LMS/SAM/S07581

Groundwater and Surface Water Monitoring Activities at Site A/Plot M

March 2011

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Contents

Figures

Tables

Abbreviations

ANL	Argonne National Laboratory
COC	constituent of concern
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
GWQS	Ground Water Quality Standard
LM	Office of Legacy Management
LTSP	Long-Term Surveillance and Maintenance Plan
pCi/L	picocuries per liter

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Executive Summary

The Long-Term Surveillance Plan (LTSP) for Site A/Plot M requires that the groundwater and surface water monitoring activities at Site A/Plot M be assessed every three to five years. This assessment report satisfies that requirement. The purpose of the assessment is to determine if changes are needed in order to continue to meet monitoring objectives. The two major monitoring objectives at Site A/Plot M are to (1) ensure that existing contaminant concentrations continue to decrease as expected due to radioactive decay and other natural processes, and (2) detect any potential future releases.

Data collected through 2009 for the two remaining constituents of concern (COC) (tritium and strontium-90) indicate that, with the exception of tritium at Plot M, COC concentrations are low and trends are consistent. Low concentrations coupled with consistent trends indicate that, with the exception of sampling for tritium at Plot M, the major monitoring objectives defined in the LTSP for Site A/Plot M can be met through annual—rather than quarterly—sampling. Sampling for tritium at Plot M though (both groundwater in the glacial drift wells and surface water) should remain on a quarterly schedule. Stakeholder input should be obtained before any change to the monitoring program is implemented.

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1.0 Background

The U.S. Department of Energy (DOE) Office of Legacy Management (LM) is responsible for the long-term custodial care of the Site A/Plot M radioactive waste disposal sites in the Palos Forest Preserve, Cook County, Illinois. These long-term responsibilities include groundwater and surface water monitoring, which are defined in the *Long-Term Surveillance and Maintenance Plan (LTSP) for Site A/Plot M, Illinois, Decommissioned Reactor* (DOE 2004).

The main constituents of concern (COC) in groundwater and surface water at Site A/Plot M are tritium and strontium-90. U.S. Environmental Protection Agency (EPA) drinking water standards found in Title 40 *Code of Federal Regulations* Part 141 do not apply to Site A/Plot M, because the affected water supply (picnic wells in the Palos Forest Preserve) does not meet the definition of a public water system. Illinois EPA Class I Ground Water Quality Standards (GWQS; Illinois Administrative Code Title 35, subpart 620) for tritium and strontium-90 of 20,000 picocuries per liter (pCi/L) and 8 pCi/L, respectively are useful contamination benchmarks. Tritium or strontium-90 concentrations at picnic wells in the Palos Forest Preserve have not exceeded these benchmarks.

Groundwater and surface water monitoring activities are conducted and reported annually by Argonne National Laboratory (ANL). The annual reports are made available to the public at the website http://www.lm.doe.gov/sitea_plotm/Sites.aspx.

The scope of the current groundwater and surface water monitoring program was implemented in February 2004. The scope is based on the outcome of a technical evaluation involving staff and contractors representing LM, ANL, DOE Chicago Operations Office, and the Illinois Emergency Management Agency (DOE 2004).

Groundwater and surface water monitoring requirements (locations, analytes, and frequencies) are defined in Table 1. Analyses are restricted to the main COCs, which are tritium and strontium-90. Sampling locations are shown in Figure 1. Monitoring results are used to assess the current status of past releases of tritium and strontium-90 from the site and to monitor elevated tritium concentrations previously detected in some of the picnic wells in the Red Gates Park section of the Palos Forest Preserve. Samples are collected quarterly. The LTSP 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 LTSP requires that the groundwater and surface water monitoring effort at Site A/Plot M be assessed every three to five years. This assessment report satisfies that requirement and includes data collected through 2009. As shown on Table 1 and Figure 1, groundwater and surface water monitoring per the LTSP are conducted at:

- Site A: Monitoring wells at Site A and five ponds in the vicinity of Site A,
- Plot M: Monitoring wells at and north of Plot M and surface water at Plot M, and
- Red Gate Woods: Picnic wells.

Results of the monitoring assessment are presented in the following sections.

Table 1. Summary of Environmental Monitoring Program for Site A and Plot M, Palos Forest Preserve, Illinois

Area	Number	Frequency and Analytes	Location
Groundwater from Monitor Wells in Glacial Drift			
Plot M	BH2	4X H/S	Downgradient from Plot M
	BH3	4X H/S	Downgradient from Plot M
	BH4	4X H/S	Downgradient from Plot M
	BH6	4X H/S	Cross gradient from Plot M
	BH9	4X H/S	Slant hole beneath Plot M
	BH10	4X H/S	Slant hole beneath Plot M
	BH11	4X H/S	Downgradient from Plot M
	BH26	4X H/S	Downgradient from Plot M
	BH35	4X H/S	Farther downgradient from Plot M
Site A	BH41	4X H/S	Onsite --downgradient to west of Site A
	BH51	4X H/S	Onsite -- south of Site A
	BH52	4X H/S	Offsite -- east of Site A
	BH54	4X H/S	Onsite -- north of Site A
	BH55	4X H/S	Onsite -- middle of Site A
	BH56	4X H/S	Onsite -- middle of Site A
Groundwater from Monitor Wells in Dolomite			
Plot M	DH3	4X H	Downgradient from Plot M
	DH4	4X H	Farther downgradient from Plot M
	DH9	4X H	Downgradient from Plot M and adjacent to picnic wells
	DH10	4X H	Downgradient from Plot M and adjacent to picnic wells
	DH11	4X H	Downgradient from Plot M and adjacent to picnic wells
	DH12	4X H	Downgradient from Plot M and adjacent to picnic wells
	DH13	4X H	Downgradient from Plot M and adjacent to picnic wells
	DH14	4X H	Downgradient from Plot M and adjacent to picnic wells
	DH15	4X H	Downgradient from Plot M and adjacent to picnic wells
	DH17	4X H	Downgradient from Plot M and adjacent to picnic wells
Groundwater from Picnic Wells in Dolomite			
	5159	4X H	Recently used picnic well -- may be used for drinking in future
	5160	4X H	Recently used picnic well -- may be used for drinking in future
Surface Water and Seep			
Plot M	0001	4X H	Upstream from Plot M
	0006	4X H	Seep -- adjacent to Plot M
	0007	4X H	Downstream from Plot M
	0008	4X H	Downstream from Plot M
Regional	Ponds - 5	4X H	Adjacent ponds in vicinity of Site A

Key:
4X = frequency per year at location
H = hydrogen-3 (tritium)
S = strontium-90

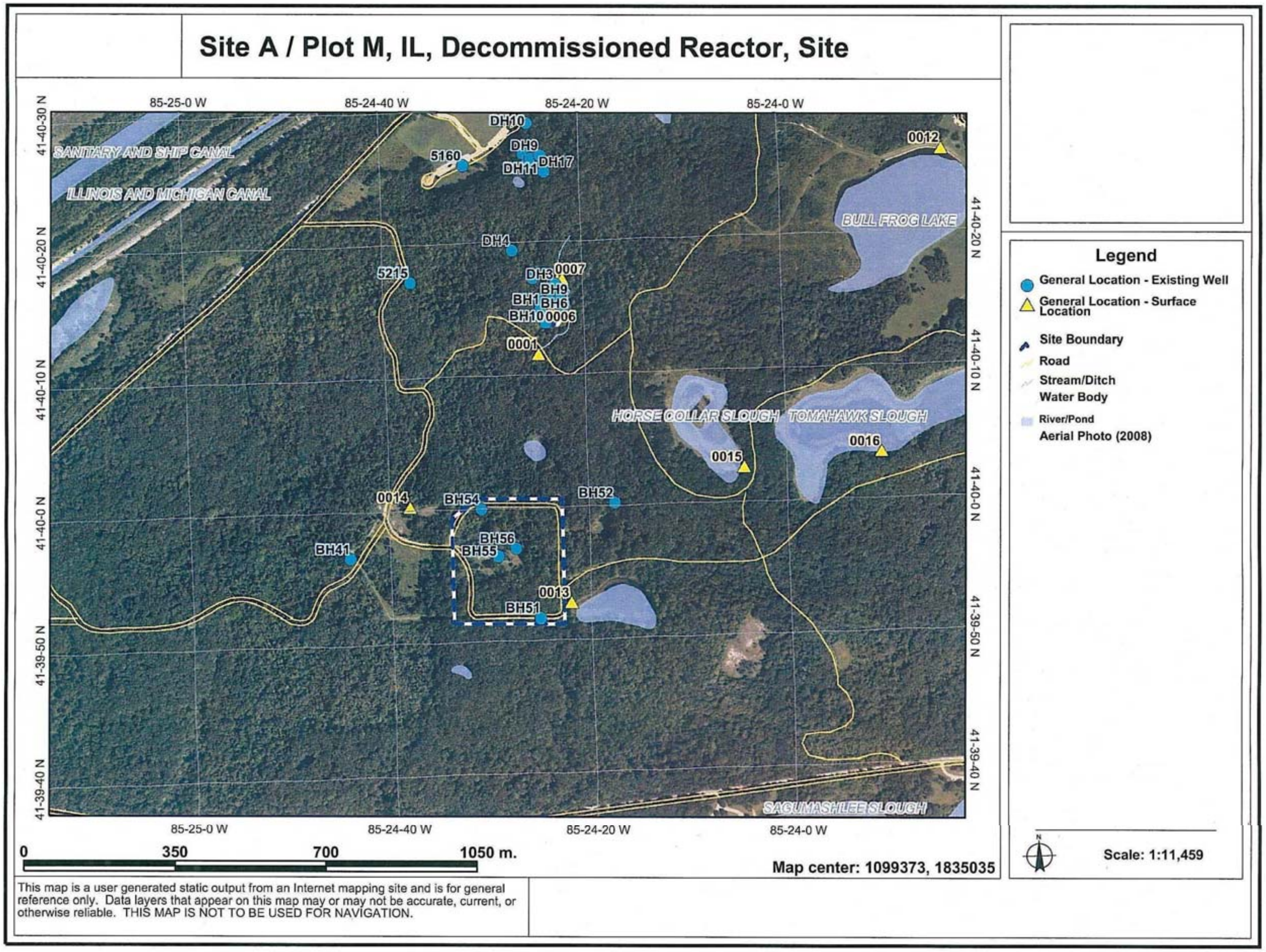

Figure 1. Sampling Locations

2.0 Site A Monitoring Results

Water quality monitoring is currently taking place at the following 11 locations (Table 1 and Figure 1) at and near Plot A:

- Six monitoring wells (BH-41, BH-51, BH-52, BH-54, BH-55, and BH-56) completed in the glacial drift are being sampled quarterly for tritium and semi-annually for strontium-90.
- Five ponds in the vicinity of Site A (Bullfrog Lake, the pond southeast of Site A, the pond northwest of Site A, Horsecollar Slough, and Tomahawk Slough) are being sampled quarterly for tritium.

2.1 Tritium Concentrations in Six Glacial Drift Wells at Site A

Figure 2 shows that from 1995 through 2009, tritium concentrations at all six monitoring wells at Site A have consistently been below the State of Illinois Class I GWQS value of 20,000 pCi/L. Two of the monitoring wells (BH-55 and BH-56) have tritium concentrations that are elevated relative to the other four wells. The relatively high tritium concentrations at these two wells are most likely from the buried CP-3 biological shield at Site A (ANL 2009). The tritium concentrations in both BH-55 and BH-56 have been decreasing since 1996. As reported by ANL, the tritium concentrations at Site A in 2009 were several orders of magnitude lower than what was measured at Plot M (ANL 2009).

The low tritium concentrations measured at Site A and the consistency of the concentration trends plotted for these wells indicate that an annual sampling effort should ensure that the two major monitoring objectives defined in the LTSP are met. Annual sampling should take place in the spring when water levels are seasonally high.

2.2 Strontium-90 Concentrations in Six Glacial Drift Wells at Site A

Figure 3 shows that from 1995 through 2009, only one well (BH-55) has exceeded the State of Illinois Class I GWQS value of 8 pCi/L for strontium-90. The last exceedance was in 2004. Stronitum-90 concentrations at all six monitoring wells have been below the State of Illinois GWQS since then and appear to be stable and/or decreasing.

The low strontium-90 concentrations measured in these wells at Site A and the consistency of the concentration trends since 2004 indicate that an annual sampling effort should ensure that the two major monitoring objectives defined in the LTSP are met. Annual sampling should take place in the spring when water levels are seasonally high.

2.3 Tritium Concentrations in Five Ponds in the Vicinity of Site A

Water samples are collected quarterly from five ponds in the vicinity of Site A to monitor for potential runoff. The locations (Bullfrog Lake, the pond southeast of Site A, the pond northwest of Site A, Horsecollar Slough, and Tomahawk Slough) are shown on Figure 1. The water samples are analyzed quarterly for tritium. Figure 4 shows the tritium concentrations measured at the five ponds from 1993 through 2009. With the exception of one result (899.2 pCi/L, November 15, 2004) the data have more or less fluctuated around the detection limit for the analysis (100 pCi/L).

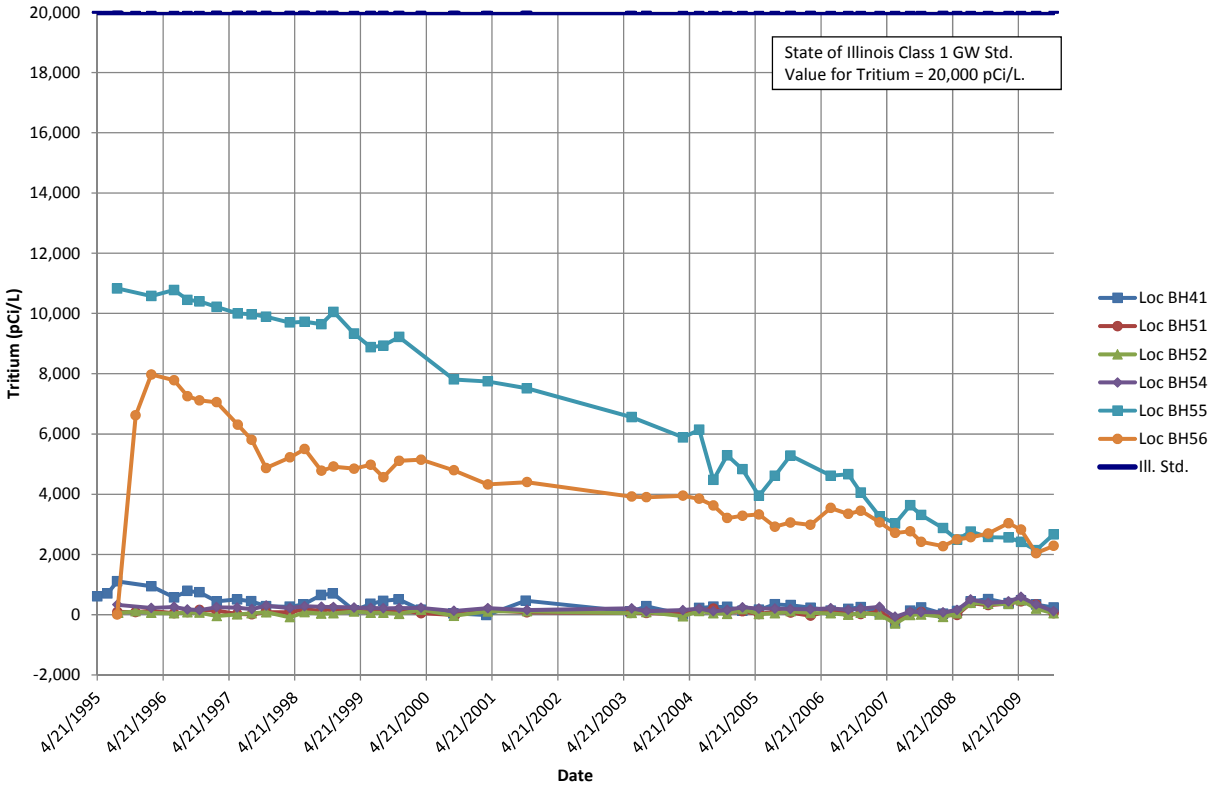

Figure 2. Tritium Concentrations in Six Glacial Drift Wells at Site A

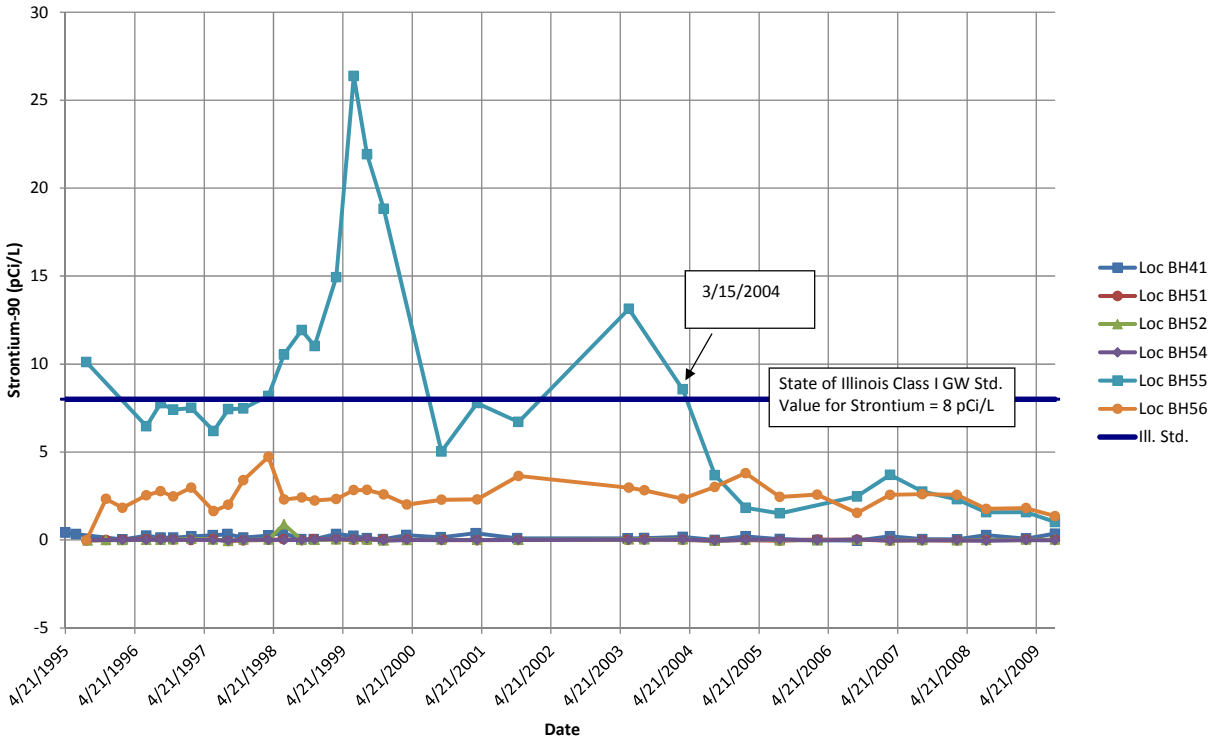

Figure 3. Strontium-90 Concentrations in Six Glacial Drift Wells at Site A

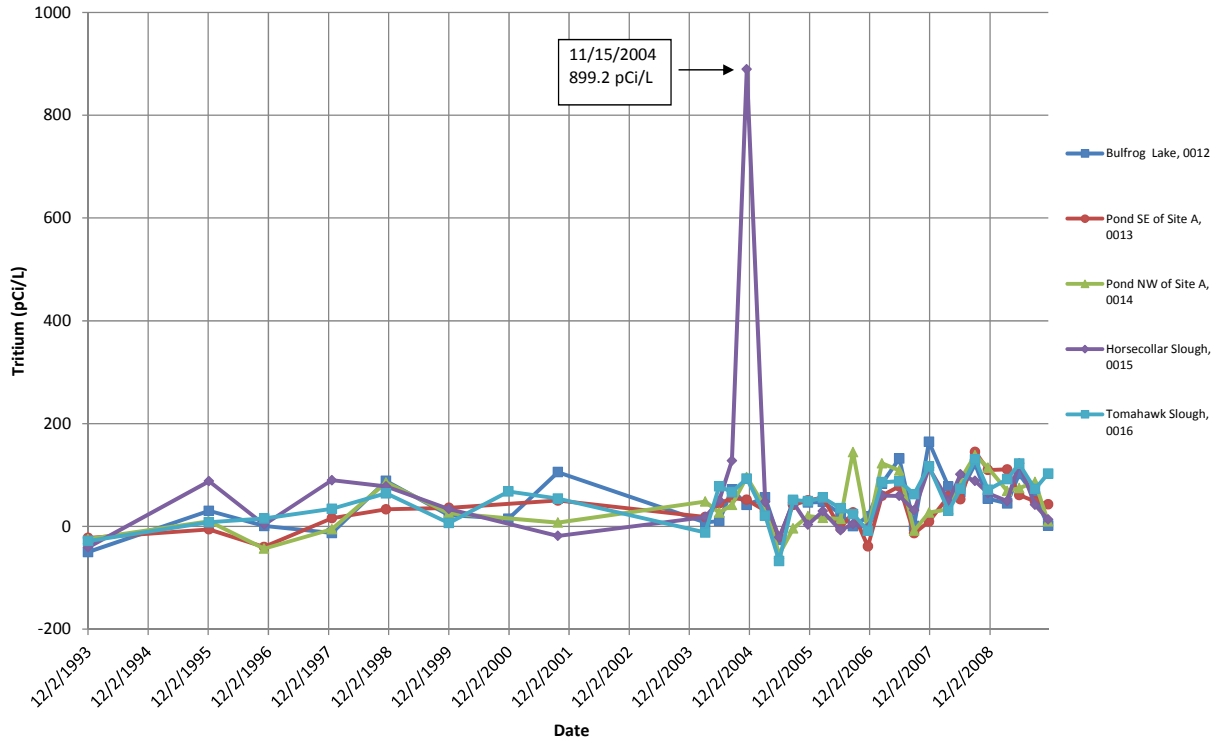

Figure 4. Tritium Concentrations in Five Ponds in the Vicinity of Site A

The consistency of the data trends and low concentration values measured indicate that an annual sampling effort should ensure that the two major monitoring objectives defined in the LTSP are met. Samples should be collected in the summer or fall when water levels might be at their seasonal lows; therefore, constituents in the water would be more concentrated.

3.0 Plot M Monitoring Results

Water quality monitoring is currently taking place at the following 23 locations (Table 1 and Figure 1) at and near Plot M:

- Nine monitoring wells completed in the glacial drift (BH-2, BH-3, BH-4, BH-6, BH-9, BH-10, BH-11, BH-26, and BH-35) are being sampled quarterly for tritium and strontium-90.
- Ten monitoring wells completed in dolomite (DH-3, DH-4, DH-9, DH-10, DH-11, DH-12, DH-13, DH-14, DH-15, and DH-17) are being sampled quarterly for tritium.
- Four surface water locations (0001, 0006, 0007, and 0008) are being sampled quarterly for tritium.

3.1 Tritium Concentrations in Nine Glacial Drift Wells at Plot M

Figure 5 provides tritium concentration data from 1993 through 2009 for the nine glacial drift monitoring wells located at Plot M. The data from 1993 through 2009 indicate that tritium concentrations have consistently been elevated above the State of Illinois Class I GWQS value of 20,000 pCi/L. Table 2 provides tritium data collected from glacial drift wells at Plot M from 2004 through 2009. The last row of Table 2 provides the average tritium concentration for each of the nine wells. As shown in the table, tritium concentrations are elevated well above the 20,000 pCi/L.

Consistently elevated tritium concentrations in all nine glacial drift monitoring wells at Plot M indicate that quarterly monitoring should continue.

3.2 Strontium-90 Concentrations in Nine Glacial Drift Wells at Plot M

Figure 6 provides strontium-90 concentration data from 1993 through 2009 for the nine glacial drift monitoring wells located at Plot M. The data indicate that since June 1993, strontium-90 concentrations have been below the State of Illinois Class I GWQS value of 8 pCi/L. The highest strontium-90 concentration measured in 2009 was in well BH-9 (6.264 pCi/L). Mann-Kendall trends tests (95% confidence level) were run on the data set from monitoring well BH-9 using ChemStat Version 6.2. The Mann-Kendall trend test did not indicate either an up or down trend for strontium concentrations at this well.

Strontium-90 concentrations consistently below the State of Illinois Class I GWQS since 1994 indicate that an annual sampling effort for strontium-90 in these wells should ensure that the two major monitoring objectives defined in the LTSP are met. Annual sampling should take place in the spring when water levels are seasonally high.

3.3 Tritium Concentrations in Ten Dolomite Wells at and North of Plot M

Ten monitoring wells are cased into dolomite bedrock to monitor tritium at and between Plot M and the Red Gate Woods area. Figure 7 shows that from 1993 through 2009, tritium concentrations in the ten monitoring wells have consistently been below the State of Illinois Class I GWQS value of 20,000 pCi/L.

The low tritium concentrations coupled with the consistent concentration trends indicate that an annual sampling effort should ensure that the two major monitoring objectives described in the LTSP are met. Annual sampling should take place in the spring when water levels are seasonally high.

3.4 Tritium Concentrations from Four Surface Water Locations at Plot M

Quarterly surface water sampling for tritium is conducted at four locations (streams and seeps) located at Plot M. Figure 8 provides tritium concentration data measured from 1993 through 2009 from the four surface water locations. As shown in Figure 8, tritium concentrations in surface water around Plot M remain elevated and continue to fluctuate seasonally. A consistent concentration pattern among the sampling locations has been reported for this data (ANL 2009). The pattern shows that concentrations of tritium are usually below the detection limit upstream of Plot M, and concentrations increase in the seep water that leaches out Plot M. Lower concentrations are then measured farther downstream of Plot M.

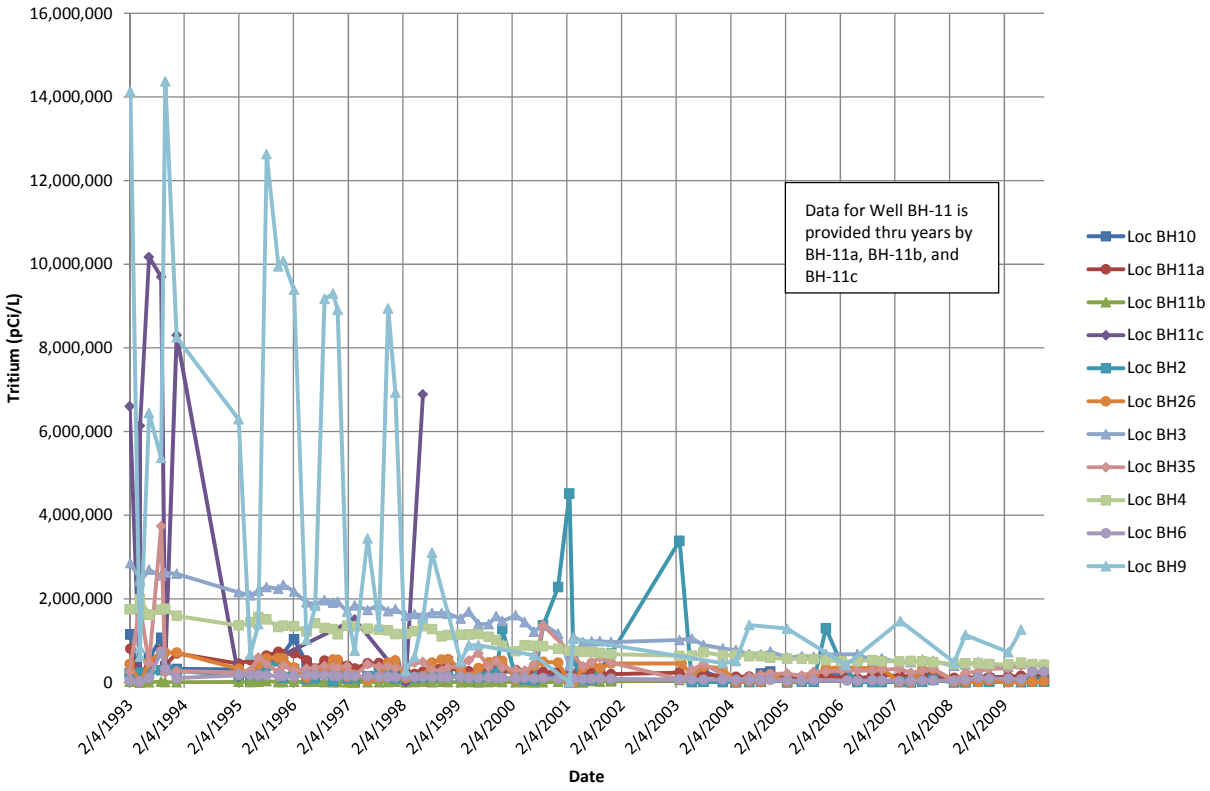

Figure 5. Tritium Concentrations in Nine Glacial Drift Wells at Plot M

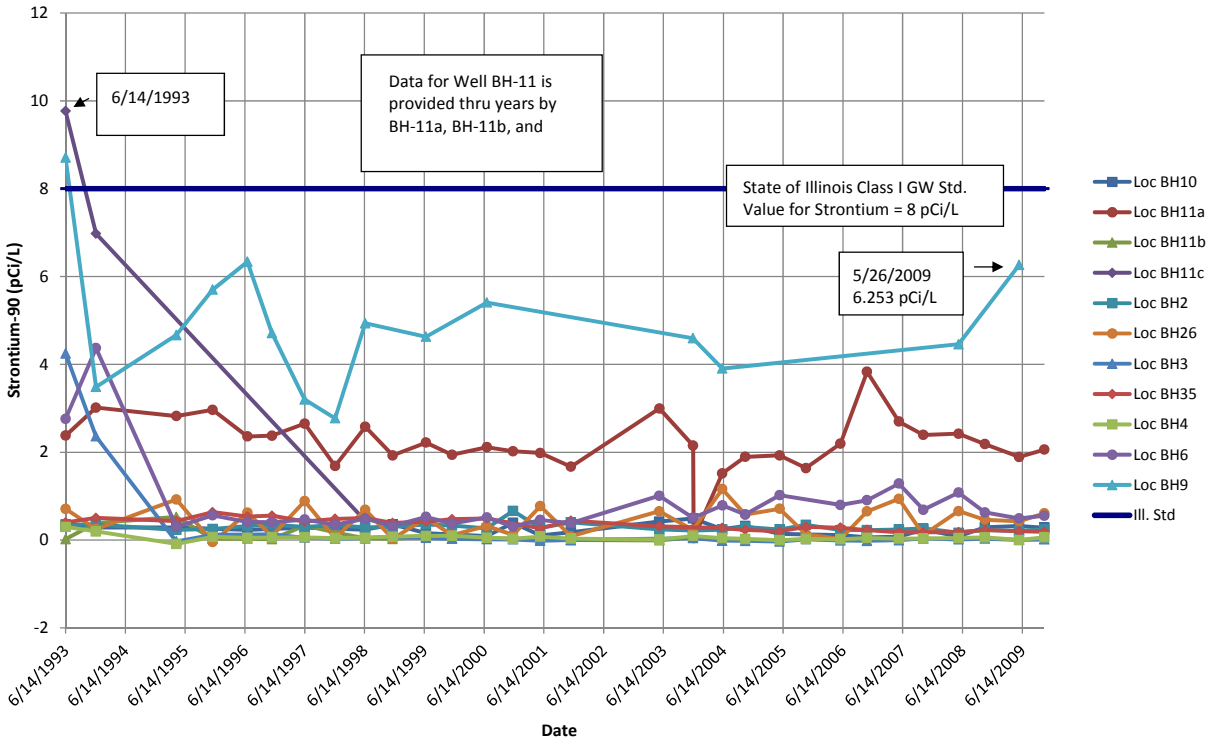

Figure 6. Strontium-90 Concentrations in Nine Glacial Drift Wells at Plot M

Table 2. Tritium Concentrations in Glacial Drift Wells at Plot M from 2004 through 2009

Sample Date	Loc BH-10 (pCi/L)	Loc BH-11a (pCi/L)	Loc BH-2 (pCi/L)	Loc BH-26 (pCi/L)	Loc BH-3 (pCi/L)	Loc BH-35 (pCi/L)	Loc BH-4 (pCi/L)	Loc BH-6 (pCi/L)	Loc BH-9 (pCi/L)
3/9/2004	455.9	132,700	5,184	63.14	774,000	29,660	661,100	60,120	511,200
6/7/2004	32,150	137,100	7,569	22,690	673,700	132,800	625,500		1,371,000
6/8/2004								48,920	
8/23/2004	211,300	143,700	9,387	4,905	666,000	179,300	623,700	49,950	
10/25/2004	256,800	147,700	102,500	197,000	738,000	201,100	590,400	59,220	
2/14/2005	232.20	116,800.00	8,433.00	2.05	591,800.00	208,800.00	564,800.00	41,670.00	1,285,000.00
5/23/2005	46,400.00	118,900.00	10,670.00	44,000.00	625,100.00	157,900.00	563,400.00	39,600.00	
8/10/2005		146,500.00	12,320.00	164,500.00	611,600.00	254,500.00	554,400.00	54,090.00	
10/31/2005		158,400.00	1,291,000.00	335,200.00	671,000.00		529,700.00		
11/1/2005						248,900.00			
2/13/2006	261,900.00		428,500.00	363,900.00		282,800.00	499,500.00		
3/14/2006		92,430.00							413,100.00
3/22/2006								45,050.00	
5/30/2006	21,010.00	97,020.00	3,598.00	342,900.00	675,500.00	282,600.00	504,500.00	35,340.00	
9/7/2006	104,300.00	142,700.00	5,418.00	344,200.00	523,800.00	278,800.00	527,400.00	48,240.00	
11/8/2006	24,130.00	187,300.00	6,201.00	337,400.00	572,900.00	300,000.00	504,500.00	42,620.00	
3/5/2007	66,330.00			3,170.00	482,400.00	322,000.00	498,600.00	27,710.00	
3/12/2007		139,700.00	6,066.00						1,462,000.00
5/21/2007	6,795.00								
5/22/2007		130,500.00	8,694.00	1,527.00	481,500.00	224,500.00	509,900.00	30,190.00	
8/6/2007	209,300.00	141,800.00	9,761.00	320,500.00		279,600.00	503,100.00	41,190.00	
8/7/2007					539,600.00				
10/18/2007	144,100.00	163,000.00	58,100.00	322,500.00	513,500.00	321,900.00	482,000.00	44,190.00	
3/6/2008	265.40	106,300.00	5,108.00	1,627.00	391,800.00	49,730.00	440,600.00	36,900.00	481,100.00
5/20/2008	939.60	111,200.00	6,485.00	324.00	419,000.00	226,700.00	451,400.00	60,390.00	1,136,000.00
8/15/2008	73,760.00	125,100.00	14,570.00	4,375.00	482,900.00	261,600.00	454,100.00	113,900.00	
10/28/2008	92,120.00	128,100.00	12,490.00	44,070.00	444,700.00	328,000.00	436,200.00	91,440.00	
3/3/2009	60,840.00	131,800.00	14,130.00	594.00	366,600.00	339,200.00	429,000.00	89,010.00	719,100.00
5/26/2009	7,857.00	159,800.00	12,670.00	9,360.00	433,900.00	400,600.00	469,800.00	75,240.00	1,256,000.00
8/10/2009	90,540.00	167,000.00	18,180.00	13,370.00	415,900.00	402,900.00	436,900.00	253,600.00	
10/27/2009	22,500.00	154,600.00	13,990.00	20,580.00	433,300.00	406,300.00	419,500.00	253,000.00	
Minimum	232.20	92,430.00	3,598.00	2.05	366,600.00	29,660.00	419,500.00	27,710.00	413,100.00
Maximum	261,900.00	187,300.00	1,291,000.00	363,900.00	774,000.00	406,300.00	661,100.00	253,600.00	1,462,000.00
Range	261,667.80	94,870.00	1,287,402.00	363,897.95	407,400.00	376,640.00	241,600.00	225,890.00	1,048,900.00
Average	**78,819.32**	**136,672.92**	**86,292.67**	**120,781.55**	**544,717.39**	**255,007.92**	**511,666.67**	**71,373.04**	**959,388.89**

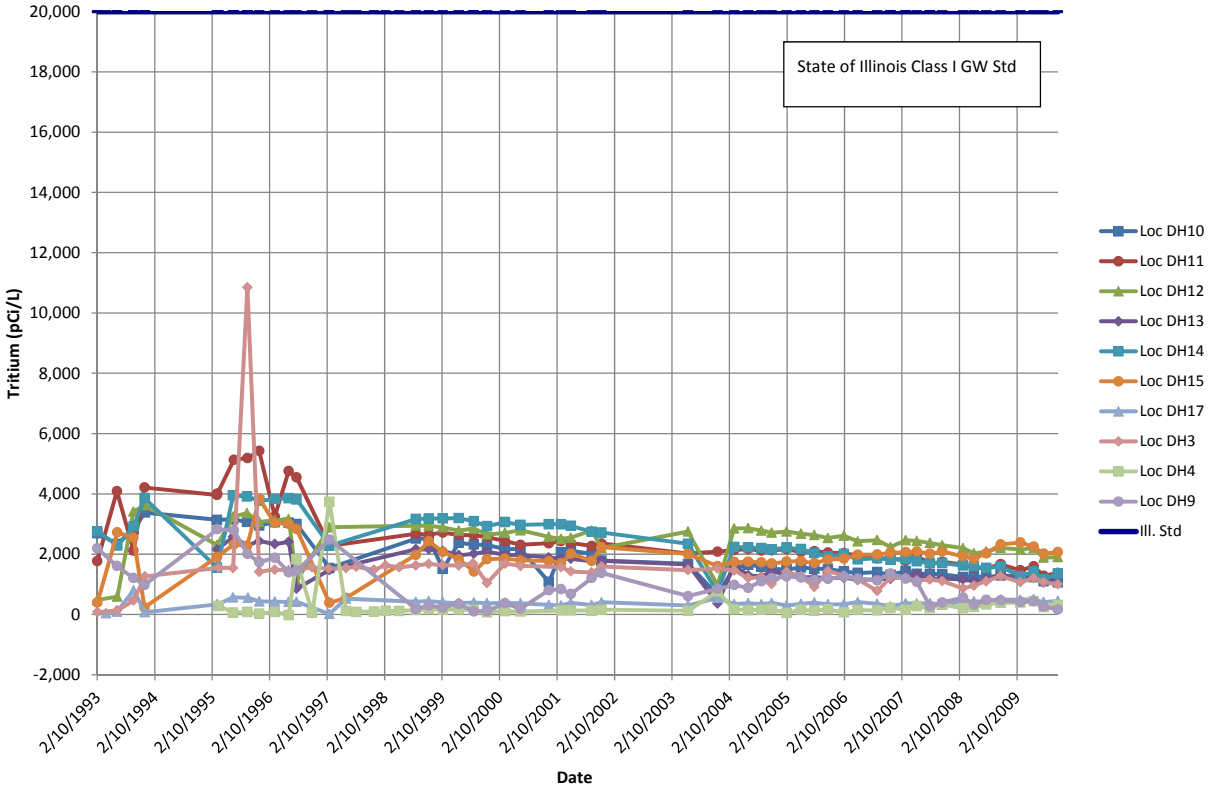

Figure 7. Tritium Concentrations in Ten Dolomite Wells at and North of Plot M

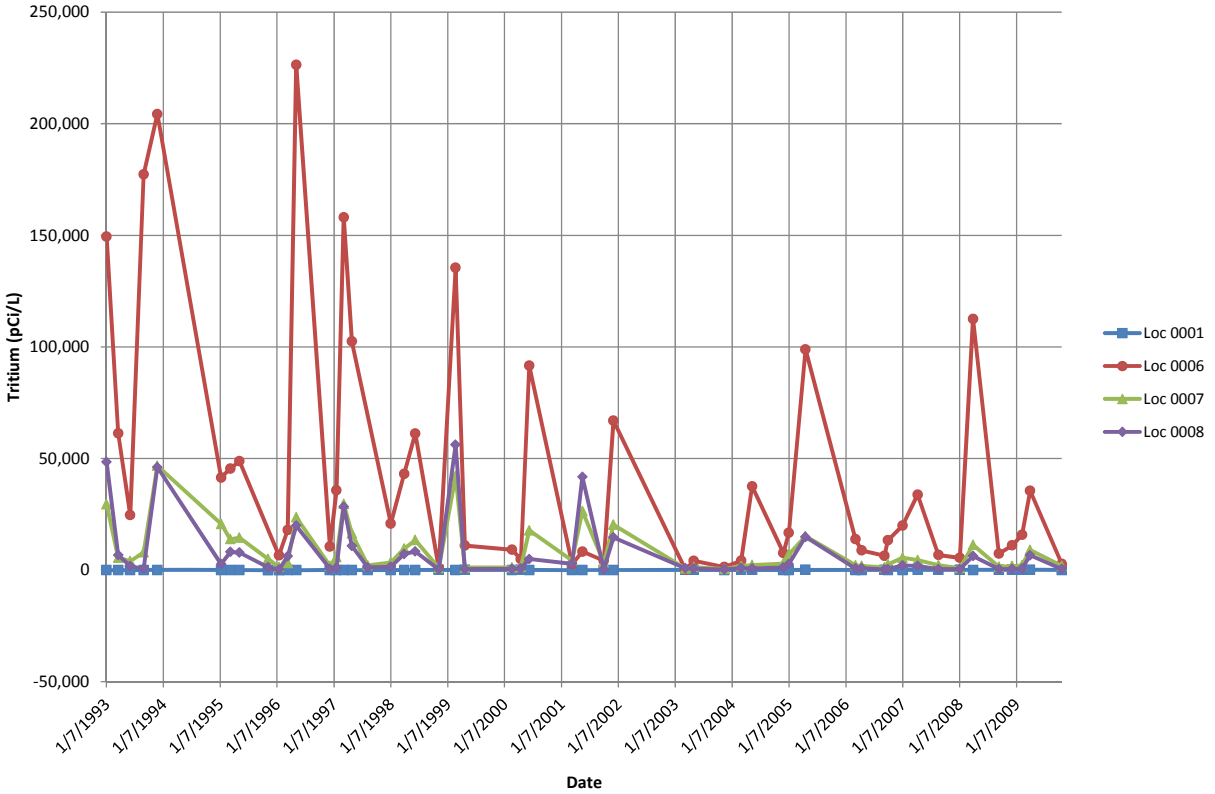

Figure 8. Tritium Concentrations from Four Surface Water Locations at Plot M

The elevated and fluctuating tritium concentrations indicate that continued quarterly monitoring of all four locations is needed in order to meet the two major monitoring objectives defined in the LTSP.

4.0 Water Quality Monitoring Results for Drinking Water Wells at Red Gates Park

Red Gates Park is located north of Plot M (Figure 1). Water quality monitoring is currently taking place at two drinking water wells at Red Gates Park (#5159 and #5160). Both wells draw water from the dolomite formation and are sampled for tritium. Well #5160 has not been available to the public since 1999 due to high coliform levels.

Figure 9 shows that from 1993 through 2009 tritium concentrations at picnic wells #5159 and #5160 have consistently been well below the State of Illinois Class I GWQS value of 20,000 pCi/L. Tritium concentrations from these wells have historically shown a seasonal pattern of high concentrations in the winter and low concentrations in the summer. This seasonal pattern is no longer readily detectable given the low tritium concentrations being measured (ANL 2009). Since 2008, tritium concentrations at both wells have been consistently low and steady.

Consistently low and steady tritium concentrations in picnic wells #5159 and #5160 indicate that an annual sampling effort should ensure that the two major monitoring objectives presented in the LTSP are met. Sampling should take place in the spring when water levels are seasonally high.

5.0 Water Level Monitoring Results

Water levels are being monitored in the following three groups of monitoring wells:

- Wells completed in the Glacial Drift at Site A,
- Wells completed in the Glacial Drift at Plot M, and
- Wells completed in a dolomite formation at and north of Plot M.

Monitoring results are discussed below.

5.1 Water Levels in Glacial Drift Wells at Site A

Groundwater levels have remained relatively constant in the six glacial drift monitoring wells at Site A since 1995. Hydrographs for the six monitoring wells completed in the glacial drift beneath Site A are shown in Figure 10. Mann-Kendall trends tests (95% confidence level) were run using ChemStat Version 6.2 Software on the data sets from each well. The Mann-Kendall trend tests indicate no trends at four of the six wells (BH-41, BH-52, BH-54, and BH-56). The water level trend in BH-51 is down (Figure 11), and the water level trend in BH-55 is up (Figure 12). The trends in BH-51 and BH-55 are slight.

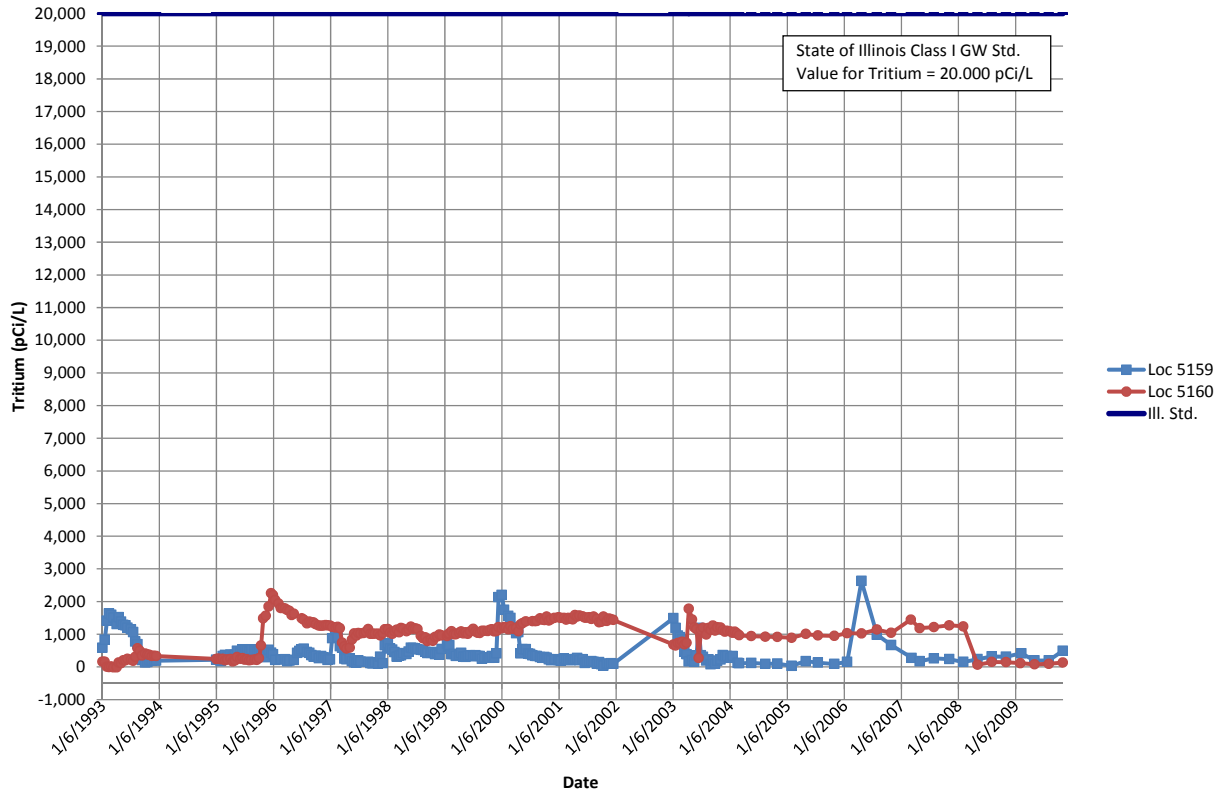

Figure 9. Tritium Concentrations in Picnic Wells at Red Gates Park

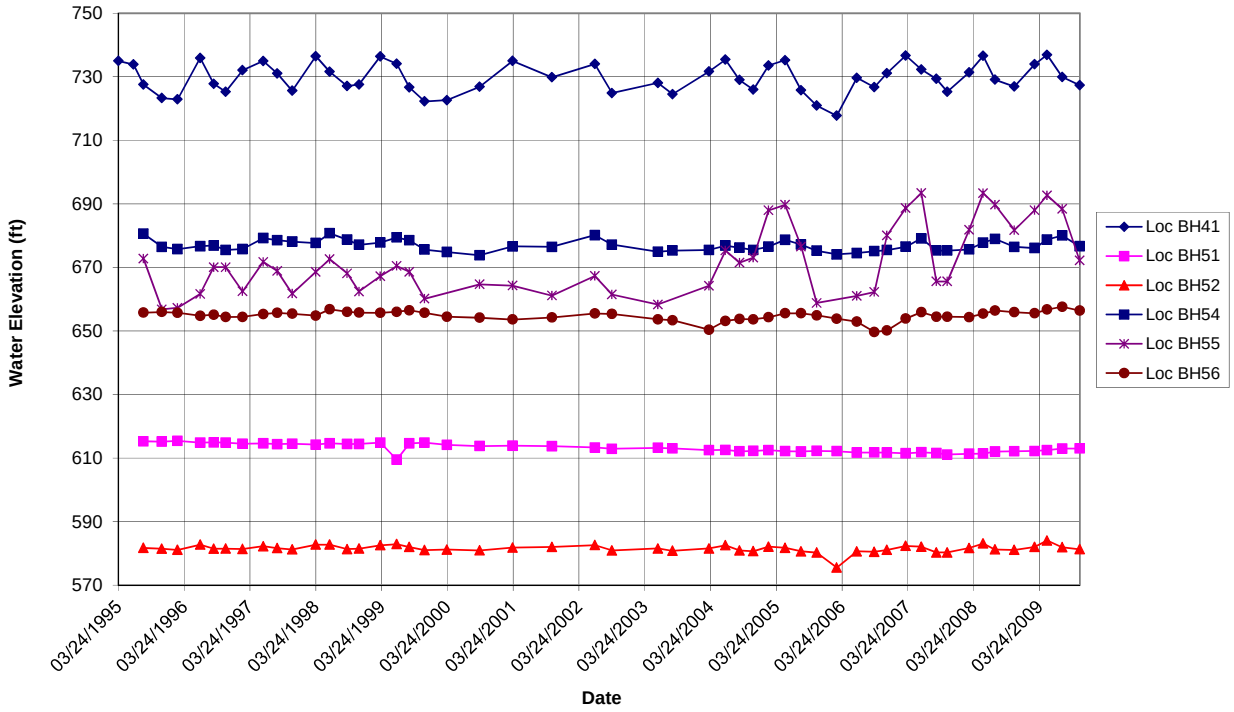

Figure 10. Hydrographs for the Six Glacial Drift Wells at Site A

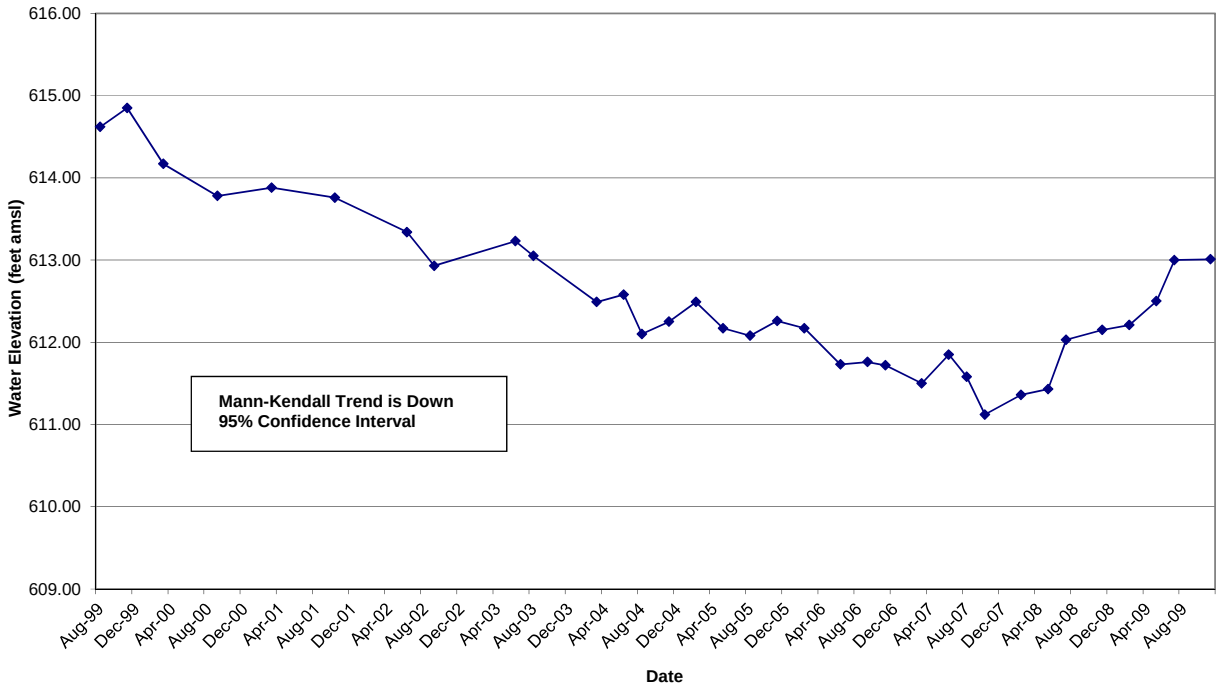

Figure 11. Hydrograph for Glacial Drift Well BH-51

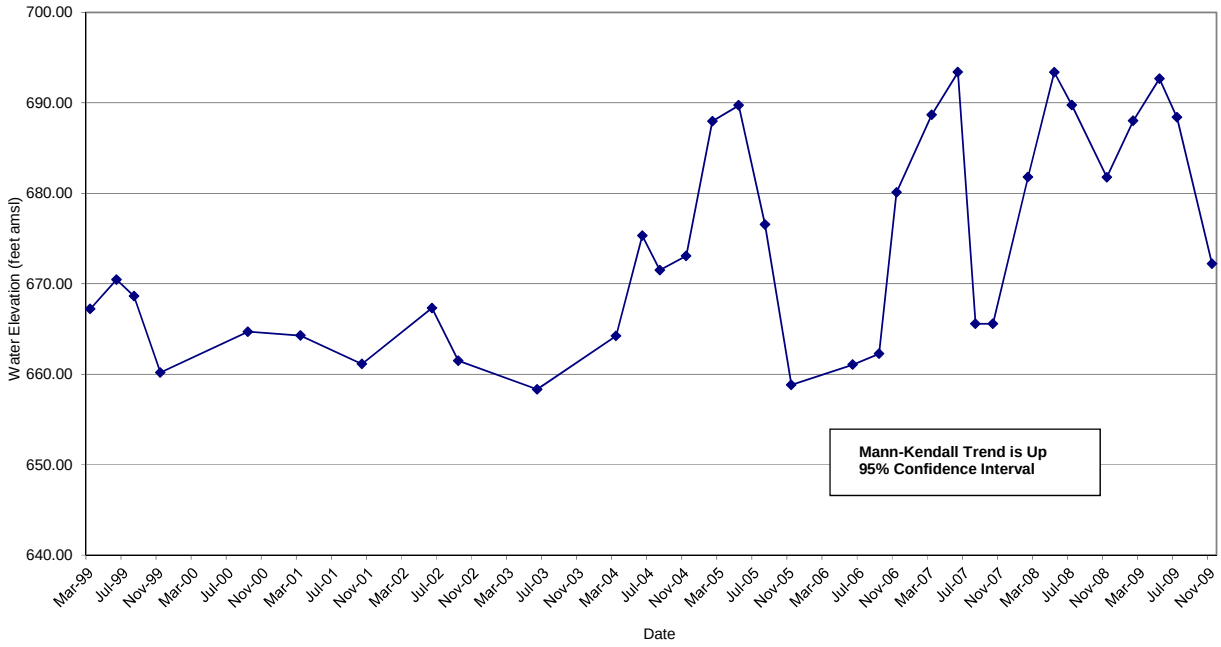

Figure 12. Hydrograph for Glacial Drift Well BH-55

5.2 Water Levels in Glacial Drift Wells at Plot M

Groundwater levels have remained relatively constant in the seven glacial drift monitoring wells at Plot M since 1994. Hydrographs for the seven monitoring wells completed in the glacial drift beneath Plot M are shown in Figure 13. Mann-Kendall trend tests (95% confidence level) were run using ChemStat Version 6.2 Software on the data sets from each well. The Mann-Kendall trend tests indicate no trends at four of the seven wells (BH-2, BH-3, BH-6, and BH-11). The water level trends at monitoring wells BH-4, BH-26, and BH-35 are down (Figures 14, 15, and 16, respectively). The down trends in BH-4, BH-26, and BH-35 are slight.

5.3 Water Levels in Dolomite Wells at and North of Plot M

Groundwater levels have remained relatively constant since 1994 in the ten monitoring wells completed in dolomite at and north of Plot M. Hydrographs for the ten monitoring wells are shown in Figure 17. Mann-Kendall trend tests (95% confidence level) were run using ChemStat Version 6.2 Software on the data sets from each well. The Mann-Kendall tests indicate that no water level trends are present in any wells.

6.0 Summary

An assessment of the groundwater and surface water monitoring data collected through 2009 at Site A/Plot M shows that:

- Quarterly monitoring for tritium should continue at all nine glacial drift monitoring wells and all four surface water locations at Plot M.
- The two major monitoring objectives defined in the LTSP for groundwater and surface water can be met through annual monitoring of the other sampling locations currently defined in the LTSP.
- Consistent groundwater levels support a less frequent monitoring schedule for COC constituents with steady concentrations that are below State of Illinois Class 1 GWQS.

7.0 References

ANL (Argonne National Laboratory), 2009, *Surveillance of Site A and Plot M Report for 2009,* Argonne National Laboratory, Argonne, Illinois.

DOE (U.S. Department of Energy), 2004, *Long-Term Surveillance and Maintenance Plan for Site A/Plot M, Illinois, Decommissioned Reactor,* Grand Junction, Colorado.

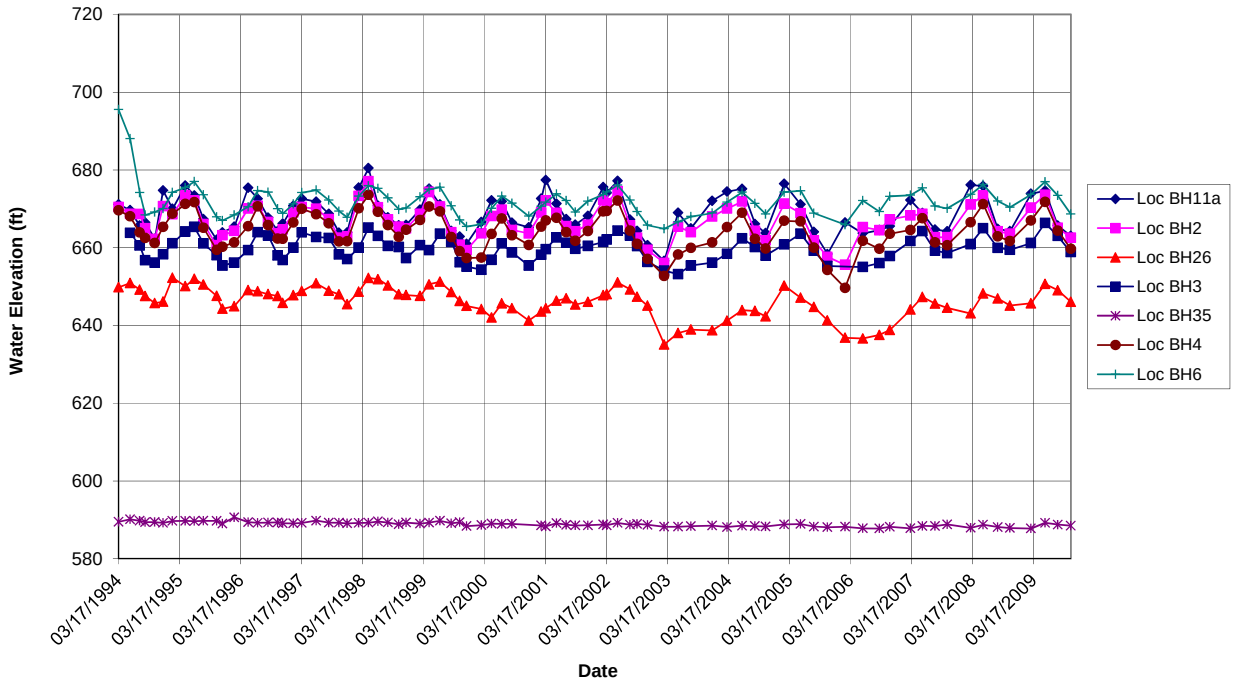

Figure 13. Hydrographs for the Seven Glacial Drift Wells at Plot M (Slant Wells BH-10 and BH-11 not included)

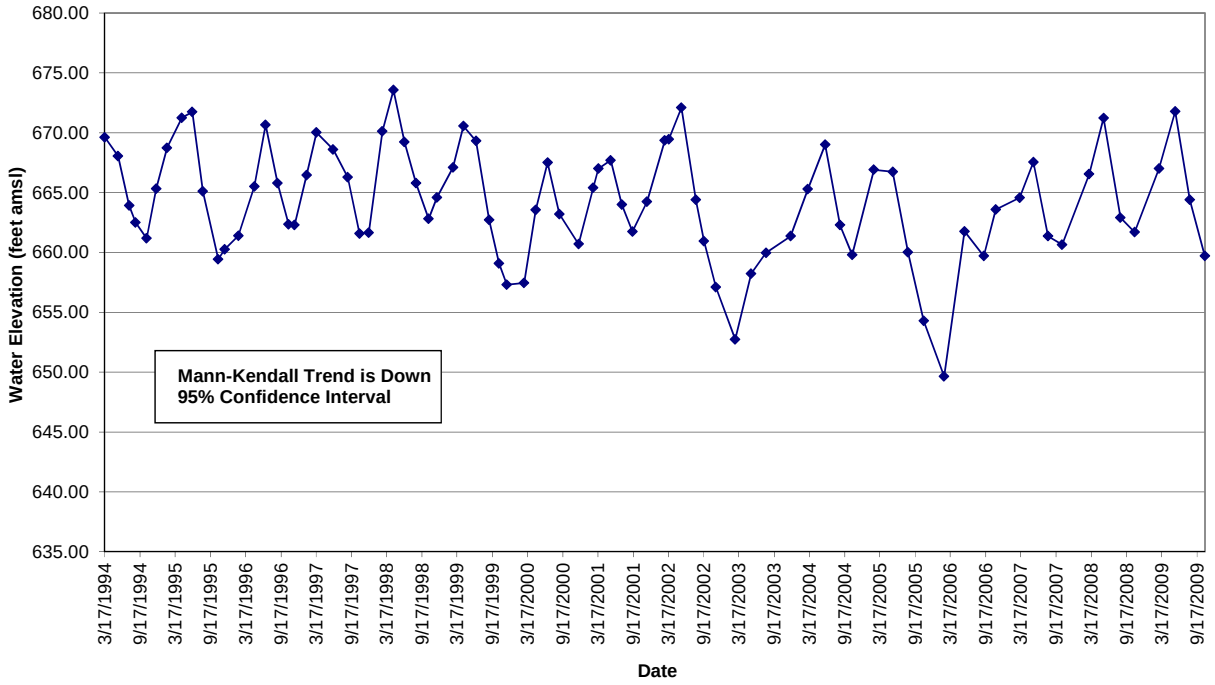

Figure 14. Hydrograph for Glacial Drift Well BH-4

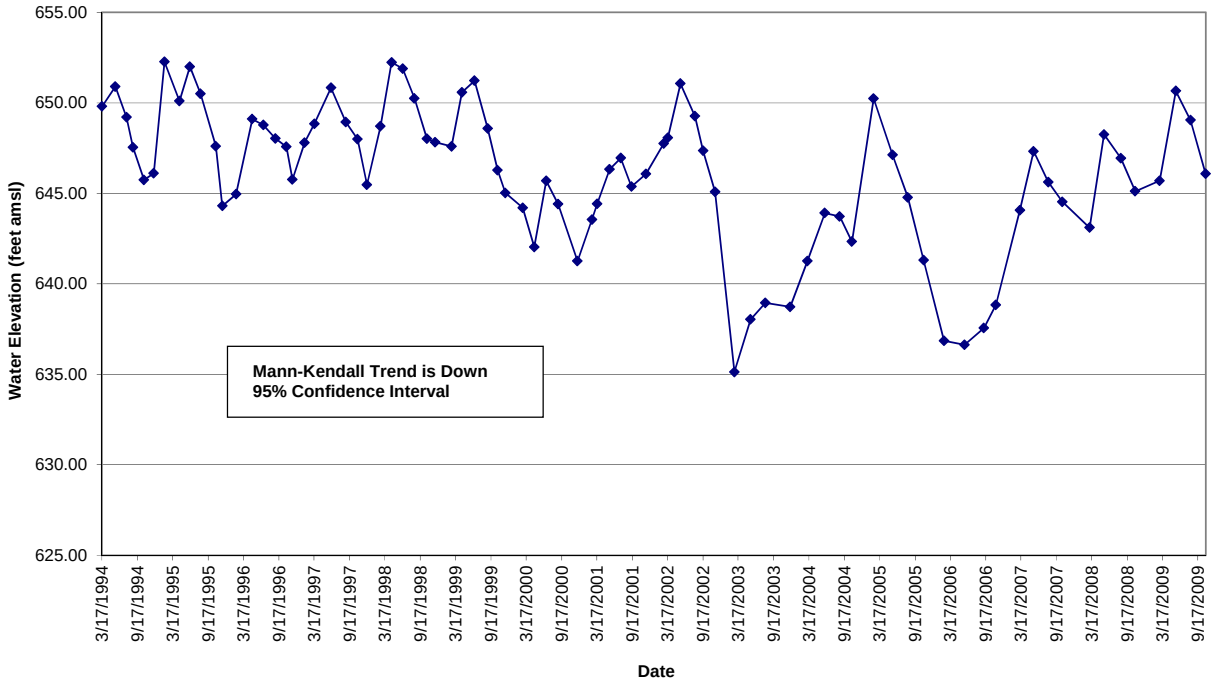

Figure 15. Hydrograph for Glacial Drift Well BH-26

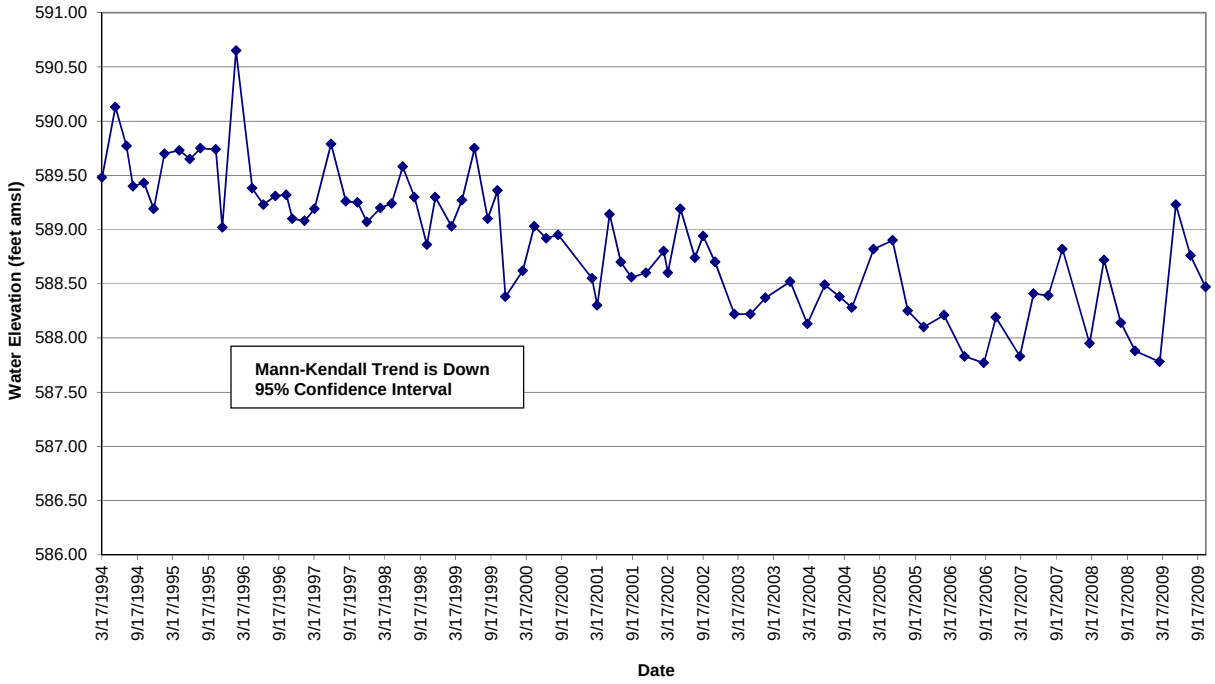

Figure 16. Hydrograph for Glacial Drift Well BH-35

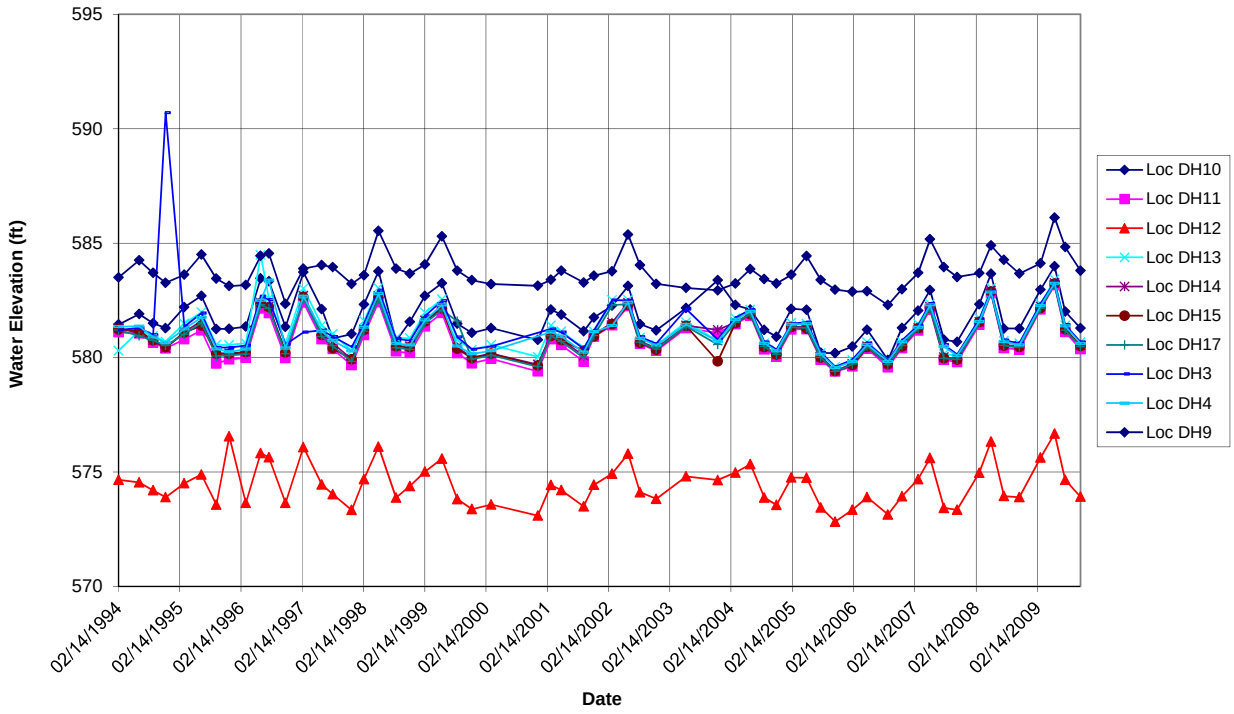

Figure 17. Hydrographs for Dolomite Wells at and North of Plot M

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