



Environment, Safety, Health, and Quality Assurance Division

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Site Environmental Report 2009
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Site Environmental Report

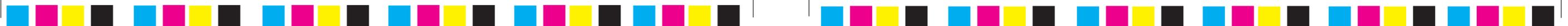
for Calendar Year 2009

Environment, Safety, Health, and Quality Assurance Division



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**Argonne National Laboratory
Site Environmental Report
for Calendar Year 2009**

Preceding Report in This Series: ANL-09/02

by
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Environment, Safety, Health, and Quality Assurance Division
Argonne National Laboratory

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This Site Environmental Report (SER) was prepared by the Environment, Safety, Health, and 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/Community_and_Environment/Environmental_Reports/ser2009.pdf.



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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
ASO	Argonne Site Office
ATLAS	Argonne Tandem Linac Accelerating System
BAT	Best Available Technology
BCG	Biota Concentration Guide
BOD₅	Biochemical Oxygen Demand
CAA	Clean Air Act
CAAPP	Clean Air Act Permit Program
CAP-88	Clean Air Act Assessment Package-1988
CARB	California Air Resources Board
CAS	Chemical Abstract Services
CCA	Compliance Commitment Agreement
CEDE	Committed Effective Dose Equivalent
CEMP	Comprehensive Emergency Management Plan
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	<i>Code of Federal Regulations</i>
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
DCG	Derived Concentration Guides
DMR	Discharge Monitoring Report
DOE	U.S. Department of Energy
DOE-ASO	DOE Argonne Site Office
EA	Environmental Assessment
EC	Environmental Compliance
EHS	Extremely Hazardous Substance
EIS	Environmental Impact Statement
EMS	Environmental Management System

ACRONYMS

ENE	East-Northeast
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right to Know Act
ESA	Endangered Species Act of 1973
ESH	Environment, Safety, and Health
ESQ	Environment, Safety, Health, and 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	<i>Illinois Administrative Code</i>
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
LEED	Leadership in Energy and Environmental Design
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
MLLW	Mixed Low-Level Wastes
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
NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NRC	National Response Center
NRHP	<i>National Register of Historic Places</i>
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 of 1976
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

ACRONYMS

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

This report discusses the status and the accomplishments of the environmental protection program at Argonne National Laboratory for calendar year 2009. 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, Argonne, and other) and are compared with applicable environmental quality standards. A U.S. Department of Energy (DOE) dose calculation methodology, based on International Commission on Radiological Protection recommendations and the U.S. Environmental Protection Agency's (EPA) CAP-88 Version 3 (Clean Air Act Assessment Package-1988) computer code, was used in preparing this report.

ABSTRACT

1. INTRODUCTION



1. INTRODUCTION

1.1. General Background Information

This annual report for calendar year 2009 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 as well as 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 450.1A¹ and 231.1A² 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 2009 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 principal non-nuclear activities at Argonne in 2009 that could have measurable impacts on the environment include the use of a coal-fired Boiler No. 5 and the discharge of

1. INTRODUCTION

wastewater from various sources. 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 and began operation in December 2009.

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,

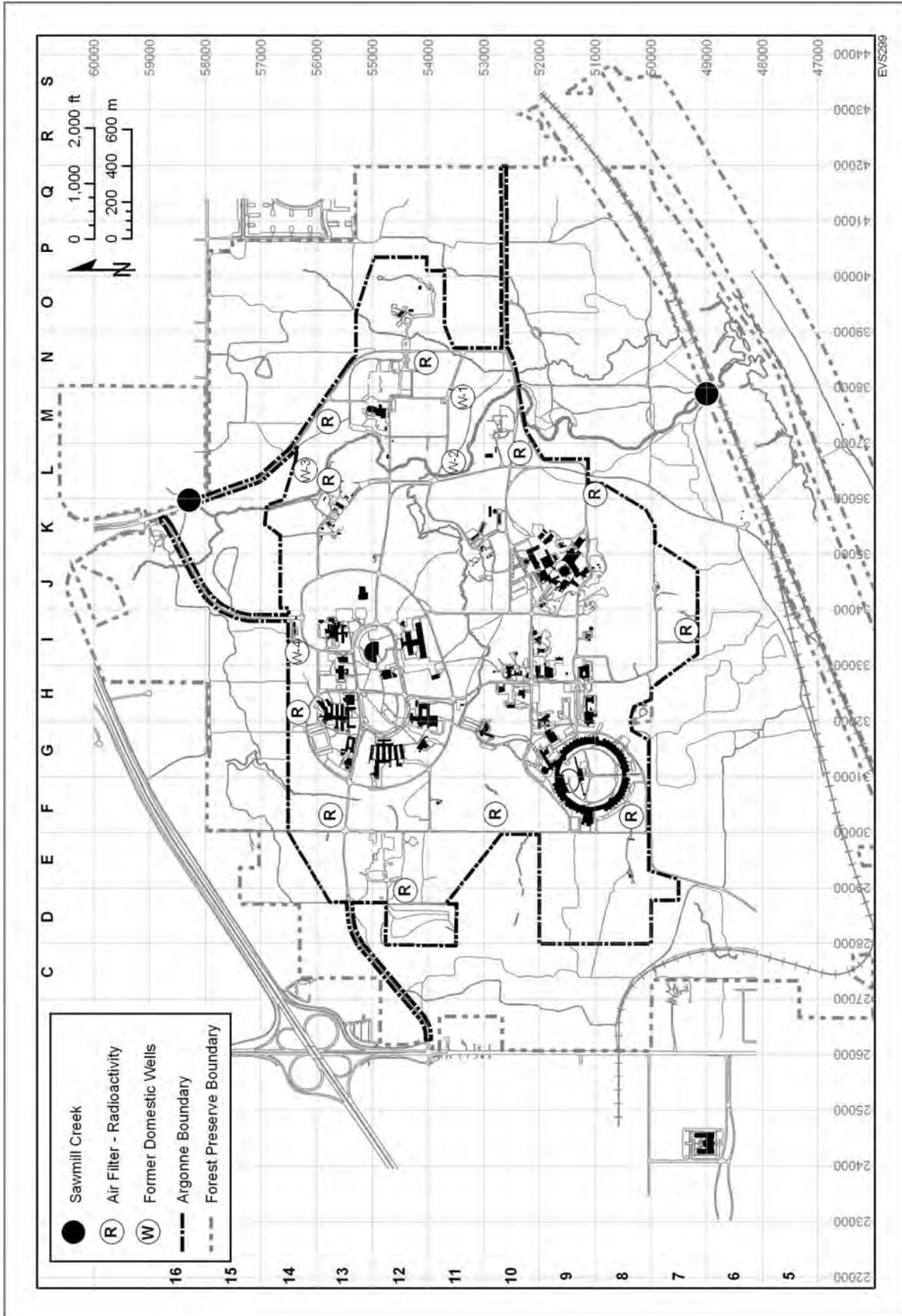


FIGURE 1.1 Sampling Locations at Argonne National Laboratory

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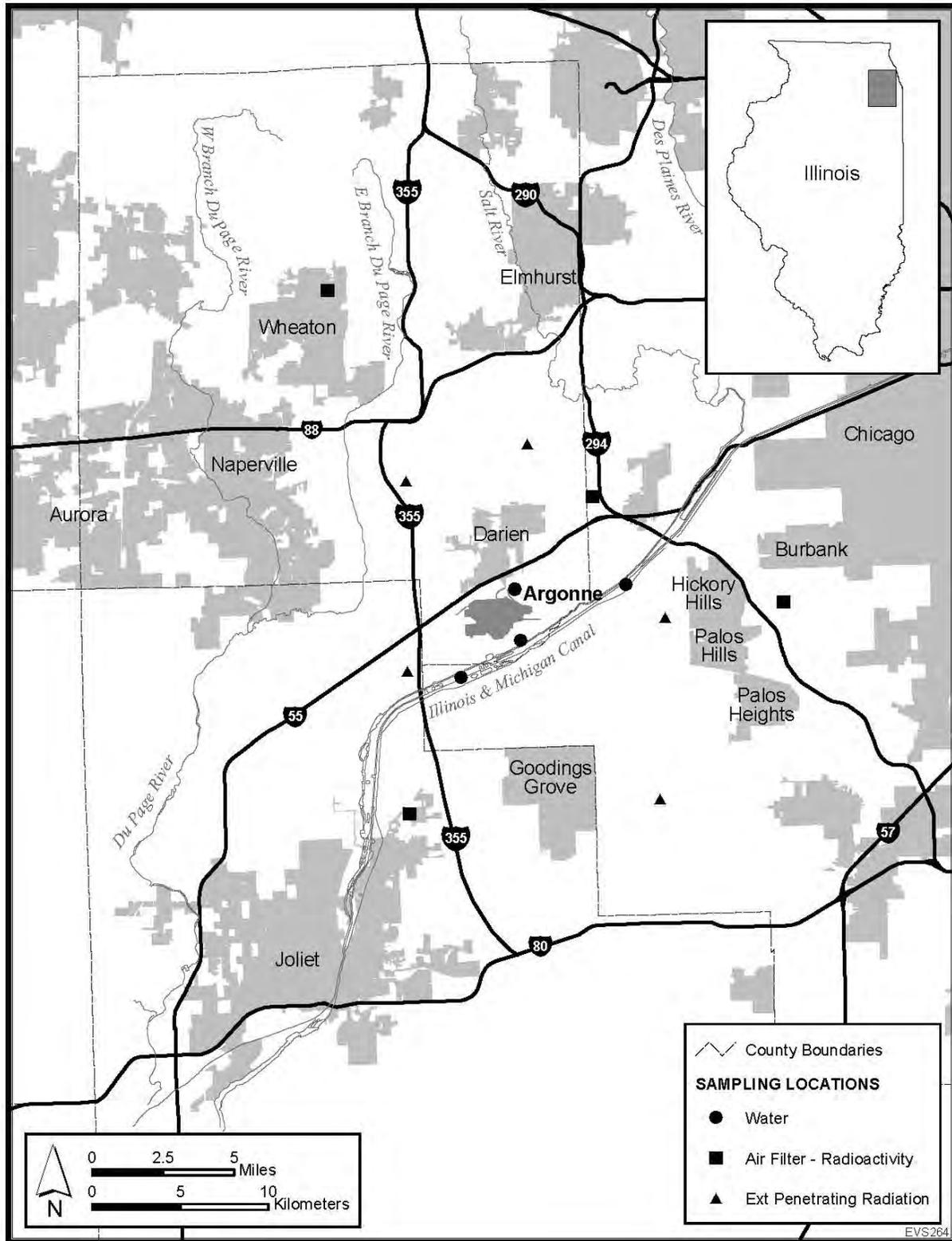


FIGURE 1.2 Sampling Locations Near Argonne National Laboratory

TABLE 1.1
Population Distribution in the Vicinity of Argonne, 2005

Direction	Miles ^a									
	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
N	0	1,260	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.

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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 2009 data were obtained from the on-site Argonne meteorological station. The annual average wind rose for 2009 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 2009 precipitation and temperature data taken at ten meters. The monthly precipitation data for 2009 show differences from the Argonne historical average primarily in March, July, September, and October. The annual total was 22% above the annual average for

TABLE 1.2

Argonne Weather Summary, 2009

Month	Precipitation (cm)		Temperature (°C)		
	Argonne 2009	Argonne Historical ^a	Argonne 2009	Argonne Historical ^a	
January	2.54	4.29	-8.7	-4.7	
February	8.99	4.19	-1.7	-1.9	
March	15.82	6.05	5.7	3.1	
April	12.39	8.34	9.0	9.4	
May	12.39	9.69	15.6	14.0	
June	12.76	8.52	19.9	20.7	
July	3.69	10.55	20.5	23.1	
August	11.01	10.34	20.9	22.1	
September	2.31	8.28	18.2	18.2	
October	19.66	8.07	8.9	11.4	
November	3.85	8.87	7.6	4.4	
December	<u>7.05</u>	<u>4.58</u>	<u>-3.0</u>	<u>-2.9</u>	
Total	112.46	91.77	Monthly Average	9.4	10.0

^a Averages were obtained from the Argonne meteorological tower by using data from the last 25 years (1983–2008).

the Argonne data. The 2009 annual monthly average temperature was 6% 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 has 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.

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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 2009, this effluent averaged 2.83 million L/day (0.75 million gal/day), which is similar to the averages for the last few years. The combined Argonne effluent consisted of 64% laboratory wastewater and 36% sanitary wastewater. The water flow in Sawmill Creek upstream of the wastewater outfall averaged about 48 million L/day (12.6 million gal/day) during 2009.

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

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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/mi² 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.

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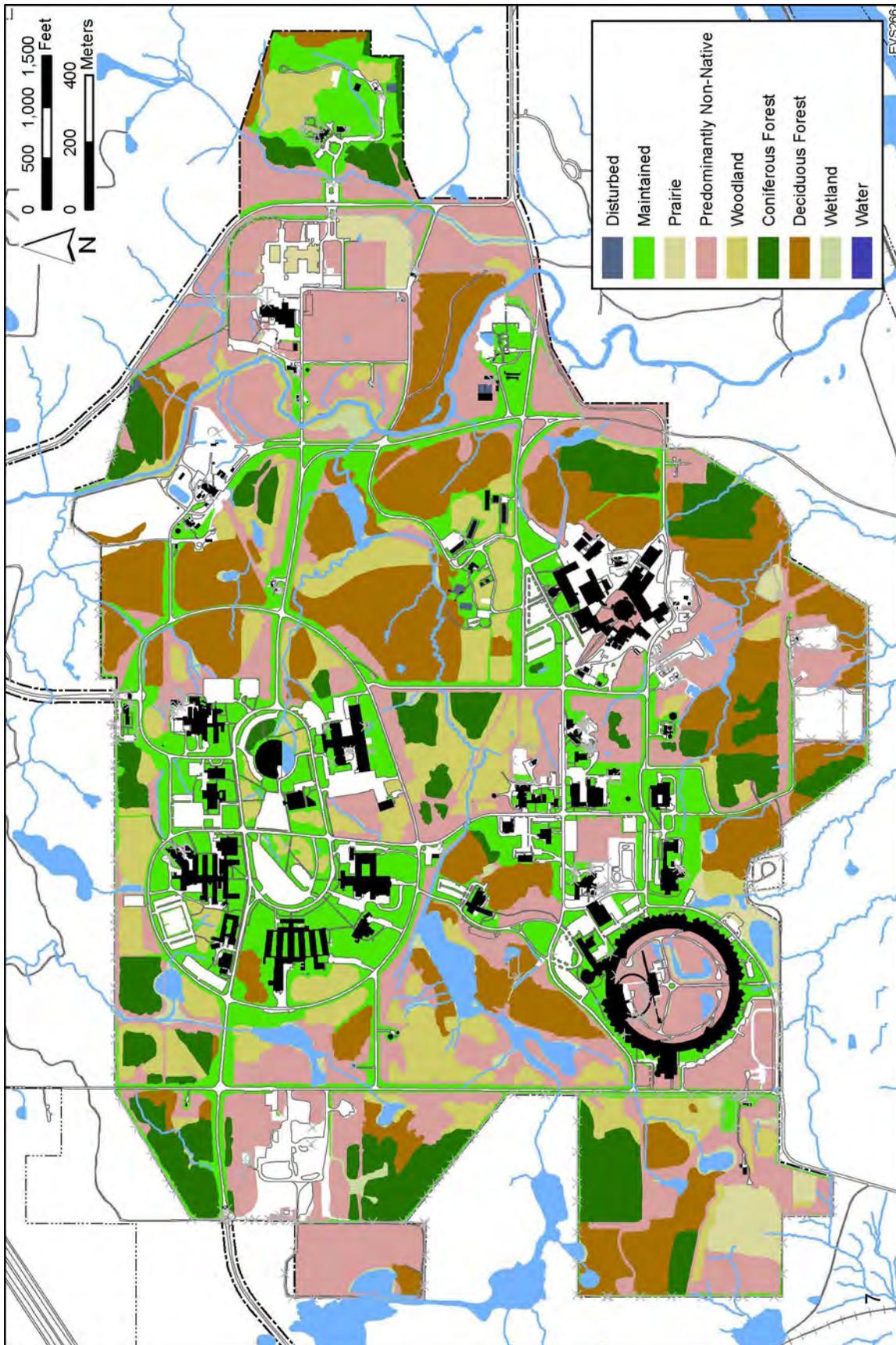


FIGURE 1.3 Argonne Vegetation Communities

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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, sunfish, 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 three areas at Argonne, the 200 Area campus, the 300 Area reactor development buildings, and the 600 Area (Freund Estate District) 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

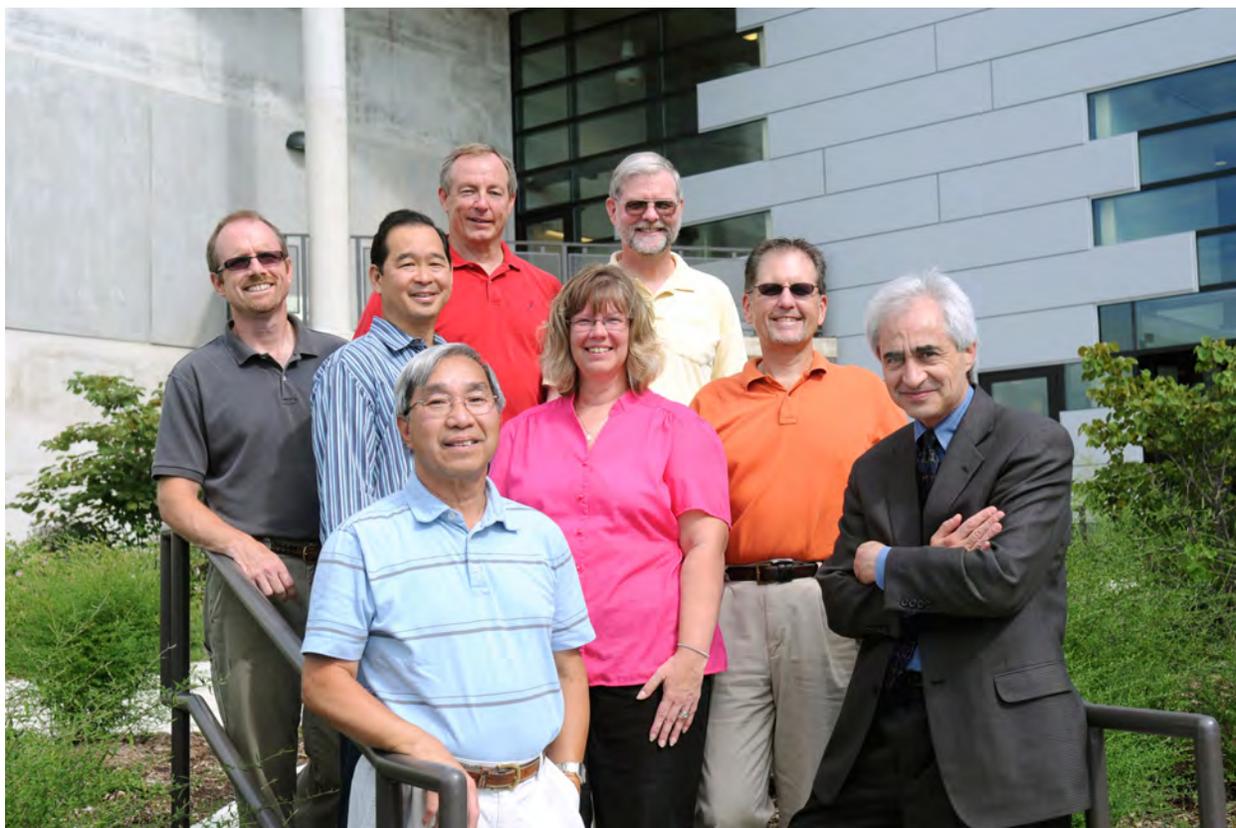
No federally-listed threatened or endangered species is known to occur on the Argonne site, and no critical habitat of federally-listed species exists on the site. Three federally-listed endangered species and one federally-listed threatened species are known to inhabit the Waterfall Glen Forest Preserve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

1. INTRODUCTION

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 herbacea*) has a planted population in Waterfall Glen Forest Preserve. Additional state-listed species that occur in the area are identified in Section 2.10.

1. INTRODUCTION

2. COMPLIANCE SUMMARY



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 2009 with regard to these authorities is discussed in this chapter.

The Atomic Energy Act of 1954 (AEA) was enacted 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 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

2. COMPLIANCE SUMMARY

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 renewed 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 2009, such equipment was not yet available for installation.

Facilities that are 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. For purposes of the Title V permit, these activities are categorized as insignificant, except in cases involving the emission of radionuclides. In 2009, a construction permit (originally issued in 2008 but renewed in 2009) was used to test two biomass-based fuels (wood chips and agricultural fuel pellets) co-fired with coal in Boiler No. 5.

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

2. COMPLIANCE SUMMARY

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 447.2 m³ (15,793 ft³) of ACM was generated from Argonne asbestos removal projects during 2009. The 76 small removal projects that were completed generated 21.2 m³ (748 ft³) of ACM waste. Ten large removal projects generated the remaining 426 m³ (15,045 ft³) of ACM waste. Table 2.1 provides asbestos abatement information for the large removal projects. The IEPA was notified during December 2009 that no more than 34 m³ (1,200 ft³) of ACM waste is expected to be generated from small-scale projects during 2010. 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 2009 was 0.0026 mrem, which is less than 0.03% of the 10 mrem/yr EPA standard. Section 4.7.1 and the 2009 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 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.

2. COMPLIANCE SUMMARY

TABLE 2.1

Asbestos Abatement Projects
DOE/IEPA Notification,
January–December 2009

Completion Date	Asbestos Abatement Contractor	Notification Quantity			Material	Building	Disposal Quantity (ft ³)	Landfill
		ft	ft ²	ft ³				
2/16/2009	Argonne Waste Management	0	3,000	0	Ceiling coating	350	1,168	Envirotech, Morris, IL
5/11/2009	Argonne Waste Management	0	428	0	Floor tile and mastic	202	32	Envirotech, Morris, IL
5/15/2009	Argonne Waste Management	0	0	140	Firestop material	202	92	Envirotech, Morris, IL
6/30/2009	Demco, Inc. (demolition contractor)	0	86	0	Window caulk and firedoor insulation ^a	301	810	Envirotech, Morris, IL
8/31/2009	Colfax Corporation	0	150	0	Transite panels ^b	108	42 ^c	Envirotech, Morris, IL
9/20/2009	LVI Environmental Services, Inc.	0	15,600	0	Shell roof mastic ^b	331	7,290	Envirotech, Morris, IL
10/2/2009	Atlantic/Insulco Environmental Services	320	1,200	0	Pipe insulation, floor tile and mastic	316	22	Envirotech, Morris, IL
11/13/2009	Interstate Asbestos Removal Company	6,720	10,900	0	Floor tile and mastic, wallboard mastic, TSI	330	4,725	River Bend Prairie, Dolton, IL
12/4/2009	Valor Technologies, Inc.	0	4,500	0	Floor tile and mastic ^b	221	810	Envirotech, Morris, IL
12/5/2009	Argonne Waste Management	0	900	0	Floor tile, mastic and ceiling tile	362	54 ^c	Envirotech, Morris, IL

^a Windows and firedoors separated from demolition debris.

^b Courtesy notification, nonfriable material.

^c On-site pending shipment to Envirotech.

2. COMPLIANCE SUMMARY

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 2009, as well as the amount of low-sulfur coal burned. There were no exceedances at Boiler No. 5 in 2009. This includes coal co-fired with biomass fuel (wood chips or agricultural fuel pellets) for testing purposes under construction permit #08100017.

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 2009, there were no deviations identified regarding compliance with the Title V permit.

Landfill gas monitoring is conducted quarterly at the 800 Area Landfill via four 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 2009, no methane was detected above action levels in the landfill perimeter gas sampling wells.

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 2009 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) 2009 (September 1, 2008–August 31, 2009) vehicles because all current MY

TABLE 2.2

Boiler No. 5 Operation, 2009		
Month	Operated (hours)	Low-Sulfur Coal Burned (tons)
January	180	602
February	0	0
March	0	0
April	0	0
May	0	0
June	0	0
July	0	0
August	0	0
September	373	1,211
October	112	291
November	0	0
December	526	1,802
Total	1,191	3,906

2. COMPLIANCE SUMMARY

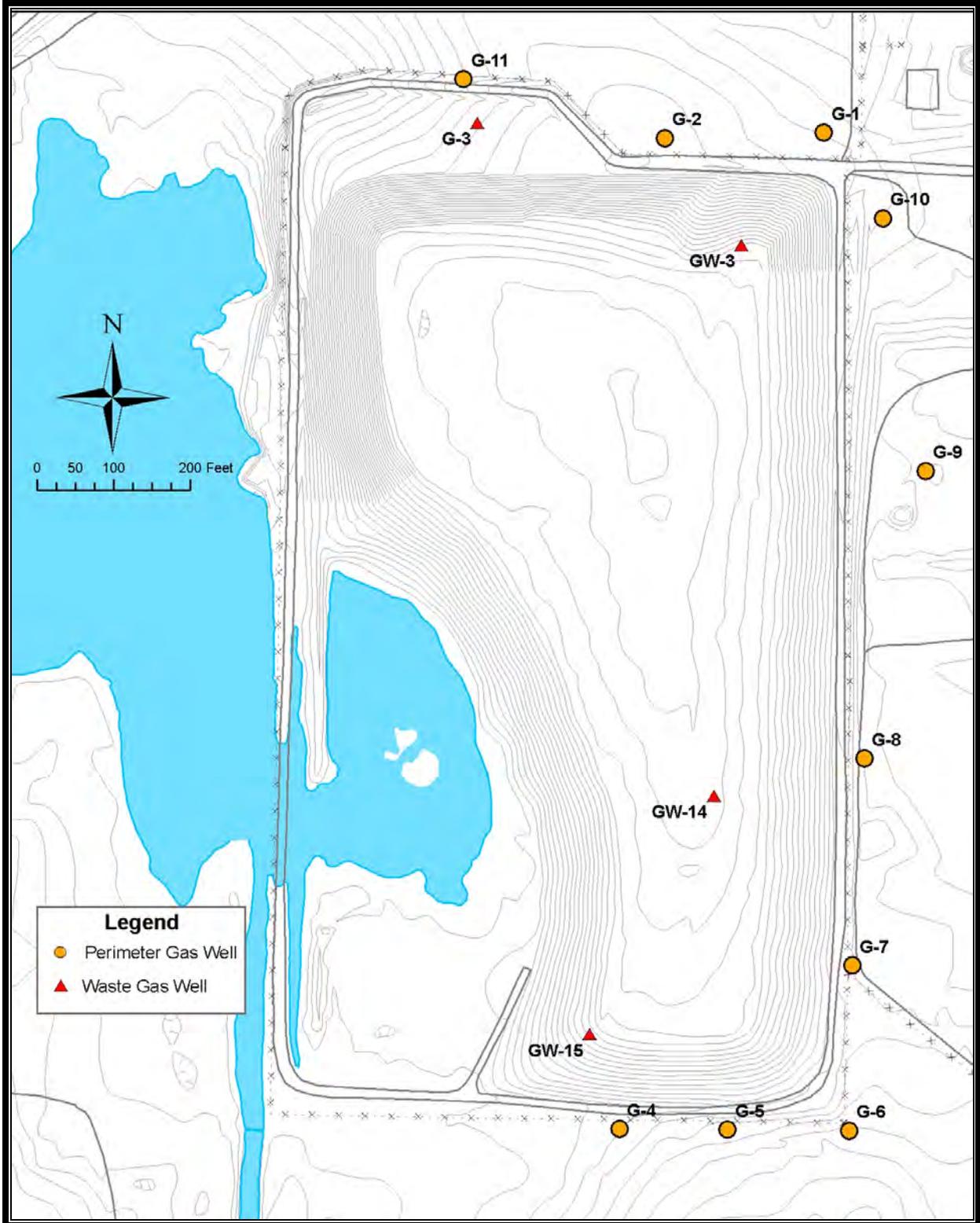


FIGURE 2.1 800 Area Landfill Gas Monitoring Wells

TABLE 2.3

2009 Annual Emissions Report: Emissions Summary,
Argonne CAAPP Permit No. 95090195^a

Building No. and Source	CO	NO _x	PM/PM ₁₀	PM _{2.5} ^e	SO ₂	VOM	HAP ^b	NH ₃ ^e	CO ₂ ^f	CH ₄ ^f	N ₂ O ^f
108: Boiler 1 (gas-fired)	22,377	26,639	2,025	506	160	1,465	-	131	32,009,861	604	60
108: Boiler 2 (gas-fired)	9,761	11,620	883	221	70	639	-	57	13,962,770	263	26
108: Boiler 3 (gas-fired)	16,195	19,280	1,465	366	116	1,060	-	94	23,167,619	437	44
108: Boiler 4 (gas-fired)	14,326	17,054	1,296	324	102	938	-	84	20,492,752	387	39
108: Boiler 5 (gas-fired)	2,917	4,236	264	66	21	191	-	17	4,172,332	79	8
108: Boiler 5 (coal-fired)	9,367	42,972	1,239	125	82,048	142	5,274	2.2	20,058,145	2,362	344
400: APS generator (Caterpillar)	260	1,353	48	48	112	37	-	1.0	28,532	1	<1
400: APS generators – Kohler (2)	585	3,045	108	108	252	98	-	1.3	36,137	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	47,756	9,293	628	382	558	2,949	-	13.3	214,437	8.6	1.7
PCB tank cleanout	-	-	-	-	-	0	-	-	-	-	-
208: Surface preparation facility	-	-	-	-	-	-	0.4	-	-	-	-
46: EtOH/gasoline storage	-	-	-	-	-	0.2	-	-	-	-	-
46: 10K-gal gasoline storage	-	-	-	-	-	0.9	-	-	-	-	-
370: Alkali reaction booth ^c	-	-	-	-	-	-	-	-	-	-	-
308: Alkali reaction booth ^c	-	-	-	-	-	-	-	-	-	-	-
363: Central Shop dust collector ^c	-	-	-	-	-	-	-	-	-	-	-
212: Building exhausts ^c	-	-	-	-	-	-	-	-	-	-	-
368: Woodshop dust collector ^c	-	-	-	-	-	-	-	-	-	-	-
108: Sulfuric acid storage ^c	-	-	-	-	-	-	-	-	-	-	-
Torch cut Pb-based paint ^c	-	-	-	-	-	-	-	-	-	-	-
206: Alkali reaction booth (R) ^g	-	-	-	-	-	-	-	-	-	-	-
306: Building vents (R)	-	-	<1	-	-	-	-	-	-	-	-
306: Vial crusher/chemical photooxidation unit (R)	-	-	-	-	-	0	-	-	-	-	-

2. COMPLIANCE SUMMARY

TABLE 2.3 (Cont.)

Building No. and Source	CO	NO _x	PM/PM ₁₀	PM _{2.5} ^d	SO ₂	VOM	HAP ^a	NH ₃ ^d	CO ₂ ^e	CH ₄ ^e	N ₂ O ^e
306: Waste bulking sheds (R)	-	-	-	-	-	59	2.0	-	-	-	-
375: Intense Pulsed Neutron Source (R)	-	-	-	-	-	-	-	-	-	-	-
200: M-Wing hot cells (R)	-	-	-	-	-	-	-	-	-	-	-
400: APS facility (R)	-	71	-	-	-	-	-	-	-	-	-
212: Alpha gamma hot cell (R)	-	-	-	-	-	-	-	-	-	-	-
330: CP-5 D&D Project (R)	-	-	-	-	-	-	-	-	-	-	-
350: NBL Pu/U Hoods (R)	-	-	-	-	-	-	-	-	-	-	-
Lab rad hoods (R)	-	-	-	-	-	-	-	-	-	-	-
WM Portable HEPA – (6) (R)	-	-	<1	<1	-	-	-	-	-	-	-
303: Mixed waste storage (R)	-	-	-	-	-	-	-	-	-	-	-
331: Rad waste facility (R)	-	-	-	-	-	-	-	-	-	-	-
595: Lab wastewater plant (R)	-	-	-	-	-	59	-	-	-	-	-
315: MACE project (R)	360	-	-	-	-	-	-	-	-	-	-
301: Hot Cell D&D project (R)	-	-	-	-	-	-	-	-	-	-	-
Total (lb/yr)	123,903	135,564	7,957	2,146	83,439	7,639	5,277	401	114,142,585	4,142	523
Total (ton/yr)	61.9514	67.7820	3.9783	1.0730	41.7194	3.8193	2.6383	0.2004	57,071.2927	2.0709	0.2614
CAAPP Permit Limit (ton/yr)	(237.60) ^c	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; N₂O = nitrous oxide; NBL = New Brunswick Laboratory; NH₃ = ammonia; NO_x = oxides of nitrogen; Pb = lead; PCB = polychlorinated biphenyl; PM = particulate matter; PM₁₀ = particulate matter less than 10 microns; PM_{2.5} = particulate matter less than 2.5 microns; Pu = plutonium; SO₂ = sulfur dioxide; U = uranium; VOM = volatile organic matter; WMO = Waste Management Operations.

^b Hazardous air pollutants (HAP) not included in VOM or Particulates (HCl, HF, methyl chloroform, methylene chloride).

^c These sources designated as insignificant in the Clean Air Act Permit Program (CAAPP) permit.

^d Not a permit limit, but is the maximum potential emission level for carbon monoxide.

^e As of 2003 emissions of PM_{2.5} and a precursor, ammonia (NH₃), must be included on the Annual Emission Report.

^f As of 2007, greenhouse gas emissions (carbon dioxide, methane, nitrous oxide) are included on the Annual Emission Report per IEPA request.

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

vehicles meet clean fuel fleet standards. Because the requirements are still in effect, in lieu of a report, Argonne submitted a letter to the DOE/Argonne Site Office (ASO) on September 10, 2009, and DOE/ASO submitted a letter to the IEPA on September 11, 2009, certifying that all vehicles acquired in MY 2009 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 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 five years and must be renewed by the submission of a permit application at least 180 days prior to the expiration of the existing permit.

Wastewater discharge at 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, and on October 19, 2009, which permitted sanitary and laboratory wastewater discharges from the newly constructed Theory and Computing Sciences (TCS) building. The current 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

2. COMPLIANCE SUMMARY

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 exceedances occurring in the winter at Outfall 001. Investigations into the causes of the increased 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 used 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 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 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. The second NPDES permit revision (as listed above) was approved by the IEPA on October 19, 2009. To date, the remaining proposed revisions (listed as 1, 3, and 4 above) have 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

2. COMPLIANCE SUMMARY

TABLE 2.4

Characterization of NPDES Outfalls at Argonne, 2009^a

Outfall Number	Description	Average 2009 Flow ^b
A01	Sanitary Treatment Plant	0.272
B01	Laboratory Treatment Plant	0.482
001	Combined outfall	0.754
B03	300 Area (condensate) and groundwater	0.012
C03	Building 205 footing tile drainage	0.027
D03/E03	Steam trench drainage (condensate)	0.052/0.0 ^c
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	0.024
A05	Westgate Road stormwater	Stormwater only
B05	800 Area east stormwater	Stormwater only
C05	Building 200 West	0.010
D05	Stormwater	Stormwater only
E05	Building 203 west footing drainage and condensate	0.003
006	Cooling tower blowdown and stormwater	0.027
007	Domestic cooling water for compressor and stormwater	0.005
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 2009.

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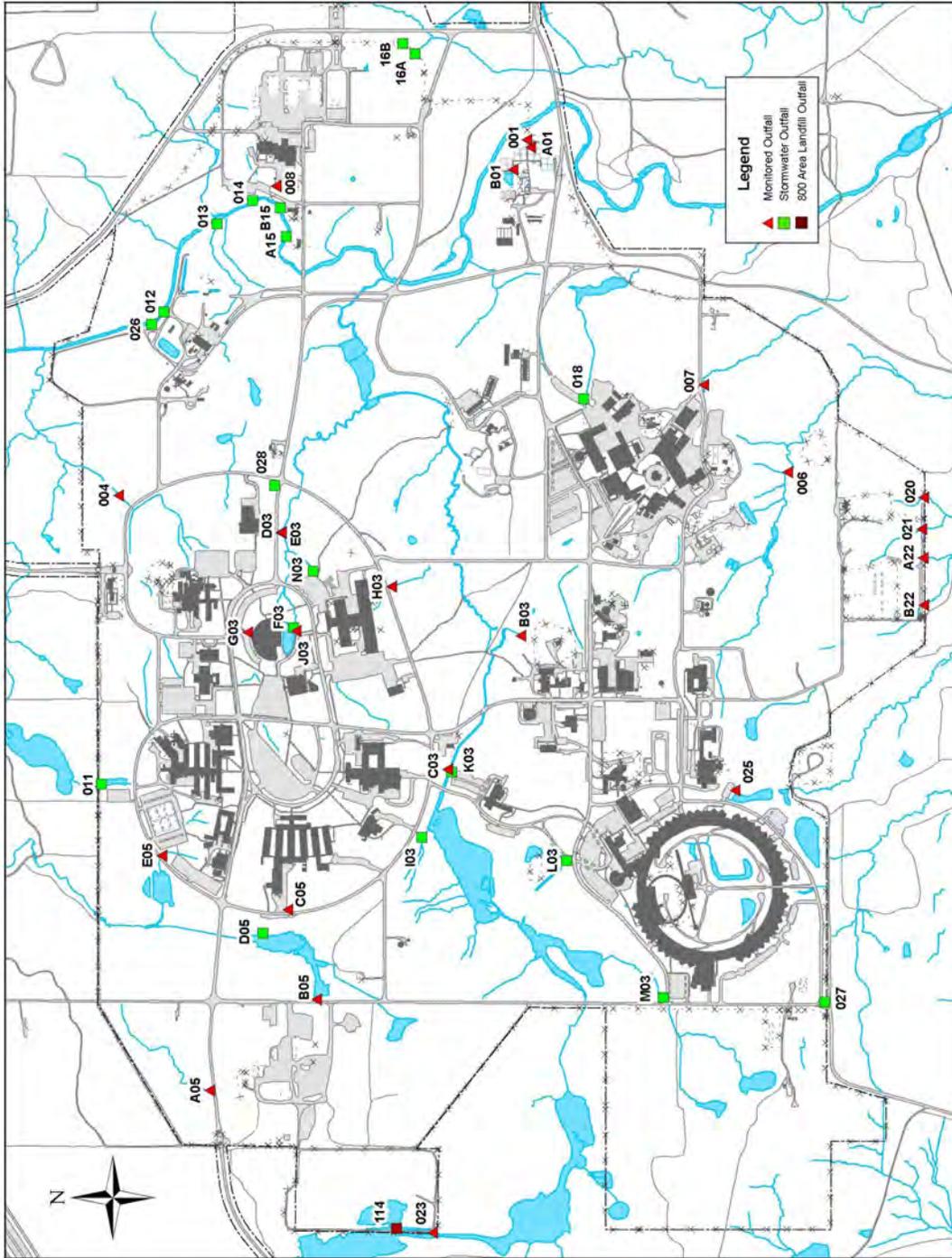


FIGURE 2.2 NPDES Outfall Locations

2. COMPLIANCE SUMMARY

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 is 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 2009 averaged 1.02 million L/day (0.27 million gal/day) for the sanitary wastewater and 1.81 million L/day (0.48 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 2009, there were five exceedances of NPDES permit limits out of approximately 1,800 measurements.

Two of the exceedances that were reported in 2009 occurred at Outfall 001, the combined wastewater discharge. The monthly limits for TDS and ammonia were exceeded one time each at this outfall. The TDS exceedance occurred during February 2009 and is the direct or indirect result of the use of road salt after snow events that occurred in early 2009. The limit for TDS was also exceeded at Outfall J03 in August 2009, which was sampled under extremely low flow conditions. The elevated TDS at this outfall, though observed during the summer season, is thought to be the result of residual road-salt contamination underneath two large parking lots located within the Outfall J03 watershed. The ammonia exceedance, which occurred in June 2009, was the result of unseasonably cool early summer temperatures coupled with a relatively large inventory of sludge in the Imhoff tank. One TSS monthly exceedance was reported at Outfall 006 in May 2009 and is most likely the result of bioturbation of sediment in a wetland area located upstream of this outfall.

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

2. COMPLIANCE SUMMARY

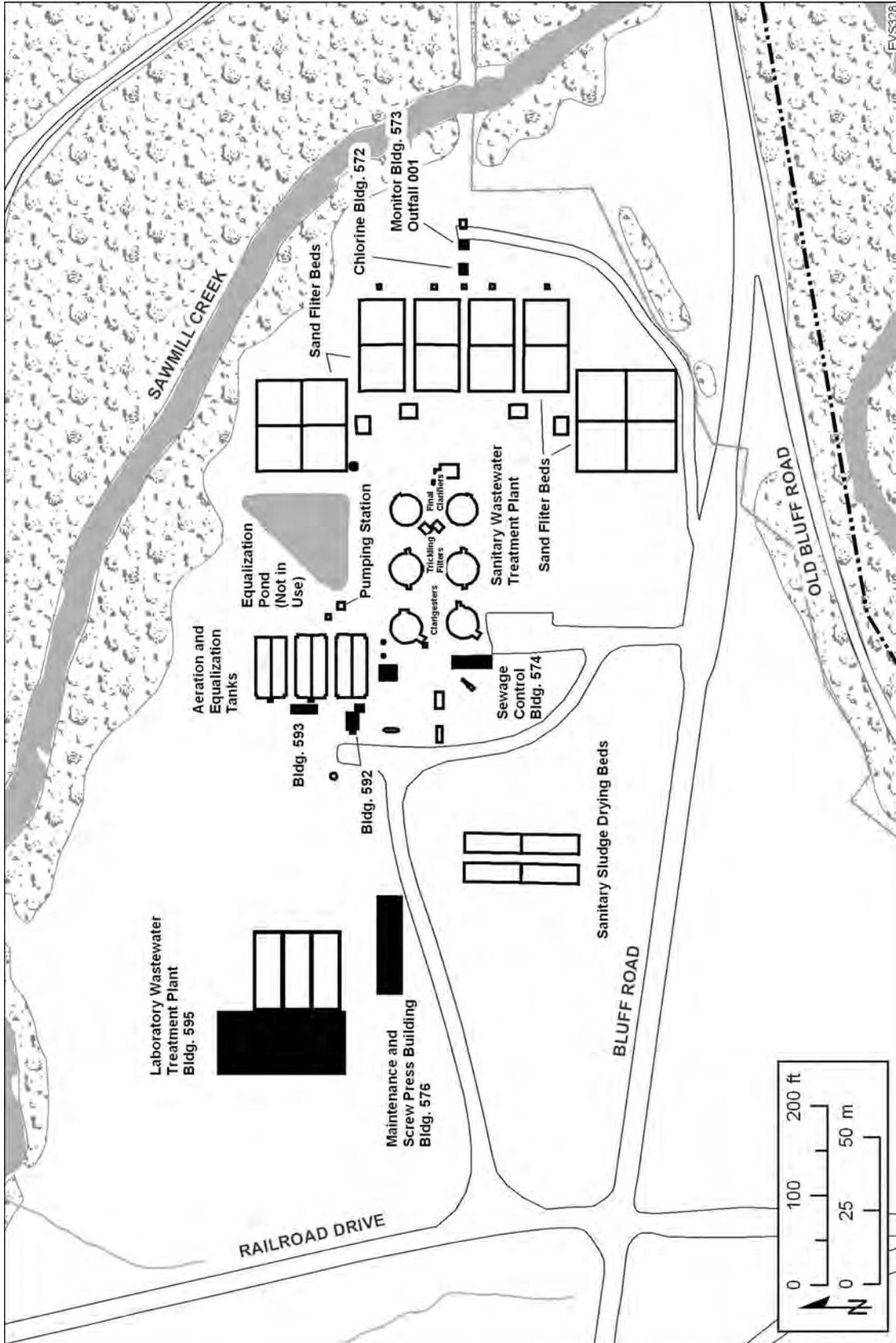


FIGURE 2.3 Argonne Wastewater Treatment Plant

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, and to three in 2009. Formal re-classification of H03 and J03 outfalls to stormwater-only will be formally requested in the 2010 NPDES Permit renewal application.

Since the IEPA changed its approach to general use water quality standards (35 IAC Part 302 Subpart A) by eliminating TDS as a water quality parameter, the Agency has indicated that the next renewal of the permit will no longer have TDS limits included. However, until the permit is renewed, Argonne will continue monitoring for TDS and reporting exceedances if they occur.

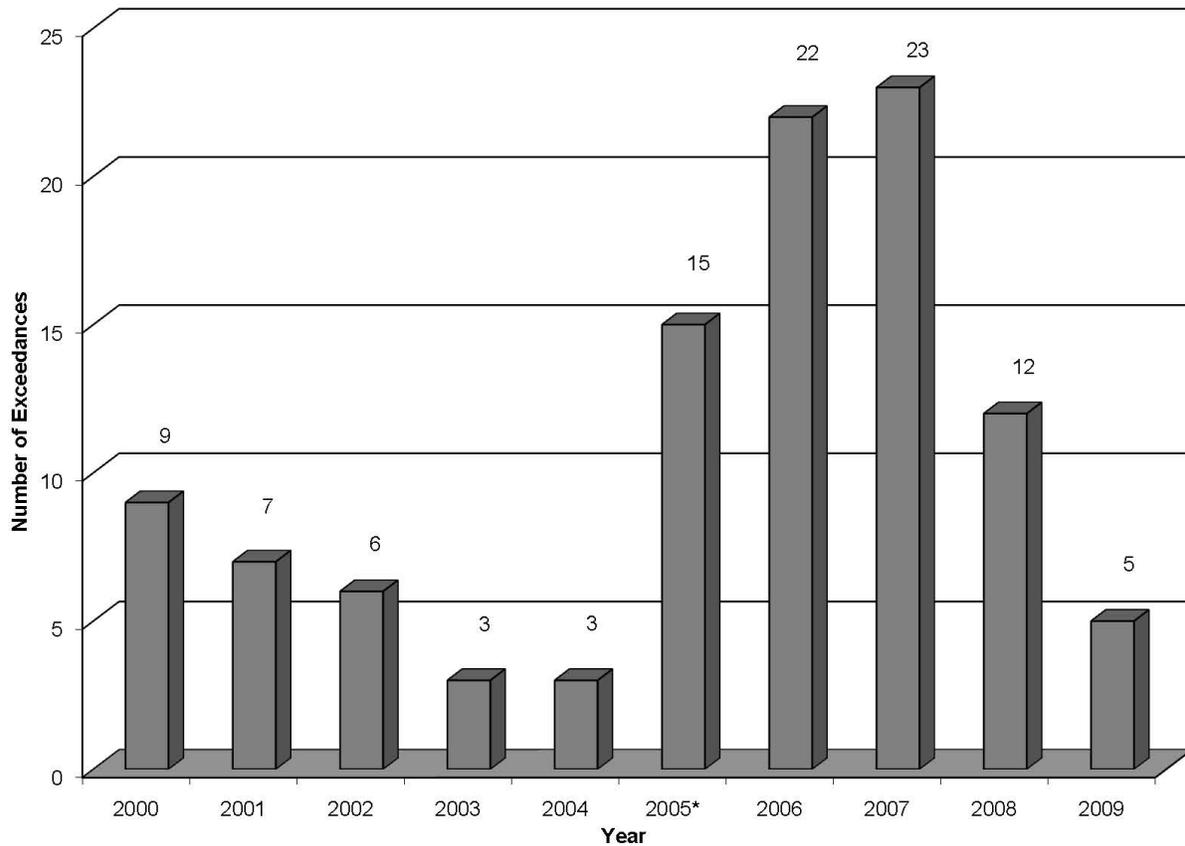
Figure 2.4 presents the total number of permit limit exceedances each year over the past 10 years. The increases in the number of exceedances from 2005 through 2007, compared with previous years, reflects the more restrictive discharge limits in the renewed permit issued in September 2005. The decreases in the number of exceedances since 2007 reflects both the site-wide re-routing of TDS-contaminated wastewater into the Laboratory wastewater sewer system and the implementation of the snow management system, which features selected road closures and reduced salt usage during and after snow events.

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 (downgradient of the 317 and 319 areas) for all the priority pollutants — 124 metals and organic compounds identified by the IEPA as being of particular concern. During 2009, the Outfall B01 samplings were conducted in June and December. In the June sample, all of the inorganic results were below the analytical detection limits. The only organic constituent present above analytical detection limits was chloroform, which was present at its detection limit of 1 µg/L. Three other organic compounds were detected at estimated concentrations (below their respective analytical detection limits), including dichlorobromomethane (0.8 µg/L), bromoform (0.7 µg/L), and chlorodibromomethane (0.9 µg/L). These compounds are trihalomethane-type compounds (THM) that are products of chlorination of drinking water purchased from the DuPage Water Commission. In the December sample, only three constituents (chloroform, bromodichloromethane, and dibromochloromethane) were detected at their analytical detection limit of 1 µg/L. One constituent (bromoform) was detected at an estimated concentration of 0.9 µg/L. No other priority pollutant constituents were detected at, or above, their respective analytical detection limits. The limit on total THM is 80 µg/L.

Outfall 021 is sampled annually and analyzed for the priority pollutant list of constituents. The 2009 sample was collected on June 18, 2009. There were no metals, semi-volatile organics, PCBs, or pesticides detected. A few VOCs were identified in the samples but the concentrations were below their detection limits. Their presence in the stormwater sample is likely the result of surface water contact with contaminated soil in the 317 Area.

2. COMPLIANCE SUMMARY



* A renewal permit (with new limits) was effective September 2005.

FIGURE 2.4 Total Number of NPDES Exceedances, 2000 to 2009

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 on June 23 and 24, 2009. 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 discharging 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 as modified on April 24, 2007. The permit contains special conditions that set forth a number of requirements that Argonne must fulfill. One of these requirements, Special Condition 9, requires Argonne to maintain its existing Stormwater

2. COMPLIANCE SUMMARY

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 also requires 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 2009, the annual inspection was completed, and a report was submitted to the IEPA in November 2009. The 2009 SWPPP assessment identified 20 minor best management practice effectiveness issues, or findings. Most of the issues and findings involve improper management of solid waste dumpsters, miscellaneous equipment in dock areas, and open scrap metal dumpsters. Eleven housekeeping issues, mostly related to uncontained refuse and other miscellaneous housekeeping issues, were also noted. These findings will be addressed during the first part of 2010. Improved best management practices include housekeeping practices related to the housekeeping inspection program and the clean sweep program, as well as implementation of the sitewide snow management program which resulted in a 31% reduction of road salt applied to site roads.

At Argonne, spills are reported to emergency responder personnel via the on-site 911 alert system. During 2009 there were 10 spills, both indoors and outdoors, across the Argonne site. Four of the spills involved oil materials. They were minor in nature and were contained and remediated without any impact to surface water. Two spills, also occurring indoors, were related to other chemicals, including battery acid, bleach, and mercury; neither of these entered storm drains or surface water. Four releases of water (two domestic, one deionized, and one sanitary wastewater), took place both indoors and outdoors. The two domestic water releases were water main breaks, releasing about 50,000 gallons and 80,000 gallons respectively. They entered site storm drains or surface water and therefore, were reported to the IEPA, in accordance with NPDES permit requirements.

Also during 2009, the construction of the TCS building in the north-central part of the site was completed. An NPDES Notice of Termination will be submitted to the IEPA once permit stormwater control measures have been established. This will most likely be in early 2010.

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 into navigable waters of the United States. Persons with specific duties and responsibilities in such situations are identified, as are reporting and recordkeeping requirements

2. COMPLIANCE SUMMARY

that are mandated by the regulations. Regular training is conducted about implementation of this plan. No reportable spills occurred in 2009 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 2009, the 2009 version of the SPCC Plan was revised to incorporate findings from a DOE functional area review and to incorporate new EPA SPCC Plan requirements as noted in the December 2008 NPDES amendments.

2.2.3. General Effluent and Stream Quality Standards

In addition to specific NPDES permit conditions, Argonne's 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 of 1976 (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 an 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 an 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 draft permit was issued in January 2010. The final permit was issued in April 2010.

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 15 Hazardous Waste Management Units: nine container storage units, one tank storage unit, three miscellaneous treatment units, and two 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 activities of the previous year. It is a summation of all RCRA waste activities, including storage, treatment, and disposal. The report describing such activities during 2009 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 and disposal take place at approved hazardous waste treatment and disposal facilities. Hazardous and nonhazardous wastes that were shipped during 2009 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 2009.

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.

2. COMPLIANCE SUMMARY

TABLE 2.5

Permitted Hazardous Waste Treatment and Storage Facilities, 2009

Description	Location	Purpose
<i>Container Storage (9)</i>		
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	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).
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 oxidizing MW.
	Building 306 – Storage Room D-001	Storage of solid MW containing toxic metal constituents.
<i>Tank Storage (1)</i>		
Waste Storage Tank	Building 306	Storage of corrosive and toxic mixed waste and radiological liquid wastes (4,000 gal; currently not used).
<i>Treatment (5)</i>		
Alkali Metal Passivation Booth	Building 206	Destruction of water reactive alkali metals possibly contaminated with radionuclides.
Alkali Metal Passivation Booth	Building 308	Destruction of water reactive alkali metals.

2. COMPLIANCE SUMMARY

TABLE 2.5 (Cont.)

Description	Location	Purpose
<i>Treatment (Cont.)</i>		
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.

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 five mixed waste treatment systems. In addition, during 2009, the majority of the mixed waste was sent off-site to Energy Solutions and Perma-fix's, out-of-state commercial treatment and disposal facilities. Mixed wastes that were generated and disposed of during 2009 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

TABLE 2.6

Non-Rad Waste Shipped in 2009^a

Category	Weight (lb)
Hazardous solids	2,269
Hazardous liquids	29,436
Hazardous gas cylinders	257
PCB ballasts	11,133
PCB liquids	0
Lead-acid batteries (recycle)	7,349
Light bulbs (recycle)	1,964
Potentially infectious waste	338
Other batteries (recycle)	245
Lead scrap (recycle)	2,718
Mercury universal waste (recycle)	188
Asbestos	440,000
Nonhazardous liquids	13,698
Nonhazardous oil (recycle)	3,932
Nonhazardous gas cylinders	79
Nonhazardous solids	17,658
Abatement waste (lead and asbestos) disposal	433
Total	531,697

^a Abbreviations: PCB = polychlorinated biphenyl.

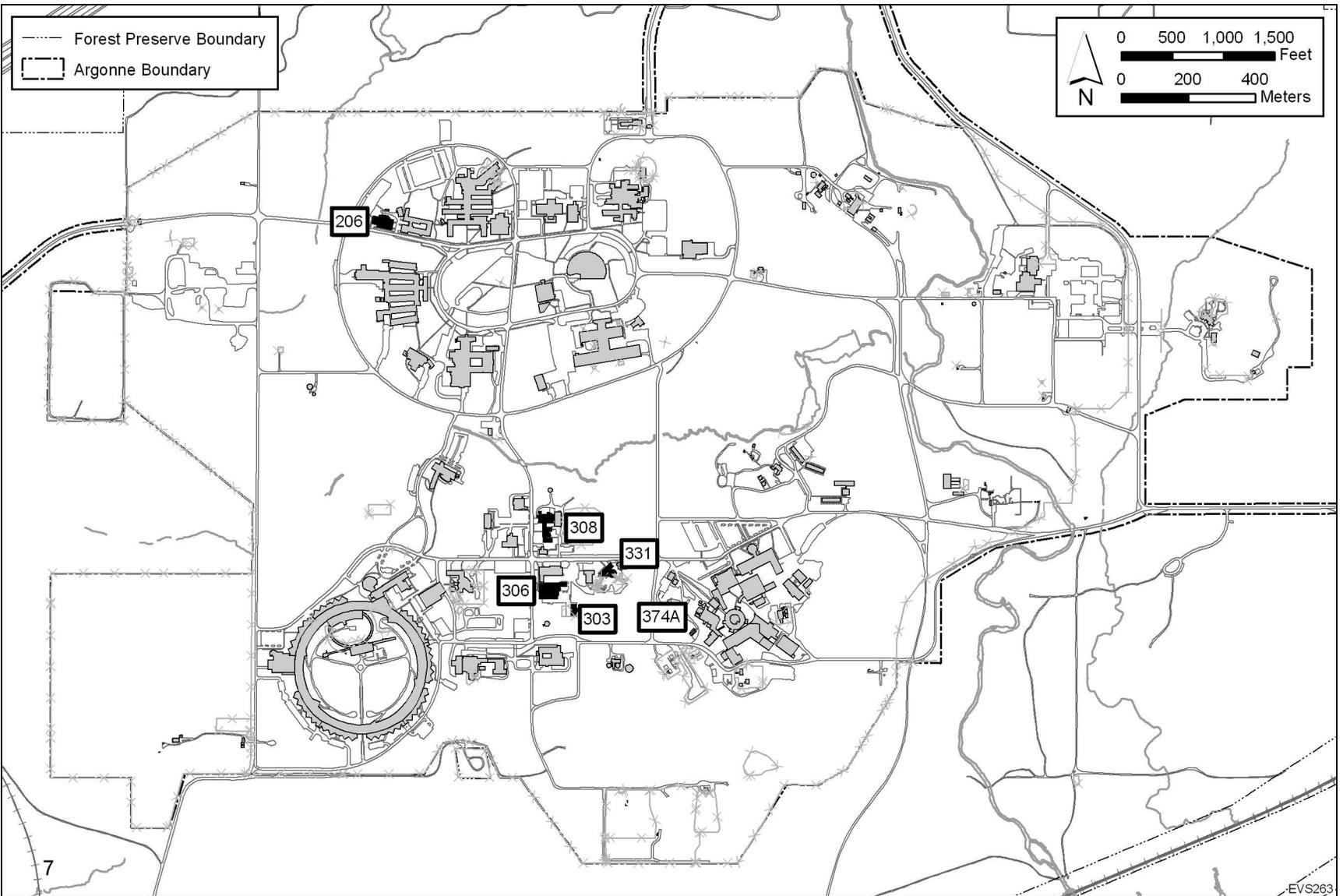


FIGURE 2.5 Major Treatment, Storage, and/or Disposal Areas at Argonne

2. COMPLIANCE SUMMARY

required by the PSTP. An update to the PSTP was provided to DOE showing treatment of new waste streams and additional volumes of existing waste streams with a target date of September 2010.

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. In April 2008, Argonne removed a 2,271-L (600-gal) diesel fuel UST. A final report on the sampling results was submitted by Argonne to the IEPA in October 2009.

2.4. Solid Waste Disposal

In September 1992, Argonne ceased operation of its 800 Area Landfill, which had begun operating in 1966. 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 191 pCi/L. The 800 Area Landfill groundwater monitoring program is discussed in detail in Section 6.5.

Argonne generates a large volume and variety of nonhazardous special wastes. Table 2.6 lists the nonhazardous special and nonspecial wastes shipped during 2009. All nonhazardous special wastes generated at Argonne in 2009 were disposed of at permitted off-site landfills. A report is submitted to the IEPA by February 1 of each year to describe the activities 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. One EA was prepared during 2009 for the Building 330 Demolition Project.

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 2009, Argonne continued an informational monitoring program at two previously used dolomite domestic wells that are still operational. Quarterly samples from these wells 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 2009, 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

2. COMPLIANCE SUMMARY

EPA-approved, that they are used properly, and that any unused chemicals are removed from the site by the contractor.

In 2009, approximately 109,820 L (28,900 gal) of commercial-grade herbicide/insecticide was applied throughout the Argonne site. Fertilizer with weed control is included in the quantity of herbicide.

Also in 2009, 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 many 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. All cleanup actions were performed under the RCRA corrective actions program. 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 with information regarding the presence and storage of hazardous substances and their planned and unplanned environmental releases, including plans for responding 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 2009 was transmitted to the LEPC and SERC during June, October, and December of 2009.

2. COMPLIANCE SUMMARY

TABLE 2.8

Status of EPCRA Reporting, 2009

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

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.

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 2009 information was transmitted to the LEPC and SERC during December of 2009.

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 2009 was provided to the SERC, LEPC, and Argonne Fire Department during February 2010. Table 2.9 lists the hazardous chemicals reported.

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 2009 for activities in 2008 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. COMPLIANCE SUMMARY

TABLE 2.9

SARA, Title III, Section 312, Chemical List, 2009

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
14464-46-1	Sand	A,C

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

^b NA = no CAS No.

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 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 TSCA regulation 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 internal processes that in turn draw upon 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 2009 was completed on March 24, 2010. 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. The Intense Pulse Neutron Source is being put into safe shutdown condition and that process should generate PCB capacitor disposal in 2010.

2.9.2. Disposal of PCBs

Disposal of PCBs from Argonne operations includes lab-packed materials as well as bulked and aggregated solids that are 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. Tables 2.6 and 2.7 contain the amount of PCBs and PCB-contaminated materials shipped by Argonne during 2009.

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 any critical habitats 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 their critical habitats. 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 habitats of federally listed species exist on the site. Three federally listed endangered species and one federally listed threatened species inhabit the Waterfall Glen Forest Preserve that surrounds the Argonne property, or 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

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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
 - Blanding’s turtle (*Emydoidea blandingii*)
 - Eastern massasauga (*Sistrurus catenatus catenatus*)*
 - Tennessee milkvetch (*Astragalus tennesseensis*)
 - Tuckerman’s sedge (*Carex tuckermanii*)
 - Yellow-crowned night heron (*Nyctanassa violacea*)

- Threatened
 - Buffalo clover (*Trifolium reflexum*)
 - Kirtland’s snake (*Clonophis kirtlandi*)
 - Marsh speedwell (*Veronica scutellata*)
 - Shadbush (*Amelanchier interior*)

*Candidate for federal listing.

Of these, the Kirtland’s snake has 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 of them 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 only 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

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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 five-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. Four of the sites have been determined eligible for listing on the NRHP. Twenty-one 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. Cultural resource

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activities in 2009 focused on the effects of projects on various historic buildings. Among the projects that underwent an NHPA Section 106 review in 2009 were the removal of the Advanced Analytical Electron Microscope in Building 212, construction of a new Energy Science Building, demolition of Buildings 310 and 330, replacement of windows in Building 200, and the replacement of the shell on Building 331, the Experimental Boiling Water Reactor Building. Argonne also began interactions with the Illinois SHPO concerning Argonne's long-term facilities modernization plans of removing many of the contributing properties in the Main Campus (200 area) Historic District.

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 generally contained within areas designated as conservation use; not intended for development. No significant structures are located in these areas, although an existing pumping station and inlet structure 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 floodplain 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

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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 m² (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 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, and also outlined procedures for the construction of a new wetland area, Wetland R.

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, 2008, and 2009. 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

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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 preservation 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. Major issues include the control of invasive species and the management of areas that have not been addressed adequately by past practices. Argonne expects that DOE will continue its high level of interest, as evidenced by contract performance measures.

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/mi² 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/mi² 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. Over the past few years, the fallow deer population has decreased.

2.16. Current Issues and Actions

The purpose of this section is to summarize the most important issues related to environmental protection encountered during 2009. Table 2.10 lists all water effluent exceedances reported during 2009. 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 2009 (see Table 2.10). In past years, the TDS concentration was the most common exceedance of the NPDES permit limits. Investigations regarding cause and corrective actions were completed and are discussed in Chapter 5.

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 solid 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 program. Ongoing activities during 2009 are summarized in Chapter 6.

TABLE 2.10

Summary of 2009 Water Effluent Exceedances

Date	Outfall	Parameter	Cause
February 12	001	TDS	Road salt associated with melting snow
February 19	001	TDS	Road salt associated with melting snow
May 22	006	TSS	Disturbance of upstream sediment
July 7	001	Ammonia-N	Large sludge inventory and low temperature
August 14	J03	TDS	Road salt and extremely low flow

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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 replaced with a new well that was screened at a lower depth. The hydrogen-3 concentrations are decreasing and the 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 2009. 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 2009. A short description of each is included in Table 2.12. Any identified issues are documented in an issues management system and tracked to completion.

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TABLE 2.11

Environmental Permits in Effect, 2009

Permit Name	Permit ID	Permit Type	Start Date	End Date
2010-11 Nuisance Wildlife Control Permit	Argonne\Group Class C Permit	Nuisance Wildlife	1/31/2010	1/31/2011
B-203 CARIBU Project Construction Permit	05120055	Construction (Air Emission Source)	3/20/2006	– ^a
Biomass Test Burn (Boiler #5) – Revised	08100017	Construction	5/26/2009	3/31/2010
Building 301 Demolition	09040048	Construction	4/30/2009	–
Building 330 Demolition	09070058	Construction	8/5/2009	–
CAAPP Title V Permit	95090195	Operating	10/17/2006	10/17/2011
Howard T. Ricketts Laboratory Construction Project	2006-EN-6007	Construction	1/12/2006	–
NPDES Wastewater Discharge Permit	IL0034592	Operating	9/1/2005	8/31/2010
Open Burn Permit – Fire Training	B091179	Operating	4/2/2009	4/2/2010
Open Burn Permit – Vegetative Control	B0908092	Operating	10/15/2009	10/15/2010
RCRA Part B Permit	IL3890008946	Operating	9/30/1997	–
Theory and Computing Sciences (TCS) Building	2009-EN-4482	Construction	10/8/2009	–
USDA Soil Permit	P330-09-00006	Operating	1/8/2009	1/8/2012
Wastewater Discharge Permit to DuPage County	18965	Wastewater	7/29/1991	–
Wastewater Treatment Plant Land Application Permit	2009-SC-2914	Operating	12/4/2009	11/30/2014

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

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TABLE 2.12

IEPA/DOE Environmental Compliance
Inspections/Appraisals, 2009

Agency	Type	Date
COA	Environmental Surveillance Program	Various
IEPA	Clean Air Act Permit Program Annual Permit Compliance Inspection	3/11/2009
COA	Clean Water Act – NPDES Assessment	10/30/2009
IEPA	RCRA Compliance Annual Inspection	9/9/2009
DOE-ASO	SPCC Assessment	10/30/2009
IEPA	NPDES Annual Inspection	11/25/2009

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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 how it continually improves its environmental stewardship performance. 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.

3.1. EMS Certification

DOE Order 450.1A, which implemented EO 13423, requires sites to have an established and implemented EMS by June 30, 2009. To meet this deadline, Argonne began in late 2008 to take a series of steps toward accomplishing this requirement by becoming International Organization for Standards (ISO) 14001:2004 certified. These activities included:

- EMS Description Document restructured to the ISO format;
- Internal audit of the EMS program conducted;
- Pre-assessment reviews;
- ISO Registrar (by NFS) readiness review; and
- Formal ISO audit.

The ISO registrar recommended Argonne for ISO 14001:2004 certification, which was issued on June 3, 2009, see Figure 3.1. On June 19, 2009, the DOE-ASO declared that Argonne had fully implemented its EMS, consistent with the requirements of DOE Order 450.1A.

In parallel with the ISO 14001:2004 certification, Argonne used its newly established Laboratory Management System (LMS) to also obtain ISO 9001:2000 certification.

3.2. Integration of the EMS with the Integrated Safety Management System

The Integrated Safety Management System (ISMS) is the DOE umbrella of environment, safety, and health programs and systems that provide the necessary structure for any work activity that could potentially affect the public, a worker, or the environment. The EMS is integrated into the ISMS through the Argonne Work Planning and Control (WP&C) process. As part of the work planning process, the NEPA Environmental Review Form is completed to indicate any potential environmental issues associated with the work so that the appropriate environmental Subject Matter Expert (SME) can be engaged to assess any environmental impacts. In December 2009, a web-based WP&C process was introduced to greatly simplify the process and eliminated much of the paper generated previously.

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FIGURE 3.1 Argonne ISO 14001:2004 Certificate

3.3. EMS Elements

The ISO 14001:2004 standard contains 17 elements which define and document the scope of the EMS. The most critical elements are discussed below.

3.3.1. Environmental Policy

The Argonne environmental policy is captured in LMS-POL-2 and is available to all Argonne employees and to the public via the Argonne public website. The policy states that “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 objective and targets process;
- Pollution prevention and waste minimization; and
- Compliance with all applicable requirements.”

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This environmental policy applies to all Argonne activities that could or do have a potential impact on the environment or compliance with applicable environmental regulations.

To support this commitment, Argonne:

- Ensures that technologies, facilities, processes, and operating procedures meet or exceed applicable environmental permit expectations and regulatory requirements;
- Actively explores, creates, and communicates new ways to minimize and prevent pollution arising from all levels of research, development, and operational activities and preserves natural resources;
- Builds partnerships inside and outside Argonne to sustain and enhance the environment; and
- Corrects conditions promptly and responsibly to eliminate or minimize potential adverse impacts on sustainable environments.

3.3.2. Environmental Aspects and Impacts

Argonne evaluates its operations to identify aspects of its operations that can impact the environment, and determine which of those impacts are significant. When operations have environmental aspects, Argonne implements the EMS to minimize or eliminate any potential adverse impacts. Argonne has established a process to catalog its environmental aspects. Most of the aspects are discussed in Chapter 2. The list of environmental aspects is reviewed and updated annually.

Regulatory and organizational roles and responsibilities are delineated in the EMS Description Document to address the management of the aspects and impacts. To determine which of the environmental aspects are significant, a scoring methodology is applied that rates each against four criteria of regulatory compliance, environmental consequence, mission consequence, and likelihood of occurrence. Four aspects have been identified as being significant; regulated air emissions, wastewater discharges, waste generation, and pollution prevention/waste minimization. All facilities that have significant aspects are required to have controls in place to minimize or eliminate their impacts.

3.3.3. Legal and Other Requirements

It is critical to continue to monitor the environmental regulations to ensure that Argonne staff are aware of proposed changes in regulations and new regulations. A number of sources of information are reviewed to identify new or changing regulations, including:

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

Identification of new requirements is communicated to managers and supervisors by subject matter experts. Evaluations are conducted to determine the impacts of proposed and final regulations on Argonne activities.

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

Of particular interest is the newly issued Executive Order 13514, “Federal Leadership in Environmental, Energy, and Economic Performance,” which requires federal agencies to develop an inventory of their greenhouse gas emissions from both direct and indirect sources. This is a significant activity since reduction goals will likely be assigned to these emission values.

3.3.4. Environmental 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 measurable interim steps to be 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.

For FY2009, 27 targets were established; grouped under five objectives. The objectives are: obtain ISO 14001:2004 certification (four targets); sustainable practices (eight targets); improved ecological stewardship (four targets); achieve full compliance with applicable environmental regulations (three targets); and enhance waste minimization/pollution prevention (eight targets). All targets were completed within the time allotted. For FY2010, 14 targets were established.

A related activity to the EMS objectives and targets process is the Performance Measures program. The Prime Contract between DOE and UChicago Argonne, LLC to operate Argonne has made provisions for a fee, based on the performance of various research and operations activities, including ESH. Performance objectives and supporting metrics are developed

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annually. For FY2009, a total of 33 measures were included in the ESH component. Of these, eight were environmental. They were:

- Revising the EMS Description Document and conducting a third-party audit of the EMS program;
- Monitoring the number of unpermitted waste water releases;
- Monitoring air emission performance at the boiler house;
- Determining the number of water effluent violations;
- Maintaining oak tree health;
- Controlling invasive species;
- Executing Land Management and Habitat Restoration work plan activities; and
- Conducting Pollution Prevention Opportunity Assessments.

All of these measures were successfully completed.

3.3.5. Pollution Prevention and Waste Minimization

Argonne implements a site-wide 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 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 ISMS to promote and institutionalize P2 strategies across the Argonne site.

3.3.5.1. Pollution Prevention Opportunity Assessment Activities

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 waste or pollution. During 2009, nine PPOAs were conducted. They are:

- Implement the Argonne Bike Share program;
- Recycle small hand-held electrical items;

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- Replace incandescent EXIT signs with light emitting capacitors to save energy;
- Replace lead seals on personnel safety boxes with metal crimp seals;
- Determine that bricks from the Building 301 D&D project cannot be recycled;
- Place recycle bins in lodging kitchens and place dumpsters in central locations for recycled materials;
- Recommend water and energy conservation measures;
- Establish a link with the Argonne day care center to reuse printer cover sheets; and
- Reduce energy used by operating variable air volume laboratory chemical hoods.

3.3.5.2. Solid Waste Recycling Program

Argonne's comprehensive solid waste recycling program effectively recycles/reduces a wide range of materials. Many of the recycling activities result in significant savings for Argonne. For example, Argonne received approximately \$31,000 for recycled mixed office paper and scrap metal. Other material that is recycled represents a cost avoidance for Argonne; that is, Argonne does not pay for disposal of the material. Table 3.1 presents a summary of the results for 2009.

TABLE 3.1

Recycled Materials, 2009

Material	Amount Recycled (tons)
Mixed office paper	310
Aluminum (70%), steel (10%), glass(10%), plastic(5%), and Styrofoam (5%)	13
Asphalt, concrete, and construction debris	320
Scrap metal	93
Computer components (PCs)	21
Computer monitors	24
Toner cartridges	3
Batteries	1.0
Engine lubricating oils	6.3
Fluorescent lightbulbs	1.0
Lead/acid batteries	2.4
Transparencies	0.1
Athletic shoes	0.1
Non-hazardous liquids	0.6
Lead scrap	2.4

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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 email system. Also, the Argonne Chemical Exchange System is being revised so that surplus chemicals can be used rather than purchasing new chemicals.

3.3.5.3. Bike Share Program

Argonne has launched an on-site bike-sharing program to provide employees with an innovative, efficient, convenient transportation alternative that is heart-healthy, saves energy, and reduces carbon dioxide emissions. Argonne introduced the Bike Share Program in conjunction with its annual Earth Day activities on May 29, 2009. Argonne partnered with Active Transportation Alliance to develop a safety training program which employees and visitors were required to take before using the bikes. Everyone who took the class was issued a helmet and a card indicating that they had completed the training. They were able to choose from 100 bicycles that were distributed around Argonne. Ten additional bike racks were purchased.



FIGURE 3.2 Bike Share Program

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The bikes were new, comfortable models, designed for safety and ease of riding for bikers of all experience levels. The bikes and helmets were paid for with funds that Argonne's Pollution Prevention Program received for recycled materials and from Argonne's participation in energy savings programs with Commonwealth Edison.

3.3.5.4. Green Building Design/Argonne Fitness Center

Argonne has developed typical architectural/engineering green practices which incorporate sustainable green building design elements to meet the DOE High Performance and Sustainable Buildings (HPSB) guidelines. Using these green building practices in the design, Argonne continues to reduce or eliminate negative environmental impacts through high-performance construction and operational practices for all facilities at Argonne. The design and construction elements of the Fitness Center project allowed Argonne to submit the project to the U.S. Green Buildings Council applying for Leadership in Energy and Environmental Design (LEED) certification.

To promote a fit and healthy workplace, the Argonne Fitness Center is the latest step in a multi-phase program to improve employee wellness opportunities. The Fitness Center includes areas for exercise equipment such as treadmills, ellipticals, free weights, and state-of-the-art



FIGURE 3.3 Argonne Fitness Center

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circuit training. The Fitness Center was designed by Argonne's FMS division, taking advantage of the existing building structure while incorporating green materials, resources, and sustainable technologies through the reuse of existing mechanical equipment, use of a motion sensor lighting system, use of non-VOC paints, and sustainable forestry wood products, amongst other sustainable materials. The design also incorporated acoustical performance, providing a comfortable exercise environment.

3.4. Sustainable Practices

Executive Order 13423, as implemented by DOE Orders 430.2B and 450.1A and in response to DOE's Transformational Energy Action Management (TEAM) initiative, resulted in Argonne forming an Energy Programs Office to lead efforts to address the sustainable practices.

3.4.1. Energy

By the end of 2009, Argonne reduced its energy intensity by 12.1%. The main energy conservation measures were in the area of chilled water, steam delivery, condensate return, and lighting. Specific projects included re-lamping of a high bay area in Building 369, installation of energy efficient exit lights, installation of a high-efficiency chiller at Building 371, repair of steam condensate lines, and installation of a package boiler which eliminated a long steam run from the Central Heating Plant. The total annual estimated savings from projects completed in 2009 is 58,409 MBtu.

3.4.2. Water

Argonne achieved a 13.4% water reduction for 2009. The major water conservation measures completed in 2009 were the steam condensate repair projects at Buildings 201, 314, 315, and 316. The package boiler project to provide localized steam to an isolated water tower also eliminated significant steam condensate losses. In addition, Argonne completed a water use and water balance study this past year.

3.4.3. Fleet Management/Transportation

During 2009, Argonne used 483 gallons less of diesel fuel and 6,087 gallons less of unleaded gasoline compared to the 2008 fuel consumption for its fleet. Although Argonne used 770 gallons less of alternative fuel (E-85) during 2009, as compared to 2008, Argonne did replace a large portion of unleaded operated fleet vehicles with new E-85 operated fleet vehicles, as well as replacing low-fuel-efficient minivans with sub-compact sedans. Additional improvements to Argonne's fleet included the lease of newer diesel vehicles with higher fuel economy standards and the use of ultra-low-sulfur diesel in all diesel applications. All of these efforts save Argonne money while decreasing the use of carbon-based fuels and emissions.

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3.4.4. Sustainable Building Design

Utilizing DOE's Building Assessment Tool, Argonne completed an assessment of 11 existing onsite buildings in 2009 (involving 252,599 gross square feet) to determine whether or not the buildings can meet the five guiding principles of High Performance and Sustainable Buildings (HPSB) design. The guiding principles incorporate the following guidelines:

- Integrated assessment, operation, and management principles;
- Optimization of energy performance;
- Protection and conservation of water;
- Enhanced indoor environmental quality; and
- Reduced environmental impact of materials.

The 11 buildings that were assessed were chosen based on those with the closest current compliance with the guiding principles and the greatest potential to be economically retrofitted. These buildings include the Building 213 Cafeteria, Building 214, Laboratory Office Modules 431-438, and the Building 216 Sub-Angstrom Microscopy and Microanalysis (SAMM) facility.

3.5. Employee/Community Awareness

Argonne conducts a number of activities focused on educating and informing both its employees and the public on the status of environmental programs and efforts to promote an environmental awareness. One example is providing information on conserving energy and promoting energy efficiency.

3.5.1. Earth Day

Argonne celebrated Earth Day on April 22, 2009. The activities were organized and coordinated by the Argonne Pollution Prevention Program and were held in the entrance to the Argonne cafeteria. The activities included: posters and handouts for energy and water conservation; information on the Argonne garden plot program; a poster on P2 program accomplishments; a raffle of a rain barrel; information on the bike-to-work program and the bike-share program; information on native plants and the importance of trees in our environment; information on invasive species; and a collection of Argonne employee hybrid cars.

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3.5.2. Argonne Open House

On Saturday, August 29, 2009, Argonne held an all-day open house in which the public was allowed to come on site and visit over 100 displays and demonstrations. Hundreds of Argonne employees provided logistical support, planned, created, set up exhibits, and manned stations displaying activities conducted by Argonne. A shuttle service was operated to transport visitors around the site and from remote parking locations. The attendance was estimated at 22,000. The open house was an opportunity for employees to be ambassadors for Argonne, to greet neighbors, offer assistance and advice to the visitors, and to answer questions about Argonne and its programs.

3.5.3. Community Relations

The Argonne Communications and Public Affairs organization builds and maintains trust within one of the Argonne key stakeholders; the community. Staff keeps local neighbors apprised of Argonne and its activities through the following activities:

- Community Leaders Round Table – Elected and appointed leaders of public and private community organizations meet quarterly for an informal update on Argonne activities that affect the surrounding communities.
- Community Update Newsletter – Issued periodically, this newsletter contains brief articles about people, discoveries, and developments at Argonne and is mailed to about 50,000 households surrounding Argonne.
- Tours – Each year, Argonne conducts dozens of tours of its grounds and scientific facilities for college, business, professional, or community groups.
- Argonne Speakers Bureau – Argonne provides community and business groups with speakers on a variety of topics related to Argonne activities.

In addition to these services, Argonne maintains a public website (www.anl.gov) which contains environmental information including: the Argonne environmental policy; copies of the SERs and Summary SERs; fact sheets on the monitoring program; and other current environmental information.

3.6. Awards

During 2009, Argonne received four national environmental awards. They are:

- White House Closing-the-Circle Award for electronics recycling;

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- U.S. Environmental Protection Agency Award for reduction of lead and mercury inventories;
- U.S. Environmental Protection Agency/Chicago Wilderness Award for use of native plants in restoration activities; and
- DOE Environmental Sustainability Award for reduction, re-use, recycling, and re-buying of dielectric oils.

In addition, six other activities were submitted for consideration for 2010 awards.

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION



4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

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4.1. Description of Monitoring Program

The radioactivity of the environment around Argonne in 2009 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 Sawmill Creek streambed 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/m³ for air, and pCi/g and fCi/g for bottom sediment. Penetrating radiation measurements are reported in units of mrem/yr, and population dose is reported in units of person-rems.

DOE has provided guidance⁵ 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 2009, 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 factors⁸ 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 4.19). Occasionally, other standards are used, and their sources are identified in the text.

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4.2. Air

The radioactive content of particles in the air was determined by collecting and analyzing air filter samples. The sampling locations are shown in Figures 1.1 and 1.2. 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 four 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 four off-site locations on glass fiber filter media. Average flow rates on the air samplers are about 70 m³/h (2,472 ft³/h). Filters are changed weekly. 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 three 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.

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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.

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 not as pronounced in 2009. 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/m³, which is similar to the average value for the past five years.

The gamma-ray emitters listed in Table 4.2 are those that have been present in the air for 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 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

The major airborne effluents released at Argonne during 2009 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,

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TABLE 4.1

Total Alpha and Beta Activities in Air-Filter Samples, 2009
(concentrations in fCi/m³)

Month	Location	No. of Samples	Alpha Activity			Beta Activity		
			Avg.	Min.	Max.	Avg.	Min.	Max.
January	Perimeter	44	3.3	1.0	4.9	43.5	21.5	54.3
	Off-Site	16	3.6	1.9	6.0	38.9	30.8	50.6
February	Perimeter	44	2.2	0.3	4.0	31.7	5.4	45.9
	Off-Site	15	2.5	1.1	4.3	29.4	19.0	39.9
March	Perimeter	44	2.9	1.3	5.8	30.5	15.5	41.2
	Off-Site	16	3.2	1.8	5.1	26.1	22.4	30.0
April	Perimeter	55	1.9	0.7	3.4	20.8	7.9	35.8
	Off-Site	17	2.0	1.1	4.2	16.9	11.2	23.4
May	Perimeter	44	1.9	0.7	3.6	21.4	8.4	33.1
	Off-Site	15	2.5	1.0	5.4	19.5	11.6	29.8
June	Perimeter	43	1.5	0.5	3.1	20.5	7.9	33.3
	Off-Site	16	1.9	1.1	2.7	20.6	12.7	32.2
July	Perimeter	55	1.2	< 0.1	2.3	18.1	1.9	25.7
	Off-Site	20	1.8	0.6	3.2	18.2	9.9	25.0
August	Perimeter	44	1.8	0.5	3.4	23.7	6.6	35.3
	Off-Site	16	2.1	0.8	3.8	22.0	12.7	31.0
September	Perimeter	55	2.1	0.5	4.1	28.9	9.2	48.3
	Off-Site	20	2.7	0.8	5.6	27.3	13.5	48.4
October	Perimeter	44	1.1	0.4	2.2	17.0	5.8	27.1
	Off-Site	16	1.6	0.1	3.3	16.5	8.9	40.4
November	Perimeter	44	1.8	0.8	2.7	25.2	10.1	33.4
	Off-Site	13	2.7	1.6	4.1	23.4	16.5	33.6
December	Perimeter	43	2.6	0.7	5.3	32.9	12.2	47.7
	Off-Site	14	3.6	1.1	6.7	29.6	19.3	37.0
Annual Summary	Perimeter	559	2.0 ± 0.4	< 0.1	5.8	26.0 ± 0.9	1.9	54.3
	Off-Site	194	2.5 ± 0.5	0.1	6.7	23.9 ± 0.9	8.9	50.6

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TABLE 4.2

Gamma-Ray Activity in Air-Filter Samples, 2009
(concentrations in fCi/m³)

Month	Location	Beryllium-7	Lead-210
January	Perimeter	136	41
	Off-Site	89	32
February	Perimeter	130	29
	Off-Site	92	24
March	Perimeter	203	25
	Off-Site	136	18
April	Perimeter	173	15
	Off-Site	109	14
May	Perimeter	224	17
	Off-Site	132	11
June	Perimeter	159	23
	Off-Site	119	14
July	Perimeter	130	20
	Off-Site	97	12
August	Perimeter	140	25
	Off-Site	102	16
September	Perimeter	139	34
	Off-Site	95	24
October	Perimeter	76	19
	Off-Site	65	13
November	Perimeter	89	23
	Off-Site	49	13
December	Perimeter	83	36
	Off-Site	58	23
Annual Summary	Perimeter	141	25
	Off-Site	95	18
Dose (mrem)	Perimeter	(0.00035)	(2.85)
	Off-Site	(0.00023)	(2.05)

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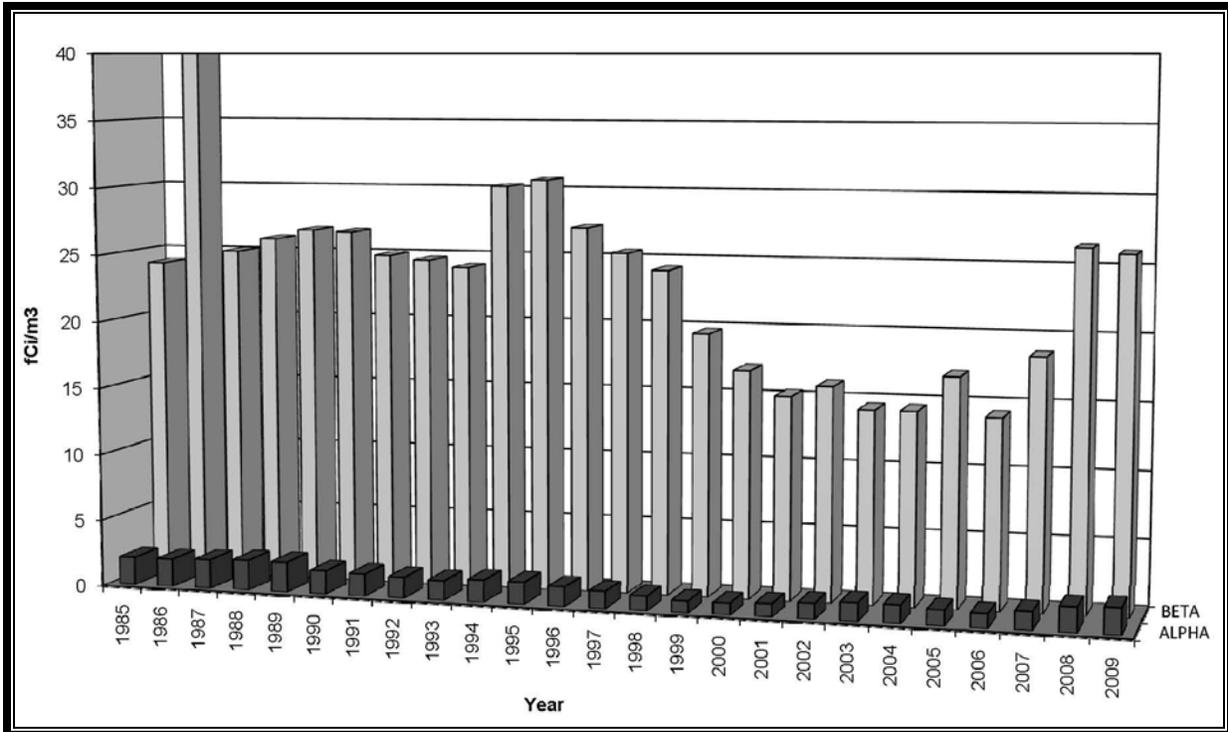


FIGURE 4.1 Comparison of Total Alpha and Beta Activities in Air Filter Samples, 1985 to 2009

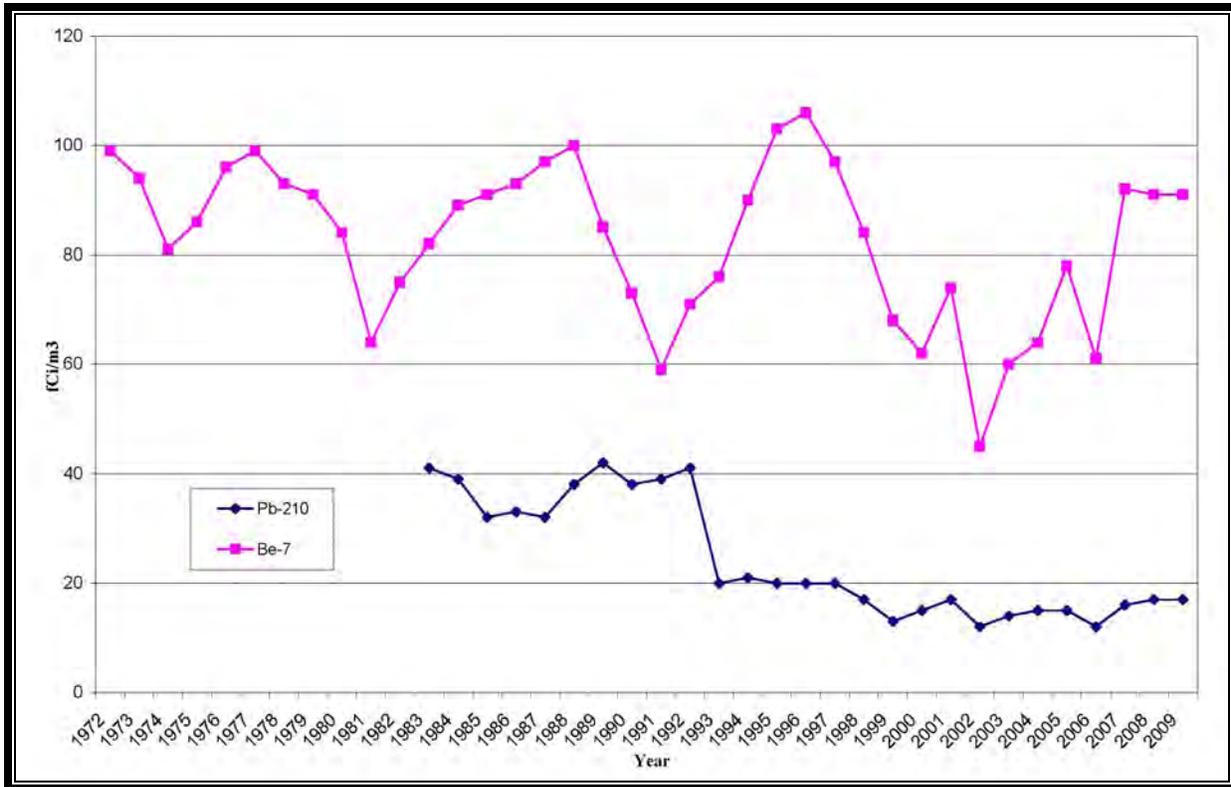


FIGURE 4.2 Comparison of Gamma-Ray Activity in Air Filter Samples, 1972 to 2009

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TABLE 4.3

Summary of Airborne Radioactive Emissions from Argonne Facilities, 2009

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 (tritiated hydrogen gas [HT])	12.3 yr	15.0	6.0×10^{11}
	Radon-220	56 s	0.20	7.3×10^9
411/415 (APS)	Carbon-11	20 min	1.3	4.7×10^{10}
	Nitrogen-13	10 min	59.7	2.2×10^{12}
	Oxygen-15	122 s	6.4	2.3×10^{11}

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 Building 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 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 2009 for all the wells was 335 pCi/L. The annual amount of hydrogen-3 released is then the product of the annual volume of water released

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for all 800 trees multiplied by the hydrogen-3 concentration in the groundwater. For 2009, the total hydrogen-3 released was 0.006 Ci. Applying the CAP-88 code,⁹ an estimate of the annual dose to the maximally exposed individual was 0.00000007 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. 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 5.8). 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 2009. 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

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TABLE 4.4

Radionuclides in Effluents from the Argonne Wastewater Treatment Plant, 2009

Activity	No. of Samples	Concentrations in pCi/L			Dose (mrem)		
		Avg.	Min.	Max.	Avg.	Min.	Max.
Alpha	52	0.79	< 0.1	2.95	– ^a	–	–
Beta	52	10.55	6.10	13.37	–	–	–
Hydrogen-3	52	106	< 100	255	0.0049	< 0.0046	0.0117
Strontium-90	52	0.28	0.21	0.38	0.027	0.020	0.036
Cesium-137	52	< 2.0	< 2.0	< 2.0	< 0.07	< 0.07	< 0.07
Uranium-234	52	0.34	0.10	0.90	0.065	0.019	0.172
Uranium-238	52	0.36	0.08	2.03	0.060	0.013	0.338
Neptunium-237	52	< 0.0010	< 0.0010	0.0072	< 0.0028	< 0.0028	0.0202
Plutonium-238	52	< 0.0010	< 0.0010	0.0052	< 0.0028	< 0.0028	0.0146
Plutonium-239	52	0.0012	< 0.0010	0.0188	0.0037	< 0.0031	0.0583
Americium-241	52	< 0.0010	< 0.0010	0.0116	< 0.0033	< 0.0033	0.0383
Curium-242 and/or Californium-252	52	< 0.0010	< 0.0010	< 0.0010	< 0.0007	< 0.0007	< 0.0007
Curium-244 and/or Californium-249	52	< 0.0010	< 0.0010	0.0024	< 0.0034	< 0.0034	0.0082

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

obtained from Lake Michigan, indicates the presence of strontium-90 at about 0.3 pCi/L. This was confirmed by the direct analysis of Lake Michigan water. The concentrations are well 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 (1.03×10^9 L) is computed. These results are given in Table 4.5.

TABLE 4.5

Total Radioactivity Released, 2009

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

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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 monthly 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.

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 130 pCi/L, and gamma-ray spectrometric analysis detected no radionuclides associated with Argonne activities above the detection limit of 2 pCi/L.

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TABLE 4.6

Radionuclides in Sawmill Creek Water, 2009

Activity	Location ^a	No. of Samples	Concentrations (pCi/L)			Dose (mrem)		
			Avg.	Min.	Max.	Avg.	Min.	Max.
Alpha (nonvolatile)	16K	12	0.91	0.37	1.96	_b	-	-
	7M	52	0.66	< 0.1	3.55	-	-	-
Beta (nonvolatile)	16K	12	5.1	3.90	8.22	-	-	-
	7M	52	9.9	6.01	16.40	-	-	-
Hydrogen-3	16K	12	< 100	< 100	156	< 0.0046	< 0.0046	0.0072
	7M	52	102	< 100	209	0.0047	< 0.0046	0.0096
Strontium-90	16K	12	< 0.25	< 0.25	< 0.25	< 0.024	< 0.024	< 0.024
	7M	52	0.27	< 0.25	0.39	0.026	< 0.024	0.037
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	0.726	0.143	1.206	0.139	0.027	0.230
	7M	52	0.421	0.119	3.430	0.080	0.023	0.655
Uranium-238	16K	12	0.676	0.132	1.133	0.112	0.022	0.188
	7M	52	0.413	0.005	2.326	0.069	0.001	0.386
Neptunium-237	16K	12	< 0.0010	< 0.0010	0.0031	< 0.0028	< 0.0028	0.0087
	7M	52	< 0.0010	< 0.0010	0.0061	< 0.0028	< 0.0028	0.0171
Plutonium-238	16K	12	0.0015	< 0.0010	0.0072	0.0042	< 0.0028	0.0202
	7M	52	0.0029	< 0.0010	0.1159	0.0081	< 0.0028	0.3245
Plutonium-239	16K	12	0.0025	< 0.0010	0.0256	0.0078	< 0.0031	0.0794
	7M	52	0.0435	< 0.0010	2.2020	0.1349	< 0.0031	6.8262
Americium-241	16K	12	< 0.0010	< 0.0010	< 0.0010	< 0.0033	< 0.0033	< 0.0033
	7M	52	0.0041	< 0.0010	0.1638	0.0135	< 0.0033	0.5405
Curium-242 and/or Californium-252	16K	12	< 0.0010	< 0.0010	< 0.0010	< 0.0007	< 0.0007	< 0.0007
	7M	52	< 0.0010	< 0.0010	< 0.0010	< 0.0007	< 0.0007	< 0.0007
Curium-244 and/or Californium-249	16K	12	< 0.0010	< 0.0010	0.0018	< 0.0034	< 0.0034	0.0061
	7M	52	< 0.0010	< 0.0010	0.0014	< 0.0034	< 0.0034	0.0048

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

^b Hyphen dash indicates no CEDEs for alpha and beta.

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TABLE 4.7

Radionuclides in Stormwater Outfalls, 2009
(concentrations in pCi/L)

Date Collected	Location 7J			Location 11D
	Hydrogen-3	Strontium-90	Cesium-137	Hydrogen-3
February 11	105	0.47	<2	264
April 3	<100	0.56	<2	143
August 28	<100	0.57	<2	Dry
October 28	<100	0.33	<2	125

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 reports¹¹ for air filter residues. The plutonium and americium were separated from the same 10-g (0.35-oz) aliquot of sediment. Results are given in terms of the oven-dried (110°C [230°F]) weight.

A set of sediment samples was collected on September 18, 2009, 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 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.

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TABLE 4.8

Radionuclides in Des Plaines River Water, 2009

Activity	Location ^a	No. of Samples	Concentrations (pCi/L)			Dose (mrem)		
			Avg.	Min.	Max.	Avg.	Min.	Max.
Alpha (nonvolatile)	A	12	2.1	0.09	10.6	_b	-	-
	B	24	0.5	< 0.01	1.8	-	-	-
Beta (nonvolatile)	A	12	8.0	5.96	13.59	-	-	-
	B	24	8.3	5.20	12.70	-	-	-
Hydrogen-3	A	12	< 100	< 100	123	< 0.0046	< 0.0046	0.0057
	B	24	< 100	< 100	165	< 0.0046	< 0.0046	0.0076
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	0.438	0.150	0.686	0.084	0.029	0.131
	B	24	0.484	0.143	0.861	0.092	0.027	0.164
Uranium-238	A	12	0.393	0.177	0.588	0.065	0.029	0.098
	B	24	0.485	0.112	2.156	0.081	0.019	0.358
Neptunium-237	A	12	< 0.0010	< 0.0010	< 0.0010	< 0.0028	< 0.0028	< 0.0028
	B	12	< 0.0010	< 0.0010	< 0.0010	< 0.0028	< 0.0028	< 0.0028
Plutonium-238	A	12	< 0.0010	< 0.0010	0.0014	< 0.0028	< 0.0028	0.0039
	B	12	< 0.0010	< 0.0010	0.0014	< 0.0028	< 0.0028	0.0039
Plutonium-239	A	12	< 0.0010	< 0.0010	0.0011	< 0.0031	< 0.0031	0.0034
	B	12	< 0.0010	< 0.0010	< 0.0010	< 0.0031	< 0.0031	< 0.0031
Americium-241	A	12	< 0.0010	< 0.0010	< 0.0010	< 0.0033	< 0.0033	< 0.0033
	B	12	< 0.0010	< 0.0010	< 0.0010	< 0.0033	< 0.0033	< 0.0033
Curium-242 and/or Californium-252	A	12	< 0.0010	< 0.0010	< 0.0010	< 0.0007	< 0.0007	< 0.0007
	B	12	< 0.0010	< 0.0010	< 0.0010	< 0.0007	< 0.0007	< 0.0007
Curium-244 and/or Californium-249	A	12	< 0.0010	< 0.0010	< 0.0010	< 0.0034	< 0.0034	< 0.0034
	B	12	< 0.0010	< 0.0010	< 0.0010	< 0.0034	< 0.0034	< 0.0034

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

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

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.9
Radionuclides in Bottom Sediment, 2009

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	14.10 ± 0.62	0.04 ± 0.02	0.66 ± 0.05	0.51 ± 0.03	0.35 ± 0.06	0.39 ± 0.33	5.37 ± 1.14	3.01 ± 1.18	
Sawmill Creek at outfall	17.70 ± 0.69	0.05 ± 0.02	1.02 ± 0.05	0.66 ± 0.04	0.50 ± 0.07	0.45 ± 0.30	2.54 ± 0.72	1.55 ± 0.64	
Sawmill Creek 50 m below outfall	15.80 ± 0.65	0.06 ± 0.02	0.74 ± 0.05	0.58 ± 0.03	0.54 ± 0.06	0.63 ± 0.41	6.12 ± 1.22	1.92 ± 0.86	
Sawmill Creek 100 m below outfall	16.60 ± 0.66	0.05 ± 0.02	0.74 ± 0.05	0.65 ± 0.03	0.56 ± 0.06	0.62 ± 0.36	9.34 ± 1.43	2.32 ± 0.83	
Sawmill Creek at Des Plaines River	21.10 ± 0.74	< 0.01	0.93 ± 0.05	0.88 ± 0.04	0.67 ± 0.07	0.37 ± 0.34	0.32 ± 0.35	1.03 ± 0.58	

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

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 101 ± 13 mrem/yr and were similar to last year's off-site average of 97 ± 15 mrem/yr.¹² To compare boundary results for individual sampling periods, the standard deviation of the 20 individual off-site results is useful. This value is 9 mrem/yr; thus, individual results in the range of 101 ± 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. Waste was packaged and temporarily stored in this area before removal for permanent disposal off-site. In 2009, the dose at this perimeter fence location was 92 ± 3 mrem/yr. Approximately 300 m (960 ft) south of the fence in grid 6I, the measured dose is 95 ± 2 mrem/yr, which is within the normal background range.

TABLE 4.10

Environmental Penetrating Radiation at Off-Site Locations, 2009

Location	Dose Rate (mrem/yr)				Average
	Period of Measurement				
	Jan. 13–April 1	April 1–July 1	July 1–Oct. 1	Oct. 1–Jan. 15	
Lemont	91	87	94	94	91 ± 3
Oak Brook	98	109	120	104	108 ± 10
Orland Park	107	146	128	102	121 ± 20
Willow Springs	88	91	106	97	96 ± 8
Woodridge	91	89	90	89	90 ± 1
Average	95 ± 8	104 ± 25	108 ± 16	97 ± 6	101 ± 13

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.11

Environmental Penetrating Radiation at Argonne, 2009

Location ^a	Dose Rate (mrem/yr)				Average
	Period of Measurement				
	Jan. 13–April 1	April 1–July 1	July 1–Oct. 1	Oct. 1–Jan. 15	
14G – Boundary	103	100	115	104	106 ± 7
14I – Boundary	90	85	93	98	92 ± 5
14L – Boundary	92	100	99	96	97 ± 3
6I – 200 m N of Quarry Road	93	94	97	95	95 ± 2
7I – Center, Waste Storage Area Facility 317	109	111	89	89	99 ± 12
7I – Boundary	96	92	88	93	92 ± 3
8H – Boundary	88	87	101	93	92 ± 6
8H – 65 m S of Building 316	90	91	95	90	92 ± 2
8H – 200 m NW of Waste Storage Area (Heliport)	95	97	105	104	100 ± 5
8H – Boundary, Center, St. Patrick Cemetery	86	95	101	98	95 ± 7
9H – 50 m SE of CP-5	90	94	97	97	95 ± 3
9H/I – 50 m E of Building 331	176	716	491	174	389 ± 264
9/10I – E of D306	406	470	653	640	542 ± 123
9/10I – 65 m NE of Building 350 230 m NE of Building 316	91	87	94	90	91 ± 3
9/10 EF – Boundary	102	102	120	104	107 ± 9
9J – 50 m W of 398A Area	477	337	298	275	347 ± 91
10/11K – Lodging Facilities	86	87	94	95	90 ± 4

^a See Figure 1.1.

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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 95 mrem/yr in 2009.

Three TLD locations monitor radioactive waste processing facilities and areas were added in recent years. 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 2009, 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 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 2009, 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. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

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 assessed.

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 code⁹ to calculate the dose for radionuclides released to the air and to demonstrate compliance with the regulation. The dose limit applicable for 2009 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 2009, 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 three 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), and Building 411/415 (APS) (Tables 4.16 and 4.17). The doses given in these tables are the committed whole body effective dose equivalents. There were no radiological operations conducted in Building 350 (NBL) in 2009.

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.

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.12

Radiological Airborne Releases from Building 200, 2009

Direction	Distance to Perimeter (m)	Dose ^a (mrem/yr)	Distance to Nearest Resident (m)	Dose ^a (mrem/yr)
N	500	1.4×10^{-2}	1,000	5.1×10^{-3}
NNE	600	1.1×10^{-2}	1,100	4.2×10^{-3}
NE	750	6.5×10^{-3}	2,600	8.7×10^{-4}
ENE	1,700	2.1×10^{-3}	3,100	7.9×10^{-4}
E	2,400	1.5×10^{-3}	3,500	7.1×10^{-4}
ESE	2,200	1.5×10^{-3}	3,600	6.9×10^{-4}
SE	2,100	1.4×10^{-3}	4,000	4.8×10^{-4}
SSE	2,000	1.4×10^{-3}	4,000	4.5×10^{-4}
S	1,500	7.1×10^{-4}	4,000	1.6×10^{-4}
SSW	1,000	4.2×10^{-3}	2,500	9.8×10^{-4}
SW	800	1.0×10^{-2}	2,200	2.3×10^{-3}
WSW	1,100	4.5×10^{-3}	1,500	2.7×10^{-3}
W	750	6.7×10^{-3}	1,500	2.1×10^{-3}
WNW	800	4.0×10^{-3}	1,300	1.8×10^{-3}
NW	600	6.4×10^{-3}	1,100	2.5×10^{-3}
NNW	600	6.9×10^{-3}	800	4.4×10^{-3}

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

TABLE 4.13

Maximum Perimeter and Individual Doses
from Building 200 Air Emissions, 2009
(dose in mrem/yr)

Pathway	Perimeter (500 m N)	Individual (1,000 m N)
Ingestion	1.6×10^{-17}	6.2×10^{-18}
Inhalation	1.4×10^{-2}	5.1×10^{-3}
Air immersion	3.0×10^{-6}	1.1×10^{-6}
Ground surface	1.3×10^{-5}	5.0×10^{-5}
Total	1.4×10^{-2}	5.1×10^{-3}
<i>Radionuclide</i>		
Thallium-208	1.0×10^{-5}	4.1×10^{-6}
Bismuth-212	1.9×10^{-4}	7.1×10^{-5}
Lead-212	1.4×10^{-2}	5.1×10^{-3}
Radon-220	7.5×10^{-9}	2.8×10^{-9}
Total	1.4×10^{-2}	5.1×10^{-3}

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.14

Radiological Airborne Releases from Building 212, 2009

Direction	Distance to Perimeter (m)	Dose ^a (mrem/yr)	Distance to Nearest Resident (m)	Dose ^a (mrem/yr)
N	800	6.6×10^{-4}	2,000	1.7×10^{-4}
NNE	1,000	4.5×10^{-4}	2,500	1.1×10^{-4}
NE	1,300	2.5×10^{-4}	2,000	1.3×10^{-4}
ENE	1,500	2.4×10^{-4}	2,500	1.1×10^{-4}
E	1,600	2.4×10^{-4}	2,800	9.8×10^{-5}
ESE	1,200	3.7×10^{-4}	2,500	1.2×10^{-4}
SE	1,400	2.5×10^{-4}	3,500	5.8×10^{-5}
SSE	1,400	2.3×10^{-4}	4,500	3.7×10^{-5}
S	1,500	6.6×10^{-5}	5,000	1.2×10^{-5}
SSW	1,600	1.9×10^{-4}	5,000	3.4×10^{-5}
SW	1,400	4.1×10^{-4}	2,400	1.9×10^{-4}
WSW	1,300	3.2×10^{-4}	2,300	1.3×10^{-4}
W	1,700	1.7×10^{-4}	2,200	1.1×10^{-4}
WNW	1,500	1.4×10^{-4}	2,000	8.5×10^{-5}
NW	1,300	1.8×10^{-4}	2,000	9.1×10^{-5}
NNW	1,000	2.9×10^{-4}	2,000	9.5×10^{-5}

^a Source terms: hydrogen-3 = 15.0 Ci (HT = gaseous tritium)
hydrogen-3 = 5.0 Ci (HTO = tritiated water vapor)
antimony-125 = 1.4×10^{-8} Ci
iodine-125 = 3.0×10^{-6} Ci
iodine-129 = 5.0×10^{-6} Ci
radon-220 = 0.036 Ci

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 three individual building assessments were then overlaid 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 southwest direction, with a maximum value of 0.023 mrem/yr (Location 10E 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 (0.007 mrem/yr), if he or she were outdoors during the entire year, is located approximately 2.7 km (1.7 mi) north of the IPNS facility. The major contributor to the whole body dose is the air immersion dose from

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TABLE 4.15

Maximum Perimeter and Individual Doses
from Building 212 Air Emissions, 2009
(dose in mrem/yr)

Pathway	Perimeter (800 m N)	Individual (2,400 m SW)
Ingestion	1.5×10^{-4}	4.2×10^{-5}
Inhalation	5.1×10^{-4}	1.5×10^{-4}
Air immersion	1.7×10^{-9}	4.9×10^{-10}
Ground surface	1.2×10^{-7}	2.4×10^{-8}
Total	6.6×10^{-4}	1.9×10^{-4}
<i>Radionuclide</i>		
Hydrogen-3	6.5×10^{-4}	1.9×10^{-4}
Antimony-125	6.2×10^{-11}	1.7×10^{-11}
Iodine-125	1.7×10^{-7}	3.3×10^{-8}
Iodine-129	5.6×10^{-6}	1.1×10^{-6}
Radon-220	4.4×10^{-12}	1.3×10^{-12}
Total	6.6×10^{-4}	1.9×10^{-4}

lead-212 (0.0014 mrem/yr). If radon-220 plus daughters were excluded from the calculation, the NESHAP reportable dose to the maximally exposed individual would be 0.0026 mrem/yr.

The individual doses to the maximally exposed members 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 4.18, 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 310 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

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TABLE 4.16

Radiological Airborne Releases from Building 411/415 (APS), 2009

Direction	Distance to Perimeter (m)	Dose ^a (mrem/yr)	Distance to Nearest Resident (m)	Dose ^a (mrem/yr)
N	1,500	2.3×10^{-3}	2,000	1.4×10^{-3}
NNE	1,600	1.9×10^{-3}	2,100	1.2×10^{-3}
NE	2,200	9.5×10^{-4}	3,100	5.5×10^{-4}
ENE	2,500	9.4×10^{-4}	3,300	6.1×10^{-4}
E	1,600	2.1×10^{-3}	3,400	6.3×10^{-4}
ESE	1,500	2.3×10^{-3}	3,500	6.1×10^{-4}
SE	400	1.4×10^{-2}	3,000	6.3×10^{-4}
SSE	400	1.2×10^{-2}	3,000	5.9×10^{-4}
S	350	3.2×10^{-3}	2,500	2.7×10^{-4}
SSW	400	1.2×10^{-2}	2,800	6.9×10^{-4}
SW	550	1.3×10^{-2}	3,000	1.2×10^{-3}
WSW	800	6.1×10^{-3}	1,400	2.5×10^{-3}
W	800	4.9×10^{-3}	1,500	1.8×10^{-3}
WNW	500	6.4×10^{-3}	1,400	1.3×10^{-3}
NW	350	1.0×10^{-2}	1,600	1.1×10^{-3}
NNW	1,500	1.3×10^{-3}	2,000	8.3×10^{-4}

^a Source terms: carbon-11 = 1.3 Ci
nitrogen-13 = 59.7 Ci
oxygen-15 = 6.4 Ci

TABLE 4.17

Maximum Perimeter and Individual Doses
from Building 411/415 (APS) Air Emissions, 2009
(dose in mrem/yr)

Pathway	Perimeter (400 m SSW)	Individual (1,400 m WSW)
Ingestion	— ^a	—
Inhalation	4.7×10^{-6}	8.4×10^{-7}
Air immersion	1.4×10^{-2}	2.5×10^{-3}
Ground surface	—	—
Total	1.4×10^{-2}	2.5×10^{-3}
<i>Radionuclide</i>		
Carbon-11	3.9×10^{-4}	7.1×10^{-5}
Nitrogen-13	1.3×10^{-2}	2.4×10^{-3}
Oxygen-15	1.5×10^{-4}	2.7×10^{-5}
Total	1.4×10^{-2}	2.5×10^{-3}

^a A hyphen indicates no exposure by this pathway.

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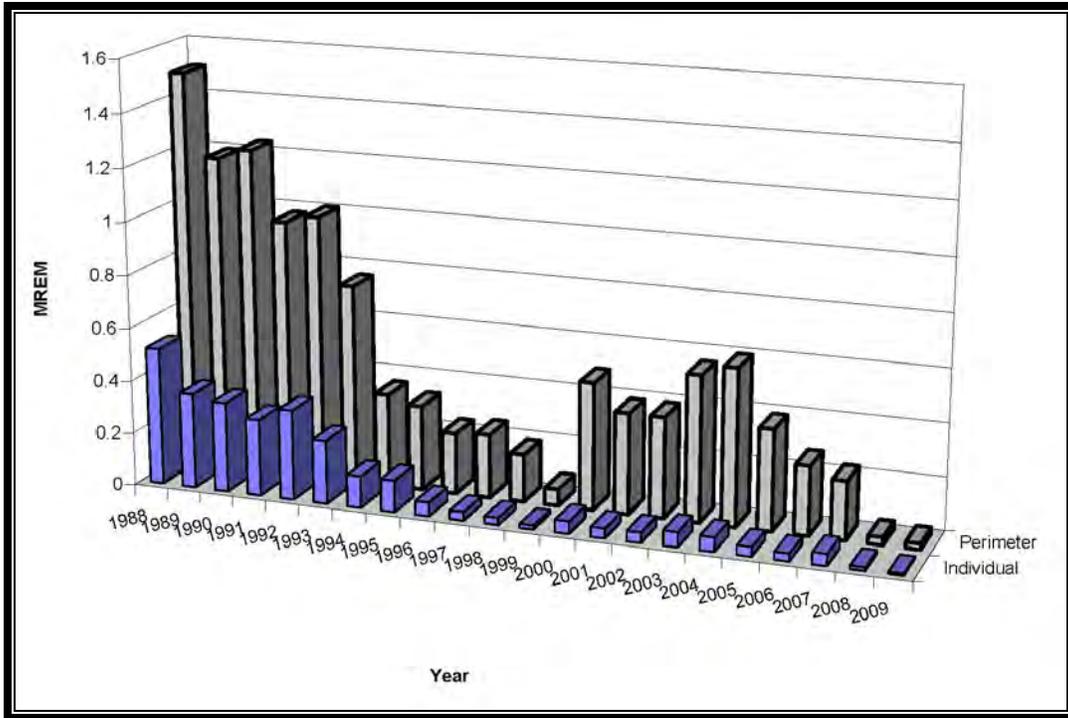


FIGURE 4.4 Individual and Perimeter Doses from Airborne Radioactive Emissions

TABLE 4.18

Population Dose within 80 km
(50 mi), 2009

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
Lead-212	0.26
Total	0.57
Natural	2.8×10^6

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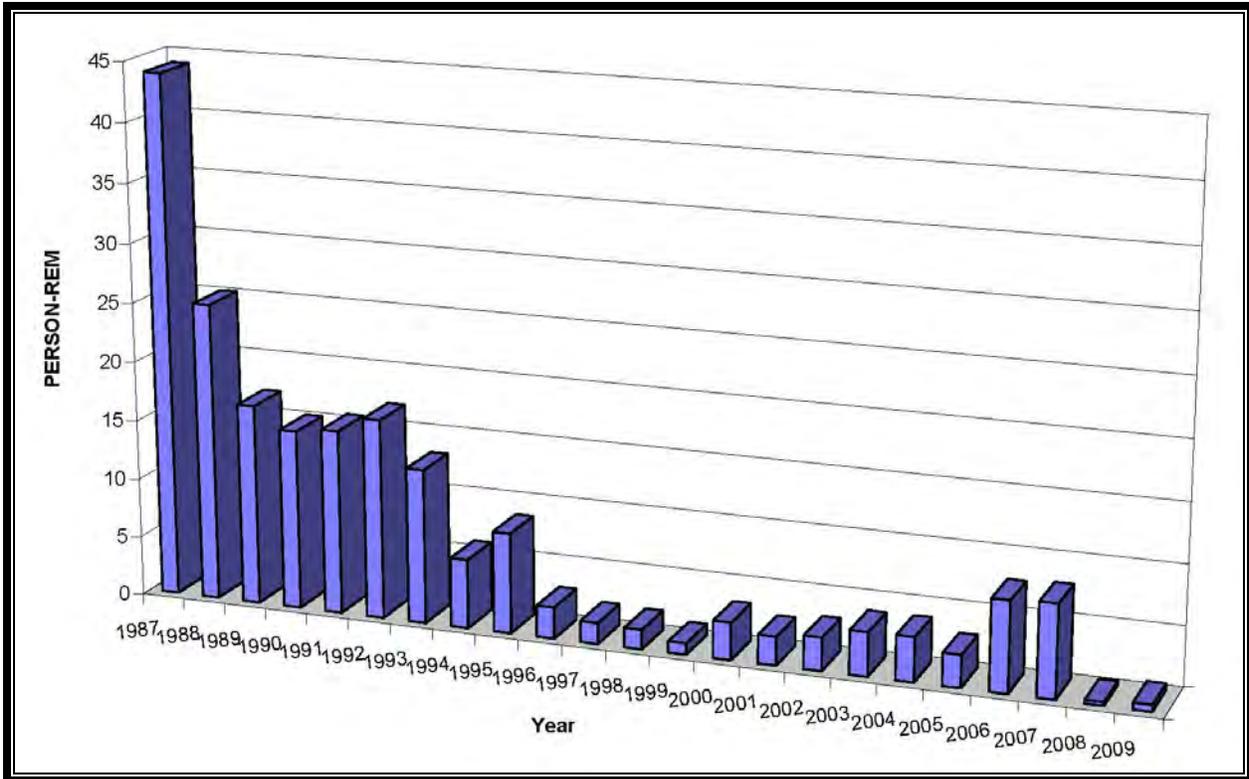


FIGURE 4.5 Population Dose from Airborne Radioactive Emissions

the case for Argonne. However, the significant decrease in population dose in 2008 and 2009 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 $8,400 \text{ m}^3/\text{yr}$.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 $\text{rem}/\mu\text{Ci}$, and this calculation gives the 50-year CEDE. Table 4.19 lists the applicable CEDE factors.

An evaluation of potential sensitive receptors of Argonne airborne releases, including children at the Argonne Child Development Center (Location 120 in Figure 1.1) was conducted. The airborne dose from Argonne is estimated to be about $0.001 \text{ mrem}/\text{yr}$ at this location. This assumes full-time, outdoor exposure. Assuming that the children are present about eight hours per day, five days per week, the actual dose is closer to $0.0003 \text{ mrem}/\text{yr}$. 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 $0.0005 \text{ mrem}/\text{yr}$. Again, assuming that the children are present at this location only six hours per day, five days per week, and for 35 weeks a year, the actual dose is closer to $0.00005 \text{ mrem}/\text{yr}$.

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TABLE 4.19

50-Year Committed Effective Dose
Equivalent Conversion Factors
(rem/ μ Ci)

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 hyphen indicates that a value is not required.

4.7.2. Water Pathway

Following the methodology outlined in DOE Order 5400.5,⁵ the annual intake of radionuclides (in μ Ci) ingested with water is obtained by multiplying the concentration of radionuclides in microcuries per milliliter (μ Ci/mL) by the average annual water consumption of a member of the general public (7.3×10^5 mL). This annual intake is then multiplied by the CEDE conversion factor for ingestion (Table 4.19) to obtain the dose received in that year. This procedure was carried out for all radionuclides, and the individual results were summed to obtain the total ingestion dose.

The only significant location where radionuclides attributable to 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

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Table 4.20. 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 (1986–2009) 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 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 $0.28 \text{ m}^3/\text{s}$ ($10 \text{ ft}^3/\text{s}$). The flow rate of the Des Plaines River in the vicinity of Argonne is about $25 \text{ m}^3/\text{s}$ ($900 \text{ ft}^3/\text{s}$). Applying this ratio to the concentration of radionuclides in Sawmill Creek listed in Table 4.20, 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 5400.5⁵ 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

TABLE 4.20

Radionuclide Concentrations and Dose Estimates
for Sawmill Creek Water, 2009

Radionuclide	Total Released (Ci)	Net Avg. Concentration (pCi/L)	Dose (mrem)
Hydrogen-3	0.11	24	0.001
Strontium-90	0.0004	0.10	0.009
Plutonium-239	<0.0001	0.0007	0.002
Americium-241	<0.0001	0.0007	0.002
Total	0.11		0.014

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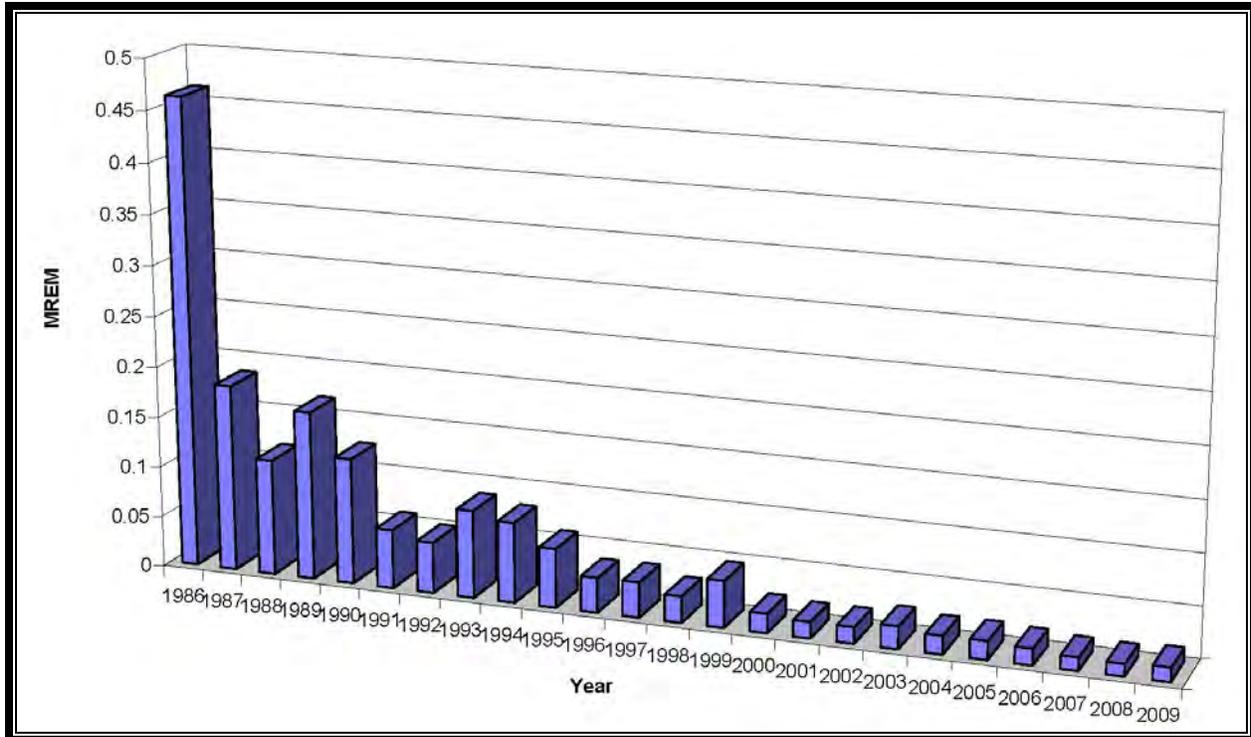


FIGURE 4.6 Comparison of Dose Estimates from Ingestion of Sawmill Creek Water

discharges its treated wastewater. Inspection of the creek at this location indicates the presence of small bluegill and carp (about 100 g [4 oz] each). The aquatic dose assessment of these species was conducted 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 0.001 to aquatic biota. This is well below a ratio of one 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 92 ± 3 mrem/yr. Approximately 300 m (960 ft) south of the fence line (grid 6I), the measured dose was 95 ± 2 mrem/yr, essentially the same as the off-site average (101 ± 13 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.

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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 residents 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.

4.7.5. Dose Summary

The total effective dose equivalent received by off-site residents during 2009 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 from the air pathway was approximately 0.007 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 0.57 person-rem. The dose pathways are presented in Table 4.21 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 0.022 mrem/yr attributable to Argonne operations into perspective, comparisons can be made with annual average doses (620 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 4.22. 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.

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TABLE 4.21

Summary of the Estimated Dose to a Hypothetical Individual, 2009 (mrem/yr)

Pathway	Argonne Estimate	Applicable Standard
Air total	0.007	10 (EPA)
Water	0.014	4 (EPA) ^a
Direct radiation	0.001	25 (NRC) ^b
Maximum dose	0.022	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.

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TABLE 4.22

Annual Average Dose Equivalent
in the U.S. Population^a

Source	Dose (mrem)
Natural	
Radon	228
Internal (⁴⁰ K and ²²⁶ Ra)	29
Cosmic	33
Terrestrial	21
Medical	
Computed Topography	147
Nuclear Medicine	77
Interventional Fluoroscopy	43
Conventional Radiography & Fluoroscopy	33
Consumer	
Building Materials	13
Commercial Air Travel	
Cigarette Smoking	
Mining and Agricultural	
Combustion of Fossil Fuels	
Highway and Road Construction Materials	
Glass and Ceramics	
Industrial	
Nuclear-power Generation	0.3
DOE Installations	
Decommissioning and Radioactive Waste	
Industrial, Medical, Educational, and Research	
Activities	
Contact with Nuclear-medicine Patients	
Security Inspection Systems	
Occupational	
Medical	0.5
Aviation	
Commercial Nuclear Power	
Industrial and Commercial	
Education and Research	
Government, DOE, and Military	
Total	624

^a NCRP report No. 160.³⁶

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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.

5.2. Monitoring Air Discharges

Argonne operations and research activities utilize a number of nonradioactive volatile chemicals, fuels, and combustion products that have the potential to adversely impact the environment, if released into the air in sufficient quantities. However, most of these materials are used or generated in small enough quantities that the potential for measureable release into the atmosphere is very low. As a result, Argonne does not conduct ambient air quality monitoring for conventional air pollutants. Air discharge amounts are estimated each year for the various sources of releases to the atmosphere. Chapter 2 (Table 2.3) contains a summary of estimated air discharges (estimated based on equipment run time and other emission factors for each source) from the permitted air point-source discharges at Argonne.

As shown in Table 2.3, the vast majority of air releases in 2009 were 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 year, all of the boilers burn natural gas, which emits relatively small amounts of regulated pollutants, and stack monitoring is not required. In Boiler No. 5, coal is used during the peak heating demand periods in the winter. Since air emissions while burning coal are much greater than natural gas, it is equipped with dedicated stack monitoring equipment for sulfur dioxide and opacity that is used only while burning coal. No exceedances were noted during 2009 over a period of 1,191 hours of coal-burning operation (see Section 2.1.2). The lack of exceedances for 2009 indicates that the boiler house is operating within its allowable discharge constraints.

Other air discharges include combustion products from a number of backup power generators that are operated periodically for maintenance reasons and a transportation research facility that evaluates internal combustion engines. The pollutants discharged are similar to those released from the boiler house.

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 the landfill. Gas composition is measured quarterly at four 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 2009 indicated that the gas within the landfill waste mound contained up to 76% methane, but no methane was found in the perimeter gas monitoring wells

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or buildings surrounding the landfill, except for three readings of 0.1% methane in three wells in September. These levels were well below the action level of 2.5% methane. The quantity of gas generated is not measured, but observations during sampling indicate that the flow is very small.

Because of the small scale 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. Small amounts of research-related volatile chemicals are released into the air when 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 monthly sample of wastewater flowing into the plant and the flow rate of wastewater through the plant. The amount potentially released into the air is estimated by using the EPA's WATER9 model, designed for determining emissions from such facilities. Table 2.3 contains the results of this estimate. During 2009, the estimated amount of VOM released from the LWTP was approximately 27 kg (59 lb), much lower than in previous years. Section 5.3 discusses the individual results of the wastewater analysis.

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 2009. The 2009 results are similar to those from recent years. Low concentrations of bromoform, bromodichloromethane, chloroform, and dibromochloromethane were found in all of the samples. These compounds are halogenated organic chemicals that are produced when chlorine is added to the water supply during treatment. 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 compounds remain in the wastewater and are detected in the influent samples. The drinking water limit for the sum of all of the THM compounds is 80 µg/L. The sum of the concentrations detected is well below this limit. 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.

In addition to the THMs, seven other chemicals were detected in at least one sample. The only chemical consistently detected was acetone. All the other chemicals were found in only one or two samples. Acetone was found in 6 of 12 samples and is likely the result of equipment cleaning. Figure 5.2 shows acetone concentrations since 1992. Since 1998 the concentrations have been very low.

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TABLE 5.1

Laboratory Influent Wastewater, 2009
(concentrations in µg/L)

Compound	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Avg. ^b
<i>Chlorination By-Products</i>													
Bromodichloromethane	2	2	1	2	1	1	2	2	1	1	2	2	1.5
Bromoform	<1 ^a	1	<1	1	3	1	7	9	9	4	5	1	3.5
Chloroform	1	1	1	1	<1	1	2	1	1	1	2	2	1.2
Dibromochloromethane	1	2	1	1	2	2	5	3	4	2	3	2	2.3
<i>Chemicals Discharged</i>													
Acetaldehyde	39	- ^c	-	-	-	-	-	-	-	-	-	-	39
Acetone	37	-	13	35	-	-	-	19	116	104	-	-	54
Carbon Tetrachloride	<1	<1	<1	<1	<1	<1	2	<1	<1	<1	2	<1	2
D-Limonene	-	-	-	-	-	-	-	-	32	-	-	-	32
Ethanol	690	-	-	-	-	-	-	-	-	-	-	-	690
Trichloroethene	<1	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1	<1

^a <1 indicates that the concentration was less than the detection limit.

^b Average calculated from values above the detection limits only.

^c A dash indicates that the compound was not detected.

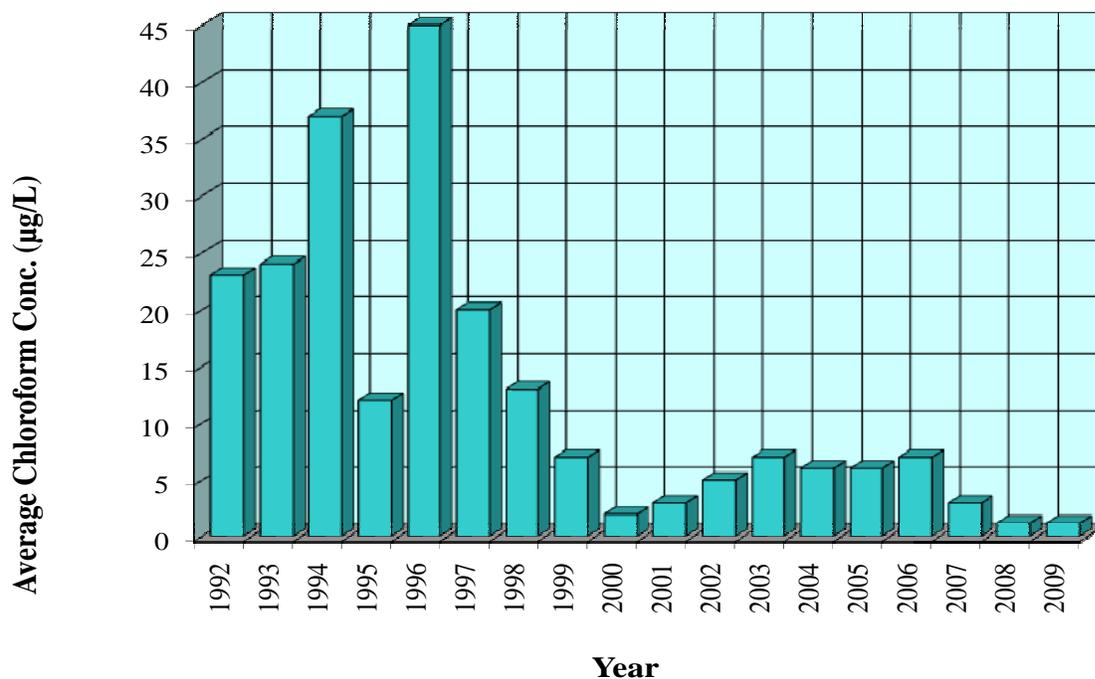


FIGURE 5.1 Average Chloroform Levels in Laboratory Influent Wastewater, 1992 to 2009

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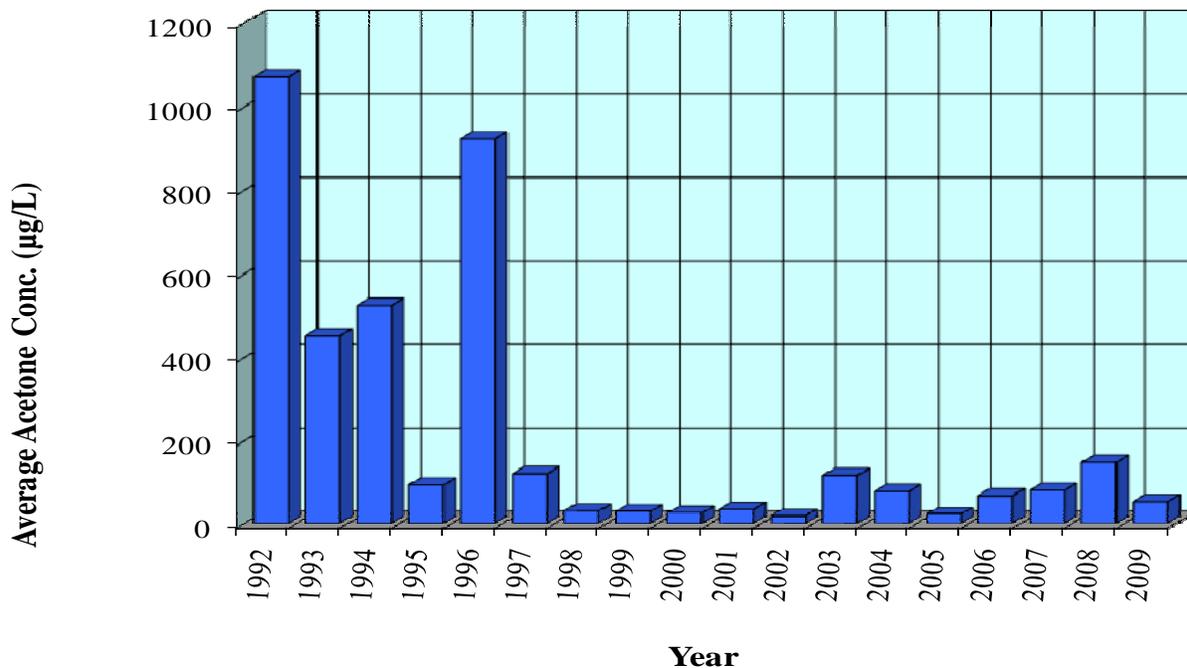


FIGURE 5.2 Average Acetone Levels in Laboratory Influent Wastewater, 1992 to 2009

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, so the small amount of volatile chemicals discharged are effectively removed in the wastewater 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 and other chemicals 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, 1,1,1-trichloroethane, trichloroethene, carbon tetrachloride, and chloroform. In July of 2009 two of these compounds were detected at concentrations near the analytical quantitation limits.

5.4. Monitoring Discharges to Surface Water

The release of nonradioactive pollutants into surface water is monitored in several different ways. Samples of wastewater discharged to on-site streams and Sawmill Creek are

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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. The results are transmitted monthly to the IEPA in a DMR.

Besides the NPDES permit-required sampling, stormwater is sampled at several locations across the site. The overall effects of the Argonne site discharges on Sawmill Creek are monitored by sampling the creek downstream of the site and comparing the results with samples collected upstream of the site.

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; 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, and condensate; 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 eliminated or rerouted to the Argonne sewer system, resulting in the elimination of dry weather flow in a number of outfalls of this type. Several outfalls are no longer sampled because all process wastewater has been diverted to the sewer. Four stormwater-only 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.

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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 and other environmental samples. These analyses are conducted by the Argonne ESQ Analytical Services (ESQ-AS) laboratory as well as commercial laboratories. Commercial laboratories are used for analyses that the Argonne laboratory does not perform due to the cost and complexity of the analyses.

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, EPA-SW-846³⁰ 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.

5.4.2.1. Wastewater Treatment Facility Outfalls

Outfall A01. This outfall consists of sanitary wastewater treated in the surface water treatment plant (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 during the month (30-day average limit). Table 5.3 also contains a summary of the monitoring results from 2009. No limits were exceeded at this outfall during 2009.

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 2009.

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TABLE 5.2

Analytical Procedures

Analyte	Description	Analytical Lab
<i>Wastewater Properties</i>		
pH	Electrochemical pH electrode method	Field
Temperature	Electronic probe method	Field
Specific conductivity and ORP	Electronic probe method	Field
Oxd/red potential	Electronic probe method	Field
<i>Inorganic Constituents</i>		
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)	<i>n, n</i> -Diethyl- <i>p</i> -phenylene diamine colorimetric method	Field
Total suspended solids (TSS)	Filtering and drying gravimetric method	Argonne
<i>Organic Constituents</i>		
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
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	Argonne
<i>Priority Pollutant List Analyses</i>		
Cyanide (total)	Distillation and colorimetric method	Commercial
Herbicides/pesticides	Liquid/liquid extraction followed by gas chromatograph and mass spectrometer 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)	ICP/atomic emission spectrometry	Argonne
antimony, arsenic, beryllium, cadmium, chromium, copper, lead, nickel, selenium, silver, thallium, zinc		
Mercury	Cold vapor atomic absorption spectrometry	Argonne

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

TABLE 5.3

Outfall A01 Effluent Limits and Monitoring Results, 2009
(concentrations mg/L except where noted)

Constituent	NPDES Permit Requirements			Monitoring Results			Exceedances in 2009
	Monitoring Frequency	30-Day Average Limit	Maximum Daily Limit	Minimum	Average	Maximum	
Flow (MGD) ^a	Continuous	NA ^b	NA	0.152	0.272	1.964	NA
pH (pH units)	Weekly	NA	6.0–9.0	6.60	6.92	7.48	0
BOD ₅	Weekly	10.0	20.0	1	3	8	0
TSS	Weekly	12.0	24.0	1	3	12	0
Copper	Weekly	0.5	1	<0.025 ^c	<0.025	0.034	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 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.

Iron and chemical oxygen demand (COD) are analyzed at this outfall as monitor-only constituents. The COD results provide a rough indication of the oxygen-consuming potential of this effluent on the receiving stream. None of the samples in 2009 had COD concentrations above the analytical detection limits of 20 mg/L. Only one sample contained iron above the detection limit of 0.5 mg/L, that concentration being 0.66 mg/L.

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 24, 2009, and December 9, 2009, 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. In general, these results indicate that the treated 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.

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TABLE 5.4

Outfall B01 Effluent Limits and Monitoring Results, 2009
(concentrations in mg/L except where noted)

Constituent	NPDES Permit Requirements			Monitoring Results			
	Monitoring Frequency	30-Day Average Limit	Maximum Daily Limit	Minimum	Average	Maximum	2009 Exceedances
Flow (MGD)	Weekly	NA ^a	NA	0.352	0.482	1.182	NA
pH (pH units)	Weekly	NA	6.0–9.0	6.73	7.15	7.90	0
BOD ₅ concentration	Weekly	10	20	1	2	5	0
BOD ₅ mass (lb/day)	Weekly	41.9	83.7	2.6	7.7	26.1	0
TSS concentration	Weekly	12	24	1	3	24	0
TSS mass (lb/day)	Weekly	50.2	100.5	2.6	11.8	26.9	0
Zinc concentration	Weekly	1	2	<0.5 ^b	<0.5	<0.5	0
Zinc mass (lb/day)	Weekly	4.19	8.37	<1.3 ^c	<2.0	<3.4	0
Mercury concentration	Weekly	0.003	0.006	<0.0002	<0.0002	<0.0002	0
Mercury mass (lb/day)	Weekly	0.0126	0.0251	<0.0005	<0.0008	<0.001	0
Oil and grease concentration	Weekly	15	30	<5	<5	7	0
Oil and grease mass (lb/day)	Weekly	62.8	125.6	<13	<20	<34	0
Iron ^d	Weekly	NA	NA	<0.5	<0.5	0.66	NA
COD ^d	Weekly	NA	NA	<20	<20	<20	NA
Priority pollutants	Semiannual	NA	NA	– ^e	–	–	NA

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

^b 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.

^c 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.

^d Monitor-only parameter.

^e A dash indicates that priority pollutant results are presented in Table 5.5.

Outfall 001. This outfall represents the combined wastewater from both treatment plants. 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 2009.

Three permit exceedances occurred at Outfall 001 in 2009. The TDS limit was exceeded twice in February and the 30-day average limit for ammonia was exceeded in June. Both TDS exceedances occurred during periods of rapid snowmelt. The exceedances are believed to be related to the introduction of salt-laden snowmelt into the sewer system. The salt appears to be introduced into the sewer system through infiltration of salty surface water through 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),

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

TABLE 5.5

Outfall B01 Effluent Priority Pollutant Monitoring Results, 2009

Compound ^a	June	December
Bromodichloromethane (µg/L)	0.8	1.0
Bromoform (µg/L)	0.7	0.9
Chloroform (µg/L)	1.0	1.0
Dibromochloromethane (µg/L)	0.9	1.0

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

which provides approximately 50% of the total water used on site. The role of road salt in the TDS exceedances is 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 2002 through 2009. This figure shows the seasonal nature of TDS levels in the outfall, corresponding with 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).

During 2009 violations of the TDS limits went from twelve down to five, and there were no exceedances of the chloride limits. Favorable weather during the winter of 2008/2009 resulted in much lower TDS concentrations in the wastewater. This can be seen in Figure 5.3 when the 2009 concentrations are compared to previous values.

In June of 2009 the average of the four samples collected and analyzed for ammonia was above the seasonally adjusted limit of 1.2 mg/L. None of the samples exceeded the maximum daily limit of 3.8 mg/L. The cause of this exceedance was traced to an unusually high amount of sludge in the primary clarifiers at the SWTP, as well as unseasonably low temperatures in June, which may have interfered with the conversion of ammonia to nitrate.

The permit requires annual biological toxicity testing of Outfall 001. This test was performed using samples collected June 23 and 24, 2009. Two types of organisms, water fleas (*Ceriodaphnia dubia*) and fathead minnows (*Pimephales promelas*), were introduced into samples consisting of various ratios of Argonne effluent and dilution water. Survival was measured over two to four days, and mortality reported as a function of effluent concentration. An off-site contract laboratory performed the analyses. This testing concluded that the concentration of wastewater that produces 50% mortality in the test population (i.e., the median lethal concentration [LC₅₀]) was greater than 100%, meaning that even the undiluted effluent is not toxic to these species. Previous toxicity tests conducted since 2001 have all concluded that the combined effluent is not toxic to these species.

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TABLE 5.6

Outfall 001 Monitoring Results and Effluent Limits, 2009
(concentrations in mg/L except where noted)

Constituent	NPDES Permit Requirements			Monitoring Results			
	Monitoring Frequency	30-day Average Limit	Maximum Daily Limit	Minimum	Average	Maximum	2009 Exceedances
Flow (MGD)	Daily	NA ^a	NA	0.504	0.754	3.037	NA
pH (pH units)	Weekly grab	NA	6.0–9.0	6.63	7.22	8.00	0
TDS	Weekly composite	NA	1,000	497	703	1059	2
Chloride	Weekly composite	NA	500	125	215	416	0
Sulfate	Weekly composite	NA	500	69	138	183	0
Dissolved iron	Weekly composite	NA	1	<0.5	<0.5	<0.5	0
Ammonia nitrogen (Nov.–March)	Weekly composite	2.4	10.8	0.12	0.85	1.85	0
Ammonia nitrogen (Apr.–Oct.)	Weekly composite	1.2	3.8	0.06	0.62	1.70	1
Copper	Weekly composite	0.031	0.051	<0.025	<0.025	<0.025	0
Manganese	Weekly composite	NA	1	<0.075	<0.075	0.14	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	0.32	0.55	0.97	NA
Beta radioactivity	Monthly grab	NA	NA	5.5	7.0	9.9	NA
Low-level mercury	Monthly grab	NA	NA	0.000002	0.000013	0.000076	NA

^a NA = not applicable

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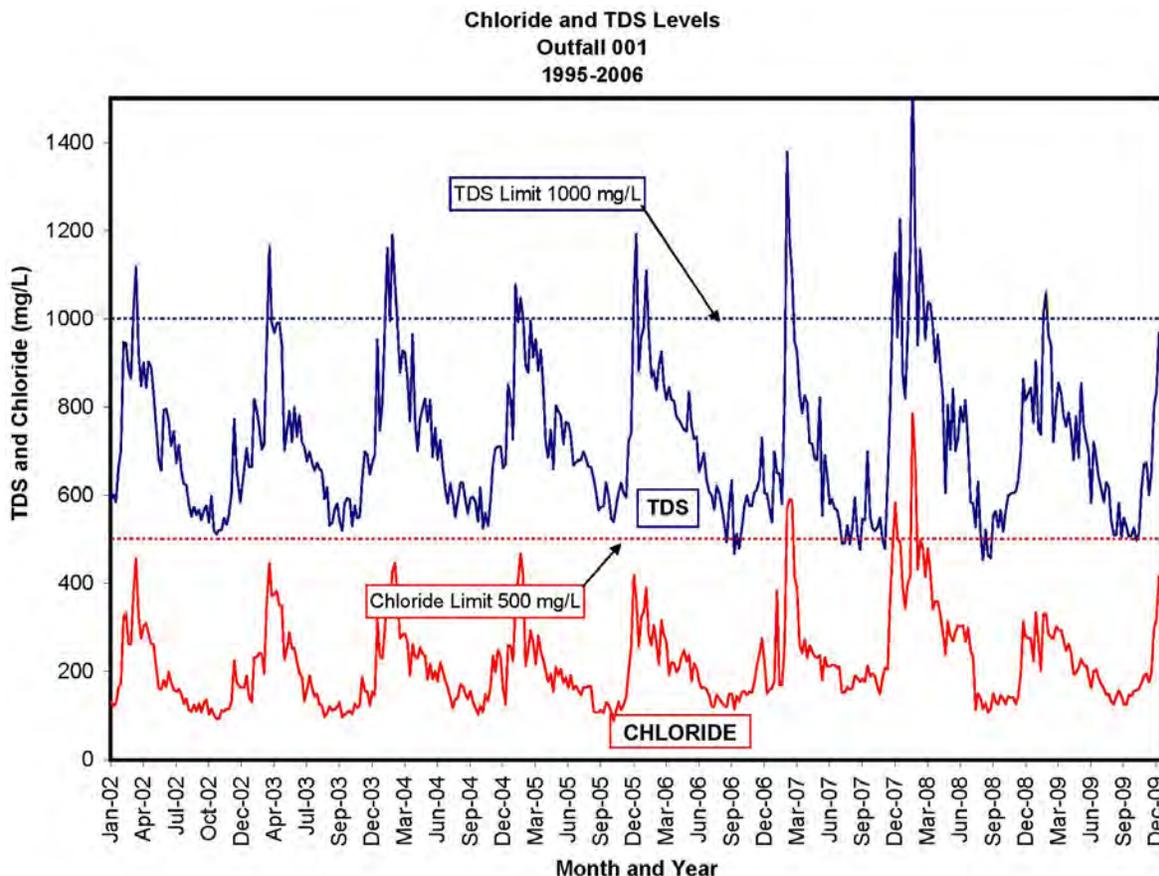


FIGURE 5.3 Total Dissolved Solids and Chloride in Outfall 001 Water, 2002 to 2009

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 in the past, process wastewater that does not require treatment prior to release, as well as stormwater. Four of the 17 outfalls discharge only stormwater. The sampling requirements and effluent limits for these outfalls are described in Table 5.7. Nine other outfalls listed in Table 2.4 but not in Table 5.7 are not sampled on a regular basis. These are outfalls which no longer have process wastewater discharges and are, therefore, no longer sampled, or outfalls where special sampling studies or investigations were required by the permit and have been completed.

Two of the direct discharge outfalls monitored in 2009 experienced permit exceedances. Outfall 006 had one exceedance of the monthly average TSS limit of 15 mg/L in May. The cause of this exceedance is not known but is probably related to the introduction of suspended matter into the wastewater stream as it passed through several natural wetland areas prior to passing through the outfall. Decaying vegetation or disturbance of the sediment by animals may have introduced enough suspended matter to cause an exceedance. There were no known Argonne operations ongoing that could have caused the violation. The second outfall to experience an exceedance was outfall J03, which is an outfall no longer routinely sampled. During 2009 it was

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

TABLE 5.7

Summary of Monitored Direct Discharge NPDES Outfalls, 2009

Outfall	Constituent	Permit Limit	Sample Results		
			Average for 2009	No. of Samples	2009 Exceedances
B03	Flow (MGD)	None	0.012	12	NA ^a
	pH	6–9	7.5–8.0	12	0
	Temperature	<2.8°C rise	13.0	12	0
	TSS	Monitor only	3	12	NA
C03	Flow (MGD)	None	0.027	12	NA
	pH	6–9	7.7–8.2	12	0
D03	Flow (MGD)	None	0.052	12	NA
	pH	6–9	7.2–7.9	12	0
	Temperature	<2.8°C rise	19.1	12	0
	TSS	Monitor only	1	12	NA
E03	Flow (MGD)	None	<0.001	1 ^b	NA
	pH	6–9	7.2	1	NA
	Temperature	<2.8°C rise	24.7	1	NA
	TSS	Monitor only	12	1	NA
G03	Flow (MGD)	None	0.016	12	NA
	pH	6–9	7.0–8.1	12	0
	Temperature	<2.8°C rise	21.0	12	0
H03	Flow (MGD)	None	<0.001	1 ^b	NA
	pH	6–9	7.8	1	0
	Temperature	<2.8°C rise	18.9	1	0
	TDS	1,000	300	1	0
	TSS	15 Avg.; 30 Max.	1	1	0
	TRC ^c	0.011 Avg.; 0.019 Max.	-	0	0
J03	Flow (MGD)	None	<0.001	1 ^b	NA
	pH	6–9	8.3	1	0
	Temperature	<2.8°C rise	21.1	1	0
	TDS	1,000	1744	1	1
	TRC ^c	0.011 Avg.; 0.019 Max.	-	0	0
004	Flow (MGD)	None	0.024	12	NA
	pH	6–9	7.5–8.0	12	0
	TSS	15 Avg.; 30 Max.	4	12	0
	TRC ^c	0.011 Avg.; 0.019 Max.	<0.05	50	0
C05	Flow (MGD)	None	0.010	12	NA
	pH	6–9	7.8–8.2	12	0
	Temperature	<2.8°C rise	14.6	12	0

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TABLE 5.7 (Cont.)

Outfall	Constituent	Permit Limit	Sample Results		
			Average for 2009	No. of Samples	2009 Exceedances
E05	Flow (MGD)	None	0.003	11	NA
	pH	6–9	6.9–7.5	11	0
	Temperature	<2.8°C rise	12.7	11	0
	TRC	0.011 Avg.; 0.019 Max.	<0.05	41	0
006	Flow (MGD)	None	0.027	11	NA
	pH	6–9	7.5–8.3	11	0
	Temperature	<2.8°C rise	12.6	11	0
	TSS	15 Avg.; 30 Max.	4	11	1
	TDS	1,000	777	11	0
	TRC ^c	0.011 Avg.; 0.019 Max.	<0.05	48	0
007	Flow (MGD)	None	0.005	12	NA
	pH	6–9	7.5–8.6	12	0
	Temperature	<2.8°C rise	12.8	12	0
021 ^d	Flow (MGD)	None	0.060	9	NA
	Hydrogen-3	Monitor only	119	9	NA
	Iron	Monitor only	0.66	9	NA
	Priority pollutants	Monitor only	– ^e	1	NA
A22 ^d	Flow (MGD)	None	0.017	2	NA
	Hydrogen-3	Monitor only	105	2	NA
B22 ^d	Flow (MGD)	None	0.18	2	NA
	Hydrogen-3	Monitor only	121	2	NA
023 ^d	Flow (MGD)	None	0.068	7	NA
	Hydrogen-3	Monitor only	166	7	NA
	Copper	Monitor only	<0.025	7	NA
025	Flow (MGD)	None	0.001	12	NA
	pH	6–9	7.2–8.0	12	0
	Temperature	<2.8°C rise	12.9	12	0
	TDS	1,000	315	12	0
	TRC ^c	0.011 Avg.; 0.019 Max.	<0.05	50	0

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

^b No process wastewater was present at this outfall; therefore, no routine sample was collected. However, one sample was collected in 2009 for the NPDES permit renewal application.

^c Analytical detection limit is 0.05 mg/L. Values less than 0.05 mg/L are considered in compliance with the discharge limits.

^d Stormwater-only outfall.

^e A dash indicates that priority pollutant results are presented in Section 5.4.2.1.

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

sampled once to provide data needed for the NPDES permit renewal application. This one sample contained TDS above the discharge limit and it was reported to the IEPA as an exceedance.

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 2009 sample was collected on June 18, 2009. None of the 124 compounds contained in the priority pollutant list was detected above analytical detection limits; however, four chlorinated solvents (carbon tetrachloride, chloroform, 1,1,1-trichloroethane and trichloroethene) were reported as being present in the sample but at concentrations less than the quantitation limit of 1 µg/L. These compounds are present in the soil and groundwater in the 317 Area, so their presence in stormwater is not unexpected. The very low concentrations present indicate that very small amounts of these chemicals are absorbed from the soil into stormwater runoff. 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 of 0.044 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 and the Des Plaines River upstream and 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.

Surface water discharges from the closed 800 Area and 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 5.8 by using the analytical procedures previously

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

TABLE 5.8

Chemical Constituents in Effluents from the Argonne
Wastewater Treatment Plant, 2009

Constituent	No. of Samples	Concentration (mg/L)			
		Average	Minimum	Maximum	IEPA Limit
Arsenic	52			< 0.025 ^a	0.25
Barium	52			< 0.5	2.0
Beryllium	52			< 0.0025	– ^b
Cadmium	52			< 0.0025	0.15
Chromium	52			< 0.05	1.0
Cobalt	52			< 0.25	–
Copper	52			< 0.025	0.5
Fluoride	52	0.786	0.330	1.15	15.0
Iron	52			< 0.50	2.0
Lead	52			< 0.09	0.2
Manganese	52			< 0.075	1.0
Mercury	52			< 0.0002	0.0005
Nickel	52			< 0.05	1.0
Silver	52			< 0.0025	0.1
Thallium	52			< 0.002	–
Vanadium	52			< 0.075	–
Zinc	52			< 0.5	1.0
pH	52	NA ^c	6.71	8.00	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 None of the metal results were above analytical detection limits in any of the 52 weekly samples collected. All 52 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

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A time-proportional sampler was used to collect a weekly composite 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, a portion of the sample was removed for fluoride analysis, the sample was acidified, filtered, and analyzed for the inorganic constituents in Table 5.9. The results obtained for 2009 are shown in Table 5.9. 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.

TABLE 5.9

Chemical Constituents in Sawmill Creek, Location 7M ^a , 2009					
Constituent	No. of Samples	Concentration (mg/L)			IEPA Limit
		Average	Minimum	Maximum	
Arsenic	52			< 0.025 ^b	0.36 ^c
Barium	52			< 0.5	5.0
Beryllium	52			< 0.0025	– ^d
Cadmium	52			< 0.0025	0.03
Chromium	52			< 0.05	3.6
Cobalt	52			< 0.25	–
Copper	52			< 0.025	0.041 ^c
Fluoride	52	0.751	0.440	1.06	1.4
Iron	52			< 0.5	1.0
Lead	52			< 0.09	0.3 ^c
Manganese	52			< 0.075	1.0
Mercury	52			< 0.0002	0.0026 ^c
Nickel	52			< 0.05	1.0
Silver	52			< 0.0025	0.005
Thallium	52			< 0.002	–
Vanadium	52			< 0.075	–
Zinc	52			< 0.5	1.0
pH	52	NA ^e	7.16	7.99	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.

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5.5.2. 800 Area Stormwater Sampling

The Postclosure Care Plan²⁴ 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. Three stormwater samples were collected in 2009. There was no runoff during the entire third quarter. The average monitoring results for 2009 are shown in Table 5.10. Comparing these values with other NPDES discharges in 2009 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 2009, but only two samples were obtained. Low levels of six chlorinated organic compounds that are present in the 317 Area soil and groundwater were found in stormwater. The compound found at the highest concentration was carbon tetrachloride at 7 µg/L. The results of this sampling are presented in Table 6.21 in Section 6.4.3, along with the discussion of groundwater sampling in this area.

TABLE 5.10

Outfall Number	Total Dissolved Solids (mg/L)	Total Suspended Solids (mg/L)	pH range
023 (113)	181	4.0	7.57-7.78
114	195	4.0	7.72-7.91

6. GROUNDWATER PROTECTION



6. GROUNDWATER PROTECTION

6. GROUNDWATER PROTECTION

Groundwater is present beneath the Argonne site in several different geologic units. The uppermost unit consists of glacial drift; a mixture of clay, silt, sand, and gravel deposited during past glacial retreat periods. Some regions within the drift contain high proportions of sand and gravel as well as 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 hydrogeology and groundwater protection program is summarized in the *Groundwater Protection Management Program Plan*.²⁵

Groundwater quality is monitored by collecting and analyzing samples from former on-site water supply wells, from a series of groundwater monitoring wells located near facilities that have the potential to impact 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 (GQS), 35 IAC, Subtitle F, Part 620.²⁶ Argonne groundwater is considered Class I (potable resource 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.

An element of this program involves 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 former east-northeast (ENE) 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 Former Potable Water Supply Wells

From the early years of the laboratory, domestic water had been supplied by four potable water supply wells that were drilled approximately 100 m (328 ft) deep into the dolomite bedrock. The well locations are shown in Figure 1.1. These wells have been sampled for many years to monitor for the release of radioactive or chemical contaminants from general 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 the DuPage Water Commission. Wells 1 and 2 are no longer operational. The remaining two wells are maintained as a backup water source in case of a loss of Lake Michigan water. Monitoring of the remaining two wells continued in 2009.

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6.1.1. Former Supply Well Monitoring Program and Results

Samples were collected quarterly at the wellheads of the two active wells. 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 6.1 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 6.2. All radiological results were similar to previous years' results. The first two sets of samples from both wells contained hydrogen-3 above the detection limit of 100 pCi/L. A number of control samples collected early in 2009 were reported to contain concentrations of hydrogen-3 greater than 190 pCi/L; thus, the detection of such low concentrations of hydrogen-3, as seen in these samples, does not necessarily indicate that contamination is occurring. Hydrogen-3 was not found in any of the samples collected during the last two quarters. 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 occasionally 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 aquifer.

TABLE 6.1

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

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TABLE 6.2

Radioactivity in Argonne Former Water Supply Wells, 2009					
Parameter (pCi/L)	Location	Sample Date			
		10-Mar-09	03-Jun-09	12-Aug-09	16-Nov-09
Alpha	Well 3	3.5	1.7	1.9	1.5
	Well 4	6.6	1.8	3.1	4.0
Beta	Well 3	12.4	10.8	9.1	9.5
	Well 4	11.4	9.5	9.4	9.7
Hydrogen-3	Well 3	118	178	< 100	< 100
	Well 4	103	145	< 100	< 100
Strontium-90	Well 3	< 0.25	< 0.25	< 0.25	< 0.25
	Well 4	< 0.25	< 0.25	< 0.25	< 0.25
Uranium-234	Well 3	0.16 ^a	–	–	–
	Well 4	0.18	–	–	–
Uranium-235	Well 3	< 0.01	–	–	–
	Well 4	< 0.01	–	–	–
Uranium-238	Well 3	0.09	–	–	–
	Well 4	0.08	–	–	–

^a Only one sample per year is analyzed for isotopic uranium.

To determine if such a release had occurred, groundwater monitoring in this part of the aquifer was begun. A monitoring well network was established along the eastern end of the site and off-site. The network consists of three wells on Argonne property and seven wells in the Waterfall Glen Forest Preserve. The well locations are shown in Figure 6.1. Well 570091D is located immediately adjacent to the former holding basin.

During 2009, samples were collected quarterly and analyzed for hydrogen-3. Table 6.3 shows the results. All results were less than or close to the detection limits of 100 pCi/L. Many of the first quarter samples, including the control samples, were reported to contain hydrogen-3 somewhat greater than the normal detection limit of 100 pCi/L. Other control samples collected during the first quarter were reported to contain hydrogen-3 up to 196 pCi/L; thus, the detected concentrations during the first quarter may have been only an artifact of the analytical process. In any case, the highest concentration, 194 pCi/L, was far below the drinking water limit of 20,000 pCi/L. The results for 2009 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.

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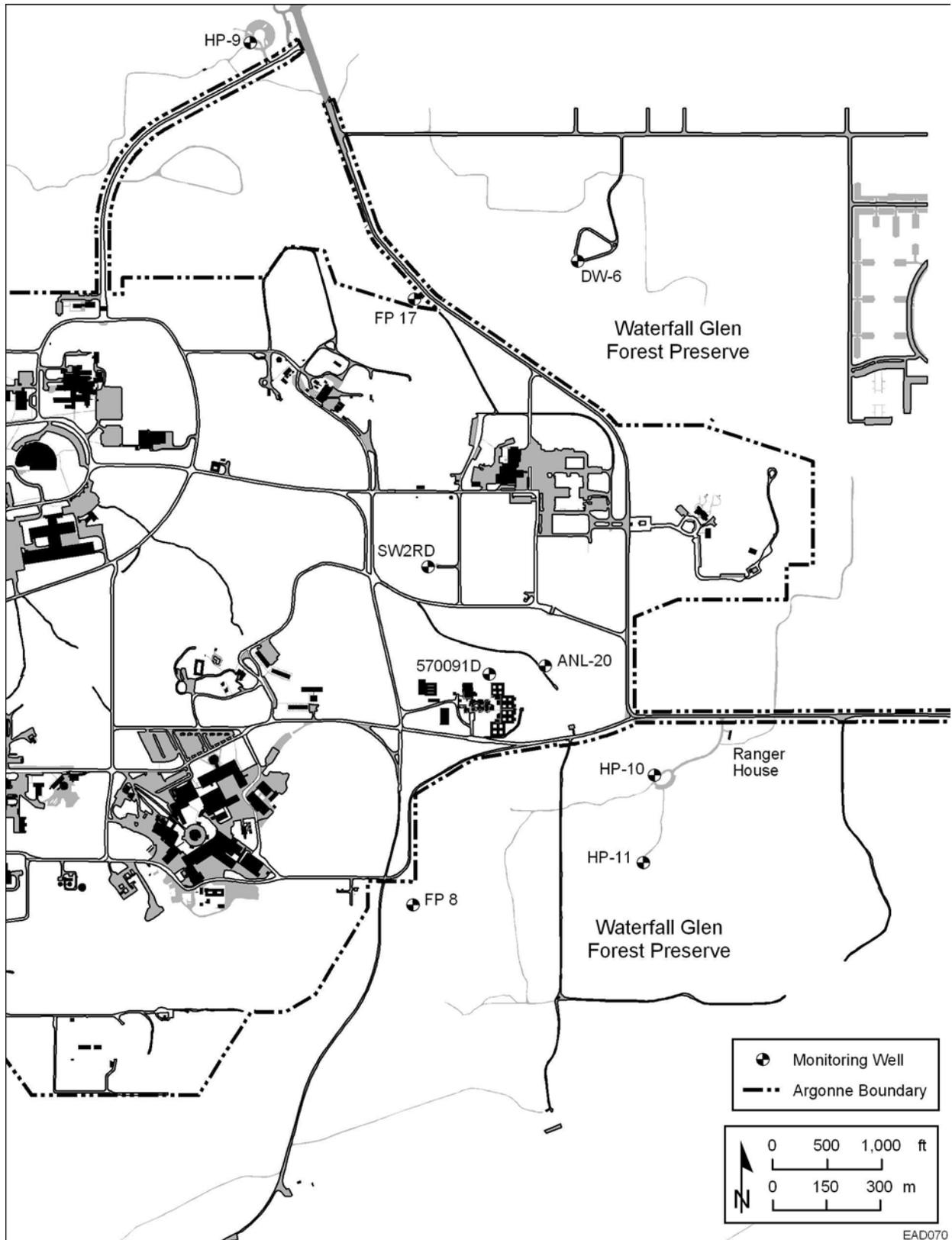


FIGURE 6.1 East Area/Forest Preserve Dolomite Monitoring Wells

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TABLE 6.3

Hydrogen-3 in Dolomite Wells, 2009
(concentrations in pCi/L)

Well	Month Collected			
	Mar.	Jun.	Sep.	Nov.
Waterfall Glen				
DW6	124	< 100	< 100	< 100
HP9	102	< 100	< 100	< 100
HP10	194	104	< 100	111
HP11	144	< 100	< 100	< 100
FP8	153	< 100	< 100	< 100
FP17	101	< 100	< 100	< 100
Ranger house	144	< 100	< 100	< 100
Argonne				
570091D	< 100	< 100	< 100	< 100
ANL-20	< 100	< 100	< 100	< 100
SW2RD	< 100	< 100	< 100	< 100
Control blank	126	< 100	< 100	< 100

6.3. Groundwater Monitoring at Former Waste Management Areas

Over the years of operation of Argonne at this location, various wastes were managed in several on-site disposal units. These ranged from pits and ditches filled with construction and demolition debris used 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 were 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 was conducted under the Argonne remediation program. Most of the sites were closed by the removal of buried waste and contaminated soil, and no further action is required. However, several waste units were closed with waste and contamination still in place requiring further monitoring. One unit, the 317/319 Area, also has ongoing cleanup operations. 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 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 into the environment, monitoring is carried out to assess the effectiveness of the

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remedial actions that are underway, and to monitor for changes in the nature and extent of the contamination. The LTS Program and related groundwater monitoring are integrated with the Argonne Environmental Monitoring 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 is currently empty. Five similar waste storage vaults in this area were cleaned and demolished in place during remedial actions. A small, above-ground 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 nonradioactive 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 were 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 contains significant amounts of these chemicals. General features of the 317 and 319 Areas are shown in Figure 6.2.

The 319 Area contains a closed 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

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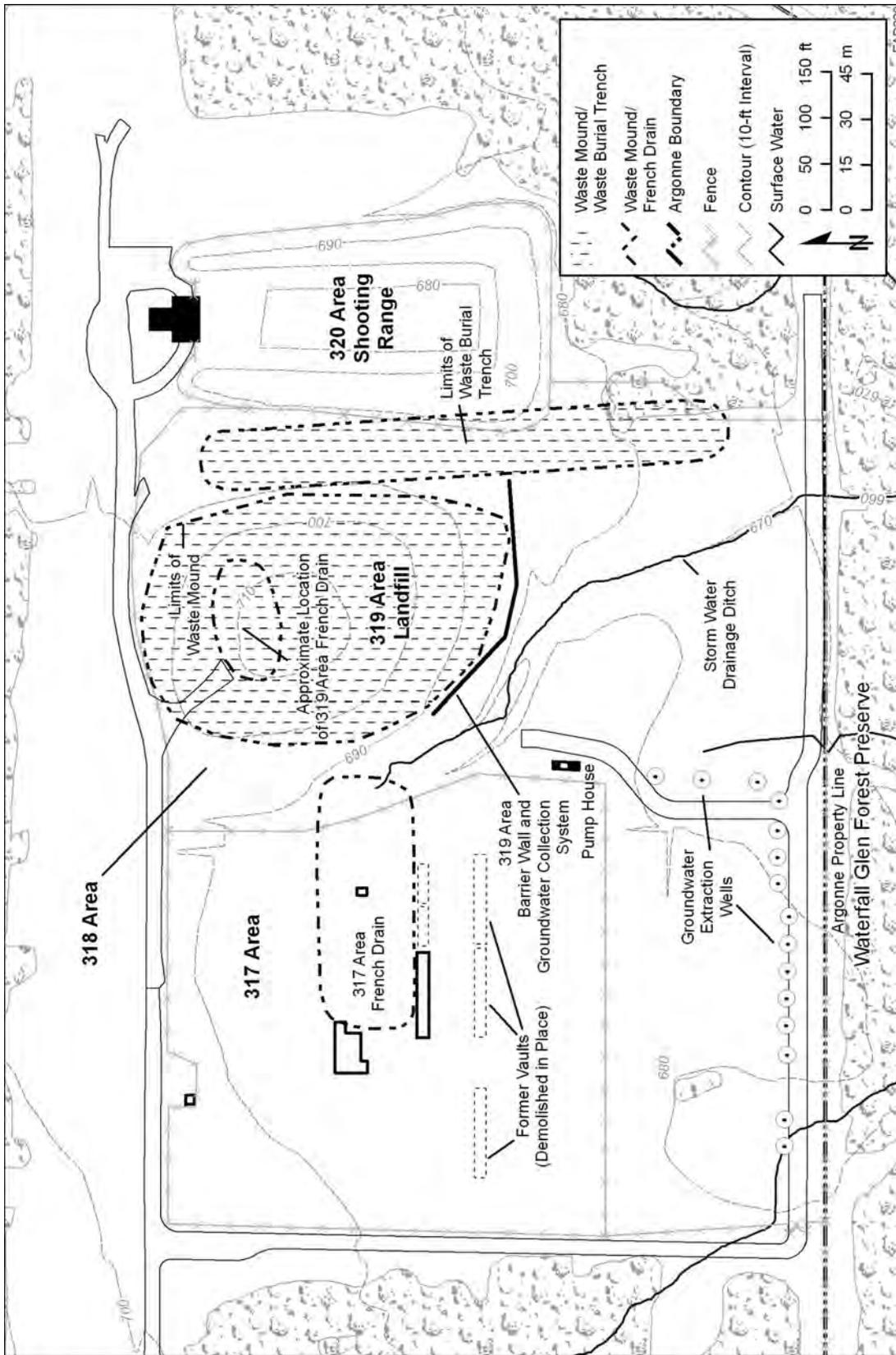


FIGURE 6.2 Locations of Components Within the 317/319/ENE Area

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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.

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 Argonne system consists of a dense planting of willow and other 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 environmental monitoring 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 that were installed starting in 1986. This groundwater surveillance network was established during the early years of the site remediation

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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 6.4. 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 most are not used to monitor the progress of the remediation systems. They are used for general groundwater surveillance for the 317 and 319 Areas as a whole. They are analyzed for a more extensive list of

TABLE 6.4

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.

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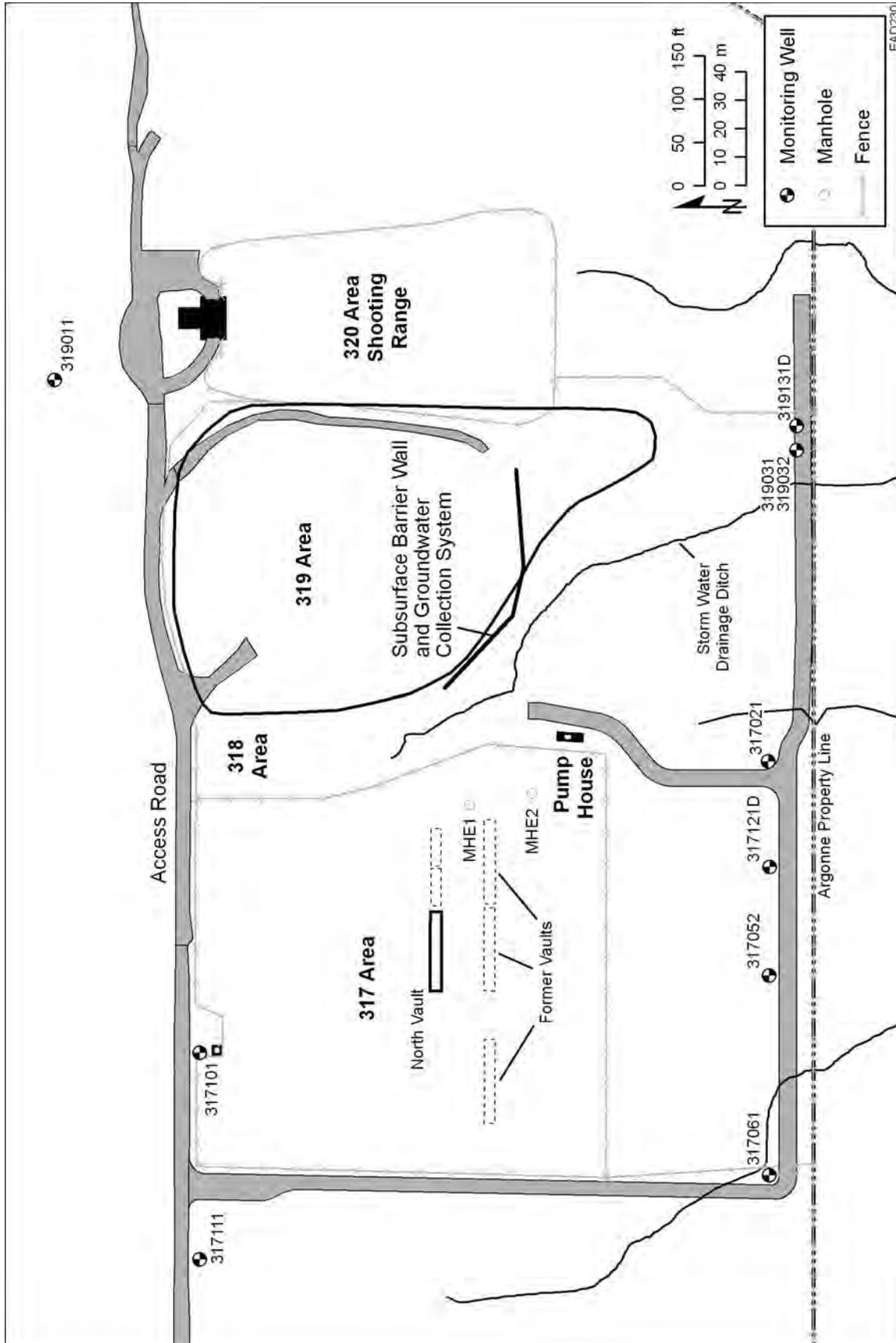


FIGURE 6.3 Groundwater Surveillance Wells in the 317/319 Area

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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 are measured only once. After the well refills, samples are collected using a dedicated Teflon[®] bailer or a dedicated pump. Samples for VOCs, SVOCs, PCBs, 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.

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 control blank is also prepared. The control 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, PCBs, and pesticides. Analyses are conducted using the methods outlined in Tables 5.2 and 6.1.

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 are shown in Table 6.5. When used to officially document compliance with state standards, the standards for metals are to be compared with analysis results from unfiltered groundwater samples. However, for

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TABLE 6.5
Illinois Class I Groundwater Quality Standards

Constituent	Standard	Constituent	Standard	Constituent	Standard
Inorganic parameters (mg/L except pH)					
Antimony	0.006	Copper	0.65	pH	6.5-9.0
Arsenic	0.05	Cyanide	0.2	Selenium	0.05
Barium	2	Fluoride	4	Silver	0.05
Beryllium	0.004	Iron	5	Sulfate	400
Boron	2	Lead	0.0075	TDS	1,200
Cadmium	0.005	Manganese	0.15	Thallium	0.002
Chloride	200	Mercury	0.002	Zinc	5
Chromium	0.1	Nickel	0.1		
Cobalt	1	Nitrate, as N	10		
Organic Parameters (µg/L)					
Alachlor	2	<i>cis</i> -1,2-Dichloroethylene	70	Pentachlorophenol	1
Aldicarb	3	<i>trans</i> -1,2-Dichloroethylene	100	Phenols	100
Atrazine	3	1,2-Dichloropropane	5	Picloram	500
Benzene	5	Di(2-ethylhexyl)phthalate	6	2,4,5-TP (Silvex)	50
Benzo(a)pyrene	0.2	Dinoseb	7	Simazine	4
Carbofuran	40	Endothall	100	Styrene	100
Carbon tetrachloride	5	Endrin	2	Tetrachloroethylene	5
Chlordane	2	Ethylbenzene	700	Toluene	1,000
2,4-D	70	Ethylene dibromide	0.05	Toxaphene	3
Dalapon	200	Heptachlor	0.4	1,1,1-Trichloroethane	200
1,2-Dibromo-3-chloropropane	0.2	Heptachlor epoxide	0.2	1,1,2-Trichloroethane	5
<i>o</i> -Dichlorobenzene	600	Hexachlorocyclopentadiene	50	1,2,4-Trichlorobenzene	70
<i>p</i> -Dichlorobenzene	75	Lindane	0.2	Trichloroethylene	5
1,2-Dichloroethane	5	Methoxychlor	40	Vinyl chloride	2
Dichloromethane	5	Monochlorobenzene	100	Xylenes	10,000
1,1-Dichloroethene	7	PCBs (decachlorobiphenyl)	0.5	Methyl tertiary-butyl ether	70
Radiological parameters (pCi/L)					
Hydrogen-3	20,000	Radium-228	20		
Radium-226	20	Strontium-90	8		

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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. Any results that exceed these standards are shown in bold in the following data tables.

The results of the field parameter measurement and the results of the chemical and radiological analyses of samples from the surveillance wells in the 317/319 Area are contained in Tables 6.6 through 6.15. 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 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 in any samples 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 high end of the acceptable range in three out of the four quarters. This well has a history of high pH, which may be related to the construction materials used to install it. 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 well 317101 they were 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.

Inorganic Parameters. IEPA-approved background values for this area have not 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. Iron and Manganese were found in Well 317052. The manganese concentrations exceeded the GQS for manganese in all four quarters. Many other wells discussed in this chapter exhibit elevated iron and manganese concentrations, indicating that it is naturally present at levels that exceed GQS.

Organic Parameters. Low levels of several VOCs were found in four of the 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. Well 319031 also contained measurable amounts of 4-methyl-2-pentanone and trichloroethene (TCE). 1,4-Dioxane was found in two shallow wells. This is a highly soluble chemical that moves easily in groundwater. Well 317061 contained tetrahydrofuran, and vinyl chloride once during 2009. None of the organics exceeded GQS standards, where such exist. However, 1,4-dioxane levels do exceed the groundwater remediation objectives (GROs) for the 317/319 Area provided to Argonne by the IEPA. All of these VOCs were also present in wells within the remediation areas, often at much higher concentrations. In general, the number of

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TABLE 6.6

Groundwater Monitoring Results, 300 Area Well 317021, 2009

Parameter	Unit	Date of Sampling			
		2/23/2009	5/18/2009	8/6/2009	11/17/2009
Field Parameters					
Conductivity	µS/cm	794	749	696	718
Oxid./Red. Potential	mV	-7	-34	0	-12
pH	pH	7.07	7.39	7.15	7.29
Temperature	° C	9.2	11.0	11.8	10.6
Water elevation ^a	m	197.94	201.76	199.41	198.34
Filtered Samples					
Chloride	mg/L	8	21	25	20
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	230	< 100	< 100	< 100
Strontium-90	pCi/L	< 0.25	0.31	0.31	0.36
VOC's Found above Quantitation Limits^b					
1,1-Dichloroethane ^c	µg/L	< 1	< 1	1	2
1,1,1-Trichloroethane	µg/L	1	< 1	1	1

^a Well point elevation = 194.38 m (MSL); ground surface elevation = 206.51 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.

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TABLE 6.7

Groundwater Monitoring Results, 300 Area Well 317052, 2009

Parameter ^a	Unit	Date of Sampling			
		2/20/2009	5/14/2009	8/4/2009	11/16/2009
Field Parameters					
Conductivity	μS/cm	932	948	946	987
Oxid./Red. Potential	mV	-1	-9	6	11
pH	pH	6.95	6.97	7.03	6.87
Temperature	°C	6.7	9.8	13.8	12.7
Water elevation ^b	m	206.61	206.66	204.77	205.45
Filtered Samples					
Chloride	mg/L	29	26	27	50
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	1.30	1.52	3.01	1.50
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.139	0.130	0.970^c	0.560
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	137	< 100	< 100	130
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 = 204.53 m (MSL); ground surface elevation = 208.18 m (MSL); casing material = PVC.

^c Bold type indicates value exceeded its GQS

6. GROUNDWATER PROTECTION

TABLE 6.8

Groundwater Monitoring Results, 300 Area Well 317061, 2009

Parameter	Unit	Date of Sampling			
		2/18/2009	5/18/2009	8/4/2009	11/4/2009
<i>Field Parameters</i>					
Conductivity	µS/cm	1089	1141	1054	936
Oxid/Red. Potential	mV	-4	-10	5	-5
pH	pH	7.02	6.96	7.04	7.14
Temperature	°C	10.3	11.2	12.5	10.8
Water elevation ^a	m	200.14	202.05	199.73	198.38
<i>Filtered Samples</i>					
Chloride	mg/L	89	130	135	112
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
<i>Radioactive Materials</i>					
Cesium-137	pCi/L	< 2.0	< 2.0	2.1	< 2.0
Hydrogen-3	pCi/L	594	401	357	297
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
<i>VOC's Found above Quantitation Limits^b</i>					
Tetrahydrofuran	µg/L	< 1	< 1	< 1	2
Vinyl Chloride	µg/L	2	< 1	< 1	< 1

^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

6. GROUNDWATER PROTECTION

TABLE 6.9

Groundwater Monitoring Results, 300 Area Well 317101, 2009

Parameter ^a	Unit	Date of Sampling			
		2/19/2009	5/14/2009	8/4/2009	11/9/2009
Field Parameters					
Conductivity	μS/cm	2,210	1,896	1,557	1,690
Oxid./Red. Potential	mV	1	-10	6	3
pH	pH	6.93	6.99	7.05	7.00
Temperature	°C	10.8	12.4	12.8	12.1
Water elevation ^b	m	203.32	205.93	203.83	202.92
Filtered Samples					
Chloride	mg/L	466^c	436	319	504
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	142	< 100	< 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 = 198.66 m (MSL); ground surface elevation = 211.01 m (MSL); casing material = PVC.

^c Bold type indicates that the value exceeds applicable standards.

6. GROUNDWATER PROTECTION

TABLE 6.10

Groundwater Monitoring Results, 300 Area Well 317111, 2009

Parameter ^a	Unit	Date of Sampling			
		2/18/2009	5/18/2009	8/4/2009	11/4/2009
Field Parameters					
Conductivity	μS/cm	1,177	1,115	925	923
Oxid./Red. Potential	mV	-3	-15	2	-4
pH	pH	7.01	7.04	7.12	7.11
Temperature	°C	10.1	10.7	12.6	11.0
Water elevation ^b	m	203.59	206.85	204.23	203.09
Filtered Samples					
Chloride	mg/L	137	146	111	138
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	2.9	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	< 100	< 100	< 100	114
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.

6. GROUNDWATER PROTECTION

TABLE 6.11

Groundwater Monitoring Results, 300 Area Well 317121D, 2009

Parameter	Unit	Date of Sampling			
		2/24/2009	5/20/2009	8/6/2009	11/12/2009
Field Parameters					
Conductivity	µS/cm	539	746	785	470
Oxid./Red. potential	mV	-173	-254	-15	-179
pH	pH	10.06^b	11.28	7.42	10.31
Temperature	°C	10.0	12.4	13.5	11.6
Water elevation ^a	m	186.51	186.85	186.60	186.56
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
VOC's Found above Quantitation Limits^c					
1,4-Dioxane ^d	µg/L	< 1	11	11	< 1

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

^b Bold type indicates that the value exceeds applicable standards.

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

^d No GQS standard exists for 1,4-Dioxane.

6. GROUNDWATER PROTECTION

TABLE 6.12

Groundwater Monitoring Results, 300 Area Well 319011, 2009

Parameter ^a	Unit	Date of Sampling			
		2/20/2009	5/19/2009	8/5/2009	11/12/2009
Field Parameters					
Conductivity	µS/cm	903	933	876	793
Oxid./Red. Potential	mV	-11	-26	4	-11
pH	pH	7.17	7.27	7.07	7.26
Temperature	°C	9.9	11.2	12.2	11.3
Water elevation ^b	m	202.90	205.97	203.47	202.67
Filtered Samples					
Chloride	mg/L	43	17	36	35
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	151	< 100	< 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.

6. GROUNDWATER PROTECTION

TABLE 6.13

Groundwater Monitoring Results, 300 Area Well 319031, 2009

Parameter	Unit	Date of Sampling			
		2/23/2009	5/19/2009	8/5/2009	11/11/2009
Field Parameters					
Conductivity	µS/cm	867	854	836	Dry
Oxid./Red. Potential	mV	-8	-12	-3	Dry
pH	pH	7.09	7.01	7.22	Dry
Temperature	°C	8.8	10.6	12.5	Dry
Water elevation ^a	m	193.15	193.21	193.14	Dry
Filtered Samples					
Chloride	mg/L	19	47	18	Dry
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	Dry
Barium	mg/L	< 0.5	< 0.5	< 0.5	Dry
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	Dry
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	Dry
Chromium	mg/L	< 0.05	< 0.05	< 0.05	Dry
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	Dry
Copper	mg/L	< 0.025	< 0.025	< 0.025	Dry
Iron	mg/L	< 0.5	< 0.5	< 0.5	Dry
Lead	mg/L	< 0.004	< 0.004	< 0.004	Dry
Manganese	mg/L	< 0.075	< 0.075	< 0.075	Dry
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	Dry
Nickel	mg/L	< 0.05	< 0.05	< 0.05	Dry
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	Dry
Thallium	mg/L	< 0.002	< 0.002	< 0.002	Dry
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	Dry
Zinc	mg/L	< 0.5	< 0.5	< 0.5	Dry
Radioactive Materials					
Cesium-137	pCi/L	< 2.0	2.9	2.6	Dry
Hydrogen-3	pCi/L	437	211	218	Dry
Strontium-90	pCi/L	< 0.25	0.26	0.25	Dry
VOCs Found above Quantitation Limits^b					
1,1,1-Trichloroethane	µg/L	3	2	2	Dry
1,4-Dioxane ^c	µg/L	42	9	14	Dry
4-Methyl-2-pentanone ^c	µg/L	< 1	< 1	3	Dry
Trichloroethene	µg/L	3	2	2	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 or 4-methyl-2-pentanone.

6. GROUNDWATER PROTECTION

TABLE 6.14

Groundwater Monitoring Results, 300 Area Well 319032, 2009

Parameter	Unit	Date of Sampling			
		2/23/2009	5/19/2009	8/5/2009	11/9/2009
Field Parameters					
Conductivity	µS/cm	905	957	901	851
Oxid./Red. Potential	mV	-2	-12	5	1
pH	pH	7.00	7.00	7.06	7.02
Temperature	°C	9.4	10.0	10.5	11.1
Water elevation ^a	m	198.76	199.66	198.42	197.98
Filtered Samples					
Chloride	mg/L	8	15	9	11
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	2.9	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	163	255	107	133
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
VOCs Found above Quantitation Limits^b					
1,1,1-Trichloroethane	µg/L	1	2	2	1
1,4-Dioxane ^c	µg/L	48	27	22	23

^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.

6. GROUNDWATER PROTECTION

TABLE 6.15

Groundwater Monitoring Results, 300 Area Well 319131D, 2009

Parameter ^a	Unit	Date of Sampling			
		2/24/2009	5/20/2009	8/6/2009	11/11/2009
<i>Field Parameters</i>					
Conductivity	μS/cm	936	925	901	885
Oxid./Red. Potential	mV	-11	-18	5	-6
pH	pH	7.14	7.11	7.08	7.18
Temperature	°C	10.1	11.9	12.4	11.1
Water elevation ^b	m	185.09	185.53	184.92	184.86
<i>Filtered Samples</i>					
Chloride	mg/L	55	55	60	62
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
<i>Radioactive Materials</i>					
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	480	461	853	417
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.

6. GROUNDWATER PROTECTION

compounds detected and concentrations were comparable to or lower than the previous years' results.

The only VOC found above detection levels in the two dolomite wells was 1,4-dioxane at levels that 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 was found in any of the wells during 2009.

Figure 6.4 shows the TCA and DCA concentrations in Well 317021 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.

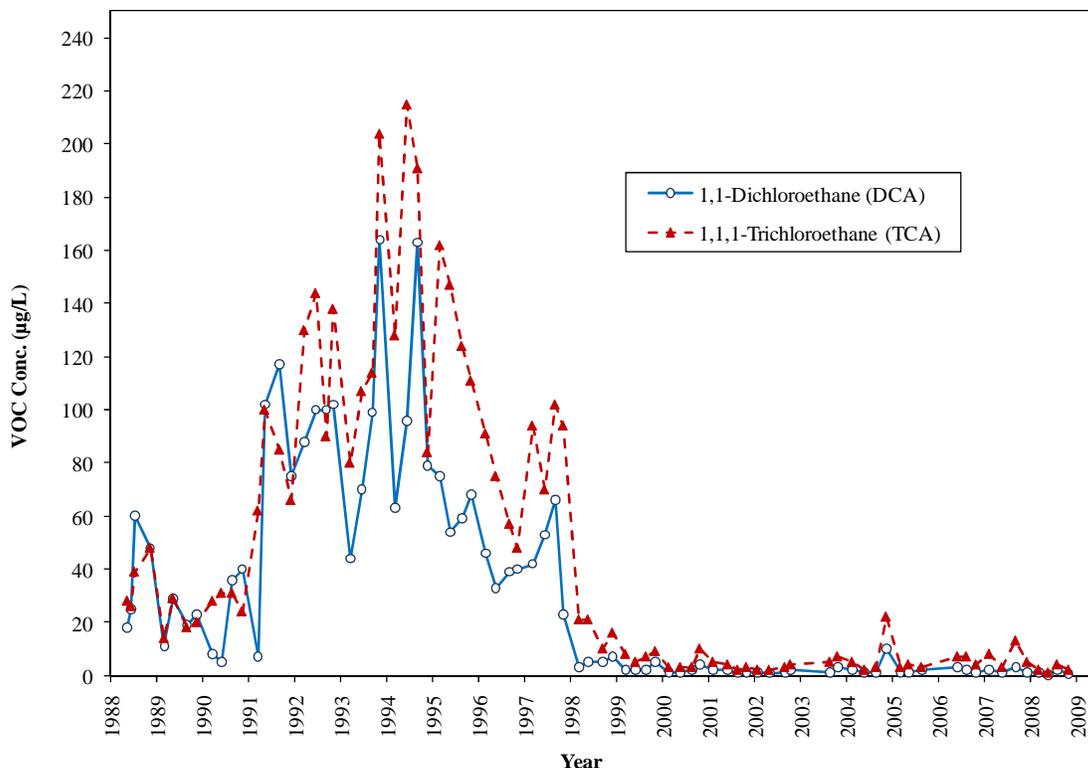


FIGURE 6.4 Concentrations of 1,1-Dichloroethane and 1,1,1-Trichloroethane in Well 317021

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While the degree of contamination in these wells is limited, it should be noted that within the remediation areas, levels of contamination are orders of magnitude higher than those described above (see Table 6.18). Many results are well in excess of GQs.

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. Cesium-137 was reported in six of the wells at levels less than two times the detection limit of 2.0 pCi/L. These detections are thought to be an anomaly related to the analytical process in the laboratory. None of these wells has exhibited cesium-137 above detection limits prior to 2008 when similar levels were reported. Strontium-90 was found in several samples from two wells; wells 317021 and 319031. The reported values were less than two times the analytical detection limits.

Hydrogen-3 was found in one sample from each of the three background wells at concentrations less than two times the detection limits. Hydrogen-3 was found at very low concentrations in many of the samples from all of the downgradient wells, including the two dolomite wells. The highest concentration was 853 pCi/L in dolomite well 319131D located south of the 319 Area. All levels were well below the drinking water standard of 20,000 pCi/L.

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 shows the annual

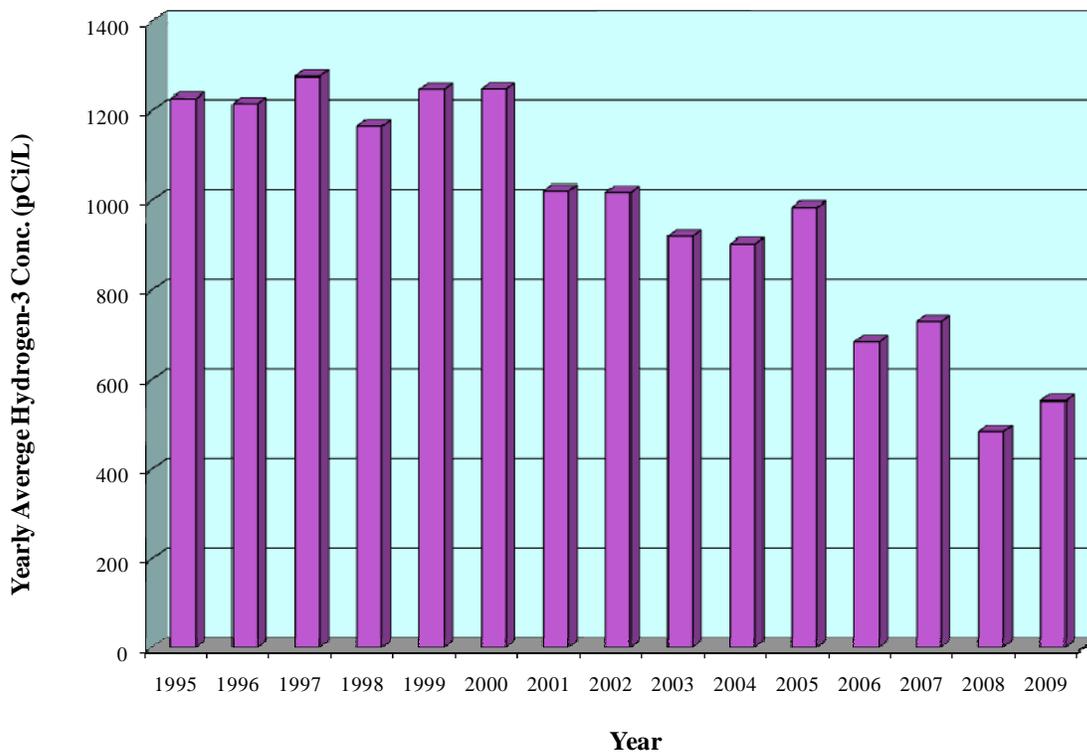


FIGURE 6.5 Hydrogen-3 in Dolomite Well 319131D

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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 the 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. This system conveys contaminated groundwater from interior drains in the North Vault and footing drains around 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 as well as contaminants discharged to the LWTP.

No record of the total volume of water pumped from Manhole E2 is maintained; however, contributions of groundwater into Manhole E2 during 2009 included an average of 2,200 L/day (578 gal/day) from the 319 Area groundwater collection system, and an average of 9,500 L/day (2,500 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 the summer and fall of 2009, groundwater was pumped from four of the highly contaminated wells in the 317 French Drain Area (317321, 317322, 317331, and 317332) into Manhole E1 to accelerate the remediation of this area. The groundwater in these wells has levels of VOCs much higher than the levels found in other nearby wells. Simple, low-cost, solar-powered pumps were used. This action resulted in the removal of 3 kg (7 lbs) of solvent in 2009. The result of this activity is that the VOC concentrations observed in the summer of 2009 were much higher than those of previous years, and are not 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 6.16 and 6.17. The results for both manholes during the summer and fall months of 2009 were much higher than the comparable months of 2008 and the number of compounds detected was higher. The remaining 2009 samples were similar to previous samples. It is thought that these samples were strongly influenced by groundwater pumped from the four groundwater monitoring wells. Figure 6.6 is a plot of total

TABLE 6.16

Volatile Organic Compounds and Radionuclides in the 317 Area: Manhole E1, 2009

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
VOCs ($\mu\text{g/L}$)												
1,1-Dichloroethane	< 1 ^a	2	2	1	2	25	2540	1660	908	119	650	17
1,1-Dichloroethene	< 1	< 1	< 1	< 1	< 1	< 1	225	39	7	5	14	< 1
1,1,1-Trichloroethane	1	2	2	1	1	1	4528	1973	350	< 1	317	10
1,1,2-Trichloroethane	< 1	< 1	< 1	< 1	< 1	1	5	2	2	< 1	3	< 1
1,1,2,2-Tetrachloroethane	< 1	< 1	< 1	< 1	< 1	1	4	2	2	< 1	5	< 1
1,2-Dichloroethane	< 1	< 1	< 1	< 1	< 1	6	275	96	43	8	39	< 1
1,2,4-Trimethylbenzene	< 1	< 1	< 1	< 1	< 1	< 1	3	< 1	< 1	< 1	< 1	< 1
1,3,5-Trimethylbenzene	< 1	< 1	< 1	< 1	< 1	< 1	2	< 1	< 1	< 1	< 1	< 1
1,4-Dioxane	23	37	45	18	46	496	1609	445	418	56	416	35
2-Butanone	ND ^b	ND	ND	ND	1	17	24	9	8	ND	12	ND
2-Methyl-1-Propanol	ND	ND	ND	ND	ND	ND	ND	ND	590	ND	569	ND
2-Propanol	ND	ND	ND	ND	ND	ND	ND	ND	126	ND	ND	ND
4-Methyl-2-Pentanol	ND	ND	ND	ND	28	953	3181	1173	1457	16	842	ND
4-Methyl-2-Pentanone	ND	ND	ND	ND	113	2126	1760	656	773	133	1249	ND
Acetone	ND	ND	ND	ND	21	326	477	166	150	13	253	ND
Benzene	< 1	< 1	< 1	< 1	9	124	241	74	78	19	174	1
Bromodichloromethane	< 1	< 1	< 1	< 1	< 1	< 1	2	< 1	< 1	< 1	2	< 1
Carbon Disulfide	ND	ND	ND	ND	ND	ND	11	ND	3	ND	ND	ND
Carbon Tetrachloride	80	< 1	< 1	< 1	< 1	< 1	8389	1996	1385	< 1	3829	132
Chlorobenzene	< 1	< 1	< 1	< 1	< 1	< 1	1	< 1	< 1	< 1	1	< 1
Chloroethane	< 5	< 5	< 5	< 5	< 5	< 5	296	113	88	6	61	< 5
Chloroform	214	< 1	< 1	< 1	< 1	< 1	3650	1392	1094	< 1	1789	327
cis-1,2-Dichloroethene	8	20	21	19	20	150	3065	1036	703	91	612	39
Decane	ND	ND	ND	ND	ND	ND	7	ND	ND	ND	ND	ND
Dichlorofluoromethane	0.6	2	3	1	1	3	7	3	2	0.9	3	< 1
Ethanol	ND	ND	ND	ND	ND	2987	2986	915	1008	79	1415	ND
Ethyl benzene	< 1	< 1	< 1	< 1	< 1	< 1	2	< 1	< 1	< 1	1	< 1

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TABLE 6.16 (Continued)

Volatile Organic Compounds and Radionuclides in the 317 Area: Manhole E1, 2009

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Ethyl Ether	0.7	1	2	1	1	14	15	7	8	1	14	1
Methylene Chloride	<1	<1	4	<1	<1	36	134	56	63	9	69	<1
m-Xylene	<1	<1	<1	<1	<1	<1	3	<1	<1	<1	1	<1
Naphthalene	<1	<1	<1	<1	<1	<1	3	<1	<1	<1	1	<1
n-Butyl Ether	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	12	<1
Nitrobenzene	ND	ND	ND	ND	39	3285	470	197	148	ND	365	ND
Nitrosobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	7	ND
n-Propylbenzene	<1	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1
o-Xylene	<1	<1	<1	<1	<1	<1	4	<1	<1	<1	2	<1
p-Xylene	<1	<1	<1	<1	<1	<1	3	<1	<1	<1	1	<1
Tetrachloroethene	8	16	20	25	27	22	105	28	39	19	59	18
Toluene	<1	<1	<1	<1	<1	7	37	5	5	1	24	<1
trans-1,2-Dichloroethene	<1	2	2	2	1	3	72	24	11	4	13	2
Trichloroethene	39	106	133	<1	158	<1	2375	319	307	153	794	105
Trichlorofluoromethane	<1	<1	<1	<1	2	24	40	10	9	2	31	<1
Undecane	ND	ND	ND	ND	ND	ND	7	ND	ND	ND	ND	ND
Vinyl Chloride	<2	<2	<2	<2	<2	9	143	55	44	5	37	2
Radionuclides (pCi/L)												
Cesium-137	6.8	<2	2.2	<2	3.0	2.0	<2	2.9	2.4	<2	<2	<2
Hydrogen-3	6791	628	592	434	445	527	502	1051	1598	463	676	531

^a The < sign means this compound was not measured above the detection limit.

^b ND means the compound was not detected in the sample. Detection limits are not determined for this compound.

TABLE 6.17

Volatile Organic Compounds and Radionuclides in the 317 Area: Manhole E2, 2009

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
VOCs ($\mu\text{g/L}$)												
1,1-Dichloroethane	2	21	4	1	5	42	762	91	57	127	271	16
1,1-Dichloroethene	<1 ^a	<1	<1	<1	<1	<1	54	2	<1	5	5	<1
1,1,1-Trichloroethane	1	16	<1	<1	<1	<1	<1	94	33	<1	154	10
1,1,2-Trichloroethane	<1	<1	<1	<1	<1	<1	2	<1	<1	<1	1	<1
1,1,2,2-Tetrachloroethane	<1	<1	<1	<1	<1	<1	2	<1	<1	<1	2	<1
1,2-Dichloroethane	<1	<1	1	<1	1	4	109	8	3	8	18	<1
1,2,4-Trimethylbenzene	<1	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1
1,4-Dioxane	32	14	13	<1	<1	16	436	51	44	58	246	25
2-Butanone	ND ^b	ND	ND	ND	ND	ND	11	ND	ND	ND	6	ND
2-Methyl-1 Propanol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	144	ND
4-Methyl-2-Pentanol	ND	ND	ND	ND	ND	ND	819	13	ND	15	371	ND
4-Methyl-2Pentanone	ND	ND	ND	ND	ND	18	615	4	0.4	85	511	ND
Acetone	ND	ND	ND	ND	ND	ND	193	ND	ND	16	152	ND
Benzene	<1	<1	<1	<1	<1	1	143	1	<1	22	90	<1
Carbon Disulfide	ND	ND	ND	ND	ND	ND	5	ND	ND	ND	ND	ND
Carbon Tetrachloride	<1	51	75	169	63	76	3293	100	90	<1	2297	583
Chloroethane	<5	<5	<5	<5	<5	<5	115	6	<5	7	23	<5
Chloroform	<1	50	67	150	56	55	1973	116	88	<1	1045	366
cis-1,2-Dichloroethene	17	4	4	5	3	5	1356	62	42	95	269	37
Dichlorofluoromethane	<1	<1	<1	<1	<1	<1	3	<1	<1	<1	1	<1
Ethanol	ND	ND	ND	ND	ND	ND	1175	ND	ND	86	82	ND
Ethyl Ether	<1	<1	<1	<1	<1	<1	7	<1	<1	1	7	<1
Methylene Chloride	<1	<1	<1	<1	<1	<1	57	7	3	8	30	<1
m-Xylene	<1	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1
n-Butyl Ether	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	5	<1

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TABLE 6.17 (Continued)

Volatile Organic Compounds and Radionuclides in the 317 Area: Manhole E2, 2009

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Nitrobenzene	ND	ND	ND	ND	ND	ND	125	ND	ND	ND	133	ND
Nitrosobenzene	ND	6	ND									
o-Xylene	<1	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1
p-Xylene	<1	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1
Tetrachloroethene	92	10	13	23	13	12	150	10	11	43	55	122
Toluene	<1	<1	<1	<1	<1	<1	14	<1	<1	2	9	<1
trans-1,2-Dichloroethene	<1	<1	<1	<1	<1	<1	28	2	<1	3	5	2
Trichloroethene	59	12	14	49	9	12	795	36	26	153	387	96
Trichlorofluoromethane	<1	<1	<1	<1	<1	<1	16	<1	<1	3	14	<1
Vinyl Chloride	<2	<2	<2	<2	<2	<2	57	2	<2	5	14	2
Radionuclides (pCi/L)												
Cesium-137	4	3	<2	<2	<2	<2	2	<2	<2	<2	<2	<2
Hydrogen-3	1863	608	928	282	1174	972	648	4371	5747	411	4427	604

^a The < sign means this compound was not measured above the detection limit.

^b ND means the compound was not detected in the sample.

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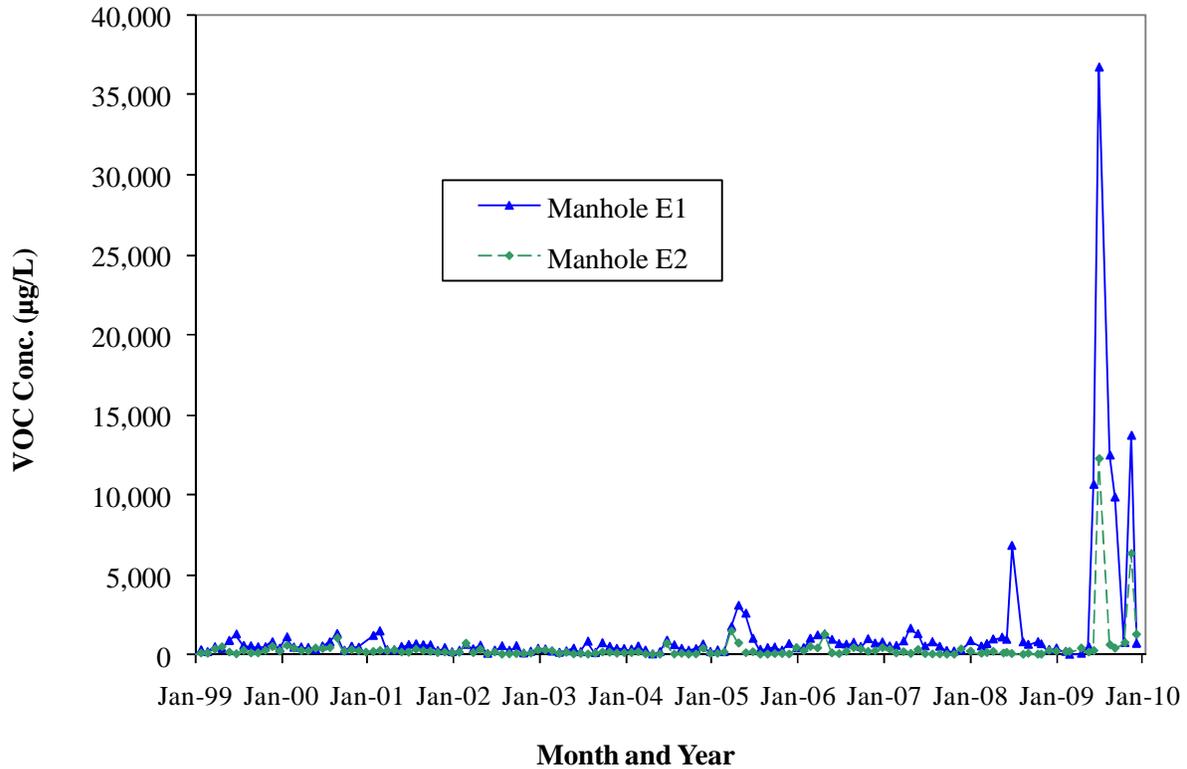


FIGURE 6.6 Total VOCs in Manholes E1 and E2

VOC concentrations (sum of all VOCs detected) since 1999. The effects of the summer pumping can be seen on this chart as a large spike on the graph that overwhelms all previous results.

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.

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 a similar vertical scale to highlight the difference in concentration. For these figures, the unusually high VOC concentrations in the summer and fall of 2009 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 four years, VOC concentrations have slowly decreased and are moving toward levels found before 2005. The VOC concentrations in Manhole E2 have varied considerably in the last few years, probably due to the introduction of the additional flows into Manhole E2 since 1997.

In addition to VOCs, the manhole water is analyzed for hydrogen-3 and gamma-ray-emitting radionuclides. Tables 6.16 and 6.17 show the results from this analysis. Hydrogen-3

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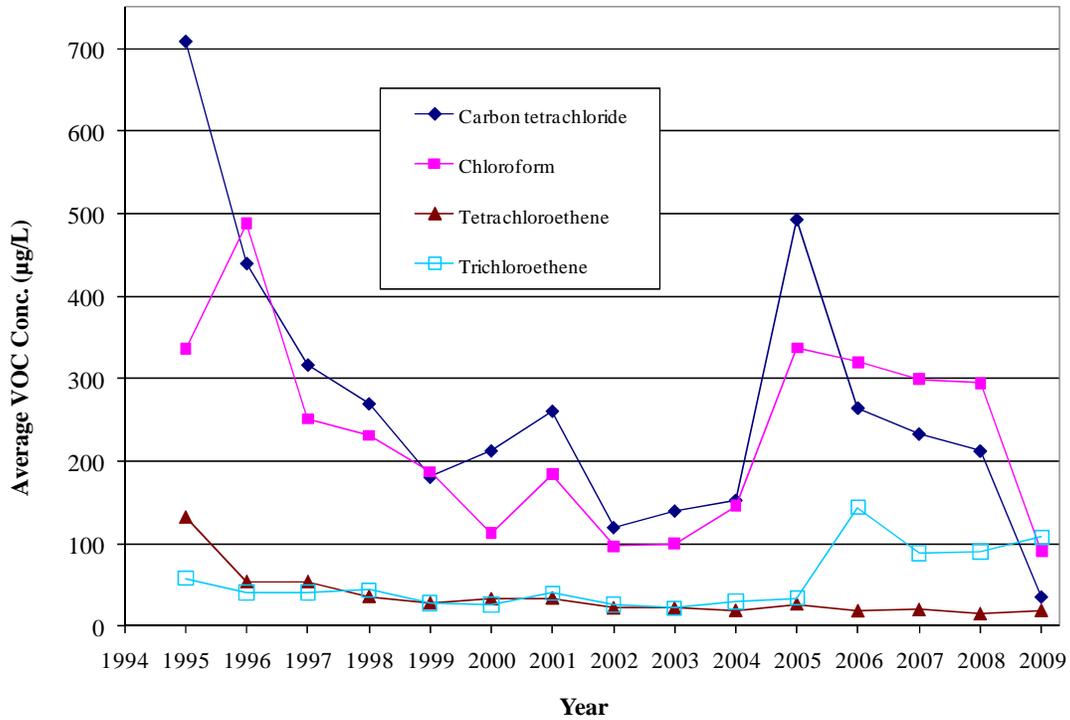


FIGURE 6.7 Select VOCs in Manhole E1

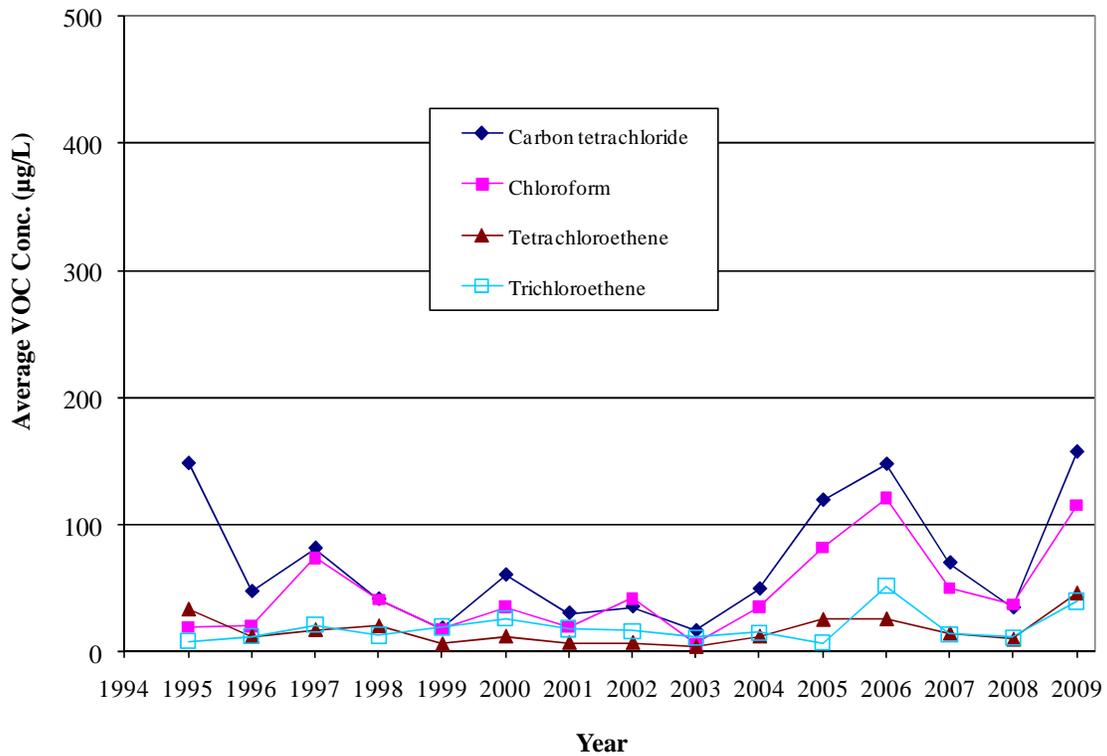


FIGURE 6.8 Select VOCs in Manhole E2

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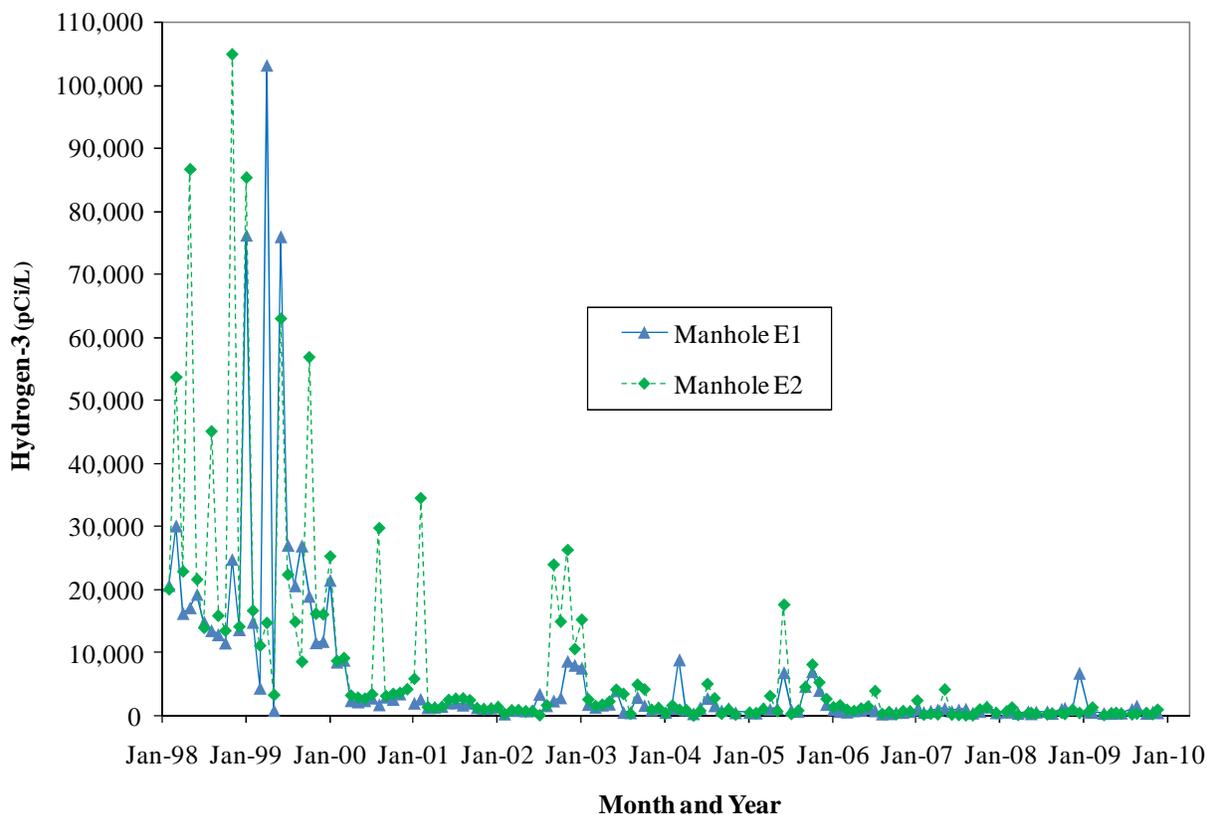


FIGURE 6.9 Hydrogen-3 in the 317 Manholes

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. 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 at concentrations slightly above the detection limit of 2 pCi/L. Cesium-137 had never been found above the detection limit prior to 2008, so these isolated detections are thought to be an artifact of the laboratory's analytical process.

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

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basis and analyzed for VOCs and hydrogen-3 by using methods discussed in Table 5.2. 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 2009 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 6.18 shows the average and maximum VOC concentrations from the 2009 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 6.18 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.

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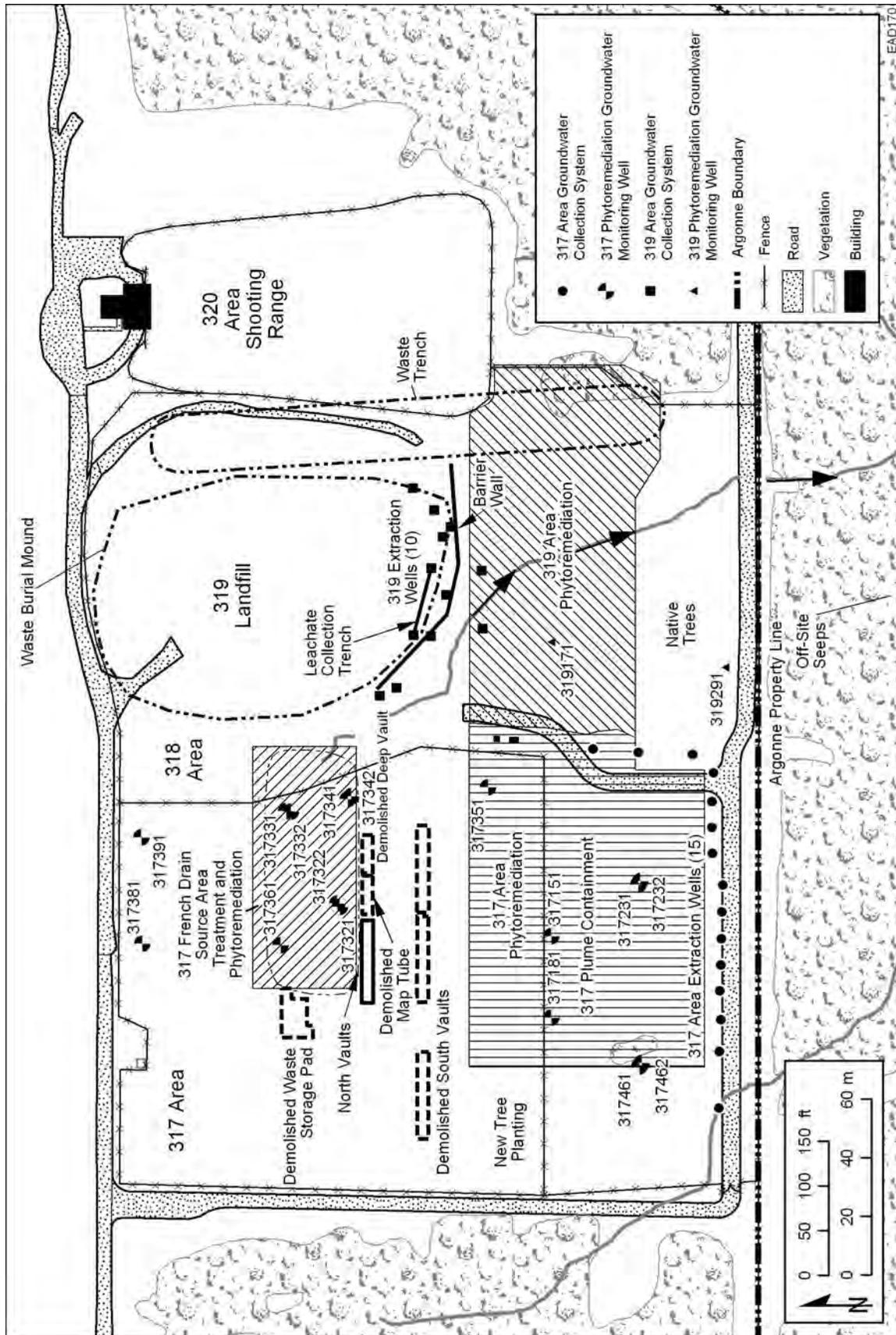


FIGURE 6.10 Phytoremediation Monitoring Wells

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TABLE 6.18

Annual Average and Maximum Concentrations of French Drain Well Water Constituents, 2009

Parameter	Well No.								TACO ^a Remediation Objective
	317321		317322		317331		317332		
	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	
VOC (µg/L)									
1,1,1-Trichloroethane	< 1	< 1	1339^b	1665	77214	112000	17460	54400	200
1,1,2-Trichloroethane	< 1	< 1	- ^c	34	< 1	< 1	< 1	< 1	5
1,1,2,2-Tetrachloroethane	< 1	< 1	-	55	< 1	< 1	< 1	< 1	420
1,1-Dichloroethane	< 1	< 1	7336	12600	8895	13900	4213	7180	700
1,1-Dichloroethene	< 1	< 1	46	53	2530	4136	410	1510	7
1,2-Dichloroethane	< 1	< 1	144	201	2161	3670	495	1550	5
1,2,4-Trimethylbenzene	< 1	< 1	-	56	< 1	< 1	< 1	< 1	NA
1,4-Dioxane	< 1	< 1	7043	12800	2306	3710	2490	6880	1
2-Butanone	< 1	< 1	423	423	< 1	< 1	< 1	< 1	NA ^d
4-Methyl-2-pentanol	8260	16376	7938	22400	< 1	< 1	< 1	< 1	NA
4-Methyl-2-pentanone	67134	105365	21263	87000	575	945	-	161	NA
Acetone	< 1	< 1	5200	6470	< 1	< 1	< 1	< 1	6300
Benzene	12282	20388	1895	7660	283	500	66	172	5
Bromodichloromethane	< 1	< 1	-	30	< 1	< 1	< 1	< 1	0.2
Carbon tetrachloride	271079	504905	31708	152000	370	370	79	93	5
Chloroethane	< 5	< 5	961	1940	85	99	-	29	2800
Chloroform	79707	129116	14492	61200	546	789	84	312	0.2
cis-1,2-Dichloroethene	1082	1760	8567	16900	13469	24100	2494	3880	70
Dichlorodifluoromethane	< 1	< 1	< 1	< 1	< 1	< 1	-	25	1400
Dichlorofluoromethane	< 1	< 1	135	135	< 1	< 1	-	14	NA
Ethanol	78954	123000	105000	105000	< 1	< 1	< 1	< 1	NA
Ethyl benzene	< 1	< 1	-	35	< 1	< 1	< 1	< 1	700
Ethyl ether	699	937	250	424	< 1	< 1	< 1	< 1	1400
Methylene chloride	776	776	1041	1970	< 1	< 1	< 1	< 1	5
Naphthalene	< 1	< 1	-	27	< 1	< 1	< 1	< 1	140
Nitrobenzene	13507	48100	94100	94100	< 1	< 1	< 1	< 1	3.5
Tetrachloroethene	1055	1420	857	1209	< 1	< 1	< 1	< 1	5
Toluene	873	1613	146	502	< 1	< 1	< 1	< 1	1000
trans-1,2-Dichloroethene	< 1	< 1	112	147	814	1410	182	426	100
Trichloroethene	26261	45137	3709	16900	23336	36600	3141	13200	5
Trichlorofluoromethane	1675	3017	307	1280	< 1	63	< 1	< 1	2100
Vinyl chloride	< 2	< 2	1067	1970	198	307	54	139	2
m-Xylene	< 1	< 1	-	44	< 1	< 1	< 1	< 1	10 ^e
o-Xylene	< 1	< 1	-	43	< 1	< 1	< 1	< 1	10 ^c
p-Xylene	< 1	< 1	-	44	< 1	< 1	< 1	< 1	10 ^c
Radioactivity (pCi/L)									
Hydrogen-3	870	994	653	968	189	210	168	280	20000

^a TACO = Tiered Approach to Cleanup Objectives.

^b Bold type indicates that the value exceeds applicable standards.

^c When a compound was detected only once during 2009 the result is listed in the Max. column.

^d NA indicates no standard exists for this compound.

^e The TACO standard for xylene is for total xylenes.

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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 6.19 contains results for detected VOCs in 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. Wells 317492 and 317811 are 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, shown in bold, are present above applicable standards. The concentrations of these compounds near the fence line have been stable or decreasing in recent years. In the fence-line wells, only chloroform, 1,4-dioxane, and trichloroethene currently exceed the limits. Apparently, the highly contaminated groundwater in the French drain area is not migrating downgradient; although significant residual contamination is still present.

Figure 6.11 shows the long-term trend in average total 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.

TABLE 6.19

Annual Average and Maximum Concentrations of Downgradient French Drain
Well Water Constituents, 2009

Parameter	Well No.								Remediation Objective
	Wells midway to fence				Wells near fence line				
	317151		317351		317492		317811		
	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	
VOC ($\mu\text{g/L}$)									
1,1,1-Trichloroethane	956^a	1170	< 1	< 1	21	34	76	197	200
1,1-Dichloroethane	232	301	< 1	< 1	17	26	61	157	700
1,1-Dichloroethene	20	25	< 1	< 1	0.5	0.6	1.5	2.0	7
1,2-Dichloroethane	15	17	< 1	< 1	< 1	< 1	-	1.0	5
1,4-Dioxane	< 1	< 1	< 1	< 1	< 1	< 1	-	22	1
Carbon tetrachloride	< 1	< 1	138	188	0.6	1.0	1.7	3.0	5
Chloroform	< 1	< 1	154	271	0.4	0.6	1.4	3.0	0.2
cis-1,2-Dichloroethene	13	15	21	26	0.3	0.3	1.8	4.0	70
Tetrachloroethene	49	59	220	270	0.2	0.2	2.7	5.0	5
Trichloroethene	259	279	6	7	3.3	5.0	15	32	5
Radioactivity (pCi/L)									
Hydrogen-3	189	263	323	422	159	211	134	240	20,000

^a Bold type indicates that the value exceeds applicable standards.

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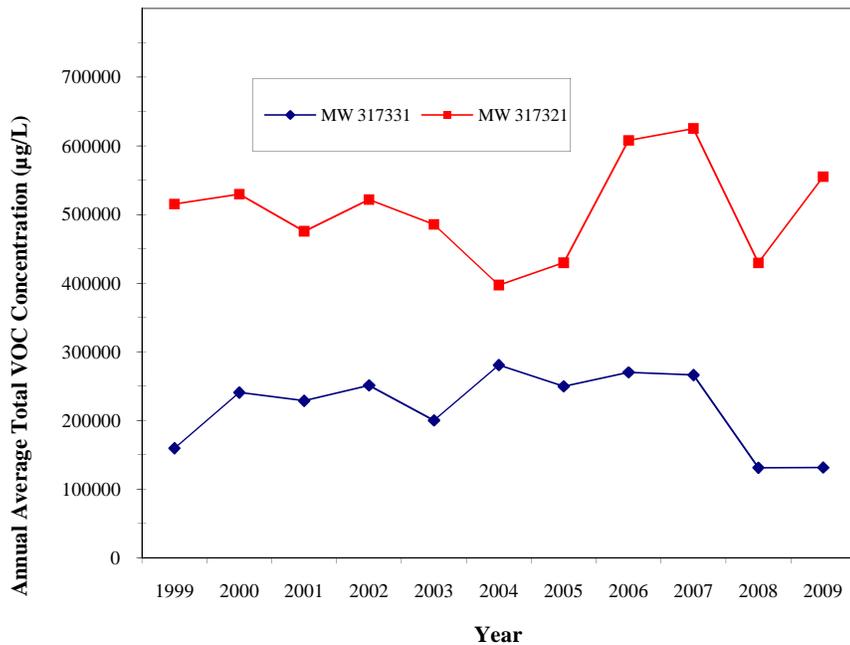


FIGURE 6.11 Annual Average Total VOC Concentrations in 317 Area French Drain Wells

Figure 6.12 is a map showing the approximate location of the region of contaminated groundwater within the contaminated aquifer based on the 2009 data. The core of the plume extends from the French drain area to the southwest. The edge of the plume extends a small distance off-site into Waterfall Glen Forest Preserve, though the extent of the plume off-site is poorly understood since there are a limited number of monitoring wells in this area. Compared with similar plume maps prepared for the 2007 and 2008 SERs, 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 previous years. The most highly contaminated parts of the plume have not changed their locations in recent years, though the concentration of individual contaminants within this part of the plume have varied significantly from sample to sample.

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 2009 indicated that each tree, on average, removes 163 to 253 L/day (43 to 67 gal/day) of contaminated groundwater during the growing season. Long-term monitoring of this system will determine its effectiveness at achieving the remediation objectives for this area.

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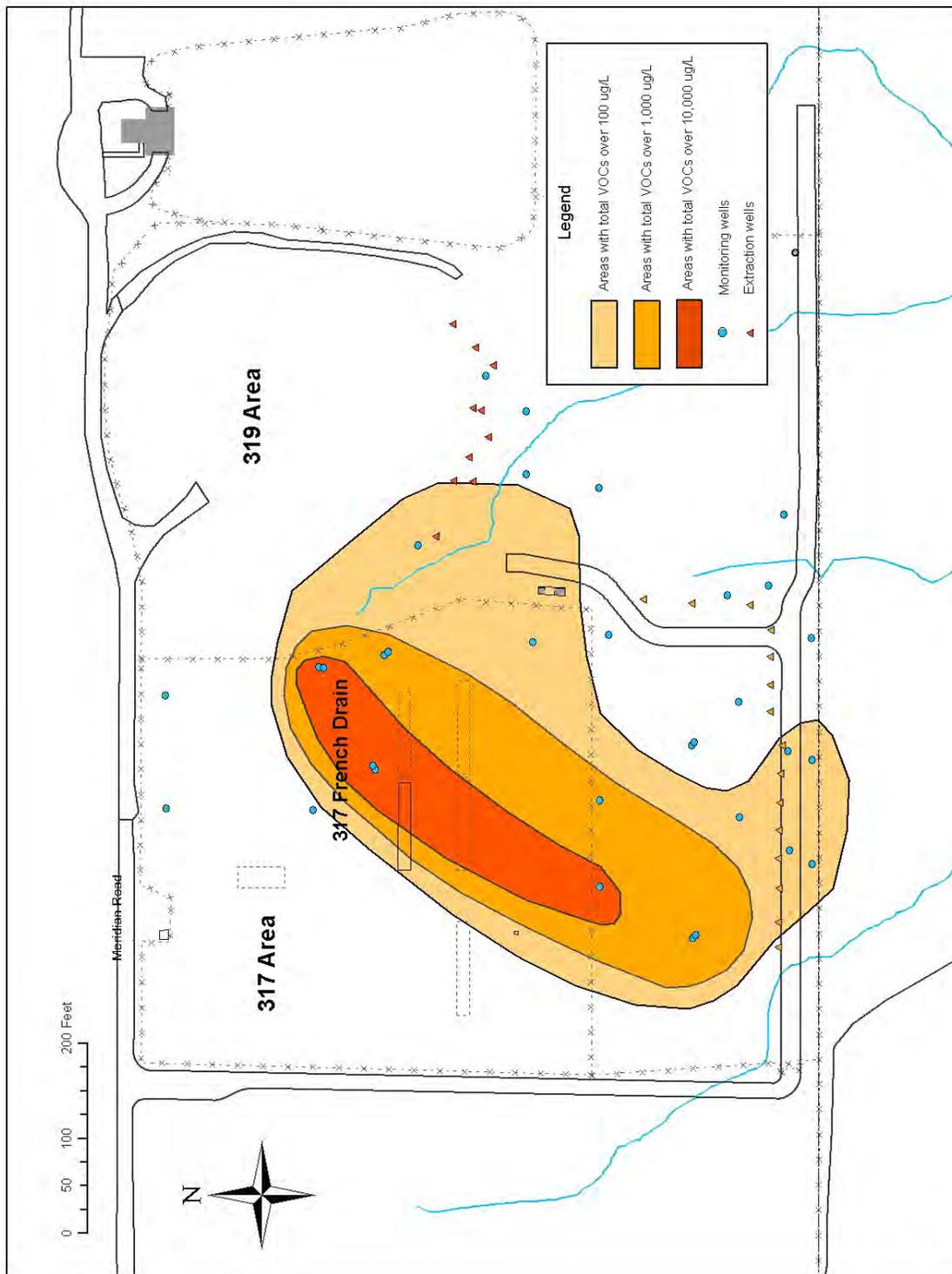


FIGURE 6.12 Region of Contaminated Groundwater in the 317/319 Area during 2009

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6.4.2. Extraction Well Monitoring

Two groundwater management systems in the 317/319 Area remove contaminated groundwater to prevent further off-site 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 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 2009 was 14,250 L/day (3,765 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 2009 was 9,500 L/day (2,500 gal/day), lower than the long-term average. The flow during the last two quarters of 2009 was much lower than the first due to dryer weather and the fact that the system was shut down for repairs for several weeks during this period. 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 2009, the average flow was 2,200 L/day (578 gal/day).

Samples are collected from each well once per year and are analyzed for VOCs and various radiological parameters. Table 6.20 summarizes the range of contaminant concentrations above detection limits in the two extraction well systems. The concentrations of most of the parameters measured were below laboratory detection limits. During 2009, three 317 Area extraction wells did not contain enough water to provide samples for full radiological analysis, which require large amounts of water. VOC and hydrogen-3 samples, however, were collected from these wells. Both systems exceeded GQSs in at least one sample during 2009. 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.

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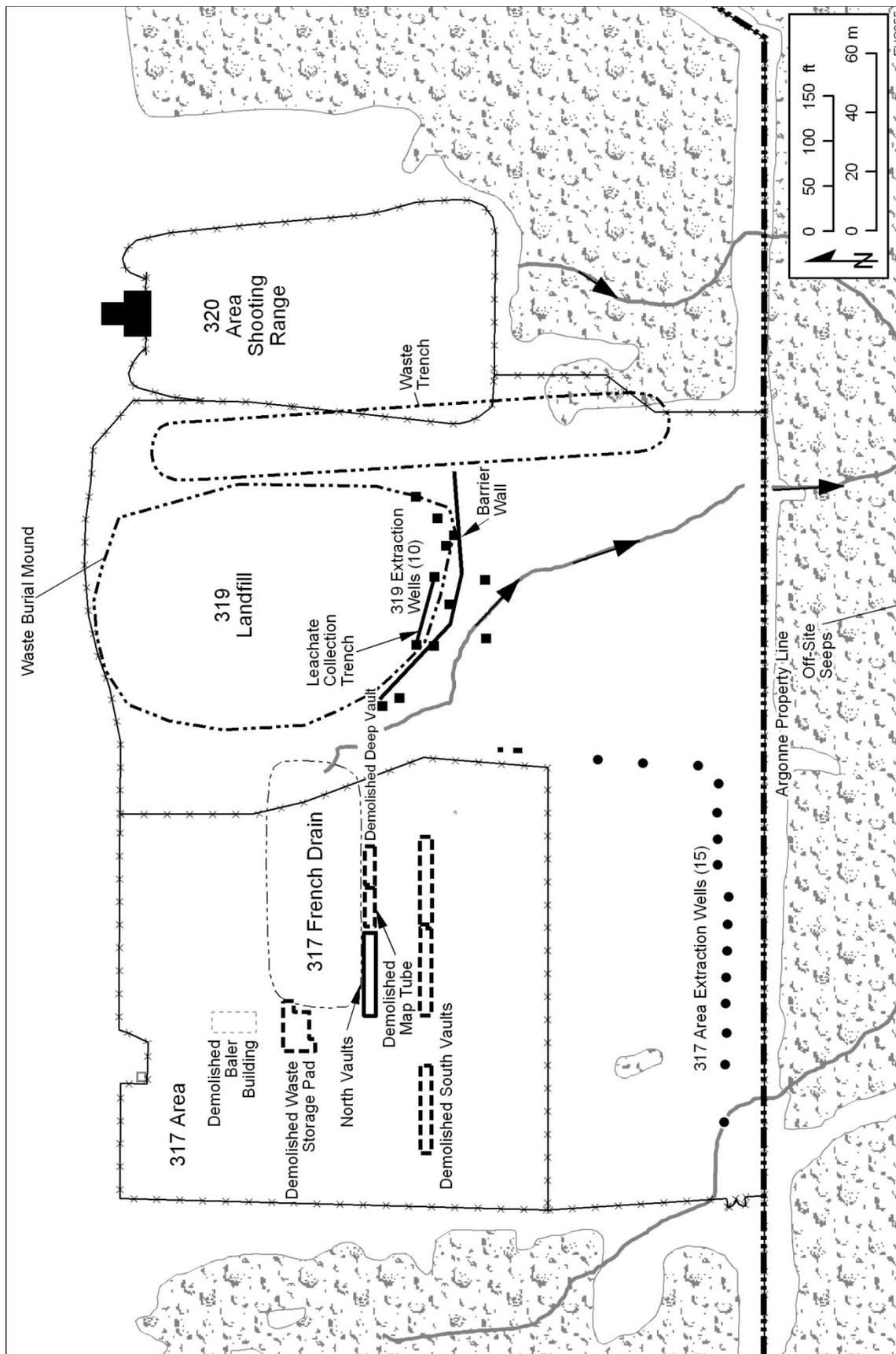


FIGURE 6.13 Extraction Wells

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TABLE 6.20

Range of VOC and Radionuclide Concentrations in the 317/319 Extraction Wells, 2009

Parameter	317 System			319 System			Remediation Objective
	No. of Detections in 15 wells	Avg.	Max.	No. of Detections in 10 wells	Avg.	Max.	
<i>VOC (µg/L)</i>							
1,1,1-Trichloroethane	12	28	133	3	3.9	9.0	200
1,1-Dichloroethane	12	37	160	4	4.8	12	700
1,1-Dichloroethene	6	1.5	3.0	2	0.4	0.5	7
1,2-Dichloroethane	10	6.7^a	38	2	0.4	0.6	5
1,4-Dioxane	11	31	58	1	- ^b	8.0	1
Acetone	2	42	72	3	37	77	6300
Chloroethane	6	1.1	2.0	0	< 1	< 1	2,800
Chloroform	7	0.8	2.0	3	0.2	0.3	0.2
cis-1,2-Dichloroethene	9	2.0	8.0	6	34	177	70
Dichlorofluoromethane	2	0.4	0.5	3	3.4	9.0	NA ^c
Tetrachloroethene	4	1.7	3.0	2	0.6	0.9	5
Tetrahydrofuran	0	< 1	< 1	2	32	62	NA
trans-1,2-Dichloroethene	1	-	0.3	2	2.3	4.0	100
Trichloroethene	10	5.4	19	7	8.9	49	5
Vinyl Chloride	1	-	0.4	1	-	6.0	2
<i>Radionuclides (pCi/L)^d</i>							
Cesium-137	12	< 2.0	< 2.0	10	< 2.0	< 2.0	NA
Hydrogen-3	15	162	255	10	8225	53,280	20,000
Uranium-234	12	0.7	1.4	10	4.3	13.1	NA
Uranium-235	0	< 0.01	< 0.01	3	< 0.30	0.8	NA
Uranium-238	12	0.6	1.0	10	4.2	13.1	NA

^a Bold type indicates that the value exceeds applicable standards.

^b A hyphen indicates the compound was detected only once, the detected value is shown in the max column.

^c NA = not applicable.

^d In the 317 Area, only 13 of the 15 wells yielded samples for radionuclide determination.

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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 6.20. The hydrogen-3 and uranium concentration were significantly higher in the 319 Area than in the 317 Area as a result of the disposal of contaminated debris in the 319 landfill. The highest hydrogen-3 concentration in the 319 Area was 53,280 pCi/L, compared to only 255 in the 317 Area wells. This high concentration was found in Well EXT271 which is near the leachate trench. None of the other extraction wells in this area exceeded the 20,000 pCi/L GQS. The levels of uranium were a factor of ten higher in the 319 Area than in the 317 Area, but both areas are generally comparable to background levels. Cesium-137 was not detected in any of the wells above the detection limit of 2.0 pCi/L.

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.

6.4.3. Stormwater Runoff Monitoring

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 2009, two samples were collected — one during February and the other in June. Several VOCs were detected in these samples, as shown in Table 6.21. Only a very small amount of hydrogen-3 was found in one of the two samples. From the type of compounds detected, and the low concentration of hydrogen-3, it is believed that the contamination noted results from rainwater contacting contaminated soil in the 317 French Drain Area.

TABLE 6.21

Results of Surface Water Sampling in the 319 Area, 2009		
Parameter	February	June
<i>VOCs (µg/L)</i>		
1,1,1-Trichloroethane	2.0	2.0
Carbon tetrachloride	< 1	7.0
Chloroform	< 1	5.0
<i>Radionuclides (pCi/L)</i>		
Hydrogen-3	151	< 100

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6.4.4. ENE Landfill Groundwater Monitoring

In September 2001, Argonne completed the remediation of a small solid waste disposal unit 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 an 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 (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 due to their potential to migrate to groundwater. The cap placed over the landfill contents was designed to prevent direct 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 were included in the quarterly monitoring program in 2009. 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 bailer.

The 2009 results of this program are summarized in Table 6.22. 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. Three of the

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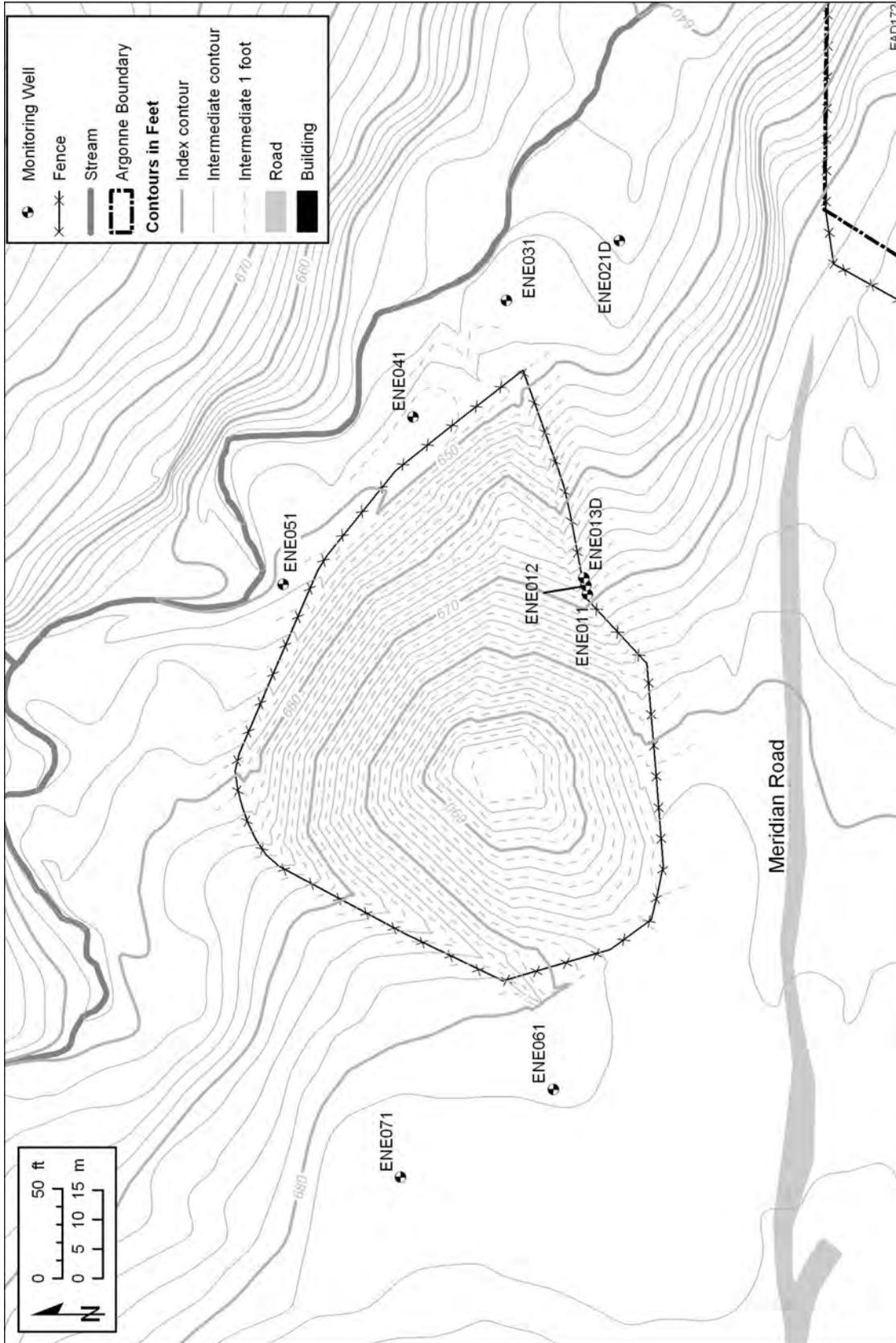


FIGURE 6.14 ENE Area Groundwater Monitoring Wells

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TABLE 6.22

Annual Average Concentrations of ENE Landfill Well Water Constituents, 2009

Parameter ^a	Well No.											Standard	
	ENE-011	ENE-012	ENE-013D	ENE-021D	ENE-031	ENE-041	ENE-051	ENE-061 ^b	ENE-071 ^b				
Arsenic-filtered	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	0.05
Arsenic-unfiltered	< 0.025	< 0.025	0.094^c	< 0.025	0.25	0.06	0.23	0.25	0.14	< 0.025	0.14	0.14	0.05
Chromium-filtered	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.1
Chromium-unfiltered	< 0.05	0.06	0.12	0.3	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.11	0.14	0.1
Lead-filtered	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	0.0075
Lead-unfiltered	< 0.004	0.009	0.014	< 0.004	0.030	0.010	0.056	0.173	0.134	< 0.004	0.134	0.134	0.0075
Manganese-filtered	< 0.075	< 0.075	< 0.075	0.08	0.27	< 0.075	< 0.075	< 0.075	< 0.075	< 0.075	0.37	0.38	0.15
Manganese-unfiltered	< 0.075	0.255	< 0.075	0.09	1.64	0.54	1.41	6.20	4.13	< 0.075	6.20	4.13	0.15
Nickel-filtered	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.1
Nickel-unfiltered	< 0.05	0.06	< 0.05	< 0.05	0.06	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.35	0.25	0.1
Selenium-filtered	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.5
Selenium-unfiltered	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.5
PCB-total (µg/L)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.0
Hydrogen-3 (pCi/L)	< 100	< 100	< 100	< 100	< 100	108	< 100	< 100	< 100	< 100	< 100	< 100	20,000

^a Concentrations in mg/L except where noted otherwise.

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

^c Bold type indicates that the value exceeds the GRO.

15 exceedances in 2009 were from filtered samples, and these exceedances were 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 2 of the 34 samples collected in 2009 were collected with the low flow pump. The only metal found in these two samples was manganese at approximately 0.09 mg/L, which was well below the limit of 0.15 mg/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 set of background values will be established. The monitoring results will then be compared with these background values as well as with 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.

6.4.5. 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 into the ravine, where it forms a small rivulet in the bottom. 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 it 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 2009, the seeps were sampled quarterly for VOCs and hydrogen-3. Table 6.23 contains the results for 2009. VOCs were noted in all three seeps, but levels of VOCs in SP01 and SP02 were very low. Seep SP04 showed the highest levels in 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 compared to the first few years of monitoring. 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.

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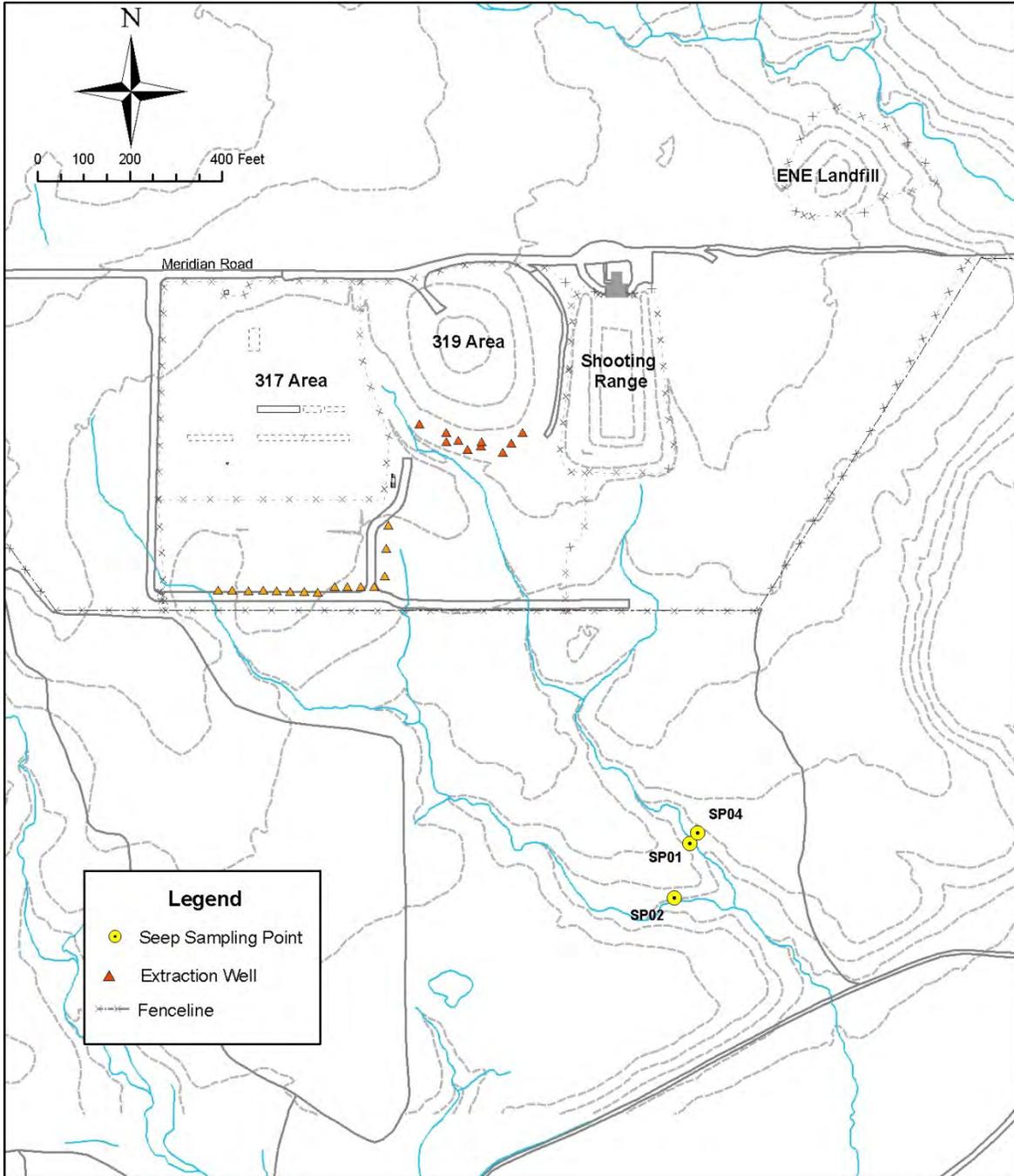


FIGURE 6.15 Seep Locations South of the 317/319 Area

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TABLE 6.23

Contaminant Concentrations in Seep Water, 2009^a

Sample Date	Carbon Tetrachloride (µg/L)	Chloroform (µg/L)	Tetrachloroethene (µg/L)	Hydrogen-3 (pCi/L)	Cesium-137 (pCi/L)
<i>SP01</i>					
2/13/2009	14	3	< 1	150	4.2
4/29/2009	2	< 1	< 1	< 100	< 2.0
7/27/2009	2	1	< 1	< 100	< 2.0
10/21/2009	3	< 1	< 1	< 100	< 2.0
<i>SP02</i>					
2/13/2009	2	< 1	< 1	161	< 2.0
4/29/2009	< 1	< 1	< 1	138	< 2.0
7/27/2009	1	< 1	< 1	101	< 2.0
10/21/2009	< 1	< 1	< 1	< 100	< 2.0
<i>SP04</i>					
2/13/2009	216	24	7	< 100	2.1
4/29/2009	108	16	4	< 100	2.3
7/27/2009	192	18	7	< 100	< 2.0
10/21/2009	96	22	< 1	< 100	< 2.0

^a In addition to the analytical results shown above, three of the SP04 samples were reported to contain TCE at concentrations less than the 1-µg/L detection limit (reported as estimated values per EPA procedures).

The concentrations appear to be strongly influenced by precipitation, as shown in Figure 6.17. 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 elevation is normal or higher than normal, the groundwater flows through more contaminated soil, resulting in higher VOC concentrations.

During 2009 several samples from seeps SP01 and SP02 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. 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 and first two quarters of 2009, the results have all been at or below detection limits since 2005. The decline in hydrogen-3 since 2000 is related to the installation of the cap over the 319 Area Landfill, the likely source of the hydrogen-3 at the seeps. The decline in hydrogen-3 has been much more rapid than would be accounted for by radioactive decay alone.

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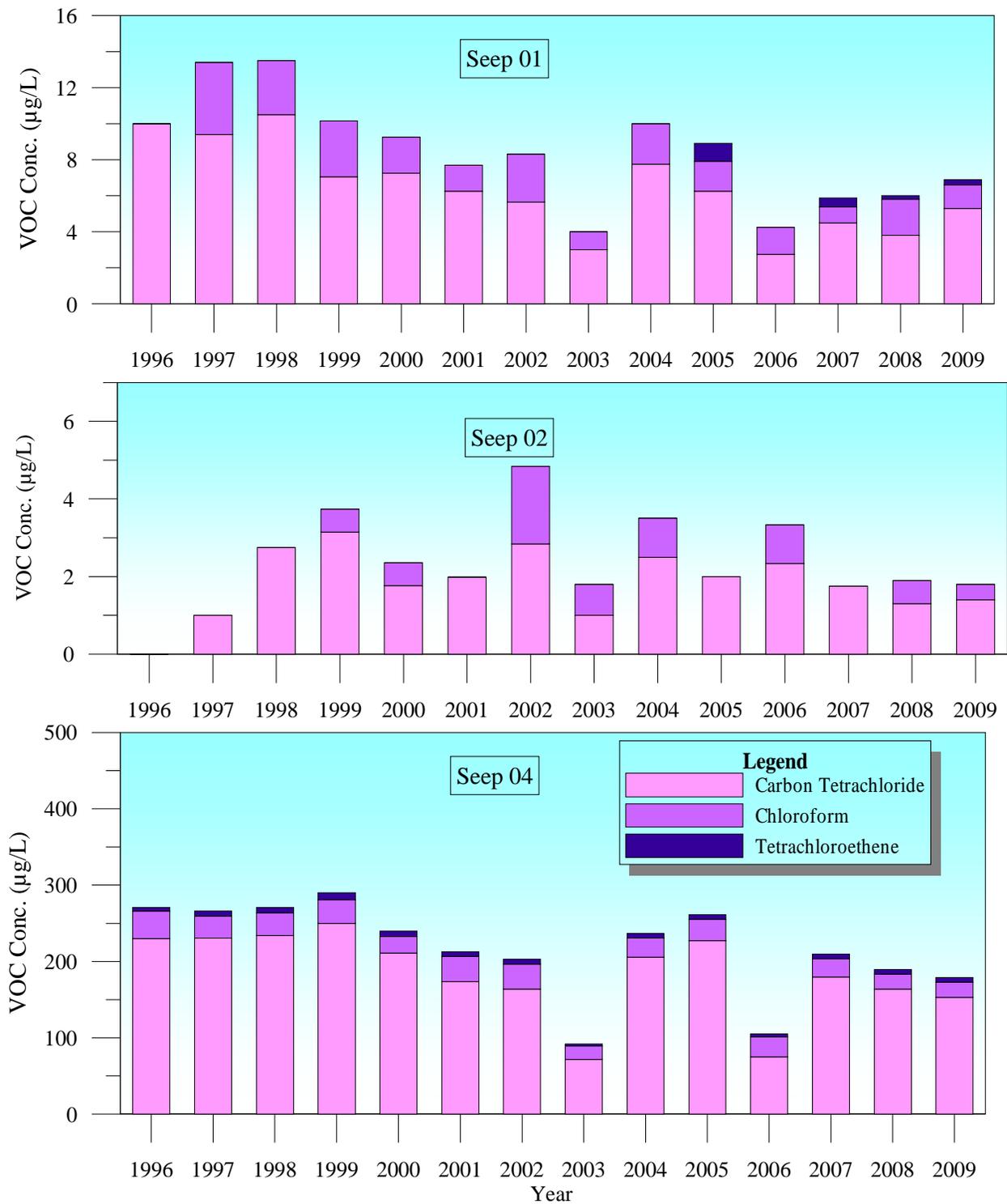


FIGURE 6.16 Groundwater Seeps Annual Average VOC Concentrations since 1996

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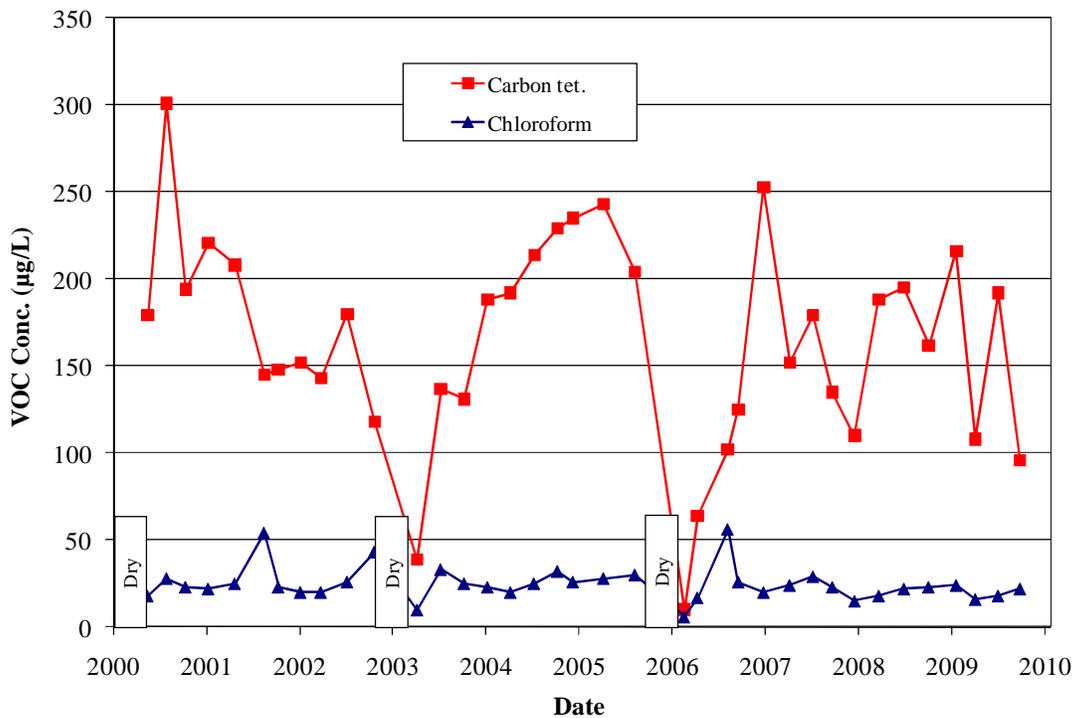


FIGURE 6.17 Carbon Tetrachloride and Chloroform Concentrations in Seep 04, 2000 to 2009

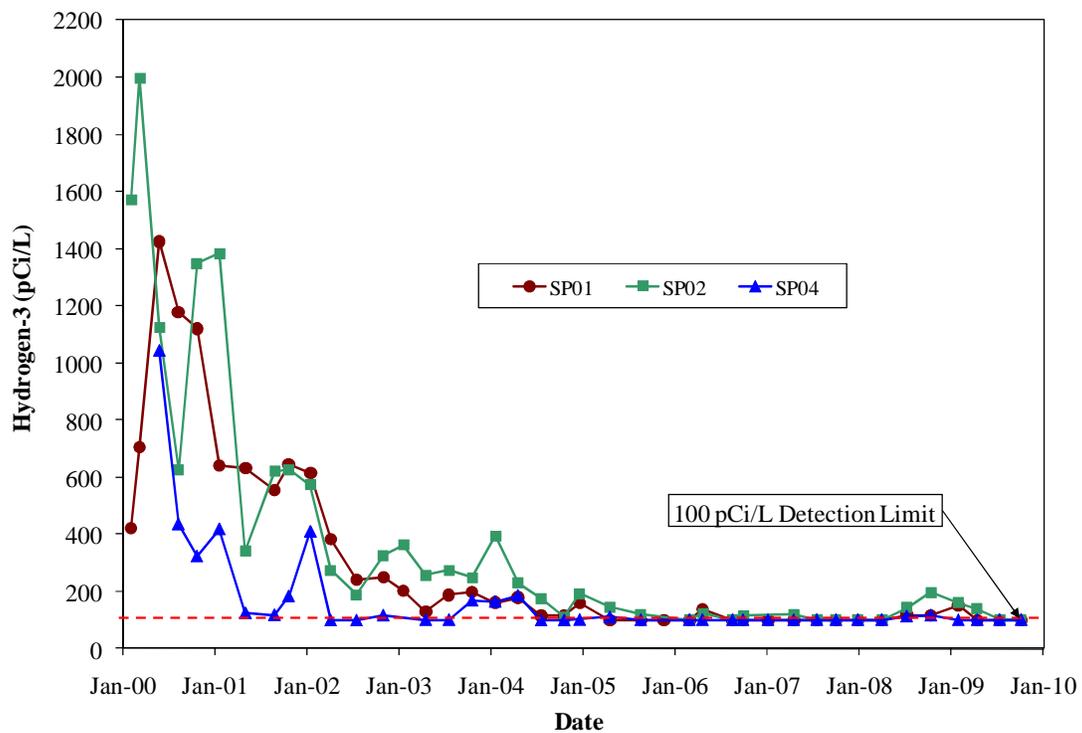


FIGURE 6.18 Hydrogen-3 Concentrations in Seep Water, 2000 to 2009

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6.4.6. 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 and site constraints, it was not feasible to remove all contaminated soil or groundwater during the active remediation phase. The phytoremediation and groundwater extraction systems were 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 and it allows for the establishment of a GMZ as a three-dimensional region that contains groundwater that exceeds one or more GQS, but is being actively remediated. 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 317121D, 317951D, 319961D, and 319131D). 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 that are known as mini-monitoring wells. Well 317941, shown in Figure 6.19, has had contamination above GROs since it was installed 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 2009 are shown in Table 6.24. The individual results were transmitted to the IEPA in the quarterly LTS report.

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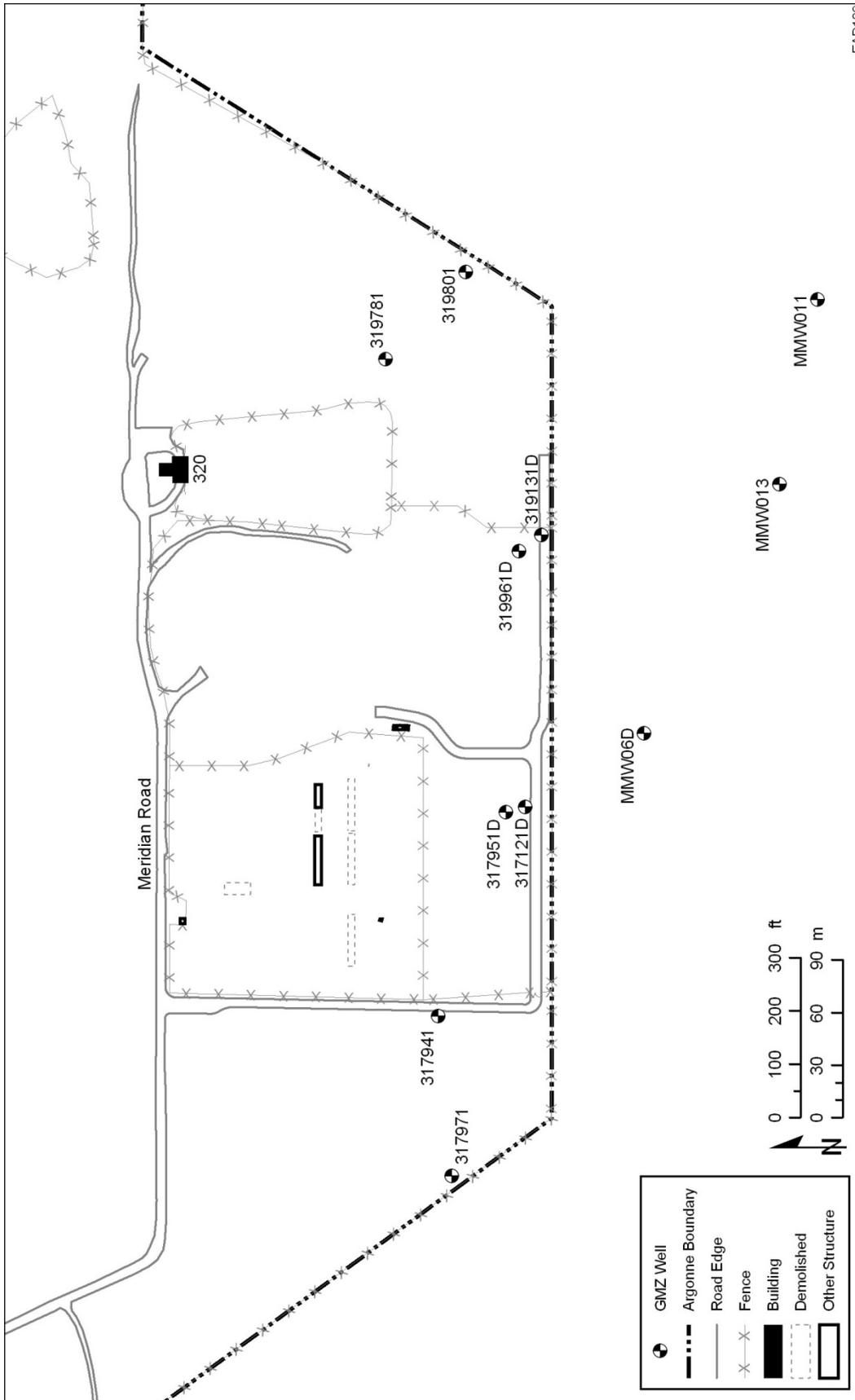


FIGURE 6.19 Location of the GMZ Monitoring Wells

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TABLE 6.24

Annual Average Results from the GMZ Monitoring Wells, 2009
(concentrations in µg/L, except hydrogen-3)

Parameter	Well No.						GRO
	319781	317951D	319961D	317121D	319131D	319801	
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	< 1.0	< 1.0	0.3	< 1.0	5.0
Chloroform	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	0.2
1,1-Dichloroethane	< 1.0	< 1.0	< 1.0	< 1.0	< 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
<i>cis</i> -1,2-Dichloroethene	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	70
1,4-Dioxane	0.6	13^a	0.8	10	0.6	< 1.0	1.0
<i>bis</i> (2-ethylhexyl)phthalate	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	6.0
Hydrogen-3 (pCi/L)	< 100	245	772	237	680	< 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	< 1.0	< 1.0	< 1.0	< 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	< 1.0	< 1.0	5.0
Vinyl chloride	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	2.0

Parameter	Well No.					GRO
	317941	317971	MMW06D ^b	MMW011 ^b	MMW013	
Alpha-BHC	< 0.03	< 0.03	NS ^c	NS ^c	NS ^c	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	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	0.2
1,1-Dichloroethane	5	< 1.0	< 1.0	< 1.0	< 1.0	700
1,2-Dichloroethane	0.3	< 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
<i>cis</i> -1,2-Dichloroethene	26	< 1.0	< 1.0	< 1.0	< 1.0	70
1,4-Dioxane	< 1.0	< 1.0	< 1.0	< 1.0	1	1.0
<i>bis</i> (2-ethylhexyl)phthalate	< 1.0	< 1.0	NS	NS	NS	6.0
Hydrogen-3 (pCi/L)	635	115	< 100	106	140	20,000
Methylene chloride	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	5.0
Nitrobenzene	< 3.5	< 3.5	NS	NS	NS	3.5
Tetrachloroethene	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	5.0
1,1,1-Trichloroethane	0.2	< 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	3	< 2.0	< 2.0	< 2.0	< 2.0	2.0

^a Bold type indicates that the value exceeds the GRO.

^b Mini-wells MMW06D, MMW011 and MWW013 were only sampled during the second semiannual sampling event. The results shown are for the single sample from each well.

^c The mini-wells did not yield enough water to perform all the analyses. Only VOCs and hydrogen-3 were analyzed.

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Monitoring results from 2009 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). It was present in several other wells at levels below the GRO of 1 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 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.

6.4.7. Monitoring of an Artesian Well

Monitoring for hydrogen-3 was 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 2009 were just above or below the detection limit of 100 pCi/L. The highest value found in 2009 was 127 pCi/L, which was recorded during the first quarter of 2009. The low value is consistent with many control sampler results from early 2009 and is likely a laboratory artifact.

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 chemical wastes that would be considered hazardous waste by current regulations were also placed in the landfill. The landfill was closed in 1992, in accordance with the closure plan established under the operating permit.

The closed landfill and associated areas are currently subject to the RCRA Corrective Action process. The landfill area includes solid waste management units (SWMUs) No. 4 (landfill mound), No. 20 (the French drain), 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 but none were found in groundwater near the landfill. The study determined that no further remedial actions were

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required. An NFA determination was received from the IEPA on March 25, 2003, in an 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 2009.

6.5.1. Sanitary Landfill Groundwater Monitoring

The current groundwater monitoring well network is shown in Figure 6.20. Table 6.25 contains a description of each active well. All monitoring wells are constructed of 0.05-m (2-in.) diameter stainless-steel casings and screens installed in boreholes sealed with bentonite grout, a concrete cap, and a 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 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 a number of intermediate wells 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. Several of these wells were closed, but three remain (800382, 800192, and 800202). Since the October 2005 RCRA Part B permit modification, monitoring of these wells is no longer required. Thus, these wells are no longer included in the program, and no data from them are included in this report.

The sanitary landfill groundwater monitoring wells were installed in stages, and a number of wells have been installed 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. No changes to the well network were made in 2009.

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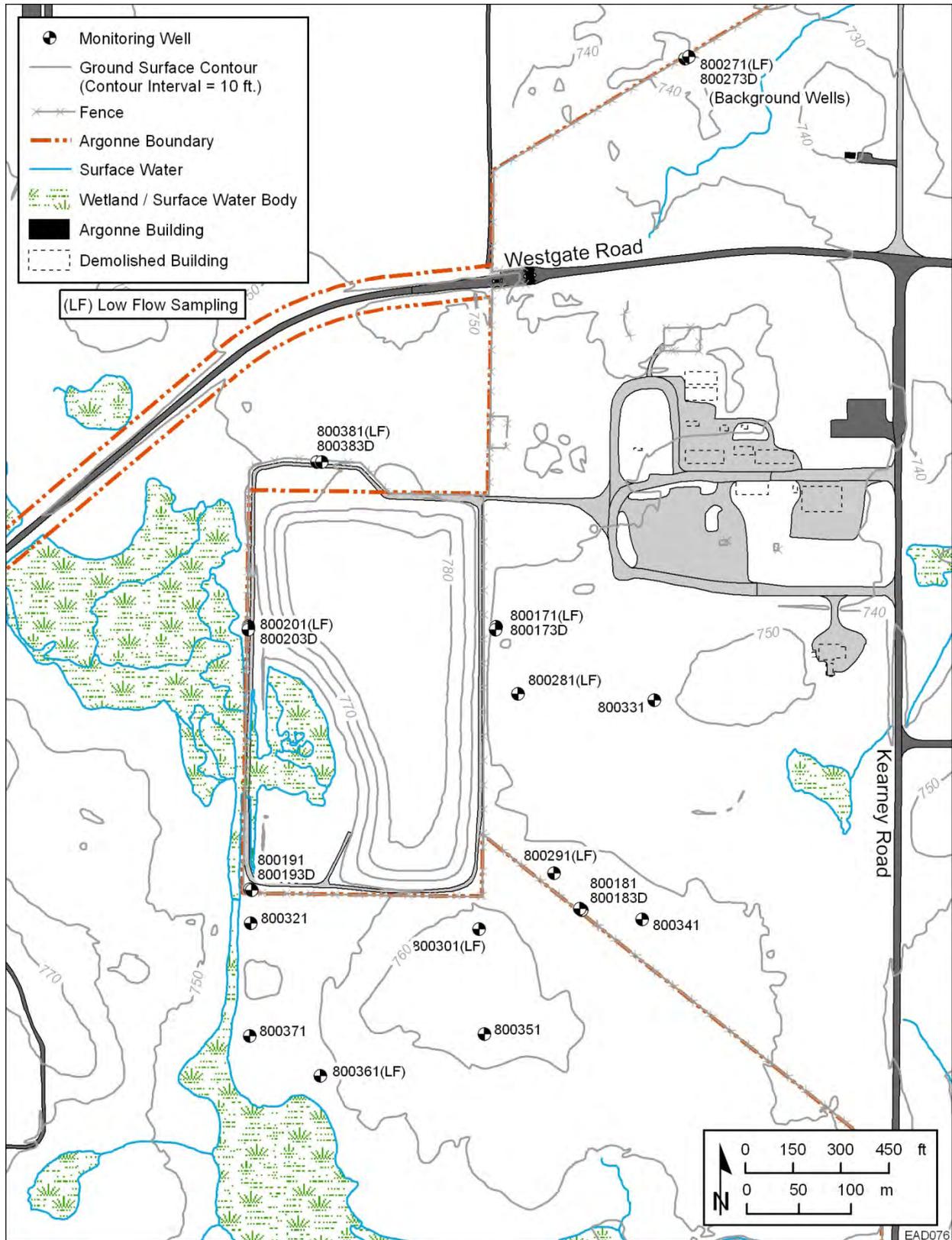


FIGURE 6.20 800 Area Landfill Monitoring Wells

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TABLE 6.25

Groundwater Monitoring Wells: 800 Area Landfill

Argonne ID Number	IEPA Well Number	Well Depth (m bgs)	Ground Surface Elevation ^a (m AMSL)	Monitoring Zone (m AMSL)	Date Drilled	Sampling Device
Background Wells						
800271	G16S	3.99	225.88	223.41-221.89	Aug-99	Low flow pump
800273D ^b	D16D	36.53	225.80	192.33-189.28	Aug-99	Submersible pump
Shallow Monitoring Wells						
800171	G06S	7.61	228.37	222.28-220.76	Oct-92	Low flow pump
800181	G08S	10.52	230.31	221.31-219.79	Oct-92	Bailer
800191R ^c	G11S	4.11	227.31	224.57-223.20	Sep-05	Bailer
800201	G14S	10.63	227.82	218.71-217.19	Oct-92	Low flow pump
800281	G17S	3.90	227.75	225.37-223.85	Jul-99	Low flow pump
800291	G18S	6.95	230.60	225.17-223.65	Jul-99	Low flow pump
800301	G19S	7.65	232.69	226.56-225.03	Sep-99	Low flow pump
800321	G21S	4.32	228.03	225.23-223.71	Sep-99	Bailer
800331	G22S	5.06	228.05	224.51-222.99	Jul-99	Bailer
800341	G23S	3.95	230.12	227.69-226.16	Jul-99	Bailer
800351	G24S	11.46	232.80	224.39-221.34	Sep-99	Bailer
800361	G25S	7.18	227.62	221.96-220.44	Sep-99	Low flow pump
800371	G26S	10.05	227.61	219.03-217.56	Sep-99	Bailer
800381	G03S	6.75	230.97	227.27-224.22	Jul-99	Low flow pump
Dolomite Bedrock Monitoring Wells						
800173D	G06D	39.31	228.39	190.59-189.07	Oct-92	Submersible pump
800183D	G08D	50.02	230.32	183.35-180.30	Oct-92	Submersible pump
800193D	G11D	46.01	227.29	184.33-181.28	Oct-92	Submersible pump
800203D	G14D	38.37	227.83	192.50-189.46	Sep-99	Submersible pump
800383D	G03D	43.32	231.11	190.84-187.80	Jul-99	Submersible pump

^a Well elevation information from 2008 well resurvey

^b Wells identified by a "D" are wells monitoring the dolomite bedrock aquifer.

^c 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 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 inside the well during the collection of samples using a bailer. The bailer agitates the water in the well as it is lowered below the water surface. 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 were sampled using a bailer. 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 necessary 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 three to five well volumes of water from 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.

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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 6.1.

6.5.1.3. Basis for Evaluation of Analytical Results

In 2005, the IEPA approved a set of background values for groundwater constituents monitored at the landfill. The background values were developed from five years of monitoring results from the two upgradient monitoring wells, one in the shallow glacial drift and one in the dolomite bedrock. 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 two times the practical quantitation limit (PQL) for that compound. Table 6.26 lists most 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 metal results do not have permit limits. These results are collected for informational purposes only and are not reported to the IEPA. To simplify the table, the limits for the long list of organics (two times PQL) are not shown. In the data tables that follow, values that exceed background values or other limits are shown in bold print.

6.5.1.4. Results of Analyses

Field parameters and the results of chemical and radiological analysis are presented in the following tables. Results for the two background wells are presented in Tables 6.27 and 6.28; the shallow landfill wells are presented in Tables 6.29 through 6.42; and the dolomite wells in Tables 6.43 through 6.47. 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 was detected above the detection limits in any of the wells. To maintain clarity in the following data tables, these organic analysis results are not shown.

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TABLE 6.26

Permit Limits for 800 Area Groundwater

Parameter	Unit	Permit Limit – Shallow Wells	Source ^a	Permit Limit – Deep Wells	Source ^a
<i>Field Parameters</i>					
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	°C	NA	–	NA	–
Water elevation	m	NA	–	NA	–
<i>Filtered Samples</i>					
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	–
<i>Unfiltered Samples</i>					
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

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TABLE 6.26 (Cont.)

Parameter	Unit	Permit Limit – Shallow Wells	Source ^a	Permit Limit – Deep Wells	Source ^a
<i>Unfiltered Samples (Cont.)</i>					
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.

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 were occurring. 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 are detected in groundwater it may indicate that waste products from the landfill are being released. Thus, there is no indication of a release of hazardous materials from the landfill. However, the monitoring data are still useful in understanding the hydrogeology and geochemistry of the area surrounding the landfill.

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TABLE 6.27

Groundwater Monitoring Results, Sanitary Landfill Background Well 800271, 2009

Parameter	Unit	Date of Sampling			
		2/2/2009	4/22/2009	7/22/2009	10/20/2009
Field Parameters					
Conductivity	µS/cm	615	595	570	611
Oxid./red. potential	mV	-13	-8	1	-5
pH	pH	7.18	6.83	7.15	7.18
Temperature	°C	5.6	10.1	14.8	12.7
Water elevation ^a	m	224.62	225.55	223.98	223.28
Filtered Samples					
Ammonia nitrogen	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Chloride	mg/L	< 1	3	2	3
Sulfate	mg/L	27	22	26	42
TDS	mg/L	292	247	273	304
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.017	0.016	0.018	0.016
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	0.011
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	- ^b	6	-	-
Cyanide (Total)	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Fluoride	mg/L	-	0.13	-	-
Hydrogen-3	pCi/L	120	< 100	< 100	< 100
Nitrate	mg/L	-	3.7	-	-
Phenols	mg/L	< 0.0050	< 0.0050	< 0.0050	< 0.0050
Sulfate	mg/L	-	23	-	-
TOCs (max. of 4 samples)	mg/L	1.1	1.6	1.3	1.7
TOXs (max. of 2 samples)	mg/L	< 0.020	< 0.020	< 0.020	< 0.020
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	-	< 0.021	-	-
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 = 221.89 m (MSL); ground surface elevation = 225.88 m (MSL); casing material = stainless steel.

^b A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.28

Groundwater Monitoring Results, Sanitary Landfill Background Well 800273D, 2009

Parameter	Unit	Date of Sampling				
		2/2/2009	4/27/2009	4/27/2009 (duplicate)	7/22/2009	10/20/2009
<i>Field Parameters</i>						
Conductivity	µS/cm	936	932	932	911	881
Oxid./red. potential	mV	-12	-15	-15	-3	-5
pH	pH	7.17	7.12	7.12	7.22	7.19
Temperature	°C	8.0	12.5	12.5	12.0	10.9
Water elevation ^a	m	193.70	194.06	194.06	194.03	193.82
<i>Filtered Samples</i>						
Ammonia nitrogen	mg/L	0.90	0.93	0.90	0.88	0.95
Chloride	mg/L	56	76	77	79	117
Sulfate	mg/L	90	94	94	96	97
TDS	mg/L	538	540	520	590	544
Arsenic	mg/L	0.004	0.003	0.004	0.005^b	0.005
Barium	mg/L	0.043	0.052	0.052	0.048	0.048
Boron	mg/L	0.15	0.16	0.16	0.15	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	0.953	0.990	0.960	1.000	0.950
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	0.012
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
<i>Unfiltered Samples</i>						
Chloride	mg/L	- ^c	76	77	-	-
Cyanide (Total)	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluoride	mg/L	- ^c	0.46	0.43	-	-
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100	< 100
Nitrate	mg/L	-	< 0.10	< 0.10	-	-
Phenols	mg/L	0.026	< 0.005	0.025	< 0.005	< 0.005
Sulfate	mg/L	-	98	102	-	-
TOCs (max. of 4 samples)	mg/L	1.1	< 1.0	< 1.0	< 1.0	1.4
TOXs (max. of 2 samples)	mg/L	< 0.020	< 0.020	< 0.020	< 0.020	0.04
Arsenic	mg/L	-	0.005	0.005	-	-
Barium	mg/L	-	0.046	0.047	-	-
Boron	mg/L	-	0.20	0.18	-	-
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	-	1.41	1.37	-	-
Lead	mg/L	-	< 0.004	< 0.004	-	-
Manganese	mg/L	-	< 0.01	0.012	-	-
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 Well point elevation = 188.28 m (MSL); ground surface elevation = 225.80 m (MSL); casing material = stainless steel.

^b Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.29

Groundwater Monitoring Results, Sanitary Landfill Well 800171, 2009

Parameter	Unit	Date of Sampling			
		1/21/2009	4/15/2009	7/20/2009	10/19/2009
<i>Field Parameters</i>					
Conductivity	µS/cm	1040^a	821	838	813
Oxid./red. potential	mV	15	-4	18	12
pH	pH	6.39	6.63	6.89	6.88
Temperature	°C	6.8	11.1	16.8	14.7
Water elevation ^b	m	226.84	227.53	225.86	225.84
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	< 0.05	0.05	< 0.05	< 0.05
Chloride	mg/L	26	19	16	23
Sulfate	mg/L	70	56	66	70
TDS	mg/L	524	410	525	525
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.050	0.044	0.052	0.057
Boron	mg/L	0.11	0.13	0.13	0.14
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	0.012	< 0.01	< 0.013	0.011
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
<i>Unfiltered Samples</i>					
Chloride	mg/L	- ^c	19	-	-
Cyanide (Total)	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Fluoride	mg/L	-	3.1	-	-
Hydrogen-3	pCi/L	139	< 100	< 100	< 100
Nitrate	mg/L	-	3.1	-	-
Phenols	mg/L	0.021	< 0.005	< 0.005	< 0.005
Sulfate	mg/L	-	52	-	-
TOCs (max of 4 samples)	mg/L	2.1	3.0	2.0	2.6
TOXs (max of 2 samples)	mg/L	0.037	0.029	< 0.020	< 0.020
Arsenic	mg/L	-	< 0.003	-	-
Barium	mg/L	-	0.05	-	-
Boron	mg/L	-	0.13	-	-
Cadmium	mg/L	-	< 0.0002	-	-
Chromium	mg/L	-	< 0.05	-	-
Cobalt	mg/L	-	< 0.25	-	-
Copper	mg/L	-	< 0.025	-	-
Iron	mg/L	-	0.91	-	-
Lead	mg/L	-	< 0.004	-	-
Manganese	mg/L	-	0.17	-	-
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 6.26

^b Well point elevation = 220.76 m (MSL); ground surface elevation = 228.37 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.30

Groundwater Monitoring Results, Sanitary Landfill Well 800181, 2009

Parameter	Unit	Date of Sampling				
		1/20/2009	4/22/2009	7/14/2009	7/14/2009 (Duplicate)	10/20/2009
<i>Field Parameters</i>						
Conductivity	µS/cm	1256^a	550	753	753	902
Oxid./red. potential	mV	-34	-44	-54	-54	-23
pH	pH	7.65	7.67	7.50	7.50	7.51
Temperature	°C	9.7	10.2	12.5	12.5	9.8
Water elevation ^b	m	228.07	229.94	228.21	228.21	221.41
<i>Filtered Samples</i>						
Ammonia nitrogen	mg/L	< 0.05	0.09	< 0.05	< 0.05	< 0.05
Chloride	mg/L	10	14	10	9	11
Sulfate	mg/L	116	34	98	96	123
TDS	mg/L	547	199	540	550	617
Arsenic	mg/L	< 0.003	< 0.003	0.006	0.006	0.013
Barium	mg/L	0.047	0.027	0.040	0.042	0.037
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	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
<i>Unfiltered Samples</i>						
Chloride	mg/L	— ^c	15	—	—	—
Cyanide (Total)	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluoride	mg/L	—	0.19	—	—	—
Hydrogen-3	pCi/L	< 100	< 100	138	< 100	< 100
Nitrate	mg/L	—	< 0.10	—	—	—
Phenols	mg/L	0.012	0.044	< 0.005	< 0.005	< 0.005
Sulfate	mg/L	—	122	—	—	—
TOCs (max. of 4 numbers)	mg/L	2.1	4.6	6.1	2.3	3.7
TOXs (max. of 2 numbers)	mg/L	0.021	< 0.020	< 0.020	< 0.020	< 0.020
Arsenic	mg/L	—	< 0.003	—	—	—
Barium	mg/L	—	0.027	—	—	—
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	—	0.43	—	—	—
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 Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^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.

6. GROUNDWATER PROTECTION

TABLE 6.31

Groundwater Monitoring Results, Sanitary Landfill Well 800191R, 2009

Parameter	Unit	Date of Sampling			
		1/12/2009	4/6/2009	7/6/2009	10/6/2009
<i>Field Parameters</i>					
Conductivity	µS/cm	1727^a	1570	1751	1467
Oxid./red. potential	mV	14	15	7	25
pH	pH	6.78	6.68	6.53	6.67
Temperature	°C	8.5	7.1	12.8	12.8
Water elevation ^b	m	225.86	226.05	225.68	225.60
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	0.23	0.76	0.68	0.49
Chloride	mg/L	101	87	117	113
Sulfate	mg/L	403	491	642	528
TDS	mg/L	1173	1279	1596	1399
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.026	0.026	0.028	0.027
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	0.349	1.580	1.320	0.690
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.45	1.02	1.11	0.99
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	< 0.006	< 0.003
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
<i>Unfiltered Samples</i>					
Chloride	mg/L	– ^c	88	–	–
Cyanide (Total)	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Fluoride	mg/L	–	0.54	–	–
Hydrogen-3	pCi/L	184	< 100	< 100	< 100
Nitrate	mg/L	–	< 0.10	–	–
Phenols	mg/L	< 0.005	< 0.005	< 0.005	< 0.005
Sulfate	mg/L	–	552	–	–
TOCs (max. of 4 samples)	mg/L	4.2	3.5	4.5	4.5
TOXs (max. of 2 samples)	mg/L	0.038	< 0.020	< 0.020	0.022
Arsenic	mg/L	–	< 0.003	–	–
Barium	mg/L	–	0.037	–	–
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	–	4.64	–	–
Lead	mg/L	–	< 0.004	–	–
Manganese	mg/L	–	1.22	–	–
Mercury	mg/L	–	< 0.0002	–	–
Nickel	mg/L	–	< 0.05	–	–
Selenium	mg/L	–	< 0.003	–	–
Silver	mg/L	–	< 0.001	–	–
Zinc	mg/L	–	< 0.02	–	–

^a Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^b Well point elevation = 223.31 m (MSL); ground surface elevation = 227.31 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.32

Groundwater Monitoring Results, Sanitary Landfill Well 800201, 2009

Parameter	Unit	Date of Sampling			
		1/27/2009	4/14/2009	7/14/2009	10/13/2009
<i>Field Parameters</i>					
Conductivity	µS/cm	1220^a	1026	969	945
Oxid./red. potential	mV	1	0	-36	7
pH	pH	6.99	6.92	7.18	6.98
Temperature	°C	6.3	7.9	19.7	10.4
Water elevation ^b	m	224.80	225.43	224.99	224.02
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	4.73	3.89	1.25	4.20
Chloride	mg/L	18	18	17	16
Sulfate	mg/L	77	78	75	71
TDS	mg/L	661	671	661	643
Arsenic	mg/L	0.008	0.007	0.007	0.009
Barium	mg/L	0.266	0.260	0.260	0.260
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	3.64	3.87	2.70	3.24
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.249	0.120	0.170	0.230
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	0.036
<i>Unfiltered Samples</i>					
Chloride	mg/L	– ^c	17	–	–
Cyanide (Total)	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Fluoride	mg/L	–	< 0.01	–	–
Hydrogen-3	pCi/L	170	< 100	< 100	< 100
Nitrate	mg/L	–	0.92	–	–
Phenols	mg/L	0.013	< 0.005	0.026	0.033
Sulfate	mg/L	–	77	–	–
TOCs (max. of 4 samples)	mg/L	31	29	29	28
TOXs (max. of 2 samples)	mg/L	< 0.020	< 0.020	< 0.020	< 0.020
Arsenic	mg/L	–	0.009	–	–
Barium	mg/L	–	0.257	–	–
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	–	4.7	–	–
Lead	mg/L	–	< 0.004	–	–
Manganese	mg/L	–	0.13	–	–
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 6.26.

^b Well point elevation = 217.19 m (MSL); ground surface elevation = 227.82 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.33

Groundwater Monitoring Results, Sanitary Landfill Well 800281, 2009

Parameter	Unit	Date of Sampling			
		1/19/2009	4/8/2009	7/14/2009	10/21/2009
<i>Field parameters</i>					
Conductivity	µS/cm	1200^a	1058	1215	1296
Oxid./red. potential	mV	15	6	5	10
pH	pH	6.46	6.61	6.77	6.35
Temperature	°C	6.6	8.5	15.9	14.5
Water elevation ^b	m	226.82	227.23	226.28	224.74
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Chloride	mg/L	55	64	66	61
Sulfate	mg/L	126	149	106	92
TDS	mg/L	610	602	723	674
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.055	0.054	0.064	0.068
Boron	mg/L	0.17	0.15	0.24	0.32
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	0.032	< 0.01	0.150	0.900
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	< 0.025	< 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
<i>Unfiltered Samples</i>					
Chloride	mg/L	– ^c	66	–	–
Cyanide (Total)	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Fluoride	mg/L	–	0.27	–	–
Hydrogen-3	pCi/L	140	< 100	131	115
Nitrate	mg/L	–	< 0.1	–	–
Phenols	mg/L	0.0088	< 0.005	< 0.005	< 0.005
Sulfate	mg/L	–	155	–	–
TOCs (max. of 4 samples)	mg/L	2.1	1.4	2.6	3.0
TOXs (max. of 2 samples)	mg/L	0.041	0.026	0.036	0.026
Arsenic	mg/L	–	< 0.003	–	–
Barium	mg/L	–	0.052	–	–
Boron	mg/L	–	0.15	–	–
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	–	< 0.004	–	–
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 Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^b Well point elevation = 223.85 m (MSL); ground surface elevation = 227.75 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.34

Groundwater Monitoring Results, Sanitary Landfill Well 800291, 2009

Parameter	Unit	Date of Sampling			
		1/13/2009	4/14/2009	7/21/2009	10/21/2009
<i>Field Parameters</i>					
Conductivity	μSs/cm	1140^a	1205	945	1128
Oxid./red. potential	mV	-10	-14	2	-13
pH	pH	6.95	6.86	7.12	6.75
Temperature	°C	8.2	8.1	13.2	13.0
Water elevation ^b	m	228.78	229.28	227.83	226.62
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	0.08	< 0.05	< 0.05	< 0.05
Chloride	mg/L	9	10	11	12
Sulfate	mg/L	181	205	205	187
TDS	mg/L	644	668	674	628
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.019	0.020	0.019	0.019
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	0.020	0.023	0.060	0.085
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
<i>Unfiltered Sample</i>					
Chloride	mg/L	- ^c	11	-	-
Cyanide (Total)	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Fluoride	mg/L	-	0.43	-	-
Hydrogen-3	pCi/L	124	< 100	< 100	< 100
Nitrate	mg/L	-	< 0.10	-	-
Phenols	mg/L	< 0.005	< 0.005	< 0.005	< 0.005
Sulfate	mg/L	-	197	-	-
TOCs (max. of 4 samples)	mg/L	2.0	2.0	2.0	2.1
TOXs (max. of 2 samples)	mg/L	< 0.020	< 0.020	< 0.020	< 0.020
Arsenic	mg/L	-	< 0.003	-	-
Barium	mg/L	-	0.037	-	-
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	-	5.6	-	-
Lead	mg/L	-	< 0.004	-	-
Manganese	mg/L	-	0.12	-	-
Mercury	mg/L	-	< 0.0002	-	-
Nickel	mg/L	-	< 0.05	-	-
Selenium	mg/L	-	< 0.003	-	-
Silver	mg/L	-	< 0.001	-	-
Zinc	mg/L	-	0.03	-	-

^a Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^b Well point elevation = 223.65 m (MSL); ground surface elevation = 230.60 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.35

Groundwater Monitoring Results, Sanitary Landfill Well 800301, 2009

Parameter	Unit	Date of Sampling			
		1/20/2009	4/15/2009	7/8/2009	10/5/2009
<i>Field Parameters</i>					
Conductivity	μS/cm	1117^a	954	944	948
Oxid./red. potential	mV	0	-6	-18	8
pH	pH	7.02	7.02	6.87	7.00
Temperature	°C	5.4	8.1	11.7	11.5
Water elevation ^b	m	229.08	231.95	230.54	228.41
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	0.17	< 0.05	0.19	0.70
Chloride	mg/L	7	7	9	8
Sulfate	mg/L	133	155	163	154
TDS	mg/L	572	594	602	585
Arsenic	mg/L	0.004	< 0.003	< 0.003	0.009
Barium	mg/L	0.021	0.021	0.021	0.027
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	1.42	0.330	0.700	6.53
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.074	0.050	0.180	0.160
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
<i>Unfiltered Samples</i>					
Chloride	mg/L	– ^c	7	–	–
Cyanide (Total)	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Fluoride	mg/L	–	0.38	–	–
Hydrogen-3	pCi/L	111	< 100	< 100	< 100
Nitrate	mg/L	–	< 0.10	–	–
Phenols	mg/L	0.021	< 0.005	< 0.005	< 0.005
Sulfate	mg/L	–	145	–	–
TOCs (max. of 4 numbers)	mg/L	1.3	1.0	1.0	1.6
TOXs (max. of 2 numbers)	mg/L	< 0.020	< 0.020	< 0.020	< 0.020
Arsenic	mg/L	–	< 0.003	–	–
Barium	mg/L	–	0.02	–	–
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	–	0.32	–	–
Lead	mg/L	–	< 0.004	–	–
Manganese	mg/L	–	0.05	–	–
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 6.26.

^b Well point elevation = 225.03 m (MSL); ground surface elevation = 232.69 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.36

Groundwater Monitoring Results, Sanitary Landfill Well 800321, 2009

Parameter	Unit	Date of Sampling			
		1/12/2009	4/6/2009	7/6/2009	10/5/2009
<i>Field Parameters</i>					
Conductivity	µS/cm	2010^a	1546	2050	Dry
Oxid./red. potential	mV	14	9	1	Dry
pH	pH	6.76	6.77	6.53	Dry
Temperature	°C	8.6	7.2	13.1	Dry
Water elevation ^b	m	226.42	226.75	226.07	Dry
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	< 0.05	1.28	< 0.05	Dry
Chloride	mg/L	25	33	39	Dry
Sulfate	mg/L	514	914	1185	Dry
TDS	mg/L	1048	1800	2335	Dry
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	Dry
Barium	mg/L	0.012	< 0.012	0.013	Dry
Boron	mg/L	< 0.1	< 0.1	< 0.1	Dry
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	Dry
Chromium	mg/L	< 0.05	< 0.05	< 0.05	Dry
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	Dry
Copper	mg/L	< 0.025	< 0.025	< 0.025	Dry
Iron	mg/L	< 0.021	< 0.021	< 0.021	Dry
Lead	mg/L	< 0.004	< 0.004	< 0.004	Dry
Manganese	mg/L	< 0.01	0.048	0.033	Dry
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	Dry
Nickel	mg/L	< 0.05	< 0.05	< 0.05	Dry
Selenium	mg/L	< 0.003	< 0.003	< 0.003	Dry
Silver	mg/L	< 0.001	< 0.001	< 0.001	Dry
Zinc	mg/L	< 0.02	< 0.02	< 0.02	Dry
<i>Unfiltered Samples</i>					
Chloride	mg/L	- ^c	36	-	Dry
Cyanide (Total)	mg/L	< 0.01	< 0.01	< 0.01	Dry
Fluoride	mg/L	-	0.5	-	Dry
Hydrogen-3	pCi/L	< 100	< 100	106	Dry
Nitrate	mg/L	-	0.14	-	Dry
Phenols	mg/L	< 0.005	< 0.005	< 0.005	Dry
Sulfate	mg/L	-	983	-	Dry
TOCs (max. of 4 samples)	mg/L	2.0	1.8	2.0	Dry
TOXs (max. of 2 samples)	mg/L	< 0.02	< 0.02	< 0.02	Dry
Arsenic	mg/L	-	0.004	-	Dry
Barium	mg/L	-	0.031	-	Dry
Boron	mg/L	-	< 0.1	-	Dry
Cadmium	mg/L	-	0.0003	-	Dry
Chromium	mg/L	-	< 0.05	-	Dry
Cobalt	mg/L	-	< 0.25	-	Dry
Copper	mg/L	-	< 0.025	-	Dry
Iron	mg/L	-	8.95	-	Dry
Lead	mg/L	-	0.005	-	Dry
Manganese	mg/L	-	0.219	-	Dry
Mercury	mg/L	-	< 0.0002	-	Dry
Nickel	mg/L	-	< 0.05	-	Dry
Selenium	mg/L	-	< 0.003	-	Dry
Silver	mg/L	-	< 0.001	-	Dry
Zinc	mg/L	-	< 0.02	-	Dry

^a Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^b Well point elevation = 223.71 m (MSL); ground surface elevation = 228.03 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.37

Groundwater Monitoring Results, Sanitary Landfill Well 800331, 2009

Parameter	Unit	Date of Sampling			
		2/3/2009	4/13/2009	7/15/2009	10/26/2009
<i>Field Parameters</i>					
Conductivity	µS/cm	823^a	903	858	938
Oxid./red. potential	mV	-16	-17	11	-15
pH	pH	7.27	6.82	6.68	6.91
Temperature	°C	7.9	7.8	12.1	11.8
Water elevation ^b	m	226.96	227.47	227.31	225.74
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	< 0.05	0.16	< 0.05	< 0.05
Chloride	mg/L	5	6	6	7
Sulfate	mg/L	130	117	129	128
TDS	mg/L	467	443	469	471
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.031	0.031	0.026	0.030
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	0.023
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
<i>Unfiltered Samples</i>					
Chloride	mg/L	- ^c	7	-	-
Cyanide (Total)	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Fluoride	mg/L	-	0.21	-	-
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100
Nitrate	mg/L	-	< 0.1	-	-
Phenols	mg/L	0.022	< 0.005	0.006	< 0.005
Sulfate	mg/L	-	120	-	-
TOCs (max. of 4 samples)	mg/L	1.4	1.1	1.8	1.6
TOXs (max. of 2 samples)	mg/L	< 0.020	< 0.020	< 0.020	< 0.020
Arsenic	mg/L	-	< 0.003	-	-
Barium	mg/L	-	0.03	-	-
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	-	0.86	-	-
Lead	mg/L	-	< 0.004	-	-
Manganese	mg/L	-	0.03	-	-
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 6.26.

^b Well point elevation = 222.99 m (MSL); ground surface elevation = 228.05 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.38

Groundwater Monitoring Results, Sanitary Landfill Well 800341, 2009

Parameter	Unit	Date of Sampling				
		1/26/2009	1/26/2009 (Duplicate)	4/22/2009	7/15/2009	10/27/2009
<i>Field Parameters</i>						
Conductivity	µS/cm	1078^a	1078	1054	1003	1024
Oxid./red. potential	mV	-20	-20	-32	-16	-16
pH	pH	7.39	7.39	7.21	7.18	7.37
Temperature	°C	6.6	6.6	7.2	12.7	12.2
Water elevation ^b	m	229.32	229.32	229.86	228.58	227.95
<i>Filtered Samples</i>						
Ammonia nitrogen	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Chloride	mg/L	10	9	10	10	10
Sulfate	mg/L	210	209	166	169	165
TDS	mg/L	569	567	539	562	541
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.027	0.026	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	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
<i>Unfiltered Samples</i>						
Chloride	mg/L	- ^c	-	9	-	-
Cyanide (Total)	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluoride	mg/L	-	-	0.38	-	-
Hydrogen-3	pCi/L	118	139	< 100	< 100	< 100
Nitrate	mg/L	-	-	0.36	-	-
Phenols	mg/L	< 0.005	0.007	< 0.005	0.029	< 0.005
Sulfate	mg/L	-	-	165	-	-
TOCs (max. of 4 samples)	mg/L	2.4	2.2	2.6	2.4	2.3
TOXs (max. of 2 samples)	mg/L	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
Arsenic	mg/L	-	-	< 0.003	-	-
Barium	mg/L	-	-	0.036	-	-
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	-	-	3.56	-	-
Lead	mg/L	-	-	< 0.004	-	-
Manganese	mg/L	-	-	0.065	-	-
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 6.26.

^b Well point elevation = 226.16 m (MSL); ground surface elevation = 230.12 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.39

Groundwater Monitoring Results, Sanitary Landfill Well 800351, 2009

Parameter	Unit	Date of Sampling				
		1/20/2009	4/15/2009	4/15/2009 (Duplicate)	7/8/2009	10/5/2009
<i>Field Parameters</i>						
Conductivity	µS/cm	937^a	870	870	844	853
Oxid./red. potential	mV	-8	-12	-12	-27	-7
pH	pH	7.14	7.12	7.12	7.02	7.26
Temperature	°C	9.4	10.0	10.0	10.4	10.4
Water elevation ^b	m	226.74	229.14	229.14	228.62	226.65
<i>Filtered Samples</i>						
Ammonia nitrogen	mg/L	0.41	0.15	0.18	0.31	0.34
Chloride	mg/L	4	3	3	3	4
Sulfate	mg/L	55	50	53	51	52
TDS	mg/L	465	471	467	468	453
Arsenic	mg/L	0.004	0.003	< 0.003	0.005	0.005
Barium	mg/L	0.084	0.087	0.086	0.085	0.087
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	0.444	0.450	0.320	0.850	1.360
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.022	0.028	0.029	0.020	0.043
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	0.029
<i>Unfiltered Samples</i>						
Chloride	mg/L	- ^c	4	4	-	-
Cyanide (Total)	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluoride	mg/L	-	0.29	0.25	-	-
Hydrogen-3	pCi/L	106	< 100	< 100	< 100	< 100
Nitrate	mg/L	-	< 0.1	< 0.1	-	-
Phenols	mg/L	0.027	< 0.005	< 0.005	0.049	< 0.005
Sulfate	mg/L	-	54	55	-	-
TOCs (max. of 4 samples)	mg/L	1.6	1.3	1.4	1.3	2.0
TOXs (max. of 2 samples)	mg/L	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
Arsenic	mg/L	-	0.006	0.006	-	-
Barium	mg/L	-	0.102	0.102	-	-
Boron	mg/L	-	0.101	< 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	-	7.38	7.42	-	-
Lead	mg/L	-	< 0.004	< 0.004	-	-
Manganese	mg/L	-	0.141	0.148	-	-
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	-	0.021	< 0.02	-	-

^a Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^b Well point elevation = 221.34 m (MSL); ground surface elevation = 232.80 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.40

Groundwater Monitoring Results, Sanitary Landfill Well 800361, 2009

Parameter	Unit	Date of Sampling			
		1/21/2009	4/8/2009	7/7/2009	10/7/2009
<i>Field Parameters</i>					
Conductivity	µS/cm	1026^a	886	881	836
Oxid./red. potential	mV	-5	-7	-22	3
pH	pH	7.09	7.06	6.95	7.05
Temperature	°C	6.0	9.7	13.5	11.1
Water elevation ^b	m	225.31	226.66	225.68	222.23
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	0.07	< 0.05	0.07	0.08
Chloride	mg/L	15	14	14	12
Sulfate	mg/L	158	161	161	156
TDS	mg/L	526	546	527	526
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.030	0.034	0.029	0.026
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	0.016	0.020	0.050	0.059
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
<i>Unfiltered Samples</i>					
Chloride	mg/L	- ^c	14	-	-
Cyanide (Total)	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Fluoride	mg/L	-	0.31	-	-
Hydrogen-3	pCi/L	145	< 100	< 100	< 100
Nitrate	mg/L	-	< 0.1	-	-
Phenols	mg/L	0.012	< 0.005	< 0.005	< 0.005
Sulfate	mg/L	-	164	-	-
TOCs (max. of 4 samples)	mg/L	1.9	1.5	1.4	1.7
TOXs (max. of 2 samples)	mg/L	< 0.020	< 0.020	< 0.020	< 0.020
Arsenic	mg/L	-	< 0.003	-	-
Barium	mg/L	-	0.033	-	-
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	-	0.027	-	-
Lead	mg/L	-	< 0.004	-	-
Manganese	mg/L	-	0.021	-	-
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 6.26.

^b Well point elevation = 220.44 m (MSL); ground surface elevation = 227.62 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.41

Groundwater Monitoring Results, Sanitary Landfill Well 800371, 2009

Parameter	Unit	Date of Sampling				
		1/21/2009	4/8/2009	7/7/2009	10/12/2009	10/12/2009 (Duplicate)
<i>Field Parameters</i>						
Conductivity	µS/cm	1283^a	1161	1143	976	976
Oxid./red. potential	mV	0	-3	-18	4	4
pH	pH	7.00	6.99	6.88	7.02	7.02
Temperature	°C	9.4	11.1	11.0	10.2	10.2
Water elevation ^b	m	218.93	219.07	219.30	219.13	219.13
<i>Filtered Samples</i>						
Ammonia nitrogen	mg/L	0.44	0.58	0.39	0.41	0.40
Chloride	mg/L	3	2	1	3	3
Sulfate	mg/L	425	445	384	324	324
TDS	mg/L	986	993	913	846	827
Arsenic	mg/L	< 0.003	< 0.003	0.003	0.003	< 0.003
Barium	mg/L	0.015	0.016	0.017	0.018	0.019
Boron	mg/L	0.10	0.11	0.11	0.11	0.11
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	0.335	0.450	0.540	0.450	0.270
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.107	0.110	0.090	0.120	0.110
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	0.024
<i>Unfiltered Samples</i>						
Chloride	mg/L	- ^c	2	-	-	-
Cyanide (Total)	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluoride	mg/L	-	0.52	-	-	-
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100	< 100
Nitrate	mg/L	-	0.16	-	-	-
Phenols	mg/L	0.012	< 0.005	0.029	< 0.005	< 0.005
Sulfate	mg/L	-	461	-	-	-
TOCs (max. of 4 samples)	mg/L	1.4	1.3	1.2	1.4	1.1
TOXs (max. of 2 samples)	mg/L	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
Arsenic	mg/L	-	0.008	-	-	-
Barium	mg/L	-	0.035	-	-	-
Boron	mg/L	-	0.12	-	-	-
Cadmium	mg/L	-	< 0.0002	-	-	-
Chromium	mg/L	-	< 0.05	-	-	-
Cobalt	mg/L	-	< 0.25	-	-	-
Copper	mg/L	-	< 0.025	-	-	-
Iron	mg/L	-	9.12	-	-	-
Lead	mg/L	-	0.005	-	-	-
Manganese	mg/L	-	0.26	-	-	-
Mercury	mg/L	-	< 0.0002	-	-	-
Nickel	mg/L	-	< 0.05	-	-	-
Selenium	mg/L	-	< 0.003	-	-	-
Silver	mg/L	-	< 0.001	-	-	-
Zinc	mg/L	-	0.036	-	-	-

^a Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^b Well point elevation = 217.56 m (MSL); ground surface elevation = 227.61 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.42

Groundwater Monitoring Results, Sanitary Landfill Well 800381, 2009

Parameter	Unit	Date of Sampling			
		1/28/2009	4/28/2009	7/15/2009	10/14/2009
<i>Field Parameters</i>					
Conductivity	µS/cm	1314^a	1473	1201	1155
Oxid./red. potential	mV	12	13	-8	15
pH	pH	6.81	6.43	6.70	6.85
Temperature	°C	6.6	11.5	17.4	10.2
Water elevation ^b	m	228.65	230.25	228.26	226.88
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	0.08	< 0.05	< 0.05	0.06
Chloride	mg/L	13	21	14	146
Sulfate	mg/L	403	323	358	408
TDS	mg/L	1066	947	1038	1122
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.026	0.042	0.027	0.034
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	0.030	0.026	< 0.021	0.360
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.084	0.180	0.220	0.280
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
<i>Unfiltered Samples</i>					
Chloride	mg/L	- ^c	19	-	-
Cyanide (Total)	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Fluoride	mg/L	-	0.16	-	-
Hydrogen-3	pCi/L	153	< 100	< 100	< 100
Nitrate	mg/L	-	0.16	-	-
Phenols	mg/L	0.011	< 0.005	0.022	< 0.005
Sulfate	mg/L	-	321	-	-
TOCs (max. of 4 samples)	mg/L	3.1	2.4	2.5	2.7
TOXs (max. of 2 samples)	mg/L	< 0.020	< 0.020	0.023	< 0.020
Arsenic	mg/L	-	< 0.003	-	-
Barium	mg/L	-	0.038	-	-
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	-	0.1	-	-
Lead	mg/L	-	< 0.004	-	-
Manganese	mg/L	-	0.17	-	-
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 6.26.

^b Well point elevation = 224.22 m (MSL); ground surface elevation = 230.97 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.43

Groundwater Monitoring Results, Sanitary Landfill Well 800173D, 2009

Parameter	Unit	Date of Sampling			
		1/26/2009	4/20/2009	7/20/2009	10/19/2009
<i>Field Parameters</i>					
Conductivity	µS/cm	1360^a	1176	1107	1019
Oxid./red. potential	mV	-6	-10	2	-2
pH	pH	7.12	7.06	7.14	7.14
Temperature	°C	10.3	12.1	14.4	14.6
Water elevation ^b	m	193.55	194.15	193.96	193.84
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	1.02	1.14	1.00	0.93
Chloride	mg/L	140	153	140	174
Sulfate	mg/L	123	121	129	124
TDS	mg/L	730	788	804	700
Arsenic	mg/L	0.004	< 0.003	0.003	0.003
Barium	mg/L	0.085	0.086	0.079	0.078
Boron	mg/L	0.14	0.15	0.15	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	1.53	1.93	1.46	1.04
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.063	0.040	0.040	0.052
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
<i>Unfiltered Samples</i>					
Chloride	mg/L	- ^c	147	-	-
Cyanide (Total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	-	0.44	-	-
Hydrogen-3	pCi/L	191	104	< 100	< 100
Nitrate	mg/L	-	< 0.10	-	-
Phenols	mg/L	0.013	< 0.005	< 0.005	0.082
Sulfate	mg/L	-	125	-	-
TOCs (max. of 4 samples)	mg/L	2.4	2.1	2.0	1.9
TOXs (max. of 2 samples)	mg/L	0.034	< 0.02	0.027	< 0.02
Arsenic	mg/L	-	0.004	-	-
Barium	mg/L	-	0.09	-	-
Boron	mg/L	-	0.17	-	-
Cadmium	mg/L	-	< 0.0002	-	-
Chromium	mg/L	-	< 0.05	-	-
Cobalt	mg/L	-	< 0.25	-	-
Copper	mg/L	-	< 0.025	-	-
Iron	mg/L	-	4.99	-	-
Lead	mg/L	-	< 0.004	-	-
Manganese	mg/L	-	0.123	-	-
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 6.26.

^b Well point elevation = 189.07 m (MSL); ground surface elevation = 228.40 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.44

Groundwater Monitoring Results, Sanitary Landfill Well 800183D, 2009

Parameter	Unit	Date of Sampling				
		1/19/2009	1/19/2009 (Duplicate)	4/22/2009	7/13/2009	10/19/2009
<i>Field Parameters</i>						
Conductivity	µS/cm	1604^a	1604	1385	1349	1179
Oxid./red. potential	mV	-7	-7	-9	-13	0
pH	pH	7.14	7.14	7.06	6.79	7.11
Temperature	°C	7.9	7.9	11.8	13.0	13.4
Water elevation ^b	m	193.73	193.73	194.05	193.99	193.80
<i>Filtered Samples</i>						
Ammonia nitrogen	mg/L	1.58	1.60	1.58	1.73	1.60
Chloride	mg/L	270	284	254	261	239
Sulfate	mg/L	101	107	108	105	95
TDS	mg/L	955	916	913	893	797
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.066	0.064	0.070	0.060	0.064
Boron	mg/L	0.15	0.15	0.16	0.16	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	0.852	0.798	0.930	0.980	0.960
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.024	0.021	0.016	0.012	0.019
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
<i>Unfiltered Samples</i>						
Chloride	mg/L	- ^c	-	259	-	-
Cyanide (Total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	-	-	0.5	-	-
Hydrogen-3	pCi/L	< 100	133	< 100	< 100	< 100
Nitrate	mg/L	-	-	< 0.1	-	-
Phenols	mg/L	< 0.005	0.038	0.005	< 0.005	0.062
Sulfate	mg/L	-	-	106	-	-
TOCs (max. of 4 samples)	mg/L	2.9	2.9	2.8	2.5	2.7
TOXs (max. of 2 samples)	mg/L	0.064	0.049	0.035	0.031	0.023
Arsenic	mg/L	-	-	< 0.003	-	-
Barium	mg/L	-	-	0.062	-	-
Boron	mg/L	-	-	0.2	-	-
Cadmium	mg/L	-	-	< 0.0002	-	-
Chromium	mg/L	-	-	< 0.05	-	-
Cobalt	mg/L	-	-	< 0.25	-	-
Copper	mg/L	-	-	< 0.025	-	-
Iron	mg/L	-	-	1.13	-	-
Lead	mg/L	-	-	< 0.004	-	-
Manganese	mg/L	-	-	0.016	-	-
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 6.26.

^b Well point elevation = 180.30 m (MSL); ground surface elevation = 230.32 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.45

Groundwater Monitoring Results, Sanitary Landfill Well 800193D, 2009

Parameter	Unit	Date of Sampling			
		1/12/2009	4/6/2009	7/6/2009	10/7/2009
<i>Field Parameters</i>					
Conductivity	µS/cm	1948^a	1721	1804	1499
Oxid./red. potential	mV	-1	-5	-22	0
pH	pH	7.04	7.02	6.94	7.10
Temperature	°C	10.1	10.2	13.5	11.2
Water elevation ^b	m	193.59	193.98	194.05	193.74
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	1.51	1.33	1.23	1.34
Chloride	mg/L	382	403	379	434
Sulfate	mg/L	107	94	86	83
TDS	mg/L	1118	1123	1119	1001
Arsenic	mg/L	< 0.003	< 0.003	0.004	0.004
Barium	mg/L	0.084	0.086	0.085	0.084
Boron	mg/L	0.14	0.16	0.16	0.13
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	1.39	1.60	1.88	1.93
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.020	0.026	0.020	0.027
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
<i>Unfiltered Samples</i>					
Chloride	mg/L	- ^c	440	-	-
Cyanide (Total)	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Fluoride	mg/L	-	0.41	-	-
Hydrogen-3	pCi/L	158	104	< 100	124
Nitrate	mg/L	-	< 0.1	-	-
Phenols	mg/L	< 0.005	< 0.005	0.009	< 0.005
Sulfate	mg/L	-	91	-	-
TOCs (max. of 4 samples)	mg/L	4.2	5.2	4.5	3.8
TOXs (max. of 2 samples)	mg/L	0.063	0.043	0.055	0.035
Arsenic	mg/L	-	0.005	-	-
Barium	mg/L	-	0.096	-	-
Boron	mg/L	-	0.15	-	-
Cadmium	mg/L	-	< 0.0002	-	-
Chromium	mg/L	-	< 0.05	-	-
Cobalt	mg/L	-	< 0.25	-	-
Copper	mg/L	-	< 0.025	-	-
Iron	mg/L	-	3.45	-	-
Lead	mg/L	-	< 0.004	-	-
Manganese	mg/L	-	0.04	-	-
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 6.26.

^b Well point elevation = 181.28 m (MSL); ground surface elevation = 227.29 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.46

Groundwater Monitoring Results, Sanitary Landfill Well 800203D, 2009

Parameter	Unit	Date of Sampling				
		1/27/2009	4/14/2009	7/14/2009	10/13/2009	10/13/2009 (Duplicate)
<i>Field Parameters</i>						
Conductivity	µS/cm	1349^a	1190	1166	1100	1100
Oxid./red. potential	mV	-3	-7	-22	1	1
pH	pH	7.06	7.04	6.95	7.07	7.07
Temperature	°C	8.1	9.7	16.5	10.8	10.8
Water elevation ^b	m	193.54	194.00	193.97	193.67	193.67
<i>Filtered Samples</i>						
Ammonia nitrogen	mg/L	2.57	2.49	2.69	2.47	2.47
Chloride	mg/L	177	185	152	163	167
Sulfate	mg/L	62	62	59	47	49
TDS	mg/L	753	782	728	691	700
Arsenic	mg/L	0.005	0.006	0.005	0.007	0.007
Barium	mg/L	0.132	0.140	0.130	0.130	0.130
Boron	mg/L	0.14	0.15	0.15	0.14	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	1.46	2.12	1.38	2.09	2.06
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.035	0.036	0.040	0.054	0.037
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
<i>Unfiltered Samples</i>						
Chloride	mg/L	- ^c	168	-	-	-
Cyanide (Total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	-	0.4	-	-	-
Hydrogen-3	pCi/L	110	< 100	< 100	< 100	< 100
Nitrate	mg/L	-	< 0.1	-	-	-
Phenols	mg/L	0.020	< 0.005	< 0.005	< 0.005	< 0.005
Sulfate	mg/L	-	61	-	-	-
TOCs (max. of 4 samples)	mg/L	5.4	4.4	4.4	4.8	4.6
TOXs (max. of 2 samples)	mg/L	0.023	< 0.020	0.020	< 0.020	< 0.020
Arsenic	mg/L	-	0.006	-	-	-
Barium	mg/L	-	0.134	-	-	-
Boron	mg/L	-	0.16	-	-	-
Cadmium	mg/L	-	< 0.0002	-	-	-
Chromium	mg/L	-	< 0.05	-	-	-
Cobalt	mg/L	-	< 0.25	-	-	-
Copper	mg/L	-	< 0.025	-	-	-
Iron	mg/L	-	2.12	-	-	-
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 6.26.

^b Well point elevation = 189.46 m (MSL); ground surface elevation = 227.83 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

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TABLE 6.47

Groundwater Monitoring Results, Sanitary Landfill Well 800383D, 2009

Parameter	Unit	Date of Sampling			
		1/28/2009	4/27/2009	7/15/2009	10/14/2009
<i>Field Parameters</i>					
Conductivity	µS/cm	1241^a	1146	1209	1103
Oxid./red. potential	mV	-5	-9	-25	-1
pH	pH	7.10	7.02	7.01	7.13
Temperature	°C	9.6	13.4	13.8	11.0
Water elevation ^b	m	193.71	194.01	194.04	193.72
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	0.93	0.88	0.90	0.95
Chloride	mg/L	196	145	167	39
Sulfate	mg/L	142	129	124	122
TDS	mg/L	768	738	818	776
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.071	0.075	0.070	0.071
Boron	mg/L	0.16	0.17	0.15	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	1.19	1.19	1.64	1.20
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.084	0.065	0.060	0.065
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	0.140	0.067	< 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	0.021
<i>Unfiltered Samples</i>					
Chloride	mg/L	- ^c	143	-	-
Cyanide (Total)	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Fluoride	mg/L	-	0.46	-	-
Hydrogen-3	pCi/L	109	< 100	< 100	< 100
Nitrate	mg/L	-	< 0.1	-	-
Phenols	mg/L	0.080	< 0.005	< 0.005	< 0.005
Sulfate	mg/L	-	135	-	-
TOCs (max. of 4 samples)	mg/L	2	1.4	1.7	1.6
TOXs (max. of 2 samples)	mg/L	0.027	0.025	0.026	0.026
Arsenic	mg/L	-	< 0.003	-	-
Barium	mg/L	-	0.07	-	-
Boron	mg/L	-	0.17	-	-
Cadmium	mg/L	-	< 0.0002	-	-
Chromium	mg/L	-	0.11	-	-
Cobalt	mg/L	-	< 0.25	-	-
Copper	mg/L	-	< 0.025	-	-
Iron	mg/L	-	2.47	-	-
Lead	mg/L	-	< 0.004	-	-
Manganese	mg/L	-	0.075	-	-
Mercury	mg/L	-	< 0.0002	-	-
Nickel	mg/L	-	0.077	-	-
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 6.26.

^b Well point elevation = 187.80 m (MSL); ground surface elevation = 231.11 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

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There were no detections of these materials in any values. The pH values ranged from 6.35 to 6.46, 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.

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 amounts of dissolved ionic material in the groundwater. Specific conductivity is a measurement of dissolved ionic material in the water and is closely correlated with TDS. All of the downgradient shallow wells exhibited TDS, conductivity, and sulfate results above the background values in at least three of the quarterly samples. Half of the wells had iron or manganese above background levels. The highest concentrations were found in the wells closest to the wetland, west of the landfill (Wells 800201, 800191R, and 800371). These wells also generally exhibit the highest concentrations of dissolved iron and manganese. The lowest dissolved ion concentrations were on the south and east sides of the landfill. 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 a 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 and 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. Two other wells with elevated chloride levels (800191R, and 800321) are near the wetlands and could be affected by road salt in runoff that flows through the wetlands.

Two wells (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. All other inorganic results were generally consistent with background values.

6.5.2.3. Metals

Metals results were obtained for both filtered (each quarter) and unfiltered (once per year) samples. Some samples were collected using bailers and others with the low-flow sampling technique. Filtered results are compared with background concentrations, and unfiltered results are compared with the GQS. The filtered samples contained a number of values above background for soluble iron or soluble manganese in 7 of the 14 downgradient wells. These results may be related to the proximity of the wetland west of the wells, as discussed in the previous section. One sample contained elevated levels of arsenic. No other filtered metal results were elevated during 2009.

Unfiltered sample results included a larger number of detectable levels of several metals; however, only a few were above the GQS. The only exceedances were for iron and manganese. 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, PCBs, pesticides, and herbicides listed in the permit. Consistent with previous years, none of the samples in 2009 contained any organic constituents above analytical detection limits. To simplify the tables, these results are not shown in the data 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 2009, elevated TOC results were found at least once in 6 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. Total phenols was found above background in two 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

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landfill, low concentrations of hydrogen-3 were detected during the RFI. None of the wells sampled in 2009 consistently contained hydrogen-3 above the 100-pCi/L detection limit. However, most of the wells were reported to contain hydrogen-3 in the 100 to 200 pCi/L range during the first two quarters of 2009. Many of the QC control samples analyzed in 2009 for hydrogen-3 were found to contain similar concentrations. 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. During the third and fourth quarter, very few detections of hydrogen-3 were reported.

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 in most of the wells. All but one chloride result in the five wells was greater than background. Ammonia was found to be higher than background in one or more samples from four of the five wells, with the highest value being 2.69 mg/L, compared with a background value of 1.0 mg/L. 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

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 wells. Four of the five dolomite wells had elevated

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iron concentrations during at least one quarter. All five wells were elevated in manganese at least once during 2009. All four samples from well 800203D exceeded the background level for arsenic.

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 in one sample 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 only two wells, TOX in two wells, and total phenols in three wells.

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 five downgradient wells were reported to contain at least one sample above the 100 pCi/L detection limit. Most of these occurred during the first and second quarters, when detectable amounts of tritium were also found in the QC control samples. It is thought that all of these detections were the results of 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 results of sampling activities disturbing sediment or the 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.

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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 five megawatt 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 its internal components, and by removal of material from the yard. The yard area surrounding the CP-5 reactor structure was classified as an SWMU and it was 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.

In late 2009, the final decontamination and demolition of the CP-5 structure was begun. By the end of 2009, preparation of the structure for demolition was underway. Included in these preparation tasks was the removal of three groundwater monitoring wells (330011, 330012D, and 330061) that were located close enough to the building that they would have been damaged during demolition and excavation of the foundation. The wells were sealed on Nov. 2, 2009, by a licensed well driller. There are no plans to replace these wells. While the full set of samples was collected in 2009, future reports will no longer include results from these three wells. In 2010, the entire structure, including the underground foundation, will be removed.

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 monitoring well network in place prior to November 2009. Table 6.48 provides information on the existing wells. The first 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 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. Well 330012D was screened in the dolomite bedrock; the remainder are screened in the glacial drift. Because of the small size of this site and its 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, chloride (filtered samples), and radioactive materials (cesium-137, hydrogen-3, and strontium-90). Field parameters are measured at the same 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 6.49 to 6.57. The results are compared to Class I GQS and any results above these limits are shown in bold.

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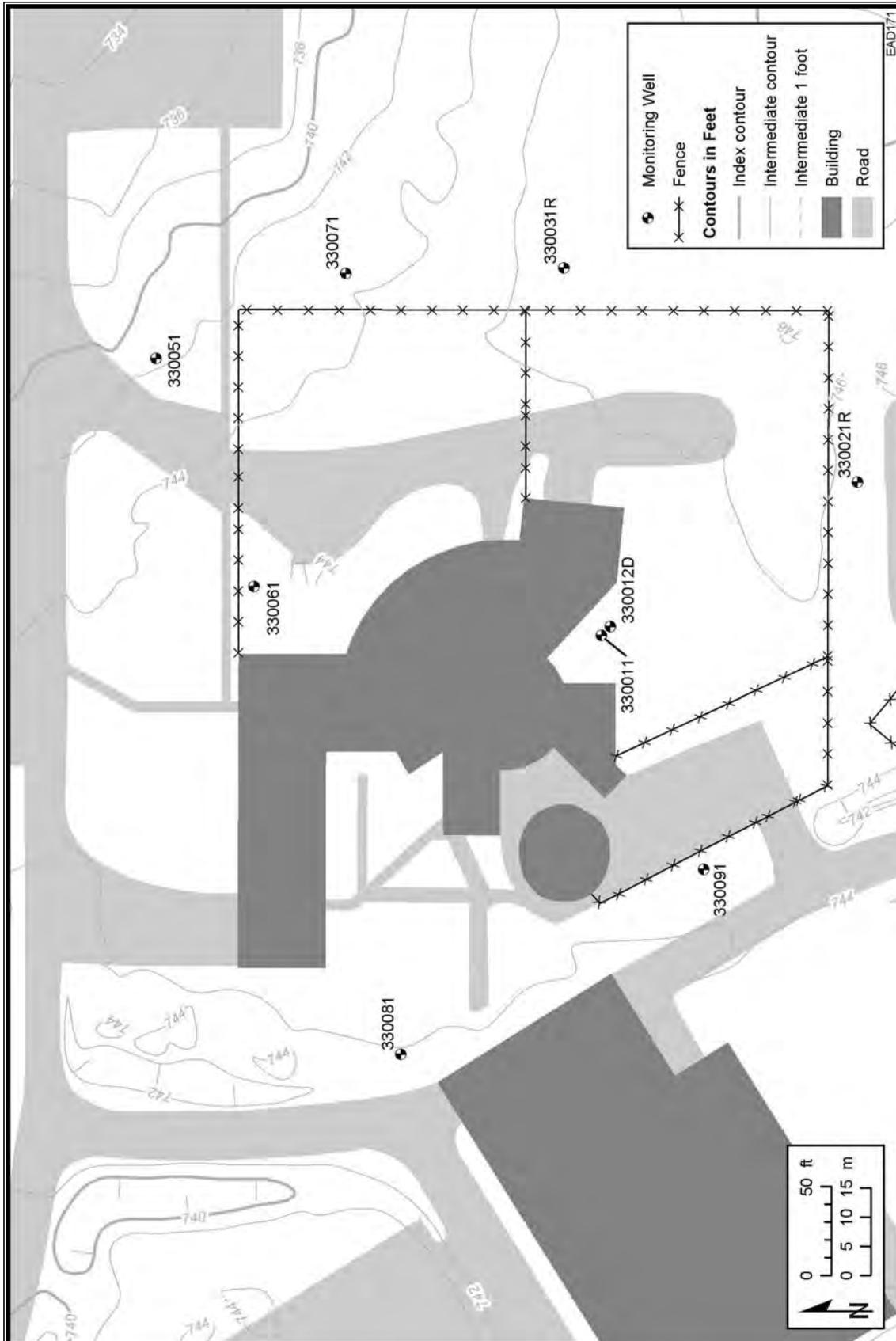


FIGURE 6.21 Monitoring Wells in the CP-5 Reactor Area

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TABLE 6.48

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	227.25	224.04 - 220.99	0.05/PVC	8/89
330012D	41.8	227.20	189.86 - 185.29	0.05/SS	6/97
330021R	11.9	227.17	216.69 - 215.17	0.05/PVC	2/03
330031R	9.8	227.68	219.29 - 217.77	0.05/PVC	2/03
330051	10.7	226.06	216.70 - 215.18	0.05/PVC	5/00
330061	9.8	227.13	218.83 - 217.30	0.05/PVC	2/03
330071	8.8	226.63	219.17 - 217.64	0.05/PVC	2/03
330081	4.6	226.72	223.58 - 222.05	0.05/PVC	2/03
330091	3.8	227.11	224.73 - 223.21	0.05/PVC	2/03

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

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. 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 levels in Wells 330081 and 330091 appear to be related to migration of soluble materials into the groundwater from a road salt storage facility near the wells. A 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 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.

6.6.2. Filtered Samples

Elevated chloride levels were found in four wells. The high conductivity results discussed above correspond to elevated levels of chloride. Wells 330021R, 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.

Seven of the nine wells sampled had at least one sample with soluble metals above analytical detection limits. Arsenic, beryllium, cadmium, iron, manganese, and nickel were detected in one or more samples. Nickel exceeded the GQS of 0.1 mg/L in Wells 330031R, 330051, and 330081. Manganese exceeded the GQS of 0.15 mg/L in Wells 330051, and 330091. It is thought that these metals are of natural origin. There are no known man-made sources of these metals near the CP-5 reactor.

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TABLE 6.49

Groundwater Monitoring Results, 330 Area Well 330011, 2009

Parameter	Unit	Date of Sampling			
		2/24/2009	5/20/2009	8/10/2009	10/16/2009
<i>Field Parameters</i>					
Water elevation ^a	m	225.95	226.11	225.37	225.24
Temperature	°C	9.2	11.9	14.4	13.4
pH	pH	7.03	7.02	7.16	7.10
Redox	mV	-4	-13	0	0
Conductivity	µS/cm	816	939	708	703
<i>Filtered Samples</i>					
Chloride	mg/L	28	39	21	21
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	0.089	< 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
<i>Radioactive Materials</i>					
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	979	1,441	653	651
Strontium-90	pCi/L	0.32	0.43	0.43	0.30

^a Well point elevation = 220.99 m (MSL); ground surface elevation = 227.25 m (MSL); casing material = PVC.

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TABLE 6.50

Groundwater Monitoring Results, 330 Area Well 330012D, 2009

Parameter	Unit	Date of Sampling				
		2/24/2009	2/24/2009	5/20/2009	8/10/2009	10/16/2009
Field Parameters						
Water elevation ^a	m	192.54	192.54	192.97	192.98	192.86
Temperature	°C	11.3	11.3	13.5	14.6	12.6
pH	pH	7.09	7.09	7.05	7.11	7.12
Redox	mV	-8	-8	-15	1	-1
Conductivity	µS/cm	860	860	946	415	395
Filtered Samples						
Chloride	mg/L	21	20	39	24	24
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	304	342	358	265	202
Strontium-90	pCi/L	0.40	0.38	0.43	0.38	0.44

^a Well point elevation = 185.29 m (MSL); ground surface elevation = 227.20 m (MSL); casing material = stainless steel.

6. GROUNDWATER PROTECTION

TABLE 6.51

Groundwater Monitoring Results, 330 Area Well 330021R, 2009

Parameter	Unit	Date of Sampling				
		2/24/2009	5/27/2009	5/27/2009 (Duplicate)	8/5/2009	11/17/2009
<i>Field Parameters</i>						
Water elevation ^a	m	216.81	217.06	217.06	216.89	216.15
Temperature	°C	10.7	12.5	12.5	13.4	10.9
pH	pH	6.36^b	6.58	6.58	6.63	6.67
Redox	mV	11	8	8	12	20
Conductivity	µS/cm	2,304	2,221	2,221	2,179	2,396
<i>Filtered Samples</i>						
Chloride	mg/L	207	232	214	232	247
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	0.042
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	0.0027	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	0.0038	< 0.0025	< 0.0025	0.0028	< 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
<i>Radioactive Materials</i>						
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	359	390	418	232	313
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25

^a Well point elevation = 215.17 m (MSL); ground surface elevation = 227.17 m (MSL); casing material = PVC.

^b Bold type indicates that the value exceeds the applicable limits shown in Table 6.5.

6. GROUNDWATER PROTECTION

TABLE 6.52

Groundwater Monitoring Results, 330 Area Well 330031R, 2009

Parameter	Unit	Date of Sampling			
		2/24/2009	5/26/2009	August	10/20/2009
<i>Field Parameters</i>					
Water elevation ^a	m	223.58	223.74	Dry	221.93
Temperature	°C	11.4	12.2	Dry	11.7
pH	pH	6.78	6.49^b	Dry	6.70
Redox	mV	9	11	Dry	-10
Conductivity	µS/cm	1,558	1,557	Dry	1,502
<i>Filtered Samples</i>					
Chloride	mg/L	122	131	Dry	156
Arsenic	mg/L	< 0.025	< 0.025	Dry	0.029
Barium	mg/L	< 0.5	< 0.5	Dry	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	Dry	< 0.0025
Cadmium	mg/L	0.0028	< 0.0025	Dry	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	Dry	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	Dry	< 0.25
Copper	mg/L	< 0.025	< 0.025	Dry	< 0.025
Iron	mg/L	0.55	< 0.5	Dry	< 0.5
Lead	mg/L	< 0.004	< 0.004	Dry	< 0.004
Manganese	mg/L	< 0.075	< 0.075	Dry	< 0.075
Mercury	mg/L	< 0.0002	< 0.0002	Dry	< 0.0002
Nickel	mg/L	< 0.05	0.27	Dry	< 0.05
Silver	mg/L	< 0.0025	< 0.0025	Dry	< 0.0025
Thallium	mg/L	< 0.002	< 0.002	Dry	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	Dry	< 0.075
Zinc	mg/L	< 0.5	< 0.5	Dry	< 0.5
<i>Radioactive Materials</i>					
Cesium-137	pCi/L	2.3	< 2.0	Dry	< 2.0
Hydrogen-3	pCi/L	33,860	34,270	Dry	33,790
Strontium-90	pCi/L	< 0.25	< 0.25	Dry	< 0.25

^a Well point elevation = 217.77 m (MSL); ground surface elevation = 227.68 m (MSL); casing material = PVC.

^b Bold type indicates that the value exceeds the applicable limits shown in Table 6.5.

6. GROUNDWATER PROTECTION

TABLE 6.53

Groundwater Monitoring Results, 330 Area Well 330051, 2009

Parameter	Unit	Date of Sampling			
		3/3/2009	5/20/2009	8/5/2009	10/20/2009
<i>Field Parameters</i>					
Water elevation ^a	m	222.50	222.83	221.85	221.64
Temperature	°C	11.3	12.6	13.7	13.9
pH	pH	6.98	6.72	6.79	6.80
Redox	mV	-2	-12	-20	-16
Conductivity	μS/cm	1,911	1,967	1,828	1,758
<i>Filtered Samples</i>					
Chloride	mg/L	351^b	334	350	313
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	0.38	< 0.075	0.08	< 0.075
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	0.43	0.09	0.11	0.06
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
<i>Radioactive Materials</i>					
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	183	140	< 100	103
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

^a Well point elevation = 215.18 m (MSL); ground surface elevation = 226.06 m (MSL); casing material = PVC.

^b Bold type indicates that the value exceeds the applicable limits shown in Table 6.5.

6. GROUNDWATER PROTECTION

TABLE 6.54

Groundwater Monitoring Results, 330 Area Well 330061, 2009

Parameter	Unit	Date of Sampling			
		3/3/2009	5/20/2009	8/5/2009	10/20/2009
<i>Field Parameters</i>					
Water elevation ^a	m	221.55	221.86	221.47	221.00
Temperature	°C	13.7	14.9	14.1	14.2
pH	pH	6.76	6.35^b	6.46	6.32
Redox	mV	10	7	1	8
Conductivity	µS/cm	3,080	3,030	3,260	3,440
<i>Filtered Samples</i>					
Chloride	mg/L	692	558	688	821
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	0.055
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	0.0034	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	0.004	< 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	0.11	0.10	0.12	0.13
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	0.06	< 0.05	0.10	0.08
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
<i>Radioactive Materials</i>					
Cesium-137	pCi/L	< 2.0	2.5	< 2.0	< 2.0
Hydrogen-3	pCi/L	974	1,009	874	886
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

^a Well point elevation = 217.30 m (MSL); ground surface elevation = 227.13 m (MSL); casing material = PVC.

^b Bold type indicates that the value exceeds the applicable limits shown in Table 6.5.

6. GROUNDWATER PROTECTION

TABLE 6.55

Groundwater Monitoring Results, 330 Area Well 330071, 2009

Parameter	Unit	Date of Sampling			
		2/24/2009	5/20/2009	8/5/2009	10/20/2009
<i>Field Parameters</i>					
Water elevation ^a	m	223.17	223.32	222.21	221.33
Temperature	°C	10.5	11.8	12.0	11.8
pH	pH	6.92	6.67	6.61	6.81
Redox	mV	1	-9	-12	-13
Conductivity	µS/cm	985	985	961	972
<i>Filtered Samples</i>					
Chloride	mg/L	8	10	10	10
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
<i>Radioactive Materials</i>					
Cesium-137	pCi/L	< 2.0	< 2.0	2.1	2.5
Hydrogen-3	pCi/L	478	407	377	372
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

^a Well point elevation = 217.34 m (MSL); ground surface elevation = 226.63 m (MSL); casing material = PVC.

6. GROUNDWATER PROTECTION

TABLE 6.56

Groundwater Monitoring Results, 330 Area Well 330081, 2009

Parameter	Unit	Date of Sampling			
		2/18/2009	5/12/2009	8/11/2009	11/17/2009
<i>Field Parameters</i>					
Water elevation ^a	m	224.59	224.42	224.08	224.24
Temperature	°C	8.9	11.3	16.8	15.3
pH	pH	6.96	6.94	6.82	7.25
Redox	mV	-23	-9	-23	-14
Conductivity	µS/cm	3,200	5,950	4,990	2,571
<i>Filtered Samples</i>					
Chloride	mg/L	1311^b	1629	1257	681
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	0.0030	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	0.0027	< 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	0.11	0.13	0.09	< 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
<i>Radioactive Materials</i>					
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	118	133	114	117
Strontium-90	pCi/L	0.40	0.36	0.32	< 0.25

^a Well point elevation = 222.05 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 6.5.

6. GROUNDWATER PROTECTION

TABLE 6.57

Groundwater Monitoring Results, 330 Area Well 330091, 2009

Parameter	Unit	Date of Sampling			
		2/18/2009	5/12/2009	8/11/2009	11/17/2009
<i>Field Parameters</i>					
Water elevation ^a	m	225.37	225.20	224.70	224.92
Temperature	°C	9.4	10.6	16.1	14.4
pH	pH	6.43^b	6.91	6.45	6.58
Redox	mV	0	-6	-3	25
Conductivity	µS/cm	32,400	18,850	18,760	19,590
<i>Filtered Samples</i>					
Chloride	mg/L	9,409	5,953	5,570	8,183
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	0.058
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	0.0035	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.004	< 0.0025	0.0036	< 0.0025
Chromium	mg/L	< 0.1	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.5	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 1.0	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.008	< 0.008	< 0.004	< 0.004
Manganese	mg/L	4.12	1.96	2.51	3.72
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.1	0.074	0.051	< 0.05
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.010	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 1.0	< 0.5	< 0.5	< 0.5
<i>Radioactive Materials</i>					
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	613	717	701	651
Strontium-90	pCi/L	0.52	< 0.25	0.31	0.52

^a Well point elevation = 223.21 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 6.5.

6. GROUNDWATER PROTECTION

6.6.3. Radioactive Constituents

Hydrogen-3 was detected during at least one quarter in all of the wells. The only well that exceeded the GQS of 20,000 pCi/L was Well 330031R, which is a replacement well for 300031. The highest concentration of hydrogen-3 in this well was 34,270 pCi/L. Strontium-90 was detected during most quarters in four of the nine wells, with the highest value being 0.52 pCi/L in Well 330091. All of the results are well below the GQS of 8 pCi/L. Cesium-137 was reported slightly above the analytical detection limit of 2 pCi/L in three of the wells. These detections are thought to be artifacts of the analytical process, as observed in other data from 2009.

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 assuming only radioactive decay has been occurring since 1999, using an initial concentration of 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 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 three 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

6. GROUNDWATER PROTECTION

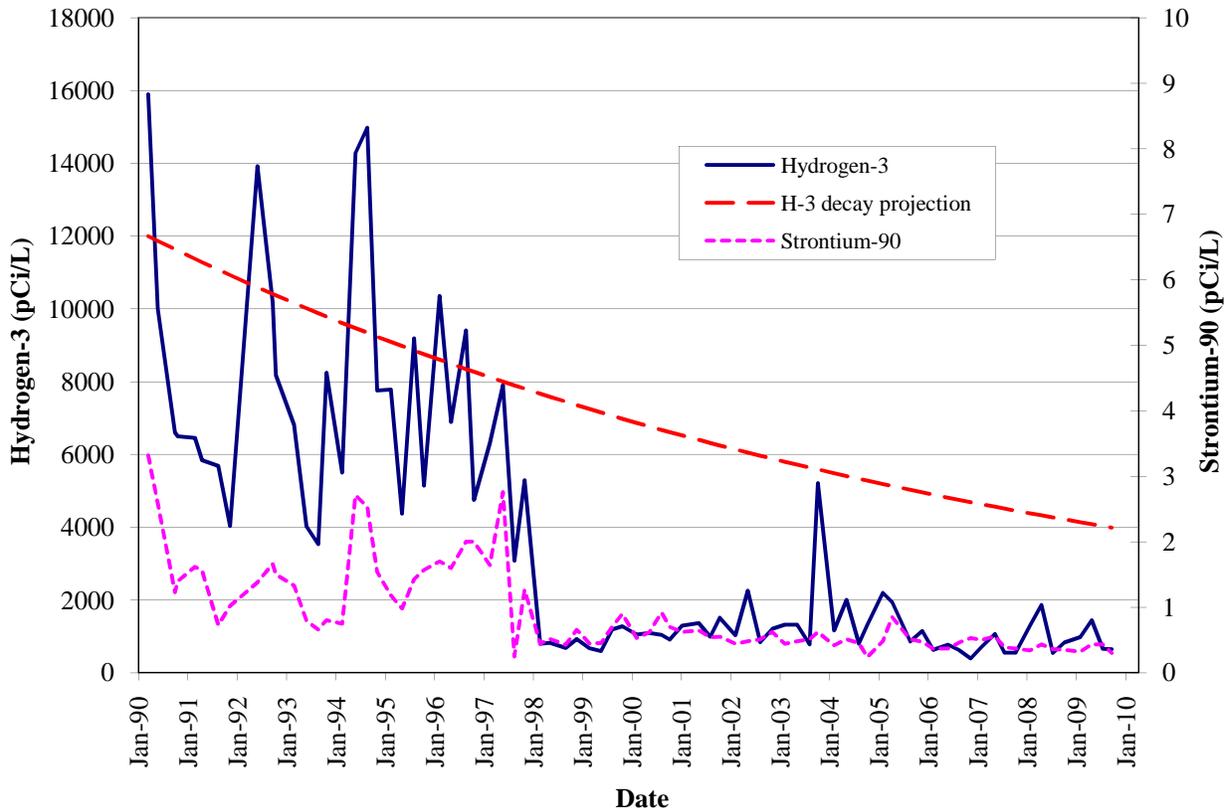


FIGURE 6.22 Hydrogen-3 and Strontium-90 in Well 330011

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. During 2009, a pump was installed in this well to remove as much groundwater from the well as possible. It is hoped that the removal of groundwater from this isolated region of saturated soil will accelerate the reduction in tritium concentrations and prevent it from migration away from the area. Throughout the summer of 2009, approximately 300 gallons of groundwater were removed from the well and discharged to the LWTP.

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. The analytical results that were generated demonstrate the degree of compliance with applicable groundwater standards and limits and they identify the need for groundwater remediation.

6. GROUNDWATER PROTECTION

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 it 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 2009 are summarized in Table 6.58. 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.

TABLE 6.58

Summary of Groundwater Monitoring by Area, 2009

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	2	8	520	95%
Dolomite wells	Environmental Surveillance	10	10	40	40	78%
317/319 Area wells and manholes	Environmental Surveillance	12	12	63	5,661	97%
317/319/ENE and GMZ wells	Permit Compliance/LTS Program	111	82	219	14,854	89%
800 Area Landfill wells	Permit Compliance	21	21	113	10,688	91%
CP-5 wells	Environmental Surveillance	9	9	37	740	82%

7. QUALITY ASSURANCE



7. QUALITY ASSURANCE

Quality assurance is an integral part of every activity at Argonne National Laboratory. A comprehensive Quality Assurance/Quality Control program is in place to ensure that all environmental monitoring samples are representative and all associated data are reliable. The environmental samples are collected by Argonne personnel. About 95% of the samples are analyzed by Argonne personnel in an in-house analytical laboratory. The remaining samples are sent to various contracted laboratories for analysis. Quality Control is maintained through instrument checks; processing blanks, spikes, and duplicates; and processing intercomparison samples. Results are reviewed and verified before being used to support decision making. Quality Assurance is maintained through data quality objectives, internal audits, quality assurance plans, operating manuals, sampling plans, and procurement contracts. Quality Assurance plans and associated documents exist for both radiological and nonradiological analyses. These documents were prepared in accordance with DOE Order 414.1C.²⁸ The *Uniform Federal Policy (UFP) for Implementing Environmental Quality Systems* (March 2005) and the associated draft *Uniform Federal Policy for Quality Assurance Project Plans* (March 2005) documents have been used as guidance in the quality assurance programs.

7.1. Sample Collection

Environmental monitoring samples (soils, waters, and air filters) were collected as specified in various documents, including standard operating procedures, Quality Assurance plans, Argonne's Environmental Monitoring Plan, Argonne's Groundwater Protection Management Plan, and various Argonne permits. Representative sampling is of prime importance. Samples are collected and stored in a manner designed to maintain the integrity of the analytical constituents. 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.

A weekly sample collection schedule is processed using a computer database system. This same computer system is used to track all pertinent information regarding the sample collection, all requested analyses, and the analytical results. Sample log-in information is transferred to the in-house analytical laboratory, along with a chain-of-custody transfer document. After the samples have been analyzed, resultant data is electronically transferred to the same computer system. Multi-level reviews are performed to validate sampling schedules, sample collection information, and resultant data.

7.2. Radiochemical Analysis

All radiological analyses are performed by the in-house analytical laboratory. Details about the radiological analyses are maintained in the in-house laboratory standard operating procedure manual. Standard sources obtained from or traceable to the National Institute of Standards and Technology (NIST) are used to calibrate instrumentation for efficiency. Secondary counting standards are used to check proper instrument response. All results recorded by the in-house laboratory contain an activity level and a total propagated uncertainty, regardless of

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detection limits. Non-detects are reported as “less than” (<) the detection limit found in this annual report. A nuclide is considered not detected if the activity level is below the analytical method detection limit. Detection limits are chosen so that the measurement uncertainty at the 95% confidence level is equal to the measured value. Detection limits for air and water are listed in Table 7.1.

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% of the measured value. Radiological activity levels are measured by observing radionuclide decay. For radionuclides with few decays over time (e.g., long half-lives), the number of decay observations can be small. This can make the relative error in a result as important as the result itself.

Within this annual report, average values at a given location 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. This value does not represent the conventional uncertainty in the average of repeated measurements on the same or identical samples. 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.

7.3. Chemical Analysis

Most non-radiological chemical analyses are performed by the in-house analytical laboratory. Approximately 5% of non-radiological analyses are performed by a contracted analytical laboratory. Chemical analyses details are maintained in the standard operating procedure manuals of the individual analytical laboratories. Contract laboratories are subject to the procurement technical specifications defined by Argonne, in addition to reviews conducted by Argonne employees.

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
Strontium-90	0.01	0.25
Uranium-234	–	0.01
Uranium-235	–	0.01
Uranium-238	–	0.01
Alpha	0.2	0.2
Beta	0.5	1

^a A dash indicates that a value is not required.

Standard reference materials that are traceable to NIST are utilized to ensure the accuracy of most inorganic analyses, and they are replaced annually. Detection limits for metal analyses are listed in Table 7.2. 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 over an extended time period. Recovery of inorganic metals, as determined by “spiking” unknown solutions, must be within the range of 75 to 120%. 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. Standards certified by the American Association for Laboratory Accreditation are utilized to ensure the accuracy of most organic analyses. At least one standard mixture is analyzed each month. Quantification limits vary with the analytical method and are listed within the appropriate standard operating procedure.

7.4 . Demonstration of Proficiency

In 2009, Argonne participated in two environmental proficiency testing programs: the Mixed Analyte Performance Evaluation Program (MAPEP) administered by the Radiological and Environmental Sciences Laboratory (RESL), and the Discharge Monitoring Report-Quality Assurance Program (DMR-QA) administered by the EPA. Proficiency testing programs involve an accredited proficiency test provider sending a series of intercomparison samples to Argonne. Argonne analyzes the samples and submits analytical results to the provider. The laboratory’s proficiency is determined by comparing the analytical results with the provider’s reference values. Argonne has consistently performed very well on these tests.

The MAPEP program consists of semiannual distribution of sample matrices containing combinations of radionuclides. The results are provided in Tables 7.3 and 7.4. The 2009 Argonne performance on the MAPEP intercomparison samples resulted in 98% (49 out of 50) of the analyses being in the MAPEP acceptable range. The one not-acceptable result was investigated, and a corrective action statement was issued. The cobalt-60 in air filter results for both MAPEP20 and MAPEP21 studies were rated as acceptable with warning. A corrective action statement summarizing the investigation was prepared and issued.

TABLE 7.2

Metals Detection Limits, 2009		
Parameter	AA ^a (mg/L)	ICP ^b (mg/L)
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-optical emission spectroscopy.

^c NA = not analyzed.

^d Colorimetric measurement.

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TABLE 7.3

Summary of MAPEP Series 20 Intercomparison Sample Results, June 2009

Analyte	Matrix	Units	Reported Value	Reference Value	Acceptance Range	Performance Evaluation
Am-241	Air filter	Bq/filter	0.19	0.205	0.144–0.267	Acceptable
Cs-134	Air filter	Bq/filter	2.25	2.93	2.05–3.81	Acceptable With Warning
Cs-137	Air filter	Bq/filter	1.65	1.52	1.06–1.98	Acceptable
Co-57	Air filter	Bq/filter	1.44	1.30	0.91–1.69	Acceptable
Co-60	Air filter	Bq/filter	1.55	1.22	0.85–1.59	Acceptable With Warning
Mn-54	Air filter	Bq/filter	1.99	2.27	1.59–2.95	Acceptable
Pu-238	Air filter	Bq/filter	0.17	0.18	0.12–0.23	Acceptable
Pu-239/240	Air filter	Bq/filter	0.14	0.157	0.110–0.204	Acceptable
Sr-90	Air filter	Bq/filter	0.56	0.640	0.448–0.832	Acceptable
U-234/233	Air filter	Bq/filter	0.18	0.198	0.139–0.257	Acceptable
U-238	Air filter	Bq/filter	0.19	0.21	0.15–0.27	Acceptable
Zn-65	Air filter	Bq/filter	0.94	1.36	0.95–1.77	Not Acceptable
Am-241	Water	Bq/L	0.64	0.636	0.445–0.827	Acceptable
Cs-134	Water	Bq/L	18.3	22.5	15.8–29.3	Acceptable
Cs-137	Water	Bq/L	0.3	<0.2	–0.2–0.2	Acceptable
Co-57	Water	Bq/L	18.6	18.9	13.2–24.6	Acceptable
Co-60	Water	Bq/L	18.1	17.21	12.05–22.37	Acceptable
H-3	Water	Bq/L	332	330.9	231.6–430.2	Acceptable
Mn-54	Water	Bq/L	14.4	14.66	10.26–19.06	Acceptable
Pu-238	Water	Bq/L	1.06	1.18	0.83–1.53	Acceptable
Pu-239/240	Water	Bq/L	0.74	0.853	0.597–1.109	Acceptable
Sr-90	Water	Bq/L	6.76	7.21	5.05–9.37	Acceptable
U-234/233	Water	Bq/L	2.70	2.77	1.94–3.60	Acceptable
U-238	Water	Bq/L	2.77	2.88	2.02–3.74	Acceptable
Zn-65	Water	Bq/L	13.1	13.6	9.5–17.7	Acceptable

The DMR-QA program consists of an annual distribution of sample proficiency testing standards containing combinations of non-radiological components. The results are provided in Table 7.5. Argonne's performance in the 2009 DMR-QA intercomparison study resulted in 94% (34 out of 36) of the analyses being in the DMR-QA acceptable range. The two not-acceptable results were investigated, and a corrective action statement summarizing the investigation was prepared and issued.

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TABLE 7.4

Summary of MAPEP Series 21 Intercomparison Sample Results, December 2009

Analyte	Matrix	Units	Reported Value	Reference Value	Acceptance Range	Performance Evaluation
Am-241	Air filter	Bq/filter	0.01	<0.01	-0.01-0.01	Acceptable
Cs-134	Air filter	Bq/filter	-0.28	<0.15	-0.15-0.15	Acceptable
Cs-137	Air filter	Bq/filter	1.46	1.40	0.98-1.82	Acceptable
Co-57	Air filter	Bq/filter	6.51	6.48	4.54-8.42	Acceptable
Co-60	Air filter	Bq/filter	1.30	1.03	0.72-1.34	Acceptable With Warning
Mn-54	Air filter	Bq/filter	5.60	5.49	3.84-7.14	Acceptable
Pu-238	Air filter	Bq/filter	0.10	0.091	0.064-0.118	Acceptable
Pu-239/240	Air filter	Bq/filter	0.15	0.138	0.097-0.179	Acceptable
Sr-90	Air filter	Bq/filter	0.90	0.835	0.585-1.086	Acceptable
U-234/233	Air filter	Bq/filter	0.31	0.300	0.210-0.390	Acceptable
U-238	Air filter	Bq/filter	0.32	0.312	0.218-0.406	Acceptable
Zn-65	Air filter	Bq/filter	3.79	3.93	2.75-5.11	Acceptable
Am-241	Water	Bq/L	0.94	1.04	0.73-1.35	Acceptable
Cs-134	Water	Bq/L	24.8	32.2	22.5-41.9	Acceptable With Warning
Cs-137	Water	Bq/L	40.5	41.2	28.8-53.6	Acceptable
Co-57	Water	Bq/L	36.4	36.6	25.6-47.6	Acceptable
Co-60	Water	Bq/L	15.6	15.4	10.8-20.0	Acceptable
H-3	Water	Bq/L	645.5	634.1	443.9-824.3	Acceptable
Mn-54	Water	Bq/L	-0.24	<0.17	-0.17-0.17	Acceptable
Pu-238	Water	Bq/L	0.02	0.018	-0.003-0.003	Acceptable
Pu-239/240	Water	Bq/L	1.28	1.64	1.15-2.13	Acceptable With Warning
Sr-90	Water	Bq/L	13.0	12.99	9.09-16.89	Acceptable
U-234/233	Water	Bq/L	2.80	2.96	2.07-3.85	Acceptable
U-238	Water	Bq/L	2.85	3.03	2.12-3.94	Acceptable
Zn-65	Water	Bq/L	23.6	26.9	18.8-35.0	Acceptable

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TABLE 7.5

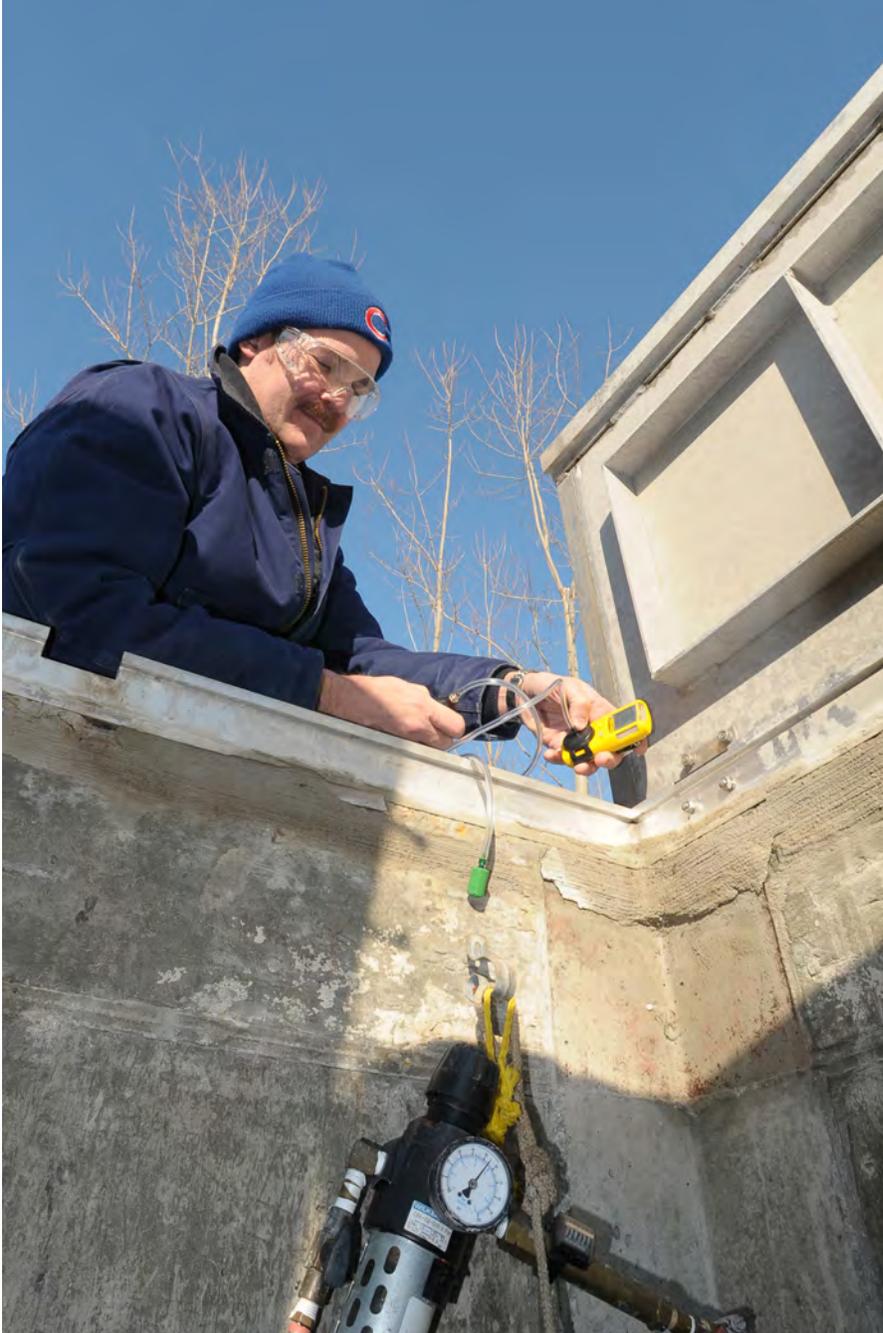
Summary of DMR-QA Study 29 Intercomparison Samples Results, 2009

Analyte	Units	Reported Value	Assigned Value	Acceptance Limits	Performance Evaluation
Antimony	µg/L	228	226	150–276	Acceptable
Arsenic	µg/L	358	361	301–424	Acceptable
Barium	µg/L	1662	1670	1450–1880	Acceptable
Beryllium	µg/L	451	474	403–535	Acceptable
Boron	µg/L	1864	1840	1500–2140	Acceptable
Cadmium	µg/L	539	555	474–630	Acceptable
Chromium	µg/L	264	262	227–298	Acceptable
Cobalt	µg/L	860	808	711–905	Acceptable
Copper	µg/L	558	555	500–610	Acceptable
Iron	µg/L	238	237	206–273	Acceptable
Lead	µg/L	557	547	476–615	Acceptable
Manganese	µg/L	711	702	630–780	Acceptable
Mercury	µg/L	17	15.2	9.35–20.6	Acceptable
Nickel	µg/L	287	282	250–318	Acceptable
Selenium	µg/L	1656	1700	1350–1970	Acceptable
Silver	µg/L	570	569	488–652	Acceptable
Thallium	µg/L	308	314	241–386	Acceptable
Vanadium	µg/L	726	726	636–812	Acceptable
Zinc	µg/L	377	378	323–438	Acceptable
Hexavalent chromium	µg/L	271	271	218–321	Acceptable
Chloride	mg/L	56	66.3	56.6–76.4	Not acceptable
Fluoride	mg/L	2.40	2.56	2.12–3.01	Acceptable
Sulfate	mg/L	37	40.4	32.8–47.0	Acceptable
Phosphorus	mg/L	4.87	4.70	3.88–5.56	Acceptable
Biochemical oxygen demand ^a	mg/L	50	42.3	21.1–63.4	Acceptable
Chemical oxygen demand	mg/L	57.6	68.2	48.4–82.4	Acceptable
Ammonia nitrogen ^a	mg/L	13.47	10.5	7.78–13.1	Not acceptable
Total residual chlorine	mg/L	2.015	1.99	1.43–2.46	Acceptable
Total Cyanide ^{a,b}	–	–	–	–	Acceptable
pH	S.U.	8.48	8.53	8.33–8.73	Acceptable
Total Phenolics ^{a,b}	–	–	–	–	Acceptable
Total suspended solids	mg/L	72.0	73.2	59.2–81.9	Acceptable
Total dissolved solids	mg/L	262	267	199–335	Acceptable
Oil & grease	mg/L	54.8	52.5	34.1–63.8	Acceptable
Fathead minnow acute toxicity ^a	LC ₅₀	30.8	31.3	11.4–50.1	Acceptable
Water flea acute toxicity ^a	LC ₅₀	34.2	32.0	4.97–59.1	Acceptable

^a Analysis performed by a contract laboratory.

^b In lieu of participation in DMR-QA Study 29, results of WP-0109 Study from January 2009 were used.

8. APPENDIX



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8.2. Distribution for 10/02

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G.A. Kulma	G. Winner (3)
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W.D. Luck	G.H. Zeman

External:

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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, Ross Natoli, Office of Corporate Safety Analysis, Office of Analysis, HS-32(3)
DOE-HQ, P.M. Dehmer, Office of Science, SC-2
DOE-HQ, Sat Goel, Office of Science, SC-31.1
DOE-NBL, J.W. Neuhoff
DOE-ASO, J.M. Livengood (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
Teri Dykhuis, Fermi National Accelerator Laboratory, Batavia, Illinois
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