DOE–EM/GJTAC2096

Office of Environmental Management – Grand Junction

MOAB UTAH UMTRA Project

Moab UMTRA Project
2012 Ground Water Program Report

Revision 0

May 2013

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

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Revision History

Revision No.	Date	Reason/Basis for Revision
0	May 2013	Initial issue.

Contents

Figures

Tables

Appendices

Acronyms and Abbreviations

bgs	below ground surface
btoc	below top of casing
CA	Contamination Area
CF	configuration
cfs	cubic feet per second
cm	centimeters
DOE	U.S. Department of Energy
ft	feet or foot
gal	gallons
gpm	gallons per minute
IA	interim action
in.	inch
kg	kilograms
lb	pounds
µmhos/cm	micromhos per centimeter
mg/L	milligrams per liter
mil	million
PVC	polyvinyl chloride
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 2012 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*, that 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.

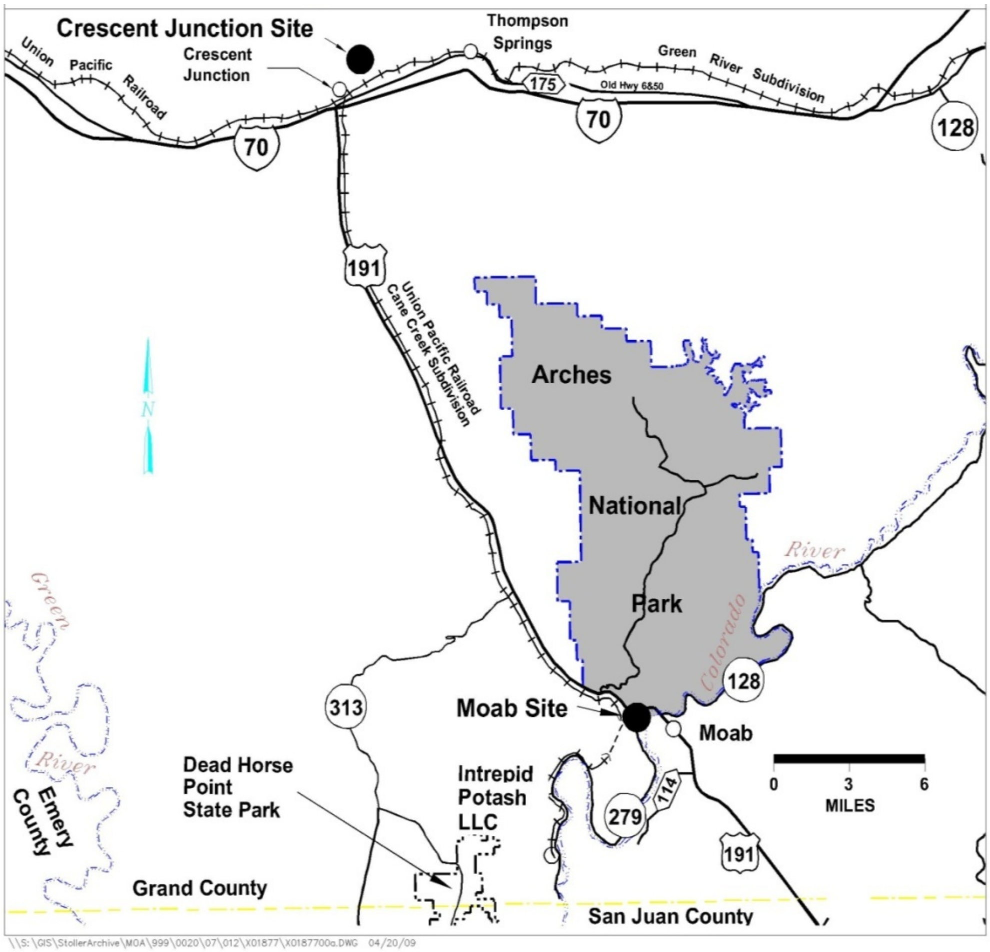

Figure 1. Location of the Moab Project Site

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 2012, CFs 1, 4, and 5 were utilized.

The objectives of the IA system are to: 1) reduce the discharge of ammonia-contaminated groundwater to backwater 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 from 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 consist 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. Figures 3 and 4 were generated using data collected in June 2012 and exhibit how ground water underlying the site discharges into the Colorado River under river baseflow conditions. Typically, the June river flow is approximately 18,000 cubic feet per second (cfs); however, the river flow was 2,150 cfs when the water levels were collected. Figure 5 shows the ground water contours in November/December 2012 when the river flow was approximately 2,430 cfs. Since the spring run-off was much below average, the two contour maps are very similar.

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 migrate vertically 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 6 and 7).

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 6 shows the ammonia plume in June 2012, and Figure 7 shows the ammonia plume in November/December 2012. The two plume maps are comparable.

In addition to ammonia, the other primary constituent of concern in ground water is uranium. Figures 8 and 9 show the distribution of dissolved uranium in shallow ground water in 2012. These plume maps are also similar.

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 run-off 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 2012 was approximately 70 percent of average, and warm unseasonable temperatures in March led to a spring peak run-off of only 5,860 cfs (average is 27,500 cfs) on April 4. Therefore, the river never reached losing conditions, and a freshwater lens did not extend into the well field. Section 7.0 includes a discussion on how the low river flow impacted IA operations in 2012.

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 2012, 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.

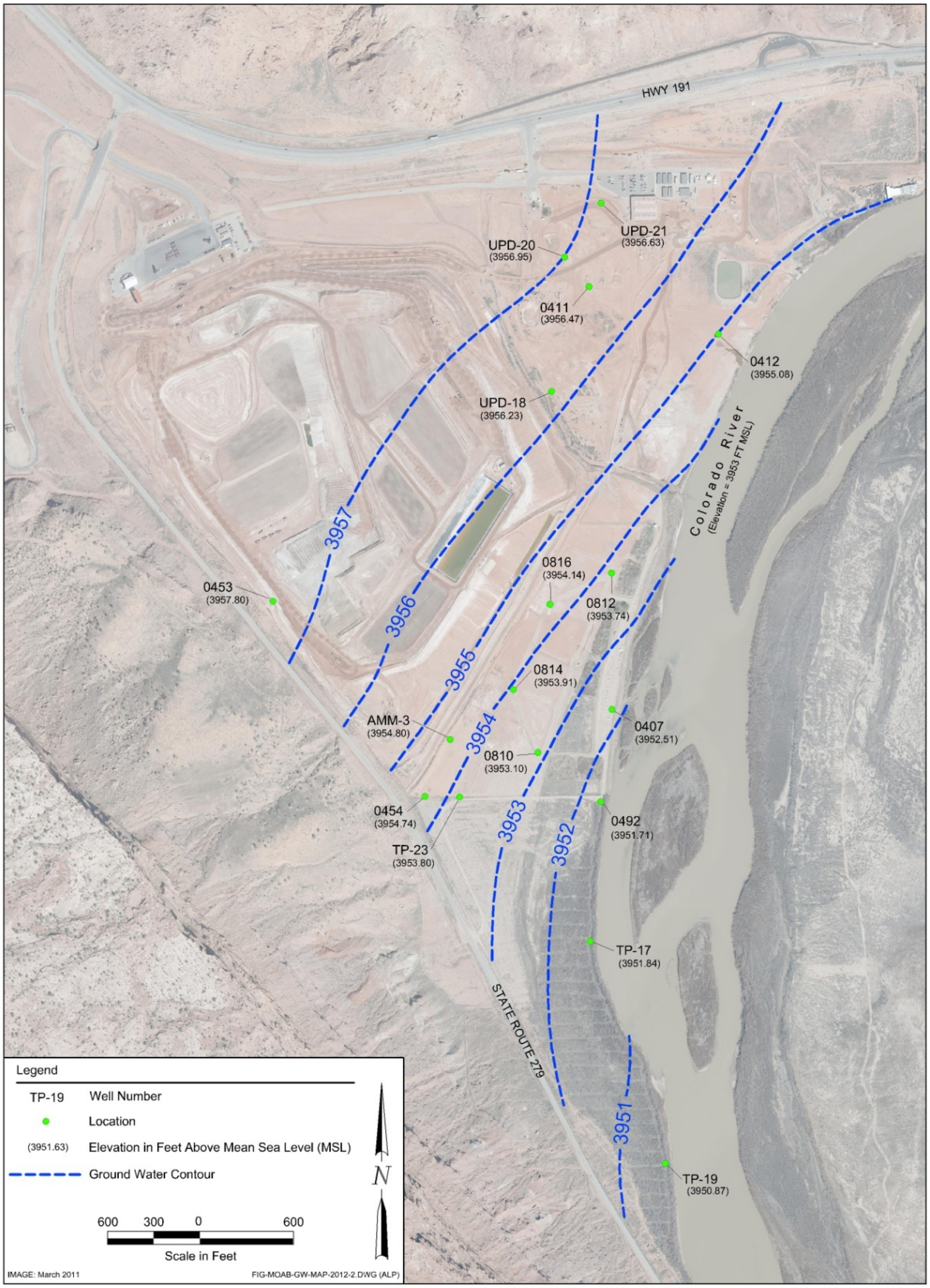

Figure 3. Ground Water Contour Map from June 2012

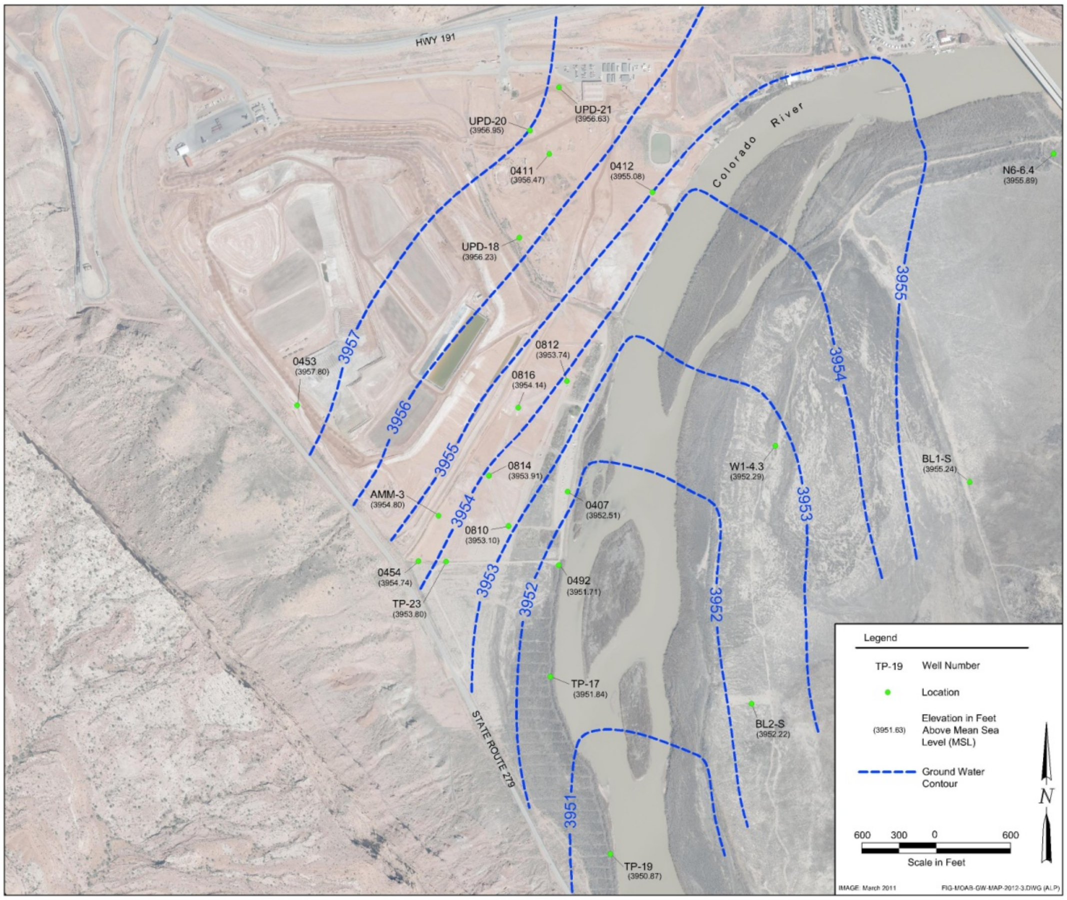

Figure 4. Regional Ground Water Contour Map from June 2012

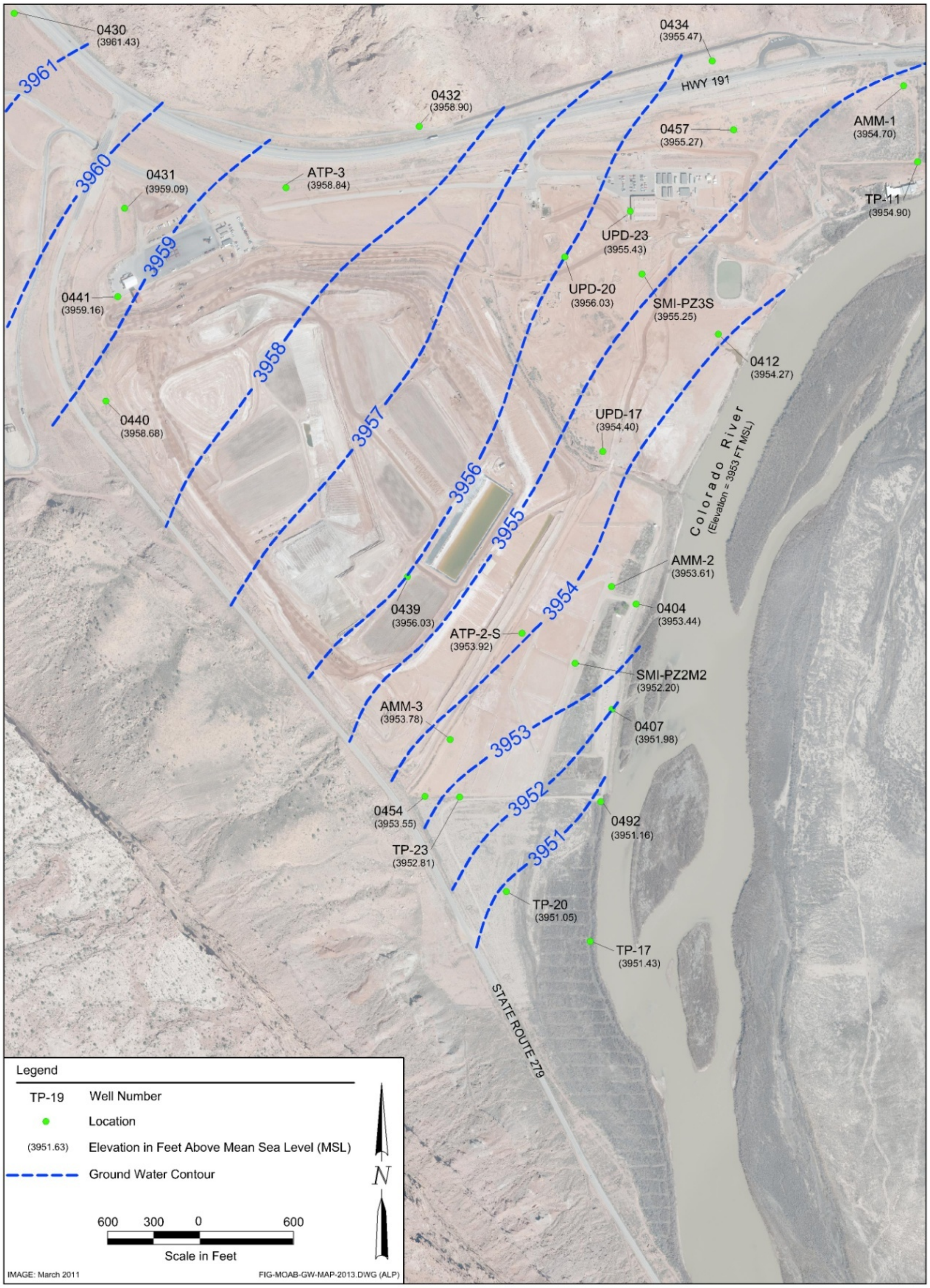

Figure 5. Site-wide Water Contour Map from November/December 2012

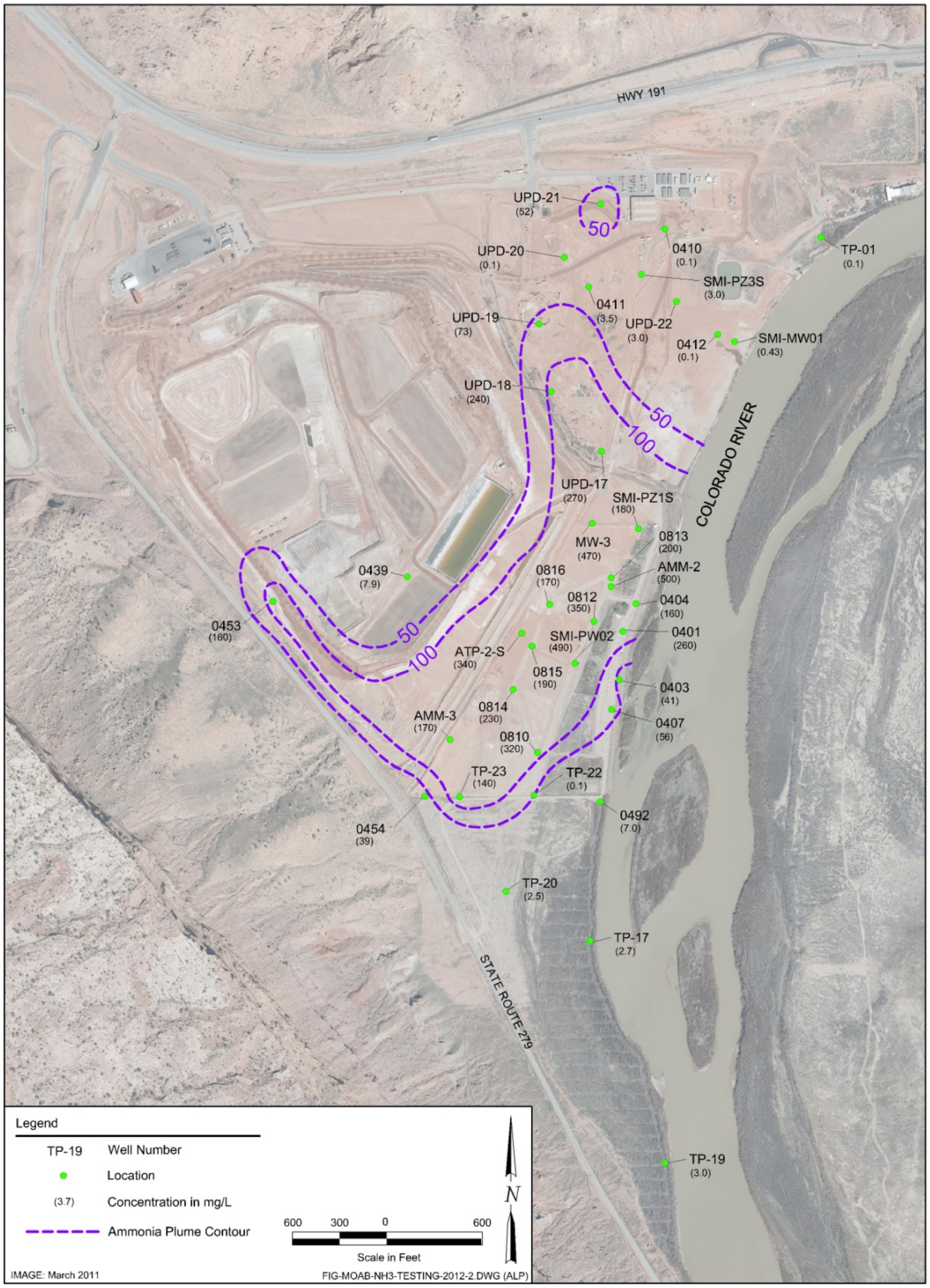

Figure 6. Ammonia Plume Map June 2012

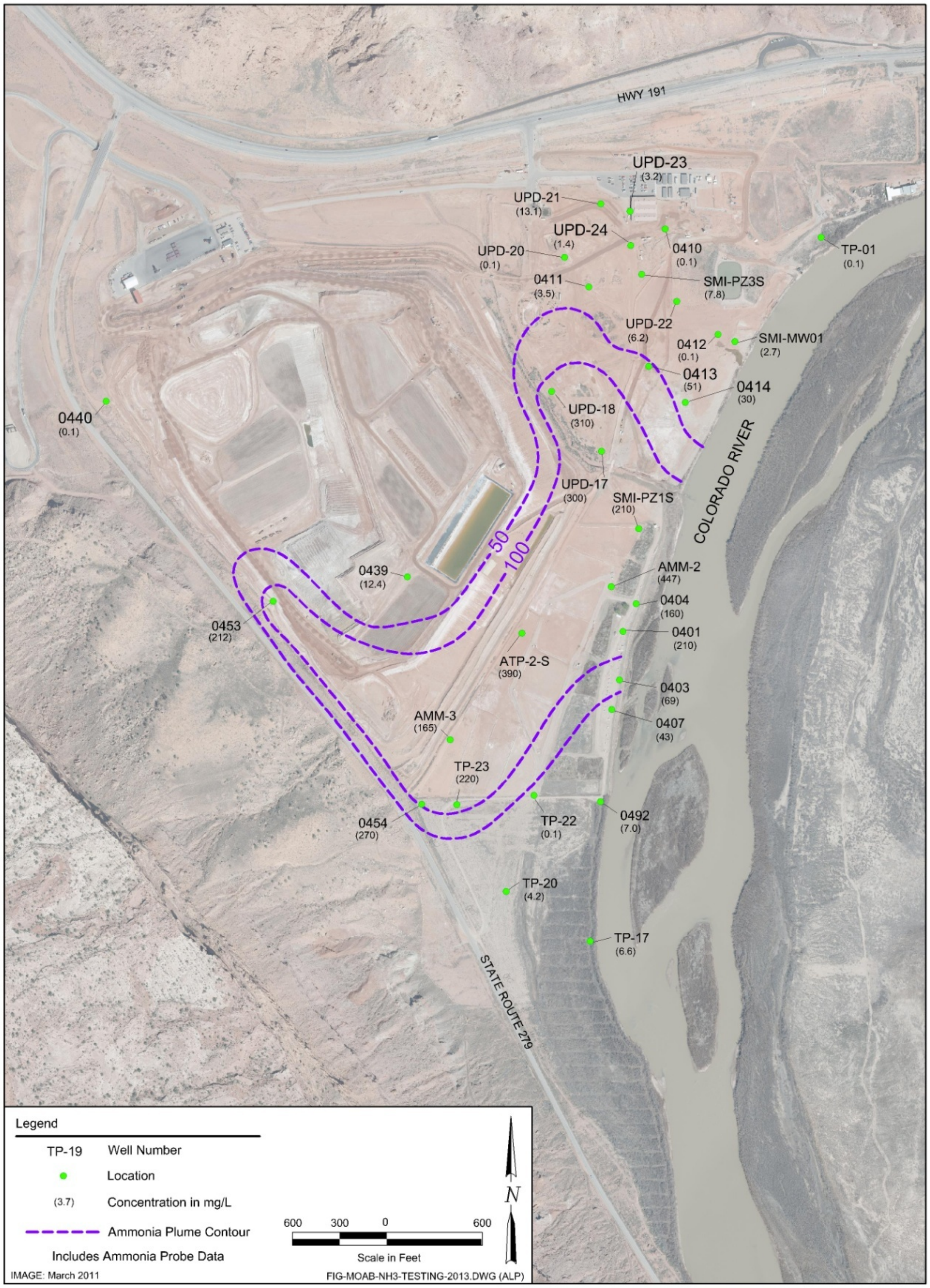

Figure 7. Ammonia Plume Map November/December 2012

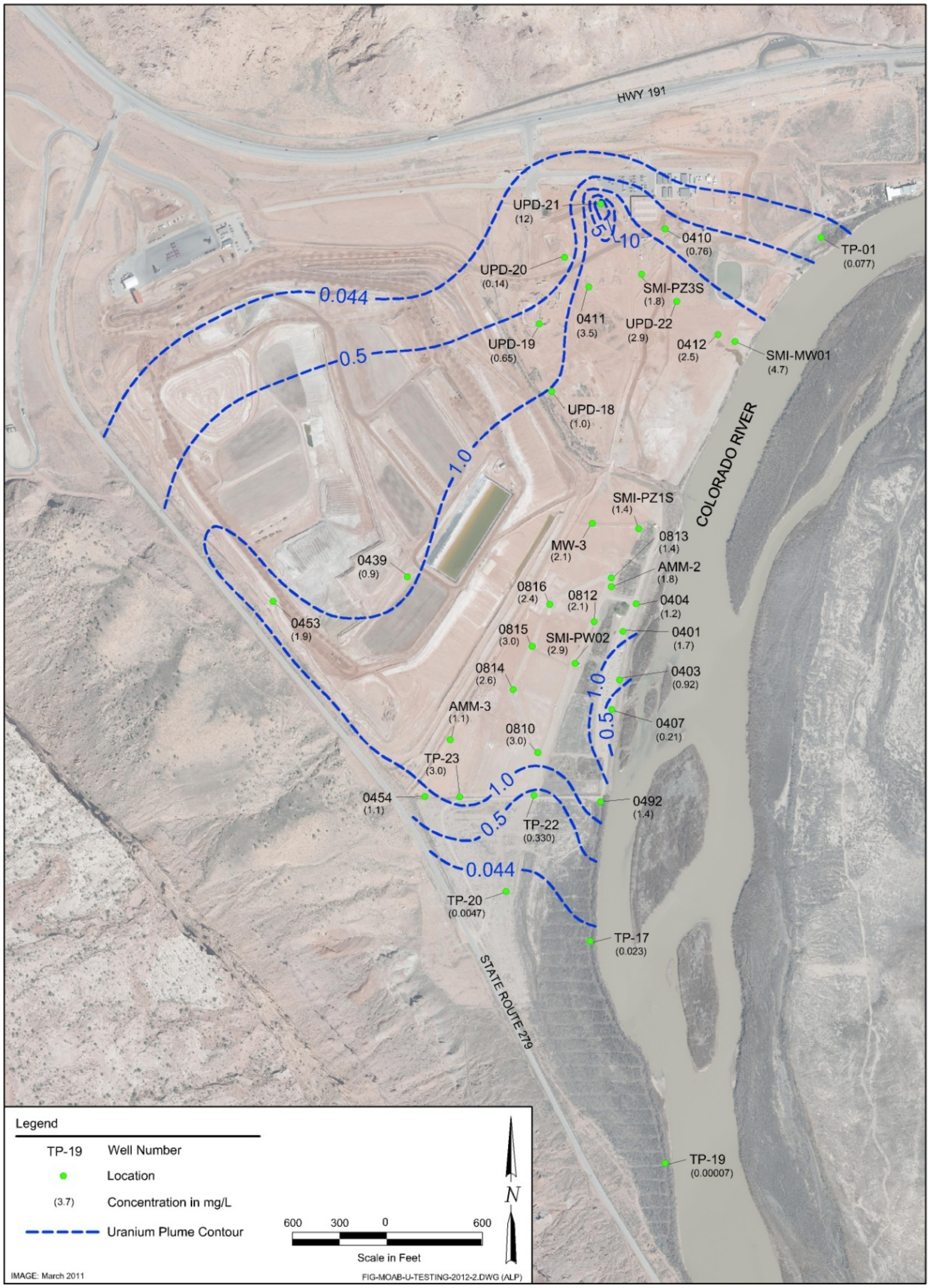

Figure 8. Uranium Plume Map June 2012

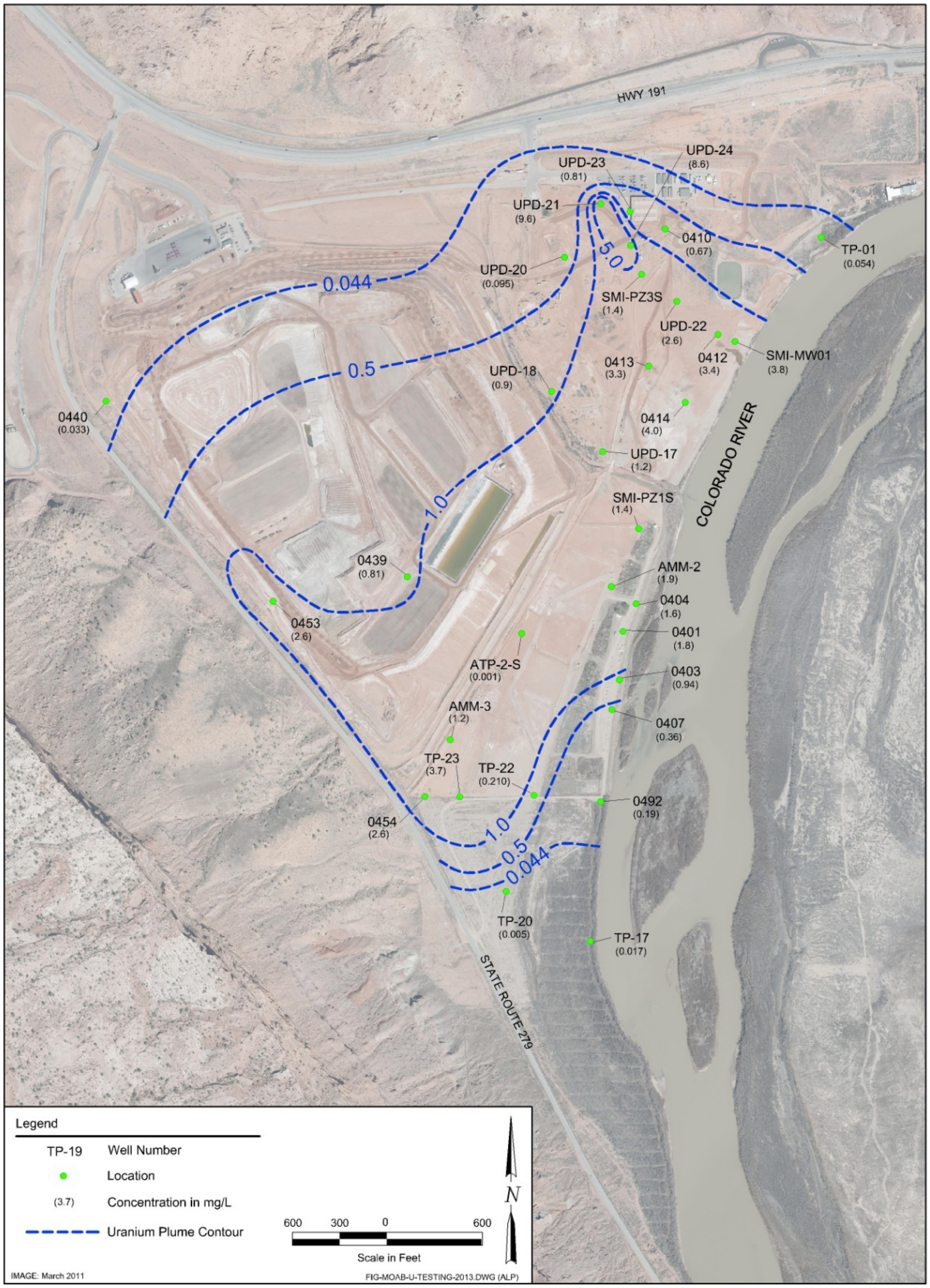

Figure 9. Uranium Plume Map November/December 2012

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 [btoc]). 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 the ALS Environmental, Inc., in Fort Collins, Colorado.

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 2012 pumping season. Also included in this section is a discussion regarding the total ground water extraction rate, hydraulic control, mass removal, water quality, and the data and analysis of a system extraction-rate test was completed in CF5 in July/August 2012. 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 2012, 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 well PW02 at a rate ranging from 30 to 50 gpm. Beginning in April, more remediation wells were utilized, and the evaporator units were initiated in May. The spring extraction rate peaked at approximately 110 gpm on May 17, 2012.

Throughout the summer, ground water extraction occurred by cycling through all eight of the CF5 wells. A system extraction-rate test took place in late July to early August. The purpose of this test was to determine the capable sustainable maximum extraction rate from CF5. The results of this test are discussed in Section 4.1.1.

In the fall and winter, the extraction rate ranged from approximately 20 to 70 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 10 provides a graphic summary of the cumulative volume of ground water extracted from CF5 in 2012. Extraction operations were nearly continuous throughout the year. A total of 16.5 mil gal of water was extracted from CF5 during 2012.

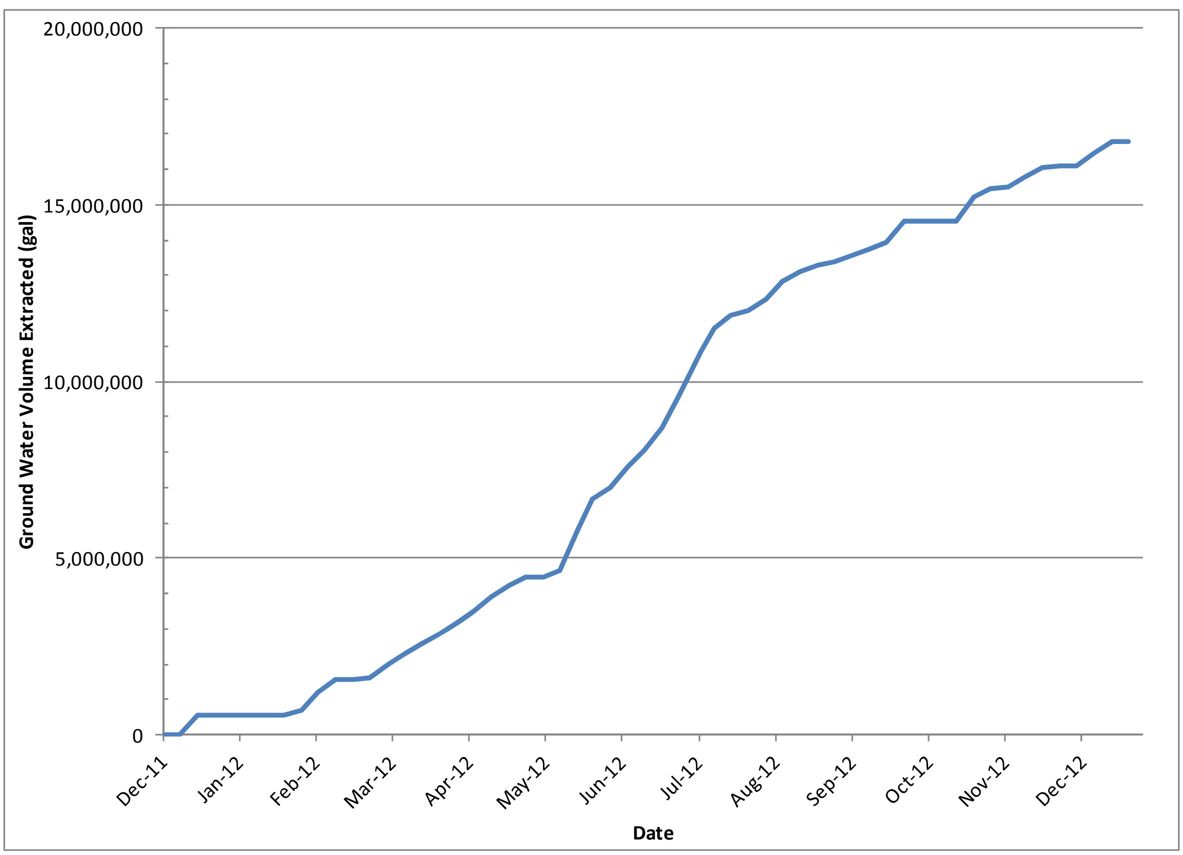

Figure 10. Cumulative Volume of Extracted Ground Water During 2012

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 2012. 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 each month in 2012 and the most of the extracted water in 2012 was removed from this well (9.5 mil gal). The second highest water volume was removed from well 0816 (1.3 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.

In late July to early August, a system extraction-rate test took place. The purpose of the test was to determine how the CF5 wells would perform under a high extraction rate. A maximum cumulative extraction rate of 405 gpm was achieved on August 6 and pump rates and water levels were recorded during the test, which lasted for approximately 5 hours (Table 1).

Table 1. Flow Rates and Water Levels in CF5 August 6, 2012

Well	Extraction Rate (gpm)	Water level (ft btoc)
0810	39.2	16.20
0811	23.8	14.90
0812	31.6	23.68
0813	81.5	11.06
0814	36.6	22.16
0815	64.2	16.56
0816	82.3	11.39
PW02	47.1	NM

ft btoc = feet below top of casing; NM = not measured

4.2 IA Extraction Performance

4.2.1 Ground Water Levels and Hydraulic Control

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 (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.

Table 2 lists 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.

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.

Table 2. Drawdown During Extraction Operations

Location	Date	Drawdown (ft)	Extraction Rate (gpm)	Specific Capacity (gpm/ft)
0810	08/08/12	11.08	42.3	3.8
	06/27/12	6.96	22.8	3.3
0811	09/12/12	8.05	29.1	3.6
	09/05/12	6.36	35.6	5.6
0812	06/13/12	11.65	33.5	2.9
	06/06/12	8.51	36.2	4.3
0813	09/19/12	1.21	69.1	57.1
	09/05/12	0.61	62.9	103
0814	05/30/12	6.37	50.3	7.9
	05/23/12	5.65	40.5	7.2
0815	08/15/12	6.49	60.1	9.3
	12/05/12	4.29	35.1	8.2
0816	08/01/12	3.21	81.3	25.3
	05/23/12	0.88	51.7	58.8
PW02	02/02/12	13.14	50.0	3.8
	06/06/12	4.46	47.6	10.7

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 was used to compute the specific capacity during the 2012 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 2).

The specific capacity varies greatly in the CF5 wells. Remediation wells 0813 and 0816 have the highest specific capacities, up to 103 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 2 is comparable to what was observed in 2011.

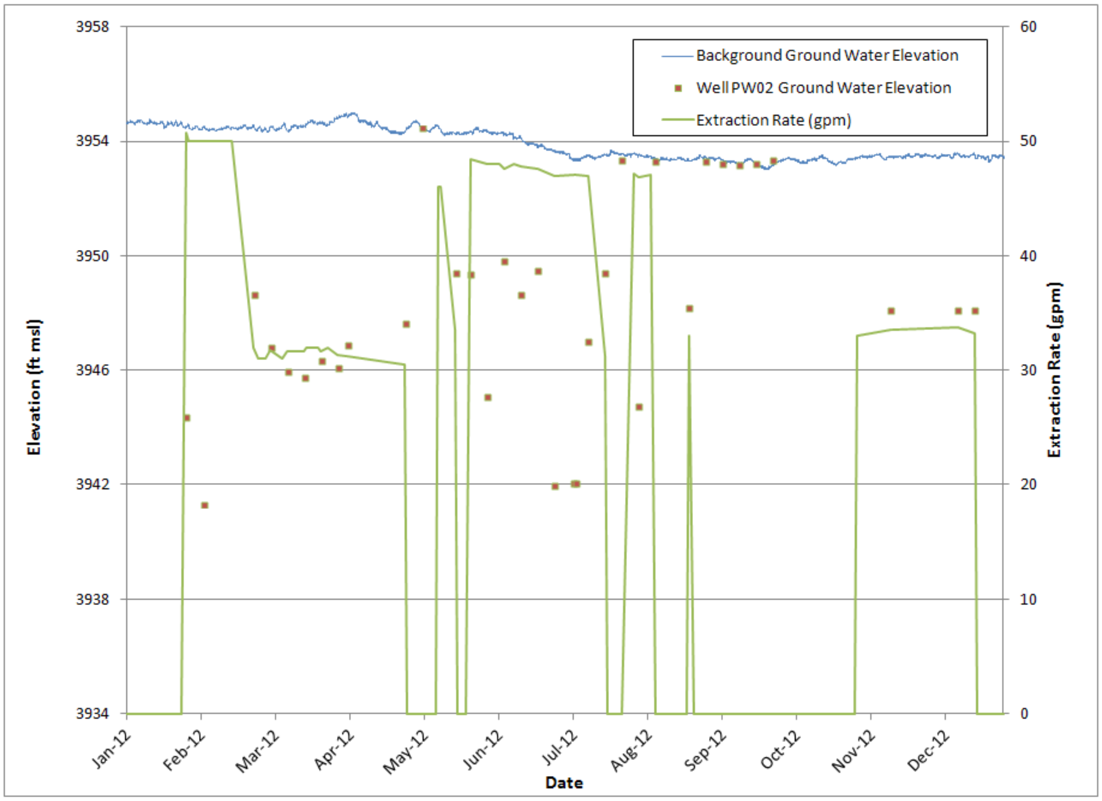

Figure 11. Drawdown Data for Extraction Well PW02

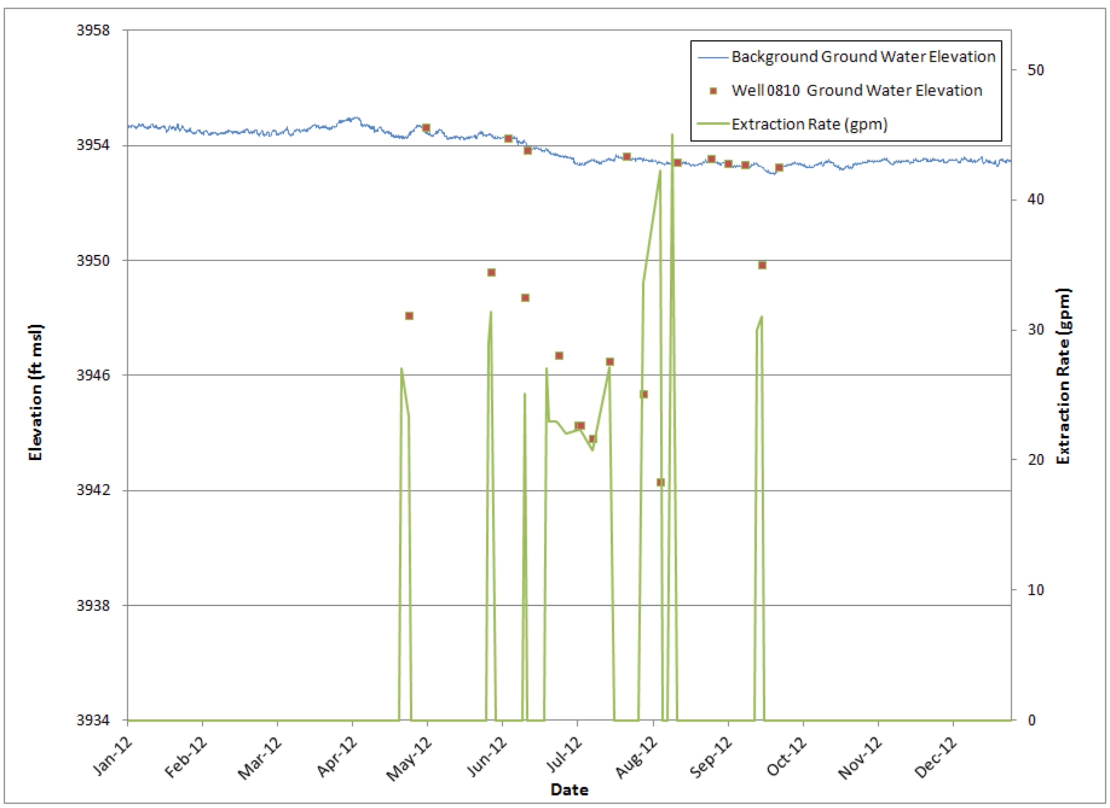

Figure 12. Drawdown Data for Extraction Well 0810

4.3 Contaminant Mass Removal

The ammonia and uranium mass removed by CF5 extraction wells in 2012 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 2012, a total of 54,659 pounds (lbs) (24,792 kilograms [kg]) of ammonia and 425 lbs (192 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, 40,848 lbs (18,528 kg) and 2,492 lbs (1,130 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 PW02 and 0815 at 293.1 lbs (132 kg) and 31.8 lbs (14 kg), respectively. These are the two CF5 wells that extracted the most volume of ground water in 2012.

4.4 Ground Water Chemistry

Analytical ground water samples were collected from the CF5 extraction wells in June 2012 (Table 3). Ammonia concentrations varied from 170 mg/L (0816) to 490 mg/L (PW02), and the uranium concentration ranged from 1.4 mg/L (0813) to 3.0 mg/L (0815 and 0810). Ammonia probe sampling was conducted in conjunction with the June sampling event. Table 3 contains the uranium and specific conductance data and also compares the analytical ammonia versus the ammonia probe results. Additional ammonia probe samples were analyzed in August and October 2012 (Table 4).

Specific conductance ranged from 12,182 µmhos/cm at well 0813 (northern end of CF5) to 32,365 µmhos/cm at well 0810 (southern end of CF5). The brine interface is typically higher in elevation towards the south. Well PW02 had the highest specific conductance concentration in CF5 (53,458 µmhos/com), because the pump is set at a lower elevation.

Table 3. CF5 Ammonia and Uranium Concentrations, June 2012

Location	Date	Ammonia (mg/L)	Ammonia Probe (mg/L)	Uranium (mg/L)	Specific Conductance (µmhos/cm)
0810	6/13/12	320	277	3.0	32,365
0812	6/13/12	360	319	2.1	20,367
0813	6/13/12	200	183	1.4	12,182
0814	6/14/12	230	201	2.8	26,232
0815	6/14/12	190	174	3.0	28,007
0816	6/14/12	170	152	2.4	24,188
PW02	6/13/12	490	458	2.7	53,458

Table 4. Ammonia Probe Data from CF5 2012

Location	Date	Ammonia Probe (mg/L)
0810	8/3/12	333
	10/22/12	335
0811	8/3/12	417
	10/22/12	418
0812	8/3/12	373
	10/22/12	404
0813	8/3/12	258
	10/22/12	305
0814	8/3/12	281
	10/22/12	217
0815	8/3/12	238
	10/22/12	147
PW02	8/3/12	509
	10/22/12	459

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, water trucks for dust suppression on top of the tailings pile, or through the use of natural evaporator units that are 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 2012, and Table B-3 contains the evaporator operations.

The Remedial Action Contractor (RAC) removed water from the pond from January until late November, at which time the system was winterized. The evaporation pond level reached 9.4 ft in mid-July, when the extraction rate was approximately 88 gpm. In the following weeks, the extraction rate decreased and the volume of water removal from the water trucks increased to nearly 800,000 gal per week. Extraction operations decreased slightly throughout the summer to lower the level of the pond so that repairs could be made to the liner.

The extraction rate remained lower through the fall to lower the pond level in order 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. Withdrawal occurred throughout the year. As Figure 13 illustrates, the outflow varied from month to month, but was the highest from July through September.

Approximately 16 mil gal of extraction water was removed from the evaporation pond by water trucks in the contamination area (CA). 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 710,000 gal of extracted water was pumped through the evaporators between May and September 2012 when the weather conditions are more conducive for evaporation. The total gallons are equal to what was pumped through the evaporators as opposed to what actually evaporated.

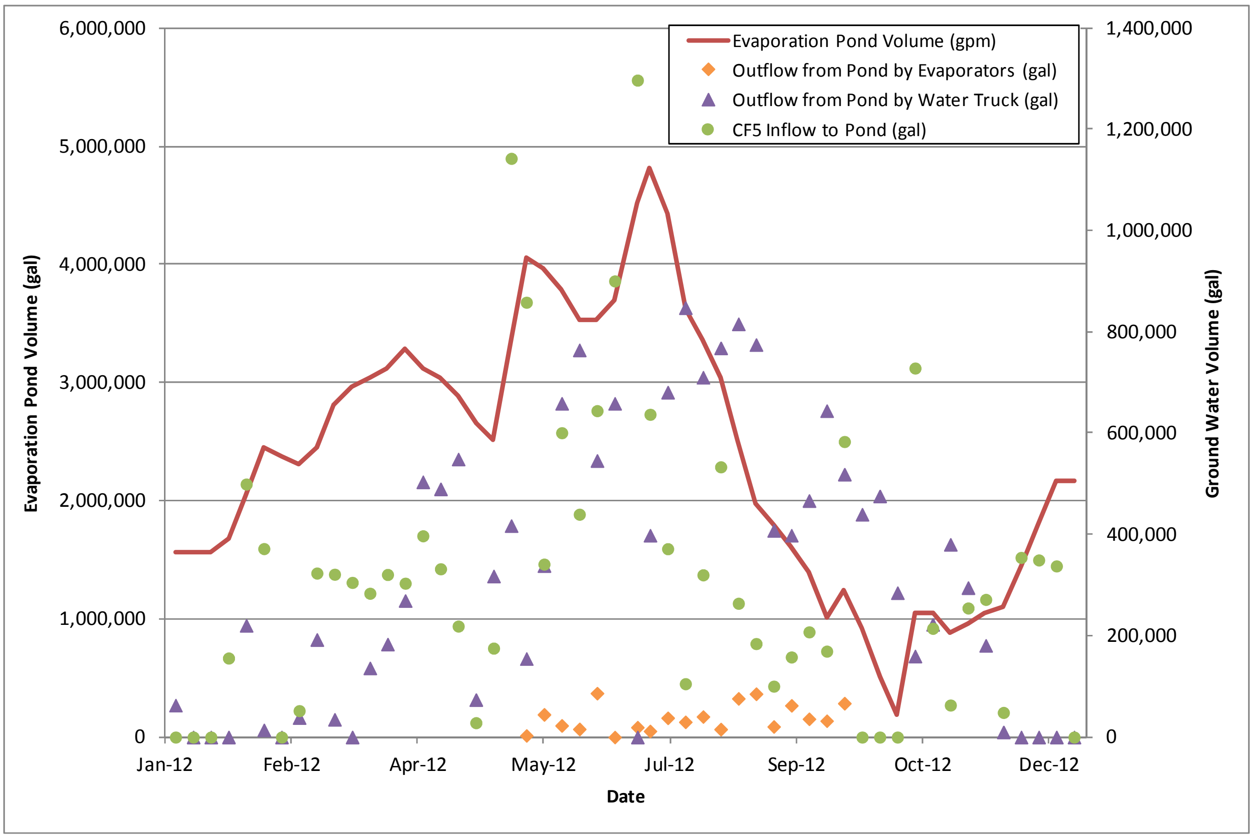

Figure 13. Rates of Water Delivery and Outflow to and from the Evaporation Pond and Pond Volume During 2012

5.2 Standing Water Samples in the CA

In December 2012, several areas of standing water were noted in the CA. It was unknown whether these samples represented pore fluids from the tailings or if they were the result of ponded water from the water trucks. Four locations were sampled, and the specific conductance and pH were measured at each location (Figure 14). Three of the sample locations had a specific conductance that ranged from 41,428 to 68,246 µmhos/cm and a pH that ranged from 7.72 to 7.85. The parameters at these three locations are indicative of natural precipitation that ponded in low-elevation spots or ground water that had been sprayed from the water trucks. The fourth location had a specific conductance of 116,353 µmhos/cm and a pH of 2.54, which is similar to pore water samples that have been analyzed over the past few years. This sample was collected near the face of the tailings excavation.

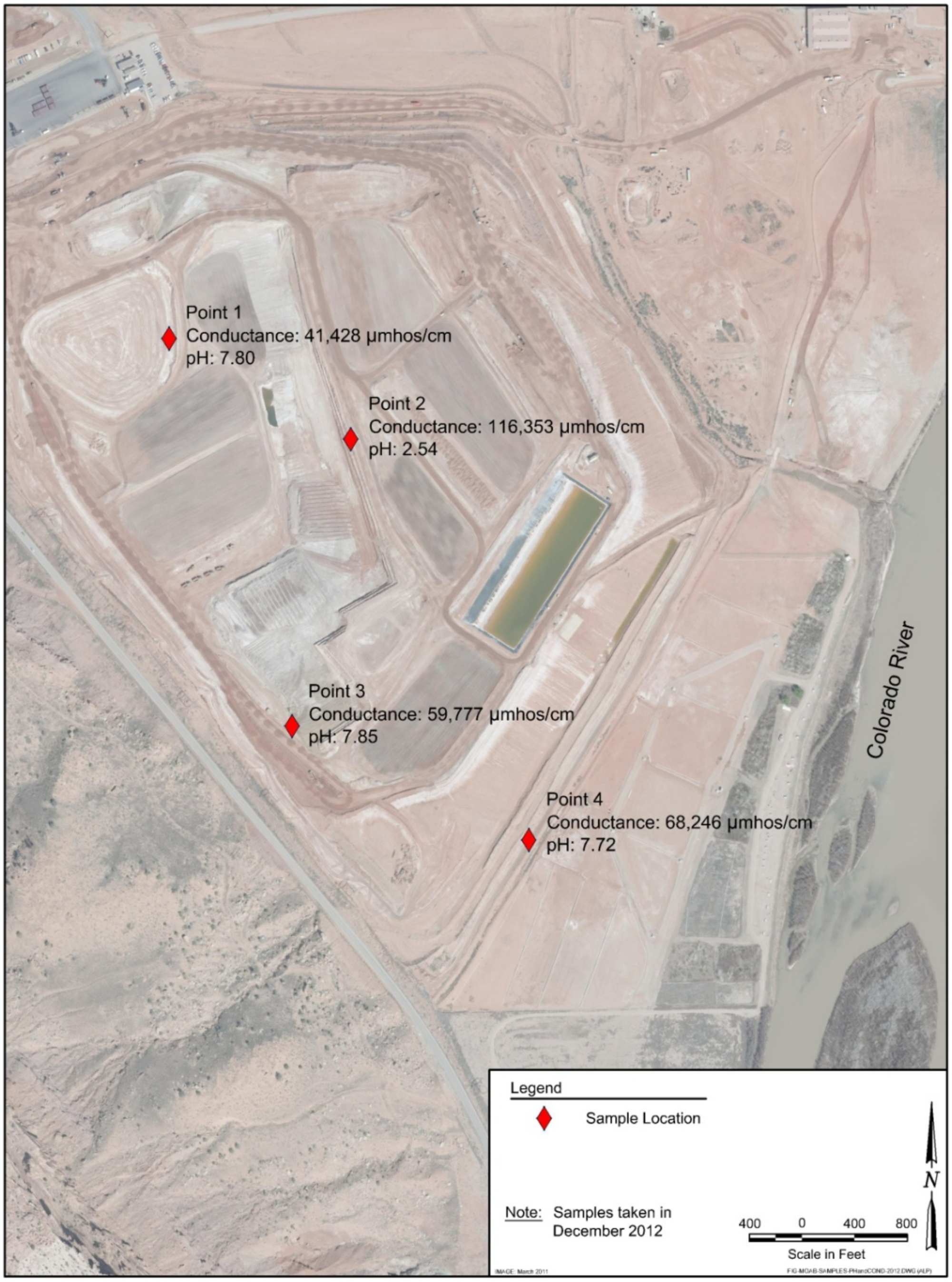

Figure 14. Standing Water Sample Locations and Parameters from December 2012

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 mid-February to mid-June and again from early October to late December 2012. Half of the CF1 injection wells were periodically utilized from early April through June 2012.

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 backwater 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 not sufficient to dilute the ammonia concentration that is introduced from the ground water.

The southern half of the CF1 injection wells (0470 through 0474) ran periodically from early April to early June to assist with protection of the northern portion of the CF4 backwater channel. The injection rate was very low (approximately 13 gpm total) and the injection water was mounding too fast, so the wells were shut down in early June.

Approximately 8.2 mil gal of freshwater was injected into CF4, and just over 400,000 gal was injected into CF1 in 2012. Approximately 11 mil gal of freshwater were injected into CF4 in 2011. The reason for the decreased injection volume in 2012 is due to the need to divert injection water directly into the CF4 channel during the summer months (discussed in Section 7.0).

6.1 Injection Performance

A chronology of injection events in 2012 can be found in Table C-2 of Appendix C. Prior to starting injection operations, ammonia probe samples were collected and analyzed in the CF4 backwater channel and observation wells, and water levels were recorded. Injection into the CF4 remediation wells began in mid-February, when the river flow was 2,900 cfs. With the exception of two spring-time power outages and having to shut the system down for routine maintenance to the filters, injection operations continued at a rate of 20 to 50 gpm until mid-June. In mid-June, the ammonia concentration in the backwater increased, and the injection water was diverted directly into the channel to assist with dilution (discussed in Section 7).

Injection operations resumed on October 10, when the river flow was 2,740 cfs. Freshwater was injected into all 10 remediation wells at a combined rate ranging from approximately 20 to 40 gpm. The system was winterized on December 20, 2012, because of below freezing temperatures.

Typically, the injection system is shut down during the peak run-off months so that the riverbank storage can infiltrate into the alluvial aquifer beneath the well field. In 2012, the peak river flow only reached 5,860 cfs and was not sufficient to impact the ammonia and uranium concentrations in the ground water in the vicinity of CF4 through June.

6.2 Summary of Chemical Data from Observation Wells

Throughout 2012, 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 2012 was measured with the ammonia probe.

Ammonia probe samples were collected prior to injection start-up in January, February, and September 2012 (Appendix C, Table C-3). The results of these samples indicate that ammonia concentrations were the lowest at 18 ft below ground surface (bgs) and the highest between 28 and 46 ft bgs.

Ammonia concentration in the well points varied greatly, and did not appear to be impacted by the slight change in river flow.

Ammonia probe samples collected during injection operations show that the downgradient concentrations are drastically lower at 18 ft bgs (Appendix C, Figures C-1, C-3, C-5). For example, the ammonia concentration in well 0784 (18 ft bgs) dropped from 101.2 mg/L before injection operations and to 2.64 mg/L after injection had been running for just over a month.

The specific conductance at the upgradient observation wells generally decreased during injection operations (Appendix C, Figures C-2, C-4, C-6). In early February, the brine interface was located between 18 and 33 ft bgs, and during injection operations, it dropped in elevation from 33 to 46 ft bgs.

The specific conductance decreased at all of the downgradient observation wells during injection operations. In January 2012, the specific conductance was 110,793 µmhos/cm at 36 ft bgs and during injection operations, it decreased to 76,787 µmhos/cm. The specific conductance at 28 ft bgs initially dropped from 23,453 to 7,935 µmhos/cm when injection operations first began in February; however, the specific conductance leveled out around 21,000 µmhos/cm through October.

Figures 15 and 16 show a cross-section through CF4 prior to injection in February 2012 and during injection operations in May 2012. The figures illustrate that the ammonia concentration is lowest in the downgradient observation wells during injection operations. Injection greatly impacts the ammonia concentration, especially at 18 ft bgs and in the riverbank well points.

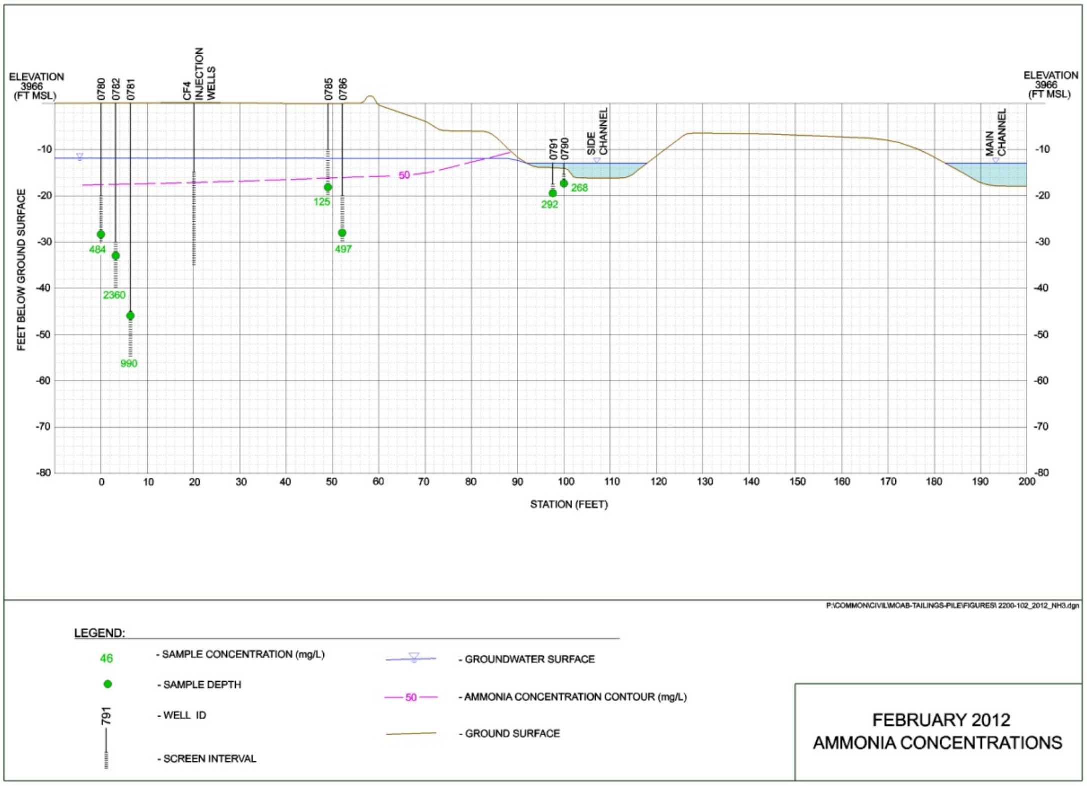

Figure 15. Cross-section through CF4 Prior to Injection Start-up, February 2012

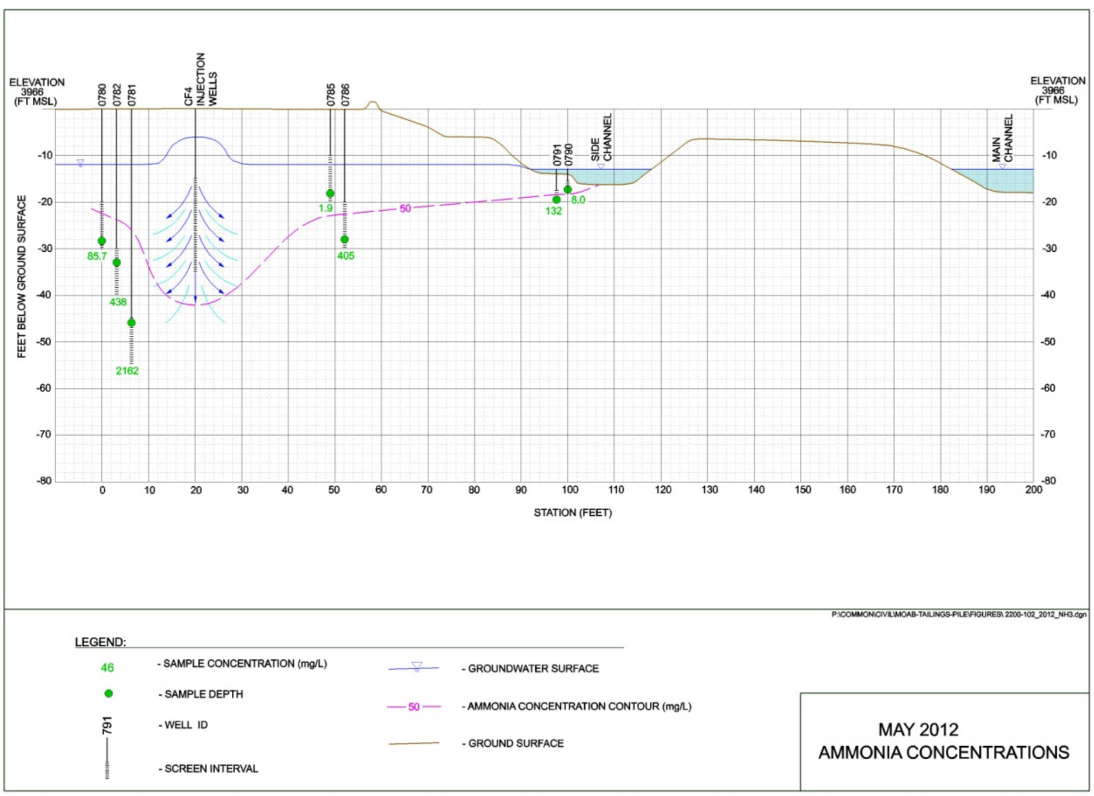

Figure 16. Cross-section through CF4 During Injection Operations, May 2012

6.3 Freshwater Mounding

Water levels were collected on a near-daily basis during injection operations and on a weekly basis for the surrounding observation wells. 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 5 and 6 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.

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 0772 and 0773 had the maximum mounding at over 14 ft during an injection rate of 2.1 and 5.0 gpm, respectively. The amount of mounding observed in 2012 is slightly higher than what was observed in 2011.

Table 5. Maximum Mounding Observed in CF4 Injection Wells

Well	Date	Type	Maximum Mounding (ft)	Injection Rate (gpm)
0770	11/26/12	Injection Well	11.88	8.0
0771	11/26/12	Injection Well	11.83	4.5
0772	10/26/12	Injection Well	14.14	2.1
0773	11/01/12	Injection Well	14.17	5.0
0774	11/05/12	Injection Well	11.81	6.1
0775	05/30/12	Injection Well	11.33	5.8
0776	11/01/12	Injection Well	12.40	2.6
0777	11/07/12	Injection Well	12.83	4.7
0778	02/12/12	Injection Well	12.51	5.5
0779	02/13/12	Injection Well	13.03	4.5

Table 6. Freshwater Mounding Observed in CF4 Observation Wells

Well	Date	Location	Maximum Mounding (ft)	Distance from Injection Source (ft)
0780	11/07/12	Upgradient	0.84	15
0781	03/01/12	Upgradient	0.26	15
0782	11/07/12	Upgradient	0.67	20
0783	11/07/12	Upgradient	1.33	30
0784	11/07/12	Downgradient	1.12	30
0785	11/07/12	Downgradient	1.13	25
0786	01/07/12	Downgradient	0.92	30
0787	11/07/12	Downgradient	0.47	30

Observation well 0783 had the most mounding on November 7, 2012, when the combined injection rate was 36.39 gpm. It is likely that this well was also impacted by freshwater irrigation that occurred directly upgradient. Well 0785 had a maximum mounding of 1.13 ft on November 7. The mounding observed in 2012 (0.26 to 1.33 ft) is slightly lower than what was observed in 2011 (1.14 to 3.5 ft). The reason for the decrease in mounding in 2012 may be due to an overall lower injection rate.

7.0 Surface Water Monitoring

In 2012, the river flow ranged from 1,940 to 5,860 cfs from January through December. On average, the flow ranges from 3,130 to 27,500 cfs. The river flow was below average for the entire year in 2012, and the channel that flows adjacent to CF4 was a habitat for most of the monitoring season, which impacted IA operations.

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 both upgradient of the site, on-site, and downgradient of the site to determine whether any contaminants are entering the river (Figure 17).

Biota monitoring is conducted yearly after the spring peak river flow begins to recede.
The purpose is to monitor the ammonia concentrations in the backwater 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.

7.1 Site-wide Surface Water Monitoring

Site-wide surface water monitoring took place in June and November 2012. Ammonia and uranium sample results were analyzed at ALS Environmental, Inc., in Fort Collins, Colorado. The results of the June 2012 sampling event can be found in the *Moab UMTRA Project Ground Water and Surface Water Monitoring January through June 2012* (DOE-EM/GJTAC2062). With the exception of samples collected from 0226 and CR3, the ammonia concentrations were below the detection limit of 0.1 mg/L. The concentration detected in the sample from location 0226 was below the acute and chronic criteria, and the sample collected from location CR3 was below the acute and just above the chronic criteria. It is important to note that location CR3 was not an established habitat at the time of this sampling event.

The results of the November 2012 sampling event can be found in the *Moab UMTRA Project Ground Water and Surface Water Monitoring July through December 2012* (DOE-EM/GJTAC2083). With the exception of the sample collected from location CR3, 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

On-site surface water samples were first tested with the ammonia probe in January and February to determine where to focus the monitoring for the spring season. Figure 18 shows that the ammonia concentration varied along the length of the well field from 1.85 mg/L north of the Moab Wash to 133 mg/L adjacent to CF4. The river was at baseflow conditions during the sampling event (2,860 to 3,170 cfs), and the backwater channel adjacent to CF4 was closed off on the upriver side, so there was no flow running through it.

The river flow peaked at 5,860 cfs in early April, and the river water flowed through the CF4 channel at that time. Typically, the river flows through the channel until mid-June; however, in 2012 the flow dropped to 4,000 cfs by late May. On June 13, a 2-inch (in.) hose was added to the injection hydrant (located on the northern end of CF4), and the outlet of the hose was placed on the northern end of the channel, north of the main gravel bar at a rate of 75 gpm. On June 15, injection operations were suspended, so all of the water was diverted to the backwater channel, and the hose outlet was placed at the main gravel bar to help to dilute contaminants further down channel. In mid-June, the ammonia concentrations in the channel varied from 16.5 to 22.9 mg/L.

From June to early July, the outlet of the diversion hose was moved periodically to assist in diluting the ammonia concentrations. Table 7 gives a brief chronology and ammonia probe sample results. On July 2, a location on the southwest portion of the bank had an ammonia concentration that reached over 110 mg/L and after the hose outlet was moved a few feet over, the concentration had decreased to 14.7 mg/L overnight.

A hydrant was added to the freshwater irrigation line on July 18 so that additional water could be applied to the CF4 backwater channel. In addition, a plumbing upgrade was completed so that the diversion water could by-pass the sand filter. A 2-in. hose was added to the irrigation hydrant, and the outlet was placed just south of the gravel bar. A length of hose was added to the injection hydrant, and that outlet was extended to the southern portion of the CF4 backwater channel (Figure 19). The irrigation water was applied to the channel when it was not being used for revegetation purposes. From mid July to early August, the ammonia concentrations ranged from 5.3 to 41.9 mg/L.

On August 7, a slotted polyvinyl chloride (PVC) manifold was added to the injection hydrant diversion hose to more evenly distribute the freshwater within the channel. As a result, the ammonia concentration decreased at all of the sample locations. The greatest decreases were at the southeastern and southwestern banks where the ammonia concentration nearly dropped by 50 percent.

On August 14, a slotted PVC manifold was also added to the irrigation hydrant hose (Figure 19), and the ammonia concentrations continued to decrease to between 6.4 and 20.1 mg/L. By adding freshwater to the channel in two locations upgradient from the highest concentrations, there was an apparent decrease in ammonia. During the month of August, the river flow remained near 2,200 cfs, and the channel was closed off on the upriver end.

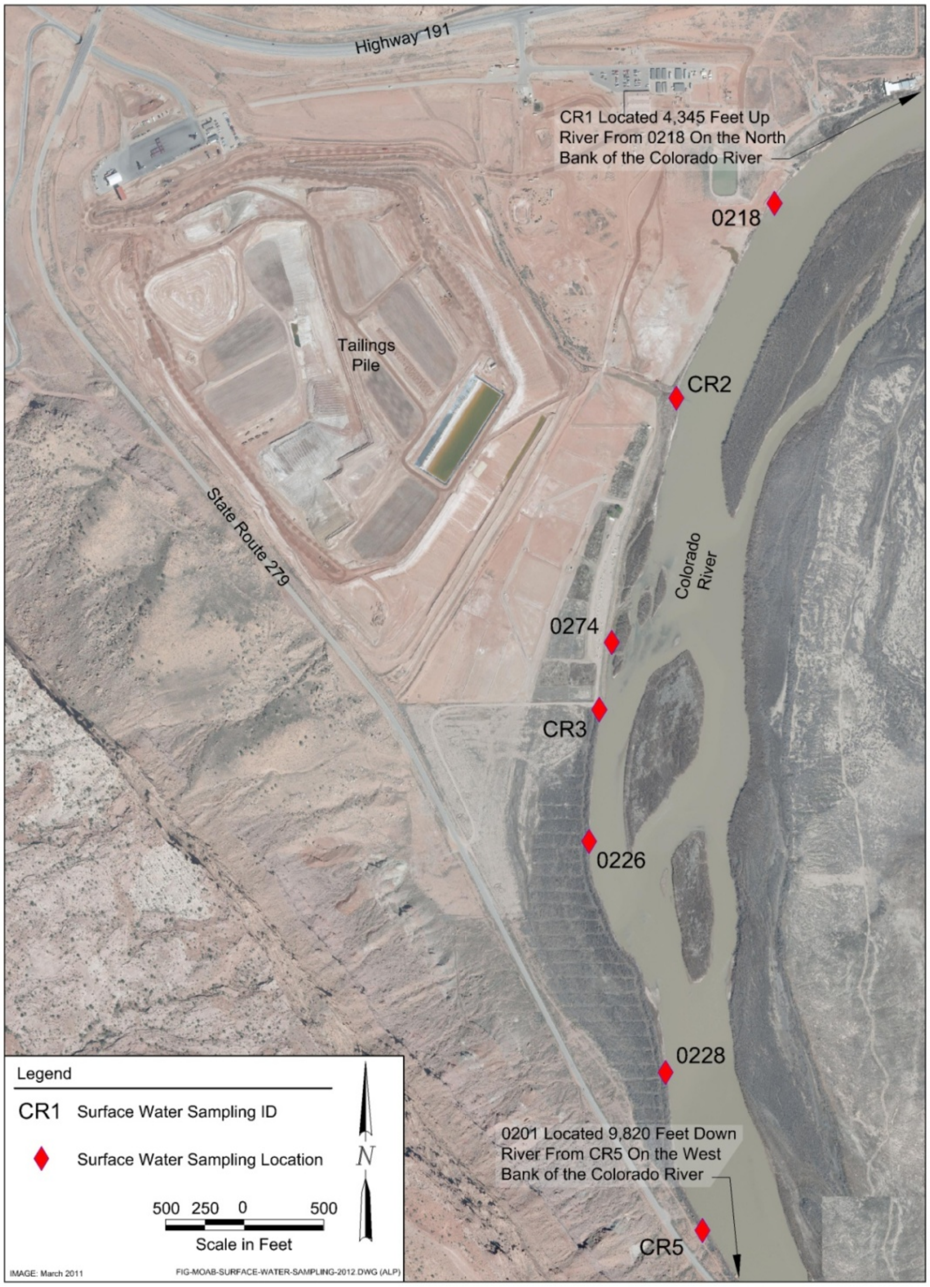

Figure 17. Site-wide Surface Water Sample Locations

Figure 18. Ammonia Probe Results from January and February 2012

During the month of September, the river flow increased slightly to approximately 2,600 cfs, and the ammonia concentrations generally decreased in the channel. In compliance with the Biological Opinion stated in the *Remediation of the Moab Uranium Mill Tailings Grand and San Juan Counties, Utah, Final Environmental Impact Statement* (DOE/EIS-0344), the biota monitoring and surface water diversion activities ended on October 2, 2012, when the river flow was 2,740 cfs. The CF4 backwater channel is no longer considered a suitable habitat after October 1.

7.3 Summary of Surface Water Monitoring

In 2012, the duration of the surface water monitoring was longer than usual because of the below-average spring peak run-off. The diversion system started with a single 2-in. hose connected from the injection hydrant to the backwater channel, and by October, included a second 2-in. hose that was connected to the irrigation line and two slotted PVC manifolds to assist with distributing the water within the channel (Figure 19).

The ammonia probe results indicate that the concentrations decreased when the manifolds were added and when there is a slight increase in river flow. Another observation from the 2012 monitoring is that the ammonia concentrations vary greatly throughout the channel. A slight adjustment in the placement of the discharge point can impact the ammonia concentration.

Typically, the highest concentrations can be found near riverbank seeps, which can be identified by a stream of water that flows out of the well field bank, perpendicular to the channel, or in stagnant areas of the channel. By placing the discharge point close to these areas of the channel, the ammonia concentrations can typically be managed.

No dead or distressed fish were found within the channel during the 2012 surface water monitoring event.

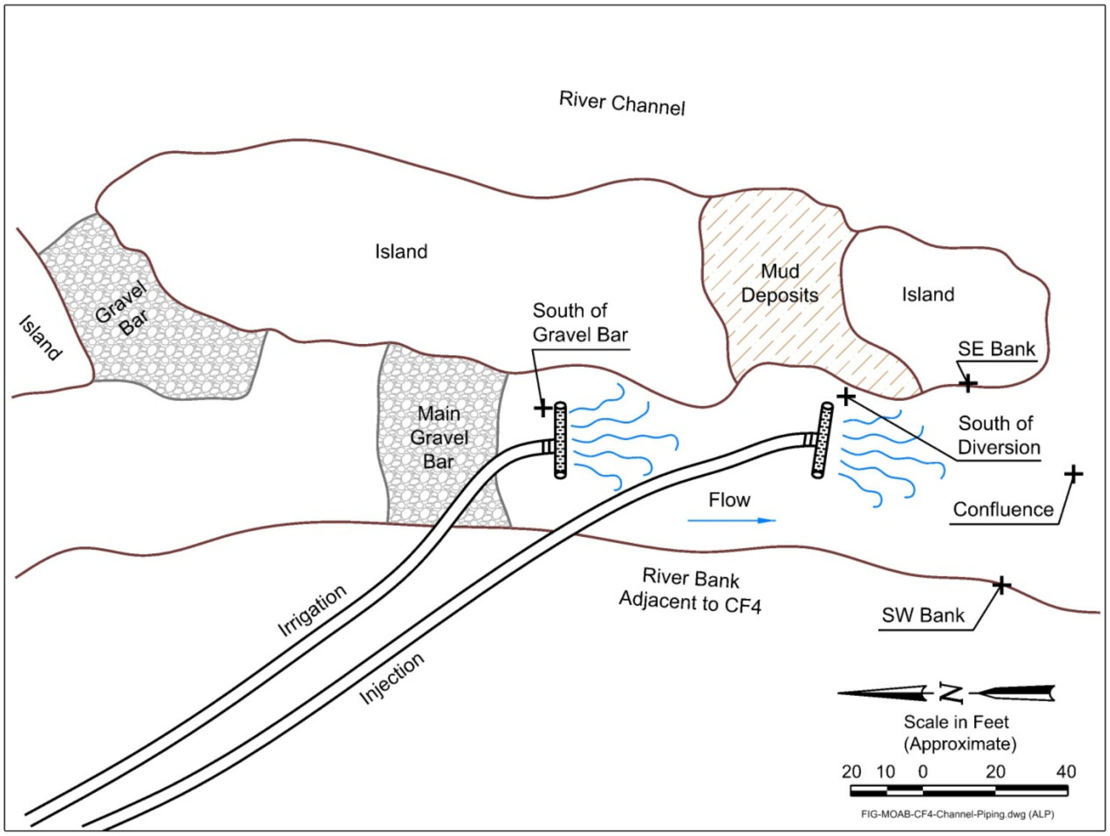

Figure 19. Surface Water Diversion Set-up in the CF4 Backwater Channel

7.4 River Baseflow Ammonia Investigation

A baseflow ammonia investigation took place on March 7, 2012, when the river flow was 3,050 cfs. A series of three gravel bars (Figure 20) had been exposed east of the CF4 backwater channel. Surface water parameters and ammonia probe samples were collected from the three channels that separate the gravel bars and from the main river channel (Figure 19). The purpose of this investigation was to determine the lateral extent of the ammonia contamination into the adjacent backwater channels.

Table 7. Ammonia Concentrations in the CF4 Backwater Channel

Date	River Flow	South of Gravel Bar	Southern Diversion	Southeastern bank	Southwesernt bank	Confluence
		Ammonia, as N (mg/L)				
2/3/12	NS	133	NS	NS	5.2	2.5
Diversion Begins from Injection Port June 13 (located south of gravel bar)						
6/15/12	2,430	22.6	NS	NS	16.5	NS
6/18/12	2,500	22.9	NS	NS	20.6	NS
6/25/12	2,120	3.4	NS	NS	9.20	11.1
6/28/12	2,110	NS	12.8	14.3	NS	NS
7/2/12	2,170	NS	12.7	15.9	110.2*	18.0
7/3/12	2,130	NS	12.3	12.7	14.7	4.5
Diversion Added from Irrigation Port on July 18 (injection port was moved south)						
7/26/12	2,610	NS	38.1	31.3	32.2	6.9
8/3/12	2,670	NS	39.1	41.9	40.3	5.3
New Manifold was added to Injection Hose on August 7						
8/7/12	2,440	NS	27.4	25.3	23.9	NS
8/8/12	2,270	NS	14.7	17.4	15.8	NS
8/9/12	2,210	NS	13.1	16.2	15.2	NS
8/10/12	2,250	NS	38.8	32.7		NS
New Manifold added to Irrigation Hose on August 14						
8/16/12	2,600	NS	18.8	18.2	18.2	6.4
8/17/12	2,500	NS	20.1	20.2	NS	NS
9/13/12	2,600	NS	12.2	14.9	NS	15.0
10/1/12	2,740	NS	15.2	15.2	NS	15.6
Diversion is shut-down on October 2						

NS= Not sampled.
*The concentration dropped from 110.2 mg/L to 14.7 mg/L overnight when the position of the manifold was shifted a few feet to the south. Sample locations are shown in Figure 19.

The ammonia concentrations ranged from 7.83 mg/L closest to the CF4 backwater channel and decreased to less than 0.75 mg/L in the main river channel (Table 8). Specific conductance ranged from 1,835 µmhos/cm (closest to the CF4 backwater channel) and decreased to 1,430 µmhos/cm in the main river channel. On the same day, the ammonia concentration in CF4 varied from 7.82 to 274 mg/L, and the specific conductance had a range of 2,160 to 16,386 µmhos/cm.

The data suggests that elevated ammonia concentrations extend past the CF4 backwater channel, although the concentrations decline rapidly with increasing distance.

Table 8. Water Quality Data from the River Baseflow Ammonia Investigation

Date	Location	Specific Conductance (µmhos/cm)	pH	Ammonia (mg/L)
3/7/12	BW2	1,835	7.56	7.83
3/7/12	BW3	1,545	7.51	1.91
3/7/12	BW4	1,466	7.71	1.03
3/7/12	BW5	1,430	7.95	0.74

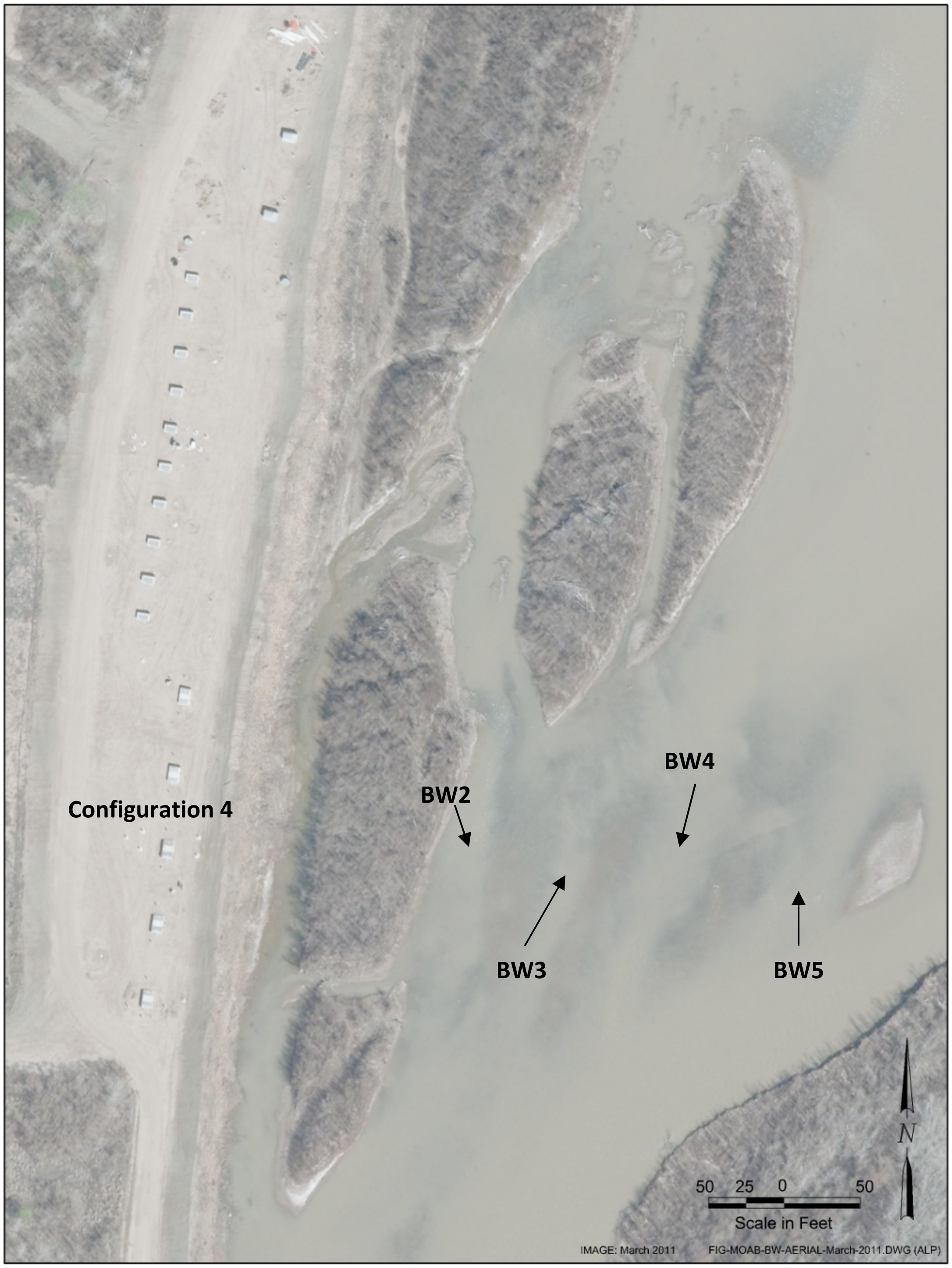

Figure 20. River Baseflow Ammonia Investigation Locations

8.0 Summary and Conclusions

In 2012, the IA operations focused on year-round ground water extraction from CF5, freshwater injection from spring through winter, and surface water diversion during the spring and summer months. The below-average river flows greatly impacted operations during the spring and summer months.

The ammonia and uranium mass removal rate and gallons of ground water extracted was higher in 2012 than it has been for the past 3 years (Figures 21 and 22). A reason for the higher contaminant removal (besides the greater extraction volume) could be due to the fact that the river was so low in 2012, and the ammonia concentrations were less diluted in the CF5 extraction wells than what was seen during high river flow in 2011.

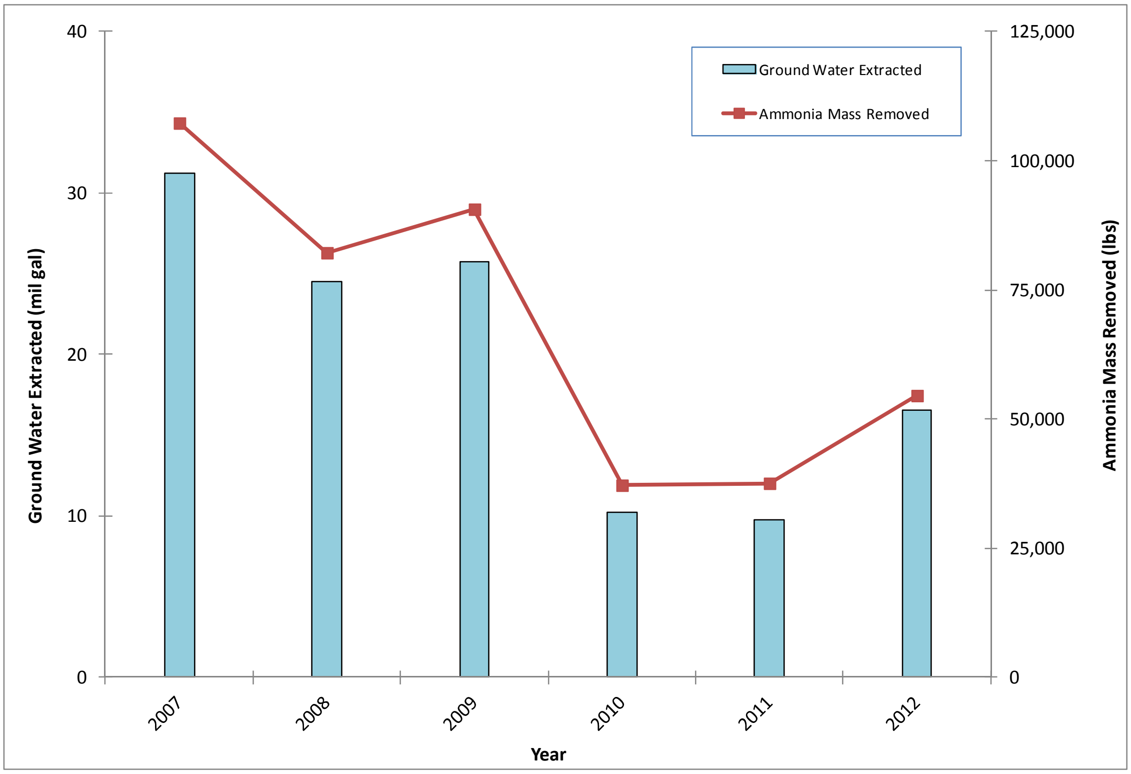

Figure 21. Volume of Ground Water Extracted and Ammonia Mass Removal, 2007 Through 2012

The extraction rate peaked at over 400 gpm in August and well PW02 extracted the most ammonia and uranium mass in 2012. Wells on the northern end of CF5 (0813 and 0816) tend to produce more water and have less drawdown than the wells on the southern end of CF5 (0810 and 0814).

Approximately 16 mil gal of extraction water was removed from the evaporation pond for dust suppression by water trucks in the CA, and 710,000 gal of extracted water was pumped through the evaporators during the spring and summer months.

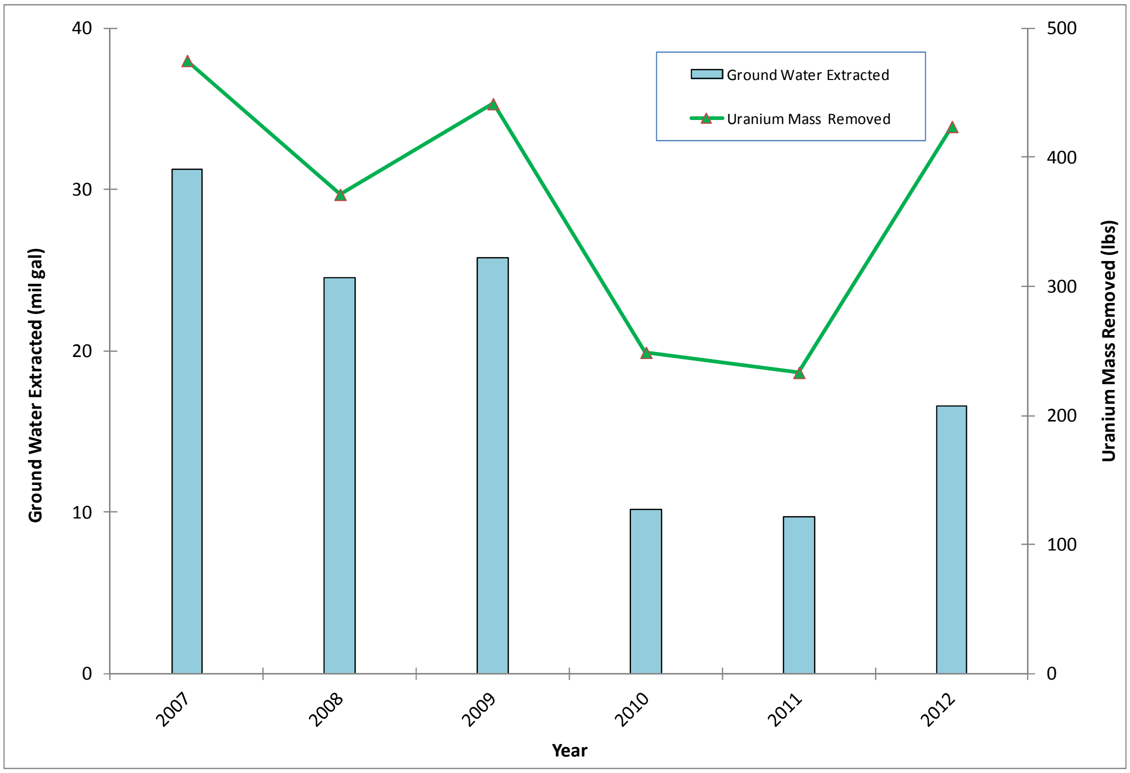

Figure 22. Volume of Ground Water Extracted and Uranium Mass Removal, 2007 Through 2012

Approximately 8.2 mil gal of freshwater was injected into CF4, and 400,000 gal were injected into CF1 in 2012. This is slightly less volume than was injected in 2011, because in June, the injection water was used for surface water diversion.

Analytical data from the CF4 observation wells during injection operations indicates that the system is effective at diluting ammonia concentrations, especially from 28 to 36 ft bgs. The brine interface was suppressed from 18 to 33 ft bgs to 33 to 46 ft bgs during operations. Specific conductance also dropped significantly at all of the downgradient observation wells.

Site-wide surface water samples indicated that the contaminants do not extend past the site boundary. Location CR3, located on the southern-most 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 2012 due to the below average river flow. During this time, both injection and irrigation water was diverted into the backwater channel adjacent to CF4 to assist with lowering the ammonia concentrations. No dead or distressed fish were observed during this time.

9.0 References

DOE (U.S. Department of Energy), *Moab UMTRA Project Surface Water/Ground Water Sampling and Analysis Plan* (DOE-EM/GJTAC1830), November 2009.

DOE (U.S. Department of Energy), *Record of Decision for the Remediation of the Moab Uranium Mill Tailings, Grand and San Juan Counties, Utah*, September 2005.

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DOE (U.S. Department of Energy), *Moab UMTRA Project Ground Water and Surface Water Monitoring January through June 2012* (DOE-EM/GJTAC2062), October 2012.

DOE (U.S. Department of Energy), *Moab UMTRA Project Ground Water and Surface Water Monitoring July through December 2012* (DOE-EM/GJTAC2083), March 2013.

Appendix A.
Tables and Data for 2012 Ground Water Extraction

Appendix A. Tables and Data for 2012 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	2,950-3,960	PW02 was started with an extraction rate of 50.85 gpm.
February	2,630-3,230	Extraction from PW02 31-50 gpm.
March	2,700-5,280	Extraction from PW02 31 gpm.
April	2,600-5,860	Extraction from PW02 31 gpm. No extraction operations due to a repair made to the 6-in.line from 4/18 to 4/23. Operations resumed from PW02 and 0810. Beginning April 27, extraction operations were suspended due to transformer damage during a windstorm.
May	3,310-4,620	Extraction operations resumed on May 9 after the transformer was repaired. Extraction occurred from PW02 (45 gpm) and from wells 0810, 0813, 0814, 0815, and 0816. The evaporators ran during optimal weather conditions.
June	2,110-4,360	Extraction operations continued from PW02, 0810, 0812, 0813, 0814. The evaporator operations were limited because the RAC was using pond water for dust suppression.
July	1,940-3,130	Extraction from wells PW02, 0810, 0812, 0814, and 0816. Operations were suspended for about a week in July due to work on nearby utilities. Evaporators were used during optimal weather conditions.
August	2,140-3,240	A maximum pump test was conducted in CF5 in late July through early August. The extraction operations reached over 400 gpm. Extraction and evaporator operations continued throughout most of the month.
September	2,190-2,910	Extraction from PW02, 0811, 0812, 0813, 0814, 0815, and 0816. The evaporators ran during most of the month. Extraction operations were suspended on September 25 to control the evaporation pond level.
October	2,040-2,820	Extraction operations continued on October 18 from 0813 and PW02. A power outage affected extraction on October 28 until October 30. Extraction resumed from PW02 on October 31. The evaporators did not run this month.
November	2,330-2,860	Extraction from PW02 and 0815. Operations were intermittent due to weather conditions.
December	2,110-2,480	Extraction from 0815 from December 1 through 18 and extraction operations from PW02 from December 12-19. The system was temporarily drained due to cold weather conditions on December 19.

Table A-3. CF5 Extraction Volumes 2012

Well	Volume Extracted (gal)												
	Jan-12	**Feb-12**	**Mar-12**	**Apr-12**	**May-12**	**Jun-12**	**Jul-12**	**Aug-12**	**Sep-12**	**Oct-12**	**Nov-12**	**Dec-12**	**Totals**
810	0	0	0	87,434	36,944	198,071	513,091	161,336	32,750	1,974	0	0	1,031,601
811	0	0	0	0	0	0	0	49,349	63,962	1,810	0	0	115,121
812	0	0	0	0	0	160,161	591,393	102,718	55,245	1,809	0	0	911,326
813	0	0	0	0	0	173,741	0	135,453	586,356	421,180	0	0	1,316,730
814	0	0	0	0	437001.42	235,575	27,088	292,080	116,661	2,936	0	0	1,111,342
815	0	0	0	86712.489	153,948	5,788	0	189,331	79,215	2,856	48,540	665,910	1,232,299
816	0	0	0	0	824,977	21,671	22,999	323,857	151,121	2,938	0	0	1,347,561
PW02	155,954	923,480	1,554,937	1,077,898	1,092,637	1,790,159	1,256,299	148,279	33,237	507,328	589,515	375,791	9,505,514
MONTHLY	155,954	923,480	1,554,937	1,252,044	2,545,507	2,585,165	2,410,870	1,402,403	1,118,547	942,831	638,055	1,041,701	
TOTAL	16,571,493												

Table A-4. CF5 Ammonia Mass Removal 2012

Well	Ammonia Mass Removed (lbs)												
	Jan-12	**Feb-12**	**Mar-12**	**Apr-12**	**May-12**	**Jun-12**	**Jul-12**	**Aug-12**	**Sep-12**	**Oct-12**	**Nov-12**	**Dec-12**	**Totals**
810	0	0	0	219	93	458	1,179	431	88	5	0	0	2,473
811	0	0	0	0	0	0	0	181	235	7	0	0	423
812	0	0	0	0	0	446	1,579	300	161	5	0	0	2,492
813	0	0	0	0	0	247	0	209	906	651	0	0	2,013
814	0	0	0	0	1,168	416	45	561	224	6	0	0	2,420
815	0	0	0	174	309	8	0	300	126	5	65	823	1,809
816	0	0	0	0	1,447	27	29	460	215	4	0	0	2,182
PW02	677	4,117	7,143	4,952	5,019	7,511	4,827	607	136	2,076	2,342	1,441	40,848
MONTHLY	677	4,117	7,143	5,344	8,035	9,114	7,659	3,050	2,090	2,759	2,407	2,264	54,659
TOTAL							54,659						

Table A-5. CF5 Uranium Mass Removal 2012

Well	Uranium Mass Removed (lbs)												
	Jan-12	**Feb-12**	**Mar-12**	**Apr-12**	**May-12**	**Jun-12**	**Jul-12**	**Aug-12**	**Sep-12**	**Oct-12**	**Nov-12**	**Dec-12**	**Totals**
810	0.0	0.0	0.0	1.9	0.8	4.3	11.1	4.0	0.8	0.0	0.0	0.0	23.1
811	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.1	0.0	0.0	0.0	1.9
812	0.0	0.0	0.0	0.0	0.0	2.5	9.4	1.8	1.0	0.0	0.0	0.0	14.7
813	0.0	0.0	0.0	0.0	0.0	1.3	0.0	1.0	4.4	3.2	0.0	0.0	9.9
814	0.0	0.0	0.0	0.0	9.9	5.3	0.6	6.3	2.5	0.1	0.0	0.0	24.7
815	0.0	0.0	0.0	2.5	4.4	0.2	0.0	4.7	2.0	0.1	1.3	16.7	31.8
816	0.0	0.0	0.0	0.0	15.8	0.4	0.4	6.5	3.0	0.1	0.0	0.0	26.3
PW02	5.1	30.1	50.7	35.1	35.6	58.3	40.9	3.3	0.7	11.4	13.3	8.5	293.1
MONTHLY	5	30	51	39	66	72	62	29	16	15	15	25	425
TOTAL	425												

Appendix A. Tables and Data for 2012 Ground Water Extraction (*continued*)

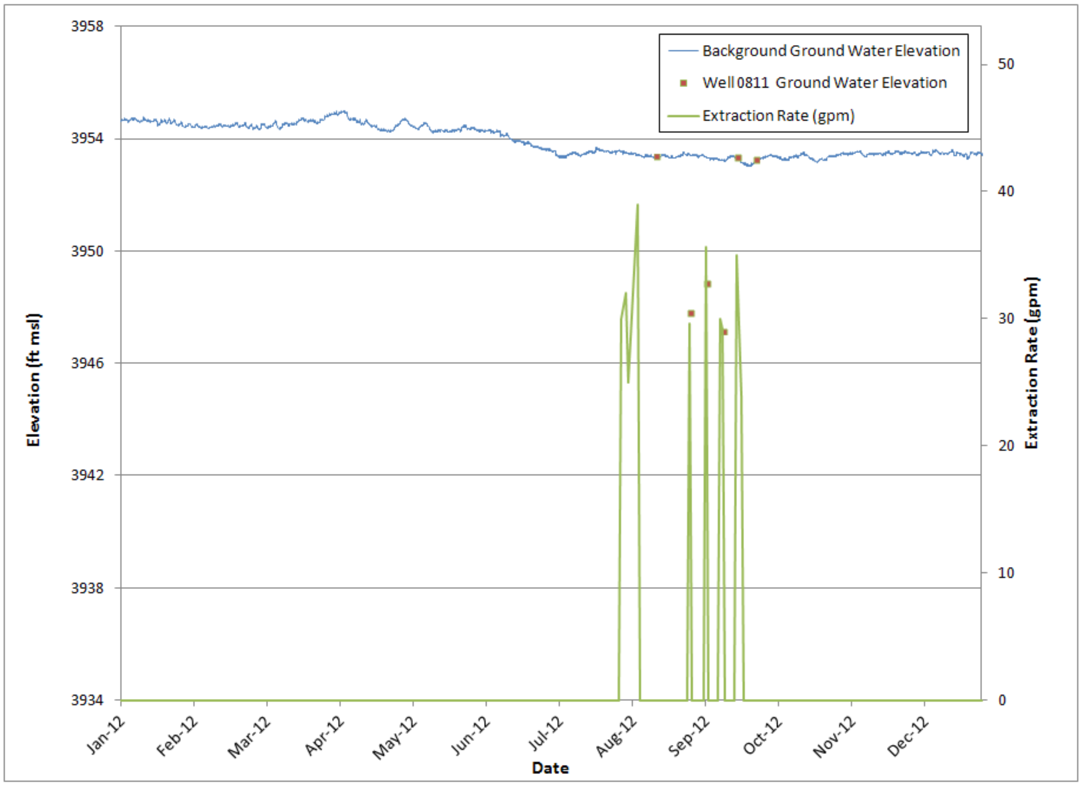


Figure A-1. Drawdown Plot for Well 0811

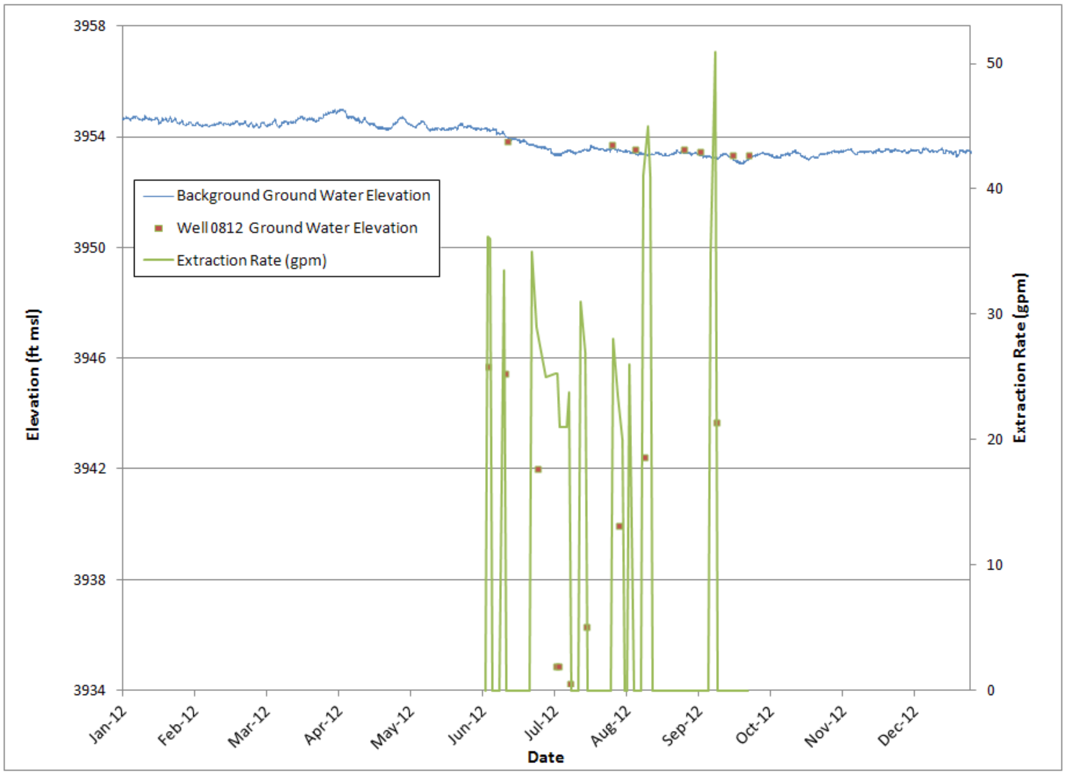


Figure A-2. Drawdown Plot for Well 0812

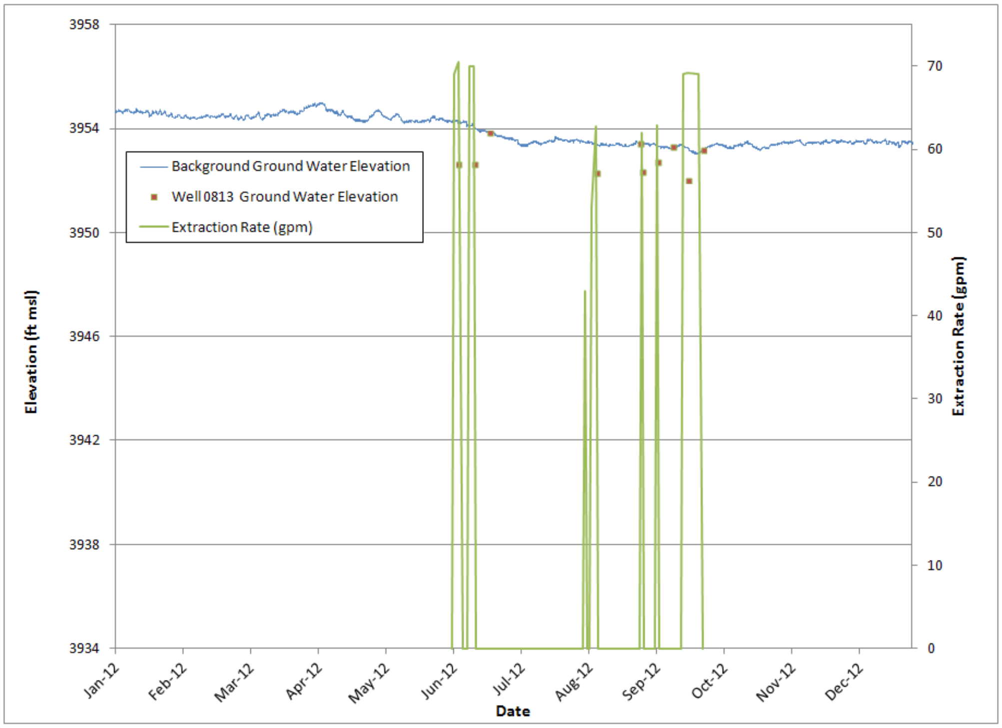


Figure A-3. Drawdown Plot for Well 0813

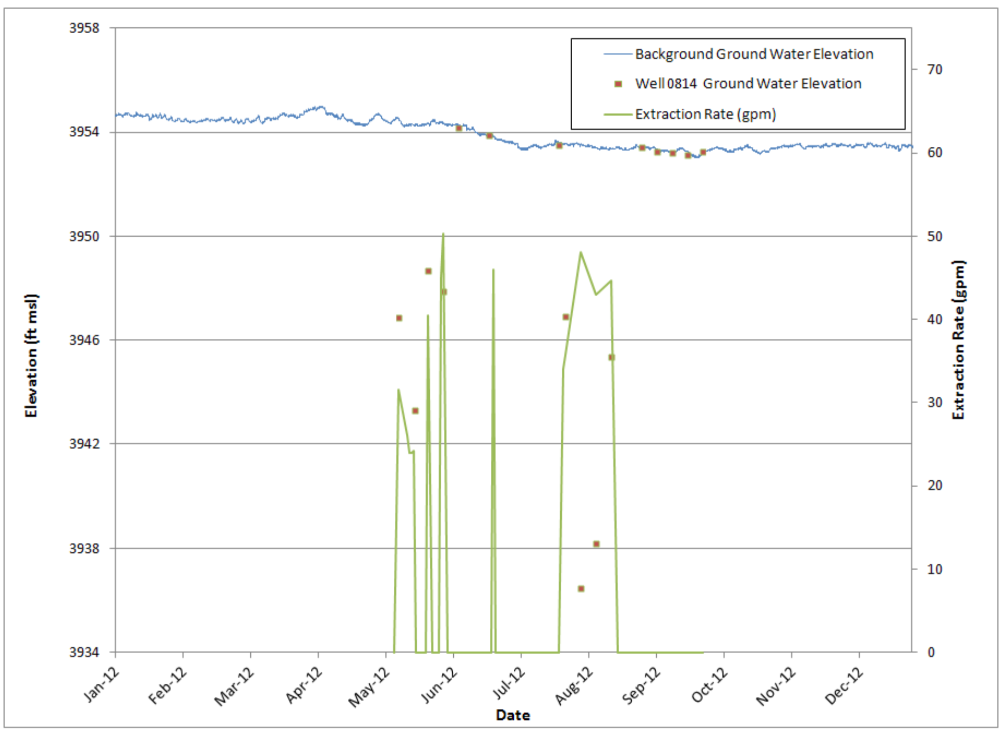


Figure A-4. Drawdown Plot for Well 0814

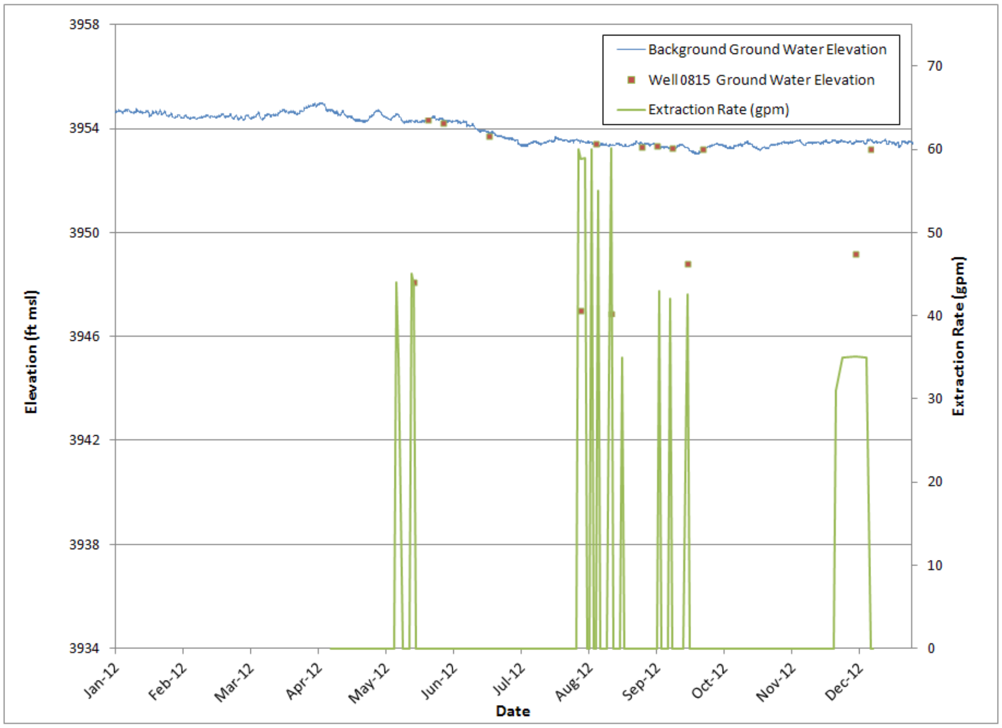


Figure A-5. Drawdown Plot for Well 0815

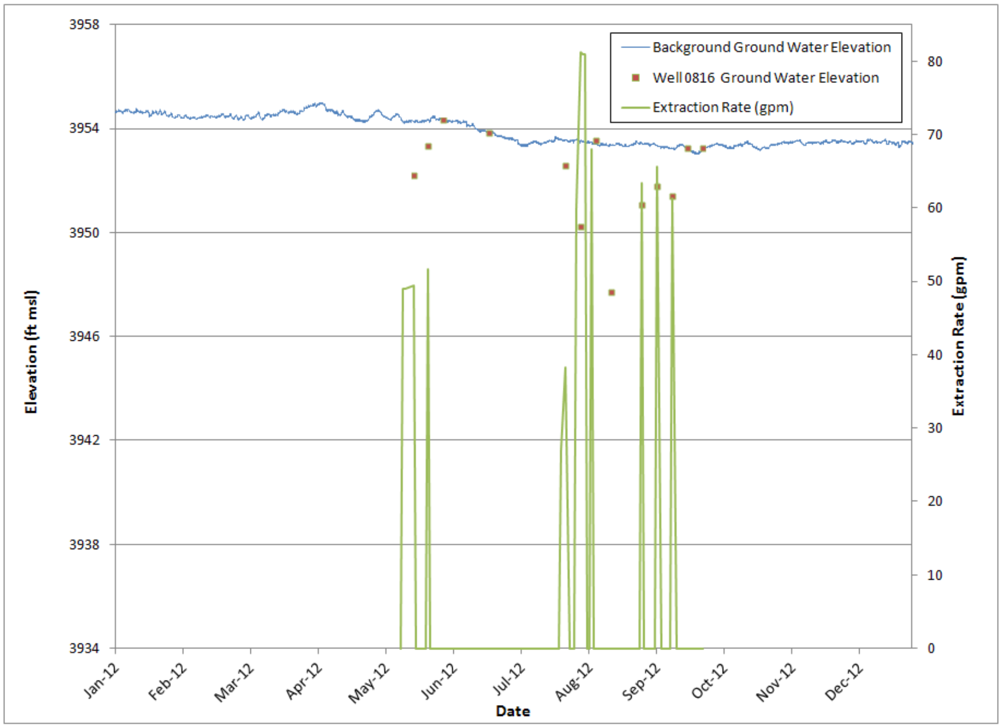


Figure A-6. Drawdown Plot for Well 0816

Appendix B.
2012 Evaporation Pond Data

Appendix B. 2012 Evaporation Pond Data

Table B-1. Evaporation Pond Chorology for 2012

Date	Pond Level (ft)	Activity
1/26/12	5.4	Restarted extraction operations for the winter
2/23/12	6.4	Repair on the 4-in. line, extract from PW02
3/15/12	7.3	Continue extraction from PW02
4/12/12	7.5	Added well 0815 to CF5 extraction and repaired the 6-in. line on top of the pile
4/16/12	7.4	Begin extracting from well 0810
4/20/12 – 4/22/12	7.4	Repairs made to line. No extraction
4/26/12	7.2	Power outage due to windstorm. No extraction.
5/9/12	6.7	Power restored, restarted extraction operations from PW02, 0814, 0815.
5/14/12	7.8	Stated up evaporator operations
5/16/12	7.8	Extraction from 0814, 0816, PW02
5/22/12	8.6	Begin using evaporator #2
6/4/12	8.3	Extraction from 0813, PW02, 0812
6/25/12	8.2	The evaporators did not run so the RAC could remove more water by water truck
7/20/12 – 7/22/12	8.1	No extraction due to work on utilities
7/23/12	8.1	Extraction re-started
7/30/12-8/3/12	7.8	Started pump test of the CF5 well field. Flow rates up to 407 gpm. Evaporators did not run during this time.
8/13/12	6.7	Extraction from 0810, 0816, PW02
9/6/12	5.3	Extraction from 0814, 0815, and 0816. No evaporator operations due to issues with the generator
9/17/12	4.1	Extraction from 0810, 0813, PW02. Evaporators back up and running.
9/25/12 – 10/18/12	4.6 to 1.5	No extraction operations in order to regulate pond level
10/22/12	4.2	Extraction from 0813 and PW02
11/5/12	3.8	Temporarily winterized all wells but PW02 and 0812
11/15/12	4.0	Extraction continued from PW02
11/21/12-11/25/12	4.2	No extraction operations
11/28/12	4.3	Last day of water truck usage from the evaporation pond in 2012
12/4/12	5.0	Extraction continued from 0815
12/15/12	5.6	Extraction continued from PW02
12/19/12	6.2	Temporarily winterized CF5 extraction

Appendix B. 2012 Evaporation Pond Data (*continued*)

Table B-2. Pond Level vs. Pond Volume 2012

Date	Pond Level (ft)	Pond Volume (gal)
1/5/12	5.2	1,560,518
1/12/12	5.2	1,560,518
1/19/12	5.2	1,560,518
1/26/12	5.4	1,674,711
2/2/12	6.0	2,041,751
2/9/12	6.6	2,445,485
2/16/12	6.5	2,375,648
2/23/12	6.4	2,306,830
3/1/12	6.6	2,445,485
3/8/12	7.1	2,809,961
3/15/12	7.3	2,962,886
3/22/12	7.4	3,040,877
3/29/12	7.5	3,119,888
4/5/12	7.7	3,280,967
4/12/12	7.5	3,119,888
4/19/12	7.4	3,040,877
4/26/12	7.2	2,885,914
5/3/12	6.9	2,661,113
5/10/12	6.7	2,516,342
5/17/12	7.8	3,363,036
5/23/12	8.6	4,056,279
5/30/12	8.5	3,966,056
6/6/12	8.3	3,788,668
6/13/12	8.0	3,530,231
6/20/12	8.0	3,530,231
6/27/12	8.2	3,701,503
7/6/12	9.1	4,522,682
7/11/12	9.4	4,814,756
7/18/12	9.0	4,427,363
7/25/12	8.1	3,615,357
8/1/12	7.8	3,363,036
8/8/12	7.4	3,040,877
8/15/12	6.7	2,516,342
8/22/12	5.9	1,978,029
8/29/12	5.6	1,792,980
9/5/12	5.3	1,617,105
9/12/12	4.9	1,396,874
9/19/12	4.1	1,005,338

Appendix B. 2012 Evaporation Pond Data (*continued*)

Table B-2. Pond Level vs. Pond Volume 2012 (continued)

Date	Pond Level (ft)	Pond Volume (gal)
9/26/12	4.6	1,242,404
10/3/12	3.9	917,647
10/10/12	2.8	508,224
10/17/12	1.5	183,368
10/24/12	4.2	1,050,713
10/31/12	4.2	1,050,713
11/7/12	3.8	875,330
11/14/12	4.0	960,983
11/21/12	4.2	1,050,713
11/28/12	4.3	1,097,107
12/5/12	5.0	1,450,403
12/12/12	5.6	1,792,980
12/19/12	6.2	2,172,252
12/26/12	6.2	2,172,252

Table B-3. Evaporator Operations 2012

Date	Total Gallons
5/22/12	3252
5/30/12	44696
6/6/12	22972
6/13/12	15979
6/20/12	86676
6/27/12	0
7/6/12	19492
7/11/12	12028
7/18/12	37977
7/25/12	30010
8/1/12	40511
8/8/12	15677
8/15/12	76386
8/22/12	85497
8/29/12	20874
9/5/12	62564
9/12/12	36025
9/19/12	32277
9/26/12	66832
10/3/12	0

Note: Evaporators winterized October 17, 2012

Appendix C.
Tables and Data for 2012 Freshwater Injection

Appendix C. Tables and Data for 2012 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 2012

Date	River Flow (cfs)	Activity
1/5/12	3,690	Ammonia probe readings in the CF4 backwater channel.
2/13/12	2,900	Collected water levels, ammonia probe readings, and flow-meter readings, bag filters changed, and injection began at 11:30.
3/18/12 to 3/19/12	4,120-4,260	Power outage, no injection.
4/19/12	2,770	Media added to the sand filter.
4/26/12	3,950	Power outage, no injection.
5/14/12	4,240	Resume injection operations.
6/11/12	3,380	Injection shut down for modifications to add diversion water into the backwater channel.
6/13/12	2,860	Started surface water diversion into CF4 backwater channel.
6/15/12	2,430	Injection operations suspended to divert water into the CF4 backwater channel.
8/7/12	2,440	A new manifold was added to the southern surface water diversion hose.
8/14/12	2,310	A new manifold was added to the northern surface water diversion hose.
10/1/12	2,740	Surface water diversion shut down. Prepared filters for injection.
10/10/12	2,080	Injection resumes.
11/7/12	2,620	Begin winterizing some injection components.
12/20/12	Ice	Injection system was winterized.

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)**
1/5/2012	3,800	NO	Not since 12/7	0	22,751	413	114,141	906	89,815	940	16,423	39.3	12,560	17.95	12,726	10.02	20,465	302	105,600	506	6,032	5.26	11,642	109.4	9,526	130.6
1/19/2012	3,110	NO	Not since 12/7	0	23,252	417	114,355	2124	95,201	2162	16,323	33.7	12,281	13.06	13,961	123.9	24,109	399	85,590	313	13,416	60.3	15,046	265	9,004	162.6
2/13/2012	2,800	NO	Not since 12/7	0	25,392	484	114,423	990	98,614	2360	17,706	72.6	15,086	101.2	15,630	125	23,453	497	110,793	604	18,311	268	17,172	292	7,820	167.1
3/8/2012	3,150	YES	Since 2/13	56	4,033	56.1	92,794	1,110	29,155	431	16,170	65.3	3,563	2.64	2,700	12.25	7,935	69.3	76,787	1416	3,123	53.7	16,708	297	8,078	179.1
5/31/2012	3,430	YES	Since 2/13	43	7,432	85.7	98,029	2162	24,700	438	19,881	182.4	2,335	3.79	1,942	1.92	21,015	405	77,491	1330	1,621	8	8,641	131.8	8,888	192.3
9/27/2012	2,750	NO	Pre-inj start up	0	18,226	329	88,852	1778	26,846	537	4,232	19.7	4,700	23.2	5,757	29.4	20,830	366	72,211	875	NS	NS	NS	NS	NS	NS
10/22/2012	2,540	YES	Since 10/4	45	6,544	109.4	66,255	1,378	22,000	419	4,987	19.95	2,804	14.89	4,100	12.68	18,567	337	25,300	414	2,560	17.14	6,511	140.9	NS	231

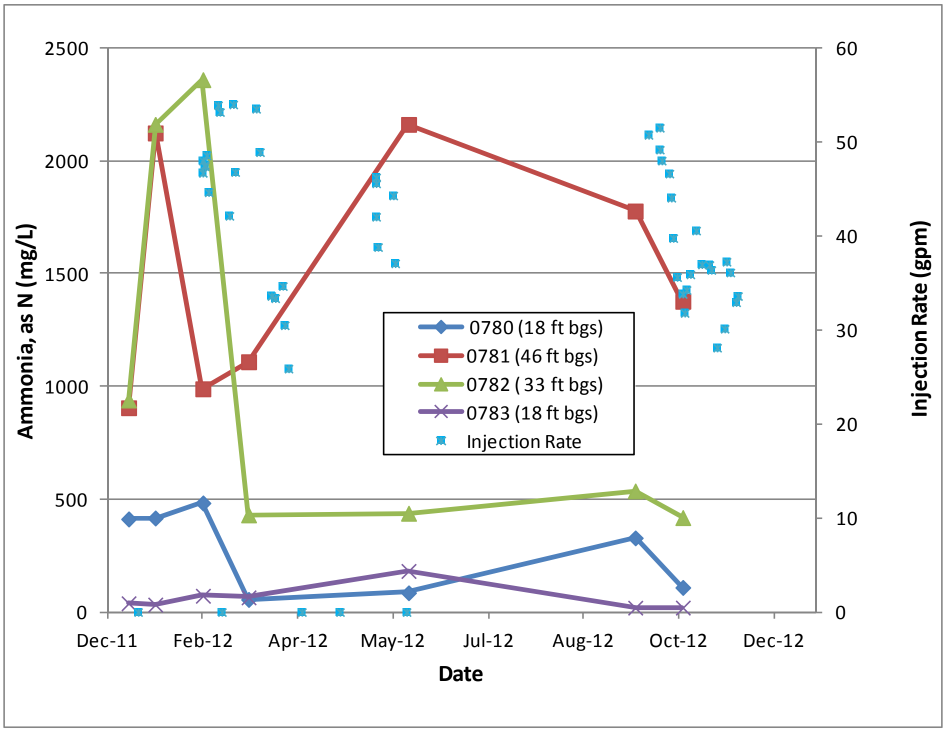


Figure C-1. Ammonia Concentration of Upgradient CF4 Observation Wells in 2012

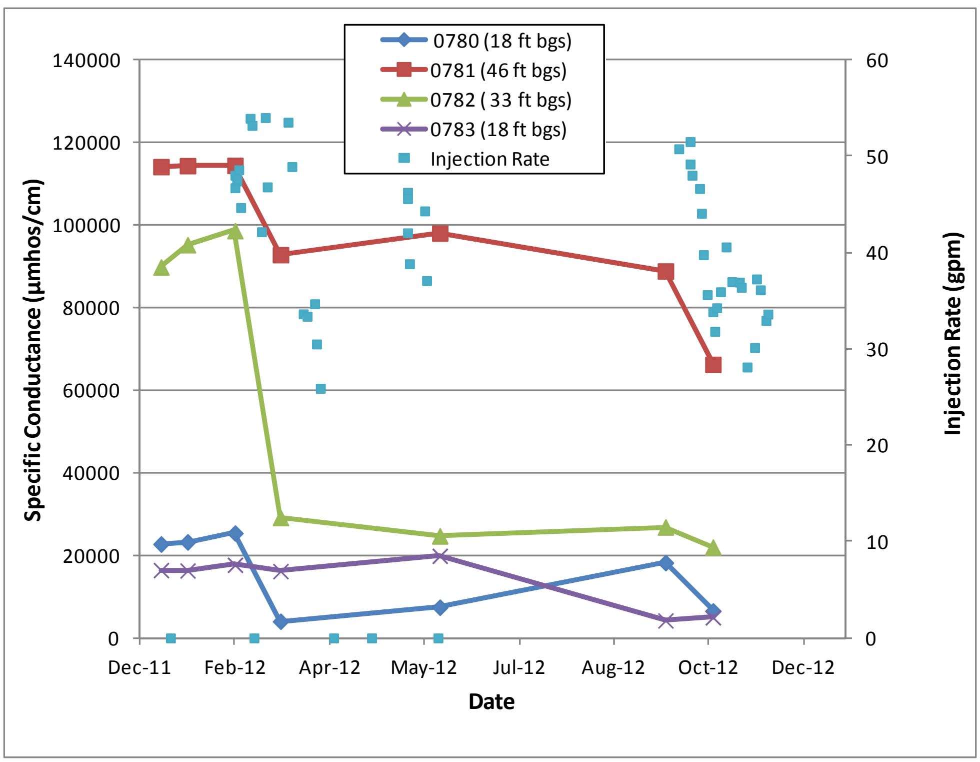


Figure C-2. Specific Conductance of Upgradient CF4 Observation Wells in 2012

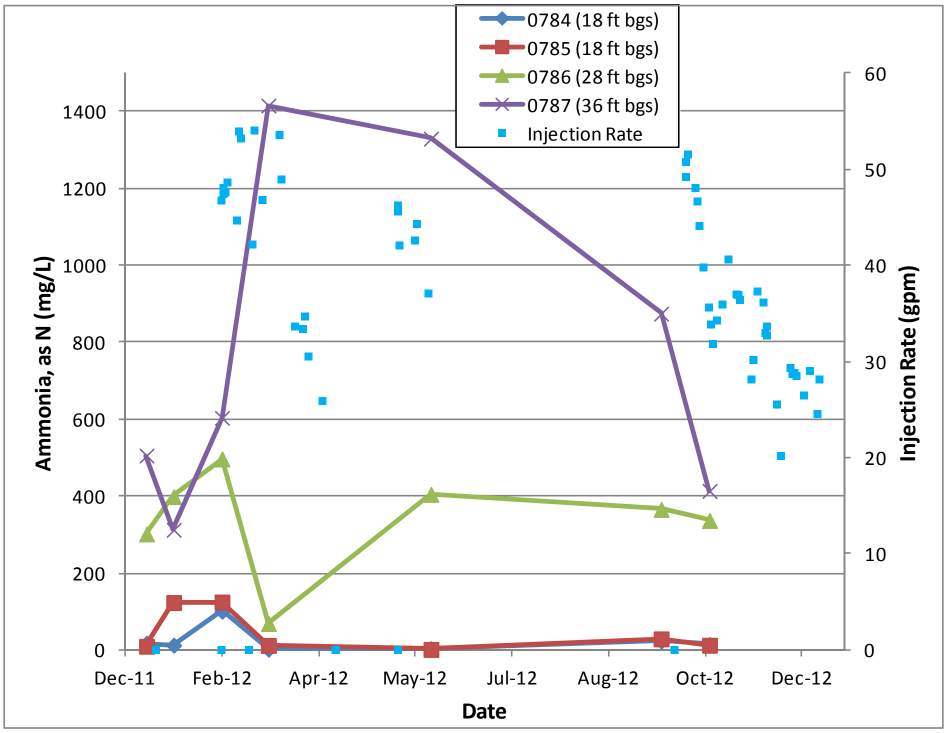


Figure C-3. Ammonia Concentration in Downgradient CF4 Observation Wells in 2012

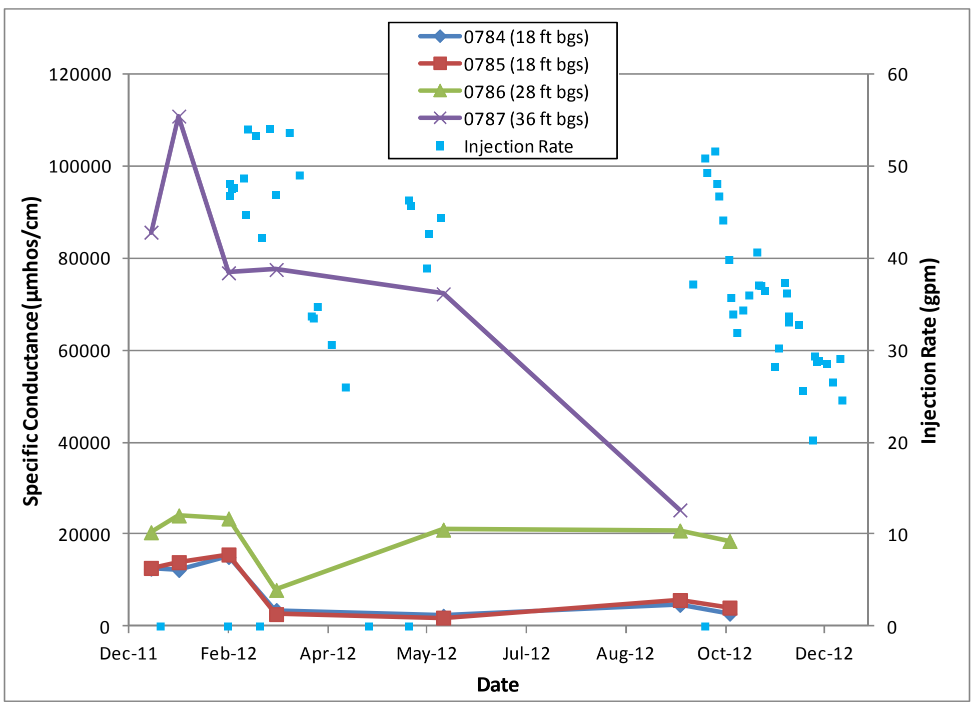


Figure C-4. Specific Conductance in Downgradient CF4 Observation Wells in 2012

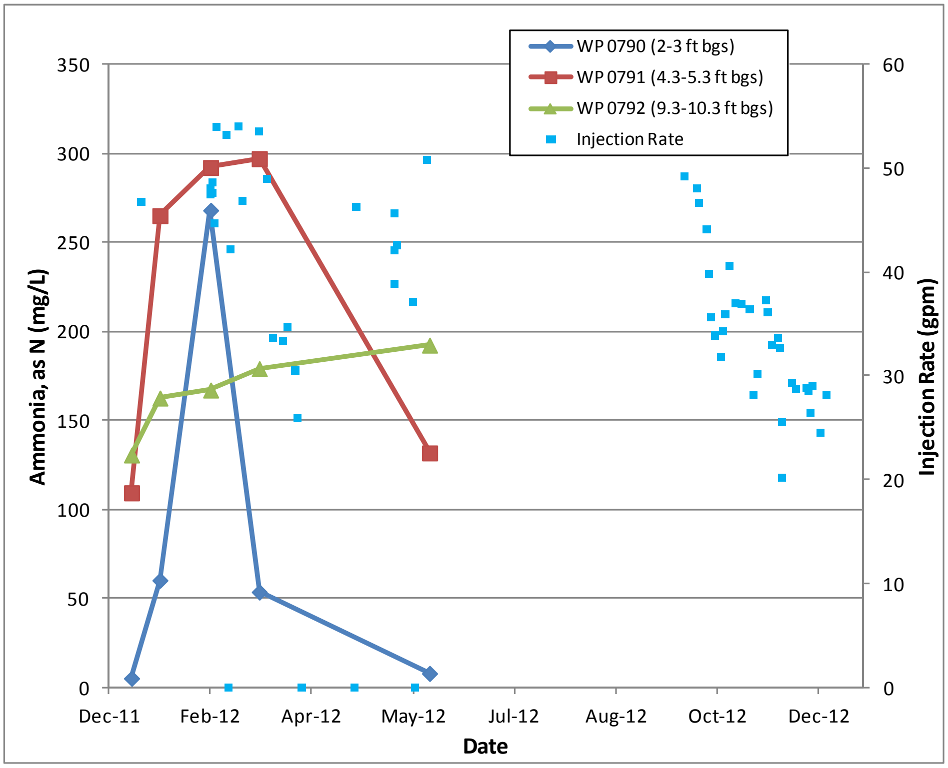


Figure C-5. Ammonia Concentration in CF4 Well Points in 2012

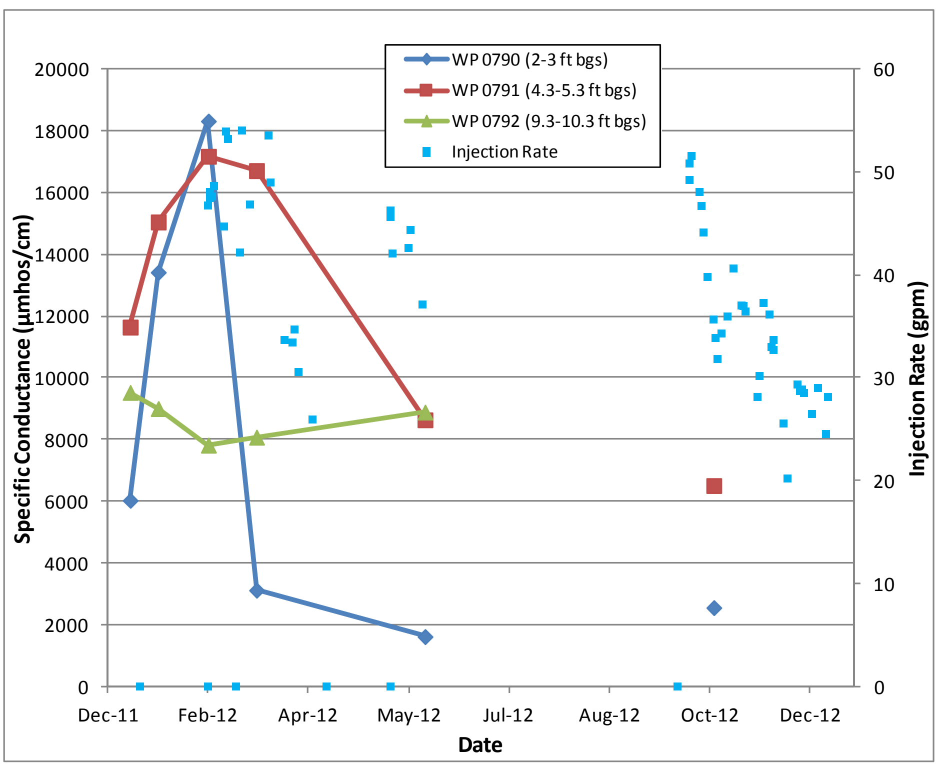


Figure C-6. Specific Conductance in CF4 Well Points in 2012

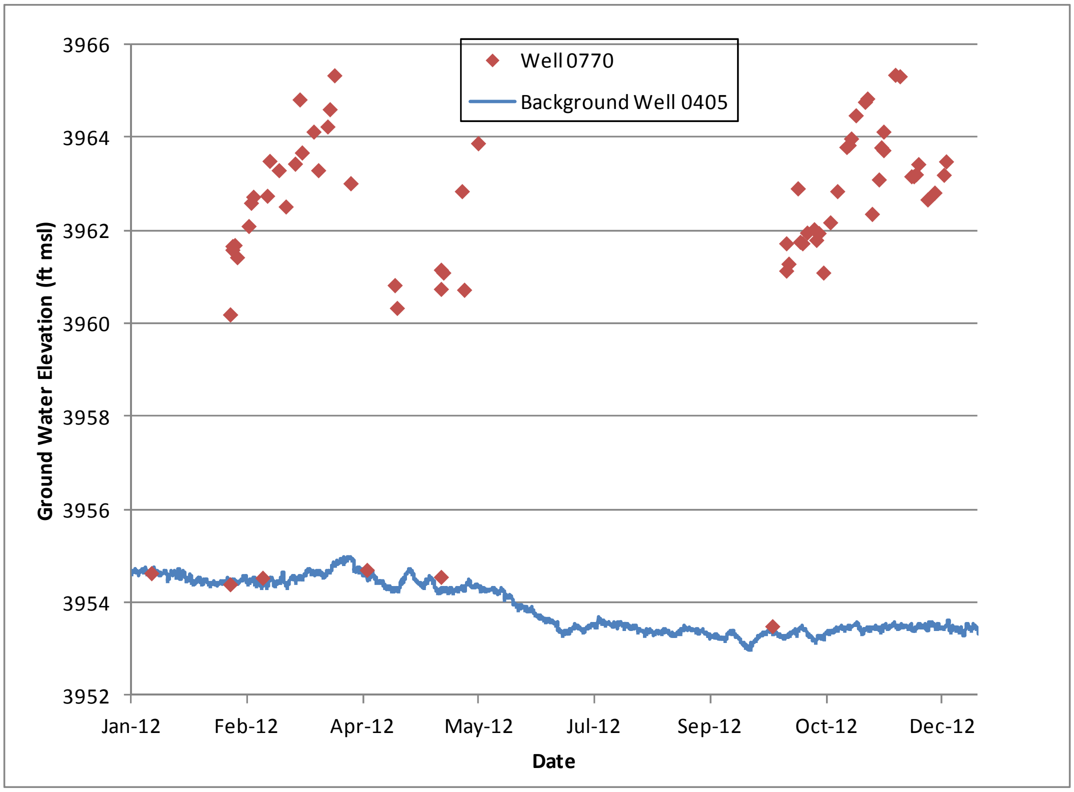


Figure C-7. Freshwater Mounding in Remediation Well 0770 During Injection

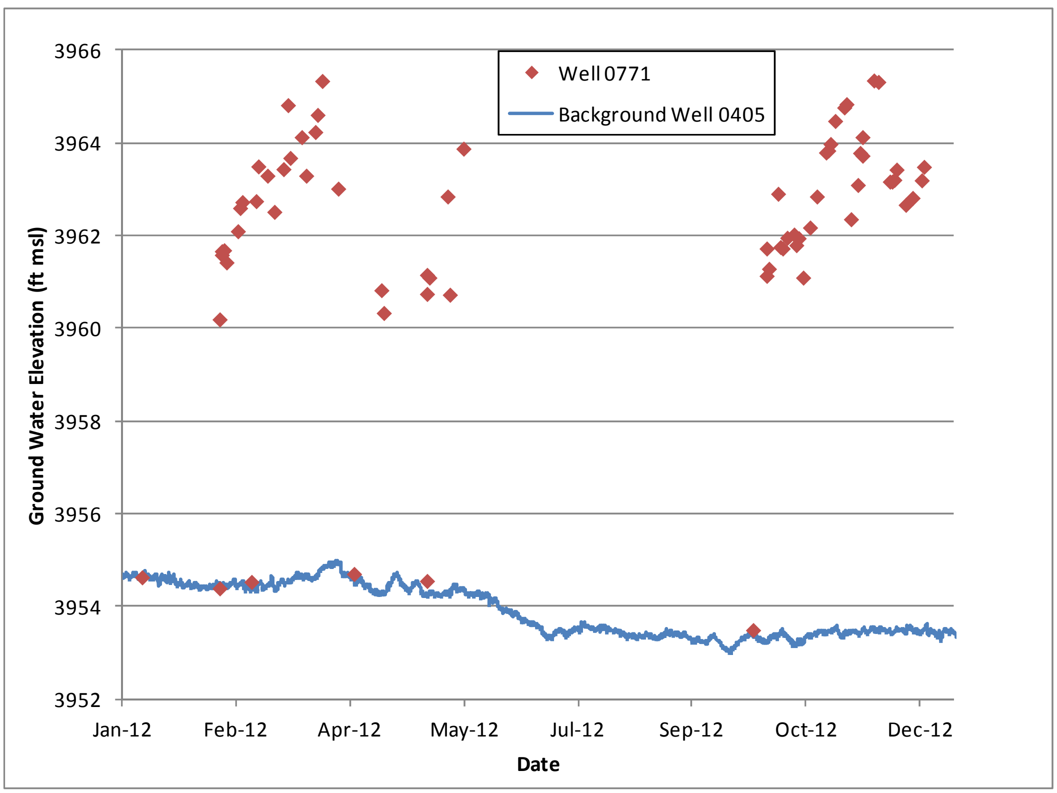


Figure C-8. Freshwater Mounding in Remediation Well 0771 During Injection

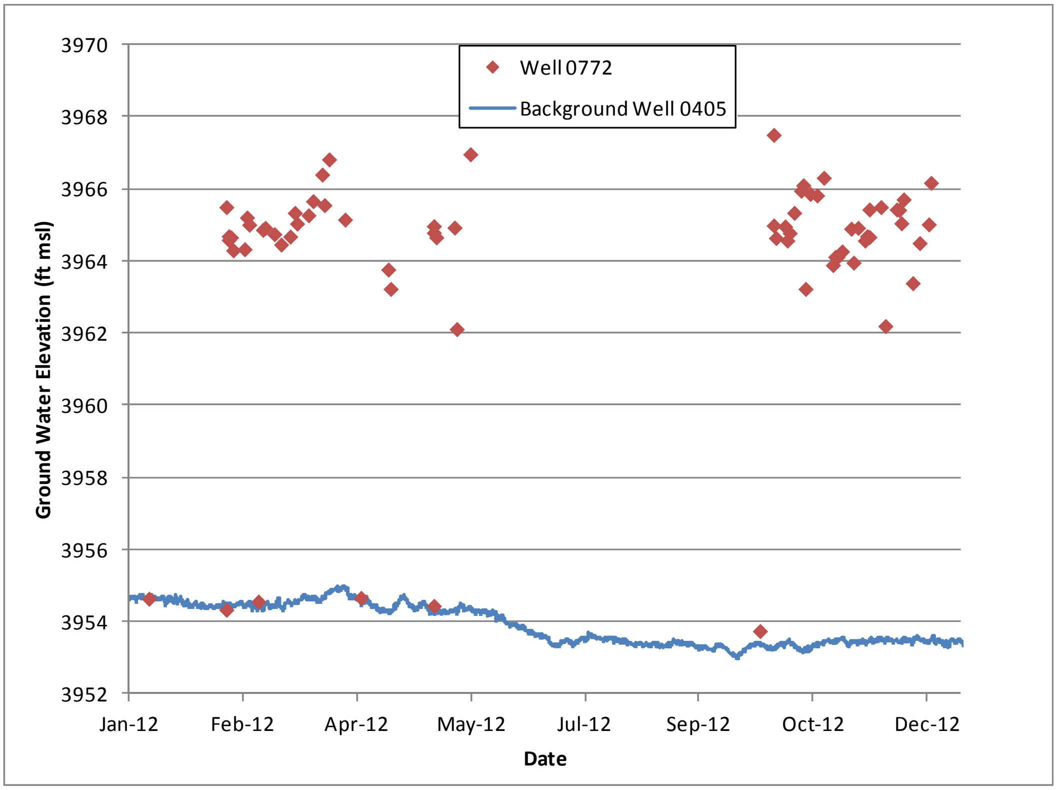


Figure C-9. Freshwater Mounding in Remediation Well 0772 During Injection

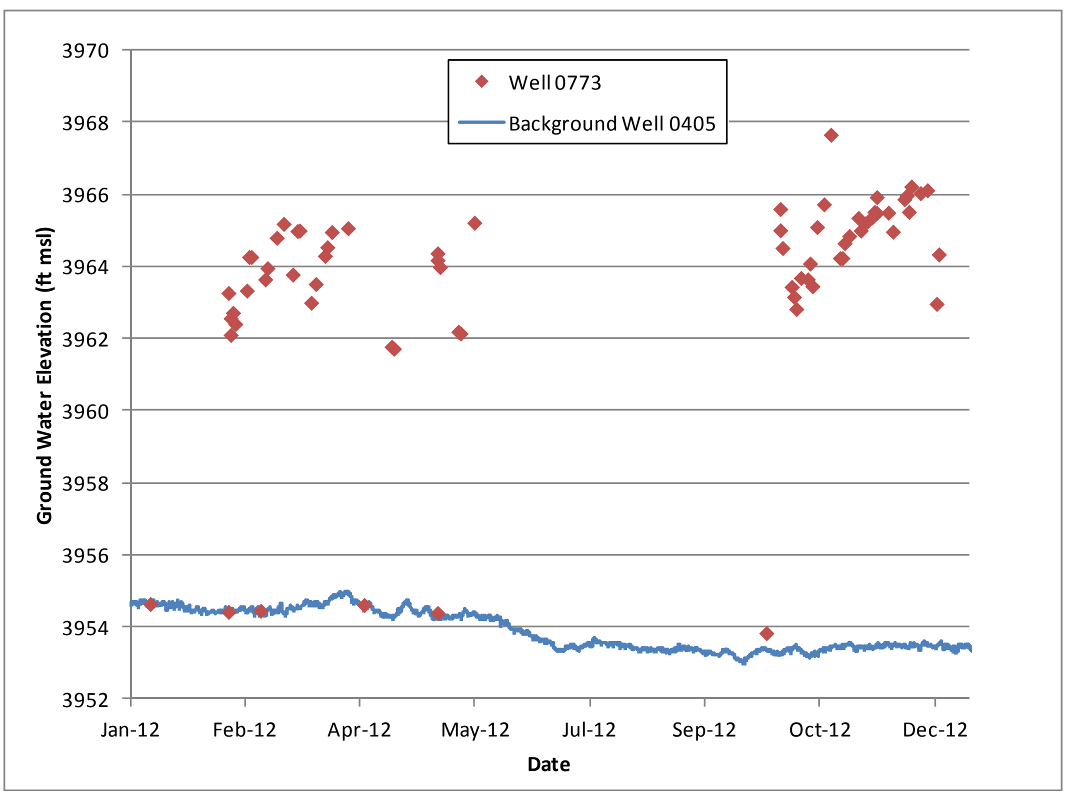


Figure C-10. Freshwater Mounding in Remediation Well 0773 During Injection

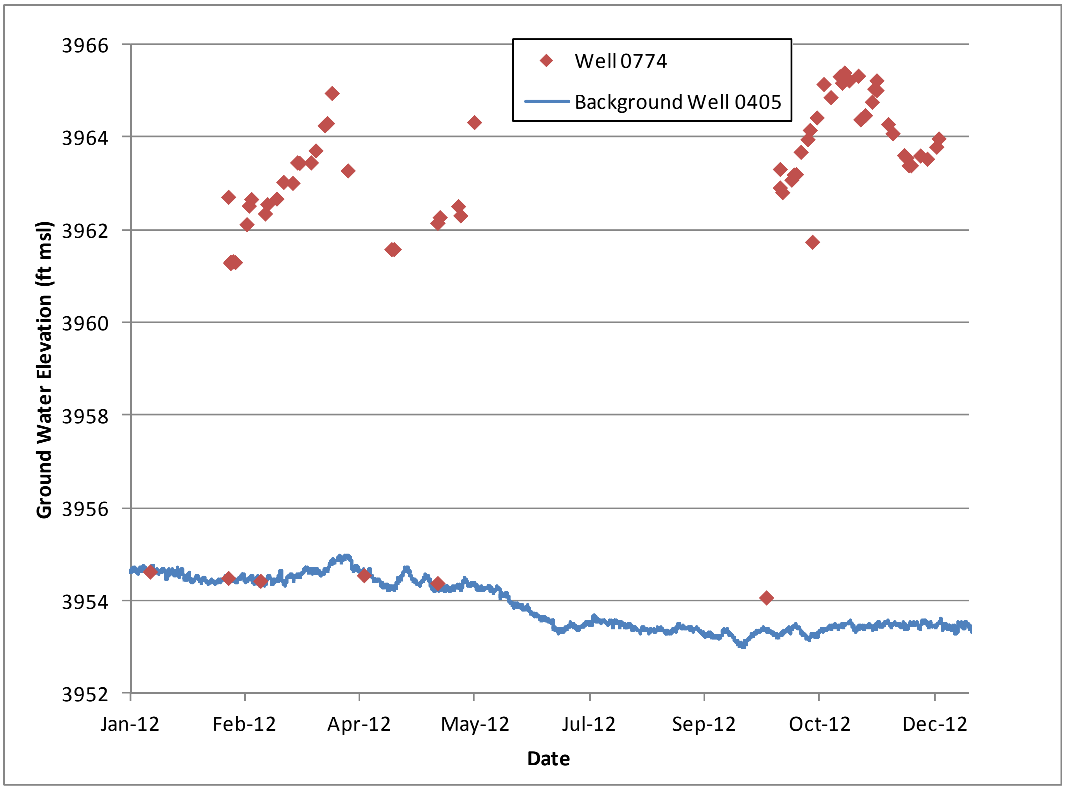


Figure C-11. Freshwater Mounding in Remediation Well 0774 During Injection

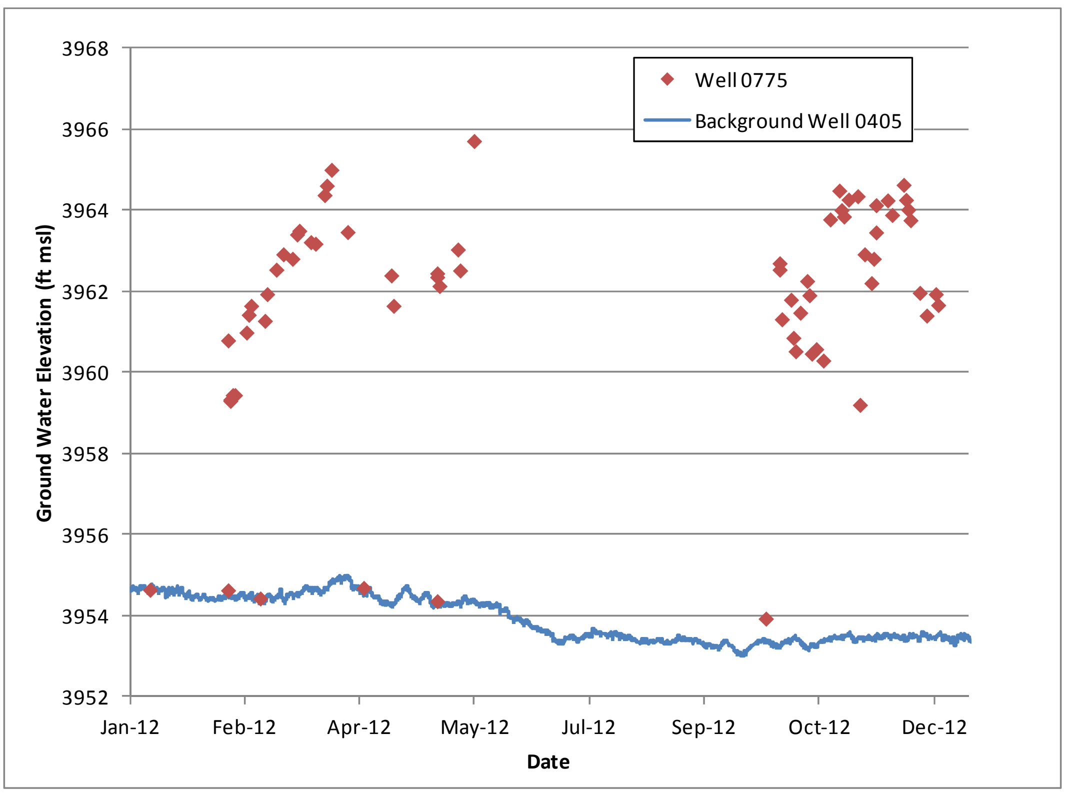


Figure C-12. Freshwater Mounding in Remediation Well 0775 During Injection

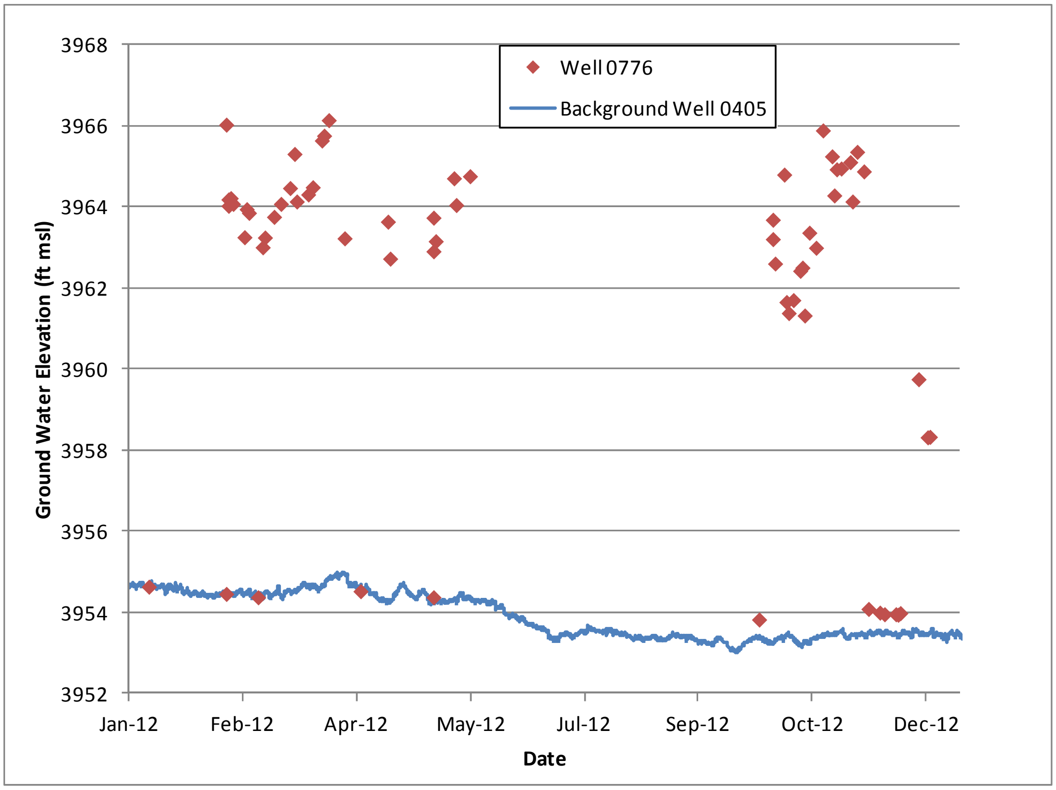


Figure C-13. Freshwater Mounding in Remediation Well 0776 During Injection

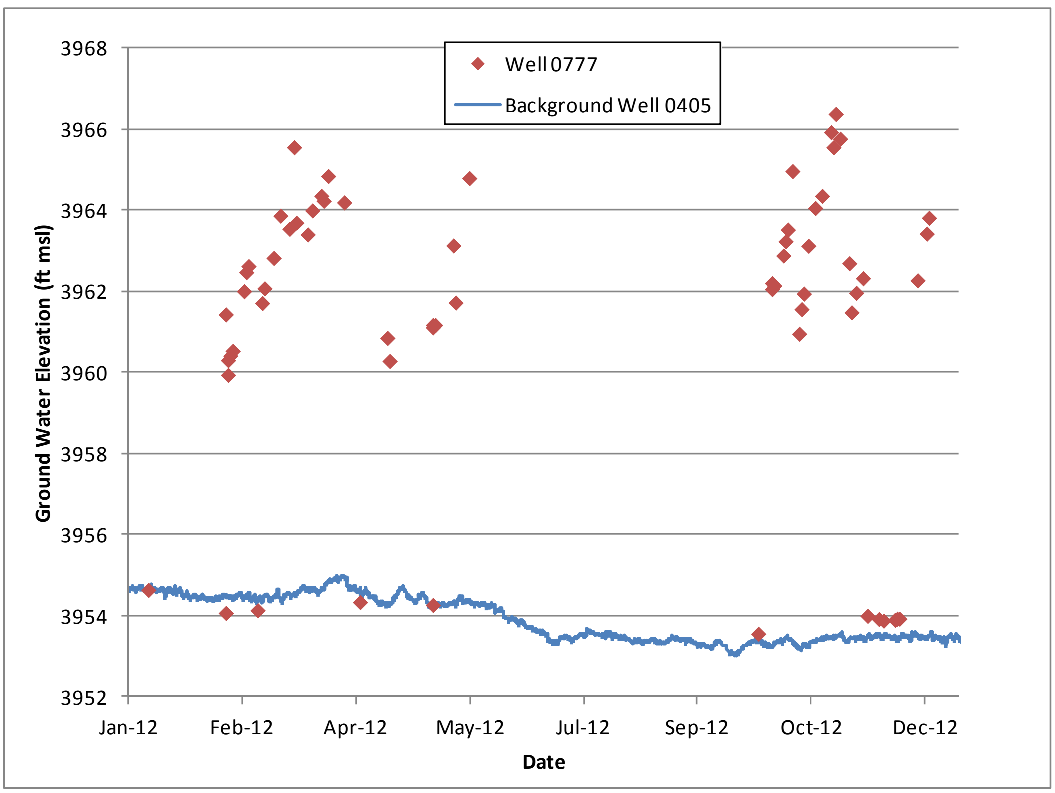


Figure C-14. Freshwater Mounding in Remediation Well 0777 During Injection

Appendix C. Tables and Data for 2012 Freshwater Injection (*continued*)

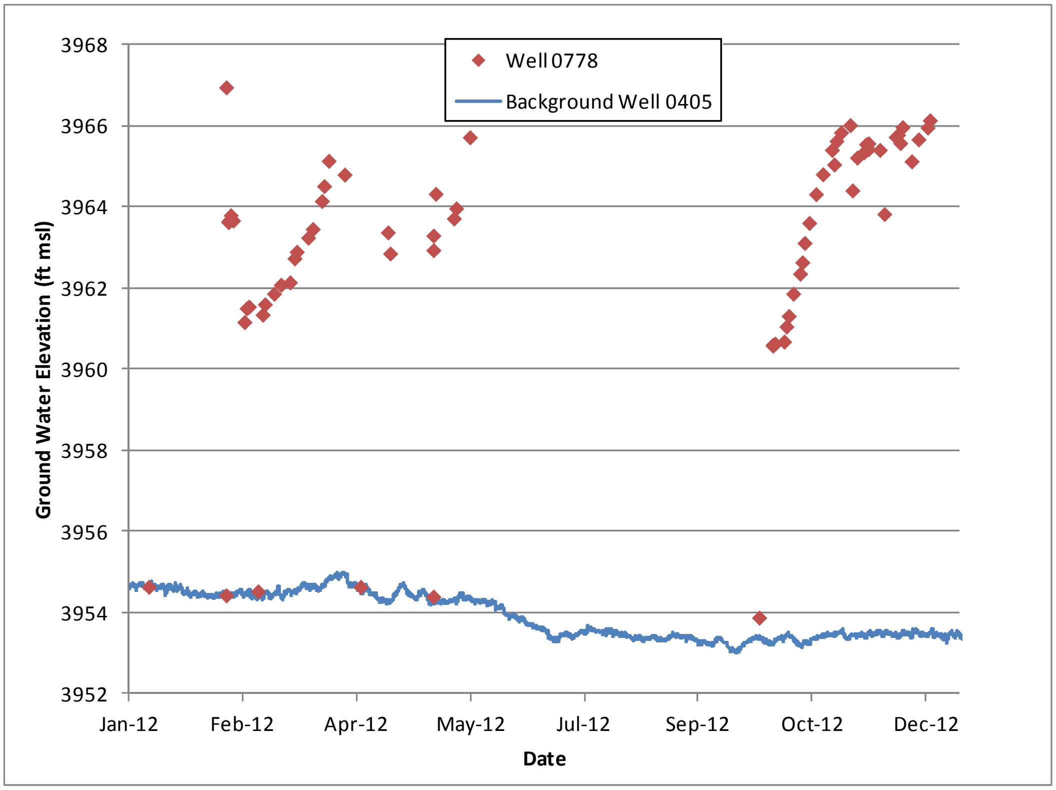


Figure C-15. Freshwater Mounding in Remediation Well 0778 During Injection

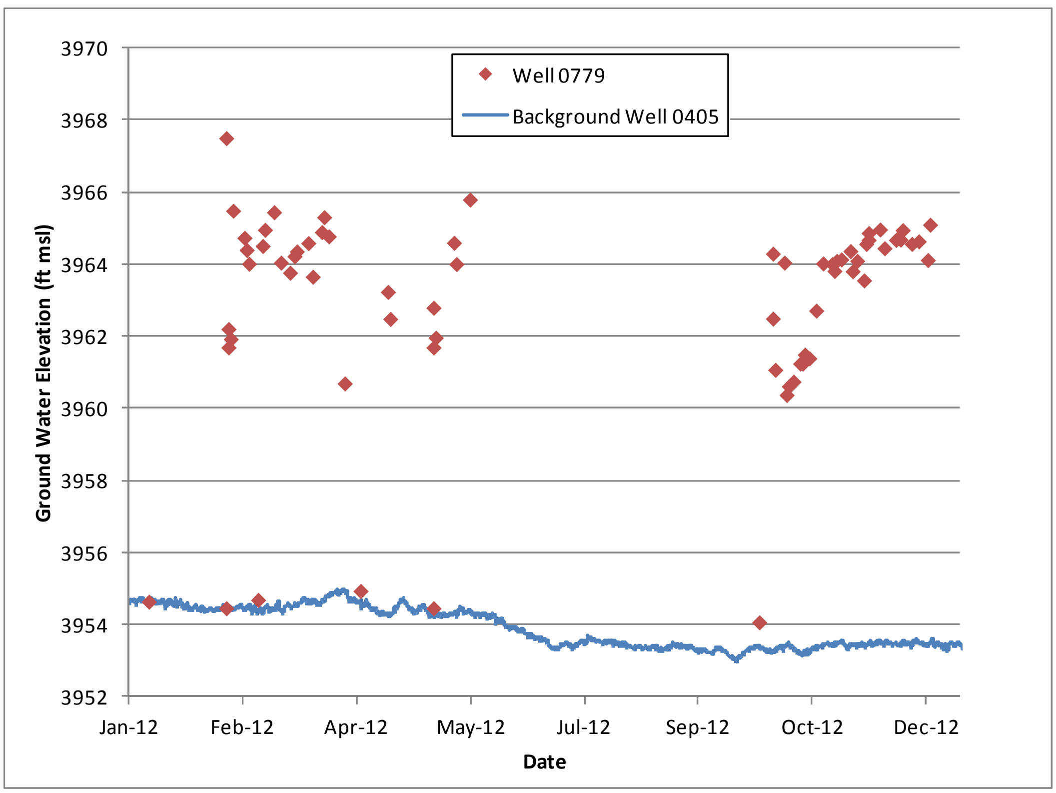
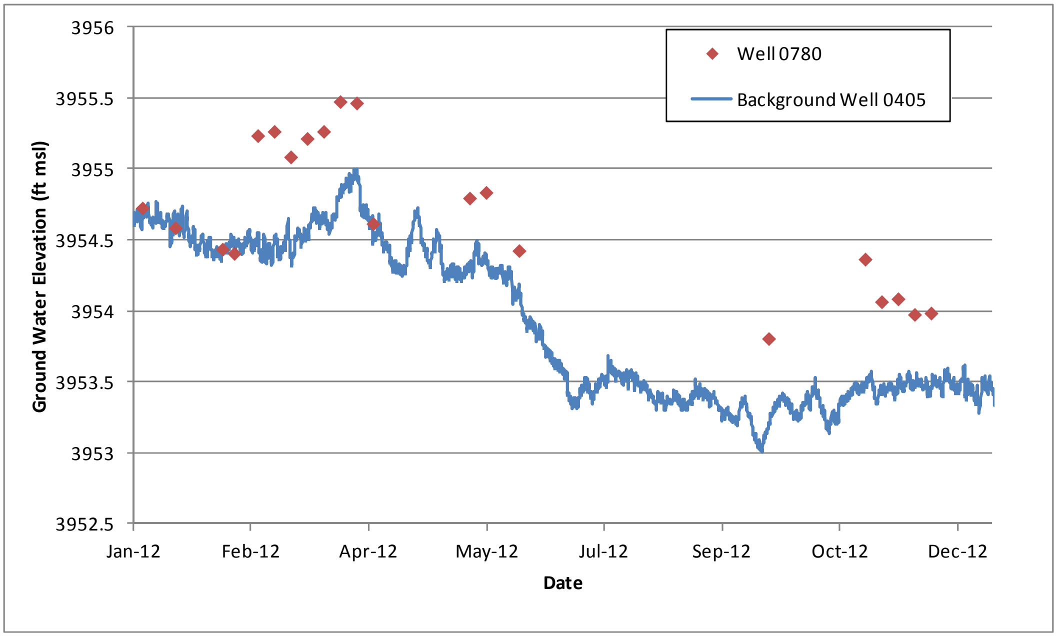
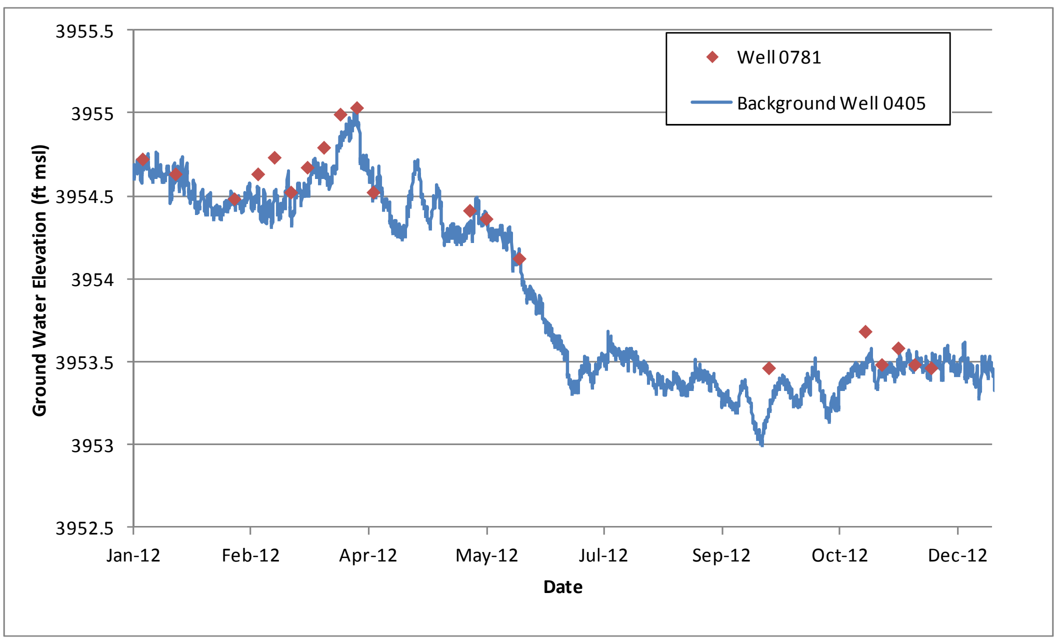


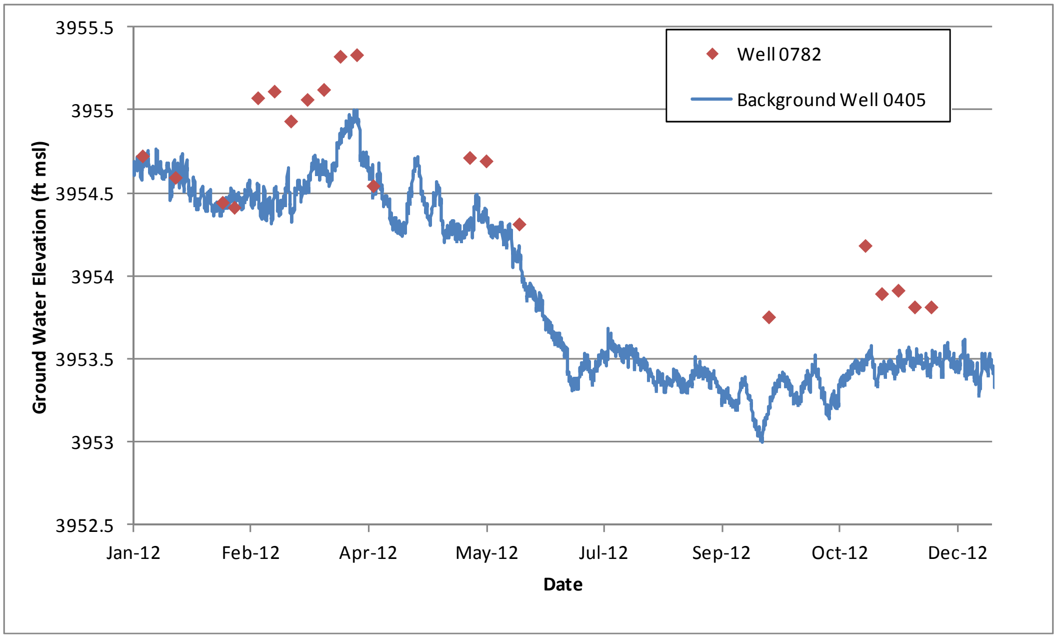
Figure C-16. Freshwater Mounding in Remediation Well 0779 During Injection



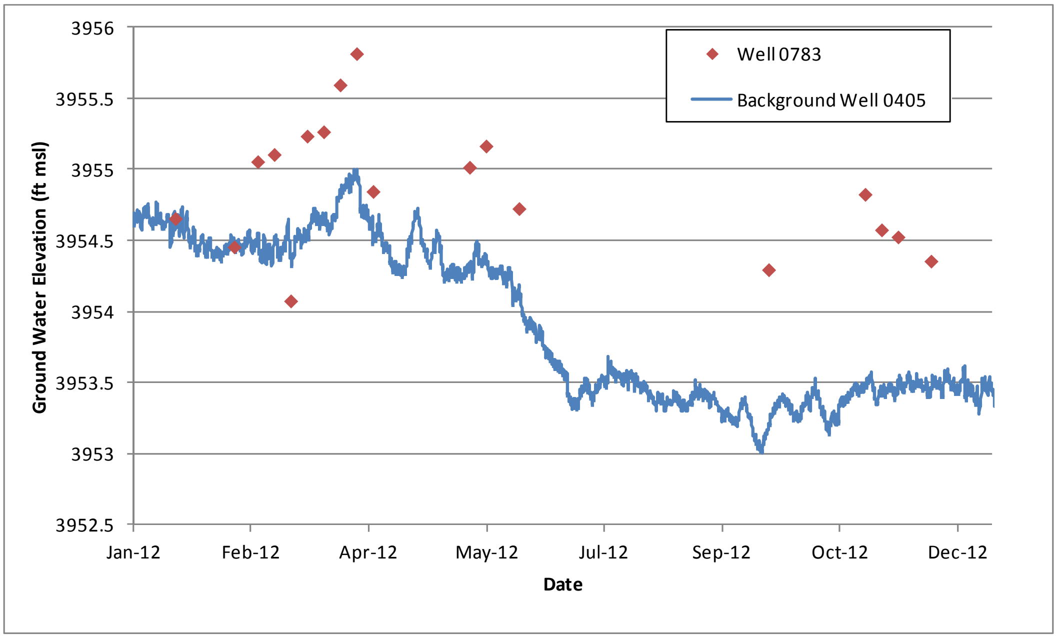
C-17. Freshwater Mounding in Observation Well 0780



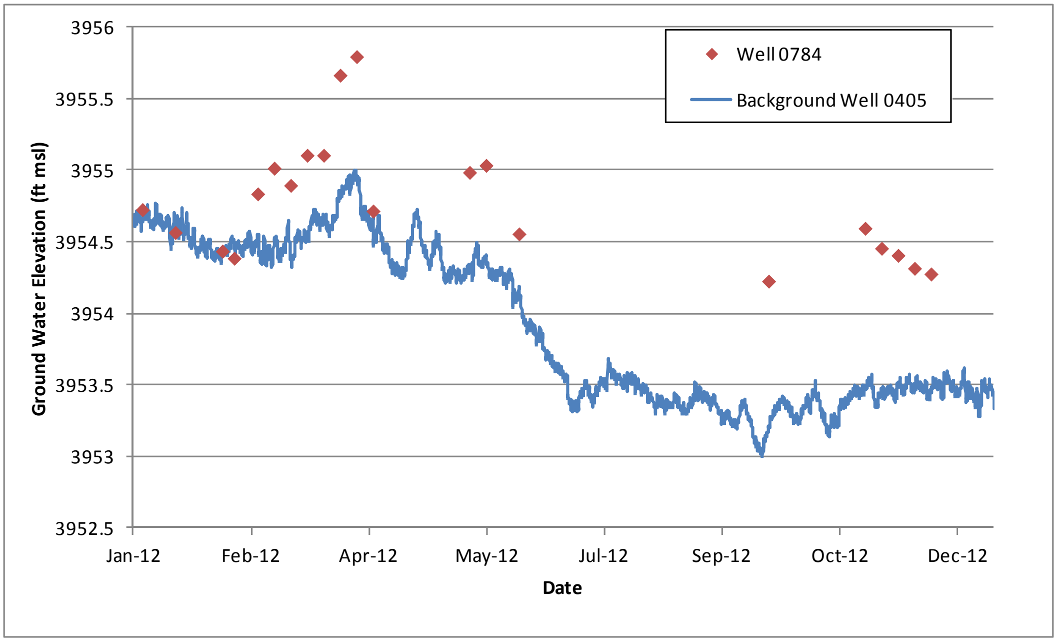
C-18. Freshwater Mounding in Observation Well 0781



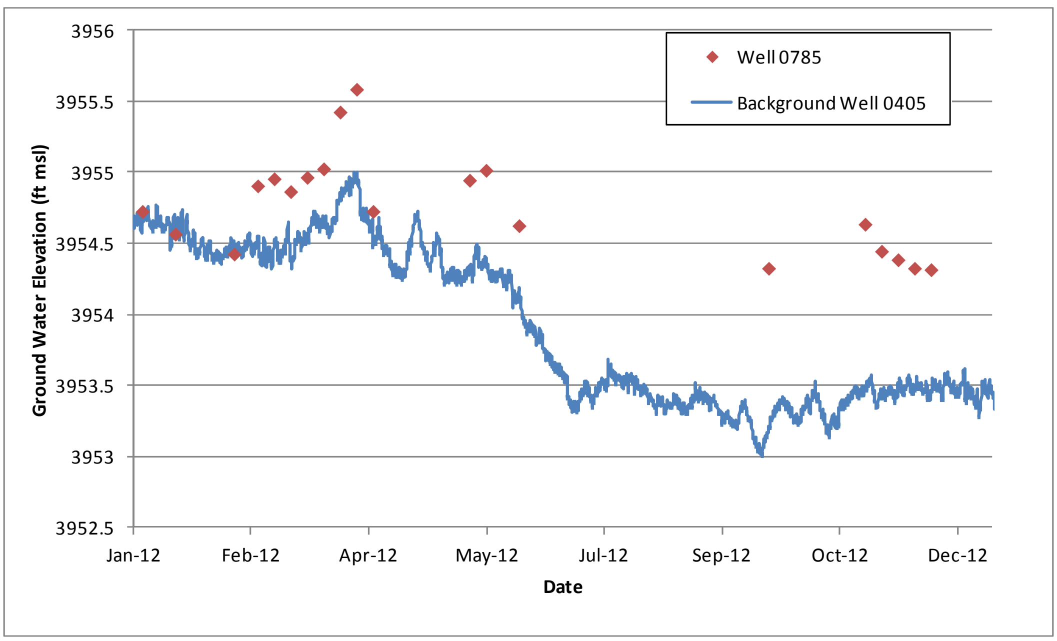
C-19. Freshwater Mounding in Observation Well 0782



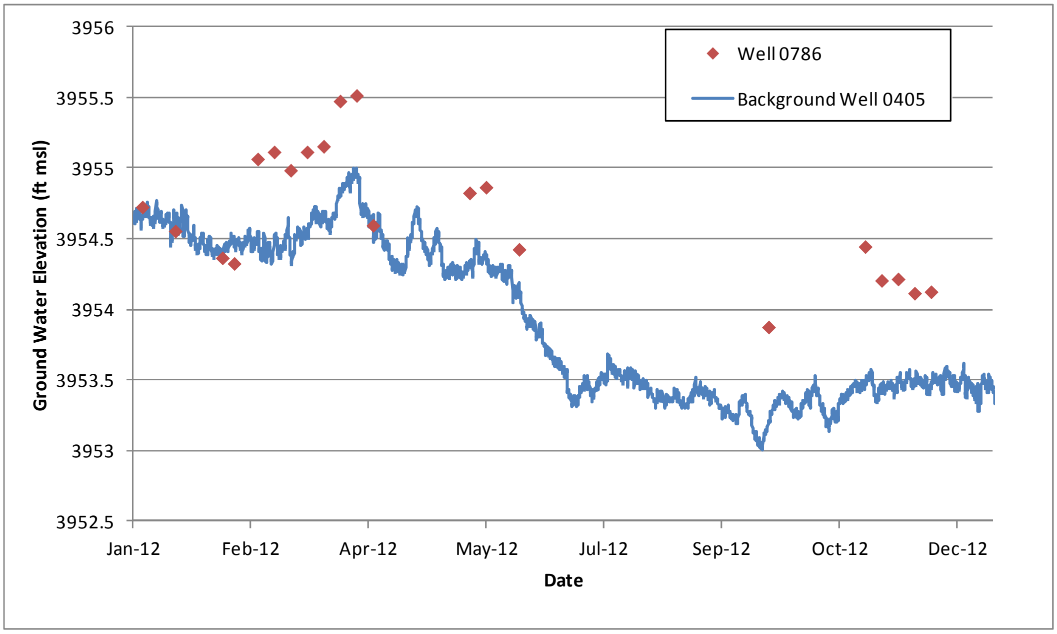
C-20. Freshwater Mounding in Observation Well 0783



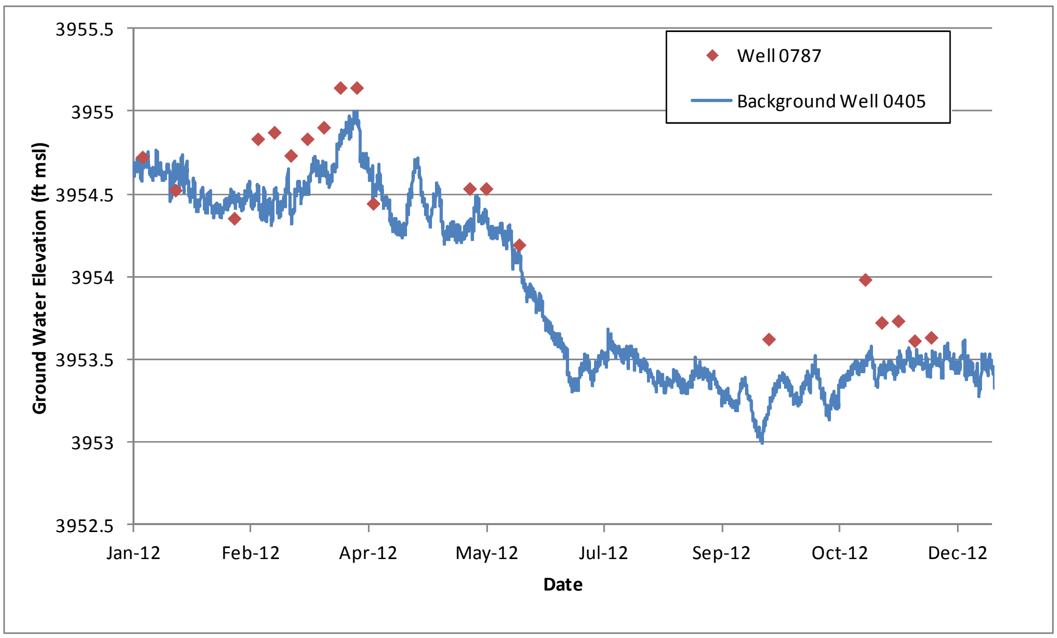
C-21. Freshwater Mounding in Observation Well 0784



C-22. Freshwater Mounding in Observation Well 0785



C-23. Freshwater Mounding in Observation Well 0786



C-24. Freshwater Mounding in Observation Well 0787