examples of such committees are the Environment, Safety, Security and Health (ESS&H) Committee; the Pollution Prevention and Waste Minimization (P2&WM) Advisory Committee; the As Low As Reasonably Achievable (ALARA) Committee; and the Stormwater Pollution Prevention Committee.

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

4.1. Description of Monitoring Program

The radioactivity of the environment around Argonne in 2008 was determined by measuring radionuclide concentrations in air, surface water, subsurface water, and sediment, and by measuring the external photon penetrating radiation exposure. Sample collections and measurements were made at the site perimeter and off-site for comparative purposes. Some on-site results are also reported when they are useful in interpreting perimeter and off-site results.

Because radioactivity is primarily transported by air and water, the sample collection program concentrates on these media. In addition, samples of materials from the streambeds also are analyzed. The program follows the guidance provided in the DOE Environmental Regulatory Guide.[4] The results of radioactivity measurements are expressed in terms of pCi/L for water, fCi/m^3 for air, and pCi/g and fCi/g for bottom sediment. Penetrating radiation measurements are reported in units of mrem/yr, and population dose is reported in units of person-rems.

DOE has provided guidance[5] for effective dose equivalent calculations for members of the public based on International Commission on Radiological Protection (ICRP) Publications 26 and 30.[6,7] Those procedures have been used in preparing this report. The methodology requires that three components be calculated: (1) the committed effective dose equivalent (CEDE) from all sources of ingestion, (2) the CEDE from inhalation, and (3) the direct effective dose equivalent from external radiation. These three components were summed for comparison with the DOE effective dose equivalent limits for environmental exposure. To ensure that at least 90% of the total CEDE is accounted for, the DOE guidance requires that sufficient data on exposure to radionuclide sources be available. For 2008, approximately 93% of the samples that were scheduled were collected. Dry wells, dry surface water locations, or equipment failures accounted for the samples that could not be collected. The primary radiation dose limit for members of the public is 100 mrem/yr. The effective dose equivalents for members of the public from all routine DOE operations (natural background and medical exposures excluded) shall not exceed 100 mrem/yr and must adhere to the ALARA process or be as far below the limits as is practical, taking into account social, economic, technical, practical, and public policy considerations. Routine DOE operations are normally planned operations and exclude actual or potential accidental or unplanned releases.

The measured or calculated environmental radionuclide concentrations were converted to a 50-year CEDE with the use of the CEDE conversion factors[8] and were compared with the annual dose limits for uncontrolled areas. The CEDEs were calculated from the DOE Derived Concentration Guides (DCGs)[5] for members of the public on the basis of a radiation dose of 100 mrem/yr. The numerical values of the CEDE conversion factors used in this report are provided later in this chapter (Table 4.21). Occasionally, other standards are used, and their sources are identified in the text.

4.2. Air

The radioactive content of particles in the air was determined by collecting and analyzing air filter samples. The sampling locations are shown in Figures 1.1 and 1.2. Argonne uses continuously operating air samplers to collect samples for the measurement of concentrations of airborne particles contaminated by radionuclides. Currently, nonradiological air contaminants in ambient air are not monitored. Particle samplers are placed at 11 locations around the Argonne perimeter and at 4 off-site locations approximately 8 km (5 mi) from Argonne, to determine the ambient or background concentrations. Samples were collected at the site perimeter to determine whether a statistically significant difference exists between perimeter measurements and measurements taken from samples collected at various off-site locations. The off-site samples establish the local background concentrations of naturally occurring or ubiquitous man-made radionuclides, such as from nuclear weapons testing fallout. Higher levels of radioactivity in the air measured at the site perimeter may indicate radioactivity releases from Argonne, provided that the perimeter sample results are greater than the background sample results 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.

Airborne particle samples for measurement of total alpha, total beta, and gamma-ray emitters are collected continuously at 11 perimeter locations and at 4 off-site locations on glass fiber filter media. One air sampler was removed on October 1, 2007, to allow for construction of a new building (location 14H in Figure 1.1). Average flow rates on the air samplers are about 70 m^3/h (2,472 ft^3/h). Filters are changed weekly. Argonne staff change the filters on perimeter samplers, and the filters on off-site samplers are changed and mailed to Argonne by cooperating local agencies. The sampling units are serviced every six months, and the flow meters are recalibrated annually.

At the time of sample collection, the date and time when sampling was begun and the date and time when sample collection was completed are recorded on a label attached to the sample container. The samples are then transported to Argonne, where this information is transferred to the Environmental Protection Data Management System.

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

Stack monitoring is conducted continuously at four locations (see Section 4.7.1), at those emission points that have a probability of releasing measurable concentrations of radionuclides. The results of these measurements are used to estimate the annual off-site dose using the required

EPA CAP-88 (Clean Air Act Assessment Package-1988)[9] atmospheric dispersion computer code and dose conversion method.

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

In April 2008, a number of the perimeter air samplers were discovered to have exposed electrical wiring. All the perimeter air samplers were removed from service and repaired. All the wiring and a number of other components were replaced. All the units were repaired or rebuilt and calibrated and returned to service by July 2008.

Comparison of perimeter to off-site alpha and beta concentrations over the past several years shows that the perimeter results are consistently lower. This was most pronounced in 2008. An investigation of this difference showed that there was significantly less particulate material collected on the perimeter air filters. In addition, the off-site samples would occasionally not be changed on the weekly schedule and remained in place for two weeks. These samples would have a significant amount of particulate material on the filter. The differences in concentration appear to be a function of the mass of material on the filter, which is probably related to the location of the air sampler. The perimeter samplers are sited in grassy, open areas, away from buildings, roads, and other sources of airborne particulate material. The off-site samplers are located within municipal complexes, within secured locations, and are typically exposed to higher levels of airborne particulate material, especially resuspended soil, which contains naturally occurring radionuclides. The perimeter beta activity averaged 26 fCi/m^3, which is similar to the average value for the past five years.

The gamma-ray emitters listed in Table 4.2 are those that have been present in the air for past years and are of natural origin. The beryllium-7 concentration increases in the spring, which indicates its stratospheric origin. The concentration of lead-210 in the air is due to the radioactive decay of gaseous radon-222 and is similar to the concentration last year. The annual average radiation values for the on-site samples were less than the off-site samples, as discussed above.

The annual average alpha and beta activities since 1985 are displayed in Figure 4.1. The elevated beta activity in 1986 was due to fallout from the Chernobyl incident. Figure 4.2 presents the annual average concentrations of the two major gamma-ray-emitting radionuclides in air. The changes in the beryllium-7 air concentrations have been observed worldwide by the DOE Environmental Measurements Laboratory's Surface Air Sampling Program and are attributed to changes in solar activity.[10]

TABLE 4.1

Total Alpha and Beta Activities in Air Filter Samples, 2008
(concentrations in fCi/m^3)

			Alpha Activity			Beta Activity		
Month	Location	No. of Samples	Avg.	Min.	Max.	Avg.	Min.	Max.
January	Perimeter	55	1.6	0.6	3.3	28.7	13.1	51.7
	Off-Site	20	3.4	0.6	8.5	37.6	13.4	63.9
February	Perimeter	44	1.9	0.8	3.4	26.8	12.9	47.3
	Off-Site	15	2.9	1.4	6.0	30.0	18.5	48.6
March	Perimeter	44	1.1	0.4	1.9	17.6	11.2	26.9
	Off-Site	16	2.1	0.8	4.2	24.1	13.9	36.6
April	Perimeter	11[a]	1.1	0.7	1.5	18.2	12.5	22.1
	Off-Site	20	2.7	1.6	5.0	21.6	13.7	29.6
May	Perimeter	0[a]	–[b]	–	–	–	–	–
	Off-Site	15	2.2	1.1	4.0	15.2	9.6	28.6
June	Perimeter	0[a]	–	–	–	–	–	–
	Off-Site	16	2.0	0.8	3.0	17.0	12.2	24.3
July	Perimeter	9[a]	1.4	0.2	2.3	18.8	0.6	25.2
	Off-Site	19	2.6	1.2	5.2	22.4	12.7	29.9
August	Perimeter	31	1.6	0.5	3.4	24.0	7.3	36.3
	Off-Site	14	2.7	1.6	5.7	22.8	12.8	31.2
September	Perimeter	33	2.0	0.5	4.3	29.4	8.4	59.7
	Off-Site	16	2.9	0.7	8.8	27.0	8.8	72.7
October	Perimeter	50	2.4	0.8	4.7	29.3	10.3	51.6
	Off-Site	20	2.3	1.0	3.4	21.0	11.2	34.8
November	Perimeter	44	2.2	0.9	3.4	24.9	8.8	32.0
	Off-Site	13	4.0	1.4	9.1	24.8	9.1	49.8
December	Perimeter	33	2.9	1.4	4.5	35.2	15.5	46.7
	Off-Site	15	4.2	1.5	6.9	33.0	19.4	41.7
Annual Summary	Perimeter	354	1.9 ± 0.4	0.2	4.7	26.4 ± 0.8	0.6	59.7
	Off-Site	199	2.8 ± 0.5	0.6	9.1	24.8 ± 1.0	8.8	72.7

[a] All the perimeter samplers were rebuilt from mid-April to mid-July.

[b] A dash indicates no data.

TABLE 4.2

Gamma-Ray Activity in Air Filter Samples, 2008
(concentrations in fCi/m^3)

Month	Location	Beryllium-7	Lead-210
January	Perimeter	95	27
	Off-Site	60	24
February	Perimeter	119	24
	Off-Site	88	21
March	Perimeter	104	14
	Off-Site	89	17
April	Perimeter[a]	110	15
	Off-Site	110	13
May	Perimeter[a]	–[b]	–[b]
	Off-Site	118	9
June	Perimeter[a]	–[a]	–
	Off-Site	107	10
July	Perimeter[a]	144	15
	Off-Site	122	13
August	Perimeter	152	19
	Off-Site	95	15
September	Perimeter	113	23
	Off-Site	77	19
October	Perimeter	147	22
	Off-Site	82	14
November	Perimeter	92	22
	Off-Site	70	18
December	Perimeter	120	33
	Off-Site	74	25
Annual Summary	Perimeter	118	22
	Off-Site	91	17
Dose (mrem)	Perimeter	(0.00029)	(2.51)
	Off-Site	(0.00022)	(1.94)

[a] All the perimeter samplers were rebuilt from mid-April to mid-July.

[b] A dash indicates no data.

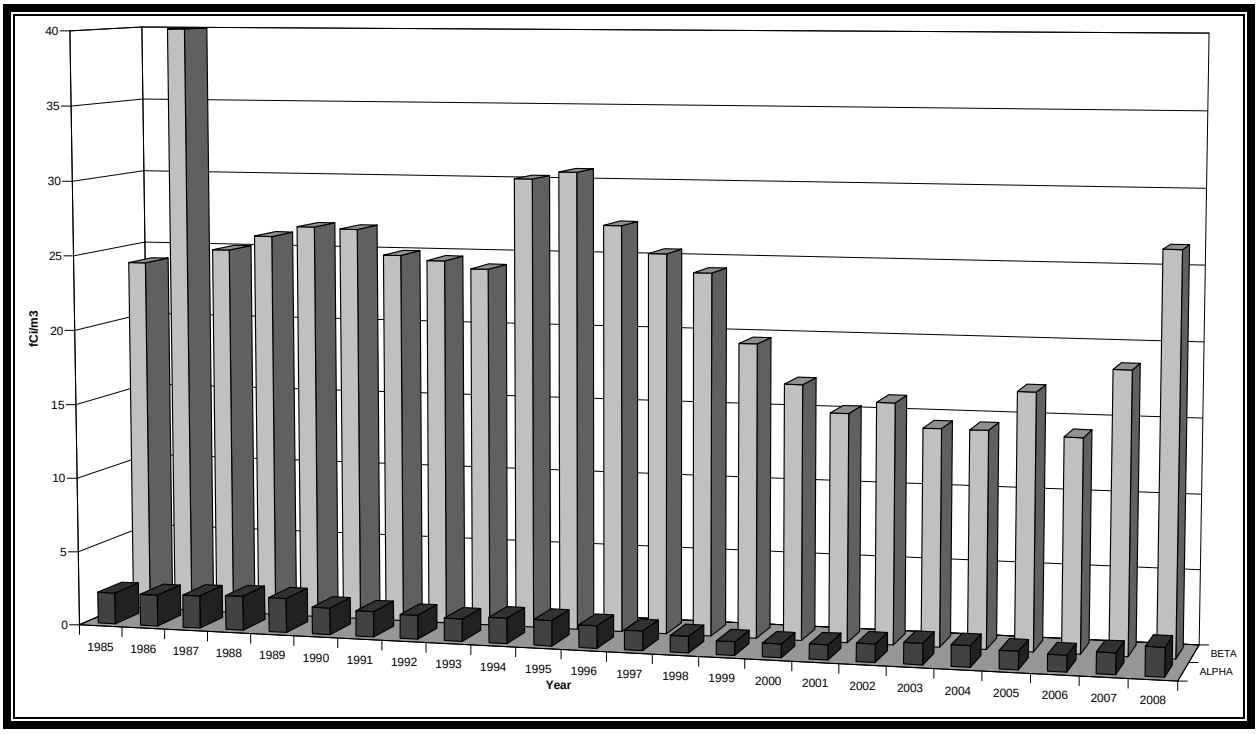


FIGURE 4.1 Comparison of Total Alpha and Beta Activities in Air Filter Samples, 1985 to 2008

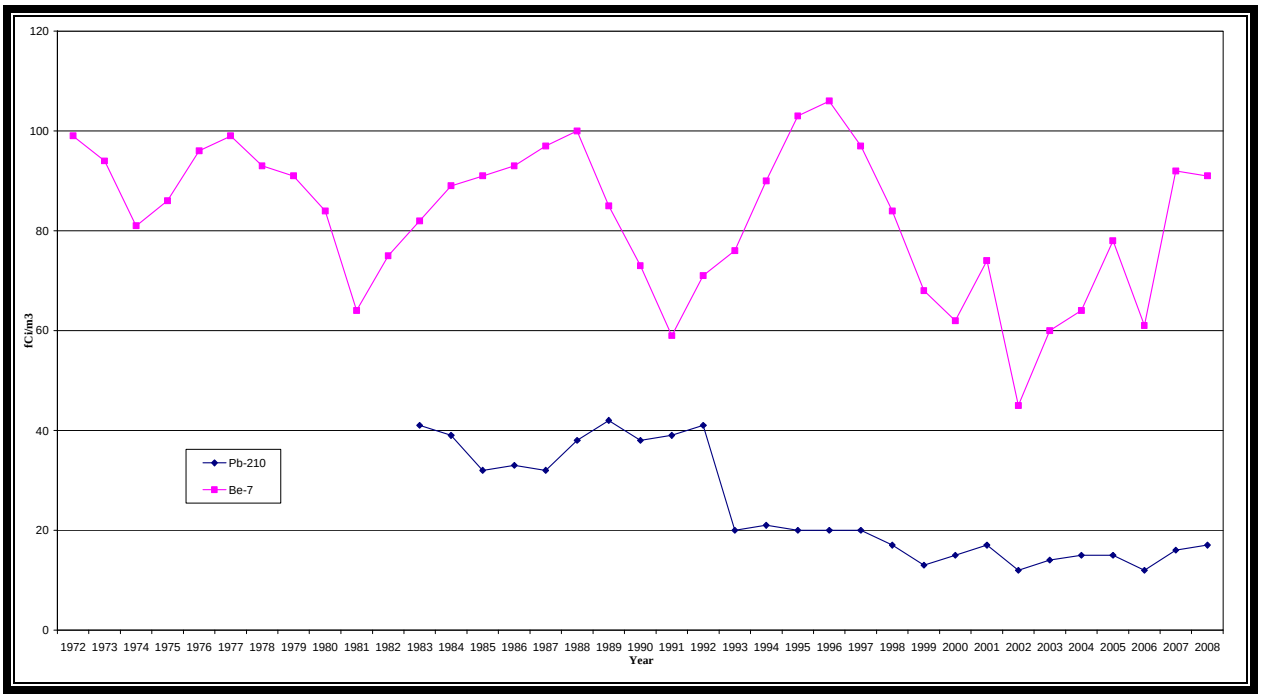


FIGURE 4.2 Comparison of Gamma-Ray Activity in Air Filter Samples, 1972 to 2008

The major airborne effluents released at Argonne during 2008 are listed by location in Table 4.3. The radon-220 releases from Building 200, due to radioactive contamination from the "proof-of-breeding" program conducted in the mid-1980s, have been greatly reduced compared with previous years. The hydrogen-3 emitted from Building 212 is from hydrogen-3 recovery studies, while short-lived neutron activation products were emitted from the APS. The operation of IPNS was terminated at the end of 2007. In addition to the radionuclides listed in Table 4.3, several other fission products also were released in millicurie or smaller amounts. The quantities listed in Table 4.3 were measured by on-line stack monitors in the exhaust systems of the buildings, except those for Buildings 350 and 411.

Phytoremediation is being performed in the 317/319 Area to complete the cleanup of the groundwater in the area, which was contaminated in the past by the disposal of liquid wastes to the soil in French drains. Phytoremediation is a natural process by which woody and herbaceous plants extract pore water and entrained chemical substances from subsurface soil, degrade volatile organic constituents, and transpire water vapor to the atmosphere. The system consists of shallow-rooted willow and special deep-rooted poplar trees. Approximately 800 poplar trees were planted in the fall of 1999. In 2003, approximately 200 willow trees were planted to expand the system near the French drains.

One of the major groundwater contaminants in the 317/319 Area is hydrogen-3, as tritiated water. The phytoremediation process will translocate the hydrogen-3 from the groundwater to the air as water vapor. Since the hydrogen-3 is released over an area of approximately 2 ha (5.5 acres), traditional point source monitoring for airborne hydrogen-3 water vapor is of little value to determine the quantity of hydrogen-3 released to the air. The

TABLE 4.3

Summary of Airborne Radioactive Emissions from Argonne Facilities, 2008

Building	Nuclide	Half-Life	Amount Released (Ci)	Amount Released (Bq)
200	Radon-220	56 s	30	1.1×10^{12}
212 (Alpha-Gamma Hot Cell Facility)	Hydrogen-3 (tritiated water vapor [HTO])	12.3 yr	5.0	2.0×10^{11}
	Hydrogen-3 (tritiate hydrogen gas [HT])	12.3 yr	15.0	6.0×10^{11}
	Radon-220	56 s	0.20	7.3×10^{9}
350 (NBL)	Uranium-234	2.4×10^{5} yr	1.8×10^{-7}	6.6×10^{1}
	Uranium-238	4.5×10^{9} yr	1.8×10^{-7}	6.6×10^{1}
411/415 (APS)	Carbon-11	20 min	1.2	4.4×10^{10}
	Nitrogen-13	10 min	57.0	2.1×10^{12}
	Oxygen-15	122 s	6.1	2.2×10^{11}

annual inventory of hydrogen-3 released to the air can be estimated from the hydrogen-3 content of the groundwater and the extraction rate at which various aged trees remove groundwater. On the basis of the age and type of tree, estimates are available on the average consumption rate of groundwater per tree per month of the growing season. For this estimate, it is assumed that all of the groundwater that is extracted is transpired.

Quarterly monitoring is conducted at the 18 wells that are within the phytoremediation plantation. The average hydrogen-3 concentration for 2008 for all the wells was 393 pCi/L. The annual amount of hydrogen-3 released is then the product of the annual volume of water released for all 800 trees multiplied by the hydrogen-3 concentration in the groundwater. For 2008, the total hydrogen-3 released was 0.007 Ci. Applying the CAP-88 code,[9] an estimate of the annual dose to the maximally exposed individual was 0.00000009 mrem. This estimated dose is extremely small compared with the 10-mrem annual dose limit of NESHAP.

4.3. Surface Water

All water samples collected in the monitoring program were acidified to 0.1N with nitric acid and filtered immediately after collection. Total nonvolatile alpha and beta activities were determined by counting the residue remaining after evaporation of the water and then applying weight-dependent counting efficiency corrections determined for plutonium-239 (for alpha activity) and thallium-204 (for beta activity) to obtain disintegration rates. Hydrogen-3 was measured from a separate aliquot. This activity does not appear in the results for total nonvolatile beta activity. Analyses for the radionuclides were performed by specific radiochemical separations followed by appropriate counting. One-liter aliquots were used for all analyses except for hydrogen-3 and the transuranium nuclides. Hydrogen-3 analyses were performed by liquid scintillation counting of 9 mL (0.3 oz) of a distilled sample in a nonhazardous cocktail. Analyses for transuranium nuclides were performed on 10-L (3-gal) samples with chemical separation methods followed by alpha spectrometry. Plutonium-236 was used to determine the yields of plutonium and neptunium, which were separated from the sample together. A group separation of a fraction containing the transplutonium elements was monitored for recovery with an americium-243 tracer. Isotopic uranium concentrations were determined by alpha spectrometry by using uranium-232 or uranium-236 as an isotopic tracer.

Liquid wastewater from buildings or facilities that use or process radioactive materials is collected in retention tanks. When a tank is full, it is sampled and analyzed for alpha and beta radioactivity. If the radioactivity exceeds the release limits, the tank is processed as radioactive waste. The release limits are based on the DCGs for plutonium-239 (0.03 pCi/mL) for alpha activity and for strontium-90 (1.0 pCi/mL) for beta activity. These radionuclides were selected because of their potential for release and their conservative allowable limits in the environment. If the radioactivity is below the release limits, the wastewater is conveyed to the LWTP in dedicated pipes to waste storage tanks. At the influent to the LWTP, all effluent wastewater is screened for gamma-ray radioactivity. The effluent monitoring program documents that no liquid releases above the DCGs have occurred and reinforces demonstration of compliance with the use of best available technology (BAT) as required by DOE Order 5400.5.[5]

Another component of the radiological effluent monitoring program is the radiological analysis of the main water treatment plant discharge (Outfall 001). Metals have also been analyzed at this location for a number of years (see Table 5.9). The same radiological constituents that are determined in Sawmill Creek are also analyzed at this location. Samples are collected daily, and equal portions are combined for each week and analyzed to obtain an average weekly concentration. Table 4.4 gives the results for 2008. The results show that the radionuclide hydrogen-3, and possibly strontium-90, detected in the effluent water can be attributed to Argonne operations. However, analysis of the Argonne domestic water, which is obtained from Lake Michigan, indicates the presence of strontium-90 at about 0.4 pCi/L. This was confirmed by the direct analysis of Lake Michigan water. The concentrations are well

TABLE 4.4

Radionuclides in Effluents from the Argonne Wastewater Treatment Plant, 2008

		Concentrations in pCi/L			Dose (mrem)		
Activity	No. of Samples	Avg.	Min.	Max.	Avg.	Min.	Max.
Alpha	53	0.96	< 0.10	3.88	–[a]	–	–
Beta	53	11.37	6.60	15.47	–	–	–
Hydrogen-3	53	108	< 100	214	0.0050	< 0.0046	0.0098
Strontium-90	53	0.34	0.27	0.44	0.033	0.026	0.042
Cesium-137	53	< 2.0	< 2.0	< 2.0	< 0.07	< 0.07	< 0.07
Uranium-234	53	0.34	0.10	0.80	0.065	0.019	0.153
Uranium-238	53	0.30	0.10	0.64	0.049	0.016	0.106
Neptunium-237	53	< 0.0010	< 0.0010	0.0029	< 0.0028	< 0.0028	0.0081
Plutonium-238	53	< 0.0010	< 0.0010	0.0050	< 0.0028	< 0.0028	0.0140
Plutonium-239	53	< 0.0010	< 0.0010	0.0068	< 0.0031	< 0.0031	0.0211
Americium-241	53	< 0.0010	< 0.0010	0.0044	< 0.0033	< 0.0033	0.0224
Curium-242 and/or Californium-252	53	0.0013	< 0.0010	0.0261	0.0009	< 0.0007	0.0183
Curium-244 and/or Californium-249	53	< 0.0010	< 0.0010	< 0.0010	< 0.0034	< 0.0034	< 0.0034

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

below the DOE limits. These findings confirmed Argonne compliance with DOE Order 5400.5 for use of BAT for releases of liquid effluents. To estimate the total annual quantity of each radionuclide released to the environment, the product of the annual average concentration and the annual volume of water discharged (1.04×10^9 L) is computed. These results are given in Table 4.5.

TABLE 4.5

Total Radioactivity Released, 2008

Radionuclide	WTP Outfall (Ci)
Hydrogen-3	0.11
Strontium-90	0.0004
Uranium-234	0.0003
Uranium-238	0.0003
Plutonium-239	<0.0001
Other transuranics	<0.0001
Total	0.11

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

Table 4.6 gives the annual summaries of the results obtained for Sawmill Creek. Comparison of the results and 95% confidence levels of the averages for the two sampling locations shows that the following radionuclides found in the creek water can be attributed to Argonne operations: hydrogen-3, strontium-90, plutonium-239, and americium-241. The concentrations of all these nuclides are low and at a small fraction of DOE concentration limits. In Sawmill Creek, downstream of the Argonne outfall, the annual average concentrations of most measured radionuclides were similar to recent annual averages. All annual averages were well below the applicable DOE standards.

On the basis of the results of the Stormwater Characterization Study, two perimeter surface water locations that contained measurable levels of radionuclides were identified. They were south of the 319 Area, Location 7J, and south of the 800 Area Landfill, Location 11D (see Figure 1.1). Samples were scheduled to be collected quarterly and analyzed for hydrogen-3, strontium-90, and gamma-ray emitters at Location 7J and hydrogen-3 at Location 11D. The results are presented in Table 4.7.

The source of the radionuclides at Location 7J appears to be leachate from the 319 Area Landfill. A subsurface barrier wall and leachate collection system were constructed south of the 319 Landfill in November 1995 and became operational in 1996. The final cap was installed in 1999. Since the construction and operation of the leachate collection system and cap, radionuclide concentrations in surface water at Location 7J have decreased substantially. The hydrogen-3 at Location 11D is probably also from the leachate; the decrease in the concentration from earlier years is due to the completion of the clay cap on the 800 Area Landfill in the fall of 1993.

TABLE 4.6

Radionuclides in Sawmill Creek Water, 2008

Activity	Location[a]	No. of Samples	Concentrations (pCi/L) Avg.	Min.	Max.	Dose (mrem) Avg.	Min.	Max.
Alpha	16K	12	0.61	< 0.10	1.40	–[b]	–	–
(nonvolatile)	7M	52	0.82	< 0.10	6.97	–	–	–
Beta	16K	12	6.30	4.28	8.47	–	–	–
(nonvolatile)	7M	52	9.40	5.70	14.43	–	–	–
Hydrogen-3	16K	12	< 100	< 100	157	< 0.0046	< 0.0046	0.0072
	7M	52	< 100	< 100	217	< 0.0046	< 0.0046	0.0100
Strontium-90	16K	12	< 0.25	< 0.25	0.28	< 0.024	< 0.024	0.343
	7M	51	0.26	0.19	0.38	0.025	0.018	0.036
Cesium-137	16K	12	< 2.0	< 2.0	< 2.0	< 0.07	< 0.07	< 0.07
	7M	52	< 2.0	< 2.0	< 2.0	< 0.07	< 0.07	< 0.07
Uranium-234	16K	12	0.690	0.152	1.139	0.131	0.029	0.217
	7M	52	0.510	0.132	5.328	0.097	0.025	1.017
Uranium-238	16K	12	0.624	0.130	1.075	0.104	0.022	0.179
	7M	52	0.477	0.096	6.129	0.079	0.016	1.018
Neptunium-237	16K	12	< 0.0010	< 0.0010	0.0028	< 0.0028	< 0.0028	0.0078
	7M	52	< 0.0010	< 0.0010	0.0028	< 0.0028	< 0.0028	0.0078
Plutonium-238	16K	12	0.0012	< 0.0010	0.0075	0.0034	< 0.0028	0.0210
	7M	52	0.0013	< 0.0010	0.0086	0.0036	< 0.0028	0.0241
Plutonium-239	16K	12	< 0.0010	< 0.0010	< 0.0010	< 0.0031	< 0.0031	< 0.0031
	7M	52	< 0.0010	< 0.0010	0.0114	< 0.0031	< 0.0031	0.0353
Americium-241	16K	12	< 0.0010	< 0.0010	< 0.0010	< 0.0033	< 0.0033	< 0.0033
	7M	52	< 0.0010	< 0.0010	0.0031	< 0.0033	< 0.0033	0.0102
Curium-242 and/or	16K	12	0.0010	< 0.0010	0.0104	0.0007	< 0.0007	0.0073
Californium-252	7M	52	0.0011	< 0.0010	0.0121	0.0008	< 0.0007	0.0085
Curium-244 and/or	16K	12	< 0.0010	< 0.0010	< 0.0010	< 0.0034	< 0.0034	< 0.0034
Californium-249	7M	52	< 0.0010	< 0.0010	0.0028	< 0.0034	< 0.0034	0.0095

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

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

TABLE 4.7

Radionuclides in Stormwater Outfalls, 2008
(concentrations in pCi/L)

Date Collected	Location 7J			Location 11D
	Hydrogen-3	Strontium-90	Cesium-137	Hydrogen-3
January 8	<100	0.34	<2	116
April 11	<100	0.72	<2	168
September 9	149	0.68	<2	Dry
December 9	139	0.50	<2	Dry

One of the Argonne waste management locations is within the 398A Area fenced area (Location 8J in Figure 1.1). Surface water drainage from this area is collected in a small pond at the south (downgradient) end of the 398A Area. To evaluate whether any radionuclides are being transported by stormwater flow through the 398A Area, quarterly sampling is conducted from the 398A Area pond and analyzed for hydrogen-3 and gamma-ray-emitting radionuclides. All hydrogen-3 results ranged from the detection limit of 100 to 192 pCi/L, and gamma-ray spectrometric analysis detected no radionuclides associated with Argonne activities above the detection limit of 2 pCi/L.

Because Sawmill Creek empties into the Des Plaines River, data on the radioactivity in this river is important in assessing the contribution of Argonne wastewater to environmental radioactivity. The Des Plaines River was sampled twice a month downstream and once a month upstream of the mouth of Sawmill Creek to determine whether the radioactivity in the creek had any effect on the radioactivity in the river. Table 4.8 gives the annual summaries of the results obtained for these two locations. The average nonvolatile alpha, beta, and uranium concentrations in the river were very similar to past averages and remained in the normal range. Average results were similar above and below the creek for all radionuclides, because the activity in Sawmill Creek was reduced by dilution to the point that it was not detectable in the Des Plaines River.

4.4. Bottom Sediment

The radioactive content of bottom sediment was measured in Sawmill Creek. A grab sample technique was used to obtain bottom sediments. After the drying, grinding, and mixing of portions of each of the bottom sediment samples, the samples were analyzed by the methods described in prior reports[11] for air filter residues. The plutonium and americium were separated from the same 10-g (0.35-oz) aliquot of sediment. Results are given in terms of the oven-dried (110ºC [230ºF]) weight.

TABLE 4.8

Radionuclides in Des Plaines River Water, 2008

Activity	Location[a]	No. of Samples	Concentrations (pCi/L) Avg.	Min.	Max.	Dose (mrem) Avg.	Min.	Max.
Alpha	A	12	0.8	< 0.1	1.5	–[b]	–	–
(nonvolatile)	B	24	0.8	< 0.1	3.1	–	–	–
Beta	A	12	9.5	5.3	15.8	–	–	–
(nonvolatile)	B	24	9.0	4.5	14.8	–	–	–
Hydrogen-3	A	12	< 100	< 100	144	< 0.0046	< 0.0046	0.0066
	B	24	< 100	< 100	159	< 0.0046	< 0.0046	0.0073
Strontium-90	A	12	< 0.25	< 0.25	< 0.25	< 0.024	< 0.024	< 0.024
	B	24	< 0.25	< 0.25	< 0.25	< 0.024	< 0.024	< 0.024
Uranium-234	A	12	0.442	0.150	0.691	0.084	0.029	0.132
	B	24	0.588	0.120	3.458	0.112	0.023	0.660
Uranium-238	A	12	0.373	0.129	0.650	0.062	0.021	0.108
	B	24	0.541	0.098	3.675	0.090	0.016	0.610
Neptunium-237	A	12	< 0.0010	< 0.0010	0.0041	< 0.0028	< 0.0028	0.0115
	B	12	< 0.0010	< 0.0010	0.0021	< 0.0028	< 0.0028	0.0059
Plutonium-238	A	12	0.0011	< 0.0010	0.0037	0.0031	< 0.0028	0.0104
	B	12	0.0019	< 0.0010	0.0061	0.0053	< 0.0028	0.0171
Plutonium-239	A	12	< 0.0010	< 0.0010	< 0.0010	< 0.0031	< 0.0031	< 0.0031
	B	12	< 0.0010	< 0.0010	0.0013	< 0.0031	< 0.0031	0.0040
Americium-241	A	12	< 0.0010	< 0.0010	0.0031	< 0.0033	< 0.0033	0.0102
	B	12	< 0.0010	< 0.0010	0.0012	< 0.0033	< 0.0033	0.0040
Curium-242 and/or	A	12	< 0.0010	< 0.0010	0.0084	< 0.0007	< 0.0007	0.0059
Californium-252	B	12	0.0016	< 0.0010	0.0165	0.0011	< 0.0007	0.0116
Curium-244 and/or	A	12	< 0.0010	< 0.0010	< 0.0010	< 0.0034	< 0.0034	< 0.0034
Californium-249	B	12	< 0.0010	< 0.0010	< 0.0010	< 0.0034	< 0.0034	< 0.0034

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

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

A set of sediment samples was collected on September 24, 2008, from the Sawmill Creek bed, above, at the outfall, and at several locations below the point at which Argonne discharges its treated wastewater (Location 7M in Figure 1.1). The results, as listed in Table 4.9, show that the concentrations in the samples collected above the outfall at Location 7M are similar to those of the off-site samples collected in past years.[11] The plutonium, americium, and cesium-137 concentrations are elevated below the outfall, which indicates that their origin is in Argonne wastewater. Plutonium results varied widely among locations and were strongly dependent on the

TABLE 4.9

Radionuclides in Bottom Sediment, 2008

Location	Concentration (pCi/g)					Concentration (fCi/g)		
	Potassium-40	Cesium-137	Radium-226	Thorium-228	Thorium-232	Plutonium-238	Plutonium-239	Americium-241
Sawmill Creek 25 m above outfall	16.41 ± 0.62	0.01 ± 0.01	0.89 ± 0.05	0.59 ± 0.03	0.56 ± 0.07	0.15 ± 0.25	1.85 ± 0.69	1.56 ± 0.75
Sawmill Creek at outfall	14.09 ± 0.58	0.42 ± 0.03	0.70 ± 0.05	0.51 ± 0.03	0.57 ± 0.07	1.08 ± 1.61	140.80 ± 9.72	38.32 ± 4.37
Sawmill Creek 50 m below outfall	15.60 ± 0.60	< 0.1	0.76 ± 0.05	0.51 ± 0.03	0.51 ± 0.07	0.10 ± 0.16	3.95 ± 0.96	1.42 ± 0.68
Sawmill Creek 100 m below outfall	16.10 ± 0.61	0.09 ± 0.02	0.74 ± 0.05	0.59 ± 0.03	0.58 ± 0.07	0.55 ± 0.42	13.05 ± 2.12	4.17 ± 1.17
Sawmill Creek at Des Plaines River	19.40 ± 0.67	0.30 ± 0.24	1.40 ± 0.06	0.77 ± 0.03	0.73 ± 0.08	0.45 ± 0.36	14.87 ± 2.04	5.43 ± 1.52

retentiveness of the sediment material. The changes in concentrations of these nuclides with time and location indicate that the sediment material in this area has a dynamic nature.

4.5. External Penetrating Gamma Radiation

Levels of external penetrating gamma radiation at and in the vicinity of the Argonne site were measured with aluminum oxide thermoluminescent dosimeter (TLD) chips provided and read by a commercial vendor. Each measurement reported represents the average of two chips exposed in the same packet. Dosimeters were exposed at 17 locations at the site boundary and on the site. Readings were also taken at five off-site locations (Figure 1.2) for comparative purposes.

The results are summarized in Tables 4.10 and 4.11, and the site boundary and on-site readings are shown in Figure 4.3. Measurements were taken during the four successive exposure periods shown in the tables, and the results were calculated in terms of annual dose for ease in comparing measurements made for different elapsed times. The uncertainty of the averages given in the tables is the 95% confidence limit calculated from the standard deviation of the average.

The off-site results averaged 97 ± 15 mrem/yr and were similar to last year's off-site average of 102 ± 13 mrem/yr.[12] To compare boundary results for individual sampling periods, the standard deviation of the 19 individual off-site results is useful. This value is 9 mrem/yr; thus, individual results in the range of 97 ± 18 mrem/yr may be considered to be the average natural background with a 95% probability. Only three locations had radiation levels above the off-site results. None of these were at the site perimeter.

The site boundary at Location 7I had past dose rates above the average background. This was the result of radiation from Argonne's 317 Area in the northern half of grid 7I. In the past,

TABLE 4.10

Environmental Penetrating Radiation at Off-Site Locations, 2008

	Dose Rate (mrem/yr) Period of Measurement				
Location	Jan. 3–April 1	April 1–July 1	July 1–Oct. 1	Oct. 1–Jan. 13	Average
Lemont	89	92	85	81	88 ± 3
Oak Brook	89	100	103	103	97 ± 7
Orland Park	108	135	118	143	120 ± 14
Willow Springs	103	100	94	94	99 ± 5
Woodridge	76	85	a	81	81 ± 6
Average	93 ± 13	102 ± 19	100 ± 14	100 ± 26	97 ± 15

[a] The sample was lost.

TABLE 4.11

Environmental Penetrating Radiation at Argonne, 2008

Location[a]	Dose Rate (mrem/yr) Period of Measurement				
	Jan. 3–April 1	April 1–July 1	July 1–Oct. 1	Oct. 1–Jan. 13	Average
14G – Boundary	92	99	104	90	96 ± 7
14I – Boundary	79	84	88	87	84 ± 4
14L – Boundary	86	97	92	98	93 ± 5
6I – 200 m N of Quarry Road	84	96	84	96	90 ± 7
7I – Center, Waste Storage Area Facility 317	81	83	93	106	91 ± 11
7I – Boundary	82	82	84	78	81 ± 3
8H – Boundary	86	89	93	81	87 ± 5
8H – 65 m S of Building 316	85	94	98	77	88 ± 9
8H – 200 m NW of Waste Storage Area (Heliport)	87	92	92	88	90 ± 3
8H – Boundary, Center, St. Patrick Cemetery	89	93	89	91	91 ± 2
9H – 50 m SE of CP-5	79	92	87	82	85 ± 5
9H/I – 50 m E of Building 331	211	256	383	271	280 ± 73
9/10I – E of D306	303	352	326	344	331 ± 22
9/10I – 65 m NE of Building 350 230 m NE of Building 316	92	112	96	85	96 ± 11
9/10E/F – Boundary	92	87	97	90	91 ± 4
9J – 50 m W of 398A Area	639	709	742	809	725 ± 71
10/11K – Lodging Facilities	79	86	83	81	82 ± 3

[a] See Figure 1.1.

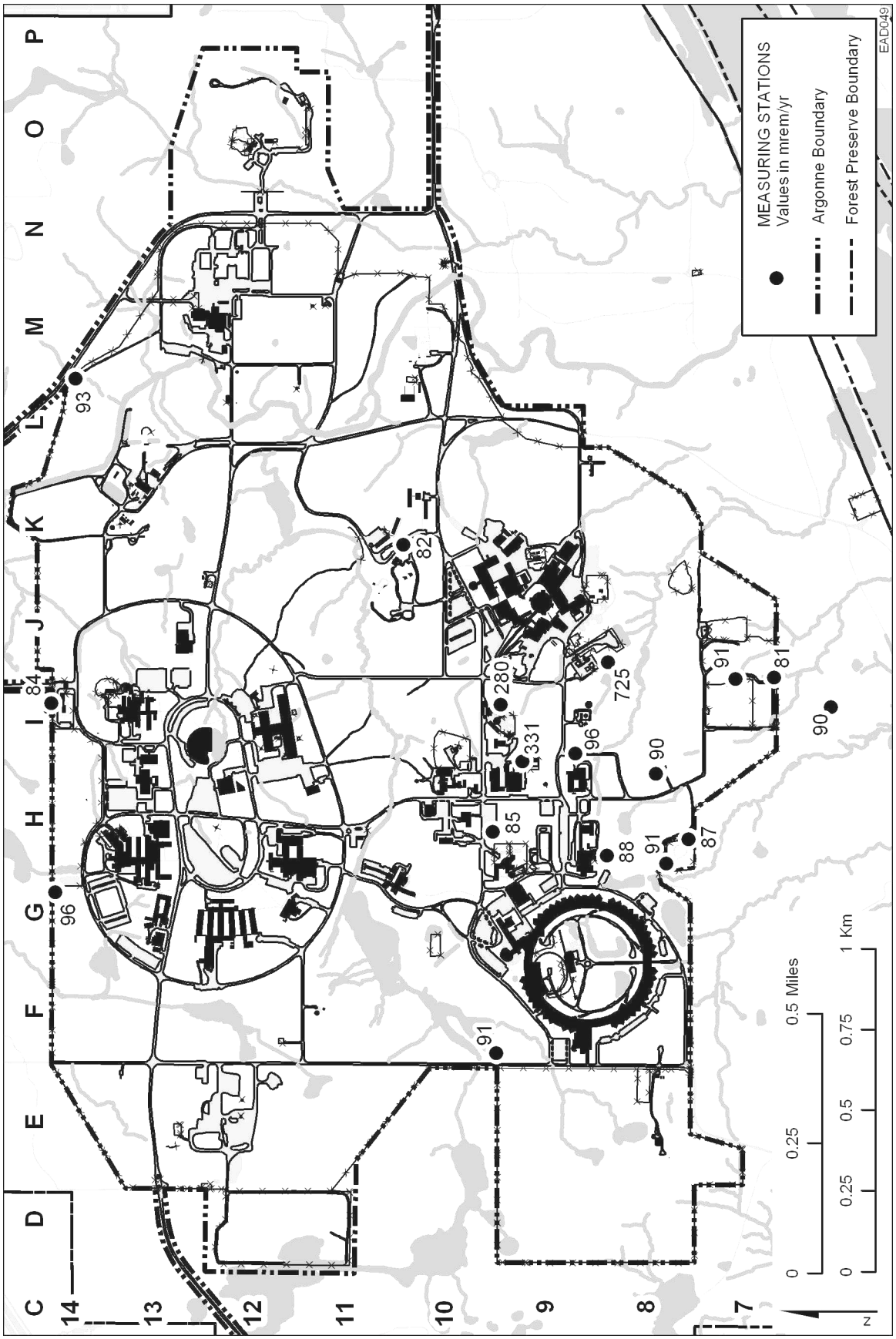


FIGURE 4.3 Penetrating Radiation Measurements at the Argonne Site, 2008

waste was packaged and temporarily stored in this area before removal for permanent disposal off-site. In 2008, the dose at this perimeter fence location was 81 ± 3 mrem/yr. Approximately 300 m (960 ft) south of the fence in grid 6I, the measured dose is 90 ± 7 mrem/yr, which is within the normal background range.

In the past, an elevated on-site dose had been measured at Location 9H, next to the CP-5 reactor, where irradiated hardware from the reactor was stored. During the past few years, considerable cleanup of the CP-5 reactor yard has occurred as part of the CP-5 reactor D&D project. The dose at Location 9H decreased from about 1,200 mrem/yr in 1989 to 85 mrem/yr in 2008.

Three locations were added in recent years to monitor radioactive waste facilities and areas. Significant movement of radioactive waste took place, principally waste from the D&D activities and the relocation of radioactive waste from the 317 Area to the 398A Area. Some waste is repacked in Building 306 (Location 9/10I). The dose from these operations was above normal background levels. The elevated dose levels in the 398A Area (Location 9J) are from waste relocated from the 317 Area, historic waste, and D&D waste temporarily stored pending shipment. The Building 331 yard (Location 9H/I) is being used as a staging area to load trucks for shipment off-site. A number of radioactive waste shipments were made during 2008, as reflected by the elevated dose rates. The 398A Area was also used as a staging area to load trucks for shipment off-site. Depending on the number of shipments, the dose rates will vary from quarter to quarter.

4.6. Compliance with DOE Order 435.1

DOE Order 435.1, “Radioactive Waste Management,” requires that an environmental monitoring and surveillance program be conducted to determine any releases or migration from low-level radioactive waste treatment, storage, or disposal sites. Compliance with these requirements is an integral part of the Argonne sitewide monitoring and surveillance program. Waste management operations in general are covered by relying on the perimeter air monitoring network and monitoring of the liquid effluent streams and Sawmill Creek.

Of particular interest is monitoring of the waste management activities conducted in the 317 Area. These include air particulate monitoring for total alpha, total beta, and gamma-ray emitters; direct radiation measurements with TLDs; surface water discharges for hydrogen-3 and gamma-ray emitters; and subsurface water samples at all monitoring wells with analyses for hydrogen-3, strontium-90, and gamma-ray emitters, plus selected monitoring for VOCs. Direct radiation measurements are also conducted at other waste management areas: Building 306, Building 331, and the 398A Area. The results are presented here and in Chapters 5 and 6 of this report.

During 2008, Argonne did not release any property containing residual radioactive material for recycle or reuse. All property that contained residual radioactivity, based on the criteria in DOE Order 5400.5, was disposed of in an off-site low-level radioactive disposal facility.

4.7. Estimates of Potential Radiation Doses

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

4.7.1. Airborne Pathway

DOE facilities with airborne releases of radioactive materials are subject to 40 CFR Part 61, Subpart H,[13] which requires the use of the EPA's CAP-88 code[9] to calculate the dose for radionuclides released to the air and to demonstrate compliance with the regulation. The dose limit applicable for 2008 for the air pathway is a 10-mrem/yr effective dose equivalent. The CAP-88 computer code uses a modified Gaussian plume equation to estimate both horizontal and vertical dispersion of radionuclides released to the air from stacks or area sources. For 2008, doses were calculated for hydrogen-3, carbon-11, nitrogen-13, oxygen-15, radon-220 plus daughters, and a number of actinide radionuclides. The annual releases are those listed in Table 4.3. Separate calculations were performed for each of the four release points. In the past, the wind stability classes had been determined by the temperature differences between the 10-m (33-ft) and 60-m (197-ft) levels. To improve the determination of stability levels, the categories were obtained from daytime measurements of solar radiation and nighttime measurements of the standard deviation of the horizontal wind speed. Doses were calculated for an area extending out to 80 km (50 mi) from Argonne. The population distribution of the 16 compass segments and 10 distance increments given in Table 1.1 was used. The dose rate was calculated at the midpoint of each interval and integrated over the entire area to give the annual population cumulative dose.

Distances from the specific facilities that exhaust radiological airborne emissions (see Table 4.3) to the fence line (perimeter) and nearest resident were determined in the 16 compass segments. Calculations also were performed to evaluate the major airborne pathways — ingestion, inhalation, and immersion — both at the point of maximum perimeter exposure and to the maximally exposed resident. The perimeter and resident doses and the maximum doses are listed, respectively, for releases from Building 200 (Tables 4.12 and 4.13), Building 212 (Tables 4.14 and 4.15), Building 350 (Tables 4.16 and 4.17), and Building 411/415 (APS) (Tables 4.18 and 4.19). The doses given in these tables are the committed whole body effective dose equivalents.

A significant D&D program was completed in 1995 for the M-Wing hot cells in Building 200, which constituted the source of the radon-220 emissions. Cleanup of the major source of the radon-220, cell M-1, resulted in a decrease of radon-220 emissions from 3,000 Ci in 1992 to 193 Ci in 1999. The radon-220 emissions were reduced further in 1999, to the present 30 Ci, because of the termination of the nuclear medical program that separates radium-224 from the thorium-228 parent and the continued D&D of other cells.

TABLE 4.12

Radiological Airborne Releases from Building 200, 2008

Direction	Distance to Perimeter (m)	Dose[a] (mrem/yr)	Distance to Nearest Resident (m)	Dose[a] (mrem/yr)
N	500	2.5×10^{-2}	1,000	8.6×10^{-3}
NNE	600	2.8×10^{-2}	1,100	1.1×10^{-2}
NE	750	1.9×10^{-2}	2,600	2.5×10^{-3}
ENE	1,700	4.5×10^{-3}	3,100	1.7×10^{-3}
E	2,400	2.8×10^{-3}	3,500	1.3×10^{-3}
ESE	2,200	2.8×10^{-3}	3,600	1.3×10^{-3}
SE	2,100	2.7×10^{-3}	4,000	9.5×10^{-4}
SSE	2,000	2.4×10^{-3}	4,000	8.2×10^{-4}
S	1,500	5.1×10^{-3}	4,000	1.4×10^{-3}
SSW	1,000	3.0×10^{-3}	2,500	7.9×10^{-4}
SW	800	1.4×10^{-2}	2,200	2.7×10^{-3}
WSW	1,100	1.2×10^{-2}	1,500	8.4×10^{-3}
W	750	1.5×10^{-2}	1,500	5.2×10^{-3}
WNW	800	1.1×10^{-2}	1,300	5.3×10^{-3}
NW	600	1.6×10^{-2}	1,100	6.0×10^{-3}
NNW	600	1.5×10^{-2}	800	1.0×10^{-2}

[a] Source term: radon-220 = 30 Ci (plus daughters).

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

The highest perimeter dose was in the north-northeast direction, with a maximum value of 0.03 mrem/yr (Location 15H in Figure 1.1). Essentially all of this dose can be attributed to air immersion of lead-212 from the Building 200 facility. The maximum perimeter dose is significantly reduced from earlier years due to the termination of operation of the IPNS facility on January 1, 2008.

The full-time resident who would receive the largest annual dose (0.013 mrem/yr), if he or she were outdoors during the entire year, is located approximately 2.7 km (1.7 mi) north-northeast of the IPNS facility. The major contributor to the whole body dose is the air immersion dose from lead-212 (0.011 mrem/yr). If radon-220 plus daughters were excluded from

TABLE 4.13

Maximum Perimeter and Individual Doses
from Building 200 Air Emissions, 2008
(dose in mrem/yr)

Pathway	Perimeter (600 m NNE)	Individual (1,100 m NNE)
Ingestion	4.0×10^{-17}	1.2×10^{-17}
Inhalation	2.8×10^{-2}	1.1×10^{-2}
Air immersion	3.0×10^{-5}	1.1×10^{-5}
Ground surface	2.3×10^{-6}	9.4×10^{-6}
Total	2.8×10^{-2}	1.1×10^{-2}
Radionuclide		
Thallium-208	4.0×10^{-5}	1.6×10^{-5}
Bismuth-212	2.5×10^{-3}	9.5×10^{-4}
Lead-212	2.6×10^{-2}	9.9×10^{-3}
Radon-220	7.0×10^{-9}	2.7×10^{-9}
Total	2.8×10^{-2}	1.1×10^{-2}

the calculation, the NESHAP reportable dose to the maximally exposed individual would also be 0.0034 mrem/yr.

The individual doses to the maximally exposed member of the public and the maximum fence line dose are shown in Figure 4.4. The decreases in individual and population doses from 1988 to 1999 are due in part to the decrease of radon-220 emissions as a result of the cleanup of the Building 200 M-Wing hot cells. The increase from 1999 to 2004 is principally due to increased emissions from the IPNS as a result of increased operating time.

The population data in Table 1.1 were used to calculate the cumulative population dose from airborne radioactive effluents from Argonne operations. The results are given in Table 4.20, along with the natural external radiation dose. The natural radiation dose listed is the product of the 80-km (50-mi) population and the natural radiation dose of 300 mrem/yr.[14] It is assumed that this dose is representative of the entire area within an 80-km (50-mi) radius. The population dose resulting from Argonne operations since 1987 is shown in Figure 4.5

The significant increase in population dose in 2006 and 2007 compared with earlier years is due to a change in the dispersion calculation in Version 3.0 of CAP-88. In the past, Version 1.0 of CAP-88 was used. The change to Version 3.0 involved the replacement of the dispersion section used in Version 1.0 with the methodology from the ICRP.[6,7] Although technically more correct, the effect is to increase the apparent population dose, which is accentuated by a combination of short half-life gases coupled with a large receptor population. This appears to be

TABLE 4.14

Radiological Airborne Releases from Building 212, 2008

Direction	Distance to Perimeter (m)	Dose[a] (mrem/yr)	Distance to Nearest Resident (m)	Dose[a] (mrem/yr)
N	800	5.3×10^{-4}	2,000	1.3×10^{-4}
NNE	1,000	5.4×10^{-4}	2,500	1.3×10^{-4}
NE	1,300	3.4×10^{-4}	2,000	1.7×10^{-4}
ENE	1,500	2.5×10^{-4}	2,500	1.1×10^{-4}
E	1,600	2.1×10^{-4}	2,800	8.3×10^{-5}
ESE	1,200	3.2×10^{-4}	2,500	1.0×10^{-4}
SE	1,400	2.3×10^{-4}	3,500	5.3×10^{-5}
SSE	1,400	1.9×10^{-4}	4,500	3.2×10^{-5}
S	1,500	2.1×10^{-4}	5,000	4.5×10^{-5}
SSW	1,600	6.7×10^{-5}	5,000	1.3×10^{-5}
SW	1,400	2.5×10^{-4}	2,400	1.1×10^{-4}
WSW	1,300	4.2×10^{-4}	2,300	2.1×10^{-4}
W	1,700	1.9×10^{-4}	2,200	1.3×10^{-4}
WNW	1,500	1.9×10^{-4}	2,000	1.2×10^{-4}
NW	1,300	2.0×10^{-4}	2,000	1.0×10^{-4}
NNW	1,000	3.1×10^{-4}	2,000	1.1×10^{-4}

[a] Source terms: hydrogen-3 = 15.0 Ci (HT = gaseous tritium)
hydrogen-3 = 5.0 Ci (HTO = tritiated water vapor)
antimony-125 = 1.0×10^{-7} Ci
iodine-125 = 2.7×10^{-6} Ci
iodine-129 = 5.0×10^{-6} Ci
radon-220 = 0.20 Ci

the case for Argonne. However, the significant decrease in population dose in 2008 is due to the termination of operation of the IPNS.

The potential radiation exposures by the inhalation pathways also were calculated by the methodology specified in DOE Order 5400.5.[5] The total quantity for each radionuclide inhaled, in microcuries (μCi), is calculated by multiplying the annual average air concentrations by the general public breathing rate of 8,400 m^3/yr.[15] This annual intake is then multiplied by the CEDE conversion factor for the appropriate lung retention class.[5] The CEDE conversion factors are in units of rem/μCi, and this calculation gives the 50-year CEDE. Table 4.21 lists the applicable CEDE factors.

An evaluation was conducted of potential sensitive receptors of Argonne airborne releases, including children at the Argonne Child Development Center (Location 120 in Figure 1.1). The airborne dose from Argonne is estimated to be about 0.03 mrem/yr at this

TABLE 4.15

Maximum Perimeter and Individual Doses
from Building 212 Air Emissions, 2008
(dose in mrem/yr)

Pathway	Perimeter (1,000 m NNE)	Individual (2,300 m WSW)
Ingestion	1.2×10^{-4}	4.7×10^{-5}
Inhalation	4.2×10^{-4}	1.6×10^{-4}
Air immersion	1.2×10^{-11}	3.6×10^{-12}
Ground surface	8.5×10^{-8}	2.1×10^{-8}
Total	5.4×10^{-4}	2.1×10^{-4}
Radionuclide		
Hydrogen-3	5.4×10^{-4}	2.1×10^{-4}
Antimony-125	3.7×10^{-10}	1.4×10^{-10}
Iodine-125	1.2×10^{-7}	2.8×10^{-8}
Iodine-129	4.5×10^{-6}	1.1×10^{-6}
Radon-220	1.2×10^{-11}	4.7×10^{-12}
Total	5.4×10^{-4}	2.1×10^{-4}

location. This assumes full-time, outdoor exposure. Assuming that the children are present about 8 hours per day, 5 days per week, the actual dose is closer to 0.01 mrem/yr. Additional potential sensitive receptors are located at the Darien school on 91st Street, west of Route 83. The estimated full-time outdoor dose at this location is about 0.003 mrem/yr. Again, assuming that the children are present at this location only 6 hours per day, 5 days per week, and for 35 weeks a year, the actual dose is closer to 0.0003 mrem/yr.

4.7.2. Water Pathway

Following the methodology outlined in DOE Order 5400.5,[5] the annual intake of radionuclides (in μCi) ingested with water is obtained by multiplying the concentration of radionuclides in microcuries per milliliter (μCi/mL) by the average annual water consumption of a member of the general public (7.3×10^5 mL). This annual intake is then multiplied by the CEDE conversion factor for ingestion (Table 4.21) to obtain the dose received in that year. This procedure was carried out for all radionuclides, and the individual results were summed to obtain the total ingestion dose.

TABLE 4.16

Radiological Airborne Releases from Building 350, 2008

Direction	Distance to Perimeter (m)	Dose[a] (mrem/yr)	Distance to Nearest Resident (m)	Dose[a] (mrem/yr)
N	1,700	2.0×10^{-7}	2,200	1.4×10^{-7}
NNE	1,800	2.7×10^{-7}	3,200	1.2×10^{-7}
NE	2,200	1.9×10^{-7}	3,100	1.2×10^{-7}
ENE	2,000	2.0×10^{-7}	3,100	1.1×10^{-7}
E	1,700	2.5×10^{-7}	2,500	1.1×10^{-7}
ESE	900	4.9×10^{-7}	3,000	1.0×10^{-7}
SE	900	4.6×10^{-7}	3,000	1.1×10^{-7}
SSE	700	4.2×10^{-7}	2,700	8.5×10^{-8}
S	600	3.3×10^{-7}	2,700	9.8×10^{-8}
SSW	400	1.8×10^{-7}	2,500	3.8×10^{-8}
SW	600	6.9×10^{-7}	2,700	1.2×10^{-7}
WSW	800	6.9×10^{-7}	2,100	2.3×10^{-7}
W	900	4.7×10^{-7}	2,200	1.5×10^{-7}
WNW	1,000	3.7×10^{-7}	2,100	1.4×10^{-7}
NW	1,900	1.4×10^{-7}	2,400	1.0×10^{-7}
NNW	1,900	1.3×10^{-7}	2,200	1.1×10^{-7}

[a] Source terms: uranium-234 = 1.8×10^{-7} Ci
uranium-238 = 1.8×10^{-7} Ci

TABLE 4.17

Maximum Perimeter and Individual Doses
from Building 350 Air Emissions, 2008
(dose in mrem/yr)

Pathway	Perimeter (600 m SW)	Individual (2,100 m WSW)
Ingestion	–[a]	–
Inhalation	6.9×10^{-7}	2.3×10^{-7}
Air immersion	3.7×10^{-15}	1.2×10^{-15}
Ground surface	–	–
Total	6.9×10^{-7}	2.3×10^{-7}
Radionuclide		
Uranium-234	3.8×10^{-7}	1.2×10^{-7}
Uranium-238	3.1×10^{-7}	1.0×10^{-7}
Total	6.9×10^{-7}	2.3×10^{-7}

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

TABLE 4.18

Radiological Airborne Releases from Building 411/415 (APS), 2008

Direction	Distance to Perimeter (m)	Dose[a] (mrem/yr)	Distance to Nearest Resident (m)	Dose[a] (mrem/yr)
N	1,500	1.7×10^{-3}	2,000	1.1×10^{-3}
NNE	1,600	2.2×10^{-3}	2,100	1.4×10^{-3}
NE	2,200	1.2×10^{-3}	3,100	7.0×10^{-4}
ENE	2,500	9.0×10^{-4}	3,300	5.8×10^{-4}
E	1,600	1.7×10^{-3}	3,400	5.1×10^{-4}
ESE	1,500	1.9×10^{-3}	3,500	5.1×10^{-4}
SE	400	1.2×10^{-2}	3,000	5.6×10^{-4}
SSE	400	8.4×10^{-3}	3,000	4.8×10^{-4}
S	350	7.6×10^{-3}	2,500	9.1×10^{-4}
SSW	400	2.7×10^{-2}	2,800	2.5×10^{-4}
SW	550	8.6×10^{-3}	3,000	6.2×10^{-4}
WSW	800	6.8×10^{-3}	1,400	3.2×10^{-3}
W	800	4.9×10^{-3}	1,500	1.9×10^{-3}
WNW	500	8.0×10^{-3}	1,400	1.7×10^{-3}
NW	350	1.1×10^{-2}	1,600	1.2×10^{-3}
NNW	1,500	1.5×10^{-3}	2,000	9.6×10^{-4}

[a] Source terms: carbon-11 = 1.2 Ci
nitrogen-13 = 57.0 Ci
oxygen-15 = 6.1 Ci

The only significant location where radionuclides attributable to Argonne operations could be found in off-site water was Sawmill Creek below the wastewater outfall (see Table 4.6). 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 Argonne wastewater, their net average concentrations in the creek, and the corresponding dose rates (if water at these concentrations was used as the sole water supply by an individual for an entire year) are given in Table 4.22. The dose rates were all well below the standards for the general population. It should be emphasized that Sawmill Creek is not used for drinking, swimming, or boating. Inspection of the area shows that there are fish in the stream; however, they do not constitute a significant source of food for any individual. Figure 4.6 is a plot (1986–2008) showing the estimated dose a hypothetical individual would receive if ingesting Sawmill Creek water.

As indicated in Table 4.6, occasional Sawmill Creek samples (fewer than 10%) contained traces of cesium-137, plutonium-238, curium-242 and 244, or californium-249 and 252; however, the averages were only slightly greater than the detection limit. The annual dose to an individual consuming water at these concentrations can be calculated with the same method used

TABLE 4.19

Maximum Perimeter and Individual Doses
from Building 411/415 (APS) Air Emissions, 2008
(dose in mrem/yr)

Pathway	Perimeter (400 m SSW)	Individual (1,400 m WSW)
Ingestion	–[a]	–
Inhalation	3.8×10^{-6}	1.0×10^{-6}
Air immersion	1.2×10^{-2}	3.2×10^{-3}
Ground surface	–	–
Total	1.2×10^{-2}	3.2×10^{-3}
Radionuclide		
Carbon-11	3.2×10^{-4}	8.8×10^{-5}
Nitrogen-13	1.1×10^{-2}	3.1×10^{-3}
Oxygen-15	1.2×10^{-4}	3.5×10^{-5}
Total	1.2×10^{-2}	3.2×10^{-3}

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

for those radionuclides more commonly found in creek water; this method of averaging, however, probably overestimates the true concentration. Annual doses range from 3×10^{-4} to 6×10^{-6} mrem/yr for these radionuclides.

Sawmill Creek flows into the Des Plaines River. The flow rate of Sawmill Creek (see Section 1.6) is about 0.28 m^3/s (10 ft^3/s). The flow rate of the Des Plaines River in the vicinity of Argonne is about 25 m^3/s (900 ft^3/s). Applying this ratio to the concentration of radionuclides in Sawmill Creek listed in Table 4.22, the dose to a hypothetical individual ingesting water from the Des Plaines River at Lemont would be about 0.0002 mrem/yr. Significant additional dilution occurs farther downstream. Very few people, either directly or indirectly, use the Des Plaines River as a source of drinking water. If 100 people used Des Plaines River water at the hypothetical concentration at Lemont, the estimated population dose would be about 10^{-5} person-rem.

4.7.3. Biota Dose Assessment

DOE Order 5400.5[5] requires an evaluation of the dose to aquatic organisms from liquid effluents. The dose limit is 1 rad/day, or 365 rad/yr. The location that could result in the highest dose to aquatic organisms is in Sawmill Creek downstream of the point where Argonne discharges its treated wastewater. Inspection of the creek at this location indicates the presence of small bluegill and carp (about 100 g [4 oz] each). The aquatic dose assessment of these species

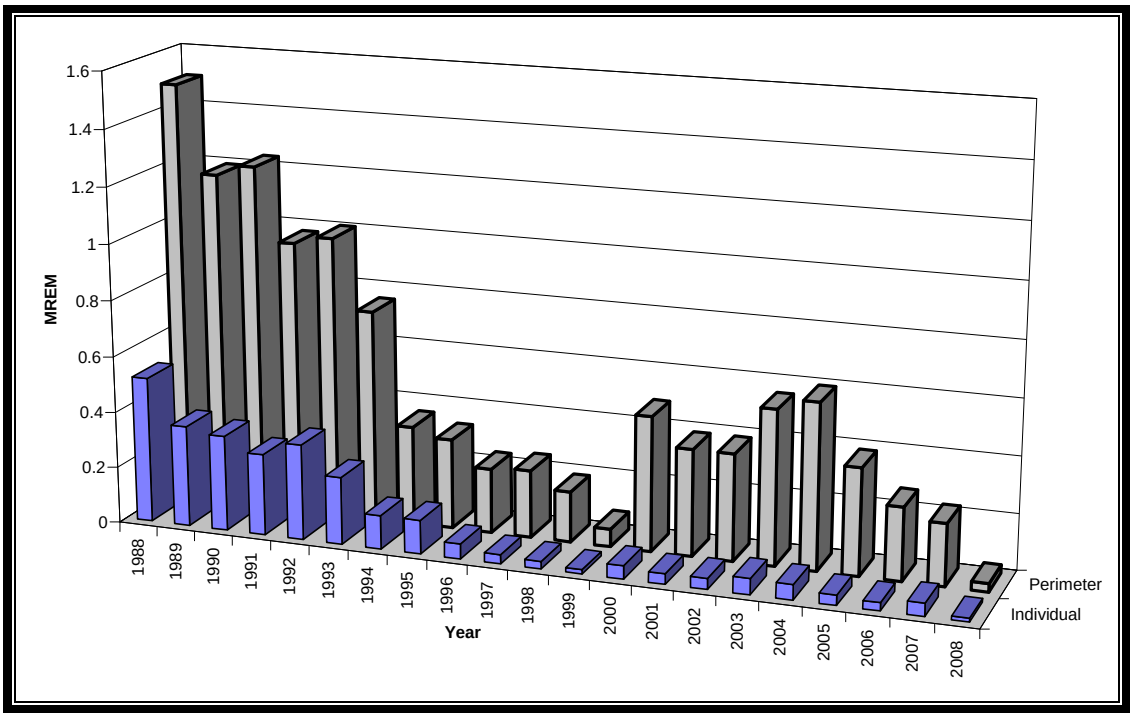


FIGURE 4.4 Individual and Perimeter Doses from Airborne Radioactive Emissions

TABLE 4.20

Population Dose within 80 km (50 mi), 2008

Radionuclide	Person-rem
Hydrogen-3	0.03
Carbon-11	<0.01
Nitrogen-13	0.26
Oxygen-15	<0.01
Antimony-125	<0.01
Iodine-125	<0.01
Iodine-129	<0.01
Radon-220	<0.01
Uranium-234	<0.01
Uranium-238	<0.01
Total	0.31
Natural	2.7×10^6

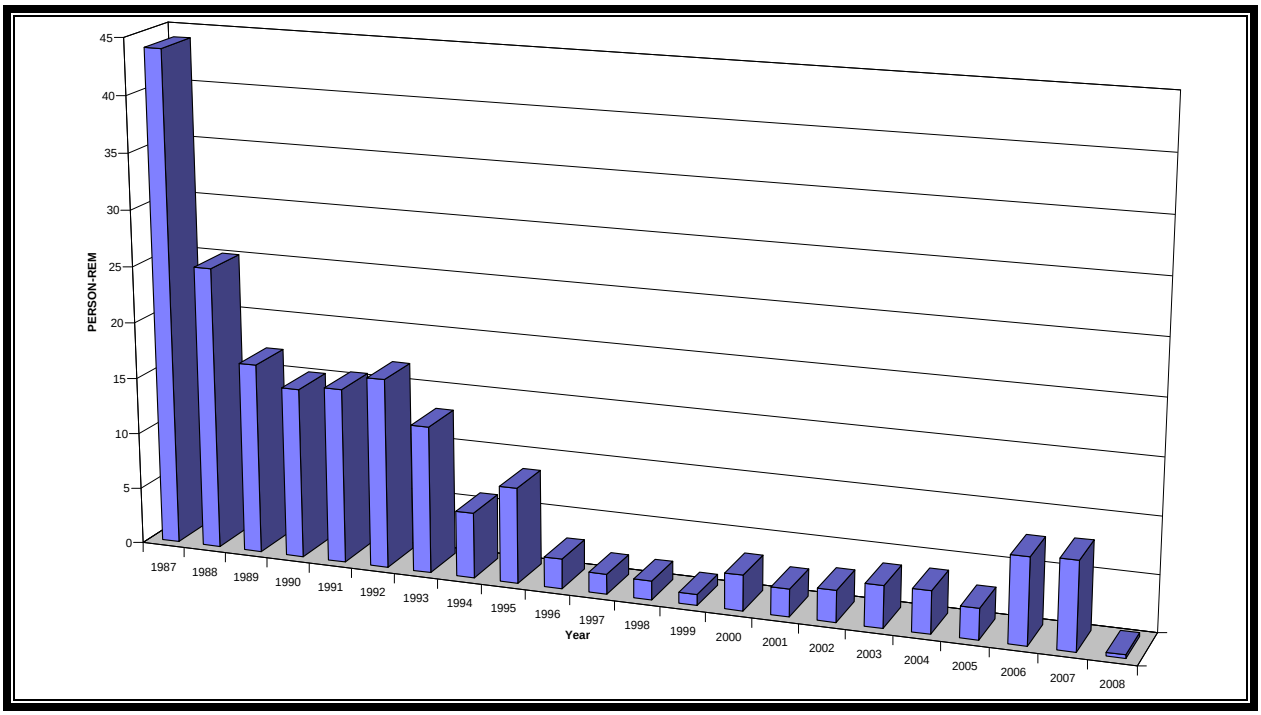


FIGURE 4.5 Population Dose from Airborne Radioactive Emissions

was conducted by using the DOE Technical Standard, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*.[16] The assessment used the general screening approach, which compares maximum water and sediment radionuclide concentrations with biota concentration guides (BCGs). Maximum water concentrations for hydrogen-3, strontium-90, plutonium-239, and americium-241 were obtained from Table 4.6, while maximum sediment concentrations for cesium-137, plutonium-239, and americium-241 were obtained from Table 4.9. Summing the ratios of their respective BCGs for each radionuclide resulted in a ratio of 0.0015 to aquatic biota. This is well below a ratio of 1 and demonstrates compliance with the limit in DOE Order 5400.5.

4.7.4. External Direct Radiation Pathway

The TLD measurements given in Section 4.5 were used to calculate the radiation dose from external sources. At Location 7I, the fence-line dose from Argonne was 81 ± 3 mrem/yr. Approximately 300 m (960 ft) south of the fence line (grid 6I), the measured dose was 90 ± 7 mrem/yr, essentially the same as the off-site average (97 ± 15 mrem/yr). No individuals live in this area. The closest residents are about 1.6 km (1 mi) south of the fence line. At this distance, the calculated dose rate from the Waste Storage Facility would be 0.001 mrem/yr, if the energy of the radiation was that of a 0.66-MeV cesium-137 gamma ray, and approximately 0.003 mrem/yr, if the energy was that of a 1.33-MeV cobalt-60 gamma ray.

TABLE 4.21

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

Nuclide	Ingestion	Inhalation
Hydrogen-3	6.3×10^{-5}	9.6×10^{-5}
Beryllium-7	–[a]	2.7×10^{-4}
Carbon-11	–	8.0×10^{-6}
Strontium-90	0.13	1.32
Cesium-137	0.05	0.032
Lead-210	–	13.2
Radium-226	1.1	–
Thorium-228	–	310
Thorium-230	–	260
Thorium-232	–	1,100
Uranium-234	0.26	130
Uranium-235	0.25	120
Uranium-238	0.23	120
Neptunium-237	3.9	–
Plutonium-238	3.8	–
Plutonium-239	4.3	330
Americium-241	4.5	–
Curium-242	0.11	–
Curium-244	2.3	–
Californium-249	4.6	–
Californium-252	0.94	–

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

At the fence line, where higher doses were measured in the past, the land is wooded and unoccupied. All of these dose calculations are based on full-time, outdoor exposure. Actual exposures to individuals would be substantially less because the individuals are indoors (which provides shielding) or away from their dwellings for part of the time. In addition to the permanent resident in the area, occasionally visitors may conduct activities around Argonne that could result in exposure to radiation from this site. Examples of these activities are cross-country skiing, horseback riding, or running in the fire lane next to the perimeter fence. If the individual spent 10 minutes per week adjacent to the 317 Area, the dose would be 0.001 mrem/yr at the 317 Area fence (Location 7I) from Argonne operations.

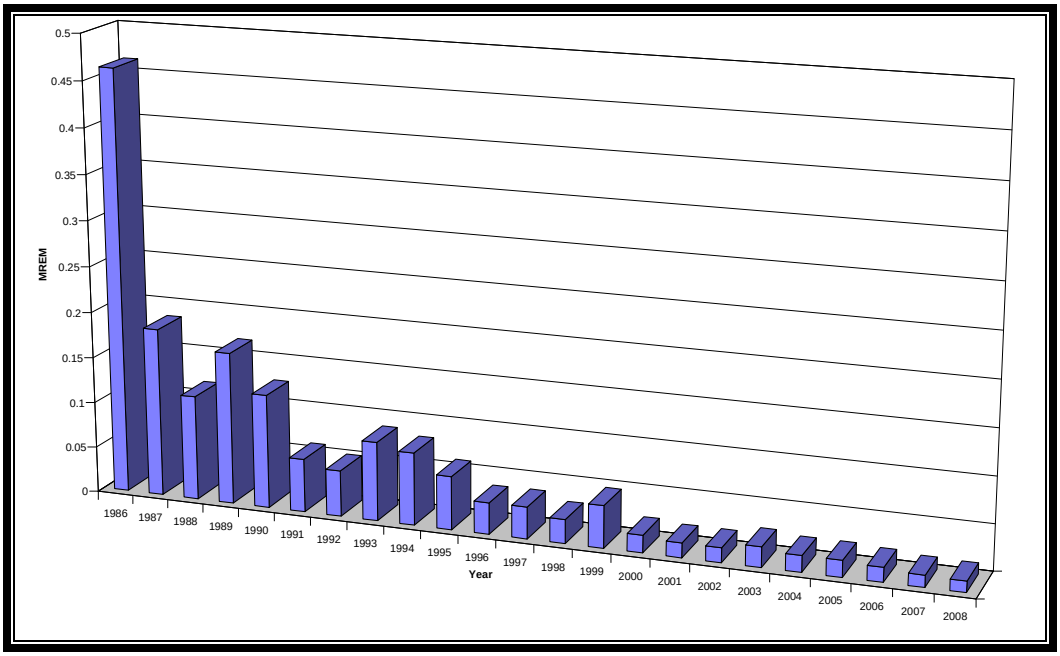


FIGURE 4.6 Comparison of Dose Estimates from Ingestion of Sawmill Creek Water

TABLE 4.22

Radionuclide Concentrations and Dose Estimates
for Sawmill Creek Water, 2008

Radionuclide	Total Released (Ci)	Net Avg. Concentration (pCi/L)	Dose (mrem)
Hydrogen-3	0.11	30	0.001
Strontium-90	0.0004	0.09	0.008
Plutonium-239	<0.0001	0.0006	0.002
Americium-241	<0.0001	0.0003	0.001
Total	0.11		0.012

4.7.5. Dose Summary

The total effective dose equivalent received by off-site residents during 2008 was a combination of the individual doses received through the separate pathways. Radionuclides that contributed through the air pathway are hydrogen-3, carbon-11, nitrogen-13, oxygen-15, radon-220 (plus daughters), and actinides. The highest dose was approximately 0.013 mrem/yr to individuals living north-northeast of the site if they were outdoors at that location during the entire year. The total annual population dose to the entire area within an 80-km (50-mi) radius was 0.31 person-rem. The dose pathways are presented in Table 4.23 and are compared with the applicable standards.

To receive the hypothetical maximum public dose, an individual would need to live at the point of maximum air and direct radiation exposure and use only water from Sawmill Creek below the Argonne wastewater discharge. This is a very conservative and unlikely situation. To put the hypothetical maximum individual dose from all pathways of 0.026 mrem/yr attributable to Argonne operations into perspective, comparisons can be made with annual average doses (360 mrem) from natural or accepted sources of radiation received by an average American who could be living anywhere in the United States. These values are listed in Table 4.24. These site-related doses are in addition to the background doses. The magnitude of the doses received from Argonne operations is insignificant compared with these sources. Therefore, the monitoring program results establish that the radioactive emissions from Argonne are very low and do not endanger the health or safety of those living in the vicinity of the site.

TABLE 4.23

Summary of the Estimated Dose to a Hypothetical Individual, 2008 (mrem/yr)

Pathway	Argonne Estimate	Applicable Standard
Air total	0.013	10 (EPA)
Water	0.012	4 (EPA)[a]
Direct radiation	0.001	25 (NRC)[b]
Maximum dose	0.026	100 (DOE)

[a] The 4-mrem/yr EPA value is not an applicable standard, since it applies to community water systems.[17] It is used here for illustrative purposes.

[b] NRC = U.S. Nuclear Regulatory Commission.

TABLE 4.24

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

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

[a] National Council on Radiation Protection and Measurements Report No. 93.[14]

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

5.1. Introduction

In addition to monitoring for the release of radioactive materials, Argonne monitors for the release of hazardous chemicals to the environment. The nonradiological monitoring program involves monitoring of point-source air discharges for certain chemicals and particulates and the collection and analysis of surface water and groundwater samples from numerous locations throughout the site. This chapter discusses the monitoring of releases to the air and surface water. Argonne's extensive groundwater monitoring program is discussed separately in Chapter 6.

5.1.1. Chapter Highlights

Air Releases. Monitoring of releases of nonradiological contaminants to the air from Argonne operations is limited to compliance monitoring of combustion products from the on-site coal-fired boiler. During 2008, there were no exceedances of the air permit limits for this facility during 2,411 hours of operation.

Surface Water. Wastewater from Argonne operations is discharged to the environment through a series of wastewater outfalls permitted under the NPDES program administered by the IEPA. These outfalls are sampled on schedules that range from weekly to semiannual. During 2008, approximately 99% of all NPDES analyses were in compliance with their applicable permit limits. During 2008, the only significant issue was the exceedance of the TDS limit at Outfall 001, the combined wastewater discharge point into Sawmill Creek, resulting from the use of road salt during the winter. There were 11 exceedances of TDS and chloride limits at Outfall 001 during 2008. No toxicity was observed at Outfall 001, which was tested for aquatic toxicity. Samples of treated effluent and water in Sawmill Creek downstream of Argonne were collected and analyzed for a variety of metals. Samples from the combined wastewater discharge and Sawmill Creek were found to meet the IEPA's criteria for effluent quality and general use water quality. Thus, it appears that, with the exception of the elevated levels of TDS and chloride from road salt, the Argonne site is in compliance with permit limits and surface water quality criteria.

5.2. Monitoring Air Discharges

Argonne operations and research activities utilize a number of nonradioactive volatile chemicals and fuels that have the potential to adversely impact the environment if released to the air in sufficient quantities. However, because of the nature of the research conducted at Argonne, most chemicals are used in small quantities within laboratories, and the potential for a significant release to the outside air is very small. These small potential discharges are not monitored. Only one exhaust point (Boiler No. 5) has the potential for significant releases, and this discharge is monitored. Argonne does not conduct ambient air quality monitoring for conventional air pollutants due to the lack of significant air emission sources.

The most significant conventional air pollutants at Argonne are combustion products discharged from the five on-site steam boilers, particularly Boiler No. 5, which is equipped to burn coal as well as natural gas. Most of the time, all of the boilers burn natural gas, which emits relatively small amounts of regulated pollutants, and do not require stack monitoring. In Boiler No. 5, coal is used during the peak heating demand periods in the winter. It is equipped with dedicated stack monitoring equipment for sulfur dioxide and opacity to be used while burning coal. No exceedances were noted during 2008 over a period of 2,411 hours of coal-burning operation (see Section 2.1.2). The lack of exceedances for 2008 indicates that the boiler house is operating within its allowable discharge constraints.

Other significant sources of air discharges include a number of backup power generators that are operated periodically for maintenance reasons and a transportation research facility that evaluates internal combustion engines. Chapter 2 (Table 2.3) contains a summary of estimated air discharges (estimated based on run time and typical emission factors for each type of equipment) from the major air point-source discharges at Argonne. The major pollutants discharged from these sources were carbon monoxide, nitrous oxides, and sulfur dioxide, nearly all of which were discharged from the boilers.

Another nonradioactive air pollutant that is monitored is methane gas generated by the decomposition of solid waste in the 800 Area Landfill. The primary purpose of this monitoring is to determine if a potential safety concern exists due to gas migration into structures around landfills. Gas composition is measured quarterly at 4 wells located in the waste mound, at 10 gas monitoring wells adjacent to the landfill but outside of the buried waste, and in two nearby structures. Monitoring in 2008 indicated that the gas within the landfill waste mound contained up to 79% methane, but no methane was found in the gas monitoring wells surrounding the landfill except for single readings of 0.2% methane in gas well G-10, well below the action level of 2.5% methane. The quantity of gas generated is not measured, but observations during sampling indicated that the flow is very small.

Small amounts of research-related volatile chemicals are released to the air as laboratory wastewater is treated in the LWTP. The amount of volatile organic matter (VOM) and HAPs in the LWTP wastewater is calculated each month on the basis of an analysis of a single sample of wastewater flowing into the plant and the flow rate of wastewater through the plant. The amount potentially released to the air is estimated by using the EPA's WATER9 model, designed for determining emissions from such facilities. Section 5.3 discusses the results of the wastewater analysis. During 2008, the estimated amount of VOM released from the LWTP was approximately 50 kg (109 lb), much lower than in previous years. There were no HAP compounds detected in 2008.

5.3. Monitoring Wastewater Treatment Plant Influent

Untreated wastewater entering the LWTP is sampled once per month and analyzed for VOCs. In addition to satisfying the requirements of Argonne's Title V air permit, this

information allows Argonne to track the success of its efforts to reduce the discharge of hazardous chemicals to the sewer system.

Table 5.1 summarizes the results of the monthly analysis of laboratory wastewater influent in 2008. The 2008 results are similar to those from previous years with the exception that the number of compounds detected was significantly lower than previous years and the maximum concentrations found were generally lower.

Low concentrations of bromoform, bromodichloromethane, chloroform, and dibromochloromethane were found in nearly all of the samples. These compounds are halogenated organic chemicals that are produced when chlorine is added to the water supply during treatment by the Chicago Water Department, which provides the water that Argonne purchases from the DuPage Water Commission. The chlorine interacts with naturally occurring organic chemicals in the water and produces low concentrations of a number of chlorinated or brominated chemicals collectively known as THMs. Some of these materials remain in the wastewater and are detected in the influent samples. The chloroform concentrations since 1992 are shown in Figure 5.1. The decrease in chloroform observed in 1997 is likely the result of the switch from Argonne well water to Lake Michigan water, which occurred in 1997. The drinking water limit for the sum of all of the THM compounds is 80 μg/L. The concentrations detected are all well below this limit.

In addition to the THMs, five other chemicals were detected in at least one sample. The chemicals consistently detected in the highest concentrations were acetone, acetaldehyde and 2-butanone. Acetone was found in 9 of 12 samples and is likely the result of equipment cleaning. Acetaldehyde was found in three samples and 2-butanone was found at concentrations just above detections limits in four samples. Figure 5.2 shows acetone concentrations since

TABLE 5.1

Laboratory Influent Wastewater, 2008
(concentrations in μg/L)

Compound	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Avg.[b]
Chlorination By-Products													
Bromodichloromethane	2	0.9	1	1	1	1	1	1	1	1	1	2	1.2
Bromoform	1	0.2	0.6	0.4	7	3	5	1	6	7	1	1	2.8
Chloroform	2	2	1	1	0.9	1	0.8	1	1	1	2	1	1.2
Dibromochloromethane	2	0.6	1	0.9	2	2	3	2	3	2	1	2	1.8
Dibromomethane	–[a]	–	–	–	–	–	–	–	–	0.2	–	–	0.2
Chemicals Discharged													
2-Butanone	1	–	–	–	–	3	–	–	2	1	–	–	1.8
Acetaldehyde	55	–	–	–	–	–	80	–	62	–	–	–	66
Acetonitrile	–	–	–	166	–	–	–	–	–	–	–	–	166
Acetone	61	20	–	–	8	5	–	166	16	142	738	175	148
Ethanol	1,246	–	–	–	–	–	–	–	–	–	–	–	1,246

[a] A dash indicates that the concentration was less than the detection limit.

[b] Average calculated from values above the detection limits only.

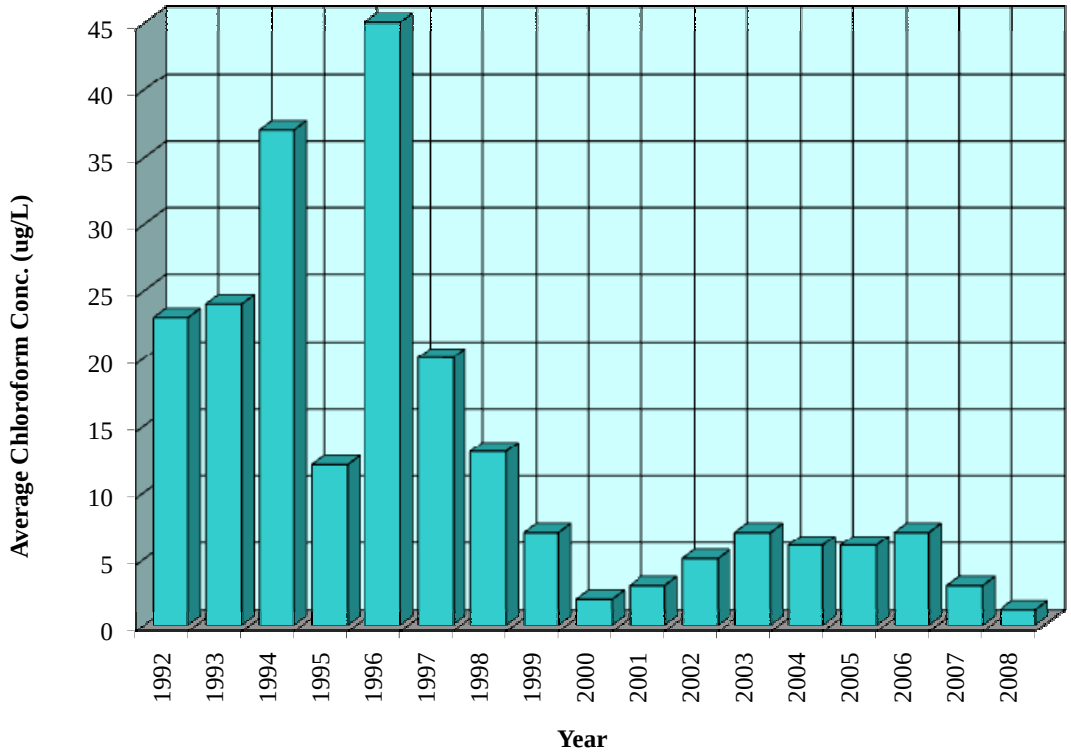


FIGURE 5.1 Average Chloroform Levels in Laboratory Influent Wastewater, 1992 to 2008

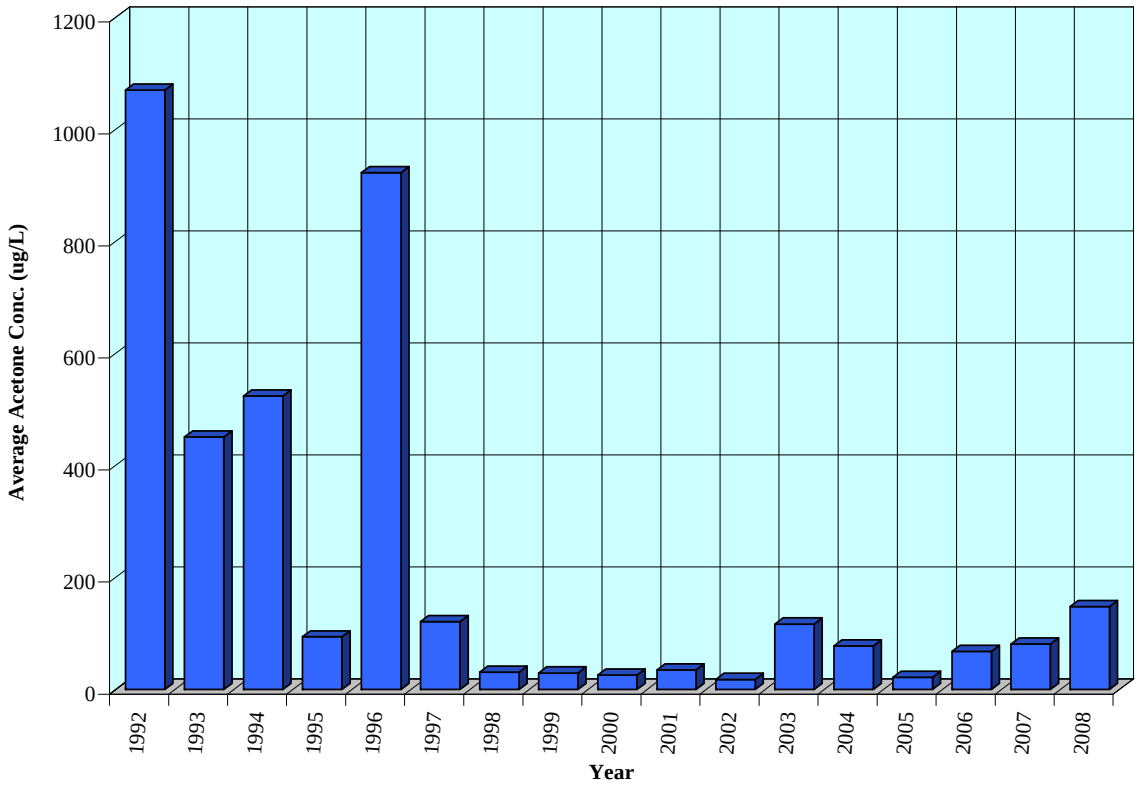


FIGURE 5.2 Average Acetone Levels in Laboratory Influent Wastewater, 1992 to 2008

1992. A significant drop in acetone concentration occurred from 1994 to 2000, and it has remained present at concentrations under 150 µg/L since. Ethanol and acetonitrile were both detected only once during 2008. The precise source of these chemicals is not known, but research activities at Argonne utilize a wide variety of chemicals for many purposes and discharge small amounts of such chemicals into the sewer from time to time. As discussed in Section 5.4.3.1 of this chapter, only THMs were detected in the effluent from the treatment plant.

As part of its ongoing pollution prevention efforts, Argonne conducts a waste generator education program in which proper handling and disposal of chemicals are explained. The decrease in influent concentrations of acetone since the late 1990s can, in part, be attributed to educational efforts related to waste disposal and pollution prevention.

In addition to laboratory activities, VOCs are discharged into the laboratory sewer from the 317/319 Area lift station, which pumps contaminated groundwater generated by Argonne's groundwater extraction systems in this area. The chemicals in the groundwater discharged to the treatment plant are organic solvents, including 1,1-dichloroethane, trichloroethene, carbon tetrachloride, and chloroform. Of these, only chloroform was detected in influent samples during 2008, and its presence was likely due to disinfection of potable water with chlorine rather than contaminated groundwater.

5.4. Monitoring Discharges to Surface Water

The release of nonradioactive pollutants to surface water is monitored in several different ways. Samples of wastewater discharged to on-site streams and Sawmill Creek are routinely collected from 16 NPDES-permitted outfalls. Sampling frequency and analyses conducted on the samples from the NPDES outfalls vary, depending on their permit-mandated monitoring requirements. The results of the analyses are compared with the permit limits for each outfall to determine whether they comply with the permit. In addition to being published in this report, the NPDES monitoring results are transmitted monthly to the IEPA in a DMR.[18] Stormwater is sampled at several locations across the site, and the overall effects of the Argonne site on Sawmill Creek are monitored by sampling the creek downstream of the site. The wastewater sampling program is discussed in this section.

5.4.1. Wastewater Discharge Monitoring

The main treated wastewater outfalls include the treated Sanitary Wastewater Treatment Plant (SWTP) discharge, Outfall A01, and the treated water from the LWTP, Outfall B01. These outfalls are internal monitoring points since their flows combine before they discharge to Sawmill Creek. The combined discharge is known as Outfall 001, which is also located at the WTP. The combined wastewater stream flows through an outfall pipe that discharges into Sawmill Creek approximately 1,100 m (3,500 ft) south of the WTP, at the location designated as 7M in Figure 1.1.

Thirteen direct discharge outfalls are also monitored. Nine of these outfalls potentially contain small amounts of process wastewater as well as rainwater runoff after a storm. The permit limits and monitoring requirements apply only to the process wastewater discharges when they are present; they are not sampled during periods when stormwater is also flowing, when no flow is visible or the outfall is completely frozen. The process wastewater in these outfalls comes from sources that do not contribute contamination, such as cooling towers, once-through cooling water, condensate, and footing drain water, and, therefore, it is not treated prior to its discharge from the outfalls. In recent years, many of the cooling tower blowdown, condensate, and cooling water discharges have been rerouted to the Argonne sewer system, resulting in a reduction or elimination of dry weather flow in a number of outfalls of this type. The remaining four outfalls convey stormwater from potentially contaminated areas in the 800 Area and the 317/319 Area. For these outfalls, stormwater runoff is collected after a significant rain event. If no runoff occurs during the sampling period, no samples are required.

5.4.1.1. Sample Collection and Analysis

Effluent samples are collected from Argonne outfalls as specified by the NPDES permit. Sampling intervals range from weekly sampling of the main treated wastewater to semiannual sampling of certain stormwater outfalls. This section summarizes the monitoring requirements and discusses the results of the monitoring.

All samples are collected in specially cleaned and labeled sample bottles with appropriate preservatives added. Custody seals and chain-of-custody sheets also are used as needed. Samples are submitted to the appropriate laboratory for analysis, so that testing can be completed within the required holding time.

Sample collection, preservation, holding times, and analytical methods are specified by the EPA. Table 5.2 provides a summary of the analytical methods used for the NPDES monitoring programs. These analyses are conducted by the Argonne ESQ Analytical Services (ESQ-AS) laboratory as well as commercial laboratories. Commercial laboratories are used for a select set of analyses that the Argonne laboratory does not perform.

NPDES sample analyses conducted by Argonne are performed in accordance with standard operating procedures (SOPs) that are issued and updated periodically as controlled documents. These SOPs cite protocols that can be found in 40 CFR Part 136, "Test Procedures for the Analysis of Pollutants under the Clean Water Act"[19] and Standard Methods.[20] Commercial laboratories utilize their own SOPs based on the same protocols.

5.4.2. Outfall Monitoring Requirements and Results

This section discusses the monitoring requirements and summarizes the results of monitoring at the outfalls covered by the NPDES permit.

TABLE 5.2

Analytical Procedures

Analyte	Description	Analytical Lab
Wastewater Properties		
pH	Electrochemical pH electrode method	Field
Temperature	Electronic probe method	Field
Inorganic Constituents		
Ammonia nitrogen	Ion-selective electrode measurement	Commercial
Chloride	Turbidimetric method	Argonne
Hexavalent/trivalent chromium	Inductively coupled plasma (ICP) emission spectroscopy	Argonne
Iron/dissolved iron	ICP emission spectroscopy	Argonne
Low-level mercury	Cold-vapor atomic fluorescence spectrometry	Commercial
Nitrate-nitrite	Colorimetric method	Commercial
Sulfate	Ultraviolet/visible absorption spectrometry	Argonne
Total dissolved solids (TDS)	Drying and gravimetric method	Argonne
Total residual chlorine (TRC)	*n*, *n*-Diethyl-p-phenylene diamine (DPD) colorimetric method	Field
Total suspended solids (TSS)	Filtering and drying gravimetric method	Argonne
Organic Constituents		
Oil and grease	Solvent partition-gravimetric method	Argonne
Biological oxygen demand (BOD_5)	Fermentation and dissolved oxygen depletion method (5-day)	Commercial
Chemical oxygen demand (COD)	Closed reflux, colorimetric method	Argonne
Carbon tetrachloride	Purge and trap gas chromatograph and mass spectrometer (GC/MS) method	Argonne
Total organic halogen (TOX)	Carbon adsorption with a microcoulometric titration detector	Commercial
Total organic carbon (TOC)	Oxidation and off-gas carbon measurement	Commercial
Phenols	Distillation followed by colorimetric measurement	Commercial
Tetrachloroethene	Purge and trap capillary-column GC/MS method	Argonne
Priority Pollutant List Analyses		
Cyanide (total)	Distillation and colorimetric method	Commercial
Herbicides/pesticides	Liquid/liquid extraction followed by GC/MS	Argonne
PCBs	Liquid/liquid extraction followed by GC/MS	Argonne
Semivolatile organics	Liquid/liquid extraction followed by GC/MS	Argonne
Volatile organics	Purge and trap capillary-column GC/MS method	Argonne
Metals (except mercury) antimony, arsenic, beryllium, cadmium, chromium, copper, lead, nickel, selenium, silver, thallium, zinc	ICP/atomic emission spectrometry	Argonne
Mercury	Cold vapor atomic absorption spectrometry	Argonne

5.4.2.1. Wastewater Treatment Facility Outfalls

Outfall A01. This outfall consists of sanitary wastewater treated in the SWTP. The effectiveness of the wastewater treatment system is evaluated by monitoring the constituents shown in Table 5.3 at the frequency shown. The results are then compared with the concentration limits shown in this table. Two sets of limits are listed; one is a maximum limit for any single sample (Daily Maximum Limit), and the other is for the average of all weekly samples collected

TABLE 5.3

Outfall A01 Effluent Limits and Monitoring Results, 2008
(concentrations mg/L except where noted)

	NPDES Permit Requirements			Monitoring Results			
Constituent	Monitoring Frequency	30-Day Average Limit	Maximum Daily Limit	Minimum	Average	Maximum	Exceedances in 2008
Flow (MGD)[a]	Continuous	NA[b]	NA	0.134	0.294	2.50	NA
pH (pH units)	Weekly	NA	6.0–9.0	6.4	c	7.8	0
BOD_5	Weekly	10.0	20.0	1.0	2.1	7.0	0
TSS	Weekly	12.0	24.0	1.0	1.9	10.0	0
Copper	Weekly	0.5	1	<0.025[d]	<0.025	0.031	0
Iron	Weekly	2	4	<0.5	<0.5	<0.5	0
Manganese	Weekly	1	2	<0.075	<0.075	0.080	0
Zinc	Weekly	1	2	<0.5	<0.5	<0.5	0

[a] MGD = million gallons per day.

[b] NA indicates that there is no limit or value of the type shown.

[c] pH is a logarithmic function and average values are not mathematically correct; therefore, only the minimum and maximum values are shown.

[d] A value shown with a "less than" (<) sign indicates that the constituent was not present above the detection limits of the analytical method. The value shown is the method detection limit.

during the month (30-Day Average Limit). Table 5.3 also contains a summary of the monitoring results from 2008. No limits were exceeded at this outfall during 2008.

Outfall B01. This outfall consists of treated wastewater from the LWTP. Table 5.4 gives the monitoring requirements and effluent limits and summarizes the monitoring results for this outfall. This outfall is subject to both concentration limits and mass discharge limits. The mass discharge limit represents the maximum weight of material that can be discharged per day. The mass discharge amount that is compared with the limit is calculated by using the constituent concentration and the flow rate measured the day that the sample was collected. There were no exceedances of either concentration or mass limits in 2008.

Iron and chemical oxygen demand (COD) are included in the permit as monitor-only constituents. The COD results provide a rough indication of the oxygen-consuming potential of this effluent on the receiving stream. Only one of the samples in 2008 had COD concentrations above the analytical detection limits of 20 mg/L. Only three samples contained iron above the detection limit of 0.5 mg/L, the highest concentration being 0.63 mg/L.

TABLE 5.4

Outfall B01 Effluent Limits and Monitoring Results, 2008
(concentrations in mg/L except where noted)

	NPDES Permit Requirements			Monitoring Results			
Constituent	Monitoring Frequency	30-Day Average Limit	Maximum Daily Limit	Minimum	Average	Maximum	2008 Exceedances
Flow (MGD)	Weekly	NA[a]	NA	0.344	0.463	1.47	NA
pH (pH units)	Weekly	NA	6.0–9.0	6.6	b	8.0	0
BOD_5 concentration	Weekly	10	20	1	1.4	3	0
BOD_5 mass (lb/day)	Weekly	41.9	83.7	2.3	5.3	17	0
TSS concentration	Weekly	12	24	1	3.1	18	0
TSS mass (lb/day)	Weekly	50.2	100.5	2.3	13	69	0
Zinc concentration	Weekly	1	2	<0.5[c]	<0.5	<0.5	0
Zinc mass (lb/day)	Weekly	4.19	8.37	<1.2[d]	<1.9	<4.3	0
Mercury concentration	Weekly	0.003	0.006	<0.0002	<0.0002	<0.0002	0
Mercury mass (lb/day)	Weekly	0.0126	0.0251	<0.00046	<0.00077	<0.00172	0
Oil and grease concentration	Weekly	15	30	<5	<5	7	0
Oil and grease mass (lb/day)	Weekly	62.8	125.6	<12	<19	<43	0
Iron[e]	Weekly	NA	NA	<0.5	<0.5	0.63	NA
COD[e]	Weekly	NA	NA	<20	<20	23	NA
Priority pollutants	Semiannual	NA	NA	–[f]	–	–	NA

[a] NA indicates that there is no limit or value of the type shown.

[b] pH is a logarithmic function and average values are not mathematically correct; therefore only the minimum and maximum values are shown.

[c] A concentration value shown with a "less than" (<) sign indicates that the constituent was not present above the detection limits of the analytical method. The value shown is the method detection limit.

[d] A mass value shown with a "less than" (<) sign indicates that one or more of the concentration values used to calculate the mass was less than the detection limits of the analytical method; thus, the mass amount is shown as a "less than" quantity.

[e] Monitor-only parameter.

[f] A dash indicates that priority pollutant results are presented in Table 5.5.

Outfall B01 is also monitored semiannually (June and December) for priority pollutant compounds. Priority pollutants are 124 organic and inorganic constituents that the EPA has determined deserve special attention in monitoring programs. The June sample is to be collected at the same time that aquatic toxicity testing of Outfall 001 is conducted. Samples were collected on June 18, 2008, and December 8, 2008, and analyzed within the required holding times. Table 5.5 gives the results for those constituents that were found above the analytical detection limits. The results for most of the VOCs, and all of the metals, semivolatile organic compounds (SVOCs), PCBs, pesticides, and cyanide were less than the detection limits of 1 to 10 µg/L. The samples contained very low concentrations of several THMs, which result from the chlorination of drinking water and were also found in the influent to the LWTP. Phenols were found in the June sample at the detection limit of 0.005 mg/L. In general, these results indicate that the treated

TABLE 5.5

Outfall B01 Effluent Priority Pollutant Monitoring Results, 2008

Compound[a]	Concentration in June Sample	Concentration in December Sample
Bromodichloromethane (µg/L)	1	< 1[b]
Bromoform (µg/L)	4	< 1
Chloroform (µg/L)	0.9	0.5
Dibromochloromethane (µg/L)	2	< 1
Phenol (total) (mg/L)	0.005	<0.005

[a] All 124 priority pollutants were analyzed. Only those found above the analytical detection limits are shown in this table.

[b] A "<" sign indicates that the element or compound was not detected above analytical detection limits. The value shown is the detection limit.

wastewater is free of most of the toxic chemicals on this list, and the few that were detected are only occasionally present at extremely low concentrations or are not the result of Argonne activities.

Outfall 001. This outfall represents the combined wastewater from both treatment plants. The combined effluent flows through a 1,100-m (3,500-ft) outfall pipe where it is eventually discharged into Sawmill Creek at the main outfall south of the Argonne site (Location 7M).

Composite and grab samples of the combined effluent are collected weekly or monthly, as required by the permit. Table 5.6 lists the monitoring requirements and limits, summarizes the results, and lists the number of exceedances of the limits during 2008.

Eleven permit exceedances occurred at Outfall 001 in 2008. The TDS limit was exceeded once in January, three times each in February and three in March, and once in April. All exceedances occurred during or after periods of heavy snowmelt. Three chloride exceedances occurred during these same time periods. The TDS and chloride exceedances are believed to be related to the introduction of salt-laden snowmelt into the sewer system. The snowmelt appears to be introduced to the sewer system through infiltration of salty surface water though cracks and gaps in the pipe, the intentional collection and discharge to the laboratory sewer of runoff from salted roadways and parking lots near the boiler house, and elevated levels of salt in the Chicago Sanitary and Ship Canal (the source of water for the Argonne Canal Water Treatment Plant), which provides approximately 50% of the total water used on site. The role of road salt in the TDS exceedances was confirmed by comparing the TDS and chloride concentrations for the same time period. Figure 5.3 shows the results of TDS and chloride analyses for 2000 through 2008. This figure shows the seasonal nature of TDS levels in the outfall, corresponding with

TABLE 5.6

Outfall 001 Monitoring Results and Effluent Limits, 2008
(concentrations in mg/L except where noted)

	NPDES Permit Requirements			Monitoring Results			
Constituent	Monitoring Frequency	30-day Average Limit	Maximum Daily Limit	Minimum	Average	Maximum	2008 Exceedances
Flow (MGD)	Daily	NA[a]	NA	0.513	0.758	3.90	NA
pH (pH units)	Weekly grab	NA	6.0–9.0	6.68	b	8.16	0
TDS	Weekly composite	NA	1,000	453	765	1,574	8
Chloride	Weekly composite	NA	500	107	283	785	3
Sulfate	Weekly composite	NA	500	58	127	213	0
Dissolved iron	Weekly composite	NA	1	<0.5	<0.5	<0.5	0
Ammonia nitrogen (Nov.–March)	Weekly composite	2.4	10.8	<0.05	1.05	2.83	0
Ammonia nitrogen (Apr.–Oct.)	Weekly composite	1.2	3.8	<0.05	0.60	1.8	0
Copper	Weekly composite	0.031	0.051	<0.025	<0.025	0.026	0
Manganese	Weekly composite	NA	1	<0.075	<0.075	0.11	0
Zinc	Weekly composite	NA	1	<0.5	<0.5	<0.5	0
Lead	Monthly composite	NA	NA	<0.09	<0.09	<0.09	NA
Hexavalent chromium	Monthly composite	NA	NA	<0.05	<0.05	<0.05	NA
Trivalent chromium	Monthly composite	NA	NA	<0.05	<0.05	<0.05	NA
Phosphorus	Monthly composite	NA	NA	0.45	0.72	1.39	NA
Beta radioactivity	Monthly grab	NA	NA	3.11	6.92	10.85	NA
Low-level mercury	Monthly grab	NA	NA	0.0000024	0.0000073	0.0000184	NA

[a] NA = not applicable.

[b] Since pH is a log function of hydrogen ion concentrations, average values are not mathematically correct. Only minimum and maximum values are listed.

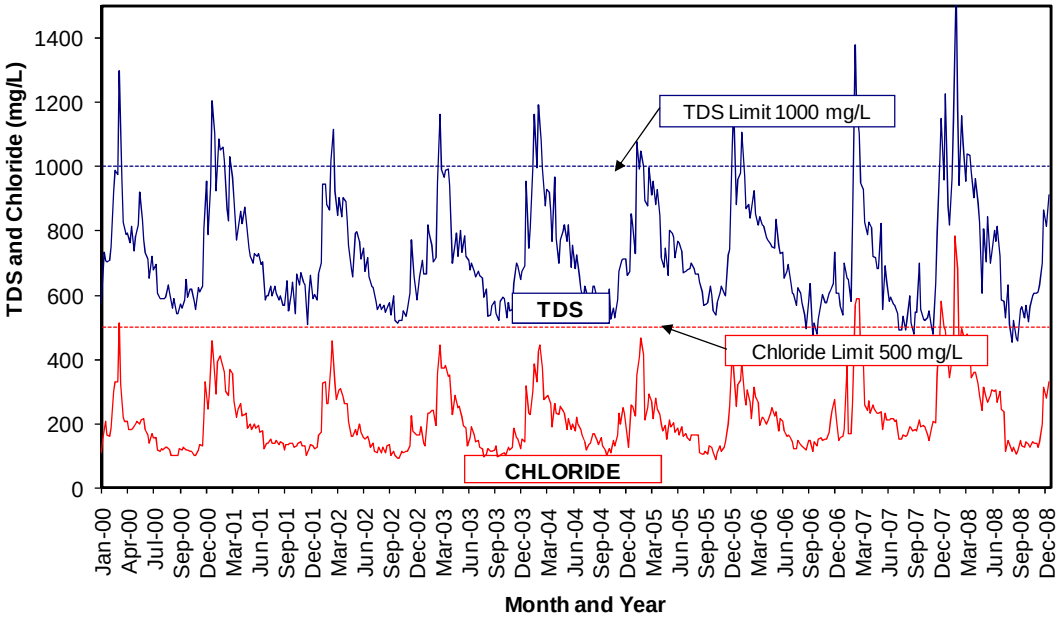


FIGURE 5.3 Total Dissolved Solids and Chloride in Outfall 001 Water, 2000 to 2008

the seasonal use of road salt, and the close correlation between TDS and chloride. High chloride levels and a close correlation between TDS and chloride indicate that the source is probably salt (sodium chloride).

The December 8, 2005, IEPA-approved biomonitoring plan called for acute toxicity testing of the effluent from Outfall 001. Prior to 2007, toxicity testing had also been required at Outfalls H03, I03, J03, 004, 006, and 025. However, past testing confirmed that there was no longer any toxicity associated with these outfalls and no more testing was needed. Only Outfall 001 was tested in 2008.

The toxicity testing of Outfall 001 was performed using samples collected June 17 to 18, 2008. The testing was performed by creating samples with various ratios of Argonne effluent and dilution water, into which two types of organisms were introduced, water fleas (*Ceriodaphnia dubia*) and fathead minnows (*Pimephales promelas*). Survival was measured over two to four days, and statistically significant mortality reported as a function of effluent concentration. An off-site contract laboratory performed the analyses. No toxicity was observed to the fathead minnow or to the water flea in the 2008 samples. Table 5.7 summarizes the results of the toxicity tests from 2001 through 2008. This table shows the concentration of wastewater that produces 50% mortality in the test population (i.e., the median lethal concentration [LC_{50}]). A value of >100 shown in this table means that even the undiluted effluent is not toxic to these species.

5.4.2.2. Direct Discharge Outfalls

In addition to the three outfalls at the wastewater treatment facilities, 17 other outfalls are routinely sampled. Thirteen of these outfalls currently discharge, or have discharged at some time

TABLE 5.7

Toxicity Testing Results, 2001 to 2008
(% of effluent producing toxicity)

	2001		2002		2002		2004		2005		2006		2007	2008
NPDES Outfall	June/July[a]	August	June/July	August	June/July	August	June/July	August	June/July	August	June/July	August	June	June
Water Flea, 48-Hour Acute Toxicity Results														
001	>100[b]	c	>100	c	>100	c	>100	c	>100	c	>100	c	>100	>100
H03	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	–[d]	–
I03	**71**	>100	>100	**88**[e]	>100	**82**	>100	>100	>100	>100	–	–	–	–
J03	**<20**	>100	**<20**	**<20**	>100	>100	>100	>100	>100	>100	>100	>100	–	–
004	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	–	–	–	–
006	**40**	**60**	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	–	–
025	**64**	>100	>100	>100	**57**	>100	**34**	**20**	**62**	**47**	>100	>100	–	–
Fathead Minnow, 96-Hour Acute Toxicity Results														
001	>100	c	>100	c	>100	c	>100	c	>100	c	>100	c	>100	>100
H03	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	–	–
I03	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	–	–	–	–
J03	**<20**	>100	**30**	**45**	>100	>100	>100	>100	>100	>100	>100	>100	–	–
004	>100	>100	>100	>100	>100	>100	>100	>100	**88**	>100	–	–	–	–
006	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	–	–
025	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	–	–

a Outfall 001 was sampled in June; the rest were sampled in July and August.

b A value of >100 indicates that the undiluted wastewater was not toxic to the test species.

c Testing not required.

d A dash indicates that toxicity testing is no longer required for these two outfalls.

in the past, process wastewater that does not require treatment prior to release, as well as stormwater. Four outfalls discharge only stormwater. The sampling requirements and effluent limits for these outfalls are described in Table 5.8. Four additional stormwater-only outfalls were sampled during 2007 for a one-time study of stormwater quality. Since this study was completed in 2007, no information on these outfalls is included in this report.

Only one of the direct discharge outfalls monitored in 2008 experienced permit exceedances. Outfall 006 had one exceedance of the TDS limit of 1,000 mg/L in June. The cause of this exceedance is not known but is probably related to residual road salt migrating through the subsurface and entering the storm drains that discharge to Outfall 006. During February of 2008, the TDS concentration also exceeded the limit; however, at that time it was clear that the exceedance was caused by road salt in melting snow from the roadways and parking lots in the 300 Area. Since this was caused by stormwater and not process wastewater, it was not reported as a permit exceedance.

Prior to 2008, numerous exceedances of the permit limits for TDS occurred at Outfalls J03 and H03. Investigations demonstrated that the elevated levels of TDS were the result of road salt that slowly discharged to these storm drains. The TDS limits at these two outfalls apply only to process wastewater. In recent years, all process wastewater that had been piped to these two storm drains was redirected to the laboratory or sanitary sewer system; therefore, there is no longer any process wastewater in these outfalls. In accordance with an agreement with the IEPA, these outfalls have not been sampled since mid 2007.

Stormwater in Outfall 021 is sampled once per year and analyzed for the priority pollutant constituents. Because of ongoing remedial actions in the 317 and 319 Areas, the potential for release of toxic organic chemicals into stormwater runoff exists. The 2008 sample was collected on June 13, 2008. None of the 124 compounds contained in the priority pollutant list was detected above analytical detection limits. Total phenols (an aggregate analysis of a class of compounds containing a benzene ring with one or more hydroxyl groups) were detected in this sample at a concentration slightly above the detection of 0.005 mg/L. This analysis is not included in the priority pollutant list but is performed by the laboratory as part of the standard procedure.

5.5. Additional Surface Water Monitoring

To supplement the permit-required monitoring, other analyses are voluntarily conducted on samples collected from the combined treatment plant effluent (Outfall 001) and Sawmill Creek downstream of the site. These samples are analyzed for a number of inorganic constituents and radiological parameters. The results of the radiological analyses are discussed in Chapter 4. The results of the inorganic analyses are presented in this chapter. The inorganic results are compared with the IEPA's General Effluent Standards and Stream Quality Standards listed in IAC, Title 35, Subtitle C, Chapter I.[21] While Argonne is not directly required to meet these standards in the effluent or Sawmill Creek, they provide a useful frame of reference against which the effluent quality and stream quality downstream of Argonne can be compared.

TABLE 5.8

Summary of Monitored Direct Discharge NPDES Outfalls, 2008

Outfall	Constituent	Permit Limit	Sample Results		
			Average for 2008	No. of Samples	2008 Exceedances
B03	Flow (MGD)	None	0.013	12	NA[a]
	pH	6–9	7.6–8.1	12	0
	Temperature	<2.8°C rise	13.4	12	0
	TSS	Monitor only	<1	12	NA
C03	Flow (MGD)	None	0.024	12	NA
	pH	6–9	8.0–8.2	12	0
D03	Flow (MGD)	None	0.026	12	NA
	pH	6–9	7.6–8.0	12	0
	Temperature	<2.8°C rise	20.9	12	0
	TSS	Monitor only	<1	12	NA
E03	Flow (MGD)	None	No Flow	0	NA
	pH	6–9	No Flow	0	NA
	Temperature	<2.8°C rise	No Flow	0	NA
	TSS	Monitor only	No Flow	0	NA
G03	Flow (MGD)	None	0.016	12	NA
	pH	6–9	7.2–8.1	12	0
	Temperature	<2.8°C rise	20.9	12	0
H03	Flow (MGD)	None	No Flow	0	NA
	pH	6–9	No Flow	0	0
	Temperature	<2.8°C rise	No Flow	0	0
	TDS	1,000	No Flow	0	0
	TSS	15 Avg.; 30 Max.	No Flow	0	0
	TRC[b]	0.011 Avg.; 0.019 Max.	No Flow	0	0
J03	Flow (MGD)	None	No Flow	0	NA
	pH	6–9	No Flow	0	0
	Temperature	<2.8°C rise	No Flow	0	0
	TDS	1,000	No Flow	0	0
	TRC[b]	0.011 Avg.; 0.019 Max.	No Flow	0	0
004	Flow (MGD)	None	0.042	12	NA
	pH	6–9	7.8–8.1	12	0
	TSS	15 Avg.; 30 Max. 30 Max.	4	12	0
	TRC[b]	0.011 Avg.; 0.019 Max.	<0.05	49	0
C05	Flow (MGD)	None	0.015	12	NA
	pH	6–9	7.1–8.3	12	0
	Temperature	<2.8°C rise	13.7	12	0

TABLE 5.8 (Cont.)

Outfall	Constituent	Permit Limit	Sample Results: Average for 2008	Sample Results: No. of Samples	Sample Results: 2008 Exceedances
E05	Flow (MGD)	None	0.003	11	NA
	pH	6–9	6.8–7.5	11	0
	Temperature	<2.8°C rise	9.5	11	0
	TRC	0.011 Avg.; 0.019 Max.	<0.05	37	0
006	Flow (MGD)	None	0.074	12	NA
	pH	6–9	8.0–8.4	12	0
	Temperature	<2.8°C rise	10.3	12	0
	TSS	15 Avg.; 30 Max.	2	12	0
	TDS	1,000	914	12	1
	TRC	0.011 Avg.; 0.019 Max.	<0.05	49	0
007	Flow (MGD)	None	0.031	12	NA
	pH	6–9	7.6–8.2	12	0
	Temperature	<2.8°C rise	12.8	12	0
021[c]	Flow (MGD)	None	0.056	8	NA
	Hydrogen-3	Monitor only	<100	8	NA
	Iron	Monitor only	0.85	8	NA
	Priority pollutants	Monitor only	–[d]	1	NA
A22[c]	Flow (MGD)	None	0.016	2	NA
	Hydrogen-3	Monitor only	<100	2	NA
B22[c]	Flow (MGD)	None	0.022	2	NA
	Hydrogen-3	Monitor only	<100	2	NA
023[c]	Flow (MGD)	None	0.091	8	NA
	Hydrogen-3	Monitor only	131	8	NA
	Copper	Monitor only	<0.025	8	NA
025	Flow (MGD)	None	0.001	12	NA
	pH	6–9	7.6–8.2	12	0
	Temperature	<2.8°C rise	11.5	12	0
	TDS	1,000	392	12	0
	TRC[b]	0.011 Avg.; 0.019 Max.	<0.05	51	0

[a] NA = not applicable; the parameter is a monitor-only constituent and limit exceedance is not applicable.

[b] Analytical detection limit it 0.05 mg/L. Values less than 0.05 mg/L are considered in compliance with the discharge limits.

[c] Stormwater-only outfall.

[d] A dash indicates that priority pollutant results are presented in Section 5.4.2.1.

Surface water discharges from the closed 800 Area and the 319 Area landfills are sampled quarterly, when flow is present, to monitor for potential leachate seepage from the waste mounds. This sampling is required by the postclosure care plans for these landfills. The results are discussed in Section 5.5.2.

5.5.1. Sample Collection and Analysis

Combined treatment plant effluent. Samples for analysis of inorganic constituents were collected daily from Outfall 001 with a refrigerated time-proportional sampler. A portion of each daily composite sample was transferred to a sample bottle. Five daily samples were composited on an equal-volume basis to produce a weekly sample that was then filtered and analyzed for the constituents shown in Table 5.9 by using the analytical procedures previously

TABLE 5.9

Chemical Constituents in Effluents from the Argonne Wastewater Treatment Plant, 2008

Constituent	No. of Samples	Concentration (mg/L)			
		Average	Minimum	Maximum	IEPA Limit
Arsenic	53			< 0.025[a]	0.25
Barium	53			< 0.5	2.0
Beryllium	53			< 0.0025	–[b]
Cadmium	53			< 0.0025	0.15
Chromium	53			< 0.05	1.0
Cobalt	53			< 0.25	–
Copper	53	<0.025	< 0.025	0.051	0.5
Fluoride	53	0.809	0.530	1.06	15.0
Iron	53	< 0.50	< 0.50	0.71	2.0
Lead	53			< 0.09	0.2
Manganese	53			< 0.075	1.0
Mercury	53			< 0.0002	0.0005
Nickel	53			< 0.05	1.0
Silver	53			< 0.0025	0.1
Thallium	53			< 0.002	–
Vanadium	53			< 0.075	–
Zinc	53			< 0.5	1.0
pH	53	NA[c]	6.69	7.70	6.0–9.0

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

[b] A dash indicates that there is no effluent limit for this constituent.

[c] NA = not applicable; pH values are not averaged since they are log functions.

discussed. The pH was within the acceptable range, and none of the results exceeded the General Effluent Limits.[22] Only two metals were present above analytical detection limits in any of the 53 weekly samples collected. Two samples contained copper above analytical detection limits, and one sample contained iron. All 53 samples contained low but detectable levels of fluoride.

Sawmill Creek. Sawmill Creek is a small natural stream that is fed primarily by stormwater runoff. During extended periods of low precipitation, the creek upstream of Argonne has a very low flow. At these times, a major portion of the water in Sawmill Creek south of the site consists of Argonne wastewater. To determine the impact that Argonne wastewaters have on Sawmill Creek, samples of the creek downstream of all Argonne discharge points were collected and analyzed. The results were then compared with IEPA General Use Water Quality Standards found in 35 IAC, Subtitle C, Part 302.[23]

A time-proportional sampler was used to collect a daily sample at a point downstream of the combined wastewater discharge point to allow mixing of the Argonne effluent with Sawmill Creek. After the pH was measured, the daily samples were acidified and then combined into equal-volume weekly composites, filtered, and analyzed for the inorganic constituents in Table 5.10. The results obtained for 2008 are shown in Table 5.10. The pH was in the appropriate range throughout the year, and none of the metals results exceeded General Use Water Quality Standards.[23] Only fluoride was present in high enough concentrations to be detected in any of the samples.

5.5.2. 800 Area Stormwater Sampling

The Postclosure Care Plan[24] for the 800 Area Landfill requires the quarterly sampling of stormwater discharges from the landfill site. Stormwater flows from the landfill area through two outfalls, 023 and 114. Outfall 023 (old Outfall 113) is also included in the NPDES program. These two outfalls are monitored for TDS, TSS, and pH. No limits are included in the plan. The average monitoring results for 2008 are shown in Table 5.11. Comparing these values with other NPDES discharges in 2008 suggests that there is no indication of stormwater contamination from landfill operations.

5.5.3. 319 Area Stormwater Sampling

The LTS Program periodically collects samples of stormwater runoff to determine if any contaminants from the remediation area are being released to surface water. Because of the characteristics of the drainage area that generates the stormwater runoff flowing past the 319 Area, flow is present only immediately after a storm event with a large amount of precipitation. Four attempts to collect stormwater were made in 2008, but only two samples were obtained. Low levels of several organics that are present in the 317 Area soil and groundwater were found in stormwater. The results of this sampling are presented in Table 6.23 in Section 6.4.2, along with the discussion of groundwater sampling in this area.

TABLE 5.10

Chemical Constituents in Sawmill Creek, Location 7M,[a] 2008

		Concentration (mg/L)			
Constituent	No. of Samples	Average	Minimum	Maximum	IEPA Limit
Arsenic	53			< 0.025[b]	0.36[c]
Barium	53			< 0.5	5.0
Beryllium	53			< 0.0025	–[d]
Cadmium	53			< 0.0025	0.03
Chromium	53			< 0.05	3.6
Cobalt	53			< 0.25	–
Copper	53			< 0.025	0.041[c]
Fluoride	53	0.614	0.330	0.910	1.4
Iron	53			< 0.5	1.0
Lead	53			< 0.09	0.3[c]
Manganese	53			< 0.075	1.0
Mercury	53			< 0.0002	0.0026[c]
Nickel	53			< 0.05	1.0
Silver	53			< 0.0025	0.005
Thallium	53			< 0.002	–
Vanadium	53			< 0.075	–
Zinc	53			< 0.5	1.0
pH	53	NA[e]	6.28	7.77	6.5–9.0

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

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

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

[d] A dash indicates that there is no effluent limit for this constituent.

[e] NA = not applicable.

TABLE 5.11

Average Monitoring Results for 800 Area Landfill Stormwater, 2008

Outfall Number	Total Dissolved Solids (mg/L)	Total Suspended Solids (mg/L)	pH range
023 (113)	220	1.7	7.6–7.9
114	265	1.5	7.7–8.1

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

6. GROUNDWATER PROTECTION

6. GROUNDWATER PROTECTION

Groundwater is present beneath the Argonne site in several different geologic units. Above the bedrock is glacial drift, which is a mixture of clay, silt, sand, and gravel deposited during past glacial retreat periods. Some regions within the drift that contain high proportions of sand and gravel contain groundwater. These regions are classified as perched aquifers. Some of these perched aquifers are interconnected and provide a path for groundwater migration, while others are isolated and have limited potential for movement. Dolomite bedrock underlies the glacial drift throughout the site. The dolomite contains numerous cracks, fissures, and solution cavities that allow groundwater to migrate through the stone. This zone contains the uppermost aquifer used near Argonne as a source of drinking water for low-capacity wells. Several hundred feet below the dolomite is a layer of porous sandstone that contains the most commonly used aquifer in this region. The sandstone is isolated from overlying soil and groundwater by a thick layer of shale. Argonne monitors the quality of groundwater in the glacial drift and the dolomite. The sandstone aquifer is too deep to be affected by Argonne operations. The Argonne groundwater program is summarized in the *Groundwater Protection Management Program Plan.*[25]

Groundwater is monitored by collecting and analyzing samples from former on-site water supply wells, from a series of groundwater monitoring wells located in areas that have the potential for impacting groundwater, and from other monitoring wells on and off the Argonne site. Regulatory standards intended to protect groundwater resources are contained in IEPA Groundwater Quality Standards (GQSs), 35 IAC, Subtitle F, Part 620.[26] Argonne groundwater is considered Class I (potable resource groundwater) groundwater under these regulations. In addition, DOE Order 450.1A contains groundwater protection requirements for DOE sites, including the need for sitewide characterization studies and monitoring well networks. This chapter documents Argonne's compliance with these requirements.

In addition, Argonne conducts permit-required groundwater monitoring at several former waste management units, including the former 800 Area landfill, the 317/319 Area remedial action site, and the East-Northeast (ENE) former landfill. Site-specific groundwater remediation objectives (GROs) exist for these units. Argonne is also voluntarily conducting groundwater monitoring near the former CP-5 reactor. This chapter summarizes the results from these monitoring programs.

6.1. Monitoring of the Former Potable Water Well System

From the early years of the laboratory, domestic water had been supplied by four potable water supply wells (described in Table 6.1) that were drilled into the dolomite bedrock. The well locations are shown in Figure 1.1. These wells are located throughout the site and have been sampled for many years to monitor for the release of radioactive or chemical contaminants from site operations. Use of these wells was discontinued in 1997 when the source of Argonne's water supply was changed to Lake Michigan water, obtained from DuPage County. Wells 1 and 2 were no longer operational by the end of 2008 due to failure of the pumps (Well No. 1 was operational until April 2008). The remaining two wells are maintained as a backup water source in case of a loss of Lake Michigan water. Monitoring of the remaining wells continued in 2008.

TABLE 6.1

Argonne Former Water Supply Wells

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

[a] AMSL = above mean sea level.

[b] bgs = below ground surface.

[c] Well no longer operational at the end of 2008.

6.1.1. Former Supply Well Monitoring Program and Results

Samples were collected quarterly at the wellheads of the two active wells. One sample from Well No. 1 was collected in January 2008. The existing pumps were used to purge the wells of stagnant water after which samples of the pump discharge were collected. The samples were analyzed for total alpha radioactivity, total beta radioactivity, hydrogen-3, strontium-90, and VOCs. Samples also were analyzed annually for isotopic uranium. Table 6.2 describes the analytical methods used for the radiological analyses. VOCs were determined by using the analytical method listed in Table 5.2.

The results are summarized in Table 6.3. All radiological results were similar to previous years' results. Only one sample from Well No. 3 contained hydrogen-3 slightly above the detection limit of 100 pCi/L. Control samples analyzed for hydrogen 3 during 2008 showed concentrations greater than 120 pCi/L on several occasions; thus the detection of such low

TABLE 6.2

Radiological Analytical Procedures

Analyte	Description	Analytical Lab
Alpha and beta radioactivity	Gas-flow proportional counting technique	Argonne
Hydrogen-3	Distillation followed by beta liquid scintillation counting	Argonne
Strontium-90	Ion-exchange and chromatographic separations followed by proportional counting.	Argonne
Uranium	Chromatographic separation followed by alpha spectrometry.	Argonne

TABLE 6.3

Radioactivity in Argonne Former Water Supply Wells, 2008
(concentrations in pCi/L)

Type of Activity	Location	No. of Samples	Average	Minimum	Maximum
Alpha	Well 1	1	–[a]	–	1.9[b]
	Well 3	4	1.8	0.7	3.1
	Well 4	4	2.3	2.0	2.6
Beta	Well 1	1	–	–	5.5
	Well 3	4	10.3	9.9	10.8
	Well 4	4	10.6	9.2	10.7
Hydrogen-3	Well 1	1	–	–	< 100
	Well 3	4	< 100	< 100	107
	Well 4	4	–	–	< 100
Strontium-90	Well 1	1	–	–	< 0.25
	Well 3	4	–	–	< 0.25
	Well 4	4	–	–	< 0.25
Uranium-234	Well 1	1	–	–	0.35
	Well 3	1	–	–	0.18
	Well 4	1	–	–	0.16
Uranium-235	Well 1	1	–	–	< 0.01
	Well 3	1	–	–	< 0.01
	Well 4	1	–	–	< 0.01
Uranium-238	Well 1	1	–	–	0.24
	Well 3	1	–	–	0.09
	Well 4	1	–	–	0.06

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

[b] When all four samples were less than the detection limit, the detection limit is shown in the maximum column.

concentrations of hydrogen-3, as seen in Well No. 3, does not necessarily indicate that contamination is occurring. Hydrogen-3 was not found in the single sample collected from Well No. 1 in 2008. All other results were consistent with normal background levels. No VOCs were detected in any of the samples; for clarity, these VOC results are not shown. The detection limits for VOCs were 1 to 10 μg/L.

6.2. Dolomite Aquifer Monitoring

Groundwater in the dolomite aquifer is monitored at several locations across the site. Most of the monitoring is conducted to satisfy permit requirements for waste management units, and those results are discussed elsewhere in this chapter. However, in the East Area, a set of dolomite wells has been monitored since 1998 to track the amount of hydrogen-3 present in the dolomite aquifer in that part of the site. Analytical data from the late 1990s identified the presence of low levels of hydrogen-3 (less than 300 pCi/L) in the former domestic supply Well No. 1. It was speculated that during the 1950s wastewater containing hydrogen-3, which was stored in an unlined earthen holding basin at the LWTP (located northwest of the existing equalization pond shown in Figure 1.1), could have migrated to the dolomite bedrock aquifer. To determine if such a release had occurred, groundwater monitoring in this part of the aquifer was begun. A monitoring well network was established throughout the eastern end of the site. The network consists of three wells on Argonne property and seven wells in the Waterfall Glen Forest Preserve east of the site. The well locations are shown in Figure 6.l. Well 570091D is located immediately adjacent to the former holding basin.

During 2008, samples were collected quarterly and analyzed for hydrogen-3. Table 6.4 shows the results. All results were less than or close to the detection limits of 100 pCi/L. The highest concentration, 230 pCi/L, was far below the drinking water limit of 20,000 pCi/L; thus there appears to be no significant impact to groundwater quality in this area. The results for 2008 are similar to previous results in recent years and significantly lower than when sampling started. It appears that dilution and radioactive decay have essentially eliminated the hydrogen-3 in this part of the dolomite aquifer.

6.3. Groundwater Monitoring at Former Waste Management Areas

Argonne has occupied its current site since 1948. Over the years of operation, various wastes generated by Argonne were managed in several on-site disposal units. These ranged from pits and ditches filled with construction and demolition debris in the 1950s to a sanitary landfill used for nonhazardous solid waste disposal, which operated until 1992. No radioactive waste was knowingly placed in any of these units for disposal; however, radiologically contaminated equipment and debris was placed in some of these units and several were contaminated with radioactive materials as they were being used for temporary storage of waste. Several contained significant amounts of chemically hazardous materials and, therefore, represented a potential threat to the environment. Extensive site characterization and remediation of these units occurred under the Argonne remediation program that was completed in September 2003. Most of the sites were closed by the removal of buried waste and contaminated soil, and no further action was required. However, several waste units were closed with waste and contamination still in place. One unit, the 317/319 Area, is still undergoing active remediation. These units are monitored as part of the LTS Program. LTS units that require routine environmental monitoring include the 317/319 Areas, the 800 Area Landfill, the ENE Landfill Areas, and three off-site

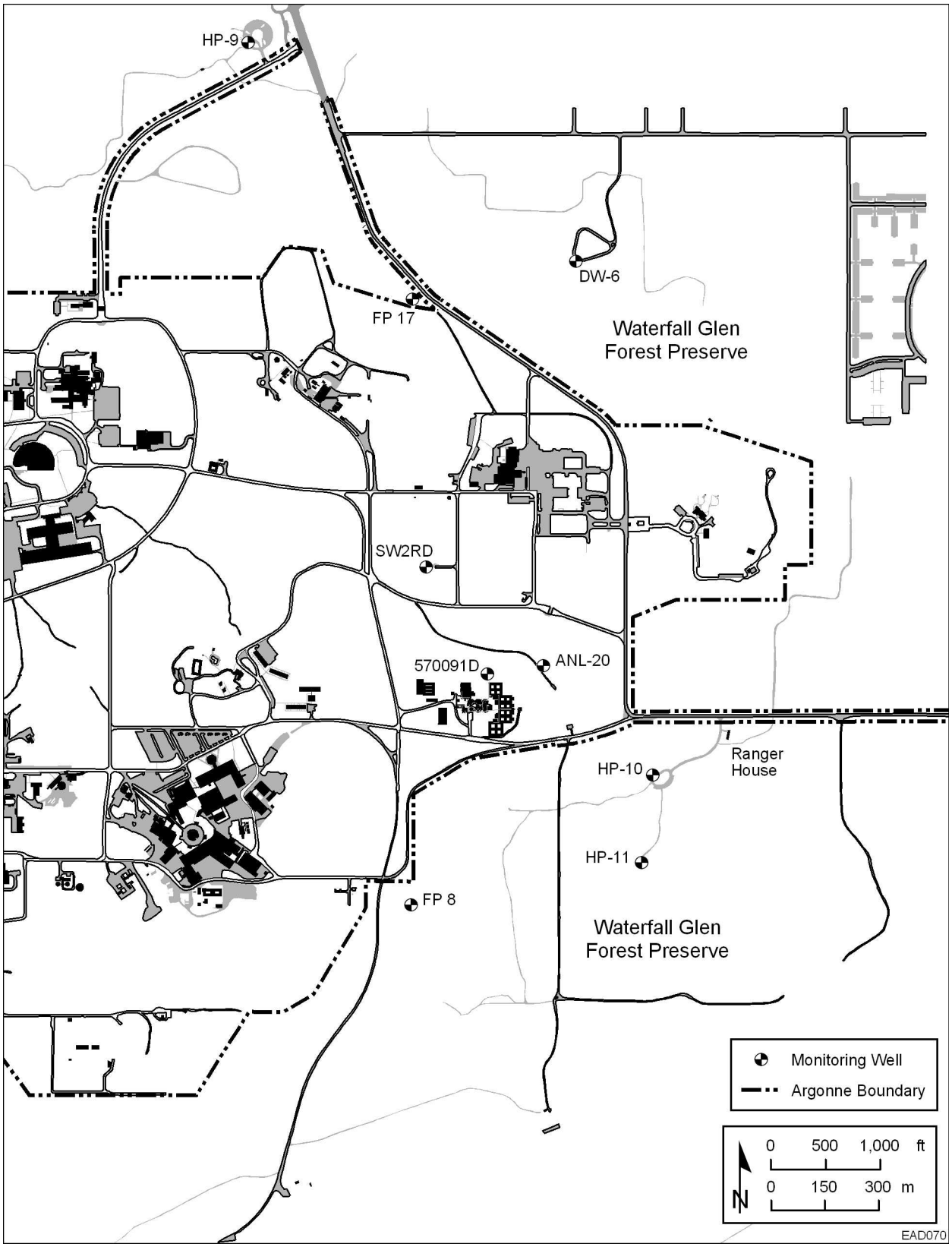


FIGURE 6.1 East Area/Forest Preserve Monitoring Wells

TABLE 6.4

Hydrogen-3 in Dolomite Wells, 2008
(concentrations in pCi/L)

	Month Collected			
Well	Mar.	Jun.	Aug.	Oct.
Waterfall Glen				
DW6	<100	<100	<100	<100
HP9	<100	<100	<100	<100
HP10	<100	<100	<100	<100
HP11	<100	109	107	<100
FP8	<100	<100	<100	124
FP17	<100	<100	<100	104
Ranger house	<100	<100	<100	<100
Argonne				
570091D	<100	230	159	193
ANL-20	<100	<100	143	<100
SW2R	<100	<100	<100	<100
Control blank	<100	127	135	<100

groundwater seeps south of the 317/319 Area. Groundwater below these sites is monitored routinely to determine if hazardous materials have migrated from the units. Where contaminants have already been released to the environment, the monitoring is carried out to assess the effectiveness of the remedial actions underway and to monitor for changes in the nature and extent of contamination. The LTS Program and related groundwater monitoring have been integrated with the Argonne Environmental Monitoring and Surveillance Program.

6.3.1. 317/319 Area

The 317/319 Area contains seven separate active or former units that have been used for handling or disposal of various types of waste. The 317 Area currently contains an active radioactive waste container storage area that includes an aboveground storage area as well as the North Vault, an in-ground radioactive material container storage vault that was refurbished in 2003 but is currently empty. Five similar waste storage vaults in this area were cleaned and demolished in place during remedial actions. A small aboveground waste processing building, the Baler Building, was also demolished. Low levels of hydrogen-3 are present in the groundwater below this area as a result of past radioactive waste management practices.

In the 1950s, the 317 Area was used for the disposal of various liquid chemical wastes in a unit known as a French drain. The drain consisted of a shallow trench filled with gravel into which an unknown quantity of liquid wastes was poured. The wastes were primarily VOCs, including chlorinated solvents. Because of these past disposal practices, there is a region of

contaminated soil in the northern half of the 317 Area. The most highly contaminated sections of the French drain area were treated by using a deep soil mixing, stream stripping and metallic iron treatment technique during 1998. However, areas of untreated soil remain, and groundwater below and downgradient of this area contain significant amounts of these chemicals. General features of the 317 and 319 Areas are shown in Figure 6.2.

The 319 Area contains an inactive landfill that was used for disposal of a variety of solid wastes generated on-site prior to 1969. It was not intended for disposal of radioactive waste; however, a small amount of radioactive material, most notably hydrogen-3, was detected in soil and leachate during site characterization activities completed in the 1990s. The 319 Area consists of two distinct segments: the waste mound, where the bulk of the waste was buried, and an adjacent burial trench, which contains a much smaller amount of mostly inert waste. This landfill also contained a French drain that was used for several years after the French drain in the 317 Area was closed. The levels of chemical contamination in the 319 Area are far lower than the levels in the 317 Area; however, tritium levels are higher.

Groundwater below the 317/319 Area is present in a network of shallow sand and gravel units, up to 6 m (20 ft) thick, within the glacial drift as well as in the upper portion of the dolomite bedrock. The presence of chemical wastes from the 317 and 319 French drains, as well as the presence of hydrogen-3 in the 319 Area Landfill, have resulted in the generation of a plume of contaminated groundwater extending to the south about 200 m (600 ft). Most of the contamination is present in a porous zone 6 to 10 m (20 to 30 ft) deep in the glacial drift; however, low levels of contamination have been found in the dolomite aquifer. Contaminated groundwater from the 317/319 Area comes to the surface approximately 360 m (1,200 ft) south of the mound, in several small groundwater seeps located at the base of a ravine directly south of the 319 Area, in the Waterfall Glen Forest Preserve. Since their discovery, these seeps have been monitored on a regular basis (see Section 6.4.4). The seeps contain low levels of several VOCs. During the first few years of monitoring, the seeps also contained hydrogen-3 at concentrations below all applicable standards; in recent years, the levels of hydrogen-3 have decreased to less than the detection limits.

Cleanup of the 317/319 Area has been under way since the late 1980s. The cleanup has been carried out in a series of interrelated actions designed to remove or contain the waste and chemical contaminants so that they will not migrate away from the waste disposal units. To prevent migration of contaminated groundwater from the 317 French Drain Area, an underground footing drain pipe around the vaults was sealed and a groundwater collection system was installed in the southern end of the 317 Area. This system consists of 15 groundwater extraction wells with screens located in the porous zone where contaminated groundwater was found during site characterization activities. This system removes contaminated groundwater and discharges it to the on-site WTP.

In the 319 Area, remedial actions included constructing a subsurface clay barrier wall to prevent migration of leachate, installing a leachate and groundwater collection system to remove accumulated leachate and contaminated groundwater from under the waste mound, and installing a multilayered impermeable cap over the landfill mound and a clay cap over the burial trench.

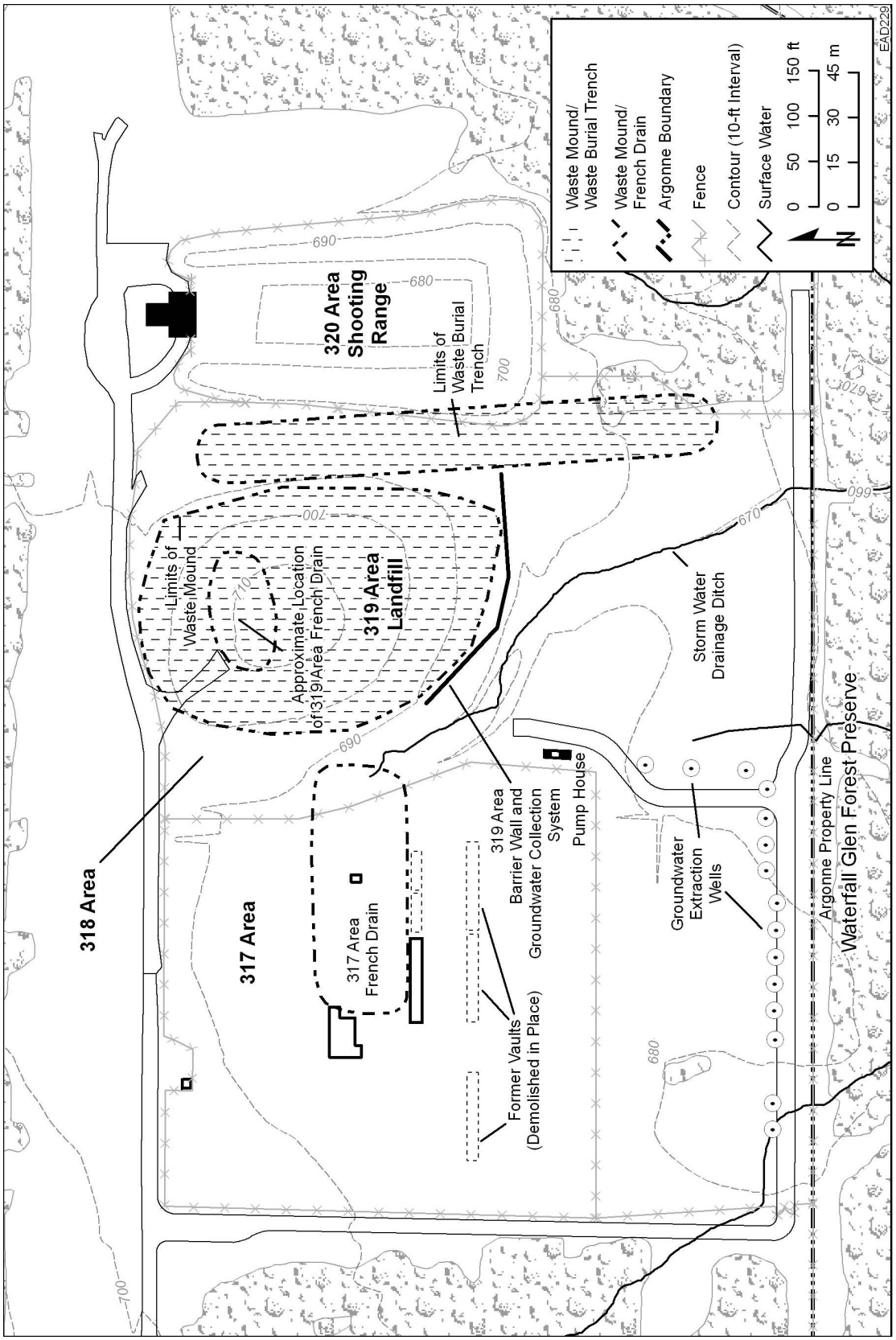


FIGURE 6.2 Locations of Components within the 317/319/ENE Area

A phytoremediation system was installed in 1999 to address the residual contamination in the 317 French Drain Area and groundwater plumes south of the 317/319 Area. Phytoremediation involves the use of green plants to remove contaminated groundwater by evapotranspiration. The plants also facilitate the biodegradation of contaminants in soil and groundwater. The Argonne system consists of a dense planting of willow trees in the vicinity of the 317 French drain and a larger planting of hybrid poplar trees downgradient of the 317/319 Area. Approximately 950 poplar and willow trees were planted. Most of the poplar trees were installed in special lined boreholes designed to force the tree roots to grow toward the contaminated zones. This system is monitored to document its ability to control groundwater flow and remove contaminants.

The landfill cap, leachate and groundwater extraction systems, and phytoremediation system require ongoing operation and maintenance, which is conducted as part of the LTS Program. Sampling and analysis of groundwater and surface water are conducted as part of the LTS Program.

The results of the IEPA-required LTS monitoring are transmitted to the IEPA on a quarterly basis through the submittal of Quarterly Progress Reports. The data from these monitoring activities are too voluminous to include in this report; however, the results are summarized and general conclusions are discussed below (see Section 6.4).

In addition to the permit-required monitoring, Argonne has voluntarily conducted groundwater sampling from a network of wells installed starting in 1986. This groundwater surveillance network was established during the early years of the site remediation program and has provided valuable insight into changes in the contaminant levels as remedial actions have progressed in the area.

6.3.2. Voluntary Groundwater Surveillance at the 317/319 Area

Groundwater sampling in the 317/319 Area was begun by the sitewide monitoring and surveillance program in 1986, prior to any remedial actions. The original wells were installed during a series of campaigns from 1986 through 1989. As time progressed, some wells were added, replaced, or removed. These original wells helped define the nature and extent of groundwater contamination in the area and still provide information on natural background levels of groundwater constituents upgradient of the area. The surveillance well network currently consists of the 10 wells described in Table 6.5. The network is shown in Figure 6.3. Eight of the wells are completed in various porous glacial drift layers less than 13 m (41 ft) deep. Wells 317121D and 319131D are completed in the dolomite aquifer about 20 m (64 ft) deep. In this area, groundwater in both the glacial drift and the dolomite flows southeast, toward the Des Plaines River. Wells 317101 and 317111 are upgradient of the 317 Area, and Well 319011 is upgradient of the 319 Area Landfill. These serve as background reference wells for the downgradient wells.

These wells are independent of wells installed during remedial actions and are not used to monitor the progress of the remediation systems. They are used for general groundwater

TABLE 6.5

Groundwater Monitoring Wells: 317/319 Area

ID Number	Well Depth (m bgs)	Ground Elevation (m AMSL)	Monitoring Zone (m AMSL)	Well Type[a]	Date Drilled
319011	12.19	209.8	199.1–197.6	0.05/PVC	9/1986
317021	12.19	209.2	198.5–197.0	0.05/PVC	9/1986
319031	12.50	204.3	194.8–191.8	0.05/PVC	9/1986
319032	7.62	204.3	198.2–196.7	0.05/PVC	6/1989
317052	4.27	208.3	207.1–204.0	0.05/PVC	6/1989
317061[b]	10.36	207.6	197.3–199.7	0.05/PVC	5/2000
317101	11.89	211.0	202.2–199.1	0.05/PVC	9/1988
317111	11.89	210.3	201.4–198.4	0.05/PVC	9/1988
317121D[c]	24.08	207.6	185.0–183.5	0.15/CS	11/1989
319131D	21.03	203.5	184.0–182.5	0.15/CS	11/1989

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

[b] Well was replaced when original well was damaged and became inoperable.

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

surveillance for the 317 and 319 Areas as a whole. They are analyzed for a more extensive list of analytes than the LTS samples. With one exception (Well 317021), they are not located in the contaminated groundwater plumes associated with the 317/319 Area and thus the contaminants and concentrations are not representative of the degree of groundwater contamination in the 317/319 Area.

6.3.2.1. Sample Collection

The monitoring wells are sampled according to EPA protocols described in the *RCRA Ground-Water Monitoring Technical Enforcement Guidance Document*.[27] Prior to collecting any samples, stagnant water is removed from the well. The volume of water to remove from the casing is calculated after measuring the water depth in the well. For those wells that recharge rapidly, at least three well volumes are purged by using dedicated submersible pumps (dolomite wells) or bailers. During well purging, the field parameters (pH, specific conductivity, redox potential, and temperature) are measured. Sampling is conducted after three well volumes are removed and field parameters have stabilized. For wells in the glacial drift that recharge slowly, the well is emptied completely and allowed to refill. For these wells, field parameters were measured only once. After the well refills, samples are collected using a dedicated Teflon® bailer or the dedicated pump. Samples for VOCs, SVOCs, PCBs and pesticides, metals, nonmetals, and radionuclide analysis are collected in that order. The samples are placed in precleaned bottles, labeled, and preserved in accordance with EPA guidance.

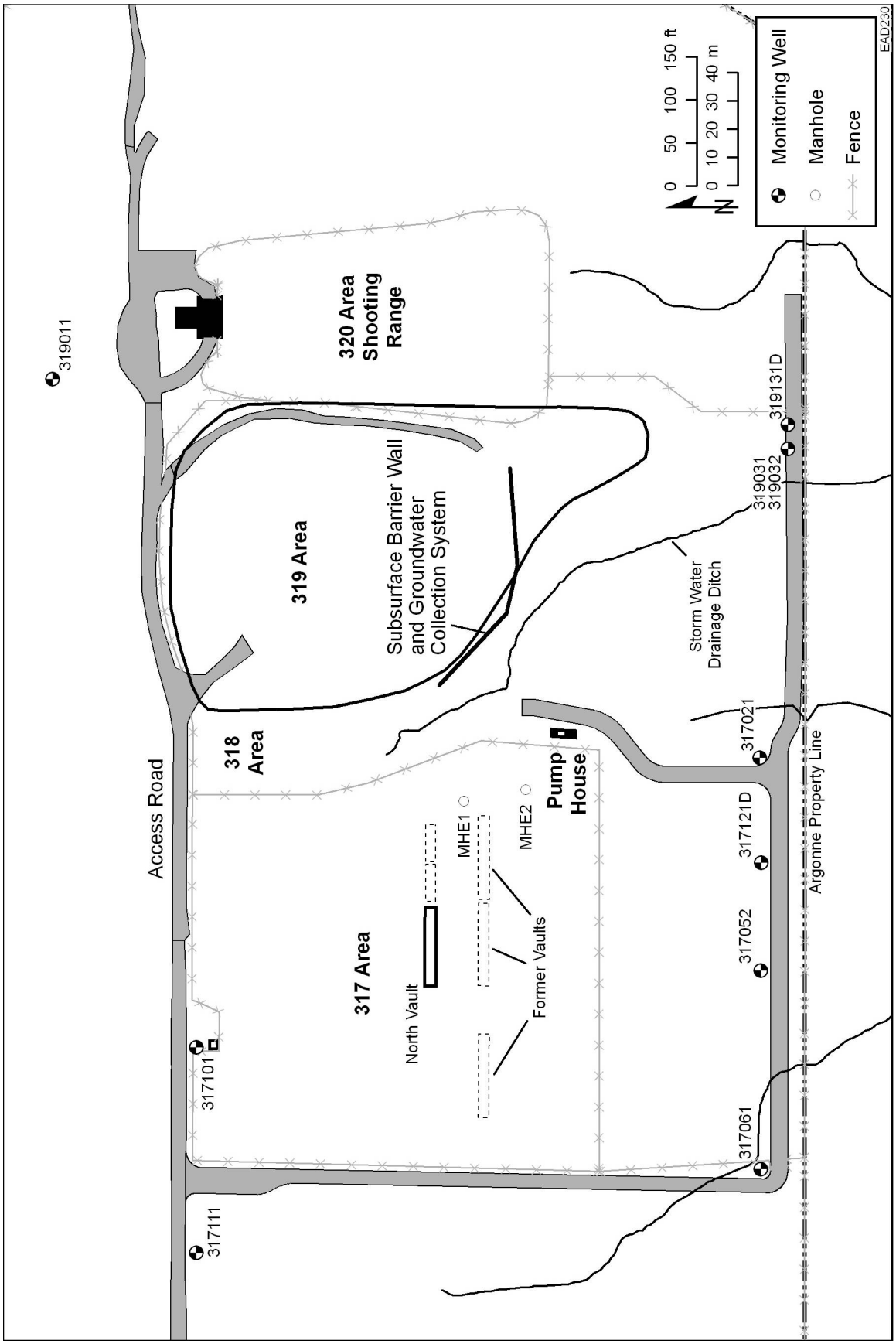


FIGURE 6.3 Groundwater Surveillance Wells in the 317/319 Area

During each sampling event, one well is selected for replicate sampling. An effort is made to vary this selection so that replicates are obtained at every well over time. In addition, a field blank is also prepared. The field blank consists of a sample bottle filled with ultra-pure water in the laboratory that is submitted for the same analysis as the field samples. This is done to verify the cleanliness of the sample bottles.

6.3.2.2. Sample Analyses — 317/319 Area Surveillance

Groundwater samples from these wells are analyzed quarterly for hydrogen-3, strontium-90, gamma-emitting radionuclides, soluble (filtered) metals, chloride, and VOCs. Once per year each well is also analyzed for semivolatile organics and PCBs and pesticides. Analyses are conducted using the methods outlined in Tables 5.2 and 6.2.

6.3.2.3. Results of Analyses

To determine if groundwater quality at these locations has been impacted, the analytical results were compared with the appropriate GQSs found in 35 IAC, Section 620.410. Standards for the most conservative groundwater classification, Class I, Potable Resource Groundwater, were used. The groundwater under this site has been designated by the IEPA as Class I, even though it is not used as a potable water supply. The current standards for inorganic and radioactive constituents are shown in Table 6.6. When used to officially document compliance with state standards, these standards are to be compared with analysis results from unfiltered groundwater samples. However, for environmental surveillance purposes, filtered samples were used. This was done to reduce the interference from suspended soil particles in the samples caused by the use of a bailer to collect water samples. The introduction of soil solids into a sample causes significantly higher metals results that do not reflect the true character of the in-situ groundwater. The standards for organic compounds are presented in Table 6.7. Results that exceed these standards are shown in bold in the following data tables.

The results of field parameter measurement and the results of chemical and radiological analyses of samples from the surveillance wells in the 317/319 Area are contained in Tables 6.8 through 6.17. All field parameter measurements and radiological and inorganic analytical results are provided in these tables. The analytical methods used for organic compounds could identify and quantify all organic compounds

TABLE 6.6

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

Constituent	Standard
Antimony	0.006
Arsenic	0.05
Barium	2.0
Beryllium	0.004
Boron	2.0
Cadmium	0.005
Chloride	200.0
Chromium	0.1
Cobalt	1.0
Copper	0.65
Cyanide	0.2
Fluoride	4.0
Hydrogen-3	20,000 pCi/L
Iron	5.0
Lead	0.0075
Manganese	0.15
Mercury	0.002
Nickel	0.1
Nitrate, as N	10.0
pH	6.5–9.0
Radium-226	20 pCi/L
Radium-228	20 pCi/L
Selenium	0.05
Silver	0.05
Strontium-90	8.0 pCi/L
Sulfate	400
TDS	1,200
Thallium	0.002
Zinc	5.0

TABLE 6.7

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

Constituent	Standard	Constituent	Standard
Alachlor	2	Ethylene dibromide	0.05
Aldicarb	3	Heptachlor	0.4
Atrazine	3	Heptachlor epoxide	0.2
Benzene	5	Hexachlorocyclopentadiene	50
Benzo(a)pyrene	0.2	Lindane	0.2
Carbofuran	40	Methoxychlor	40
Carbon tetrachloride	5	Monochlorobenzene	100
Chlordane	2	PCBs (decachlorobiphenyl)	0.5
2,4-D	70	Pentachlorophenol	1
Dalapon	200	Phenols	100
1,2-Dibromo-3-chloropropane	0.2	Picloram	500
o-Dichlorobenzene	600	2,4,5-TP (Silvex)	50
p-Dichlorobenzene	75	Simazine	4
1,2-Dichloroethane	5	Styrene	100
Dichloromethane	5	Tetrachloroethylene	5
1,1-Dichloroethene	7	Toluene	1,000
cis-1,2-Dichloroethylene	70	Toxaphene	3
trans-1,2-Dichloroethylene	100	1,1,1-Trichloroethane	200
1,2-Dichloropropane	5	1,1,2-Trichloroethane	0.5
Di(2-ethyhexyl)phthalate	6	1,2,4-Trichlorobenzene	70
Dinoseb	7	Trichloroethylene	5
Endothall	100	Vinyl chloride	2
Endrin	2	Xylenes	10,000
Ethylbenzene	700	Methyl tertiary-butyl ether	70

contained in the EPA's Contract Laboratory Program (CLP) Target Compound List if present above the detection limits, typically 1 to 10 μg/L. However, only a few of these compounds were detected in the samples. The results for compounds present above the analytical detection limits are listed toward the bottom of the data tables. Compounds that were not detected above the detection limit are not included.

Field Parameters. The field parameter results listed in the tables are the final readings obtained at the time of sampling. The only parameter with a GQS is pH. The only pH values that were outside of the acceptable pH range were found in dolomite Well 317121D, which exceeded the range all four quarters. This well has a history of high pH, which may be related to the construction materials used to install this well. As in past years, the conductivity in background Wells 317101 and 317111 and downgradient Well 317061 was higher than in the other wells. Chloride levels in these wells were also elevated, in some cases above the GQS. It is likely that the elevated conductivity and chloride are related to the fact that these wells are located near a road that is salted during the winter.

TABLE 6.8

Groundwater Surveillance Results, 300 Area Well 317021, 2008

Parameter	Unit	Date of Sampling 3/18/2008	6/3/2008	8/12/2008	11/11/2008
Field Parameters					
Water elevation[a]	m	200.67	202.35	199.93	199.52
Temperature	ºC	10.8	12.0	12.1	10.4
pH	pH	7.13	6.95	7.19	7.15
Redox	mV	-4	3	-5	-7
Conductivity	µS/cm	886	763	977	829
Filtered Samples					
Chloride	mg/L	17	11	34	18
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Radioactive Materials					
Cesium-137	pCi/L	< 2.0	< 2.0	2.0	< 2.0
Hydrogen-3	pCi/L	< 100	123	115	< 100
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	0.28
VOCs Found above Quantitation Limits[b]					
1,1,1-Trichloroethane	µg/L	2	< 1	4	2
1,1-Dichloroethane[c]	µg/L	1	< 1	2	< 1

[a] Well point elevation = 197.44 m (MSL); ground surface elevation = 209.16 m (MSL); casing material = PVC.

[b] Only VOCs detected in at least one sample above detection limits are shown.

[c] No GQS exists for 1,1-dichloroethane.

TABLE 6.9

Groundwater Monitoring Results, 300 Area Well 317052, 2008

Parameter	Unit	Date of Sampling 3/13/2008	6/2/2008	8/13/2008	11/10/2008
Field Parameters					
Water elevation[a]	m	206.33	205.62	204.70	204.91
Temperature	ºC	7.8	10.1	13.7	13.3
pH	pH	6.95	7.04	7.08	7.01
Redox	mV	6	0	2	1
Conductivity	µS/cm	1,220	1,086	1,642	1,108
Filtered Samples					
Chloride	mg/L	16	39	33	38
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	1.39	2.88	1.51
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.075	**0.51**[b]	**0.22**	**0.26**
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Radioactive Materials					
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	144	123	150	120
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
VOCs Found above Quantitation Limits[c]					
1,4-Dioxane[d]	µg/L	10	< 1	< 1	< 1

[a] Well point elevation = 204.53 m (MSL); ground surface elevation = 208.18 m (MSL); casing material = PVC.

[b] Bold type indicates value exceeded its GQS.

[c] Only VOCs detected in at least one sample above detection limits are shown.

[d] No GQS exists for 1,4-dioxane.

TABLE 6.10

Groundwater Monitoring Results, 300 Area Well 317061R, 2008

Parameter	Unit	Date of Sampling 3/13/2008	5/29/2008	8/13/2008	11/11/2008
Field Parameters					
Water elevation[a]	m	199.22	199.95	198.15	198.00
Temperature	ºC	11.2	11.5	11.7	9.8
pH	pH	6.96	7.05	7.08	7.09
Redox	mV	6	-1	1	-2
Conductivity	µS/cm	1,479	1,330	1,303	1,211
Filtered Samples					
Chloride	mg/L	164	199	95	102
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Radioactive Materials					
Cesium-137	pCi/L	< 2.0	< 2.0	<2.0	3.2
Hydrogen-3	pCi/L	746	622	591	596
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
VOC's Found above Quantitation Limits[b]					
Methylene chloride[c]	µg/L	< 1	22	< 1	< 1
Tetrahydrofuran	µg/L	< 1	< 1	9	8
Vinyl chloride	µg/L	< 1	< 1	2	2

[a] Well point elevation = 197.68 m (MSL); ground surface elevation = 207.57 m (MSL); casing material = PVC.

[b] Only VOCs detected in at least one sample above detection limits are shown.

[c] No GQS exists for methylene chloride.

TABLE 6.11

Groundwater Monitoring Results, 300 Area Well 317101, 2008

Parameter[a]	Unit	Date of Sampling 3/18/2008	5/29/2008	8/12/2008	11/10/2008
Field Parameters					
Water elevation[b]	m	203.21	204.76	203.28	202.78
Temperature	ºC	11.9	11.9	12.6	12.3
pH	pH	6.91	6.99	7.02	6.97
Redox	mV	8	2	5	3
Conductivity	µS/cm	3,610	2,810	2,310	2,000
Filtered Samples					
Chloride	mg/L	**900[c]**	**814**	**360**	**365**
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.004	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Radioactive Materials					
Cesium-137	pCi/L	< 2.0	< 2.0	2.0	< 2.0
Hydrogen-3	pCi/L	< 100	< 100	137	< 100
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

[a] No VOCs above analytical detection limits were found in this well.

[b] Well point elevation = 198.66 m (MSL); ground surface elevation = 211.01 m (MSL); casing material = PVC.

[c] Bold type indicates that the value exceeds applicable standards.

TABLE 6.12

Groundwater Monitoring Results, 300 Area Well 317111, 2008

Parameter[a]	Unit	Date of Sampling 3/18/2008	5/29/2008	8/13/2008	11/10/2008
Field Parameters					
Water elevation[b]	m	203.41	205.16	203.55	202.96
Temperature	ºC	10.9	11.2	12.3	10.0
pH	pH	7.04	7.07	7.11	7.07
Redox	mV	1	-2	0	-3
Conductivity	µS/cm	1,452	1,233	1,318	1,295
Filtered Samples					
Chloride	mg/L	188	197	122	168
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Radioactive Materials					
Cesium-137	pCi/L	< 2.0	< 2.0	2.4	< 2.0
Hydrogen-3	pCi/L	< 100	< 100	< 100	117
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

[a] No VOCs above analytical detection limits were found in this well.

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

TABLE 6.13

Groundwater Monitoring Results, 300 Area Well 317121D, 2008

Parameter[a]	Unit	Date of Sampling			
		3/13/2008	6/4/2008	8/13/2008	11/12/2008
Field Parameters					
Water elevation[b]	m	186.67	186.88	186.68	186.61
Temperature	°C	10.9	11.8	12.5	11.1
pH	pH	**9.60[c]**	**10.48**	**10.35**	**9.07**
Redox	mV	-143	-193	-183	-113
Conductivity	µS/cm	698	581	538	620
Filtered Samples					
Chloride	mg/L	131	83	84	97
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Radioactive Materials					
Cesium-137	pCi/L	< 2.0	< 2.0	2.2	< 2.0
Hydrogen-3	pCi/L	123	185	212	216
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

a No VOCs above analytical detection limits were found in this well.

b Well point elevation = 183.49 m (MSL); ground elevation = 207.57 m (MSL); casing material = steel.

c Bold type indicates that the value exceeds applicable standards.

TABLE 6.14

Groundwater Monitoring Results, 300 Area Well 319011, 2008

Parameter[a]	Unit	Date of Sampling 3/12/2008	6/3/2008	8/13/2008	11/11/2008
Field Parameters					
Water elevation[b]	m	202.80	204.37	203.19	202.75
Temperature	ºC	10.5	11.7	11.4	10.3
pH	pH	7.31	6.78	7.13	7.36
Redox	mV	-15	12	-2	-18
Conductivity	µS/cm	958	1,048	1,055	1,010
Filtered Samples					
Chloride	mg/L	56	62	41	38
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Radioactive Materials					
Cesium-137	pCi/L	< 2.0	< 2.0	2.1	2.4
Hydrogen-3	pCi/L	< 100	120	< 100	< 100
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

[a] No VOCs above analytical detection limits were found in this well.

[b] Well point elevation = 197.51 m (MSL); ground elevation = 209.80 m (MSL); casing material = PVC.

TABLE 6.15

Groundwater Monitoring Results, 300 Area Well 319031, 2008

Parameter	Unit	Date of Sampling			
		3/11/2008	6/3/2008	August	November
Field Parameters					
Water elevation[a]	m	193.22	193.20	Dry	Dry
Temperature	°C	10.2	11.0	Dry	Dry
pH	pH	7.20	7.02	Dry	Dry
Redox	mV	-9	0	Dry	Dry
Conductivity	µS/cm	1,174	992	Dry	Dry
Filtered Samples					
Chloride	mg/L	31	28	Dry	Dry
Arsenic	mg/L	< 0.025	< 0.025	Dry	Dry
Barium	mg/L	< 0.5	< 0.5	Dry	Dry
Beryllium	mg/L	< 0.0025	< 0.0025	Dry	Dry
Cadmium	mg/L	< 0.0025	< 0.0025	Dry	Dry
Chromium	mg/L	< 0.05	< 0.05	Dry	Dry
Cobalt	mg/L	< 0.25	< 0.25	Dry	Dry
Copper	mg/L	< 0.025	< 0.025	Dry	Dry
Iron	mg/L	< 0.5	< 0.5	Dry	Dry
Lead	mg/L	< 0.004	< 0.004	Dry	Dry
Manganese	mg/L	< 0.075	< 0.075	Dry	Dry
Mercury	mg/L	< 0.0002	< 0.0002	Dry	Dry
Nickel	mg/L	< 0.05	< 0.05	Dry	Dry
Silver	mg/L	< 0.0025	< 0.0025	Dry	Dry
Thallium	mg/L	< 0.002	< 0.002	Dry	Dry
Vanadium	mg/L	< 0.075	< 0.075	Dry	Dry
Zinc	mg/L	< 0.5	< 0.5	Dry	Dry
Radioactive Materials					
Cesium-137	pCi/L	< 2.0	< 2.0	Dry	Dry
Hydrogen-3	pCi/L	393	383	Dry	Dry
Strontium-90	pCi/L	< 0.25	< 0.25	Dry	Dry
VOCs Found above Quantitation Limits[b]					
1,1,1-Trichloroethane	µg/L	1	1	Dry	Dry
1,4-Dioxane[c]	µg/L	9	15	Dry	Dry
Bromoform	µg/L	2	2	Dry	Dry

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

[b] Only VOCs detected in at least one sample above detection limits are shown.

[c] No GQS exists for 1,4-dioxane.

TABLE 6.16

Groundwater Monitoring Results, 300 Area Well 319032, 2008

Parameter	Unit	Date of Sampling 3/11/2008	6/3/2008	8/12/2008	11/10/2008	11/10/2008 (Duplicate)
Field Parameters						
Water elevation[a]	m	198.51	198.59	197.95	197.83	197.83
Temperature	ºC	10.0	10.2	10.8	10.3	10.3
pH	pH	7.02	6.99	7.07	7.02	7.02
Redox	mV	2	2	2	0	0
Conductivity	µS/cm	1,185	1,080	1,118	1,020	1,020
Filtered Samples						
Chloride	mg/L	16	19	9	10	10
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.075	< 0.075	< 0.075	< 0.075	< 0.075
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Radioactive Materials						
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	144	240	198	148	188
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
VOCs Found above Quantitation Limits[b]						
1,1,1-Trichloroethane	µg/L	< 1	< 1	2	2	1
1,4-Dioxane[c]	µg/L	10	42	<1	70	41

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

[b] Only VOCs detected in at least one sample above detection limits are shown.

[c] No GQS exists for 1,4-dioxane.

TABLE 6.17

Groundwater Monitoring Results, 300 Area Well 319131D, 2008

Parameter[a]	Unit	Date of Sampling 3/12/2008	6/4/2008	8/13/2008	11/12/2008
Field Parameters					
Water elevation[b]	m	184.97	185.15	184.81	184.72
Temperature	ºC	10.8	11.7	12.3	10.8
pH	pH	7.11	7.17	7.08	7.10
Redox	mV	-3	-8	1	-3
Conductivity	µS/cm	1,222	1,050	1,145	1,086
Filtered Samples					
Chloride	mg/L	75	79	57	68
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Radioactive Materials					
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	408	508	497	522
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

[a] No VOCs above analytical detection limits were found in this well.

[b] Well point elevation = 182.77 m (MSL); ground elevation = 203.55 m (MSL); casing material = steel.

Inorganic Parameters. IEPA-approved background values for this area have not yet been developed; however, Wells 317111, 317101, and 319011 are upgradient of the 317/319 Area and represent background conditions. None of these contained any metal above the detection limits. Manganese was the only metal found in any of the wells. Well 317052 exceeded the GQS for manganese three of the four quarters. Many other wells discussed in this chapter exhibit elevated manganese concentrations, indicating that it is naturally present at levels that exceed GQS.

Organic Parameters. Low levels of several VOCs were found in all five downgradient glacial drift wells. Well 317021 contained very low levels of 1,1,1-trichloroethane (TCA) and 1,1-dichloroethane (DCA) as it has for years. DCA is often found along with TCA since it is a biodegradation product of TCA. Low levels of TCA were also found in Wells 319031 and 319032. 1,4-Dioxane was found in three shallow wells. This is a highly soluble chemical that moves easily in groundwater. Bromoform was detected in Well 319031. Well 317061 contained methylene chloride, tetrahydrofuran, and vinyl chloride at least once during 2008. All of these VOCs were also present in wells within the remediation areas, often at much higher concentrations. In general, the number of compounds detected and concentrations were lower than the 2007 results. No VOCs were found above detection levels in the two dolomite wells or three background wells. None of the results were above the GQSs; however, many of the 1,4-dioxane results were above the 1-µg/L GRO established for the 317/319 Area remedial actions.

Once during the year, the wells were sampled and analyzed for SVOCs, PCBs, pesticides, and herbicides. None of these types of compounds were found in any of the wells during 2008.

Figure 6.4 shows the TCA and DCA concentrations in Well 310021 since 1988, a period that spans all of the remediation activities completed in this area. As shown in the figure, the concentrations of these two compounds roughly parallel each other. The levels were low and relatively consistent until 1991, at which time a trend of increasing concentrations continues until 1995 when a rapid decrease in concentrations begins. This period represents the time when active remediation of the 317/319 Area began. The East Vaults Footing Drain, a former footing drain discharge pipe that was known to transport contaminated groundwater to the south, was sealed in 1997. A groundwater collection system was installed in the vicinity of this well in late 1997, and contaminated soil in the 317 French Drain Area was treated in 1998. A phytoremediation system was installed in 1999. All of these remedial actions may be responsible for the rapid decrease in VOC concentrations in this well since 1994. Since 1999, only very low residual amounts of VOCs have been present at this well.

The results from these wells imply that only a low level of groundwater contamination exists in the 317/319 Area, outside of the remedial action zones. However, it should be noted that monitoring conducted within the remediation areas as part of the LTS Program, described in Section 6.4, routinely detects orders of magnitude higher concentrations of VOCs than those described above (see Table 6.20); many results are well in excess of GQSs. These samples are collected closer to the 317 French drain and landfill areas and within shallow saturated soil

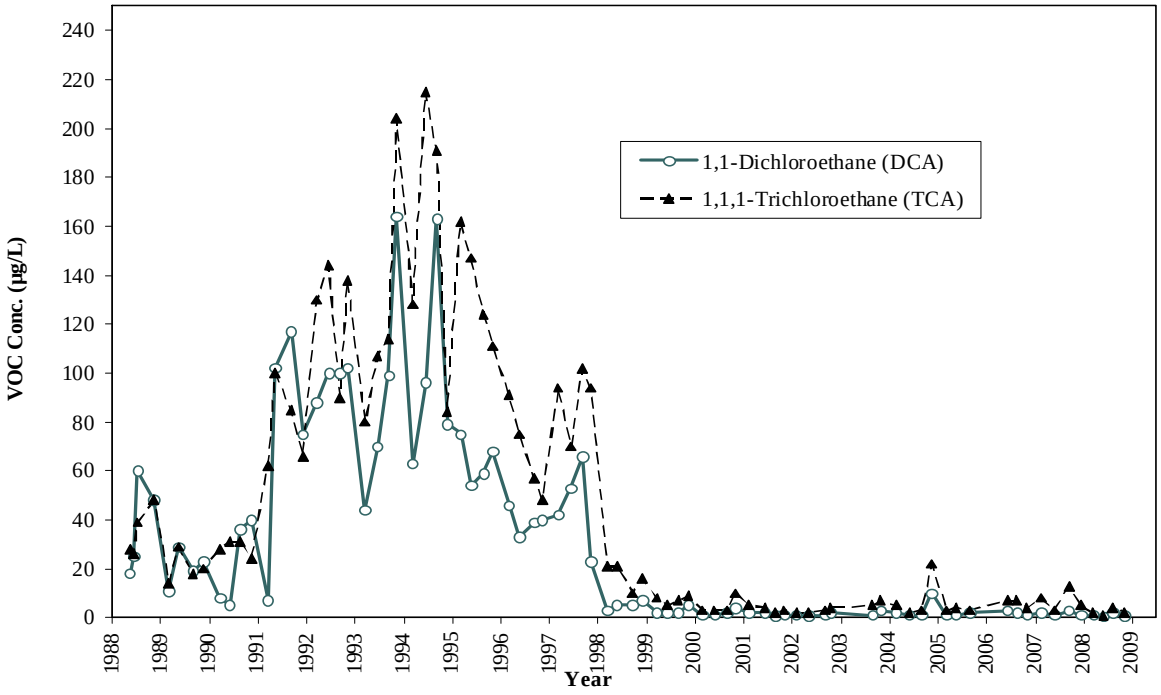


FIGURE 6.4 Concentrations of 1,1-Dichloroethane and 1,1,1-Trichloroethane in Well 317021

layers known to be contaminated. Higher concentrations of contaminants at these targeted zones are expected at this point in the remediation process.

Radiological Parameters. Because the 317 and 319 Areas were used to process radioactive materials and contaminated equipment, three isotopes were monitored in these wells — cesium-137, hydrogen-3, and strontium-90. No cesium-137 was detected in any of the samples collected in the first or second quarter, but all of the wells, including the three upgradient wells, exhibited detectable cesium-137 in the third quarter, and most also exhibited detectable amounts in the fourth quarter. These detections are thought to be an anomaly related to the analytical process in the laboratory. None of these wells have exhibited cesium-137 above detection limits in the past. Strontium-90 was found in only one sample from Well 319021 at a level only slightly higher than the analytical detection limits. Hydrogen-3 was found in one sample each from the three background wells at concentrations only slightly above the detection limits. Hydrogen-3 was found at very low concentrations in all of samples from all of the downgradient wells, including the two dolomite wells. The highest concentration was 746 pCi/L in Well 317061 located southwest of the 317 Area. All levels were well below the drinking water standard of 20,000 pCi/L.

In previous years dolomite Well 319131D, south of the 319 Area, had contained the highest hydrogen-3 levels. The source of hydrogen-3 is thought to be leachate from the 319 Area Landfill, which migrated away from the landfill prior to the start of remedial actions. Figure 6.5

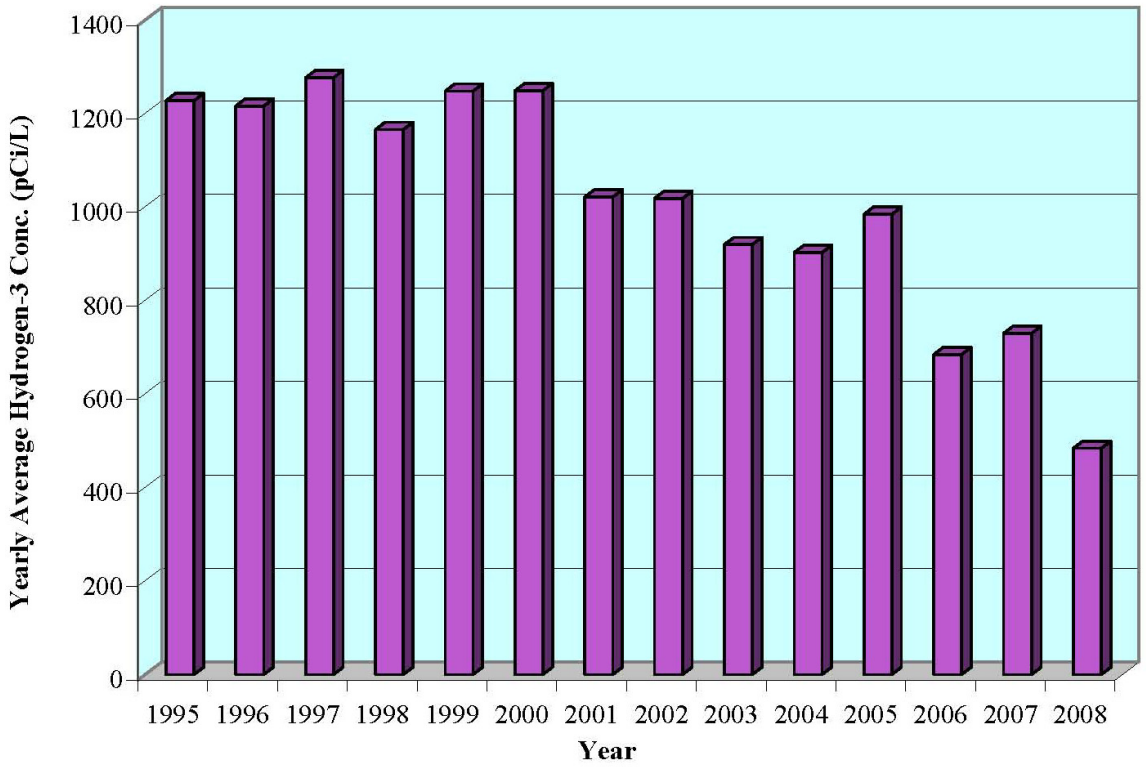


FIGURE 6.5 Hydrogen-3 in Dolomite Well 319131D

shows the annual average hydrogen-3 concentrations in this well since 1995. This figure shows that there is a downward trend, particularly since 2001, compared with relatively stable concentrations prior to 2001. The decrease is related to the construction of the cap over the 319 Area Landfill in 1999 as well as radioactive decay of residual hydrogen-3 in the groundwater.

6.3.3. 317 Area Manhole Sampling

In addition to the wells in this area, two manholes associated with the waste storage vault footing drain sewer system are monitored on a monthly basis. Figure 6.3 shows the locations of these two manholes. These manholes convey contaminated groundwater from footing drains around the North Vault and several of the now-demolished vaults (the footing drains were left in place after the vaults were demolished) through Manhole E1 and on to Manhole E2. A pump located in Manhole E2 pumps the water to the on-site LWTP. There it is treated and discharged to Sawmill Creek. Since 1997, water collected by the 317 and 319 leachate and groundwater collection systems has also been discharged to Manhole E2 where it is pumped to the treatment plant. Thus, the water in these manholes, particularly Manhole E2, is a mixture of groundwater from vaults in the 317 Area, leachate and groundwater from the 319 Area landfill, and groundwater from the 317 Area groundwater collection system. Monitoring contaminant concentrations in these manholes provides additional information about the progress of remedial actions in the 317 French Drain Area.

No record of the total volume of water pumped from Manhole E2 is maintained; however, contributions of groundwater into Manhole E2 during 2008 included an average of 1,500 L/day (394 gal/day) from the 319 Area groundwater collection system, and an average of 19,900 L/day (5,257 gal/day) from the 317 Area groundwater collection system, in addition to an unknown amount of groundwater originating in the 317 Area footing drains around the vaults. The relatively low flow from the 319 Area is the result of the impermeable cap installed over the waste mound during the summer of 1999.

During much of the summer of 2008, groundwater was pumped from two of the highly contaminated wells in the 317 French Drain Area (317321 and 317331) into Manhole E1 to accelerate the remediation of this area. The groundwater in these wells has levels of VOCs much higher than the levels typically found. The disposal of purge water from these wells is the probable source of the higher levels of VOCs in Manhole E1. The result of this unusual activity is that the VOC concentrations observed in the summer of 2008 may not be representative of footing drain water since it was a mixture of water sources.

Manholes E1 and E2 were sampled monthly and analyzed for VOCs using methods discussed previously. The results are presented in Tables 6.18 and 6.19. Except for the Manhole E1 sample collected in July, the results were similar to previous samples in recent years. The July sample contained much higher levels of VOCs than all previous samples, and a number of compounds were detected only in this sample. The remaining 2008 samples were similar to previous samples. It is thought that this sample was strongly influenced by groundwater pumped from the two groundwater monitoring wells. Figure 6.6 is a plot of total VOC concentrations (sum of all VOCs detected) since 1994. The effects of the July sample can be seen on this chart as a large spike on the graph. Similar to previous years, the highest concentrations were often found in the early spring when groundwater elevations are the highest.

As in previous years, the VOC concentrations in Manhole E2 are much lower than in Manhole E1. The much lower levels of VOCs in Manhole E2 are likely due to the introduction of the discharges from the 317 and 319 Areas, which have less VOC contamination than the groundwater from the footing drain. No significant decreasing trend in VOC concentrations is evident.

Figures 6.7 and 6.8 show the annual average VOC results for four of the most abundant compounds since 1995, with VOC values from both manholes shown on the same vertical scale to highlight the difference in concentration. For these figures, the unusually high VOC concentrations in the July sample from Manhole E1 were deleted from the average VOC concentrations to avoid skewing the trend line. As seen in Figure 6.7, the annual average VOC concentrations in Manhole E1 had decreased significantly from initial levels detected in 1995 and 1996 until unusually high levels were noted in 2005. In the last three years, VOC concentrations have slowly decreased and are moving toward levels found before 2005. The VOC concentrations in Manhole E2 have also decreased to normal levels in 2008 after increasing in 2005 and 2006; however, the introduction of the additional flows into Manhole E2 since 1997 makes it difficult to interpret the changes in VOC concentrations in this manhole.

TABLE 6.18

Volatile Organic Compounds and Radionuclides in the 317 Area: Manhole E1, 2008

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
VOCs (µg/L)												
1,1,1-Trichloroethane	4	1	1	1	< 1	< 1	613	16	3	49	19	2
1,1,2-Trichloroethane	< 1	< 1	< 1	< 1	< 1	< 1	2	< 1	< 1	< 1	< 1	< 1
1,1-Dichloroethane	3	2	1	2	1	< 1	110	7	2	15	7	2
1,1-Dichloroethene	< 1	< 1	< 1	< 1	< 1	< 1	12	< 1	< 1	< 1	< 1	< 1
1,2-Dichloroethane	< 1	< 1	< 1	< 1	< 1	< 1	81	8	< 1	12	7	< 1
1,4-Dioxane	18	24	34	12	48	20	1,030	359	50	201	269	38
2-Butanone	ND[a]	ND	ND	ND	ND	ND	16	ND	ND	ND	ND	ND
2-Methylpropanal	ND	ND	ND	ND	ND	ND	170	ND	ND	ND	ND	ND
2-Propanol	ND	ND	ND	ND	ND	ND	142	ND	ND	ND	ND	ND
4-Methyl-2-pentanol	ND	ND	ND	ND	ND	ND	308	ND	ND	ND	ND	ND
4-Methyl-2-pentanone	ND	ND	ND	ND	ND	ND	1,080	0.5	ND	2	ND	ND
Acetaldehyde	ND	ND	ND	ND	ND	ND	106	ND	ND	ND	ND	ND
Acetone	ND	ND	ND	ND	ND	ND	257	ND	ND	ND	ND	ND
Benzene	< 1	< 1	< 1	< 1	< 1	< 1	33	< 1	< 1	1	< 1	< 1
Carbon tetrachloride	216	131	212	450	432	471	442	101	137	73	84	33
Chloroform	447	271	307	346	415	313	717	203	302	273	222	142
cis-1,2-Dichloroethene	21	13	17	14	23	16	410	18	18	34	26	19
Ethanol	ND	ND	ND	ND	ND	ND	588	ND	ND	ND	ND	ND
Dichlorofluoromethane	7	1	1	1	1	0.9	ND	0.6	1	2	1	0.8
Ethyl ether	1	1	1	1	0.8	0.4	10	ND	0.8	2	0.8	0.4
Methylene chloride	< 1	< 1	< 1	< 1	< 1	< 1	12	< 1	< 1	< 1	< 1	< 1
Nitrobenzene	ND	ND	ND	ND	ND	ND	72	ND	ND	ND	ND	ND
Tetrachloroethene	30	13	11	15	17	14	22	7	15	18	15	11
Toluene	< 1	< 1	< 1	< 1	< 1	< 1	1	< 1	< 1	< 1	< 1	< 1
trans-1,2-Dichloroethene	2	< 1	1	1	2	1	11	< 1	1	2	< 1	< 1
Trichloroethene	103	62	84	116	132	98	557	54	94	101	< 1	56
Trichlorofluoromethane	< 1	< 1	< 1	< 1	< 1	< 1	1	< 1	< 1	< 1	< 1	< 1
Vinyl chloride	< 1	< 1	< 1	< 1	< 1	< 1	2	< 2	< 1	2	< 1	< 1
Total VOC	853	521	671	960	1,075	937	6,806	775	626	788	653	306
Radionuclides (pCi/L)												
Cesium-137	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	5.78	4.57	5.66	< 2.0	4.07
Hydrogen-3	551	653	697	455	703	378	635	727	423	1,100	1,260	1,100

TABLE 6.19

Volatile Organic Compounds and Radionuclides in the 317 Area: Manhole E2, 2008

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
VOCs (µg/L)												
1,1,1-Trichloroethane	2	8	17	16	13	13	24	6	3	5	5	2
1,1-Dichloroethane	11	12	18	13	11	11	18	5	10	4	9	2
1,2-Dichloroethane	< 1	< 1	< 1	< 1	< 1	< 1	1	1	2	< 1	2	< 1
1,4-Dioxane	ND[a]	ND	ND	ND	11	12	ND	ND	5	ND	ND	28
4-Methyl-2-pentanone	ND	ND	ND	ND	ND	ND	1	ND	ND	ND	ND	ND
Carbon tetrachloride	67	25	44	80	24	46	3	< 1	14	1	1	40
Chloroform	80	27	26	54	15	28	2	< 1	27	4	4	108
cis-1,2-Dichloroethene	5	2	2	2	1	2	1	< 1	2	< 1	< 1	13
Tetrachloroethene	20	8	8	12	4	7	2	< 1	5	< 1	< 1	13
Trichloroethene	17	6	9	19	6	11	7	1	8	2	2	42
Total VOC	203	80	124	196	86	132	60	14	76	185	25	250
Radionuclides (pCi/L)												
Cesium-137	< 2.0	< 2.0	< 2.0	< 2.0	25.4	21.4	< 2.0	3.68	4.42	3.16	< 2.0	< 2.0
Hydrogen-3	509	748	1,370	176	455	515	379	310	402	529	324	509

[a] ND = nondetect.

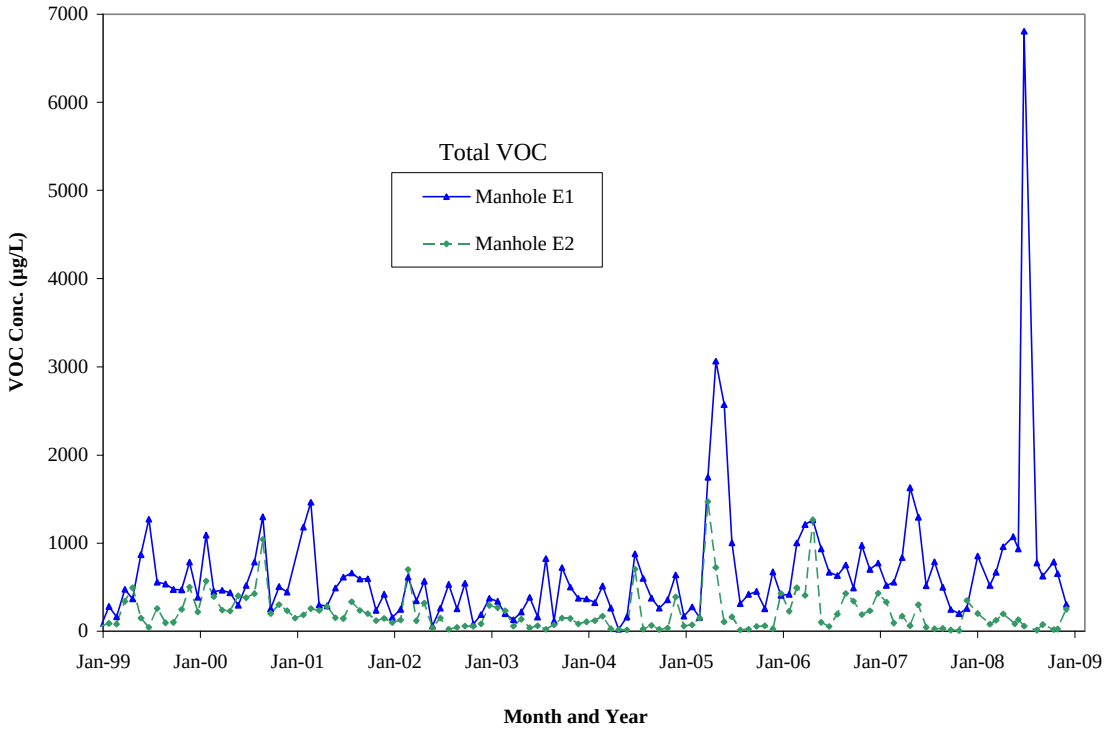


FIGURE 6.6 Total VOCs in Manholes E1 and E2

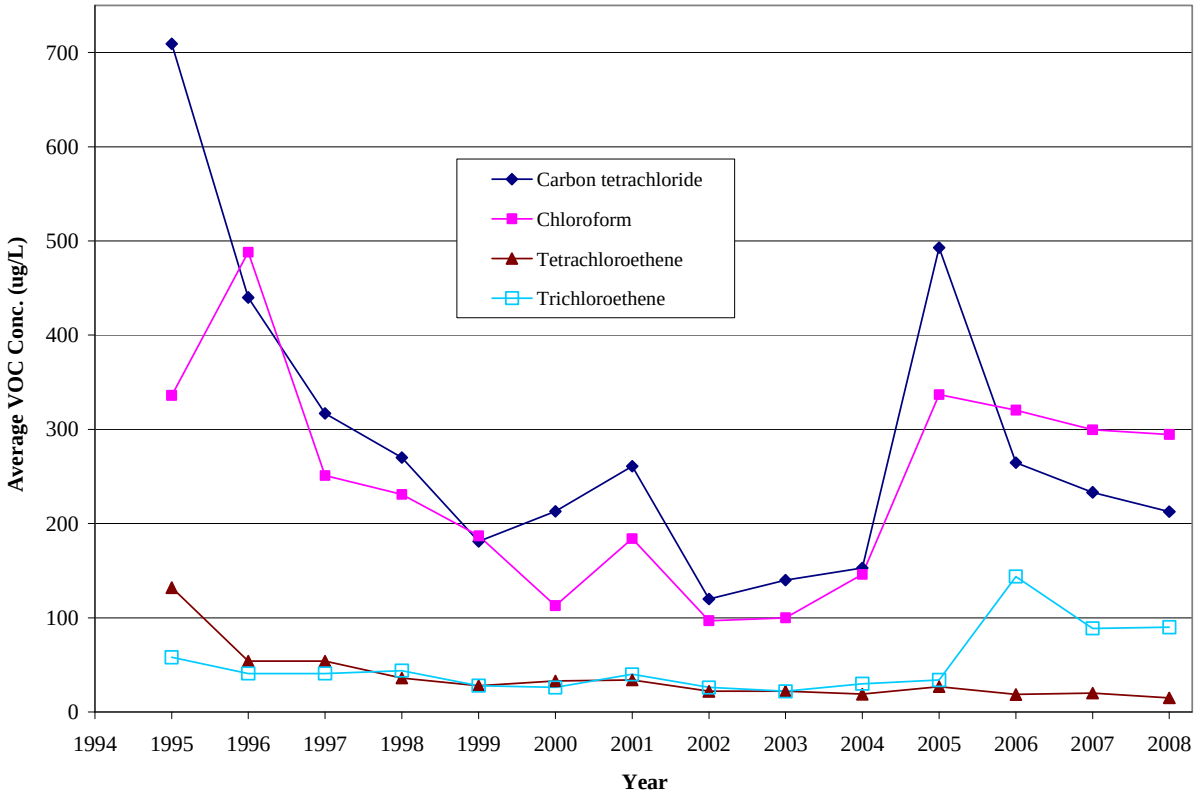


FIGURE 6.7 Select VOCs in Manhole E1

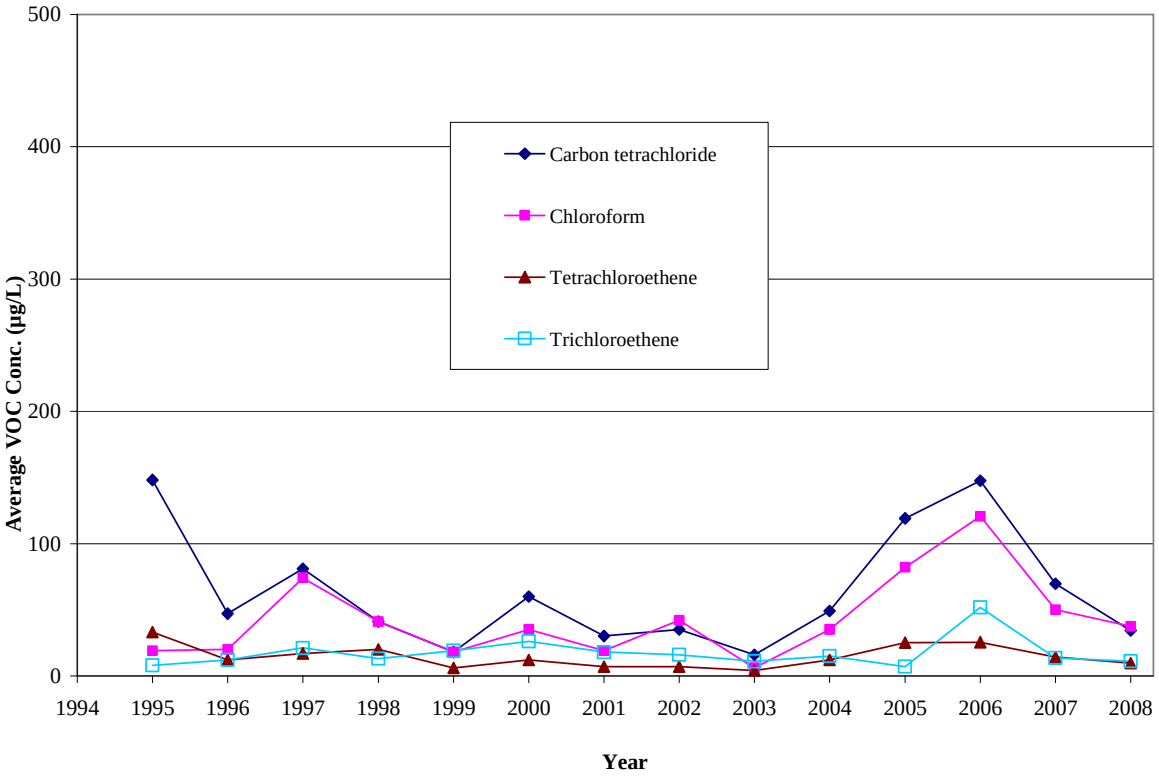


FIGURE 6.8 VOCs in Manhole E2

In addition to VOCs, the manhole water is analyzed for hydrogen-3 and gamma-ray-emitting radionuclides. Tables 6.18 and 6.19 show the results from this analysis. Hydrogen-3 was detected in all of the samples; however, all of the results are well below the GQS of 20,000 pCi/L. Unlike the VOCs, Manhole E2 often exhibits higher hydrogen-3 concentrations than Manhole E1. The primary source of the additional hydrogen-3 is the 319 Area groundwater extraction system that handles groundwater with elevated hydrogen-3 levels up to 10,000 pCi/L. Figure 6.9 shows the trend in hydrogen-3 concentrations since 1998. The dramatic decrease in hydrogen-3 concentration since 1999 is the result of the cap placed over the 319 Area Landfill, which was completed in 1999.

Cesium-137 was reported in a number of the samples from both manholes, particularly the May and June samples from E2 and all samples from August, September, and October. Cesium has never been found above the detection limit of 2 pCi/L in the past, so these isolated detections are thought to be an artifact of the laboratory's analytical process. Similar unusual cesium-137 results were observed in the 317 Groundwater monitoring wells and associated control samples in the last quarter of 2008. The control sample collected in June was reported to contain 26 pCi/L, and the August and November control samples contained 2.7 and 2.3 pCi/L of cesium-137, respectively, very similar to the manhole samples collected in late 2008.

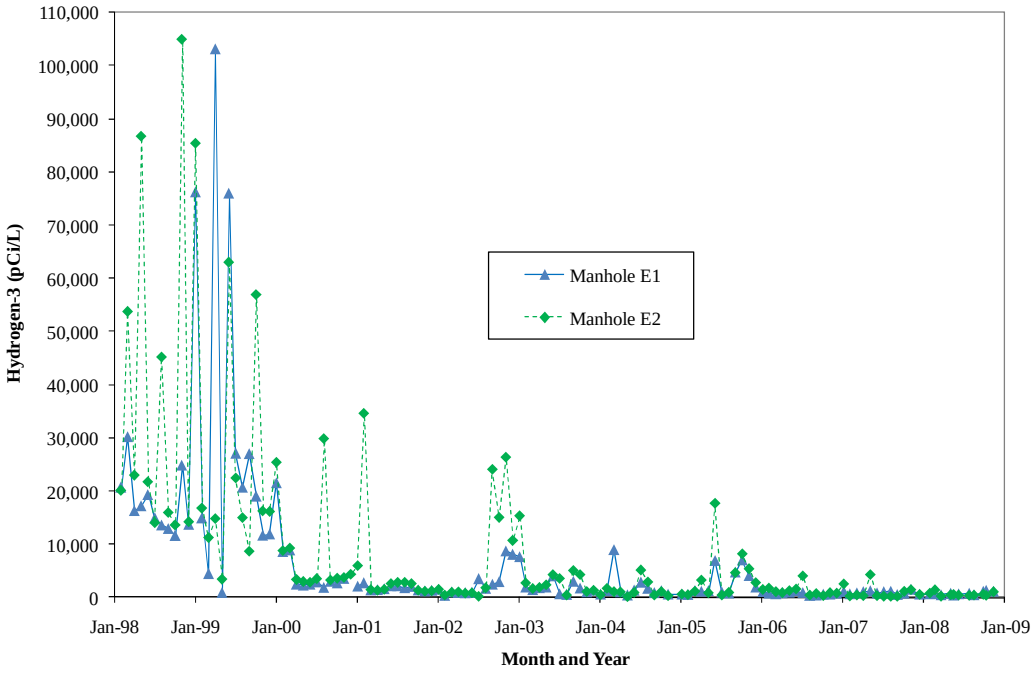


FIGURE 6.9 Hydrogen-3 in the 317 Manholes

6.4. Permit-Required Groundwater Monitoring at the 317/319 Area

The LTS Program includes the collection of groundwater data from an extensive network of monitoring wells and other sampling points located throughout the 317/319 Area. The purpose of this monitoring is to track the movement of contaminated groundwater, to determine the rate at which contaminant levels are decreasing, and to monitor the performance of the various remedial actions constructed in the 317 and 319 Areas. Most samples are collected on a quarterly basis and analyzed for VOCs and hydrogen-3 by using methods discussed elsewhere in this chapter. Once per year, samples of groundwater from several of these wells are also analyzed for metals, SVOCs, PCBs, pesticides, and radionuclides other than hydrogen-3. These data are transmitted to the IEPA quarterly and are summarized in this section.

Because of the number of wells and other sampling points sampled in this area, the volume of analytical data generated is quite large. To simplify the presentation of the data in this report, only a summary of the most significant results is presented. No organics other than VOCs were detected, and no metals other than naturally occurring metals were detected. Only normal background levels of other radionuclides were detected. None of these results are discussed in this chapter.

Overall, the monitoring results generated during 2008 indicate that the two groundwater collection systems south of the 319 Area Landfill and the 317 Area are effectively preventing off-site migration of contaminated groundwater that moves south toward the Des Plaines River. High concentrations of a number of VOCs are still present in groundwater in the immediate vicinity of the former 317 French Drain Area. However, downgradient (south) of the French

drain the levels are much lower than in the French drain area itself, though still in excess of GQSs. Contaminant concentrations at the Argonne fence line are slowly decreasing.

6.4.1. 317 Area Groundwater Monitoring

Remediation in the 317 Area consisted of in-situ soil treatment in the former French drain area (source area), operation of a groundwater extraction system at the site boundary, and installation of a phytoremediation system. The French drain soil treatment completed in 1998 resulted in the removal of approximately 80% of the subsurface contaminants. The groundwater extraction system has been operational since 1997. The phytoremediation trees were planted in 1999 to accelerate the removal of residual soil and groundwater contamination. Phytoremediation is a process that relies on plants to extract pore water and dissolved contaminants from subsurface soils, degrade and/or sequester them, and transpire water vapor and some volatile constituents into the atmosphere. To monitor the effectiveness of these remedial processes, monitoring wells were installed throughout the 317 Area. The current set of wells is shown in Figure 6.10.

Table 6.20 shows the average and maximum VOC concentrations from the 2008 quarterly samples from the four most highly contaminated wells in the French drain area. These four wells form two well clusters, with one well in each cluster in the uppermost saturated zone (4 to 5 m [13 to 16 ft] deep) and the other in a deeper saturated zone (9 to 10 m [29 to 33 ft] deep). Organics that were below the quantitation limit in all four wells are not shown in this table. Values that exceed the applicable IEPA's Tier 1 GRO are indicated in bold type. A number of constituents found do not have Tier 1 objectives.

The data in Table 6.20 indicate that pockets of elevated VOCs remain in the French drain area. The contaminants present and concentrations in these wells vary tremendously from well to well, and even between the wells in the same cluster, illustrating the heterogeneity of the area. These values are consistent with results found in past sampling events and no consistent trend in concentrations has yet been observed, indicating that the phytoremediation process has not yet resulted in a significant reduction of VOCs in the French drain area.

Table 6.21 contains results for the same constituents listed in Table 6.20 for four downgradient wells south of the French drain. Two wells (317151 and 317351) are approximately midway between the French drain and the southern fence line; Well 317232 is 46 m (150 ft) north of the fence line, and Well 317811 is immediately north of the fence line. The concentrations found in these wells are much lower than in the French drain area; however, several of the constituents are present above applicable standards. Most of the contaminant concentrations decrease with increasing distance from the French drain. The concentrations of these compounds south of the French drain have been stable or decreasing in recent years. In this fence-line well, only chloroform and trichloroethene (TCE) currently exceed the limits. Other wells at the fence line also exceed the limit for 1,4-dioxane. Apparently, the highly contaminated groundwater in the French drain area is not migrating downgradient; although significant residual contamination is still present.

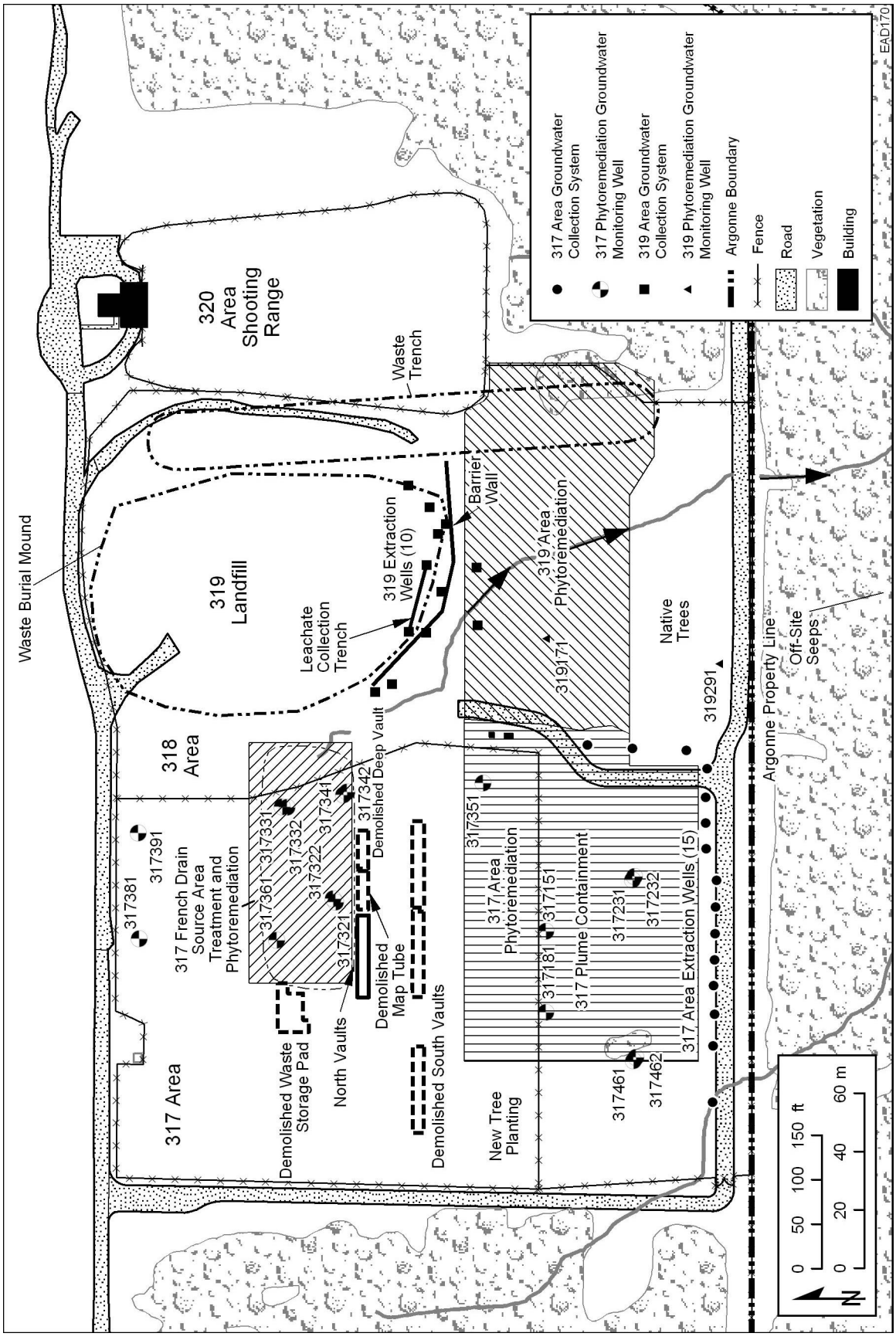


FIGURE 6.10 Phytoremediation Monitoring Wells

TABLE 6.20

Annual Maximum and Minimum Concentrations of French Drain Well Water Constituents, 2008

	Well No.								
	317321		317322		317331		317332		TACO[a]
Parameter	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Remediation Objective
VOC (μg/L)									
1,1,1-Trichloroethane	< 1	< 1	< 1	< 1	**75,525**[b]	**92,500**	**8,805**	**14,500**	200
1,1-Dichloroethane	< 1	< 1	**1,608**	**3,320**	**7,858**	**14,800**	**2,853**	**4,590**	700
1,1-Dichloroethene	< 1	< 1	**490**	**1,930**	**1,763**	**2,780**	**136**	**239**	7
1,2-Dichloroethane	< 1	< 1	**52**	**74**	**2,548**	**4,780**	**238**	**388**	5
1,4-Dioxane	< 1	< 1	**2,246**	**6,660**	**5,743**	**10,000**	**2,465**	**4,520**	1
2-Butanone	< 1	< 1	54	213	< 1	< 1	< 1	< 1	NA[c]
2-Hexanol	286	1,140	86	184	< 1	< 1	< 1	< 1	NA
2-Propanol	< 1	< 1	411	1,640	< 1	< 1	< 1	< 1	NA
4-Methyl-2-Pentanone	110,275	147,000	13,685	25,300	951	3,270	< 1	< 1	NA
4-Methyl-2-pentanol	< 1	< 1	4,816	17,000	< 1	< 1	< 1	< 1	NA
Acetone	**7,276**	**16,100**	1,084	2,800	< 1	< 1	< 1	< 1	6,300
Benzene	**10,605**	**11,300**	**1,083**	**2,480**	**268**	**437**	**21**	**39**	5
Carbon tetrachloride	**305,250**	**490,000**	**3,746**	**9,680**	< 1	< 1	< 1	< 1	5
Chloroethane	< 1	< 1	55	115	18	69	11	15	2,800
Chloroform	**55,975**	**74,900**	**7,811**	**18,700**	**496**	**642**	**21**	**40**	0.2
cis-1,2-Dichloroethene	**485**	**681**	**16,025**	**23,700**	**11,873**	**19,600**	**1,562**	**2,520**	70
Dichlorodifluoromethane	< 1	< 1	37	144	44	95	22	29	1,400
Dichlorofluoromethane	< 1	< 1	< 1	< 1	70	217	< 1	< 1	NA
Ethanol	225,800	423,000	< 1	< 1	< 1	< 1	< 1	< 1	NA
Ethylether	501	774	73	205	< 1	< 1	< 1	< 1	1,400
Methylene chloride	< 1	< 1	**1,482**	**3,610**	< 1	< 1	< 1	< 1	5
Nitrobenzene	**2,726**	**10,900**	< 1	< 1	< 1	< 1	< 1	< 1	3.5
Tetrachloroethene	**820**	**1,080**	**338**	**560**	< 1	< 1	< 1	< 1	5
Toluene	965	**1,060**	63	153	< 1	< 1	< 1	< 1	1,000
trans-1,2-Dichloroethene	< 1	< 1	**167**	**229**	**698**	**1,060**	100	**167**	100
Trichloroethene	**26,200**	**29,500**	**1,049**	**2,580**	**24,100**	**37,200**	**800**	**1,090**	5
Trichlorofluoromethane	1,910	**2,380**	87	220	< 1	< 1	< 1	< 1	2,100
Vinyl chloride	< 1	< 1	**2,300**	**2,890**	**178**	**413**	**40**	**58**	2
Radioactivity (pCi/L)									
Hydrogen-3	1,225	1,260	645	815	219	232	235	292	20,000

[a] TACO = Tiered Approach to Cleanup Objectives.

[b] Bold type indicates that the value exceeds applicable standards.

[c] NA indicates no standard exists for this compound.

Figure 6.11 shows the long-term trend in average VOC concentrations in the two most contaminated wells in the 317 French Drain Area since 1999. This chart indicates that the contaminant levels have been essentially unchanged since monitoring began in 1999, though there is significant variation from year to year.

Figure 6.12 is a map showing the approximate location of the region of contaminated groundwater within the contaminated aquifer below the 317 Area based on the 2008 data. The

TABLE 6.21

Annual Maximum and Minimum Concentrations of Downgradient French Drain Well Water Constituents, 2008

	Well No.								
	Wells midway to fence				Wells near fence line				
	317151		317351		317232		317811		
Parameter	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Remediation Objective
VOC (µg/L)									
1,1,1-Trichloroethane	**1,015**[a]	**1,230**	<1	<1	<1	<1	59	93	200
1,1-Dichloroethane	191	253	<1	<1	0.5	1	47	65	700
1,1-Dichloroethene	**16**	**23**	<1	<1	<1	<1	<1	2	7
1,2-Dichloroethane	**13**	**15**	<1	<1	<1	<1	<1	<1	5
1,4-Dioxane	<1	<1	<1	<1	<1	<1	<1	<1	1
2-Butanone	<1	<1	<1	<1	<1	<1	<1	<1	NA[b]
2-Hexanol	<1	<1	<1	<1	<1	<1	<1	<1	NA
2-Propanol	<1	<1	<1	<1	41	161	<1	<1	NA
4-Methyl-2-Pentanone	<1	<1	<1	<1	<1	<1	<1	<1	NA
4-Methyl-2-pentanol	<1	<1	<1	<1	<1	<1	<1	<1	NA
Acetone	<1	<1	<1	<1	<1	<1	4.8	16	6,300
Benzene	<1	<1	<1	<1	<1	<1	<1	<1	5
Carbon tetrachloride	<1	<1	**144**	**324**	1.1	2.0	<1	<1	5
Chloroethane	<1	<1	<1	<1	<1	<1	<1	<1	2,800
Chloroform	**3.0**	**9.0**	**137**	**222**	**0.5**	**0.6**	**1.3**	**2.0**	0.2
cis-1,2-Dichloroethene	8.3	11.0	11	28	<1	<1	1.1	2.0	70
Dichlorodifluoromethane	<1	<1	<1	<1	<1	<1	<1	<1	1,400
Dichlorofluoromethane	<1	<1	<1	<1	<1	<1	<1	<1	NA
Ethanol	<1	<1	<1	<1	<1	<1	<1	<1	NA
Ethylether	<1	<1	<1	<1	<1	<1	<1	<1	1,400
Methylene chloride	<1	<1	<1	<1	<1	<1	<1	<1	5
Nitrobenzene	<1	<1	<1	<1	<1	<1	<1	<1	3.5
Tetrachloroethene	**27**	**44**	**163**	**340**	<1	<1	1.9	3.0	5
Toluene	10	37	<1	<1	<1	<1	<1	<1	1,000
trans-1,2-Dichloroethene	<1	<1	<1	<1	<1	<1	<1	<1	100
Trichloroethene	**290**	**342**	4.3	**7.0**	<1	<1	**12**	**15**	5
Trichlorofluoromethane	<1	<1	<1	<1	<1	<1	<1	<1	2,100
Vinyl chloride	<1	<1	<1	<1	<1	<1	<1	<1	2
Radioactivity (pCi/L)									
Hydrogen-3	223	240	288	418	427	452	185	253	20,000

[a] Bold type indicates that the value exceeds applicable standards.

[b] NA indicates no standard exists for this compound.

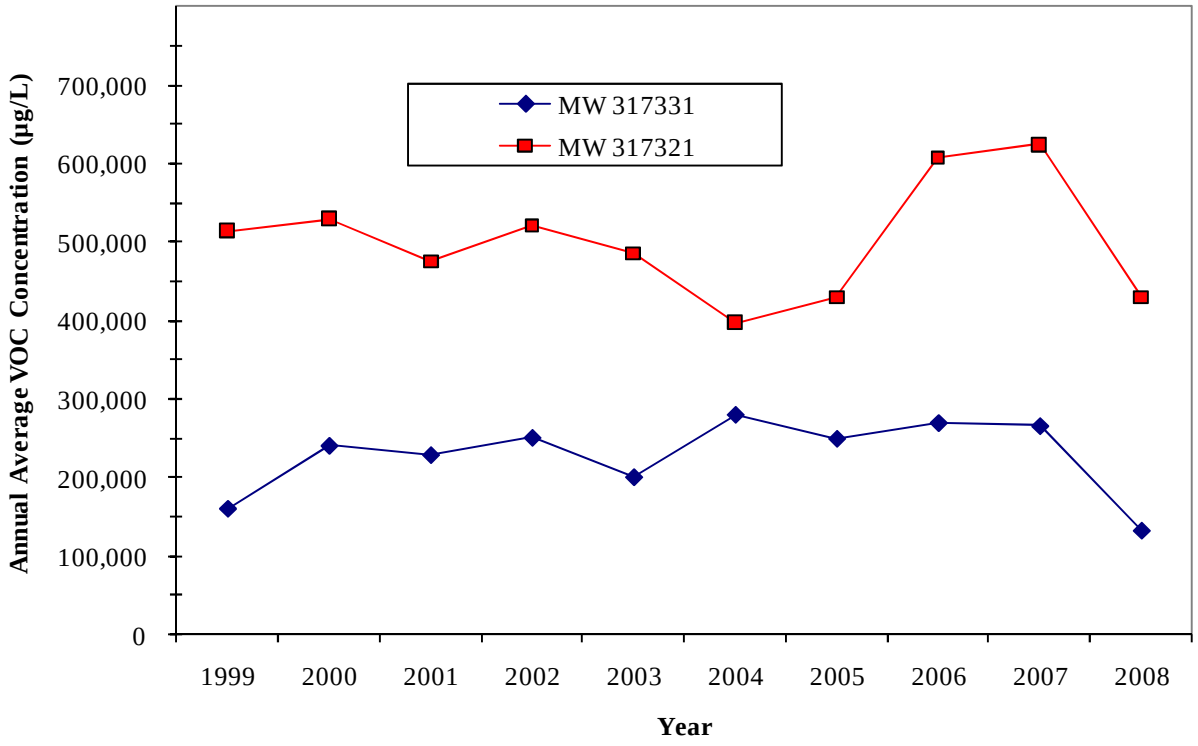


FIGURE 6.11 Annual Average VOC Concentrations in 317 Area French Drain Wells

core of the plume extends from the French drain area to the southwest. The plume extends a small distance off-site into Waterfall Glen Forest Preserve. Compared with the plume map prepared for the 2007 SER, the plume has decreased in size to the southeast of the 317 French drain since several wells in this area contained significantly less VOCs than in 2007.

The phytoremediation plantation encompasses most of this plume area. Plant tissue monitoring conducted in the phytoremediation system during the last few years indicates that the trees are indeed taking up the organic contaminants from the soil and transpiring them to the air or degrading them within the plant. Sap flow measurements in 2008 indicted that each tree, on average, removes 100 to 150 L/day (26 to 40 gal/day) of contaminated groundwater during the growing season. Because of the difficulty of estimating sap flow rates and measuring contaminant concentrations in sap, it has not yet been possible to measure the rate at which the trees are removing VOCs or how quickly they will reduce residual contaminant levels. Long-term monitoring of this system will determine its effectiveness at achieving the remediation objectives for this area.

6.4.2. Extraction Well Monitoring

Two groundwater management systems in the 317/319 Area remove contaminated groundwater to prevent further migration. A line of 15 groundwater extraction wells was installed near the 317 Area south fence, and 10 wells (8 groundwater and 2 leachate collection

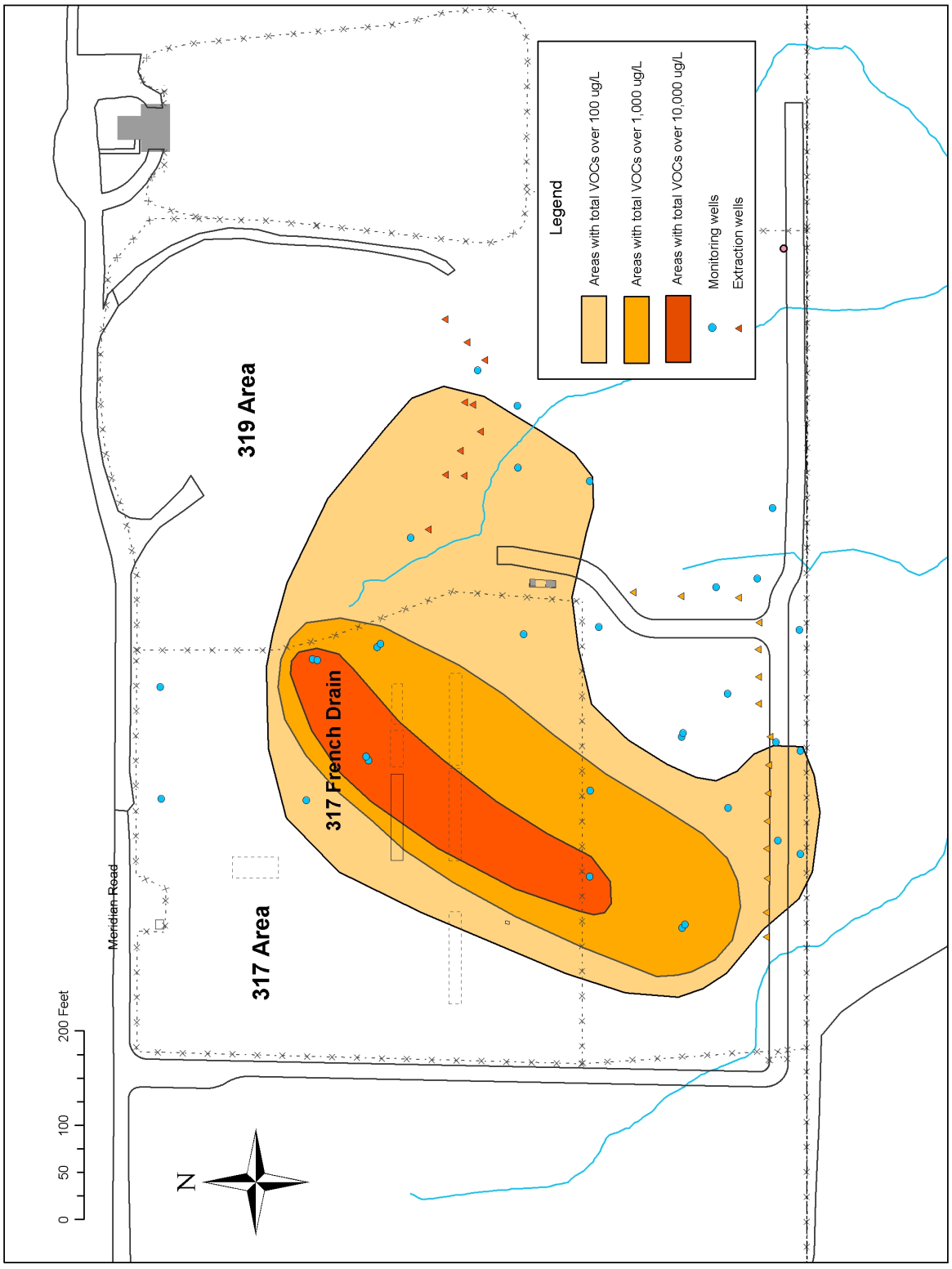


FIGURE 6.12 Region of Contaminated Groundwater in the 317/319 Area during 2008

wells) were installed south of the 319 Area Landfill. The groundwater extraction wells were installed at approximately 10-m (30-ft) intervals at a depth of 10 to 15 m (30 to 50 ft) in the porous zones. The discharge from the extraction wells is routed to the lift station in the 317 Area where the combined wastewater is pumped to the LWTP. The locations of the extraction wells are shown in Figure 6.13.

The flow from the 317 Area extraction wells is influenced by the amount of precipitation as well as the uptake of groundwater by the phyto trees during the warm months. The long-term average flow from this system through 2008 was 14,400 L/day (3,807 gal/day), with the flow prior to 2002 often exceeding 30,000 L/day (8,000 gal/day). The flow rate decreased significantly starting in late 2002, possibly because of the trees removing groundwater from the shallow aquifers. The average flow rate during 2008 was 19,900 L/day (5,257 gal/day), more than twice the flow recorded in 2007. The flow rate from the 319 Area collection system is much lower than that of the 317 Area system because the system is much smaller, and an impermeable clay cap was installed over the 319 Area Landfill, greatly reducing the amount of leachate and groundwater generated. Prior to installation of the cap, flows averaged approximately 5,680 L/day (1,500 gal/day). During 2008, the average flow was less than 1,500 L/day (394 gal/day), significantly lower than the 2007 flows. The higher flow in the 317 Area is likely the result of the abnormally wet weather experienced in 2008. In addition, during 2008, improvements were made to the flow metering system in this area, which may have resulted in higher flow rate measurements. The reason for lower flows from the 319 Area in 2008 is not known; however, the 2007 flow was abnormally high during the first two quarters of that year, resulting in a higher than normal average flow. The 2008 flows were more typical of the years prior to 2007.

Samples are collected from each well once per year and are analyzed for VOCs and various radiological parameters. Table 6.22 summarizes the range of contaminant concentrations above detection limits in the two extraction well systems. The concentrations of most of the parameters were below laboratory detection limits. During 2008, two 317 Area extraction wells were partially dry, preventing the collection of samples for radiological analysis, which require large amounts of water. VOC samples, however, were collected from these wells. Both systems exceeded GQSs in at least one sample during 2008. The highest VOC concentrations in the 317 Area extraction wells are several orders of magnitude lower than the highest concentrations in groundwater under the French drain (see Section 6.4.1.). This indicates that the groundwater in the French drain area is not migrating, and that only a relatively small amount of this contamination had migrated south of this area prior to the start of remediation. The remaining contamination south of the French drain should slowly decrease because of dilution from rainwater, natural biodegradation, and the effects of the phytoremediation plantation.

In addition to VOCs, the extraction well water was also analyzed for cesium-137, isotopic uranium, and hydrogen-3. The results for the detectable amounts are shown in Table 6.22. Cesium-137 was reported in eight wells from the 317 Area and four in the 319 Area. Previous samples from these wells did not find any cesium-137 above the 2.0-pCi/L detection limit. The detections in 2008 are likely related to be the analytical issues discussed elsewhere in this chapter, since many samples collected in late 2008 exhibited similar low levels of cesium-137.

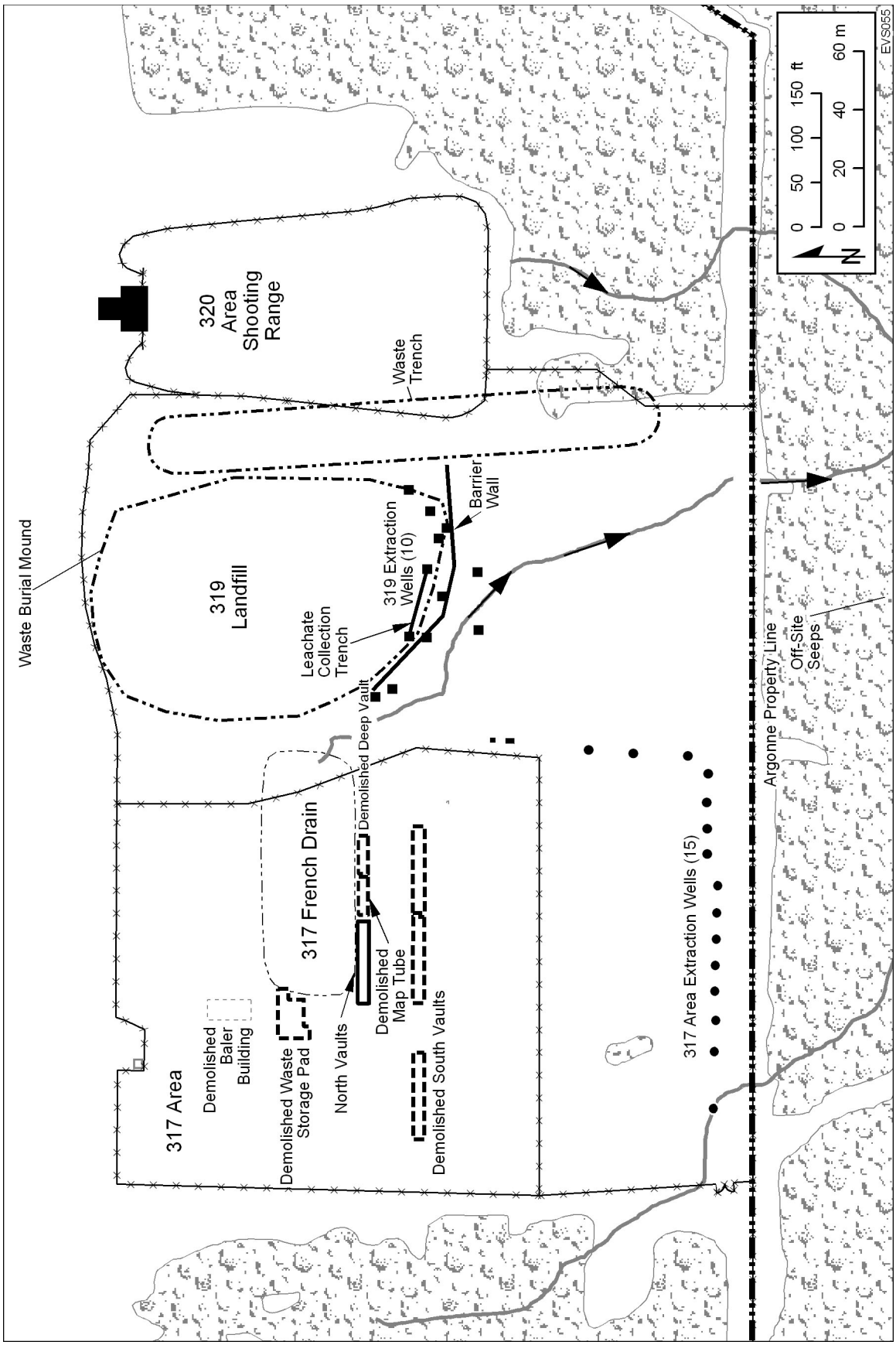


FIGURE 6.13 Extraction Wells

TABLE 6.22

Range of VOC and Radionuclide Concentrations in the 317/319 Extraction Wells, 2008

	317 System			319 System			
Parameter	No. of Detections in 15 wells	Avg.	Max.	No. of Detections in 10 wells	Avg.	Max.	Remediation Objective
VOC (µg/L)							
1,1,1-Trichloroethane	9	34	**268**[a]	4	26	125	200
1,1-Dichloroethane	15	96	630	7	11	52	700
1,1-Dichloroethene	4	1.5	3.0	3	1.9	5.0	7.0
1,2-Dichloroethane	13	**6.3**	**32.0**	4	2.4	**8.0**	5.0
1,4-Dioxane	5	**27**	**88**	6	**91**	**333**	1.0
Chloroethane	12	1.4	5.0	2	1.2	2.0	2,800
Chloroform	2	**1.2**	**2.0**	5	**0.4**	**0.6**	0.2
cis-1,2-Dichloroethene	3	4.3	6.0	8	37	**167**	70
Dichlorofluoromethane	2	1.0	1.0	4	7.8	19	NA[b]
Tetrahydrofuran	0	<1	<1	2	56	100	NA
trans-1,2-Dichloroethene	2	0.3	0.3	4	1.9	4.0	100
Tetrachloroethene	3	2.3	**6.0**	4	0.6	1.0	5
Trichloroethene	9	**5.2**	**39**	8	**12**	**45**	5
Vinyl Chloride	2	0.5	1	1	**3.0**	**3.0**	2
Total VOC	-	138	693		131	526	NA
Radionuclides (pCi/L)[c]							
Cesium-137	8	3.0	5.5	4	1.6	4.2	NA
Hydrogen-3	13	296	413	10	13,786	**45,200**	20,000
Uranium-234	13	0.88	1.13	10	4.8	16.3	NA
Uranium-238	13	0.67	0.86	10	4.9	16.7	NA

[a] Bold type indicates that the value exceeds applicable standards.

[b] NA = not applicable.

[c] In the 317 Area, only 13 of the 15 wells yielded samples for radionuclide determination.

Several wells in the 319 Area are removing groundwater with significant amounts of hydrogen-3, as evidenced by the highest hydrogen-3 concentration of 45,200 pCi/L maximum, which was found in Well EXT271 near the leachate trench. Two other wells in the same area, EXT251 and EXT261, also exceeded the 20,000-pCi/L GQS. The maximum tritium concentration was much lower than the 2007 value. Leachate from the landfill and underlying groundwater is known to contain hydrogen-3. Since the landfill cap was installed, the amount of leachate produced has been very small, and most sampling attempts of the two leachate wells do not yield a sample. The levels of uranium were higher in the 319 Area than in the 317 Area, but both areas are consistent with normal background levels.

Each quarter the groundwater elevations around the extraction wells are analyzed to determine the effectiveness of the extraction systems. On the basis of this analysis and

estimations of groundwater flow directions, the extraction wells appear to be effectively preventing migration of contaminated groundwater from the Argonne site.

Each quarter an attempt is made to collect a sample of surface water from the stormwater ditch south of the 317 and 319 Areas. The samples are analyzed for VOCs and hydrogen-3. During 2008, two samples were collected — one during June and the other in September. Several VOCs were detected in these samples, as shown in Table 6.23. Results in this table that are less than 1.0 are estimated values that are lower than the normal reporting limits but are still believed to be present. Only a very small amount of hydrogen-3 was found in one of the two samples. From the type of compounds detected, and the lack of hydrogen-3, it is believed that the contamination noted results from rainwater contacting contaminated soil in the 317 French Drain Area.

6.4.3. ENE Landfill Groundwater Monitoring

In September 2001, Argonne completed the remediation of a small solid waste disposal area used in the early years of the site for the disposal of demolition debris, old equipment, and other items, known as the ENE Landfill. Waste material was consolidated, and a clay cap was constructed over the waste mound. Five monitoring wells were installed to facilitate monitoring of the groundwater around the landfill. Two of the wells (ENE061 and ENE071) were installed upgradient of the landfill, and the other three wells (ENE031, ENE041, and ENE051) were installed immediately downgradient of the landfill. Four other wells southeast of the mound (ENE011, ENE012, ENE013D, and ENE021D), which had been installed earlier as part of the 317/319/ENE RCRA Facility Investigation (RFI) in 1996, were incorporated into the sampling network. Figure 6.14 shows the well locations.

In April 2003, the IEPA issued a RCRA corrective action permit covering postclosure care and groundwater monitoring for the ENE Landfill. The purpose of groundwater monitoring at the ENE Landfill is to verify that contaminants found in the landfill contents, including metals

TABLE 6.23

Results of Surface Water Sampling in the 319 Area

Parameter	June 9, 2008 Sample	September 15, 2008 Sample
VOCs (µg/L)		
1,1,1-Trichloroethane	0.8	1.0
1,1-Dichloroethane	0.3	0.3
Carbon tetrachloride	10	0.8
Chloroform	5	1
Tetrachloroethene	0.3	<1
Radionuclides (pCi/L)		
Hydrogen-3	<100	139

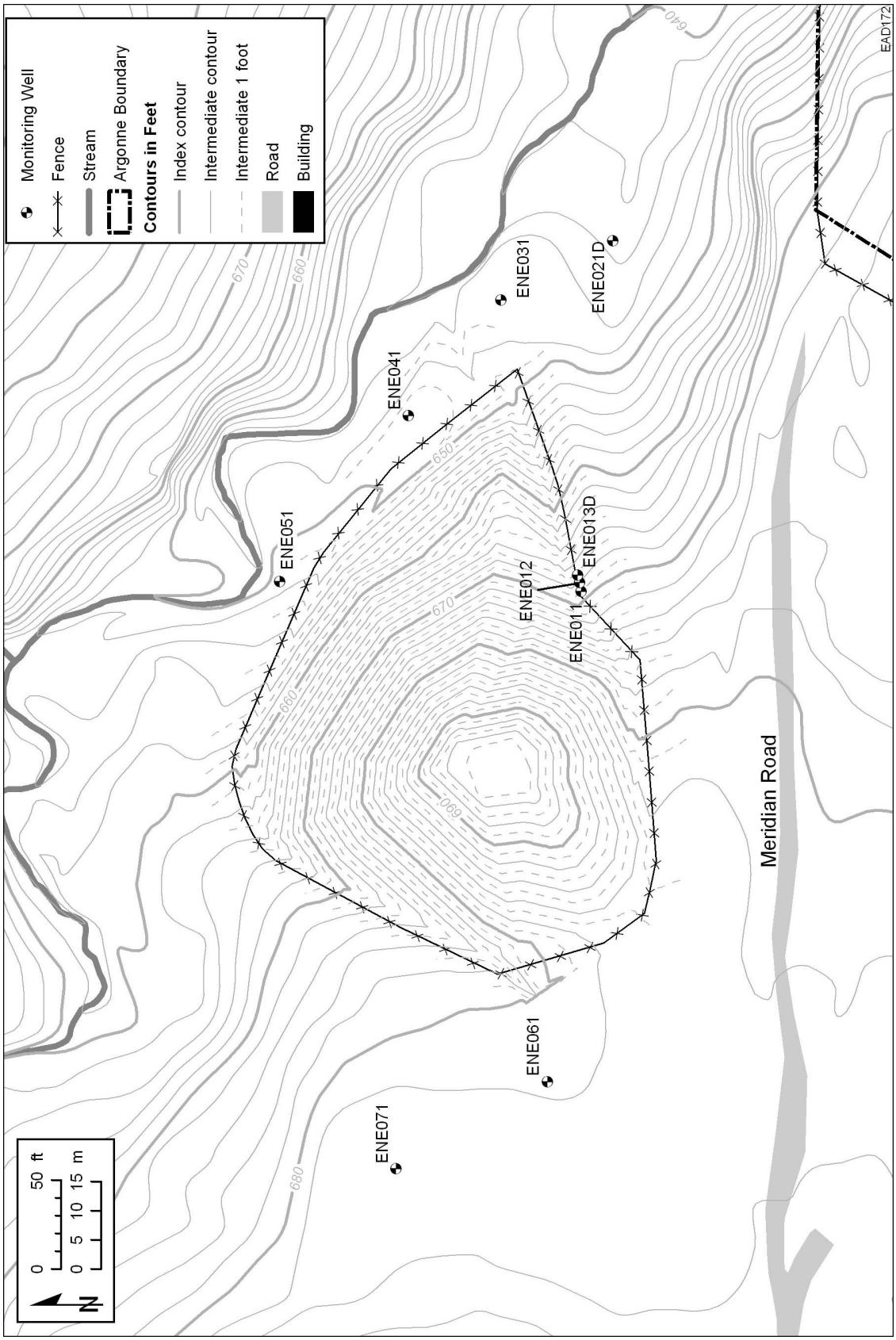


FIGURE 6.14 ENE Area Groundwater Monitoring Wells

(chromium, lead, and selenium) and PCB Aroclor 1254, which were all above their respective Tier 1 soil remediation objectives (as found in 35 IAC Part 742 [i.e., Tiered Approach to Corrective Action Objectives]), as well as hydrogen-3 and other radionuclides, are not of concern with regard to shallow groundwater. The contaminants in the landfill soil were only of concern because of their potential ingestion risk and not their potential to migrate to groundwater. The cap placed over the landfill contents was designed to prevent exposure to future site workers, thus eliminating the ingestion pathway, and not to prevent the generation of contaminated groundwater or leachate. Nonetheless, the groundwater sampling program is in place to monitor for possible future releases of waste constituents from the former landfill. As required by the IEPA, monitoring at the ENE Landfill will be conducted throughout the 15-year postclosure care period, which started in December 2002.

All wells shown in Figure 6.14 are included in the quarterly monitoring program. Parameters analyzed on a quarterly basis include total PCBs and filtered and unfiltered arsenic, chromium, lead, manganese, nickel, and selenium. Some of the wells are equipped with low flow samplers to reduce the impact of suspended sediment in the samples and to produce a more representative groundwater sample. Samples are collected using these samplers whenever possible; however, frequently, groundwater levels are too low to allow this type of sampler to operate. At times, site conditions prevented a vehicle from accessing the wells, which prevented the use of the low flow sampler since the vehicle is needed to operate the pumps. In such a situation, the pump was removed from the well and the sample was collected by hand with a baler.

The 2008 results of this program are summarized in Table 6.24. The averages of quarterly results that were above detection limits from each well are shown (the individual values were submitted to the IEPA with the required quarterly LTS report). As shown in this table, a number of average results exceed the GROs in unfiltered samples for arsenic, chromium, lead, manganese, and nickel in at least one of the eight wells sampled. The data show that total (unfiltered) metals results were much higher than dissolved (filtered) metals results. Only 1 of the 15 exceedances in 2008 was from a filtered sample, and this exceedance was for manganese, which is a relatively soluble and abundant naturally occurring metal. The higher metals concentrations found in unfiltered samples indicate that soil solids in the sample contributed to the elevated metals. Only 4 of the 35 samples collected in 2008 were collected with the low flow pump. Metals were found in only one of these samples, manganese at 90 µg/L, which was well below the limit of 150 µg/L. Thus, low flow sampling has a profound effect on metals concentrations in these wells. PCBs were not detected above the analytical detection limit of 0.5 µg/L in any of the eight wells.

Argonne is currently gathering data on normal background levels of naturally occurring groundwater constituents, such as iron, manganese, and nickel. Once a sufficient number of samples are obtained from the two upgradient wells, a statistical analysis of the results will be completed and a set of IEPA-approved background values established. The monitoring results will then be compared with these background values as well as the GROs. It is anticipated that many of the sample results that currently appear elevated will be shown to be consistent with natural background levels. Some of the highest levels of arsenic, lead, manganese, and nickel were found in the two background wells.

TABLE 6.24

Annual Average Concentrations of ENE Landfill Well Water Constituents, 2008

	Well No.									
Metal[a]	ENE-011	ENE-012	ENE-013D	ENE-021D	ENE-031	ENE-041	ENE-051	ENE-061[b]	ENE-071[b]	Standard
Arsenic–filtered	<25	<25	<25	<25	<25	<25	<25	<25	<25	50
Arsenic–unfiltered	<25	<25	<25	<25	34	<25	<25	**73**[c]	**51**	50
Chromium–filtered	<50	<50	<50	<50	<50	<50	<50	<50	<50	100
Chromium–unfiltered	<50	<50	<50	**224**	<50	<50	<50	80	66	100
Lead–filtered	<4	<4	<4	<4	<4	<4	<4	<4	<4	7.5
Lead–unfiltered	4	<4	<4	<4	**19**	**8**	**18**	**93**	**57**	7.5
Manganese–filtered	<75	<75	<75	85	**359**	87	<75	<75	145	150
Manganese–unfiltered	140	134	<75	102	**1,111**	**861**	**902**	**3,902**	**2,231**	150
Nickel–filtered	<50	<50	<50	<50	<50	<50	<50	<50	<50	100
Nickel–unfiltered	<50	<50	<50	<50	<50	<50	<50	**203**	90	100
Selenium–filtered	<10	<10	<10	<10	<10	<10	<10	<10	<10	50
Selenium–unfiltered	<10	<10	<10	<10	<10	<10	<10	<10	<10	50
PCB–total	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.0

[a] Concentrations in µg/L.

[b] Wells ENE-061 and ENE-071 are upgradient, background wells.

[c] Bold type indicates that the value exceeds the GRO.

6.4.4. Monitoring of the Seeps South of the 300 Area

In 1996, during the RFI of the 317/319 Area, a series of groundwater seeps was discovered in a network of steeply eroded ravines in the Waterfall Glen Forest Preserve southeast of the 317 and 319 Areas. Shallow monitoring wells were placed in three locations where the seeps are visible at the surface. These wells (SP01, SP02, and SP04) are located about 200 m (600 ft) south of the 319 Area. SP04 is located adjacent to an old hand-dug well. The locations are shown in Figure 6.15. The seeps are located in a pristine, heavily wooded section of the forest preserve. The ravines carry stormwater drainage from the 317 and 319 Areas and intersect a thin shallow sandy layer containing small amounts of groundwater. Water emanating from the exposed sandy layer flows to the nearby ravine, where it forms a small rivulet in the bottom of the ravine. Approximately 30 m (100 ft) downstream of the seep area, the water from the seeps is usually no longer visible because it drains back into the soil in the bed of the ravine or evaporates. During extended dry-weather conditions, the seeps disappear completely.

All three seeps have been monitored on a regular basis since discovery. Only hydrogen-3 and three VOCs (carbon tetrachloride, chloroform, and tetrachloroethene) have been consistently found. During 2008, the seeps were sampled quarterly for VOCs and hydrogen-3. Table 6.25 contains the results for 2008. VOCs were noted in all three seeps, but levels of VOCs in SP01 and SP02 were very low. Seep SP04 showed the highest levels all four quarters, and it was the only seep that contained tetrachloroethene (PCE) above detection limits. Figure 6.16 contains a series of charts showing annual average concentrations for these three constituents since 1996. As seen in this figure, the VOC concentrations vary significantly from year to year. The VOCs in seeps SP01 and SP04 appear to be declining slowly. The VOCs in SP02 increased for several years after monitoring began but have been slowly decreasing since 2002. The VOC concentrations in SP04 are several orders of magnitude higher than the other seeps. The concentrations appear to be strongly influenced by precipitation, as shown in Figure 6.17. This figure shows how the concentrations of carbon tetrachloride and chloroform vary in SP04. In three instances during extended dry periods, SP04 was completely dry. Immediately after such dry periods, the carbon tetrachloride and chloroform concentrations were found to have decreased significantly. They then increased to relatively high levels, which in turn slowly decreased once normal precipitation patterns returned. These fluctuations may indicate that a decreasing groundwater elevation caused the groundwater to flow through relatively clean portions of the saturated zone, where it picked up little contamination. During periods when groundwater is normal or higher than normal, the groundwater flows through more contaminated soil, resulting in higher VOC concentrations.

During 2008, the samples from all three seeps were reported to contain hydrogen-3 at levels slightly above the detection limit of 100 pCi/L. The slightly elevated results are believed to be artifacts of the analytical process rather than actual detections. Prior to these samples, hydrogen-3 had not been found in SP01 or SP04 since 2005, and in SP02 since 2007. Figure 6.18 shows the hydrogen-3 results in all three seeps since 1997. This figure shows that, with the exception of the last two quarters of 2008, there was a rapid decline in hydrogen-3 concentrations between 1999 and 2005, and since 2005 the results have all been at or below detection limits.

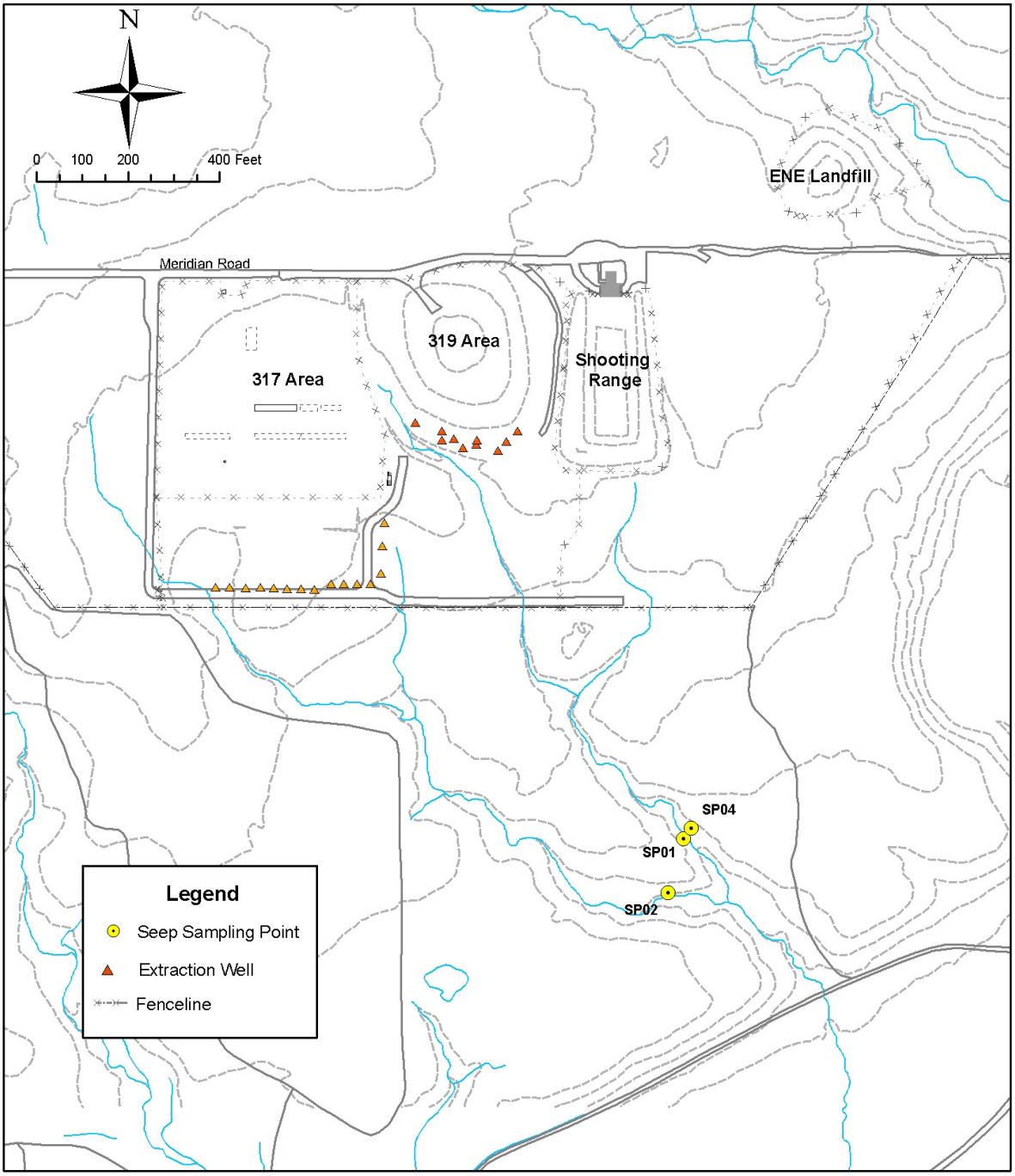


FIGURE 6.15 Seep Locations South of the 317/319 Area

TABLE 6.25

Contaminant Concentrations in Seep Water, 2008[a]

Sample Date	Carbon Tetrachloride (µg/L)	Chloroform (µg/L)	Tetrachloroethene (µg/L)	Hydrogen-3 (pCi/L)	Cesium-137 (pCi/L)
SP01					
1/11/2008	6	2	<1	< 100	< 2.0
4/15/2008	3	< 1	<1	< 100	< 2.0
7/23/2008	2	1	<1	118	12.6
10/27/2008	4	3	<1	117	6.8
SP02					
1/11/2008	2	1	<1	< 100	< 2.0
4/15/2008	1	< 1	<1	< 100	< 2.0
7/23/2008	1	< 1	<1	142	9.2
10/27/2008	1	< 1	<1	196	2.1
SP04					
1/11/2008	110	15	5	< 100	< 2.0
4/15/2008	188	18	6	< 100	< 2.0
7/23/2008	195	22	7	113	6.5
10/27/2008	162	23	7	116	< 2.0

[a] In addition to the analytical results shown above, the seeps were reported to contain several VOCs at concentrations less than the 1-µg/L detection limit (reported as estimated values per EPA procedures). These included 111-TCA, bromoform, and TCE. 2-Propanol was found in SP02 at 20 µg/L and in SP04 at 11 µg/L. This compound was found in the 317 French drain but has not been detected in the seeps previously.

The decline in hydrogen-3 is related to the installation of the cap over the 319 Area Landfill, which is the likely source of the hydrogen-3 at the seeps. The decline in hydrogen-3 has been much more rapid than radioactive decay alone would account for.

The cesium-137 samples for the last two quarters also were reported to contain values above the detection limits of 2 pCi/L. As discussed elsewhere, these results are also thought to be laboratory artifacts since cesium-137 has only been previously detected once, in 2003 in one seep, Many other 2008 radiological analysis results from unrelated samples collected during the last two quarters also exhibited unusual results slightly above detection limits.

Monitoring for hydrogen-3 was also conducted quarterly in the forest preserve at an artesian well located about 2,000 m (6,000 ft) southwest of the 317 Area (grid location 3E in Figure 1.1). All hydrogen-3 concentrations in 2008 were below the detection limit of 100 pCi/L. This finding suggests that any subsurface hydrogen-3 contamination does not extend to this location.

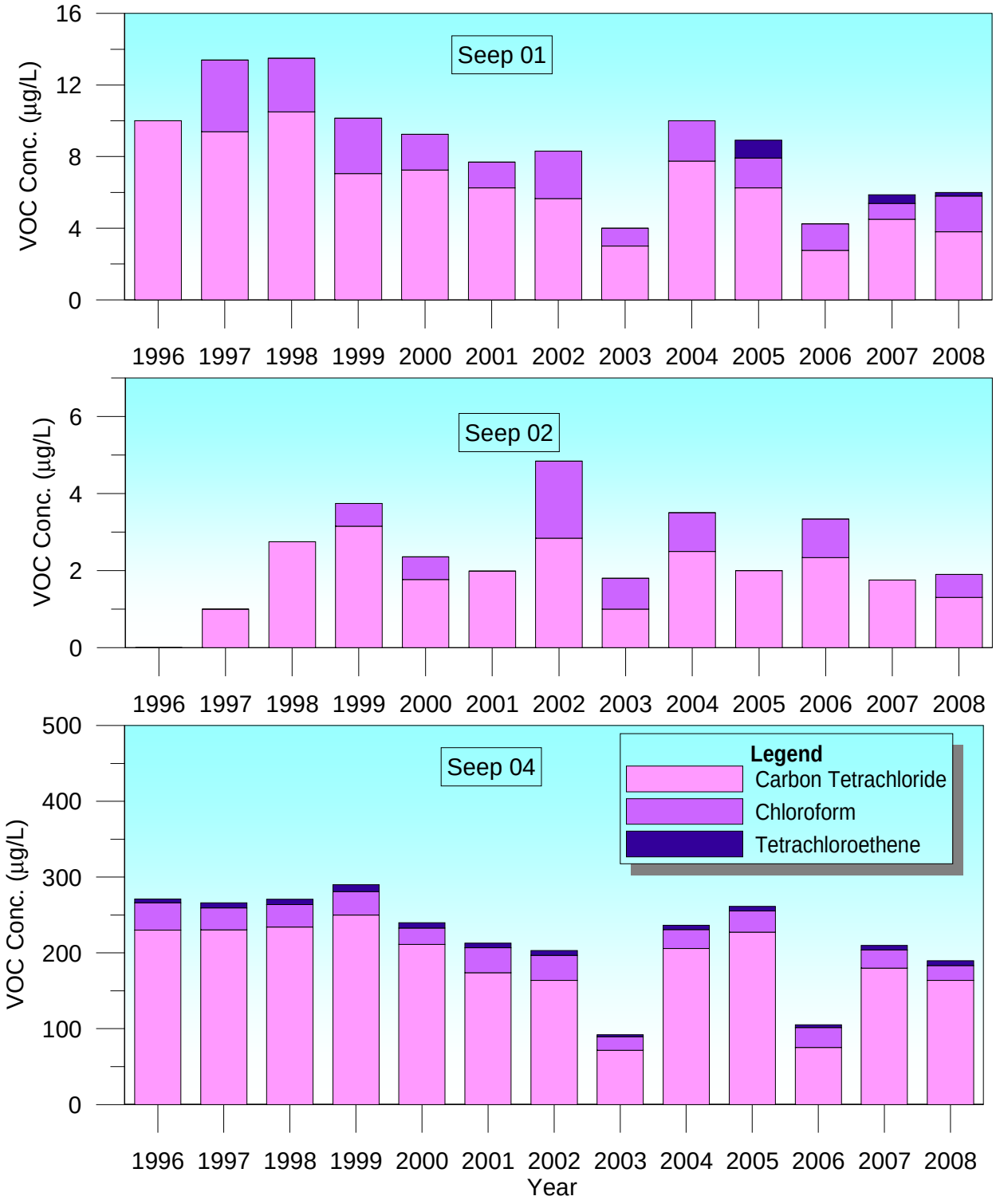


FIGURE 6.16 Groundwater Seeps Annual Average VOC Concentrations since 1996

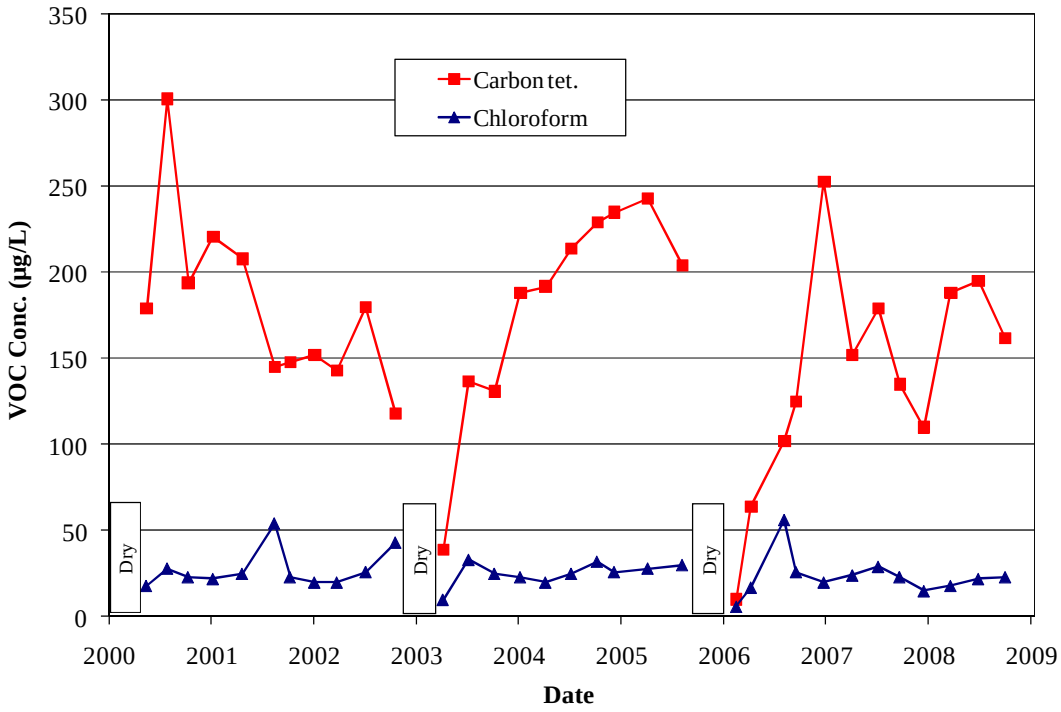


FIGURE 6.17 Carbon Tetrachloride and Chloroform Concentrations in Seep 04, 2000 to 2008

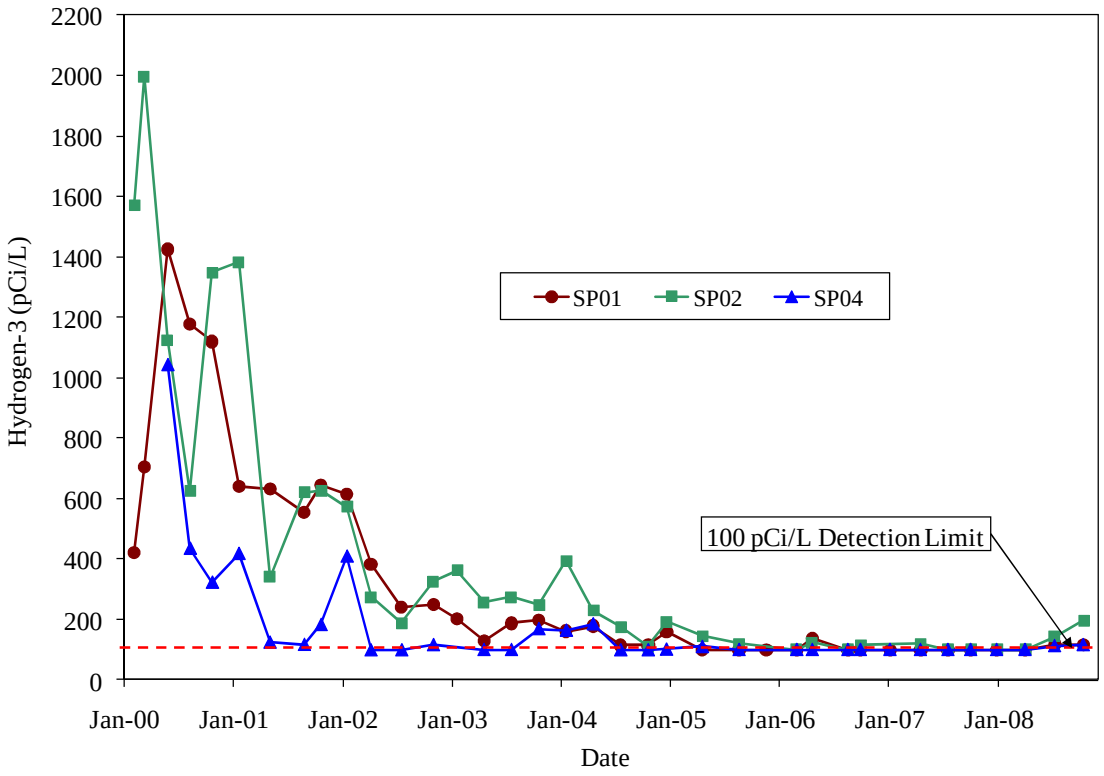


FIGURE 6.18 Hydrogen-3 Concentrations in Seep Water, 2000 to 2008

6.4.5. Monitoring at the Groundwater Management Zone (GMZ) Area

Remedial investigations and remedial actions have been underway in the 317/319 Area since 1994. Many of these actions have been discussed elsewhere in this chapter. These actions were focused on identifying, removing, or containing sources of contamination. The final such action was the installation of the phytoremediation system in 1999. Because of the nature, extent, and depth of contamination, it was not feasible to remove all contaminated soil or groundwater during the active remediation phase. The phytoremediation system, as well as the groundwater extraction systems, was intended to contain residual contamination and slowly reduce contaminant levels until the GRO levels are attained. The regulatory tool the IEPA utilizes to oversee such a remedial process is a GMZ. 35 IAC Part 620.250 allows for the establishment of a GMZ as a three-dimensional region containing groundwater being actively remediated to clean up contamination caused by past releases. For a GMZ to be sustained, the groundwater within the proposed GMZ must be managed to ensure that cleanup of the contaminants continues until GRO levels, or some alternative standard approved by the IEPA, are achieved. Because of the proximity of the 317 and 319 Areas and the fact that the groundwater plumes have intermingled and emerged to the surface in the seeps, the entire area encompassing the 317 Area, 319 Area, and the area extending down to the seeps was included within the GMZ. The GMZ measures approximately 8.9 ha (22 acres) in extent. The GMZ was approved by the IEPA on November 22, 2000.

The boundaries of the GMZ are delineated by a set of monitoring wells that are located on the outer boundary of the region of contaminated groundwater, both laterally and vertically. These wells are intended to be in clean groundwater unaffected by past releases. Figure 6.19 shows the locations of these boundary wells. Three of these perimeter wells are screened in the glacial drift (Wells 317971, 319781, and 319801), and four are in the upper dolomite bedrock (Wells 317012D, 317951D, 319961D, and 319013D). The network includes three mini-monitoring wells (MMW06D, MMW013, and MMW011) installed in the shallow glacial drift in the forest preserve between the Argonne site and the seeps. Because of the inaccessibility of this area, a different well installation technique was used that required the installation of small diameter wells, termed mini-monitoring wells. Well 317941, show in Figure 6.19, has had contamination above GROs for several years and was replaced by Well 317971 in 2002. Well 317941 continues to be sampled but is no longer considered a perimeter GMZ well. Wells 317951D and 319961D were installed in 2002 to replace existing dolomite Wells 317121D and 319131D, which were installed in 1988 by using techniques that are no longer used to install groundwater monitoring wells. Both the original and replacement wells will be sampled for several years to compare results. If similar results are found, the older wells will be closed.

Samples from the GMZ wells are collected semiannually. The samples are analyzed for the list of Contaminants of Concern for the 317 and 319 Areas, which includes a number of VOCs, two semivolatile organics *(bis*(2-ethylhexyl)phthalate and nitrobenzene), one pesticide (alpha-BHC), and hydrogen-3. The purpose of this monitoring is to determine if contamination has migrated beyond the perimeter of the approved GMZ. The averages of the two semiannual samples collected in 2008 are shown in Table 6.26. The individual results were transmitted to the IEPA in the quarterly LTS report.

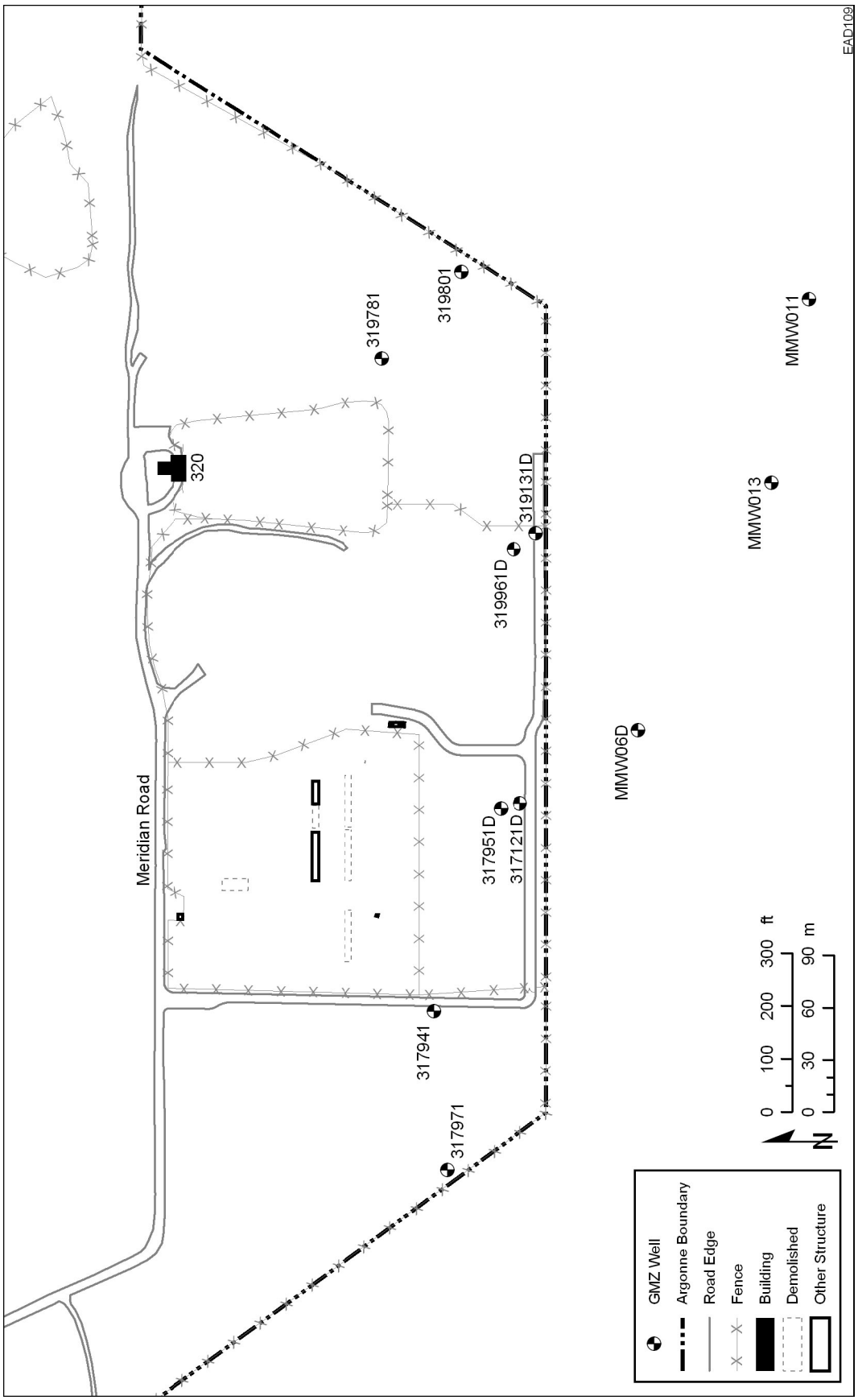


FIGURE 6.19 Locations of Monitoring Wells in the GMZ within the 317/319 Area and Adjacent Forest Preserve Property

TABLE 6.26

Annual Average Results from the GMZ Monitoring Wells, 2008
(concentrations in µg/L, except hydrogen-3)

	Well No.						
Parameter	319781	317951D	319961D	317121D	319131D	319801	GRO
Alpha-BHC	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.03
Benzene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	5.0
Carbon tetrachloride	<1.0	<1.0	0.4	<1.0	0.6	<1.0	5.0
Chloroform	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.2
1,1-Dichloroethane	<1.0	<1.0	<1.0	0.4	<1.0	<1.0	700
1,2-Dichloroethane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	5.0
1,1-Dichloroethene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	7.0
cis-1,2-Dichloroethene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	70
1,4-Dioxane	<1.0	**14**[a]	0.9	**5.5**	**2.0**	<1.0	1.0
bis(2-ethylhexyl)phthalate	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	6.0
Hydrogen-3 (pCi/L)	<100	267	1,124	185	886	<100	20,000
Methylene chloride	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	5.0
Nitrobenzene	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	3.5
Tetrachloroethene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	5.0
1,1,1-Trichloroethane	<1.0	<1.0	0.2	<1.0	0.2	<1.0	200
1,1,2-Trichloroethane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.5
Trichloroethene	<1.0	<1.0	<1.0	<1.0	0.2	<1.0	5.0
Vinyl chloride	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.0

	Well No.					
Parameter	317941	317971	MMW06[b]	MMW011[b]	MMW013	GRO
Alpha-BHC	<0.03	<0.03	DRY[c]	<0.03	<0.03	0.03
Benzene	<1.0	<1.0	<1.0	<1.0	<1.0	5.0
Carbon tetrachloride	<1.0	<1.0	<1.0	<1.0	<1.0	5.0
Chloroform	<0.2	<0.2	<0.2	<0.2	<0.2	0.2
1,1-Dichloroethane	2.0	<1.0	<1.0	<1.0	<1.0	700
1,2-Dichloroethane	0.5	<1.0	<1.0	<1.0	<1.0	5.0
1,1-Dichloroethene	<1.0	<1.0	<1.0	<1.0	<1.0	7.0
cis-1,2-Dichloroethene	22	<1.0	<1.0	<1.0	<1.0	70
1,4-Dioxane	0.8	<1.0	<1.0	<1.0	1.0	1.0
bis(2-ethylhexyl)phthalate	<6.0	<6.0	DRY[c]	<6.0	<6.0	6.0
Hydrogen-3 (pCi/L)	1,202	<100	126	<100	149	20,000
Methylene chloride	<1.0	<1.0	<1.0	<1.0	<1.0	5.0
Nitrobenzene	<3.5	<3.5	DRY[c]	<3.5	<3.5	3.5
Tetrachloroethene	<1.0	<1.0	<1.0	<1.0	<1.0	5.0
1,1,1-Trichloroethane	<1.0	<1.0	<1.0	<1.0	<1.0	200
1,1,2-Trichloroethane	<1.0	<1.0	<1.0	<1.0	<1.0	0.5
Trichloroethene	<1.0	<1.0	<1.0	<1.0	<1.0	5.0
Vinyl chloride	**7.0**	<2.0	<2.0	<2.0	<2.0	2.0

[a] Bold type indicates that the value exceeds the GRO.

[b] Mini-well MMW06 was only sampled during the second semiannual sampling event, and MMW011 was only sampled during the first. The results shown are for the single samples from each well.

[c] Mini-well MMW06 did not yield enough water to perform all the analyses. Only VOCs were analyzed.

Monitoring results from 2008 indicate that 1,4-dioxane was the only compound in the perimeter wells that was present above GROs. 1,4-Dioxane is present above the GRO in two adjacent bedrock monitoring wells (317121D and 317951D) and in the other older dolomite well, 319131D. The replacement dolomite well at this location had 1,4-dioxane present at a level just below the GRO. The fact that both the original and replacement wells contained 1,4-dioxane tends to indicate that its presence is likely the result of migration through the glacial till overlying the bedrock, and not the result of outdated or deteriorating well construction, as previously believed. 1,4-Dioxane was found in MMW013 at the GRO of 1.0 µg/L. Well 317941 exceeds the GRO for vinyl chloride; however, this well does not represent the western boundary of the GMZ.

The presence of 1,4-dioxane in the deepest of the GMZ wells indicates that the vertical extent of the contaminated region is not yet be defined. If subsequent monitoring of the replacement well continues to confirm the presence of contamination above GROs, it may be necessary to install a deeper well to better delineate the bottom of the contaminated region.

6.5. Sanitary Landfill

The former Argonne sanitary landfill is located in the 800 Area on the western edge of the site (see Figure 1.1). The 8.8-ha (21.8-acre) former landfill received miscellaneous solid waste from 1966 until September 1992 and was operated under IEPA Permit No. 1981-29-OP, which was issued in 1981. The landfill received general refuse, construction debris, boiler house ash, and other nonradioactive solid waste. The landfill was also used for the disposal of liquid wastes from 1969 to 1978. The wastes were placed into the landfill through a French drain, which consisted of a pipe inserted into the waste mound. The liquid waste was poured into the pipe and allowed to absorb into the waste. Historic documentation indicates that 109,000 L (29,000 gal) of liquid waste was placed in this drain. Most of this material was used oil or used machining coolant (an oil-water emulsion), though small quantities of toxic wastes were also placed in the landfill.

The landfill was closed in 1992 pursuant to Permit No. 1992-002-SP and Supplemental Permit Nos. 1994-506-SP, 1997-295-SP, 1998-017-SP, 1999-107-SP, 1999-476-SP, and 2002-194-SP. Closure of the landfill and associated areas was also subject to the RCRA Corrective Action process since the landfill area included SWMUs No. 4 (landfill mound), No. 20 (the French drain), and No. 744 (a small area of buried waste adjacent to the main waste mound), and AOC-B (wetlands immediately adjacent to the landfill) and AOC-C (leachate seeps from the waste mound). Closure included the installation of a 0.6-m (2-ft) thick compacted clay cap over the waste mounds. An RFI was required under the RCRA Corrective Action program. This RFI was conducted to determine if any hazardous materials had migrated from the landfill. It consisted of an extensive characterization program that was completed in 1997. Measurable amounts of several hazardous materials were identified in leachate in the waste mound itself and a small amount in the adjacent wetlands, but none were found in groundwater near the landfill. The study determined that no further remedial actions were required. An NFA determination was received from the IEPA on March 25, 2003, in a RCRA Part B permit modification. This letter specified that postclosure care and future groundwater monitoring activities at the 800 Area Landfill would be carried out under the corrective action provisions (Section V) of Argonne's RCRA Part B permit.

The 15-year postclosure care period for the landfill began in 1999. The primary requirements during postclosure are groundwater monitoring and maintenance and inspection of the landfill cap. This section discusses the groundwater monitoring results for 2008.

On October 25, 2005, the IEPA modified the RCRA corrective action permit for the 800 Area Landfill to include a set of background values for groundwater constituents upgradient of the landfill. The background values were developed from five years of monitoring results from two upgradient monitoring wells, one in the shallow glacial drift and one in the dolomite bedrock. These background levels, along with IEPA groundwater quality standards for unfiltered samples, are compared with the analytical results from landfill perimeter wells to determine if a release has occurred from the landfill. The background values are discussed in Section 6.5.1.3.

6.5.1. Sanitary Landfill Groundwater Monitoring

The current groundwater monitoring well network is shown in Figure 6.20. Table 6.27 contains a description of each active well. All wells are specially designed groundwater monitoring wells consisting of 0.05-m (2-in.) diameter stainless-steel casings and screens installed in boreholes sealed with bentonite grout, a concrete cap, and locking steel protective cover. The network consists of three groups of wells. Fifteen shallow wells are screened in shallow glacial till between 4 and 14 m (13 and 46 ft) deep. These wells have well screens situated in a series of thin porous sandy zones within the glacial drift under the 800 Area. They provide samples of the uppermost layers of groundwater under and adjacent to the landfill. Five deep wells are screened in the top of the dolomite limestone bedrock underlying the glacial till. The upper part of the dolomite bedrock represents the uppermost true aquifer under the landfill that has the potential for off-site migration of groundwater. These five wells are situated near five of the shallow wells, forming five well clusters. Two background wells (800271 and 800273D) are located in a cluster approximately 670 m (2,200 ft) to the northeast of the landfill mound. These wells are located out of the influence of the landfill and provide information on the normal background level of groundwater constituents.

Prior to 2005, the network also included four intermediate wells (800382, 800192, 800202, and 800272) that were part of three-well clusters with shallow and deep dolomite wells. These wells were usually dry and did not yield meaningful results for the monitoring program. They were removed from the network by the October 2005 RCRA Part B permit modification. Thus, these wells are no longer included in the program, and no data from them are included in this report.

The wells were installed in stages, and a number of wells have been installed, monitored, and removed from the network over the last 20 years. Only the currently active wells are described in this report. The oldest set of active wells was installed in 1992 as part of the closure process. Additional wells were installed in 1999 to enhance the effectiveness of the network. Well 800191R, installed in 2005, is a replacement for the original 800191 well, which was removed because its sampling pump failed and could not be removed from the well.

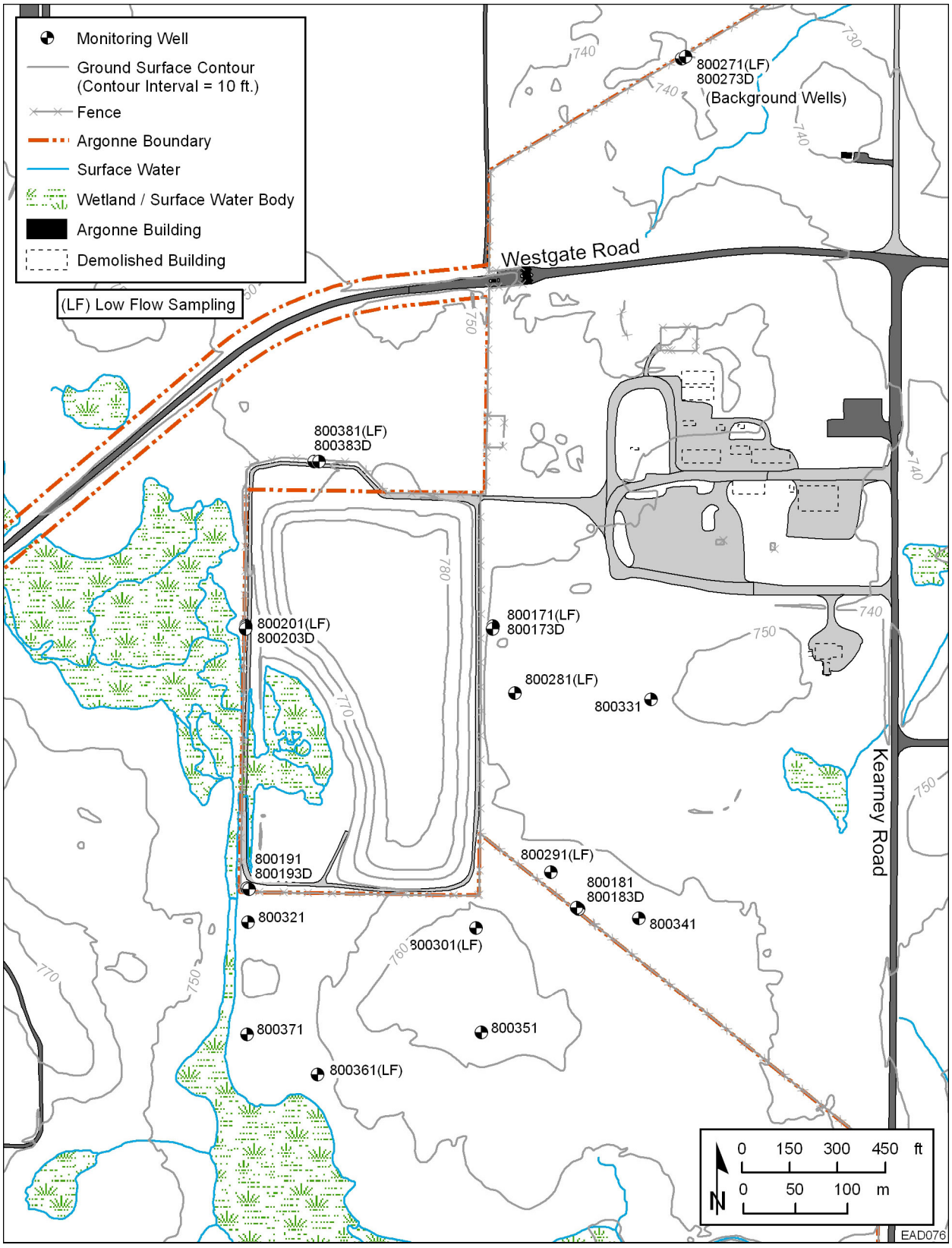


FIGURE 6.20 800 Area Landfill Monitoring Wells

TABLE 6.27

Groundwater Monitoring Wells: 800 Area Landfill

Argonne ID Number	IEPA Well Number	Well Depth (m bgs)	Ground Elevation (m AMSL)	Monitoring Zone (m AMSL)	Date Drilled	Sampling Device
Background Wells						
800271	G16S	4.57	225.62	223.18–221.65	Aug. 1999	Low flow pump
800273D[a]	D16D	37.49	225.61	191.78–188.12	Aug. 1999	Submersible pump
Shallow Monitoring Wells						
800171	G06S	7.62	228.42	222.32–220.80	Oct. 1992	Low flow pump
800181	G08S	10.67	230.52	221.37–219.85	Oct. 1992	Bailer
800191R[b]	G11S	4.63	227.38	224.43–222.90	Sept. 2005	Bailer
800201	G14S	10.67	227.93	218.78–217.26	Oct. 1992	Low flow pump
800281	G17S	3.96	227.66	225.52–224.00	Sept. 1999	Low flow pump
800291	G18S	7.01	230.49	225.00–223.48	Sept. 1999	Low flow pump
800301	G19S	7.62	232.53	226.51–224.91	Sept. 1999	Low flow pump
800321	G21S	4.27	227.93	225.26–223.66	Sept. 1999	Bailer
800331	G22S	5.18	227.93	224.27–222.75	Sept. 1999	Bailer
800341	G23S	3.96	229.97	227.53–226.01	Sept. 1999	Bailer
800351	G24S	11.89	232.75	223.91–220.86	Sept. 1999	Bailer
800361	G25S	7.01	227.24	222.12–220.52	Sept. 1999	Low flow pump
800371	G26S	9.75	227.50	219.27–217.44	Sept. 1999	Bailer
800381	G03S	7.31	231.11	227.44–224.40	June 1999	Low flow pump
Dolomite Bedrock Monitoring Wells						
800173D	G06D	39.62	228.40	192.13–189.09	Oct. 2001	Submersible pump
800183D	G08D	49.99	230.37	183.43–180.38	Oct. 2001	Submersible pump
800193D	G11D	46.02	227.34	184.40–181.35	Oct. 2001	Submersible pump
800203D	G14D	38.40	227.92	192.63–189.47	Sept. 2001	Submersible pump
800383D	G03D	44.50	231.24	190.39–187.35	June 2001	Submersible pump

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

[b] Replacement for original Well 800191.

6.5.1.1. Sample Collection

Each well is sampled quarterly in accordance with the RCRA Part B permit. During the first, third, and fourth quarters, only the List 1 (field parameters of groundwater depth, pH, specific conductivity, and temperature) and List 2 (filtered metals, sulfate, chloride, TDS, cyanide, phenols, total organic carbon [TOC], and total organic halogen [TOX]) properties and constituents are measured. During the second quarter, additional samples are collected and analyzed for List 3 and 3A parameters (unfiltered metals, VOCs, SVOCs, PCBs, pesticides, and herbicides). In addition to the required annual analyses, VOCs and hydrogen-3 are also monitored voluntarily by Argonne during all quarters to provide better documentation of conditions under the landfill.

During the early years of monitoring the landfill, it was noted that high levels of unfiltered metals were detected in samples with high levels of turbidity. The turbidity resulted from the resuspension of soil solids in the sample during the collection of samples using a bailer. The bailer agitates the water in the well as it is lowered into the well. It was thought that many of the high metals concentrations in shallow wells were artifacts of this type of sampling and not a result of landfill operations. To reduce this source of interference, low flow sampling was implemented. Starting in 2003, IEPA-approved low flow sampling devices were installed in Wells 800171, 800201, 800281, 800291, 800301, 800361, and 800381 and the shallow background Well 800271. This low flow sampling system allows samples to be collected at a steady, low flow rate that does not disturb the sediment in the well. The remaining wells are sampled using a baler. The wells with low flow samplers in Figure 6.20 have "(LF)" next to the well number.

Samples from the deeper dolomite wells are collected by using an electronic submersible pump. These wells are screened in fractured rock that does not produce as much sediment as the glacial drift does. Thus, low flow samplers are not required in these wells.

Wells that are equipped with a bailer or submersible pumps are sampled after stagnant water is purged from the well by removing 3 to 5 well volumes of water out of the well. The temperature, pH, conductivity, and redox potential are measured periodically as the purging process progresses. Samples are collected after the water quality parameters have stabilized.

Wells equipped with low flow samplers are sampled once water quality parameters stabilize regardless of the amount of water removed. The low flow sampling system pumping rate is controlled by monitoring the field parameters while pumping at a rate low enough to prevent significant drawdown of water in the well. Turbidity of the groundwater is also monitored during this process. For these wells, samples are collected after the field parameters have stabilized and turbidity has reached its target level. Field parameter values reported are those measured after purging is complete.

6.5.1.2. Sample Analyses — 800 Area

The analysis of 800 Area groundwater samples is conducted by ESQ-AS as well as several commercial laboratories. The 800 Area sample analyses were performed using EPA-approved analytical procedures discussed in Chapter 5, Table 5.2, and radiological analyses procedures shown in Table 6.2.

6.5.1.3. Basis for Evaluation of Analytical Results

The monitoring results are evaluated by comparing the results with either the IEPA-approved background values or the GQS for each constituent, where such limits exist. For routine indicator parameters (Lists 1 and 2), the permit requires the comparison of the individual results with background results. For unfiltered metals and organic analyses, the results are compared with the GQSs for Class I Potable Resource Groundwater (35 IAC Part 620.410),

where such standards exist. Otherwise, they are compared with the practical quantitation limit (PQL) for that compound. Table 6.28 lists all of the applicable permit limits for the 800 Area landfill. Footnotes to this table explain the source of the individual groundwater quality limits. A number of filtered metals results do not have permit limits. These results are collected for informational purposes only and are not reported to the IEPA. In the data tables that follow, values that exceed these background values or permit limits are shown in bold print.

6.5.1.4. Results of Analyses

Field parameters measured during sample collection and the results of chemical and radiological analysis are presented in the following tables. Results for the two background wells are presented in Tables 6.29 and 6.30; the shallow landfill wells are presented in Tables 6.31 through 6.44; and the dolomite wells in Tables 6.45 through 6.49. The results for all inorganic species measured are shown in these tables. In addition to the inorganics, each well was analyzed quarterly for VOCs and annually for SVOCs, PCBs, and pesticides. The analytical method used for these compounds is able to identify and quantify all of the compounds contained in the CLP Target Compound List to concentrations of less than 1 to 10 μg/L. However, none were detected above the detection limits in any of the wells. These constituents are not shown in the following tables for clarity.

6.5.2. Discussion of Results — Shallow Wells

The shallow wells produce groundwater samples from the uppermost saturated zones underlying the landfill. As such, they would be the first to show evidence of migration of hazardous materials from the landfill if such migration was occurring. The soil in these saturated zones is a highly heterogeneous mix of clay, silt, sand, and gravel, with somewhat different geochemistry in each saturated region. As a result, the concentrations of naturally occurring constituents will vary considerably from zone to zone.

The RFI of the 800 Landfill identified several potential contaminants of concern in the leachate from the waste. The most significant contaminants were low levels of PCBs and pesticides (Aroclor 1260, DDE, and DDT), several VOCs (toluene, acetone, and methylene chloride), and SVOCs (several phthalates). Many of these were thought to be artifacts caused by inadvertent contamination of the samples in the laboratory and were not actually present in the landfill. Several metals were detected above background in soil, but these were attributed to natural variation in soil composition. Thus, if VOCs or SVOCs were detected in groundwater it may indicate that waste products from the landfill are being released. As the following data tables demonstrate, there were no detections of these materials in any of the groundwater samples collected in 2008. Thus, there is no indication of a release of hazardous materials from the landfill. However, the data are useful in understanding the hydrogeology and geochemistry of the area surrounding the landfill.

TABLE 6.28

Permit Limits for 800 Area Groundwater

Parameter	Unit	Permit Limit – Shallow Wells	Source[a]	Permit Limit – Deep Wells	Source[a]
Field Parameters					
Conductivity	µS/cm	703	4	1,306	1
Oxid./red. potential	mV	NA[b]	–[c]	NA	–
pH	pH	6.57–7.88	1	6.48–7.74	1
Temperature	ºC	NA	–	NA	–
Water elevation	m	NA	–	NA	–
Filtered Samples					
Ammonia nitrogen	mg/L	0.90	4	1.0	4
Chloride	mg/L	20	4	137	1
Sulfate	mg/L	58.54	1	152	1
TDS	mg/L	428.45	1	880	1
Arsenic	mg/L	0.010	2	0.0048	4
Barium	mg/L	NA	–	NA	–
Boron	mg/L	NA	–	NA	–
Cadmium	mg/L	0.001	2	0.001	2
Chromium	mg/L	NA	–	NA	–
Cobalt	mg/L	NA	–	NA	–
Copper	mg/L	NA	–	NA	–
Iron	mg/L	0.099	4	1.60	1
Lead	mg/L	0.01	2	0.01	2
Manganese	mg/L	0.097	4	0.021	4
Mercury	mg/L	0.002	2	0.002	2
Nickel	mg/L	NA	–	NA	–
Selenium	mg/L	NA	–	NA	–
Silver	mg/L	NA	–	NA	–
Zinc	mg/L	NA	–	NA	–
Unfiltered Samples					
Chloride	mg/L	200	3	200	3
Cyanide (total)	mg/L	0.011	4	0.04	2
Fluoride	mg/L	4.0	3	4.0	3
Nitrate	mg/L	10.0	3	10.0	3
Phenols	mg/L	0.033	4	0.033	4
Sulfate	mg/L	400	3	400	3
TOC	mg/L	2.71	5	5.3	4
TOX	mg/L	0.086	4	0.041	4
Arsenic	mg/L	0.05	3	0.05	3
Barium	mg/L	2.0	3	2.00	3
Boron	mg/L	2.0	3	2.00	3
Cadmium	mg/L	0.005	3	0.005	3
Chromium	mg/L	0.10	3	0.10	3
Cobalt	mg/L	1.0	3	1.00	3
Copper	mg/L	0.65	3	0.65	3
Iron	mg/L	5.0	3	5.00	3

TABLE 6.28 (Cont.)

Parameter	Unit	Permit Limit – Shallow Wells	Source[a]	Permit Limit – Deep Wells	Source[a]
Unfiltered Samples (Cont.)					
Lead	mg/L	0.008	3	0.008	3
Manganese	mg/L	0.15	3	0.15	3
Mercury	mg/L	0.002	3	0.002	3
Nickel	mg/L	0.10	3	0.10	3
Selenium	mg/L	0.05	3	0.05	3
Silver	mg/L	0.05	3	0.05	3
Zinc	mg/L	5.0	3	5.0	3

[a] The various permit limits were generated in the following manner:
1 = Calculated from 95% upper confidence interval of the data set. Calculation uses one-half the detection limits for values less than the detection limits.
2 = Background values equal the PQL for that constituent. All measured values in background wells were below PQLs.
3 = IEPA's Class 1 Groundwater Quality Standard.
4 = Background value based on nonparametric statistical methods for data sets with more than 15% but less than 100% of measured values below detection limits.
5 = Calculated from 95% upper confidence interval for data set that was first transformed by calculating the natural log of the measured values.

[b] NA indicates that no permit limit exists for this constituent. The data are collected for informational purposes only.

[c] A dash indicates that no limit exists, and thus listing a source is not necessary.

A discussion of groundwater flow direction and all analytical results for 2008 are summarized in the 2008 Annual Summary Assessment of the groundwater monitoring program for the 800 Area Landfill, which was sent to the IEPA in July 2009.

6.5.2.1. Field Parameters

Field parameters include well and water depth information, pH, specific conductivity, oxidation/reduction potential, and water temperature. The only parameter with approved background values is pH. Only two pH values in 2008 in a single well were outside of the range of background values. Well 800281 had one sample with a pH of 6.43 and a second with a value of 6.40, compared with the background lower limit of 6.57. The specific conductivity results are discussed in the next section. In general, the results are consistent from quarter to quarter and are similar to results obtained in previous years.

TABLE 6.29

Groundwater Monitoring Results, Sanitary Landfill Background Well 800271, 2008

Parameter	Unit	Date of Sampling 2/5/2008	4/22/2008	7/22/2008	10/21/2008
Field Parameters					
Conductivity	µS/cm	455	584	614	655
Oxid./red. potential	mV	-5	-15	-7	-7
pH	pH	7.23	7.30	7.24	7.13
Temperature	ºC	6.0	11.1	16.5	12.1
Water elevation[a]	m	224.82	225.25	224.18	224.08
Filtered Samples					
Ammonia nitrogen	mg/L	< 0.05	< 0.05	< 0.05	0.13
Chloride	mg/L	5	7	5	3
Sulfate	mg/L	30	22	23	23
TDS	mg/L	266	255	281	256
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.016	0.015	0.019	0.020
Boron	mg/L	< 0.1	< 0.1	< 0.1	< 0.1
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.021	< 0.021	< 0.021	< 0.021
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.02	0.021	< 0.02	0.031
Unfiltered Samples					
Chloride	mg/L	–[b]	7	–	–
Cyanide (Total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	–	0.14	–	–
Hydrogen-3	pCi/L	< 100	< 100	< 100	166
Nitrate	mg/L	–	9.3	–	–
Phenols	mg/L	< 0.005	< 0.005	< 0.005	< 0.005
Sulfate	mg/L	–	22	–	–
TOCs (max. of 4 samples)	mg/L	1.0	1.3	1.3	1.3
TOXs (max. of 2 samples)	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Arsenic	mg/L	–	< 0.003	–	–
Barium	mg/L	–	0.015	–	–
Boron	mg/L	–	< 0.1	–	–
Cadmium	mg/L	–	< 0.0002	–	–
Chromium	mg/L	–	< 0.05	–	–
Cobalt	mg/L	–	< 0.25	–	–
Copper	mg/L	–	< 0.025	–	–
Iron	mg/L	–	0.023	–	–
Lead	mg/L	–	< 0.004	–	–
Manganese	mg/L	–	< 0.01	–	–
Mercury	mg/L	–	< 0.0002	–	–
Nickel	mg/L	–	< 0.05	–	–
Selenium	mg/L	–	< 0.003	–	–
Silver	mg/L	–	< 0.001	–	–
Zinc	mg/L	–	< 0.02	–	–

[a] Well point elevation = 221.65 m (MSL); ground surface elevation = 225.62 m (MSL); casing material = stainless steel.

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

TABLE 6.30

Groundwater Monitoring Results, Sanitary Landfill Background Well 800273D, 2008

Parameter	Unit	Date of Sampling 2/5/2008	4/22/2008	7/22/2008	10/21/2008
Field Parameters					
Conductivity	µS/cm	784	1,062	1,015	1,057
Oxid./red. potential	mV	-2	-9	-7	-9
pH	pH	7.20	7.13	7.23	7.19
Temperature	ºC	8.7	11.7	12.7	10.6
Water elevation[a]	m	192.96	193.25	193.31	193.47
Filtered Samples					
Ammonia nitrogen	mg/L	0.63	0.90	0.92	**1.14**[b]
Chloride	mg/L	137	**147**	**141**	77
Sulfate	mg/L	113	105	107	101
TDS	mg/L	56	675	640	505
Arsenic	mg/L	0.004	0.003	0.004	**0.005**
Barium	mg/L	0.048	0.050	0.046	0.047
Boron	mg/L	0.15	0.16	0.15	0.17
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	1.08	1.01	1.03	0.73
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.02	< 0.02	< 0.02	0.023
Unfiltered Samples					
Chloride	mg/L	–[c]	138	–	–
Cyanide (Total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	–	0.38	–	–
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100
Nitrate	mg/L	–	< 0.1	–	–
Phenols	mg/L	0.026	< 0.005	0.025	< 0.005
Sulfate	mg/L	–	104	–	–
TOCs (max. of 4 samples)	mg/L	< 1.0	1.1	1.1	1.3
TOXs (max. of 2 samples)	mg/L	< 0.02	< 0.02	< 0.02	0.031
Arsenic	mg/L	–	0.004	–	–
Barium	mg/L	–	0.047	–	–
Boron	mg/L	–	0.158	–	–
Cadmium	mg/L	–	< 0.0002	–	–
Chromium	mg/L	–	< 0.05	–	–
Cobalt	mg/L	–	< 0.25	–	–
Copper	mg/L	–	< 0.025	–	–
Iron	mg/L	–	1.27	–	–
Lead	mg/L	–	< 0.004	–	–
Manganese	mg/L	–	0.011	–	–
Mercury	mg/L	–	< 0.0002	–	–
Nickel	mg/L	–	< 0.05	–	–
Selenium	mg/L	–	< 0.003	–	–
Silver	mg/L	–	< 0.001	–	–
Zinc	mg/L	–	< 0.02	–	–

[a] Well point elevation = 188.12 m (MSL); ground surface elevation = 225.61 m (MSL); casing material = stainless steel.

[b] Bold type indicates that the value exceeds the applicable limits shown in Table 6.28.

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

TABLE 6.31

Groundwater Monitoring Results, Sanitary Landfill Well 800171, 2008

Parameter	Unit	Date of Sampling 1/14/2008	4/9/2008	7/14/2008	7/14/2008 (Duplicate)	10/15/2008
Field Parameters						
Conductivity	µS/cm	600	**758**[a]	**1,015**	**1,015**	**1,027**
Oxid./red. potential	mV	15	5	13	13	13
pH	pH	6.83	7.18	6.88	6.88	6.80
Temperature	ºC	7.5	9.2	15.5	15.5	13.6
Water elevation[b]	m	227.29	227.75	225.43	225.43	226.00
Filtered Samples						
Ammonia nitrogen	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Chloride	mg/L	**43**	**41**	**62**	**55**	**28**
Sulfate	mg/L	50	46	**80**	**81**	**74**
TDS	mg/L	408	399	**547**	**546**	**537**
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.044	0.042	0.053	0.054	0.061
Boron	mg/L	0.14	0.12	0.11	0.11	0.16
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.021	< 0.021	< 0.021	< 0.021	< 0.021
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	0.02
Unfiltered Samples						
Chloride	mg/L	–[c]	39	–	–	–
Cyanide (Total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	–	0.17	–	–	–
Hydrogen-3	pCi/L	107	< 100	118	< 100	174
Nitrate	mg/L	–	2.6	–	–	–
Phenols	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Sulfate	mg/L	–	42	–	–	–
TOCs (max of 4 samples)	mg/L	**2.8**	2.6	1.9	1.9	2.4
TOXs (max of 2 samples)	mg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02
Arsenic	mg/L	–	< 0.003	–	–	–
Barium	mg/L	–	0.044	–	–	–
Boron	mg/L	–	0.134	–	–	–
Cadmium	mg/L	–	< 0.0002	–	–	–
Chromium	mg/L	–	< 0.05	–	–	–
Cobalt	mg/L	–	< 0.25	–	–	–
Copper	mg/L	–	< 0.025	–	–	–
Iron	mg/L	–	0.201	–	–	–
Lead	mg/L	–	< 0.004	–	–	–
Manganese	mg/L	–	0.034	–	–	–
Mercury	mg/L	–	< 0.0002	–	–	–
Nickel	mg/L	–	< 0.05	–	–	–
Selenium	mg/L	–	< 0.003	–	–	–
Silver	mg/L	–	< 0.001	–	–	–
Zinc	mg/L	–	< 0.02	–	–	–

[a] Bold type indicates that the value exceeds the applicable limits shown in Table 6.28.

[b] Well point elevation = 220.80 m (MSL); ground surface elevation = 228.42 m (MSL); casing material = stainless steel.

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

TABLE 6.32

Groundwater Monitoring Results, Sanitary Landfill Well 800181, 2008

Parameter	Unit	Date of Sampling			
		1/14/2008	4/29/2008	7/29/2008	10/15/2008
Field Parameters					
Conductivity	µS/cm	**948**[a]	621	**954**	**1,202**
Oxid./red. potential	mV	-20	-33	-23	-28
pH	pH	7.48	7.63	7.49	7.52
Temperature	ºC	8.9	8.9	11.9	10.8
Water elevation[b]	m	227.82	228.40	227.50	226.25
Filtered Samples					
Ammonia nitrogen	mg/L	<0.05	<0.05	<0.05	<0.05
Chloride	mg/L	13	15	15	8
Sulfate	mg/L	**148**	51	**131**	**113**
TDS	mg/L	**706**	299	**703**	**589**
Arsenic	mg/L	< 0.003	< 0.003	0.010	0.009
Barium	mg/L	0.042	0.025	0.038	0.039
Boron	mg/L	< 0.1	< 0.1	< 0.1	< 0.1
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.021	< 0.021	< 0.021	< 0.021
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.01	0.01	< 0.01	< 0.01
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.020	0.024	< 0.020	0.029
Unfiltered Samples					
Chloride	mg/L	–[c]	15	–	–
Cyanide (Total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	–	0.41	–	–
Hydrogen-3	pCi/L	< 100	< 100	< 100	111
Nitrate	mg/L	–	< 0.1	–	–
Phenols	mg/L	< 0.005	0.006	< 0.005	< 0.005
Sulfate	mg/L	–	151	–	–
TOCs (max. of 4 numbers)	mg/L	2.7	2.7	2.2	2.6
TOXs (max. of 2 numbers)	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Arsenic	mg/L	–	< 0.003	–	–
Barium	mg/L	–	0.026	–	–
Boron	mg/L	–	< 0.1	–	–
Cadmium	mg/L	–	< 0.0002	–	–
Chromium	mg/L	–	< 0.05	–	–
Cobalt	mg/L	–	< 0.25	–	–
Copper	mg/L	–	< 0.025	–	–
Iron	mg/L	–	0.114	–	–
Lead	mg/L	–	< 0.004	–	–
Manganese	mg/L	–	0.017	–	–
Mercury	mg/L	–	< 0.0002	–	–
Nickel	mg/L	–	< 0.05	–	–
Selenium	mg/L	–	< 0.003	–	–
Silver	mg/L	–	< 0.001	–	–
Zinc	mg/L	–	< 0.02	–	–

[a] Bold type indicates that the value exceeds the applicable limits shown in Table 6.28.

[b] Well point elevation = 219.85 m (MSL); ground surface elevation = 230.52 m (MSL); casing material = stainless steel.

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

TABLE 6.33

Groundwater Monitoring Results, Sanitary Landfill Well 800191R, 2008

Parameter	Unit	Date of Sampling 1/9//2008	4/8/2008	7/7/2008	10/6/2008
Field Parameters					
Conductivity	µS/cm	**1,501**[a]	**2,020**	**2,100**	**1,546**
Oxid./red. potential	mV	23	20	26	17
pH	pH	6.69	6.70	6.65	6.73
Temperature	ºC	9.8	7.5	12.2	13.3
Water elevation[b]	m	226.30	225.87	225.60	225.69
Filtered Samples					
Ammonia nitrogen	mg/L	0.20	**1.35**	0.90	0.26
Chloride	mg/L	**141**	**164**	**165**	**94**
Sulfate	mg/L	**579**	**630**	**693**	**377**
TDS	mg/L	**1,467**	**1,557**	**1,670**	**1,257**
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.026	0.028	0.024	0.028
Boron	mg/L	< 0.1	< 0.1	< 0.1	< 0.1
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	**0.777**	**2.060**	**0.305**	**0.116**
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	**0.916**	**1.080**	**0.565**	**0.380**
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.003	< 0.003	< 0.003	< 0.006
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Unfiltered Samples					
Chloride	mg/L	–[c]	165	–	–
Cyanide (Total)	mg/L	< 0.01	< 0.01	< 0.01	**0.034**
Fluoride	mg/L	–	0.49	–	–
Hydrogen-3	pCi/L	105	< 100	116	129
Nitrate	mg/L	–	0.13	–	–
Phenols	mg/L	< 0.005	< 0.005	< 0.005	< 0.005
Sulfate	mg/L	–	**622**	–	–
TOCs (max. of 4 samples)	mg/L	**4.4**	**4.6**	**4.1**	**4.2**
TOXs (max. of 2 samples)	mg/L	< 0.02	0.022	< 0.02	0.028
Arsenic	mg/L	–	0.004	–	–
Barium	mg/L	–	0.082	–	–
Boron	mg/L	–	< 0.1	–	–
Cadmium	mg/L	–	0.0005	–	–
Chromium	mg/L	–	< 0.05	–	–
Cobalt	mg/L	–	< 0.25	–	–
Copper	mg/L	–	< 0.025	–	–
Iron	mg/L	–	**13.4**	–	–
Lead	mg/L	–	< 0.004	–	–
Manganese	mg/L	–	**1.32**	–	–
Mercury	mg/L	–	< 0.0002	–	–
Nickel	mg/L	–	< 0.05	–	–
Selenium	mg/L	–	< 0.003	–	–
Silver	mg/L	–	< 0.001	–	–
Zinc	mg/L	–	< 0.02	–	–

[a] Bold type indicates that the value exceeds the applicable limits shown in Table 6.28.

[b] Well point elevation = 222.90 m (MSL); ground surface elevation = 227.38 m (MSL); casing material = stainless steel.

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

TABLE 6.34

Groundwater Monitoring Results, Sanitary Landfill Well 800201, 2008

Parameter	Unit	Date of Sampling			
		1/21/2008	4/16/2008	7/16/2008	10/13/2008
Field Parameters					
Conductivity	µS/cm	**809**[a]	**1,066**	246	**1,132**
Oxid./red. potential	mV	12	9	-3	8
pH	pH	6.89	6.87	6.85	6.89
Temperature	ºC	7.8	13.4	19.8	13.8
Water elevation[b]	m	224.44	225.32	224.67	224.62
Filtered Samples					
Ammonia nitrogen	mg/L	**3.52**	**4.98**	**2.08**	**4.35**
Chloride	mg/L	**25**	**24**	**28**	16
Sulfate	mg/L	**81**	**74**	**83**	**78**
TDS	mg/L	**645**	**2,654**	**662**	**631**
Arsenic	mg/L	0.008	0.008	0.004	0.008
Barium	mg/L	0.29	0.29	0.24	0.28
Boron	mg/L	< 0.1	< 0.1	< 0.1	< 0.1
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	**4.74**	**4.84**	**1.70**	**3.67**
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	**0.231**	**0.186**	**0.109**	**0.285**
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Unfiltered Samples					
Chloride	mg/L	–[c]	24	–	–
Cyanide (Total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	–	0.31	–	–
Hydrogen-3	pCi/L	< 100	< 100	< 100	127
Nitrate	mg/L	–	0.13	–	–
Phenols	mg/L	< 0.005	0.022	< 0.005	< 0.005
Sulfate	mg/L	–	73	–	–
TOCs (max. of 4 samples)	mg/L	**30**	**33**	**29**	**30**
TOXs (max. of 2 samples)	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Arsenic	mg/L	–	0.01	–	–
Barium	mg/L	–	0.29	–	–
Boron	mg/L	–	< 0.1	–	–
Cadmium	mg/L	–	< 0.0002	–	–
Chromium	mg/L	–	< 0.05	–	–
Cobalt	mg/L	–	< 0.25	–	–
Copper	mg/L	–	< 0.025	–	–
Iron	mg/L	–	**6.01**	–	–
Lead	mg/L	–	< 0.004	–	–
Manganese	mg/L	–	**0.196**	–	–
Mercury	mg/L	–	< 0.0002	–	–
Nickel	mg/L	–	< 0.05	–	–
Selenium	mg/L	–	< 0.003	–	–
Silver	mg/L	–	< 0.001	–	–
Zinc	mg/L	–	<0.02	–	–

[a] Bold type indicates that the value exceeds the applicable limits shown in Table 6.28.

[b] Well point elevation = 217.26 m (MSL); ground surface elevation = 227.93 m (MSL); casing material = stainless steel.

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

TABLE 6.35

Groundwater Monitoring Results, Sanitary Landfill Well 800281, 2008

Parameter	Unit	Date of Sampling			
		2/4/2008	5/6/2008	7/22/2008	10/20/2008
Field parameters					
Conductivity	µS/cm	**978**[a]	**1,176**	288	**1,236**
Oxid./red. potential	mV	24	20	18	10
pH	pH	7.05	6.73	**6.43**	**6.40**
Temperature	ºC	6.7	13.0	15.5	15.9
Water elevation[b]	m	226.62	226.91	225.96	226.02
Filtered Samples					
Ammonia nitrogen	mg/L	0.11	< 0.05	0.10	0.16
Chloride	mg/L	**89**	**74**	**78**	**53**
Sulfate	mg/L	**75**	**86**	**78**	**97**
TDS	mg/L	**741**	**706**	**788**	**670**
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.080	0.071	0.081	0.079
Boron	mg/L	0.32	0.25	0.30	0.33
Cadmium	mg/L	< 0.0002	< 0.0002	0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.021	< 0.021	< 0.021	< 0.021
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	**1.45**	**0.51**	**1.23**	**0.66**
Mercury	mg/L	< 0.0002	< 0.0002	0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Unfiltered Samples					
Chloride	mg/L	–[c]	73	–	–
Cyanide (Total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	–	0.2	–	–
Hydrogen-3	pCi/L	216	168	225	245
Nitrate	mg/L	–	< 0.1	–	–
Phenols	mg/L	< 0.005	< 0.005	< 0.005	0.0064
Sulfate	mg/L	–	86	–	–
TOCs (max. of 4 samples)	mg/L	**3.0**	2.2	**3.2**	**3.0**
TOXs (max. of 2 samples)	mg/L	0.064	0.040	0.031	0.023
Arsenic	mg/L	–	< 0.003	–	–
Barium	mg/L	–	0.066	–	–
Boron	mg/L	–	0.22	–	–
Cadmium	mg/L	–	< 0.0002	–	–
Chromium	mg/L	–	< 0.05	–	–
Cobalt	mg/L	–	< 0.25	–	–
Copper	mg/L	–	< 0.025	–	–
Iron	mg/L	–	< 0.021	–	–
Lead	mg/L	–	0.006	–	–
Manganese	mg/L	–	**0.464**	–	–
Mercury	mg/L	–	< 0.0002	–	–
Nickel	mg/L	–	< 0.05	–	–
Selenium	mg/L	–	< 0.003	–	–
Silver	mg/L	–	< 0.001	–	–
Zinc	mg/L	–	< 0.02	–	–

[a] Bold type indicates that the value exceeds the applicable limits shown in Table 6.28.

[b] Well point elevation = 224.00 m (MSL); ground surface elevation = 227.66 m (MSL); casing material = stainless steel.

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

TABLE 6.36

Groundwater Monitoring Results, Sanitary Landfill Well 800291, 2008

Parameter	Unit	Date of Sampling 1/29/2008	4/29/2008	7/23/2008	10/21/2008
Field Parameters					
Conductivity	µSs/cm	**783**[a]	**1,064**	240	**1,173**
Oxid./red. potential	mV	3	-7	-2	-8
pH	pH	7.06	7.17	6.91	6.73
Temperature	ºC	8.9	8.0	15.9	12.1
Water elevation[b]	m	228.35	228.90	227.84	227.55
Filtered Samples					
Ammonia nitrogen	mg/L	< 0.05	< 0.05	0.08	0.19
Chloride	mg/L	14	19	17	8
Sulfate	mg/L	**167**	**160**	**177**	**194**
TDS	mg/L	**642**	**650**	**652**	**644**
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.020	0.021	0.021	0.022
Boron	mg/L	< 0.1	< 0.1	< 0.1	< 0.1
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	0.041	< 0.021	< 0.021	< 0.021
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.054	0.040	0.030	0.084
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.02	< 0.02	< 0.02	0.044
Unfiltered Sample					
Chloride	mg/L	–[c]	17	–	–
Cyanide (Total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	–	0.4	–	–
Hydrogen-3	pCi/L	< 100	< 100	< 100	131
Nitrate	mg/L	–	< 0.1	–	–
Phenols	mg/L	< 0.005	< 0.005	< 0.005	0.008
Sulfate	mg/L	–	134	–	–
TOCs (max. of 4 samples)	mg/L	1.6	1.9	1.9	1.9
TOXs (max. of 2 samples)	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Arsenic	mg/L	–	< 0.003	–	–
Barium	mg/L	–	0.022	–	–
Beryllium	mg/L	–	< 0.1	–	–
Cadmium	mg/L	–	< 0.0002	–	–
Chromium	mg/L	–	< 0.05	–	–
Cobalt	mg/L	–	< 0.25	–	–
Copper	mg/L	–	< 0.025	–	–
Iron	mg/L	–	0.376	–	–
Lead	mg/L	–	< 0.004	–	–
Manganese	mg/L	–	< 0.046	–	–
Mercury	mg/L	–	< 0.0002	–	–
Nickel	mg/L	–	< 0.05	–	–
Selenium	mg/L	–	< 0.003	–	–
Silver	mg/L	–	< 0.001	–	–
Zinc	mg/L	–	< 0.02	–	–

[a] Bold type indicates that the value exceeds the applicable limits shown in Table 6.28.

[b] Well point elevation = 223.48 m (MSL); ground surface elevation = 230.49 m (MSL); casing material = stainless steel.

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

TABLE 6.37

Groundwater Monitoring Results, Sanitary Landfill Well 800301, 2008

Parameter	Unit	Date of Sampling				
		1/16/2008	1/16/2008 (Duplicate)	4/30/2008	7/8/2008	10/7/2008
Field Parameters						
Conductivity	µS/cm	**759**[a]	**759**	**1,001**	**1,043**	**1,105**
Oxid./red. potential	mV	10	10	6	9	5
pH	pH	6.93	6.93	6.91	6.96	6.95
Temperature	ºC	7.9	7.9	9.9	13.5	11.9
Water elevation[b]	m	227.24	227.24	232.04	230.27	228.68
Filtered Samples						
Ammonia nitrogen	mg/L	< 0.05	< 0.05	0.10	0.18	0.19
Chloride	mg/L	11	11	12	11	6
Sulfate	mg/L	**173**	**188**	**137**	**158**	**170**
TDS	mg/L	**629**	**614**	**590**	**616**	**604**
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.023	0.023	0.022	0.024	0.023
Boron	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	**2.25**	**2.32**	**0.59**	**3.61**	**0.94**
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	**0.181**	**0.183**	**0.162**	**0.159**	**0.150**
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Unfiltered Samples						
Chloride	mg/L	–[c]	–	12	–	–
Cyanide (Total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	**0.026**
Fluoride	mg/L	–	–	0.27	–	–
Hydrogen-3	pCi/L	< 100	< 100	< 100	132	188
Nitrate	mg/L	–	–	< 0.1	–	–
Phenols	mg/L	0.006	0.009	< 0.005	< 0.005	**0.098**
Sulfate	mg/L	–	–	134	–	–
TOCs (max. of 4 numbers)	mg/L	1.2	1.1	1.1	1.3	1.4
TOXs (max. of 2 numbers)	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Arsenic	mg/L	–	–	< 0.003	–	–
Barium	mg/L	–	–	0.022	–	–
Boron	mg/L	–	–	< 0.1	–	–
Cadmium	mg/L	–	–	< 0.0002	–	–
Chromium	mg/L	–	–	< 0.05	–	–
Cobalt	mg/L	–	–	< 0.25	–	–
Copper	mg/L	–	–	< 0.025	–	–
Iron	mg/L	–	–	1.52	–	–
Lead	mg/L	–	–	< 0.004	–	–
Manganese	mg/L	–	–	**0.161**	–	–
Mercury	mg/L	–	–	< 0.0002	–	–
Nickel	mg/L	–	–	< 0.05	–	–
Selenium	mg/L	–	–	< 0.003	–	–
Silver	mg/L	–	–	< 0.001	–	–
Zinc	mg/L	–	–	< 0.02	–	–

[a] Bold type indicates that the value exceeds the applicable limits shown in Table 6.28.

[b] Well point elevation = 224.91 m (MSL); ground surface elevation = 232.53 m (MSL); casing material = stainless steel.

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

TABLE 6.38

Groundwater Monitoring Results, Sanitary Landfill Well 800321, 2008

Parameter	Unit	Date of Sampling 1/9/2008	4/8/2008	7/14/2008	10/6/2008
Field Parameters					
Conductivity	µS/cm	**1,137**[a]	**2,130**	**2,300**	**1,812**
Oxid./red. potential	mV	12	19	22	13
pH	pH	6.90	6.74	6.71	6.80
Temperature	ºC	9.4	7.7	11.4	12.7
Water elevation[b]	m	226.83	226.64	225.34	225.64
Filtered Samples					
Ammonia nitrogen	mg/L	< 0.05	**1.28**	< 0.05	0.60
Chloride	mg/L	**25**	**33**	**39**	**22**
Sulfate	mg/L	**514**	**914**	**1,185**	**775**
TDS	mg/L	**1,048**	**1,800**	**2,335**	**1,648**
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.012	< 0.012	0.013	0.013
Boron	mg/L	< 0.1	< 0.1	< 0.1	< 0.1
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.021	< 0.021	< 0.021	< 0.021
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.01	0.048	0.033	< 0.01
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.003	< 0.003	< 0.003	< 0.006
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Unfiltered Samples					
Chloride	mg/L	–[c]	36	–	–
Cyanide (Total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	–	0.5	–	–
Hydrogen-3	pCi/L	< 100	< 100	106	108
Nitrate	mg/L	–	0.14	–	–
Phenols	mg/L	< 0.005	< 0.005	< 0.005	0.007
Sulfate	mg/L	–	**983**	–	–
TOCs (max. of 4 samples)	mg/L	2.0	1.8	2.0	2.1
TOXs (max. of 2 samples)	mg/L	< 0.02	< 0.02	< 0.02	0.025
Arsenic	mg/L	–	0.004	–	–
Barium	mg/L	–	0.031	–	–
Boron	mg/L	–	< 0.1	–	–
Cadmium	mg/L	–	0.0003	–	–
Chromium	mg/L	–	< 0.05	–	–
Cobalt	mg/L	–	< 0.25	–	–
Copper	mg/L	–	< 0.025	–	–
Iron	mg/L	–	**8.95**	–	–
Lead	mg/L	–	0.005	–	–
Manganese	mg/L	–	**0.219**	–	–
Mercury	mg/L	–	< 0.0002	–	–
Nickel	mg/L	–	< 0.05	–	–
Selenium	mg/L	–	< 0.003	–	–
Silver	mg/L	–	< 0.001	–	–
Zinc	mg/L	–	< 0.02	–	–

[a] Bold type indicates that the value exceeds the applicable limits shown in Table 6.28.

[b] Well point elevation = 223.66 m (MSL); ground surface elevation = 227.93 m (MSL); casing material = stainless steel.

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

TABLE 6.39

Groundwater Monitoring Results, Sanitary Landfill Well 800331, 2008

Parameter	Unit	Date of Sampling				
		2/4/2008	4/23/2008	4/23/2008 (Duplicate)	7/30/2008	10/20/2008
Field Parameters						
Conductivity	µS/cm	654	**880**[a]	**880**	**846**	**915**
Oxid./red. potential	mV	-7	-21	-21	-8	-9
pH	pH	7.28	7.41	7.41	7.24	7.18
Temperature	ºC	8.9	9.3	9.3	13.5	12.1
Water elevation[b]	m	226.76	227.39	227.39	226.09	226.04
Filtered Samples						
Ammonia nitrogen	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	0.19
Chloride	mg/L	8	11	12	9	5
Sulfate	mg/L	**164**	**105**	**102**	**129**	**139**
TDS	mg/L	**492**	**440**	**433**	**459**	**461**
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.033	0.030	0.030	0.029	0.030
Boron	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.021	< 0.021	< 0.021	< 0.021	< 0.021
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.020	0.024	0.023	< 0.02	0.032
Unfiltered Samples						
Chloride	mg/L	–[c]	10	11	–	–
Cyanide (Total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	–	0.39	0.36	–	–
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100	182
Nitrate	mg/L	–	< 0.1	< 0.1	–	–
Phenols	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	0.009
Sulfate	mg/L	–	99	95	–	–
TOCs (max. of 4 samples)	mg/L	1.1	1.4	1.5	1.4	1.4
TOXs (max. of 2 samples)	mg/L	< 0.020	< 0.020	0.024	0.052	< 0.020
Arsenic	mg/L	–	< 0.003	< 0.003	–	–
Barium	mg/L	–	0.032	0.030	–	–
Boron	mg/L	–	< 0.1	< 0.1	–	–
Cadmium	mg/L	–	< 0.0002	< 0.0002	–	–
Chromium	mg/L	–	< 0.05	< 0.05	–	–
Cobalt	mg/L	–	< 0.25	< 0.25	–	–
Copper	mg/L	–	< 0.025	< 0.025	–	–
Iron	mg/L	–	1.20	0.86	–	–
Lead	mg/L	–	< 0.004	< 0.004	–	–
Manganese	mg/L	–	0.056	0.028	–	–
Mercury	mg/L	–	< 0.0002	< 0.0002	–	–
Nickel	mg/L	–	< 0.05	< 0.05	–	–
Selenium	mg/L	–	< 0.003	< 0.003	–	–
Silver	mg/L	–	< 0.001	< 0.001	–	–
Zinc	mg/L	–	< 0.02	< 0.02	–	–

[a] Bold type indicates that the value exceeds the applicable limits shown in Table 6.28.

[b] Well point elevation = 222.75 m (MSL); ground surface elevation = 227.93 m (MSL); casing material = stainless steel.

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

TABLE 6.40

Groundwater Monitoring Results, Sanitary Landfill Well 800341, 2008

Parameter	Unit	Date of Sampling 1/29/2008	5/5/2008	7/28/2008	10/20/2008
Field Parameters					
Conductivity	µS/cm	**728**[a]	**957**	**942**	**989**
Oxid./red. potential	mV	-11	-13	-12	-14
pH	pH	7.33	7.34	7.33	7.29
Temperature	ºC	8.6	7.8	11.8	12.8
Water elevation[b]	m	229.30	229.59	228.68	228.49
Filtered Samples					
Ammonia nitrogen	mg/L	< 0.05	< 0.05	< 0.05	0.15
Chloride	mg/L	18	16	16	9
Sulfate	mg/L	**210**	**170**	**180**	**220**
TDS	mg/L	**581**	**533**	**550**	**582**
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.030	0.027	0.032	0.036
Boron	mg/L	< 0.1	< 0.1	< 0.1	< 0.1
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.021	< 0.021	< 0.021	< 0.021
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.01	0.03	< 0.01	< 0.01
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.02	< 0.02	< 0.02	0.03
Unfiltered Samples					
Chloride	mg/L	–[c]	16	–	–
Cyanide (Total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	–	0.39	–	–
Hydrogen-3	pCi/L	< 100	< 100	< 100	174
Nitrate	mg/L	–	0.4	–	–
Phenols	mg/L	0.006	< 0.005	0.024	0.008
Sulfate	mg/L	–	165	–	–
TOCs (max. of 4 samples)	mg/L	2.2	2.0	2.2	2.1
TOXs (max. of 2 samples)	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Arsenic	mg/L	–	0.004	–	–
Barium	mg/L	–	0.05	–	–
Boron	mg/L	–	< 0.1	–	–
Cadmium	mg/L	–	< 0.0002	–	–
Chromium	mg/L	–	< 0.05	–	–
Cobalt	mg/L	–	< 0.25	–	–
Copper	mg/L	–	< 0.025	–	–
Iron	mg/L	–	**9.68**	–	–
Lead	mg/L	–	0.008	–	–
Manganese	mg/L	–	**0.22**	–	–
Mercury	mg/L	–	< 0.0002	–	–
Nickel	mg/L	–	< 0.05	–	–
Selenium	mg/L	–	< 0.003	–	–
Silver	mg/L	–	< 0.001	–	–
Zinc	mg/L	–	0.027	–	–

[a] Bold type indicates that the value exceeds the applicable limits shown in Table 6.28.

[b] Well point elevation = 226.01 m (MSL); ground surface elevation = 229.97 m (MSL); casing material = stainless steel.

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

TABLE 6.41

Groundwater Monitoring Results, Sanitary Landfill Well 800351, 2008

Parameter	Unit	Date of Sampling 1/16/2008	4/28/2008	7/8/2008	10/7/2008
Field Parameters					
Conductivity	µS/cm	662	**893**[a]	**896**	**975**
Oxid./red. potential	mV	-5	-6	-3	-7
pH	pH	7.20	7.16	7.17	7.17
Temperature	°C	9.2	9.8	11.2	10.5
Water elevation[b]	m	225.76	229.48	228.49	226.94
Filtered Samples					
Ammonia nitrogen	mg/L	0.22	0.27	0.33	0.38
Chloride	mg/L	5	6	6	3
Sulfate	mg/L	54	46	50	53
TDS	mg/L	**439**	**451**	**455**	**453**
Arsenic	mg/L	< 0.003	0.004	< 0.003	0.004
Barium	mg/L	0.089	0.091	0.087	0.091
Boron	mg/L	< 0.1	< 0.1	< 0.1	< 0.1
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	**0.466**	0.074	**0.774**	**0.273**
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.024	0.029	0.024	0.024
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.02	< 0.02	< 0.02	0.02
Unfiltered Samples					
Chloride	mg/L	–[c]	6	–	–
Cyanide (Total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	–	0.24	–	–
Hydrogen-3	pCi/L	< 100	< 100	< 100	159
Nitrate	mg/L	–	< 0.1	–	–
Phenols	mg/L	< 0.005	< 0.005	< 0.005	**0.042**
Sulfate	mg/L	–	46	–	–
TOCs (max. of 4 samples)	mg/L	1.8	1.5	1.5	2.0
TOXs (max. of 2 samples)	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Arsenic	mg/L	–	0.007	–	–
Barium	mg/L	–	0.108	–	–
Boron	mg/L	–	< 0.1	–	–
Cadmium	mg/L	–	< 0.0002	–	–
Chromium	mg/L	–	< 0.05	–	–
Cobalt	mg/L	–	< 0.25	–	–
Copper	mg/L	–	< 0.025	–	–
Iron	mg/L	–	**10.6**	–	–
Lead	mg/L	–	0.008	–	–
Manganese	mg/L	–	**0.20**	–	–
Mercury	mg/L	–	< 0.0002	–	–
Nickel	mg/L	–	< 0.05	–	–
Selenium	mg/L	–	< 0.003	–	–
Silver	mg/L	–	< 0.001	–	–
Zinc	mg/L	–	< 0.02	–	–

[a] Bold type indicates that the value exceeds the applicable limits shown in Table 6.28.

[b] Well point elevation = 220.86 m (MSL); ground surface elevation = 232.75 m (MSL); casing material = stainless steel.

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

TABLE 6.42

Groundwater Monitoring Results, Sanitary Landfill Well 800361, 2008

Parameter	Unit	Date of Sampling 1/28/2008	4/14/2008	7/9/2008	10/8/2008
Field Parameters					
Conductivity	µS/cm	**789**[a]	**949**	**969**	**993**
Oxid./red. potential	mV	11	2	6	2
pH	pH	6.93	7.02	7.01	7.01
Temperature	°C	6.9	11.4	13.0	11.7
Water elevation[b]	m	221.80	226.56	224.78	224.08
Filtered Samples					
Ammonia nitrogen	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Chloride	mg/L	**23**	**21**	**22**	13
Sulfate	mg/L	**260**	**157**	**171**	**146**
TDS	mg/L	**672**	**548**	**578**	**512**
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.024	0.030	0.027	0.031
Boron	mg/L	< 0.1	< 0.1	< 0.1	< 0.1
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.021	< 0.021	< 0.021	< 0.021
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.013	0.020	0.056	0.040
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.02	< 0.02	< 0.02	0.03
Unfiltered Samples					
Chloride	mg/L	–[c]	22	–	–
Cyanide (Total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	–	0.27	–	–
Hydrogen-3	pCi/L	< 100	< 100	176	< 100
Nitrate	mg/L	–	< 0.1	–	–
Phenols	mg/L	0.005	< 0.005	< 0.005	**0.044**
Sulfate	mg/L	–	155	–	–
TOCs (max. of 4 samples)	mg/L	1.6	1.9	1.5	2.2
TOXs (max. of 2 samples)	mg/L	< 0.02	< 0.02	0.03	0.03
Arsenic	mg/L	–	< 0.003	–	–
Barium	mg/L	–	0.026	–	–
Boron	mg/L	–	< 0.1	–	–
Cadmium	mg/L	–	< 0.0002	–	–
Chromium	mg/L	–	< 0.05	–	–
Cobalt	mg/L	–	< 0.25	–	–
Copper	mg/L	–	< 0.025	–	–
Iron	mg/L	–	0.051	–	–
Lead	mg/L	–	< 0.004	–	–
Manganese	mg/L	–	0.025	–	–
Mercury	mg/L	–	< 0.0002	–	–
Nickel	mg/L	–	< 0.05	–	–
Selenium	mg/L	–	< 0.003	–	–
Silver	mg/L	–	< 0.001	–	–
Zinc	mg/L	–	< 0.02	–	–

[a] Bold type indicates that the value exceeds the applicable limits shown in Table 6.28.

[b] Well point elevation = 220.52 m (MSL); ground surface elevation = 227.24 m (MSL); casing material = stainless steel.

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

TABLE 6.43

Groundwater Monitoring Results, Sanitary Landfill Well 800371, 2008

Parameter	Unit	Date of Sampling 1/15/2008	4/14/2008	7/9/2008	10/8/2008
Field Parameters					
Conductivity	µS/cm	**1,203**[a]	**1,508**	**1,409**	**1,465**
Oxid./red. potential	mV	14	12	10	6
pH	pH	6.85	6.82	6.92	6.94
Temperature	ºC	8.1	10.3	11.1	10.3
Water elevation[b]	m	218.49	218.61	218.83	218.97
Filtered Samples					
Ammonia nitrogen	mg/L	< 0.05	0.64	0.45	0.51
Chloride	mg/L	**23**	4	4	2
Sulfate	mg/L	**260**	**509**	**503**	**477**
TDS	mg/L	**672**	**1,245**	**1,735**	**1,098**
Arsenic	mg/L	< 0.003	0.005	< 0.003	0.004
Barium	mg/L	0.024	0.016	0.016	0.016
Boron	mg/L	< 0.1	0.12	< 0.1	0.11
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.021	**1.150**	**0.815**	**1.270**
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.013	**0.131**	**0.141**	**0.126**
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.003	< 0.003	< 0.003	< 0.006
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Unfiltered Samples					
Chloride	mg/L	–[c]	4	–	–
Cyanide (Total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	–	0.47	–	–
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100
Nitrate	mg/L	–	0.46	–	–
Phenols	mg/L	0.005	< 0.005	< 0.005	< 0.005
Sulfate	mg/L	–	**494**	–	–
TOCs (max. of 4 samples)	mg/L	1.6	1.5	1.4	1.6
TOXs (max. of 2 samples)	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Arsenic	mg/L	–	0.03	–	–
Barium	mg/L	–	0.14	–	–
Boron	mg/L	–	0.173	–	–
Cadmium	mg/L	–	0.0007	–	–
Chromium	mg/L	–	< 0.05	–	–
Cobalt	mg/L	–	< 0.25	–	–
Copper	mg/L	–	0.064	–	–
Iron	mg/L	–	**51**	–	–
Lead	mg/L	–	**0.073**	–	–
Manganese	mg/L	–	**1.08**	–	–
Mercury	mg/L	–	< 0.0002	–	–
Nickel	mg/L	–	< 0.05	–	–
Selenium	mg/L	–	< 0.003	–	–
Silver	mg/L	–	< 0.001	–	–
Zinc	mg/L	–	< 0.02	–	–

[a] Bold type indicates that the value exceeds the applicable limits shown in Table 6.28.

[b] Well point elevation = 217.44 m (MSL); ground surface elevation = 227.50 m (MSL); casing material = stainless steel.

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

TABLE 6.44

Groundwater Monitoring Results, Sanitary Landfill Well 800381, 2008

Parameter	Unit	Date of Sampling 1/28/2008	1/28/2008 (Duplicate)	4/21/2008	7/15/2008	10/14/2008
Field Parameters						
Conductivity	µS/cm	**1,152**[a]	**1,152**	**1,324**	346	**1,480**
Oxid./red. potential	mV	25	25	13	3	16
pH	pH	6.64	6.64	6.80	6.74	6.76
Temperature	ºC	9.1	9.1	13.9	19.5	15.3
Water elevation[b]	m	227.98	227.98	229.92	228.05	227.87
Filtered Samples						
Ammonia nitrogen	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Chloride	mg/L	**32**	**32**	**26**	**31**	**24**
Sulfate	mg/L	**492**	**484**	**346**	**450**	**395**
TDS	mg/L	**1,152**	**1,158**	**968**	**1,132**	**1,078**
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.029	0.030	0.032	0.028	0.032
Boron	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.021	< 0.021	< 0.021	< 0.021	**0.139**
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	**0.191**	**0.193**	**0.106**	**0.236**	**0.326**
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.006
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Unfiltered Samples						
Chloride	mg/L	–[c]	–	26	–	–
Cyanide (Total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	–	–	0.33	–	–
Hydrogen-3	pCi/L	< 100	< 100	< 100	132	123
Nitrate	mg/L	–	–	1	–	–
Phenols	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Sulfate	mg/L	–	–	342	–	–
TOCs (max. of 4 samples)	mg/L	**2.9**	**2.9**	2.6	**2.9**	**3.6**
TOXs (max. of 2 samples)	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	0.02
Arsenic	mg/L	–	–	< 0.003	–	–
Barium	mg/L	–	–	0.032	–	–
Boron	mg/L	–	–	< 0.1	–	–
Cadmium	mg/L	–	–	< 0.0002	–	–
Chromium	mg/L	–	–	< 0.05	–	–
Cobalt	mg/L	–	–	< 0.25	–	–
Copper	mg/L	–	–	< 0.025	–	–
Iron	mg/L	–	–	0.113	–	–
Lead	mg/L	–	–	< 0.004	–	–
Manganese	mg/L	–	–	0.097	–	–
Mercury	mg/L	–	–	< 0.0002	–	–
Nickel	mg/L	–	–	< 0.05	–	–
Selenium	mg/L	–	–	< 0.003	–	–
Silver	mg/L	–	–	< 0.001	–	–
Zinc	mg/L	–	–	< 0.02	–	–

[a] Bold type indicates that the value exceeds the applicable limits shown in Table 6.28.

[b] Well point elevation = 224.40 m (MSL); ground surface elevation = 231.21 m (MSL); casing material = stainless steel.

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

TABLE 6.45

Groundwater Monitoring Results, Sanitary Landfill Well 800173D, 2008

Parameter	Unit	Date of Sampling			
		1/14/2008	4/9/2008	7/15/2008	10/20/2008
Field Parameters					
Conductivity	µS/cm	1,261	**1,634**[a]	**1,510**	**1,423**
Oxid./red. potential	mV	-1	0	0	-3
pH	pH	7.14	7.27	7.10	7.69
Temperature	ºC	8.3	11.2	14.9	13.6
Water elevation[b]	m	192.94	193.24	193.37	193.62
Filtered Samples					
Ammonia nitrogen	mg/L	**1.02**	**1.11**	0.48	**1.27**
Chloride	mg/L	**405**	**410**	**342**	**218**
Sulfate	mg/L	92	82	140	103
TDS	mg/L	**938**	**933**	875	813
Arsenic	mg/L	< 0.003	< 0.003	0.004	0.004
Barium	mg/L	0.104	0.100	0.097	0.099
Boron	mg/L	0.13	0.14	0.13	0.15
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	**2.21**	**2.06**	**2.26**	0.36
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	**0.061**	**0.060**	**0.053**	**0.061**
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.02	< 0.02	< 0.02	0.02
Unfiltered Samples					
Chloride	mg/L	–[c]	**371**	–	–
Cyanide (Total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	–	0.36	–	–
Hydrogen-3	pCi/L	< 100	< 100	104	103
Nitrate	mg/L	–	< 0.1	–	–
Phenols	mg/L	0.005	< 0.005	< 0.005	0.011
Sulfate	mg/L	–	85	–	–
TOCs (max. of 4 samples)	mg/L	4.1	3.8	2.7	3.6
TOXs (max. of 2 samples)	mg/L	0.036	**0.048**	< 0.020	0.029
Arsenic	mg/L	–	0.005	–	–
Barium	mg/L	–	0.109	–	–
Boron	mg/L	–	0.153	–	–
Cadmium	mg/L	–	< 0.0002	–	–
Chromium	mg/L	–	< 0.05	–	–
Cobalt	mg/L	–	< 0.25	–	–
Copper	mg/L	–	< 0.025	–	–
Iron	mg/L	–	4.02	–	–
Lead	mg/L	–	< 0.004	–	–
Manganese	mg/L	–	0.093	–	–
Mercury	mg/L	–	< 0.0002	–	–
Nickel	mg/L	–	< 0.05	–	–
Selenium	mg/L	–	< 0.003	–	–
Silver	mg/L	–	< 0.001	–	–
Zinc	mg/L	–	< 0.02	–	–

[a] Bold type indicates that the value exceeds the applicable limits shown in Table 6.28.

[b] Well point elevation = 189.09 m (MSL); ground surface elevation = 228.40 m (MSL); casing material = stainless steel.

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

TABLE 6.46

Groundwater Monitoring Results, Sanitary Landfill Well 800183D, 2008

Parameter	Unit	Date of Sampling			
		1/14/2008	4/21/2008	7/15/2008	10/14/2008
Field Parameters					
Conductivity	µS/cm	943	1,241	**1,373**[a]	**1,568**
Oxid./red. potential	mV	0	-2	3	-1
pH	pH	7.11	7.07	7.05	7.06
Temperature	ºC	10.6	14.6	13.5	12.1
Water elevation[b]	m	192.95	193.30	193.39	193.61
Filtered Samples					
Ammonia nitrogen	mg/L	0.96	**1.07**	0.10	**1.53**
Chloride	mg/L	**290**	**205**	**262**	**223**
Sulfate	mg/L	127	106	115	100
TDS	mg/L	707	830	821	**890**
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.049	0.056	0.056	0.067
Boron	mg/L	0.164	0.170	0.140	0.170
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	0.83	0.65	1.22	1.08
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.015	**0.027**	**0.068**	0.021
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Unfiltered Samples					
Chloride	mg/L	–[c]	**201**	–	–
Cyanide (Total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	–	0.34	–	–
Hydrogen-3	pCi/L	< 100	< 100	127	< 100
Nitrate	mg/L	–	< 0.1	–	–
Phenols	mg/L	< 0.005	0.020	< 0.005	< 0.005
Sulfate	mg/L	–	111	–	–
TOCs (max. of 4 samples)	mg/L	2.4	2.5	2.6	2.9
TOXs (max. of 2 samples)	mg/L	0.031	0.034	0.027	0.025
Arsenic	mg/L	–	< 0.003	–	–
Barium	mg/L	–	0.05	–	–
Boron	mg/L	–	0.163	–	–
Cadmium	mg/L	–	< 0.0002	–	–
Chromium	mg/L	–	< 0.05	–	–
Cobalt	mg/L	–	< 0.25	–	–
Copper	mg/L	–	< 0.025	–	–
Iron	mg/L	–	1.07	–	–
Lead	mg/L	–	< 0.004	–	–
Manganese	mg/L	–	0.018	–	–
Mercury	mg/L	–	< 0.0002	–	–
Nickel	mg/L	–	< 0.05	–	–
Selenium	mg/L	–	< 0.003	–	–
Silver	mg/L	–	< 0.001	–	–
Zinc	mg/L	–	< 0.02	–	–

[a] Bold type indicates that the value exceeds the applicable limits shown in Table 6.28.

[b] Well point elevation = 180.38 m (MSL); ground surface elevation = 230.37 m (MSL); casing material = stainless steel.

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

TABLE 6.47

Groundwater Monitoring Results, Sanitary Landfill Well 800193D, 2008

Parameter	Unit	Date of Sampling 1/9/2008	4/8/2008	7/7/2008	10/7/2008
Field Parameters					
Conductivity	µS/cm	1,131	**1,611**[a]	**1,848**	**2,030**
Oxid./red. potential	mV	4	0	5	0
pH	pH	7.05	7.07	7.02	7.04
Temperature	°C	11.0	11.2	12.8	11.7
Water elevation[b]	m	192.92	193.30	193.42	193.64
Filtered Samples					
Ammonia nitrogen	mg/L	0.88	**1.17**	**1.25**	**1.30**
Chloride	mg/L	**238**	**344**	**442**	**369**
Sulfate	mg/L	**156**	119	117	108
TDS	mg/L	**938**	**931**	**1,105**	**1,151**
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.076	0.083	0.084	0.094
Boron	mg/L	0.16	0.16	0.14	0.16
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	1.47	**1.68**	1.43	1.57
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	**0.023**	**0.025**	**0.029**	**0.046**
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Unfiltered Samples					
Chloride	mg/L	–[c]	**332**	–	–
Cyanide (Total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	–	0.34	–	–
Hydrogen-3	pCi/L	< 100	< 100	< 100	117
Nitrate	mg/L	–	< 0.1	–	–
Phenols	mg/L	< 0.005	< 0.005	< 0.005	< 0.005
Sulfate	mg/L	–	118	–	–
TOCs (max. of 4 samples)	mg/L	3.1	3.4	3.7	4.1
TOXs (max. of 2 samples)	mg/L	< 0.020	0.033	0.025	0.041
Arsenic	mg/L	–	0.006	–	–
Barium	mg/L	–	0.088	–	–
Boron	mg/L	–	0.166	–	–
Cadmium	mg/L	–	< 0.0002	–	–
Chromium	mg/L	–	< 0.05	–	–
Cobalt	mg/L	–	< 0.25	–	–
Copper	mg/L	–	< 0.025	–	–
Iron	mg/L	–	4.37	–	–
Lead	mg/L	–	< 0.004	–	–
Manganese	mg/L	–	0.038	–	–
Mercury	mg/L	–	< 0.0002	–	–
Nickel	mg/L	–	< 0.05	–	–
Selenium	mg/L	–	< 0.003	–	–
Silver	mg/L	–	< 0.001	–	–
Zinc	mg/L	–	< 0.02	–	–

[a] Bold type indicates that the value exceeds the applicable limits shown in Table 6.28.

[b] Well point elevation = 181.35 m (MSL); ground surface elevation = 227.34 m (MSL); casing material = stainless steel.

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

TABLE 6.48

Groundwater Monitoring Results, Sanitary Landfill Well 800203D, 2008

Parameter	Unit	Date of Sampling				
		1/21/2008	4/16/2008	4/16/2008 (Duplicate)	7/15/2008	10/13/2008
Field Parameters						
Conductivity	µS/cm	986	**1,510**[a]	**1,510**	**1,447**	**1,473**
Oxid./red. potential	mV	3	10	10	4	0
pH	pH	7.06	6.87	6.87	7.03	7.03
Temperature	ºC	10.0	11.9	11.9	12.4	11.6
Water elevation[b]	m	192.94	193.33	193.33	193.40	193.61
Filtered Samples						
Ammonia nitrogen	mg/L	**1.89**	**2.43**	**2.20**	0.45	**2.56**
Chloride	mg/L	**274**	**364**	**357**	**334**	**215**
Sulfate	mg/L	70	64	67	67	57
TDS	mg/L	755	**988**	**990**	**923**	783
Arsenic	mg/L	0.004	0.004	0.004	0.004	**0.007**
Barium	mg/L	0.14	0.16	0.16	0.15	0.15
Boron	mg/L	0.14	0.15	0.14	0.13	0.15
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	**1.94**	**2.38**	**2.42**	**1.90**	**2.23**
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	**0.037**	**0.049**	**0.050**	**0.047**	**0.044**
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	0.03
Unfiltered Samples						
Chloride	mg/L	–[c]	**369**	**371**	–	–
Cyanide (Total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	–	0.38	0.40	–	–
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100	< 100
Nitrate	mg/L	–	< 0.1	< 0.1	–	–
Phenols	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	0.010
Sulfate	mg/L	–	65	65	–	–
TOCs (max. of 4 samples)	mg/L	5.3	4.7	4.7	5.0	**5.6**
TOXs (max. of 2 samples)	mg/L	**0.047**	0.022	0.032	0.027	0.025
Arsenic	mg/L	–	0.004	0.004	–	–
Barium	mg/L	–	0.159	0.165	–	–
Boron	mg/L	–	0.155	0.151	–	–
Cadmium	mg/L	–	< 0.0002	< 0.0002	–	–
Chromium	mg/L	–	< 0.05	< 0.05	–	–
Cobalt	mg/L	–	< 0.25	< 0.25	–	–
Copper	mg/L	–	< 0.025	< 0.025	–	–
Iron	mg/L	–	2.59	2.67	–	–
Lead	mg/L	–	< 0.004	< 0.004	–	–
Manganese	mg/L	–	0.049	0.050	–	–
Mercury	mg/L	–	< 0.0002	< 0.0002	–	–
Nickel	mg/L	–	< 0.05	< 0.05	–	–
Selenium	mg/L	–	< 0.003	< 0.003	–	–
Silver	mg/L	–	< 0.001	< 0.001	–	–
Zinc	mg/L	–	< 0.02	< 0.02	–	–

[a] Bold type indicates that the value exceeds the applicable limits shown in Table 6.28.

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

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

TABLE 6.49

Groundwater Monitoring Results, Sanitary Landfill Well 800383D, 2008

Parameter	Unit	Date of Sampling 1/28/2008	4/21/2008	7/15/2008	10/14/2008
Field Parameters					
Conductivity	µS/cm	1,121	**1,531**[a]	**1,525**	**1,670**
Oxid./red. potential	mV	5	0	3	-2
pH	pH	7.20	7.03	7.06	7.06
Temperature	ºC	10.7	13.0	13.0	11.6
Water elevation[b]	m	192.62	192.83	192.91	193.11
Filtered Samples					
Ammonia nitrogen	mg/L	0.72	0.90	< 0.05	**1.17**
Chloride	mg/L	**340**	**327**	**340**	**276**
Sulfate	mg/L	118	110	125	117
TDS	mg/L	863	**998**	**962**	**926**
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.086	0.088	0.088	0.089
Boron	mg/L	0.14	0.15	0.14	0.16
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	1.55	1.49	**2.60**	1.47
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	**0.049**	**0.072**	**0.080**	**0.061**
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	0.07	0.06	< 0.05
Selenium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Unfiltered Samples					
Chloride	mg/L	–[c]	**321**	–	–
Cyanide (Total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	–	0.42	–	–
Hydrogen-3	pCi/L	< 100	< 100	125	< 100
Nitrate	mg/L	–	< 0.1	–	–
Phenols	mg/L	0.007	0.014	< 0.005	< 0.005
Sulfate	mg/L	–	107	–	–
TOCs (max. of 4 samples)	mg/L	2.1	2.3	2.3	2.5
TOXs (max. of 2 samples)	mg/L	0.03	0.02	< 0.02	< 0.02
Arsenic	mg/L	–	< 0.003	–	–
Barium	mg/L	–	0.089	–	–
Boron	mg/L	–	0.157	–	–
Cadmium	mg/L	–	< 0.0002	–	–
Chromium	mg/L	–	**0.113**	–	–
Cobalt	mg/L	–	< 0.25	–	–
Copper	mg/L	–	< 0.025	–	–
Iron	mg/L	–	3.47	–	–
Lead	mg/L	–	< 0.004	–	–
Manganese	mg/L	–	0.113	–	–
Mercury	mg/L	–	< 0.0002	–	–
Nickel	mg/L	–	0.097	–	–
Selenium	mg/L	–	< 0.003	–	–
Silver	mg/L	–	< 0.001	–	–
Zinc	mg/L	–	< 0.02	–	–

[a] Bold type indicates that the value exceeds the applicable limits shown in Table 6.28.

[b] Well point elevation = 187.35 m (MSL); ground surface elevation = 231.24 m (MSL); casing material = stainless steel.

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

6.5.2.2. Filtered Inorganic Constituents

Several inorganic constituents were detected above their respective limits. The most common exceedances were TDS, specific conductivity, sulfate, chloride, iron, and manganese, which are measures of the amount of dissolved ionic material in the groundwater. Almost all of the downgradient wells sampled exhibited TDS, conductivity, sulfate, and chloride results above the background values in at least one sample. Half of the wells had iron and manganese above background levels. The wells with the highest TDS and conductivity values generally exhibited higher sulfate concentrations also. The highest concentrations were found in the wells closest to the wetland west of the landfill (Wells 800371, 800191R, and 800321). These wells also generally exhibit the highest concentrations of dissolved iron and manganese. The lowest dissolved ion concentrations were on the southeast side of the landfill, the farthest away from the wetland. None of these elevated results appeared to correlate with the proximity of the well to the landfill. It is likely that the elevated concentrations of dissolved inorganic matter are related to the proximity of the large wetland that contains deposits of high-organic-content soil. This type of soil produces slightly acidic anaerobic conditions that can increase the solubility of many naturally occurring materials that could migrate to the shallow groundwater near the wetlands. It could also be related to dissolved material in stormwater runoff (including road salt) that originates in a nearby intersection between a large highway and major surface roadway. This runoff flows through the wetlands immediately adjacent to the landfill.

The fact that all of the wells had higher levels of TDS/conductivity than the background well may be an indication that the background well is located in a region with different geochemistry than the 800 Area wells. Because of the heterogeneous nature of the glacial drift under the landfill, groundwater geochemistry could vary significantly over short distances.

Chloride levels were elevated in a number of wells east of the landfill, particularly 800171, 800281, and 800381. These wells are near roadways in the 800 Area and near a former road salt storage area that had been located in the 800 Area for a number of years. It is possible that chloride from the sodium chloride in road salt has migrated to the shallow wells in this area. The other wells with elevated chloride levels (800191R, and 800321) are generally near the wetlands and could be affected by road salt in runoff that flows through the wetlands.

All other inorganic results were generally consistent with background values. Three wells (800191R, 800201 and 800321) contained ammonia results above background. These wells are immediately adjacent to the wetland, but only Well 800201 is near the waste mound. The source of the ammonia may be related to decomposing vegetation in the wetland.

6.5.2.3. Metals

Metals results were obtained for both filtered (each quarter) and unfiltered samples (once per year). Some samples were collected using balers and others with the low flow sampling technique. Filtered results are compared with background concentrations, and unfiltered results are compared with the GQS. Filtered samples contained many values above background for soluble iron and soluble manganese. These results may be related to the proximity of the wetland

west of the wells, as discussed in the previous section. No other filtered metal results were elevated during 2008.

Unfiltered sample results included a larger number of detectable levels of several metals; however, only a few were above the GQS. The most common exceedances were iron and manganese. In addition to iron and manganese, there was one instance of elevated lead. The elevated lead result occurred in a sample with high levels of iron and manganese as well. The highest unfiltered metals results were generally found in samples collected using a bailer rather than the low flow sampler. The added turbulence caused by the bailer suspends sediment in the well, which increases the metal results in these samples since the suspended soil particles are digested and the natural metal contained in the soil adds to the soluble metals present in solution. Thus, the presence of elevated metals levels in groundwater is likely to be a function of the sampling method and is probably not an indication of contaminants migrating from the landfill.

6.5.2.4. Organics

Groundwater samples are measured each quarter for VOCs and annually for the set of SVOCs and PCBs and pesticides listed in the permit. Consistent with previous years, none of the samples contained any organic constituents above analytical detection limits in 2008. These results are not shown in the data tables to simplify the tables.

6.5.2.5. Unfiltered Miscellaneous Constituents

These parameters include cyanide, phenols (total recoverable), TOC, and TOX and are measured each quarter. The results are compared with background levels. During 2008, elevated TOC results were found in 5 of 14 wells sampled. Only one well had a result significantly higher than the background concentration of 2.7 mg/L. This well, 800201, also had elevated ammonia, iron, and manganese levels and is located immediately adjacent to the landfill mound as well as the wetland. The elevated TOC content in this well could be related to organic materials leaching from the waste or naturally occurring organics coming from the wetland soil. Cyanide was found above background in two wells and total phenols in three wells.

6.5.2.6. Radioactive Constituents

Samples collected from the 800 Area Landfill monitoring wells were also analyzed for hydrogen-3. Although the disposal of radioactive materials was prohibited in the sanitary landfill, concentrations of hydrogen-3 were detected during the RFI. Hydrogen-3 was found consistently above the 100-pCi/L detection limit during the first two quarters of 2008 only in Wells 800191R 800281, and 800171. All 14 downgradient wells and the upgradient well were reported to contain hydrogen-3 at concentrations less than the detection limit of 100 pCi/L in the third or fourth quarter of 2008. These detections are thought to be analytical artifacts, which were found in other samples discussed in this chapter. In any case, all results were well below the GQS of 20,000 pCi/L.

6.5.3. Discussion of Results — Bedrock Monitoring Wells

The monitoring wells installed in the dolomite bedrock are situated in the uppermost region of the bedrock, the layer in contact with the glacial drift above. It is a zone containing many cracks, fissures, and solution cavities. Groundwater flow in this formation moves generally to the southeast. Because of the different mineral structure of this formation, the geochemistry is significantly different from that of the shallow wells, which is reflected in the different values for background levels of the various constituents.

6.5.3.1. Field Parameters

Except for specific conductivity, which is discussed in the next section, all of the field parameters were consistent with the background values.

6.5.3.2. Filtered Inorganic Constituents

The amount of dissolved matter in all of the five downgradient dolomite wells was higher than background levels, as evidenced by elevated TDS, conductivity, and chloride values. All but one chloride result in the five wells was greater than background. Two of the four chloride results in the background well, 800273D, were also above the established background values in 2008. Only one well had consistently elevated sulfate levels. Ammonia was found to be higher than background in one or more samples from all five wells, with the highest value being 2.43 mg/L, compared with a background value of 1.0 mg/L. The background well had one value above the established background levels. All of these constituents are naturally occurring materials and are not considered a hazard at the concentrations found. While some constituents such as TDS, chloride, and sulfate could originate in the landfill leachate, it is likely that the elevated levels detected reflect natural variation in the soil composition around and above the monitoring wells, or the presence of road salt, rather than past releases of materials from the landfill.

6.5.3.3. Metals

The only metals detected consistently above background levels in filtered samples were iron and manganese. Because of the difference in geochemistry between the two aquifers sampled, the background levels of these two metals vary considerably. Iron is much higher in the dolomite, with a background value of 1.6 mg/L compared with 0.099 mg/L in the shallow well. Manganese, on the other hand, is lower in the dolomite, with a background value of 0.021 mg/L compared with 0.097 mg/L in the shallow well. Four of the five dolomite wells had elevated iron concentrations during at least one quarter. All five wells were consistently elevated in manganese, with the highest concentration being 0.072 mg/L. One of the four samples from the background well and two samples from one downgradient well exceeded the calculated background level for arsenic, which illustrates the natural variability in metals composition of groundwater samples.

Unfiltered samples were analyzed for total metals once per year for each well. Only one unfiltered metal result exceeded any of the GQSs, which in most cases are higher than the background levels used for the filtered samples. Chromium in Well 800383D was found to be slightly higher than the GQS of 0.1 mg/L.

6.5.3.4. Unfiltered Miscellaneous Constituents

The exceedance of groundwater quality criteria for these parameters was limited to chloride, which was elevated in all five wells, TOC in one well, and TOX in two wells. TOC and TOX were elevated in only one of the four samples from two different wells; the remainder of the samples from these wells were consistent with background values. Fluoride was detected in all of the wells, but all results were well below the criterion of 4.0 mg/L. No cyanide was found in any of the deep wells. Measureable amounts of total phenol were found in two different wells, but none of the results were above the GQS of 0.033 mg/L.

6.5.3.5. Organics

As with the shallow wells, no organic constituents were found above the analytical detection limits.

6.5.3.6. Radioactive Constituents

All samples collected during the first or second quarter were below the hydrogen-3 analytical detection limit of 100 pCi/L. Four of the six wells were reported to contain hydrogen-3 slightly above the detection limits during the third for fourth quarter due to the analytical artifacts discussed elsewhere.

6.5.4. Summary of 800 Area Groundwater Monitoring Results

While a number of the constituents monitored in the wells exceeded their respective background values or the GQS, these constituents were naturally occurring materials present in the soil and groundwater. The elevated concentrations are likely the result of sampling activity disturbing sediment or natural variation in geochemistry in the highly heterogeneous soil underlying the landfill. The use of road salt in the 800 Area and nearby roads could also contribute to some exceedances. None of the man-made contaminants detected in the landfill waste and leachate (VOCs, SVOCs, PCBs, or pesticides) have ever been found in the groundwater; thus there is no indication that the landfill is releasing hazardous materials into the environment.

6.6. CP-5 Reactor Area

In addition to the required sampling of former waste sites, Argonne is voluntarily monitoring the condition of groundwater beneath the former CP-5 reactor. The CP-5 reactor was a 5-MW research reactor that was used from 1954 until operations ceased in 1979. In addition to the reactor vessel inside its containment dome, the CP-5 complex contained several cooling towers and an outdoor equipment yard for storing equipment and supplies. The reactor and associated yard area have been decommissioned by removal of the reactor and internal components and removal of material from the yard. The yard area surrounding the CP-5 reactor structure was classified as a SWMU and was, therefore, investigated for chemically hazardous groundwater releases under the RCRA Part B permit. The investigation and corrective actions were completed in 2002, and the IEPA issued a notice of NFA in 2003. Radioactive contamination in the yard was cleaned up in 2001 under DOE supervision.

Groundwater under and adjacent to the reactor complex has been monitored through a series of groundwater monitoring wells installed in stages beginning in 1989. Figure 6.21 shows the current monitoring well network. Table 6.50 provides information on the current set of wells. The first exploratory monitoring well (330011) was installed in 1989 behind the reactor building, just outside the reactor fuel storage area of the complex. Additional wells were added from 1992 through 2001 to support the various characterization studies. Argonne expanded the monitoring well network to its current configuration in 2003 and replaced two existing shallow wells, 330021 and 330031, with new wells (330021R and 330031R) with shorter screens targeting thin saturated zones within the drift. One well, 330012D, is screened in the dolomite bedrock; the remainder are screened in the glacial drift. Because of the small size of this site and complex glacial geology, it is difficult to identify the shallow groundwater flow direction or to identify which wells are upgradient and which are downgradient. All wells are treated as downgradient wells in this discussion. The current network of wells is sampled quarterly and analyzed for soluble metals and chloride (filtered samples) and radioactive materials (cesium-137, hydrogen-3, and strontium-90). Field parameters are measured at the time samples are collected.

Descriptions of each well, field parameters measured during sample collection, and the results of chemical and radiological analysis of samples from the wells in the 330 Area are presented in Tables 6.51 to 6.59.

6.6.1. Field Parameters

Field parameters include such items as well and water depth, pH, specific conductivity, oxidation/reduction potential, and temperature of water. These parameters are measured each quarter. Water from two wells (330081 and 330091) had elevated conductivity levels compared with the other wells. The conductivity of Well 330091 was higher than that of the other wells by a factor of 10. The elevated conductivity and chloride levels in Wells 330081 and 330091 appear to be related to migration of chloride into the groundwater from a road salt storage facility near the wells. An old steel dome structure immediately southwest of the reactor was converted to a road salt storage area several years ago. The building is not closed, and trucks entering and

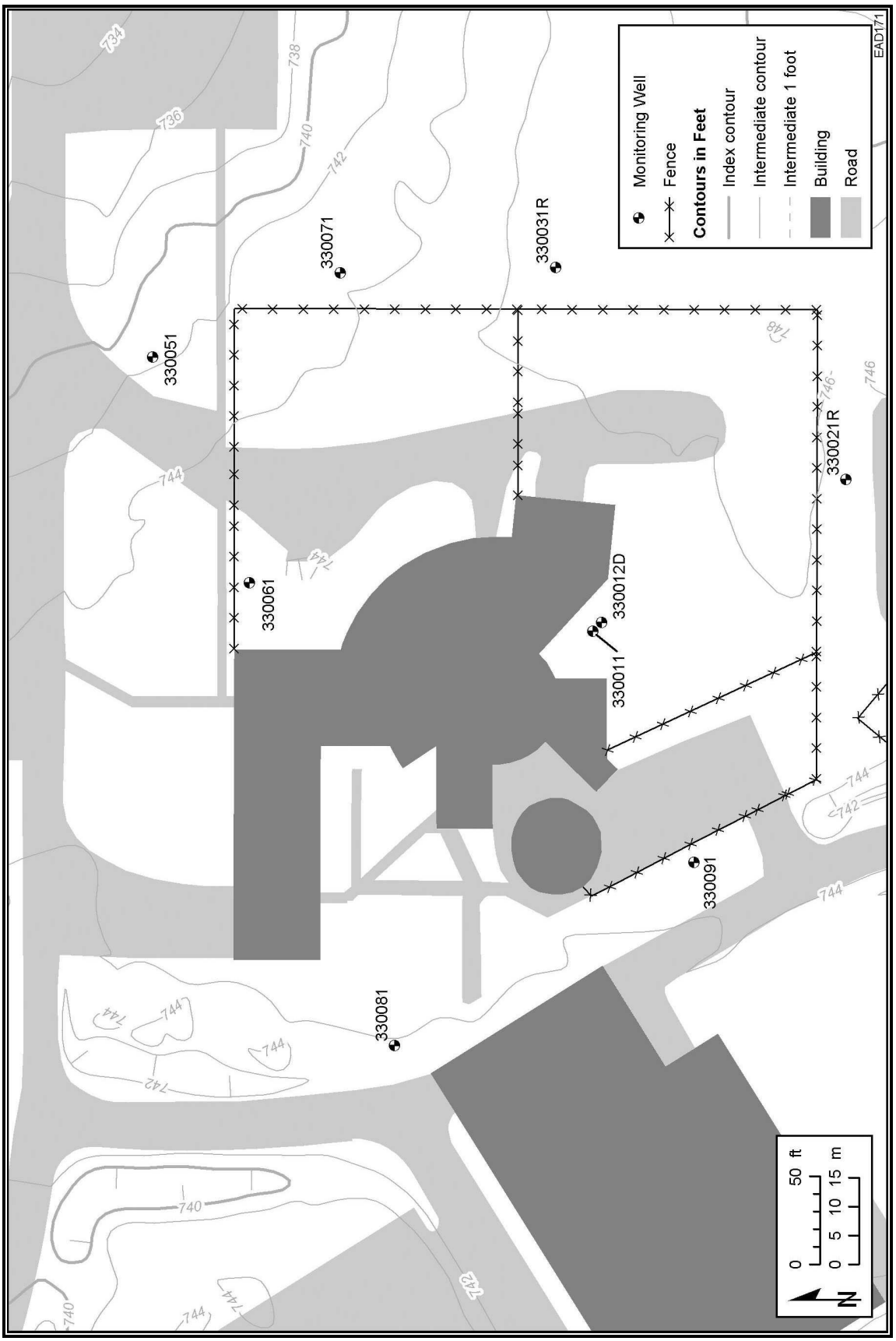


FIGURE 6.21 Monitoring Wells in the CP-5 Reactor Area

TABLE 6.50

Groundwater Monitoring Wells: 330 Area/CP-5 Reactor

ID Number	Well Depth (m bgs)	Ground Elevation (m AMSL)	Monitoring Zone (m AMSL)	Well Type[a]	Date Drilled
330011	6.1	227.23	224.2–221.0	0.05/PVC	8/89
330012D	41.5	227.08	191.7–185.7	0.05/SS	6/97
330021R	11.9	227.04	216.6–215.2	0.05/PVC	2/03
330031R	9.8	227.65	219.4–217.9	0.05/PVC	2/03
330051	7.0	226.72	221.2–219.7	0.05/PVC	5/00
330061	9.7	227.11	218.8–217.4	0.05/PVC	2/03
330071	8.8	226.64	219.3–217.8	0.05/PVC	2/03
330081	4.5	226.60	223.5–222.0	0.05/PVC	2/03
330091	3.8	227.07	224.7–223.3	0.05/PVC	2/03

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

leaving the yard spill salt in the yard and along nearby roadways. Well 330091 is immediately adjacent to the yard area where trucks are loaded. Well 330081 is located along the stormwater flow path from this area. The high conductivity results corresponded to similarly elevated levels of chloride. Wells 330051 and 330061 also had elevated chloride concentrations that may also be due to the use of road salt since these wells are situated near roadways and parking areas.

6.6.2. Filtered Metals

Seven of the nine wells sampled had at least one sample with soluble metals above analytical detection limits. In these wells, manganese, nickel, and iron were detected in one or more samples. Nickel exceeded the GQS of 0.1 mg/L in Wells 330051 and 330081. Manganese exceeded the GQS of 0.15 mg/L in Wells 330011, 330021R, 330031R, 330081, and 330091. In addition to natural variation of metals concentrations in shallow groundwater, it appears that these elevated levels may be associated with disturbance of fine silt in the well during sampling, thereby increasing the turbidity of the sample. All of the wells with elevated metals concentrations were bailed. There are no known man-made sources of these metals near the CP-5 reactor.

6.6.3. Radioactive Constituents

Hydrogen-3 was detected during at least one quarter in all of the wells. The levels of hydrogen-3 in these wells ranged from less than 100 to 38,760 pCi/L. The only well that exceeded the GQS of 20,000 pCi/L was Well 330031R, which is a replacement well for 300031. Strontium-90 was detected during most quarters in four of the nine wells, with the highest value being 0.47 pCi/L in Well 33012D. All of the results are well below the GQS of 8 pCi/L.

TABLE 6.51

Groundwater Monitoring Results, 300 Area Well 330011, 2008

Parameter	Unit	Date of Sampling 2/18/2008	5/13/2008	8/6/2008	10/30/2008
Field Parameters					
Water elevation[a]	m	226.32	226.16	225.36	225.56
Temperature	ºC	10.2	11.9	13.9	14.9
pH	pH	7.11	7.04	7.11	6.98
Redox	mV	1	-1	0	2
Conductivity	µS/cm	728	1,005	844	933
Filtered Samples					
Chloride	mg/L	57	69	14	26
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.075	< 0.075	**1.03[b]**	**0.30**
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Radioactive Materials					
Cesium-137	pCi/L	< 2.0	< 2.0	4.5	2.0
Hydrogen-3	pCi/L	1,295	1,863	540	834
Strontium-90	pCi/L	0.34	0.43	0.36	0.35

[a] Well point elevation = 220.98 m (MSL); ground surface elevation = 227.23 m (MSL); casing material = stainless steel.

[b] Bold type indicates that the value exceeds the applicable limits shown in Table 6.6.

TABLE 6.52

Groundwater Monitoring Results, 300 Area Well 330012D, 2008

Parameter	Unit	Date of Sampling 2/18/2008	5/13/2008	8/6/2008	10/30/2008
Field Parameters					
Water elevation[a]	m	191.62	191.94	192.14	192.32
Temperature	°C	11.1	13.8	14.2	12.9
pH	pH	7.17	7.04	7.15	7.07
Redox	mV	-2	-2	-3	-3
Conductivity	µS/cm	665	937	1,029	985
Filtered Samples					
Chloride	mg/L	32	35	23	24
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Radioactive Materials					
Cesium-137	pCi/L	< 2.0	< 2.0	6.6	< 2.0
Hydrogen-3	pCi/L	391	197	175	371
Strontium-90	pCi/L	0.47	0.37	0.39	0.42

[a] Well point elevation = 185.50 m (MSL); ground surface elevation = 227.08 m (MSL); casing material = stainless steel.

TABLE 6.53

Groundwater Monitoring Results, 300 Area Well 330021R, 2008

Parameter	Unit	Date of Sampling 2/21/2008	5/14/2008	8/14/2008	10/28/2008
Field Parameters					
Water elevation[a]	m	215.67	216.78	216.33	216.00
Temperature	ºC	9.7	12.6	13.5	10.8
pH	pH	6.74	6.80	6.70	6.77
Redox	mV	22	12	5	15
Conductivity	µS/cm	1,679	2,300	2,375	2,541
Filtered Samples					
Chloride	mg/L	**304[b]**	**300**	**235**	**234**
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.133	0.095	< 0.075	**0.16**
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Radioactive Materials					
Cesium-137	pCi/L	< 2.0	< 2.0	4.4	< 2.0
Hydrogen-3	pCi/L	354	308	312	339
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

[a] Well point elevation = 216.60 m (MSL); ground surface elevation = 227.04 m (MSL); casing material = stainless steel.

[b] Bold type indicates that the value exceeds the applicable limits shown in Table 6.6.

TABLE 6.54

Groundwater Monitoring Results, 300 Area Well 330031R, 2008

		Date of Sampling			
Parameter	Unit	2/21/2008	5/15/2008	8/15/2008	10/28/2008
Field Parameters					
Water elevation[a]	m	222.61	222.89	222.54	222.91
Temperature	ºC	11.0	11.7	14.0	10.9
pH	pH	6.85	6.84	6.96	6.94
Redox	mV	13	10	-11	4
Conductivity	µS/cm	1,028	1,469	1,548	1,578
Filtered Samples					
Chloride	mg/L	178	187	123	128
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	0.55	0.56	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	**0.238[b]**	< 0.075	< 0.075	< 0.075
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	0.097	0.058	0.059	0.072
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Radioactive Materials					
Cesium-137	pCi/L	< 2.0	< 2.0	5.0	< 2.0
Hydrogen-3	pCi/L	**38,300**	**38,760**	**38,070**	**36,020**
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

[a] Well point elevation = 217.89 m (MSL); ground surface elevation = 227.65 m (MSL); casing material = stainless steel.

[b] Bold type indicates that the value exceeds the applicable limits shown in Table 6.6.

TABLE 6.55

Groundwater Monitoring Results, 300 Area Well 330051, 2008

Parameter	Unit	Date of Sampling 2/21/2008	5/14/2008	8/13/2008	10/29/2008
Field Parameters					
Water elevation[a]	m	223.36	223.47	222.78	222.75
Temperature	°C	12.0	12.1	13.4	13.6
pH	pH	7.04	7.05	6.98	7.07
Redox	mV	4	-2	-13	-4
Conductivity	µS/cm	1,562	1,872	2,043	1,819
Filtered Samples					
Chloride	mg/L	**566[b]**	**529**	**278**	**284**
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.095	< 0.075	0.083	< 0.075
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	**0.152**	0.084	**0.131**	0.067
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Radioactive Materials					
Cesium-137	pCi/L	< 2.0	< 2.0	2.2	< 2.0
Hydrogen-3	pCi/L	232	191	173	210
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

[a] Well point elevation = 219.71 m (MSL); ground surface elevation = 226.72 m (MSL); casing material = PVC.

[b] Bold type indicates that the value exceeds the applicable limits shown in Table 6.6.

TABLE 6.56

Groundwater Monitoring Results, 300 Area Well 330061, 2008

		Date of Sampling			
Parameter	Unit	2/21/2008	5/14/2008	8/12/2008	10/29/2008
Field Parameters					
Water elevation[a]	m	221.50	221.65	221.40	221.27
Temperature	ºC	13.5	14.2	14.5	14.3
pH	pH	6.82	6.68	6.68	6.77
Redox	mV	17	18	5	14
Conductivity	µS/cm	2,070	2,570	3,420	3,370
Filtered Samples					
Chloride	mg/L	**913[b]**	**801**	**654**	**715**
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.131	0.089	0.126	0.103
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	0.06	< 0.05	< 0.05	< 0.05
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.004	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Radioactive Materials					
Cesium-137	pCi/L	< 2.0	< 2.0	2.4	3.4
Hydrogen-3	pCi/L	1050	869	1113	1067
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

[a] Well point elevation = 217.28 m (MSL); ground surface elevation = 227.11 m (MSL); casing material = PVC.

[b] Bold type indicates that the value exceeds the applicable limits shown in Table 6.6.

TABLE 6.57

Groundwater Monitoring Results, 300 Area Well 330071, 2008

		Date of Sampling			
Parameter	Unit	2/21/2008	2/21/2008	5/14/2008	8/14/2008
Field Parameters					
Water elevation[a]	m	223.27	223.27	223.38	222.05
Temperature	ºC	10.7	10.7	10.1	12.0
pH	pH	7.05	7.05	6.98	6.99
Redox	mV	4	4	1	-12
Conductivity	µS/cm	703	703	892	991
Filtered Samples					
Chloride	mg/L	11	11	17	9
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Radioactive Materials					
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	2.7
Hydrogen-3	pCi/L	438	413	399	499
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

[a] Well point elevation = 217.80 m (MSL); ground surface elevation = 226.64 m (MSL); casing material = PVC.

TABLE 6.58

Groundwater Monitoring Results, 300 Area Well 330081, 2008

		Date of Sampling				
Parameter	Unit	2/14/2008	5/15/2008	5/15/2008	8/5/2008	10/29/2008
Field Parameters						
Water elevation[a]	m	224.34	224.58	224.58	224.40	224.15
Temperature	ºC	10.9	11.0	11.0	18.2	16.3
pH	pH	7.17	6.95	6.95	6.93	7.18
Redox	mV	-1	3	3	6	-9
Conductivity	µS/cm	3,460	5,120	5,120	2,880	3,820
Filtered Samples						
Chloride	mg/L	**1,738**[b]	**1,986**	**1,969**	**852**	**872**
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.075	**0.158**	0.143	< 0.075	< 0.075
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	**0.152**	**0.340**	**0.287**	0.099	0.097
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.004	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Radioactive Materials						
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	3.1	< 2.0
Hydrogen-3	pCi/L	215	138	104	103	188
Strontium-90	pCi/L	0.31	0.40	0.43	0.27	< 0.25

[a] Well point elevation = 222.03 m (MSL); ground surface elevation = 226.60 m (MSL); casing material = PVC.

[b] Bold type indicates that the value exceeds the applicable limits shown in Table 6.6.

TABLE 6.59

Groundwater Monitoring Results, 300 Area Well 330091, 2008

Parameter	Unit	Date of Sampling 2/14/2008	5/15/2008	8/5/2008	10/29/2008
Field Parameters					
Water elevation[a]	m	225.27	225.43	225.16	224.88
Temperature	ºC	9.5	10.7	17.3	16.5
pH	pH	6.69	6.65	6.77	6.61
Redox	mV	25	20	19	23
Conductivity	µS/cm	17,050	24,000	19,520	33,200
Filtered Samples					
Chloride	mg/L	**12,135[b]**	**12,261**	**8,938**	**9,882**
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.005	**0.0057**	**0.0057**
Cadmium	mg/L	< 0.0025	< 0.0025	0.0038	0.0037
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.008	< 0.008
Manganese	mg/L	**4.26**	**3.67**	**4.43**	**4.75**
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	0.061	< 0.05	< 0.05
Silver	mg/L	< 0.0025	< 0.005	< 0.005	< 0.005
Thallium	mg/L	< 0.01	< 0.004	< 0.01	< 0.01
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Radioactive Materials					
Cesium-137	pCi/L	< 2.0	< 2.0	4.9	< 2.0
Hydrogen-3	pCi/L	839	875	819	841
Strontium-90	pCi/L	0.43	0.35	0.36	0.37

[a] Well point elevation = 223.26 m (MSL); ground surface elevation = 227.07 m (MSL); casing material = PVC.

[b] Bold type indicates that the value exceeds the applicable limits shown in Table 6.6.

Cesium-137 was reported above the analytical detection limit of 2 pCi/L in all of the wells during the third or fourth quarter of 2008, but not in the first or second quarter. Cesium has not been found in any of these wells before; therefore, these detections are thought to be artifacts of the analytical process, as observed in other data from these two quarters.

The CP-5 reactor was a heavy-water-moderated reactor. The normal operation of the reactor systems released water vapor containing hydrogen-3 from the main ventilation system. Over the years of operation, condensed water vapor, containing trace amounts of hydrogen-3, fell to the ground with precipitation, resulting in low levels of hydrogen-3 in the shallow groundwater. In addition, during its operational life, several incidents occurred that released small amounts of heavy water containing high concentrations of hydrogen-3 to the environment. In two separate incidents, one in 1964 and a second in 1971, the cooling system for the reactor failed, releasing water with hydrogen-3 into the cooling tower. Overspray, spills, and sewer disposal of this contaminated water appear to have released small amounts of hydrogen-3 to the subsurface. These activities are believed to be responsible for the low levels of hydrogen-3 that have been found in the groundwater for a number of years. The hydrogen-3 levels near the reactor (Well 330011) have been decreasing since monitoring began in 1990 due to radioactive decay as well as dilution. Figure 6.22 shows hydrogen-3 and strontium-90 levels in Well 330011 since monitoring started. It also contains a projection of hydrogen-3 concentrations as if only radioactive decay had been occurring since 1999, assuming the initial concentration was 12,000 pCi/L. The reason for the sharp drop in hydrogen-3 between 1997 and 1999 is not known. Strontium-90 experienced a similar decline during those years.

The high levels of hydrogen-3 at Well 330031R may be the result of other factors as well as those mentioned above. Before replacement, the original Well 330031 had hydrogen-3 concentrations that averaged 260 pCi/L. After the replacement well was installed in February 2003, the hydrogen-3 concentrations averaged 3,330 pCi/L for the balance of 2003 — about a factor of 10 higher than the old well. The first quarter results in 2004 revealed that hydrogen-3 concentrations had increased by another factor of 10, to 43,670 pCi/L, and they have remained in the 30,000 to 50,000 pCi/L range since. These high levels have been traced back to the 1964 cooling tower incident. After this leak was stopped, the contaminated cooling water was disposed of by diluting it, in batches, with large amounts of ordinary, uncontaminated wastewater and processing the mixture through the regular wastewater disposal system. This discharge was conducted over a period of about 3 months. The contaminated cooling water was pumped to a laboratory sewer manhole near the cooling tower. The sewer line ran east under the CP-5 yard fence and then north to Bluff Road where it connected to a larger sewer and eventually flowed to the LWTP. A manhole exists at the point where the sewer line turns north. This manhole is located within 10 m (33 ft) of monitoring Well 330031R. It is theorized that a small amount of leakage from this sewer mixed with groundwater in an isolated porous region of soil near the sewer, thereby creating a pocket of relatively high levels of hydrogen-3. The hydrogen-3 appears to have remained isolated at this location since 1964. Apparently, replacement Well 330031R happened to penetrate this isolated zone. An investigation performed in 2006 confirmed that the hydrogen-3 is isolated in this small porous zone and there is little migration of groundwater away from the reactor.

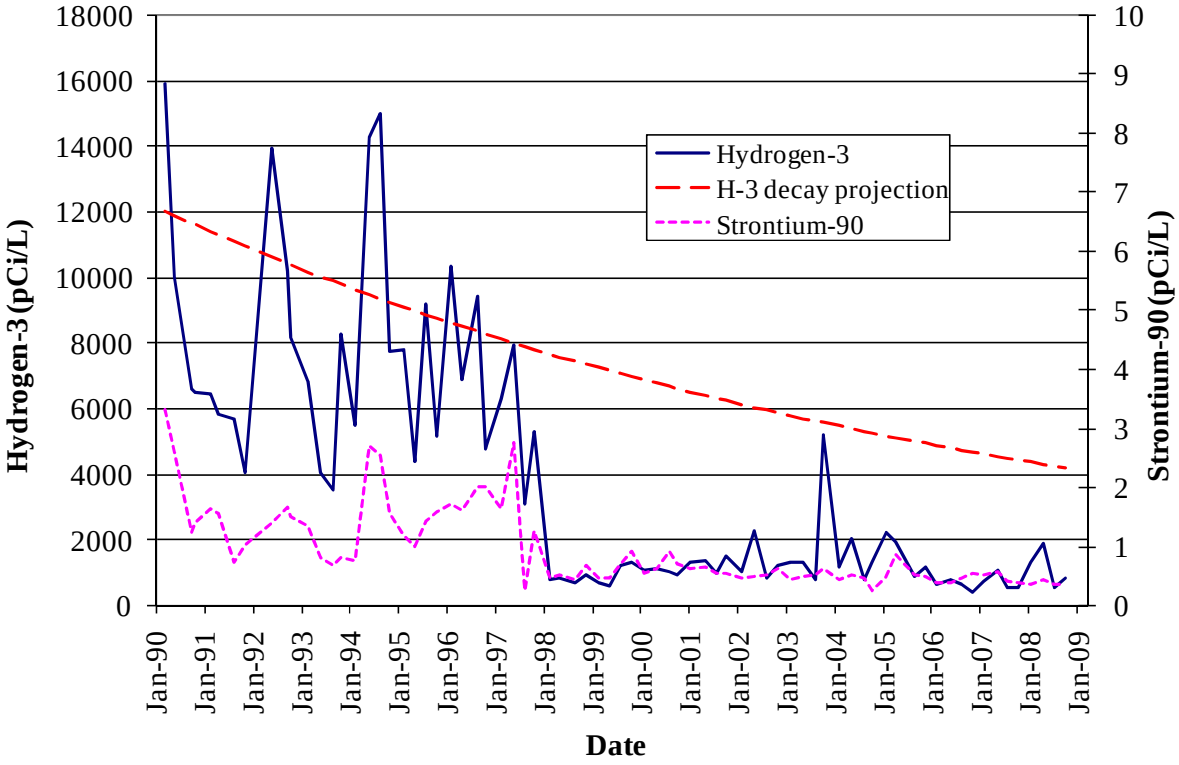


FIGURE 6.22 Hydrogen-3 and Strontium-90 in Well 330011

6.7. Groundwater Monitoring Program Summary

This chapter summarizes the information on groundwater monitoring results from various voluntary and permit-required monitoring programs. Compiling and analyzing these results supports the Argonne groundwater management strategy. The groundwater monitoring strategy focuses monitoring resources on those areas that have the potential to impact groundwater. Analytical results generated demonstrate the degree of compliance with applicable groundwater standards and limits and identify the need for groundwater remediation. Overall, groundwater quality at Argonne is good, with significant contamination present at only one location, the 317/319 Area on the extreme southern end of the site where concentrations of VOCs and hydrogen-3 in groundwater are above applicable standards. Some of this groundwater comes to the surface in several small groundwater seeps in an isolated part of the Waterfall Glen Forest Preserve. Several active remedial actions are underway in this area to reduce contaminant levels. Groundwater under the 800 Area Landfill exhibits elevated levels of a number of naturally occurring metals and inorganic constituents; however, they are probably not related to landfill operations. Elevated levels of hydrogen-3 have been found in one well adjacent to the CP-5 reactor; however, hydrogeological studies have determined that this water is not migrating away from the reactor and does not represent a hazard. There is little evidence of contamination in the dolomite aquifer, which is the uppermost usable aquifer under the site. Only two dolomite wells in the 317 Area contain man-made contamination above applicable limits. There is no known off-site impact to groundwater in this aquifer.

Argonne groundwater sampling activities during 2008 are summarized in Table 6.60. Because the various elements of the program are integrated into the overall monitoring schedule, some of the wells, monitoring events, and analytical results are used for multiple purposes that address different elements of the groundwater protection program. The vast majority of the analytical results were below detection limits. Only a small fraction of the detectable results represent chemical or radioactive materials above applicable groundwater quality standards. These instances are discussed in detail in other sections of this chapter.

TABLE 6.60

Summary of Groundwater Monitoring by Area, 2008

Groundwater Monitoring Element	Purpose	Number of Wells in Network	Number of Wells Sampled	Number of Sampling Events	Number of Analyses Performed	Percent of Results Nondetectable
Former water supply wells	Environmental Surveillance	4	3	9	585	96%
Dolomite wells	Environmental Surveillance	10	10	40	40	80%
317/319 Area wells and manholes	Environmental Surveillance	12	12	63	9195	96%
317/319/ENE and GMZ wells	Permit Compliance/LTS Program	111	82	188	14,907	92%
800 Area Landfill wells	Permit Compliance	21	21	112	18,326	95%
CP-5 wells	Environmental Surveillance	9	9	37	740	81%

7. QUALITY ASSURANCE

7. QUALITY ASSURANCE

Quality assurance (QA) plans and associated documents exist for both radiological and nonradiological analyses. QA documents were prepared in accordance with DOE Order 414.1C[28] and discuss who is responsible for QA and for auditing. Operating manuals have been prepared and are periodically reviewed and revised if necessary.

7.1. Sample Collection

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

The monitoring wells are sampled by using the protocols listed in the *RCRA Ground-Water Monitoring Technical Enforcement Guidance Document*.[27] The volume of water in the casing is determined by measuring the water depth from the surface and the depth to the bottom of the well. This latter measurement also determines whether siltation has occurred that might restrict water movement in the screened area. For those wells in the glacial drift that do not recharge rapidly, the well is emptied and the volume removed is compared with the calculated volume. In most cases, these volumes are nearly identical. The well is then sampled by bailing with a Teflon® bailer. In a number of wells, low flow sampling equipment has been installed to minimize the turbidity created by sampling with a bailer.

Samples for parameters such as priority pollutants are collected, and field parameters for these samples (pH, specific conductivity, redox potential, and temperature) are measured per well volume while purging. For sampling in the porous saturated zone, which recharges rapidly, three well volumes are purged by using bailers or submersible pumps. If field parameters are measured, samples are collected as soon as these readings stabilize. All samples are placed in precleaned bottles, labeled, and preserved. All non-dedicated field measurement and sampling equipment is cleaned by field rinsing with Type II deionized water. The sample log-in information is transferred to the analytical laboratory along with a computer disk that generates a one-page list of all samples. This list acts as the chain-of-custody transfer document.

7.2. Radiochemical Analysis and Radioactivity Measurements

The documentation for radiological analyses is contained in the ESQ-AS procedure manual. All nuclear instrumentation is calibrated with standard sources obtained from or traceable to the National Institute of Standards and Technology (NIST). The equipment is checked with secondary counting standards to ensure proper operation. Samples are periodically analyzed in duplicate or with the addition of known amounts of a radionuclide to check precision and accuracy. When a nuclide is not detected, the result is given as “less than” (<) the detection

limit by the analytical method used. The detection limits are chosen so that the measurement uncertainty at the 95% confidence level is equal to the measured value. The air and water detection limits for all radionuclides for which measurements were made in 2008 are given in Table 7.1.

TABLE 7.1

Air and Water Detection Limits

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

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

The relative error in a result decreases with increasing concentration. At a concentration equal to twice the detection limit, the error is approximately 50% of the measured value; at 10 times the detection limit, the error is approximately 10% at the 95% confidence level.

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

In 2008, Argonne participated in the Mixed Analyte Performance Evaluation Program (MAPEP) administered by the Radiological and Environmental Sciences Laboratory (RESL). The program consists of semiannual distribution of two different sample matrices containing combinations of radionuclides that are analyzed. The results are provided in Tables 7.2 and 7.3. The Argonne performance on the MAPEP intercomparison samples resulted in 96% (48 out of 50) of the analyses being in the MAPEP acceptable range. The two not-acceptable results were investigated, and a corrective action statement was issued.

TABLE 7.2

Summary of April MAPEP Intercomparison Samples, 2008

Analyte	Matrix	Units	Reported Value	Assigned Value	Acceptance Limits	Performance Evaluation
Am-241	Air filter	Bq/filter	0.150	0.158	0.111–0.205	Acceptable
Cs-134	Air filter	Bq/filter	2.10	2.52	1.76–3.28	Acceptable
Cs-137	Air filter	Bq/filter	2.60	2.70	1.89–3.51	Acceptable
Co-57	Air filter	Bq/filter	3.60	3.55	2.49–4.62	Acceptable
Co-60	Air filter	Bq/filter	1.50	1.31	0.92–1.70	Acceptable
Mn-54	Air filter	Bq/filter	0.10	< 0.10	–0.10–0.10	Acceptable
Pu-238	Air filter	Bq/filter	0.110	0.105	0.074–0.137	Acceptable
Pu-239/240	Air filter	Bq/filter	0.120	0.114	0.080–0.148	Acceptable
Sr-90	Air filter	Bq/filter	1.48	1.55	1.08–2.01	Acceptable
U-233/234	Air filter	Bq/filter	0.210	0.218	0.153–0.283	Acceptable
U-238	Air filter	Bq/filter	0.210	0.225	0.158–0.293	Acceptable
Zn-65	Air filter	Bq/filter	1.30	2.04	1.43–2.65	Not Acceptable
Am-241	Water	Bq/L	1.10	1.23	0.86–1.60	Acceptable
Cs-134	Water	Bq/L	–0.10	< 0.20	–0.20–0.20	Acceptable
Cs-137	Water	Bq/L	0.10	< 0.20	–0.20–0.20	Acceptable
Co-57	Water	Bq/L	21.9	22.8	16.0–29.6	Acceptable
Co-60	Water	Bq/L	8.6	8.4	2.88–10.92	Acceptable
H-3	Water	Bq/L	496	472	330–614	Acceptable
Mn-54	Water	Bq/L	11.5	12.1	8.5–15.7	Acceptable
Pu-238	Water	Bq/L	0.51	0.73	0.51–0.95	Not Acceptable
Pu-239/240	Water	Bq/L	0.010	0.014	0.004–0.014	Acceptable
Sr-90	Water	Bq/L	10.52	11.40	7.98–14.82	Acceptable
U-233/234	Water	Bq/L	3.16	3.63	2.54–4.72	Acceptable
U-238	Water	Bq/L	3.30	3.74	2.62–4.86	Acceptable
Zn-65	Water	Bq/L	14.0	16.3	11.4–21.2	Acceptable

7.3. Chemical Analysis

The documentation for nonradiological analyses is contained in the ESQ-AS procedure manual. All samples for NPDES and groundwater are collected and analyzed in accordance with EPA regulations found in 40 CFR Part 136,[19] EPA-600/4-84-017,[29] and EPA-SW-846.[30]

Standard reference materials traceable to the NIST are utilized to ensure the accuracy of most inorganic analyses (see Table 7.4) and are replaced annually. Detection limits are determined with techniques listed in 40 CFR Part 136[19] and are given in Table 7.5. In general, the detection limit is the measure of the variability of a standard material measurement at 5 to 10 times the instrument detection limit as measured over an extended time period. Recovery of inorganic metals, as determined by "spiking" unknown solutions, must be within the range of 75 to 125%. The precision, as determined by analysis of duplicate samples, must be within 20%. These measurements must be taken for at least 10% of the samples. Comparison samples for organic constituents were formerly available from the EPA. They are now commercially available under the Cooperative Research and Development Agreement that exists between the

TABLE 7.3

Summary of November MAPEP Intercomparison Samples, 2008

Analyte	Matrix	Units	Reported Value	Assigned Value	Acceptance Limits	Performance Evaluation
Am-241	Air filter	Bq/filter	0.002	<0.001	–0.001–0.001	Acceptable
Cs-134	Air filter	Bq/filter	2.16	2.63	1.84–3.42	Acceptable
Cs-137	Air filter	Bq/filter	–0.01	<0.16	–0.16–0.16	Acceptable
Co-57	Air filter	Bq/filter	1.58	1.50	1.05–1.95	Acceptable
Co-60	Air filter	Bq/filter	0.17	<0.18	–0.18–0.18	Acceptable
Mn-54	Air filter	Bq/filter	2.63	2.64	1.85–3.43	Acceptable
Pu-238	Air filter	Bq/filter	0.121	0.118	0.083–0.153	Acceptable
Pu-239/240	Air filter	Bq/filter	0.140	0.152	0.106–0.198	Acceptable
Sr-90	Air filter	Bq/filter	1.14	1.12	0.78–1.46	Acceptable
U-233/234	Air filter	Bq/filter	0.24	0.262	0.183–0.341	Acceptable
U-238	Air filter	Bq/filter	0.26	0.272	0.190–0.354	Acceptable
Zn-65	Air filter	Bq/filter	0.85	0.94	0.66–1.22	Acceptable
Am-241	Water	Bq/L	0.002	<0.003	–0.003–0.003	Acceptable
Cs-134	Water	Bq/L	15.4	19.5	13.7–25.4	Acceptable
Cs-137	Water	Bq/L	23.4	23.6	16.5–30.7	Acceptable
Co-57	Water	Bq/L	–0.06	<0.16	–0.16–0.16	Acceptable
Co-60	Water	Bq/L	12.1	11.6	8.1–15.1	Acceptable
H-3	Water	Bq/L	360.0	341	239–443	Acceptable
Mn-54	Water	Bq/L	12.9	13.7	9.6–17.8	Acceptable
Pu-238	Water	Bq/L	0.403	0.5	0.4–0.7	Acceptable
Pu-239/240	Water	Bq/L	0.005	<0.001	–0.001–0.001	Acceptable
Sr-90	Water	Bq/L	6.61	6.45	4.52–8.39	Acceptable
U-233/234	Water	Bq/L	3.13	3.44	2.41–4.47	Acceptable
U-238	Water	Bq/L	3.18	3.55	2.49–4.62	Acceptable
Zn-65	Water	Bq/L	14.7	17.1	12.0–22.2	Acceptable

EPA and commercial laboratories. In addition, standards are available that are certified by the American Association for Laboratory Accreditation, under a Memorandum of Understanding with the EPA. Many of these standards were used in this work. At least one standard mixture is analyzed each month; Tables 7.6 and 7.7 show the 2008 results for VOCs and SVOCs, respectively. The recoveries listed are those required by the respective methods.

7.4. NPDES Analytical Quality Assurance

Argonne conducts the majority of the analyses required for inclusion in the DMR. These analyses are conducted in accordance with EPA-approved methods set out in 40 CFR Part 136.[19] To demonstrate the capabilities of the Argonne laboratory for these analyses, the EPA requires that Argonne participate in the DMR-QA Program. An EPA-accredited provider sends a series of intercomparison samples to Argonne annually, and the ensuing analytical results are submitted to the provider for review. The proficiency of the laboratory is determined by comparing the

TABLE 7.4

Standard Reference Materials Used for Inorganic Analysis

Parameter	Reference Material[a]
Antimony	HP10002-2
Arsenic	HP10003-1
Barium	HP10004-1
Beryllium	HP10005-1
Boron	HP-10007-4
Cadmium	HP-10008-1
Chromium	HP100012-1
Cobalt	HP100013-1
Copper	HP100014-1
Iron	HP100026-1
Lead	HP100028-1
Manganese	HP100032-1
Mercury	N9300253
Nickel	HP100036-1
Selenium	HP100049-1
Silver	HP100051-1
Thallium	HP100058-1
Vanadium	HP100065-1
Zinc	HP100068-1
Sulfate	8110-32
Chloride	AS-CL9-2Y
Fluoride	AS-F9-1Y
Phosphorous	HACH 14204-16

[a] AS = SPEX CertiPrep; HACH = Hach Company; HP = High Purity; N = Perkin Elmer; and sulfate is from Ricca Chemical Company.

TABLE 7.5

Detection Limit for Metals Analysis, 2008

	Detection Limit (mg/L)	
Parameter	AA[a]	ICP[b]
Antimony	0.0030	NA[c]
Arsenic	0.0030	0.025
Barium	NA	0.012
Beryllium	0.0025	0.0025
Boron	NA	0.10
Cadmium	0.0025	0.0025
Chromium	0.15	0.05
Cobalt	NA	0.25
Copper	0.010	0.025
Hexavalent chromium[d]	0.011	NA
Iron	0.040	0.021
Lead	0.0040	0.09
Manganese	0.015	0.010
Mercury	0.0002	NA
Nickel	0.030	0.05
Selenium	0.010	0.121
Silver	0.0025	0.0025
Thallium	0.0020	0.082
Vanadium	NA	0.075
Zinc	0.1	0.02

[a] AA = atomic absorption spectroscopy.

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

[c] NA = not analyzed.

[d] Colorimetric measurement.

analytical results for the submitted samples with the provider values. Argonne has consistently performed very well on these tests. In 2008, all results were acceptable, with the exception of chloride and phosphorus. A Corrective Action Statement was prepared and forwarded to the EPA provider and the IEPA. The results of these analyses are shown in Table 7.8.

TABLE 7.6

Quality Check Sample Results: Volatile Analyses, 2008

Parameter	Recovery[a] (%)	Quality Limit (%)
Benzene	99	73–126
Bromobenzene	107	76–133
Bromodichloromethane	100	50–140
Bromoform	90	57–156
Butylbenzene	98	71–125
sec-Butylbenzene	95	71–145
t-Butylbenzene	102	69–134
Carbon tetrachloride	92	86–118
Chlorobenzene	110	80–137
Chloroform	102	68–120
o-Chlorotoluene	104	81–146
p-Chlorotoluene	105	73–144
1,2-Dibromo-3-chloropropane	67	36–154
Dibromochloromethane	103	68–130
1,2-Dibromoethane	99	75–149
Dibromomethane	124	65–143
1,2-Dichlorobenzene	101	59–174
1,3-Dichlorobenzene	108	84–143
1,4-Dichlorobenzene	109	58–172
1,1-Dichloroethane	93	71–142
1,2-Dichloroethane	110	70–134
1,1-Dichloroethene	103	18–209
cis-1,2-Dichloroethene	108	85–124
trans-1,2-Dichloroethene	109	67–141
1,2-Dichloropropane	107	19–179
1,3-Dichloropropane	115	73–145
1,1-Dichloropropene	102	71–133
Ethyl benzene	108	84–130
Isopropylbenzene	107	70–144
4-Isopropyltoluene	99	72–140
Methylene chloride	96	D–197[b]
n-Propylbenzene	100	78–139
1,1,1,2-Tetrachloroethane	75	88–133
Tetrachloroethene	114	84–132
Toluene	104	81–130
1,1,1-Trichloroethane	92	68–149
1,1,2-Trichloroethane	114	70–133
Trichloroethene	109	91–135
1,2,3-Trichloropropane	116	50–158
1,2,4-Trimethylbenzene	99	80–144
1,3,5-Trimethylbenzene	101	76–142
o-Xylene	104	79–141
p-Xylene	102	74–138

[a] Average of two determinations.

[b] D denotes that the compound was detected.

TABLE 7.7

Quality Check Sample Results:
Semivolatile Analyses, 2008

Parameter	Recovery[a] (%)	Quality Limit (%)
2-Fluorophenol[b]	31.1	21–100
Phenol-d5[b]	32.8	10–94
Phenol	19.6	17–100
2-Chlorophenol	46.9	36–120
1,3-Dichlorobenzene	54.7	33–95
1,4-Dichlorobenzene	50.9	37–106
n-Nitroso-n-propylamine	144.4	24–198
Nitrobenzene-d5[b]	77.3	35–114
1,2,4-Trichlorobenzene	62.9	57–129
4-Chloro-3-methylphenol	83.6	41–128
2-Fluorobiphenyl[b]	70.8	43–116
2-Methylnaphthalene	56.3	45–113
Acenaphthene	47.6	47–145
2,4-Dinitrotoluene	84.0	48–127
2,4,6-Tribromophenol[b]	55.0	10–123
Pentachlorophenol	96.0	38–152
Pyrene	86.8	70–100
Terphenyl-d14[b]	85.8	33–141

[a] Average of three independent determinations.

[b] Required surrogates.

TABLE 7.8

Summary of DMR-QA Intercomparison Samples, 2008

Analyte	Units	Reported Value	Assigned Value	Acceptance Limits	Performance Evaluation
Antimony	µg/L	282	284	193–345	Acceptable
Arsenic	µg/L	171	177	145–210	Acceptable
Barium	µg/L	1,185	1,180	1,020–1,330	Acceptable
Beryllium	µg/L	575	601	511–679	Acceptable
Boron	µg/L	1,581	1,580	1,290–1,840	Acceptable
Cadmium	µg/L	525	538	459–611	Acceptable
Chromium	µg/L	483	491	427–556	Acceptable
Cobalt	µg/L	722	686	603–769	Acceptable
Copper	µg/L	585	585	526–644	Acceptable
Iron	µg/L	749	742	654–840	Acceptable
Lead	µg/L	280	282	242–321	Acceptable
Manganese	µg/L	502	489	438–543	Acceptable
Mercury	µg/L	21	16.9	10.4–22.8	Acceptable
Nickel	µg/L	1,885	1,860	1,670–2,070	Acceptable
Selenium	µg/L	404	400	315–464	Acceptable
Silver	µg/L	201	206	176–236	Acceptable
Thallium	µg/L	551	558	451–669	Acceptable
Vanadium	µg/L	613	622	545–696	Acceptable
Zinc	µg/L	707	683	586–786	Acceptable
Hexavalent chromium	µg/L	448	434	352–511	Acceptable
Chloride	mg/L	52.8	42.5	35.9–49.8	Not Acceptable
Fluoride	mg/L	3.65	3.74	3.15–4.34	Acceptable
Sulfate	mg/L	29	34.2	27.5–40.0	Acceptable
Phosphorus	mg/L	0.74	4.96	4.10–5.86	Not Acceptable
Biochemical oxygen demand	mg/L	58	56.4	28.3–84.4	Acceptable
Chemical oxygen demand	mg/L	82.5	91.0	66.9–107	Acceptable
Ammonia nitrogen	mg/L	13.43	13.0	9.66–16.2	Acceptable
Total residual chlorine	mg/L	0.79	0.792	0.573–0.992	Acceptable
Total cyanide	mg/L	0.86	0.873	0.560–1.18	Acceptable
pH	S.U.	6.82	6.80	6.60–7.00	Acceptable
Total phenolics	mg/L	0.98	1.10	0.608–1.60	Acceptable
Total suspended solids	mg/L	33.8	33.1	23.8–39.3	Acceptable
Total dissolved solids	mg/L	248	238	176–300	Acceptable
Oil and grease	mg/L	36.1	40.0	24.4–50.0	Acceptable
Fathead minnow acute toxicity	LC_{50}	17.68	29.4	6.91–51.9	Acceptable
Water flea acute toxicity	LC_{50}	<6.25	36.0	0.00–80.1	Acceptable

8. APPENDIX

8. APPENDIX

8.1. References

1. U.S. Department of Energy, 2008, "Environmental Protection Program," DOE Order 450.1A, June 4.

2. U.S. Department of Energy, 2007, "Environment, Safety, and Health Reporting," DOE Order 231.1A, June 12.

3. U.S. Army Corps of Engineers, 1987, *Corps of Engineers Wetlands Delineation Manual*, Technical Report Y-87-1, Washington, DC.

4. U.S. Department of Energy, 1991, *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*, DOE/EH-0173T, Washington, DC.

5. U.S. Department of Energy, 2000, "Radiation Protection of the Public and the Environment," DOE Order 5400.5, Oct. 6.

6. International Commission on Radiological Protection, 1977, *Recommendations of the International Commission on Radiological Protection*, ICRP Publication 26, Annals of the ICRP, 1(2), Pergamon Press, New York, NY.

7. International Commission on Radiological Protection, 1979–1982, *Limits for Intakes of Radionuclides by Workers*, ICRP Publication 30, Part 1 (and Supplement), Part 2 (and Supplement), Part 3 (and Supplements A and B), and Index, Annals of the ICRP, Pergamon Press, New York, NY.

8. U.S. Department of Energy, 1988, *Internal Dose Conversion Factors for Calculation of Dose to the Public*, DOE/EH-0071, Washington, DC.

9. Parks, B.S., 1992, *User's Guide for CAP88-C, Version 1.0*, EPA 402-B-92-001, Office of Radiation Programs, U.S. Environmental Protection Agency, Las Vegas, NV.

10. Larsen, R.J., 1993, "Global Decrease of Beryllium-7 in Surface Air," *Journal of Environmental Radioactivity* 18:85–87.

11. Golchert, N.W., and R.G. Kolzow, 1998, *Argonne National Laboratory-East Site Environmental Report for Calendar Year 1997*, ANL-98/02, Argonne National Laboratory, Argonne, IL.

12. Golchert, N.W., T.M. Davis, and L.P. Moos, 2008, *Argonne National Laboratory Site Environmental Report for Calendar Year 2007*, ANL-08/05, Argonne National Laboratory, Argonne, IL.

13. U.S. Environmental Protection Agency, 1990, "National Emission Standards for Hazardous Air Pollutants," *Code of Federal Regulations*, Title 40, Part 61, Subpart H.

14. National Council on Radiation Protection and Measurements, 1987, *Ionizing Radiation Exposure of the Population of the United States*, NCRP Report No. 93, Washington, DC.

15. International Commission on Radiological Protection, 1975, *Reference Man: Anatomical, Physiological, and Metabolic Characteristics*, ICRP Publication 23, Pergamon Press, New York, NY.

16. U.S. Department of Energy, 2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*, DOE-STD-1153, 2002, Washington, DC, July.

17. U.S. Environmental Protection Agency, 1993, "National Primary Drinking Water Regulations," *Code of Federal Regulations*, Title 40, Part 141.

18. U.S. Environmental Protection Agency, 1984, "EPA Administered Permit Program: The National Pollutant Discharge Elimination System," *Code of Federal Regulations*, Title 40, Part 122.

19. U.S. Environmental Protection Agency, 1986, "Test Procedures for the Analysis of Pollutants under the Clean Water Act," *Code of Federal Regulations*, Title 40, Part 136.

20. American Water Works Association, 2005, *Standard Methods for the Examination of Water and Wastewater*, 21st ed., American Public Health Association, American Water Works Association, and Water Environment Federation, Oct. 15.

21. State of Illinois, *Rules and Regulations*, 1985, Title 35, "Environmental Protection," Subtitle C, Water Pollution, Chapter 1.

22. State of Illinois, *Rules and Regulations*, 2002, Title 35, "Environmental Protection," Subtitle C, Part 304, Dec. 20.

23. State of Illinois, *Rules and Regulations*, 2002, Title 35, "Environmental Protection," Subtitle C, Part 302, Dec. 20.

24. Argonne National Laboratory, 1991, *800 Area Landfill Closure Plan, Post-Closure Care Plan, and Cost Estimate*, Argonne National Laboratory's Environmental and Waste Management Program, Document Number J0500-101-W-T003.

25. Golchert, N.W., L.P. Moos, and J.J. Quinn, 2008, *Groundwater Protection Management Program Plan*, ANL-08/28, Argonne National Laboratory, Argonne, IL.

26. State of Illinois, *Rules and Regulations*, 2002, Title 35, "Groundwater Quality Standards," Subtitle F, Part 620, Dec. 20.

27. U.S. Environmental Protection Agency, 1986, *RCRA Ground-Water Monitoring Technical Enforcement Guidance Document*, OSWER-9950.1, Office of Solid Waste and Emergency Response, Washington, DC.

28. U.S. Department of Energy, 2005, "Quality Assurance," DOE Order 414.1C, June 17.

29. U.S. Environmental Protection Agency, 1984, *Methods for Chemical Analysis of Water and Wastes*, EPA-600/4-84-017, Washington, DC.

30. U.S. Environmental Protection Agency, 1986, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*, EPA-SW-846, 3rd ed., Nov. 1986 and subsequent updates, Office of Solid Waste, Washington, DC.

8.2. Distribution for 09/02

Internal:

B. Arnold
T. Barkalow
S.I. Baker
G.L. Barrett
G.A. Baudino
A.B. Beach
R.M. Beaver
J.J. Benkert
T.S. Bray
W.S. Bray
J.L. Caldwell
D.R. Cook
T.M. Davis (5)
M. Dunn
A.J. Dvorak
G.R. Dyrkacz
A.T. Fracaro
J.M. Gibson
N.W. Golchert (50)
J.L. Gomez
G.E. Griffin
M.R. Hale
A.M. Harris
D.A. Haugen
D.S. Hodge
P.E. Hollopeter
R. Hrabak
E.D. Isaacs
M.A. Kamiya
G.A. Kulma
S.K. Lorenz
W.D. Luck
P.L. Lynch
J.F. MacLean
S.G. Meredith
B.J. Micklich
S.A. Minnick
L.P. Moos (5)
G.D. Mosho
W.J. Munyon
B.G. Pierce
R.J. Patchak
R.E. Piorkowski
J. Quinn
S. Richardson
C.M. Rock
A.P. Sattelberger
T. Schneider
C.M. Sholeen
R.L. Stevens
G.Y. Stine
K. Trychta
J.L. Tucker
N. VanWermeskerken
D. Whitaker-Sheppard
L. Wilewski
C.L. Wilkinson (2)
G. Winner (3)
B.M. Wozny
G.H. Zeman

External:

DOE-HQ, Glenn S. Podonsky, Chief Health, Safety and Security Officer, HS-1
DOE-HQ, Andrew C. Lawrence, Director, Office of Nuclear Safety and Environment, HS-20
DOE-HQ, William Roege, Director, Office of Corporate Safety Analysis, HS-30
DOE-HQ, William A. Eckroade, Director, Office of Independent Oversight, HS-60
DOE-HQ, Ross Natoli, Office of Corporate Safety Analysis, Office of Analysis, HS-32(3)
DOE-HQ, P.M. Dehmer, Office of Science, SC-10
DOE-HQ, Van Nguyen, Office of Science, SC-83
DOE-NBL, J.W. Neuhoff
DOE-ASO, R.J. Lutha (15)

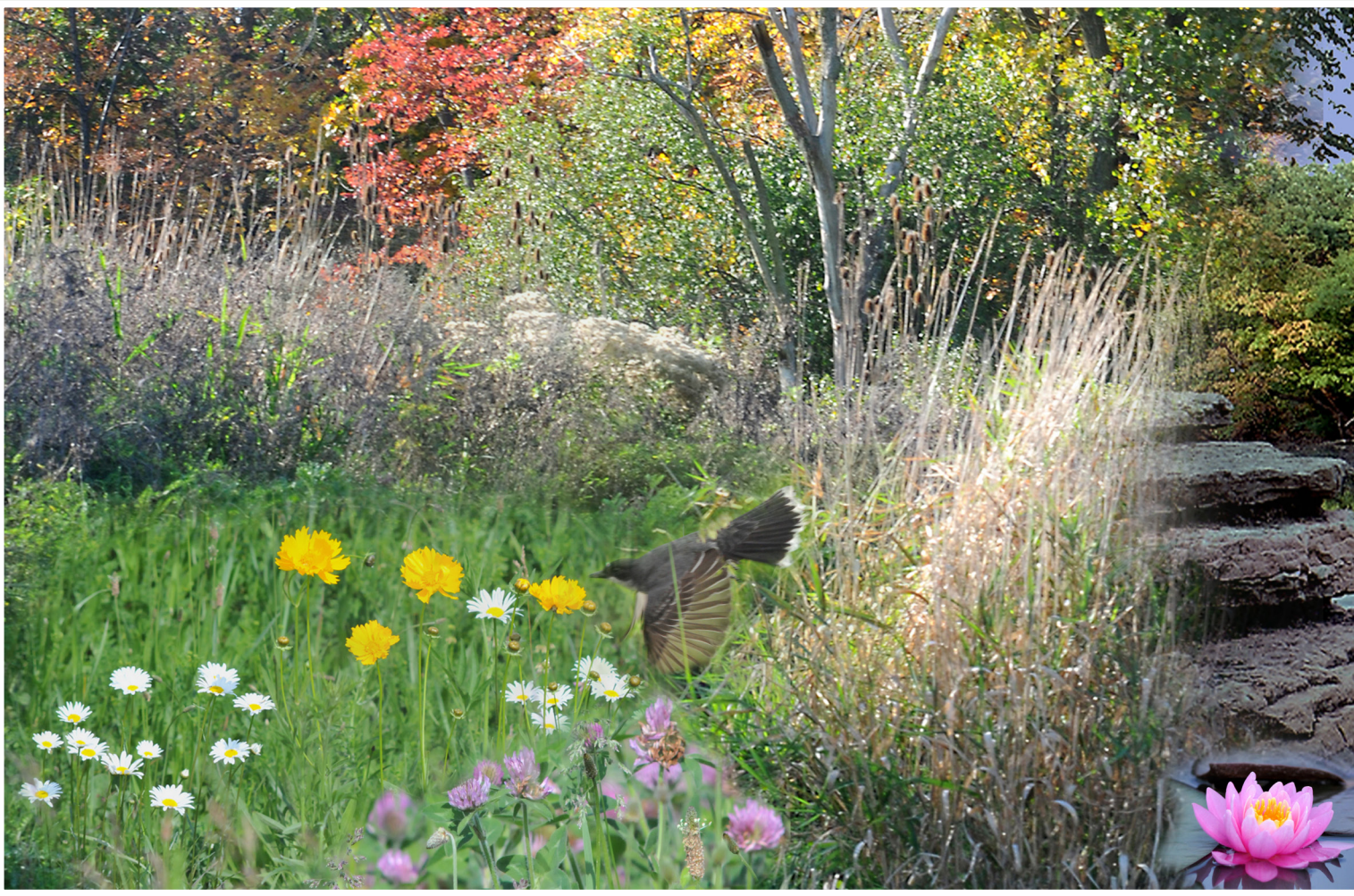
David Antonacchi, Illinois Department of Public Health, Springfield, Illinois
Matt Blazek, DuPage County Forest Preserve District, Wheaton, Illinois
Jim Blough, U.S. Environmental Protection Agency, Region 5, Chicago, Illinois
Magaly Bascones Dominguez, CERN, Geneva, Switzerland
Mike Garretson, Water Compliance, Illinois Environmental Protection Agency, Springfield, Illinois
William Griffing, Fermi National Accelerator Laboratory, Batavia, Illinois
James D. Heffner, Westinghouse Savannah River Company, Aiken, South Carolina
Robert C. Holland, Sandia National Laboratories, Livermore, California
Betsy Holmes, DOE Idaho Operations Office, Idaho Falls, Idaho
Joan Hughes, Oak Ridge National Laboratory, Oak Ridge, Tennessee
Bruce Hurley, DOE Nevada Site Office, Las Vegas, Nevada
Lorna Jereza, U.S. Environmental Protection Agency, Region 5, Chicago, Illinois
Chris Kallis, Illinois Environmental Protection Agency, Des Plaines, Illinois
David Klenk, West Valley Environmental Services LLC, West Valley, New York
Judith Kriz, U.S. Environmental Protection Agency, Region 5, Chicago, Illinois
Mark Liska, Illinois Environmental Protection Agency, Springfield, Illinois
Bob Lorenz, Westinghouse Savannah River Company, Aiken, South Carolina
Gary McCandless, Illinois Emergency Management Agency, Springfield, Illinois
Dale Meyer, U.S. Environmental Protection Agency, Region 5, Chicago, Illinois
Jim Moore, Illinois Environmental Protection Agency, Springfield, Illinois
Joyce Munie, Illinois Environmental Protection Agency, Springfield, Illinois
Michael Murphy, U.S. Environmental Protection Agency, Region 5, Chicago, Illinois
Terri Myers, Illinois Environmental Protection Agency, Springfield, Illinois
Steve Nightingale, Illinois Environmental Protection Agency, Springfield, Illinois
J. O'Connor, Illinois Department of Public Health, West Chicago, Illinois
Michael Palazzetti, DuPage County Forest Preserve District, Wheaton, Illinois
Doug Paquette, Brookhaven National Laboratory, Upton, New York
Ted Poston, Pacific Northwest National Laboratories, Richland, Washington
Karen Ratel, Brookhaven National Laboratory, Upton, New York
John Riekstins, Illinois Environmental Protection Agency, Springfield, Illinois
Michael Ruggieri, Ernest Orlando Lawrence Berkeley National Laboratory, Berkeley, California
Stephanie Salinas, Sandia National Laboratories, Albuquerque, New Mexico
Cathy Wills, Bechtel-Nevada, Las Vegas, Nevada

8. APPENDIX

Argonne NATIONAL LABORATORY

Environment, Safety, and Health/Quality Assurance Division
Argonne National Laboratory
9700 South Cass Avenue, Bldg. 201
Argonne, IL 60439-4832

www.anl.gov



U.S. DEPARTMENT OF ENERGY