DOE–EM/GJTAC2233

Office of Environmental Management – Grand Junction

MOAB UTAH UMTRA Project

Moab UMTRA Project
2016 Ground Water Program Report

July 2017

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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Acronyms and Abbreviations

ALS	ALS Global
bgs	below ground surface
CA	Contamination Area
CF	configuration
cfr	Code of Federal Regulations
cfs	cubic feet per second
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ft	feet or foot
gal	gallon or gallons
gpm	gallons per minute
HMI	human machine interface
IA	interim action
kg	kilograms
lb	pounds
µmhos/cm	micromhos per centimeter
mg/L	milligrams per liter
mil	million or millions
msl	mean sea level
TDS	total dissolved solids
UMTRA	Uranium Mill Tailings Remedial Action

1.0 Introduction

1.1 Purpose and Scope

The purpose of the annual Ground Water Program Report is to assess the performance measures the U.S. Department of Energy (DOE) has taken to remediate 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 2016 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 by removing 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. When necessary, surface water diversion takes place in the side channel adjacent to the IA well field when the area is considered a suitable habitat for endangered young-of-year fish species. Ground water and surface water monitoring is performed in conjunction with injection and extraction operations and through water level and analytical data. Surface water diversion performance is measured by analytical data.

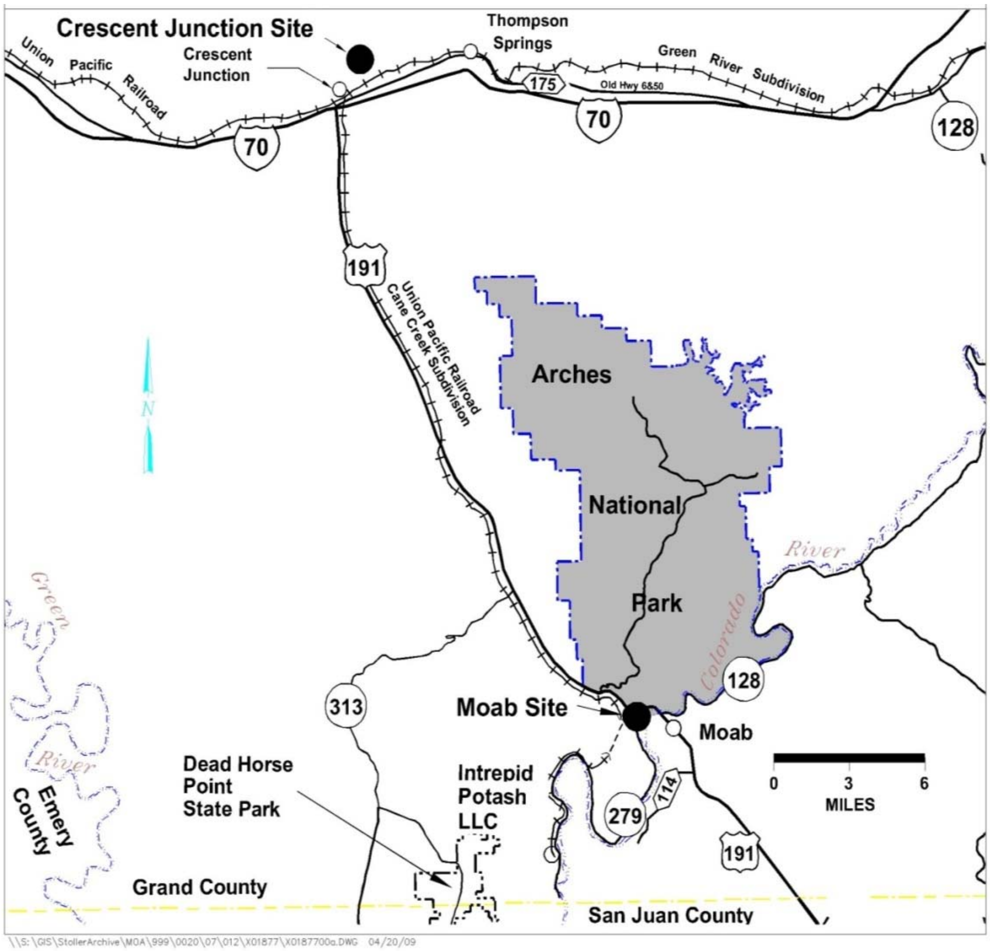

Figure 1. Location of the Moab Project Site

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 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 to select and design a final ground water remedy.

Contaminated ground water from the shallow plume is extracted through a series of eight extraction wells (CF5). The IA system also includes injection of diverted river water into the underlying alluvium through remediation wells (potential CFs 1 through 4) and an infiltration trench installed near the western bank of the river. A surface water diversion system adjacent to the IA well field delivers fresh water to the side channel adjacent to the IA well field. This diversion occurs when the channel is considered a suitable habitat for endangered young-of-year fish species and the ammonia concentrations exceed either the acute or chronic established EPA (Environmental Protection Agency) criteria. Monitoring wells are also part of the IA system for evaluation purposes. In 2016, CFs 1 and 4 were used for freshwater injection; extraction operations occurred at CF5.

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 the Colorado River 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 an 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 July 2016 and exhibits how ground water underlying the site discharges into the Colorado River. The river flow ranged from 5,910 to 6,670 cubic feet per second (cfs) when the ground water elevation was measured. Figure 4 shows the ground water contours in December/January 2016/2017, when the river flow ranged from 2,150 to 2,630 cfs. The ground water elevation in July was higher due to the bank storage during the peak river flow on the Colorado River.

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, which is equivalent to 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, which allows this fluid 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).

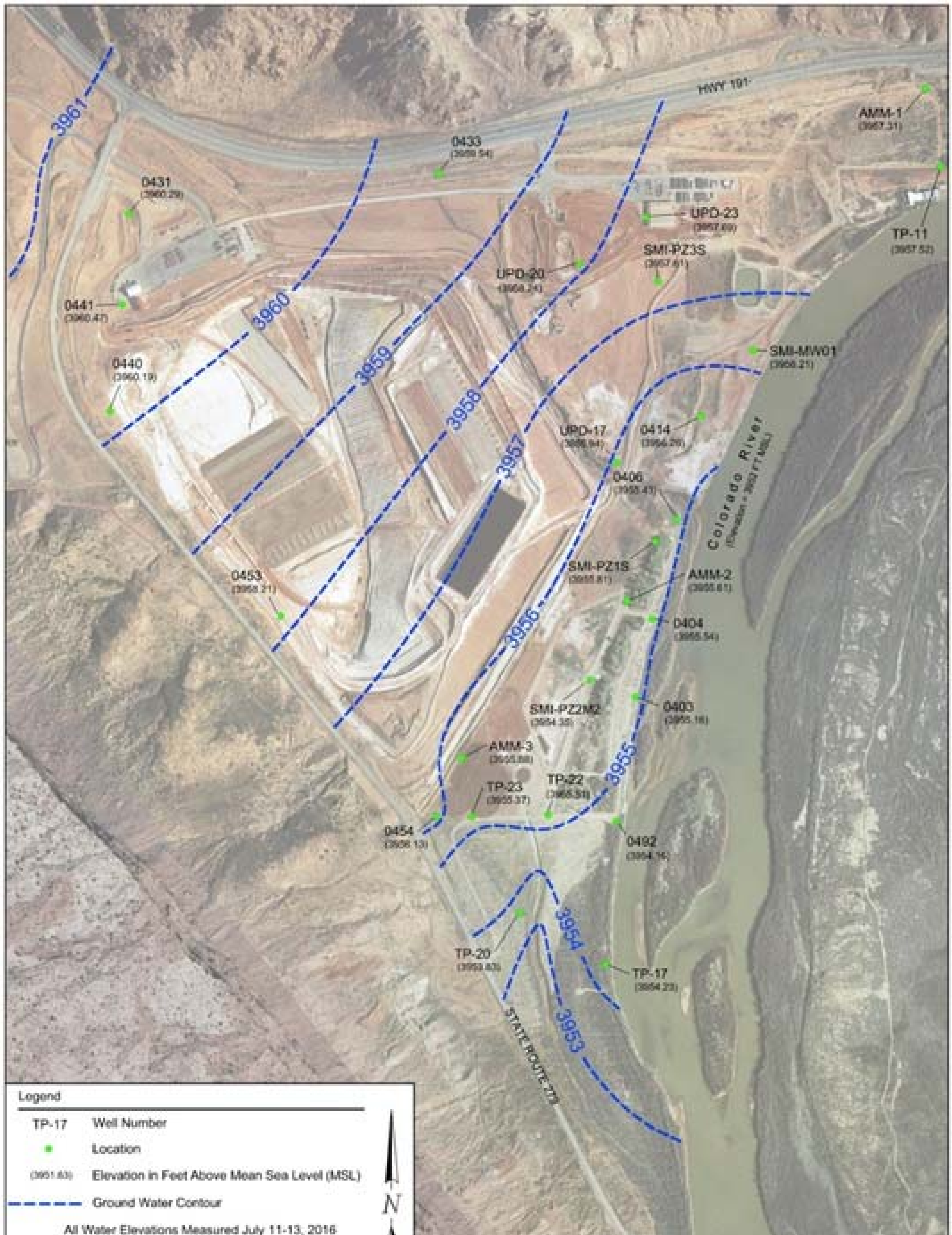

Figure 3. Site-wide Water Contour Map July 11 through 13, 2016

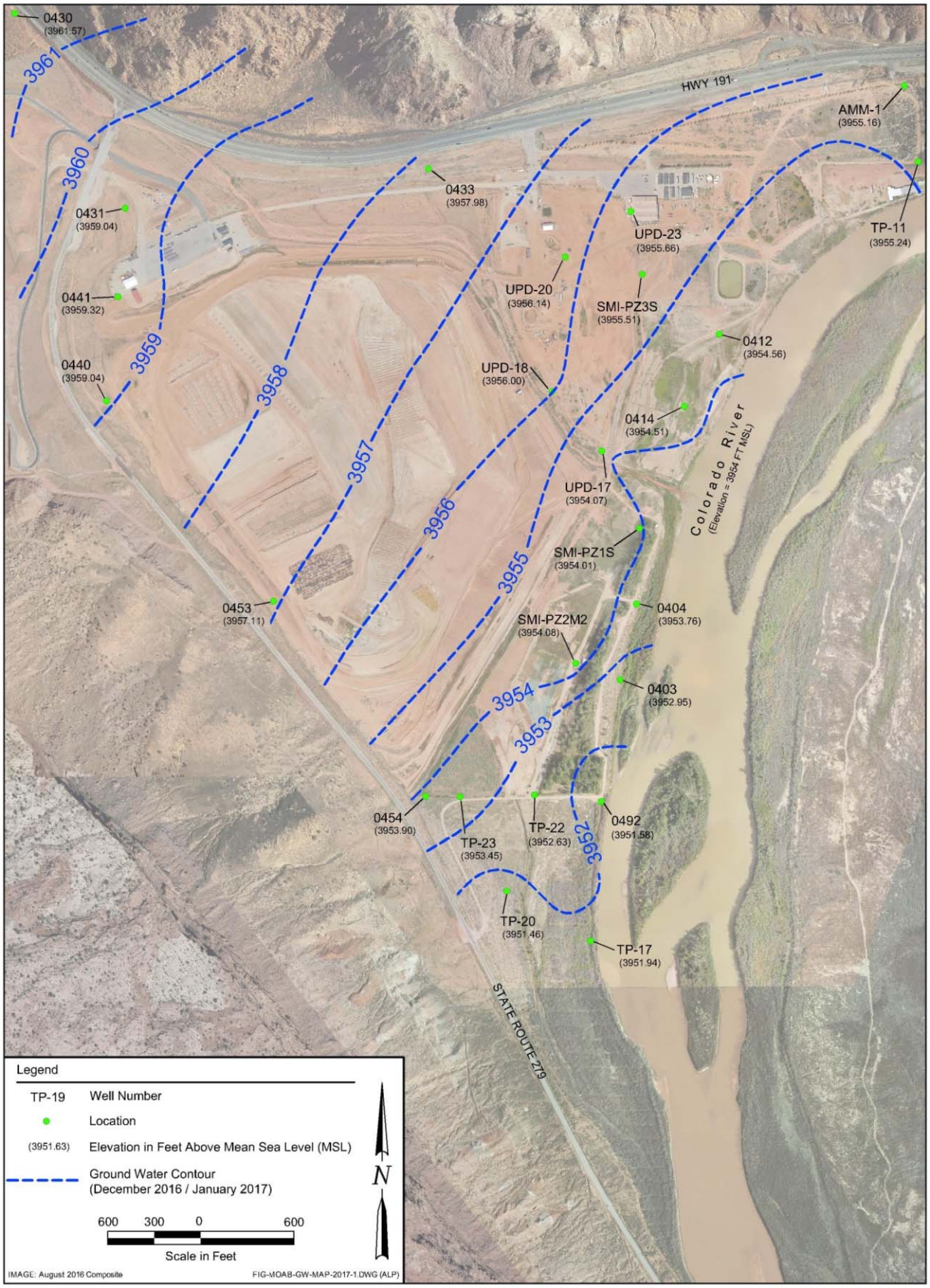

Figure 4. Site-wide Water Contour Map December/January 2016/2017

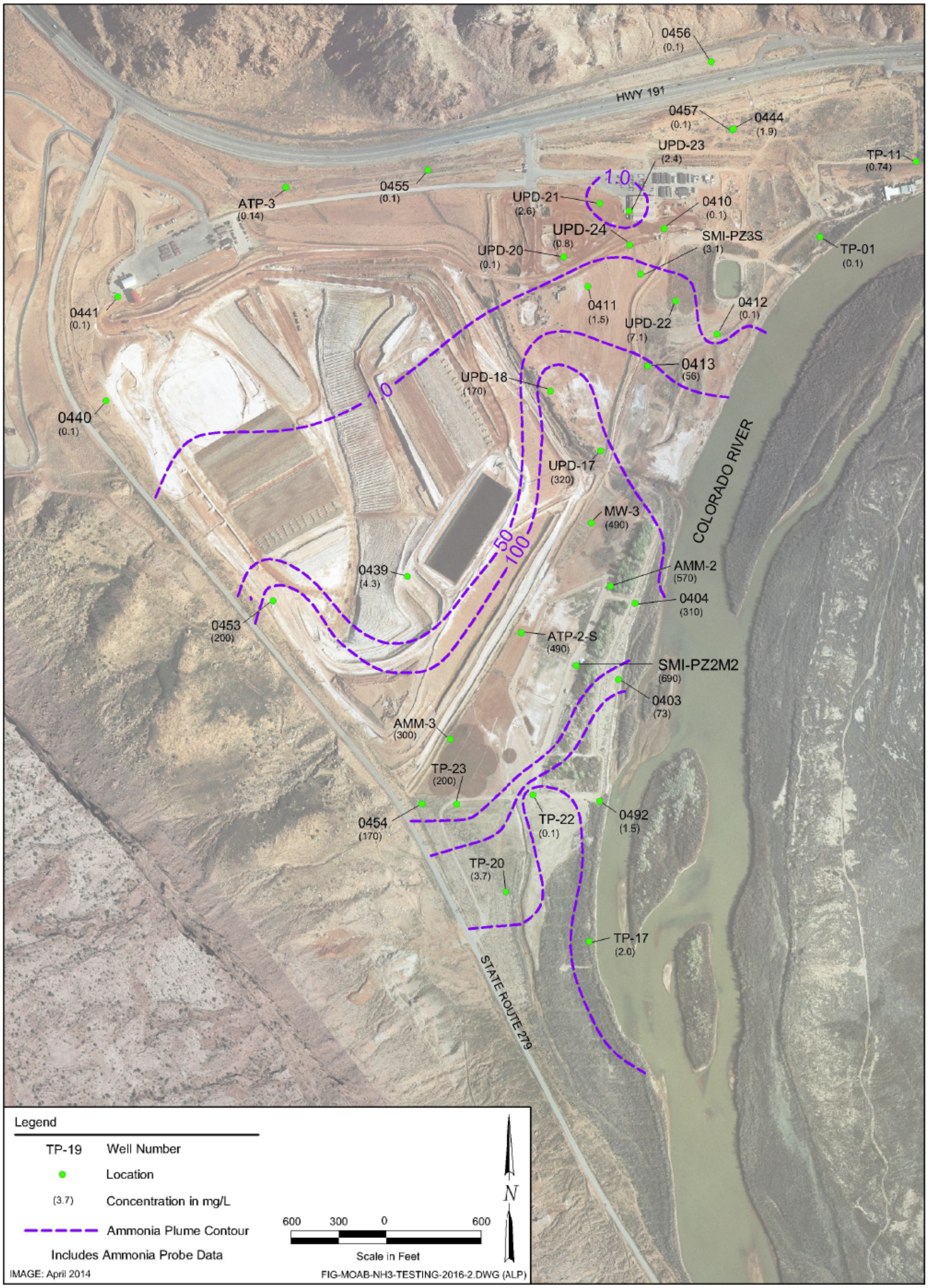

Figure 5. Ammonia Plume in Shallow Ground Water June/July 2016

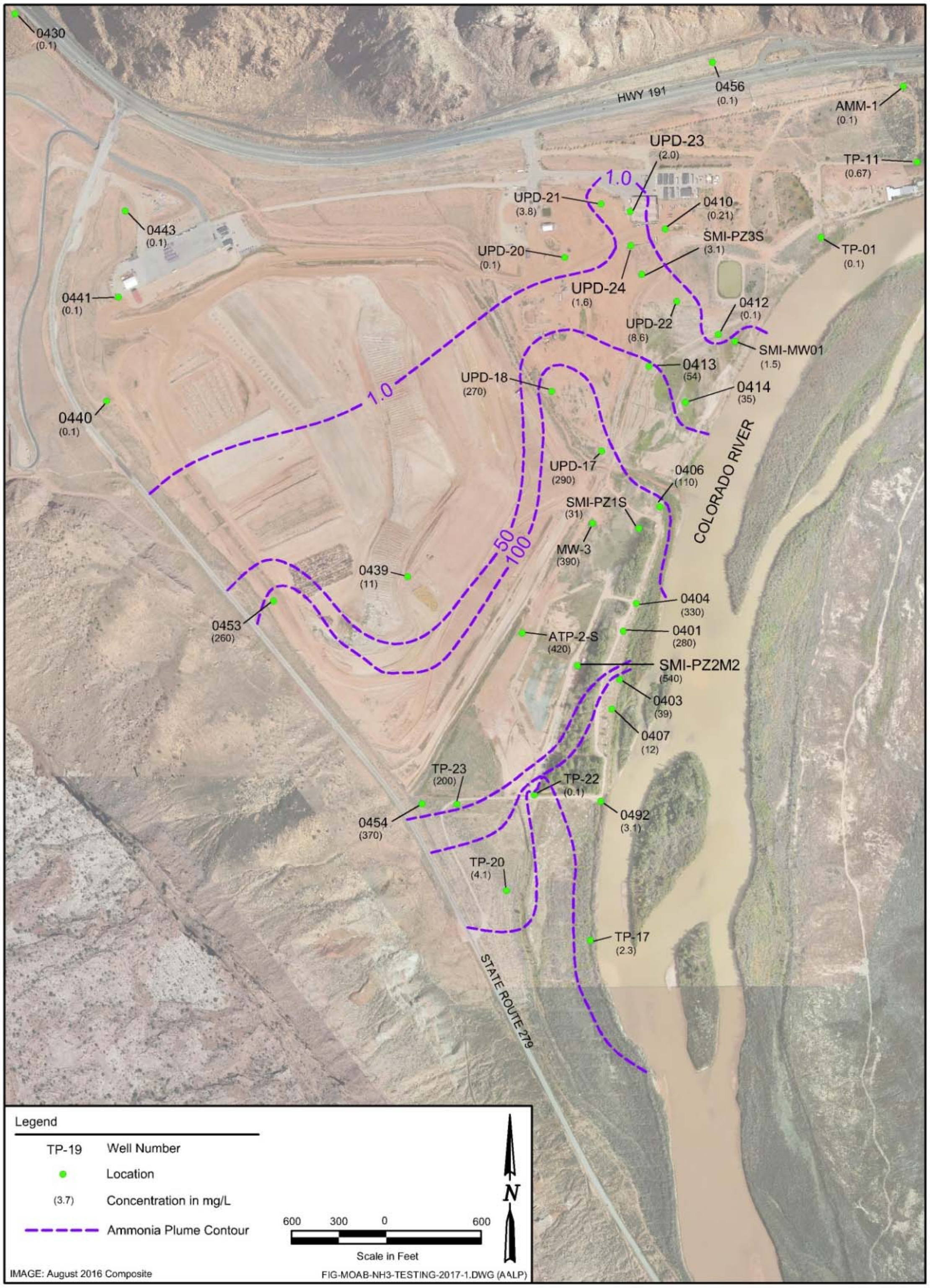

Figure 6. Ammonia Plume in Shallow Ground Water December/January 2016/17

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 fresh water due to density stratification of the brine zone. Figure 5 shows the ammonia plume in June/July 2016, and Figure 6 shows the ammonia plume in December/January 2016/17. The two plume maps are comparable.

There is no standard associated with ammonia, while the uranium ground water standard of 0.044 mg/L is based on Table 1 in Title 40 Code of Federal Regulations Part 192, Subpart A (40 CFR 192A), “Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings, Standards for the Control of Residual Radioactive Materials from Inactive Uranium Processing Sites.” 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 2016. The uranium plume is similar in the spring and winter.

2.3 Surface Water/Ground Water Interaction

Previous investigations have shown that Colorado River flows impact the ground water elevations and contaminant concentrations in the well field. For the majority of the year, when the river is experiencing baseflows (less than 5,000 cfs), ground water discharges into the river (gaining conditions). As the river flow increases in response to the spring runoff, the river changes from gaining to losing conditions and a freshwater lens starts to develop in the subsurface underlying the well field. At this time, the ground water gradient direction reverses in the vicinity of the riverbank, and the ground water contaminant concentrations are diluted. Once the river flows subside, the river switches back from losing to gaining, the ground water gradient direction is re-established towards the river (to the southeast), and the freshwater lens recedes.

Figure 9 displays the ground water elevation and the elevation of the Colorado River in 2016. The elevation of the Colorado River was calculated using the river flows from the USGS Cisco gaging station and converting them to an elevation using the site rating curve included in the *Moab UMTRA Project Flood Mitigation Plan* (DOE-EM/GJTAC1640). The 2016 peak flow was 24,500 cfs (on June 9), which corresponds to an elevation of 3962.4 ft mean sea level (msl).

In 2016, between January and mid –April the Colorado River was under gaining conditions (when the ground water elevation was higher than the river surface elevation). Because of this elevation difference the ground water tends to readily discharge into the river (Figure 9). In mid-April as the river stage increased due to the spring runoff, the river switched to losing conditions (with the river surface elevation higher than the ground water elevation) through June 2016. Starting in July 2017, as typically occurs, the river switched back primarily to gaining conditions.

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 2016, the IA well field operations included extraction at CF5 and injection at CFs 1 and 4.

Figure 7. Uranium Plume in Shallow Ground Water June/July 2016

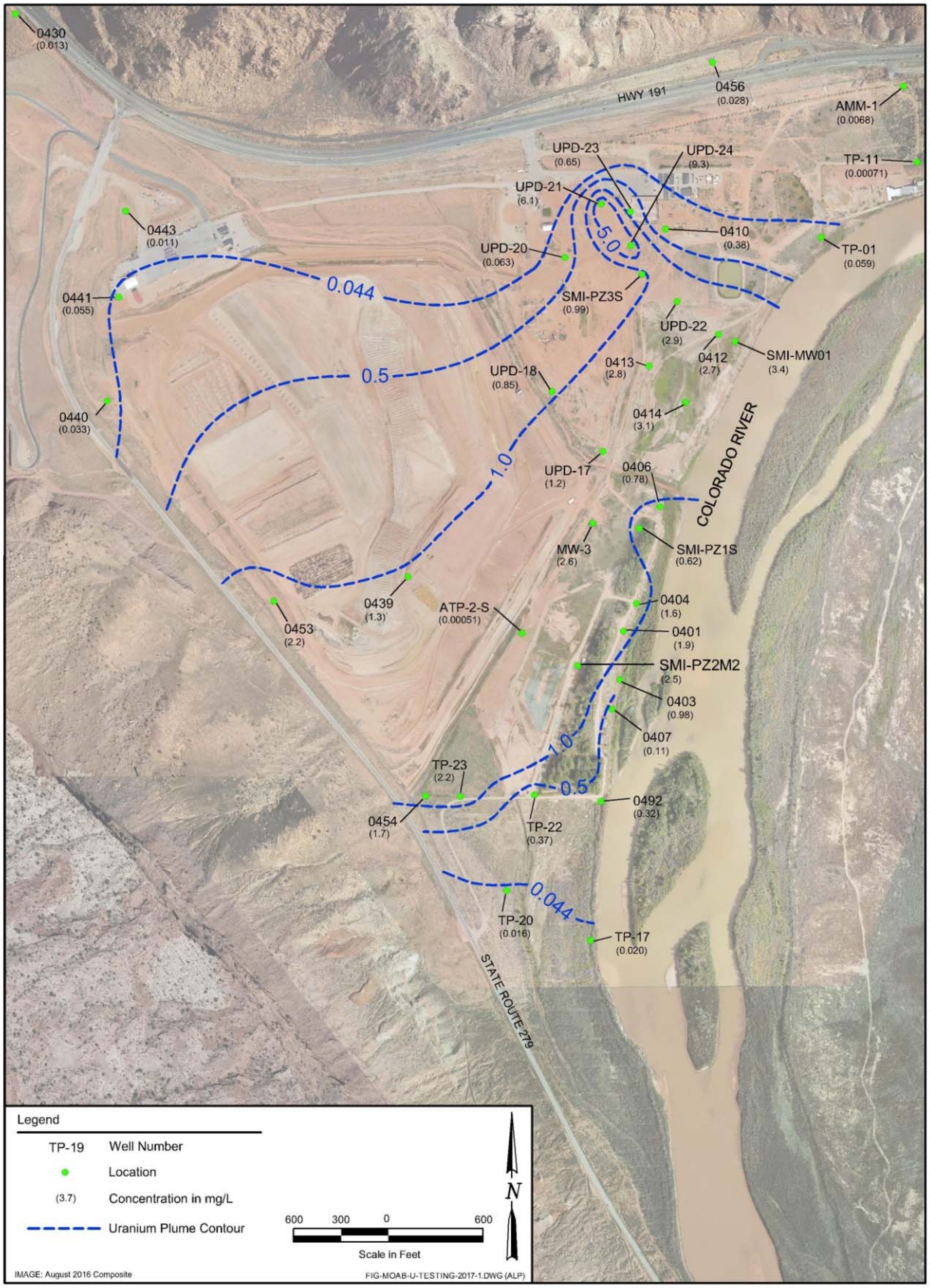

Figure 8. Uranium Plume in Shallow Ground Water December/January 2016/2017

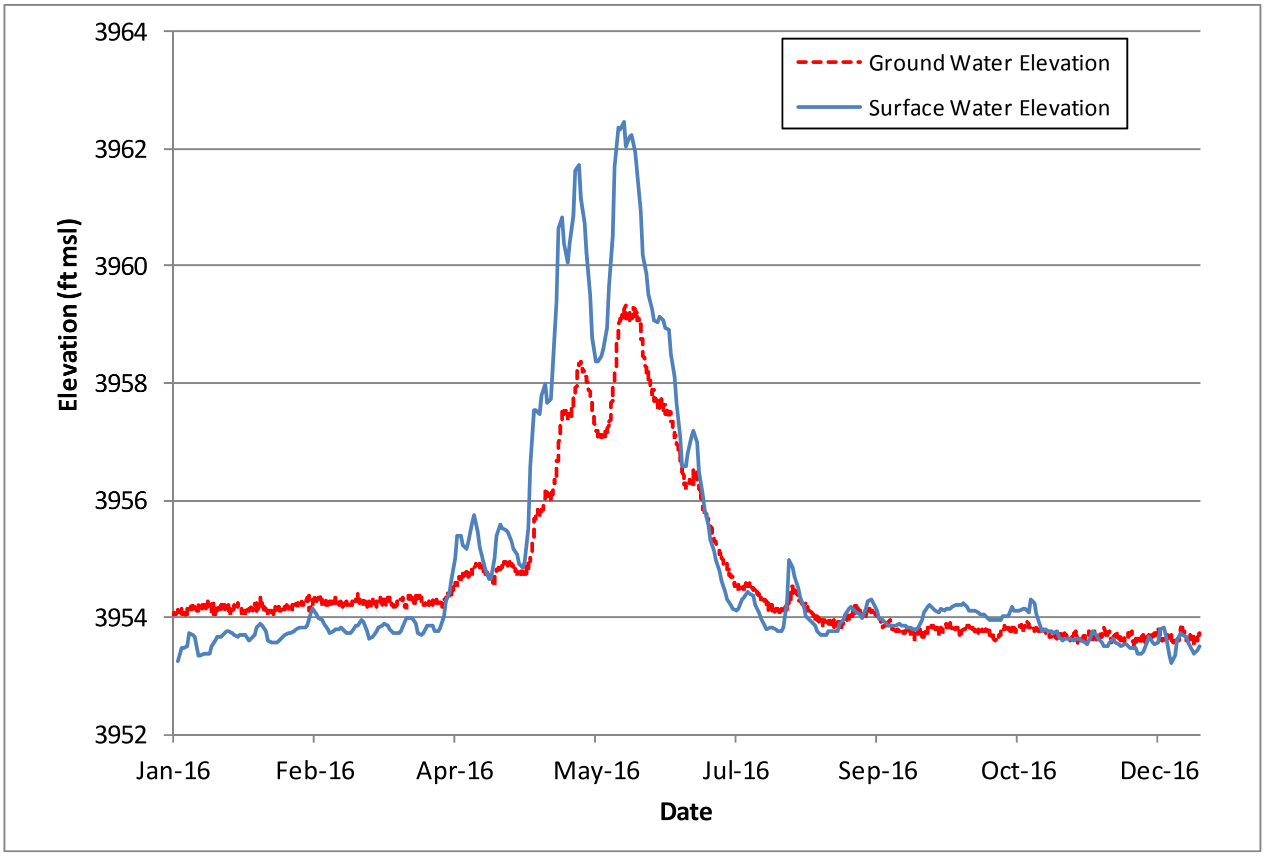

Figure 9. Ground Water Surface Elevation Compared to the Colorado River Surface Elevation 2016

3.1 Remediation Well Extraction

Each extraction well 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 contaminated water is then used as dust suppression in the Contamination Area (CA). Any contaminants deposited as salts in the CA will eventually be removed for disposal with tailings and transported to the Crescent Junction disposal site.

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 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 is installed at various locations to measure water levels more frequently.

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, the field parameters, which include temperature, pH, and conductivity 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 Global (ALS) in Fort Collins, Colorado, for analysis.

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 2016 pumping season. This section also includes a discussion of 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), and mass removal (Tables A-4 and A-5).

The evaporation pond was decommissioned in as excavation of the tailings continued. An updated extraction system was installed and first utilized in May 2016. The extraction operations are now controlled by an automated system. Ground water from extraction wells is pumped directly into two 21,000-gal frac tanks that serve as holding tanks. The water is then pumped directly into a 12,000-gal Klein tank. The water from the Klein tank is transferred to water trucks and used for dust suppression in the CA. The system is controlled from an HMI (Human Machine Interface) system which is located in the Project 2 office trailer. Extraction operations are limited by how much water is needed for dust suppression in the CA and weather conditions (wet weather leads to less extraction, and warm, windy weather leads to more extraction).

In 2016, the extraction system operated in the late spring, summer, and fall months. The extraction schedule was focused on optimizing ammonia and uranium mass removal and rotating through each of the eight CF5 remediation wells. An extraction system test, which included extraction directly to the Klein tank, was completed on April 21. The system was manually run throughout mid- to late May, and the system was fully operational in automatic mode on June 16. Operations continued until November, when the system was winterized.

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 2016. A total of approximately 5.4 mil gal of water was extracted from CF5 during 2016.

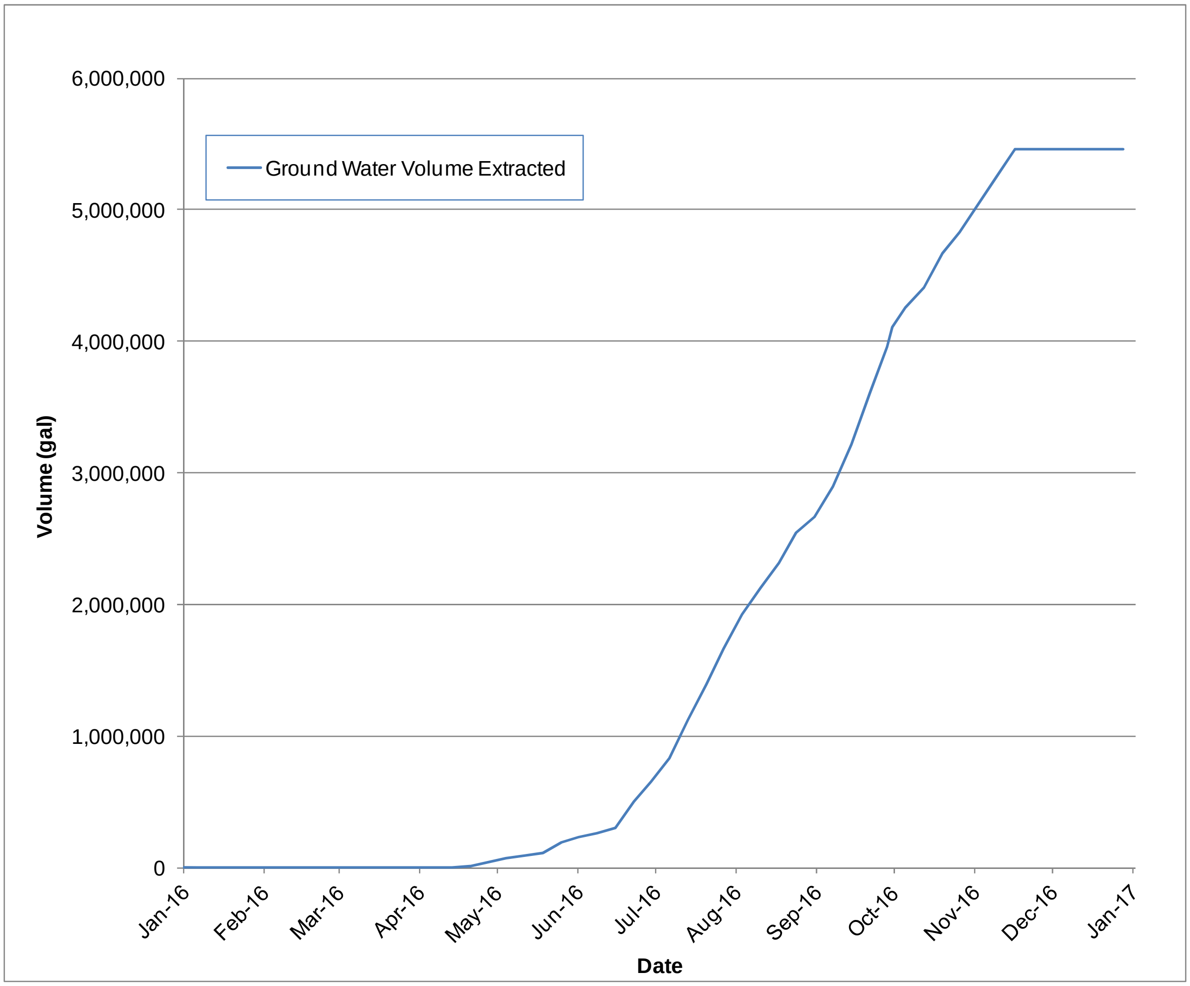

Figure 10. Cumulative Volume of Extracted Ground Water during 2016

4.1.1 CF5 Pumping Rate and Ground Water Extracted Volume

Monthly extraction volumes for each of the eight extraction wells are listed in Table A-3 (Appendix A). The majority of the 2016 extracted water was removed from well 0810 (1.0 mil gal) and 0816 (923,238 gal). The remaining CF5 wells extracted between 396,588 and 785,375 gal in 2016. Extraction operations were maximized in September, when more than 1.4 million gal were removed from the ground water system.

4.2 Contaminant Mass Removal

The ammonia and uranium mass removed by CF5 extraction wells in 2016 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 extracted volume by the corresponding contaminant mass concentration measured in each well's discharge.

The concentrations used in these calculations were drawn from analytical data presented in Appendix C (available on the Project's SharePoint website). 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 a representative concentration. In 2016, a total of 13,557 pounds (lb) (6,149 kilograms [kg]) of ammonia and 142 lb (64 kg) of uranium were extracted from the ground water.

Table A-4 in Appendix A shows that extraction wells PW02 and 0810 removed the most ammonia mass at 2,625 lb (2,625 kg) and 2,757 lb (1,250 kg), respectively. Estimated mass withdrawals of uranium at CF5 extraction wells are presented in Table A-5 in Appendix A, which shows the greatest mass of uranium was extracted from wells 0810 and 0815 at 34 lb (15 kg) and 22 lb (10 kg), respectively.

4.3 Ground Water Chemistry

Ground water samples were collected from the CF5 extraction wells in July and October (Table 1). Ammonia concentrations varied from 190 mg/L (Wells 0815 and 0816) to 550 mg/L (0812), and the uranium concentration ranged from 1.5 mg/L (0813) to 4.9 mg/L (0810). Specific conductance ranged from 16,348 µmhos/cm at well 0813 (northern end of CF5) to 33,488 µmhos/cm at well 0810 (southern end).

Table 1. CF5 Ammonia and Uranium Concentrations, 2016

Location	Date	Ammonia (mg/L)	Uranium (mg/L)	Specific Conductance (µmhos/cm)
0810	07/19/16	350	4.9	33,488
	10/25/16	360	3.0	29,883
0811	07/19/16	390	3.2	23,842
	10/25/16	470	1.9	22,210
0812	07/19/16	380	3.2	18,506
	10/25/16	550	1.9	16,901
0813	07/19/16	380	1.8	16,348
	10/25/16	490	1.5	16,560
0814	07/25/16	200	2.8	23,593
	10/25/16	230	2.8	21,620
0815	07/21/16	200	3.4	25,851
	10/25/16	190	3.4	21,794
0816	07/25/16	190	2.7	23,684
	10/25/16	190	2.5	21,223
PW02	07/19/16	410	3.6	29,244
	10/25/16	500	3.3	20,830

5.0 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 January to May and again from June to December. Injection into the southern six CF1 wells occurred from August to November. This was the first time CF1 wells were used since 2012.

The injection system uses Colorado River water that is diverted to a freshwater pond and is then pumped through sand and filters and injected into the remediation wells. Construction information for the CF1/CF4 wells can be found in Table B-1 of Appendix B, and Table B-2 contains a chronology of CF1/CF4 activities.

CFs 1 and 4 are located in the southern portion of the IA well field, adjacent to a prominent side channel that typically 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 ground water discharges to the adjacent backwater channel. Approximately 8.7 mil gal of fresh water were injected into CF4, and 1.8 mil gal of fresh water were injected into CF1 in 2016.

5.1 Injection Performance

Injection into all 10 CF4 wells began on January 11 (Table B-2, Appendix B). The system ran into mid-May when it was temporarily shut down during the peak river flow, following the *Flood Mitigation Plan*. CF4 operations resumed on June 27 when the river flow dropped below 15,000 cfs. Injection wells 0470 − 0476 were utilized beginning August 11 to help to protect the surface water just upriver of the potential habitat area. CF4 injection was suspended while the wells were re-developed by Beeman Drilling from September 8 to 20, 2016.

Injection into CF1 began on August 11 through November 15, and all of the CF1 and CF4 injection wells were winterized for the year on December 15.

5.2 Summary of Chemical Data from Observation Wells

In 2016, ground water samples were collected from the CF4 observation wells during injection operations in February, May, and October to assess the effectiveness of the system (Appendix B, Table B-3). The CF1 observation wells were also sampled in October after starting to inject fresh water into these wells starting in mid-August. It is important to note that the CF4 injection wells are screened from 15 to 35 ft below ground surface (ft bgs) and the CF1 injection wells are screened form 10 to 20 ft bgs. All samples were submitted to ALS for ammonia and uranium analysis and field parameters (temperature, pH, and specific conductance) are measured during the sample collection. Of primary concern regarding the sampling associated with the injection system performance are the ammonia concentrations due to its toxicity to aquatic life.

As expected because of the CF4 well screen intervals, the analytical results indicate ammonia concentrations downgradient of the injection wells were below 1 mg/L in the samples collected from 18 and 28 ft bgs. The highest concentrations were associated with the samples collected from a depth of 46 ft bgs (up to 2,900 mg/L at upgradient well 0781), which is more than 10 ft below the depth at which the fresh water is injected into the subsurface.

In October 2016 the specific conductance at the upgradient wells at a depth of 33 ft bgs had a specific conductance greater than 1,000 µmhos/cm, while at a depth of 46 ft bgs the specific conductance exceeded 55,000 µmhos/cm. This implies the brine interface was located at a depth of approximately 45 ft bgs during injection during this time.

The CF1 observation wells were sampled in October 2016 after the system had been injecting into these wells for approximately six weeks. The ammonia concentrations at a depth of 18 ft bgs decreased from 16 mg/L upgradient of the CF1 injection wells to 2 mg/L downgradient of the wells. Likewise, the concentration decreased from 300 mg/L (upgradient) to 60 mg/L (downgradient) at a depth of 30 ft bgs.

5.3 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 water level data were plotted against the water levels measured in background well 0405.

The water levels in each well were adjusted to match well 0405 during non-pumping, baseflow conditions. Tables 3 and 4 summarize the mounding data that are shown in Figures B-1 to B-10 in Appendix B for the injection wells. Figures B-11 through B-18 in Appendix B illustrate the mounding data in CF4 observation wells. Figures B-19 through B-24 summarize the mounding data in the CF1 injection wells, and Figures B-25 through B-31 illustrate the associated mounding in the CF1 observation wells.

Figures 11 and 12 are contour maps showing the CF4 freshwater mounding in May and October 2016, respectively. The highest 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 individual well efficiency and the injection rate.

Table 2 presents the maximum mounding measured in each of the injection wells and the corresponding injection rate. The mounding in the CF4 observation wells varied from 0.1 to 0.8 ft in the upgradient wells and from 0.4 to 0.7 ft in the downgradient wells. The mounding at the CF1 observation wells varied from 0.2 to 0.6 ft in the upgradient wells and 0.04 to 0.5 ft in the downgradient observation wells (Table 3).

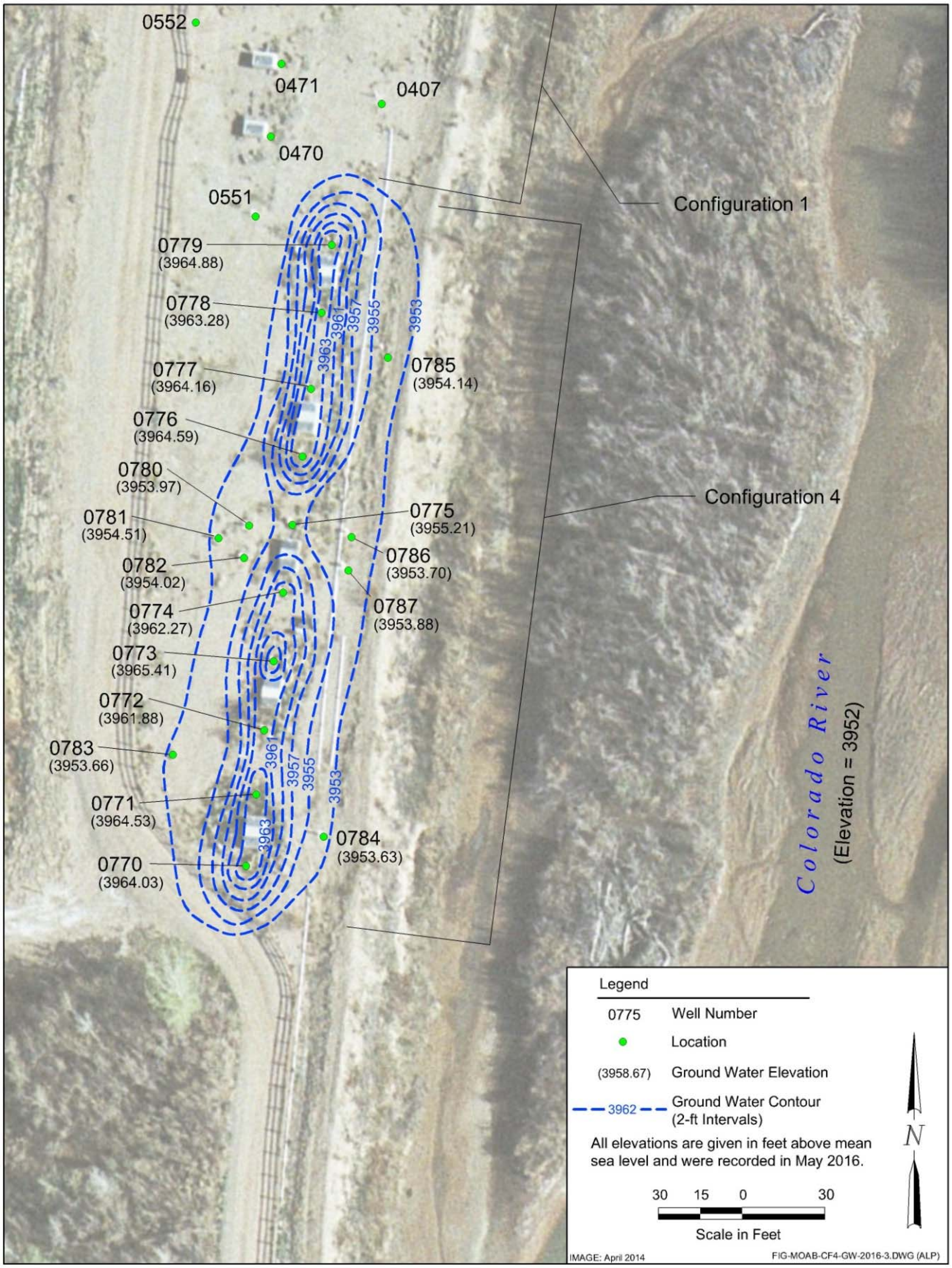

Figure 11. Freshwater Mounding at CF4 during Injection Operations May 2016

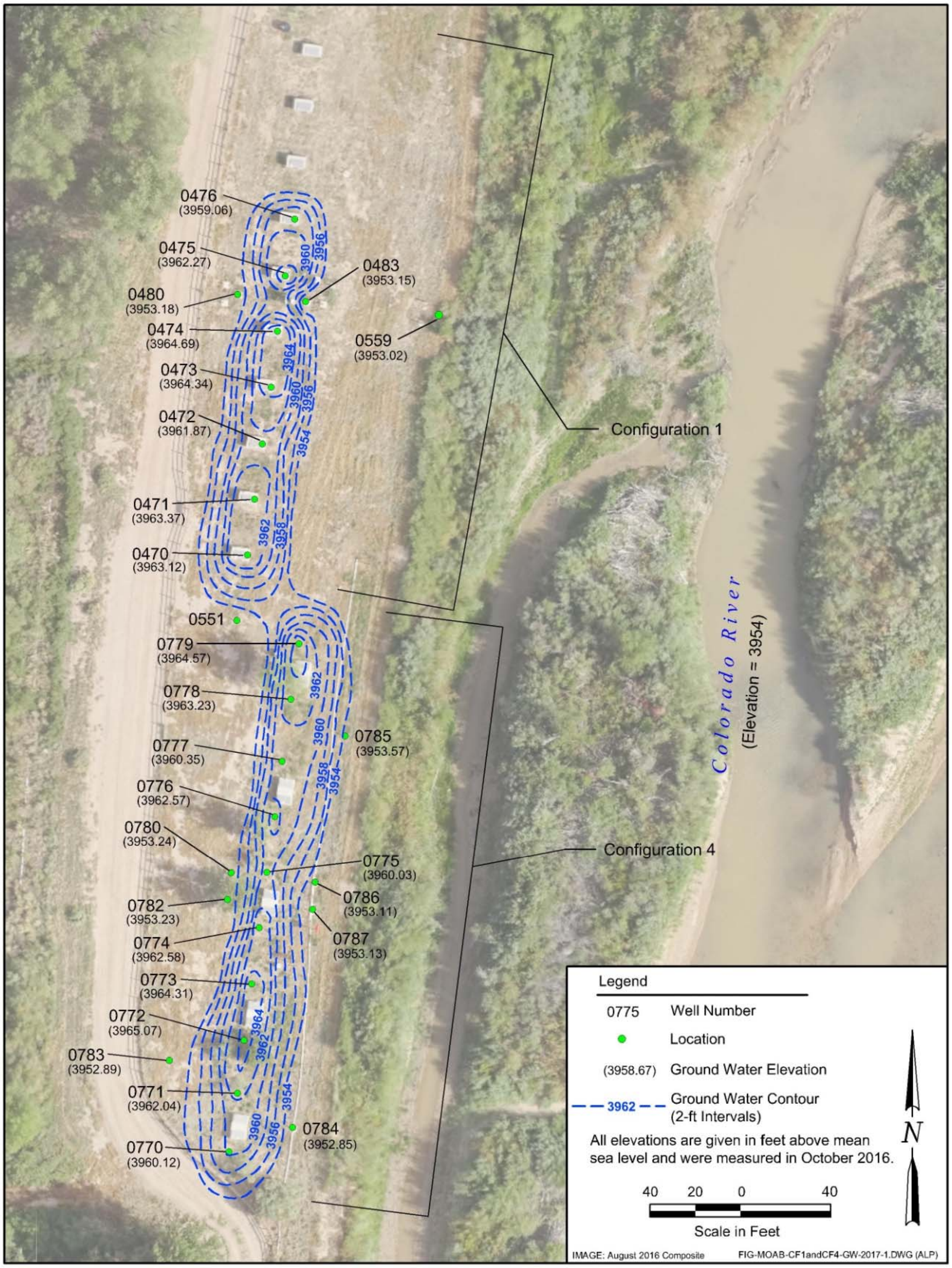

Figure 12. Freshwater Mounding at CF4 and CF1 during Injection Operations October 2016

Table 2. Maximum Mounding Observed in Injection Wells

Well	Date	Type	Maximum Mounding (ft)	Injection Rate (gpm)
Configuration 4				
0770	04/01/16	Injection Well	11.6	4.2
0771	11/21/16	Injection Well	11.6	5.9
0772	10/20/16	Injection Well	12.2	2.2
0773	10/24/16	Injection Well	12.9	5.7
0774	03/30/16	Injection Well	12.3	4.3
0775	03/22/16	Injection Well	12.6	1.4
0776	03/08/16	Injection Well	12.2	2.1
0777	02/18/16	Injection Well	11.8	2.3
0778	02/09/16	Injection Well	11.6	2.5
0779	02/16/16	Injection Well	11.3	1.9
Configuration 1				
0470	08/30/16	Injection Well	9.0	2.7
0471	10/11/16	Injection Well	10.5	1.2
0472	11/09/16	Injection Well	10.4	1.6
0473	10/26/16	Injection Well	11.5	1.0
0474	10/26/16	Injection Well	11.9	1.9
0475	10/31/16	Injection Well	10.1	2.1
0476	11/09/16	Injection Well	8.7	4.9

Table 3. Freshwater Mounding Observed in Observation Wells

Well	Date	Location	Maximum Mounding (ft)	Distance from Injection Source (ft)
Configuration 4				
0780	10/17/16	Upgradient	0.6	25
0781	05/02/16	Upgradient	0.1	30
0782	03/23/16	Upgradient	0.5	25
0783	10/17/16	Upgradient	0.8	30
0784	10/17/16	Downgradient	0.7	30
0785	10/17/16	Downgradient	0.7	25
0786	10/17/16	Downgradient	0.6	30
0787	10/17/16	Downgradient	0.4	30
Configuration 1				
0480	10/19/16	Upgradient	0.6	30
0481	11/15/16	Upgradient	0.2	30
0483	10/19/16	Downgradient	0.7	30
0484	10/22/16	Downgradient	0.04	30
0558	10/19/16	Downgradient	0.5	30
0559	10/19/16	Downgradient	0.5	75
0560	11/15/16	Downgradient	0.05	75

6.0 Surface Water Monitoring

In 2016, the river flow ranged from 2,470 to 24,500 cfs from January through December. The channel that flows adjacent to CF4 was not considered a suitable habitat for young-of-year fish during the monitoring season (June through September) because during those 3 months, the river flow at the Cisco Gage varied from 3,470 to 24,500 cfs.

Surface water monitoring is completed through site-wide surface water sampling. 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.

6.1 Site-wide Surface Water Monitoring

Site-wide surface water sampling was conducted adjacent to the well field in June/July 2016. Locations were sampled in preparation for the post-spring runoff peak flows, when the side channel could potentially develop into a suitable habitat.

The results of this sampling event can be found in the *Moab UMTRA Project Ground Water and Surface Water Monitoring January through June 2016* (DOE-EM/GJTAC2217). All of the sample results were below the U.S. Environmental Protection Agency (EPA) acute and chronic criteria.

Surface water samples were collected in December/January when the river was at baseflow conditions. At the time, the channel was dry and not considered a habitat. The results can be found in the *Moab UMTRA Project Ground Water and Surface Water Monitoring July through December 2016* (DOE-EM/GJTAC2231). All of the ammonia concentrations were below EPA acute and chronic criteria.

6.2 Surface Water/Habitat Monitoring

Surface water monitoring adjacent to CF4 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).

In 2016, the back water channel adjacent to CF4 did not meet the definition of a habitat during the months of June through September (closed off upriver, open downriver). Figure 13 shows the condition of the CF4 side channel, it remained nearly dry for most of the season.

6.3 Summary of Surface Water Monitoring

All of the surface water ammonia samples collected in 2016 were below EPA acute and chronic criteria. The CF4 side channel shallow and closed off to the main river channel after the peak runoff. Habitat monitoring and surface water diversion was not necessary in 2016.

Figure 13. CF4 Side Channel on August 18, 2016

7.0 Investigations

7.1 Moab Sampling Events

Sampling events occurred throughout the year in 2016. CF4 and observation wells adjacent to the tree plots were sampled in February, May, and October of 2016. CF5 extraction wells, CF1 observation wells, and the tree plot wells were sampled in October 2016. The site-wide sampling event took place in June/July 2016 during the peak river flow and in December/January 2016/2017 during baseflow conditions.

Maps of sample locations and the sample results can be found in the *Ground Water Surface Water Monitoring Report January through June 2016* and the *Ground Water Surface Water Monitoring Report July through December 2016*.

7.2 Crescent Junction Well 0205 Sampling and Recharge Monitoring

The placement of the cell cover has significantly altered the surface runoff/hydrology of the vicinity of well 0205. Before the installation of the cell cover, the majority of precipitation would evaporate with larger storm events producing surface runoff with a very small portion slowly infiltrating over a much larger area. With the cover material in place, there is often less evaporation and more surface runoff that tends to accumulate in discrete areas of the site and provides a longer-term source of infiltration.

Water was first encountered in well 0205 in late June 2015 and has been present in the well since that time. Observations show that after a significant event or multiple precipitation events, the runoff collects into the retention ditch at the toe of the pile. As this water infiltrates into the subsurface, it likely intercepts a fracture system that is at least in part connected to the fracture observed inside well 0205 and eventually seeps into the well.

The results of water samples (Table 4) collected in February, April, July, and December 2016, and the 11 short-term recovery tests were utilized to determine the source of the water. The manner in which the water elevation responds to the site precipitation and the fluctuation of the recharge rate suggest a connection between the water present in well 0205 and the surface runoff.

Analytical results indicate a clear distinction between the two isotopic signatures of ground water encountered in well 0205 and Moab site ground water that has been impacted by site operations, suggesting the water present in well 0205 is not associated with the tailings placed in the disposal cell. All data are provided in the *Moab UMTRA Project Crescent Junction Monitoring Well 0205 Activity Summary June 2015 through December 2016* (DOE-EM/GJTAC2232).

Table 4. Well 0205 Analytical Data

Analyte	Sample Date and Analyte Concentration (mg/L)			
	2/10/16	4/26/16	7/27/16	12/5/16
Ammonia as N	16	13	15	15
Arsenic	0.039#	0.039#	0.039#	0.002#
Barium	0.014	0.012	0.013	0.020
Bicarbonate as $CaCO_3$	N/A	N/A	990	1,000
Boron	1.1	1.3	1.2	1.4
Bromide	10#	20#	10#	10#
Cadmium	0.00033#	0.0033#	0.00033#	0.00021#
Calcium	270	350	300	320
Carbonate as $CaCO_3$	N/A	N/A	20#	20#
Chloride	3,300	3,400	2,900	3,200
Chromium	0.017	0.0051#	0.00051#	0.0015
Copper	0.0034	0.0097#	0.0026	0.023
Fluoride	5#	10#	5#	5#
Iron	0.0095	0.049#	0.0064	0.016
Lead	0.0013#	0.013#	0.0013#	0.0018#
Magnesium	1,000	1,000	1,000	1,100
Manganese	0.35	0.47	0.42	0.59
Molybdenum	0.019	0.011#	0.0022	0.0047#
Nitrate/ Nitrite as N	920	930	960	1,000
Nitrate as N	990	N/A	N/A	N/A
Nitrite as N	5#	N/A	N/A	N/A
Potassium	64	53	69	32
Selenium	4.9	4.4	4.6	6.0
Sodium	9,600	10,000	9,900	11,000
Sulfate	21,000	21,000	21,000	22,000
Total Alkalinity as $CaCO_3$	N/A	N/A	990	1,000
Total Dissolved Solids	40,000	24,000	40,000	27,000
Uranium $_{234}$	N/A	N/A	35.7	33.1
Uranium $_{235}$	N/A	N/A	0.81	0.64
Uranium $_{238}$	N/A	N/A	12.2	11.1
Uranium	0.033	0.033	0.034	0.029

8.0 Summary and Conclusions

In 2016, the IA operations focused on ground water extraction (from CF5) and freshwater injection (CF1 and CF4); the surface water diversion system operation was not required during the year, because a suitable habitat did not develop in the side channel.

A total of 5.5 mil gal of water were extracted from CF5 in 2016. The extraction rate peaked in July through September, and operations continued through the fall. Each of the eight extraction wells were utilized in 2016. Figure 15 shows the ammonia and uranium mass removed and the volume of ground water extracted from the CF5 extraction wells in 2016.

The volume and mass removed is less than previous years because of the removal of the evaporation pond; however, the mass removal rate per volume of water extracted has increased for uranium and slightly decreased for ammonia. Approximately 142 lb of uranium and more than 13,500 lb of ammonia were removed from the ground water in 2016.

Approximately 10.5 mil gal of fresh water were injected into CF4/CF1 in 2016. Laboratory 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. The surface water diversion system was not necessary in 2016 since the side channel adjacent to CF4 did not meet the definition of a suitable habitat for young-of-year endangered fish species. This is the third season the channel was not a suitable habitat.

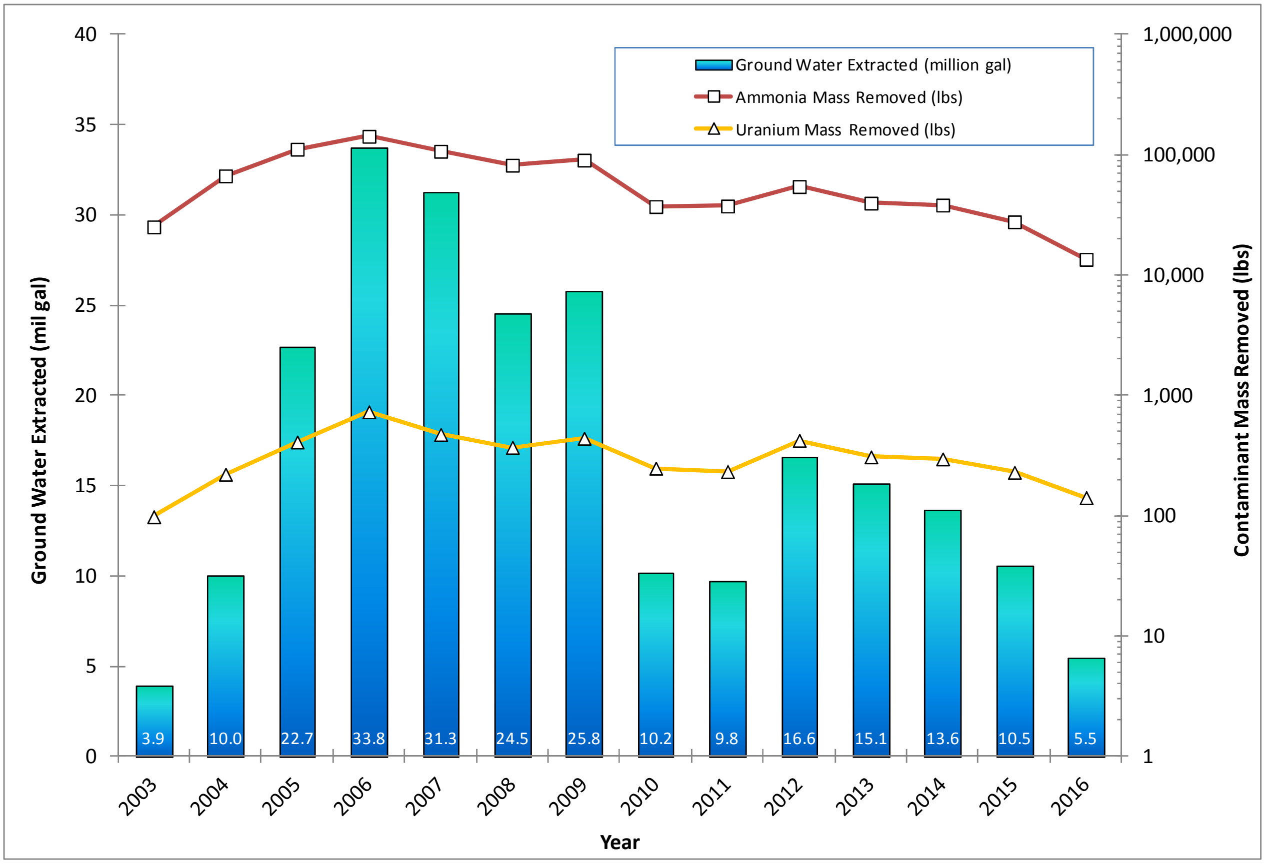

Figure 14. 2016 Mass Removal

9.0 References

40 CFR 192A (U.S. Code of Federal Regulations), "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings, Standards for the Control of Residual Radioactive Materials from Inactive Uranium Processing Sites."

DOE (U.S. Department of Energy), *Moab UMTRA Project Crescent Junction Monitoring Well 0205 Activity Summary June 2015 through December 2016* (DOE-EM/GJTAC2232).

DOE (U. S. Department of Energy), *Moab UMTRA Project Flood Mitigation Plan* (DOE-EM/GJTAC1640).

DOE (U.S. Department of Energy), *Moab UMTRA Project Ground Water and Surface Water Monitoring January through June 2016* (DOE-EM/GJTAC2217).

DOE (U.S. Department of Energy), *Moab UMTRA Project Ground Water and Surface Water Monitoring July through December 2016* (DOE-EM/GJTAC2231).

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

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).

Appendix A.
Tables and Data for 2016 Ground Water Extraction

Appendix A. Tables and Data for 2016 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	20.0 – 60.0	60.3

In. = inch

Table A-2. Chronology of CF5 Activities in 2016

Date	River Flow (cfs)	Activity
January	3,170 to 3,850	No extraction
February	3,350 to 4,060	No extraction
March	3,310 to 4,160	No extraction
April	3,530 to 7,320	Extraction system test directly to Klein tank completed on April 21
May	5,800 to 20,600	Extraction system manually operated on May 16, 17, 18, 21
June	9,450 to 24,500	Extraction system full operational in automatic mode on June 16.
July	9,450 to 25,000	Extraction system operational in automatic mode
August	3,510 to 6,140	Extraction system operational in automatic mode
September	3,610 to 4,850	Extraction system operational in automatic mode
October	3,890 to 4,920	Extraction system operational in automatic mode
November	3,030 to 5,140	Winterized the CF5 vaults (Nov 16), pumphouse (Nov 17), and components (Nov 28).
December	2,360 to 3,960	Winterized

Table A-3. CF5 Extraction Volumes 2016

Well	Volume Extracted (gal)												
	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Totals
810	0	0	0	0	21,332	90,437	216,740	209,360	250,134	114,356	104,029	0	1,006,388
811	0	0	0	0	7,333	37,910	81,813	83,456	119,653	56,880	50,483	0	437,528
812	0	0	0	0	20,664	80,856	76,175	0	72,308	92,451	54,134	0	396,588
813	0	0	0	6,865	24,267	34,843	118,597	173,723	187,440	106,759	70,952	0	723,446
814	0	0	0	0	13,276	46,597	97,993	99,749	146,704	9,673	81,017	0	495,009
815	0	0	0	12,520	29,051	43,041	113,010	175,048	234,911	85,607	92,187	0	785,375
816	0	0	0	14,196	22,318	64,796	180,152	130,907	248,498	145,784	116,587	0	923,238
PW02	0	0	0	4,733	19,602	59,570	129,862	123,633	183,608	105,285	70,142	0	696,435
MONTHLY TOTAL:	0	0	0	38,314	157,843	458,050	1,014,342	995,876	1,443,256	716,795	639,531	0	
ANNUAL TOTAL:													**5,464,007**

Table A-4. CF5 Ammonia Mass Removal 2016

Well	Ammonia Mass Removed (lbs)												
	Jan-16	**Feb-16**	**Mar-16**	**Apr-16**	**May-16**	**Jun-16**	**Jul-16**	**Aug-16**	**Sep-16**	**Oct-16**	**Nov-16**	**Dec-16**	**Totals**
810	0	0	0	0	53	226	541	571	729	333	303	0	2,757
811	0	0	0	0	20	104	225	252	389	185	164	0	1,338
812	0	0	0	0	57	222	209	0	229	293	171	0	1,181
813	0	0	0	19	67	96	326	509	593	338	225	0	2,172
814	0	0	0	0	19	66	139	156	244	16	135	0	775
815	0	0	0	22	51	75	198	298	391	143	154	0	1,331
816	0	0	0	19	30	86	240	196	393	231	184	0	1,379
PW02	0	0	0	20	53	226	541	571	729	333	303	0	2,265
MONTHLY TOTAL:	0	0	0	80	381	1,134	2,440	2,454	3,595	1,897	1,575	0	
ANNUAL TOTAL:													**13,557**

Table A-5. CF5 Uranium Mass Removal 2016

Well	Uranium Mass Removed (lbs)												
	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Totals
810	0	0	0	0	0.6	2.3	5.6	7.1	10.2	4.7	4.2	0	34.7
811	0	0	0	0	0.2	0.8	1.8	2.3	4.0	1.9	1.7	0	12.6
812	0	0	0	0	0.3	1.2	1.1	0	1.9	2.5	1.4	0	8.5
813	0	0	0	0.1	0.3	0.4	1.5	2.4	2.8	1.6	1.1	0	10.1
814	0	0	0	0	0.3	1.1	2.3	2.4	3.7	0.2	2.0	0	12.0
815	0	0	0	0.3	0.8	1.2	3.1	4.9	6.7	2.4	2.6	0	22.0
816	0	0	0	0.3	0.5	1.5	4.1	2.9	5.6	3.3	2.6	0	20.8
PW02	0	0	0	0.2	0.6	1.9	4.2	3.8	5.5	3.2	2.1	0	21.6
MONTHLY TOTAL:	0	0	0	0.9	3.6	10.5	23.6	25.9	40.3	19.7	17.8	0	
ANNUAL TOTAL:													**142.3**

Appendix B.
Tables and Data for 2016 Freshwater Injection

Appendix B. Tables and Data for 2016 Freshwater Injection

Table B-1. CF4/CF1 Well Construction

Well	Well Type/ Relative Depth	Diameter (in.)	Ground Surface Elevation (ft above msl)	Screen Interval (ft bgs)	Total Depth (ft bgs)
Configuration 4					
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

Table B-1. CF4/CF1 Well Construction (continued)

Well	Well Type/ Relative Depth	Diameter (in.)	Ground Surface Elevation (ft above msl)	Screen Interval (ft bgs)	Total Depth (ft bgs)
Configuration 1					
0470	Remediation/Intermediate	4	3966.56	10.3 - 19.7	21.3
0471	Remediation/Intermediate	4	3966.59	10.3 - 19.7	21.3
0472	Remediation/Intermediate	4	3966.62	10.3 - 19.7	21.3
0473	Remediation/Intermediate	4	3966.67	10.3 - 19.7	21.3
0474	Remediation/Intermediate	4	3967.02	10.3 - 19.7	21.3
0475	Remediation/Intermediate	4	3967.13	10.3 - 19.7	21.3
0476	Remediation/Intermediate	4	3967.38	10.3 - 19.7	21.3
0480	Observation/Shallow	4	3966.94	15.5 - 19.8	20.3
0481	Observation/Intermediate	4	3967.01	25.4 - 29.7	31.3
0483	Observation/Shallow	4	3967.00	15.5 - 19.8	20.3
0484	Observation/Intermediate	4	3967.19	25.5 - 29.8	30.3
0558	Observation/Intermediate	6	3966.85	35.0 - 45.0	45.1
0559	Observation/Shallow	1	3967.84	10.5 - 20.5	20.7
0560	Observation/Intermediate	6	3966.95	30.0 - 40.0	40.4

Table B-2. Chronology of CF1/CF4 Activities in 2016

Month	River Flow (cfs)	Activity
January	3,170 to 3,850	Injection system was started at CF4 on January 11.
February	3,350 to 4,060	Injection system operated all month but Feb 28-29 due to low volume in the freshwater pond.
March	3,310 to 4,160	Injection system operated all month but March 6-8 due to a leak at the pump.
April	3,530 to 7,320	Injection system operated all month but April 4-12 for freshwater pond work and again from April 23-25 due to a site power outage.
May	5,800 to 20,600	Injection system was shut down on May 16 due to high river stage.
June	9,450 to 24,500	Injection operations were re-started on June 27.
July	9,450 to 25,000	Injection system operated all month.
August	3,510 to 6,140	Injection system operated all days, began injection from CF1 on August 11.
September	3,610 to 4,850	CF 4 injection wells were re-developed by Beeman Drilling from September 8-20.
October	3,890 to 4,920	Injection system operated all month.
November	3,030 to 5,140	Injection system operated all month.
December	2,360 to 3,960	Injection system was winterized on December 15.

Table B-3. Analytical Sample Results 2016

Location	Location from Injection	Sample Depth (ft bgs)	Date	Ammonia, as N (mg/L)	Uranium (mg/L)	Specific Conductance (µmhos/cm)
0780	Upgradient	28	02/02/16	0.98	0.0099	1,185
			05/02/16	4.5	0.14	3,430
			10/18/16	0.79	0.0098	1,298
0781	Upgradient	46	02/02/16	2,100	2.5	73,480
			05/02/16	2,700	1.4	96,557
			10/17/16	2,500	3.4	55,347
0782	Upgradient	33	02/02/16	0.1	0.15	2,301
			05/02/16	360	2.3	20,503
			10/18/16	16	0.062	1,472
0783	Upgradient	18	02/11/16	2	0.13	1,829
			05/03/16	1.4	0.092	1,359
			10/18/16	0.56	0.046	1,285
0784	Downgradient	18	02/08/16	0.1	0.01	1,222
			05/03/16	0.1	0.011	970
			10/18/16	0.1	0.013	1,267
0785	Downgradient	18	02/08/16	0.1	0.0089	1,206
			05/02/16	0.1	0.0092	985
			10/18/16	0.1	0.019	1,383
0786	Downgradient	28	02/08/16	0.1	0.008	1,210
			05/03/16	30	0.69	9,112
			10/18/16	1.4	0.018	1,270
0787	Downgradient	36	02/08/16	820	2	42,738
			05/03/16	2,900	1.5	93,158
			10/18/16	94	0.53	5,057
0480	Upgradient	18	10/19/16	16	0.11	1,380
0481	Upgradient	30	10/19/16	300	1.7	14,450
0483	Downgradient	18	10/19/16	2	0.031	1,324
0484	Downgradient	30	10/19/16	60	0.2	2,419
0557	Upgradient	44	10/27/16	410	2.4	18,646
0558	Downgradient	44	10/19/16	410	2.6	23,355
0559	Downgradient	18	10/19/16	39	0.23	2,338
0560	Downgradient	36	10/19/16	370	2.1	21,039
0596	Downgradient	25	10/19/16	30	0.16	1,670

µmhos/cm = micromhos per centimeter

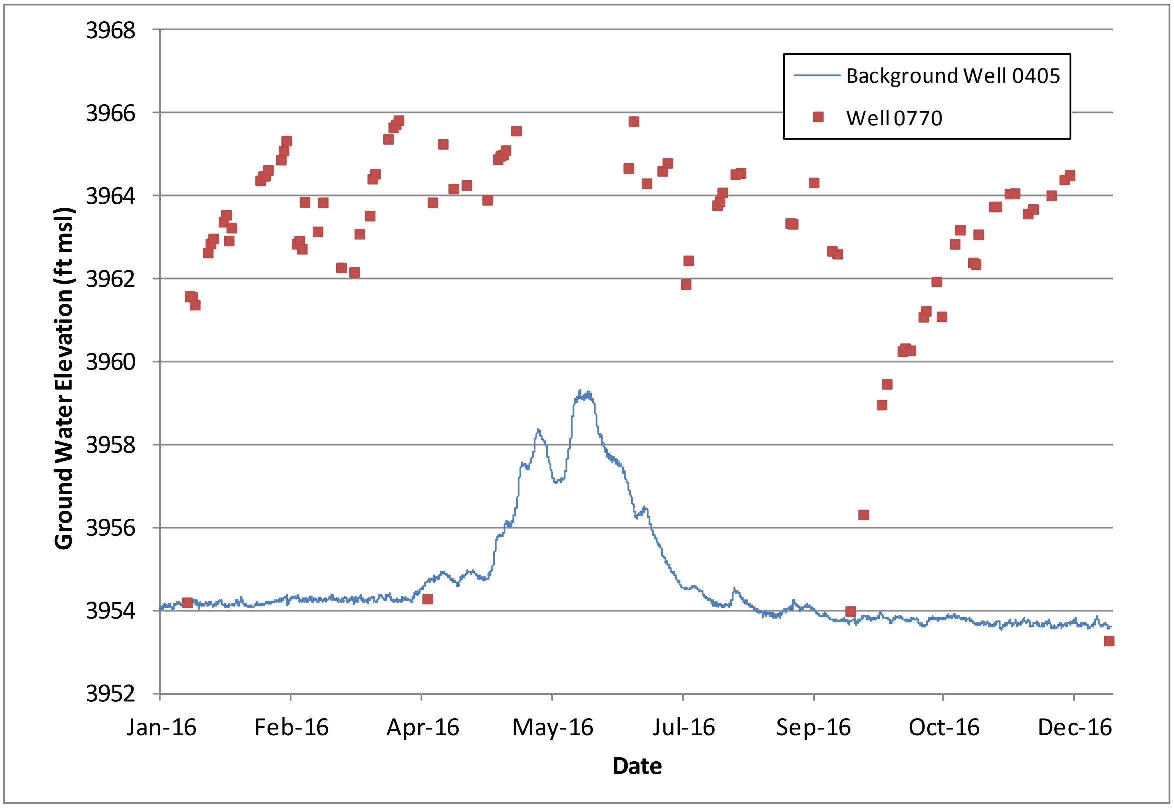

Figure B-1. Freshwater Mounding in Remediation Well 0770 during Injection

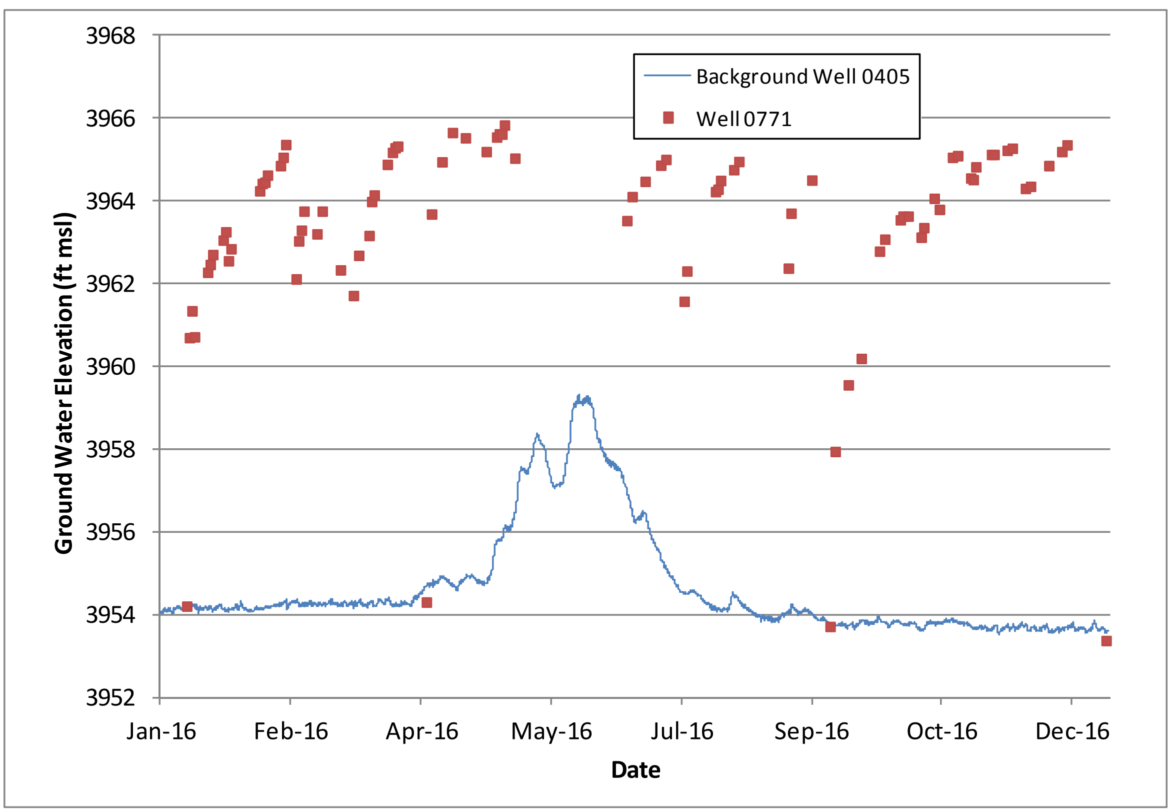

Figure B-2. Freshwater Mounding in Remediation Well 0771 during Injection

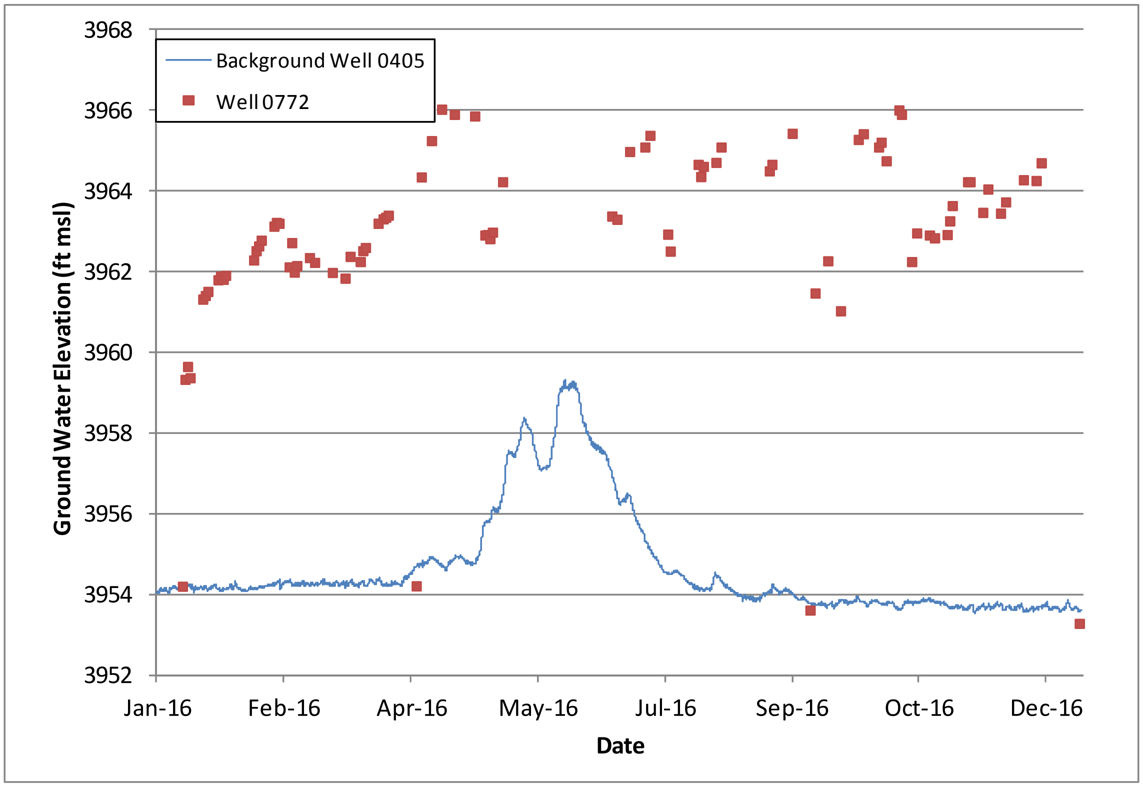

Figure B-3. Freshwater Mounding in Remediation Well 0772 during Injection

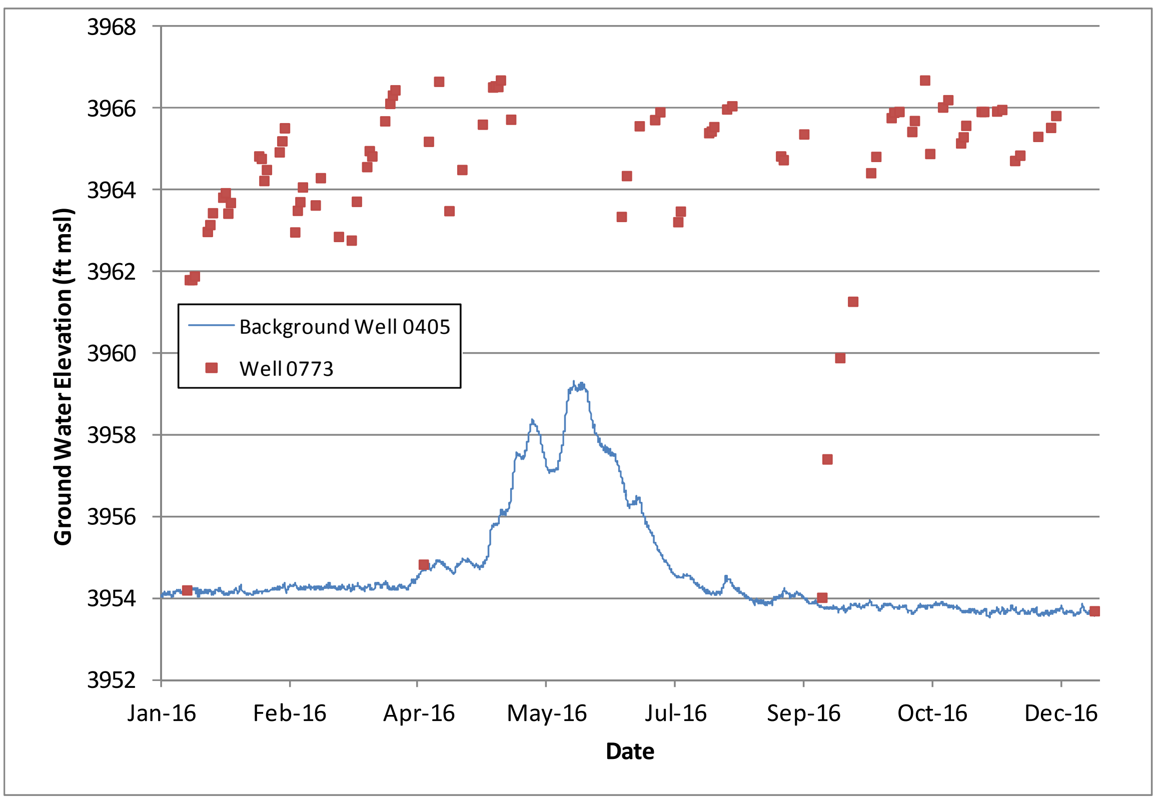

Figure B-4. Freshwater Mounding in Remediation Well 0773 during Injection

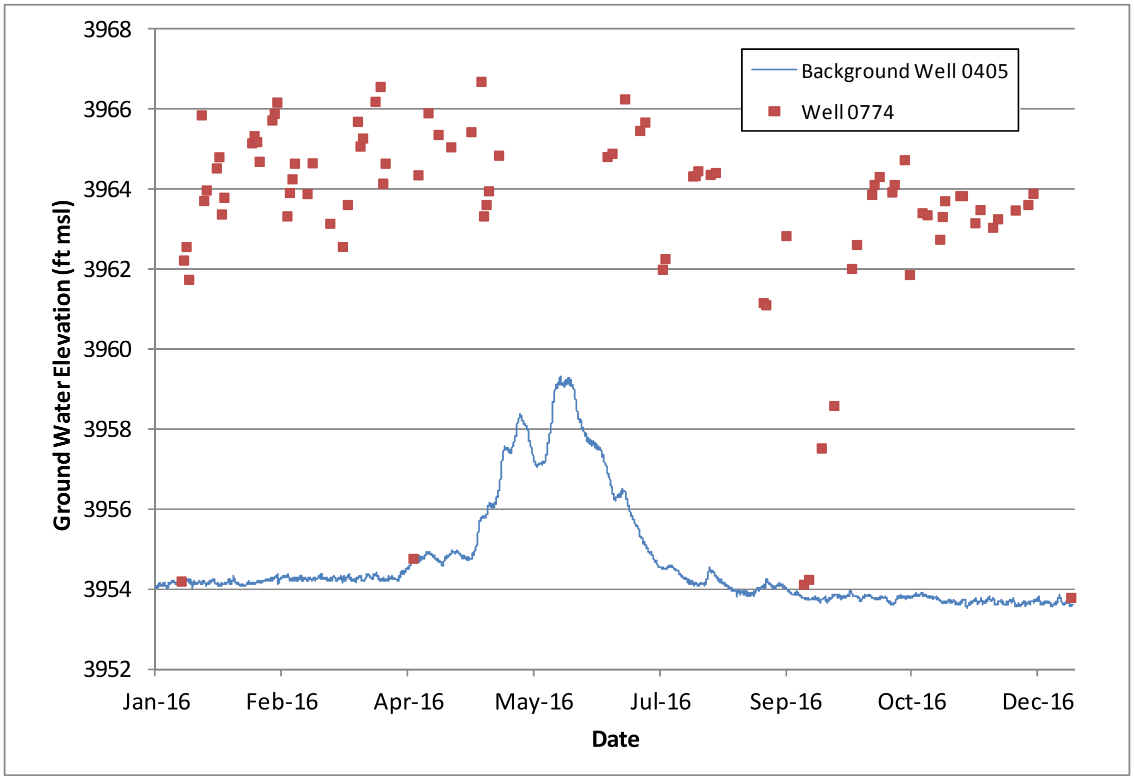

Figure B-5. Freshwater Mounding in Remediation Well 0774 during Injection

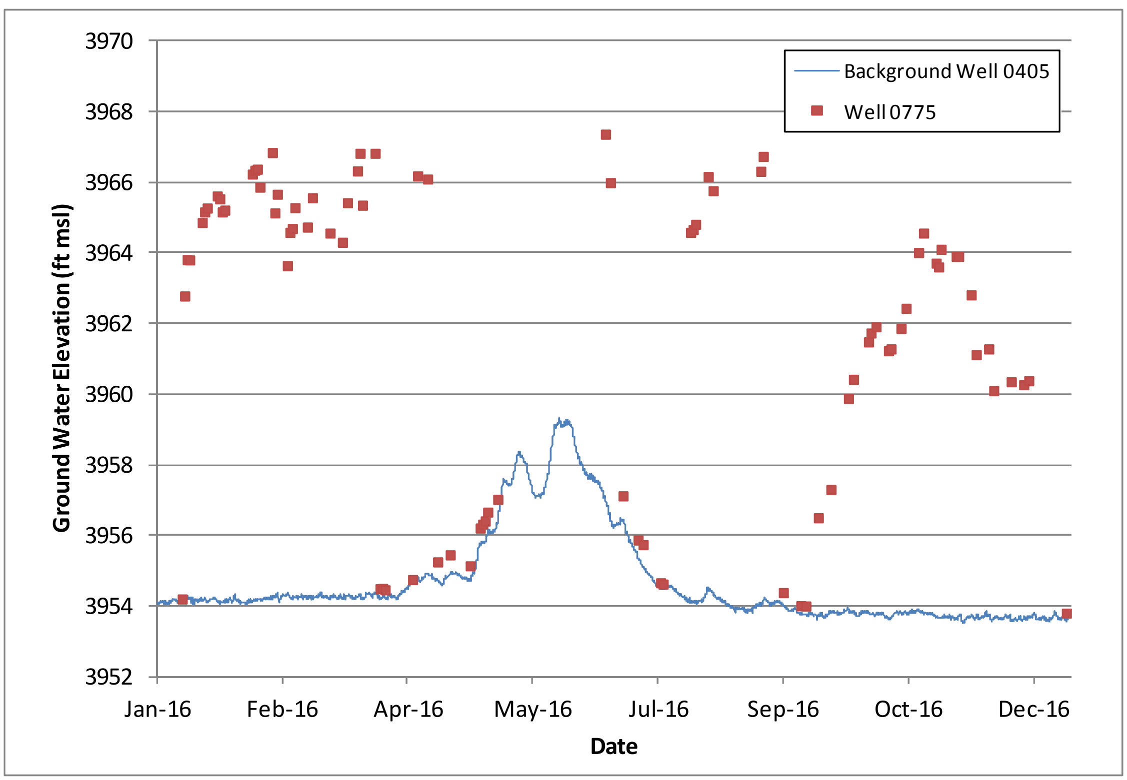

Figure B-6. Freshwater Mounding in Remediation Well 0775 during Injection

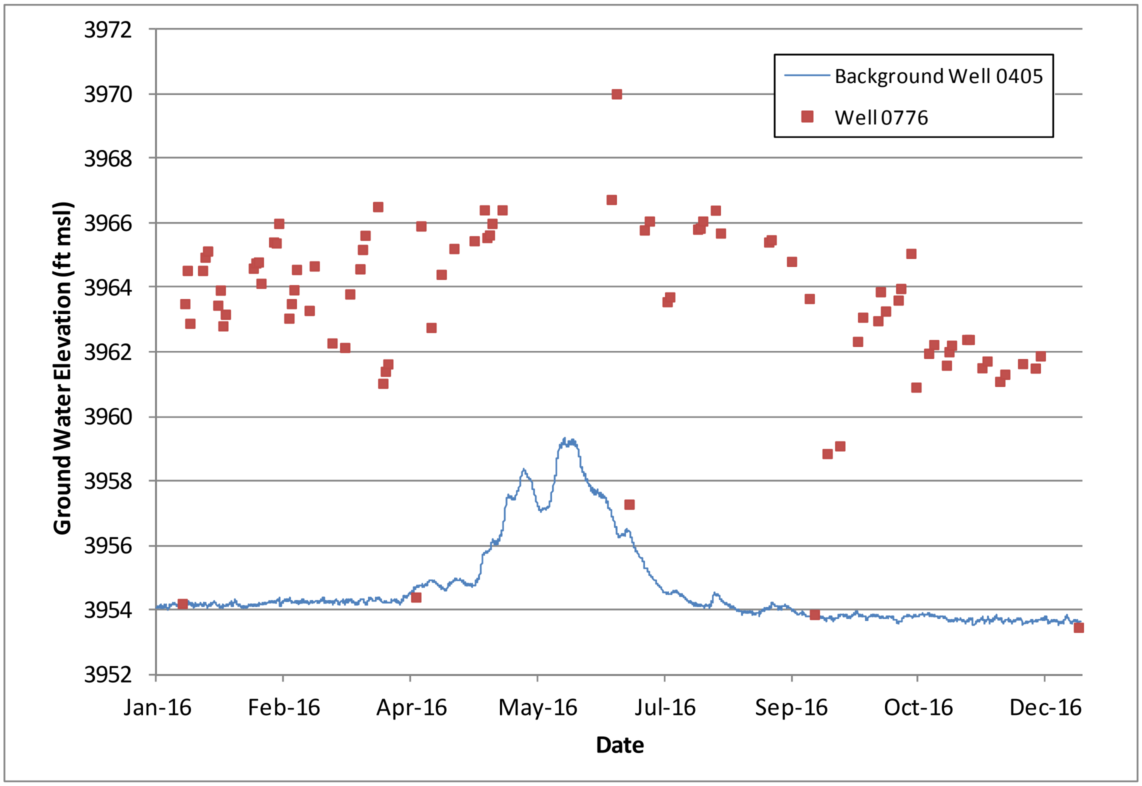

Figure B-7. Freshwater Mounding in Remediation Well 0776 during Injection

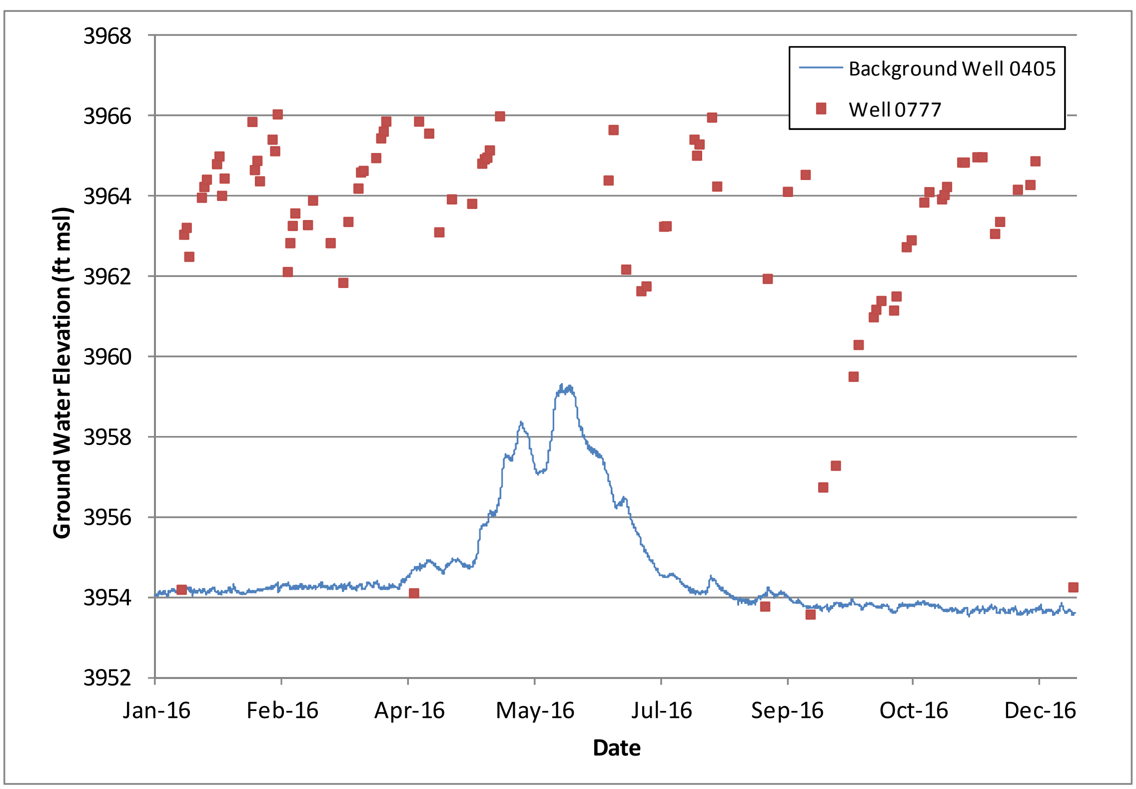

Figure B-8. Freshwater Mounding in Remediation Well 0777 during Injection

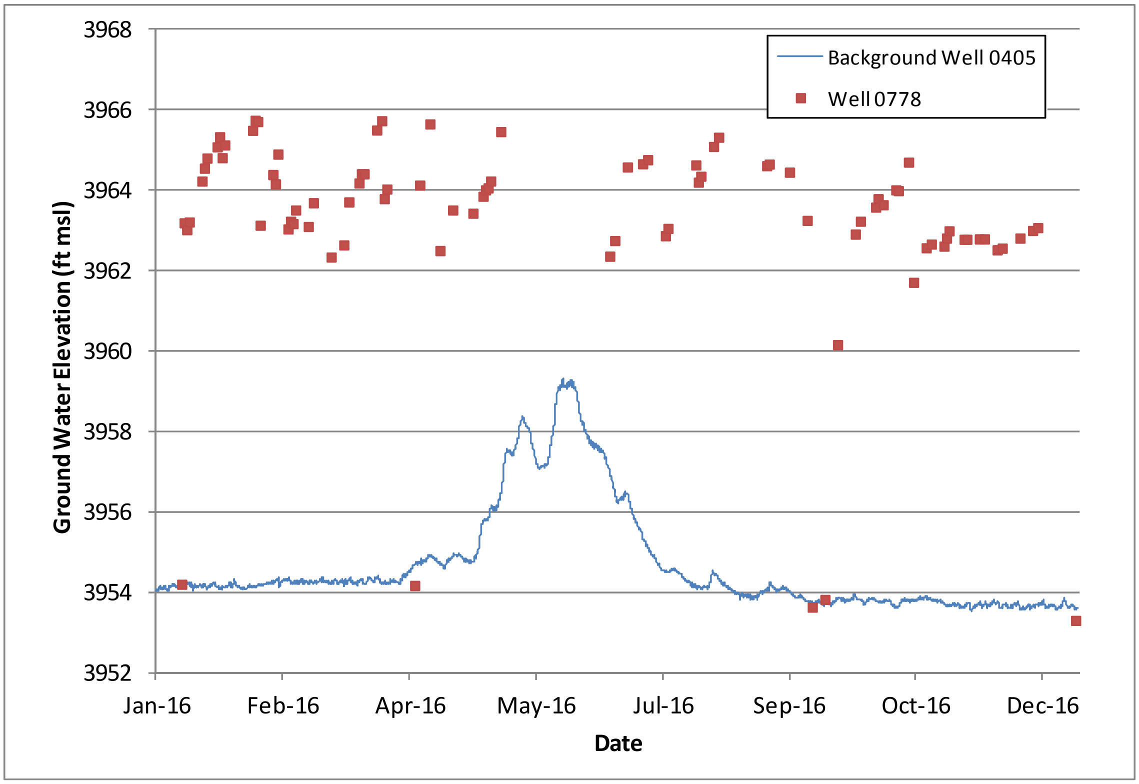

Figure B-9. Freshwater Mounding in Remediation Well 0778 during Injection

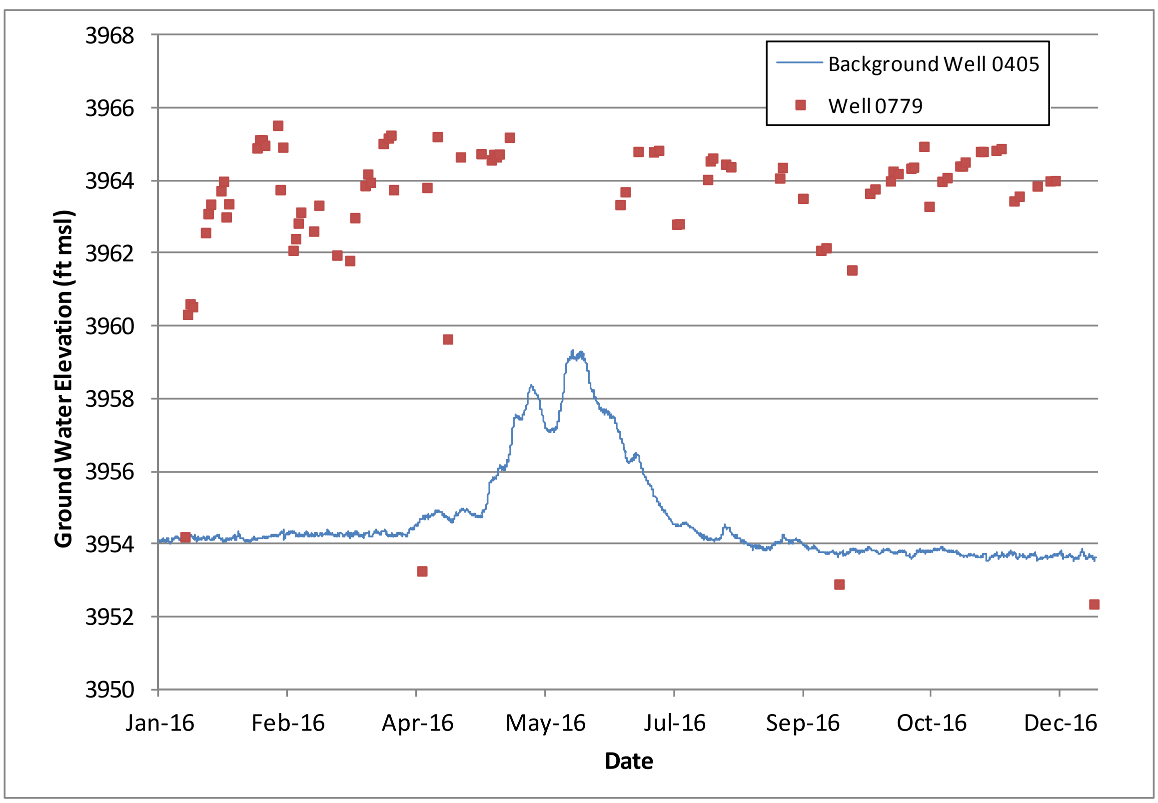

Figure B-10. Freshwater Mounding in Remediation Well 0779 during Injection

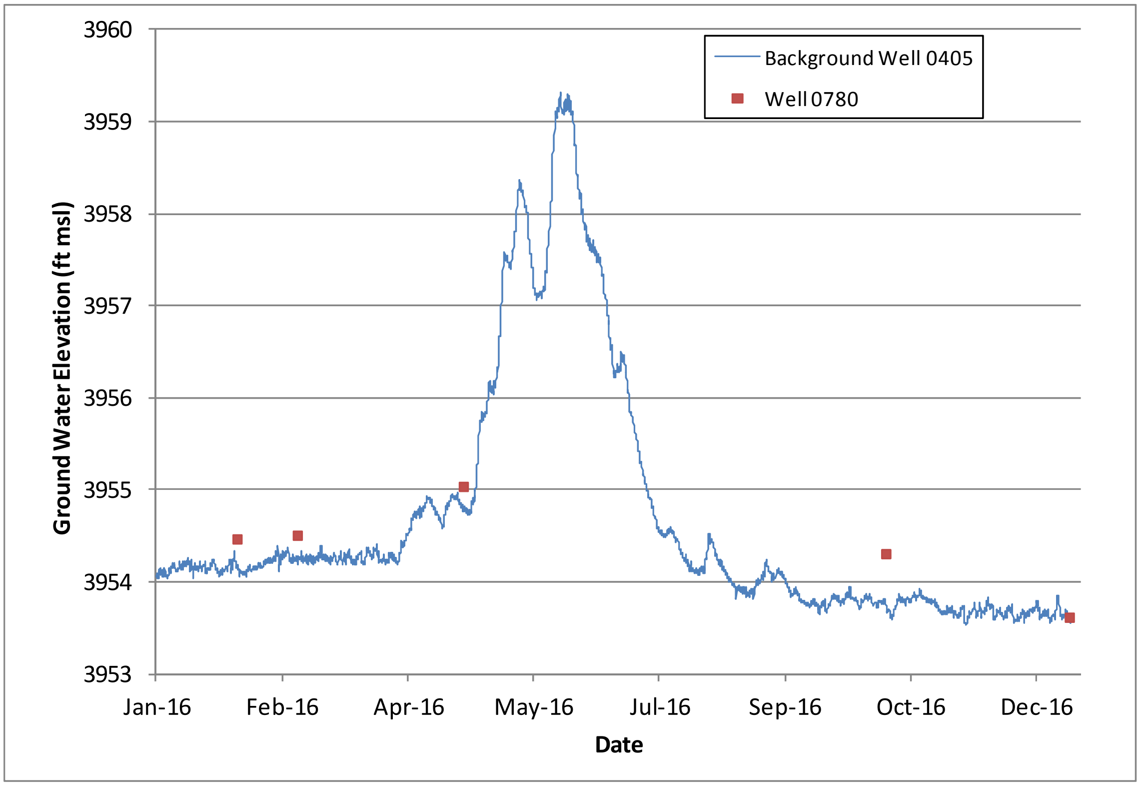

Figure B-11. Freshwater Mounding in Observation Well 0780

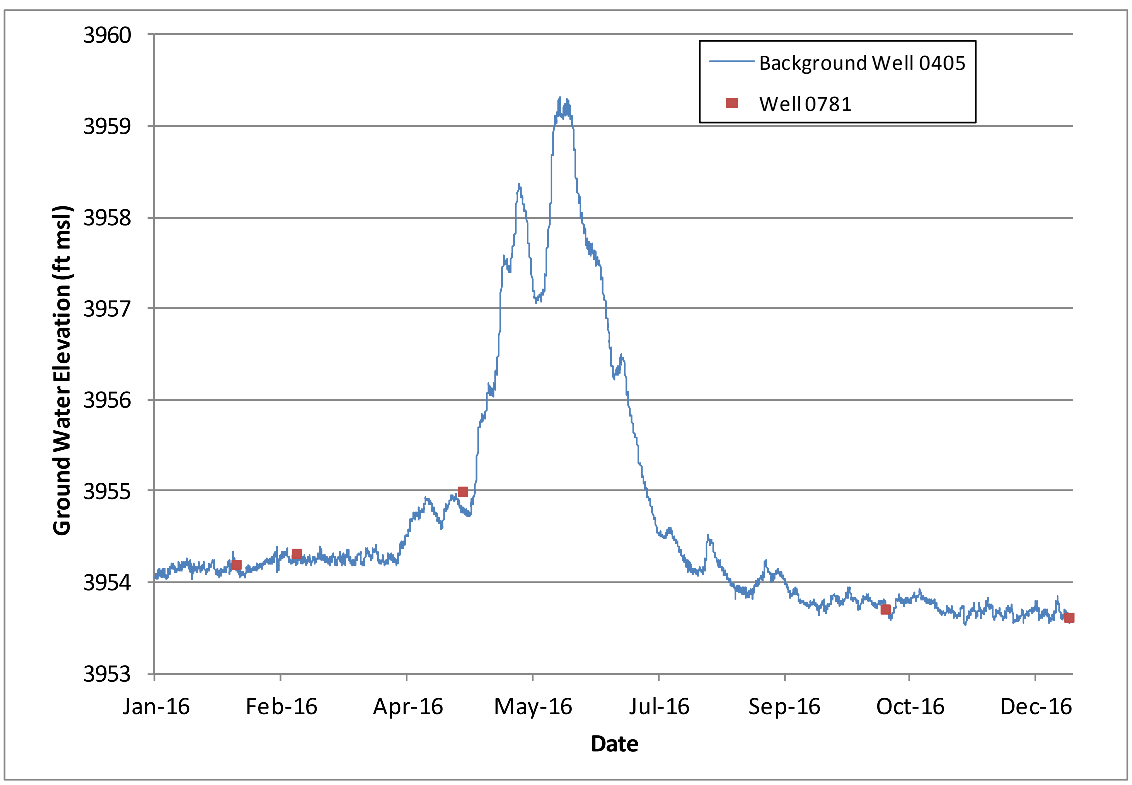

Figure B-12. Freshwater Mounding in Observation Well 0781

Appendix B. Tables and Data for 2016 Freshwater Injection (*continued*)

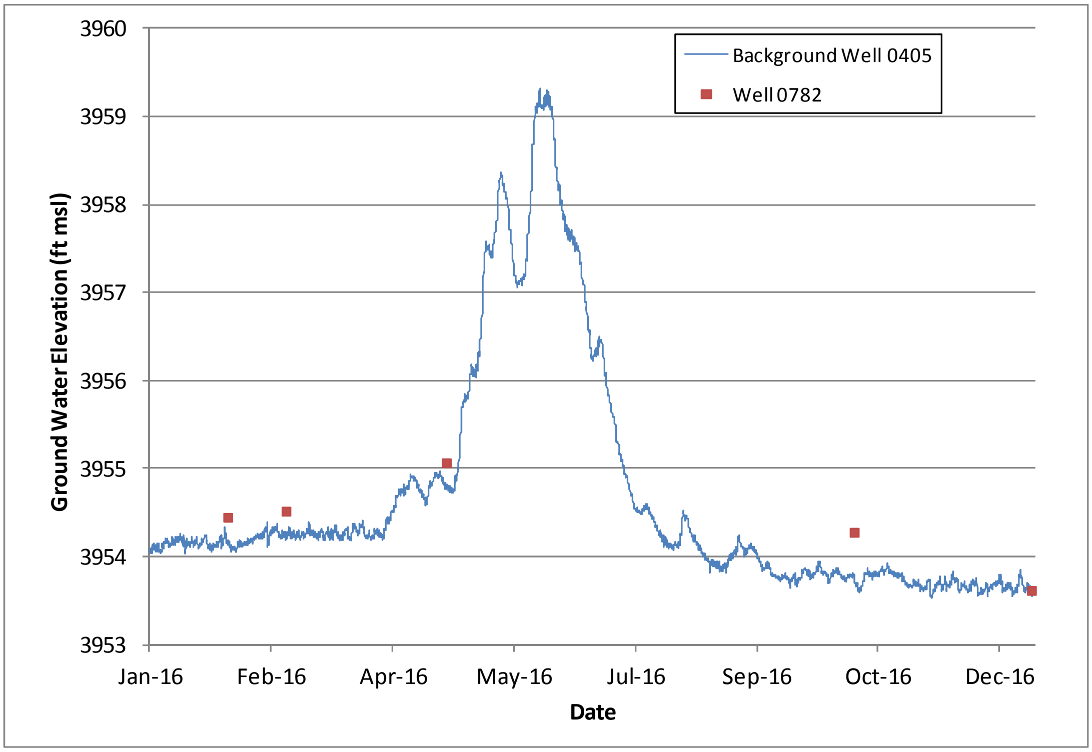

Figure B-13. Freshwater Mounding in Observation Well 0782

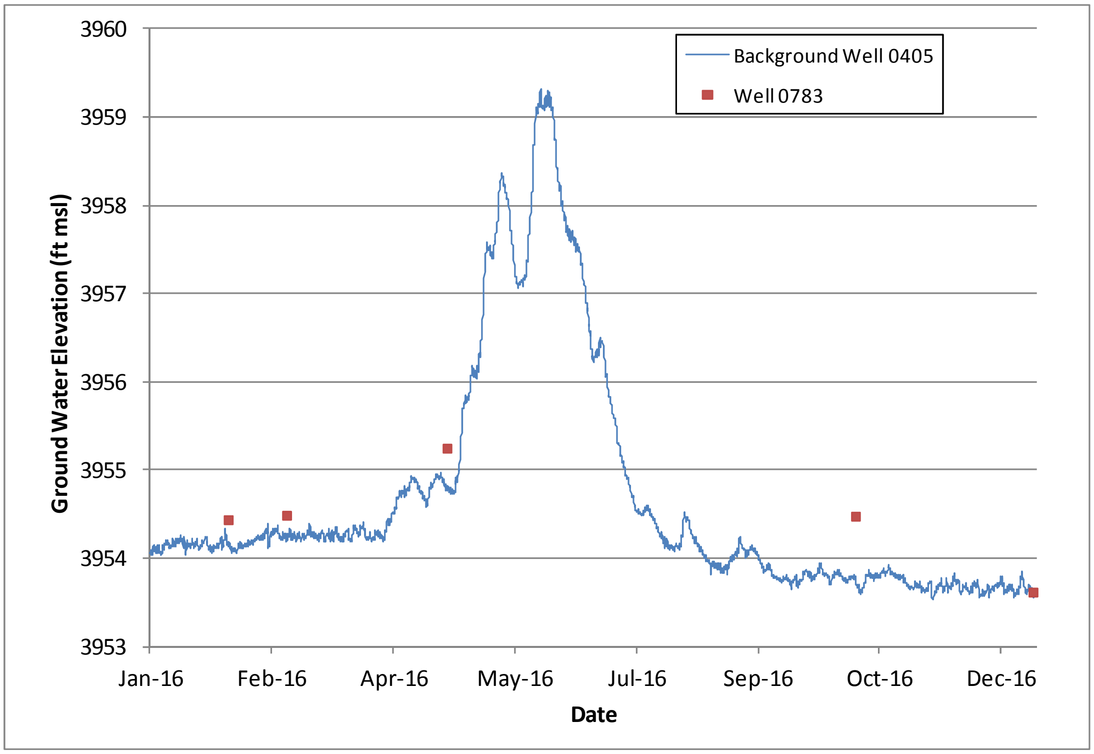

Figure B-14. Freshwater Mounding in Observation Well 0783

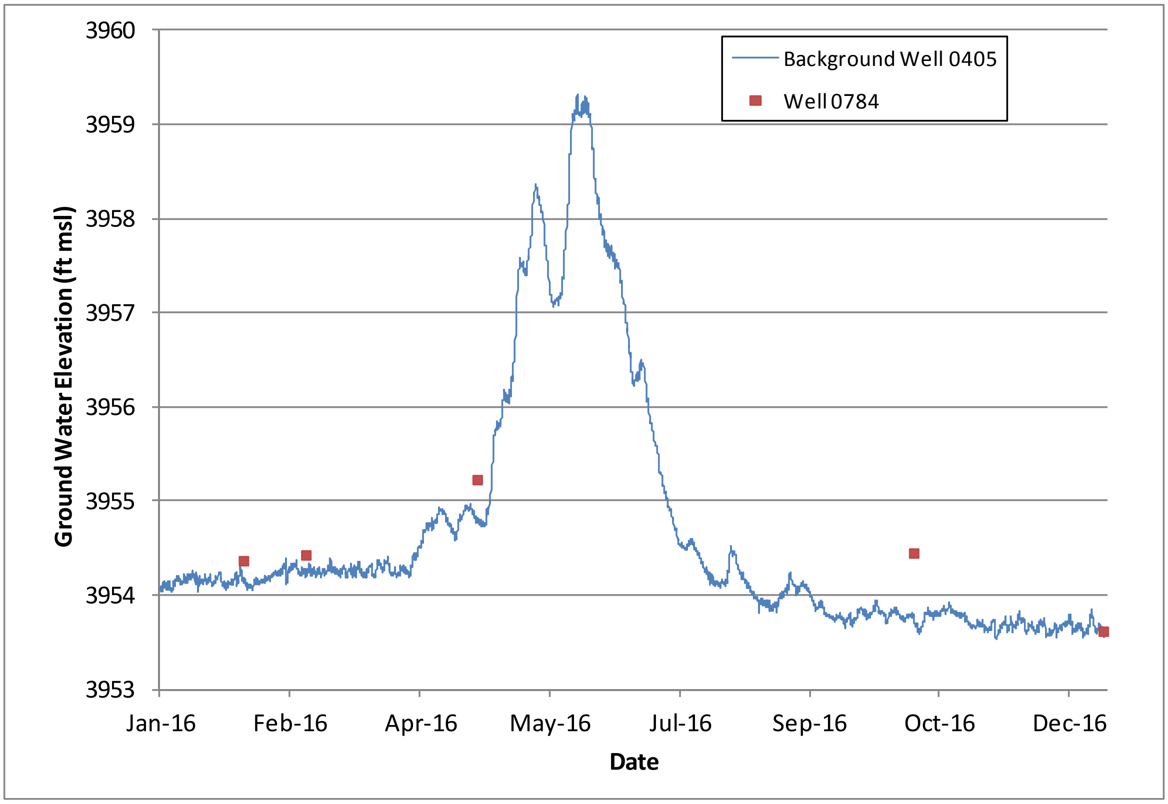

Figure B-15. Freshwater Mounding in Observation Well 0784

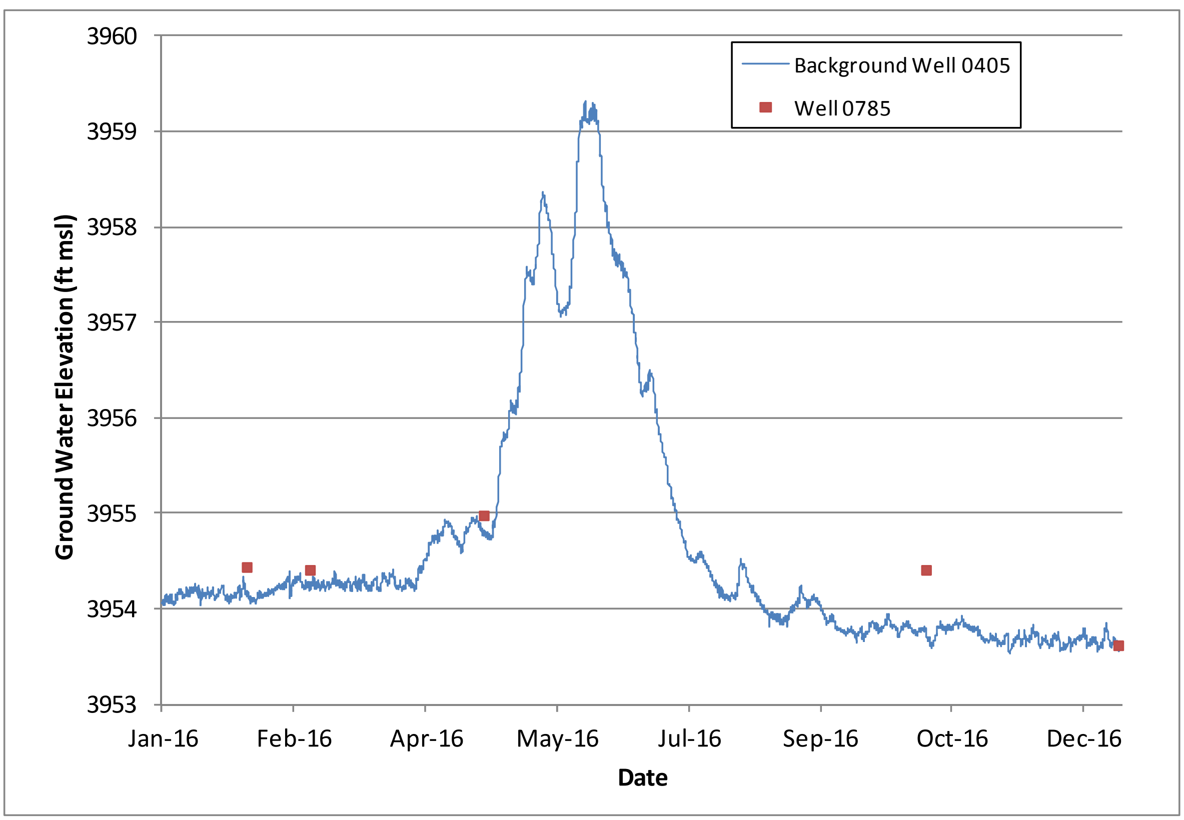

Figure B-16. Freshwater Mounding in Observation Well 0785

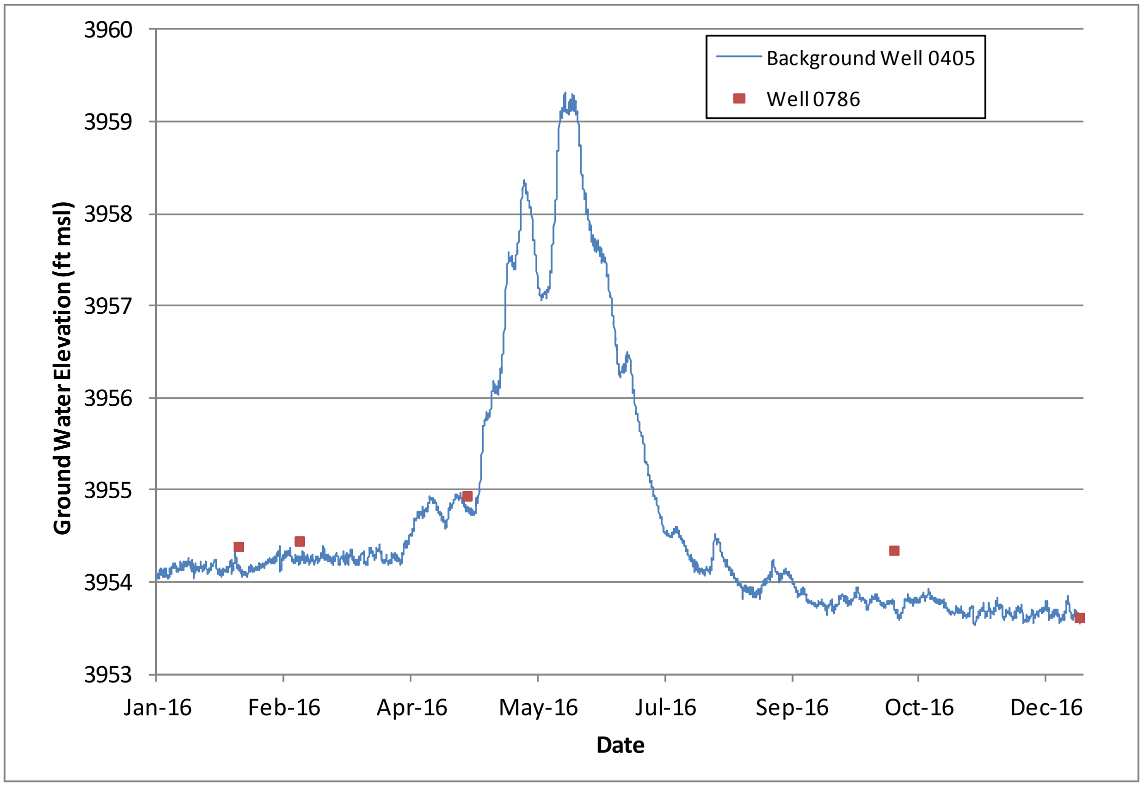

Figure B-17. Freshwater Mounding in Observation Well 0786

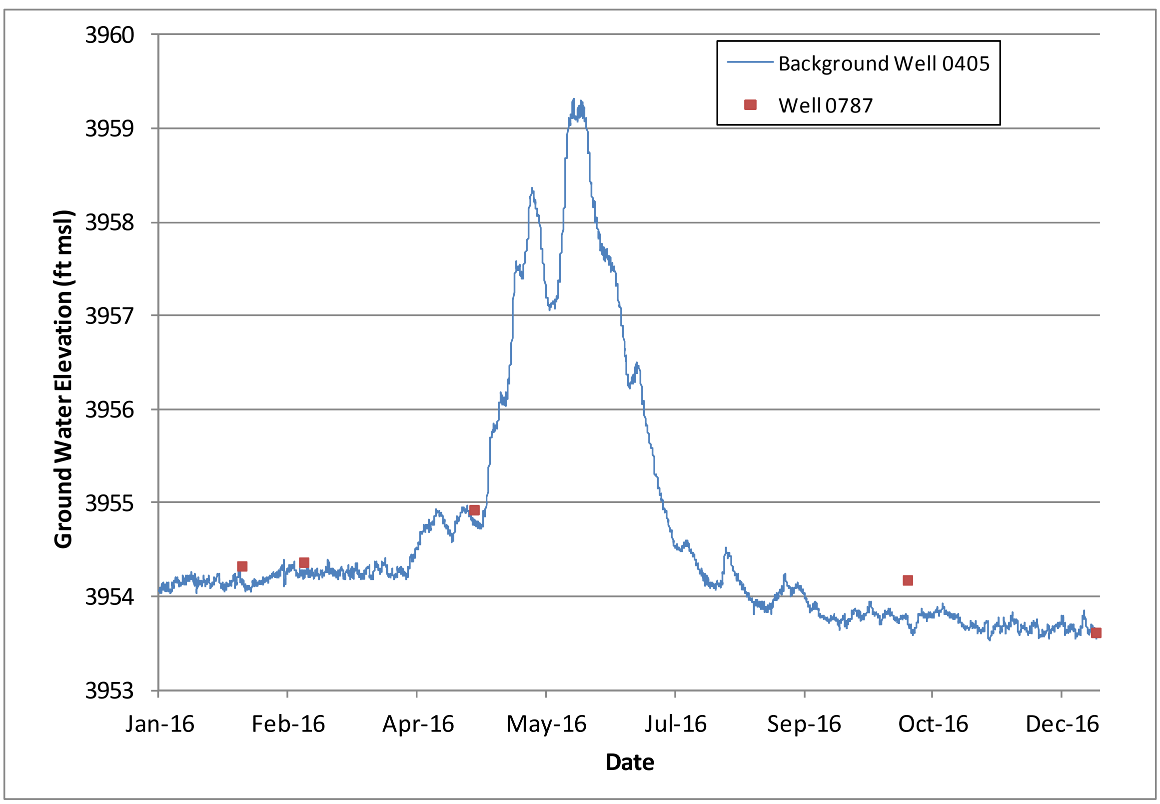

Figure B-18. Freshwater Mounding in Observation Well 0787

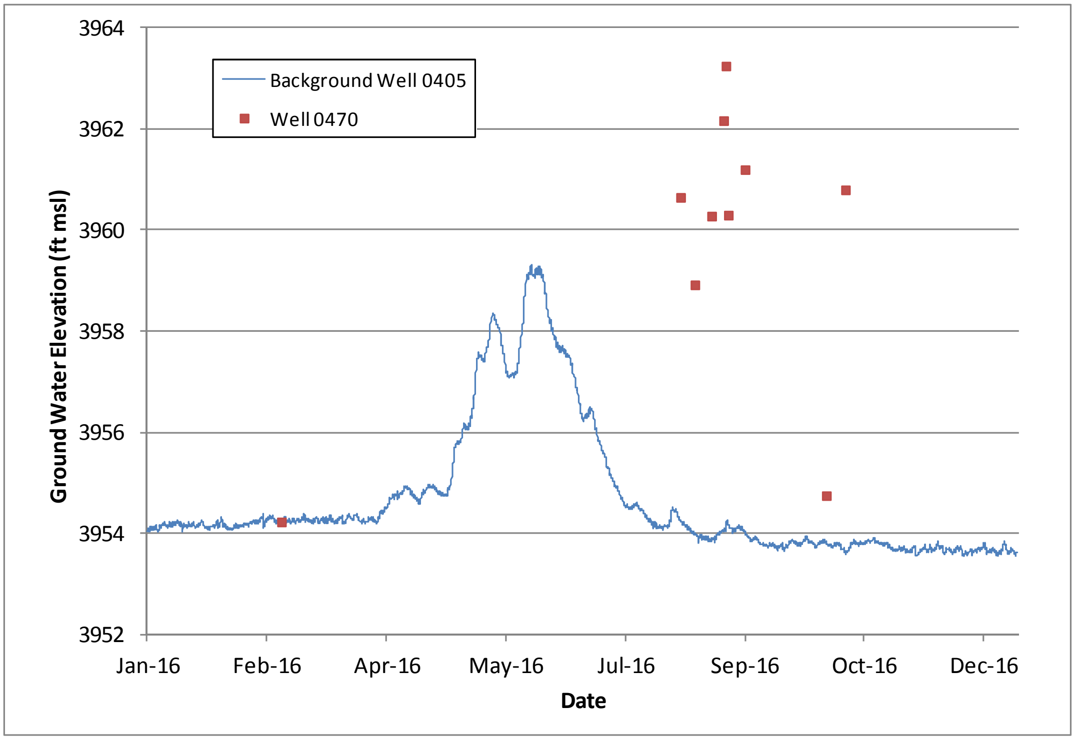

Figure B-19. Freshwater Mounding in Injection Well 0470

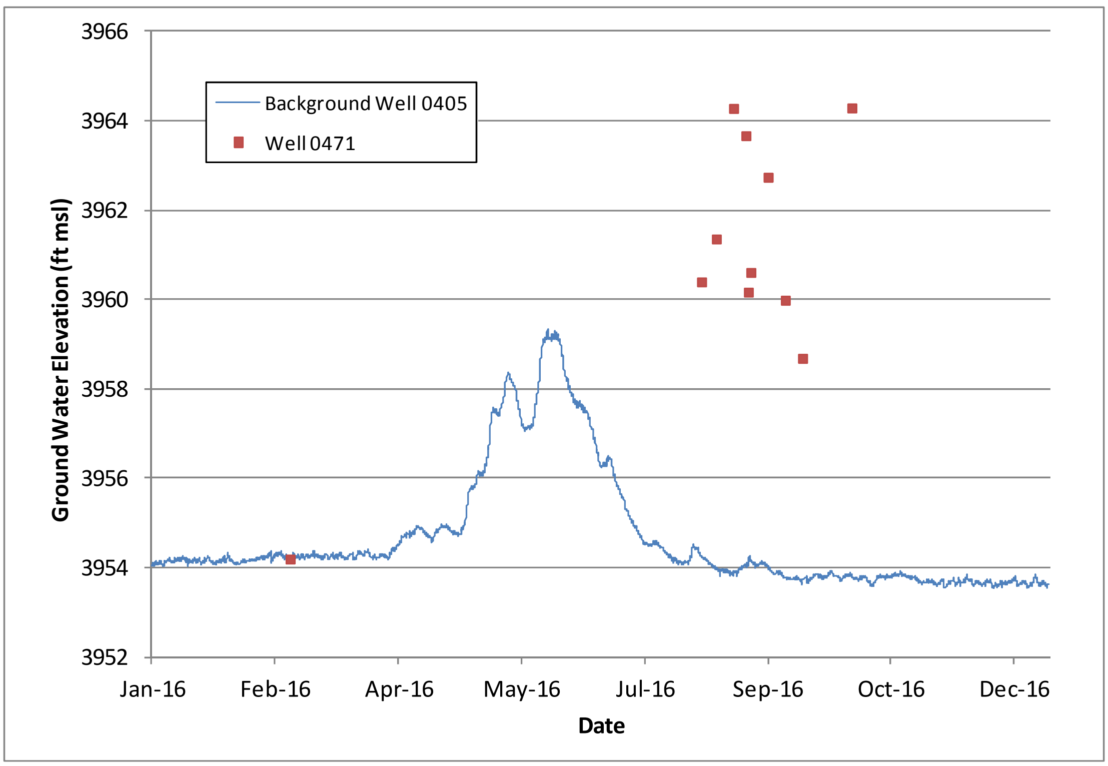

Figure B-20. Freshwater Mounding in Injection Well 0471

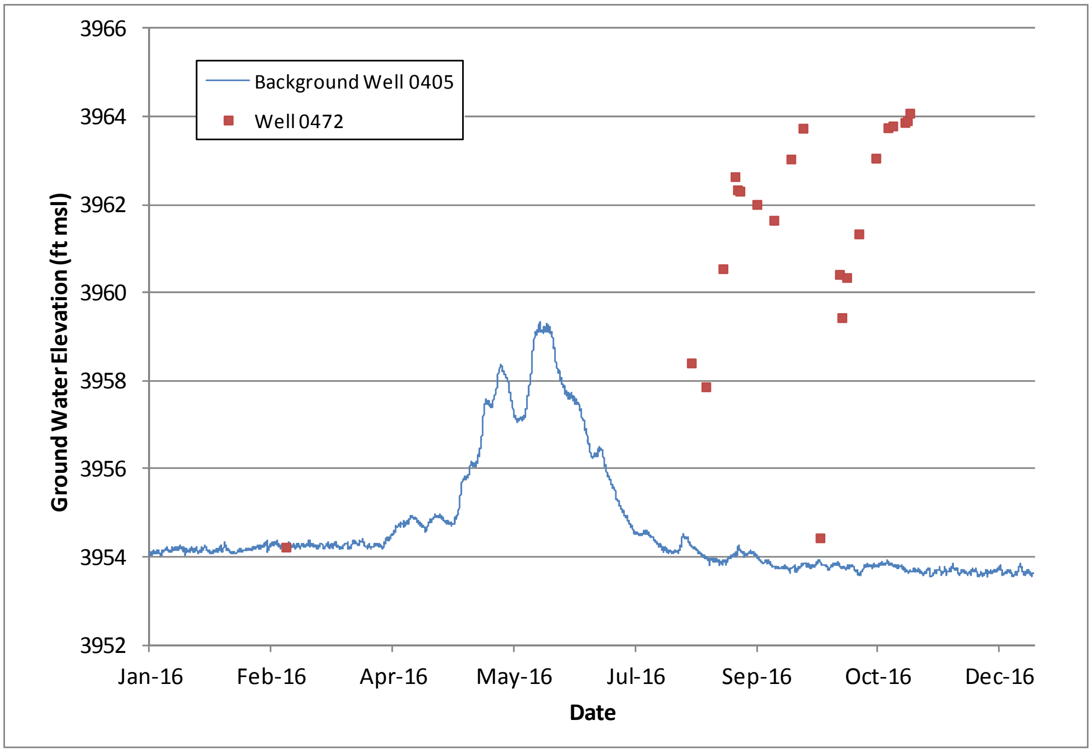

Figure B-21. Freshwater Mounding in Injection Well 0472

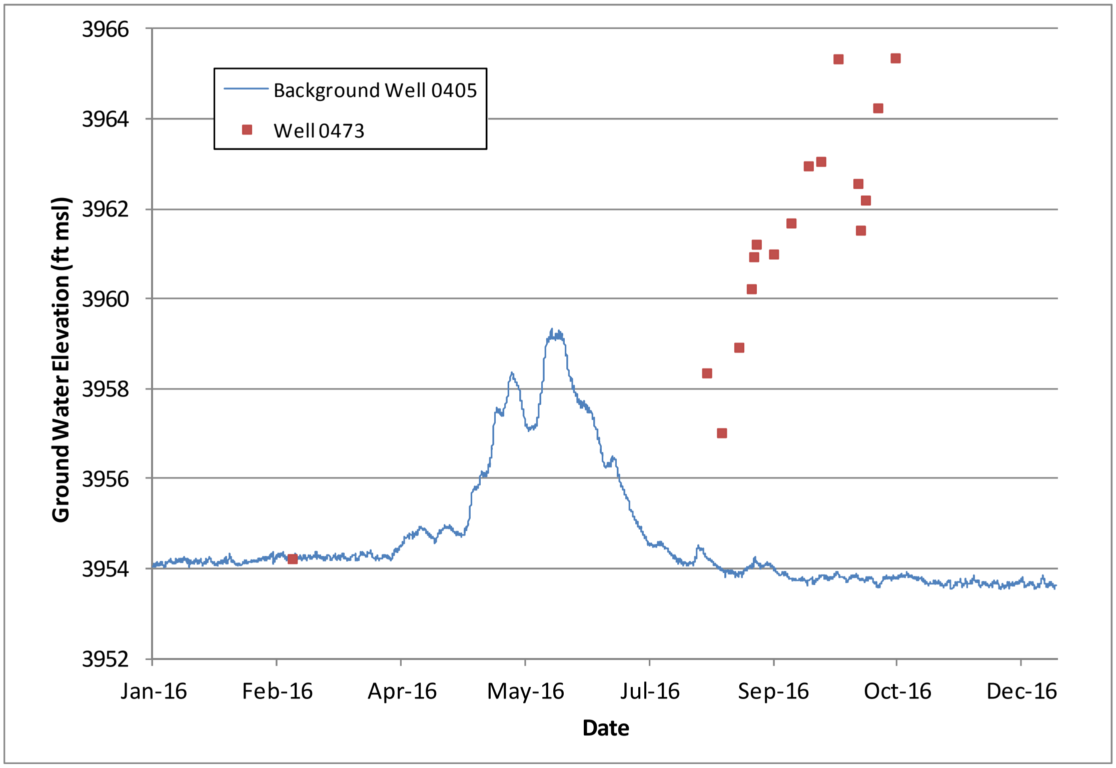

Figure B-22. Freshwater Mounding in Injection Well 0473

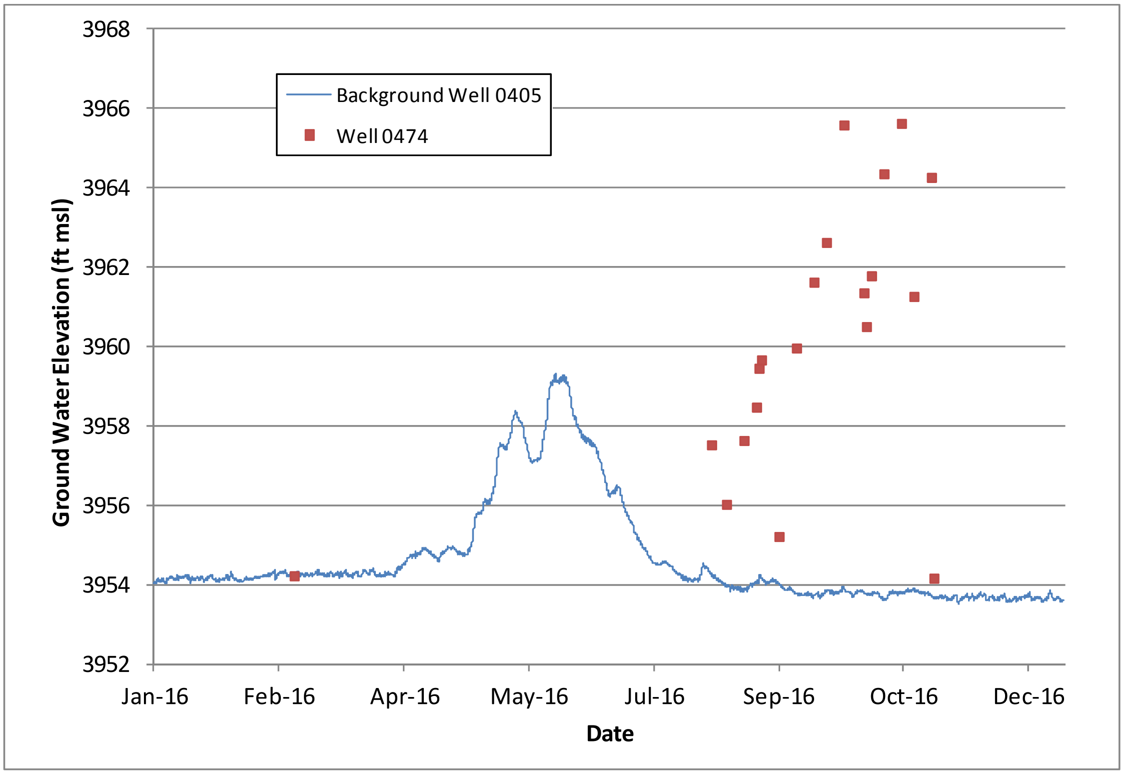

Figure B-23. Freshwater Mounding in Injection Well 0474

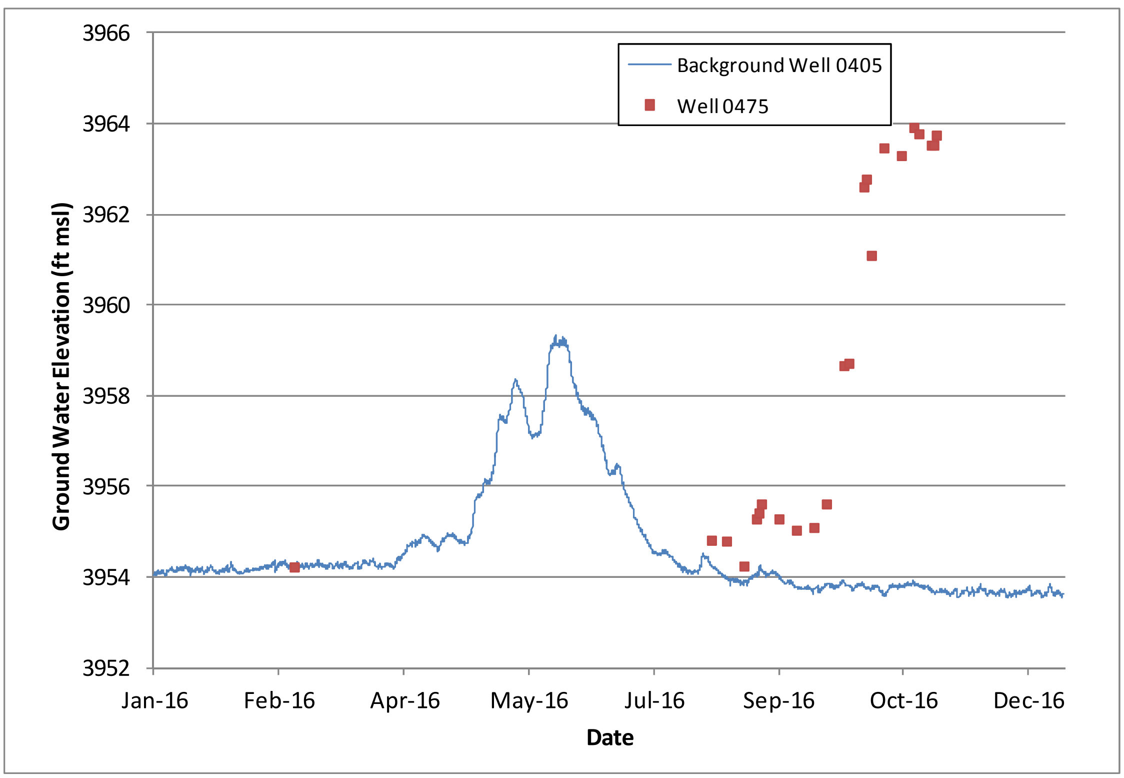

Figure B-24. Freshwater Mounding in Injection Well 0475

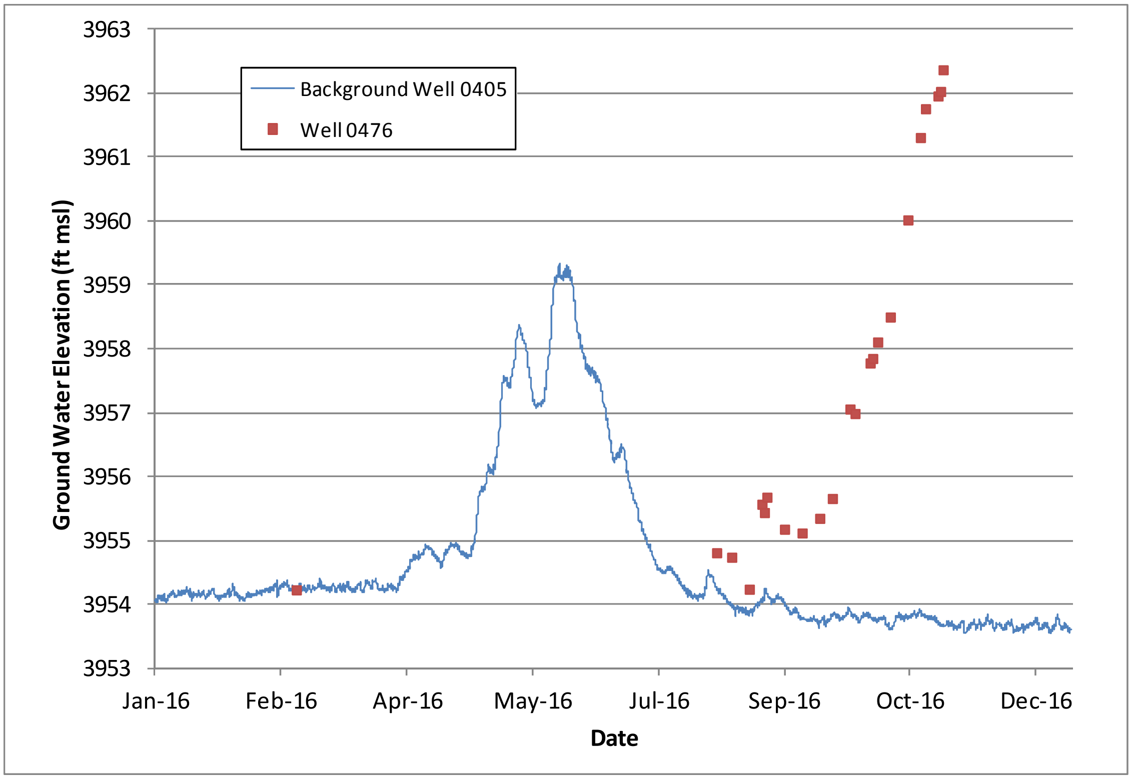

Figure B-25. Freshwater Mounding in Injection Well 0476

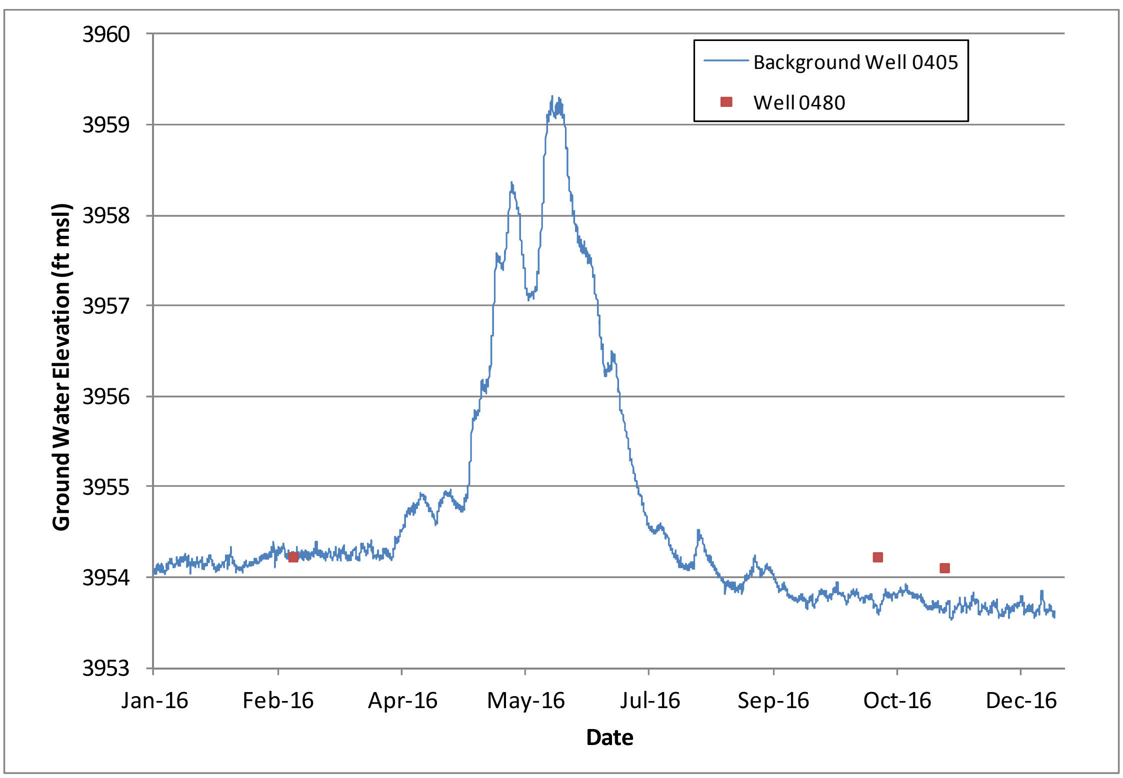

Figure B-26. Freshwater Mounding in Observation Well 0480

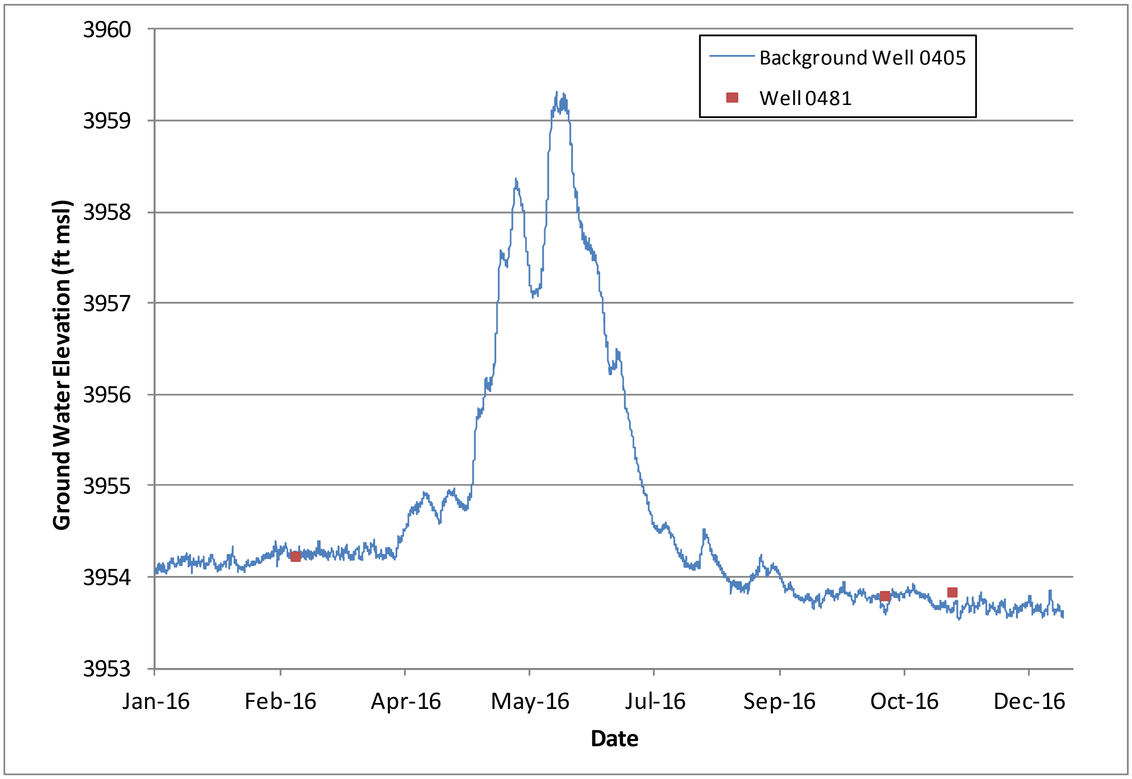

Figure B-27. Freshwater Mounding in Observation Well 0481

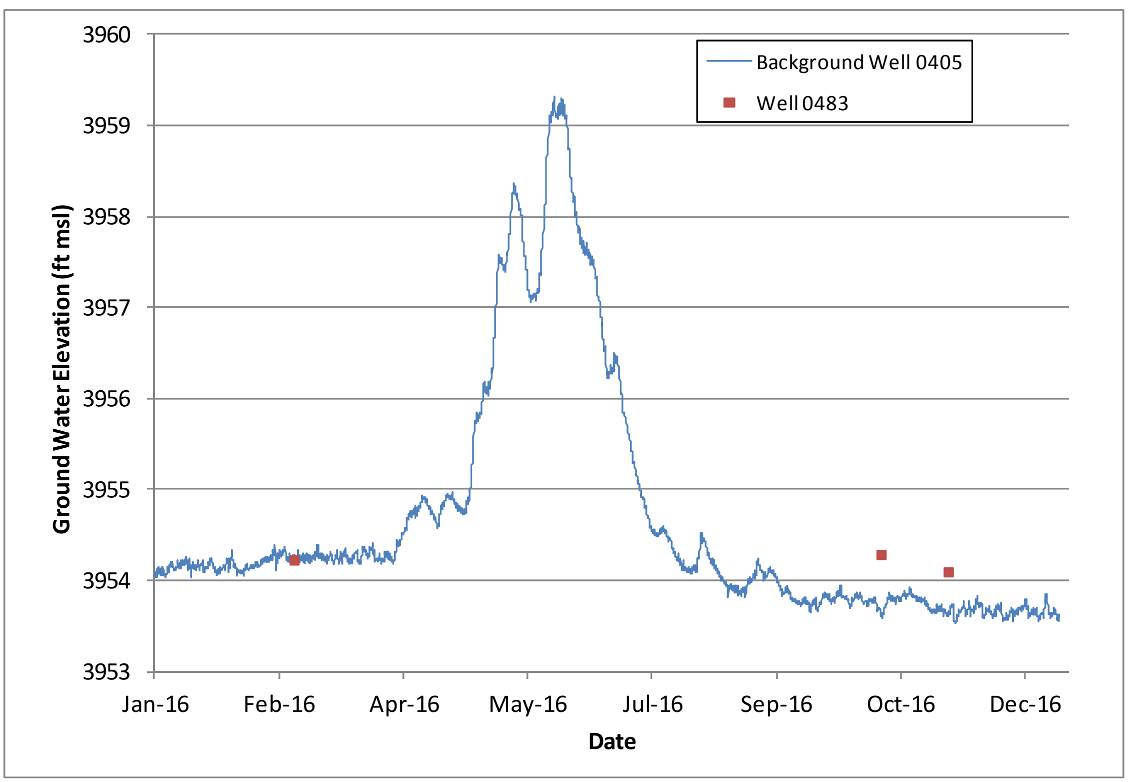

Figure B-28. Freshwater Mounding in Observation Well 0483

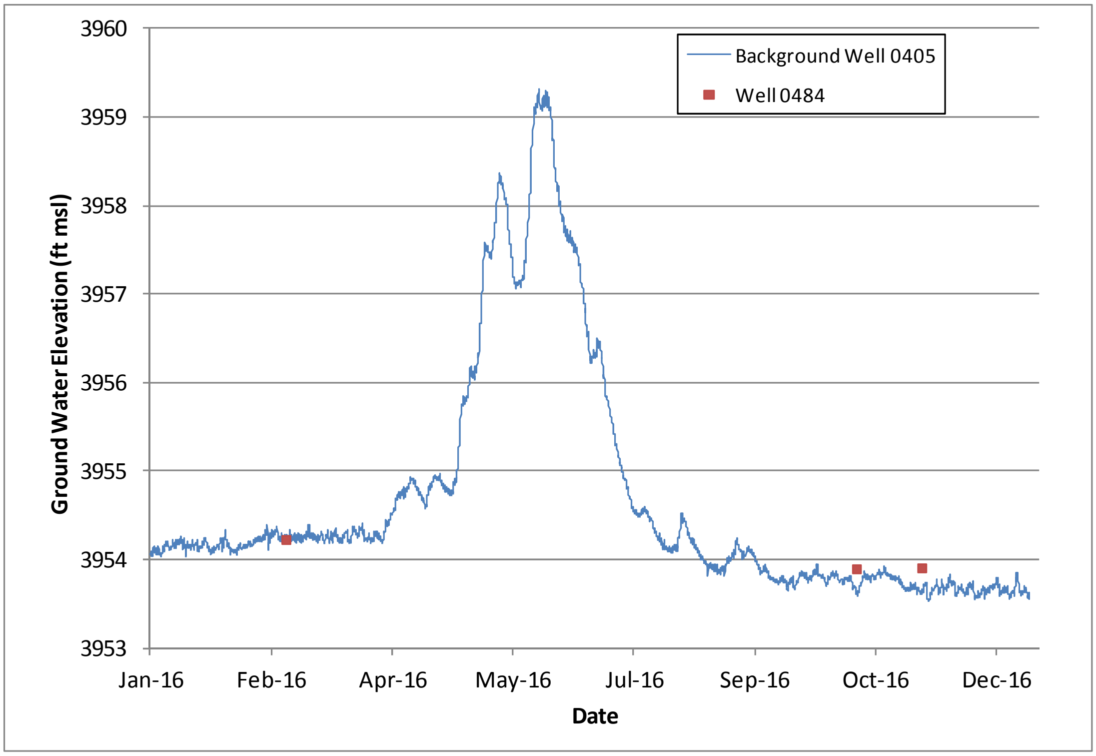

Figure B-29. Freshwater Mounding in Observation Well 0484

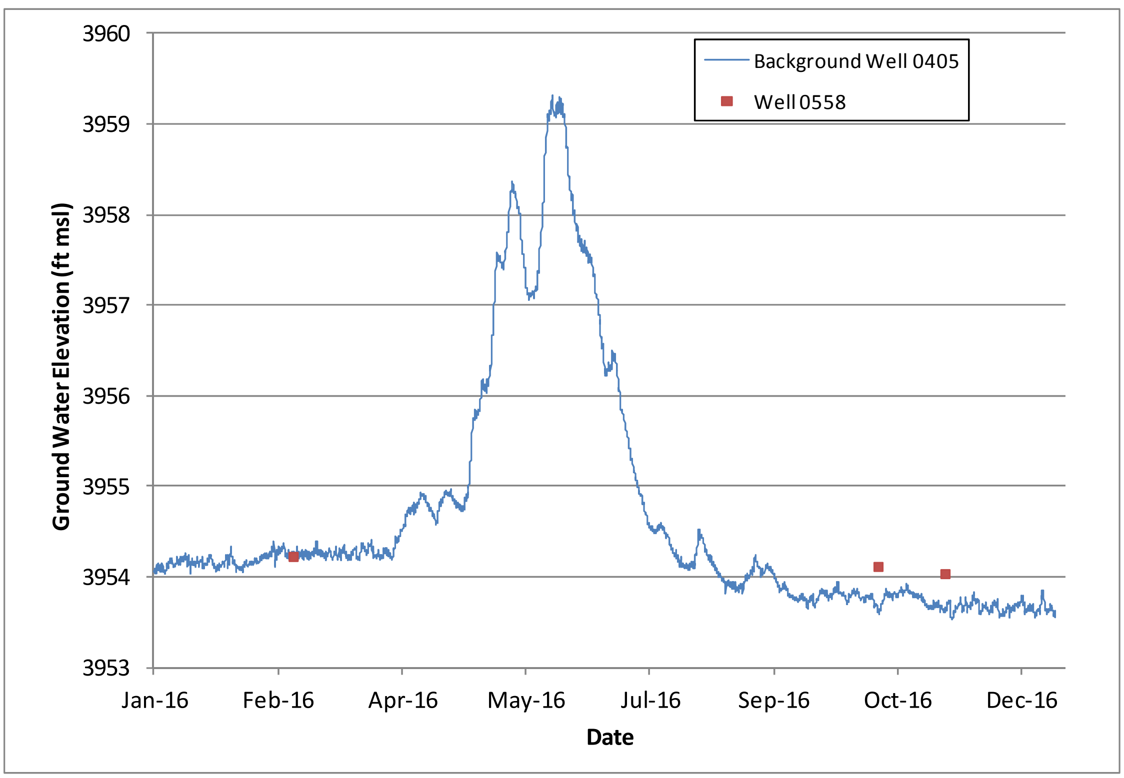

Figure B-30. Freshwater Mounding in Observation Well 0558

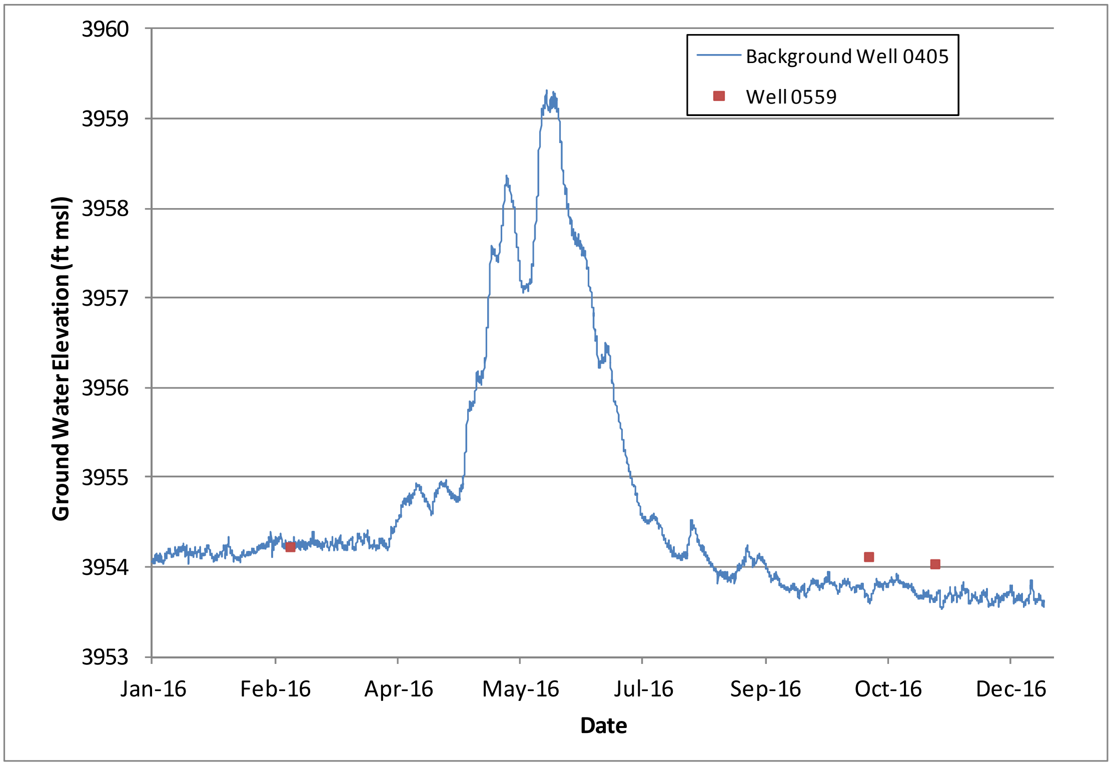

Figure B-31. Freshwater Mounding in Observation Well 0559

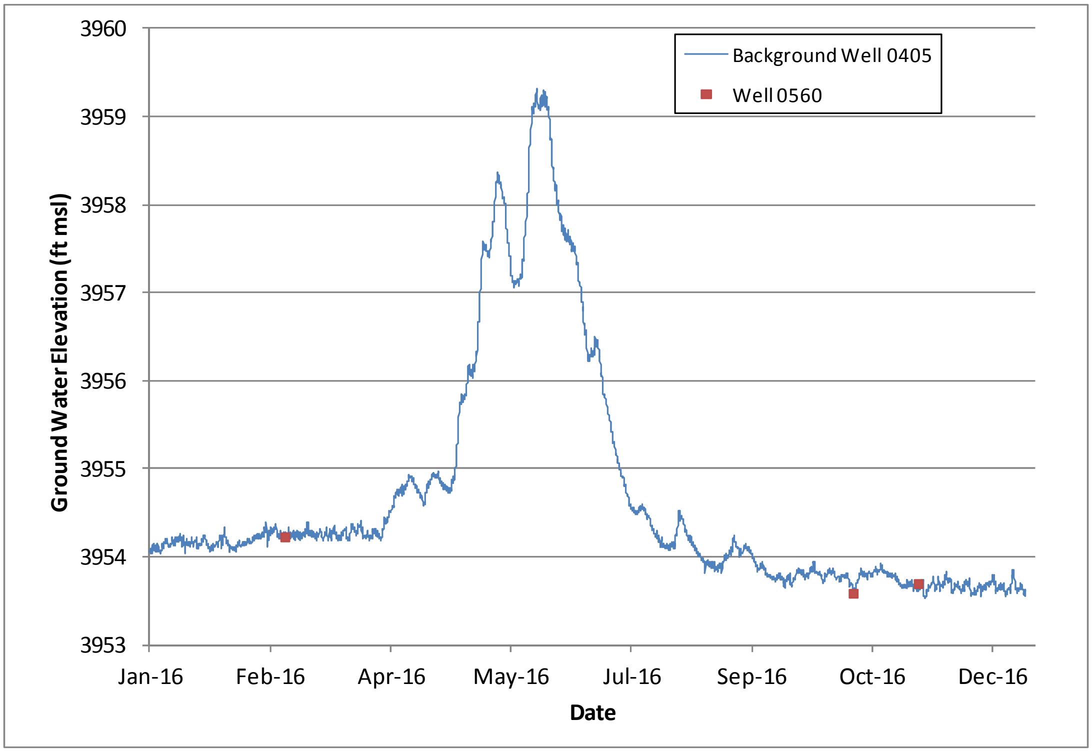

Figure B-32. Freshwater Mounding in Observation Well 0560