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Office of Environmental Management – Grand Junction

UMTRA Project

Moab UMTRA Project
2013 Ground Water Program Report

Revision 0

May 2014

U.S. Department of Energy

Office of Environmental Management

Prepared by the Technical Assistance Contractor under contract number DE-EM0002067 for the U.S. Department of Energy Office of Environmental Management, Grand Junction, Colorado.

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Revision 0

Review and Approval

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Revision History

Revision No.	Date	Reason/Basis for Revision
0	May 2014	Initial issue.

Contents

Figures

Tables

Appendices

Attachment

Acronyms and Abbreviations

bgs	below ground surface
CF	configuration
cfs	cubic feet per second
DOE	U.S. Department of Energy
ft	feet or foot
gal	gallon or gallons
gpm	gallons per minute
IA	interim action
in.	inch(es)
kg	kilogram(s)
lb	pound(s)
µmhos/cm	micromhos per centimeter
mg/L	milligrams per liter
mil	million(s)
RAC	Remedial Action Contractor
TDS	total dissolved solids
UMTRA	Uranium Mill Tailings Remedial Action

1.0 Introduction

1.1 Purpose and Scope

The purpose of the Ground Water Program Report is to assess the performance measures the U.S. Department of Energy (DOE) has taken to remediate the ground water at the Moab Uranium Mill Tailings Remedial Action (UMTRA) Project site and to protect endangered fish habitat in the Colorado River adjacent to the site.

This report describes the Ground Water Program activities for the Moab Project during 2013 and evaluates how the ground water system at the Moab site responds to various pumping regimes and fluctuating river flow.

1.2 Site History and Background

The Moab Project site is a former uranium ore-processing facility located approximately 3 miles northwest of the city of Moab in Grand County, Utah (Figure 1). The Moab mill operated from 1956 to 1984. When the processing operations ceased, an estimated 16 million (mil) tons of uranium mill tailings accumulated in an unlined impoundment. A portion of the impoundment is in the 100-year floodplain of the Colorado River. In 2001, ownership of the site was transferred to DOE. Since April 2009, tailings have been relocated by rail to a disposal cell 30 miles north, near Crescent Junction, Utah.

Site-related contaminants, including ammonia and uranium, have leached from the tailings pile into the shallow ground water. Some of the more mobile constituents have migrated downgradient and are discharging to the Colorado River adjacent to the site.

In 2005, DOE issued the *Record of Decision for the Remediation of the Moab Uranium Mill Tailings, Grand and San Juan Counties, Utah* (6450-01-P) which includes the cleanup alternative to continue, and expand as necessary, its ongoing active remediation of contaminated ground water at the Moab site. As an interim action (IA), DOE began limited ground water remediation that involves extraction of contaminated ground water from on-site remediation wells and evaporation of the extracted water in a lined pond. Diverted river water is also injected into remediation wells to protect fish habitat in riparian areas along the Colorado River.

2.0 Ground Water Program Description

The Ground Water Program at the Moab site is designed to limit ecological risk from contaminated ground water discharging to potential endangered fish species habitat areas along the Colorado River. This protection is accomplished through removal of contaminant mass with ground water extraction wells and by freshwater injection between the river and the tailings pile to create a hydraulic barrier that reduces discharge of contaminated water to suitable habitat areas. Ground water and surface water monitoring is performed in conjunction with injection and extraction operations through water levels and analytical data.

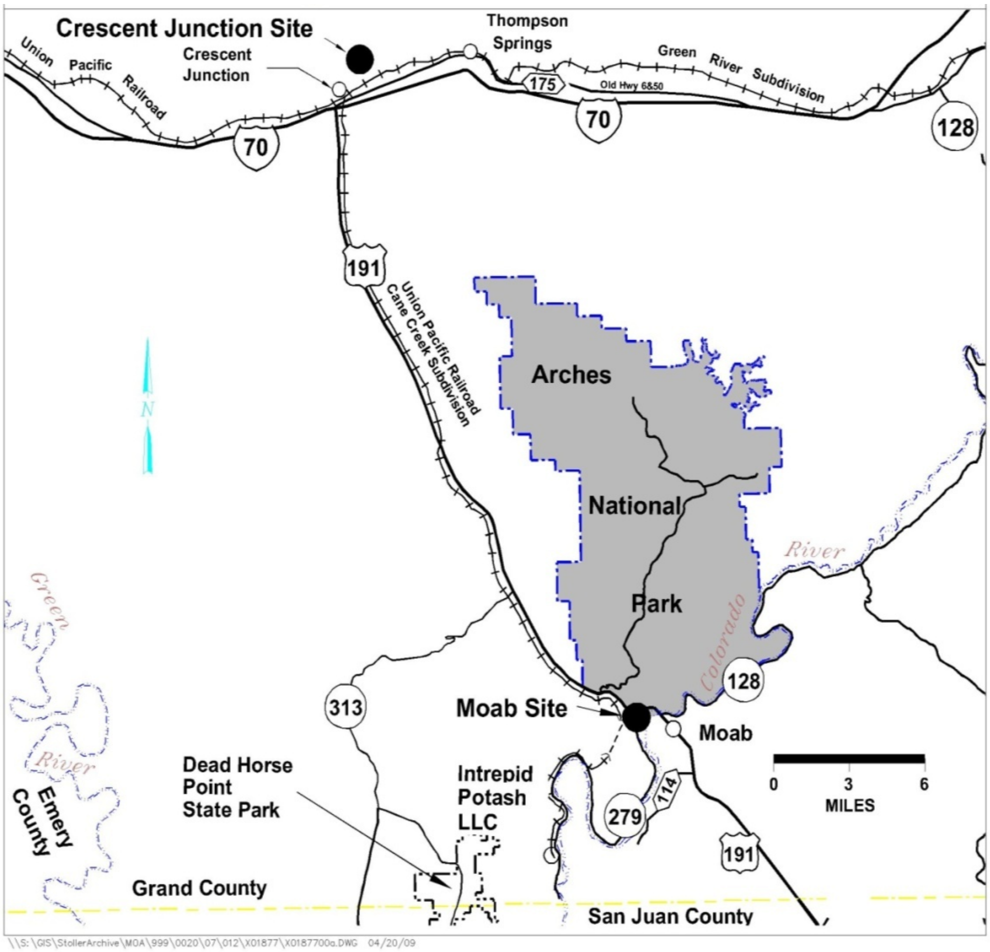


Figure 1. Location of the Moab Project Site

2.1 IA Ground Water System

DOE installed and began operating the first of several configurations (CFs) of extraction/injection wells that comprise the IA ground water system in 2003 (Figure 2). The well field consists of five configurations of wells, an infiltration trench, and a baseline area. In 2013, CFs 4 and 5 were utilized.

The objectives of the IA system are to: 1) reduce the discharge of ammonia-contaminated ground water to side channels that may be suitable habitat for endangered aquatic species; 2) remove contaminant mass through ground water extraction; and 3) to provide performance data for use in selecting and designing a final ground water remedy.

Contaminated ground water from the shallow plume above the brine zone is extracted through a series of eight extraction wells (CF5) and pumped to an evaporation pond or through evaporation units on top of the tailings pile. The IA system also includes injection of diverted river water into the underlying alluvium through remediation wells and an infiltration trench installed near the western bank of the river. Monitoring wells are also part of the IA system for evaluation purposes.

Figure 2. Location of IA Wells

2.2 Hydrology and Contaminant Distribution

The primary hydrogeologic unit present at the Moab site consists of unconsolidated alluvium and salt beds of the Paradox Formation. The alluvium at the Moab site is mostly comprised of either the Moab Wash alluvium or basin-fill alluvium. The Moab Wash alluvium is composed of fine-grained sand, gravelly sand, and detrital material that travels down the Moab Wash and interfingers near the northwestern boundary of the site into the basin-fill alluvium deposited by the Colorado River.

The basin-fill alluvium is comprised of two distinct types of material. The upper unit consists mostly of fine sand, silt, and clay and ranges in thickness up to 15 feet (ft) near the saturated zone in some areas. This shallow unit is made of overbank deposits from the Colorado River. The lower part of the basin-fill alluvium consists mostly of a gravelly sand and sandy gravel, with minor amounts of silt and clay. This deeper, coarse alluvium pinches out to the northwest along the subsurface bedrock contact and thickens to the southwest toward the river more than 450 ft near the deepest part of the basin. The upper silty-sand unit typically has a hydraulic conductivity that ranges from 100 to 200 ft/day.

Water table contour maps indicate the ground water in this area discharges into the Colorado River. Figure 3 was generated using data collected in May 2013 and exhibits how ground water underlying the site discharges into the Colorado River. The river flow ranged from 3,210 to 12,800 cubic feet per second (cfs) when the ground water elevation was measured. Figure 4 shows the ground water contours in November/December 2013 when the river flow ranged from 2,980 to 4,000 cfs. The ground water elevation in May was slightly higher due to the higher Colorado River flow.

Most ground water beneath the site contains total dissolved solids (TDS) concentrations greater than 10,000 milligrams per liter (mg/L) (brackish water and brine). A brine interface occurs naturally beneath the Moab site that is delineated at a TDS concentration of 35,000 mg/L or a specific conductance of approximately 50,000 micromhos per centimeter (µmhos/cm). The interface moves laterally and vertically during the course of each year in response to stresses, such as changes in river stage.

The tailings-pile fluids contain TDS exceeding 35,000 mg/L, allowing this fluid to have sufficient density to vertically migrate downward in ground water under previous operating conditions at the site. This former density-driven flow has created a legacy plume of dissolved ammonia that now resides below the brackish water/brine interface. The ammonia beneath the interface represents a potential long-term source of contamination to the upper alluvial ground water system.

Since the cessation of milling operations at the site, the flux of relatively fresh water entering the site upgradient of the tailings pile may have diluted the ammonia levels in the shallow ground water (Figures 5 and 6).

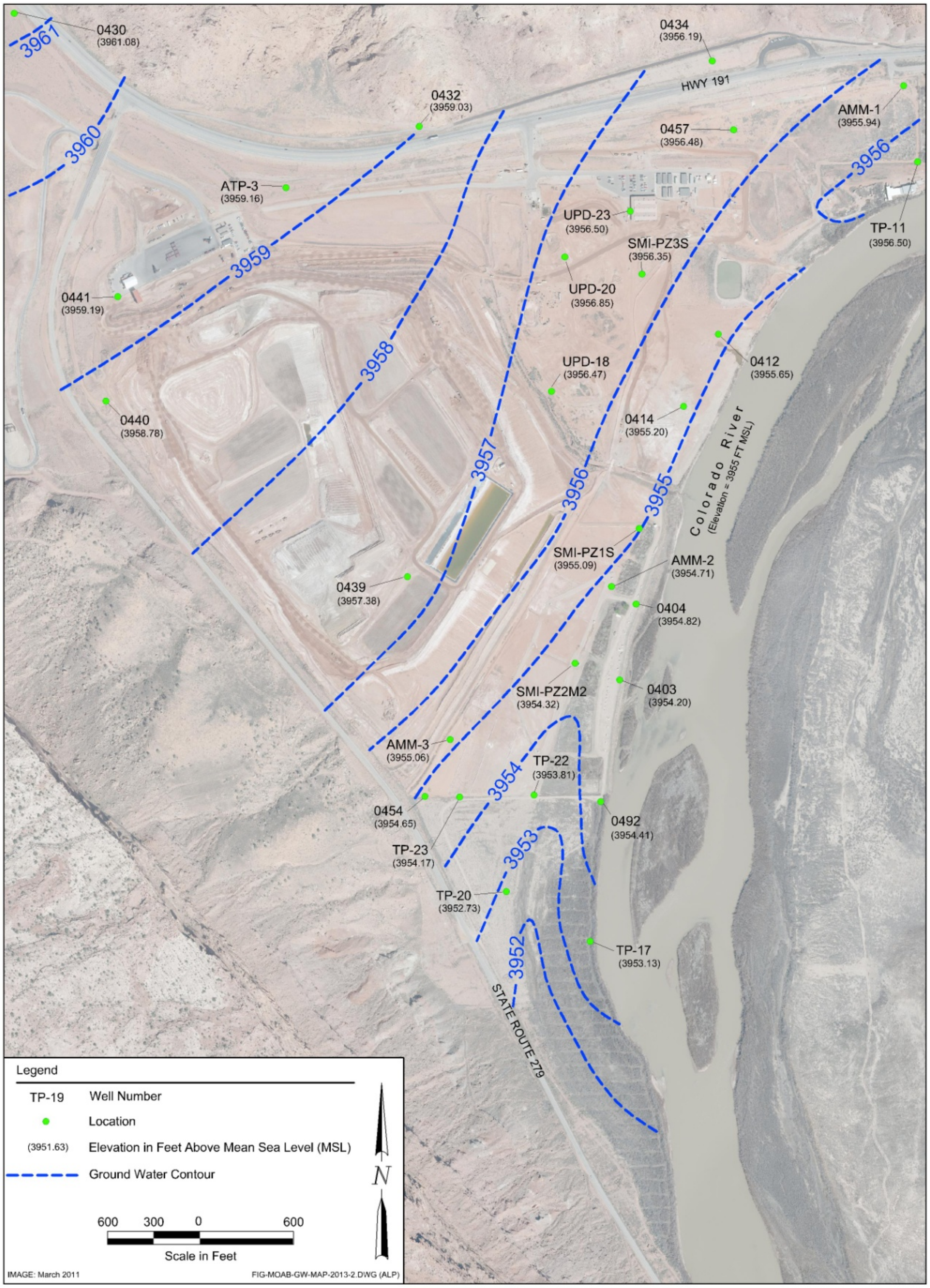


Figure 3. Ground Water Contour Map May 2013

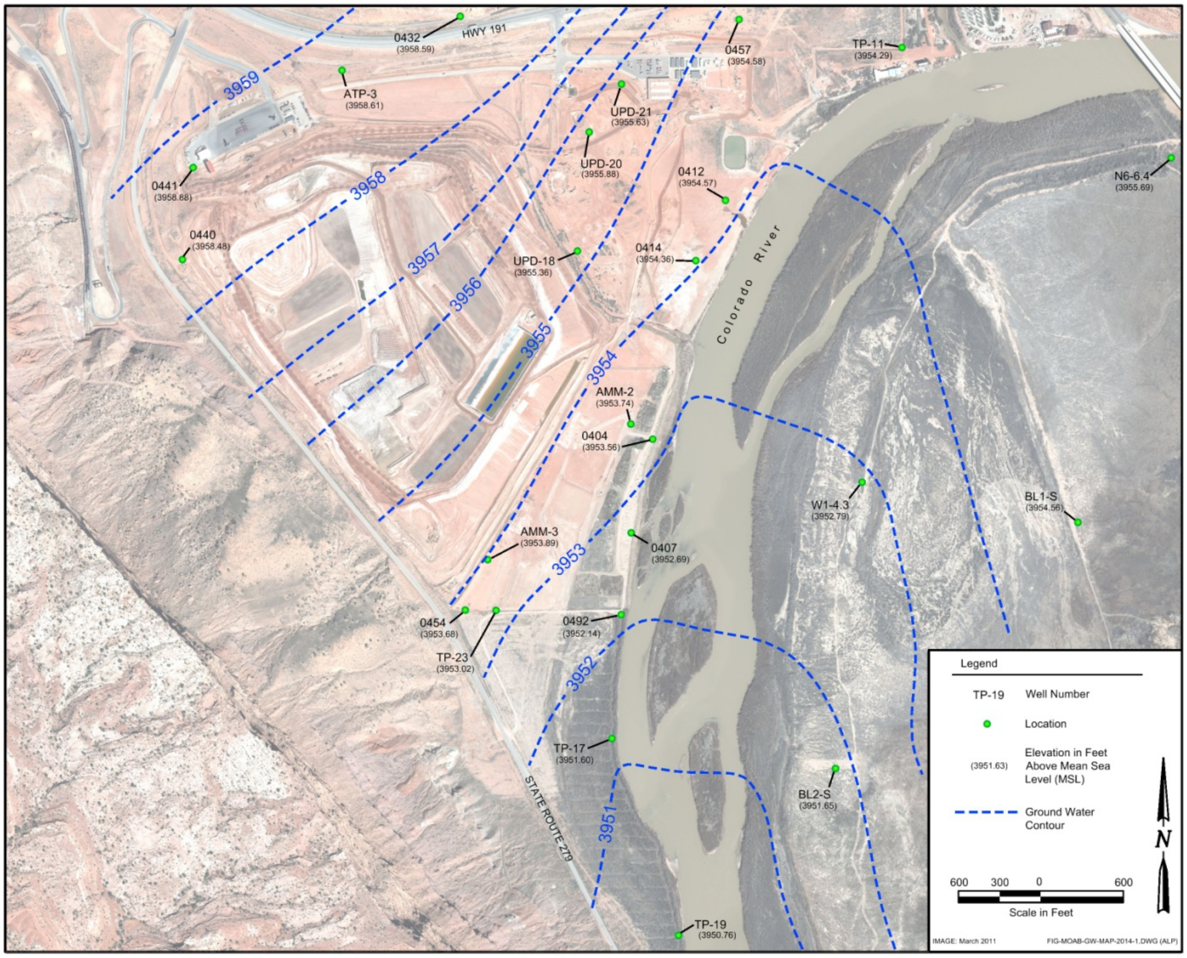


Figure 4. Site-wide Water Contour Map November/December 2013

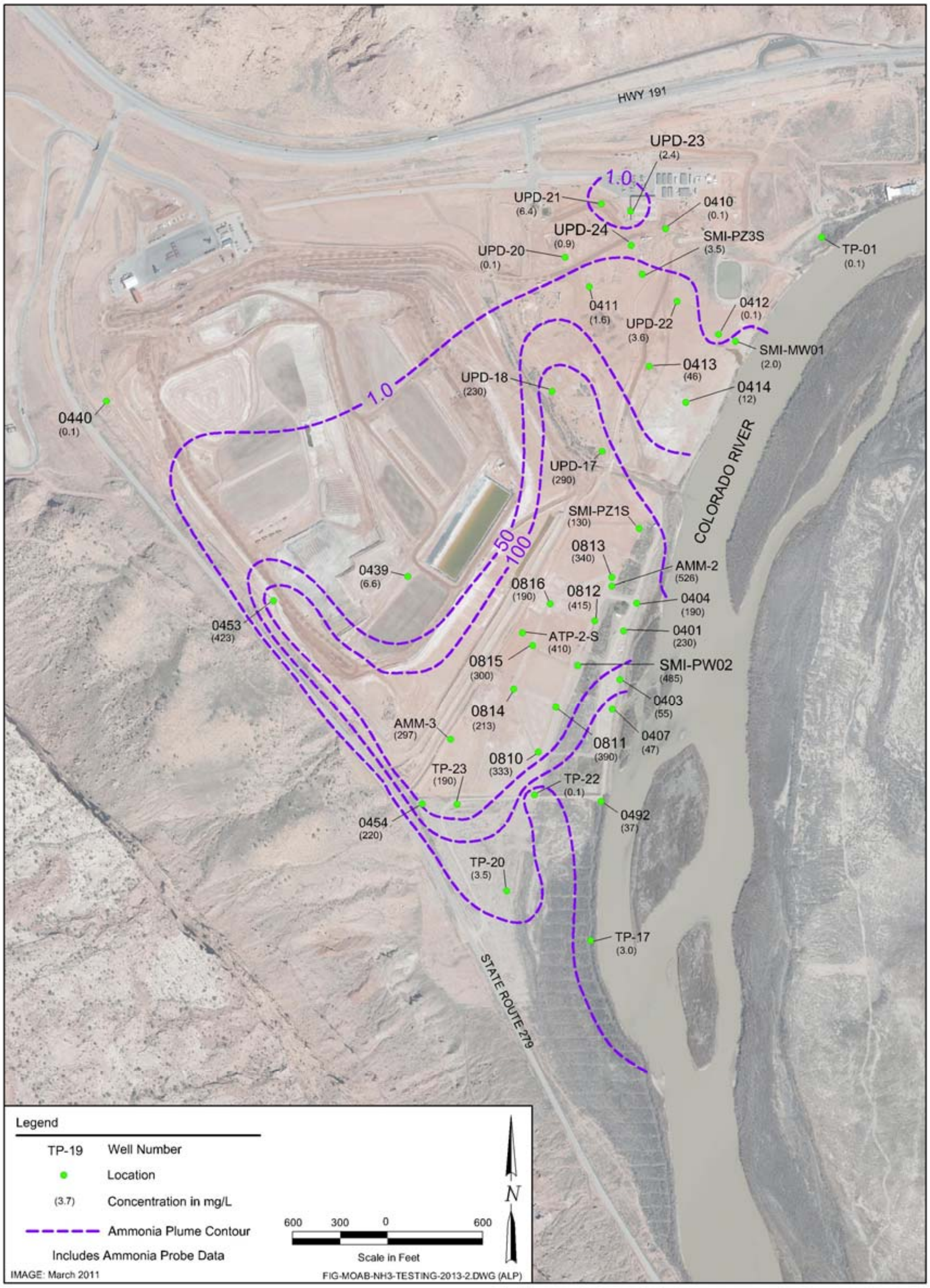


Figure 5. Ammonia Plume Map May 2013

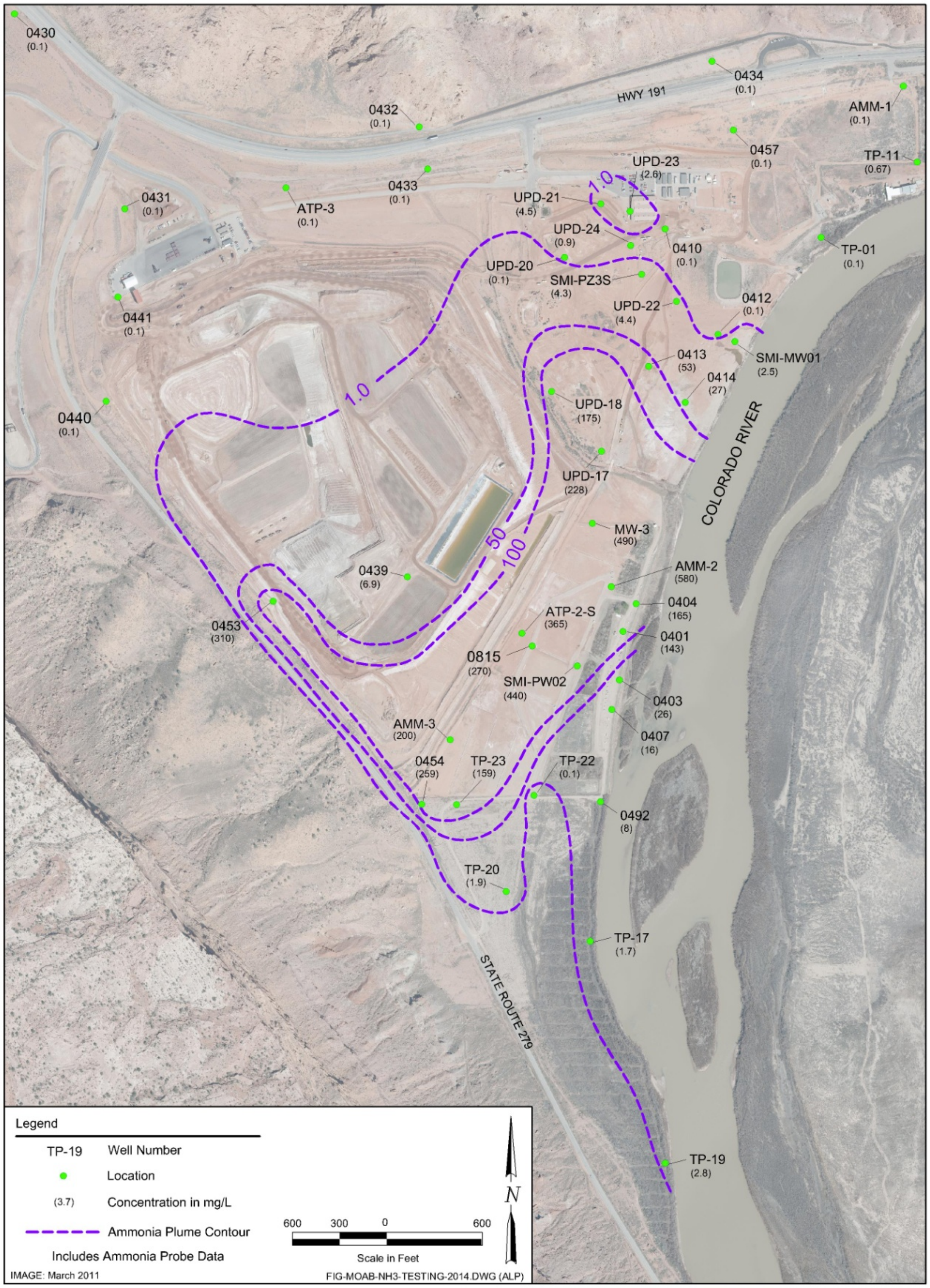


Figure 6. Ammonia Plume Map November/December 2013

Oxidation of ammonia to nitrate or nitrogen may also contribute to lower ammonia concentrations observed in the upgradient shallow ground water beneath the tailings pile, where aerobic conditions are more likely; however, there is now flushing of the legacy plume by advective flow of freshwater due to density stratification of the brine zone.

Figure 5 shows the ammonia plume in May 2013, and Figure 6 shows the ammonia plume in November/December 2013. The two plume maps are comparable.

In addition to ammonia, the other primary constituent of concern in ground water is uranium. Figures 7 and 8 show the distribution of dissolved uranium in shallow ground water in 2013.

2.3 Surface Water/Ground Water Interaction

Previous investigations have shown that surface water flow in the Colorado River can strongly affect ground water elevations and contaminant concentrations in the well field. As the Colorado River reaches peak spring runoff flows of about 10,000 cfs, it changes from gaining to losing conditions, and a lens of freshwater expands in the soils along the river.

The snowpack in 2013 was approximately 80 percent of average, and warm unseasonable temperatures in March led to a spring peak runoff of only 12,800 cfs (average is 27,500 cfs) on May 19. The spring runoff led to a minor rise in the ground water elevation, but not as much as documented in past years.

3.0 Methods

Well field performance is assessed by measuring extraction/injection rates of remediation wells, measuring water levels, and sampling surface water locations, extraction wells, and monitoring wells. In 2013, the IA well field operations included extraction, injection, and surface water diversion.

3.1 Remediation Well Extraction

Each extraction well also contains a flow meter that displays the instantaneous flow rate in gallons (gal) per minute (gpm), the cumulative total volume extracted (displayed at “Total 1” on the flow meter), and the net volume since the last reset of the internal memory (displayed as “Total 2” on the flow meter). Flow-meter readings are manually recorded on a weekly basis during extraction operations and are used in conjunction with water-quality data to evaluate the performance of the system.

When the extraction wells are sampled, the resulting ammonia and uranium concentrations are used to calculate the contaminant mass removal. The contaminant mass that is removed is discharged to the evaporation pond on top of the tailings pile, sprayed through the evaporators, and used for dust suppression by water trucks. The evaporated contaminants are deposited as salt and will be removed for disposal with tailings and transported to the Crescent Junction disposal site.

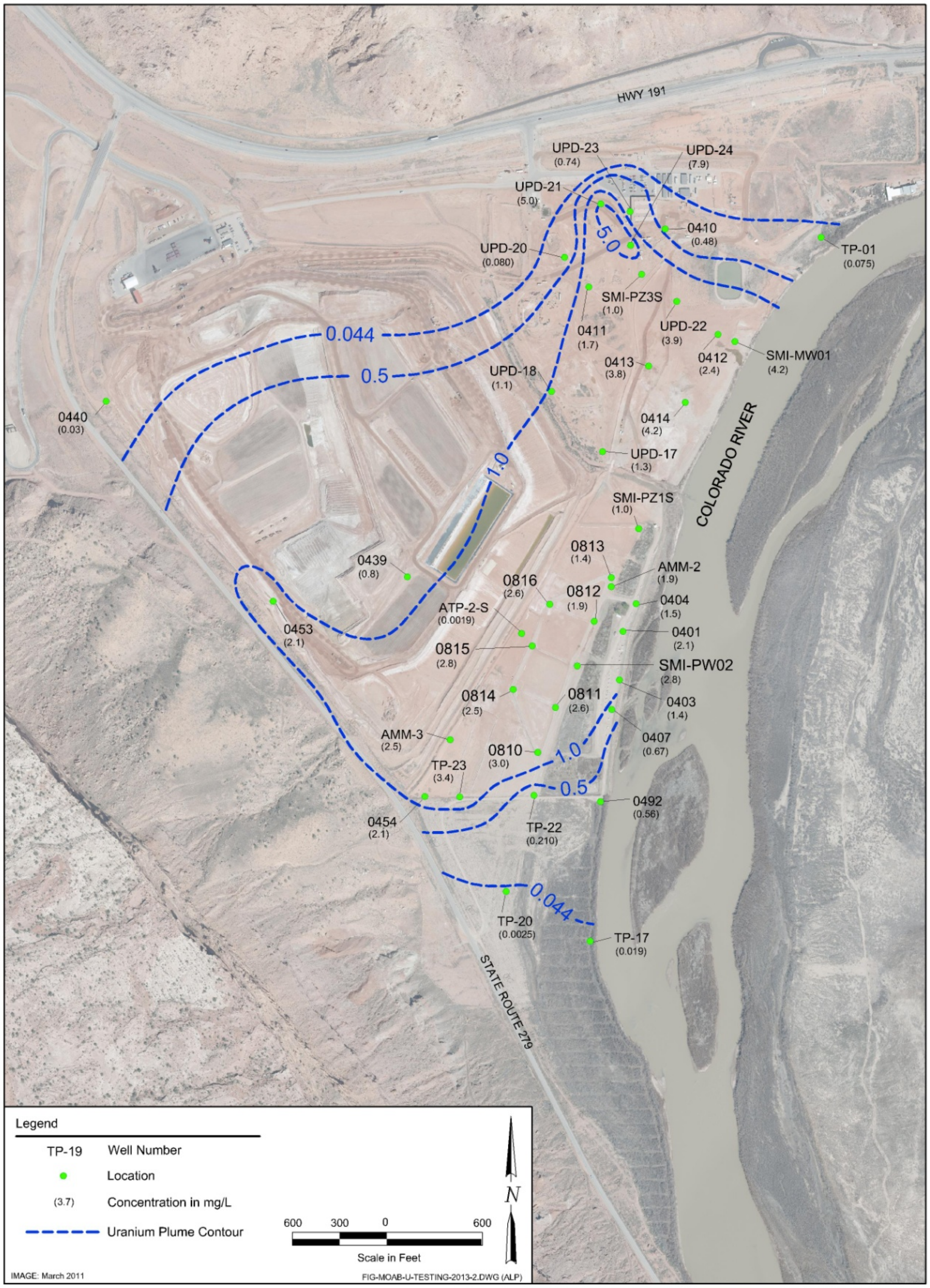


Figure 7. Uranium Plume Map May 2013

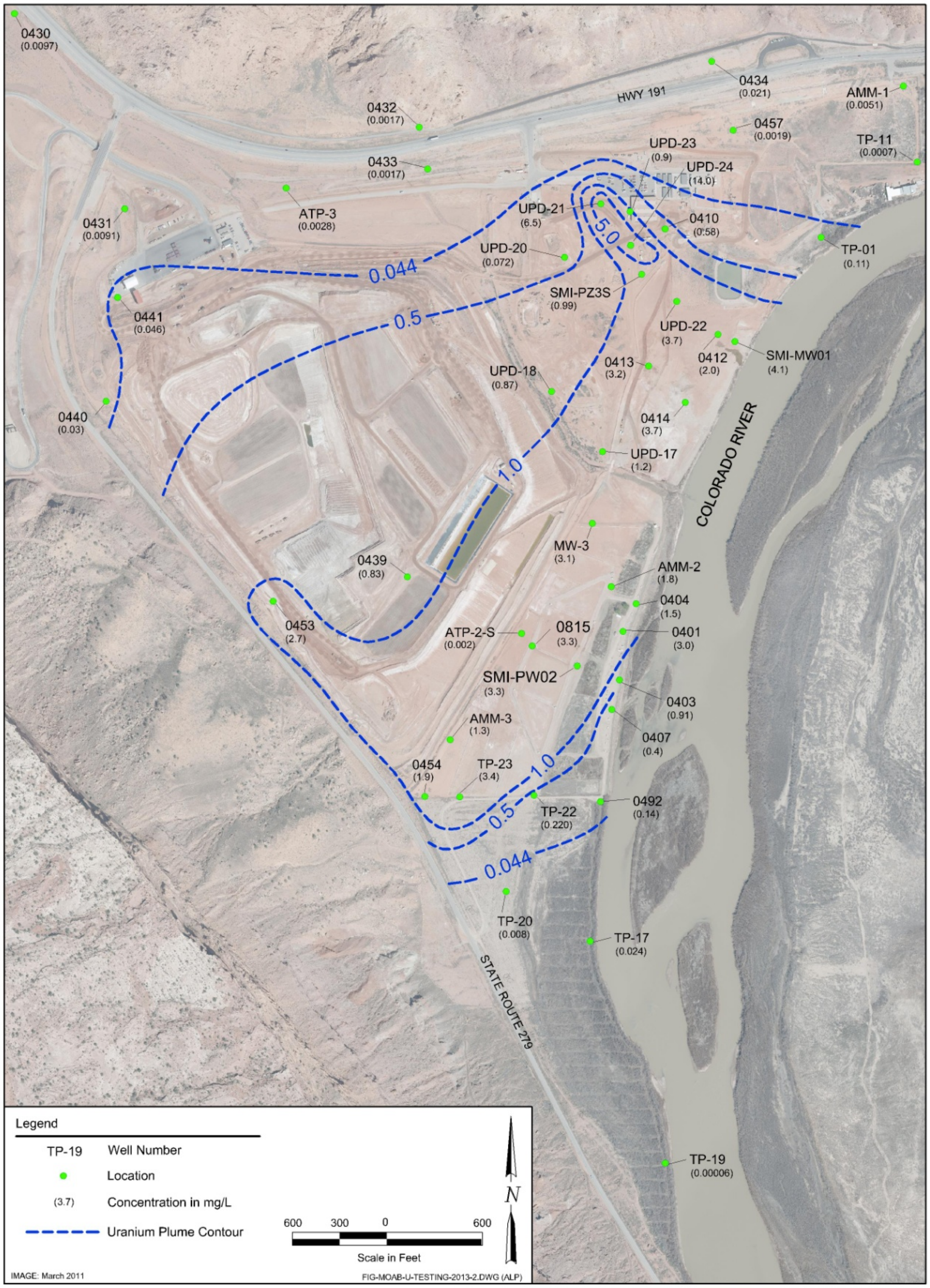


Figure 8. Uranium Plume Map November/December 2013

3.2 Remediation Well Injection

Each injection well contains a flow meter that displays the instantaneous injection rate in gpm and the total volume. Flow-meter readings are recorded manually on a weekly basis during injection operations and are used in conjunction with water level data to estimate the amount of freshwater mounding in each well.

3.3 Water Levels

Ground water levels are recorded in the IA well field on a weekly basis during pumping and injection operations to monitor ground water drawdown and freshwater mounding. A water-level indicator is used to measure the depth to ground water (below top of casing). Data-logging equipment with pressure transducers are installed at various locations to measure water levels on a more frequent basis.

3.4 Water Quality

Selected well and surface water locations are sampled at various times, depending on the purpose of the sampling event. Before sampling, field parameters, including temperature, pH, oxidation reduction potential, conductivity, dissolved oxygen, and turbidity are measured and recorded. Observation wells are sampled with dedicated down-hole tubing and a peristaltic pump, while remediation wells are sampled with dedicated submersible pumps. Water samples are collected at various depths and locations to monitor the primary contaminants of concern, ammonia (as N) and uranium. All water sampling was performed in accordance with the *Moab UMTRA Project Surface Water/Ground Water Sampling and Analysis Plan* (DOE-EM/GJTAC1830). Samples are shipped overnight to ALS Environmental, Inc., in Fort Collins, Colorado, for analysis.

An ammonia probe is used on site to obtain ammonia concentrations. The probe is used at surface water locations, observation wells during injection, and at extraction wells during operation. Periodically, the ammonia probe data are verified with a laboratory sample analysis. Ammonia data that were recorded with the ammonia probe are presented in this report are stated as such. All other ammonia analyses were provided by ALS Environmental, Inc.

4.0 Ground Water Extraction Operations and Performance

4.1 IA Operations

This section provides information regarding the IA well field extraction performance during the 2013 pumping season. Also included in this section is a discussion regarding the total ground water extraction rate, hydraulic control, mass removal, and water quality. Appendix A contains tables of well construction information (Table A-1), chronology (Table A-2), pumping volumes (Table A-3), mass removal (Tables A-4 and A-5), and drawdown data (Figures A-1 through A-6).

In 2013, the extraction system operated year-round, and the evaporator units were used as dictated by the weather conditions. The extraction schedule was focused on optimizing ammonia and uranium mass removal and on rotating through each of the CF5 remediation wells.

Extraction operations began with wells PW02 and 0815 at a rate of approximately 66 gpm. Beginning in February, more remediation wells were utilized, and evaporator unit 2 was initiated in March. A modification was made to evaporator 1 so that water could be pulled directly from the evaporation pond. The spring extraction rate peaked at approximately 79 gpm on May 12.

Throughout the summer, ground water extraction occurred by cycling through seven of the eight CF5 wells. The extraction rate peaked at 103 gpm on July 17. In the fall and winter, the extraction rate measured was up to 28 gpm. The system was temporarily drained on December 19 due to below-average air temperatures.

The associated volume of ground water extracted by each well in CF5 is shown in Appendix A, Table A-3. Figure 9 provides a graphic summary of the cumulative volume of ground water extracted from CF5 in 2013. Extraction operations were nearly continuous throughout the year. A total of 15.1 mil gal of water was extracted from CF5 during 2013.

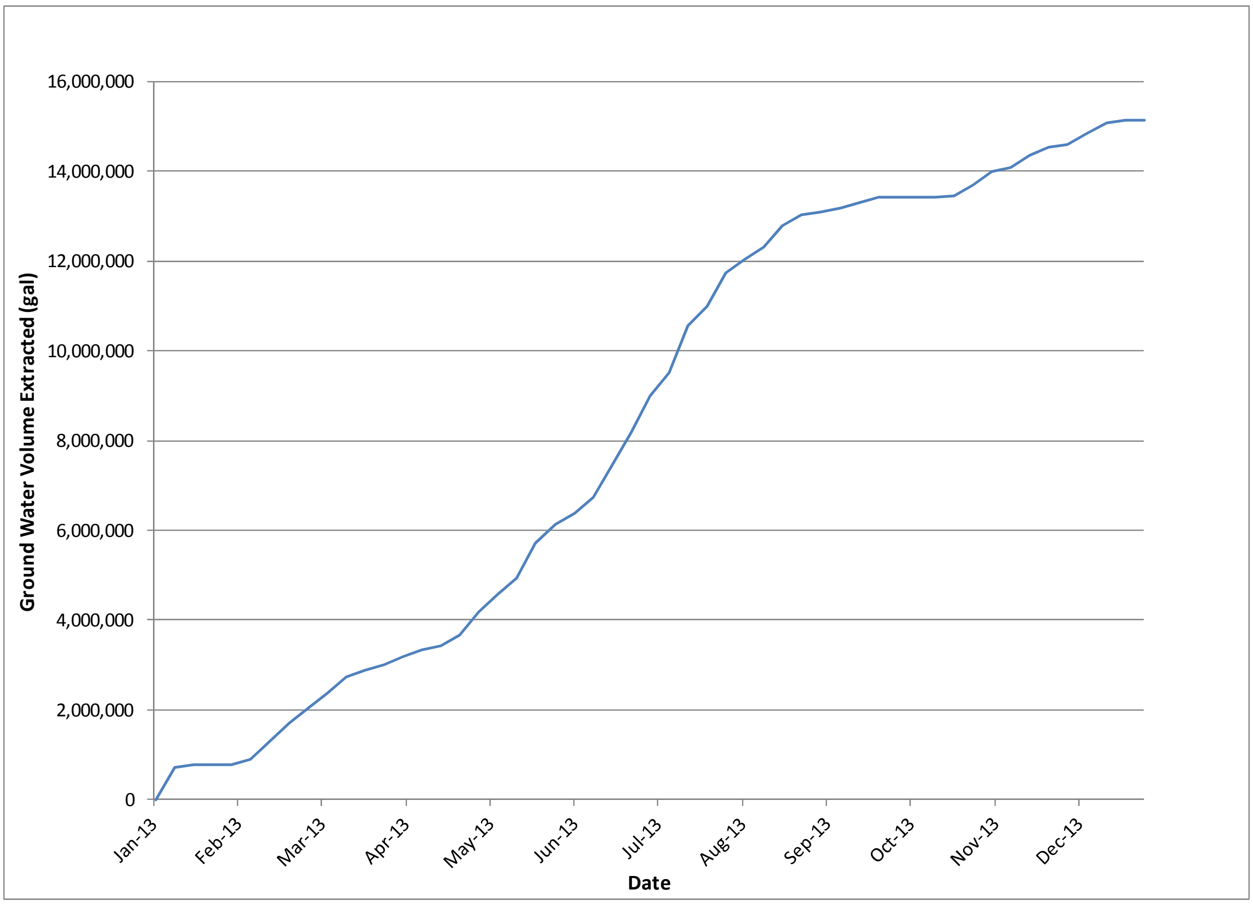


Figure 9. Cumulative Volume of Extracted Ground Water during 2013

4.1.1 CF5 Pumping Rate and Ground Water Extracted Volume

As previously mentioned, CF5 extraction wells 0810 through 0816 and PW02 were used to extract ground water in 2013. The well screens are placed at varying depths (Appendix A, Table A-1) due to varying depths to the brine interface in the CF5 area.

Monthly extraction volumes for each of the eight extraction wells are listed in Table A-3 (Appendix A). Well PW02 was used to extract ground water for most of 2013, and most of the extracted water in 2013 was removed from this well (2.4 mil gal).Wells 0810, 0812, 0815, and 8016 all extracted between 2.3 and 1.9 mil gal. Extraction operations were maximized from May to July, when the evaporation potential was at its highest. The evaporator units and water trucks were used to dispose of the extracted water.

4.2 IA Extraction Performance

4.2.1 Ground Water Levels and Hydraulic Control

Figure 10 shows the drawdown data for each of the CF5 wells. The wells with the highest drawdown (0810, 0811, and 0812) are located on the southern portion of CF5, while the wells on the northern end of CF5 (0813 and 0816) are more productive. This difference is likely due to variation in underlying sediments. The results are similar to what was measured in previous years.

Hydrographs were prepared to compare background ground water elevations (from observation well 0405 located in the northern end of the well field) and ground water elevations of the CF5 extraction wells during the pumping season (see Figures 11 and 12 and A-1 to A-6 in Appendix A). Applicable extraction rates for each well were plotted against the ground water elevations. Well 0405 water-elevation data were adjusted so that both wells were assigned the same non-pumping water level. The difference between the two wells gives a qualitative estimate of drawdown in response to pumping.

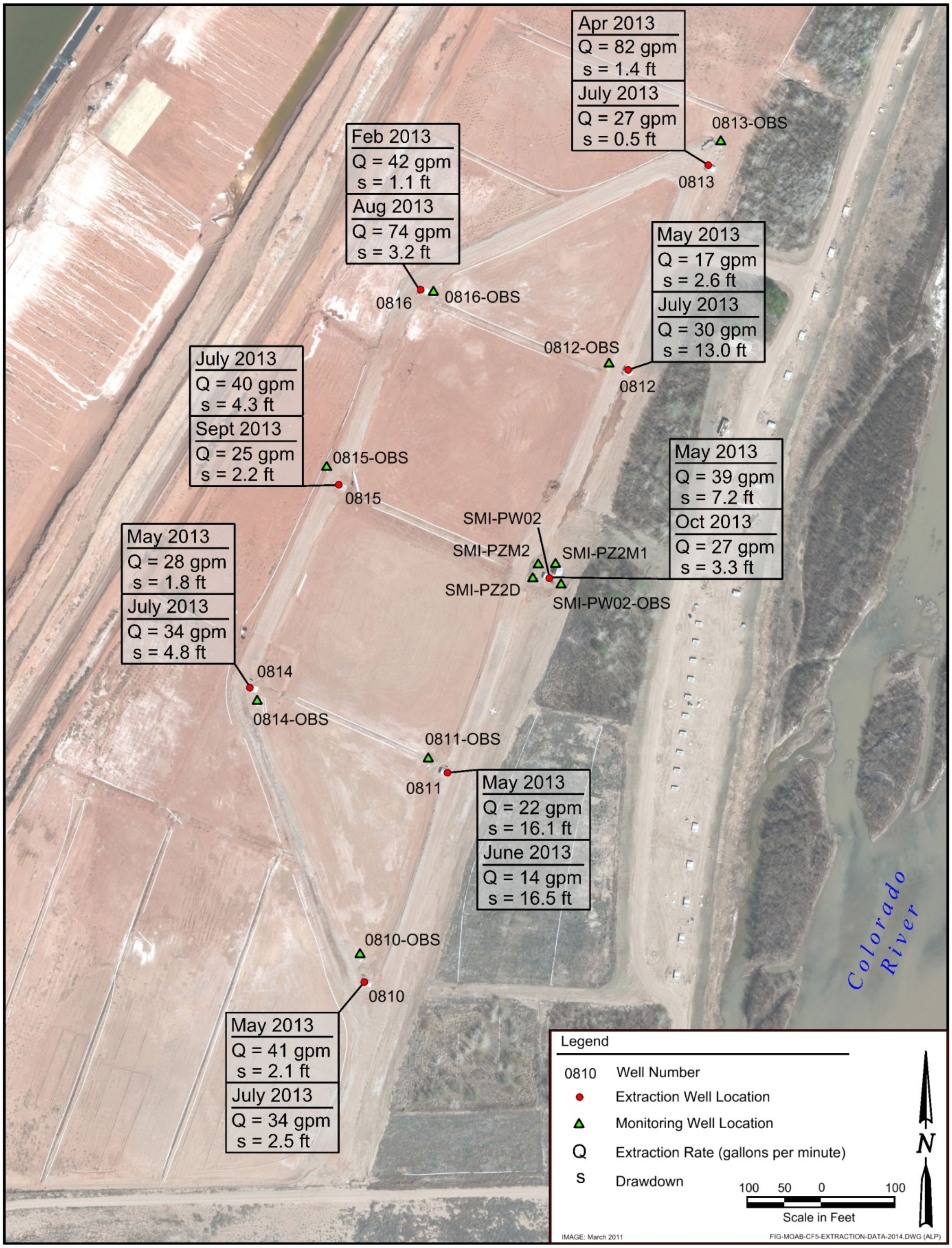


Figure 10. Flow Rates and Drawdowns in CF5 in 2013

Figures 11 and 12 show drawdown during extraction operations for wells PW02 and 0810 compared to the background ground water surface fluctuation (measured in well 0405). Both wells had maximum drawdown during higher rates of extraction, and the water levels rebounded quickly after the extraction operations were shut down.

4.2.2 Extraction Well Specific Capacity

Specific capacity is the measure of a well’s performance relative to formation hydraulic characteristics. Individual extraction well drawdown data were used to compute the specific capacity during the 2013 pumping season. While this is not a rigorous method of calculating specific capacity because it does not account for well interference, it provides a qualitative evaluation of the relative performance of each extraction well (Table 1).

The specific capacity varies greatly in the CF5 wells. Remediation wells 0813 and 0816 have the highest specific capacities; up to 58.6 gpm/ft was measured in well 0813. More drawdown is observed in the wells with the lower specific capacity values (0810, 0811, and 0812). The data shown in Table 1 is comparable to what was observed in 2012.

Table 1. Drawdown during Extraction Operations

Location	Date	Drawdown (ft)	Extraction Rate (gpm)	Specific Capacity (gpm/ft)
0810	5/15/13	2.1	41	19.5
	7/24/13	2.5	34	13.6
0811	6/19/13	16.5	14	0.8
	5/29/13	16.1	22	1.4
0812	7/24/13	13.0	30	2.3
	5/15/13	2.6	17	11.5
0813	4/24/13	1.4	82	58.6
	7/10/13	0.5	27	54.0
0814	7/24/13	4.8	34	7.1
	5/15/13	1.8	28	15.6
0815	7/10/13	4.3	40	9.3
	10/23/13	2.2	25	11.4
0816	8/21/13	3.2	74	23.1
	2/8/13	1.1	42	38.2
PW02	5/8/13	7.2	39	5.4
	10/30/13	3.3	27	8.2

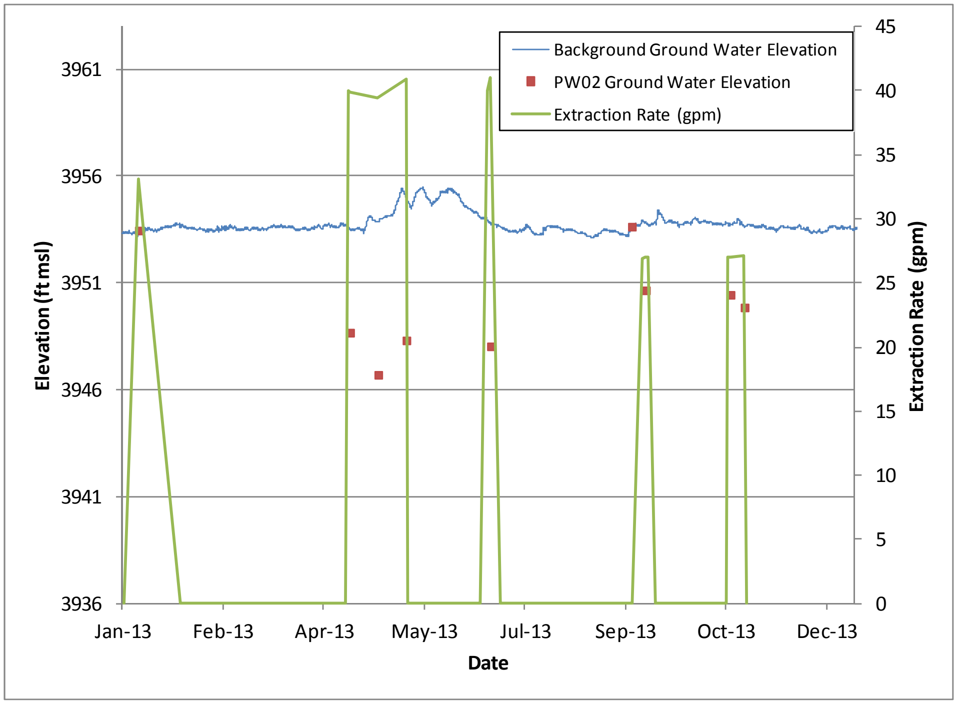


Figure 11. Drawdown Data for Extraction Well PW02

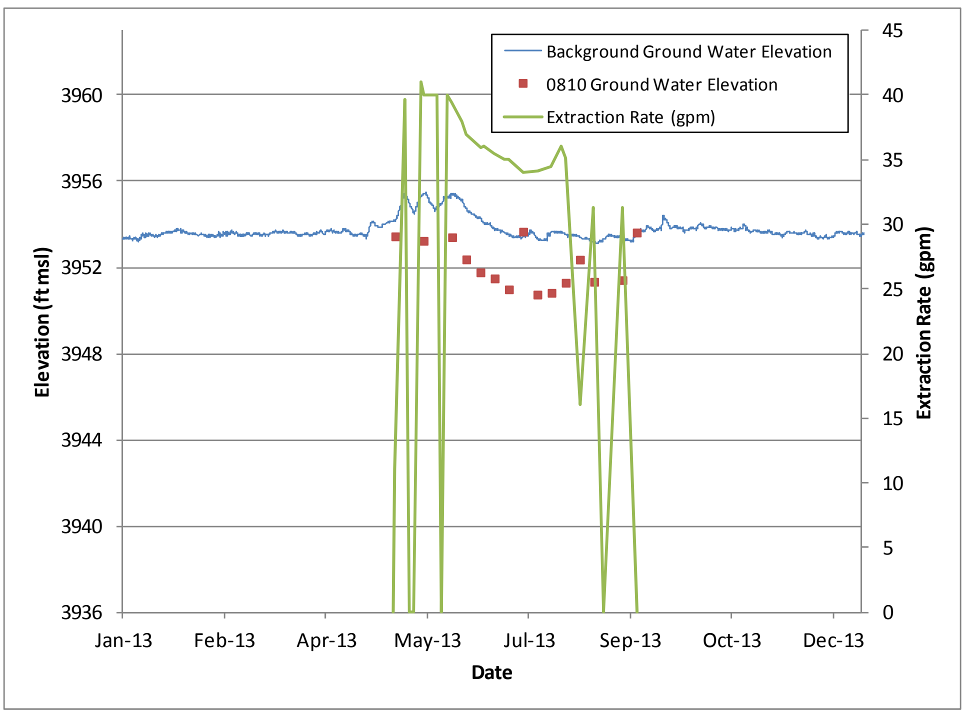


Figure 12. Drawdown Data for Extraction Well 0810

4.3 Contaminant Mass Removal

The ammonia and uranium mass removed by CF5 extraction wells in 2013 is presented in Tables A-4 and A-5 of Appendix A. These values are based on ground water extraction volumes recorded by individual flow meters. The mass of ammonia and uranium removed from ground water by the extraction wells was calculated by multiplying the extraction volumes by the corresponding concentrations of ammonia and uranium in each well.

The concentrations used in these calculations were drawn from analytical data presented in Appendix D (provided in accompanying CD). To estimate the contaminant mass removed when analytical data were not available for the specific month, concentrations were derived from previous and subsequent months to provide an approximate concentration.

In 2013, a total of 39,795 pounds (lb) (63,406 kilograms [kg]) of ammonia and 308 lb (139 kg) of uranium were extracted from the ground water. Table A-4 in Appendix A shows that extraction wells PW02 and 0812 removed the most ammonia mass, at 9,512 lb (4,314 kg) and 6,686 lb (3,032 kg), respectively. Estimated mass withdrawals of uranium at CF5 extraction wells are presented in Appendix A, Table A-5, which shows the greatest mass of uranium was extracted from wells 0815 and PW02 at 57 lb (25 kg) and 56 lb (25 kg), respectively. Wells 0815 and PW02 extracted the most volume of ground water in 2013.

4.4 Ground Water Chemistry

Analytical ground water samples were collected from the CF5 extraction wells in May 2013 (Table 2), and samples were collected from wells 0815 and PW02 again in November 2013. Ammonia concentrations varied from 180 mg/L (0816) to 490 mg/L (PW02), and the uranium concentration ranged from 1.4 mg/L (0813) to 3.3 mg/L (PW02). During the May sampling event, several samples were collected from each extraction well during various extraction rates to determine whether the rate impacts the contaminant concentration. The sample results indicate that the extraction rate does not impact the ammonia or uranium concentrations. Specific conductance, however, does increase slightly as the extraction rate increases. This is likely the result of slightly deeper ground water entering the well screen.

Ammonia-probe sampling was conducted in conjunction with the May sampling event. Table 2 contains the uranium and specific conductance data and compares the analytical ammonia vs. the ammonia probe results.

Specific conductance ranged from 15,066 µmhos/cm at well 0813 (northern end of CF5) to 40,204 µmhos/cm at well 0815 when the extraction rate was 42.8 gpm. Well PW02 had the highest specific conductance concentration in CF5 (41,511 µmhos/cm), because the pump is set at a lower elevation.

Table 2. CF5 Ammonia and Uranium Concentrations, 2013

Location	Date	GPM	Ammonia (mg/L)	Ammonia Probe (mg/L)	Uranium (mg/L)	Specific Conductance (µmhos/cm)
0810	05/15/13	12.9	340	313	3	31,160
	05/16/13	25.2	330	315	3	31,179
	05/21/13	38.8	330	309	3	31,440
0811	05/15/13	13.7	380	392	2.6	22,649
	05/16/13	23.1	400	378	2.5	22,988
0812	05/16/13	25.9	430	404	1.9	18,946
	05/21/13	15.9	430	395	2	19,872
	05/22/13	39.8	410	443	1.9	25,951
0813	05/21/13	15.2	340	337	1.4	15,066
	05/22/13	25.2	340	348	1.4	15,066
	05/24/13	43.6	340	341	1.4	16,125
0814	05/15/13	19.6	200	203	2.6	25,004
	05/16/13	31.0	200	211	2.5	26,214
	05/22/13	38.6	240	223	2.5	29,348
0815	05/15/13	13.2	300	310	2.5	34,098
	05/16/13	32.8	290	308	3	35,398
	05/24/13	42.8	310	294	2.8	40,204
	11/04/13	25.0	270	191	3.3	25,302
0816	05/21/13	15.0	180	173	2.4	25,524
	05/22/13	25.4	190	177	2.9	25,789
	05/24/13	46.7	200	190	2.3	27,318
PW02	05/21/13	26.1	480	451	2.8	37,527
	05/22/13	40.8	490	473	2.7	41,511
	11/04/13	27.0	440	428	3.3	29,848

5.0 Evaporation Pond Operations

The evaporation pond, located on the southeastern portion of the tailings pile, stores the ground water that was extracted from the CF5 wells. Water stored in the pond is removed by evaporation, by water trucks for dust suppression on top of the tailings pile, or through the use of natural evaporator units located on the edge of the pond. A chronology of the evaporation pond operations can be found in Table B-1 in Appendix B and is summarized here. Table B-2 contains the evaporation pond level and volume for 2013, and Table B-3 contains the evaporator operations.

The Remedial Action Contractor (RAC) removed water from the pond for dust suppression from March until late November, at which time the system was winterized. The evaporation pond level reached 9.2 ft in mid-March due to winter extraction operations. Water trucks removed the most water from the pond in May and June to assist with water removal during extraction operations.

The extraction rate remained lower through the fall to lower the pond level to maximize storage capacity over the winter. Evaporation pond water was not available for dust suppression during the winter months, so the focus in the fall was to keep the evaporation pond at a manageable level so that extraction operations could continue through the winter.

5.1 Evaporation Pond Water Balance

Water inflows and outflows, along with the pond level, are illustrated in Figure 13. As Figure 13 illustrates, the outflow varied from month to month, but was the highest from March through June.

Approximately 14 mil gal of extraction water was removed from the evaporation pond by water trucks in the Contamination Area. Most of the water was removed during the spring and summer months (April through September) when the evaporation potential is the highest (Figure 13). This water is used for dust suppression on top of the tailings pile.

Approximately 5.5 mil gal of extracted water was pumped through the evaporators between April and November, when the weather conditions are more conducive to evaporation. When the weather was conducive, the evaporators ran overnight. The total gallons are equal to what was pumped through the evaporators as opposed to what actually evaporated.

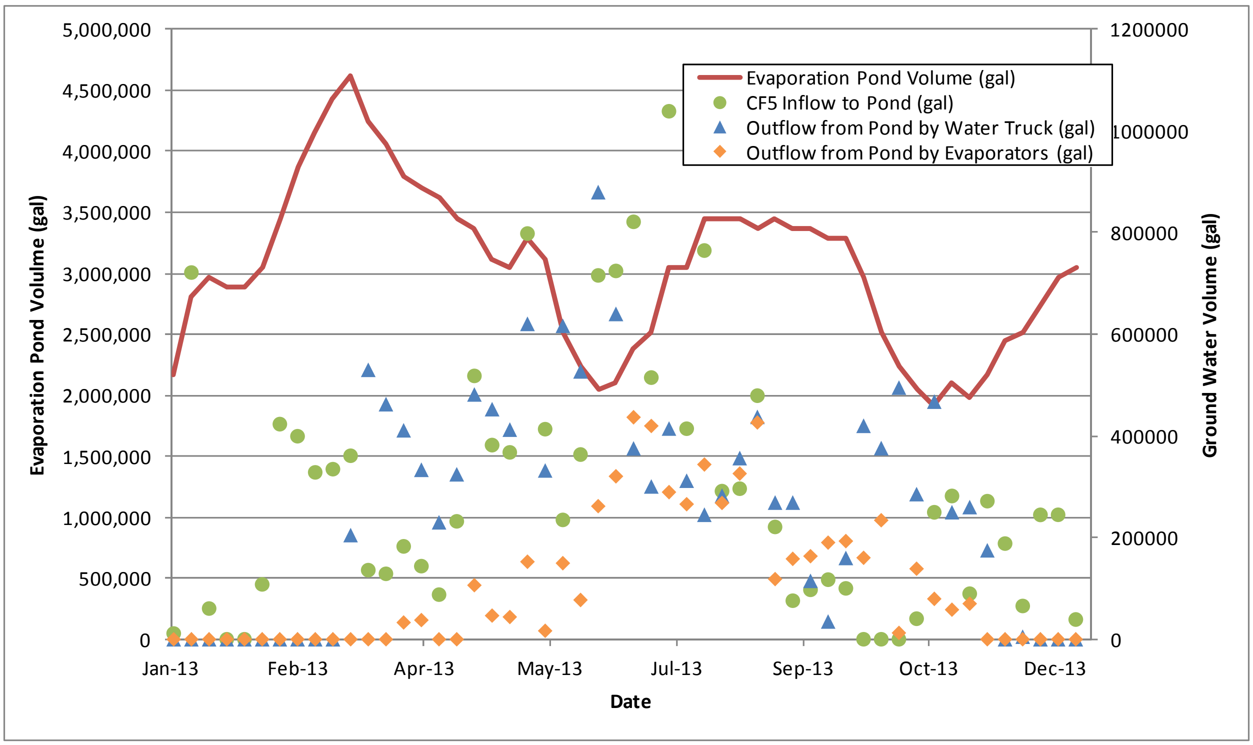


Figure 13. Rates of Water Delivery and Outflow to and from the Evaporation Pond and Pond Volume during 2013

6.0 Injection Operation and Performance

The main objective of freshwater injection is to form a hydrologic barrier between the tailings pile and the backwater channel that flows adjacent to the well field and to dilute contaminants before ground water discharges into the backwater channel. Freshwater injection into the CF4 wells occurred from February to August and again from October to late December.

The injection system runs off of Colorado River water that is diverted to the freshwater pond and is then pumped through a sand and bag filter and injected into the remediation wells. Construction information for the CF4 wells can be found in Table C-1 of Appendix C, and Table C-2 contains a chronology of CF4 activities.

CF4 is located in the southern portion of the IA well field, adjacent to a prominent side channel that remains open to the main channel until the river flow drops below 3,000 cfs. The brine/freshwater interface is higher in elevation in this portion of the well field, and sample results have indicated that the ground water discharges to the adjacent backwater channel. During baseflow conditions, the volume of water flowing into the channel is insufficient to dilute the ammonia concentration that is introduced from the ground water.

Approximately 9.4 mil gal of freshwater was injected into CF4 in 2013. The main reason for the increase is that the river flow was below average throught the year, leading to injecting even during peak flow months, and our surface water diversion system (see Section 7.0) was upgraded; injection water was not needed to supply the system, as in 2012.

6.1 Injection Performance

A chronology of injection events in 2013 can be found in Table C-2 of Appendix C. Before starting injection operations, ammonia-probe samples were collected and analyzed in the CF4 observation wells and water levels were recorded.

Injection into all 10 wells began on February 4, when the river flow was 1,320 cfs. The system ran until late April, when the injection wells were temporarily shut down for well development. Operations resumed in early May and continued until July 18, when the system was shut down for approximately 1 week due to high suspended solids in the freshwater pond. Injection was shut down due to high suspended solids again from August 28 until October 10. High precipitation events in the Colorado River Basin left the river water extremely turbid. Operations were suspended in November while upgrades were made to the sand filter shed, and the system was turned on once again in December.

Typically, the injection system is shut down during the peak runoff months so that the riverbank storage can infiltrate into the alluvial aquifer beneath the well field. In 2013, the peak river flow only reached 12,800 cfs and was insufficient to impact the ammonia and uranium concentrations in the ground water in the vicinity of CF4 through May and June.

6.2 Summary of Chemical Data from Observation Wells

Throughout 2013, ammonia probe samples were collected from the CF4 observation wells and well points before and during injection operations to access the effectiveness of the system (Appendix C, Table C-3). Chemical data plots of ammonia and specific conductance can be found in Appendix C, Figures C-1 to C-6. All of the ammonia data for CF4 in 2013 was measured with the ammonia probe.

Ammonia-probe samples were collected before injection startup in January, and during operations in April, June, and August 2013 (Appendix C, Table C-3). Ammonia samples were also analyzed in September, when the injection system was temporarily shut down. The results of these samples indicate ammonia concentrations were the lowest at 18 ft below ground surface (bgs) (2.36 mg/L at downgradient well 0784) and the highest between 28 and 46 ft bgs (up to 1,664 mg/L at up-gradient well 0781).

Ammonia-probe samples collected during injection operations show that the downgradient concentrations are drastically lower at 36 ft bgs (Appendix C, Figures C-1, C-3, and C-5). For example, the ammonia concentration in well 0787 (36 ft bgs) dropped from 1,416 mg/L before injection operations to 7 mg/L in August. When injection was temporarily shut down, the ammonia increased to 627 mg/L.

The specific conductance decreased at all of the downgradient observation wells during injection operations. Before injection operations, the specific conductance varied from 3,000 µs/cm (18 ft bgs) to 93,000 µs/cm (36 ft bgs). During operations, the specific conductance dropped to between 1,600 µs/cm (28 ft bgs) and 16,086 µs/cm (36 ft bgs). The drop in conductivity is due to the suppression of the brine interface during operations. Conductivity increased again when the injection was temporarily suspended in the fall.

Ammonia concentrations in the upgradient wells showed a slightly different trend from the downgradient wells. During operations, the ammonia concentration decreased from 18 to 33 ft bgs. However, ammonia fluctuated greatly at 46 ft bgs. For example, the ammonia concentration in well 0781 (46 ft bgs) went from 3,015 to 392 to 1,432 mg/L, all during injection operations.

The specific conductance at the upgradient observation wells followed the same trend as the ammonia concentrations (Appendix C, Figures C-2, C-4, and C-6). Conductivity dropped from 18 to 33 ft bgs, but varied greatly at 46 ft bgs. For example, the conductivity in well 0781 varied from 1,830 to 108,430 µs/cm during injection operations. It is likely that the brine interface was located near 46 ft bgs and was impacted by the injection rate.

6.3 Freshwater Mounding

Water levels were collected on a near-daily basis during injection operations. To determine the amount of freshwater mounding in each well, the collected water levels were plotted against the pressure transducer water levels in background well 0405. The water levels in each well were calibrated to match well 0405 during non-pumping, baseflow conditions.

Tables 3 and 4 summarize the mounding data that is shown in Appendix C, Figures C-7 to C-16 for the injection wells. Figures C-17 through C-24 in Appendix C illustrate the mounding data in CF4 observation wells.

Figure 14 shows the freshwater mounding at CF4 on June 25. The most mounding occurs within 30 ft of the injection system. Maximum mounding occurred in each injection well at varying dates in the spring and fall. The amount of mounding was dependent on the injection rate at each individual well. Wells 0773, 0774, 0775, and 0776 had the maximum mounding at over 16 ft during an injection rate of 1.26 and 3.13 gpm, respectively (Table 3). The mounding in the observation wells varied from 0.41 to 1.94 ft in the upgradient wells, and from 0.36 to 1.28 ft in the downgradient wells (Table 4). The amount of mounding observed in 2013 was slightly higher than what was observed in 2012.

Table 3. Maximum Mounding Observed in CF4 Injection Wells

Well	Date	Type	Maximum Mounding (ft)	Injection Rate (gpm)
0770	02/04/13	Injection Well	11.01	7.5
0771	03/20/13	Injection Well	11.49	5.1
0772	02/20/13	Injection Well	13.05	1.9
0773	05/06/13	Injection Well	16.25	1.3
0774	05/06/13	Injection Well	16.09	1.7
0775	02/08/13	Injection Well	16.88	3.1
0776	05/08/13	Injection Well	16.16	0.7
0777	02/08/13	Injection Well	12.75	3.6
0778	03/11/13	Injection Well	12.10	3.4
0779	05/09/13	Injection Well	15.59	0.5

Table 4. Freshwater Mounding Observed in CF4 Observation Wells

Well	Date	Location	Maximum Mounding (ft)	Distance from Injection Source (ft)
0780	06/19/13	Upgradient	1.26	15
0781	06/19/13	Upgradient	0.41	15
0782	06/19/13	Upgradient	1.26	20
0783	06/19/13	Upgradient	1.94	30
0784	09/24/13	Downgradient	0.36	30
0785	06/19/13	Downgradient	1.19	25
0786	06/19/13	Downgradient	1.28	30
0787	06/19/13	Downgradient	1.02	30

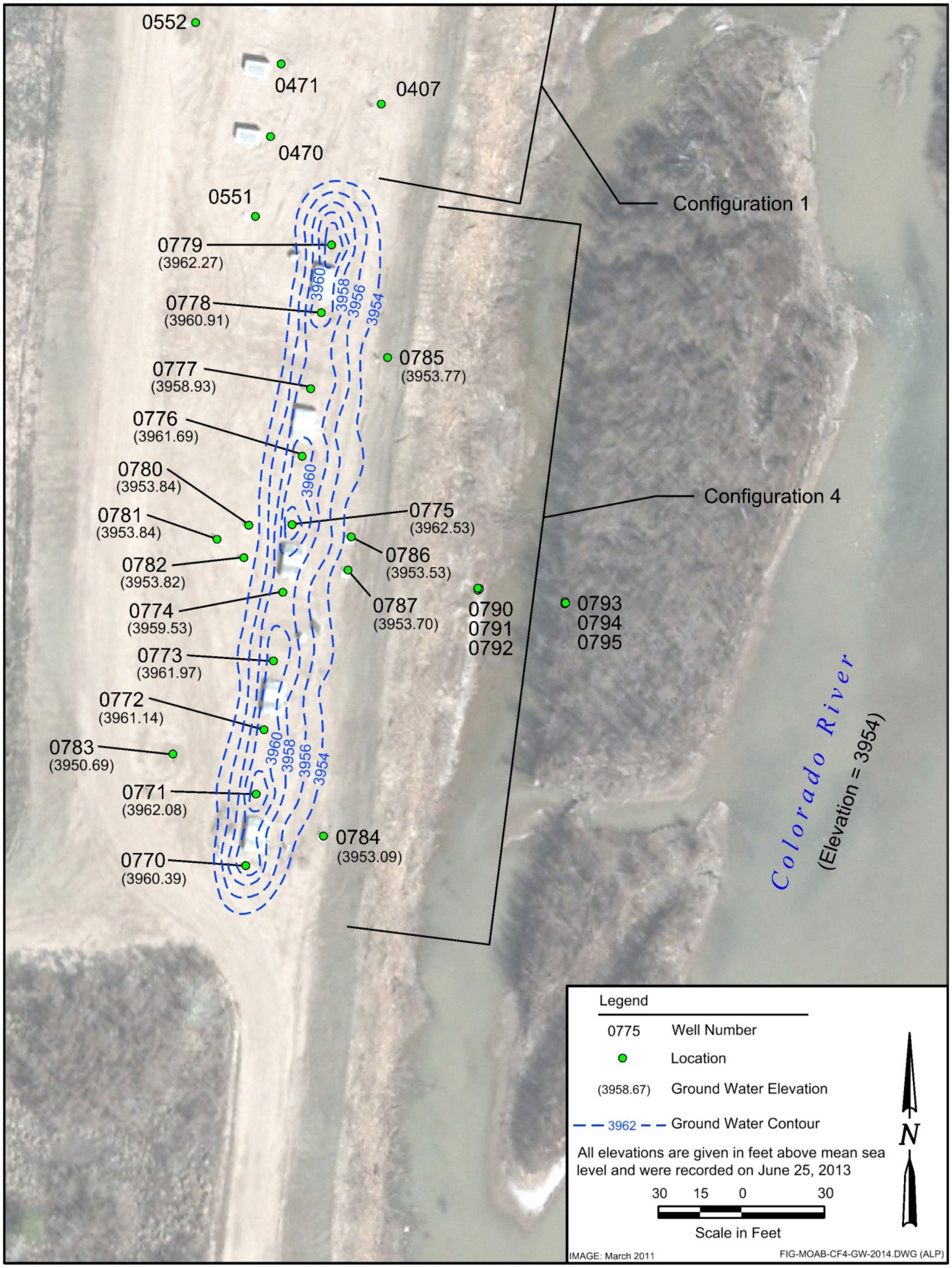


Figure 14. Freshwater Mounding at CF4 during Injection Operations June 2013

Nearly all of the observation wells had the highest mounding on June 19. Observation well 0783 had the most mounding on June 19, when the combined injection rate was 29.30 gpm. It is likely that this well was also impacted by the spring runoff on the Colorado River.

7.0 Surface Water Monitoring

In 2013, the river flow ranged from 1,570 to 12,800 cfs from January through December. On average, the flow ranges from 3,130 to 27,500 cfs. The channel that flows adjacent to CF4 was a habitat for most of the monitoring season (June through September).

Surface water monitoring was completed through site-wide surface water sampling and biota monitoring. The site-wide sampling event occurs twice a year, and surface water samples are collected upgradient of the site, on-site, and downgradient of the site (Figure 15).

Biota monitoring is conducted yearly after the spring peak river flow begins to recede. The purpose is to monitor the ammonia concentrations in the side channel adjacent to the site, because the channel is a potential habitat for young-of-year endangered fish species (e.g., Colorado pikeminnow, razorback sucker). The Biota Monitoring Program includes collecting ammonia-probe samples and surface water diversion. More than 17.9 mil gal of freshwater were diverted to the side channels adjacent to CF4 in 2013.

7.1 Site-wide Surface Water Monitoring

Site-wide surface water monitoring took place in May and in November/December. Ammonia and uranium sample results were analyzed by ALS Environmental, Inc. The results of the May 2013 sampling event can be found in the *Moab UMTRA Project Ground Water and Surface Water Monitoring January through June 2013* (DOE-EM/GJTAC2108). With the exception of a sample collected from CR3, the ammonia concentrations were below the detection limit of 0.1 mg/L. The ammonia concentration in the sample from CR3 was below the acute and chronic criteria.

The results of the November/December 2013 sampling event can be found in the *Moab UMTRA Project Ground Water and Surface Water Monitoring July through December 2013* (DOE-EM/GJTAC2123). All of the ammonia concentrations were below the detection limit of 0.1 mg/L. The ammonia concentrations were all below both the acute and chronic criteria.

7.2 Biota Surface Water Monitoring

Biota monitoring begins after the Colorado River flow peaks in the spring and when the side channel adjacent to the Moab Project site becomes a suitable habitat. A suitable habitat is defined as a side channel that is closed off on the upriver side, but open downriver. In 2013, the side channel adjacent to CF4 became a suitable habitat on June 28, when the river flow decreased to 3,510 cfs. The side channel is approximately 500 ft long and approximately 15 ft wide. In addition, a secondary side channel developed just east of the CF4 channel.

June 2013
Biota monitoring began on June 4, when the river flow was over 6,000 cfs. At this time, there was only flow in the channel adjacent to CF4. A new surface water diversion system was installed on June 24, when the flow was 4,700 cfs. The new system includes an electrical panel and a trash pump that diverts water from downriver into the side channel through a series of diversion ports. The system was initiated at 180 gpm on June 25, when the river flow was 4,440 cfs. Ammonia-probe samples were collected before starting the system, and the concentration ranged from 12 to 16 mg/L. The location of inlets was adjusted, and a total of four diversion ports were utilized by June 27. On June 28, the side channel adjacent to CF4 became a suitable habitat when the river flow was 3,510 cfs.

July 2013
Ammonia probe samples were collected on July 1, 8, 15, and 25. The concentration ranged from less than 1 to 34 mg/L. As a result, two of the diversion points were moved to areas of higher ammonia concentration. On July 11, a flow meter was added to the diversion line. A stormy weather pattern increased the river flow to 4,590 cfs on July 29, and the diversion system was shut down because the channel adjacent to CF4 was no longer a suitable habitat.

August 2013
The channel adjacent to CF4 became a suitable habitat again on August 5, when the flow decreased to 3,810 cfs. The diversion system was down due to high turbidity and debris along the pump intake, so water was diverted into the channel through the injection system. The diversion system was re-started on August 6 at 190 gpm.

It was noted that another suitable habitat was forming just east of the CF4 channel. Ammonia samples were collected from the channel on August 22, and the concentration was between 8 and 18 mg/L. To help dilute the ammonia concentration, one of the southernmost diversion hoses was moved into the central portion of this side channel (referred to as Channel B).

September 2013
Ammonia samples collected on September 4 indicated the concentration had greatly decreased. The CF4 channel had concentrations of 1 mg/L, and the highest concentration in Channel B was 1.94 mg/L. The diversion system was shut down on September 11 due to debris interfering with the diversion intake resulting from a storm system. Diversion remained off for the rest of the month, because the river flow remained above 4,000 cfs, and the channel adjacent to CF4 was not a suitable habitat. Final ammonia-probe samples and laboratory samples were collected and analyzed on September 30, and the concentration was below 1.5 mg/L at all of the sample locations. Locations 0278, 0279, 0280, and 0281 were all slightly above the chronic criteria; however, the side channel was not considered a suitable habitat when samples were collected (Figure 16).

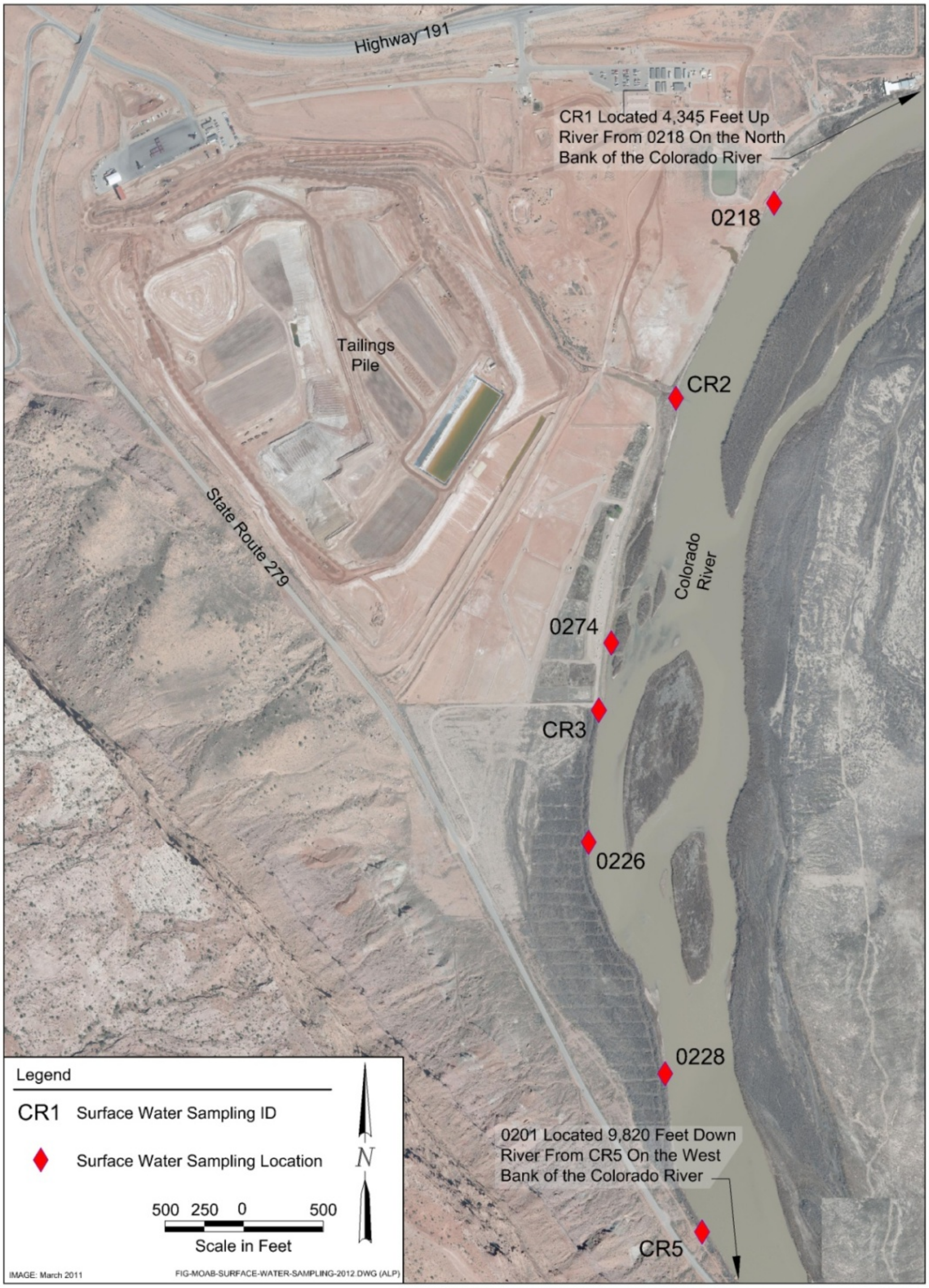


Figure 15. Site-wide Surface Water Sample Locations

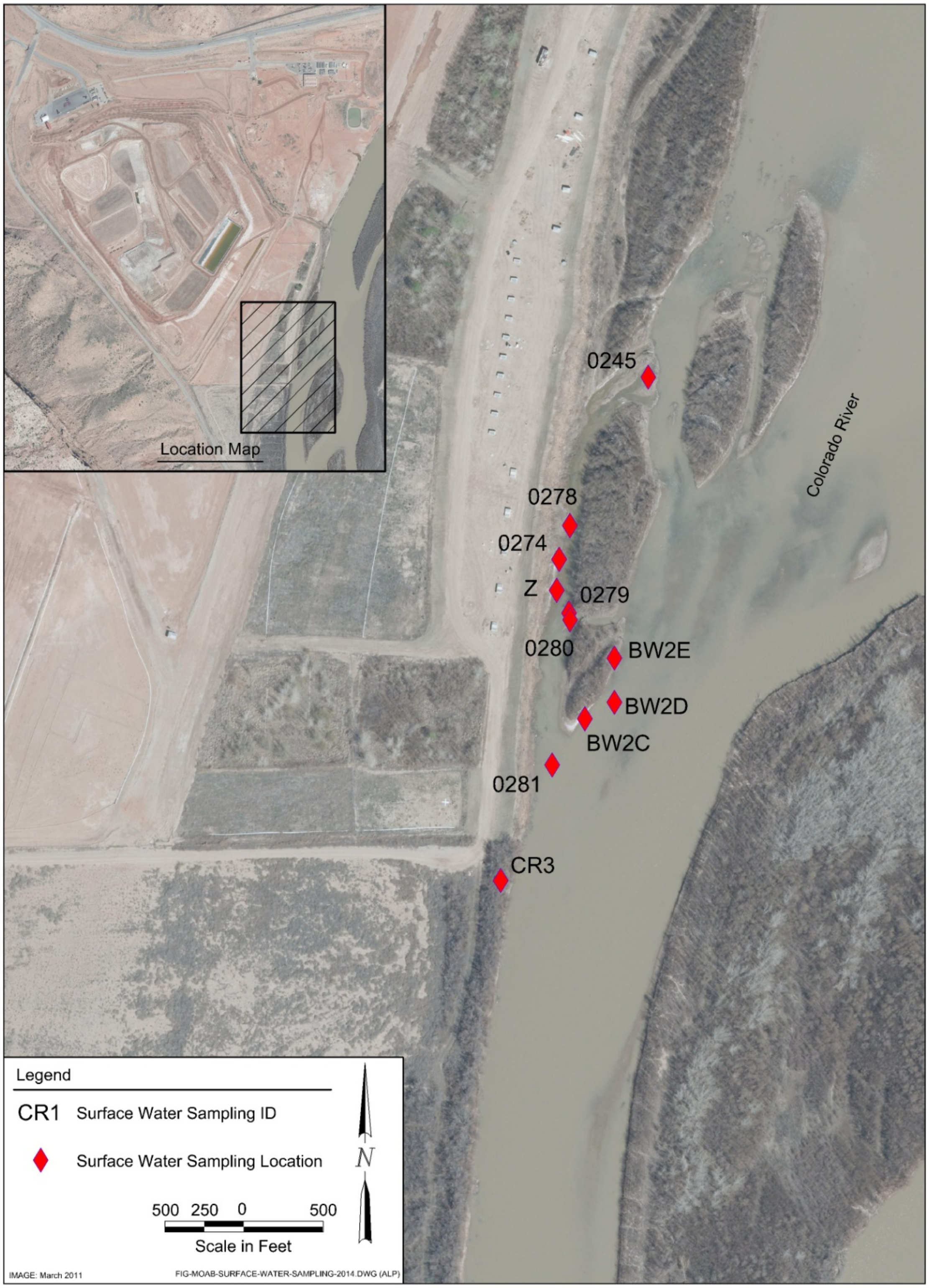


Figure 16. Surface Water Locations in September 2013

7.3 Summary of Surface Water Monitoring

In 2013, an electric panel and trash pump were installed to divert the fresh river water into the CF4 side channel. This system proved to be successful in diluting ammonia concentrations and delivering water into the channel; however, the location of the pump intake was a challenge because during storm events, wood debris would get caught on the line.

The low river flow combined with the frequent storm events resulted in the accumulation of silt in the CF4 side channel. After the habitat monitoring season, the southern end of the channel (where it connects to the main river channel) was dry for most of the winter months. Channel B became a suitable habitat in August when the river flow was near 2,500 cfs. No dead or distressed fish were found within the channel during the 2013 biota monitoring event.

In 2013, the duration of the surface water monitoring was longer than usual because of the below-average spring peak runoff. Figure 17 shows the number of habitat days present and the Colorado River flow from 2006 to 2013. It is evident that when the river flow is near or above 40,000 cfs, there are fewer habitat days. Many factors, such as storm events, sediment supply, and location of beaver dams impact the formation of a suitable habitat.

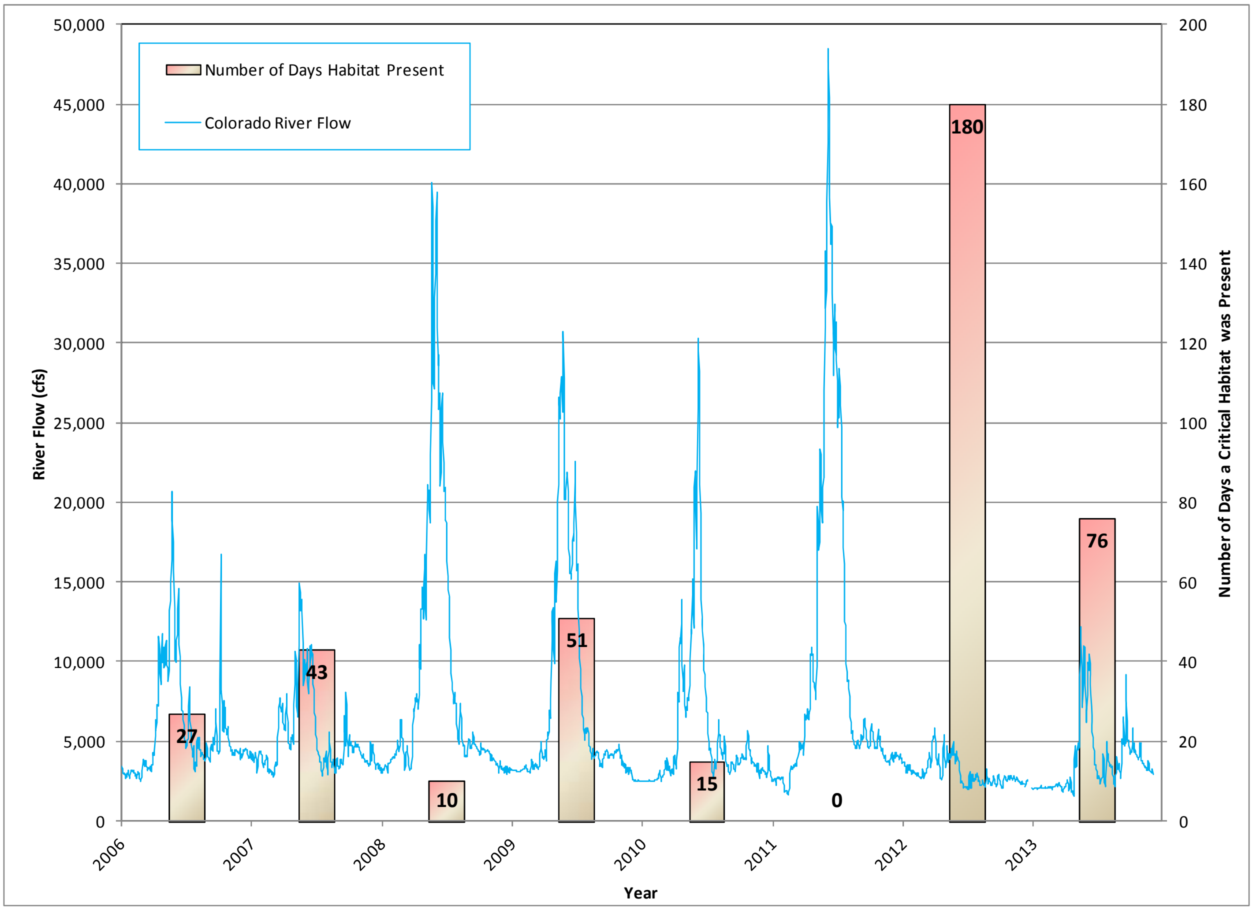


Figure 17. Number of Habitat Days vs. River Flow

8.0 Investigations

8.1 Ground Water Transport Modeling

Ground water transport modeling was completed by Florida International University using the calibrated flow model developed by A.D. Laase Hydrologic Consulting (see Attachment 1). The transport model was used to predict the capture zones for different operating scenarios, mass removal, and time to complete remediation. The simulations using this SEAWAT model were completed to analyze the nitrogen cycle constituents and uranium concentrations and provide forecasting capabilities for the fate and transport of these contaminants.

9.0 Summary and Conclusions

In 2013, the IA operations focused on year-round ground water extraction (from CF5) and freshwater injection (CF4), and surface water diversion during the spring and summer months.

A total of 15.1 mil gal of water was extracted from CF5 in 2013. The extraction rate peaked at 108 gpm in July, and operations continued year-round. Each of the eight extraction wells were utilized in 2013. Figure 18 shows the ammonia and uranium mass removed and the volume of ground water extracted from the CF5 extraction wells in 2013. The volume and mass removed is similar to the past few years. More than 308 lb of uranium and more than 39,000 lb of ammonia were removed from the ground water in 2013.

Approximately 5.5 mil gal of extracted water was pumped through the evaporators, and 14 mil gal of extracted water were used by water trucks for dust suppression in the contaminated area. The evaporators were run overnight when conditions were favorable. The volume of water run through the evaporators increased significantly since 2012, when 710,000 gal were pumped through the system.

Approximately 9.4 mil gal of freshwater was injected into CF4 in 2013. Ammonia-probe data from the CF4 observation wells during injection operations indicate the system is effective at diluting ammonia concentrations, especially from 28 to 36 ft bgs. Specific conductance also decreases at the downgradient observation wells during freshwater injection.

Site-wide surface water samples indicated the contaminants do not extend past the site boundary. Location CR3, located on the southernmost edge of the property, had a slightly elevated ammonia concentration, but was not considered a habitat at the time of sampling.

Biota monitoring took place from June through October in 2013 due to the below-average river flow. During this time, a trash pump and diversion manifolds were used to divert river water into the side channels adjacent to CF4. The volume of water through the system was greater than what was available in previous years, and the ammonia concentrations were lower than previously observed. A new suitable habitat, Channel B, formed just to the east of the CF4 channel, and river water was diverted into this channel starting in August. Over 17.9 mil gal of freshwater was diverted to the side channels in 2013.

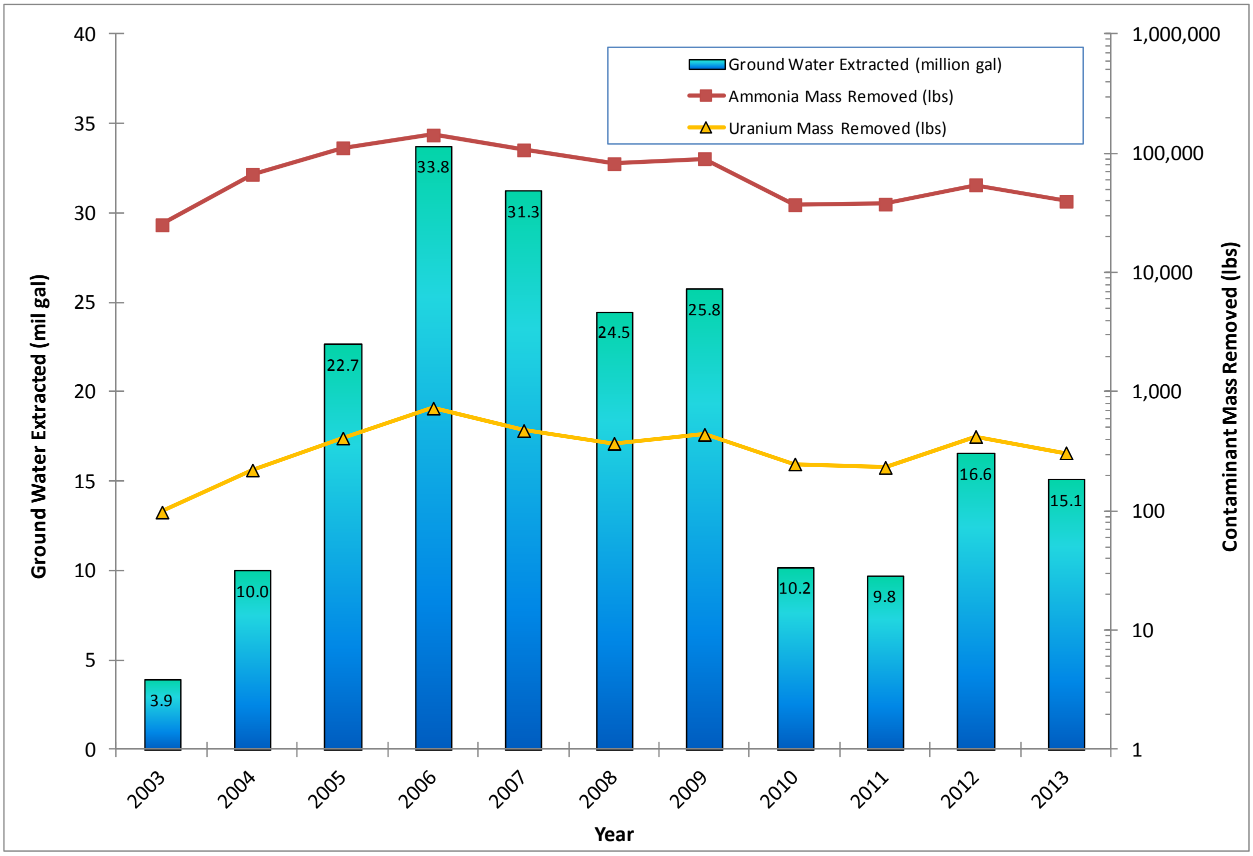


Figure 18. Volume of Ground Water Extracted and Ammonia Mass Removal, 2003 Through 2013

10.0 References

DOE (U.S. Department of Energy), *Record of Decision for the Remediation of the Moab Uranium Mill Tailings, Grand and San Juan Counties, Utah* (6450-01-P).

DOE (U.S. Department of Energy), *Remediation of the Moab Uranium Mill Tailings, Grand and San Juan Counties, Utah, Final Environmental Impact Statement* (DOE/EIS-0355).

DOE (U.S. Department of Energy), *Moab UMTRA Project Ground Water and Surface Water Monitoring January through June 2013* (DOE-EM/GJTAC2108).

DOE (U.S. Department of Energy), *Moab UMTRA Project Ground Water and Surface Water Monitoring July through December 2013* (DOE-EM/GJTAC2123).

DOE (U.S. Department of Energy), *Moab UMTRA Project Surface Water/Ground Water Sampling and Analysis Plan* (DOE-EM/GJTAC1830).

Appendix A.
Tables and Data for 2013 Ground Water Extraction

Appendix A. Tables and Data for 2013 Ground Water Extraction

Table A-1. Well Construction for CF5 Extraction Wells

Well	Well Type/Relative Depth	Diameter (in.)	Ground Surface Elevation (ft above msl)	Screen Interval (ft bgs)	Total Depth (ft bgs)
0810	Extraction	8	3,966.56	10.4 – 40.4	40.4
0811	Extraction	8	3,966.59	8.8 – 38.6	38.6
0812	Extraction	8	3,966.62	14.2 – 44.2	44.2
0813	Extraction	8	3,966.67	14.4 – 44.4	44.4
0814	Extraction	8	3,967.02	12.4 – 42.4	42.4
0815	Extraction	8	3,967.13	21.7 – 51.7	51.7
0816	Extraction	8	3,967.38	20.9 – 50.9	50.9
SMI-PW02	Extraction	4	3,965.60	20 - 60	60.3

msl = mean sea level

Table A-2. Chronology of CF5 Activities in 2012

Date	River Flow (cfs)	Activity
January	Ice	Extraction from PW02 and 0815 began at 14:30 (total 66 gpm) on January 2. Well 0815 was winterized on January 9. PW02 was winterized on January 14.
February	Ice	Extraction from 0816 from February 4 to February 19 (40 gpm). Extraction from well 0814 from February 19 to February 20 (30 gpm). Extraction from 0813 on February 20 (33 gpm).
March	1,750 to 2,450	Extraction from 0812, 0813, 0815, and 0816. Evaporator #2 was utilized starting on March 27.
April	1,450 to 3,270	Extraction from 0810, 0811, 0812, 0813, 0814, 0815, 0816, and PW02. The evaporator was used when weather conditions were favorable. A modification was made to evaporator #1 so that water can be pulled directly from the evaporation pond. CF5 wells were developed through April and May.
May	3,190 to 11,500	Extraction from 0810, 0811, 0812, 0813, 0814, 0815, 0816, and PW02. The evaporator was used when weather conditions were favorable. CF5 sampling event on May 22.
June	3,310 to 11,300	Extraction from 0810, 0811, 0812, 0813, 0814, and 0815. The evaporator was used when weather conditions were favorable.
July	2,160 to 6,310	Extraction from 0810, 0811, 0812, 0814, and PW02. The evaporator was used when weather conditions were favorable.
August	2,900 to 4,700	Extraction from 0810, 0811, 0812, 0814, and 0816. The evaporator was used when weather conditions were favorable. The extraction system was shut down from August 26 to 29 for valve repairs
September	2,650 to 7,340	Extraction resumed on September 1 from wells 0810, 0811, and 0816. No operations from September 9 to 16 due to weather. Extraction from 0811, 0812, 0813, 0814, and PW02 on September 18, then it was shut down for the rest of the month to control the evaporation pond level.
October	3,850 to 6,240	Evaporators ran off of the evaporation pond water. The wells on the 6-inch line were winterized on October 15. Extraction wells 0815 and PW02 ran from October 22 through the end of the month.
November	3,050 to 4,740	Extraction from PW02 and 0815. The evaporators were winterized on November 14. The system was winterized on November 27 for the holiday weekend.
December	2,230 to 3,170	Extraction from 0815 until it was winterized on December 19.

Table A-3. CF5 Extraction Volumes 2013

Well	Volume Extracted (gal)												
	Jan-13	**Feb-13**	**Mar-13**	**Apr-13**	**May-13**	**Jun-13**	**Jul-13**	**Aug-13**	**Sep-13**	**Oct-13**	**Nov-13**	**Dec-13**	**Totals**
810	0	0	0	75,313	185,531	537,900	938,227	319,986	42,225		0	0	2,099,182
811	0	0	0	166,855	128,141	250,215	146,759	177,617	64,777	0	0	0	934,364
812	0	0	304,251	143,930	206,260	515,080	696,890	43,160	48,880	0	0	0	1,958,451
813	0	0	941,241	34,365	300,183	84,686	38,162	0	41,093	0	0	0	1,439,730
814	0	32,909	0	0	343,252	467,164	942,991	48,581	58,664	0	0	0	1,893,561
815	378,495	0	42,904	37,594	440,393	183,532	356,473	1,293	0	260,349	9,492	593,953	2,304,478
816	0	897,783	0	134,302	229,091	0	0	697,035	99,045	0	0	0	2,057,256
PW02	403,638	0	0	53,892	642,520	0	434,310	0	35,940	29,910	822,760	0	2,422,970
MONTHLY	782,133	930,692	1,288,396	646,251	2,475,371	2,038,577	3,553,812	1,287,672	390,624	290,259	832,252	593,953	15,109,992
TOTAL	15,109,992												

Table A-4. CF5 Ammonia Mass Removal 2013

Well	Ammonia Mass Removed (lbs)												
	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Totals
810	0	0	0	211	513	1,464	2,602	887	117	11	0	0	5,794
811	0	0	0	581	440	809	477	577	210	0	0	0	3,094
812	0	0	1,023	484	704	1,763	2,396	148	168	0	0	0	6,686
813	0	833	1,558	87	789	240	108	0	116	0	0	0	3,731
814	0	59	0	0	620	827	1,673	86	104	0	0	0	3,369
815	466	0	53	46	653	458	891	3	0	650	24	1,335	4,580
816	0	1,256	0	1,878	326	0	0	1,103	157	0	0	0	3,029
PW02	1,585	0	0	206	2,454	0	1,752	0	145	121	3,249	0	9,512
MONTHLY	2,051	2,148	2,634	3,493	6,499	5,561	9,899	2,804	1,017	782	3,272	1,335	39,795
TOTAL							39,795						

Table A-5. CF5 Uranium Mass Removal 2013

Well	Uranium Mass Removed (lbs)												
	Jan-13	**Feb-13**	**Mar-13**	**Apr-13**	**May-13**	**Jun-13**	**Jul-13**	**Aug-13**	**Sep-13**	**Oct-13**	**Nov-13**	**Dec-13**	**Totals**
810	0	0	0	1.9	4.6	13.4	23.4	8.0	1.1	0	0	0	52
811	0	0	0	2.8	2.1	4.8	3.1	3.7	1.3	0	0	0	18
812	0	0	5.3	2.5	3.7	8.4	11.0	0.7	0.8	0	0	0	32
813	0	2.5	4.6	0.3	2.2	1.0	0.4	0	0.5	0	0	0	11
814	0	0.7	0	0	7.4	9.9	19.6	1.0	1.2	0	0	0	40
815	9.5	0	1.1	0.9	11.0	4.1	8.0	0	0	5.9	0.2	16.3	57
816	0	17.9	0	2.7	4.6	0	0	14.5	2.1	0	0	0	42
PW02	9.3	0	0	1.2	14.4	0	9.8	0	0.8	0.7	19.4	0	56
MONTHLY	18.8	21.1	11.0	12.3	50.1	41.7	75.4	27.9	7.7	6.5	19.6	16.3	308.5
TOTAL	308.5												

Appendix A. Tables and Data for 2013 Ground Water Extraction (*continued*)

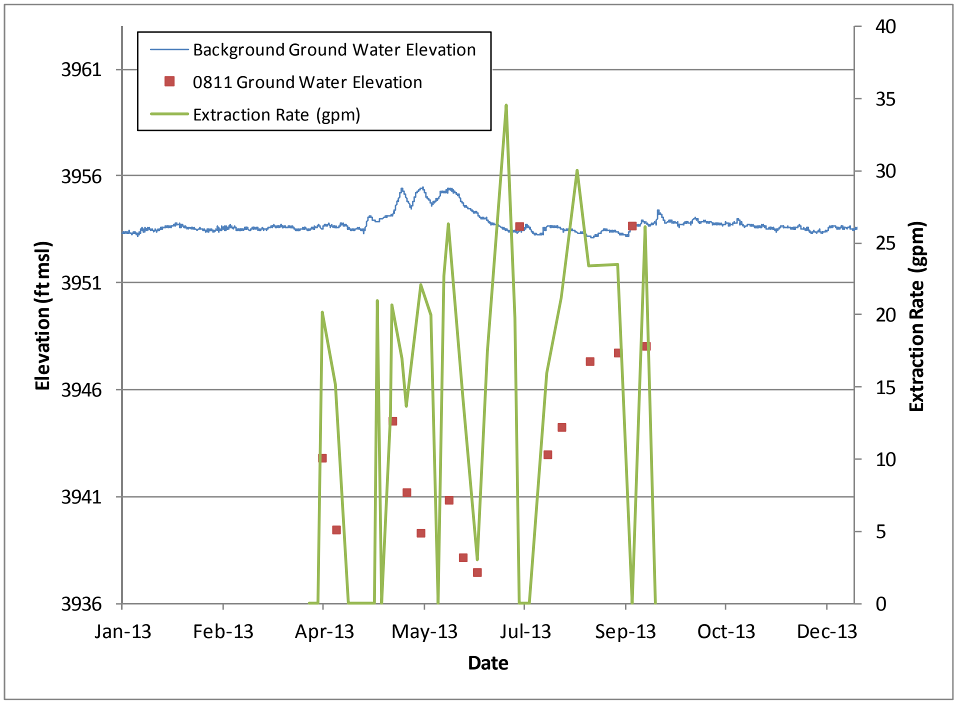


Figure A-1. Drawdown Plot for Well 0811

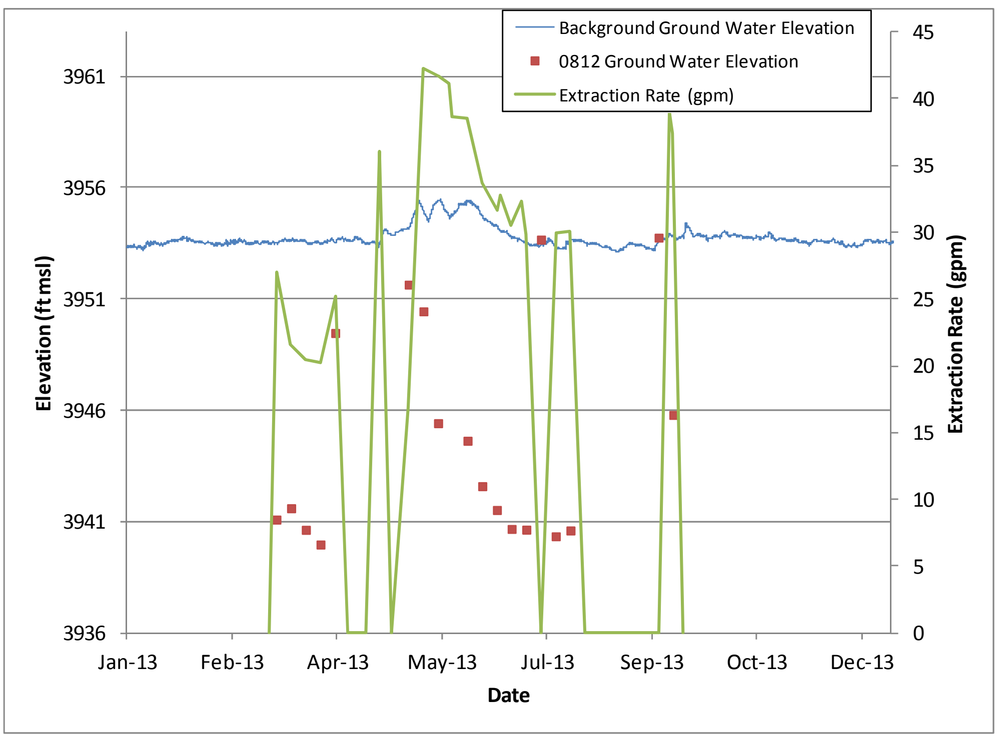


Figure A-2. Drawdown Plot for Well 0812

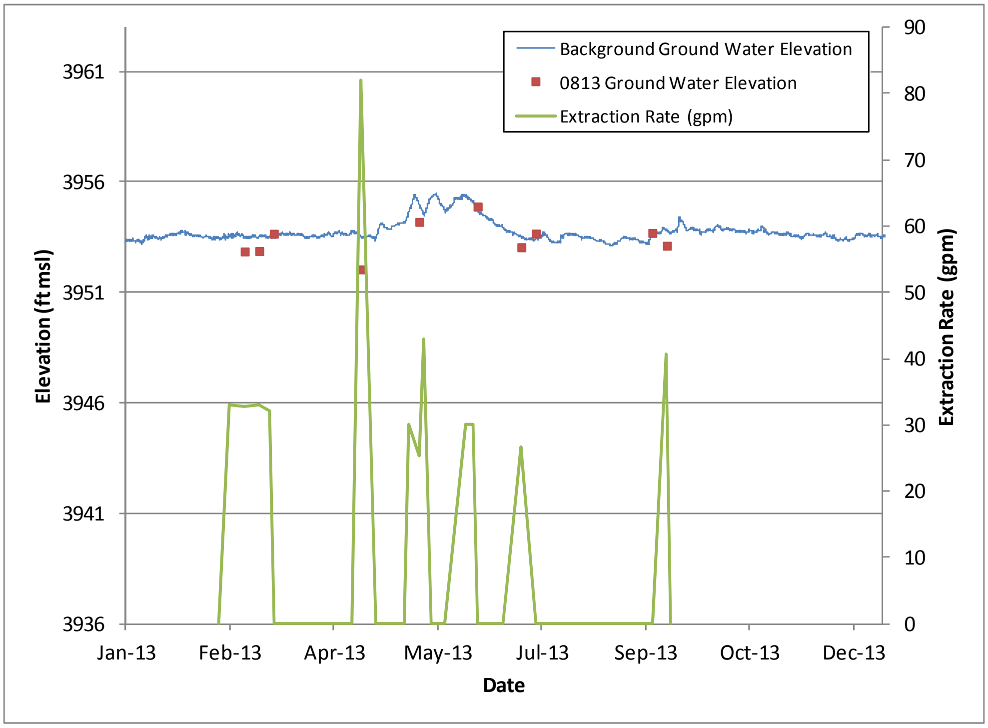


Figure A-3. Drawdown Plot for Well 0813

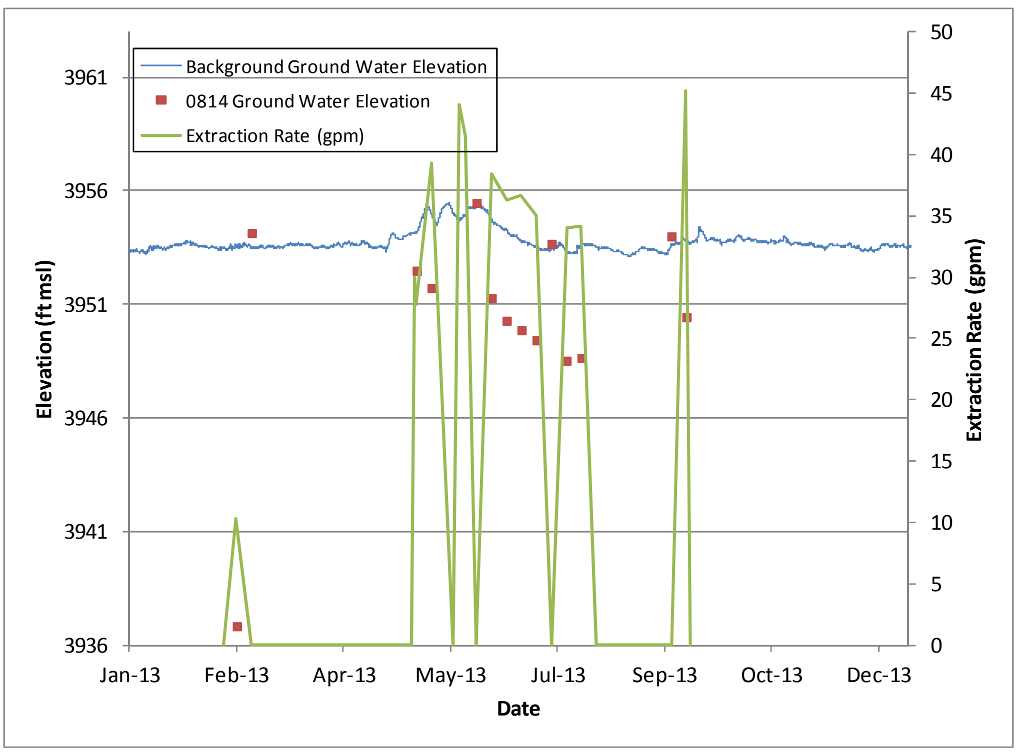


Figure A-4. Drawdown Plot for Well 0814

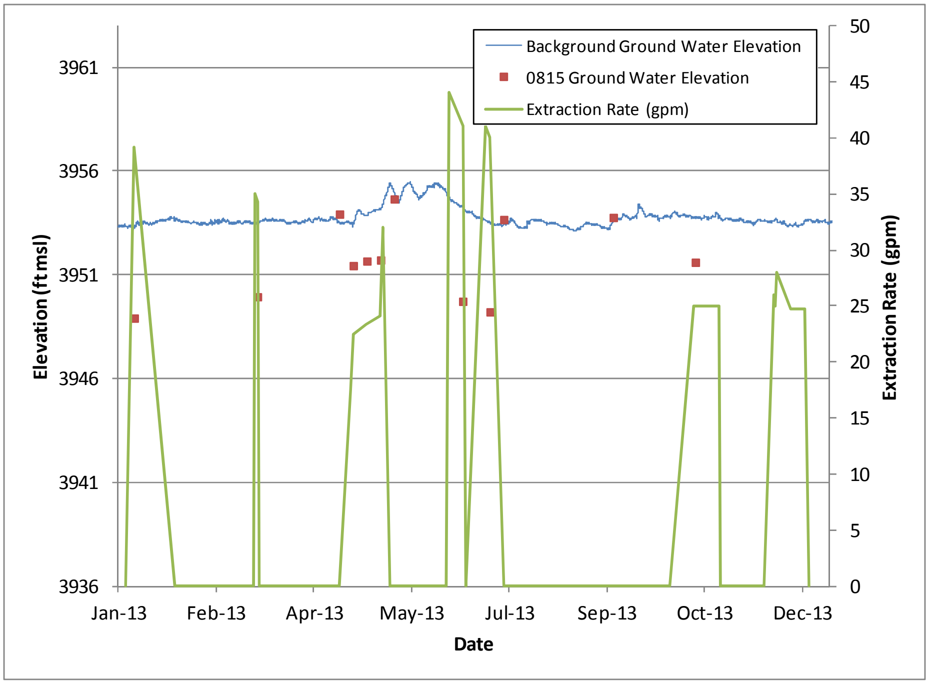


Figure A-5. Drawdown Plot for Well 0815

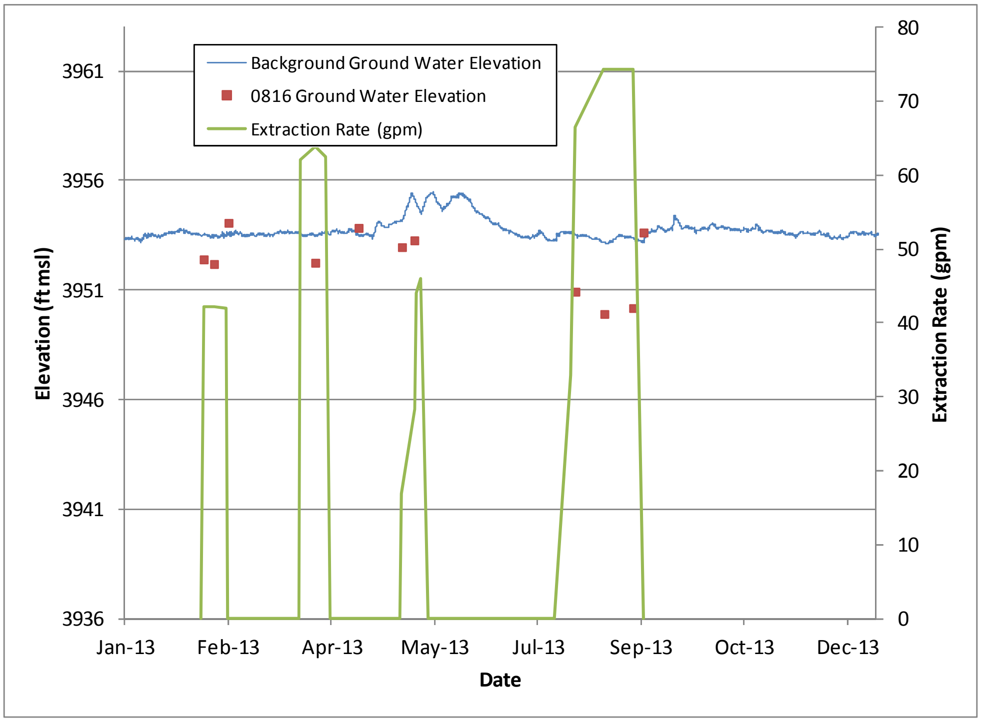


Figure A-6. Drawdown Plot for Well 0816

Appendix B.
2013 Evaporation Pond Data

Appendix B. 2013 Evaporation Pond Data

Table B-1. Evaporation Pond Chorology for 2013

Date	Pond Level (ft)	Activity
1/10/13	7.1	PW02 shut down due to power issue
2/4/13	7.4	Started extraction from CF5
3/11/13	9.2	RAC began to remove water from the evaporation pond
3/27/13	9.0	Landshark #2 operations begin
4/18/13	8.1	Landshark #1 unit modified to draw directly from the pond
4/24 to 5/8/13	7.5 to 7.9	Well development at CF5 and CF4
07/2013	7.4	Maximized extraction operations
9/19/13	7.7	Shut down extraction to control pond level
10/22/13	6.0	Re-started extraction from 0815 and all 6 inch wells were winterized
11/14/13	5.9	Winterized evaporators
11/27/13	6.6	Shut down extraction for holiday weekend
12/2/13	6.7	Re-started extraction from 0815
12/9/13	7.0	Shut down extraction for the holiday

Table B-2. Pond Level vs. Pond Volume 2013

Date	Pond Level (ft)	Pond Volume (gal)
01/02/13	6.2	2172251
01/09/13	7.1	2809960
01/16/13	7.3	2962885
01/23/13	7.2	2885913
01/30/13	7.2	2885913
02/06/13	7.4	3040877
02/13/13	7.9	3446123
02/20/13	8.4	3876852
02/27/13	8.7	4147520
03/06/13	9	4427363
03/13/13	9.2	4619020
03/20/13	8.8	4239782
03/27/13	8.6	4056278
04/03/13	8.3	3788668
04/10/13	8.2	3701503
04/17/13	8.1	3615357
04/24/13	7.9	3446123
05/01/13	7.8	3363035
05/08/13	7.5	3119888
05/15/13	7.4	3040877
05/22/13	7.7	3280967

Table B-2. Pond Level vs. Pond Volume 2013 (continued)

Date	Pond Level (ft)	Pond Volume (gal)
05/29/13	7.5	3119888
06/05/13	6.7	2516341
06/12/13	6.3	2239031
06/19/13	6	2041751
06/26/13	6.1	2106491
07/03/13	6.5	2375648
07/10/13	6.7	2516341
07/17/13	7.4	3040877
07/24/13	7.4	3040877
07/31/13	7.9	3446123
08/07/13	7.9	3446123
08/14/13	7.9	3446123
08/21/13	7.8	3363035
08/28/13	7.9	3446123
09/04/13	7.8	3363035
09/11/13	7.8	3363035
09/18/13	7.7	3280967
09/25/13	7.7	3280967
10/02/13	7.3	2962885
10/09/13	6.7	2516341
10/16/13	6.3	2239031
10/23/13	6	2041751
10/30/13	5.8	1915327
11/06/13	6.1	2106491
11/13/13	5.9	1978029
11/20/13	6.2	2172251
11/27/13	6.6	2445485
12/04/13	6.7	2516341
12/11/13	7	2735027
12/18/13	7.3	2962885
12/25/13	7.4	3040877

Table B-3. Evaporator Operations 2013

Date	Total Gallons
04/03/13	33,066
04/10/13	37,710
05/01/13	106,348
05/08/13	46,545
05/15/13	43,824
05/22/13	152,483
05/29/13	16,656
06/05/13	149,743
06/12/13	77,346
06/19/13	261,847
06/26/13	320,563
07/03/13	436,702
07/10/13	419,570
07/17/13	289,396
07/24/13	265,745
08/07/13	268,124
08/14/13	325,881
08/21/13	426,429
08/28/13	118,452
09/4/13	158,183
09/11/13	163,383
09/18/13	190,196
09/25/13	193,115
10/02/13	160,300
10/09/13	234,098
10/16/13	12,600
10/23/13	138,814
10/30/13	79,551
11/06/13	58,217
11/13/13	69,966

Appendix C.
Tables and Data for 2013 Freshwater Injection

Appendix C. Tables and Data for 2013 Freshwater Injection

Table C-1. CF4 Well Construction

Well	Well Type/ Relative Depth	Diameter (in.)	Ground Surface Elevation (ft above msl)	Screen Interval (ft bgs)	Total Depth (ft bgs)
0770	Remediation/Deep	6	3,968.86	14.9 – 34.8	35.2
0771	Remediation/Deep	6	3,969.04	15.0 – 34.9	35.3
0772	Remediation/Deep	6	3,969.21	15.2 – 35.1	35.5
0773	Remediation/Deep	6	3,969.15	15.2 – 35.1	35.5
0774	Remediation/Deep	6	3,968.77	15.5 – 35.4	35.8
0775	Remediation/Deep	6	3,969.18	15.1 – 35.0	35.4
0776	Remediation/Deep	6	3,968.97	15.2 – 35.1	35.5
0777	Remediation/Deep	6	3,968.76	15.3 – 35.2	35.6
0778	Remediation/Deep	6	3,968.93	15.1 – 35.0	35.4
0779	Remediation/Deep	6	3,968.34	15.7 – 35.6	36.0
0780	Observation/Shallow	6	3,968.45	20.3 – 30.1	30.5
0781	Observation/Deep	6	3,968.56	44.8 – 54.5	55.0
0782	Observation/Deep	6	3,968.46	31.0 – 40.8	41.2
0783	Observation/Shallow	2	3,968.82	8.6 – 18.6	19.1
0784	Observation/Shallow	2	3,968.73	9.4 – 19.4	19.9
0785	Observation/Shallow	2	3,968.24	9.6 – 19.6	19.9
0786	Observation/Shallow	6	3,968.14	20.5 – 30.3	30.7
0787	Observation/Deep	6	3,968.43	35.4 – 45.2	45.7
0790	Well Point/Shallow	1	3,953.91	2.0 – 3.0	3.0
0791	Well Point/Intermediate	1	3,953.91	4.3 – 5.3	5.3
0792	Well Point/Deep	1	3,953.91	9.3 – 10.3	10.3
0793	Well Point/Shallow	1	3,952.69	2.0 – 3.0	3.0
0794	Well Point/Intermediate	1	3,952.69	4.3 – 5.3	5.3
0795	Well Point/Deep	1	3,952.69	9.3 – 10.3	10.3

msl = mean sea level

Table C-2. Chronology of CF4 Activities in 2013

Month	River Flow (cfs)	Activity
January	Ice	Injection system winterized.
February	Ice	Injection started February 4. Material was added to the sand filter on February 21.
March	1,750 to 2,450	Injection system operated all month.
April	1,450 to 3,270	Injection system operated through the end of the month. The injection wells were developed from late April through early May.
May	3,190 to 11,500	Injection system operated all month.
June	3,310 to 11,300	Injection system operated all month.
July	2,160 to 6,310	Injection system was shut down on July 18 due to high suspended solids in the freshwater pond. Operations resumed July 25.
August	2,900 to 4,700	Injection system ran until August 28, when it was shut down due to high suspended solids in the freshwater pond.
September	2,650 to 7,340	No injection due to high suspended solids in the river and freshwater pond.
October	3,850 to 6,240	Injection operations resumed on October 10.
November	3,050 to 4,740	Injection shut down for modifications to the sand filter shed.
December	2,230 to 3,170	Injection operations resumed from December 9 through 19.

Table C-3. Ammonia Probe Sample Results 2012

					780 (Up-18' bgs)		781 (Up-46' bgs)		782 (Up-33' bgs)		783 (Up-18' bgs)		784 (D-18' bgs)		785 (D-18' bgs)		786 (D-28' bgs)		787 (D-36' bgs)		790 (tallest)		791 (short)		792 (mid)	
Date	**River Flow (cfs)**	**Inj?**	**Length of time?**	**Total gpm**	**Conductivity (µmhos/cm)**	**Ammonia (mg/L)**	**Conductivity (µmhos/cm)**	**Ammonia (mg/L)**	**Conductivity (µmhos/cm)**	**Ammonia (mg/L)**	**Conductivity (µmhos/cm)**	**Ammonia (mg/L)**	**Conductivity (µmhos/cm)**	**Ammonia (mg/L)**	**Conductivity (µmhos/cm)**	**Ammonia (mg/L)**	**Conductivity (µmhos/cm)**	**Ammonia (mg/L)**	**Conductivity (µmhos/cm)**	**Ammonia (mg/L)**	**Conductivity (µmhos/cm)**	**Ammonia (mg/L)**	**Conductivity (µmhos/cm)**	**Ammonia (mg/L)**	**Conductivity (µmhos/cm)**	**Ammonia (mg/L)**
01/31/13	ICE	NO	Not since 12/21/12	0	22,287	408	106,085	1,664	26,129	504	6,252	13.87	4,158	2.36	3,057	3.87	22,015	388	93,094	1,224	N/A	N/A	N/A	N/A	N/A	N/A
04/08/13	2,380	YES	Since 2/4/13	20	3,769	7.18	108,430	3,015	24,900	3	4,846	17.54	3,229	1.24	1,823	0.13	2,500	9.77	89,170	1,416	1,666	1.05	3,564	44.3	11,296	269
06/25/2013	2,800	YES	Since 5/15	25	3,245	17.7	22,121	392	7,352	107.4	3,904	3.48	4,218	3.7	8,236	3.7	1,602	6.08	23,531	131.8	5084	1	4,040	30	10761	214
08/6/2013	3,150	YES	Since 7/23	25	1,855	13.9	81,411	1432	11,520	273	3,902	2.04	1,652	3.73	2,532	1	4,492	760	42,577	13.15	1924	1.81	4160	14.79	10294	190.5
08/13/2013	3,430	YES	Since 7/23	25	2,518	13.74	11,830	190	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1,464	9.02	16,086	7.02	N/A	N/A	N/A	N/A	N/A	N/A
0/24/2013	2,750	NO	Not since	0	10,359	159	81,410	1,220	16,497	295	3,228	1.1	2,150	2.1	1,670	1.3	12,995	163	37,775	627	N/A	N/A	N/A	N/A	N/A	N/A

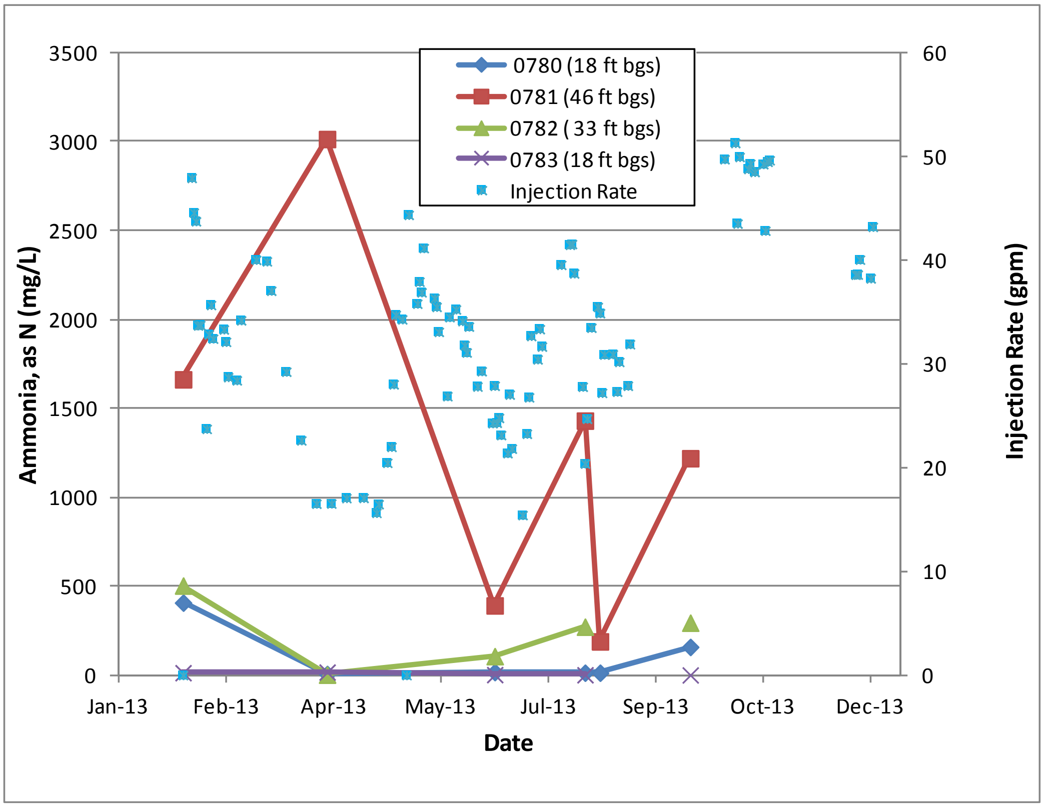


Figure C-1. Ammonia Concentration of Upgradient CF4 Observation Wells in 2013

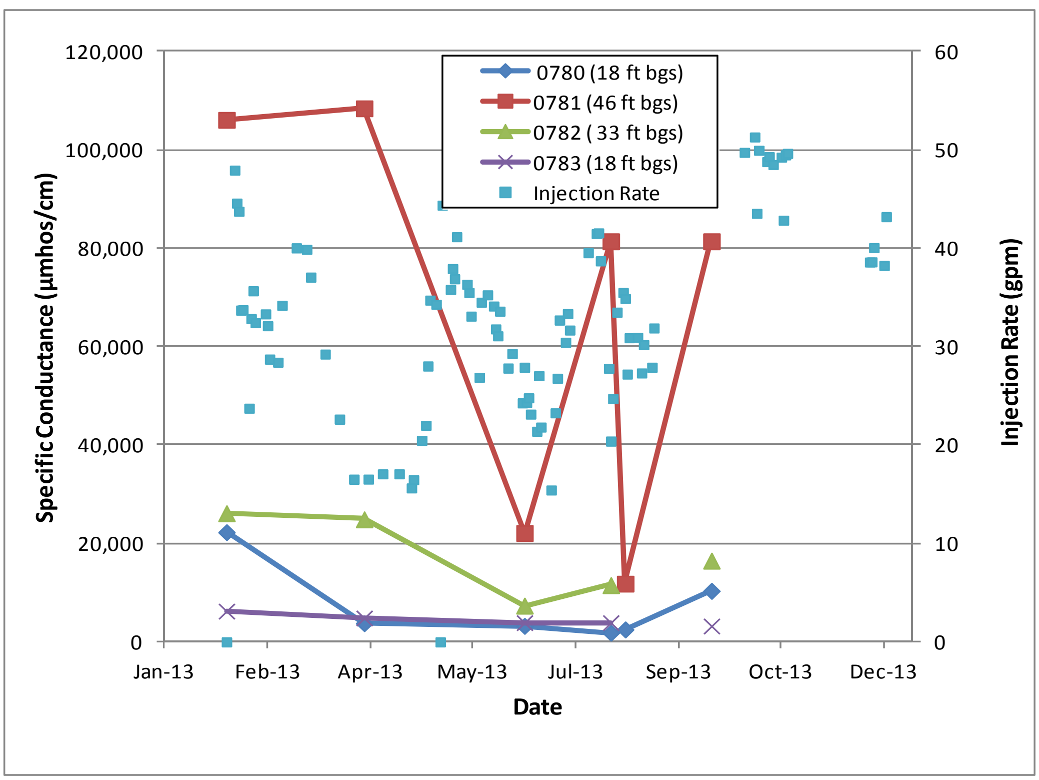


Figure C-2. Specific Conductance of Upgradient CF4 Observation Wells in 2013

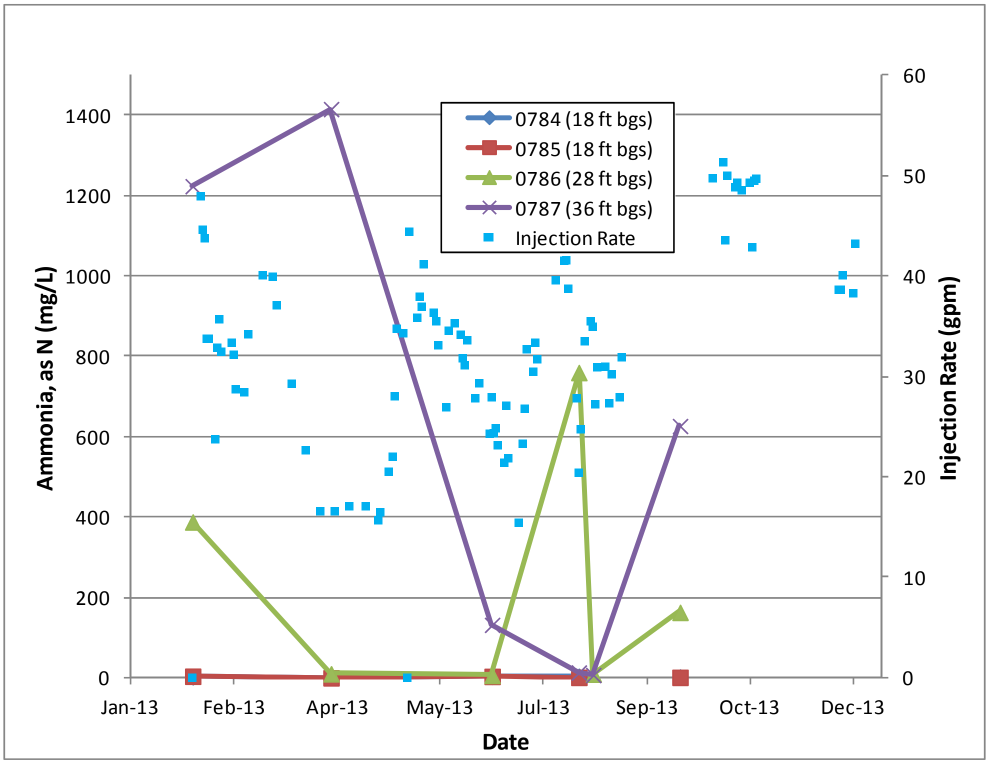


Figure C-3. Ammonia Concentration in Downgradient CF4 Observation Wells in 2013

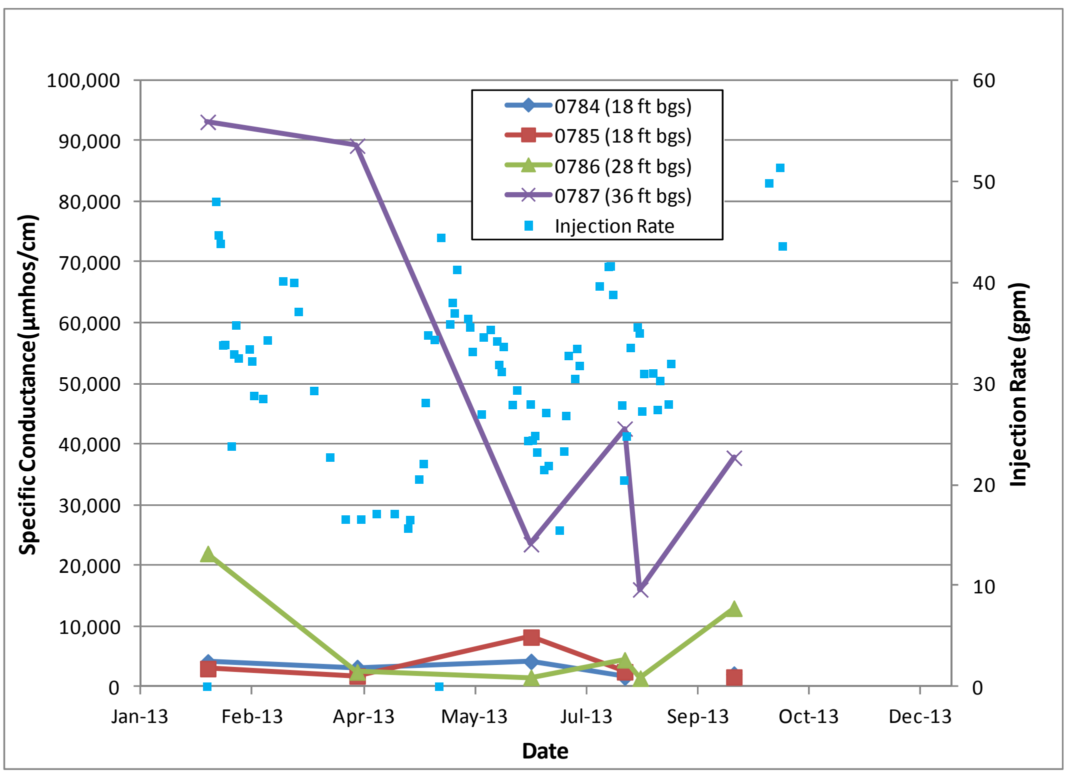


Figure C-4. Specific Conductance in Downgradient CF4 Observation Wells in 2013

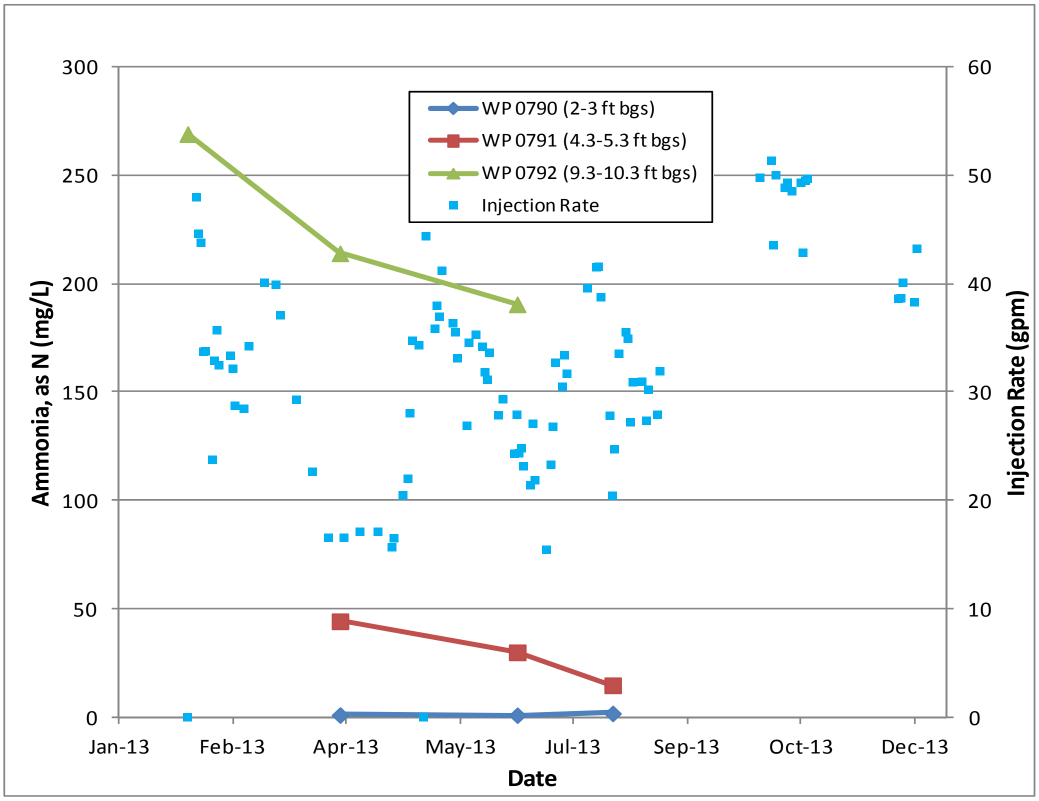


Figure C-5. Ammonia Concentration in CF4 Well Points in 2013

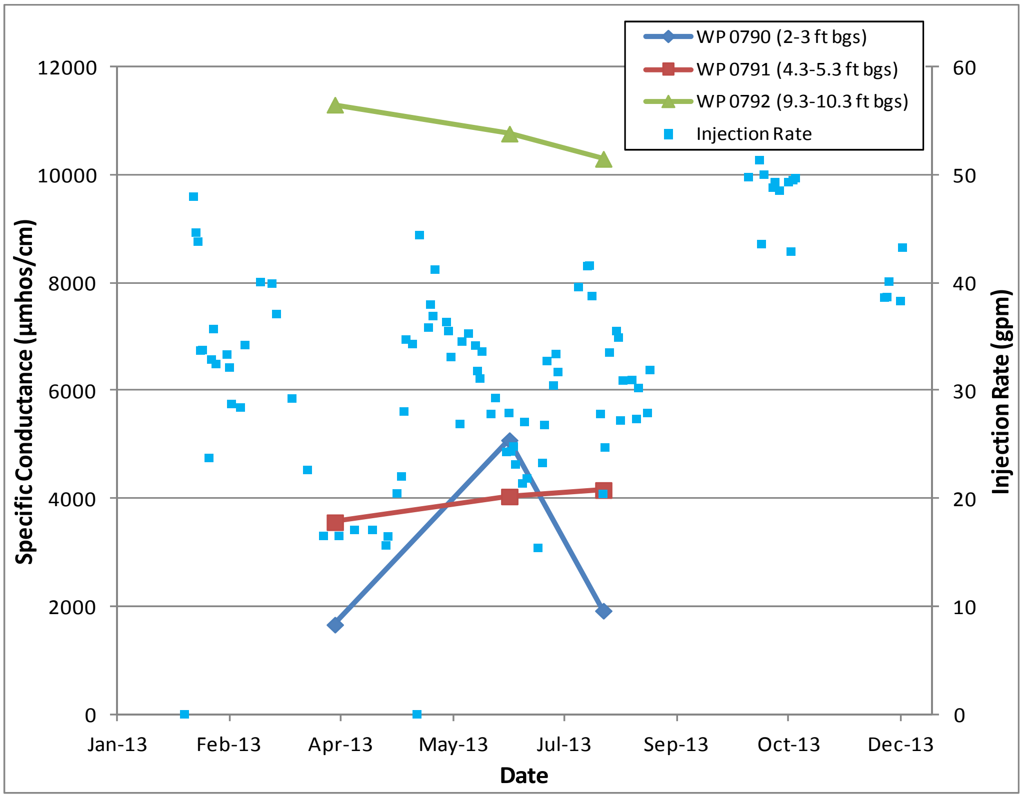


Figure C-6. Specific Conductance in CF4 Well Points in 2013

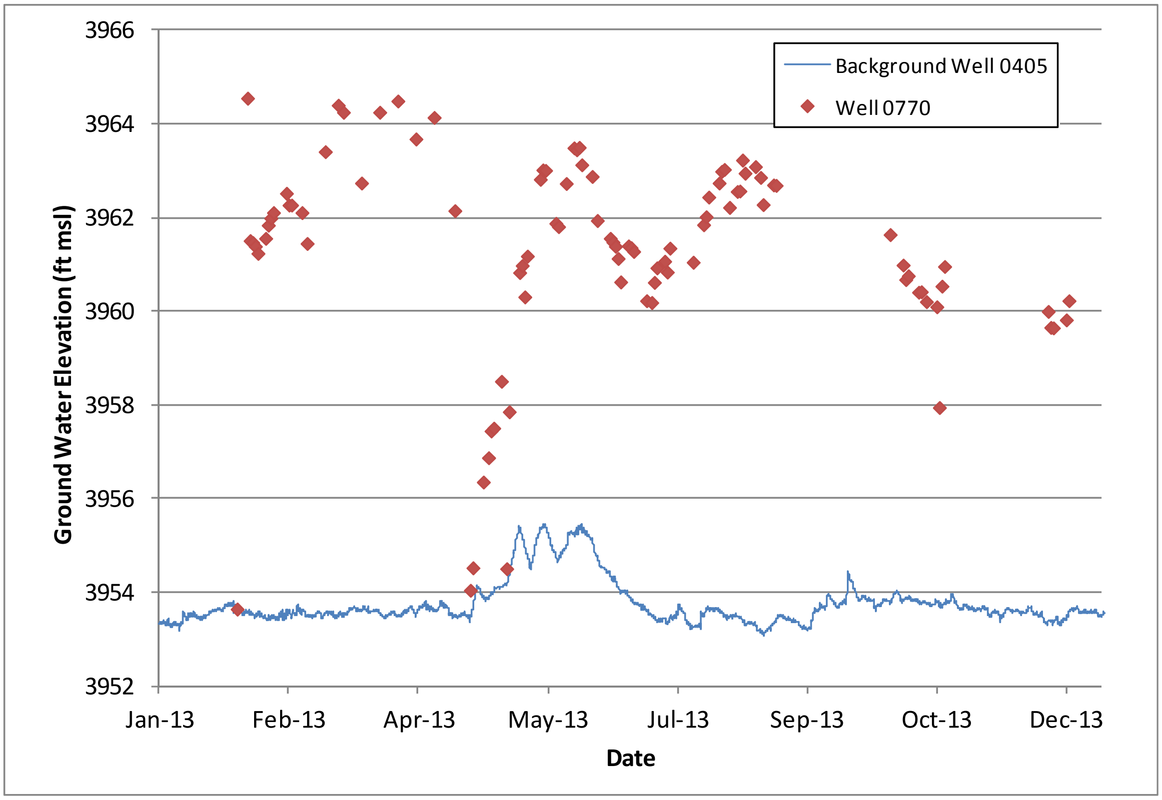


Figure C-7. Freshwater Mounding in Remediation Well 0770 during Injection

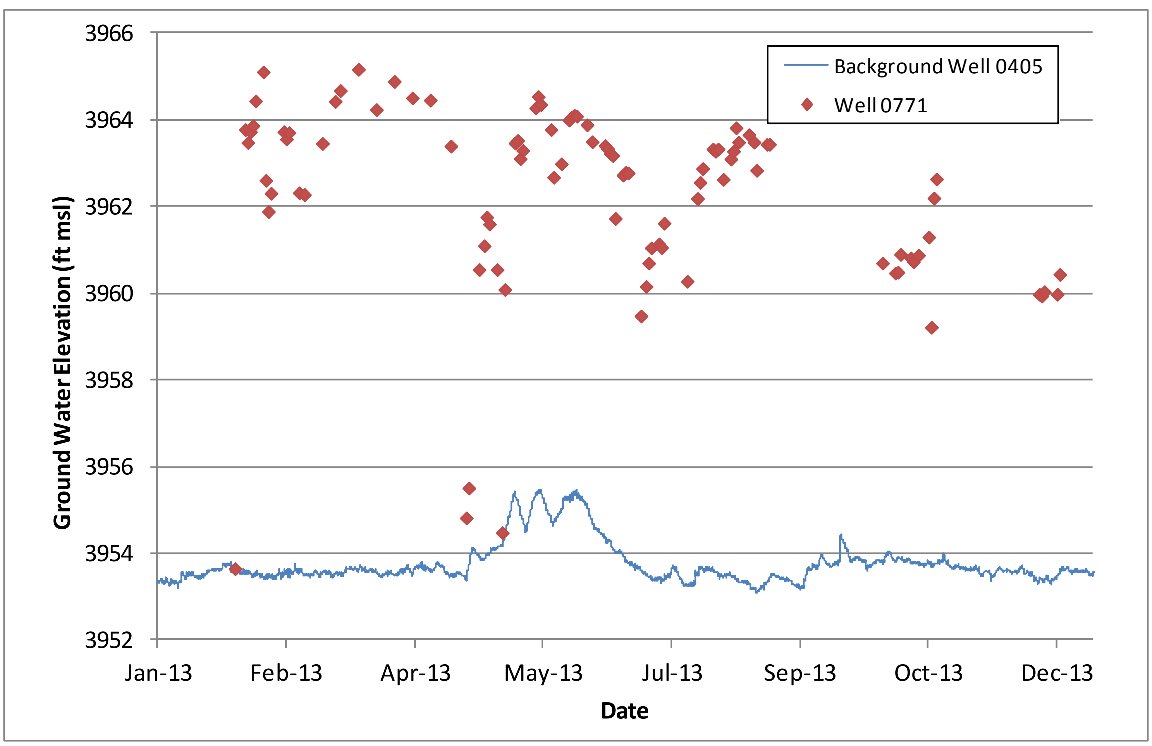


Figure C-8. Freshwater Mounding in Remediation Well 0771 during Injection

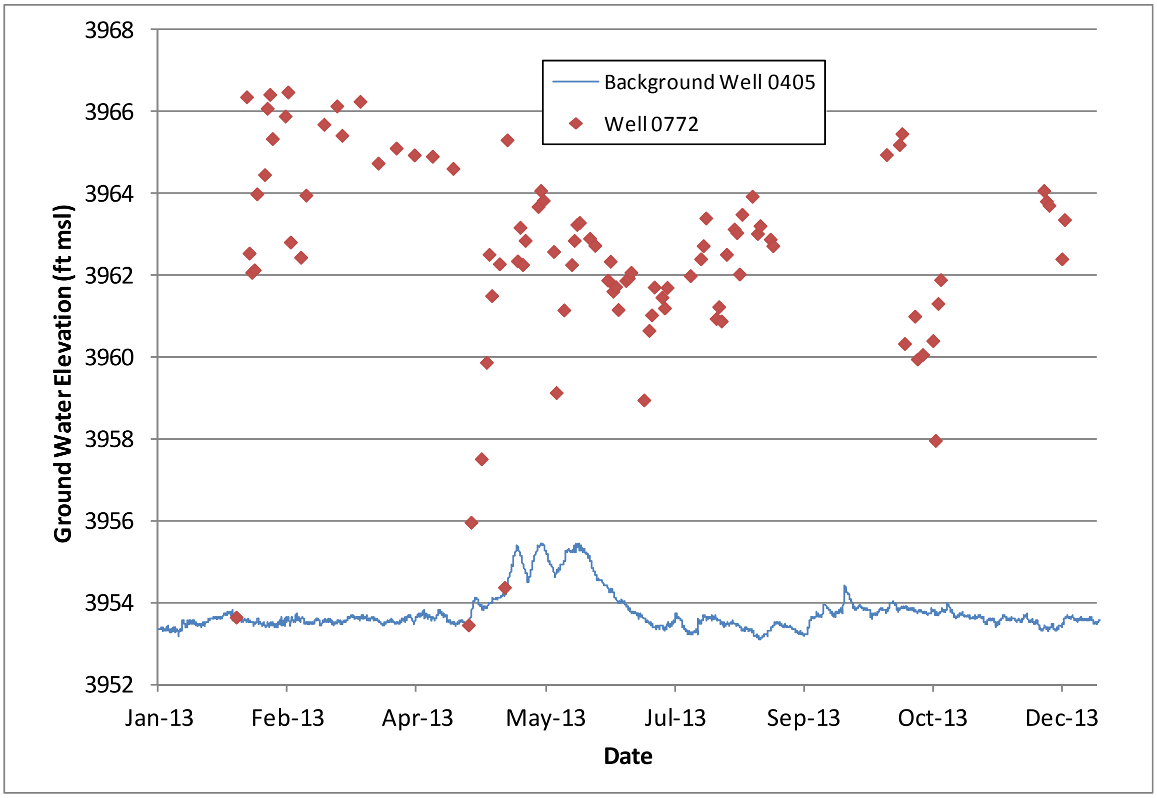


Figure C-9. Freshwater Mounding in Remediation Well 0772 during Injection

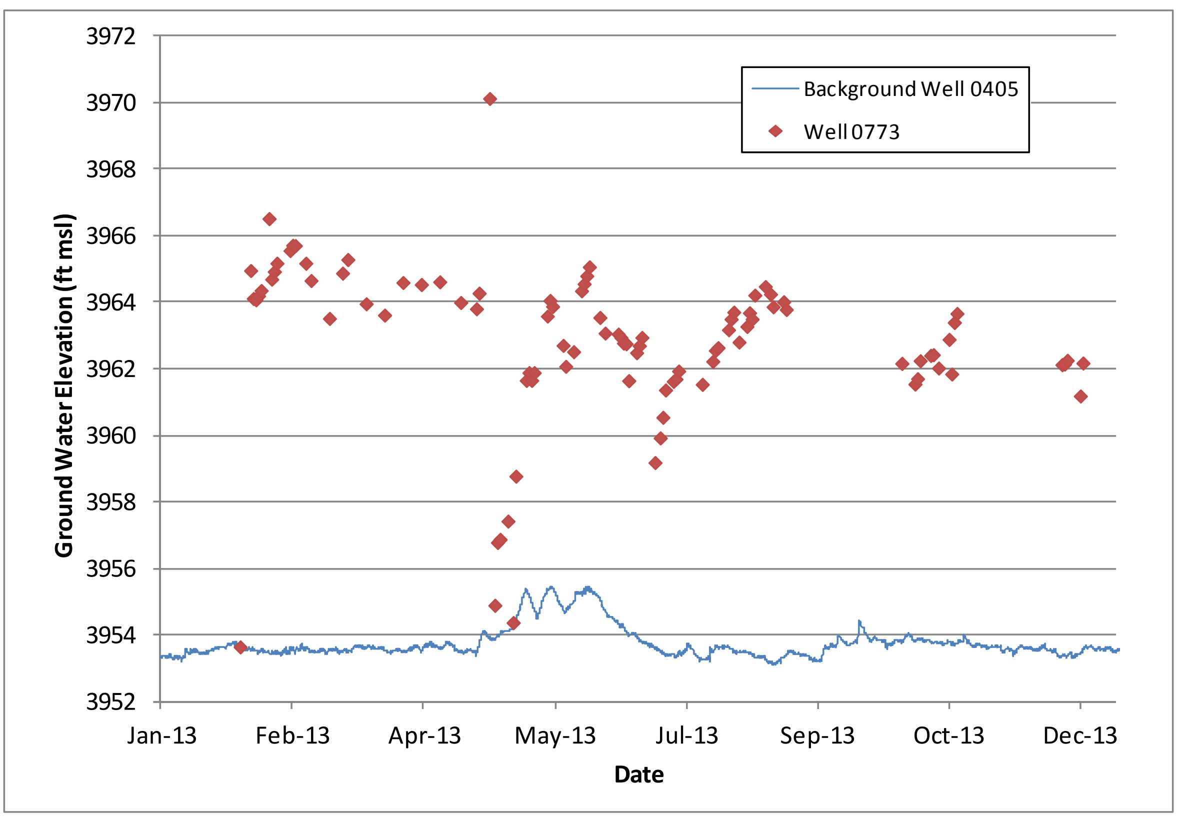


Figure C-10. Freshwater Mounding in Remediation Well 0773 during Injection

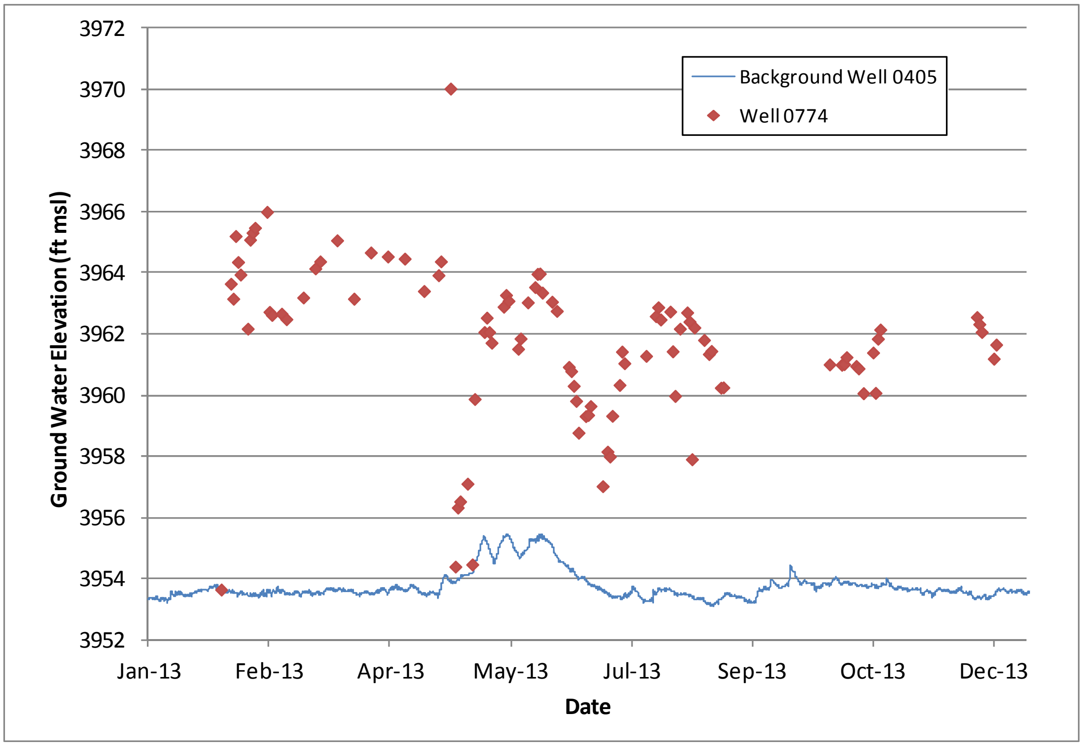


Figure C-11. Freshwater Mounding in Remediation Well 0774 during Injection

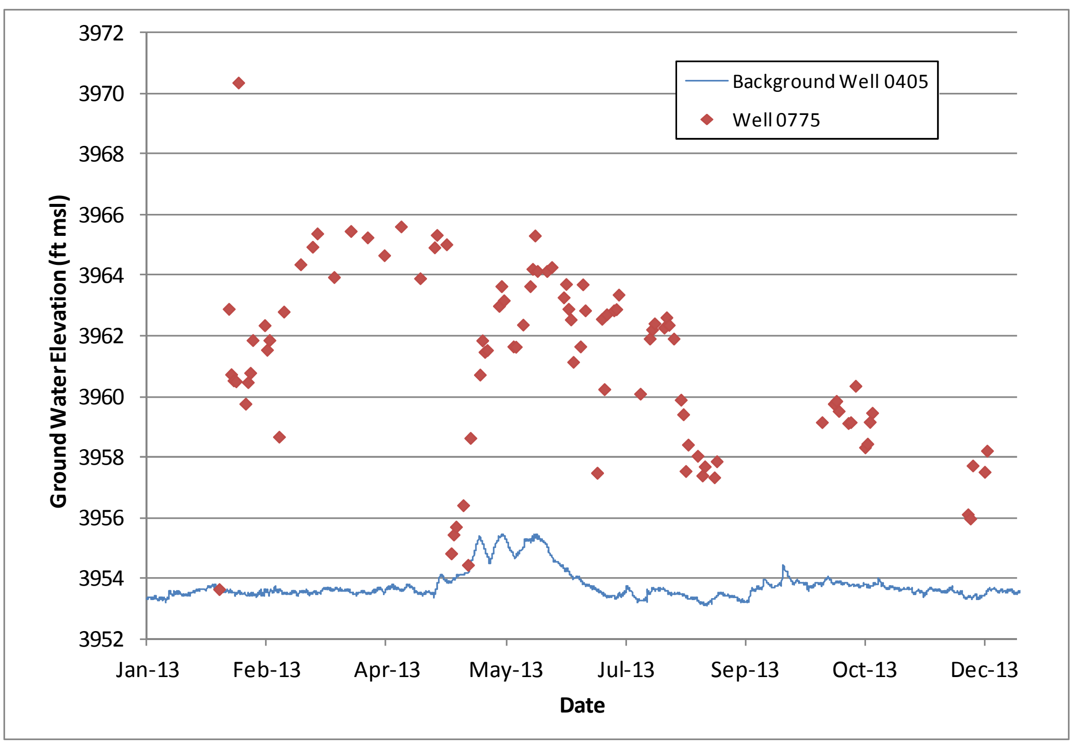


Figure C-12. Freshwater Mounding in Remediation Well 0775 during Injection

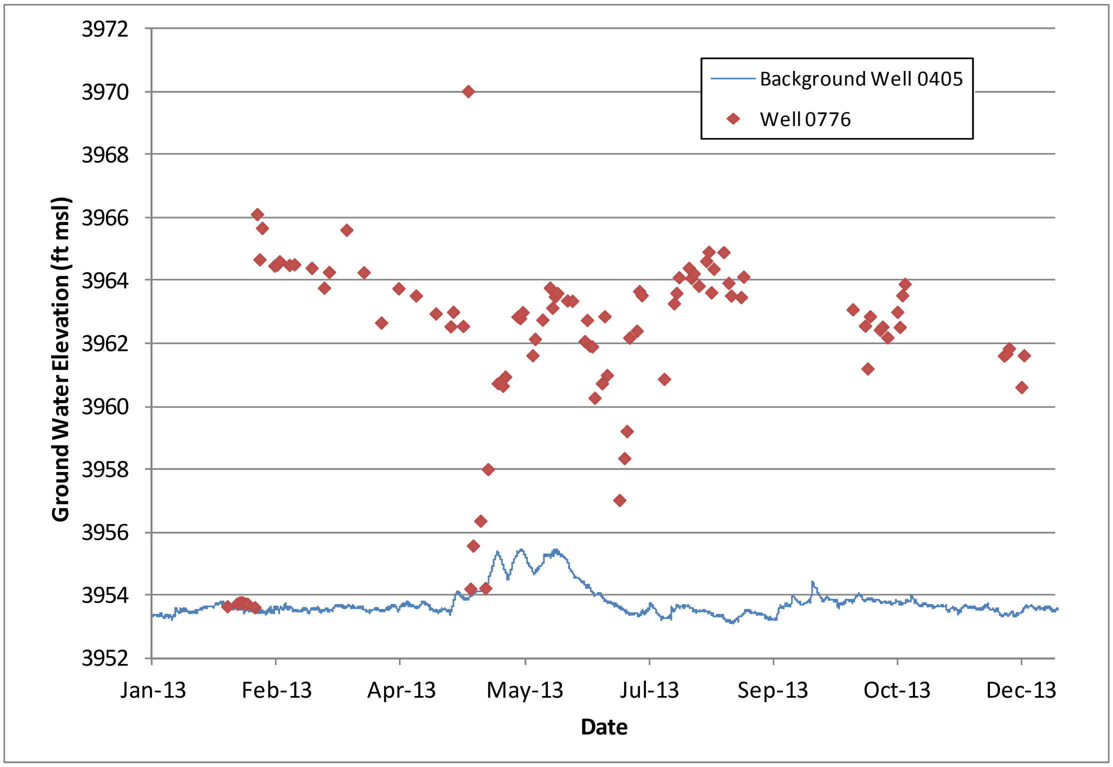


Figure C-13. Freshwater Mounding in Remediation Well 0776 during Injection

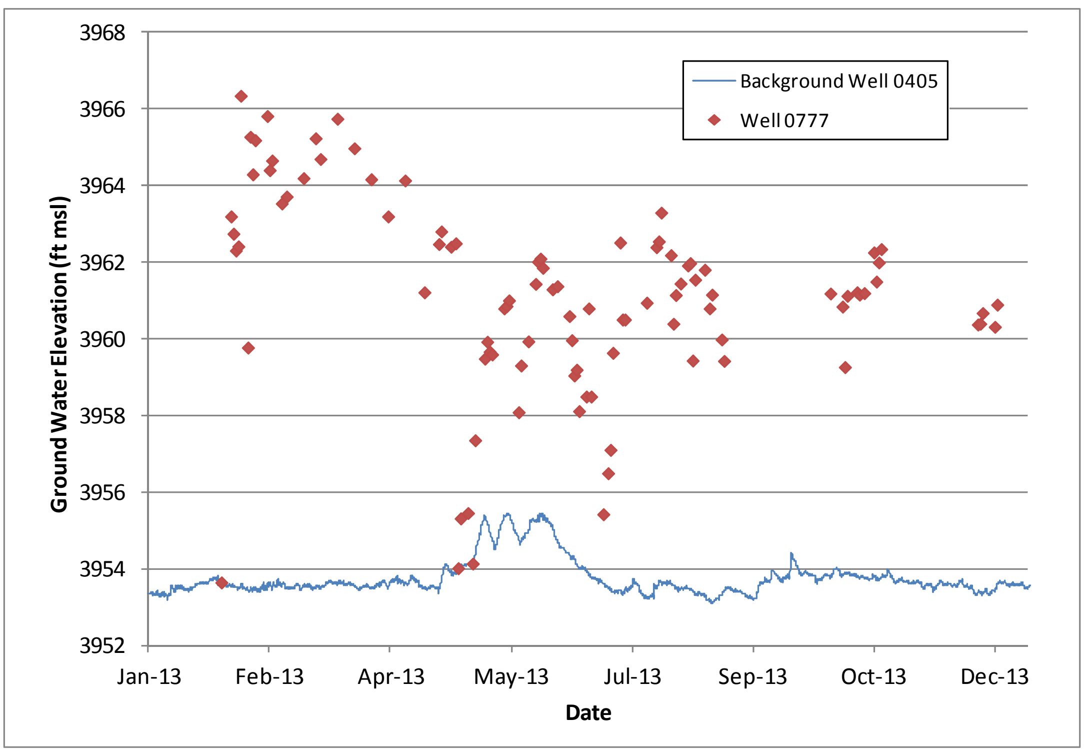


Figure C-14. Freshwater Mounding in Remediation Well 0777 during Injection

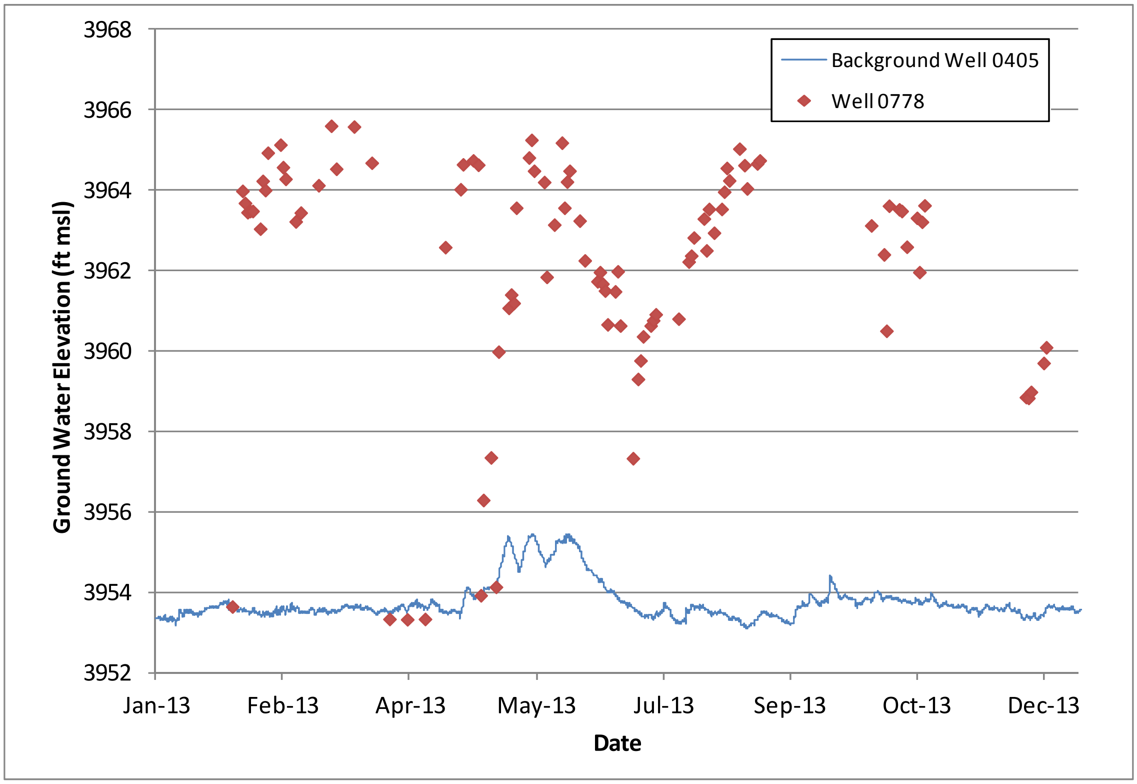


Figure C-15. Freshwater Mounding in Remediation Well 0778 during Injection

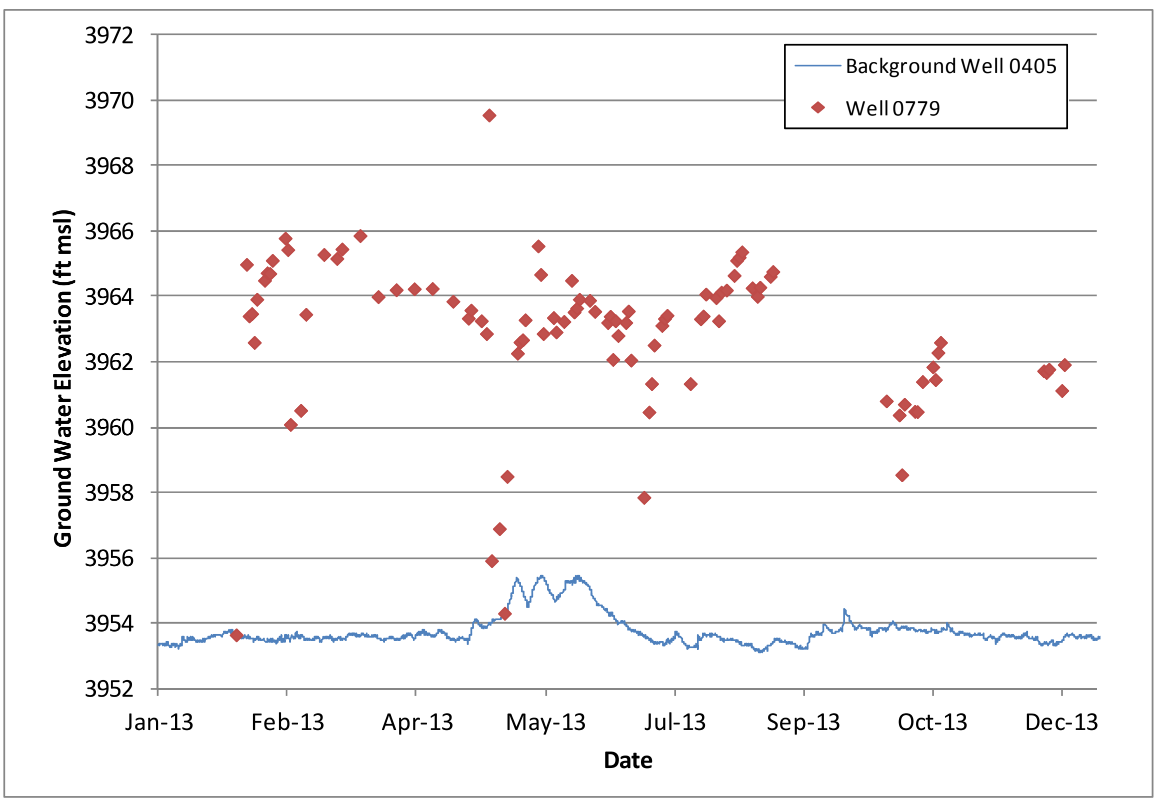
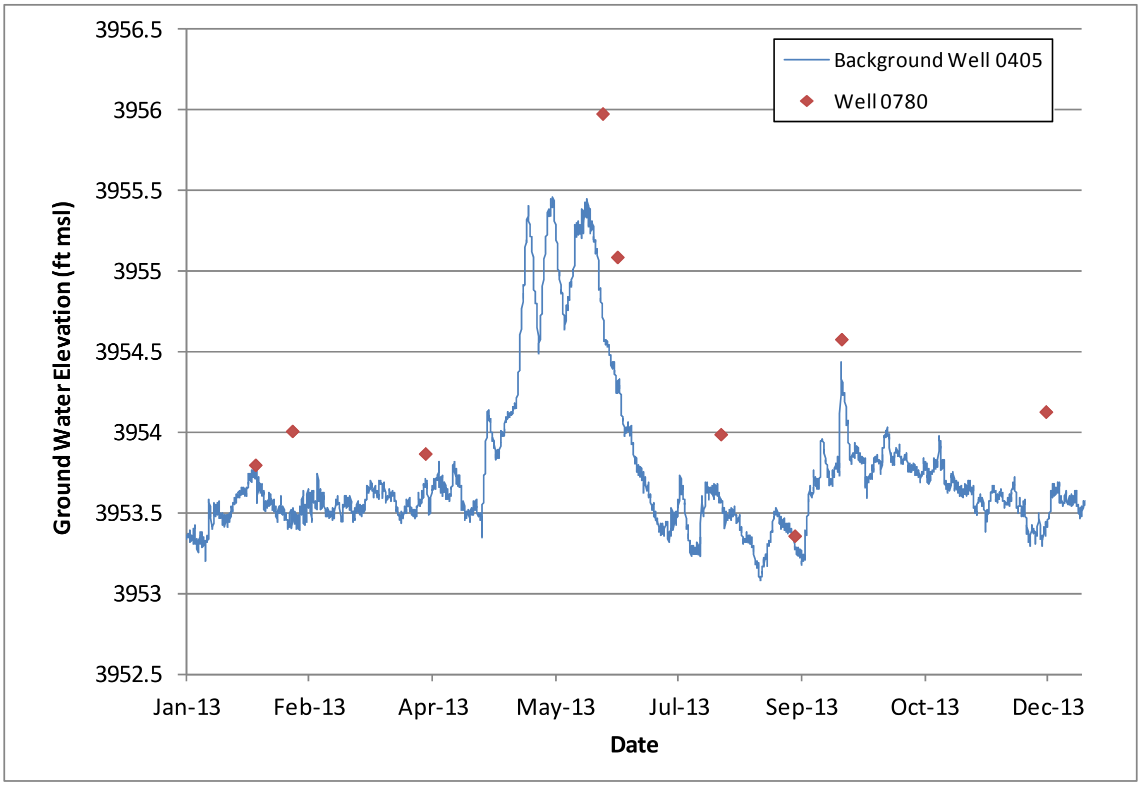
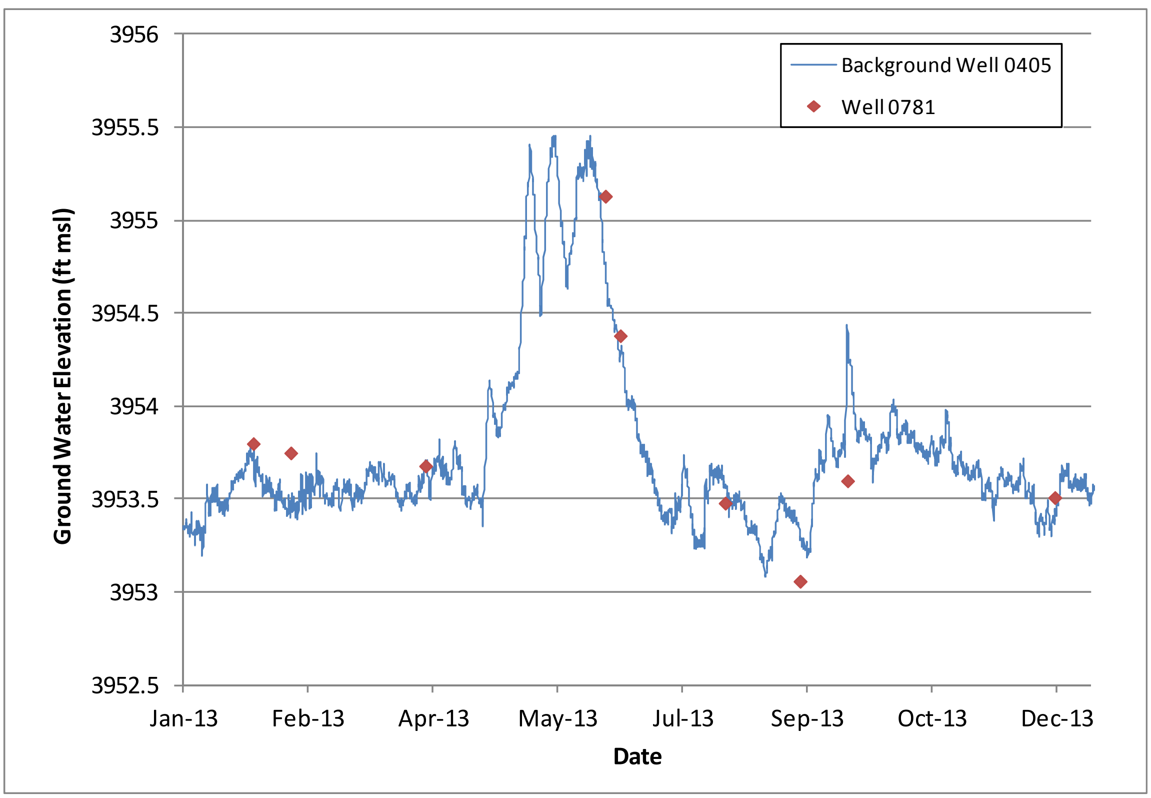


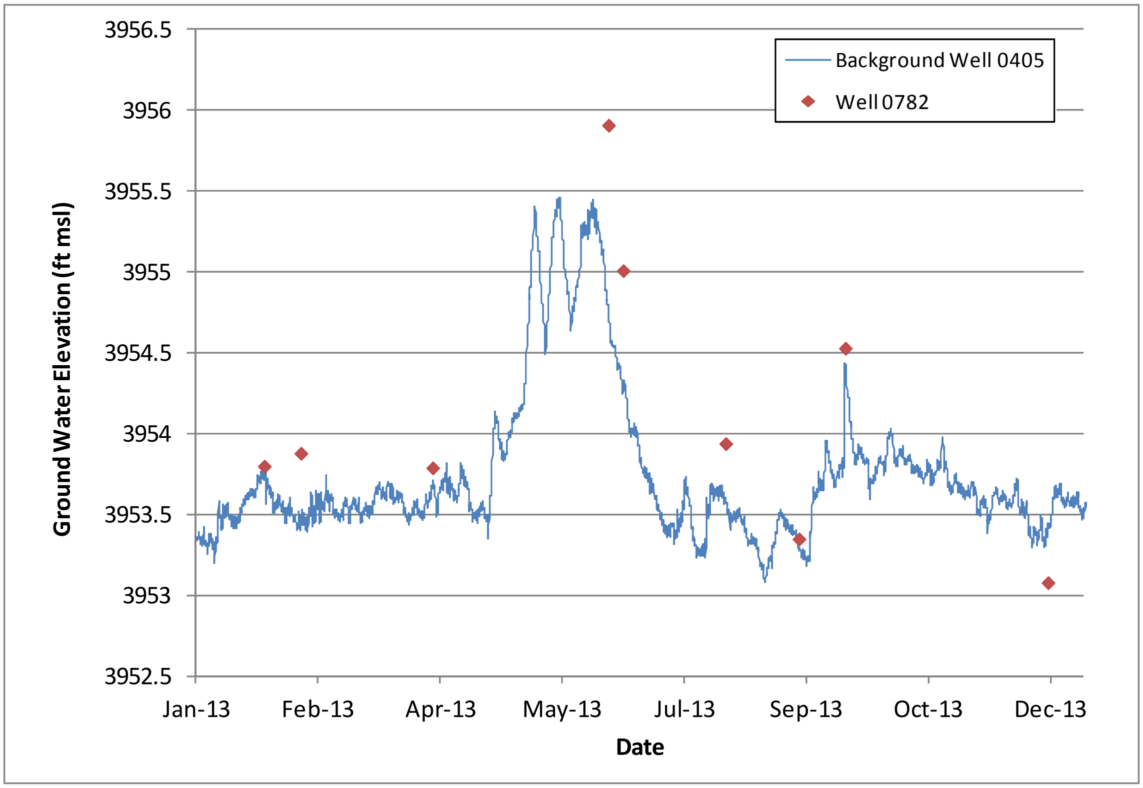
Figure C-16. Freshwater Mounding in Remediation Well 0779 during Injection



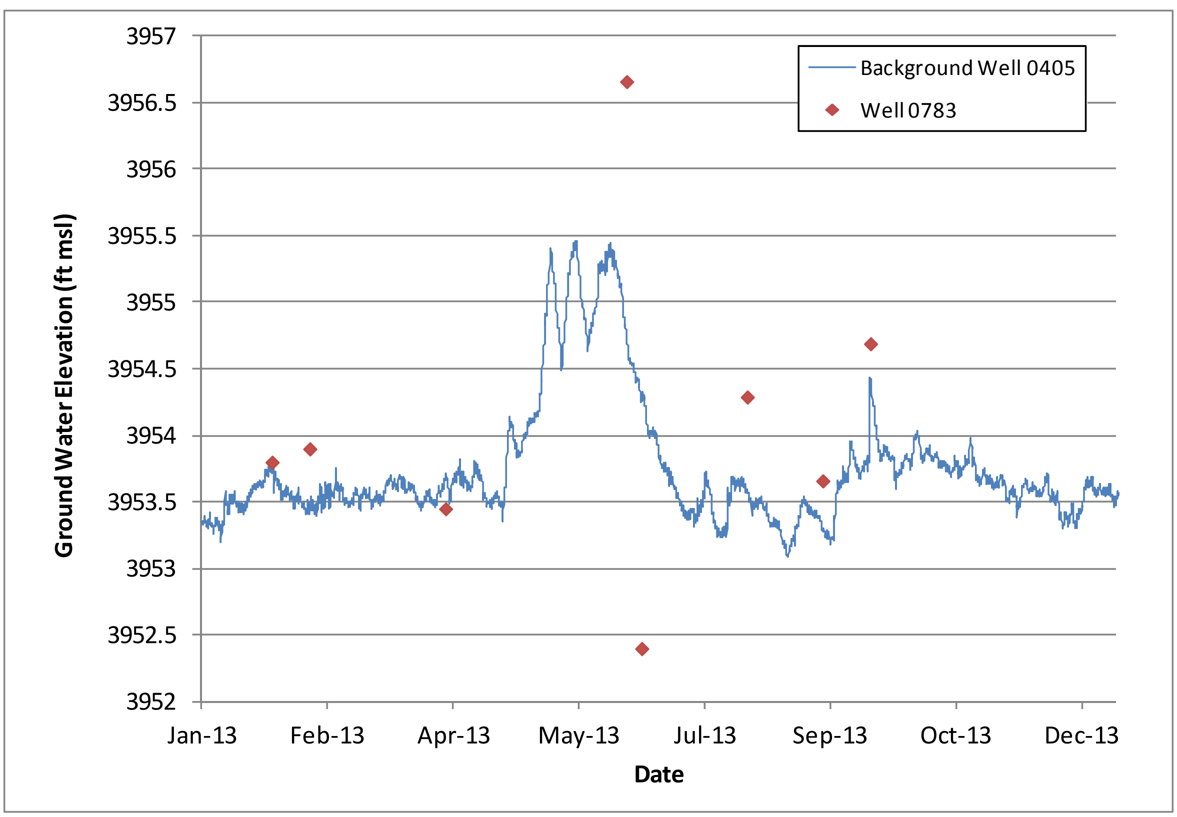
C-17. Freshwater Mounding in Observation Well 0780



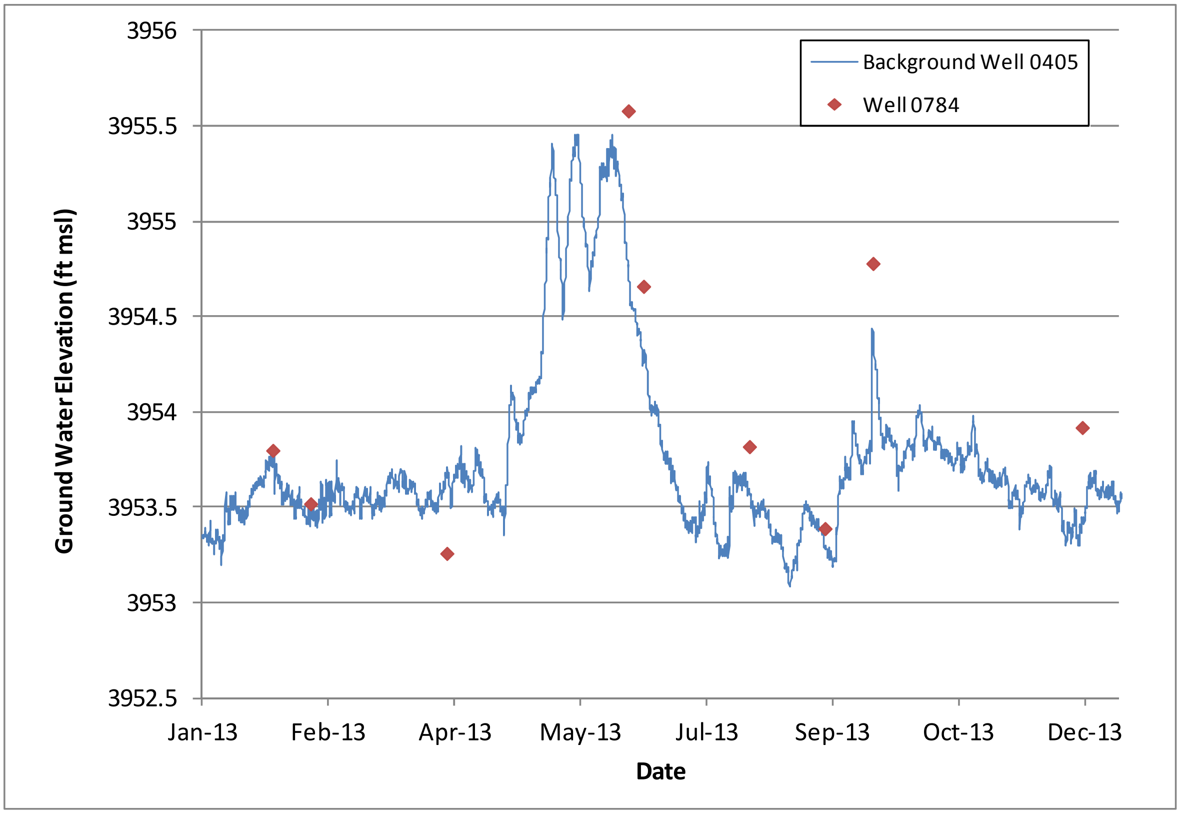
C-18. Freshwater Mounding in Observation Well 0781



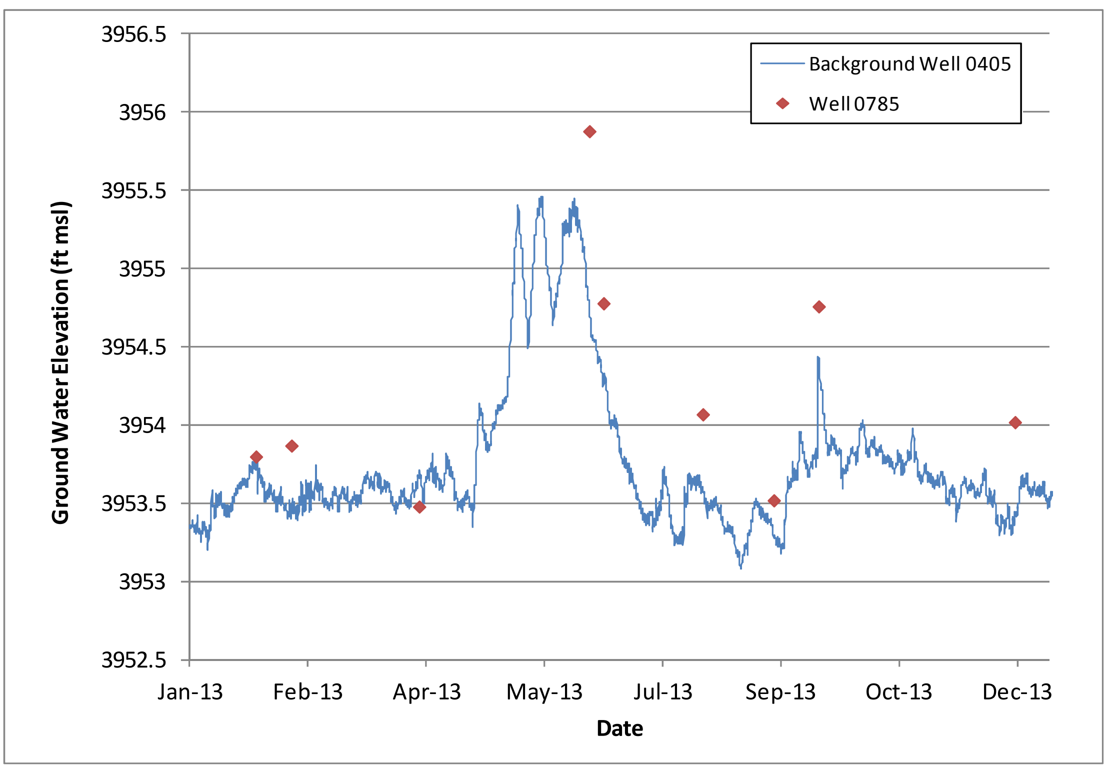
C-19. Freshwater Mounding in Observation Well 0782



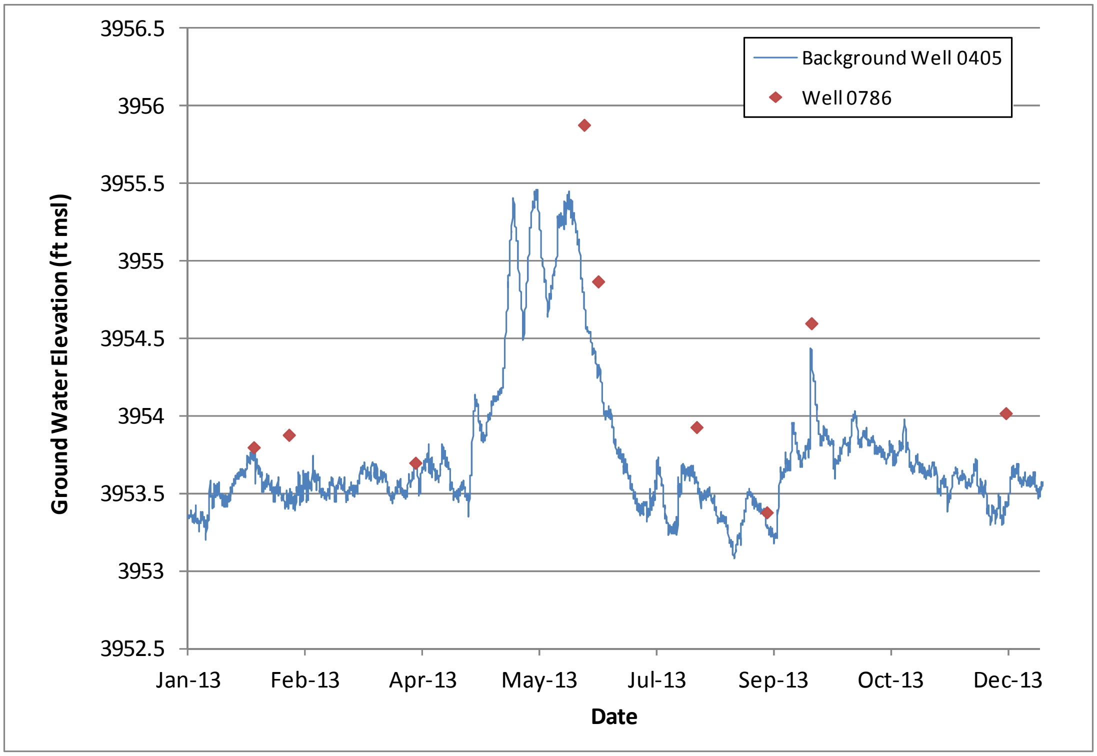
C-20. Freshwater Mounding in Observation Well 0783



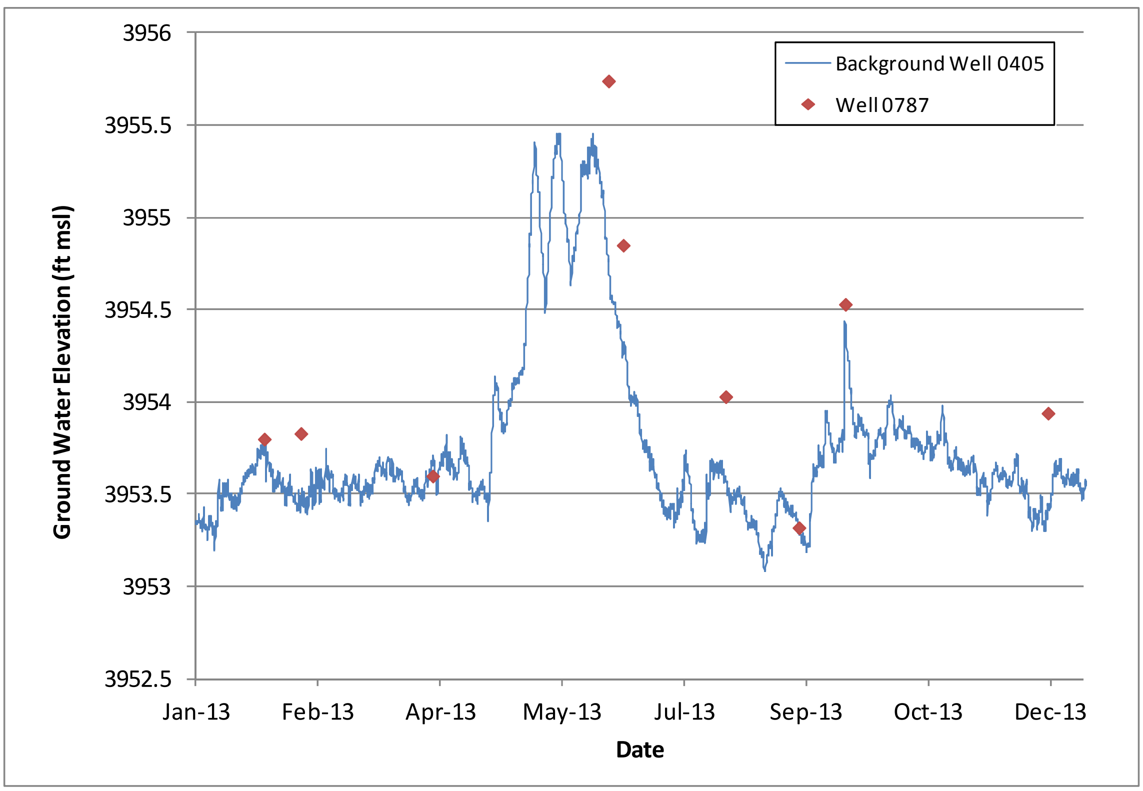
C-21. Freshwater Mounding in Observation Well 0784



C-22. Freshwater Mounding in Observation Well 0785



C-23. Freshwater Mounding in Observation Well 0786



C-24. Freshwater Mounding in Observation Well 0787