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Office of Environmental Management – Grand Junction

MOAB UTAH UMTRA Project

Moab UMTRA Project
2019 Groundwater Program Report

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Moab UMTRA Project 2019 Groundwater Program Report

Revision 0

Review and Approval

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Revision History

Revision	Date	Description
0	August 2020	Initial issue.

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Acronyms and Abbreviations

ALS	ALS Environmental
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
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 Groundwater Program Report is to assess the groundwater-related performance measures the U.S. Department of Energy (DOE) has taken at the Moab Uranium Mill Tailings Remedial Action (UMTRA) Project site. This report describes the Groundwater Program activities for the Moab Project during 2019, and evaluates the effectiveness of the remediation systems to remove contaminant mass from the groundwater system and protect endangered fish habitats that may develop in the Colorado River adjacent to the site.

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 within 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, primarily ammonia and uranium, have leached from the tailings pile into the shallow groundwater. Some of the more mobile constituents have migrated downgradient and are discharging into 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 its ongoing active remediation of contaminated groundwater at the Moab site, as necessary. As an interim action (IA), DOE began limited groundwater remediation that involves extraction of contaminated groundwater from on-site remediation wells that is used for dust suppression inside the Contamination Area (CA). In addition, remediation activities also include the utilization of freshwater injection and surface water diversion systems.

2.0 Groundwater Program Description

The Groundwater Program at the Moab site is designed to limit ecological risk from contaminated groundwater discharging to potential endangered fish species habitat areas along the Colorado River. This protection is accomplished by removing contaminant mass with groundwater 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 areas of the Colorado River adjacent to the IA well field when suitable habitats develop for endangered young-of-year fish species.

Groundwater 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.

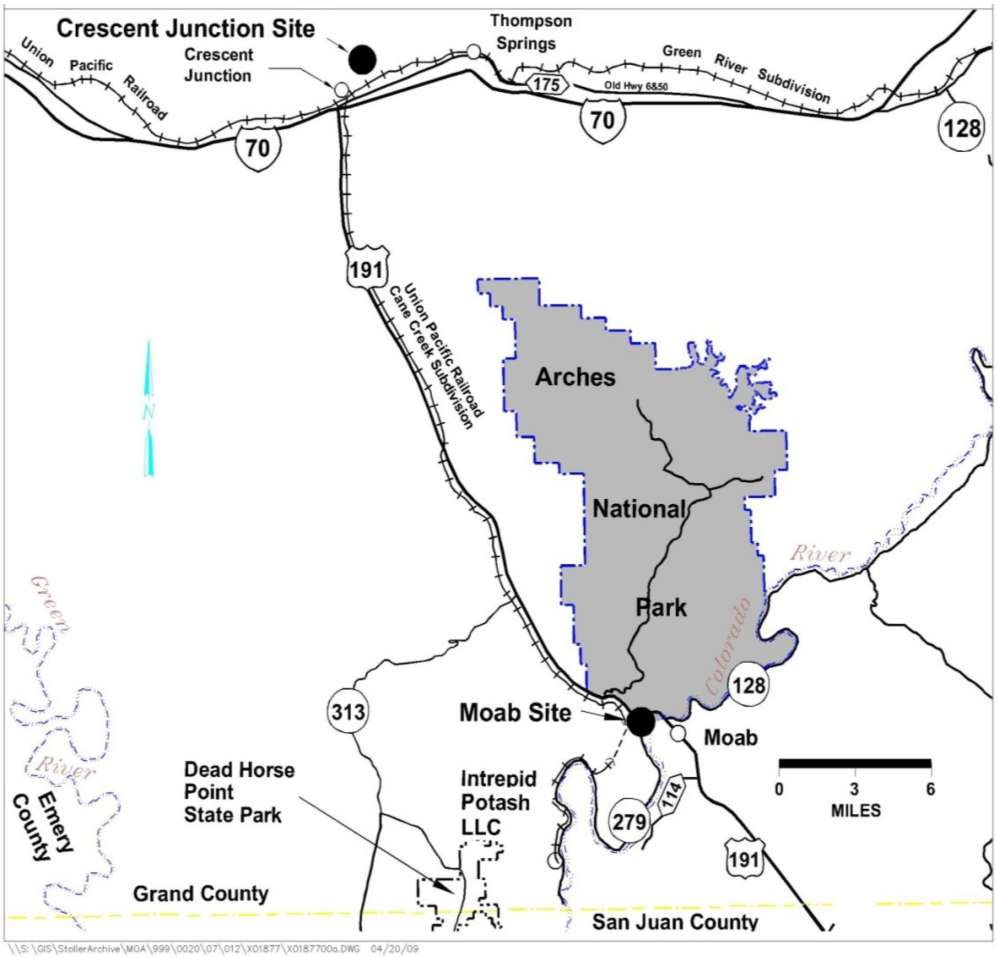

Figure 1. Location of the Moab Project Site

2.1 IA Groundwater System

DOE installed and began operating the first of several configurations (CFs) of extraction/injection wells that comprise the IA groundwater system in 2003 (Figure 2). The objectives of the IA system are to: 1) reduce the discharge of ammonia-contaminated groundwater to side channels that may be suitable habitat for endangered aquatic species, 2) remove contaminant mass through groundwater extraction, and 3) to provide performance data to select and design a final groundwater remedy. Contaminated groundwater from the shallow plume is extracted through a series of eight extraction wells (CF5). The IA system also includes injection of filtered river water into the underlying alluvium through remediation wells (CF4) located near the western bank of the river.

A surface water diversion system is designed to deliver fresh water to any area (primarily side channels) adjacent to the IA well field. This diversion occurs when an area develops into a suitable habitat for endangered young-of-year fish species and the ammonia concentrations exceed either the acute or chronic established U.S. Environmental Protection Agency (EPA) criteria. Monitoring wells are also part of the IA system for evaluation purposes. In 2019, CF4 wells were used for freshwater injection, and extraction operations occurred utilizing the CF5 extraction wells. In addition, the diversion system operated from late September through early October in 2019.

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. Moab Wash alluvium is composed of fine-grained sand, gravelly sand, and detrital material that travels down the Moab Wash and is deposited along the northwestern boundary of the site with the Colorado River basin-fill alluvium.

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 mostly consists 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.

Because of the conductive nature of the sands and gravels in the subsurface, any fluctuations in the Colorado River flows impact the groundwater surface elevations. Water table contour maps indicate the groundwater in this area discharges into the Colorado River under base flow conditions. Figure 3 was generated using data collected in May 2019 and exhibits how groundwater underlying the site discharges into the Colorado River. The river flow ranged from 1,710 to 39,100 cubic feet per second (cfs) throughout 2019. Figure 3 shows the groundwater surface contours in May 2019 when the hydrograph was rising toward peak flows at 11,100 to 11,600 cfs. Figure 4 shows the groundwater contours in October/November (during base flows), when the river flow ranged from 4,700 to 4,960 cfs.

Most groundwater 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 naturally occurs 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 groundwater 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 groundwater system.

Since the cessation of milling operations at the site in 1984, the flux of relatively fresh water entering the site upgradient of the tailings pile may have diluted the ammonia concentrations in the shallow groundwater (Figures 5 and 6).

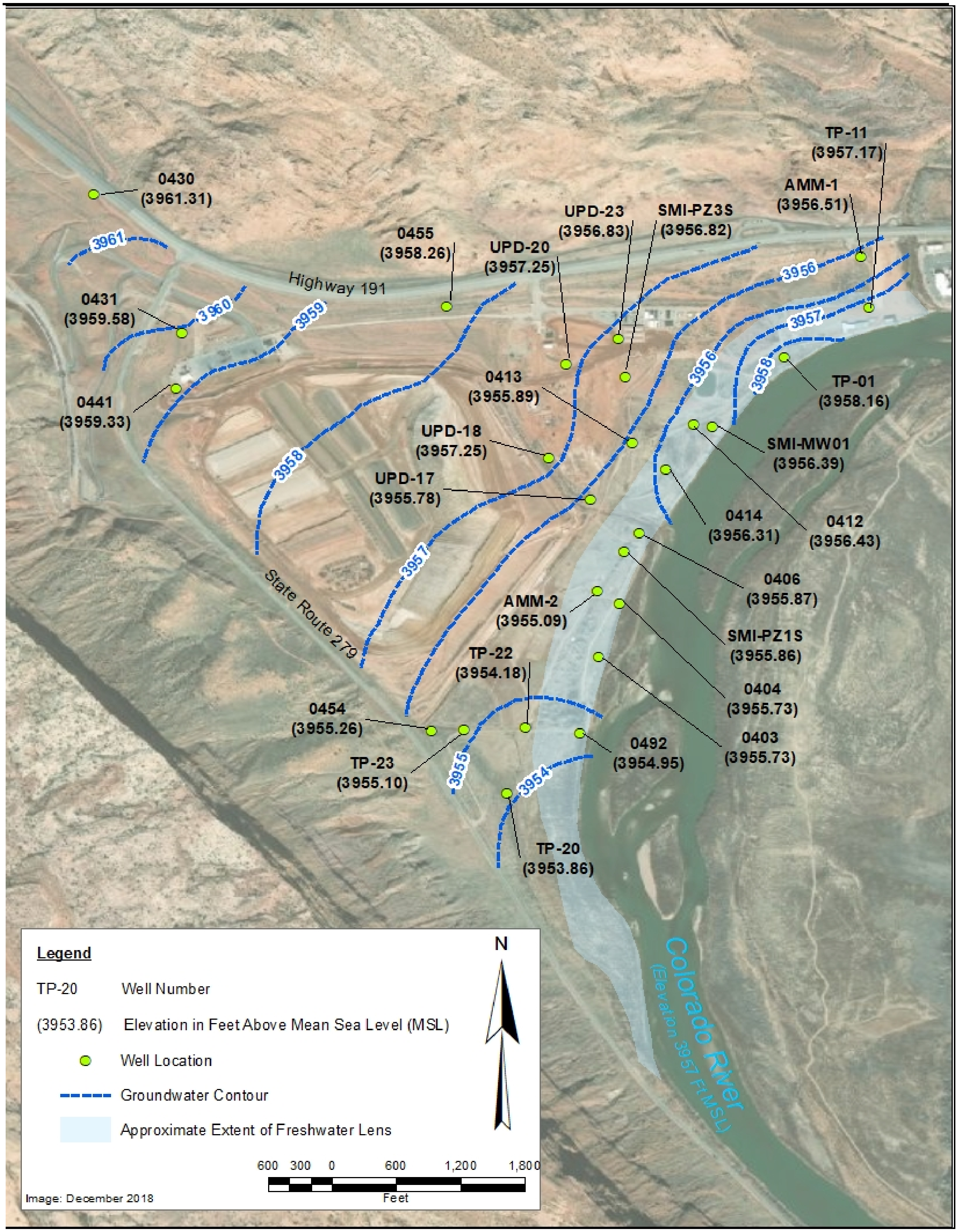

Figure 3. Site-wide Groundwater Elevations, May 13 through May 14, 2019

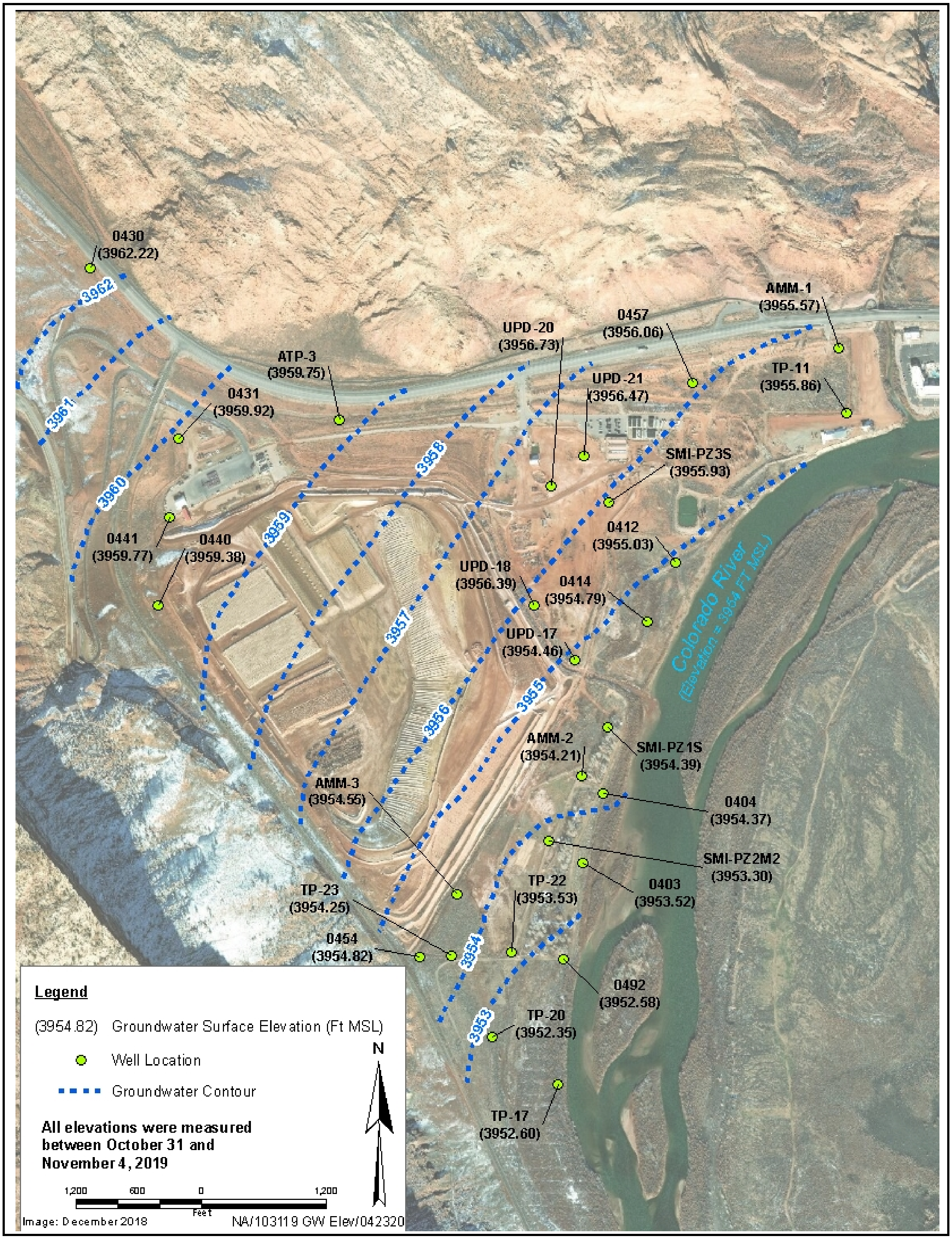

Figure 4. Site-wide Groundwater Elevations, October 31 through November 6, 2019

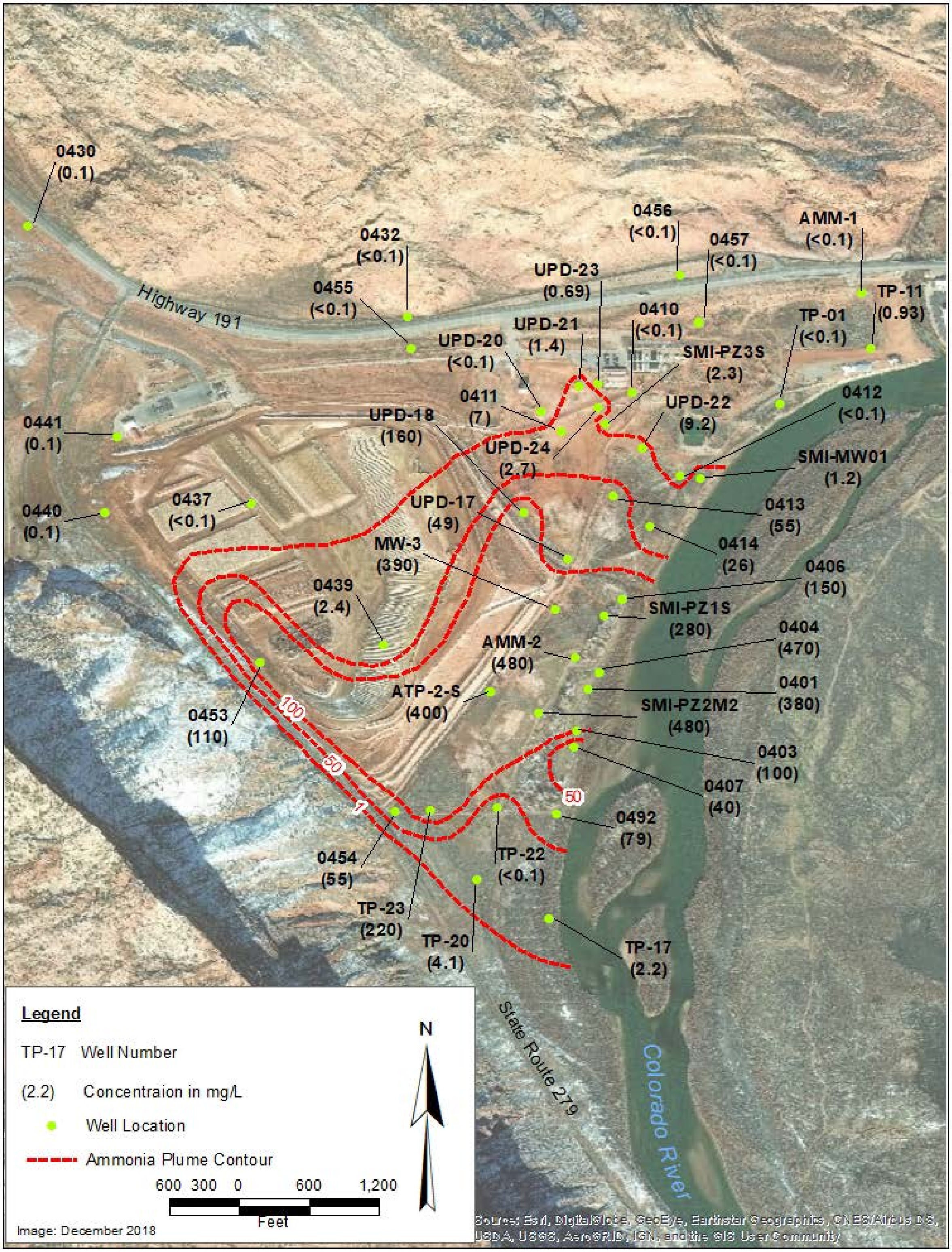

Figure 5. Ammonia Plume in Shallow Groundwater May/June 2019

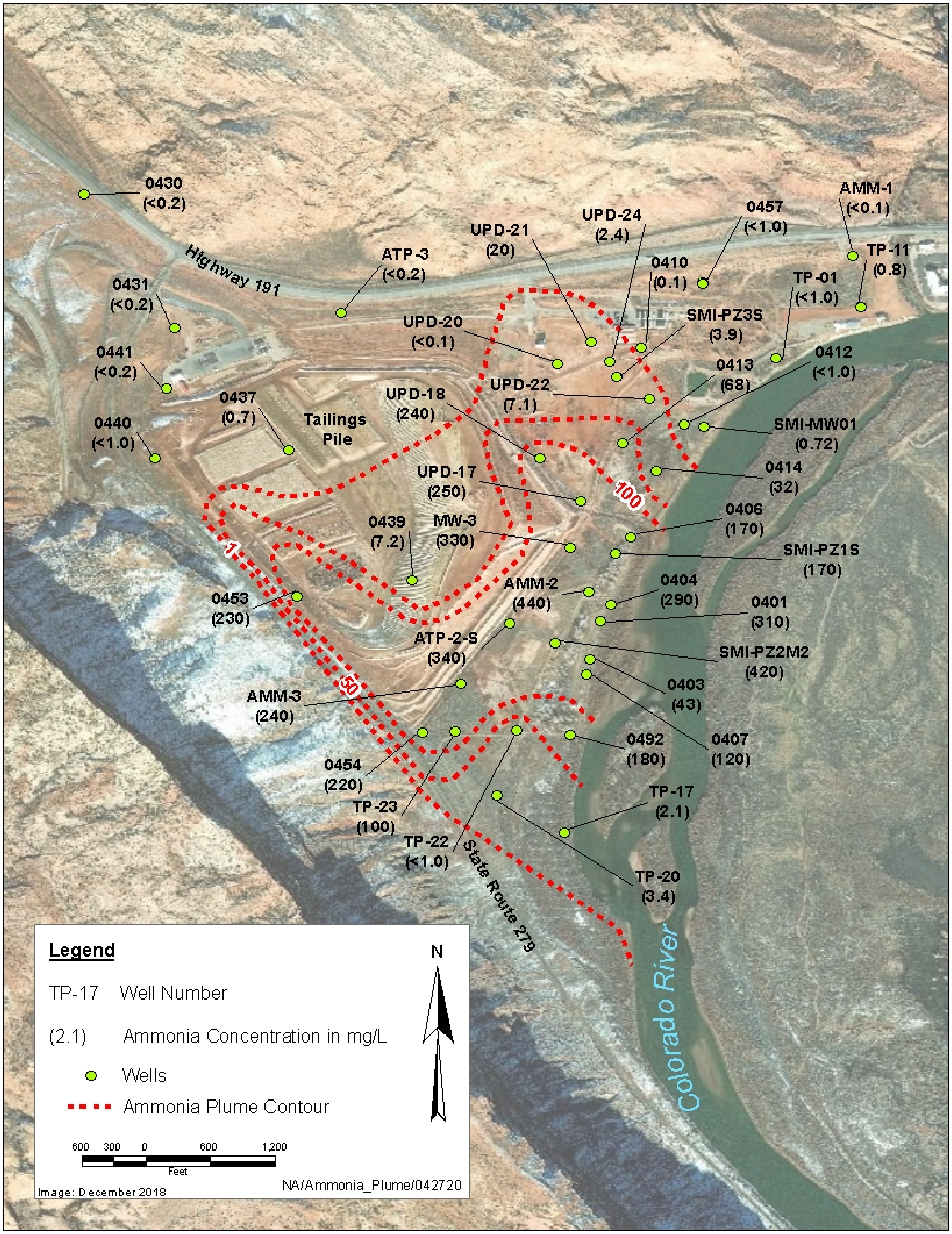

Figure 6. Ammonia Plume in Shallow Groundwater November/December 2019

Oxidation of ammonia to nitrate or nitrogen may also contribute to lower ammonia concentrations observed in the upgradient shallow groundwater beneath the tailings pile, where aerobic conditions are more likely; however, there is no flushing of the legacy plume by an advective flow of fresh water due to density stratification of the brine zone. Figure 5 shows the ammonia plume in May/June 2019, and Figure 6 shows the ammonia plume in November/December 2019. The two plume maps are comparable.

There is no standard associated with ammonia, while the uranium groundwater 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 groundwater is uranium. Figures 7 and 8 show the distribution of dissolved uranium in shallow groundwater in 2019. The uranium plumes are similar with the exception of the area near the riverbank, where the concentrations may become diluted during Colorado River spring runoff flows.

2.3 Surface Water/Groundwater Interaction

Previous investigations have shown that Colorado River flows impact the groundwater elevations and contaminant concentrations in the well field. For the majority of the year, when the river is experiencing baseflow (less than 5,000 cfs), groundwater 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 alluvium underlying the well field.

During higher flows, the groundwater gradient direction reverses in the vicinity of the riverbank, and the groundwater contaminant concentrations are diluted. Once these flows subside, the river switches back from losing to gaining, the groundwater gradient direction is re-established towards the river (to the southeast), and the freshwater lens recedes.

Figure 9 displays the groundwater elevation and the elevation of the Colorado River in 2019. 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 and Drought Mitigation Plan* (DOE-EM/GJTAC1640). The Colorado River Basin experienced a high water year in 2019 due to an above average snowpack.

Between January and April 2019, the Colorado River was under gaining conditions (when the groundwater elevation was higher than the river surface elevation). The river had brief stages of losing conditions in the spring but made the complete switch by the end of April as the basin experienced unusually high water and flooding. The river remained in losing condition (with the river surface elevation higher than the groundwater elevation) until late July when it switched back to gaining through the remainder of 2019.

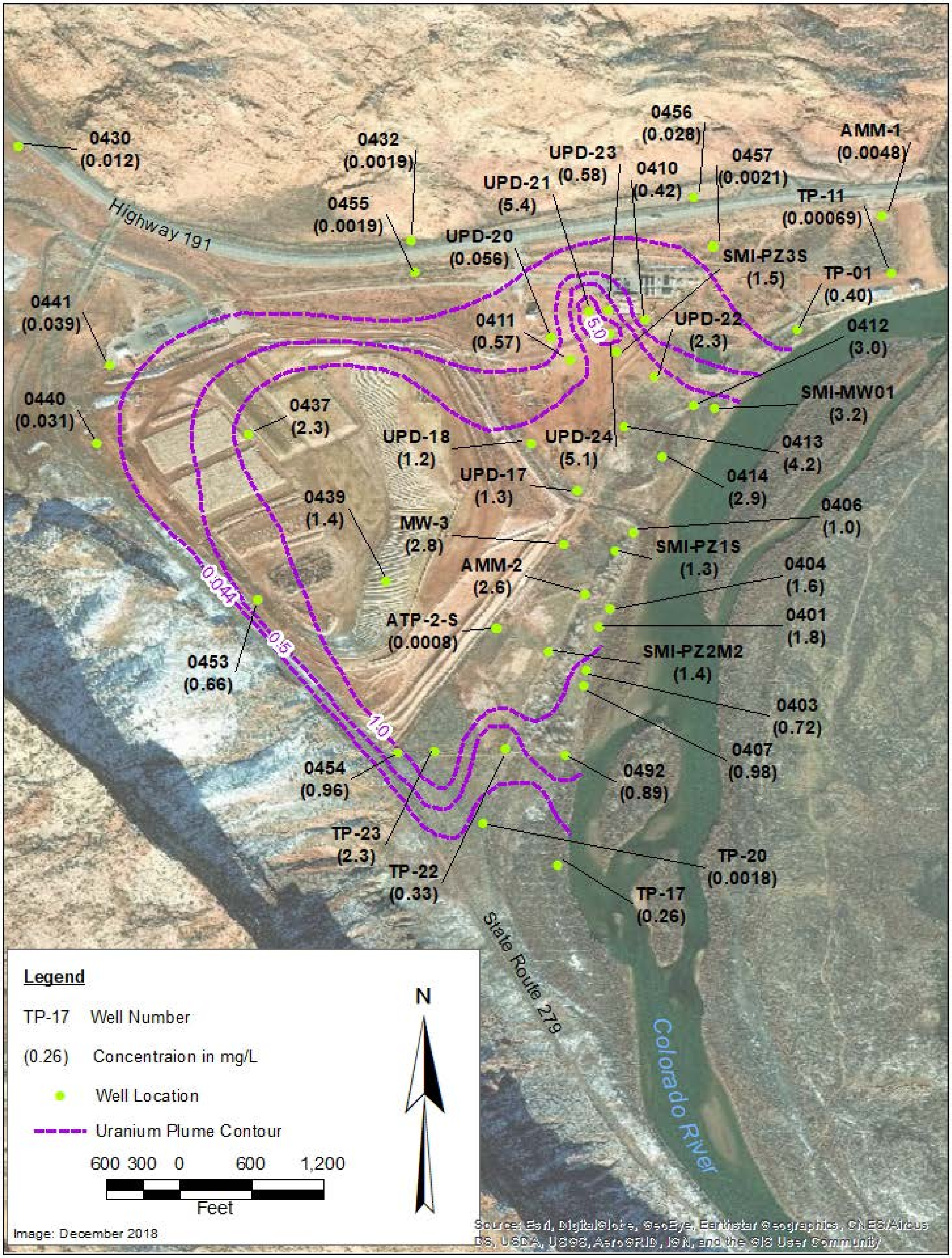

Figure 7. Uranium Plume in Shallow Groundwater May/June 2019

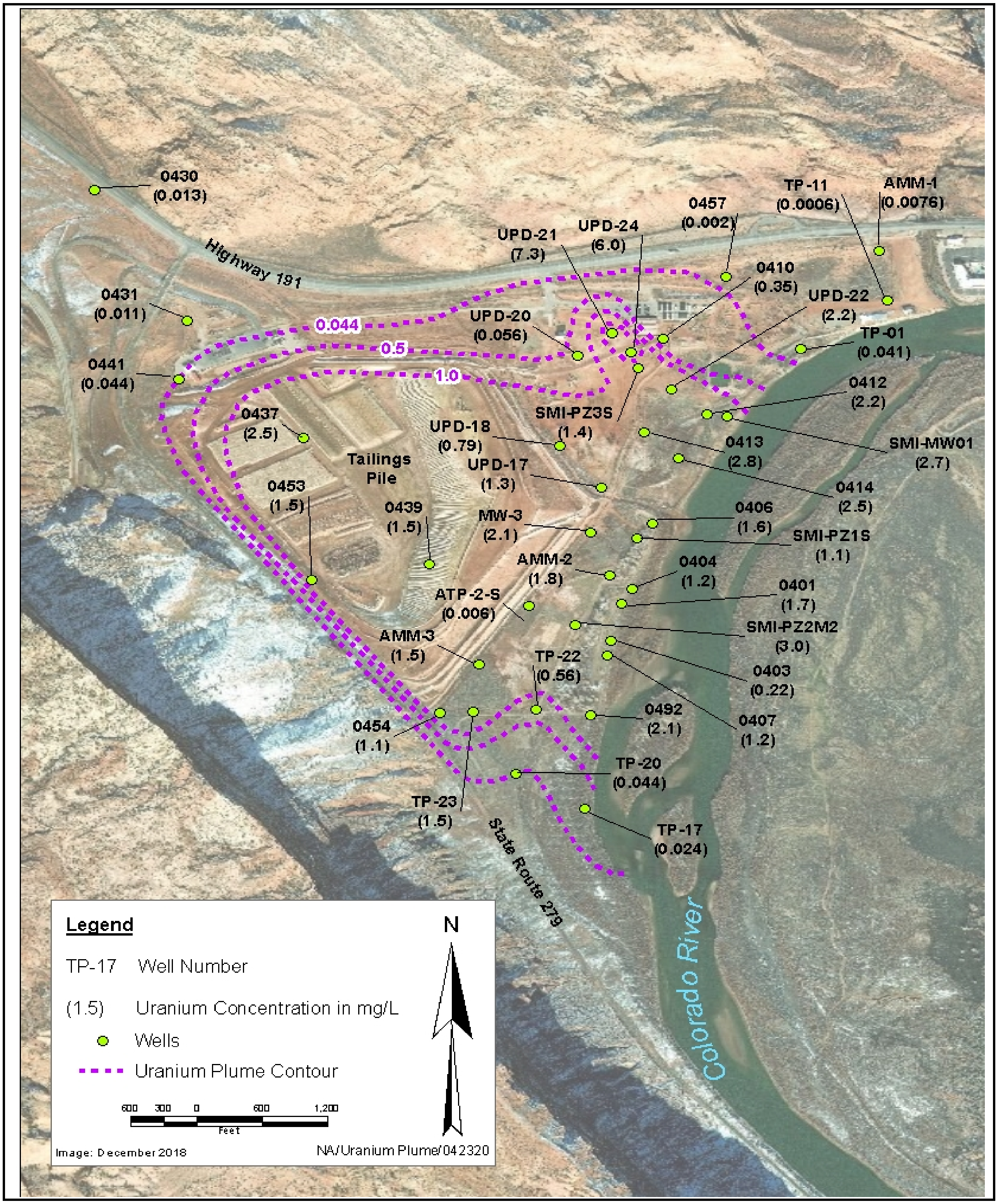

Figure 8. Uranium Plume in Shallow Groundwater November/December 2019

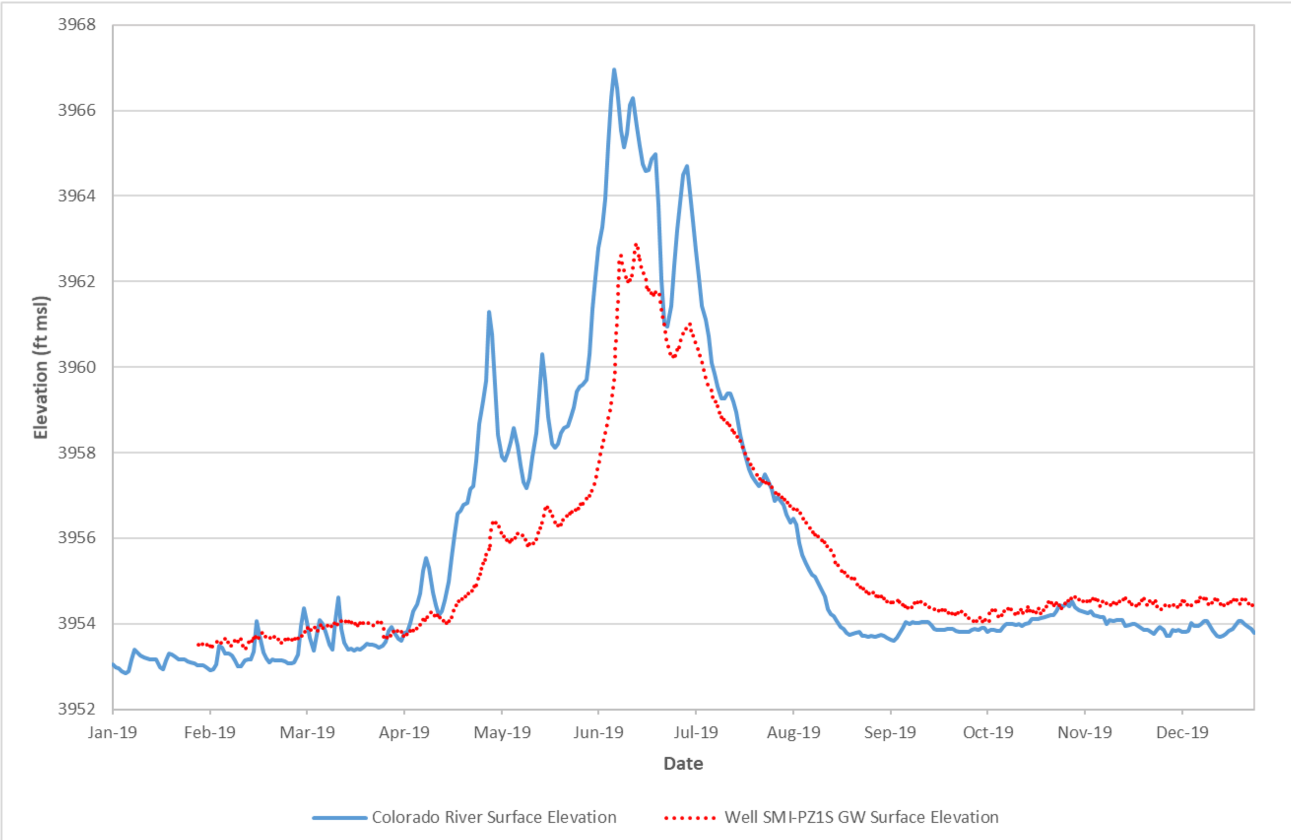

Figure 9. Groundwater Surface Elevation Compared to the Colorado River Surface Elevation 2019

3.0 Methods

Well field performance is assessed by measuring extraction/injection rates of remediation wells, measuring water levels, and the collection of samples from surface water locations, extraction wells, and monitoring wells for analytical analysis. In 2019, the IA well field operations included extraction at CF5 and injection at CF4. In addition, the surface water system was operational starting in late September through early October 2019.

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, and the net volume since the last reset of the internal memory. Flow meter readings are manually recorded on a weekly basis during extraction operations and are used in conjunction with water quality data to calculate the contaminant mass removal and evaluate the performance of the system.

The extracted groundwater is used as dust suppression in the 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. Water level data are used to calculate the elevation of freshwater mounding in each well.

3.3 Water Levels

Groundwater levels are recorded in the IA well field on a weekly basis during injection operations to monitor groundwater drawdown and freshwater mounding. A water level indicator is used to measure the depth to groundwater (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. Prior to collecting a sample, the field parameters (which include temperature, pH, and conductivity) are measured and recorded. Observation wells are primarily sampled with dedicated down-hole tubing and a peristaltic pump, while extraction wells are sampled with dedicated submersible pumps.

Water samples are collected from observation wells 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/Groundwater Sampling and Analysis Plan* (DOE- EM/GJTAC1830). Samples are shipped overnight to ALS Environmental (ALS) in Fort Collins, Colorado, for analysis.

4.0 Groundwater Extraction System Operations and Performance

4.1 IA Operations

This section provides information regarding the IA well field extraction performance during the 2019 pumping season. This section also includes a discussion of the total groundwater extraction rate, hydraulic control, mass removal, and water quality. Appendix A contains tables of well construction information (Table A-1), a chronology of 2019 activities (Table A-2), pumping volumes (Table A-3), and mass removal (Tables A-4 and A-5).

The evaporation pond was decommissioned in 2015 as excavation of the tailings continued. The modified extraction system was installed in early 2016. It was first utilized in May 2016, and fully operational in June 2016. The extraction operations are now controlled by an automated system. Groundwater from extraction wells is pumped directly into two 21,000-gal frac tanks that serve as holding tanks. The water is then pumped into a 12,000-gal Klein tank, where it transferred to water trucks and used for dust suppression in the CA.

Extraction operations are limited by how much water is needed for dust suppression in the CA and by weather conditions (wet weather leads to less extraction, and warm, windy weather leads to more extraction). The extraction schedule was focused on optimizing ammonia and uranium mass removal and rotating through each of the eight CF5 remediation wells. In 2019, the extraction system was re-started in mid-March and operated through early June, at which time the system was shut down in preparation of flooding.

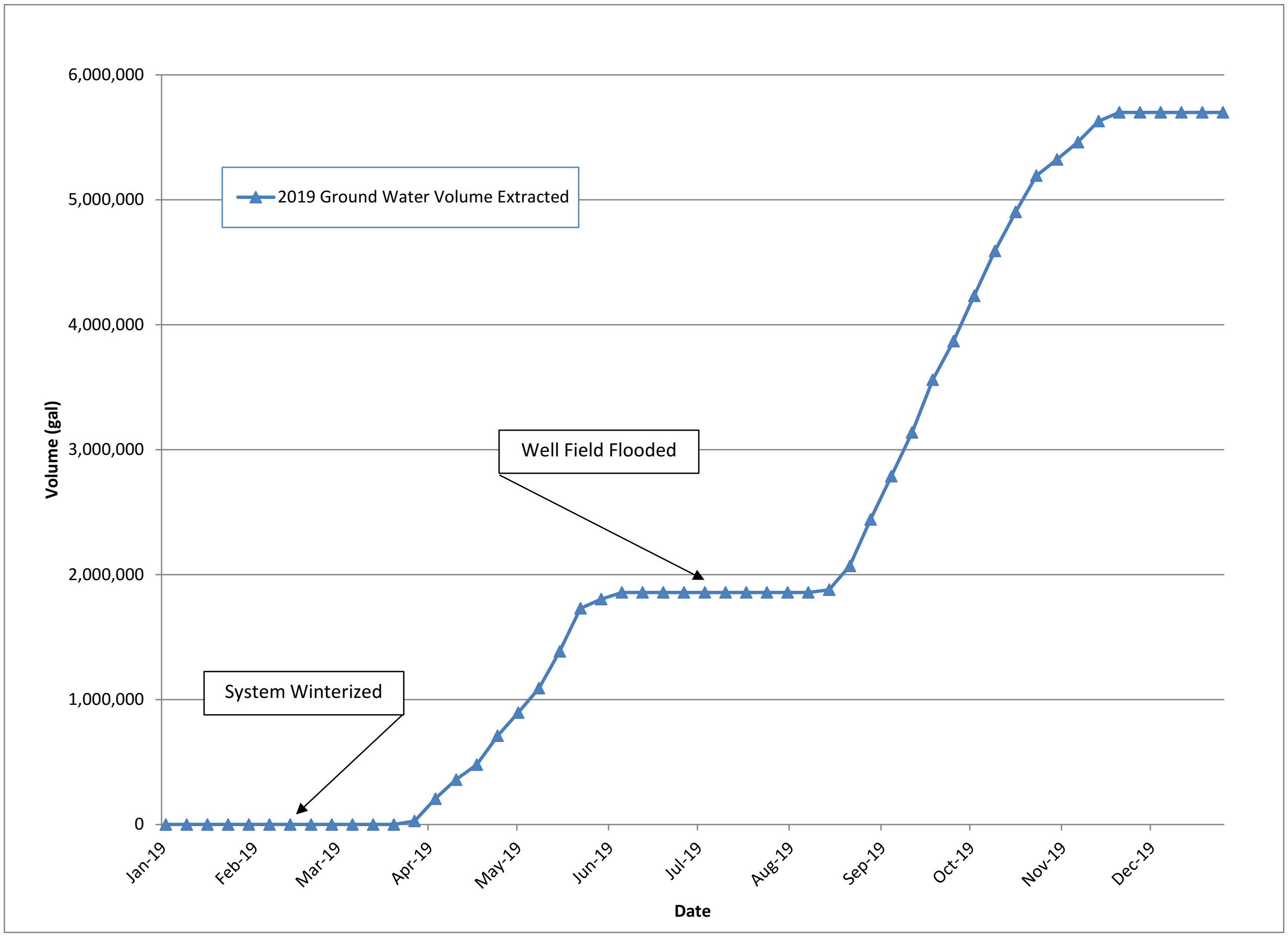

Figure 10. Cumulative Volume of Extracted Groundwater during 2019

After flood waters had receded and the area cleared, extraction resumed in mid-August and was operational until the system was winterized in mid-November. More details regarding the well field flooding are provided in the *Moab UMTRA Project 2019 Flood Response Summary* (DOE-EM/GJTAC3035).

The associated volume of groundwater extracted by each well in CF5 is shown in Table A-3. Figure 10 provides a graphic summary of the cumulative volume of groundwater extracted from CF5 in 2019. A total of approximately 5.7 mil gal of water was extracted from CF5 during 2019.

4.2 CF5 Groundwater Volume Extracted and Contaminant Mass Removal

Monthly extraction volumes for each of the eight extraction wells are listed in Table A-3. The majority of the 2019 extracted water was removed from wells 0813 (1.2 mil gal) and SMI-PW02 (868,100 gal). The remaining CF5 wells extracted between approximately 26,400 and 822,885 gal in 2019. Extraction operations were maximized in October when 1.5 mil gal were removed from the groundwater system.

The ammonia and uranium mass removed by CF5 extraction wells in 2019 is presented in Tables A-4 and A-5. These values are based on groundwater extraction volumes recorded by individual flow meters. The mass of ammonia and uranium removed from groundwater 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 Table 1 and in Appendix D (available on the Project's SharePoint website). In 2019, a total of 14,804 pounds (lb) (6,715 kilograms [kg]) of ammonia and 138.8 lb (63.0 kg) of uranium were extracted from the groundwater system.

Table A-4 shows that extraction wells 0813 and PW02 removed the most ammonia mass at 4,137 lb (1,877 kg) and 3,204 lb (1,453 kg), respectively. Estimated mass withdrawals of uranium at CF5 extraction wells are presented in Table A-5, which shows the greatest mass of uranium was extracted from wells 0813 and PW02 at 26.8 lb (12.2 kg) and 25.2 lb (11.4 kg), respectively.

4.3 Groundwater Chemistry

Groundwater samples were collected from the CF5 extraction wells twice in 2019, in April and September (Table 1). Ammonia concentrations varied from 120 mg/L (well 0815) to 460 mg/L (well 0812), and the uranium concentration ranged from 1.2 mg/L (well 0813) to 3.3 mg/L (wells PW02 and 0815). Specific conductance ranged from 11,334 µmhos/cm at well 0813 (northern end of CF5) to 30,939 µmhos/cm at well 0810 (located at the southern end of the well field).

Figures 11 through 14 are time versus concentration plots that display trends of the CF5 extraction wells from 2011 through 2019, which represents the majority of the CF5 well field lifespan (extraction was started in April 2010). Figure 11 is the time versus ammonia concentration plot for extraction wells 0810 through 0813 and SMI-PW02, all of which are located along the CF5 southeastern boundary. Figure 12 displays a time versus uranium concentration plot for the same set of wells. Figures 13 and 14 are the time versus ammonia and uranium concentration plots, respectively, for CF5 wells 0814 through 0816 which are located closer to the base of the tailings pile.

During 2019, the flooding of the well field likely impacted the contaminant concentrations, diluting the groundwater system with fresh water over the six weeks. Standing water was present in the well field. Well SMI-PW02, which is located at the center of this line of wells (and near the center of the groundwater contaminant plume), has generally had the highest contaminant concentrations.

Taking into account all eight extraction wells, the ammonia concentrations continue to be significantly higher (in some cases twice as high) in the samples collected from wells located along the CF5 southeastern boundary compared to the wells located along the toe of the tailings pile. A similar trend is not apparent regarding the uranium concentrations, with both lines of wells having very similar results. In general, contaminant concentrations associated with samples collected from these wells have been gradually decreasing in the past 3 to 4 years.

Similar plots (Figures 15 and 226) were generated based on sampling results for wells SMI-PZ2M2 and AMM-2 since 2009. Both of these wells are located within the CF5 well field, with SMI-PZ2M2 part of the SMI-PW02 well cluster, and well AMM-2 approximately 75 ft south of CF5 well 0813. While it is difficult to assess the difference between the impact of extraction and changes in the river stage, ammonia concentrations at both locations appear to have gradually decreased after CF5 extraction was initiated in April 2010. Since 2009 uranium concentrations have ranged from 0.5 and 2.6 mg/L and 0.5 and 3 mg/L in samples collected from AMM-2 and SMI-PZ2M2, respectively, displaying no apparent trend.

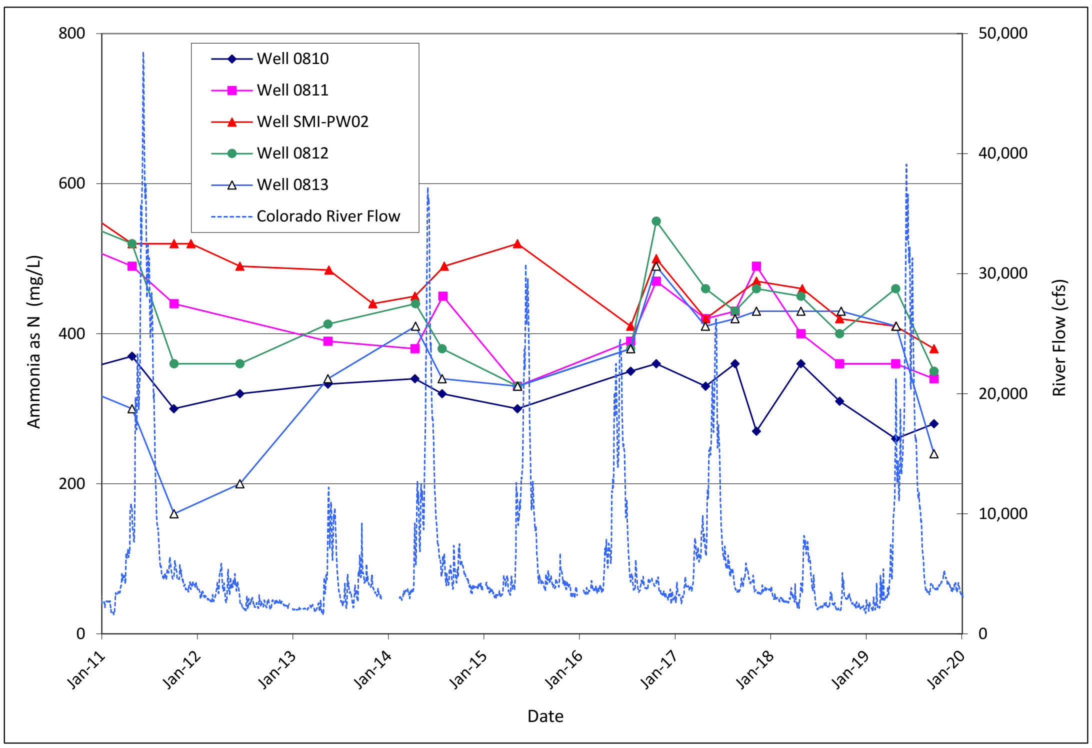

Figure 11. CF5 Extraction Wells 0810, 0811, 0812, 0813, and SMI-PW02 Time versus Ammonia Concentration Plot

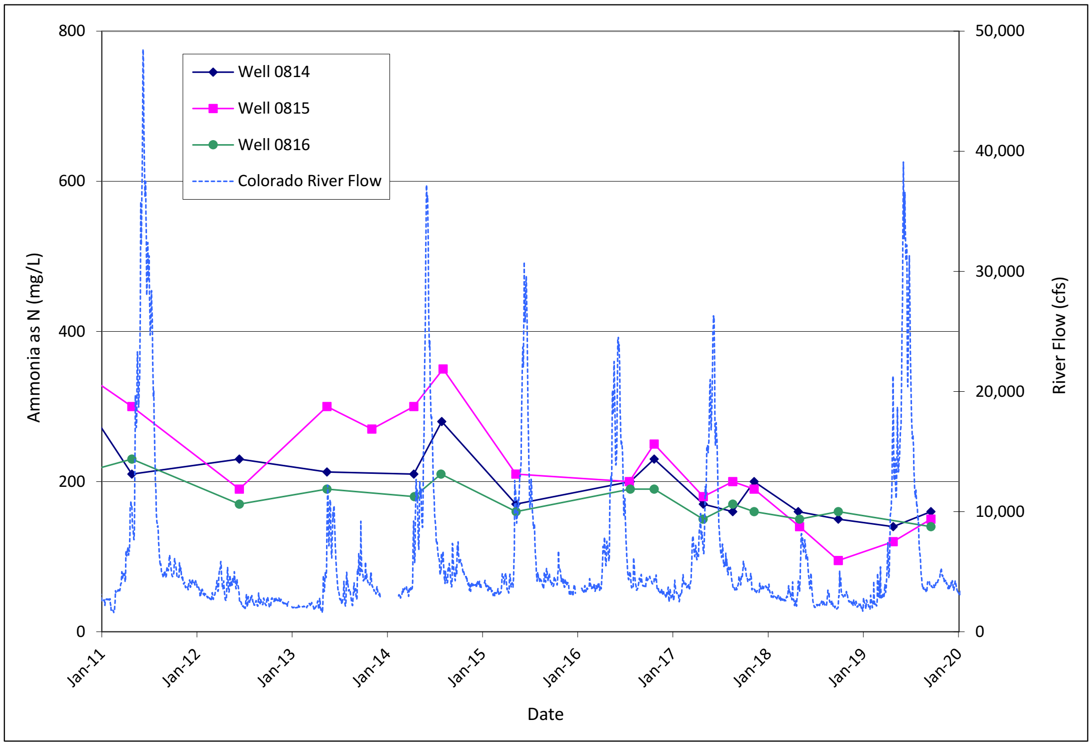

Figure 12. CF5 Extraction Wells 0814, 0815, and 0816 Time versus Ammonia Concentration Plot

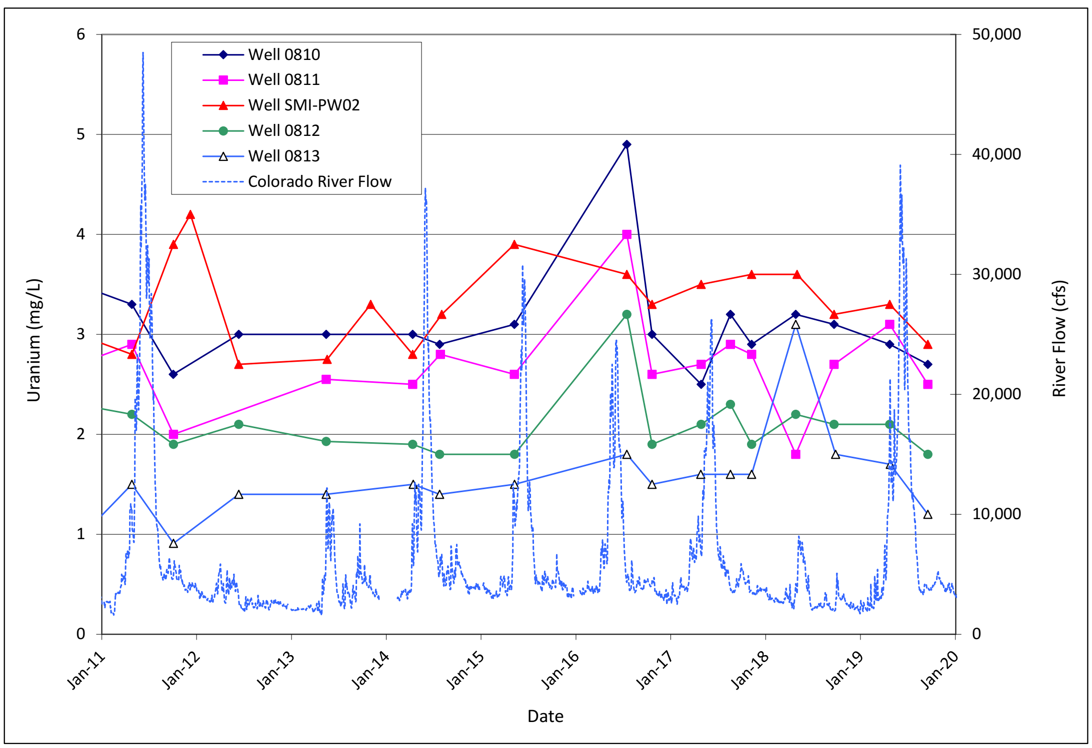

Figure 13. CF5 Extraction Wells 0810, 0811, 0812, 0813, and SMI-PW02 Time versus Uranium Concentration Plot

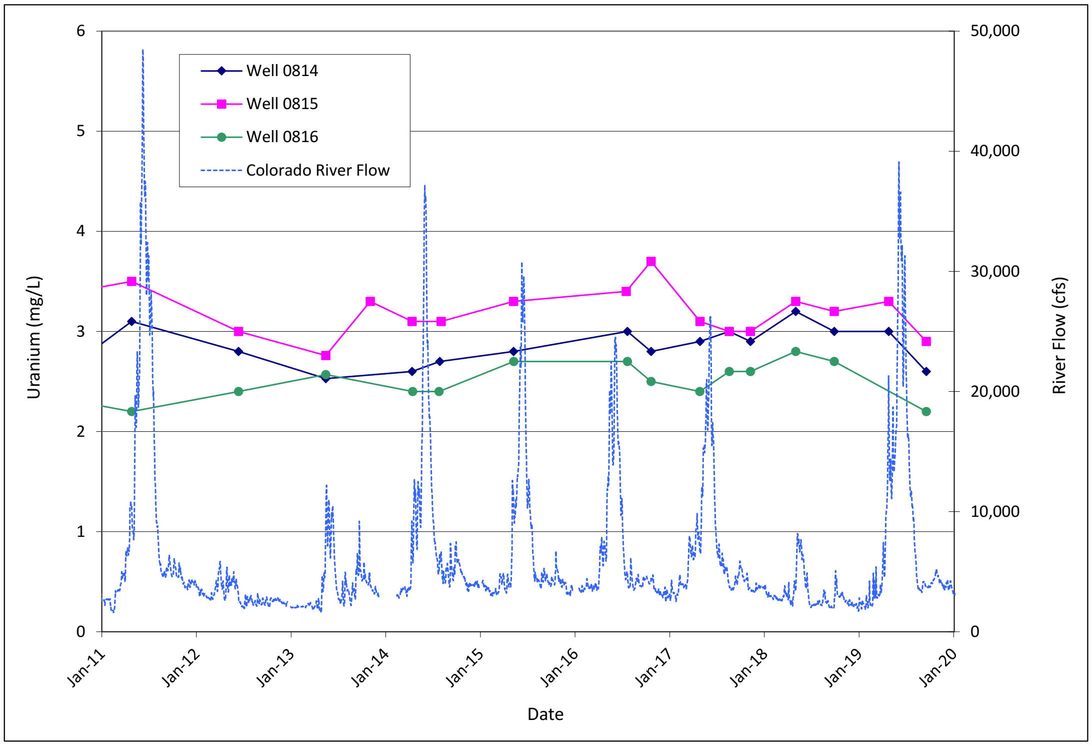

Figure 14. CF5 Extraction Wells 0814, 0815, and 0816 Time versus Uranium Concentration Plot

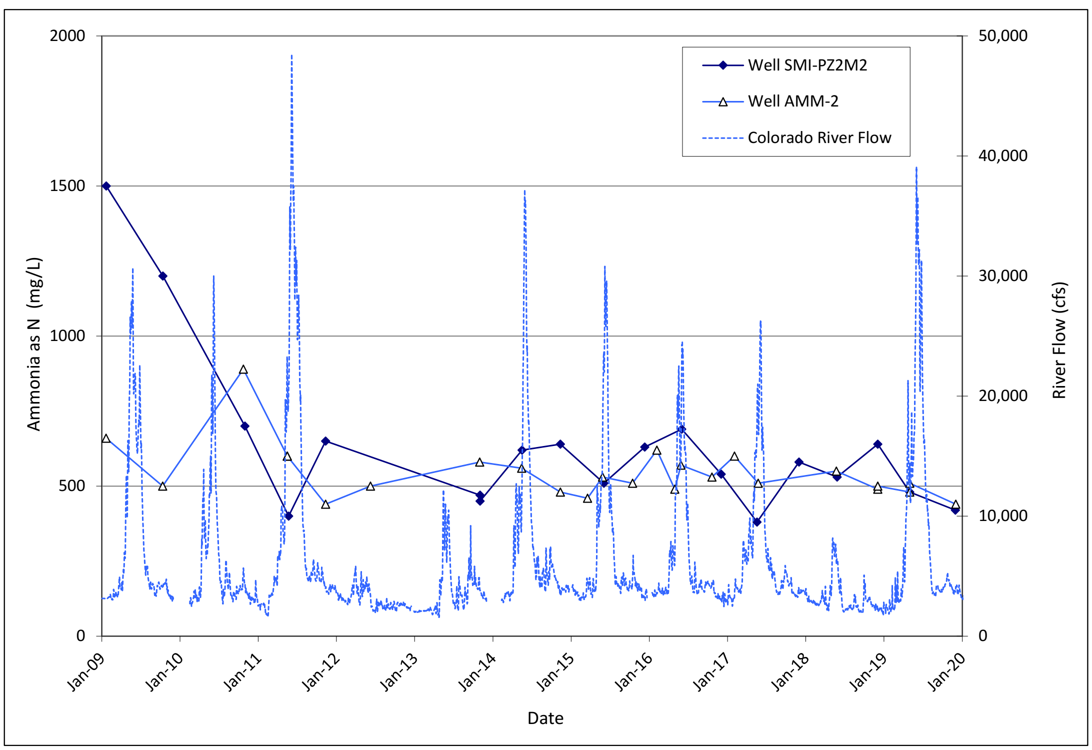

Figure 15. Wells AMM-2 and SMI-PZ2M2 Time versus Ammonia Concentration Plot

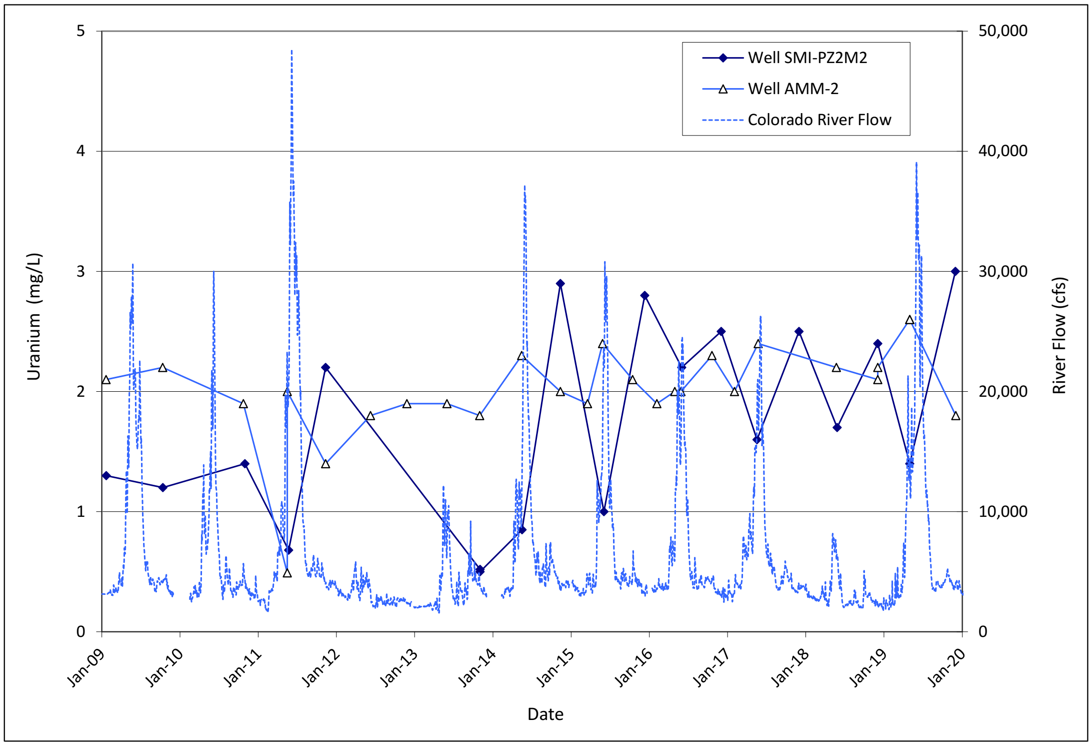

Figure 16. Wells AMM-2 and SMI-PZ2M2 Time versus Uranium Concentration Plot

5.0 Freshwater Injection System 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. In addition, groundwater bypassing the injection wells is diluted before groundwater discharges into the backwater channel.

Table 1. CF5 Ammonia, Uranium, and Specific Conductance Results, 2019

Location	Date	Ammonia (mg/L)	Uranium (mg/L)	Specific Conductance (µmhos/cm)
0810	4/30/19	260	2.9	30,939
	9/24/19	280	2.7	27,754
0811	4/30/19	360	3.1	21,427
	9/24/19	340	2.5	20,033
0812	4/30/19	460	2.1	18,970
	9/24/19	350	1.8	14,075
0813	5/2/19	410	1.7	15,525
	9/24/19	240	1.2	11,334
0814	5/2/19	140	3.0	26,508
	9/24/19	160	2.6	23,281
0815	5/2/19	120	3.3	22,224
	9/24/19	150	2.9	20,730
0816	9/24/19	140	2.2	18,596
PW02	4/30/19	410	3.3	30,870
	9/24/19	380	2.9	26,332

The injection system uses Colorado River water that is diverted to the freshwater pond. This water is pumped through a sand and gravel media, and then through 1 to 5 micron bag filters prior to being injected into the CF4 remediation wells. Construction information for the CF4 wells can be found in Table B-1 of Appendix B. Table B-2 also contains a chronology of CF4 activities.

CF4 is located in the southern portion of the IA well field adjacent to a prominent side channel that typically remains open to the main channel until the river flow drops below 3,000 cfs. During 2019, the side channel flowed through longer than usual due to high water and an extended runoff event that lasted well into summer.

5.1 Injection Performance

Freshwater injection into the CF4 wells in 2019 occurred inconsistently due to power issues, well field flooding, and sand filter operation issues. The system primarily operated from March through May, and from September through early October and as a result injected only 3.7 mil gal in 2019. However, due to the higher than average spring runoff flows in 2019, a fresh water lens developed in the subsurface that naturally diluted the ammonia concentrations.

5.2 Observation Well Chemical Data Summary

Groundwater samples were collected from the CF4 observation wells during January, April, and September 2019 to assess the effectiveness of the system (Table B-3). It is important to note that the January samples were collected after only limited operation of the system during the previous four months, with only approximately 560,000 gal injected into the subsurface during this time interval. The April samples were collected after the system was operational for the prior seven weeks (and after approximately 1.2 mil gal had been injected).

The system was not active between May and August due to flooding, and the September samples were collected after one month of operation (after 1.0 mil gal of fresh water had been injected). All samples were submitted to ALS for ammonia and uranium analysis, with the ammonia results provided in Table 2.

Table 2. CF4 Observation Well Ammonia Concentrations, January through September 2019

Location	Sample Depth (ft bgs)	Relative Location to Injection Wells	January 2019 Concentration (mg/L)	April 2019 Concentration (mg/L)	September 2019 Concentration (mg/L)
0780	28	Upgradient	330	1.4	18
0781	46	Upgradient	1,900	1,400	510
0782	33	Upgradient	1,100	180	64
0783	18	Upgradient	20	15	2.2
0784	18	Downgradient	1.1	1.7	1.7
0785	18	Downgradient	17	7	0.1
0786	28	Downgradient	480	11	41
0787	36	Downgradient	2,100	450	400

ft bgs = feet below ground surface

The CF4 wells are screened to deliver fresh water into the subsurface from 15 to 35 feet below ground surface (ft bgs). Samples collected from observation wells 0780, 0783, 0784, 0785, and 0786 are all screened within this shallow zone, and represent the ammonia concentrations directly impacted by the freshwater injection. Wells 0781, 0782, and 0787 represent the conditions near the bottom of the zone where the CF4 injection wells deliver fresh water into the subsurface when the system is active. Samples collected from these locations typically have the highest concentrations. Based on historical results and the limited injected volume of water during the last half of 2018, the January results are considered to be representative of baseline conditions within the subsurface from approximately 20 ft bgs and below. In the most shallow zone (above 20 ft bgs), the limited injected volume had impacted the ammonia concentrations in both the upgradient and downgradient directions.

The ammonia concentration associated with one of the downgradient samples collected from a depth less than 20 ft bgs (well 0784) in January 2019 was only 1.1 mg/L. The sample from directly upgradient in the shallow zone (well 0783) had an ammonia concentration of 20 mg/L. Historically samples collected from this location exceeded 350 mg/L during prolonged periods of no active injection, providing further evidence of the effectiveness of the system in decreasing contaminant concentrations both upgradient and downgradient of the line of CF4 injection wells.

Table 2 displays the decrease in the samples collected from April and the impacts that were primarily from the freshwater lens that developed in the shallow subsurface during the 2019 spring runoff river flows in the September samples. The 2019 ammonia concentrations included in Table 2 are graphically displayed in Figure 17 for the upgradient and Figure 18 for the downgradient observation wells, respectively. Included in these plots is the volume of freshwater injected on a weekly basis in 2019.

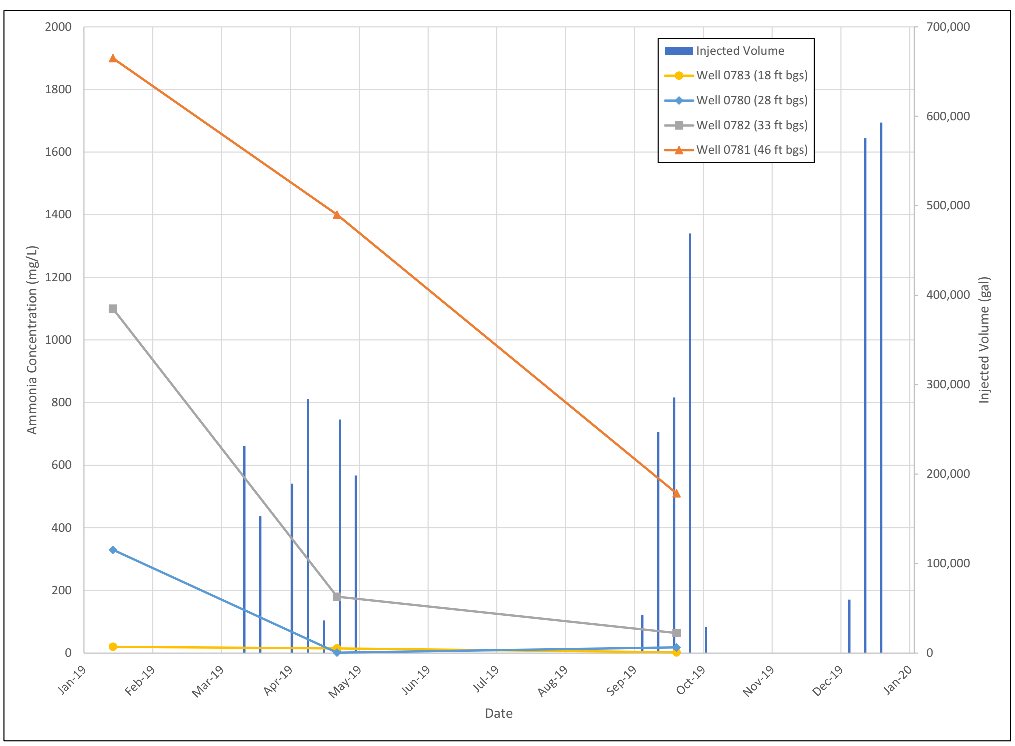

Figure 17. CF4 Upgradient Observation Wells 2019 Ammonia Concentrations

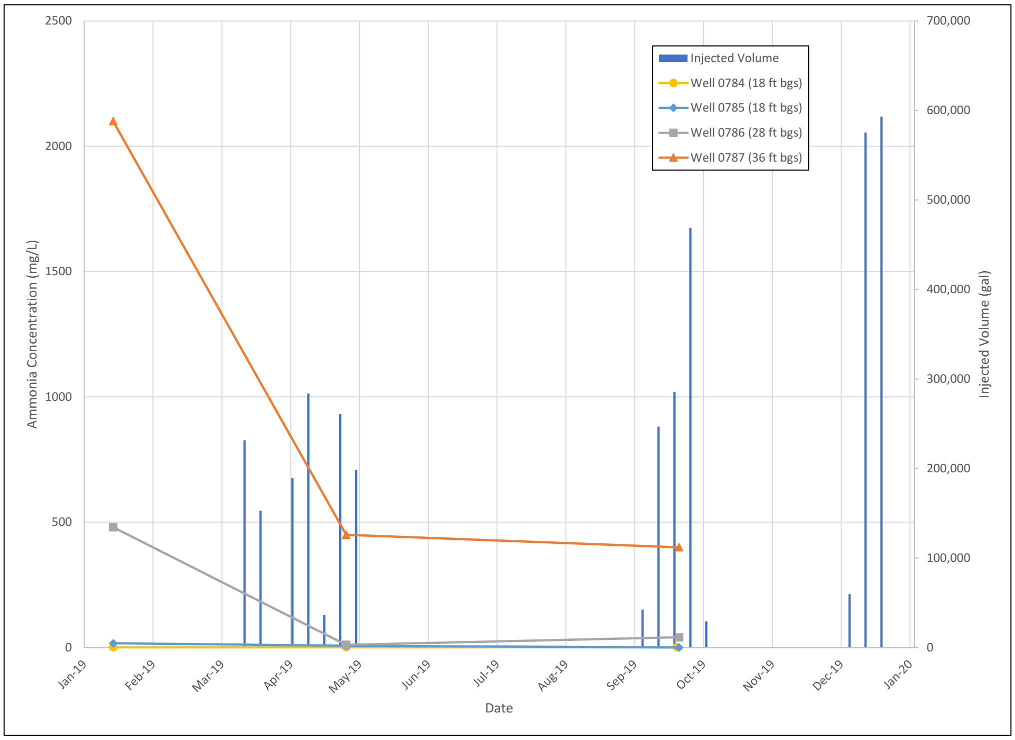

Figure 18. CF4 Downgradient Observation Wells 2019 Ammonia Concentrations

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 SMI-PZ1S.

The water levels in each well were adjusted to match well SMI-PZ1S during non-pumping, baseflow conditions. Tables 3 and 4 summarize the mounding data that are shown in Figures B-1 to B-10 (Appendix B) for the injection wells. Mounding data were collected when the injection system was operating and not undergoing maintenance. Figures B-11 through B-18 illustrate the mounding data in CF4 observation wells.

Figure 19 is a map showing the CF4 freshwater mounding by groundwater elevations in monitoring and injection wells in April 2019. The highest mounding occurs within 30 ft of the injection system. Maximum mounding occurred in each injection well at varying dates in the spring, fall, and winter. The amount of mounding was dependent on the individual well's efficiency and the corresponding injection rate.

Table 3 presents the maximum mounding measured in each of the injection wells and the corresponding injection rate. The maximum mounding in the CF4 observation wells is presented in Table 4 and varied from 0 to 0.48 ft in the upgradient wells and from 0.34 to 0.60 ft in the downgradient wells. Maximum mounding in the CF4 observation wells occurred on December 5 in all but well 0781; its maximum mounding occurred on February 7.

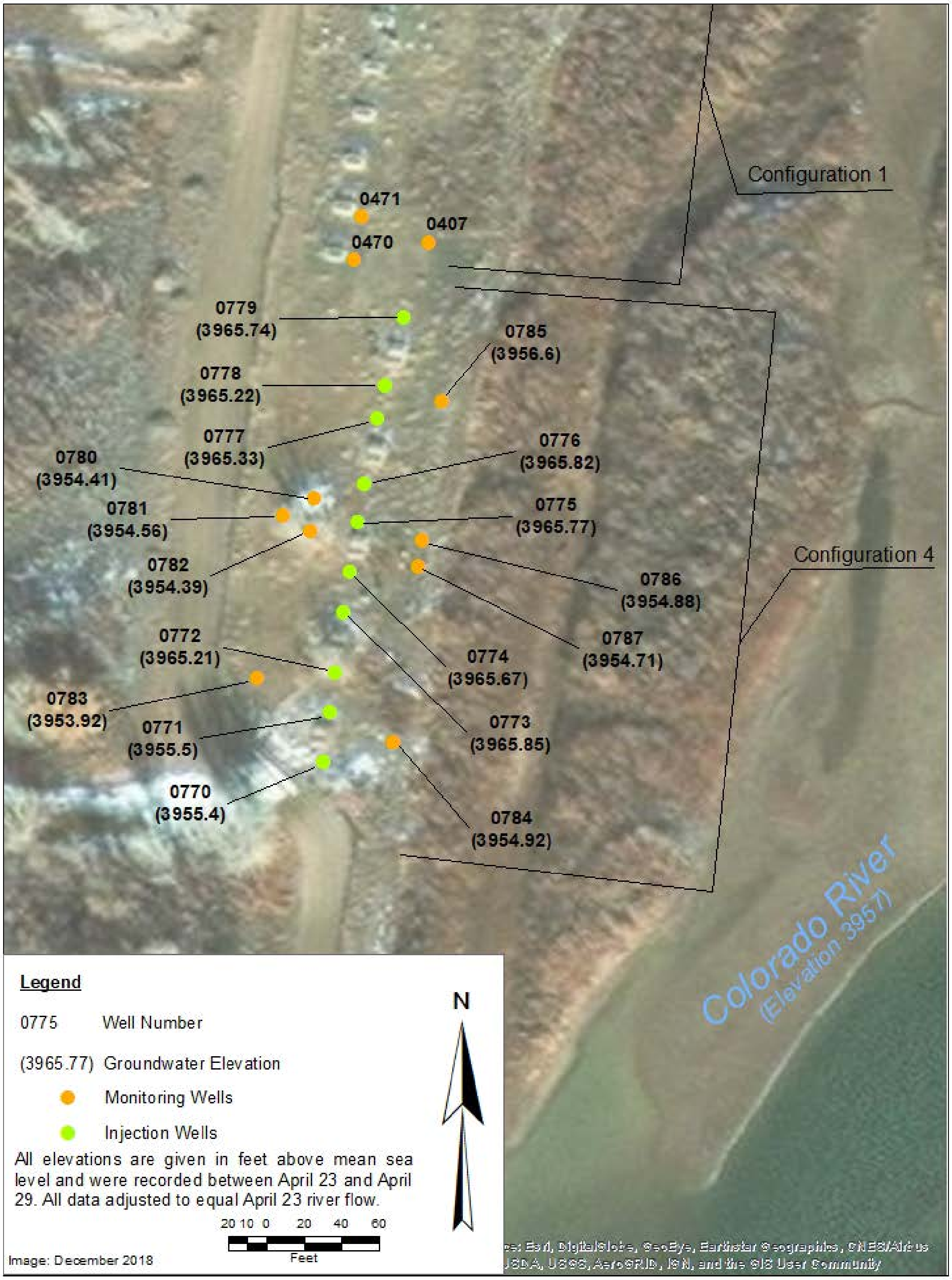

Figure 19. Freshwater Mounding at CF4 during Injection Operations April 2019

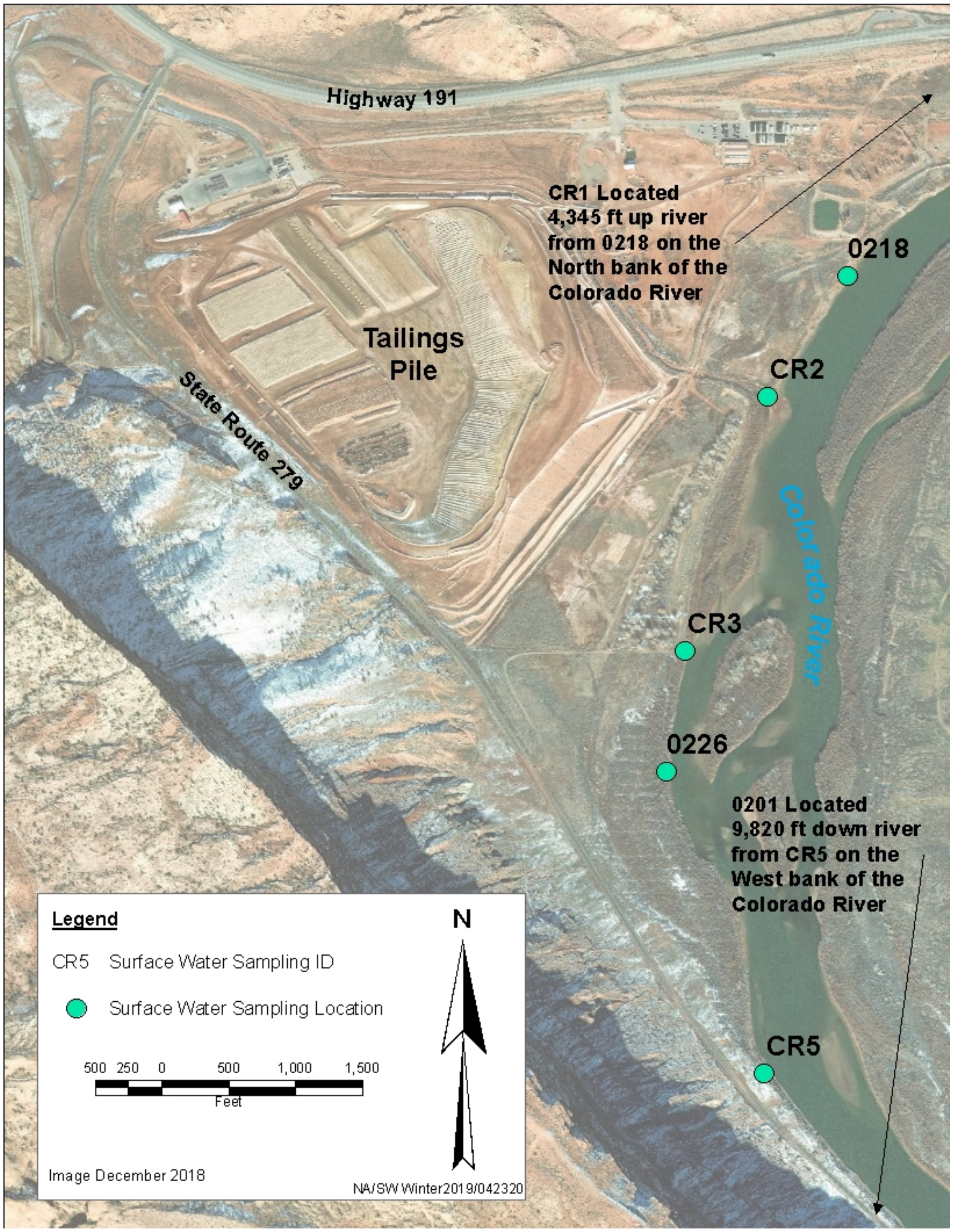

Figure 20. 2019 Site-wide Surface Water Sampling Locations

6.0 Surface Water Monitoring

In 2019, the mean daily Colorado River flows ranged from 1,710 to 39,100 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. The riverine zone adjacent to CF4 is monitored from June to September to determine if and when it becomes a suitable habitat for young-of-year fish. By late September in 2019, the high waters had receded enough for the side channel to be considered a viable habitat and was monitored as such until October 3.

6.1 Site-wide Surface Water Monitoring

Site-wide surface water sampling was conducted adjacent to the well field in June and December 2019 (locations are shown on Figure 20). The results of this sampling event can be found in the *Moab UMTRA Project Groundwater and Surface Water Monitoring January through June 2019* (DOE-EM/GJTAC3024) and *Moab UMTRA Project Groundwater and Surface Water Monitoring July through December 2019* (DOE-EM/GJTAC3031). Results are presented in Table 5.

Table 3. Maximum Mounding Observed in CF4 Injection Wells

Well	Date	Type	Maximum Mounding (ft)	Injection Rate (gpm)
0770	12/19/19	Injection Well	9.76	ND
0771	12/18/19	Injection Well	9.18	5.4
0772	4/24/19	Injection Well	13.08	2.8
0773	9/23/19	Injection Well	13.34	3.0
0774	9/11/19	Injection Well	12.88	2.3
0775	9/11/19	Injection Well	12.84	3.7
0776	9/11/19	Injection Well	12.56	3.8
0777	9/09/19	Injection Well	12.42	4.2
0778	9/11/19	Injection Well	12.29	2.1
0779	9/11/19	Injection Well	12.97	2.8

ND = No data collected

Table 4. Freshwater Mounding Observed in CF4 Observation Wells

Well	Date	Location	Maximum Mounding (ft)	Distance from Injection Source (ft)
0780	12/05/19	Upgradient	0.48	25
0781	2/07/19	Upgradient	0.0	30
0782	12/05/19	Upgradient	0.41	25
0783	12/05/19	Upgradient	0.38	30
0784	12/05/19	Downgradient	0.34	30
0785	12/05/19	Downgradient	0.60	25
0786	12/05/19	Downgradient	0.46	30
0787	12/05/19	Downgradient	0.34	30

Table 5. May and December 2019 Site-wide Surface Water Ammonia Concentrations and Comparisons to EPA Acute and Chronic Criteria

Location	Date	Temp (ºC)	pH	Ammonia as N (mg/L)	EPA - Acute Total as N (mg/L)*	EPA - Chronic Total as N (mg/L)**
0201	5/30/19	14.74	7.79	<0.1	8.8	1.1
	12/30/19	0.93	7.47	<0.2	21	3.2
0218	5/28/19	14.48	8.05	<0.1	8.8	1.1
	12/30/19	1.46	7.75	<0.2	13	2.3
0226	5/29/19	14.18	8.48	<0.1	3.3	0.51
	12/31/19	0.26	6.91	<0.2	41	4.5
CR1	5/28/19	20.9	7.59	<0.1	18	1.7
	12/30/19	0.93	7.60	<0.2	18	2.9
CR2	5/28/19	15.06	8.14	<0.1	7.3	0.92
	12/30/19	1.60	7.57	<0.2	18	2.9
CR3	5/29/19	14.07	8.02	<0.1	8.8	1.1
	12/30/19	1.71	8.60	<0.2	2.8	0.68
CR5	5/30/19	14.17	8.26	<0.1	4.9	0.34
	12/30/19	1.60	7.47	<0.2	21	3.2

*U.S. EPA Aquatic Life Ambient Water Quality Criteria for Ammonia – Freshwater State (Effective April 2013), Table N.4., Temperature and pH-Dependent Values, Acute Concentration of Total Ammonia as N (mg/L)
**U.S. EPA Aquatic Life Ambient Water Quality Criteria for Ammonia – Freshwater State (Effective April 2013), Table 6. Temperature and pH-Dependent Values, Chronic Concentration of Total Ammonia as N (mg/L)

The ammonia concentrations measured during this event were all below the respective detection limits, with all surface water ammonia concentrations below the applicable EPA criteria (for a suitable habitat) for both acute and chronic concentrations.

6.2 Surface Water/Habitat Monitoring

Surface water monitoring adjacent to CF4 is typically conducted after the spring peak river flow begins to recede and a suitable habitat develops. The purpose is to monitor the water quality and protect young-of-year endangered fish species (e.g., Colorado pikeminnow, razorback sucker) from elevated ammonia concentrations. In 2019, the side channel adjacent to CF4 was delayed in its livability for young-of-year fish as it was flowing through for longer than usual due to the extended high water period.

Once it was confirmed as suitable habitat, samples were collected on four different occasions. The first three sample events in mid-September were prior to running the surface water diversion. On September 25, staff began diverting fresh water into the backwater section of the side channel habitat, and staff ran the system through October 3 for best management practice. Since the high water year had delayed the emergence of the habitat, it was decided to run fresh water through it for an additional week, past the end of compliance obligations.

The habitat sampling results were collected to confirm the surface water diversion system was effective in lowering the ammonia concentrations below the acute and chronic concentrations. The sample results are also an effective tool for staff to determine the best placement of surface water diversion manifolds.

The results of all four sample events are summarized in Table 6 along with the EPA acute and chronic criteria. In addition, samples were taken during the September 11 sampling event further into the main channel for staff to use as reference as background data.

As shown in Table 6, there were several locations in the backwater section of the habitat that exceeded EPA criteria for ammonia concentrations. These data were used to determine the necessity to operate surface water diversion in 2019. The final sampling event on September 30 shows that, while surface water diversion was running, all ammonia levels were below both acute and chronic criteria, highlighting the effectiveness of the diversion system.

Figure 13 shows the general location of the backwater and embayment sections of suitable habitat in 2019, as well as the six sample locations. The ammonia concentrations in Figure 6 are from the September 30 sampling event, while diversion was running.

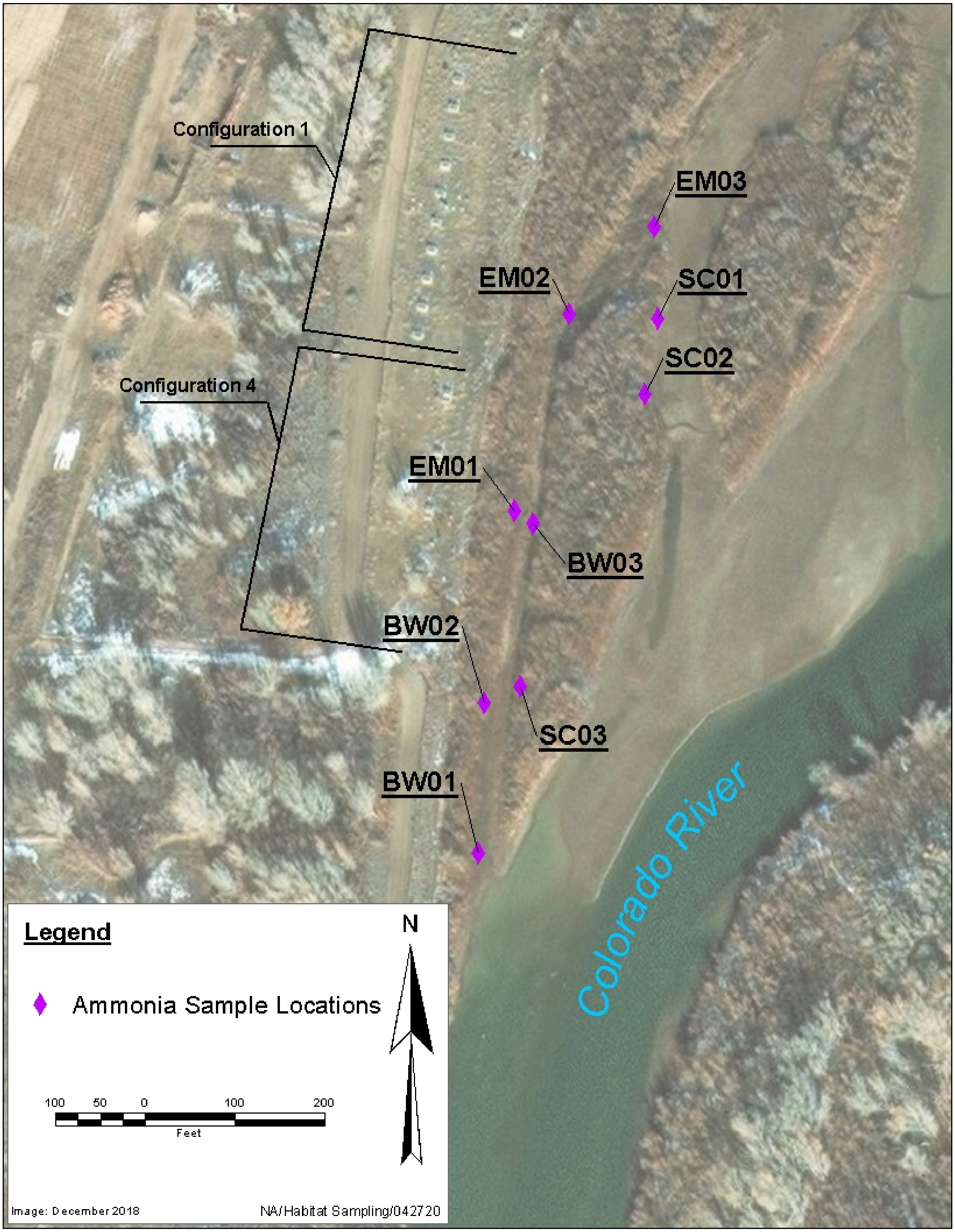

Figure 21. 2019 Habitat Area Sampling Locations

Table 6. September and October 2019 Habitat Area Surface Water Ammonia Concentrations and Comparisons to EPA Acute and Chronic Criteria

Location	Date	Ammonia Total as N (mg/L)	EPA - Acute Total as N (mg/L)[1]	EPA - Chronic Total as N (mg/L)[2]
BW01	9/11/19	0.78	NA	NA
BW01	9/17/19	0.25	1.4	0.14
BW01	9/23/19	0.80	24	1.3
BW01	9/30/19	0.36	24	1.6
BW02	9/11/19	4.16	2.8	0.26
BW02	9/17/19	0.26	4.9	0.49
BW02	9/23/19	0.45	4.0	0.37
BW02	9/30/19	0.03	8.8	0.68
BW03	9/11/19	4.33	7.3	0.76
BW03	9/17/19	0.27	6.0	0.61
BW03	9/23/19	0.04	5.1	0.44
BW03	9/30/19	0.05	8.8	1.0
EM01	9/11/19	5.6	8.8	0.88
EM01	9/17/19	0.28	6.0	0.61
EM01	9/23/19	0.09	7.3	0.71
EM01	9/30/19	0.12	13	1.4
EM02	9/11/19	3.33	6.0	0.65
EM02	9/17/19	0.24	4.9	0.49
EM02	9/23/19	0.62	11	0.89
EM02	9/30/19	0.30	11	1.3
EM03	9/11/19	0.38	4.1	0.39
EM03	9/17/19	0.19	3.3	0.35
EM03	9/23/19	1.06	4.9	0.49
EM03	9/30/19	0.40	8.8	0.94
SC01	9/11/19	0.22	NA	NA
SC02	9/11/19	0.22	3.3	0.33
SC03	9/11/19	0.23	3.3	0.31

[1]EPA Aquatic Life Ambient Water Quality Criteria for Ammonia – Freshwater State (Effective April 2013), Table N.4
[2]Temperature and pH-Dependent Values, Acute Concentration of Total Ammonia as Nitrogen (N) (mg/L)
NA = Sample data out of range for EPA table

6.3 Surface Water Monitoring Summary

Due to an extended period of high water in 2019 the side channel area was only a suitable habitat for a brief time during the second half of September. Slightly elevated ammonia levels detected in sampling events prompted staff to implement the surface water diversion system. This system was operational from September 25 to October 3, and pumped a total of 228,700 gallons of fresh water through the suitable habitat.

7.0 Investigations

In addition to the operation of the groundwater extraction, fresh water injection, and surface water diversion systems, other activities were completed during 2019. These include the surface water/groundwater interaction investigation and the monitoring of Crescent Junction wells 0202 and 0205. These activities are discussed in Sections 7.1 and 7.2, respectively.

7.1 Surface Water/Groundwater Interaction

Throughout 2019 groundwater parameters (primarily specific conductance) were monitored in a series of well clusters located in the well field. These wells are sampled over various depths of the subsurface, as shown in Table 7.

Table 7. Surface Water/Groundwater Interaction Well Clusters

Well Cluster	Well Number	Sample Depth (ft bgs)
SMI-PW01	SMI-PZ1S	18
	SMI-PZ1M	57
Baseline Area	0405	18
	0488	39
	0493	54
CF1 Upgradient	0480	18
	0557	40
	0482	58
CF1 Midpoint	0483	18
	0558	36
	0485	58
CF1 Downgradient	0559	19
	0560	31
	0561	50

Groundwater parameter data collected from these different zones provided information regarding the impact of the Colorado River flows on the groundwater system by comparing the specific conductivity at varying depths to river stage over time.

The time vs specific conductance plots for each of these well clusters are presented in Appendix C. The plots also display the Colorado River conductivity and elevation for 2019. As these plots display, the deepest well in each of the five clusters has the highest conductivity, and typically decreases as the river moves into losing conditions.

The same can be seen in the more shallow wells of the clusters, but less dramatically as their conductivity levels are not as high to begin with. The decreases in monitoring well conductivity levels as the river elevations rise demonstrates how the losing conditions of the river depresses the freshwater lens to a lower elevation into the groundwater system.

7.2 Crescent Junction Wells 0202 and 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. Observations show that after a significant event or multiple precipitation events, the runoff collects into the retention ditch at the toe of the cell. As this water infiltrates into the subsurface, it likely intercepts a fracture system that is in part connected to the fracture observed inside well 0205 and eventually seeps into the well. A sample was collected from well 0205 in March 2019, with the results presented in Table 8.

Between the March and late June 2019 quarterly monitoring events in Crescent Junction, water flowed into well 0202, located to the west of the completed portion of the disposal cell (Figure 21). A sample of this water was collected in early July 2019 and was submitted to the analytical lab for the same analyte suite as that of samples collected from well 0205.

A short-term recovery test was completed in October 2019 on well 0202, and the recharge rate (0.002 gpm) was an order of magnitude lower compared to that measured in any of the previous 0205 tests. The results of the analysis of the water sample collected from well 0202 is also presented in Table 8. Analytical results indicate a clear distinction between the isotopic signatures of groundwater encountered in wells 0202 and 0205 and Moab site groundwater that has been impacted by site operations. The results suggest the water present in these wells is not associated with the tailings placed in the disposal cell.

The manner in which the well 0205 water elevation responds to the site precipitation (Figure 22) and the fluctuation of the recharge rate (Figure 23) since 2015 suggests a connection between the water present in well 0205 and the surface runoff.

Table 8. 2019 Crescent Junction Wells 0202 and 0205 Analyte Concentrations

Analyte	Analyte Concentration in Well 0202 on 7/11/19	Analyte Concentration in Well 0205 on 3/19/19
Ammonia as N	14	13
Arsenic	0.039#	0.039#
Barium	NA	NA
Bicarbonate as $CaCO_3$	1,200	1,100
Boron	1,500	1,400
Bromide	12	20#
Cadmium	0.0033#	0.0033#
Calcium	410	330
Carbonate as $CaCO_3$	50#	20#
Chloride	7,200	3,500
Chromium	0.0051#	0.0051#
Copper	0.0097#	0.0097#
Fluoride	1#	10#
Iron	0.050	0.049#
Lead	0.013#	0.013#
Magnesium	730	820
Manganese	0.440	0.360
Molybdenum	11#	11#
Nitrate/ Nitrite as N	450	960
Potassium	94	47
Selenium	0.027#	3.1
Sodium	8,900	8,500
Sulfate	28,000	23,000
Total Alkalinity as $CaCO_3$	1,200	1,100
Total Dissolved Solids	46,000	39,000
Uranium $_{234}$	37.2 +/- 6.60 pCi/L	30.1 +/- 6 pCi/L
Uranium $_{235}$	0.49 +/- 0.32 pCi/L	1.45 +/- 0.75 pCi/L
Uranium $_{238}$	8.2 +/- 1.8 pCi/L	12.2 +/- 2.8 pCi/L
Uranium	0.025	0.025

= Concentration at or below the detection limit, NA = Sample not analyzed for this analyte Note: All concentrations in mg/L, except where noted

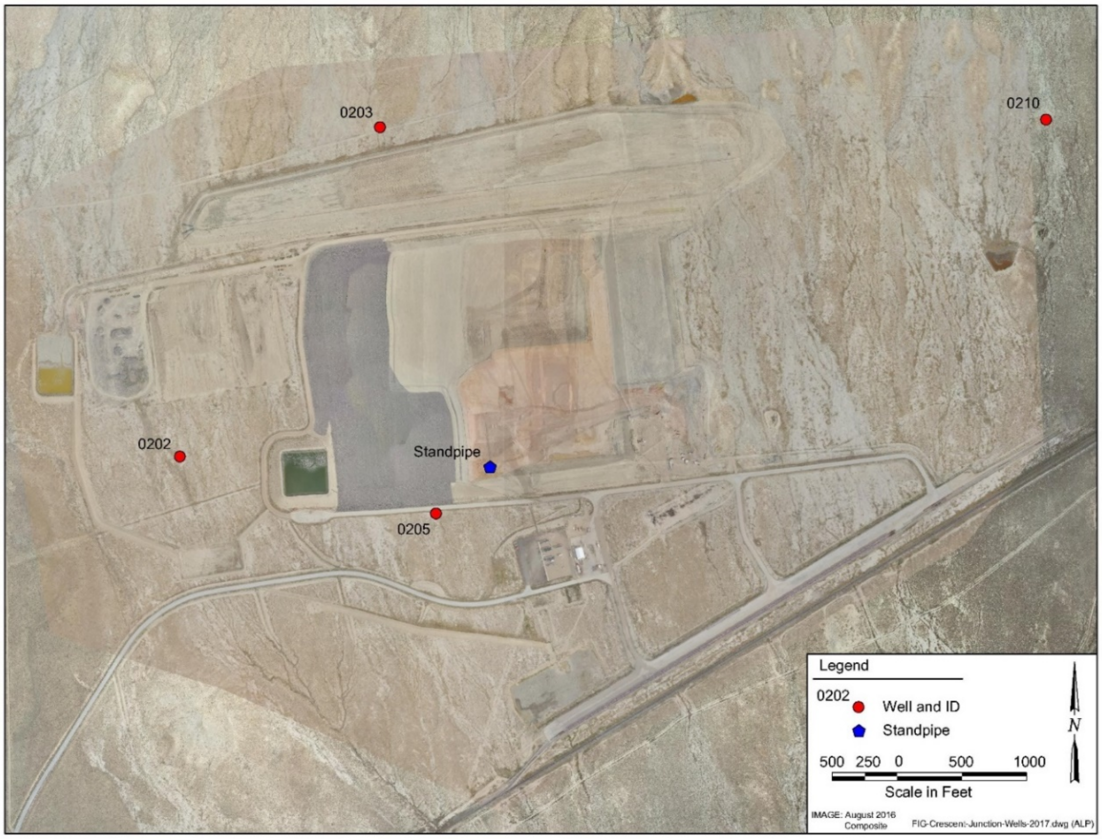

Figure 22. Crescent Junction Well Location Map

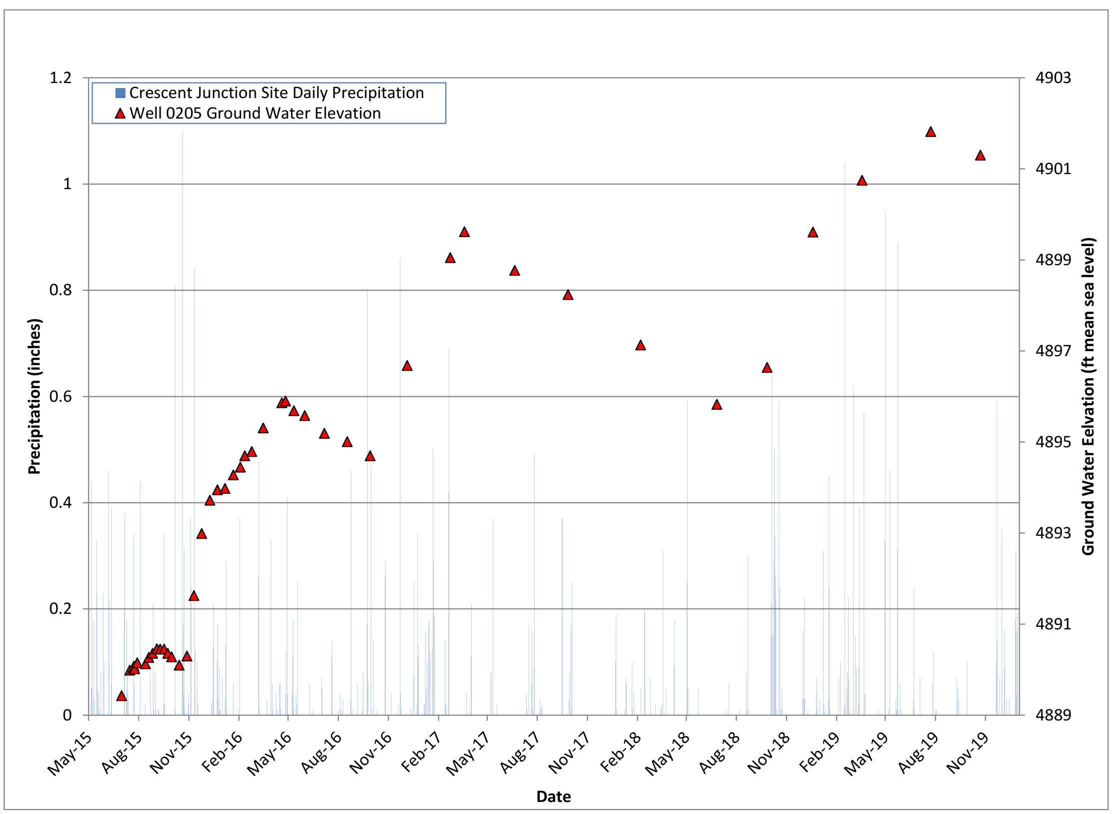

Figure 23. Crescent Junction Well 0205 Water Level Changes in Response to Precipitation through 2019

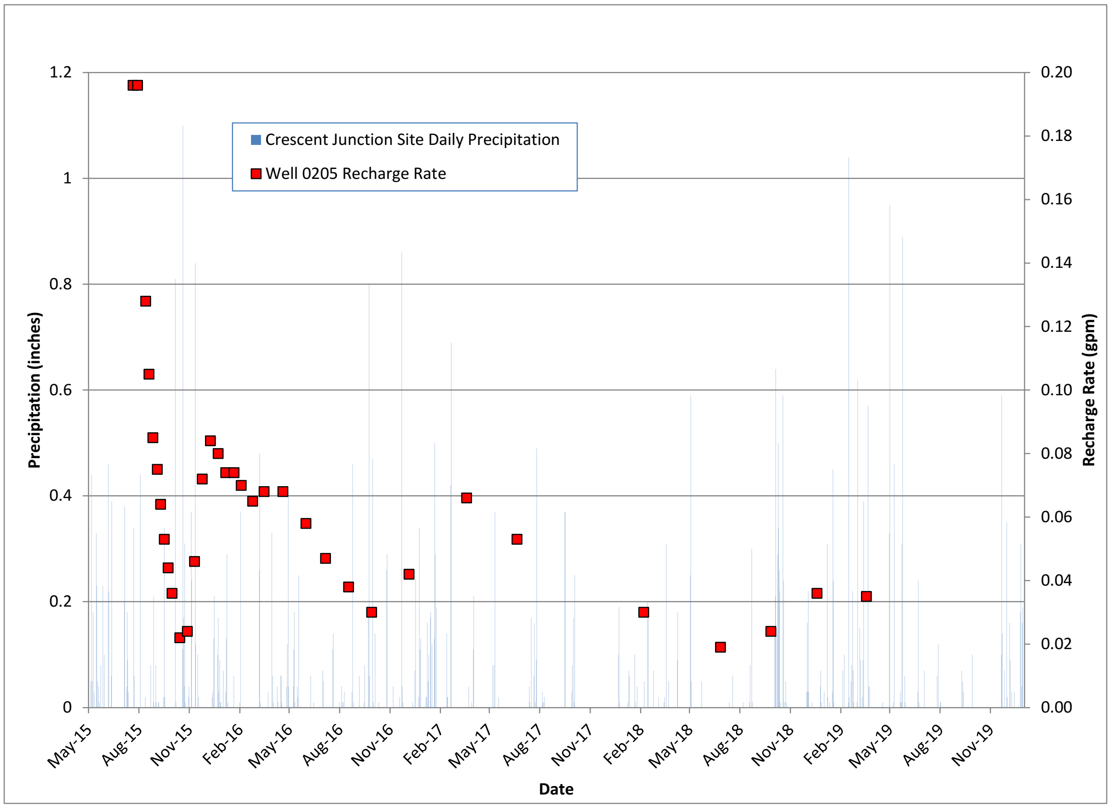

Figure 24. Crescent Junction Well 0205 Recharge Rate Changes in Response to Precipitation through 2019

8.0 Summary and Conclusions

In 2019, the IA operations focused on groundwater extraction (from CF5) and freshwater injection (CF4); the surface water diversion system was operational from September 25 to October 3 in an area located to the east of the CF4 side channel.

A total of 5.7 mil gal of water were extracted from CF5 in 2019. The extraction rate peaked in June through August, and operations continued through the fall. Each of the eight extraction wells were utilized in 2019. Figure 25 shows the ammonia and uranium mass removed and the volume of groundwater extracted from the CF5 extraction wells from 2003 through 2019.

The volume of groundwater and amount of contaminant mass removed was lower in 2019 compared to the previous year. A total of 14,804 lb of ammonia and 138.8 lb of uranium were extracted from the groundwater system in 2019.

Approximately 3.7 mil gal of fresh water were injected into CF4 in 2019. Laboratory data from the CF4 observation wells during injection operations indicate the system is effective at diluting ammonia concentrations, especially from the groundwater surface down to a depth of 28 ft bgs. Site-wide surface water samples indicated the contaminants do not extend past the site boundary.

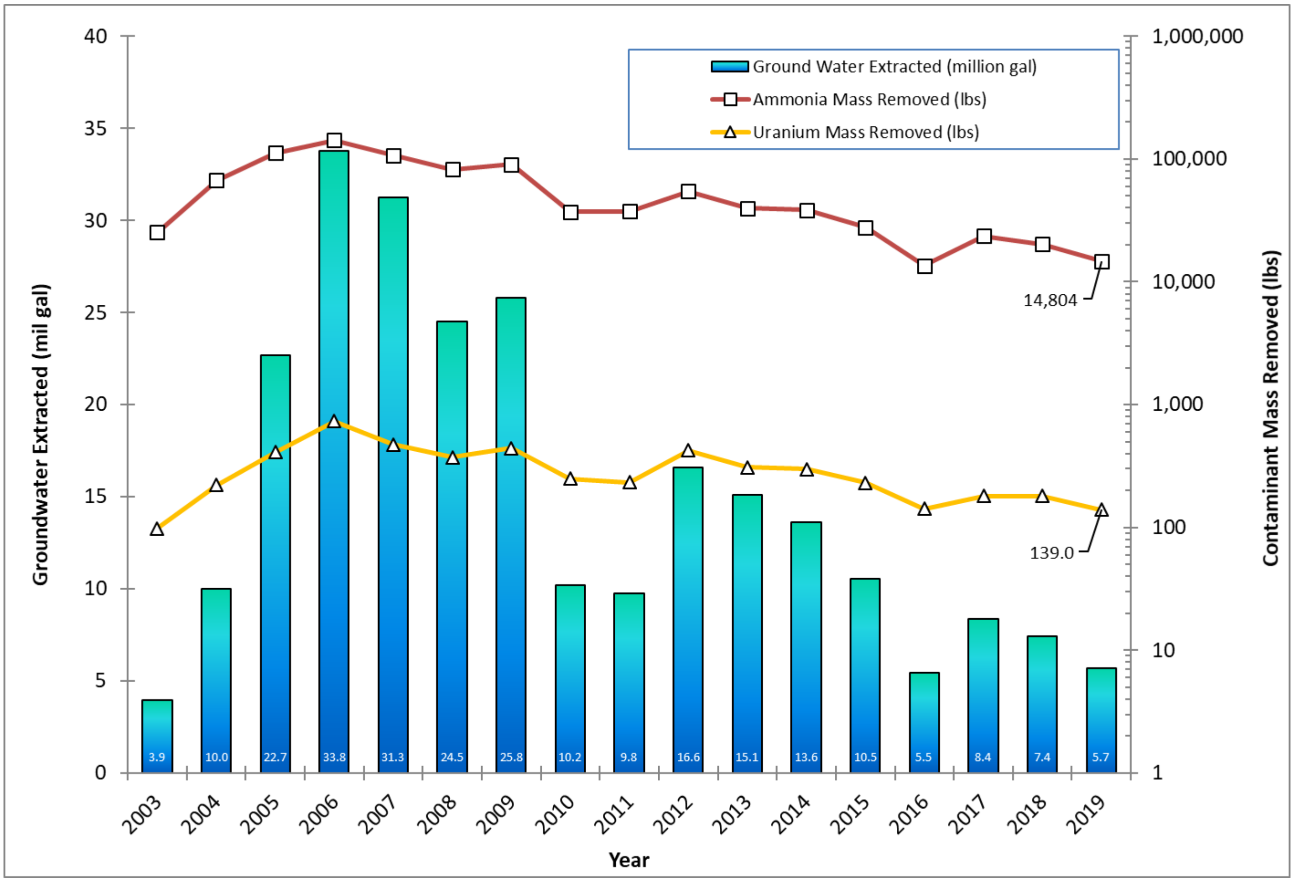

Figure 25. Groundwater Extracted Volume and Contaminant Mass Removal, 2003 through 2019

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 2019 Flood Response Summary* (DOE-EM/GJTAC3035).

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

DOE (U.S. Department of Energy), *Moab UMTRA Project Groundwater and Surface Water Monitoring January through June 2019* (DOE-EM/GJTAC3024).

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DOE (U.S. Department of Energy), *Moab UMTRA Project Surface Water/Groundwater 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 2019 Groundwater Extraction

Appendix A. Tables and Data for 2019 Groundwater Extraction

Table A-1. Well Construction for CF5 Extraction Wells

Well	Well Type	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. 2019 Chronology of CF5 Activities

Date	Activity
January	System winterized.
February	System winterized.
March	Restarted extraction system on March 26.
April	Extraction system shut down due to low pressure on April 9. After flushing the line between the pumphouse and the frac tanks, extraction was restarted on April 15.
May	The extraction system was shut down on May 30 in preparation of flooding. BODEC Electric removed electrical panels on May 3 through 5 and the pumphouse was relocated.
June	No extraction due to flood water in well field.
July	No extraction due to flood water in well field. Pumphouse moved back into place on July 30, and BODEC Electric started replacing electrical components on July 31.
August	BODEC Electric completed replacing electrical components by August 12, and system restarted August 13.
September	Submersible pumps were replaced in Wells 0815 and 0816 on September 8 and 9.
October	Extraction system operation in automatic mode.
November	Winterization of the extraction system (well vaults, pump house, and storage tanks) occurred on Nov 18 and 19.
December	System winterized.

Appendix A. Tables and Data for 2019 Groundwater Extraction (*continued*)

Table A-3. CF5 Extraction Volumes 2019

Well	Extraction Volumes Removed (gal)												
	Jan-19	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Well Total
0810	0	0	8,649	89,267	165,309	10,097	0	102,464	241,259	151,612	54,228	0	822,885
0811	0	0	3,574	25,187	49,588	3,902	0	46,794	107,327	64,624	25,373	0	326,369
0812	0	0	5,773	41,946	83,634	6,529	0	87,259	85,257	101,629	6,516	0	418,543
0813	0	0	503	190,069	298,467	16,604	0	170,091	194,822	274,802	40,682	0	1,186,040
0814	0	0	1,820	43,715	138,874	7,628	0	81,765	214,990	166,490	44,873	0	700,155
0815	0	0	312	83,808	156,707	0	0	0	141,058	203,751	48,043	0	633,679
0816	0	0	0	105,098	31,897	0	0	0	214,928	293,528	98,718	0	744,169
SMI-PW02	0	0	6,892	103,650	168,991	8,792	0	94,730	228,485	198,840	57,708	0	868,088
Monthly Total	0	0	27,523	682,740	1,093,467	53,552	0	583,103	1,428,126	1,455,276	376,141	0	
Annual Total													**5,699,928**

Appendix A. Tables and Data for 2019 Groundwater Extraction (*continued*)

Table A-4. CF5 Ammonia Mass Removal 2019

Well	Ammonia Mass Removed (lbs)												
	Jan-19	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Well Total
0810	0	0	26	268	496	30	0	307	723	328	126	0	2,304
0811	0	0	12	84	165	13	0	156	357	194	72	0	1,053
0812	0	0	22	157	313	24	0	327	319	389	19	0	1,571
0813	0	0	2	681	1,069	59	0	609	698	938	81	0	4,137
0814	0	0	2	58	185	10	0	109	286	194	60	0	905
0815	0	0	0	98	183	0	0	0	164	204	60	0	709
0816	0	0	0	131	40	0	0	0	268	367	115	0	921
SMI-PW02	0	0	26	397	647	34	0	363	875	679	183	0	3,204
Monthly Total	0	0	90	1,873	3,098	171	0	1,871	3,692	3,293	716	0	
Annual Total													**14,804**

Table A-5. CF5 Uranium Mass Removal 2019

Well	Uranium Mass Removed (lbs)												
	Jan-19	**Feb-19**	**Mar-19**	**Apr-19**	**May-19**	**Jun-19**	**Jul-19**	**Aug-19**	**Sep-19**	**Oct-19**	**Nov-19**	**Dec-19**	**Well Total**
0810	0.0	0.0	0.2	2.4	4.4	0.3	0.0	2.7	6.4	3.7	1.2	0.0	21.3
0811	0.0	0.0	0.1	0.4	0.7	0.1	0.0	0.7	1.6	1.7	0.5	0.0	5.7
0812	0.0	0.0	0.1	0.8	1.5	0.1	0.0	1.6	1.6	1.8	0.1	0.0	7.6
0813	0.0	0.0	0.0	4.9	7.7	0.4	0.0	4.4	5.0	3.9	0.4	0.0	26.8
0814	0.0	0.0	0.0	1.2	3.7	0.2	0.0	2.2	5.7	4.2	1.0	0.0	18.2
0815	0.0	0.0	0.0	2.3	4.3	0.0	0.0	0.0	3.9	5.6	1.2	0.0	17.3
0816	0.0	0.0	0.0	2.5	0.7	0.0	0.0	0.0	5.0	6.8	1.8	0.0	16.9
SMI-PW02	0.0	0.0	0.2	3.1	5.1	0.3	0.0	2.8	6.8	5.5	1.4	0.0	25.2
Monthly Total	0.0	0.0	0.7	17.5	28.2	1.3	0.0	14.4	36.1	33.1	7.6	0.0	
Annual Total													**138.8**

Appendix B.
Tables and Data for 2019 Freshwater Injection

Appendix B. Tables and Data for 2018 Freshwater Injection

Table B-1. CF4 Well Construction Details

Well	Well Type / Relative Depth	Diameter (in)	Screen Interval (ft bgs)	Total Depth (ft bgs)
0770	Remediation/Deep	6	14.9 – 34.8	35.2
0771	Remediation/Deep	6	15.0 – 34.9	35.3
0772	Remediation/Deep	6	15.2 – 35.1	35.5
0773	Remediation/Deep	6	15.2 – 35.1	35.5
0774	Remediation/Deep	6	15.5 – 35.4	35.8
0775	Remediation/Deep	6	15.1 – 35.0	35.4
0776	Remediation/Deep	6	15.2 – 35.1	35.5
0777	Remediation/Deep	6	15.3 – 35.2	35.6
0778	Remediation/Deep	6	15.1 – 35.0	35.4
0779	Remediation/Deep	6	15.7 – 35.6	36.0
0780	Observation/Shallow	6	20.3 – 30.1	30.5
0781	Observation/Deep	6	44.8 – 54.5	55.0
0782	Observation/Deep	6	31.0 – 40.8	41.2
0783	Observation/Shallow	2	8.6 – 18.6	19.1
0784	Observation/Shallow	2	9.4 – 19.4	19.9
0785	Observation/Shallow	2	9.6 – 19.6	19.9
0786	Observation/Shallow	6	20.5 – 30.3	30.7
0787	Observation/Deep	6	35.4 – 45.2	45.7

Appendix B. Tables and Data for 2019 Freshwater Injection (*continued*)

Table B-2. 2019 Chronology of CF4 Activities

Month	Activity
January	Injection system did not run due to power center issues.
February	Injection system did not run due to power center issues.
March	Power center replaced, system restarted March 6.
April	System operational.
May	System shut down due to high river flows/flooding.
June	System shut down due to high river flows/flooding.
July	System shut down due to high river flows/flooding.
August	System shut down due to high river flows/flooding.
September	Injection system restarted September 3. Wells developed September 11 through 18.
October	System shut down for sand filter media replacement.
November	System shut down for sand filter media replacement.
December	System restarted December 3, shut down for the holidays December 20.

Appendix B. Tables and Data for 2019 Freshwater Injection (*continued*)

Table B-3. CF4 Observation Well Analytical Sample Results 2019

Location	Location from Injection	Sample Depth (ft bgs)	Date	Ammonia as N (mg/L)	Uranium (mg/L)	Specific Conductance (µmhos/cm)
0780	Upgradient	28	1/14/2019	330	2.5	22321
			4/25/2019	1.4	0.024	1334
			9/25/2019	18	0.16	2372
0781	Upgradient	46	1/14/2019	1900	1.3	95617
			4/25/2019	1400	2.8	62038
			9/25/2019	510	1.9	26514
0782	Downgradient	33	1/14/2019	1100	2.6	51204
			4/25/2019	180	0.63	7234
			9/25/2019	64	0.39	3518
0783	Downgradient	18	1/14/2019	20	0.4	5109
			4/25/2019	15	0.082	1415
			9/25/2019	2.2	0.1	1765
0784	Downgradient	18	1/14/2019	1.1	0.018	1747
			4/29/2019	1.7	0.066	2493
			9/25/2019	1.7	0.028	1267
0785	Downgradient	18	1/14/2019	17	0.084	1951
			4/29/2019	7	0.073	1687
			9/26/2019	0.1	0.012	1149
0786	Downgradient	28	1/14/2019	480	2.7	25622
			4/29/2019	11	0.072	1712
			9/26/2019	41	0.19	2208
0787	Downgradient	36	1/14/2019	2100	1.9	87732
			4/29/2019	450	1.6	26380
			9/26/2019	400	1.8	22650

Note: µmhos/cm = micromhos per centimeter

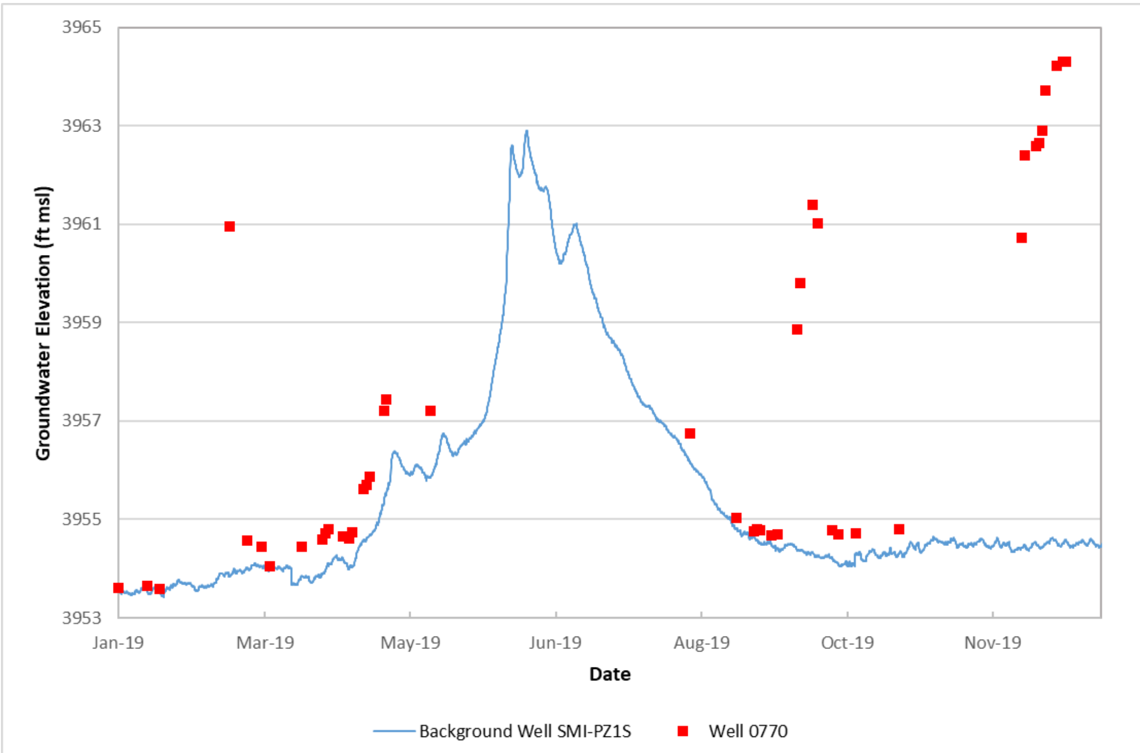

Figure B-1. Freshwater Mounding in Remediation Well 0770 during Injection

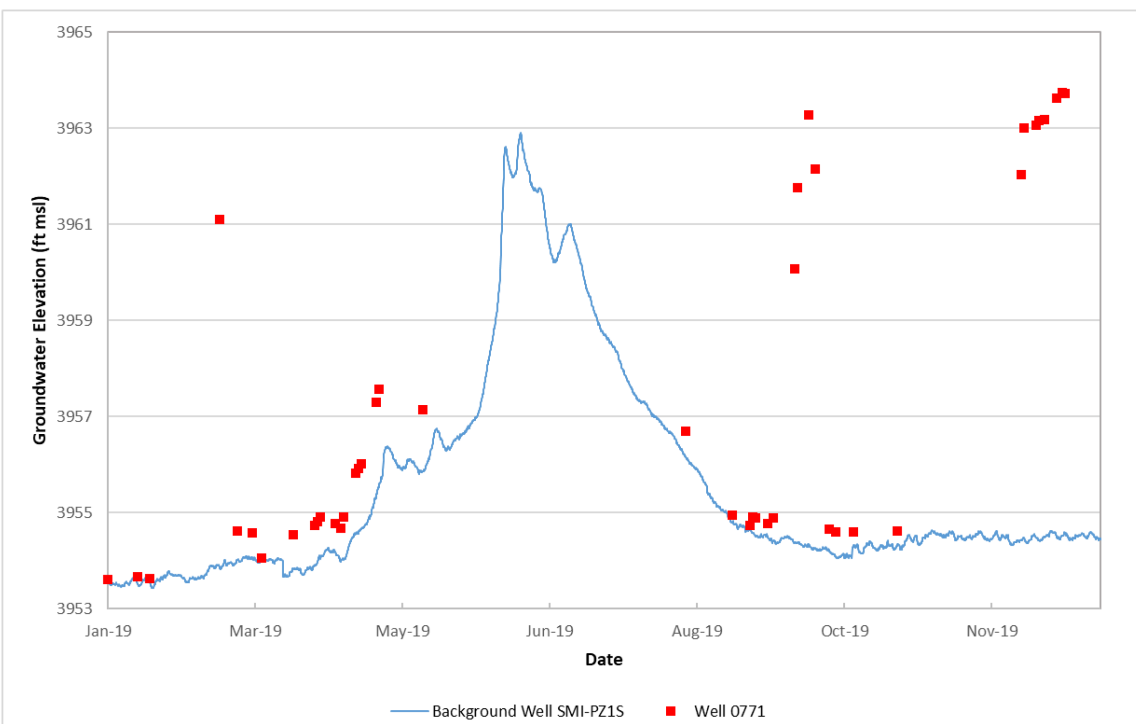

Figure B-2. Freshwater Mounding in Remediation Well 0771 during Injection

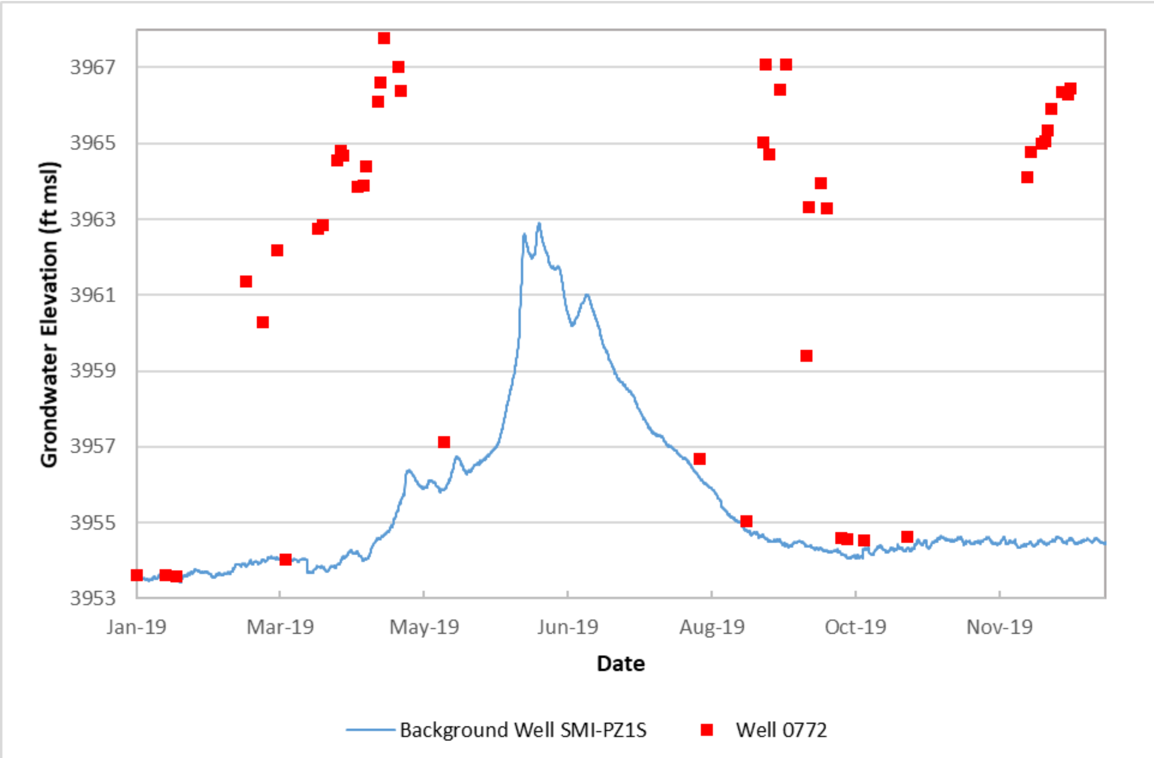

Figure B-3. Freshwater Mounding in Remediation Well 0772 during Injection

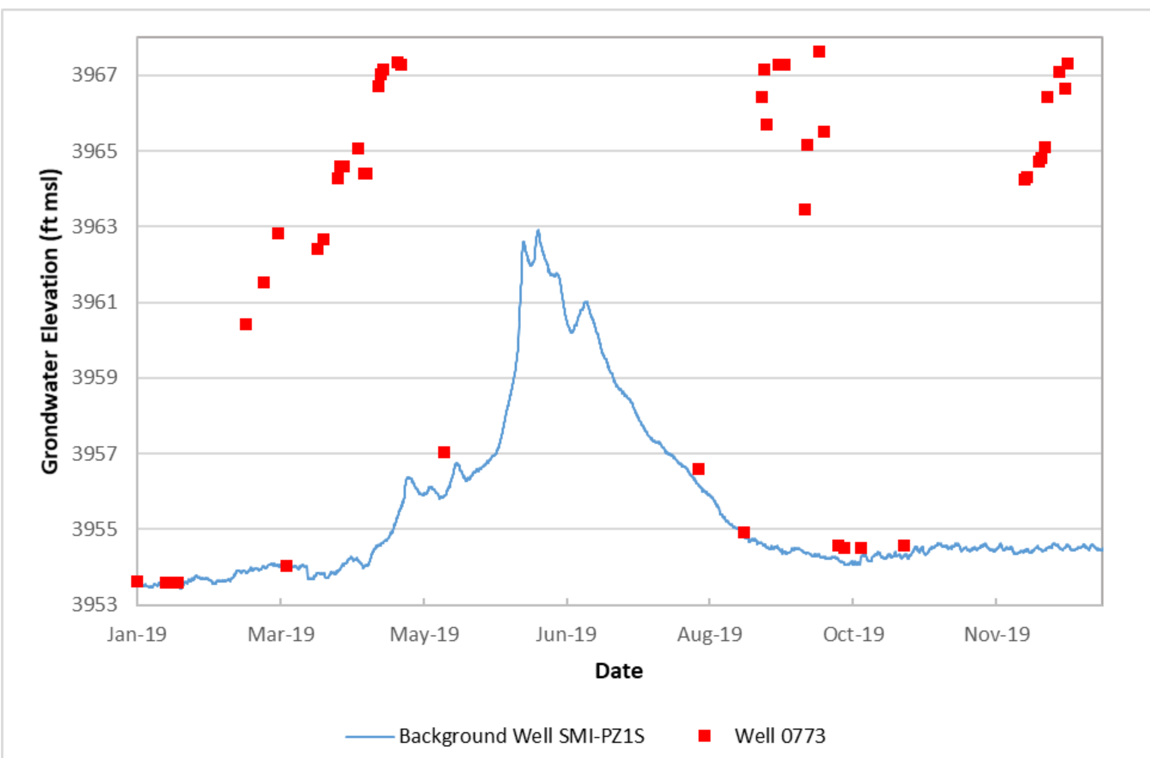

Figure B-4. Freshwater Mounding in Remediation Well 0773 during Injection

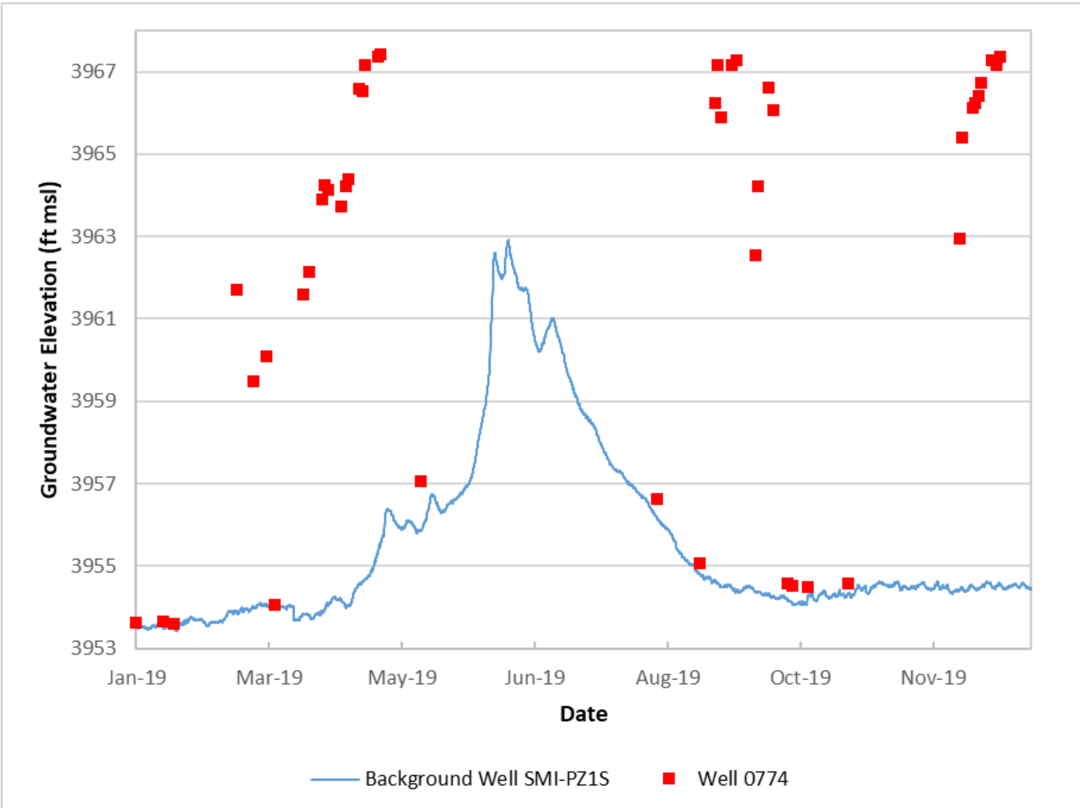

Figure B-5. Freshwater Mounding in Remediation Well 0774 during Injection

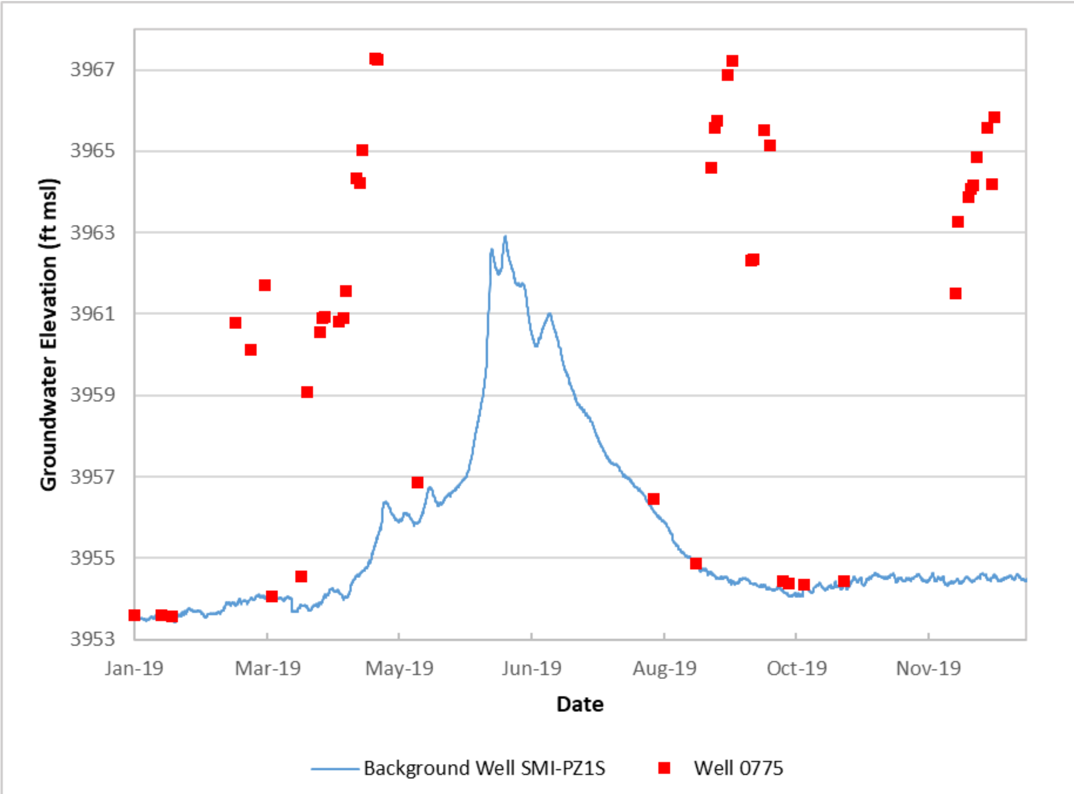

Figure B-6. Freshwater Mounding in Remediation Well 0775 during Injection

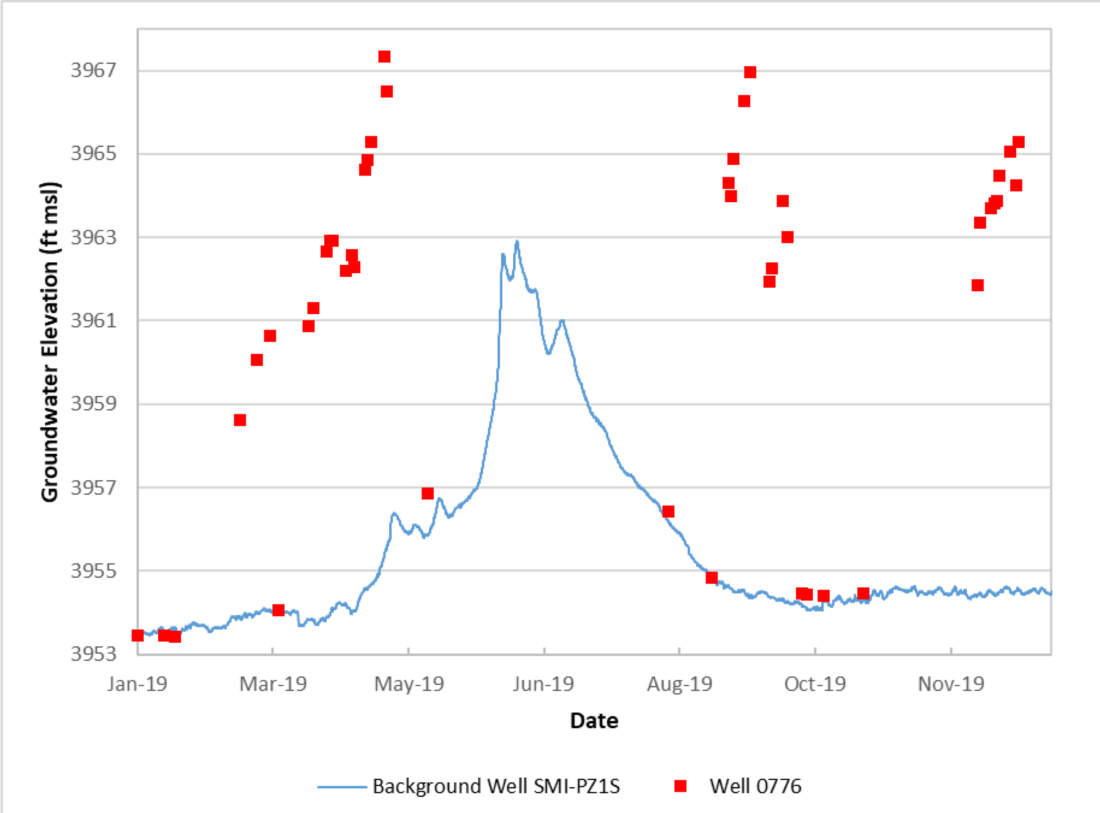

Figure B-7. Freshwater Mounding in Remediation Well 0776 during Injection

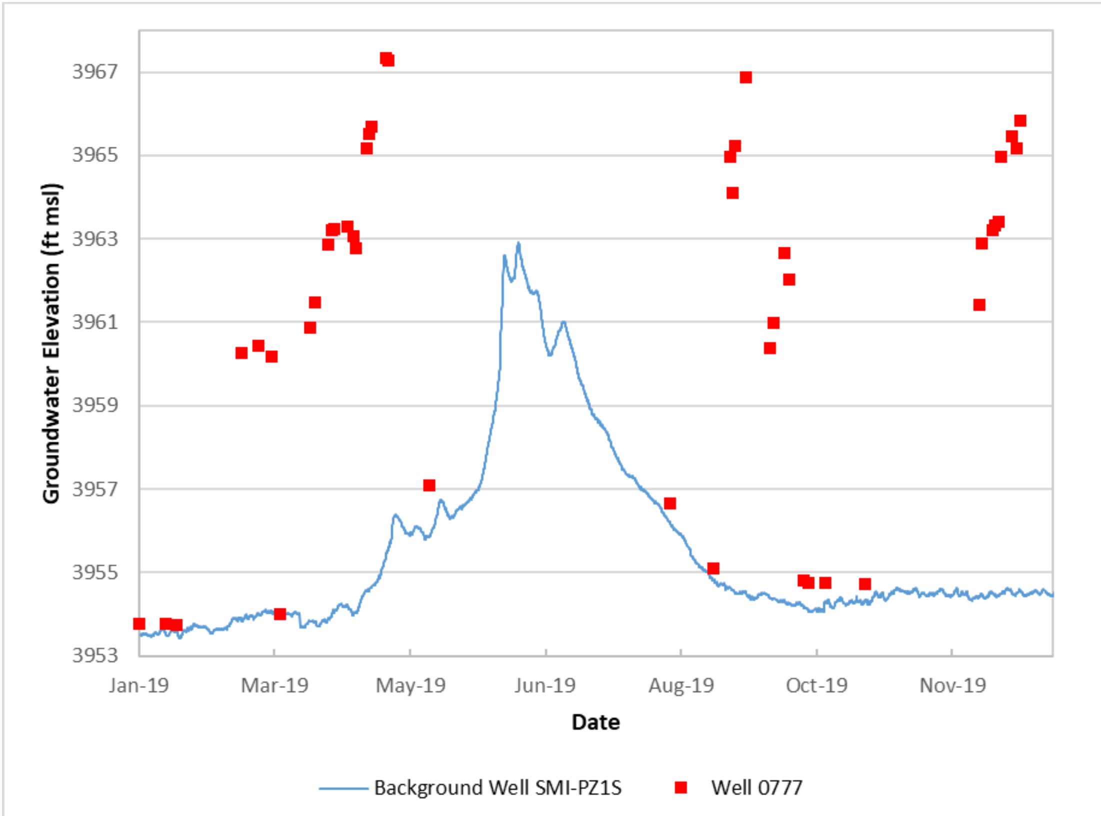

Figure B-8. Freshwater Mounding in Remediation Well 0777 during Injection

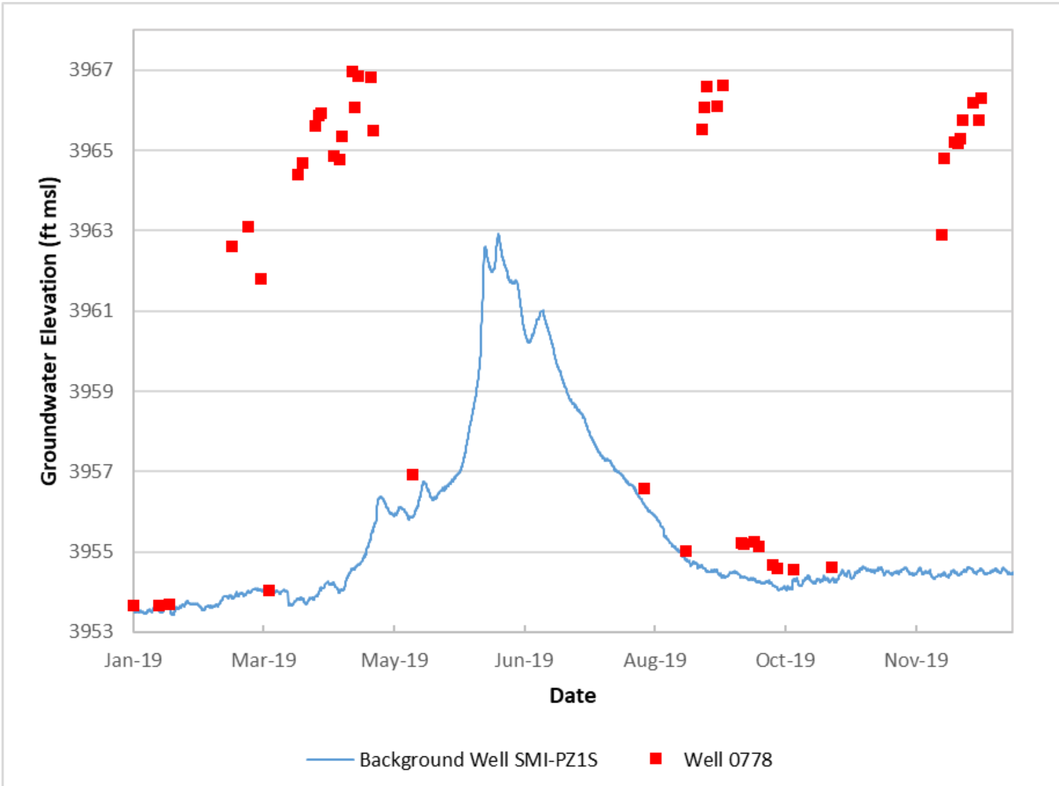

Figure B-9. Freshwater Mounding in Remediation Well 0778 during Injection

Appendix B. Tables and Data for 2019 Freshwater Injection (*continued*)

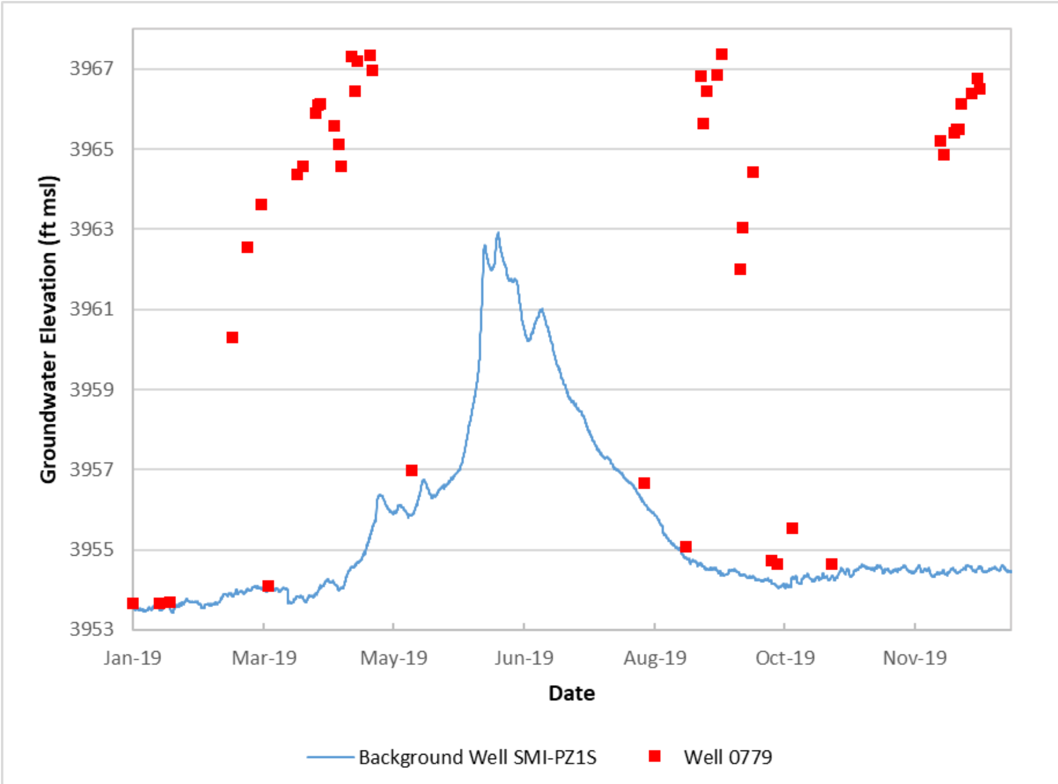

Figure B-10. Freshwater Mounding in Remediation Well 0779 during Injection

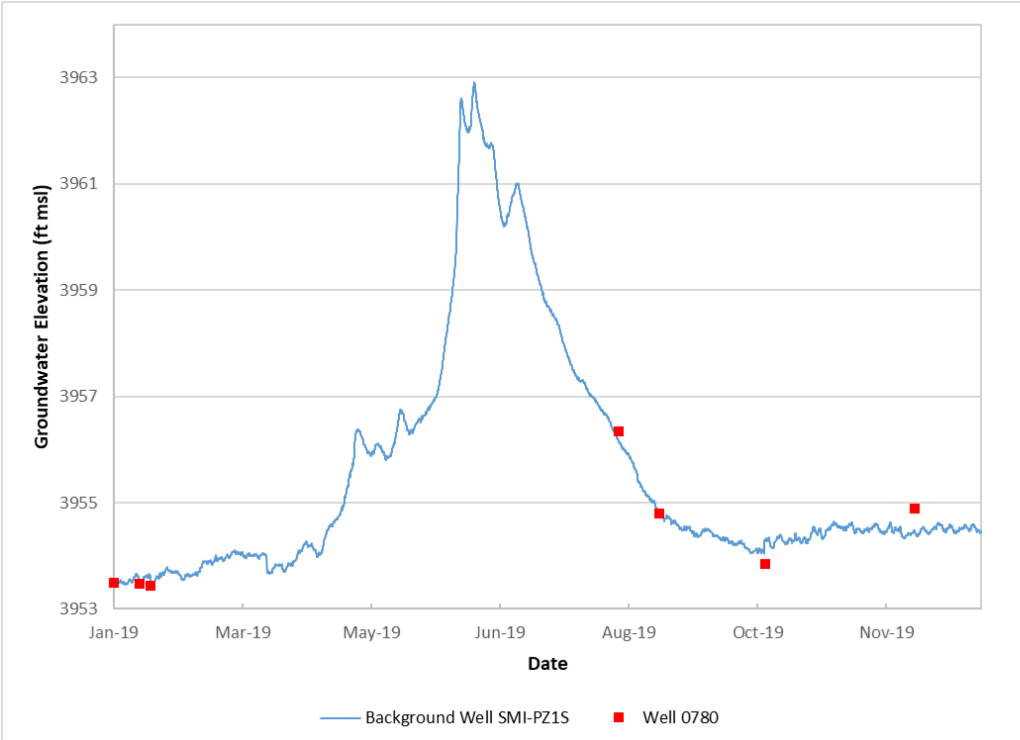

Figure B-11. Freshwater Mounding in Observation Well 0780

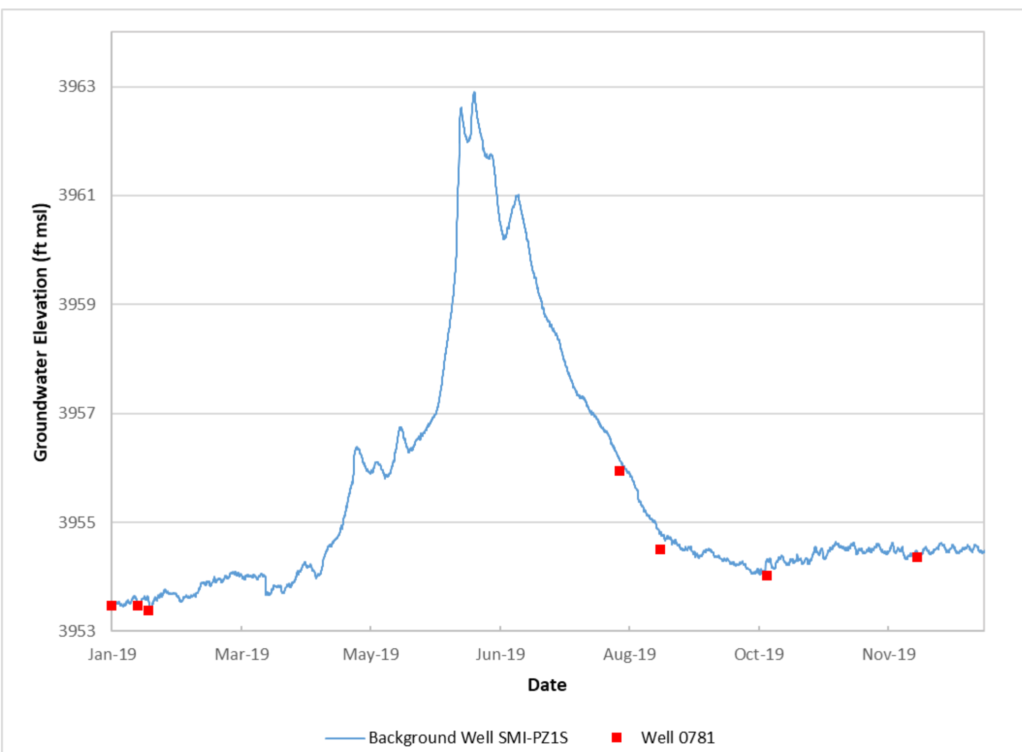

Figure B-12. Freshwater Mounding in Observation Well 0781

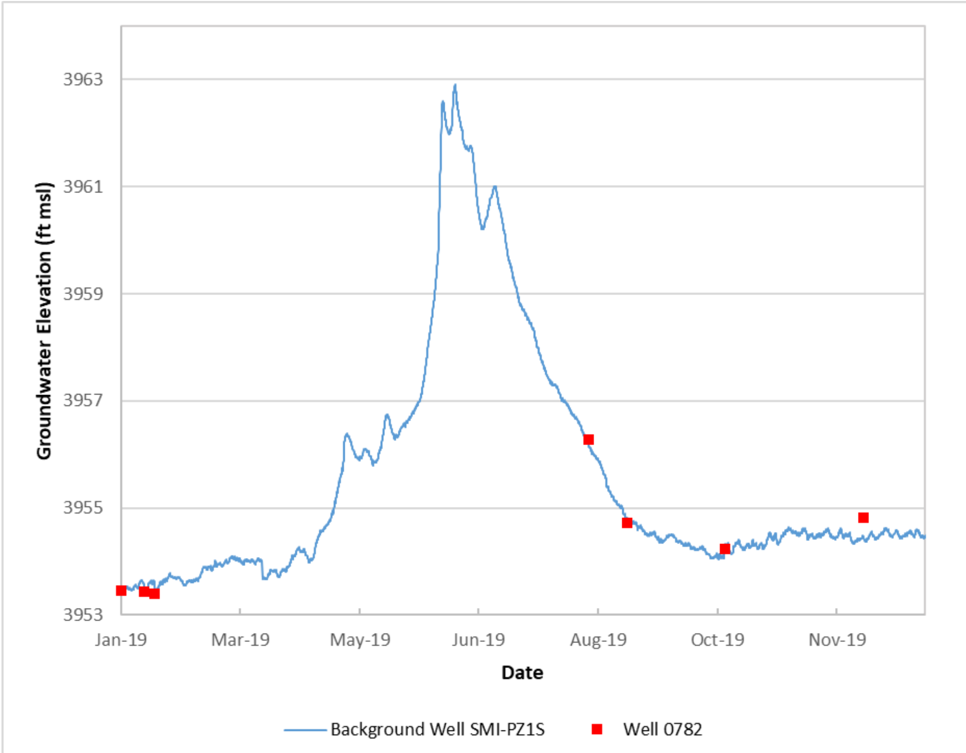

Figure B-13. Freshwater Mounding in Observation Well 0782

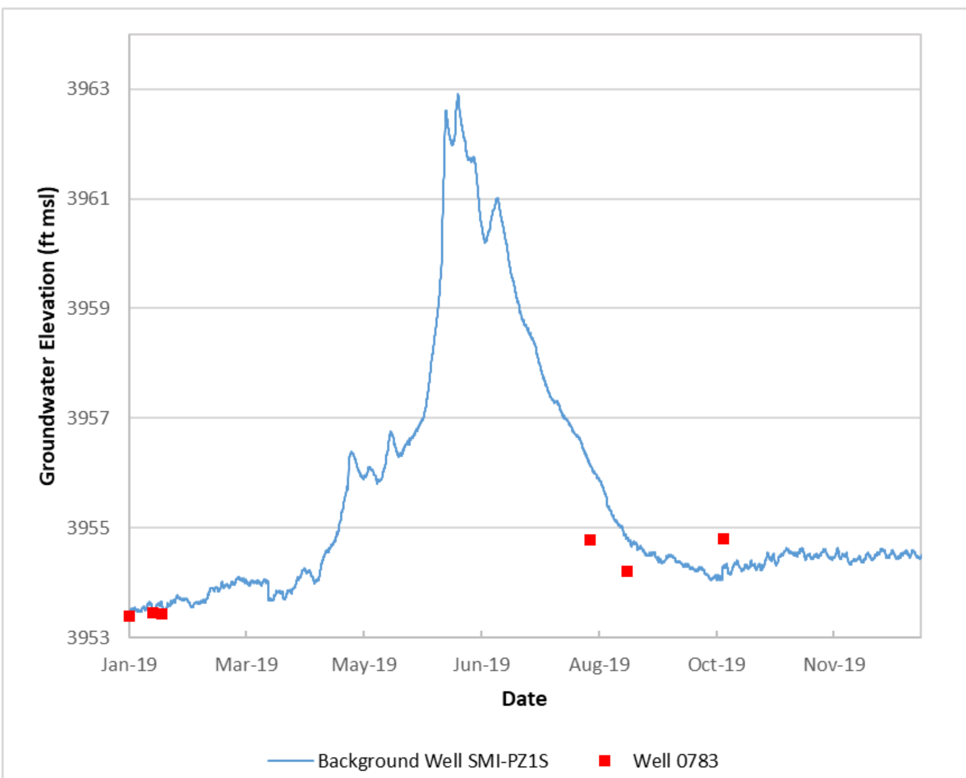

Figure B-14. Freshwater Mounding in Observation Well 0783

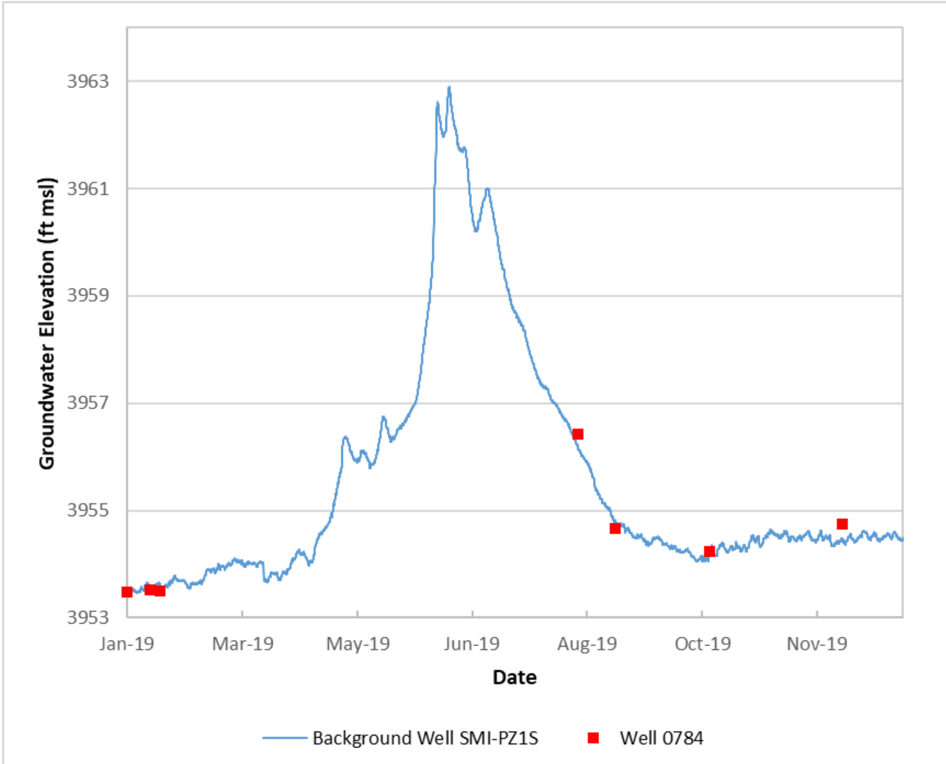

Figure B-15. Freshwater Mounding in Observation Well 0784

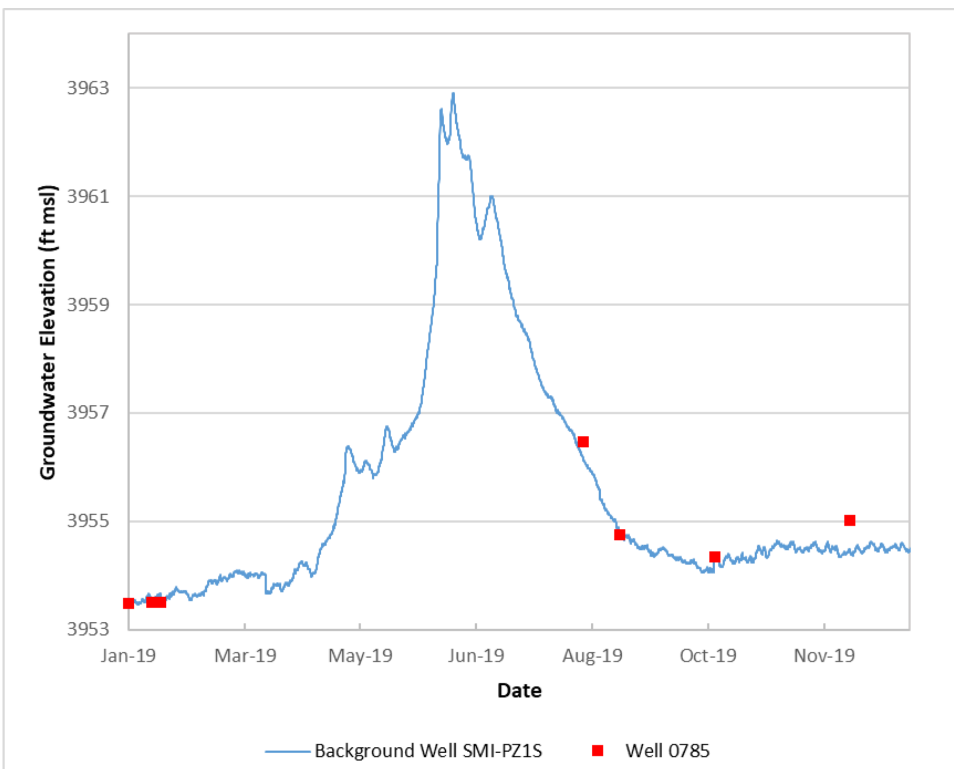

Figure B-16. Freshwater Mounding in Observation Well 0785

Figure B-17. Freshwater Mounding in Observation Well 0786

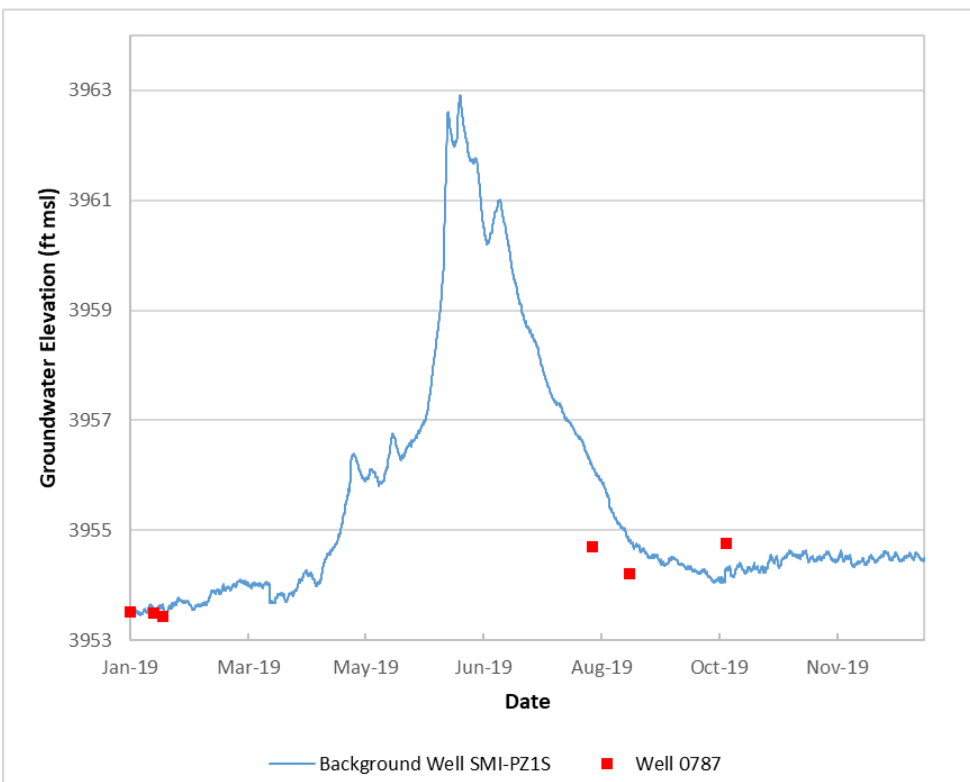

Figure B-18. Freshwater Mounding in Observation Well 0787

Appendix C.
2019 Surface Water/Groundwater Investigation Plots

Appendix C. 2019 Surface Water/Groundwater Investigation Plots

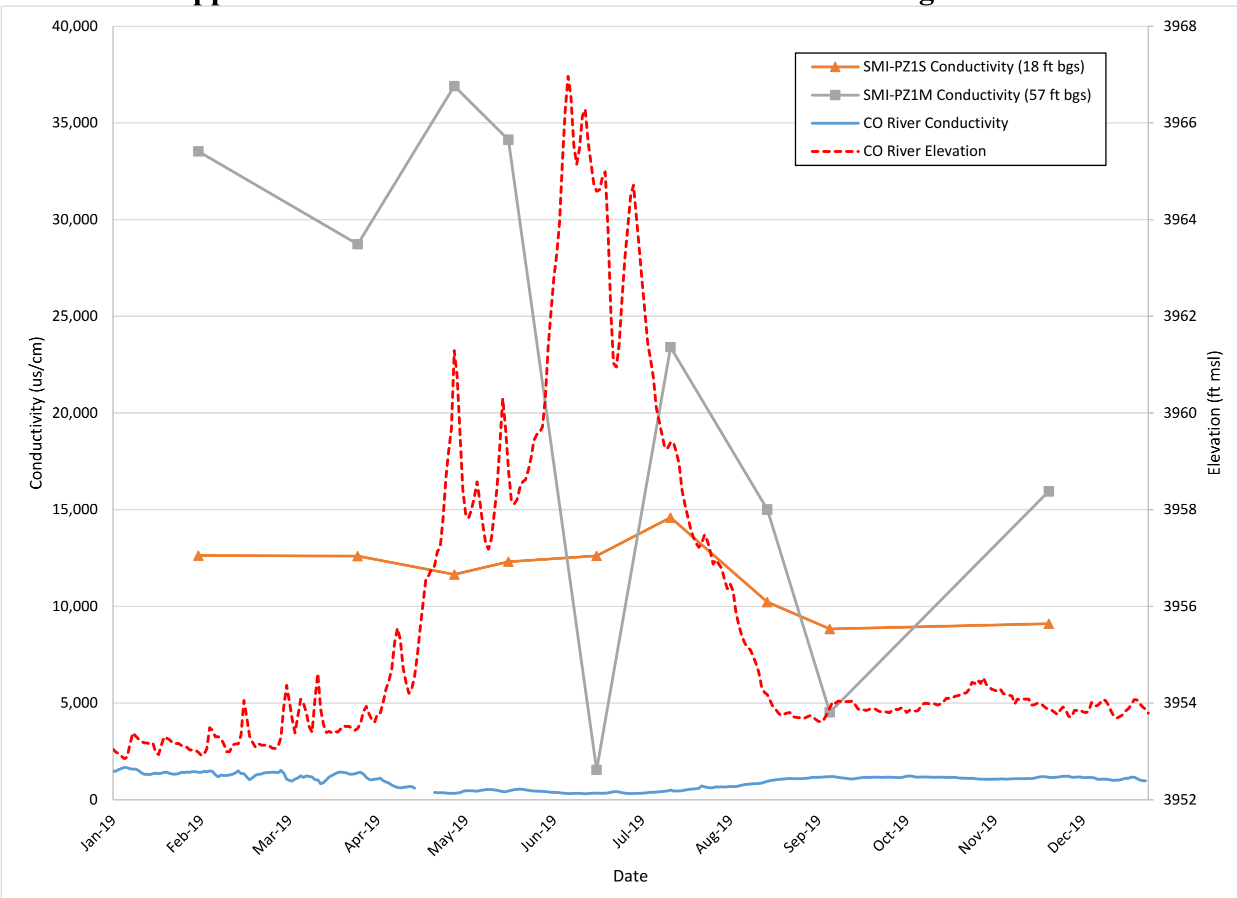

Figure C-1. SMI-PW01 Well Cluster Specific Conductance

Appendix C. 2019 Surface Water/Groundwater Investigation Plots (*continued*)

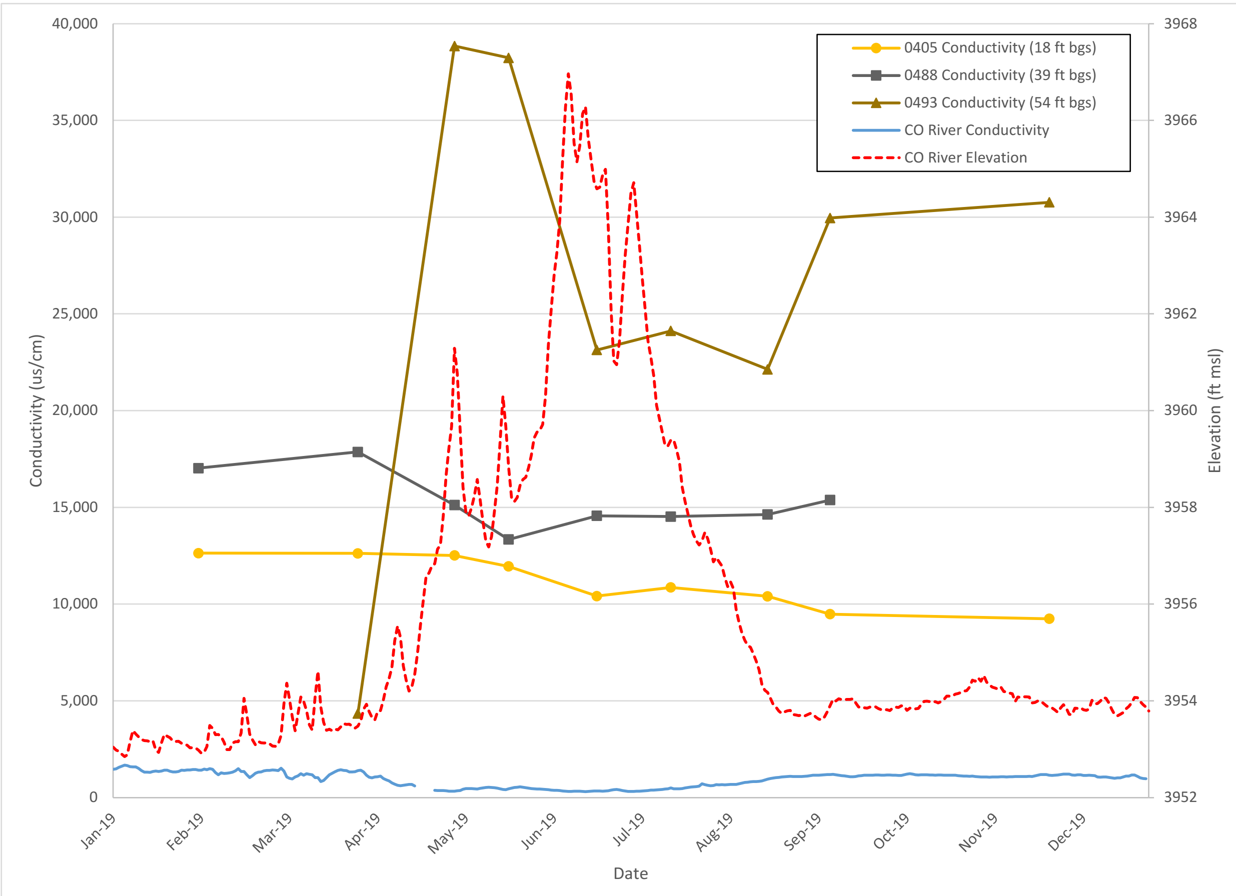

Figure C-2. Baseline Area Well Cluster Specific Conductance 2019

Appendix C. 2019 Surface Water/Groundwater Investigation Plots (*continued*)

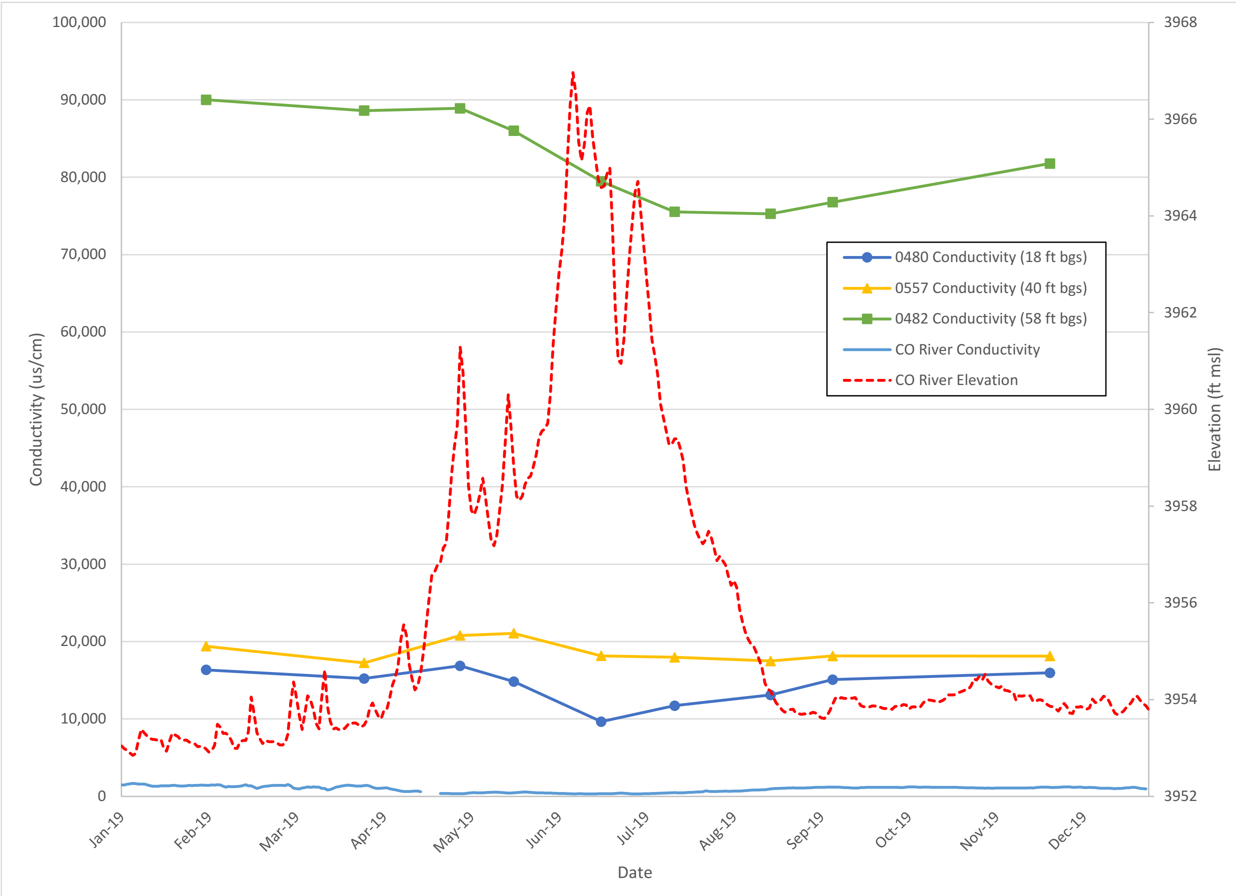

Figure C-3. CF1 Upgradient Well Cluster Specific Conductance 2019

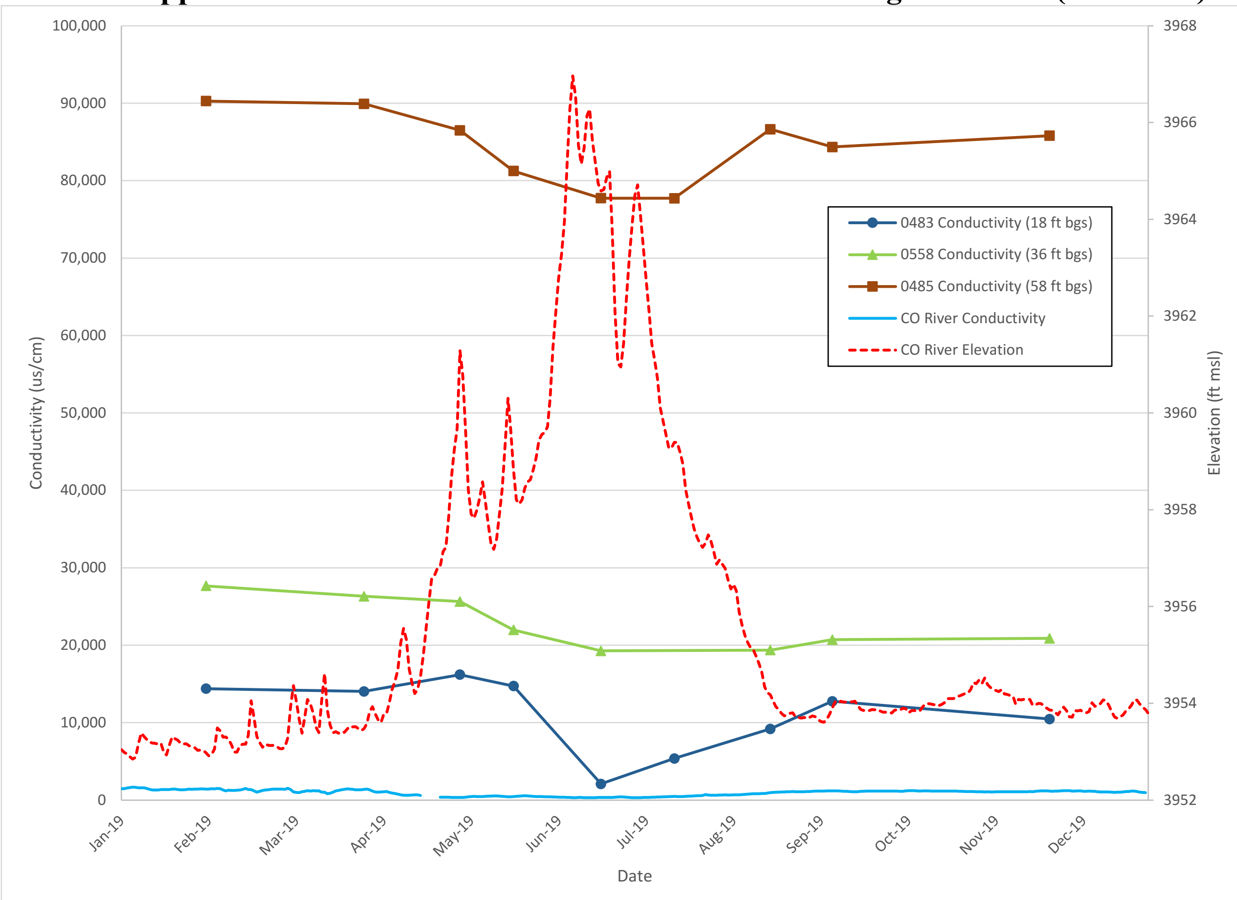

Figure C-4. CF1 Midpoint Well Cluster Specific Conductance 2019

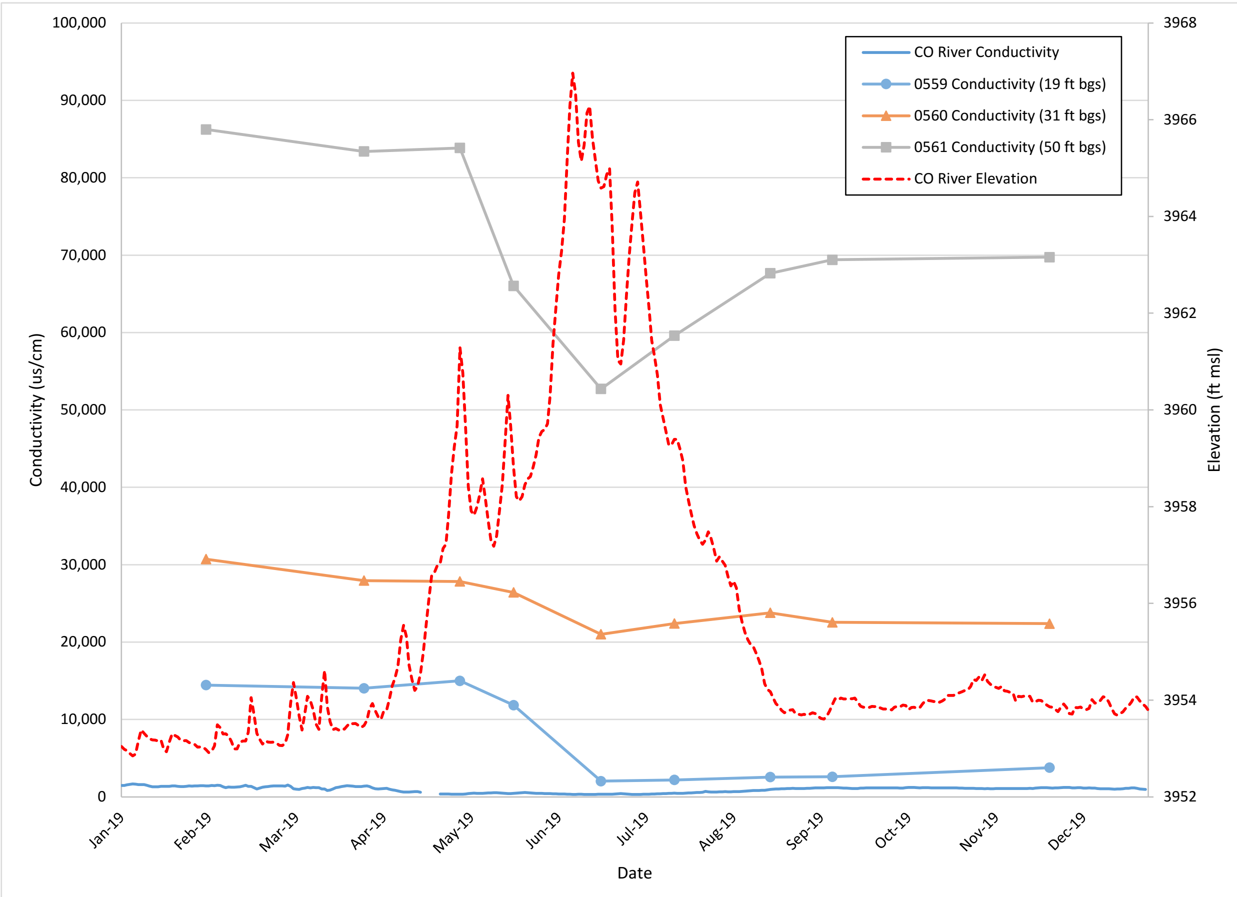

Figure C-5. CF1 Downgradient Well Cluster Specific Conductance 2019