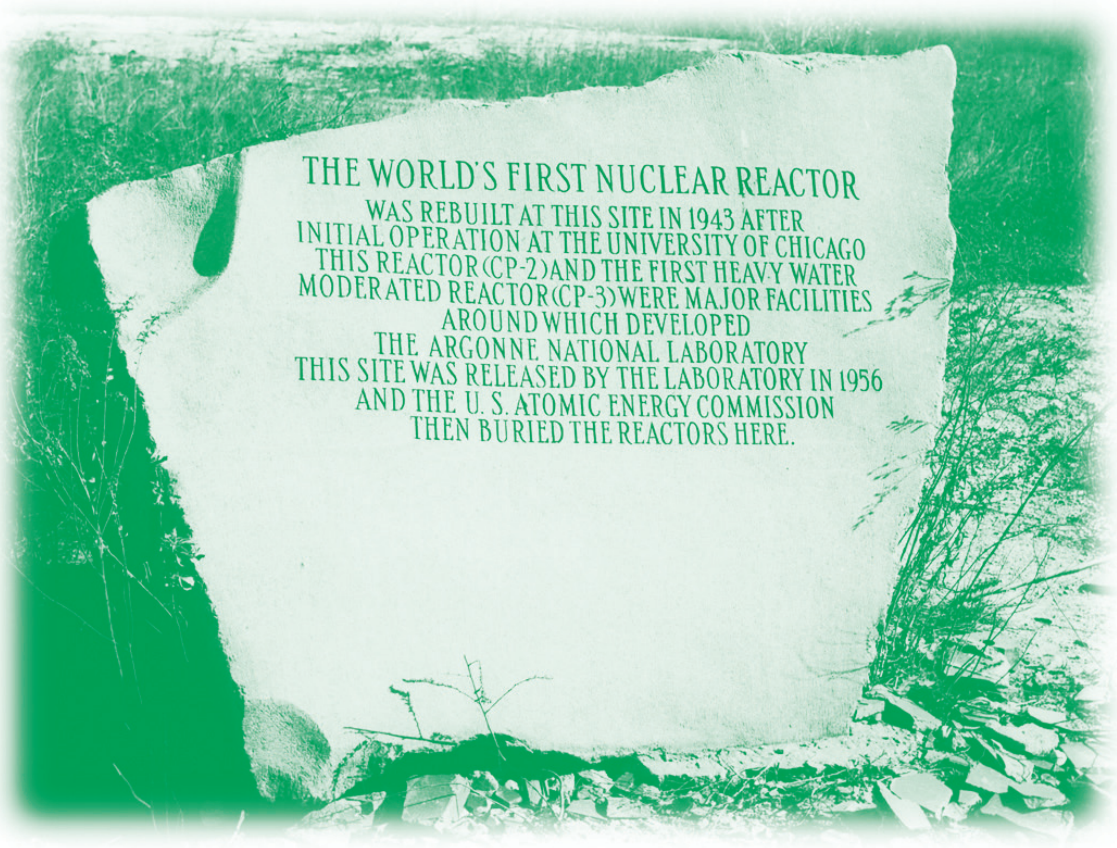
Argonne NATIONAL LABORATORY

ANL-12/01

Surveillance of Site A and Plot M Report for 2011

Environment, Safety, and Quality Assurance



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

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

ANL-12/01

Surveillance of Site A and Plot M
Report for 2011

by
Norbert W. Golchert and Lawrence P. Moos
Environment, Safety, and Quality Assurance, Argonne National Laboratory

June 2012

Page intentionally left blank

PREFACE

This report is prepared for the U. S. Department of Energy (DOE) by the Environment, Safety, and Quality Assurance Division (ESQ) at Argonne National Laboratory (Argonne). The results of the environmental monitoring program at Site A and Plot M and an assessment of the impact of the site on the environment and the public are presented in this publication. Funding to support this program was provided by the DOE Office of Legacy Management (LM) through the DOE Grand Junction Office.

Most of the tables and some of the figures were prepared by Jennifer Tucker of the Data Management Team. Sample collection and field measurements were conducted under the direction of Lawrence Moos of the ESQ Environmental Monitoring Group by:

Jenny Gomez
Rob Piorkowski
Nathan Visser

The analytical separations and measurements were conducted under the direction of Theresa Davis of the ESQ Analytical Services by:

Tim Branch
Alan Demkovich
Robert Froom
Mary Salisbury
Anil Thakkar
Bettylou Wahl
Jianhua Zhang

This manuscript was typed and prepared for publication by Terri Schneider (ESQ).

Page intentionally left blank

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Page intentionally left blank

SURVEILLANCE OF SITE A AND PLOT M
REPORT FOR 2011

ABSTRACT

The results of the environmental surveillance program conducted at Site A/Plot M in the Palos Forest Preserve area for Calendar Year 2011 are presented. Based on the results of the 1976-1978 radiological characterization of the site, a determination was made by DOE that a surveillance program be established. The characterization study determined that very low levels of hydrogen-3 (as tritiated water) had migrated from the burial ground and were present in two nearby hand-pumped picnic wells. The surveillance program, which began in 1980, was modified in 2004 and currently consists of sample collection and analysis of surface and subsurface water. The results of the analyses are used to monitor the migration pathway of hydrogen-3 contaminated water from the burial ground (Plot M) to two hand-pumped picnic wells (currently disabled due to unrelated bacterial contamination) and monitor for the presence of radioactive materials in the environment near the site. Hydrogen-3 in the Red Gate Woods picnic wells was detected again this year. The average concentrations in the wells were higher than in recent years, but were similar to average concentrations seen within the last five years. The maximum concentration in Well 5159 was the highest observed to date, though similar to historical maximums. Hydrogen-3 continues to be detected in a number of monitoring wells, boreholes, dolomite holes, and a surface stream. The hydrogen-3 concentrations in well BH06 adjacent to Plot M exhibited unusually high concentrations the last two quarters of 2011 while Well BH09, a slant well located under Plot M, exhibited unusually low hydrogen-3 concentrations. Similar to results observed since 1984, the 2011 results indicate the presence of low levels of strontium-90 in water from four boreholes next to Plot M and two at Site A. The results of the surveillance program continue to indicate that the radioactivity remaining at Site A/Plot M does not endanger the health or safety of the public visiting the site, using the picnic area, or living in the vicinity.

Page intentionally left blank

1.0 INTRODUCTION

1.1 Site History

This report presents and discusses the surveillance data obtained during 2011. The surveillance program is the ongoing activity that resulted from the 1976-1978 radiological characterization of the former site of Argonne National Laboratory and its predecessor, the University of Chicago's Metallurgical Laboratory. This site was part of the World War II Manhattan Engineer District Project and was located in the Palos Forest Preserve southwest of Chicago, IL. The Laboratory used two locations in the Palos Forest Preserve: Site A, a 19-acre area that contained experimental laboratories and nuclear reactor facilities; and Plot M, a 150 ft x 140 ft area used for the burial of radioactive waste. The location of the Palos Forest Preserve is shown in Figure 1.1 and the locations of Site A and Plot M are shown in Figure 1.2. Previous comprehensive reports on this subject[1,2] provide additional detail and illustrations on sampling locations and provide descriptive material along with the results through 1981. There are annual reports available for 1982 through 2010.[3-31] While earlier data will not be repeated in this report, reference is made to some of the results.

Operations at Site A began in 1943 and ceased in 1954. Among the research programs carried out at Site A were reactor physics studies, fission product separations, hydrogen-3 recovery from irradiated lithium, and work related to the metabolism of radionuclides in laboratory animals. Radioactive waste and radioactively-contaminated laboratory articles from these studies were buried at Plot M. At the termination of the programs, the reactor fuel and heavy water, used for neutron moderation and reactor cooling, were removed and shipped to Oak Ridge National Laboratory. The biological shield for the CP-3 reactor located at Site A, together with various pipes, valves, and building debris, was buried in place in 1956.

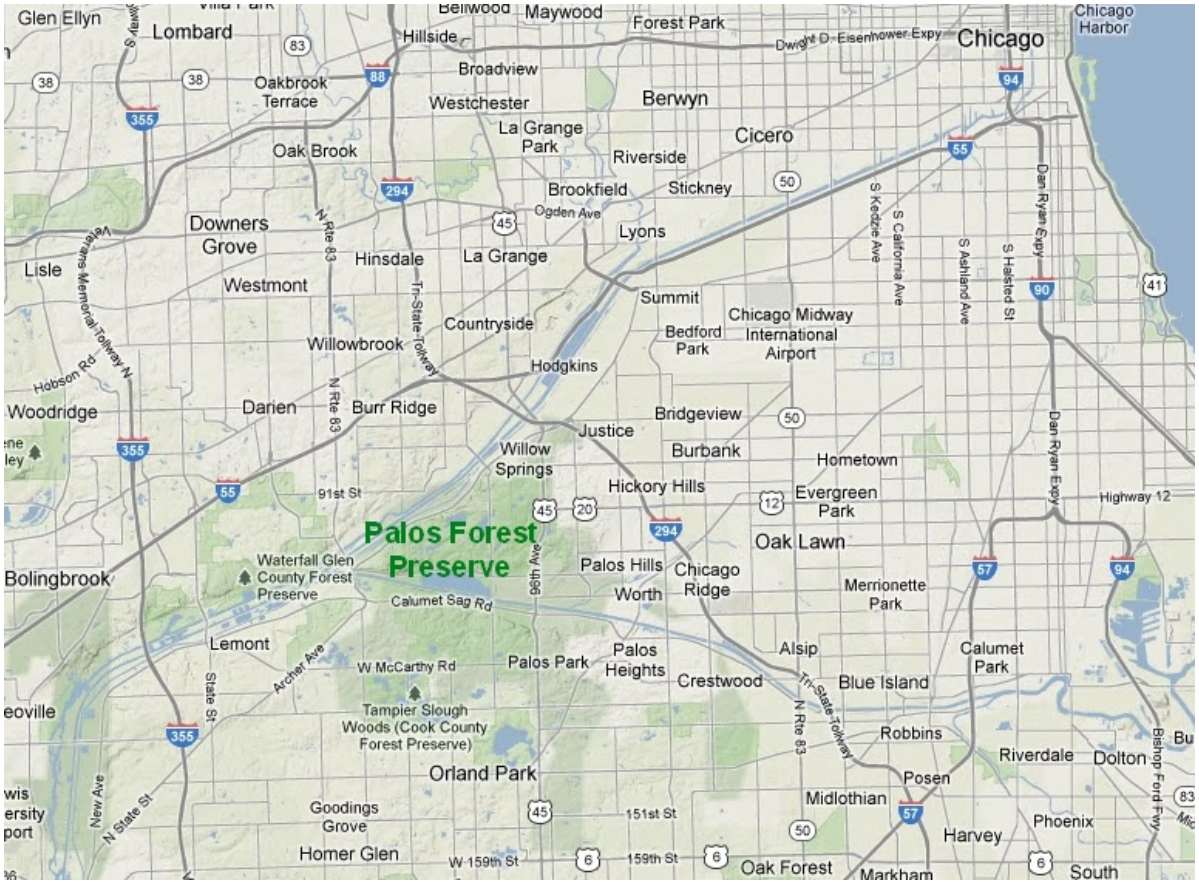


Figure 1.1 Location of Palos Forest Preserve on Chicago-Area Map

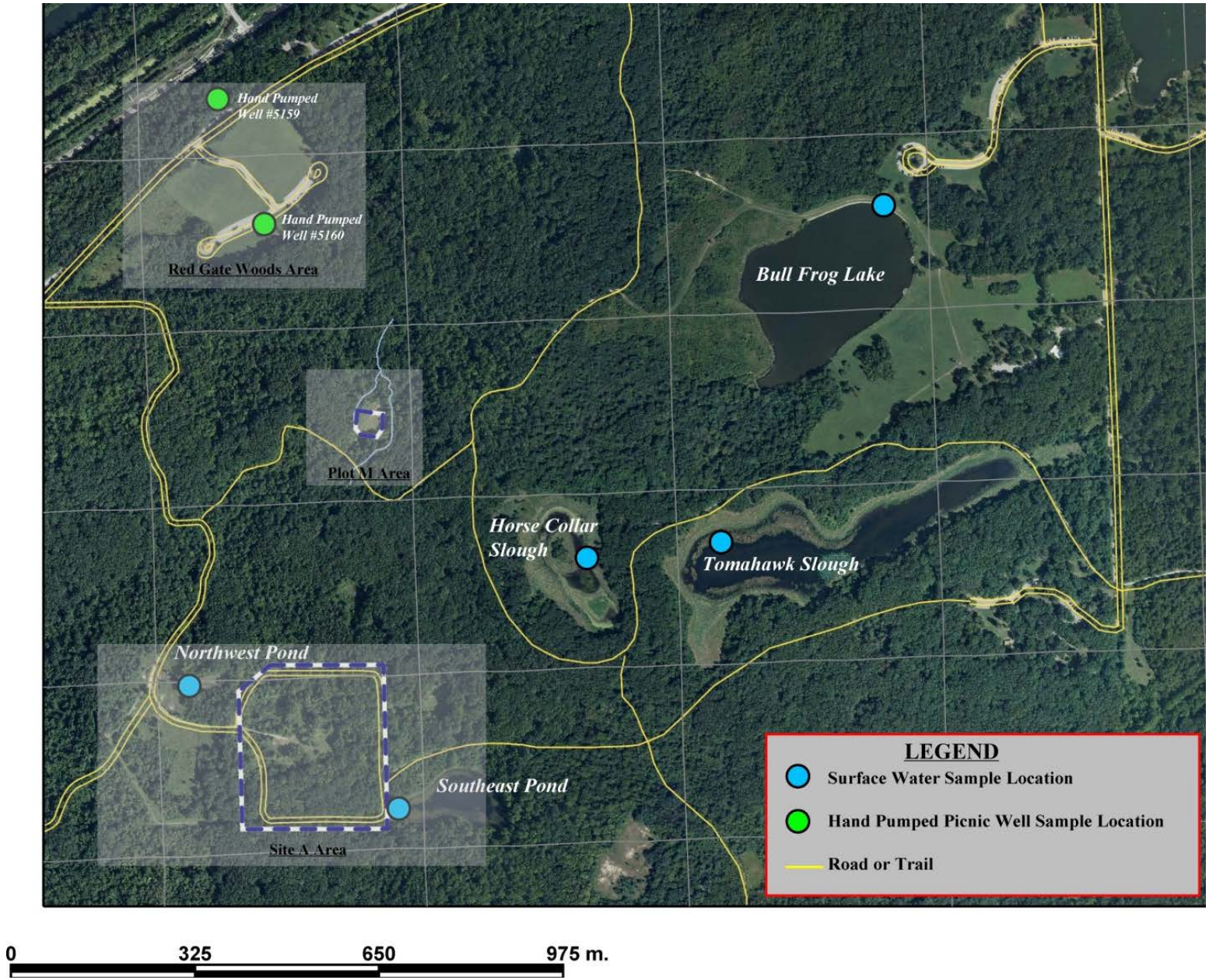


Figure 1.2 Palos Forest Preserve Showing Location of Site A/Plot M Surface Water Bodies and Former Picnic Wells

Burial of radioactive waste at Plot M began in 1944 and was discontinued in 1949. Waste was buried in six-foot deep trenches and covered with soil until 1948, after which burial took place in steel bins. The steel bins were removed in 1949 and sent to Oak Ridge National Laboratory for disposal, but the waste buried in trenches was allowed to remain in place. Concrete sidewalls, eight feet deep, were poured around the perimeter of the burial area and a one-foot thick reinforced concrete slab was poured over the top. The concrete slab was covered with soil and seeded with grass. Both the Site A and Plot M areas were decommissioned in 1956.

In 1973, elevated levels of hydrogen-3 (as tritiated water) were detected by Argonne in two nearby hand-pumped picnic wells (#5167 and #5159). Later investigations found the hydrogen-3 to be migrating from the burial plot into the surrounding soil and aquifers. As a result, a radiological survey of the entire Palos Forest Preserve site was conducted by Argonne in 1976 with special emphasis on the Site A and Plot M areas.[1]

In 1990, elevated levels of radioactivity were discovered outside the original developed area. In 1997, additional characterization and remediation was completed by DOE to remove residual radioactivity and document the remediation of the area.

The terminology used in previous reports is continued in this report. A hole drilled and completed into the glacial drift is called a borehole. Some boreholes were cased and screened to form monitoring wells. Water from such wells is called groundwater. Test wells drilled into the dolomite bedrock are called dolomite holes or deep holes. Water from such wells is called dolomite water. The former hand-pumped drinking water wells, which are completed into or close to the dolomite bedrock, are called water wells or picnic wells. They are identified by a location name or well number. Except for well #5160, these were in existence before the radiological and hydrological monitoring of the area was begun.

The results of radioactivity measurements are expressed in this report in terms of picocuries per liter (pCi/L) for strontium-90 and nanocuries per liter (nCi/L) for hydrogen-3 in water samples. Radiation effective dose equivalent calculations are reported in units of millirem (mrem) or millirem per year (mrem/y). The use of the term dose throughout this report means effective dose equivalent. Other abbreviations of units are defined in the text.

1.2 Site Characteristics

Geologically, Plot M is constructed on a moraine upland which is dissected by two valleys, the Des Plaines River valley to the north and the Calumet Sag valley to the south. The upland is characterized by rolling terrain with poorly developed drainage. Streams are intermittent and drain internally or flow to one of the valleys. The area is underlain by glacial drift, dolomite, and other sedimentary rocks. The uppermost bedrock is Silurian dolomite, into which both the picnic wells and some of the monitoring wells are placed, as described in the text. The dolomite bedrock is about 200 feet thick. The overlying glacial drift has a thickness that ranges from 165 feet at Site A to zero at the Des Plaines River and Calumet Sag Canal, and some of the monitoring wells terminate in this layer. The depth to bedrock at Plot M is about 130 feet.

Hydrologically, the surface water consists of ponds and intermittent streams. When there is sufficient precipitation, the intermittent stream that drains Plot M flows from the highest point near Site A, past Plot M, then continues near the Red Gate Woods well (#5160 in Figure 1.2) and discharges into the Illinois and Michigan (I&M) Canal. The groundwater in the glacial drift and dolomite forms two distinct flow systems. The flow in the drift is controlled principally by topography. The flow in the dolomite, which is recharged by groundwater from the glacial drift, is controlled by two discharge areas, the Des Plaines River Valley to the north and the Calumet Sag Canal to the south. There is no groundwater usage downgradient of Site A/Plot M. The two remaining former hand-pumped picnic wells have been disabled by removing the handles. These wells are currently used only for groundwater monitoring.

The climate is that of the upper Mississippi valley, as moderated by Lake Michigan, and is characterized by cold winters and hot summers. Precipitation averages about 37 inches annually. The largest rainfalls occur between April and September. The average monthly temperature ranges from 21°F in January to 73°F in July. Approximately 9.2 million people reside within 50 miles of the site; the population within a five-mile radius is about 150,000. The only portion of the Palos Forest Preserve in the immediate area of Plot M and Site A that is developed for public use is the Red Gate Woods picnic area (Figure l.2), although small numbers of individuals use the more remote areas of the Palos Forest Preserve.

1.3 Purpose of Monitoring Program

The monitoring conducted at Site A/Plot M was conducted in accordance with the *Long-Term Surveillance and Maintenance Plan for Site A and Plot M, Palos Forest Preserve, Cook County, Illinois*, issued in December 2004[32]. DOE−LM conducts stewardship activities at Site A and Plot M to protect human health and the environment and to comply with applicable regulations. The overall goal of this plan is to maintain protectiveness at the site through a combination of government ownership, conducting regular inspections, maintaining public awareness, and monitoring environmental media and institutional controls. This report discussed the results of the monitoring portion of this plan.

The sampling locations for the monitoring program are based on technical and stakeholder concerns. The distribution of sampling locations was chosen to ensure that conditions will be known to remain protective. The main constituents of concern (COC) in groundwater and surface water at Site A/Plot M are hydrogen-3 and strontium-90. The current monitoring program is focused on these parameters. The Long Term Stewardship Plan defines the following two major monitoring objectives:

- Ensure that existing contaminant concentrations continue to decrease as expected due to radioactive decay and other natural processes, and
- Detect any potential future releases.

The monitoring program is assessed every three to five years to determine if these goals are being met. At each review, changes to the monitoring program may be recommended. Since several of the wells and surface water locations currently exceed the Illinois EPA Class I Ground Water Quality Standards for hydrogen-3, it is likely that monitoring of Site A/Plot M will continue for the foreseeable future, with occasional modification to the sampling program. Once the hydrogen-3 concentrations at all sampling locations have decreased to less than the groundwater quality standards, it is possible that monitoring will be terminated.

Page intentionally left blank

2.0 SUMMARY

Surface water samples were collected each quarter in 2011 from two streams that flow around Plot M. They showed the same hydrogen-3 concentration pattern seen in the past. Concentrations were at the ambient level of less than 0.1 nCi/L upstream of the Plot, increased to as high as 43.0 nCi/L at the seep adjacent to the Plot, then decreased further downstream. The maximum downstream concentration was 8.0 nCi/L. Samples of surface water from five ponds near Site A were collected and analyzed for hydrogen-3. None of the ponds contained detectable amounts of hydrogen-3.

The hydrogen-3 concentrations in the samples from the boreholes and dolomite holes follow a pattern generally consistent with that observed in the past. The hydrogen-3 concentration was highest in those boreholes nearest Plot M and downgradient of the Plot. Water from four of nine boreholes analyzed for strontium-90 contained concentrations greater than the detection limit of 0.25 pCi/L. The elevated strontium-90 levels (up to 2.85 pCi/L) found in some boreholes is probably due to migration of strontium-90 before the Plot was capped. Strontium-90 is a relatively mobile radionuclide and its presence in the borehole water is not unexpected. The strontium-90 results are consistent with those measured in the past.

Samples of water from the two disabled picnic wells shown in Figure 1.2 were collected each quarter of 2011. The maximum and average hydrogen-3 concentrations of well #5160 in 2011 were 0.91 nCi/L and 0.67 nCi/L, respectively, the highest since 2007. The well opposite the entrance to Red Gate Woods (#5159) had a maximum hydrogen-3 concentration of 3.6 nCi/L and an annual average concentration of 1.10 nCi/L. The maximum value in Well #5159 was found during the first quarter of 2011. This result was the highest value found in this wells in many years. The fourth quarter result was <0.1 nCi/L, one of the lowest values found in this well. The average result was similar to average values seen in recent years.

Since there is no consumption of water from these wells, the hydrogen-3 present does not represent a health risk. However, estimating the potential exposure if this water were consumed provides a basis to compare the significance of these findings. If water equal to the Red Gate

Woods North Well (#5160) with an average hydrogen-3 concentration of 0.67 nCi/L was the sole source of water for an individual, the annual dose from hydrogen-3 would be 0.035 mrem using the DOE derived concentration technical standard.[33] Consumption of one liter of this water would produce a dose of 5×10^{-5} mrem. Similarly, if the well opposite Red Gate Woods (#5159) with an average hydrogen-3 concentration of 1.10 nCi/L was assumed to be the sole water source, the estimated annual dose would be 0.058 mrem. The dose for a single liter would be 8×10^{-5} mrem. Although the U. S. Environmental Protection Agency (EPA) drinking water regulations[34] are not applicable because the former picnic wells would not meet the EPA definition of a public drinking water supply if they were still operational, these concentrations are only about 3-18% of the EPA Primary Drinking Water standard of 20 nCi/L. The Illinois Class I Groundwater Quality Standards utilize this limit for groundwater in Illinois as stipulated in 35 IAC 620.410. Table 4.3 provides a relative comparison of these calculated doses to natural and other sources of radiation.

The results of this program show that the radioactivity remaining at Site A, Plot M, and the Red Gate Woods area does not endanger the health or safety of the public visiting the site or those living in the vicinity. The potential radiation doses are very low compared to the relevant standards.

3.0 MONITORING PROGRAM

The Site A/Plot M program follows the guidance for monitoring at DOE facilities.[35] Although it is recognized that Site A/Plot M is not a DOE facility, the same monitoring principles are applicable to this site. The monitoring program is designed to assess the current status of past releases of hydrogen-3 and strontium-90 from the site and to monitor elevated hydrogen-3 (as tritiated water) concentrations previously detected in some of the former picnic wells in the Palos Forest Preserve. This is accomplished by analyzing water from wells, deep holes, and surface water in the area. Samples are collected with a frequency ranging from quarterly to semiannually, depending on past results and proximity to Plot M.

In early 2004, a review of the monitoring program was conducted to determine the optimum monitoring strategy for Site A/Plot M. The evaluation of over 20 years of monitoring data revealed a significant reduction of hydrogen-3 and strontium-90 concentrations in surface water and groundwater. DOE-LM staff worked closely with the property owner, representatives from the State of Illinois, Argonne National Laboratory, local stakeholders, and the DOE Chicago Operations Office to develop an environmental monitoring program that focuses on pathways and locations that provide the most pertinent information. A number of sampling locations were deleted, sampling frequencies were changed, and the analyses reduced to target hydrogen-3 and strontium-90 only. The streamlined program was implemented in early 2004 and this program was followed in 2011.

During 2011, 141 samples were collected, 171 analyses were performed, and 90 field measurements were conducted. Individual results are presented in this section. For calculation of annual averages, all data, as measured, were retained in the database and used to compute the average. Where applicable, results are compared to the U. S. Department of Energy Radiation Protection Standard of 100 mrem/y.[36]

The uncertainties listed along with individual concentrations given in some of the tables are the statistical counting errors at the 95% confidence level. Because of the amount of hydrogen-3

data presented in many of the tables, the uncertainty values are not included. In such cases, the following typical uncertainties apply:

Hydrogen-3 Concentration (nCi/L)	Uncertainty (% of Conc.)
0.1-1.0	40-5%
1-10	5-1%
> 10	1%

The detection limit for hydrogen-3 in water is 0.1 nCi/L and 0.25 pCi/L for strontium-90 in water.

3.1 Surface Water

Water samples were collected quarterly during 2011 from the two streams that flow around Plot M at four sampling locations. The sampling locations are shown in Figure 3.1. The four sets of samples were analyzed for hydrogen-3 and the results are shown in Table 3.1. The same concentration pattern in the water flowing around Plot M was observed this year as in the past. Concentrations were at or below the detection limits upstream of Plot M (Location 1); hydrogen-3 was found in the seep water that leached out of the burial site (Location 6); and lower concentrations were found downstream of the Plot (Locations 7 & 8). In general the hydrogen-3 concentrations vary from year to year and are dependent on the amount of precipitation. However, in general the hydrogen-3 concentrations in the seep have exhibited a steady decline since the 1990s.

To monitor other surface water in other nearby areas, samples were collected quarterly from five surface water bodies in the vicinity of Site A. They are the pond northwest of Site A; the pond southeast of Site A; Horse Collar Slough; Tomahawk Slough; and Bull Frog Lake. These locations are identified in Figure 1.2. The samples were analyzed for hydrogen-3 and the results are shown in Table 3.2. All hydrogen-3 concentrations were below the detection limit of 0.1 nCi/L.

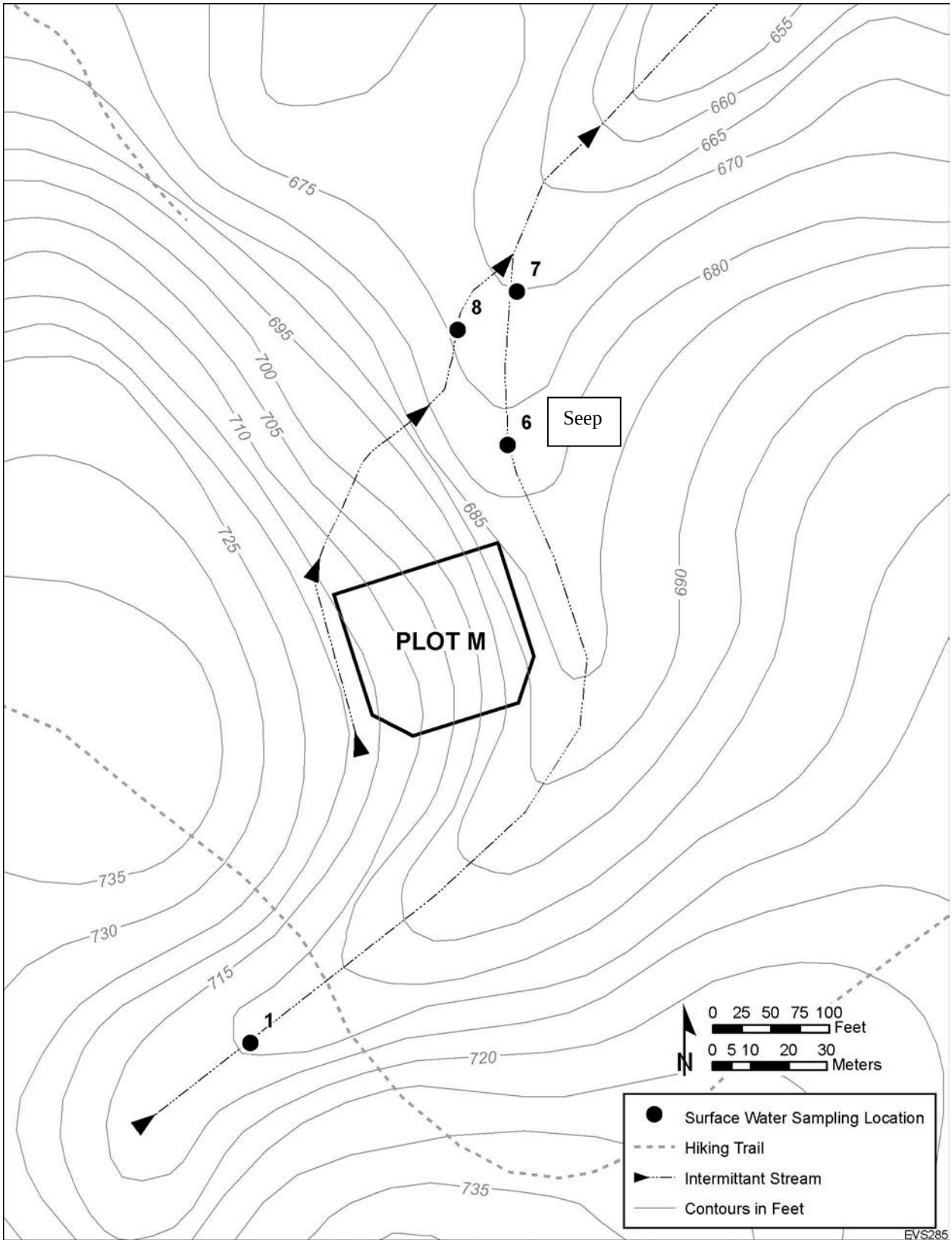


Figure 3.1 Stream Sampling Locations Near Plot M

Table 3.1

Hydrogen-3 Content of Stream Next to Plot M, 2011
(Concentrations in nCi/L)

Location Number*	Date Collected			
	March 4	April 20	September 26	November 9
1	< 0.1	0.1	< 0.1	0.1
6 (Seep)	31.0	43.0	DRY	10.0
7	8.0	7.1	< 0.1	3.9
8	1.9	2.4	DRY	0.4

* See Figure 3.1

Table 3.2

Hydrogen-3 Content of Site A Area Ponds, 2011
(Concentrations in nCi/L)

Location*	Date Collected			
	January 26	April 21	July 27	November 7
NW Site A	< 0.1	< 0.1	< 0.1	< 0.1
SE Site A	< 0.1	< 0.1	< 0.1	< 0.1
Bull Frog Lake	< 0.1	< 0.1	< 0.1	< 0.1
Horsecollar Slough	< 0.1	< 0.1	< 0.1	< 0.1
Tomahawk Slough	< 0.1	< 0.1	< 0.1	< 0.1

* See Figure 1.2

3.2 Subsurface Water

3.2.1 Monitoring Wells - Plot M

A number of boreholes are present in and around the Plot M area (Figure 3.2) that are fitted with plastic casing and screens and serve as monitoring wells within the glacial drift. Two wells (BH09 and BH10) are drilled at a 45° angle under the waste. Water samples were collected and water level measurements were made in these nine Plot M monitoring wells quarterly. Each well was purged to remove stagnant water before sampling.

All the water samples were analyzed for hydrogen-3 and the results are shown in Table 3.3. The hydrogen-3 concentrations varied widely as in past years. With the exception of BH06 and BH09, the magnitudes of the hydrogen-3 concentrations are similar to those observed over the past several years. Boreholes BH03 and BH04, which historically contained some of the highest hydrogen-3 concentrations, continued to show a steady decline. BH09, which is a slant well screened directly beneath the waste trenches, has often contained high and highly variable hydrogen-3 concentrations. The concentrations recorded in the last two quarters of 2011 were the lowest in over 10 years. However, during these same quarters, BH06 recorded the highest hydrogen-3 results observed in many years. This variability may be weather related since the last two quarters of 2011 were unusually wet, compared to previous years.

The measured groundwater surface elevations in the vertical Plot M wells are shown in Table 3.4. Water levels were not recorded for the two slant wells since the angle of the wells distorts the water depth measurement. The elevation of the groundwater surface in the shallow wells responded to the spring precipitation by an increase in elevation followed by a drop during summer and fall when moisture was used for plant growth. The water levels in BH35, the single deep drift well which is 105 ft. deep, were relatively constant throughout the year. The water level in BH06 was unusually high in the fourth quarter compared to the fourth quarter in previous years. The groundwater elevations in 2011 were generally consistent with historical measurements and support the conclusion of the 1994 IT study[37] that the groundwater is moving slowly to the north.

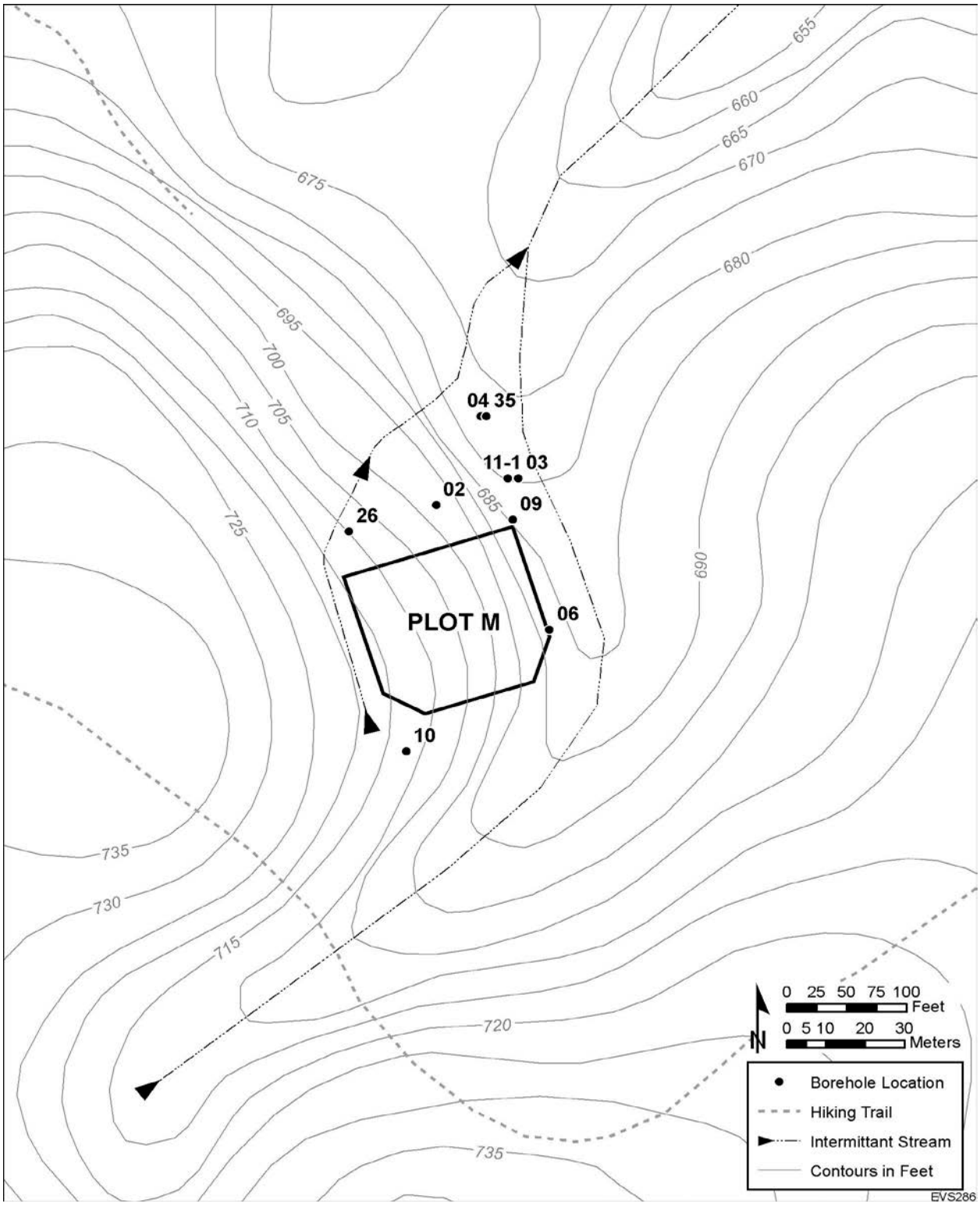


Figure 3.2 Map of Plot M Showing Topography, Intermittent Stream, and Monitoring Well Locations

Table 3.3

Hydrogen-3 in Plot M Monitoring Well Water, 2011
(Concentrations in nCi/L)

Borehole Number	Depth (ft)	Date Collected			
		March 4	June 27	August 24	November 10
02	39.41	7.4	7.2	7.3	9.2
03	40.00	384.4	343.4	357.5	370.9
04	36.05	395.1	391.6	400.1	409.2
06	40.30	114.8	299.7	1534.0	1061.0
09	40.00*	334.2	489.6	DRY	196.5
10	40.00*	46.4	12.7	107.5	110.8
11	39.30	129.0	122.5	129.2	112.9
26	60.65	58.4	112.5	210.9	220.4
35	105.50	449.1	448.7	481.1	510.3

* Slant holes drilled at a 45º angle to a depth of 40 ft below the surface.

.

Table 3.4

Water Level Measurements in Monitoring Wells Near Plot M, 2011

Well Number[1]	Depth to Bottom (ft.)	Top of Casing Elevation (ft AMSL)[2]	Date Measured							
			4-Mar		27-Jun		24-Aug		10-Nov	
			Depth to water	Water Surface Elevation	Depth to water	Water Surface Elevation	Depth to water	Water Surface Elevation	Depth to water	Water Surface Elevation
2	39.41	692.70	--[3]	--[3]	19.91	672.80	27	665.70	25.08	667.60
3	40.00	693.30	34.3	659.00	28.69	664.60	33.64	659.70	34.9	658.40
4	36.05	682.20	19.81	662.40	11.53	670.70	18.04	664.20	20.02	662.20
6	40.30	704.90	31.86	673.00	25.65	679.30	31.22	673.70	29.79	675.10
11	39.30	693.00	20.35	672.70	16.67	676.30	26.39	666.60	22.55	670.50
26	60.65	692.30	47.19	645.10	42.2	650.10	43.26	649.00	45.4	646.90
35	105.5	682.40	94.02	588.40	93.1	589.30	93.38	589.00	93.92	588.50

[1] Water depth for wells 09 and 10 are not shown since these are slant wells.

[2] From 1994 IT study report.

[3] Water depth was not recorded for this well on this date.

Groundwater from the monitoring wells was analyzed twice for strontium-90. Large volume water samples were collected to obtain greater sensitivity in the analysis. Samples were collected from all wells that yielded sufficient water for analysis. The results are shown in Table 3.5. Strontium-90 concentrations greater than the detection limit of 0.25 pCi/L were found in four of the nine sampled wells. Levels above 0.25 pCi/L would not be expected in this water due to fallout, and no other source is known, thus the source is likely to be waste in Plot M. The highest strontium-90 concentration in 2011 was 3.02 pCi/L in water from BH09. All results are less than the State of Illinois Class 1 Ground Water Quality Standard value of 8 pCi/L. As in the past, BH06, which is between the buried waste and the stream that flows around Plot M, showed measurable strontium-90 concentrations. The data suggest that small but measurable amounts of strontium-90 have migrated from the waste into the surrounding glacial drift.

Table 3.5

Strontium-90 Content of Monitoring Well Water Samples Near Plot M, 2011
(Concentrations in pCi/L)

Well Number*	Depth (ft.)	June 27	November 10
02	39.41	< 0.25	0.25
03	40.00	< 0.25	< 0.25
04	36.05	< 0.25	< 0.25
06	40.30	0.80 ± 0.07	0.72 ± 0.07
09	40.00**	2.85 ± 0.30	3.02 ± 0.24
10	40.00**	< 0.25	< 0.25
11	39.30	1.81 ± 0.15	1.86 ± 0.15
26	60.65	0.31 ± 0.04	< 0.25
35	105.50	< 0.25	< 0.25

* See Figure 3.2
** Slant hole

3.2.2 Monitoring Wells - Site A

Prior to 1994, 16 monitoring wells were present around Site A. The monitoring program evaluation in 2004 identified only six of these wells that required ongoing monitoring. These wells are in Figure 3.3. Samples from these six monitoring wells are collected quarterly and analyzed for hydrogen-3 and semi-annually for strontium-90.

Hydrogen-3 results for the Site A monitoring well samples are shown in Table 3.6. The hydrogen-3 concentrations were all low and consistent, with the highest concentrations in BH55 and BH56 near the center of Site A. The hydrogen-3 in BH55 and BH56 most likely is from the buried CP-3 biological shield. The hydrogen-3 concentrations at Site A were several orders of magnitude lower than Plot M. The results of the strontium-90 analyses are shown in Table 3.7. The elevated strontium-90 results appear to track with elevated hydrogen-3 results. BH55 and BH56 had measurable levels of hydrogen-3 and strontium-90 throughout the year. Groundwater surface elevations were also measured in these monitoring wells and these measurements appear in Table 3.8.

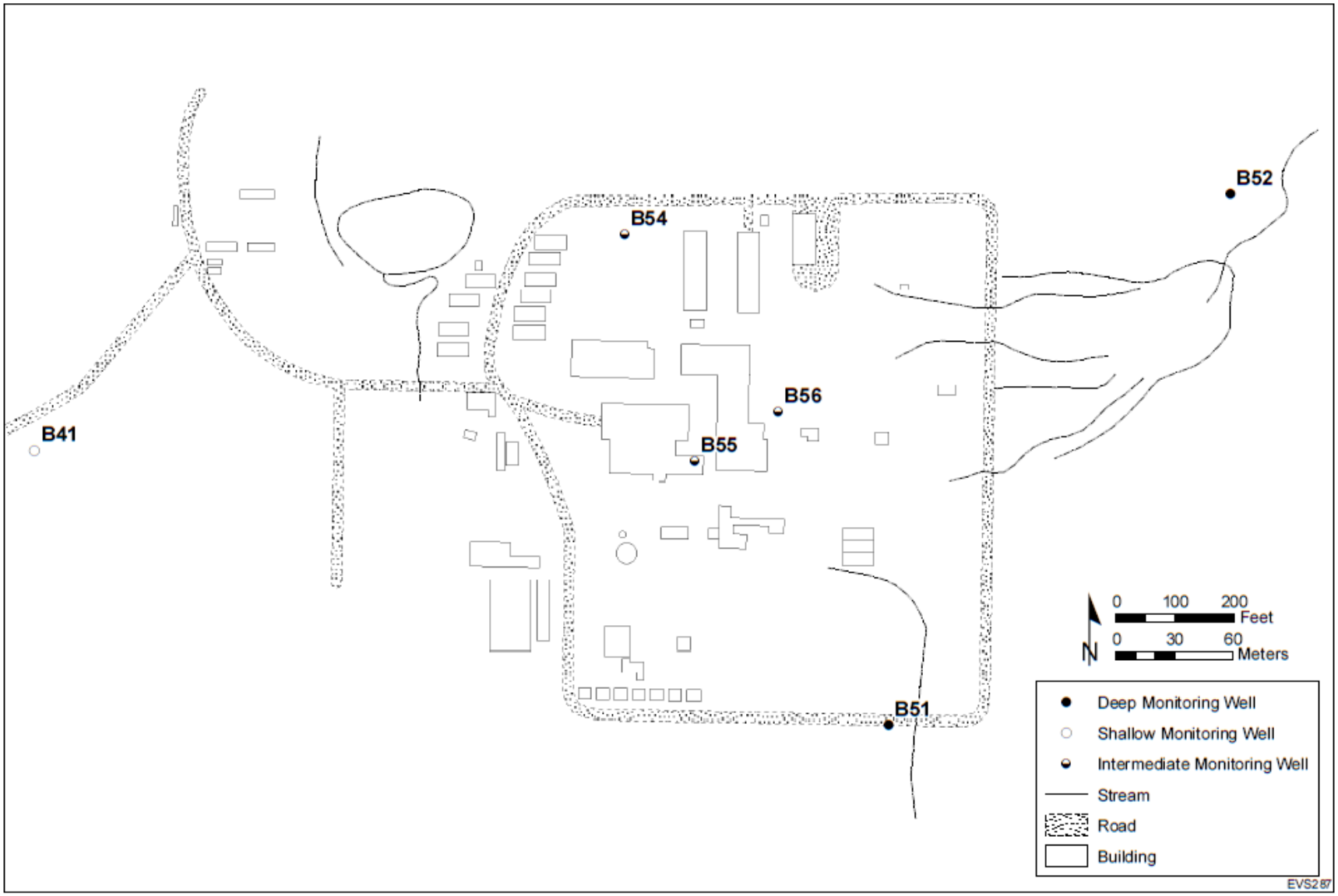


Figure 3.3 Monitoring Wells at Site A

Table 3.6

Hydrogen-3 in Site A Groundwater, 2011
(Concentrations in nCi/L)

Well Number	Depth (ft.)	Date Collected			
		January 19	June 23	September 2	November 10
B41	25.83	0.1	< 0.1	< 0.1	0.1
B51	116.40	< 0.1	< 0.1	< 0.1	< 0.1
B52	165.00	< 0.1	< 0.1	< 0.1	0.2
B54	63.40	0.1	0.1	0.2	0.2
B55	87.20	2.2	1.4	1.6	1.5
B56	102.40	2.6	2.5	1.9	2.0

Table 3.7

Strontium-90 Content of Monitoring Well Water Samples Near Site A, 2011
(Concentrations in pCi/L)

Borehole Number	Depth (ft.)	Date Collected	
		January 19	September 2
B41	25.83	< 0.25	< 0.25
B51	116.40	< 0.25	< 0.25
B52	165.00	< 0.25	< 0.25
B54	63.40	< 0.25	< 0.25
B55	87.20	1.48 ± 0.13	0.89 ± 0.08
B56	102.40	1.54 ± 0.13	1.45 ± 0.12

Table 3.8

Water Level Measurements in Monitoring Wells Near Site A, 2011

Well Number	Depth to Bottom (ft.)	Top of Casing Elevation (ft AMSL)[1]	Date Measured							
			January 19		June 23		September 2		November 10	
			Depth to water	Water Surface Elevation	Depth to water	Water Surface Elevation	Depth to water	Water Surface Elevation	Depth to water	Water Surface Elevation
B41	25.83	737.38	12.38	725.00	1.39	735.99	9.69	727.69	11.15	726.23
B51	116.40	715.93	101.47	614.46	100.90	615.03	101.02	614.91	101.02	614.91
B52	165.00	713.43	132.44	580.99	129.88	583.55	131.90	581.53	132.12	581.31
B54	63.40	732.03	56.08	675.95	53.31	678.72	54.20	677.83	56.12	675.91
B55	87.20	743.78	77.59	666.19	58.11	685.67	63.58	680.20	67.87	675.91
B56	102.40	742.23	86.35	655.88	85.31	656.92	85.36	656.87	85.79	656.44

[1] From 1996 Advanced Surveying and Mapping topographical map

3.2.3 Dolomite Well Water

Ten wells cased into the dolomite bedrock are sampled to monitor the movement of hydrogen-3 in this aquifer. Most of the dolomite wells are located north of Plot M and east of the Red Gate Woods North Well (#5160), as shown in Figure 3.4.

Samples were collected from the dolomite wells quarterly. All samples were analyzed for hydrogen-3 and the results are shown in Table 3.9. Groundwater surface elevations were also measured in the dolomite wells and these measurements are in Table 3.10. The groundwater elevations in these wells were consistent with historical measurements in the wells and support the conclusion in the 1994 IT report [37] that groundwater in this area is moving to the northwest towards the Des Plaines River Valley.

The results of the hydrogen-3 analyses of the dolomite wells are consistent with concentrations measured in the past. All of the dolomite wells had measurable hydrogen-3 concentrations. The highest hydrogen-3 levels were in dolomite holes, D15, D12, and D13. The presence of hydrogen-3 in these wells is supported by findings from a 1988 USGS investigation[38] that indicated a hydrogen-3 plume underlies the stream which flows from Plot M and passes to the northeast of these wells (see Section 3.2). The plume has spread downward as well as downgradient resulting in small amounts of hydrogen-3 in the dolomite. One other dolomite well with elevated hydrogen-3 is D03, which is immediately downgradient from Plot M. Previous analyses of soil core samples[38] indicated the presence of hydrogen-3 down to the drift-dolomite interface near D03. In any case, all of the dolomite wells were well below the Class 1 Groundwater Quality Standard of 20 nCi/L

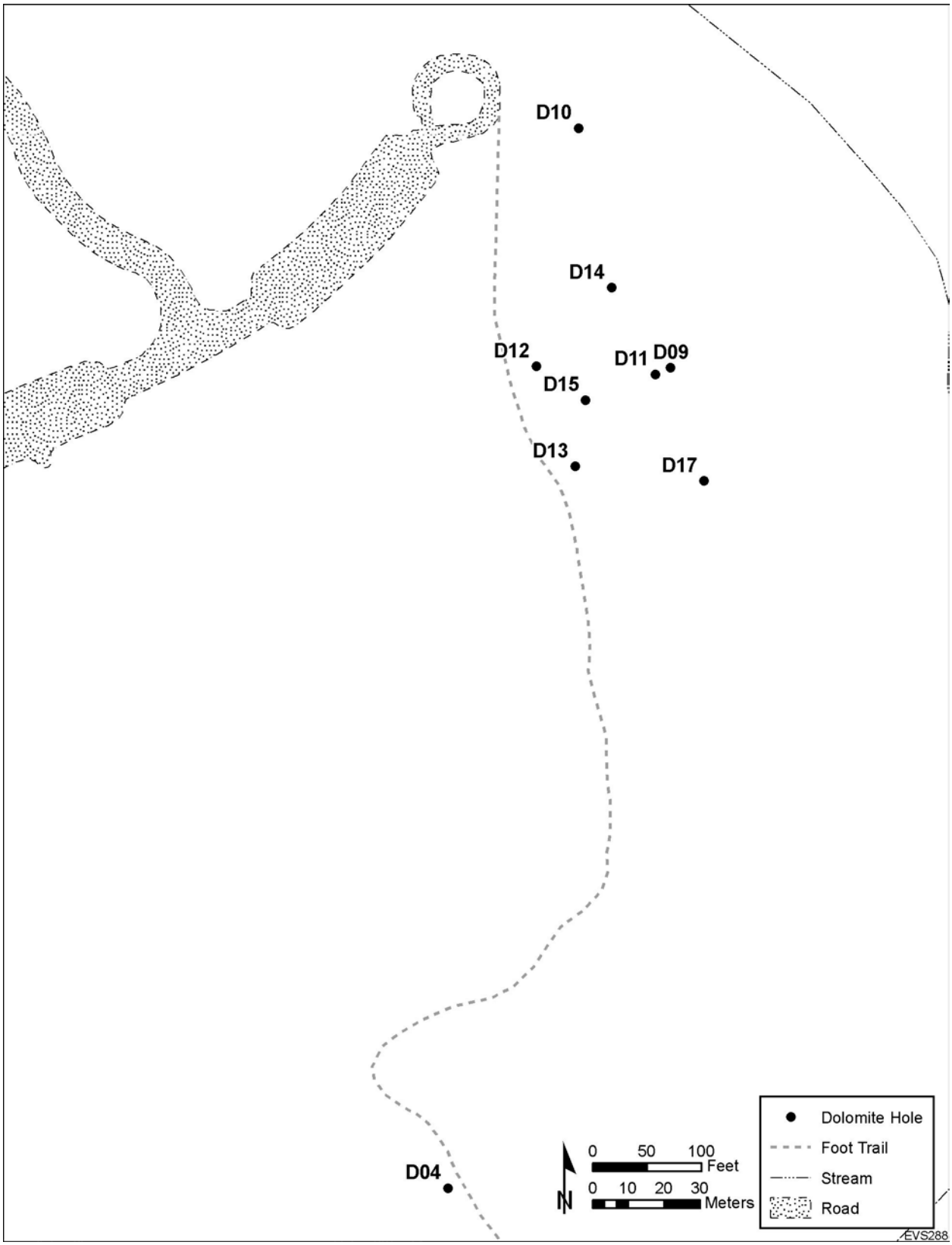


Figure 3.4 Locations of Dolomite Wells North of Plot M

Table 3.9

Hydrogen-3 in Dolomite Wells, 2011
(Concentrations in nCi/L)

Dolomite Well Number	Date Collected			
	March 4	June 14	August 30	November 10
D03	1.0	1.1	1.1	0.9
D04	0.7	0.7	0.7	0.7
D09	0.2	0.2	0.3	0.2
D10	0.8	0.8	0.8	0.8
D11	1.0	1.0	1.1	0.9
D12	1.4	1.2	0.9	1.2
D13	1.1	1.0	1.2	1.1
D14	1.0	1.0	1.0	0.9
D15	2.4	2.1	2.4	2.4
D17	0.3	0.2	0.3	0.3

Table 3.10

Water Level Measurements in Dolomite Wells, 2011

Well Number	Ground Surface Elevation (ft AMSL)[1]	Top of Casing Elevation (ft AMSL)[1]	Date Measured							
			4-Mar		13-Jun		30-Aug		10-Nov	
			Depth to Water	Water Surface Elevation	Depth to Water	Water Surface Elevation	Depth to Water	Water Surface Elevation	Depth to Water	Water Surface Elevation
D03	678.10	679.50	98.38	581.12	96.29	583.21	98.24	581.26	98.83	580.67
D04	673.80	674.60	93.7	580.90	-- [2]	--[2]	93.54	581.06	94.2	580.40
D09	655.50	656.30	73.21	583.09	71.29	585.01	72.74	583.56	73.05	583.25
D10	644.90	646.10	65.02	581.08	62.91	583.19	65.38	580.72	64.7	581.40
D11	655.36	656.90	76.21	580.69	74.19	582.71	76.78	580.12	76.76	580.14
D12	650.34	651.60	77.29	574.31	75.27	576.33	77.79	573.81	77.88	573.72
D13	658.10	659.20	77.93	581.27	75.93	583.27	78.43	580.77	78.41	580.79
D14	651.43	653.20	72.29	580.91	70.12	583.08	72.86	580.34	72.89	580.31
D15	659.14	660.80	79.93	580.87	77.92	582.88	80.45	580.35	80.52	580.28
D17	654.35	656.00	75.21	580.79	73.09	582.91	75.75	580.25	75.68	580.32

[1] From 1994 IT Study report. Ground surface elevation for D12 through D17 estimated from TOC elevation.

[2] Water depth was not recorded for this well on this date

3.2.4 Former Picnic Wells

Sampling was conducted quarterly at two disabled forest preserve picnic wells (#5160 and #5159) located north of Plot M and shown in Figure 1.2. All the samples were analyzed for hydrogen-3 and the results are listed in Table 3.11. The Red Gate Woods North Well (#5160) was disabled in 1999 by removing the pump handle because of high fecal coliform levels. The well opposite Red Gate Woods (#5159) is not usable as a water source since the pump handle has also been removed. The maximum and average hydrogen-3 concentrations since 1996 for wells #5160 and #5159 are presented in Table 3.12. The hydrogen-3 concentrations in well #5160 were higher than what has been measured in the last three years; however, they were consistent with results observed prior to 2008. The sample collected during the first quarter from well #5159 contained the highest concentration seen since 1990; however, the third and fourth quarter samples contained some of the lowest concentrations measured. The average was higher than most previous years, though the 2002 and 2006 averages were comparable.

The hydrogen-3 concentration over the past few years is illustrated in Figure 3.5, which is a plot of the hydrogen-3 concentrations in wells #5160 and #5159 since 1995. The hydrogen-3 concentrations in the well opposite Red Gate Woods (#5159) vary significantly over time which may be related to the amount of precipitation. The hydrogen-3 concentrations have rapidly increased by over a factor of ten several times since 1995, including 2011, before rapidly decreasing to the normal levels. Between these spikes, the concentrations remain at previous levels (See Figure 3.5).

Table 3.11

Hydrogen-3 Content of Wells Near Site A/Plot M, 2011

(Concentrations in nCi/L)

Date Collected	Red Gate North 5160	Opposite Red Gate 5159
January 19	0.3	3.6
May 6	0.6	0.6
August 24	0.8	0.1
November 7	0.9	< 0.1
Average	0.7	1.1

TABLE 3.12

Annual Maximum and Average Hydrogen-3 Concentrations in the Red Gate Woods Wells
(Concentrations in nCi/L)

Year	Red Gate Woods North (#5160)		Opposite Red Gate Woods (#5159)	
	Maximum	Annual Average	Maximum	Annual Average
1996	2.2	1.6	0.6	0.3
1997	1.3	1.0	1.1	0.4
1998	1.2	1.0	0.7	0.5
1999	1.2	1.1	2.1	0.5
2000	1.5	1.3	2.2	0.7
2001	1.6	1.5	0.3	0.2
2002	1.5	1.0	3.2	0.5
2003	1.8	1.1	1.5	0.4
2004	1.1	1.0	0.3	0.2
2005	1.0	1.0	0.3	0.2
2006	1.1	1.1	2.6	1.1
2007	1.5	1.3	0.7	0.3
2008	1.2	0.3	0.3	0.3
2009	0.1	0.1	0.5	0.3
2010	0.3	0.2	0.5	0.3
2011	0.9	0.7	3.6	1.1

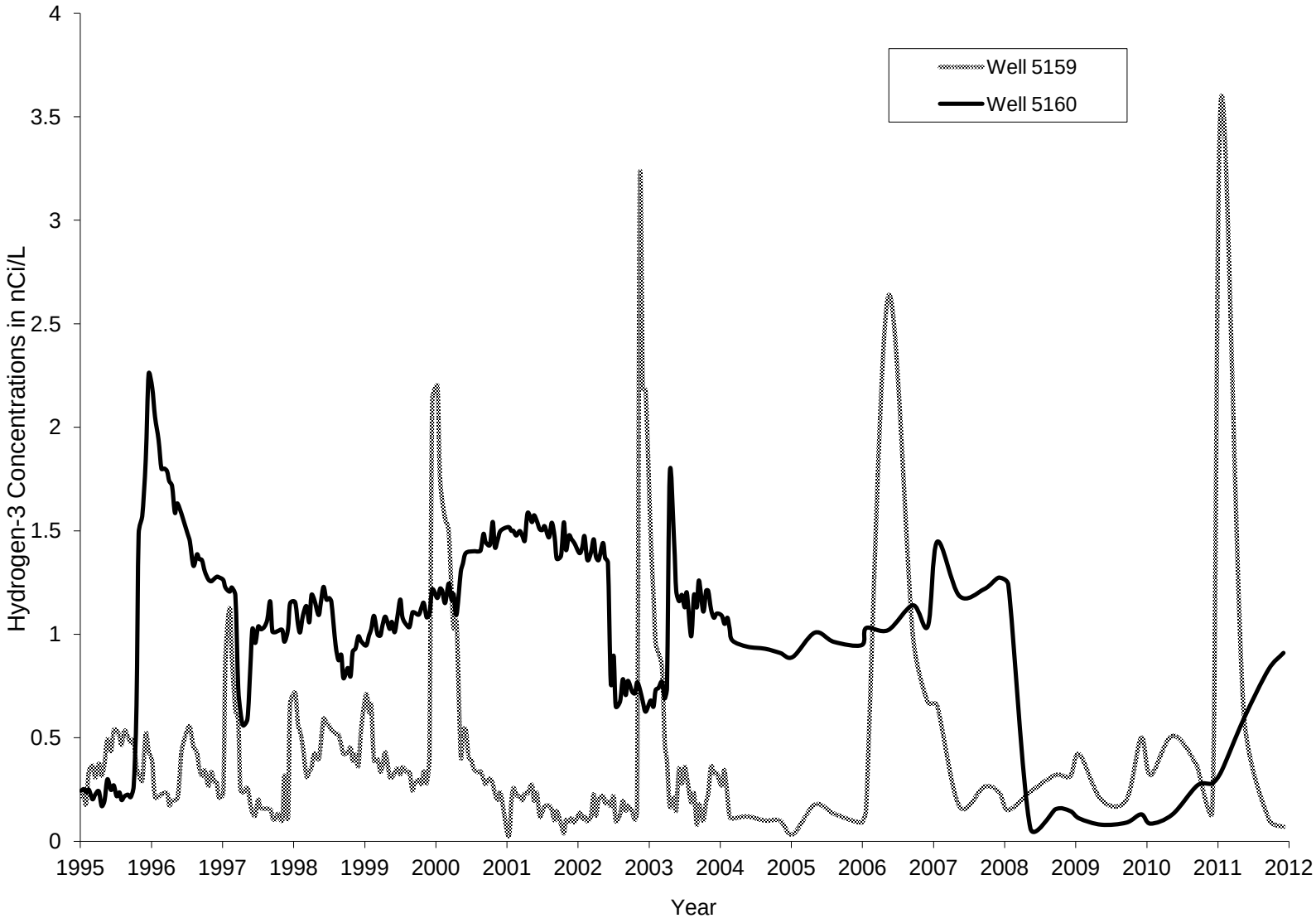


Figure 3.5 Hydrogen-3 Concentrations in Opposite Red Gate Woods (#5159) and Red Gate Woods North (#5160) Wells From 1995 Through 2011

The hydrogen-3 concentrations in Well #5160 showed an increase from the previous three years, which had exhibited unusually low concentrations. The amount measured in 2011 was typical for this well prior to 2008. As discussed in Section 4, the potential radiation dose from hydrogen-3 was estimated for Well #5160 using a value equal to the Red Gate Woods North well maximum hydrogen-3 concentration. Assuming water with a maximum hydrogen-3 concentration of 0.91 nCi/L was the sole source of water for an individual, the annual dose from the hydrogen-3 would be 0.048 mrem. If an individual consumed one liter of this water, the dose would be 7×10^{-5} mrem. In a similar way, the potential dose associated with hydrogen-3 in the Opposite Red Gate Woods well (#5159) was estimated. The dose from the maximum hydrogen-3 concentration, assuming this well was the sole water source, would be 0.19 mrem/y and the dose for a single liter of this water would be 3×10^{-4} mrem. All doses are well below any applicable standard.

4.0 SUMMARY OF POTENTIAL RADIATION DOSE AND RISK ESTIMATES

4.1 Dose Estimates

To put the risk associated with residual contamination into perspective, the potential radiation dose to a hypothetical individual was estimated. Taking a very conservative approach, it was assumed the hypothetical individual drank only water containing hydrogen-3 at the levels found at Plot M. The dose was estimated employing methodology prescribed in DOE guidance.[34] The committed effective dose equivalent from consumption of water was estimated by first calculating the total quantity of hydrogen-3 potentially ingested. The concentration of hydrogen-3 was multiplied by the general public water ingestion rate of 730 L/y.[39] This annual intake was then multiplied by the 50-year Committed Effective Dose Equivalent (CEDE) factor.[33] The CEDE for hydrogen-3 in water is 7.2×10^{-5} rem/μCi (based on the derived concentration standard of 1.9E-03 μCi/mL). The highly conservative worst case scenario assumes that the hypothetical individual used water with the maximum hydrogen-3 concentration found in the seep (Location #6). The annual dose based on the maximum 2011 concentration of 43.0 nCi/L would be about 2.26 mrem/y. A slightly less conservative estimate of dose based on the annual average seep concentration of 28.0 nCi/L would be 1.47 mrem/y. Similar dose calculations were made assuming the water in former Red Gate Woods North Well (#5160) was the sole source of water consumed. In this case the maximum dose would be 0.048 mrem/y and the average dose would be 0.035 mrem/y. Similar estimates for the Opposite Red Gate Woods Well (#5059) are 0.19 mrem/y for the maximum concentration and 0.058 mrem/y for the average concentration. The DOE dose limit for the public is 100 mrem/y, so even under highly conservative scenarios, the potential dose is well below DOE limits. These estimated doses are shown in Table 4.1.

A more meaningful estimation was made based on the scenario of an occasional visitor to the Plot M area. Assuming a visitor drinks one liter of water from the surface stream or picnic well, the doses from this potential exposure were estimated and presented in Table 4.2. As defined here, the maximum potential total dose received by an occasional visitor is the sum of doses from seep water plus doses from drinking water from the former Opposite Red Gate Woods North Well (#5159). This maximum dose would be 0.0033 mrem per visit.

In order to put the doses into perspective with other types of radiation exposure, comparisons can be made to annual average doses received by the public from natural or other generally accepted sources of radiation[40]. These are listed in Table 4.3. It is obvious that the magnitude of the doses potentially received near Plot M from residual radioactive substances remaining from work conducted in this area are insignificant compared to these sources.

4.2 Risk Estimates

Risk estimates of possible health effects from radiation doses to the public from Plot M were made to provide another perspective in interpreting the radiation doses. Estimates for carcinogenic risk, the risk of contracting cancer from these exposures, are included in Table 4.1 and Table 4.2. Based on the BIER V report,[41] a dose of one mrem/y equates to an increased cancer risk of 7×10^{-7}. This conversion ratio is used to estimate risk in these tables. The radiation risks represent incremental risk above to the normal incident rate of cancer in the general population. For example, a carcinogenic risk of 10^{-7} would mean on average one additional cancer to 10,000,000 people exposed under the assumed exposure conditions. The EPA environmental protection standards are generally based on an acceptable risk between 10^{-4} and 10^{-6}. This would imply that a risk of greater than 10^{-4} would be unacceptable and a risk of less than 10^{-6} would be acceptable. Examination of Table 4.1 indicates that even under the very conservative assumptions of sole source use of the water containing hydrogen-3 at Plot M at the annual average concentrations, the risk is less than the EPA standards. Table 4.2 shows that the hypothetical average surface water dose to an occasional visitor of 0.002 mrem would result in an increased cancer risk of about 1.4×10^{-9}. The incremental risk from exposure to radionuclides at Plot M can be compared to the risk associated with various events. A few examples are collected in Table 4.4. The risk from the naturally-occurring sources of radioactivity listed in Table 4.3 is estimated to be about one additional cancer in a population of 8,000. Since the incremental risk under even the most conservative assumptions is so low, the monitoring program results have established that the impact of radioactivity at Site A/Plot M is very low and it does not endanger the health of those living in the area or visiting the site.

TABLE 4.1

Dose from Continuous Exposure to Hydrogen-3 at Selected Locations, 2011

Assumed Source	Maximum Conc.	Maximum Dose	Annual Average Conc.	Annual Average Dose	DOE Dose Limit	Maximum Carcinogenic Risk
Surface Water						
Seep	43.0 nCi/L	2.26 mrem/y	28.0 nCi/L	1.47 mrem/y	100 mrem/y	1.0×10^{-6}
Well Water						
Red Gate Woods North (#5160)	0.91 nCi/L	0.048 mrem/y	0.67 nCi/L	0.035 mrem/y	100 mrem/y	2.5×10^{-8}
Opposite Red Gate Woods (#5159)	3.6 nCi/L	0.19 mrem/y	1.10 nCi/L	0.058 mrem/y	100 mrem/y	4.0×10^{-8}

TABLE 4.2

Estimates of Hydrogen-3 Exposures to a Casual Visitor to Plot M, 2011

Pathway	Quantity	Maximum Dose	Annual Average	DOE Dose Limit	Average Carcinogenic Risk
Surface Water					
Seep	One Liter	0.003 mrem	0.002 mrem	100 mrem/y	1.4×10^{-9}
Well Water					
Red Gate Woods North (#5160)	One Liter	0.00007 mrem	0.00005 mrem	100 mrem/y	3.4×10^{-11}
Red Gate Woods North (#5160)	One Liter	0.00030 mrem	0.00008 mrem	100 mrem/y	5.5×10^{-11}

TABLE 4.3

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

Source	(mrem)
Natural Sources	
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	13
Building Materials	
Commercial Air Travel	
Cigarette Smoking	
Mining and Agricultural	
Combustion of Fossil Fuels	
Highway and Road Construction Materials	
Glass and Ceramics	
Industrial	0.3
Nuclear-power Generation	
DOE Installations	
Decommissioning and Radioactive Waste	
Industrial, Medical, Educational, and Research Activities	
Contact with Nuclear-medicine Patients	
Security Inspection Systems	
Occupational	0.5
Medical	
Aviation	
Commercial Nuclear Power	
Industrial and Commercial	
Education and Research	
Government, DOE, and Military	
Total	624

*NCRP report No. 160.[40]

TABLE 4.4

Risk of Death from Various Events

Cause	Risk
Lightning Strike	5×10^{-8}
Tornado	1×10^{-7}
Flood	1×10^{-7}
Hurricane	2.5×10^{-7}
Drowning	8×10^{-6}
Air Travel	3×10^{-6}
Firearms	2×10^{-6}

5.0 REFERENCES

1. Golchert, N. W. and Sedlet, J., *Formerly Utilized MED/AEC Sites Remedial Action Program - Radiological Survey of Site A, Palos Park Forest Preserve, Chicago, Illinois*, U. S. Department of Energy Report DOE/EV-0005/7 (April 1978).

2. Golchert, N. W., Sedlet, J., and Hayes, K. A., *Environmental Surveillance of the Palos Park Forest Preserve,* Argonne National Laboratory Report ANL-83-6 (January 1983).

3. Golchert, N. W. and Sedlet, J., *Site Surveillance and Maintenance Program for Palos Park - Report for 1982,* Argonne National Laboratory (available from the authors) (April 1984).

4. Golchert, N. W. and Sedlet, J., *Site Surveillance and Maintenance Program for Palos Park - Report for 1983,* Argonne National Laboratory (available from the authors) (June 1984).

5. Golchert, N. W. and Sedlet, J., *Site Surveillance and Maintenance Program for Palos Park - Report for 1984,* Argonne National Laboratory (available from the authors) (April 1985).

6. Golchert, N. W. and Sedlet, J., *Site Surveillance and Maintenance Program for Palos Park - Report for 1985,* Argonne National Laboratory Report ANL-86-25 (April 1986).

7. Golchert, N. W., *Site Surveillance and Maintenance Program for Palos Park - Report for 1986,* Argonne National Laboratory Report ANL-87-8 (April 1987).

8. Golchert, N. W., *Site Surveillance and Maintenance Program for Palos Park - Report for 1987,* Argonne National Laboratory Report ANL-88-12 (April 1988).

9. Golchert, N. W., *Site Surveillance and Maintenance Program for Palos Park - Report for 1988,* Argonne National Laboratory Report ANL-89/7 (April 1989).

10. Golchert, N. W., *Surveillance of Site A and Plot M - Report for 1989,* Argonne National Laboratory Report ANL-90/7 (April 1990).

11. Golchert, N. W., *Surveillance of Site A and Plot M - Report for 1990,* Argonne National Laboratory Report ANL-91/2 (May 1991).

12. Golchert, N. W., *Surveillance of Site A and Plot M - Report for 1991,* Argonne National Laboratory Report ANL-92/13 (May 1992).

13. Golchert, N. W., *Surveillance of Site A and Plot M - Report for 1992,* Argonne National Laboratory Report ANL-93/4 (May 1993).

14. Golchert, N. W., *Surveillance of Site A and Plot M - Report for 1993,* Argonne National Laboratory Report ANL-94/9 (May 1994).

15. Golchert, N. W., *Surveillance of Site A and Plot M - Report for 1994,* Argonne National Laboratory Report ANL-95/7 (May 1995).

16. Golchert, N. W., *Surveillance of Site A and Plot M - Report for 1995,* Argonne National Laboratory Report ANL-96/2 (June 1996).

17. Golchert, N. W., *Surveillance of Site A and Plot M - Report for 1996,* Argonne National Laboratory Report ANL-97/5 (May 1997).

18. Golchert, N. W., *Surveillance of Site A and Plot M - Report for 1997,* Argonne National Laboratory Report ANL-98/1 (May 1998).

19. Golchert, N. W., *Surveillance of Site A and Plot M - Report for 1998,* Argonne National Laboratory Report ANL-99/2 (May 1999).

20. Golchert, N. W., *Surveillance of Site A and Plot M - Report for 1999,* Argonne National Laboratory Report ANL-00/3 (May 2000).

21. Golchert, N. W., *Surveillance of Site A and Plot M - Report for 2000,* Argonne National Laboratory Report ANL-01/1 (May 2001).

22. Golchert, N. W., *Surveillance of Site A and Plot M - Report for 2001,* Argonne National Laboratory Report ANL-02/1 (May 2002).

23. Golchert, N. W., *Surveillance of Site A and Plot M - Report for 2002,* Argonne National Laboratory Report ANL-03/1 (May 2003).

24. Golchert, N. W., *Surveillance of Site A and Plot M – Report for 2003,* Argonne National Laboratory Report ANL-04/1 (May 2004).

25. Golchert, N. W., *Surveillance of Site A and Plot M – Report for 2004,* Argonne National Laboratory Report ANL-05/01 (April 2005).

26. Golchert, N. W., *Surveillance of Site A and Plot M – Report for 2005,* Argonne National Laboratory Report ANL-06/01 (April 2006).

27. Golchert, N. W., *Surveillance of Site A and Plot M – Report for 2006,* Argonne National Laboratory Report ANL-07/01 (April 2007).

28. Golchert, N. W., *Surveillance of Site A and Plot M – Report for 2007,* Argonne National Laboratory Report ANL-08/04 (March 2008).

29. Golchert, N. W., *Surveillance of Site A and Plot M – Report for 2008,* Argonne National Laboratory Report ANL-09/01 (April 2009).

30. Golchert, N. W., *Surveillance of Site A and Plot M – Report for 2009,* Argonne National Laboratory Report ANL-10/01 (April 2010).

31. Golchert, N. W., *Surveillance of Site A and Plot M – Report for 2010,* Argonne National Laboratory Report ANL-11/01 (May 2011).

32. U. S. Department of Energy Office of Legacy Management, “Long-Term Surveillance and Maintenance Plan for Site A and Plot M, Palos Forest Preserve, Cook County, Illinois”, DOE-LM/GJ704–2004, December, 2004

33. U. S. Department of Energy, "Derived Concentration Technical Standard," *DOE-STD-1196-2011,* April 2011.

34. U. S. Environmental Protection Agency, "National Primary Drinking Water Regulations," 40 CFR Part 141.

35. U. S. Department of Energy, "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance," *DOE/EH-0173T,* January 1991.

36. U. S. Department of Energy, "Radiation Protection of the Public and the Environment," *DOE O 458.1, Change 2, June 6, 2011*

37. International Technology Corporation, “Tritium Migration and Hydrogeological Studies in the Vicinity of Plot M Palos Forest Preserve”, August, 1994

38. Nicholas, J. R. and Healy, R. W., "Hydrogen-3 Migration from a Low-Level Radioactive-Waste Disposal Site Near Chicago, Illinois," U. S. Geological Survey Water-Supply Paper 2333, 1988.

39. International Commission on Radiological Protection, "Basic Anatomical and Physiological Data for use in Radiological Protection: Reference Values," *ICRP Publication 89,* Pergamon Press, New York, NY (2002).

40. National Council on Radiation Protection and Measurements, *Ionizing Radiation Exposure of the Population of the United States,* NCRP Report No. 160, August 20, 2009.

41. Committee on Biological Effects of Ionizing Radiation, *Health Effects on Populations of Exposure to Low Levels of Ionizing Radiation - BEIR V Report,* National Academy Press, Washington, 1990.

42. Golchert, N. W., Davis, T. M., and Moos, L. P., *Argonne National Laboratory Site Environmental Report for Calendar Year 2010,* Argonne National Laboratory Report, ANL-11/02 (September 2011).

43. U. S. Environmental Protection Agency, 1986, RCRA Ground Water Monitoring Technical Enforcement Guidance Document, OSWER-9950.1, Office of Solid Waste and Emergency Response, Washington, DC.

Page intentionally left blank

6.0 APPENDICES

6.1 Quality Assurance Program

All nuclear analytical instrumentation is calibrated with standardized sources obtained from or traceable to the U. S. National Institute of Standards and Technology (NIST). The equipment is checked prior to the sample measurements with secondary counting standards to insure proper operation. Samples were periodically analyzed in duplicate or with the addition of known amounts of a radionuclide to check precision and accuracy. Argonne participates in the DOE Mixed-Analyte Performance Evaluation Program (MAPEP), a twice per year analysis of two different sample matrices containing known amounts of various radionuclides. The results of our participation in this program for 2010 are published in ANL-11/02.[42]

Many factors enter into an overall quality assurance program other than the analytical quality control discussed above. Representative sampling is of prime importance. Appropriate sampling protocols are followed for each type of sampling being conducted. Water samples are pre-treated in a manner designed to maintain the integrity of the analytical constituent. For example, samples for strontium-90 analysis are acidified immediately after collection to prevent hydrolytic loss of metal ions and filtered to reduce leaching from suspended solids. Samples for hydrogen-3 analysis do not require filtration or acidification.

The volume of stagnant water in a monitoring well casing is determined by measuring the water depth from the surface. In accordance with EPA guidance[43], stagnant water is removed from the wells prior to sampling. From one to three times the well volume is removed. After the well refills with groundwater, it is sampled by bailing with a Teflon bailer. The Red Gate Woods dolomite wells are not purged since they are open boreholes drilled into the bedrock where stagnant water does not accumulate. All samples are placed in precleaned bottles, labeled, filtered, and preserved (strontium-90 samples). All sampling equipment is cleaned by field rinsing with Type II deionized water. The samples are transferred to the analytical laboratory along with a chain-of-custody transfer document.

6.2 Applicable Standards

The standard that is relevant to this study is the DOE Order 458.1 which established a total effective dose limit of 100 mrem/y.[36] The dose limit and dose calculation methodology are applicable to all media: surface water, deep holes, boreholes, and picnic well water. The EPA drinking water standard[34] is not applicable to the picnic wells since they do not meet the definition of a public water system. However, the EPA standard of 20 nCi/L for hydrogen-3 or the IEPA Class I groundwater standard of 8 pCi/L for strontium-90 may be useful for some comparison purposes.

6.3 Analytical Methods

The analytical methods used to obtain the data in this report are the same as those used in ANL-11/02.[42]

6.4 Distribution for ANL-12/01

Internal

T. M. Davis (10)
R. D. Enge
J. L. Gomez
D. W. Hearnsberger
W. D. Luck
L. P. Moos (10)
R. E. Piorkowski
T. J. Schneider
J. L. Tucker
N. T. Visser
C. L. Wilkinson
TIS File

External

J. Barnette, U. S. Environmental Protection Agency, Region V
N. Golchert
M. Hart, Forest Preserve District of Cook County
S. Heston, DOE Argonne Site Office
G. Hooten, DOE Westminster Office (10)
T. Hyde, U. S. Environmental Protection Agency
A. Khayyat, Illinois Emergency Management Agency
Mayor of Willow Springs
V. Parola, Illinois Emergency Management Agency
B. Quirke, DOE Chicago Operations Office
D. Robbins, Illinois Emergency Management Agency
T. Varchmin, Cook County Department of Public Health

Environment, Safety, and Quality Assurance Division
Argonne National Laboratory
9700 South Cass Avenue, Bldg. 201
Argonne, IL 60439-4832

www.anl.gov

Argonne National Laboratory is a U.S. Department of Energy
laboratory managed by UChicago Argonne, LLC