DOE–EM/GJTAC1941

Office of Environmental Management – Grand Junction

MOAB UTAH UMTRA

UMTRA Project

Moab UMTRA Project 2009 Ground Water Program Report

November 2010

U.S. Department of Energy

Office of Environmental Management

Prepared by the Technical Assistance Contractor under contract number DE-AC30-07CC60012 for the U.S. Department of Energy Office of Environmental Management, Grand Junction, Colorado.

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Revision 0

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Revision History

Revision No.	Date	Reason/Basis for Revision
0	November 2010	Initial issue.

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Acronyms and Abbreviations

°C	degrees Centigrade
AWQC	ambient water quality criteria
bgs	below ground surface
CF	configuration
cfs	cubic feet per second
DOE	U.S. Department of Energy
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ft	feet
gal	gallons
gpm	gallons per minute
IA	interim action
kg	kilogram
mg/L	milligrams per liter
msl	mean sea level
RAC	Remedial Action Contractor
TDS	total dissolved solids
UMTRA	Uranium Mill Tailings Remedial Action
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

1.0 Introduction

1.1 Purpose

The purpose of this Ground Water Program Report is to assess the performance of measures the U.S. Department of Energy (DOE) has taken to remediate the ground water at the Moab Uranium Mill Tailings Remedial Action (UMTRA) Project site in Utah and to protect the surface water quality of the Colorado River near the site during 2009.

1.2 Scope

This report describes the ground water program activities for the Moab Project conducted during 2009. The report also evaluates how the ground water at the Moab site responds to various pumping regimes and fluctuating river flow.

1.3 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 tons of uranium mill tailings, material that ranges from a dry sand to wet “slime” clay that remains after the ore is processed, had accumulated in an unlined impoundment, a portion of which is in the 100-year floodplain of the Colorado River. In 2001, ownership of the site was transferred to DOE. Relocation of the tailings, by rail, began in April 2009 to a disposal cell constructed 30 miles north near Crescent Junction, also in Utah.

Results of investigations indicated that site-related contaminants have leached from the tailings pile into the shallow ground water and that some of the more mobile constituents have migrated downgradient and are discharging to the Colorado River adjacent to the site. The most pervasive and highest concentration constituents are ammonia and uranium.

The main driver for remediation of the ground water at the Moab site is to protect surface water quality in the Colorado River. In 2005, DOE issued a Record of Decision that includes the cleanup alternative to continue and expand as necessary its ongoing active remediation of contaminated ground water at the Moab site.

The U.S. Fish and Wildlife Service (USFWS) granted DOE an incidental take of Colorado River endangered fish species for a period of 10 years following the issuance of its Biological Opinion, which was appended to the Final Environmental Impact Statement (EIS) in 2005. DOE agreed to implement several measures to minimize the adverse impacts of incidental take of the endangered fishes. To address some of these measures, USFWS also established a target goal of 3.0 milligrams per liter (mg/L) or less of ammonia in ground water discharging to the river.

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. The IA system is discussed in further detail in Section 2.0. An expanded ground water remediation program may use evaporation or one or more of the other treatment technologies assessed in the Final EIS to treat or dispose of contaminated ground water.

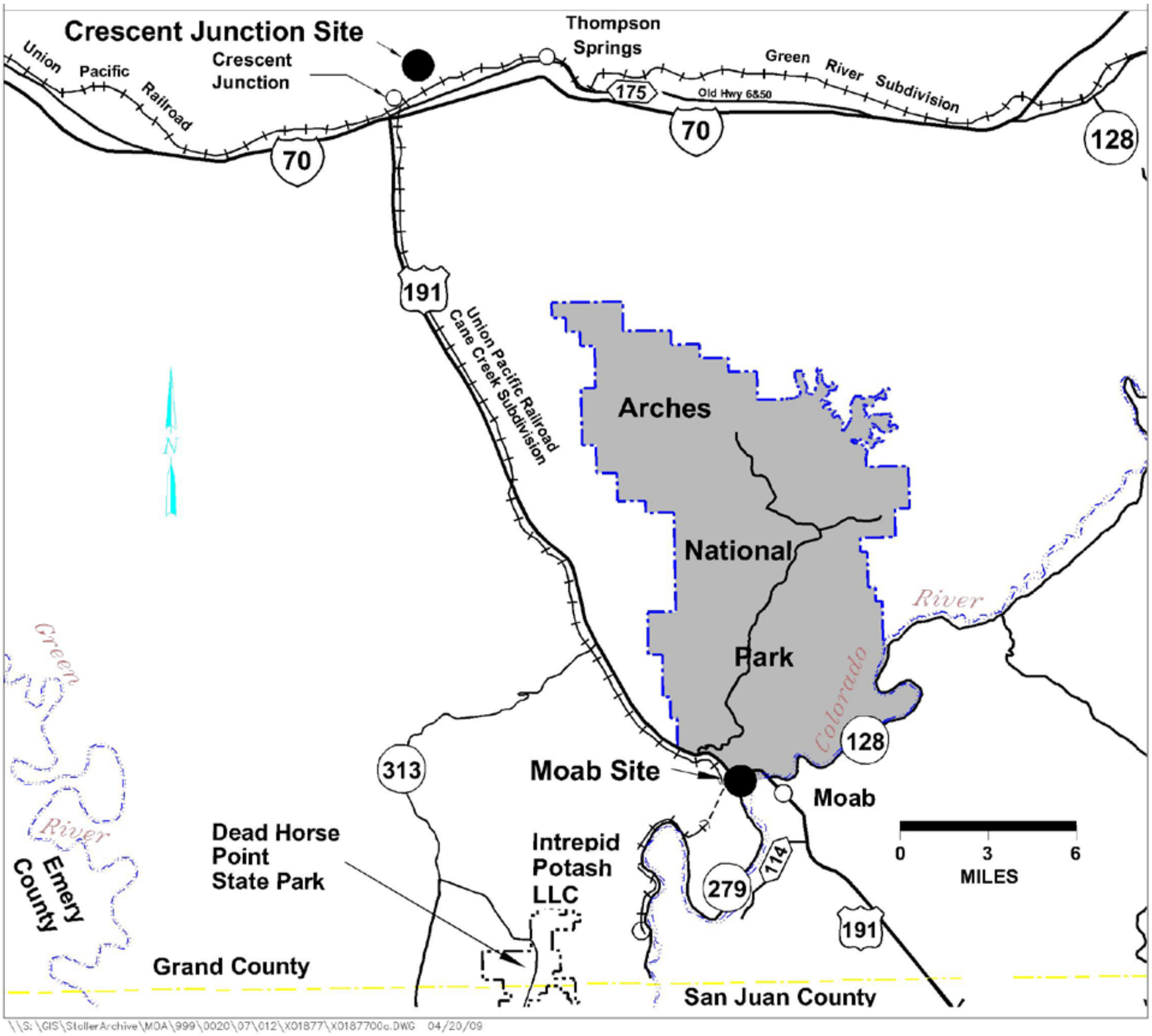


Figure 1. Site Location

Selection of a final ground water remedy will be documented in a Ground Water Compliance Action Plan that will be submitted to the U.S. Nuclear Regulatory Commission for concurrence.

1.4 Hydrology and Contaminant Distribution

The primary hydrogeologic unit present at the Moab site is unconsolidated alluvial soils (Figure 2). Underlying the alluvium are salts beds of the Paradox Formation. The alluvial soils at the Moab site are mostly from either the Moab Wash alluvium or basin-fill alluvium. The Moab Wash alluvium is composed of fine-grained sand, gravelly sand, and detrital material that travels down the Moab Wash and interfingers near the northwest boundary of the site into the basin-fill alluvium deposited by the Colorado River.

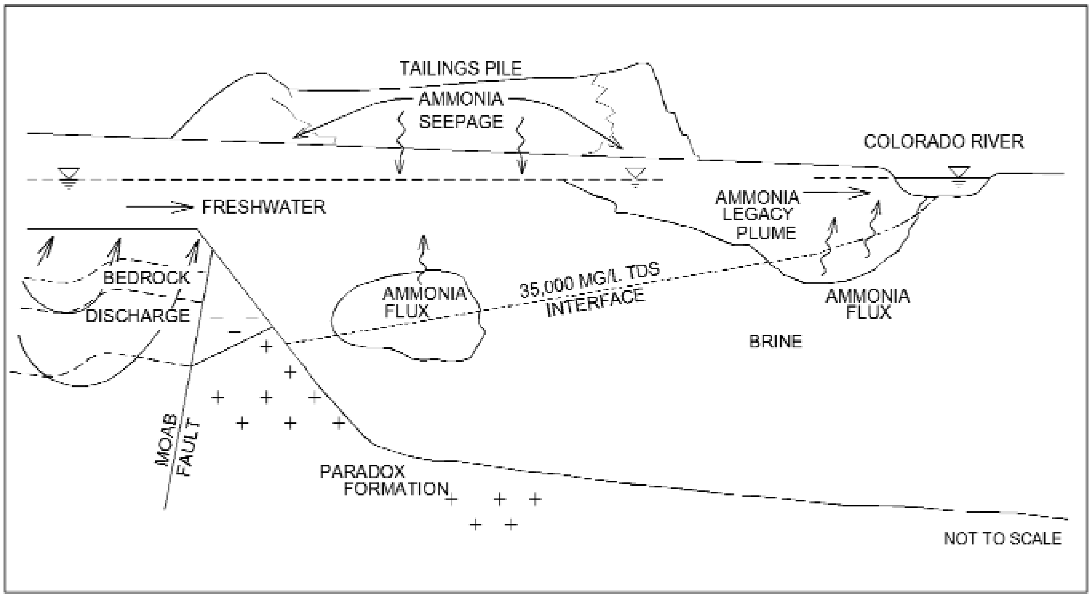


Figure 2. Cross Sectional Conceptual Site Model

The basin-fill alluvium is composed of two distinct types of material. The upper material consists mostly of fine sand, silt, and clay (silty sand unit), ranges in thickness from 15 feet (ft) near the river to 40 ft in the northern and northwestern portions of the Moab site, and extends into 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 (gravelly sand unit). This coarser alluvium pinches out to the northwest along the subsurface bedrock contact and thickens to the southeast toward the river to over 450 ft near the deepest part of the basin. The silty-sand unit typically has a hydraulic conductivity of less than 2 ft/day, whereas underlying gravelly sand unit has a hydraulic conductivity that ranges from 100 to 200 ft/day.

Ground water surface elevation contours (Figure 3) and pore water velocities indicate that nearly all of the ground water moving southeast toward the river discharges along a relatively small portion of the total river bed, all in an area lying close to the river's west bank. The greatest discharge occurs at the west bank and gradually decreases with distance toward the center of the river.

Most of the aquifer beneath the site is characterized by ground water containing total dissolved solids (TDS) concentrations greater than 10,000 mg/L (brackish water and brine). A saline water interface occurs naturally beneath the Moab site that is delineated at 35,000 mg/L. The interface moves laterally and vertically over the course of each year in response to such stresses as seasonal transpiration and changes in stage of the river.

The tailings pile fluids contain TDS exceeding 35,000 mg/L, the concentration of the saline water interface, such that they have sufficient density to migrate vertically downward. This density-driven flow has created a reservoir of dissolved ammonia that now resides below the saline water interface. This ammonia beneath the saltwater interface represents a long-term source of contamination to the upper alluvial ground water system.

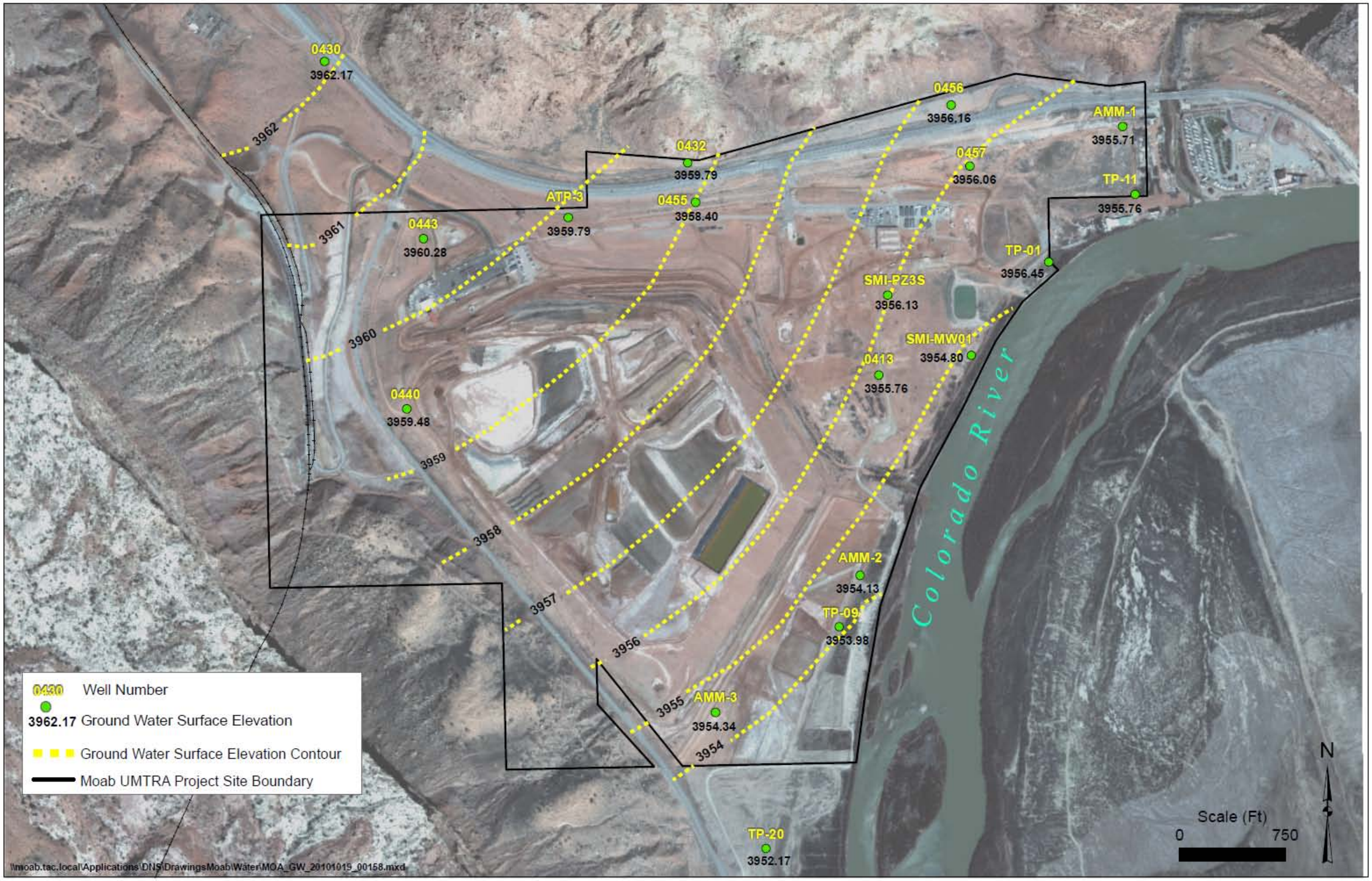


Figure 3. Ground Water Surface Elevation Contours

Since the release of tailings pond fluids containing high TDS concentrations infiltrated the ground water during milling operations, the volume of relatively freshwater entering the site upgradient of the tailings pile may have diluted the ammonia levels in the shallow ground water (Figure 4). Advective flow of freshwater through the higher-density fluids is insignificant, thus, the ammonia concentrations persist at depth. 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.

Wells to monitor water quality have been installed on the site over a series of 10 different investigations. The first monitoring wells associated with site characterization were installed in 1970.

In addition to ammonia, the other primary contaminant of concern in ground water is uranium. Figure 5 shows the distribution of dissolved uranium in shallow ground water.

1.5 Surface Water/Ground Water Interaction

Previous investigations have shown that the surface water flow in the Colorado River can strongly affect ground water elevations and contaminant concentrations in the well field. As the Colorado River reaches peak spring runoff flows, it changes from gaining to losing conditions, and a lens of freshwater migrates into the well field ground water system.

The freshwater lens is more prominent on the southern end of the well field, where a prominent backwater channel flows adjacent to the river bank.

A geochemical investigation conducted in 2008 indicated that in the southern half of the well field, where Colorado River side channels are located off the near bank (and adjacent to the well field), a freshwater lens begins to form beneath the well field when the river flow is above 10,000 cubic feet per second (cfs). Figure 6 presents the base flow conditions prior to the spring runoff. During peak flows (e.g., 39,500 cfs in June 2008), the freshwater lens propagated up to 200 ft horizontally and 36 ft vertically (Figure 7). This freshwater lens slowly rebounded to base flow conditions by September.

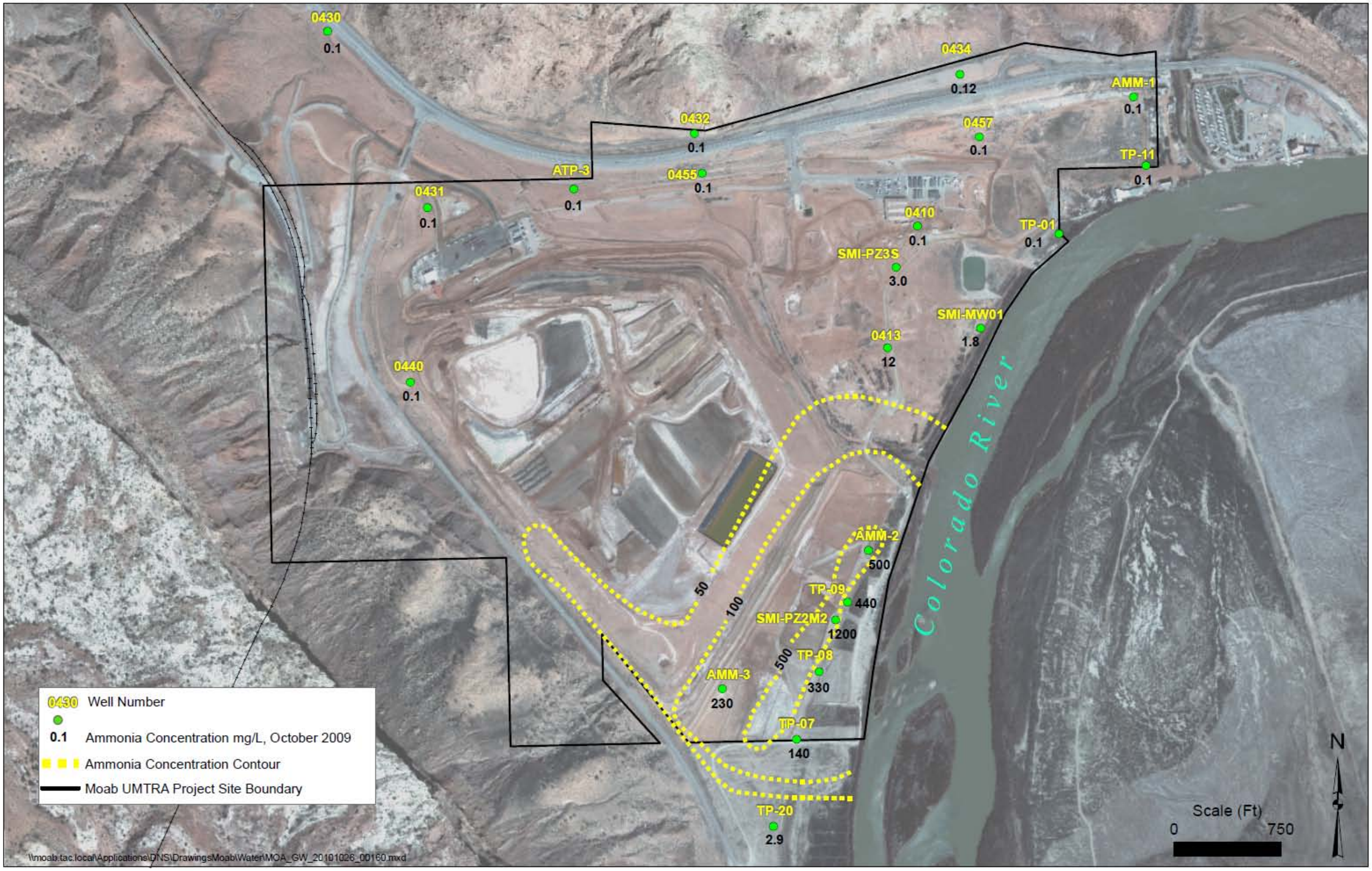


Figure 4. Location of Ammonia Plume in Shallow Ground Water

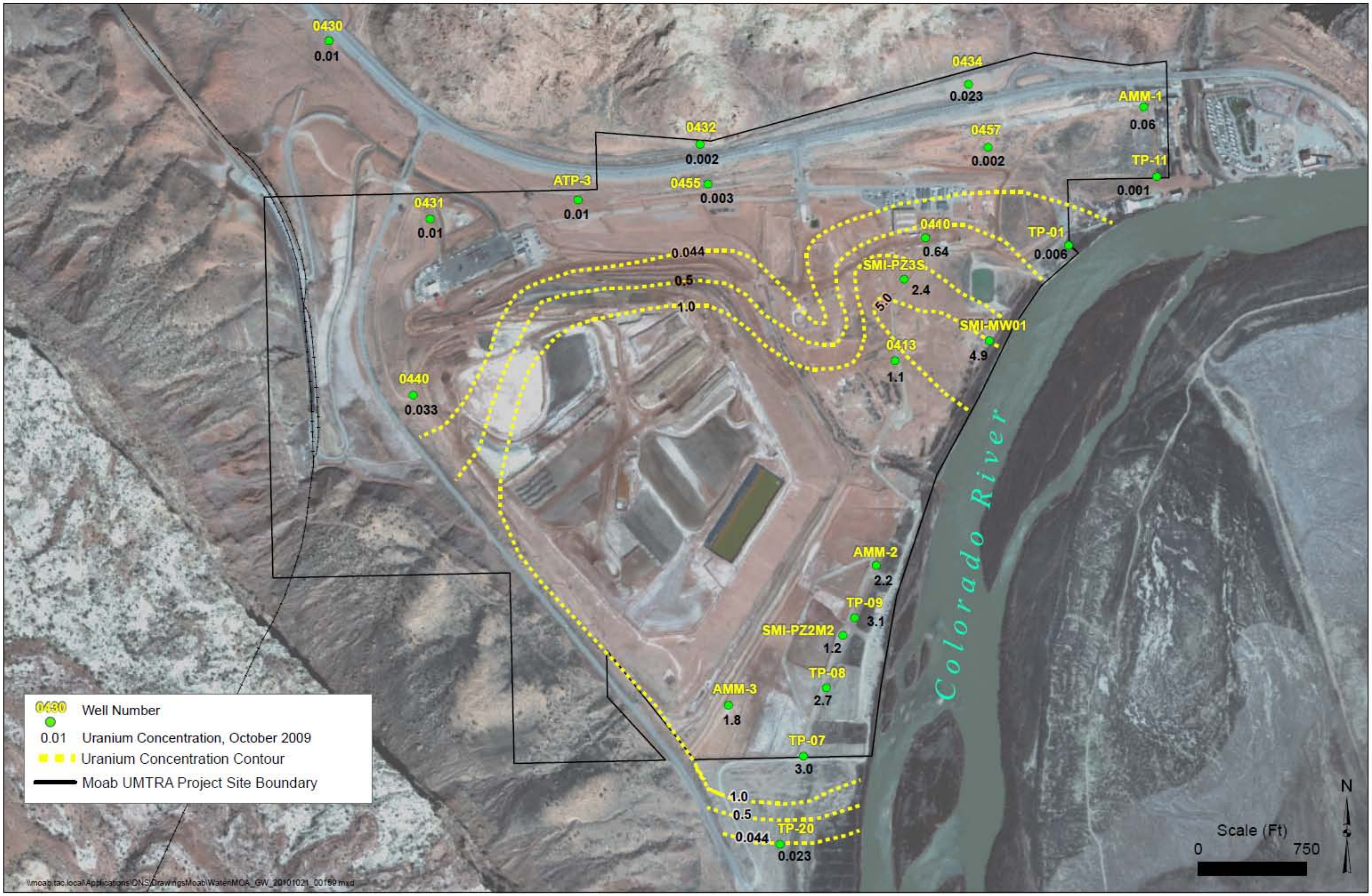


Figure 5. Location of Uranium Plume in Shallow Ground Water

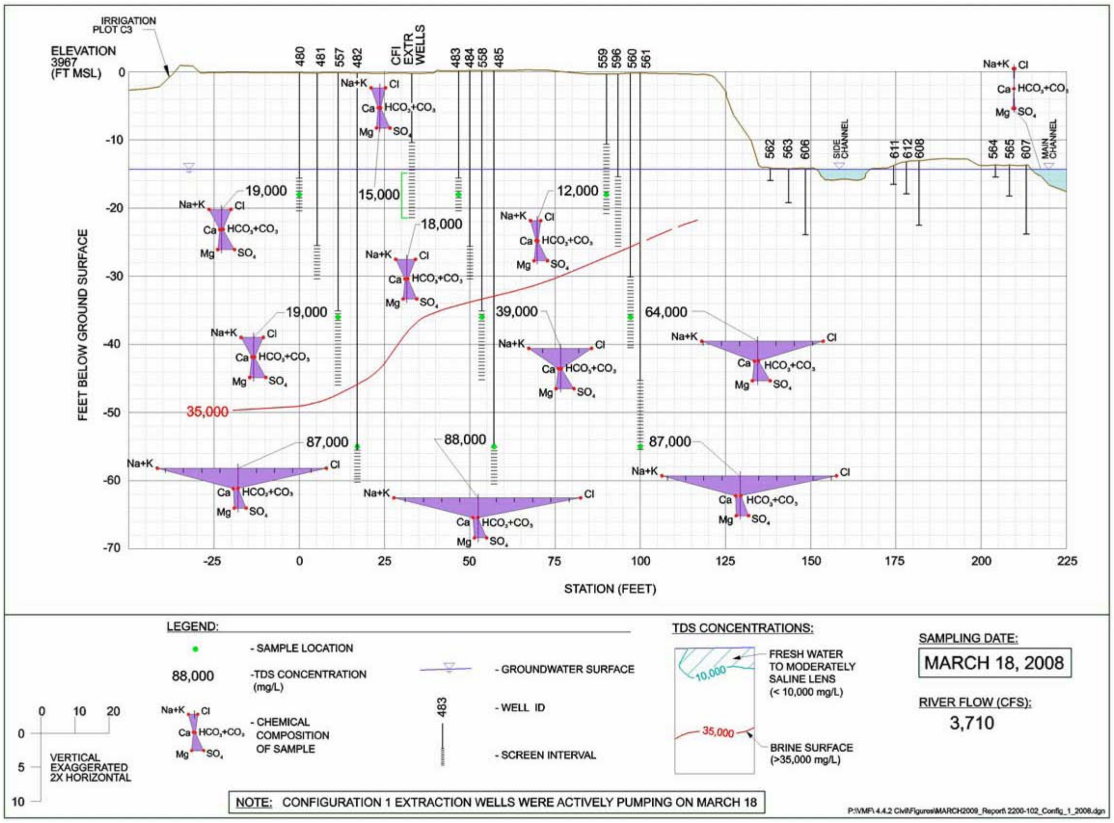


Figure 6. Configuration 1 Cross Section and Water Chemistry, March 2008

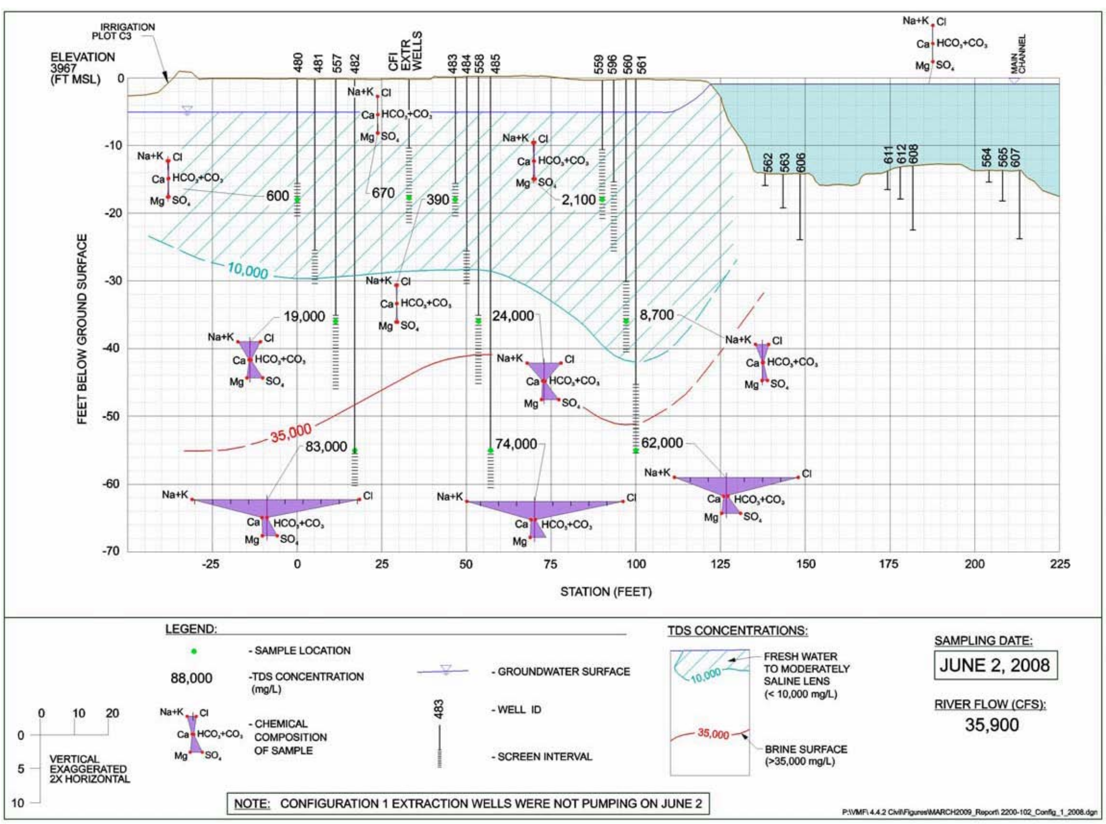


Figure 7. Configuration 1 Cross Section and Water Chemistry, June 2008

2.0 Ground Water Program Description

The primary purpose of active ground water remediation at the Moab site is to maintain surface water quality in the Colorado River. The ground water program at the Moab site is designed to protect the river and the potential endangered fish species habitat areas. This protection is accomplished through removal of contaminant mass before it reaches the river and by injecting freshwater between the river and the tailings pile to create a hydraulic barrier. When critical habitat areas exist in the surface water, unaffected surface water is diverted to the area to reduce contaminant levels.

The program consists of the ground water IA and the surface water action, which has previously been called the initial action. Ground water and surface water monitoring are performed with each action. Each of these aspects will be discussed in separate sections in this report.

2.1 IA Ground Water System

Since 2003, when DOE installed and began operating the first of several configurations of extraction/injection wells that compose the IA ground water system (Figure 8)—a total of 4 configurations with 10 remediation wells each—have existed, along with SMI-PW02, which was initially installed for site characterization purposes, and later converted to allow ground water extraction.

The objectives of the IA system are to reduce the discharge of ammonia-contaminated ground water to backwater areas that may potentially be suitable habitat for threatened and endangered aquatic species and to provide performance data for use in selecting and designing a final ground water remedy.

Contaminated ground water from the shallow plume is extracted through series of wells and pumped to an evaporation pond on top of the tailings pile. The evaporation pond has a sloped-side design to maximize evaporation. Additionally, water from the evaporation pond was sprayed on the pile using a sprinkler system until the sprinkling system was dismantled; the water was also spread for dust control by water trucks. The IA system also includes injection of diverted river water into the aquifer through the wells and an infiltration trench installed near the west bank of the river. Monitoring wells are also part of the IA system for evaluation purposes.

In 2009, the IA system involved extraction from three of the four well configurations, each consisting of 10 remediation wells and sampling from monitoring wells.

In May 2009, the Moab Project received American Recovery and Reinvestment Act funds, parts of which were used to expand the IA well field closer to the contaminant source. The activities associated with the IA expansion are focused on more effectively extracting contaminated ground water with limited treatment capabilities.

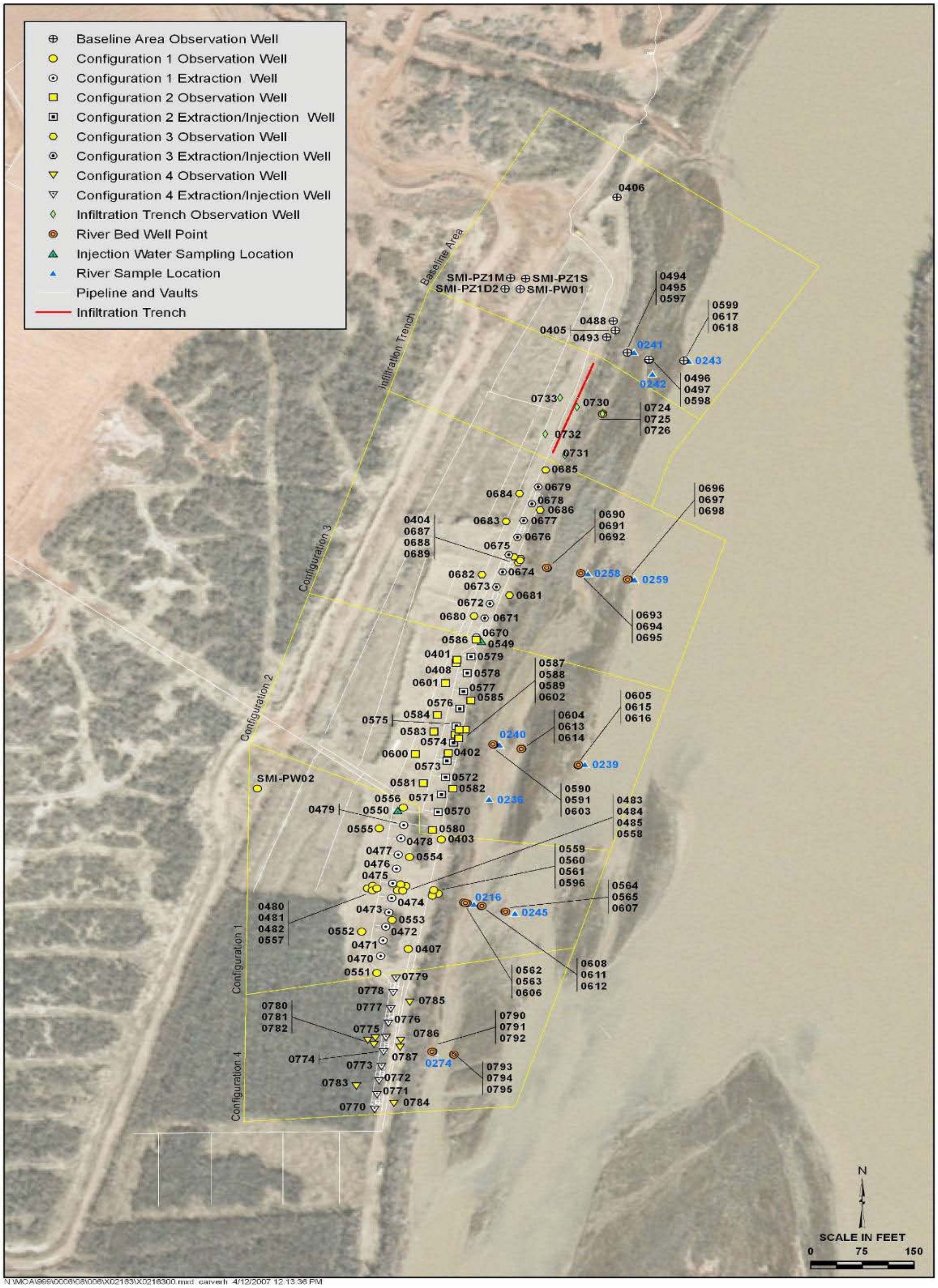


Figure 8. Location of IA Wells

3.0 Methods

Performance is assessed by measuring extraction/injection rates of remediation wells, measuring water levels in wells and in the river, and sampling remediation and monitoring wells. In 2009, the IA well field ran exclusively on extraction mode, so recording injection data was not applicable.

3.1 Remediation Well Discharge

Each extraction well contains a flow meter that displays the instantaneous flow rate in gallons per minute (gpm), the cumulative total volume extracted (displayed as "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 meters). Flow meter readings are manually recorded on a weekly basis during extraction operations and are used in conjunction with water quality data to estimate the contaminant mass removal from the well.

When the remediation wells are sampled, the ammonia and uranium concentrations are used to calculate the contaminant mass removal. The ammonia and uranium mass removal values are used in conjunction with the ground water extraction to calculate the mass removal. The contaminant mass that is removed is discharged to the evaporation pond on top of the tailings pile.

3.2 Water Levels

Ground water levels are recorded in the IA well field on a weekly basis during pumping operations to monitor ground water drawdown, which is used to assess contaminant capture. A water level indicator is used to measure the depth to ground water (below top of casing) in most wells. Data logging equipment with pressure transducers are installed at various locations to measure water levels on a more frequent basis.

3.3 Water Quality

Selected well and surface water locations are sampled at various times, depending on the purpose of the event. Prior to sampling, field parameters are measured and recorded, including temperature, pH, oxidation reduction potential, conductivity, dissolved oxygen, and turbidity.

Observation wells are sampled with dedicated down-hole tubing and a peristaltic pump, and 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), uranium, and TDS. Table 1 presents the U.S. Environmental Protection Agency (EPA) method number and required maximum detection limit for constituents analyzed in 2009. Water sampling was performed in accordance with the *Moab UMTRA Project Surface Water/Ground Water Sampling and Analysis Plan* (DOE-EM/GJTAC1830). Samples were shipped overnight to the ALS Laboratory Group in Fort Collins, Colorado.

Table 1. Analyte EPA Methods and Detection Limits

Analyte	EPA Method	Detection Limit
Ammonia-N	350.1	0.1 mg/L
Chloride	9056	0.5 mg/L
Bromide	9056	0.5 mg/L
Sulfate	9056	0.5 mg/L
TDS	160.1	10 mg/L
Copper	SW-846 6010B	25 µg/L
Selenium	SW-846 6020A	0.1 µg/L
Manganese	SW-846 6010B	5 µg/L
Uranium	SW-846 6020A	0.1 µg/L

An ammonia probe was purchased in late 2008 to obtain real-time ammonia concentrations. The probe is used mostly at surface water locations to determine whether the ammonia concentration exceeds the acute or chronic criterion for fish early life stages after the spring runoff. Frequently, the ammonia probe data is verified with a laboratory sample analysis. All of the ammonia data stated in this report is laboratory data, unless otherwise noted. In 2009, the ammonia probe was used in conjunction with the laboratory data to determine how the laboratory and probe data compare since they analyze using different methods.

4.0 Ground Water Operations and Performance

4.1 IA Operations

This section provides information regarding the ground water IA well field performance during the 2009 pumping season when Configurations (CFs) 1, 3, and 4 were actively extracting ground water. Also included in this section is a discussion regarding the total well field ground water extraction rate, evaporation pond storage volume, and the volume discharged through the sprinkler system.

The IA well field was impacted by several factors. In February 2009, the Remedial Assistance Contractor (RAC) began excavating and conditioning tailings at the Moab site. Excavation and conditioning activities included removing the interim cover, benching and excavating tailings, spreading the tailings to allow the wet fraction to dry, and stockpiling the conditioned tailings. As a result, the sprinkler system on top of the pile to enhance dispersal from the evaporation pond was dismantled to allow space for tailings drying beds. With the reduction and eventual elimination of the sprinkler system, the overall evaporative ability was limited to water spread by trucks to control dust and from the pond itself. Two forced air evaporators were added to aid in ground water elimination.

In 2009, well field operations followed the *Moab UMTRA Project Well Field Optimization Plan* (DOE-EM/GJTAC1791). The extraction schedule was altered to focus on extracting from well field configurations adjacent to backwater habitat channels in the river. In accordance with the *Optimization Plan*, a majority of the well field was shut down during the peak river flow in May to June to eliminate the extraction of diluted ground water to the evaporation pond and to allow infiltration of river water into the aquifer beneath the site.

In November 2009, the RAC began removal of surficial soils of an approximately 20-acre off-pile area between the IA well field and the tailings pile. During the removal, the extraction line leading from the well field to the evaporation pond was dismantled, and the well field was shut down for the remainder of the year.

CF2 did not operate since the remediation wells have not shown adequate productivity and have a low specific capacity. CF2 used to be adjacent to the location of an endangered fish habitat; however, the habitat area has since migrated south towards CFs 1 and 4 due to river channel migration and sediment filling. The infiltration trench on the northern end of the IA well field was not operated in 2009 because the area adjacent to the trench is no longer considered a potential habitat area.

Table 2 presents the average ground water extraction rates and the total volume removed from each well configuration during 2009. As shown, the average extraction rate from the entire well field was 114.77 gpm, and more than 24 million gallons (gal) of ground water were removed.

Table 2. Average Ground Water Extraction Rate and Total Volume During 2009

Well Field Configuration	Average Extraction Rate (gpm)	Total Volume Extracted (gal)
1	18.6	4,363,000
SMI-PW02*	19.2	5,130,000
3	53.0	12,879,000
4	24.0	1,808,000
Total	**115**	**24,181,000**

*separated from CF1 due to its location

The individual pumping rates and associated volume of ground water extracted by each well contained within CFs 1, 3, and 4 are presented in Appendices A, B, and C, respectively. The data listed were generally based on flow rates recorded at meters installed at each extraction well head. These flow meters occasionally malfunctioned, which meant that some pumping rates had to be assumed using rates that were accurately captured prior to and after periods of malfunction. Figure 9 provides a graphic summary of the cumulative volume of ground water extracted from each configuration in 2009. CF1 ran on extraction mode during the winter in early 2009, but the entire well field was shut down in November 2009 to allow off-pile soil cleanup just west of the well field.

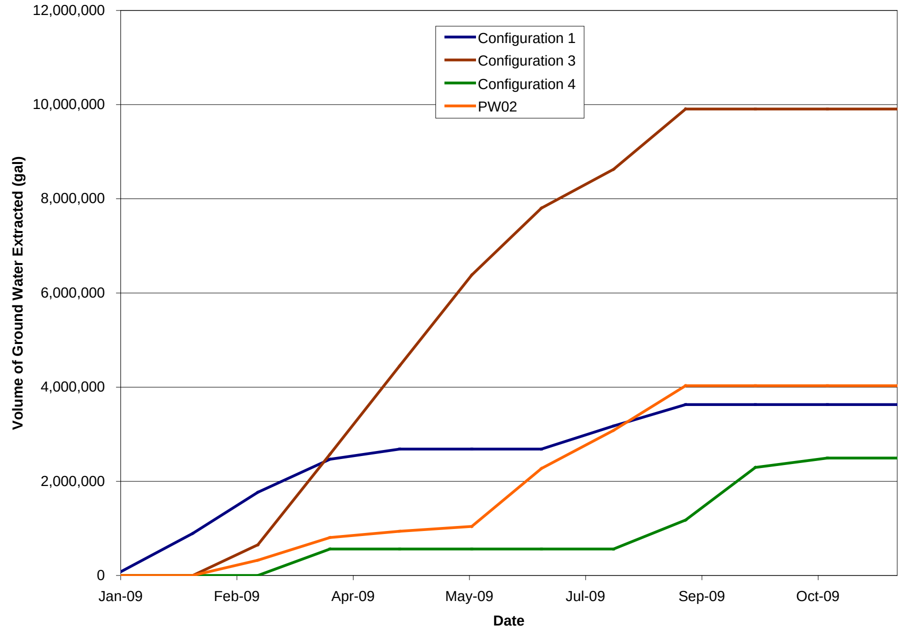


Figure 9. Cumulative Volume of Extracted Ground Water from Each Configuration During 2009

4.1.1 CF1 Pumping Rate and Ground Water Extracted Volume

CF1 extraction wells 0470 through 0479 (Figure 10) ran through the winter of 2008-2009 and were shut down on May 12 to allow infiltration of river water during high river flow in accordance with the *Optimization Plan*. Additional data tables are presented in Appendix A. Extraction wells 0470 through 0479 are screened from approximately 10 to 20 ft below ground surface (bgs) (3,957 to 3,947 ft mean sea level [msl]), and wells 0478 and 0479 are screened from approximately 10 to 25 ft bgs (3,957 to 3,942 ft msl). Extraction resumed on August 17 after river flow sufficiently declined to create a backwater channel habitat. On September 11, the CF1 extraction wells were shut down because of limited capacity in the evaporation pond. The wells did not extract during the winter of 2009-2010 to allow off-pile cleanup between the tailings pile and the IA well field.

Monthly extraction volumes between January and December 2009 for each of the 10 wells comprising the CF1 system are listed in Appendix B, Table B-2. CF1 wells individually extracted between approximately 91,339 gal and 580,973 gal in 2009. CF1 wells extracted a combined volume of about 4.3 million gal of ground water, and pumping from extraction well SMI-PW02 removed over 5 million gal of ground water in 2009.

4.1.2 CF3 Pumping Rate and Ground Water Extracted Volume

CF3 remediation wells 0670 through 0679 (Figure 11) were used to extract ground water during 2009. The well screens are placed at 15 to 45 ft bgs (3,952 to 3,921 ft msl). The CF3 remediation wells began extracting ground water on March 23, 2009, and were shut down to regulate the evaporation pond level on July 16, 2009. The wells were re-started on August 19 and were shut down for the year on September 17, 2009.

Estimated pumping rates and extraction volumes between March and September 2009 for each of the 10 wells comprising CF3 are presented in Appendix C, Table C-2. CF3 wells individually extracted between approximately 988,950 gal and 1,668,183 gal. CF3 wells extracted a combined volume of 12.8 million gal.

4.1.3 CF4 Pumping Rate and Ground Water Extracted Volume

CF4 remediation wells 0770 through 0779 (Figure 12) were used to extract ground water in 2009. The well screens are placed at 35 ft bgs (3,951 to 3,930 ft msl). CF4 ran from April 9 to 15 and then again from September 14 to November 11, 2009, to protect adjacent habitat areas.

Estimated monthly pumping rates and extraction volumes between April and November 2009 for each of the remediation wells are listed in Appendix D, Table D-2. A total of approximately 2 million gal of ground water was extracted from the CF4 wells during the 2009 pumping season.

CF4 wells individually extracted between approximately 36,341 gal and 576,637 gal in 2009. The amount (gal) pumped was limited to the evaporation pond capacity.

4.1.4 Evaporation Pond Operations

Ground water that is extracted from the IA well field is pumped up the southeast side of the tailings pile to the evaporation pond, which is the source of the sprinkler system. In 2009, the RAC used the space on top of the pile for tailings drying beds; as a result, the sprinkler system was reduced to only the southeast portion of the pile (formerly referred to as the System 2 sprinklers, Figure 13). By the end of 2009, the sprinkler system was dismantled and no longer used.

4.1.5 Well Field and Sprinkler System Pumping Rates and Volumes

Prior to the startup of the evaporation pond sprinkler system, the CF1 wells were running on extraction mode. The southeast portion of the sprinkler system was used to evaporate water starting on February 26, 2009, when the evaporation pond level was at 6.6 ft. On March 12, the pond level had decreased to 5.8 ft, and extraction well SMI-PW02 was restarted. Extraction began at CF3 on March 23, 2009, and CF4 was extracting by early April 2009.

When the spring runoff began in June, most of the extraction wells (except for SMI-PW02 and CF3) were shut down to due to the natural infiltration of river water into the well field. CF3 was shut down on July 16 because the pond level was 9 ft. By August 17, the evaporation pond level had dropped to 5.6 ft because the RAC began to use the evaporation water for dust suppression in the contamination area. As a result, the extraction wells were slowly brought back online.

In late September, the evaporation pond level had risen to over 9 ft, so many of the extraction wells were shut down to control the pond level. On September 24, an enhanced evaporation unit was installed to assist in the removal of the extracted ground water, and the RAC used the evaporation pond water for water-truck dust suppression in the contaminated area.

All of the extraction wells were shut down by mid-November because the extraction line that connects the well field to the evaporation pond had to be temporarily removed for off-pile soil remediation. Figure 14 shows a graphic record of well field ground water volume extracted into the evaporation pond, volume of water from evaporation pond to the sprinkler system, and pond levels during 2009.

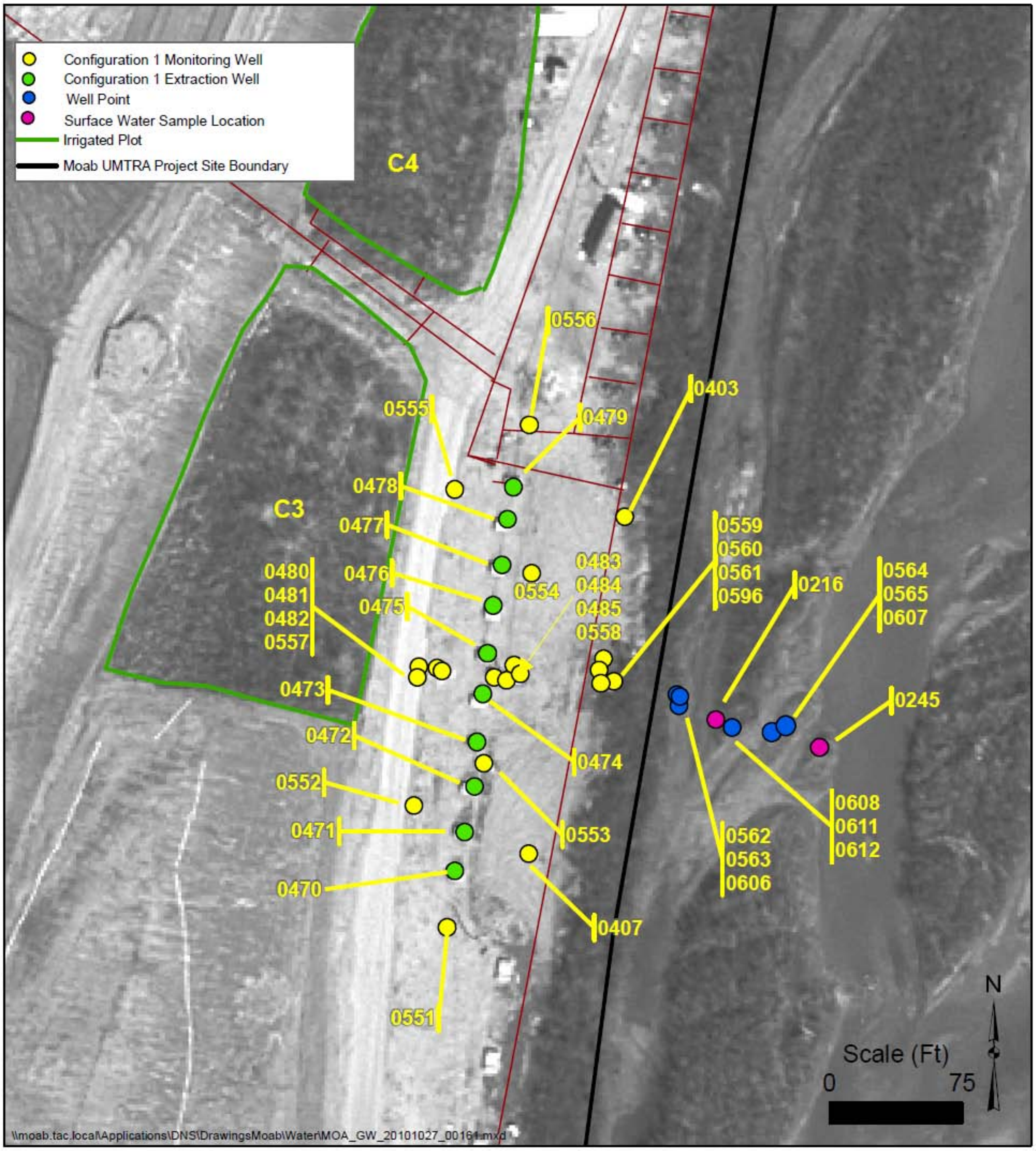


Figure 10. Location of Wells in CF1

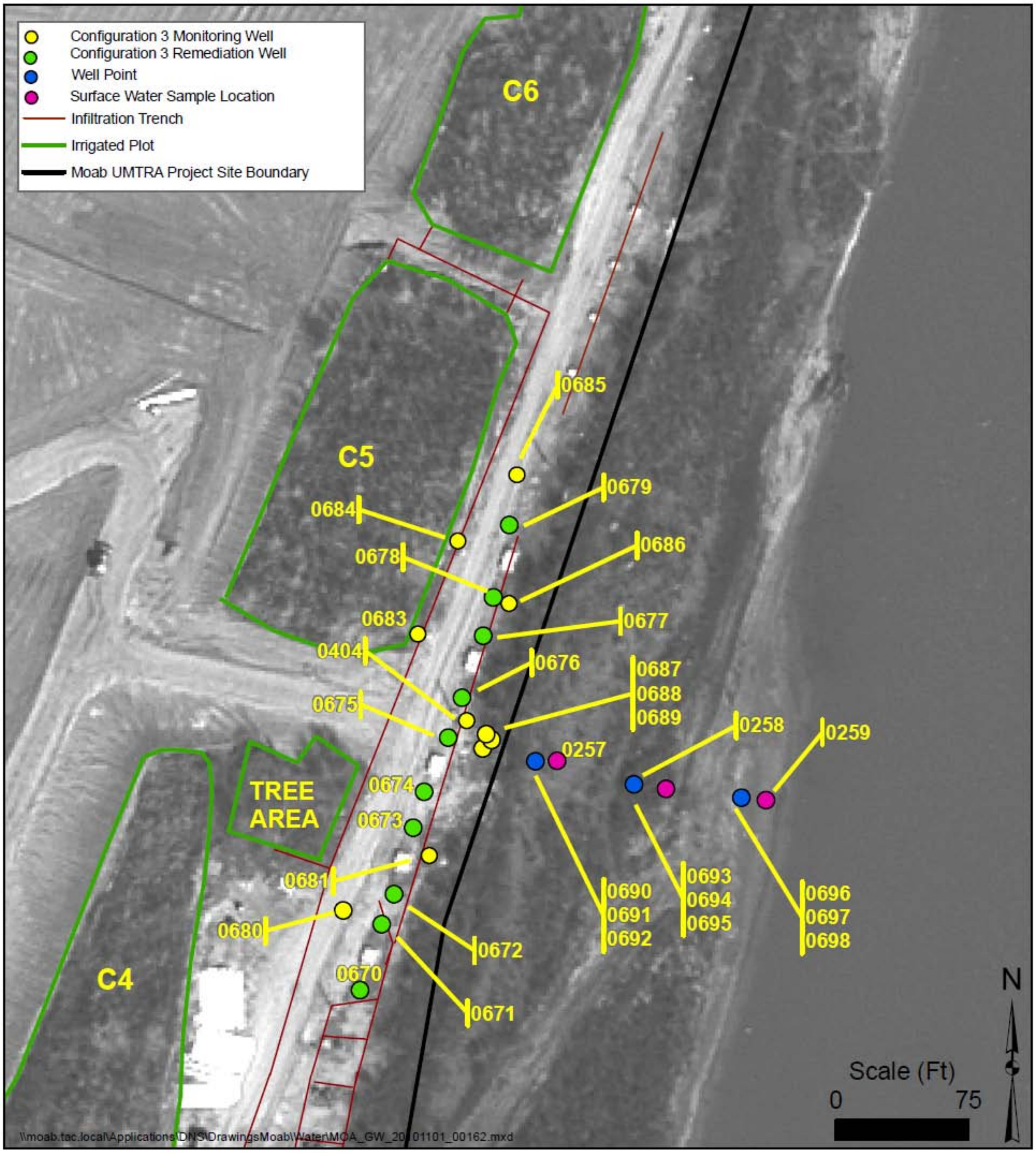


Figure 11. Location of Wells in CF3

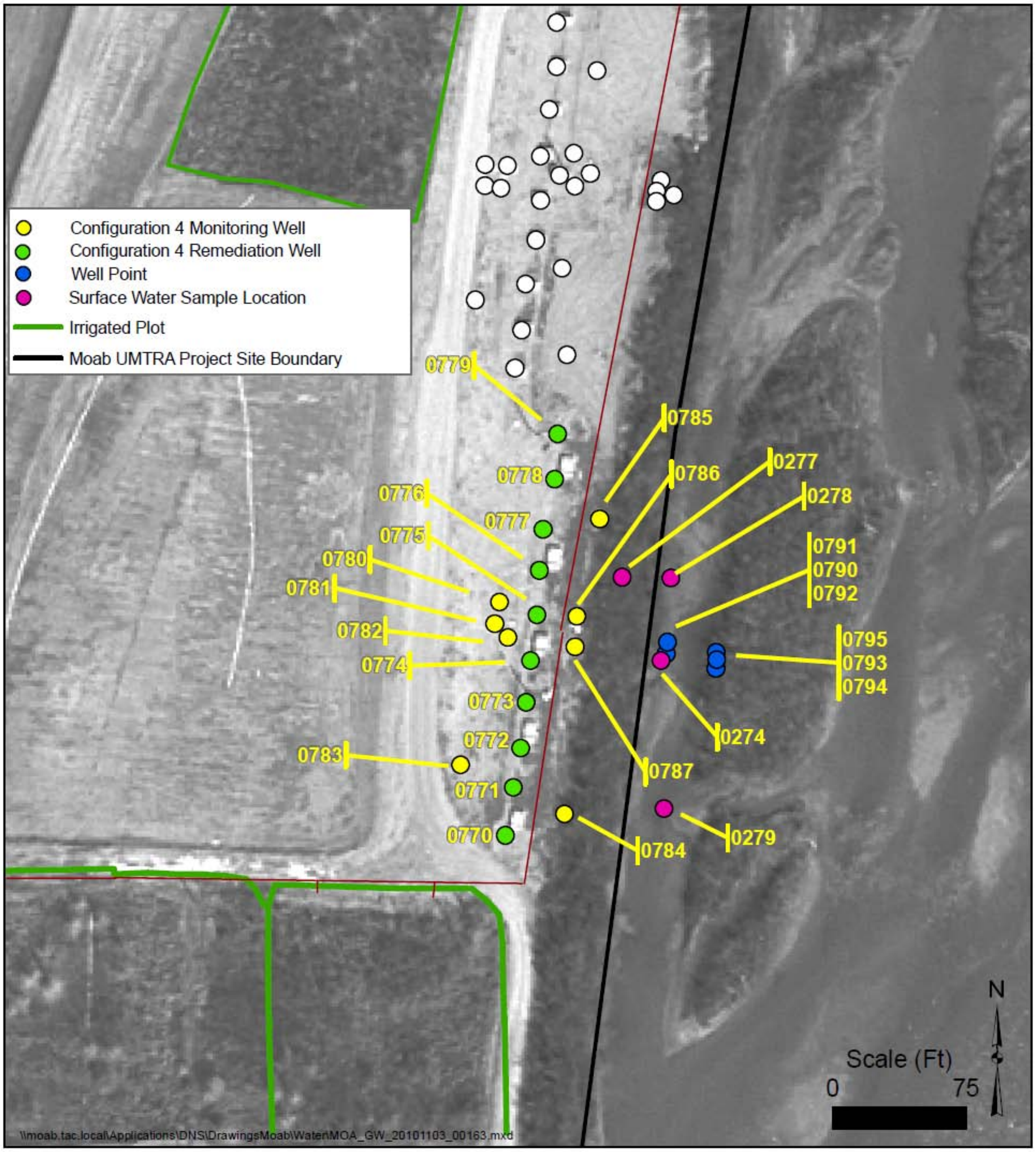


Figure 12. Location of Wells in CF4

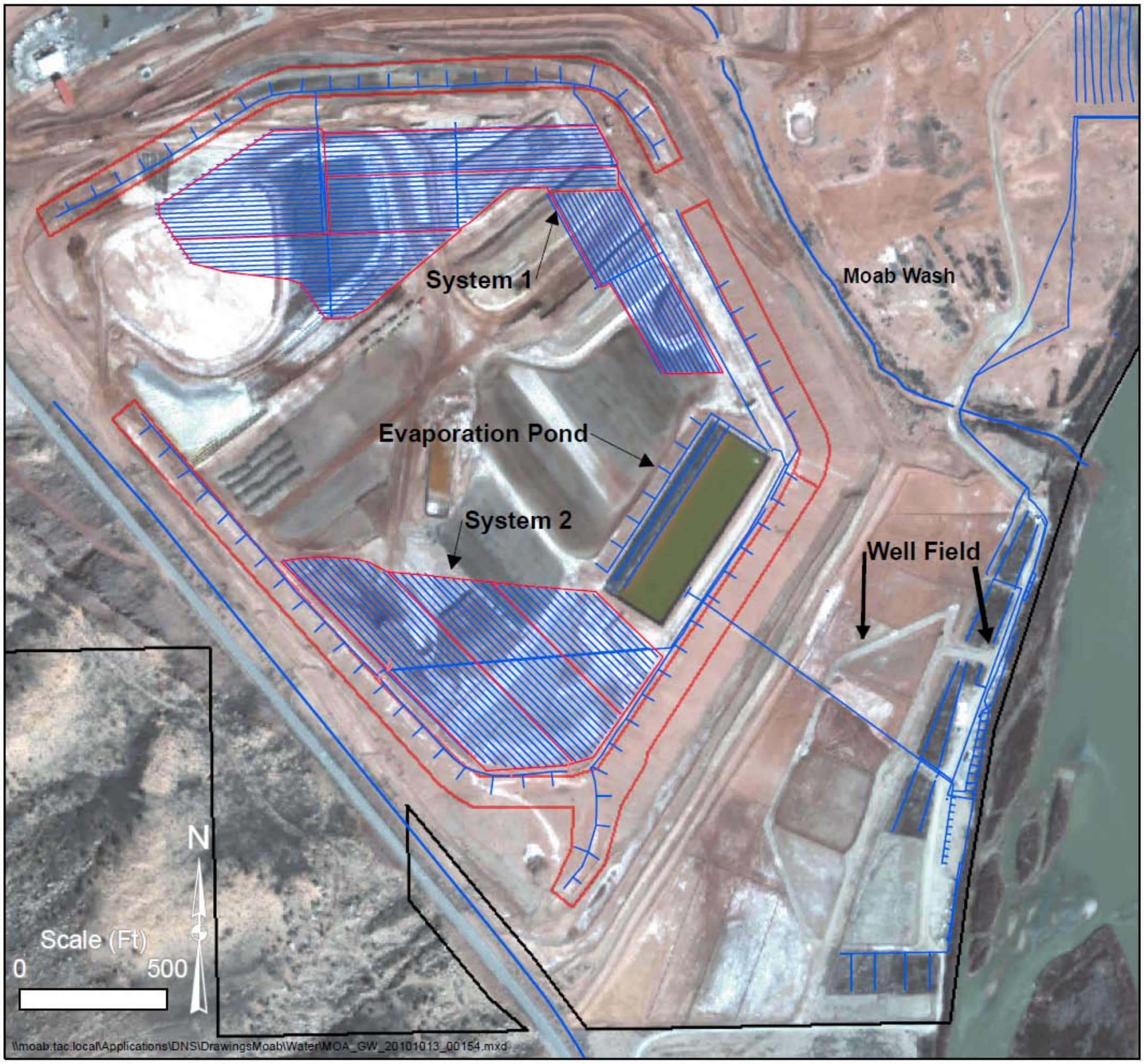


Figure 13. Treatment System Components

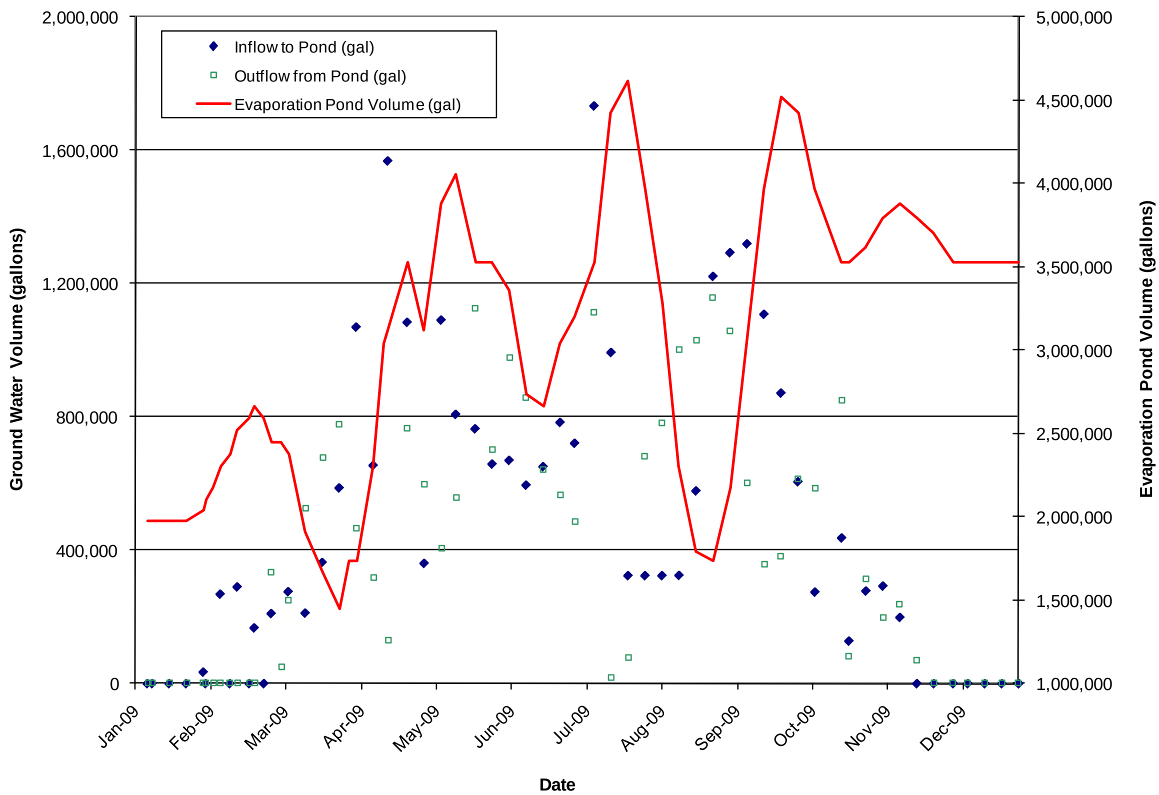


Figure 14. Rates of Water Delivery to the Evaporation Pond and the Sprinkler System and Pond Depths During 2009

4.2 IA Performance

4.2.1 Ground Water Levels and Hydraulic Control

Hydrographs were created by comparing ground water elevations from observation well 0406 located in the Baseline Area and applicable pumping rates for the period of extraction wells from the well field configurations. Baseline Area water elevation data was adjusted so that both wells were assigned the same non-pumping water level. Differences between the two curves are a qualitative estimate of drawdown in response to pumping. The drawdown hydrographs show that it becomes difficult to gauge extraction and observation well drawdowns during the months of high runoff in the river or a long period after startup. The peak flow of the Colorado River in 2009 was 31,200 cfs on May 26, which represents a greater than average peak flow (approximately 23,000 cfs).

Figure 15 is a temporal plot comparing the ground water elevation measured in the Baseline Area to observation well 0406 and the Colorado River flow measured at the U.S. Geological Survey (USGS) Cisco gauging station during 2009. Figure 15 shows that ground water elevation fluctuations are in response to changes in river flow. As typically occurs during the spring runoff, the Colorado River changes from gaining to losing conditions, which results in a freshwater influx to the ground water system. Figure 15 shows how the ground water elevation remained high after the Colorado River peak flow had diminished.

Figure 16 presents an example plot of measured ground water levels at observation well 0480, along with adjusted ground water elevation fluctuations measured in Baseline Area well 0406.

The water level in 0406 was manually adjusted to match the measured water level in 0480 during non-pumping conditions. Also shown in the plot is the CF1 total extraction rate over the same time period. During CF1 pumping, the water level in 0480 decreased up to 1.02 ft (as noted by the blue rectangles in Figure 16). When the well field was shut off in September 2009, the ground water level as well 0480 matched the ground water level at Baseline Area well 0406.

Computed drawdown data is summarized in Table 3, along with drawdown measured during the 2008 pumping season for comparison purposes. The results show that the drawdown data is comparable to those measured in 2008. CF1 well 0480 had a greater drawdown than the 2008 observation. Because CF4 did not run consistently throughout the 2009 pumping season, representative drawdown data was not available.

Table 3. Computed Drawdowns at Selected Observation Wells During 2009

Well Field Configuration	Well	Distance from Well Field Axis (ft)	2009 Drawdown (ft)	2008 Drawdown (ft)
1	0480	23	1.02	0.5
	0552	30	0.73	0.4
3	0682	26	0.65	0.6
	0688	20	1.09	1.8

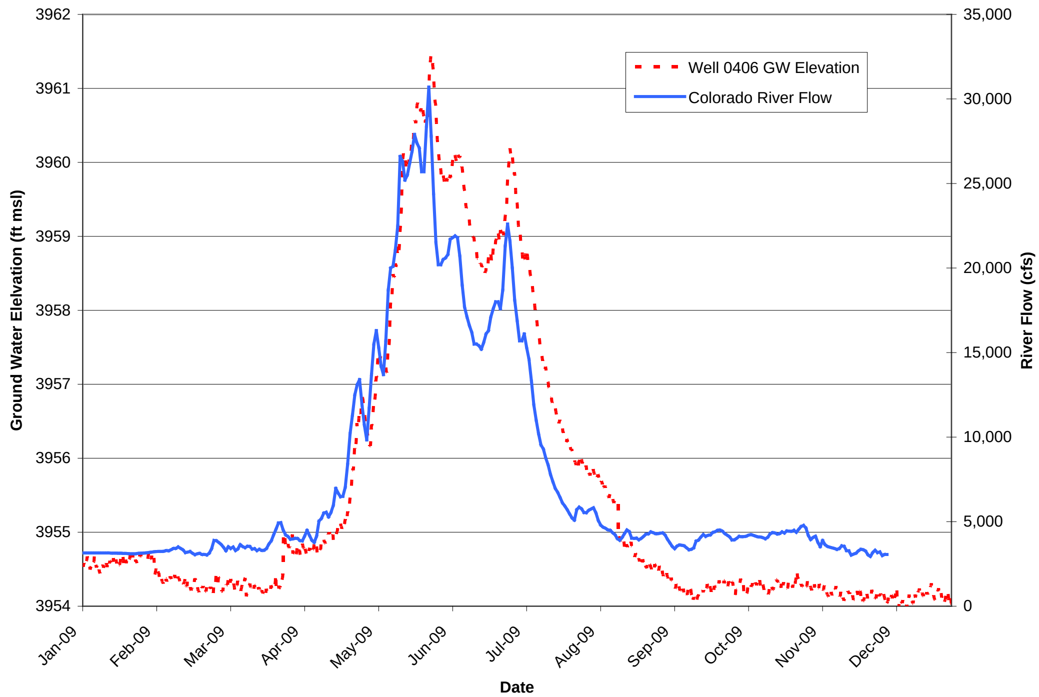


Figure 15. Hydrograph of Baseline Area Well 0406 Ground Water Elevation and Colorado River Flow in 2009

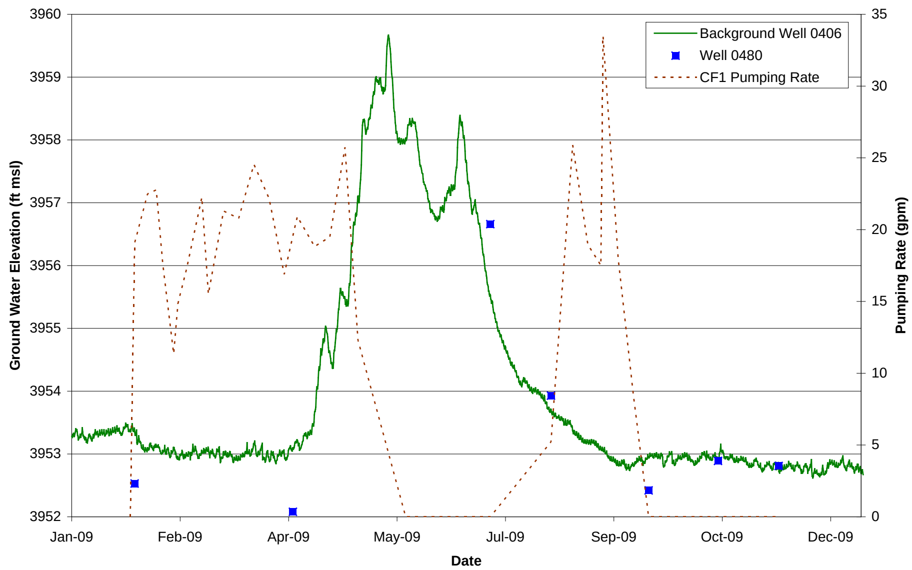


Figure 16. Ground Water Elevations at Observation Well 0480 and Baseline Area Well 0406 During 2009

4.2.2 Remediation Well Specific Capacity

Specific capacity is a measure of a well's performance relative to formation hydraulic characteristics. Figure 17 shows an example plot of discernible drawdowns at extraction well 0470 in 2009 (note that the ground water elevation for well 0406 was adjusted to the ground water elevation of 0470 in October 2009). Figure 17 shows that ground water elevation data collected from extraction well 0470 drops below the background fluctuation elevation data. This difference represents the approximate drawdown inside the remediation well casing due to ground water extraction.

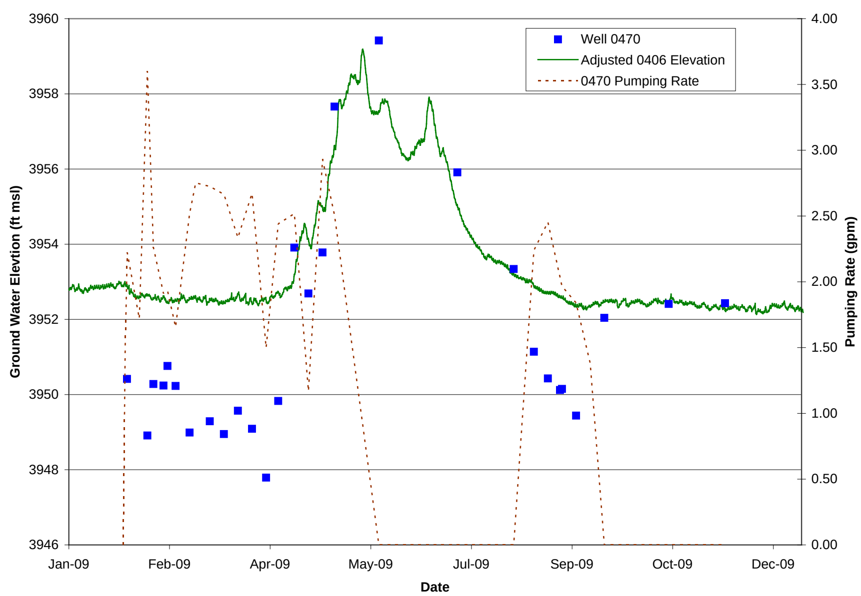


Figure 17. Well 0470 Ground Water Elevations and Pumping Rates Plotted with Background Well 0406 Fluctuation During 2009

Additional hydrographs are presented in Appendices B, C, and D for select CFs 1, 3, and 4 extraction wells, respectively. Well drawdown data were used to compute the specific capacity during the 2009 pumping season. While this is not a rigorous method of calculating specific capacity because it does not account for well interference, it provides a qualitative evaluation of the relative performance of each configuration.

The wells listed in Table 4 were selected based on calculated specific capacity estimates in 2009 and represent wells associated with the lowest and highest specific capacities in each of the three configurations that were used for extraction in 2009. The results also include the range of specific capacities calculated during 2008 for comparison purposes.

Table 4. Computed Specific Capacities at Selected Extraction Wells During 2009

Well Field Configuration	Well	2009 Specific Capacity (gpm/ft)	2008 Specific Capacity Range (gpm/ft)
1	0478	0.65	0.6 to 2.8
	0475	3.74	
3	0675	1.61	2.3 to 6.2
	0679	3.68	
4	0774	1.82	4.5 to 17
	0770	12.09	

4.3 Contaminant Mass Removal

The estimated ammonia and uranium mass removed by CFs 1, 3, and 4 extraction wells in 2009 is presented in Table 5. These estimates are based on the ground water extraction rate and volumes recorded by flow meters located along the well head discharge pump lines. The masses of ammonia and uranium removed from ground water by the extraction wells was estimated by multiplying the monthly extraction volumes by corresponding concentration of ammonia and uranium in each well.

The concentrations used in these calculations were drawn from analytical data presented in Appendices B, C, and D for CFs 1, 3, and 4, respectively. To estimate the contaminant mass removed when analytical data was not available for a specific month, concentrations were from previous and subsequent months were averaged to provide an approximate concentration.

As shown in Table 5, during the 2009 pumping season, a total of approximately 39,610 kilograms (kg) of ammonia and 189.3 kg of uranium were extracted from the ground water.

Table 5. Contaminant Mass Removal in 2009

Well Field Configuration	Total Ammonia Mass Removed (kg)	Total Uranium Mass Removed (kg)
1	18,255	84.5
3	18,289	89.3
4	3,066	15.5
Total	**39,610**	**189.3**

4.3.1 CF1 Contaminant Mass Removal

Table 5 indicates that an estimated total of 18,255 kg of ammonia was extracted from the ground water at CF1 wells during the 2009 pumping season. Tables presented in Appendix B show that the largest mass removal quantities were associated with wells SMI-PW02, 0475, and 0477.

The 2009 ammonia mass removal for CF1 is higher than what was recorded in 2008. One reason is that extraction well SMI-PW02 ran for 8 months with an extraction rate between 0.6 and 32.4 gpm. Besides SMI-PW02, the largest ammonia removal from the CF1 ground water occurred in March 2009, when more than 1,500 kg of ammonia was extracted.

Estimated masses of uranium removed from ground water during 2009 pumping of CF1 were developed using the same techniques applied to ammonia. The monthly estimates of uranium mass removed by CF1 wells are listed in Appendix B. The 10 CF1 wells removed an estimated total of 84.5 kg of uranium from the ground water in 2009. Wells SMI-PW02 and 0475 extracted the most uranium mass at 53.7 and 4.2 kg, respectively. The largest mass was removed in August and September 2009.

4.3.2 CF3 Contaminant Mass Removal

Table 5 indicates that an estimated total of 18,289 kg of ammonia was extracted from the ground water at CF3 wells during the 2009 pumping season. The mass removal is greater than what was observed in the other configurations due to a high extraction rate in CF3 over the summer months.

Extraction wells 0671 (2,181 kg) and 0673 (2,533 kg) extracted the most ammonia mass in CF3 in 2009 and had the highest extraction volumes. The greatest concentration of ammonia was removed from CF3 during June and September 2009.

Estimated mass withdrawals of uranium at CF3 extraction wells are presented in Appendix C, which shows that a total of approximately 89.3 kg of uranium was removed from the ground water between March and September 2009. The greatest concentration of uranium was extracted from wells 0671 (11.5 kg) and 0673 (10.6 kg).

4.3.3 CF4 Contaminant Mass Removal

Table 5 shows that an estimated 3,066 kg of ammonia was extracted from ground water at CF4 wells during the 2009 pumping season. The ammonia mass removal represents the lowest of the three configurations during 2009. The reason for the lower mass removal is because CF4 only ran for 4 months, and not all of the extraction wells were utilized each month.

CF4 wells 0772 (688 kg) and 0778 (456 kg) extracted the most ammonia mass. The greatest concentration of ammonia mass removal occurred in April and October 2009.

Estimated uranium mass withdrawals from CF4 can be found in Appendix D, Table D-4. The results indicate that the greatest uranium mass was extracted from wells 0772 (5.2 kg) and 0778 (1.9 kg). The greatest concentration of uranium was extracted in September and October 2009.

4.4 Ground Water Chemistry

Ground water samples were collected from well field wells from February through November 2009. Sample collection occurred during various river stages and pumping regimes. The following sections describe the ground water and surface water chemistry from the IA well field.

Ground water samples are collected from the IA well field and shipped to ALS Laboratory Group, Inc., in Fort Collins, Colorado. In 2009, most of the ground water samples were analyzed for uranium, ammonia (as N), and TDS. All analyses performed by an off-site laboratory are validated and documented in a data validation package.

4.4.1 CF1

CF1 wells were sampled up to eight different times in 2009. Sampling was conducted during various river stages and pumping regimes. Results are summarized in Appendix B, which presents the contaminant concentration range of the CF1 locations that were sampled more than twice in 2009. The 2009 concentration range for each well was then compared to the historical range.

Some of the CF1 locations display a large range in concentration because the Colorado River flow impacts the contaminants. Four of the CF1 well points had an ammonia concentration above the historical range (0563, 0606, 0611, and 0612). The high concentrations were observed during March and November 2009, when the river was at base-flow. Shallow observation well 0483 had an ammonia concentration (49 mg/L in May 2009) lower than the historical range (51 to 1,500 mg/L).

Three observation wells (0557 at 40 ft bgs, 0559 at 18 ft bgs, and 0560 at 36 ft bgs) had TDS concentrations below the historical range during the months of May and June of 2009. The same four well points that had a high ammonia concentration also had a TDS concentration that was higher than the historical range. River flow has a large impact on the contaminant concentration in the well points.

Observation wells 0559 (18 ft bgs) and 0560 (36 ft bgs) had uranium concentrations below the historical range in June 2009. These two observation wells are located next to the river bank in CF1, and the low concentrations likely represent the introduction of river water into the bank during the spring runoff.

4.4.2 CF3

The CF3 wells were sampled in up to seven sampling events in 2009. Sampling occurred during various river stages and pumping regimes, both of which impact contaminant concentration. Appendix C, Table C-5 summarizes the sampling data of the CF3 wells that were sampled more than twice in 2009. The 2009 concentration range for each well was then compared to the historical range.

Well point 0690 had an ammonia concentration of 10 mg/L in August that was higher than the historical range (0.11 to 1.5 mg/L). The river flow at this time was 4,400 cfs, which is close to base-flow conditions.

Observation well 0688 (39 ft bgs) had TDS concentrations that were both above and below the historical range. Well points 0690 and 0691 also had a TDS concentration that was lower than average in August 2009.

Observation well 0688 (39 ft bgs) had a uranium concentration of 1.9 mg/L in July, which is right below the historical average of 2.0 to 4.1 mg/L. Observation well 0689 (54 ft bgs) had a uranium concentration of 0.25 mg/L, which is below the historical average of 0.41 mg/L. In addition, two well points (0690 and 0691) had uranium concentrations (0.64 and 0.79 mg/L, respectively) that were lower than the historical range in November 2009. Well point 0690 also contained a uranium concentration of 2.9 mg/L in March, which is just slightly above the historical range of 0.79 to 2.8 mg/L.

4.4.3 CF4

The CF4 observation wells were sampled throughout the year during various river flow stages and pumping regimes in 2009. Appendix D, Table D-5 summarizes the sampling data of the CF4 wells that were sampled more than twice in 2009. The 2009 concentration range for each well was then compared to the historical range.

Observation well 0782 contained ammonia concentrations that were both above (1,000 mg/L) and below (63 mg/L) the historical range of 140-750 mg/L. Well point 0790 also had an ammonia concentration (720 mg/L) above the historical high (240 mg/L). Since the brine interface is higher in elevation in the vicinity of CF4, contaminant concentrations frequently fluctuate with the river flow and extraction rate.

Observation wells 0786 and 0787 are located approximately 40 ft from a backwater channel that flows most of the year. When the river flow increases, the backwater channel flow greatly impacts the contaminant concentration in these wells. In May 2009, well 0782 had a TDS concentration 1,800 mg/L, which is far below the historical range of 10,000 to 90,000 mg/L. The low TDS value indicates that a freshwater lens had formed in the river bank during the spring runoff. Well point 0791 had a TDS concentration of 26,000 mg/L, which is above the historical range of 660 to 23,000 mg/L.

Observation well 0787 had a uranium concentration (0.81 mg/L) that was above the historical range of 0.11 to 0.72 mg/L. Well point 0790 also had a uranium concentration of 2.9 mg/L that was above the historical range (0.011 to 1.6 mg/L) in March 2009.

4.5 Evaporation Pond Chemical Trends

Samples from the evaporation pond were collected when the IA well field was actively extracting ground water. Samples were collected from the ground water discharge leading into the evaporation pond and from the recirculation pump that fef the sprinkler system until it was dismantled.

The inlet sample (0547) is representative of the extracted ground water transported to the pond from the entire well field, and the outlet sample is collected off of the water stored in the evaporation pond (0548).

Time versus TDS, ammonia, and uranium concentration plots generated from data collected during 2009 are presented in Figure 18. Each was plotted with the evaporation pond level data collected during the same time frame.

Water chemistry data indicate that the ammonia concentration increased in April and then remained fairly constant for the rest of the year. The pond concentration increased greatly in November 2009. The TDS concentration of the inlet coincides with Colorado River base-flow conditions, which is when the contaminant concentrations in the ground water are higher. Uranium concentrations follow the same trend as TDS, increasing during low river flow and decreasing during high river flow.

5.0 Surface Water Operations and Performance

5.1 Surface Water Operations

The surface water action system (previously referred to as the initial action system) consists of a pump that diverts fresh river water into the backwater channel to dilute ammonia concentrations in habitat areas formed after the peak runoff until late September. On occasion, the surface water action system is used as a preventative measure if a backwater channel is approaching habitat flows during this time frame.

Habitat flows vary from year to year based on erosion and deposition in the backwater channels. The original area of concern was a backwater channel adjacent to the Baseline Area (Figure 8); however, deposition has occurred in the backwater channels and the potential habitat in 2009 was located adjacent to CFs 1 and 4 (Table 6).

Surface water monitoring occurs in the Colorado River at various times throughout the year, depending on the sampling objectives. In 2009, surface water locations were sampled in March, August, September, and November. Each location was sampled for ammonia (as N), TDS, and uranium.

Table 6. Habitat Flow Ranges from 2006 to 2009

Well Field Configuration Opposite of River Critical Habitat	2006 Habitat Flow Range (cfs)	2007 Habitat Flow Range (cfs)	2008 Habitat Flow Range (cfs)	2009 Habitat Flow Range (cfs)
Infiltration Trench	11,500-10,400	NA	NA	NA
1	~4,500	5,000-4,000	NA	4,300-3,700
2	5,400-4,500	6,790-5,500	7,400-6,000	7,800-6,500
3	7,500-4,570*	6,790-5,700*	7,790-7,400*	NA
4	NA	<3,400	NA	<3,500

NA = not applicable; *indicates an approximate range

The objective of surface water monitoring is to observe the channel morphology and evaluate the impact of the site activities on river water quality. Monitoring is in accordance with the *Sampling and Analysis Plan*.

Additional surface water monitoring, referred to as biota monitoring, occurs in the summer after the spring runoff has peaked and as the river flow rate diminishes to base flow (approximately 3,000 cfs). This additional monitoring occurs from July through September, when the endangered young-of-year Colorado pikeminnow may reside in the backwater channels that may form adjacent to the site.

During the summer months, observations on the morphology of the backwater channels and the presence or absence of fish is noted in a log, and surface water samples are collected from locations that may be a potential habitat. The samples are analyzed for ammonia either by ALS Laboratory Group or by the real-time ammonia probe. The EPA has a set standard for acute and chronic criterion for freshwater aquatic habitats, which is dependent on pH and temperature. If a habitat area adjacent to the site contains an ammonia concentration above the acute/chronic criteria, the surface water action system is started.

5.2 Surface Water Quality

5.2.1 Monitoring During Critical Habitat

Surface water monitoring commenced on July 13, 2009 (Appendix F, Photos 1-3) when the river flow was 9,310 cfs at the Cisco gauge station, upriver of the site (Figure 19). One main backwater channel was documented from the backwater area adjacent to the southern end of CF3, south towards CF4. Isolated pockets of water were located adjacent to the Baseline Area and CF3.

On July 16, 2009 (Appendix F, Photos 4-8), the river flow had decreased to 7,810 cfs, and the upriver end of the main backwater channel was barely open to the river. Ammonia samples were collected from six locations, including the confluence of the backwater channel and the river (which is now new sample location 0248), an isolated pocket of water at Baseline and CF3, and the backwater channel adjacent to CF2. All of the ammonia probe samples were under the acute and chronic criteria for fish habitats.

On July 20, 2009 (Appendix F, Photos 9-14), when the river flow was 6,520 cfs, the confluence of the backwater channel and river was closed off. This portion of the channel ended near the area adjacent to CF2, so it was not considered a habitat. Just north of the CF2 well points, the back water channel continued and flowed south towards CF1. Since this portion of the channel was closed off upriver but open downriver, it was considered a habitat. A surface water sample was collected in the habitat area (adjacent to CF2), and the results indicated that the ammonia concentration was 0.39 mg/L, which was below acute and chronic criteria.

A rainstorm in western Colorado increased the river flow to near 7,000 cfs on July 27, 2009. Observations recorded on the morning of July 28 indicate that the main backwater channel flowed all the way through to CF4 (Photos 15-17). The portion of the backwater channel adjacent to CF2 contained isolated pockets of water. The deepest pocket of water was located adjacent to the CF2 well points, where many small fish were observed. The backwater channel flowing through CF1 was very turbid in result of the increased river flow.

Throughout the month of July, the backwater channel continued to flow through to the river adjacent to CFs 1 and 4.

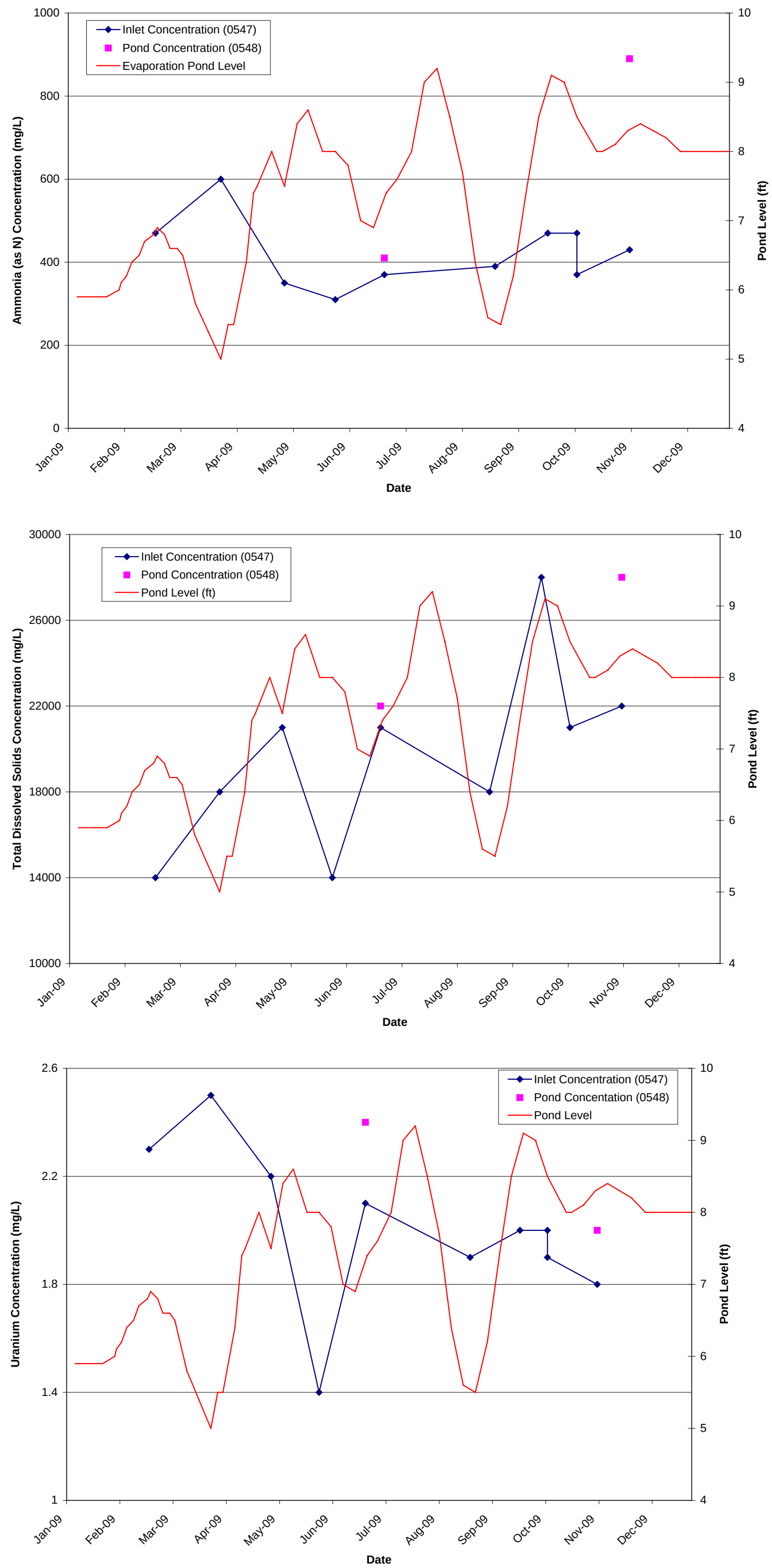


Figure 18. Measured Concentrations of Ammonia, TDS, and Uranium at 0547 (Pond Inlet) and 0548 (Pond Storage) During 2009

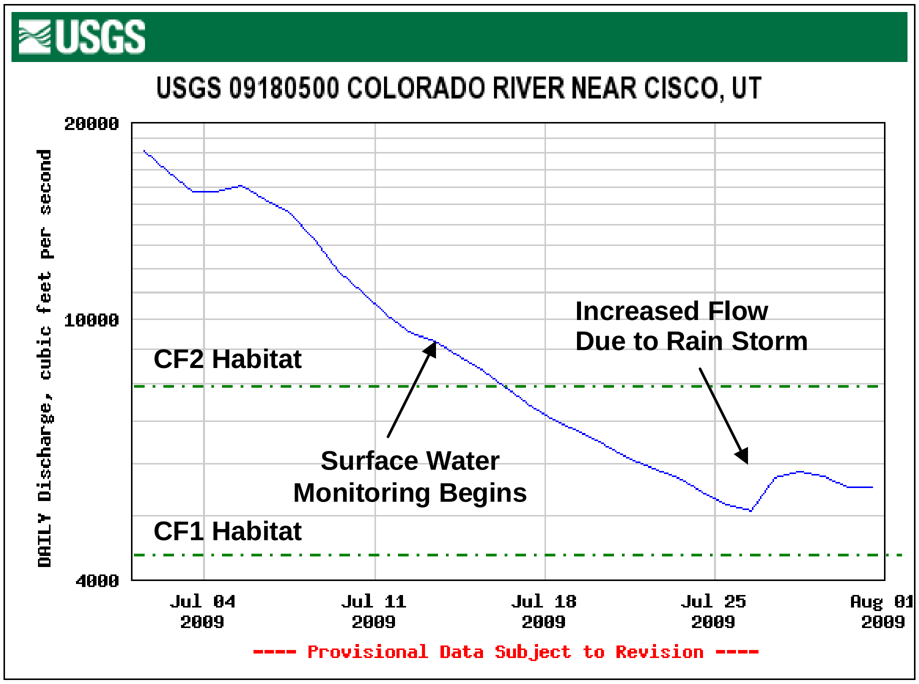


Figure 19. July 2009 Cisco Gauge Hydrograph

On August 3, 2009, the river flow was 5,760 cfs (Figure 20) at the Cisco gauging station. At this time, the backwater channel adjacent to CF3 was dry, and the area adjacent to CF2 consisted of isolated pockets of water. The deepest pocket of water was located next to the CF2 river bank well points. Numerous fish were found swimming in the pocket of water. The backwater channel was flowing through CFs 1 and 4.

As the river flow decreased, the CFs 1 and 4 channels became shallower, and the isolated pockets at CF2 evaporated. Surface water samples were collected during an August sampling event. The ammonia results indicate that CFs 1 and 4 backwater channels were slightly over the chronic ammonia concentration (See Appendix F for concentrations). The Baseline river edge surface water location was also above the chronic ammonia concentration. At this time, CFs 1 and 4 were not considered habitat areas because they were connected to the river both up and downstream.

In early September, the river flow varied from 3,260 to 4,000 cfs (Figure 21 and Appendix F, Photo 18). The backwater channel adjacent to CF1 was dry when the river flow was 3,640 cfs on September 8. At this time, the channel adjacent to CF4 was only 3 inches deep and was close to becoming a habitat.

On Thursday, September 10, 2009, the Colorado River flow was approximately 3,600 cfs (Figure 21), and a large gravel bar was present in the central portion of the CF4 backwater channel. This channel was nearing habitat conditions because it was just slightly open on the upriver side. Real-time ammonia probe readings indicated that the concentration ranged between 7 and 34 mg/L, which is an exceedance of the acute and chronic criteria (Appendix F). The highest concentrations were located directly south of the gravel bar.

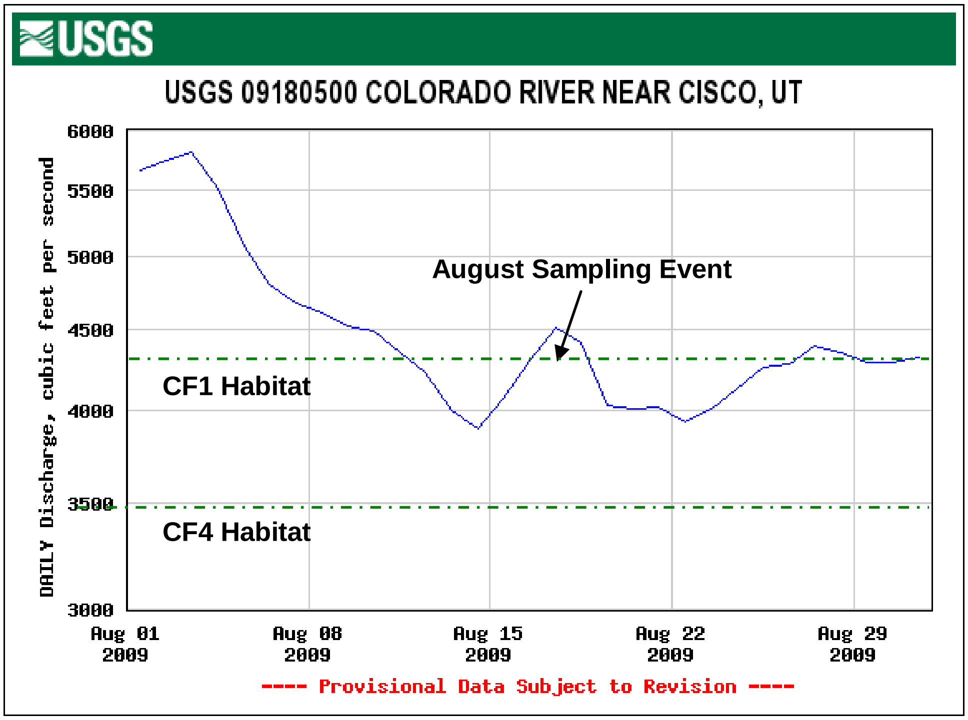


Figure 20. August 2009 Cisco Gauge Hydrograph

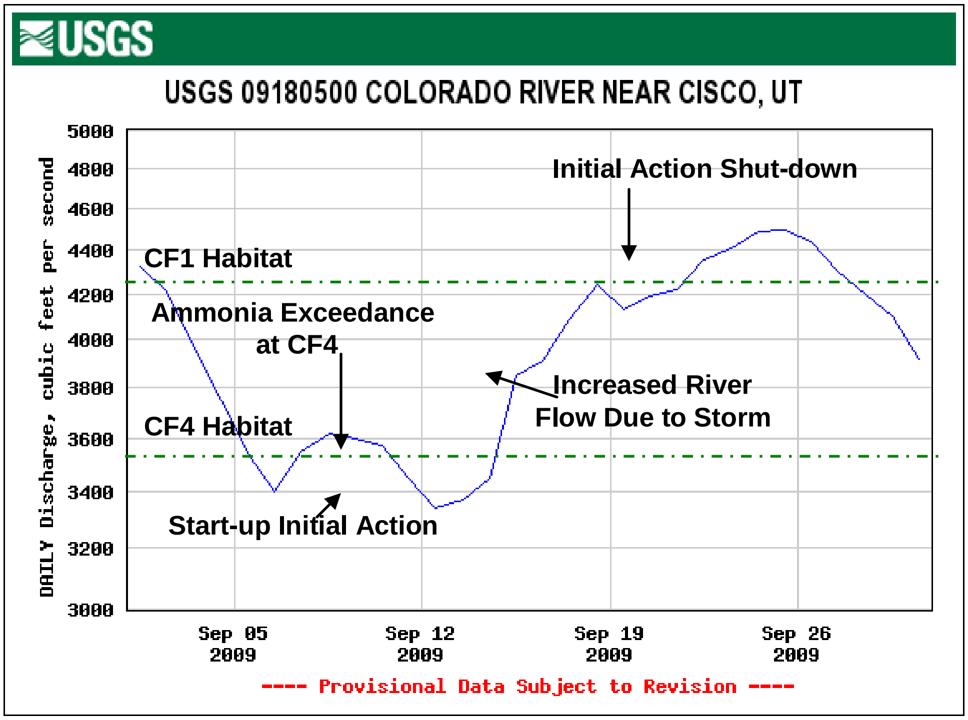


Figure 21. September 2009 Cisco Gauge Hydrograph

On Friday, September 11, project staff began flushing diverted river water (through a hose from the irrigation line) into this backwater channel to dilute the ammonia concentrations as a proactive measure of protect potential habitat.

On Monday, September 14, real-time ammonia probe readings indicated that the ammonia concentration was still elevated (0.98 to 30.6 mg/L) and one dead fish (carp) was observed on the gravel bar, where the highest concentrations were recorded. The diverted river water outlet was moved further upchannel to dilute the concentrations.

In result of a stormy weather pattern, the river flow increased to over 4,000 cfs by September 15, and the ammonia concentrations were below 2 mg/L. As of September 17, the concentrations were still below the acute and chronic criteria, although the staff continued to flush the CF4 channel with diverted river water as a preventative measure.

Diverted river water was introduced to the CF4 backwater channel through a hose from September 11 to September 21, when the ammonia probe indicated that the concentration was below 0.2 mg/L. The river flow had increased to over 4,000 cfs, and the channel adjacent to CF4 was flowing open to the river on both the upriver and downriver ends. At that time, the surface water action was halted.

Backwater channel ammonia concentrations in 2009 were higher than what was observed in 2008. There are a few explanations for the observed increase in ammonia concentration. First of all, the July to September river flow was much less in 2009 than what was observed in 2008. When the river flow is higher, ammonia concentrations are more likely to be diluted. In addition, the use of the real-time ammonia probe allows for more convenient sample collection.

5.2.2 Monitoring Throughout the Year

Surface water locations associated with the well field were sampled intermittently in 2009 when water was present. Table 7 summarizes the ammonia concentration recorded for each surface water location and the corresponding state/federal ambient water quality criteria (AWQC) acute and chronic concentrations for fish in early life stages. The ammonia concentrations listed in the table are results from laboratory data.

Locations 0216 (August and November), 0239 (March), 0243 (August), 0245 (March), 0259 (March), 0274 (August and September), and 0279 (September) exceeded the chronic criteria for ammonia. These samples were collected when the river was at base flow conditions. Locations 0274, 0277, 0278, and 0279 are all located in the backwater channel adjacent to CF4. The results in Table 7 show that the ammonia concentration on any given day can vary greatly over a short distance.

Two of the locations, 0274 in March and 0278 in September, exceeded the acute criteria. In March, location 0274 was not considered a habitat area due to low river flow, and during the September exceedence, the surface water action was used to dilute the ammonia concentrations.

Figure 22. Surface Water Locations

Table 7. Surface Water Sample Ammonia (as N) Results Compared to Acute and Chronic Criteria

Location	Date	Ammonia Total as N (mg/L)	State/Federal AWQC – Acute Total as N (mg/L)	State/Federal AWQC – Chronic Total as N (mg/L)
0216	8/18/09	2.2	5.72	0.973
0216	11/3/09	7.7	10.1	2.8
0239	3/18/09	2.4	6.95	2.10
0239	11/4/09	0.3	4.71	1.52
0243	3/19/09	0.6	5.72	1.79
0243	8/17/09	1.4	5.72	0.973
0243	11/5/09	0.5	4.71	1.52
0245	3/17/09	1.1	2.65	0.646
0245	11/3/09	0.23	5.72	1.79
0259	3/18/09	4.0	8.40	1.17
0259	8/18/09	0.35	5.72	1.11
0259	11/5/09	0.82	4.71	2.23
0274	3/16/09	69	12.1	1.22
0274	8/19/09	1.6	4.71	1.22
0274	9/11/09	2.5	5.72	1.43
0274	9/15/09	0.8	6.95	1.91
0274	11/2/09	2.4	8.40	2.43
0277	9/15/09	0.3	19.9	3.97
0278	9/11/09	56	5.72	1.63
0278	9/16/09	1.5	5.72	1.63
0279	9/11/09	1.5	3.88	1.07
0279	9/15/09	0.43	4.71	1.07

6.0 Conclusions

In 2009, the IA operations followed the *Optimization Plan*, although ground water extraction was limited by the evaporation pond capacity (primarily due to the elimination of the sprinkler system). CF1 extracted ground water from January until May 2009 when the river stage was high, and it was re-started in August and ran until September. CF3 extracted ground water from March until July 2009 and again from August until September. CF4 ran the least in 2009. It ran for a short time in April and then again in September until November when it was shut down for the off-pile soil cleanup. Extraction well SMI-PW02 ran periodically from March until October 2009.

Table 8 presents the ammonia and uranium mass removal rates from 2009 compared to those from previous years. To determine the mass removal rate, the total mass removed from each of the configurations was divided into the total number of extracted gallons for a given year. The ammonia mass removal has remained constant for the past 3 years, but was lower than the mass removal in 2006. The uranium mass removal has also increased since 2007, but is lower than what was observed in 2006.

Table 8. Ammonia and Uranium Mass Removal from 2006 to 2009

Year	Ammonia Mass Removal (kg/gal)	Uranium Mass Removal (kg/gal)
2006	$1.9x10^{-3}$	$9.8x10^{-6}$
2007	$1.5x10^{-3}$	$6.9x10^{-6}$
2008	$1.5x10^{-3}$	$6.8x10^{-6}$
2009	$1.5x10^{-3}$	$7.7x10^{-6}$

Water quality in the well field and surface water was impacted by the above average Colorado River peak flow in late May and early June 2009. The *Optimization Plan* was utilized to maximize mass removal from the well field due to the lack of storage space in the evaporation pond. With the loss of the sprinkler system for tailings drying bed space, an enhanced evaporation unit was added to the ground water system in September 2009.

Surface water monitoring occurred throughout 2009, during the Colorado River base and peak flow conditions. The results indicate that as the river flow decreases, the ammonia concentration in the backwater channels adjacent to the site is likely to increase. After the peak-flow recedes in the late spring and summer months, surface water action is in place to dilute any elevated ammonia concentrations in the potential endangered fish habitat. In 2009, the surface water action system ran from September 11 to 21.

7.0 Future Objectives and Strategies

The future objectives of the Moab UMTRA ground water program is to continue to extract and inject in the IA well field, research possible water treatment, and to investigate various water management strategies.

7.1 Ammonia Bench Scale Test

A small scale ammonia bench test was conducted at Mesa State College in Grand Junction, Colorado, from October to December 2009. The purpose of the test was to observe the affects of temperature and pH on the ammonia in the ground water for possible water treatment options.

Water from observation well 0480 was divided into 24 parts, and each portion was subjected to various temperatures (13, 12, and 28 degrees Centigrade [ºC]), and the sodium hydroxide was titrated into each sample to increase the pH to between 8 and 10.5. Ammonia and nitrate concentrations were recorded on a daily basis for 8 days. The results concluded that with an increased pH, the lower the ammonia concentration was over time. Higher temperatures decreased the ammonia concentrations over a shorter period of time.

A second, similar bench test was conducted with ground water from well 0782, and the results were similar to that of the first test; an increase in pH and temperature decreased the ammonia concentration over time.

The time versus concentration plots and a more detailed summary of the bench test can be found in Attachment G. Information gained in the bench test will be considered if a water treatment plant is added to the IA system.

7.2 Pumping Strategies

Since water storage is currently an issue, the ground water pumping strategy at the Moab UMTRA Project is crucial to the success of the program. In late 2009 through early 2010, seven new extraction wells (referred to as CF5) were added to the IA well field. These wells are located between the tailings pile and the original IA well field and vary in depth from 38.6 to 51.7 ft bgs. Each well has a dedicated submersible pump that was set at a depth that corresponds to the highest contaminant level.

The CF5 wells will run on extraction mode throughout the year when possible to extract contaminants closer to the source (the tailings pile). This portion of the well field is not greatly impacted by the freshwater lens that forms along the river bank during spring runoff, so the wells will still be capable of contaminant extraction during the spring months.

In conjunction with the CF5 extraction, freshwater injection will occur from June to October in configurations that are adjacent to backwater channels. By starting injection in June, the injected water will add to the freshwater lens and help to further dilute the contaminants. Injection will also help to form a hydrologic barrier between the tailings pile and the river.

8.0 References

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

DOE (U.S. Department of Energy) *Moab UMTRA Project Well Field Optimization Plan* (DOE-EM/GJTAC1791), April 2009.

Appendix A.
Well Construction Data

Table A-1. Summary of Baseline Area Well and Well Point Construction

Well	Well Type/Relative Depth	Diameter (inches)	Ground Surface Elevation (ft above msl)	Screen Interval (ft bgs)	Total Depth (ft bgs)
0405	Observation/Shallow	1	3,966.40	15.1 - 20.0	20.3
0406	Observation/Shallow	1	3,967.90	13.1 – 18.0	18.3
0488	Observation/Intermediate	6	3,966.82	25.0 - 40.0	40.3
0493	Observation/Deep	6	3,966.08	45.0 - 55.0	55.3
SMI-PW01	Observation/Deep	4	3,966.40	20.1 – 60.1	60.2
SMI-PZ1S	Observation/Shallow	2	3,966.70	13.9 – 18.9	19.1
SMI-PZ1M	Observation/Intermediate	2	3,966.30	55.5 – 60.5	60.8
SMI-PZ1D2	Observation/Deep	2	3,966.40	69.8 – 74.8	75.0
0494	Well Point/Shallow	1	3,957.41	2.4 – 3.4	3.4
0495	Well Point/Intermediate	1	3,957.41	4.6 – 5.6	5.6
0597	Well Point/Deep	1	3,957.41	9.3 – 10.3	10.3
0496	Well Point/Shallow	1	3,955.62	2.2 – 3.2	3.2
0497	Well Point/Intermediate	1	3,955.62	4.0 – 4.9	4.9
0598	Well Point/Deep	1	3,955.62	9.1 – 10.1	10.1
0617	Well Point/Shallow	1	3,954.24	1.7 – 2.7	2.7
0618	Well Point/Intermediate	1	3,954.24	5.3 – 6.3	6.3
0599	Well Point/Deep	1	3,954.24	9.4 – 10.4	10.4

Table A-2 Summary of Well and Well Point Construction in CF1

Well	Well Type/Relative Depth	Diameter (inches)	Ground Surface Elevation (ft above msl)	Screen Interval (ft bgs)	Total Depth (ft bgs)
0470	Extraction	4	3,966.56	10.3–19.7	21.3
0471	Extraction	4	3,966.59	10.3–19.7	21.3
0472	Extraction	4	3,966.62	10.3–19.7	21.3
0473	Extraction	4	3,966.67	10.3–19.7	21.3
0474	Extraction	4	3,967.02	10.3–19.7	21.3
0475	Extraction	4	3,967.13	10.3–19.7	21.3
0476	Extraction	4	3,967.38	10.3–19.7	21.3
0477	Extraction	4	3,967.30	10.3–19.7	21.3
0478	Extraction	4	3,966.82	9.6–23.9	25.5
0479	Extraction	4	3,966.60	9.3–23.6	25.2
SMI-PW02	Extraction	4	3,965.60	20–60	60.3
0403	Observation/Shallow	1	3,966.90	13.3–18.2	18.4
0407	Observation/Shallow	1	3,967.20	13.3–18.3	18.5
0480	Observation/Shallow	4	3,966.94	15.5–19.8	20.3
0481	Observation/Intermediate	4	3,967.01	25.4–29.7	31.3
0482	Observation/Deep	4	3,967.03	55.4–59.7	61.3
0483	Observation/Shallow	4	3,967.00	15.5–19.8	20.3
0484	Observation/Intermediate	4	3,967.19	25.5–29.8	30.3
0485	Observation/Deep	4	3,966.99	55.6–59.9	60.4
0551	Observation/Shallow	1	3,966.65	10.3–20.3	20.6
0552	Observation/Shallow	1	3,966.33	10.2–20.2	20.4
0553	Observation/Shallow	1	3,966.87	10.6–20.5	20.8
0554	Observation/Shallow	1	3,967.63	10.4–20.4	20.6

Table A-2 Summary of Well and Well Point Construction in CF1 (continued)

Well	Well Type/Relative Depth	Diameter (inches)	Ground Surface Elevation (ft above msl)	Screen Interval (ft bgs)	Total Depth (ft bgs)
0555	Observation/Shallow	1	3,967.32	10.2–20.1	20.4
0556	Observation/Shallow	1	3,966.69	10.2–20.1	20.4
0557	Observation/Intermediate	6	3,967.01	35.0–45.0	45.9
0558	Observation/Intermediate	6	3,966.85	35.0–45.0	45.1
0559	Observation/Shallow	1	3,967.84	10.5–20.5	20.7
0560	Observation/Intermediate	6	3,966.95	30.0–40.0	40.4
0561	Observation/Deep	6	3,966.46	45.2–55.2	55.3
0596	Observation/Shallow	1	3,966.91	15.3–25.3	25.5
0562	Well point/Shallow	1	3,953.82	1.3−2.3	2.3
0563	Well point/Intermediate	1	3,953.82	4.6−5.6	5.6
0606	Well point/Deep	1	3,953.79	9.3−10.3	10.3
0611	Well point/Shallow	1	3,954.57	2.2−3.2	3.2
0612	Well point/Intermediate	1	3,954.57	4.3−5.3	5.3
0608	Well point/Deep	1	3,954.57	8.9−9.9	9.9
0564	Well point/Shallow	1	3,953.50	1.2−2.2	2.2
0565	Well point/Intermediate	1	3,953.50	4.0−5.0	5.0
0607	Well point/Deep	1	3,952.99	9.6−10.6	10.6

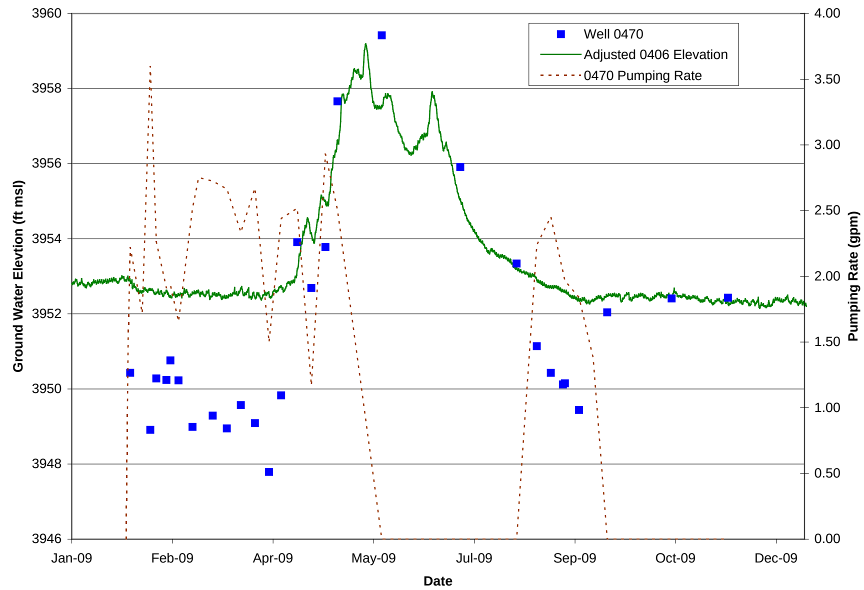
Table A-3. Summary of Well and Well Point Construction in CF3

Well	Well Type/Relative Depth	Diameter (inches)	Ground Surface Elevation (ft above msl)	Screen Interval (ft bgs)	Total Depth (ft bgs)
0670	Remediation/Deep	6	3,967.05	15.9–45.9	46.3
0671	Remediation/Deep	6	3,967.31	14.4–44.4	44.8
0672	Remediation/Deep	6	3,967.27	15.0–45.0	45.4
0673	Remediation/Deep	6	3,967.19	16.3–46.3	46.7
0674	Remediation/Deep	6	3,967.11	15.1–45.1	45.5
0675	Remediation/Deep	6	3,966.99	16.0–46.0	46.4
0676	Remediation/Deep	6	3,967.27	15.9–45.9	46.3
0677	Remediation/Deep	6	3,967.17	15.2–45.2	45.6
0678	Remediation/Deep	6	3,967.11	16.3–46.3	46.6
0679	Remediation/Deep	6	3,967.03	15.0–45.0	45.4
0404	Observation/Shallow	1	3,967.70	13.0–17.9	18.9
0680	Observation/Shallow	1	3,967.75	9.9–19.8	20.0
0681	Observation/Shallow	1	3,967.65	10.2–20.2	20.4
0682	Observation/Shallow	1	3,968.25	19.6–29.5	29.7
0683	Observation/Shallow	1	3,968.76	21.2–31.2	31.4
0684	Observation/Shallow	1	3,968.48	11.3–21.3	21.5
0685	Observation/Shallow	1	3,967.11	20.0–30.0	30.2
0686	Observation/Shallow	1	3,967.08	10.0–20.0	20.2
0687	Observation/Shallow	1	3,966.74	20.0–30.0	30.2
0688	Observation/Intermediate	6	3,966.57	30.6–40.6	41.0
0689	Observation/Deep	6	3,966.62	46.0–56.0	56.4
0690	Well point/Shallow	1	3,957.15	3.3–4.3	4.3
0691	Well point/Intermediate	1	3,957.15	6.5–7.5	7.5
0692	Well point/Deep	1	3,957.15	9.7–10.1	10.1
0693	Well point/Shallow	1	3,955.36	2.0–3.0	3.0
0694	Well point/Intermediate	1	3,955.36	4.3–5.3	5.3
0695	Well point/Deep	1	3,955.36	9.3–10.3	10.3
0696	Well point/Shallow	1	3,954.50	1.3–2.3	2.3
0697	Well point/Intermediate	1	3,954.50	4.3–5.3	5.3
0698	Well point/Deep	1	3,954.50	9.9–10.3	10.3

Table A-4. Summary of Well and Well Point Construction in CF4

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

Appendix B.
CF1 Additional Information



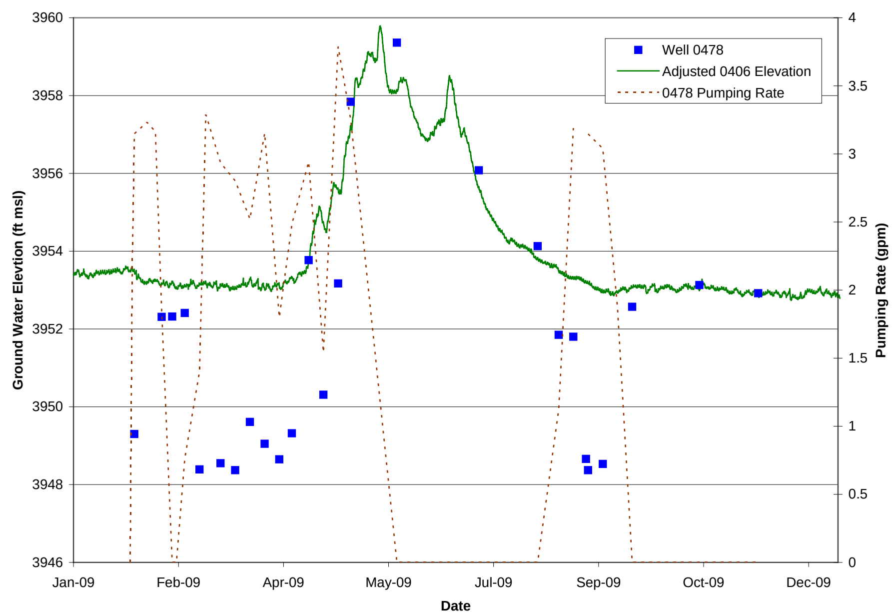


Figure B-1. Ground Water Elevations at CF1 Extraction Wells 0472 and 0478 and Baseline Area Well 0406 During 2009

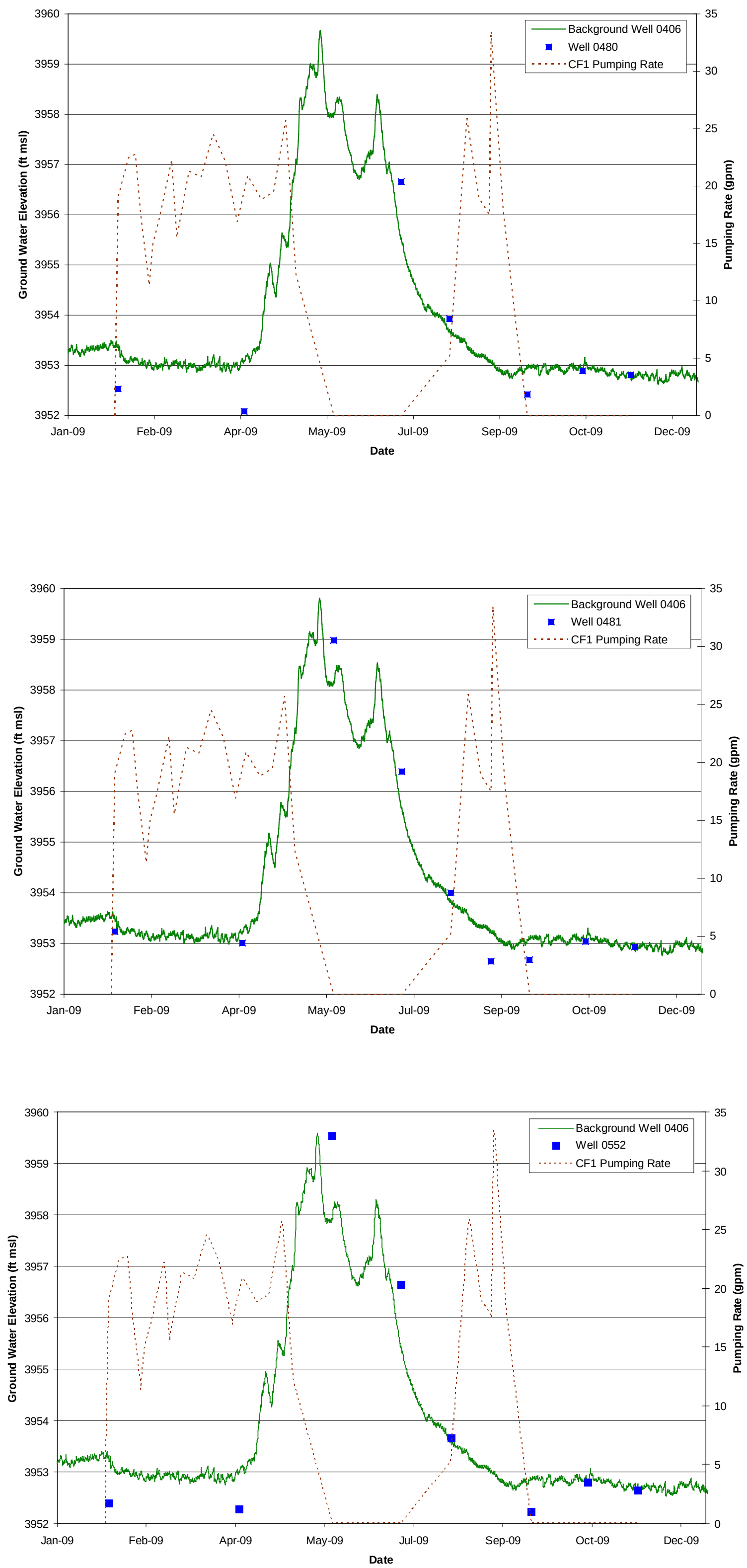


Figure B-2. Ground Water Elevations at CF1 Observation Wells 0480, 0481, and 0552 and Baseline Area Well 0406 During 2009

Table B-1. Chronology of CF1 Activities in 2009

Date	River Flow (daily mean cfs)	Activity	Samples Collected
Dec 18, 2008 to Jan 28, 2009	3,070 to 3,430	CF1 shut down due to cold air temperatures	N/A
Jan 28, 2009	3,160	CF1 restarted	N/A
Feb 9, 2009	3,420	Shut down half of CF1 well to decrease flow to pond	N/A
Feb 17-19, 2009	2,800 to 2,870	Monthly sampling	Five extraction wells (0471, 0473, 0475, 0476, 0477), seven observation wells (0403, 0407, 0480, 0483, 0559, 0560)
Feb 26, 2009	3,870	All CF1 wells operating	N/A
March 16-26, 2009	3,250 to 4,870	Monthly sampling	Six extraction wells (0470, 0473, 0474, 0475, 0479, PW02), Seven observation wells (0403, 0407, 0480, 0483, 0557, 0559, 0560), nine well points (0562,0563, 0564, 0565, 0606, 0607, 0608, 0611, 0612), one surface location (0245)
April 28-30, 2009	9,590 to 11,600	Monthly sampling	Six extraction wells (0471, 0473, 0475, 0477, 0479, PW02)
May 12, 2009	21,100	All wells shut down due to high river flow	N/A
May 26-28, 2009	24,500 to 31,000	Monthly sampling	Seven observation wells (0403, 0407, 0480, 0483, 0557, 0559, 0560)
June 22-25, 2009	17,000 to 17,400	Monthly sampling	One extraction well (PW02), seven observation wells (0403, 0407, 0480, 0483, 0557, 0559, 0560)
July 15-21, 2009	6,230 to 8,400	Monthly sampling	One extraction well (PW02), seven observation wells (0403, 0407, 0480, 0483, 0557, 0559, 0560)
Aug 17, 2009	4,510	Restarted CF1 to protect habitat	N/A
Aug 17-24, 2009	3,930 to 4,490	Monthly sampling	Six extraction wells (0470, 0472, 0474, 0476, 0478, PW02), eight well points (0562, 0563, 0564, 0565, 0606, 0608, 0611, 0612), one surface water location (0216)
Sept 11-24, 2009	3,490 to 4,540	Monthly sampling	Five extraction wells (0471, 0473, 0475, 0477, 0479), seven observation wells (0403, 0407, 0480, 0483, 0557, 0559, 0560)
Sept 11, 2009	3,450	All wells shut down due to high river flow	N/A
Oct 6-8, 2009	4,150 to 4,680	Monthly sampling	Seven observation wells (0403, 0407, 0480, 0483, 0557, 0559, 0560)
Nov 2-6, 2009	3,540 to 4,160	Monthly sampling	Nine well points (0562, 0563, 0564, 0565, 0606, 0607, 0608, 0611, 0612), two surface water locations (0216, 0245)

Table B-2. Monthly Average Pumping Rates and Extraction Volumes at CF1 Remediation Wells, January through December 2009

Month	Well 0470		Well 0471		Well 0472		Well 0473		Well 0474	
	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)
Jan 2009	6,699	1.86	7,083	1.98	5,405	1.57	3,793	1.07	1,237	0.34
Feb 2009	74,515	2.18	32,438	3.00	43,704	2.35	90,242	2.29	77,090	2.48
Mar 2009	114,647	2.59	7,858	2.62	18,307	1.84	153,295	3.45	133,072	2.99
Apr 2009	103,626	2.06	91,524	2.32	0	0	132,358	2.62	143,674	2.86
May 2009	51,502	2.72	76,276	4.02	0	0	62,893	3.32	39,261	3.76
June 2009	0	0	0	0	0	0	0	0	0	0
July 2009	0	0	0	0	0	0	0	0	0	0
Aug 2009	56,867	2.34	60,612	2.76	98,437	8.11	48,171	2.19	50,963	2.31
Sept 2009	52,306	1.73	89,686	2.98	129,733	4.30	89,910	2.97	87,608	2.90
Oct 2009	0	0	0	0	0	0	0	0	0	0
Nov 2009	0	0	0	0	0	0	0	0	0	0
Dec 2009	0	0	0	0	0	0	0	0	0	0
Annual Avg/Total	**460,162**	**2.21**	**365,477**	**2.52**	**295,586**	**3.63**	**580,662**	**2.55**	**532,905**	**2.11**

Q = pumping rate; Vol = volume

Table B-2. Monthly Average Pumping Rates and Extraction Volumes at CF1 Remediation Wells, January through December 2009 (continued)

Month	Well 0475		Well 0476		Well 0477		Well 0478		Well 0479	
	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)
Jan 2009	0	0	7,929	2.18	4,030	1.13	9,625	2.69	2,648	N/A
Feb 2009	82,253	2.47	49,777	1.64	77,364	2.26	57,936	2.24	39,317	2.22
Mar 2009	135,181	2.70	2,492	0.25	109,063	2.18	111,185	2.59	103,450	2.43
Apr 2009	145,106	2.89	0	0	128,373	2.56	120,587	2.38	113,124	2.24
May 2009	71,600	3.78	0	0	46,107	4.42	66,576	3.52	67,368	3.57
June 2009	0	0	0	0	0	0	0	0	0	0
July 2009	0	0	0	0	0	0	0	0	0	0
Aug 2009	64,479	2.92	31,120	1.40	85,862	3.52	47,765	2.15	21,156	0.87
Sept 2009	82,354	2.74	21	N/A	80,876	2.73	81,090	2.68	82,779	2.74
Oct 2009	0	0	0	0	0	0	0	0	0	0
Nov 2009	0	0	0	0	0	0	0	0	0	0
Dec 2009	0	0	0	0	0	0	0	0	0	0
Annual Avg/Total	**580,973**	**2.91**	**91,339**	**1.36**	**531,675**	**2.68**	**494,764**	**2.60**	**429,842**	**2.34**

Q = pumping rate; Vol = volume

Month	SMI-PW02	
	Vol (gal)	Q (gpm)
Mar 2009	352,000	13.43
Apr 2009	479,855	12.45
May 2009	314,031	10.22
June 2009	101,627	6.10
July 2009	1,327,838	25.35
Aug 2009	1,133,032	28.92
Sept 2009	1,448,367	28.78

Q = pumping rate; Vol = volume

Table B-3. Estimated Ammonia Mass Withdrawals at CF1 Extraction Wells During 2009

Month	Well 0470		Well 0471		Well 0472		Well 0473		Well 0474	
	NH_3-N Conc (mg/L)	Mass Removed (kg)	NH_3-N Conc (mg/L)	Mass Removed (kg)	NH_3-N Conc (mg/L)	Mass Removed (kg)	NH_3-N Conc (mg/L)	Mass Removed (kg)	NH_3-N Conc (mg/L)	Mass Removed (kg)
Jan 2009	520	13.2	372	10.0	372	7.6	372	5.3	372	2.0
Feb 2009	520	146.5	372	45.6	372	61.5	450	153.5	425	154.4
Mar 2009	680	294.7	555	16.5	540	37.4	510	295.5	530	161.0
Apr 2009	400	156.7	400	138.4	N/A	N/A	320	160.1	320	173.8
May 2009	400	77.9	400	115.3	N/A	N/A	320	76.1	320	47.5
Aug 2009	720	154.8	520	119.1	320	119.1	620	112.9	930	179.2
Sept 2009	172	34.0	310	105.1	230	112.8	140	47.6	140	46.4
Total		**878**		**550**		**338**		**851**		**764**

NH_3-N = ammonia

Month	Well 0475		Well 0476		Well 0477		Well 0478		Well 0479	
	NH_3-N Conc (mg/L)	Mass Removed (kg)	NH_3-N Conc (mg/L)	Mass Removed (kg)	NH_3-N Conc (mg/L)	Mass Removed (kg)	NH_3-N Conc (mg/L)	Mass Removed (kg)	NH_3-N Conc (mg/L)	Mass Removed (kg)
Jan 2009	N/A	N/A	372	11.1	372	5.7	372	13.5	372	3.7
Feb 2009	400	124.4	260	48.9	230	67.3	245	53.7	245	36.4
Mar 2009	450	229.9	430	4.1	410	169.0	410	172.3	410	160.3
Apr 2009	320	175.5	N/A	N/A	240	116.5	245	111.7	250	106.9
May 2009	320	86.6	N/A	N/A	240	41.8	245	61.7	250	63.7
Aug 2009	540	131.6	150	17.6	165	53.6	180	32.5	180	14.4
Sept 2009	140	43.6	115	0.0	90	27.5	136	41.7	180	56.3
Total		**792**		**82**		**481**		**487**		**442**

NH_3-N = ammonia

Table B-3. Estimated Ammonia Mass Withdrawal at CF1 Extraction Wells During 2009 (continued)

Month	SMI-PW02	
	NH_3-N Conc (mg/L)	Mass Removed (kg)
Mar 2009	780	958.2
Apr 2009	530	961.3
May 2009	570	676.6
June 2009	610	234.3
July 2009	750	3764.4
Aug 2009	620	2655.4
Sept 2009	610	2912.3
Oct 2009	610	427.3
Total		**12,590**

NH_3-N = ammonia

Table B-4. Estimated Uranium Mass Withdrawals at CF1 Extraction Wells During 2008

Month	Well 0470		Well 0471		Well 0472		Well 0473		Well 0474	
	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)
Jan 2009	2.5	0.1	2.5	0.1	2.5	0.1	2.5	0.0	2.5	0.0
Feb 2009	2.5	0.7	2.5	0.3	2.4	0.4	2.3	0.8	2.3	0.7
Mar 2009	2.5	1.1	2.5	0.1	2.4	0.2	2.3	1.3	2.3	1.2
Apr 2009	2.0	0.8	2	0.7	N/A	N/A	1.7	0.9	2	1.1
May 2009	2.0	0.4	2	0.6	N/A	N/A	N/A	N/A	N/A	N/A
Aug 2009	1.9	0.4	1.6	0.4	1.3	0.5	1	0.2	0.85	0.2
Sept 2009	1.9	0.4	1.3	0.4	1.05	0.5	0.8	0.3	0.82	0.3
Total		**3.8**		**2.5**		**1.6**		**3.5**		**3.4**

U = uranium

Month	Well 0475		Well 0476		Well 0477		Well 0478		Well 0479	
	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)
Jan 2009	N/A	N/A	2.5	0.1	2.5	0.0	2.5	0.1	2.5	0.0
Feb 2009	2.4	0.7	2.1	0.4	2.3	0.7	2.4	0.5	2.3	0.3
Mar 2009	2.3	1.2	2.3	0.0	2.2	0.9	2.2	0.9	2.6	1.0
Apr 2009	2.3	1.3	N/A	N/A	2.2	1.1	2.5	1.1	2.9	1.2
May 2009	2	0.5	N/A	N/A	2.2	0.4	2.5	0.6	2.9	0.7
Aug 2009	0.96	0.2	1.1	0.1	1.3	0.4	1.5	0.3	1.2	0.1
Sept 2009	0.83	0.3	N/A	N/A	0.83	0.3	0.83	0.3	0.83	0.3
Total		**4.2**		**0.6**		**3.7**		**3.8**		**3.7**

U = uranium

Table B-4. Estimated Uranium Mass Withdrawals at CF1 Extraction Wells During 2008 (continued)

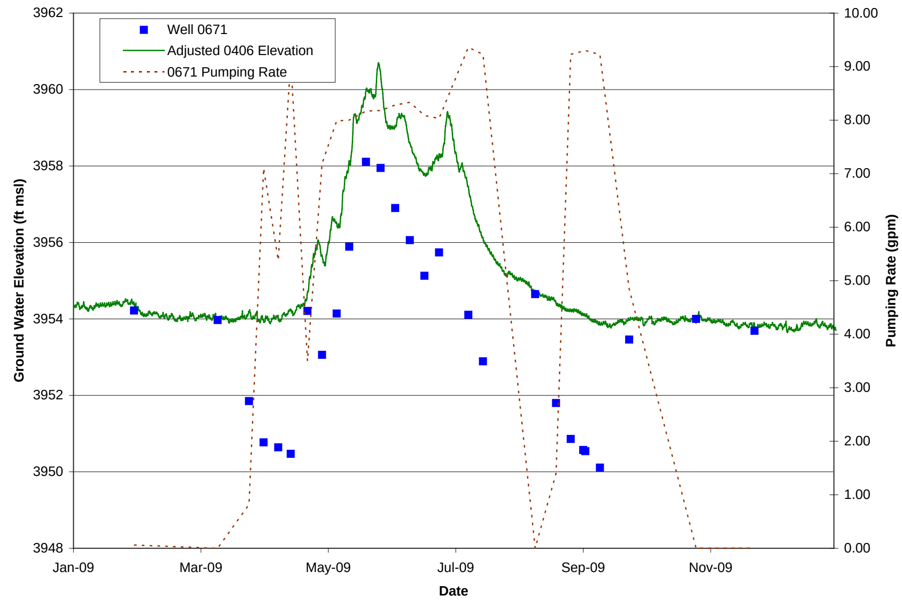
Month	**SMI-PW02**	
	U Conc (mg/L)	**Mass Removed (kg)**
Mar 2009	2.8	3.4
Apr 2009	3.1	5.6
May 2009	3.1	3.7
June 2009	3.1	1.2
July 2009	2.7	13.6
Aug 2009	2.8	12.0
Sept 2009	2.6	12.4
Oct 2009	2.6	1.8
Total		**53.7**

U = uranium

Table B-5. Summary of CF1 Ammonia (as N), TDS, and Uranium Ground Water Concentrations (mg/L) During 2009 versus. Historical Range

Location	N	Type	Ammonia Concentration Range (mg/L)	Historical Ammonia Concentration Range (mg/L)	TDS Concentration Range (mg/L)	Historical TDS Concentration Range (mg/L)	Uranium Concentration Range (mg/L)	Historical Uranium Concentration Range (mg/L)
0470	3	Extraction	520 - 720	40 – 1,100	9,900 - 17,000	190 – 26,000	1.8 - 2.5	0.47 – 4.6
0473	4	Extraction	140 - 510	60 – 1,100	4,900 - 15,000	1,600 – 25,000	0.80 - 2.3	0.35 – 4.5
0475	4	Extraction	140 - 450	95 – 1,100	4,800 - 14,000	4,000 – 25,000	0.83 - 2.4	0.73 – 4.2
0477	3	Extraction	90 - 230	100 – 1,200	4,800 - 12,000	4,000 – 26,000	0.83 - 2.3	0.59 – 3.7
0403	8	Observation	31 - 280	15 - 780	490 - 12,000	530 – 19,000	0.13 - 2.2	0.008 – 3.1
0407	8	Observation	16 - 410	2.6 - 690	360 - 12,000	300 – 19,000	0.08 - 1.6	0.039 – 3.1
0480	7	Observation	76 - 610	50 – 1,100	1,300 - 20,000	600 – 28,000	0.34 - 2.9	0.31 – 4.18
0483	7	Observation	49 - 700	51 – 1,500	770 - 18,000	390 – 34,000	0.37 - 2.3	0.18 – 3.4
0557	7	Observation	490 - 710	410 – 2,400	17,000 - 31,000	18,000 – 70,000	2.6 - 3.1	1.3 – 3.4
0559	7	Observation	3.3 - 270	0.87 - 800	360 - 9,500	590 – 22,000	0.07 - 1.7	0.12 – 2.4
0560	7	Observation	150 - 1,600	340 – 2,400	4,200 - 63,000	8,700 – 75,000	0.52 - 2.3	0.74 – 2.4
0562	3	Well Point	74 - 96	1.2 - 150	4,300 - 5,400	410 – 11,000	0.58 - 1.0	0.00045 – 1.5
0563	3	Well Point	77 - 300	0.1 - 142	2,000 - 7,600	420 – 5,870	0.34 - 0.62	0.014 – 0.85
0606	3	Well Point	220 - 600	52.5 - 500	5,200 - 18,000	750 – 12,000	0.7 - 1.8	0.01 – 1.2
0611	3	Well Point	1.5 - 9.6	0.63 – 3.1	940 – 1,700	502 – 1,210	0.02 - 0.04	0.000019 – 0.03
0612	3	Well Point	24 - 69	0.427 - 22	1,400 - 3,800	479 – 3,000	0.11 – 0.36	0.0000059 – 0.18
0565	3	Well Point	0.87 - 1.8	0.81 - 53	680 - 760	427 – 2,000	0.004 – 0.009	0.00021 – 0.02

Appendix C.
CF3 Additional Information



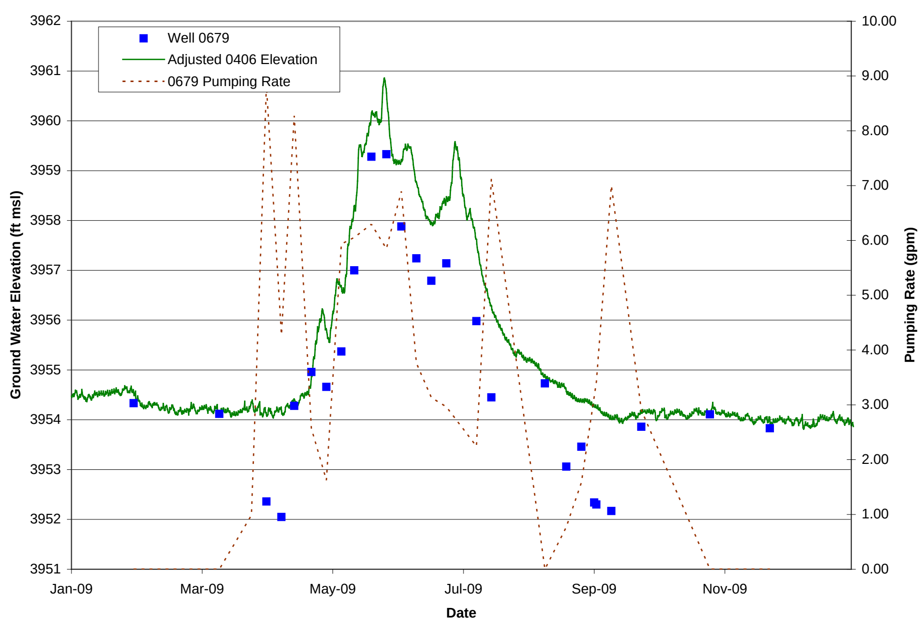
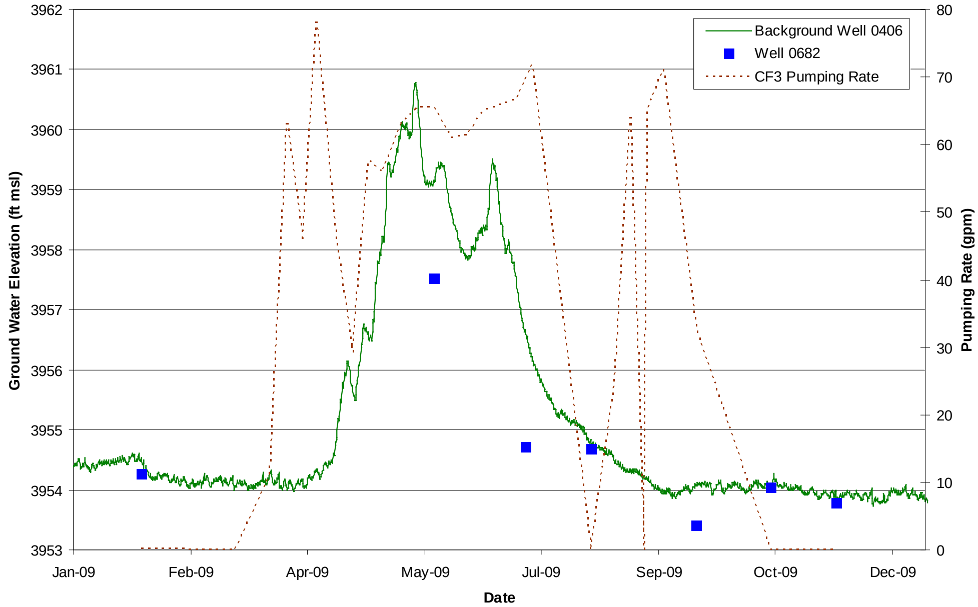


Figure C-1. Ground Water Elevations at CF3 Extraction Wells 0671 and 0679 and Background Well 0406 During 2009



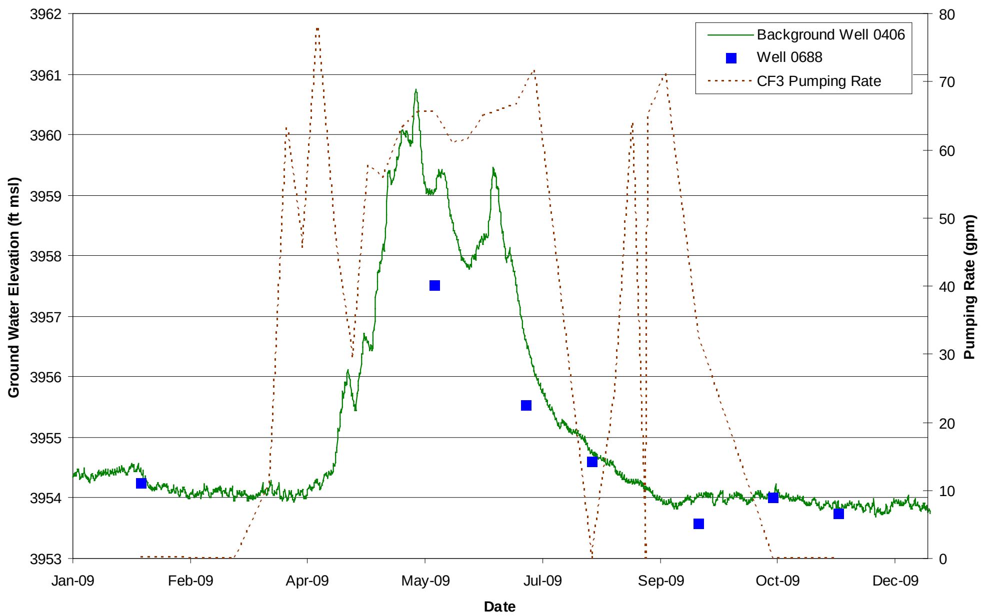


Figure C-2. Ground Water Elevations at CF3 Observation Wells 0682 and 0688 and Background Well 0406 During 2009

Table C-1. Chronology of CF3 Activities in 2009

Date	River Flow (daily mean cfs)	Activity	Samples Collected
Oct 15, 2009 to Mar 23, 2009	4,460	CF3 shut down for winter	N/A
Feb 17-19, 2009	2,800 to 2,870	Monthly sampling	Three observation wells (0683, 0688-39, 0689-54)
March 16-26, 2009	3,250 to 4,870	Monthly sampling	Five extraction wells (0671, 0674, 0675, 0676, 0678), three observation wells (0683, 0688-31, 0689-46), four well points (0690, 0691, 0692, 0696), one surface location (0274)
Mar 23, 2009	4,560	Restarted CF3	N/A
April 28-30, 2009	9,590 to 11,600	Monthly sampling	Five extraction wells (0671, 0673, 0675, 0677, 0679)
May 26-28, 2009	24,500 to 31,000	Monthly sampling	Five extraction wells (0671, 0674, 0675, 0676, 0678), three observation wells (0683, 0688-39, 0689-54)
June 22-25, 2009	17,000 to 17,400	Monthly sampling	Five extraction wells (0671, 0673, 0675, 0677, 0679), three observation wells (0683, 0688-31, 0689-46)
July 15-21, 2009	6,230 to 8,400	Monthly sampling	Three observation wells (0683, 0688-39, 0689-54), one surface water location (248)
July 16, 2009	7,790	Shut down CF3 to control pond level	N/A
Aug 17-24, 2009	3,930 to 4,490	Monthly sampling	Five extraction wells (0670, 0672, 0674, 0676, 0678), five well points (0690, 0691, 0692, 0696, 0697), one surface location (0259)
Aug 19, 2009	4,030	Restarted CF2	N/A
Sept 11-24, 2009	3,490 to 4,540	Monthly sampling	Five extraction wells (0671, 0673, 0675, 0677, 0679), three observation wells (0683, 0688-31, 0689-46)
Sept 17, 2009	4,090	Shut down CF3	N/A
Oct 6-8, 2009	4,150 to 4,680	Monthly sampling	Three observation wells (0683, 0688-39, 0689-54)
Nov 2-6, 2009	3,540 to 4,160	Monthly sampling	Five well points (0690, 0691, 0692, 0696, 697), one surface location (0229)

Table C-2. Monthly Average Pumping Rates and Extraction Volumes at CF3 Remediation Wells, March through September 2009

Month	Well 0670		Well 0671		Well 0672		Well 0673		Well 0674	
	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)
Mar 2009	11,930	0.55	17,591	0.82	71,488	3.19	22,276	1.03	17,488	0.81
Apr 2009	227,403	4.56	315,726	6.46	203,807	4.11	363,560	7.28	253,749	6.59
May 2009	142,485	4.29	327,155	8.08	219,310	5.41	277,649	6.86	222,589	5.49
June 2009	244,776	6.04	331,408	8.18	263,328	6.49	314,685	7.76	256,626	6.33
July 2009	222,532	7.39	279,248	9.29	213,843	7.09	255,802	8.52	209,868	6.89
Aug 2009	83,810	3.98	111,983	5.31	58,687	2.70	103,578	4.91	173,757	7.03
Sept 2009	202,064	5.63	285,072	7.79	207,535	5.71	249,330	6.97	201,000	5.61
Annual Avg/Total	**1,135,000**	4.63	**1,668,183**	6.56	**1,237,998**	4.95	**1,586,880**	6.19	**1,335,077**	5.47

Q = pumping rate; Vol = volume

Month	Well 0675		Well 0676		Well 0677		Well 0678		Well 0679	
	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)
Mar 2009	18,600	0.86	22,997	1.14	15,166	0.70	22,995	1.07	21,249	0.99
Apr 2009	244,000	4.84	270,103	5.39	206,346	4.25	255,404	6.57	248,661	5.11
May 2009	283,012	6.99	194,051	4.56	207,459	5.30	344,977	8.60	244,482	6.03
June 2009	288,854	7.13	282,605	6.97	189,249	4.67	220,919	5.48	169,163	4.18
July 2009	218,664	7.28	238,627	7.94	146,473	5.33	148,772	4.86	115,221	4.68
Aug 2009	177,116	7.04	93,742	4.40	90,747	4.26	78,556	3.55	27,009	1.17
Sept 2009	184,209	5.10	153,995	4.15	156,075	4.48	233,392	6.42	163,165	4.43
Annual Avg/Total	**1,414,455**	5.60	**1,256,120**	4.93	**1,011,515**	4.14	**1,305,015**	5.22	**988,950**	4.46

Q = pumping rate; Vol = volume

Table C-3. Estimated Ammonia Mass Withdrawals at CF3 Extraction Wells During 2009

Month	Well 0670		Well 0671		Well 0672		Well 0673		Well 0674	
	NH_3-N Conc (mg/L)	Mass Removed (kg)	NH_3-N Conc (mg/L)	Mass Removed (kg)	NH_3-N Conc (mg/L)	Mass Removed (kg)	NH_3-N Conc (mg/L)	Mass Removed (kg)	NH_3-N Conc (mg/L)	Mass Removed (kg)
March 2009	450	20	450	30	450	122	530	45	530	35
Apr 2009	520	447	520	621	490	377	460	632	470	451
May 2009	230	124	260	322	290	240	295	310	300	252
June 2009	180	167	180	225	280	279	380	452	385	373
July 2009	280	236	302	319	470	380	380	367	450	357
Aug 2009	380	120	425	180	470	104	460	180	450	296
Sept 2009	450	344	450	485	515	404	580	547	540	410
Oct 2009	0	0	450	30	450	122	530	45	0	0
Total		**1,457**		**2,181**		**1,906**		**2,533**		**2,175**

NH_3-N = ammonia

Month	Well 0675		Well 0676		Well 0677		Well 0678		Well 0679	
	NH_3-N Conc (mg/L)	Mass Removed (kg)	NH_3-N Conc (mg/L)	Mass Removed (kg)	NH_3-N Conc (mg/L)	Mass Removed (kg)	NH_3-N Conc (mg/L)	Mass Removed (kg)	NH_3-N Conc (mg/L)	Mass Removed (kg)
March 2009	410	29	380	33	340	19	340	30	340	27
Apr 2009	480	443	460	470	440	343	400	386	360	338
May 2009	270	289	240	176	210	165	160	209	160	148
June 2009	390	426	420	449	450	322	355	296	260	166
July 2009	387	320	320	289	450	249	210	118	260	113
Aug 2009	385	258	320	113	265	91	210	62	210	21
Sept 2009	500	348	495	288	490	289	480	423	470	290
Oct 2009	0	0	0	0	0	0	0	0		0
Total		**2,112**		**1,818**		**1,478**		**1,525**		**1,104**

NH_3-N = ammonia

Table C-4. Estimated Uranium Mass Withdrawals at CF3 Extraction Wells During 2009

Month	Well 0670		Well 0671		Well 0672		Well 0673		Well 0674	
	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)
March 2009	2.3	0.1	2.3	0.2	2.3	0.6	2.4	0.2	2.5	0.2
Apr 2009	2.3	2.0	2.3	2.7	2.3	1.8	2.2	3.0	2.3	2.2
May 2009	1.0	0.5	1.0	1.2	1.1	0.9	1.2	1.3	1.4	1.2
June 2009	1.9	1.8	1.9	2.4	1.8	1.8	1.7	2.0	1.8	1.7
July 2009	2.1	1.8	2.0	2.1	1.7	1.4	1.8	1.7	1.9	1.5
Aug 2009	2.3	0.7	2.0	0.8	1.7	0.4	1.8	0.7	2.0	1.3
Sept 2009	1.9	1.5	1.9	2.0	1.8	1.4	1.8	1.7	1.9	1.4
Total		**8.3**		**11.5**		**8.3**		**10.6**		**9.6**

U = uranium

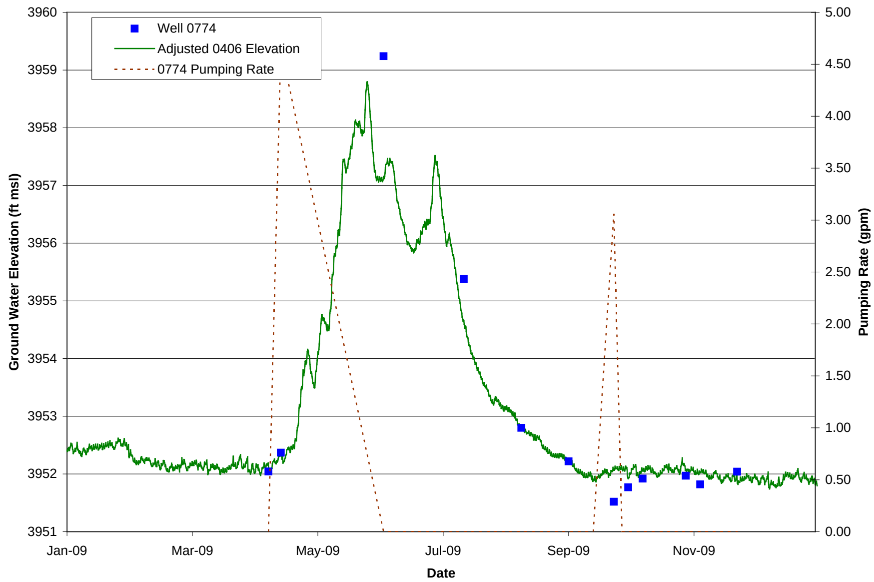
Month	Well 0675		Well 0676		Well 0677		Well 0678		Well 0679	
	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)
March 2009	2.4	0.2	2.1	0.2	2	0.1	2	0.2	2	0.2
Apr 2009	2.4	2.2	2.5	2.6	2.6	2.0	2.5	2.4	2.4	2.3
May 2009	1.3	1.4	1.3	1.0	1.1	0.9	0.9	1.2	1.0	0.9
June 2009	1.9	2.1	1.8	1.9	1.8	1.3	1.6	1.3	1.4	0.9
July 2009	1.9	1.6	1.8	1.6	1.8	1.0	1.6	0.9	1.5	0.7
Aug 2009	1.9	1.3	1.9	0.7	1.7	0.6	1.5	0.4	1.6	0.2
Sept 2009	2.0	1.4	2.1	1.2	2.2	1.3	2.1	1.9	2.1	1.3
Total		**10.1**		**9.1**		**7.2**		**8.3**		**6.3**

U = uranium

Table C-5. Summary of CF3 Ammonia (as N), TDS, and Uranium Ground Water Concentrations (mg/L) During 2009 vs. Historical Range

Location	N	Type	Ammonia Concentration Range (mg/L)	Historical Ammonia Concentration Range (mg/L)	TDS Concentration Range (mg/L)	Historical TDS Concentration Range (mg/L)	Uranium Concentration Range (mg/L)	Historical Uranium Concentration Range (mg/L)
0671	4	Remediation	180 - 520	80 - 540	14,000 - 22,000	2,200 – 24,000	1.9 - 2.3	0.31 – 3.1
0673	3	Remediation	380 - 580	83 - 940	27,000 - 32,000	2,200 – 33,000	1.7 - 2.2	0.3 – 3.2
0674	3	Remediation	300 - 530	19 - 980	16,000 - 20,000	2,200 – 30,000	1.4 - 2.5	0.33 – 3.4
0675	4	Remediation	390 - 500	82 - 570	16,000 - 22,000	2,300 – 27,000	1.9 - 2.4	0.33 – 5.3
0676	3	Remediation	240 - 380	36 - 520	11,000 - 15,000	3,200 – 25,000	1.3 - 2.1	0.53 – 4.6
0677	3	Remediation	440 - 490	27 - 870	17,000 - 21,000	2,100 – 24,000	1.8 - 2.6	0.3 – 4.2
0678	3	Remediation	160 - 340	19 - 830	6,600 - 12,000	2,100 – 25,000	0.92 - 2.0	0.31 – 4.3
0679	3	Remediation	260 - 470	34 - 890	10,000 - 15,000	2,500 – 24,000	1.4 - 2.4	0.36 – 4.7
0683	7	Observation	350 - 410	260 - 510	13,000 - 16,000	7,400 – 20,000	2.0 - 2.4	1.3 – 3.2
0688-39	5	Observation	390 - 900	450 - 960	15,000 - 52,000	16,000 - 46,000	1.9 - 2.4	2.0 – 4.1
0689-54	4	Observation	390 - 660	130 - 950	40,000 - 80,000	22,000 – 87,000	0.25 - 0.6	0.41 - 4.9
0690	3	Well Point	0.11 - 10	0.1 – 1.5	3,000 - 9,800	4,900 – 14,000	0.64 - 2.9	0.79 – 2.8
0691	3	Well Point	110 - 180	98 - 276	3,500 - 10,000	4,600 – 67,100	0.79 - 2.0	0.94 – 2.36
0692	3	Well Point	210 - 310	130 - 469	4,200 - 13,000	2,800 – 16,900	0.75 - 2.3	0.353 – 2.3
0696	3	Well Point	51 - 230	16 - 240	770 - 6,200	510 – 8,700	0.21 - 1.1	0.0011 – 1.2

Appendix D.
CF4 Additional Information



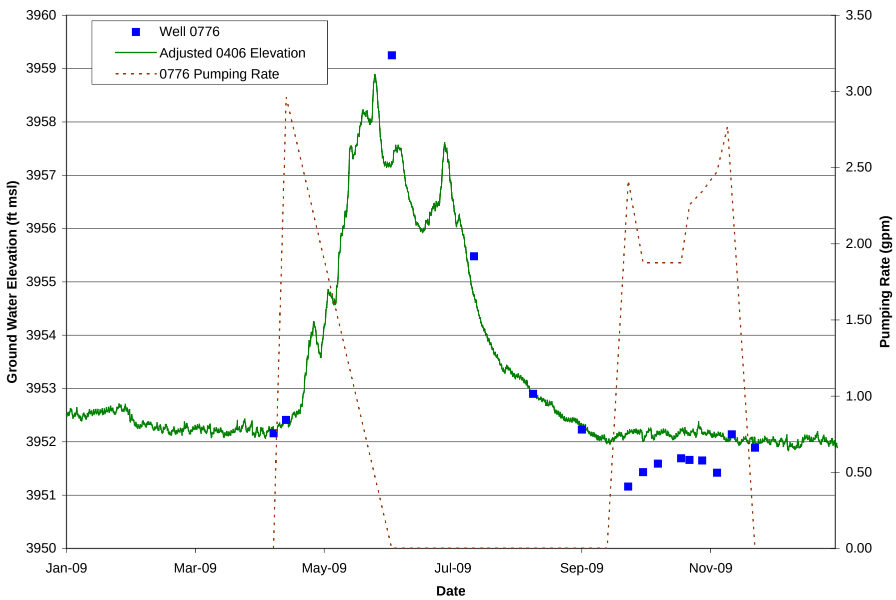
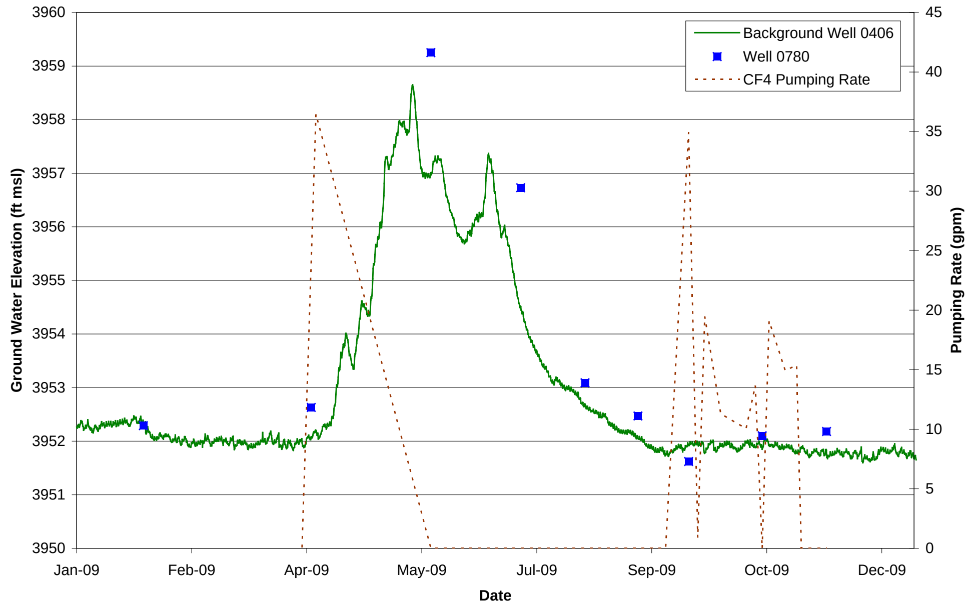


Figure D-1. Ground Water Elevations at CF4 Extraction Wells 0774 and 0776 and Background Well 0406 During 2009



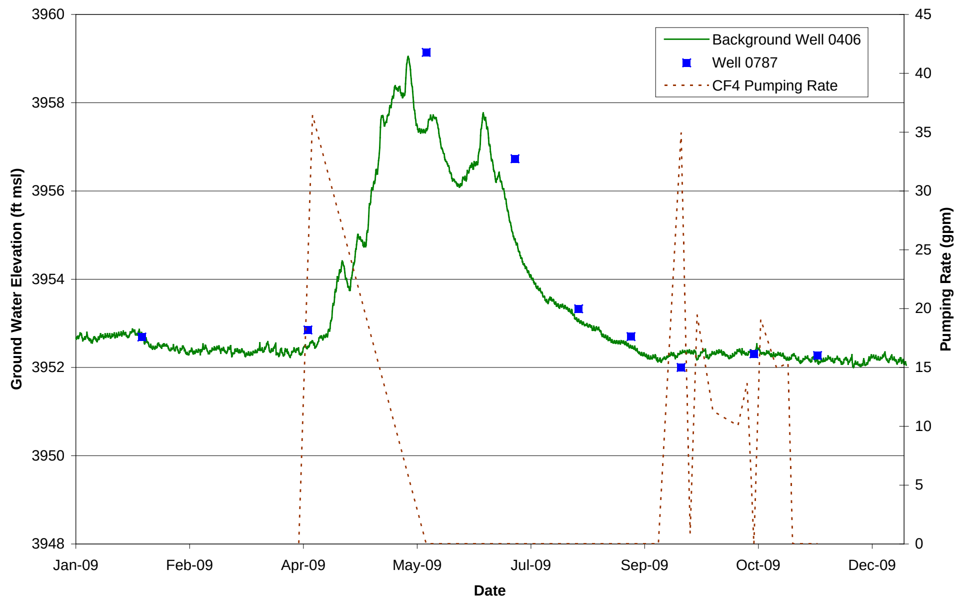


Figure D-2. Ground Water Elevations at CF4 Observation Wells 0780 and 0787 and Background Well 0406 During 2009

Table D-1. Chronology of CF4 Activities in 2009

Date	River Flow (daily mean cfs)	Activity	Samples Collected
Oct 16, 2008 to April 9, 2009	3,630 to 4,150	CF4 shut down for winter	N/A
Feb 17-19, 2009	2,800 to 2,870	Monthly Sampling	Four observation wells (0781, 0782, 0786, 0787)
March 16-26, 2009	3,250 to 4,870	Monthly Sampling	Four observation wells (0781, 0782, 0786, 0787), 3 well points (0790, 0791, 0792), one surface location (0274)
Apr 9, 2009	2,950 to 4,940	CF4 initiated on extraction mode	N/A
Apr 15, 2009	14,500 to 16,700	CF4 shut down to repair leak	N/A
May 26-28, 2009	24,500 to 31,000	Monthly Sampling	Four observation wells (0781, 0782, 0786, 0787)
June 22-25, 2009	17,000 to 17,400	Monthly Sampling	Four observation wells (0781, 0782, 0786, 0787)
July 15-21, 2009	6,230 to 8,400	Monthly Sampling	Four observation wells (0781, 0782, 0786, 0787)
Aug 17-24, 2009	3,930 to 4,490	Monthly Sampling	Two well points (0790, 0791), one surface location (0274)
Sept 11-24, 2009	3,490 to 4,540	Monthly Sampling	Five remediation wells (0770, 0772, 0775, 0776, 0778), four observation wells (0781, 0782, 0786, 0787), four surface water locations (0274, 0277, 0278, 0279)
Sept 14, 2009	3,450	CF4 restarted	N/A
Sept 28, 2009	4,200	Portion of CF4 shut down to reduce flow to pond	N/A
Oct 6-8, 2009	4,150 to 4,680	Monthly Sampling	Four observation wells (0781, 0782, 0786, 0787)
Nov 2-6, 2009	3,540 to 4,160	Monthly Sampling	Five remediation wells (0770, 0772, 0776, 0778, 0779), 3 well points (0790, 0791, 0792), one surface water location (0274)
Nov 10, 2009	3,490	Shut down CF4 for off-pile cleanup	N/A

Table D-2. Monthly Average Pumping Rates and Extraction Volumes at CF4 Remediation Wells, April through November 2009

Month	Well 0770		Well 0771		Well 0772		Well 0773		Well 0774	
	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)
Apr 2009	3,116	0.37	0	0	51,145	6.01	59,270	6.97	39,704	4.67
Sept 2009	0	0	0	0	99,499	6.67	159,564	10.69	45,691	3.06
Oct 2009	68,794	4.01	0	0	318,377	6.31	70,502	6.77	0	0
Nov 2009	64,947	3.94	0	0	107,616	6.50	0	0	0	0
Annual Avg/Total	**136,857**	**2.77**	**0**	**0**	**576,637**	**6.37**	**289,336**	**8.14**	**85,395**	**3.86**

Q = pumping rate; Vol = volume

Month	Well 0775		Well 0776		Well 0777		Well 0778		Well 0779	
	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)	Vol (gal)	Q (gpm)
Apr 2009	70,157	8.24	25,227	2.96	61,662	7.24	0	0	0	0
Sept 2009	20,400	0.97	36,110	2.42	84,547	5.66	80,968	5.41	0	0
Oct 2009	0	0	100,790	2.04	0	0	130,733	2.86	27,341	0.89
Nov 2009	0	0	44,780	2.62	0	0	28,481	1.66	9,000	0.87
Annual Avg/Total	**90,557**	**4.60**	**206,907**	**2.51**	**146,209**	**6.45**	**240,182**	**3.31**	**36,341**	**0.88**

Q = pumping rate; Vol = volume

Table D-3. Estimated Ammonia Mass Withdrawals at CF4 Extraction Wells During 2009

Month	Well 0770		Well 0771		Well 0772		Well 0773		Well 0774	
	NH_3-N Conc (mg/L)	Mass Removed (kg)	NH_3-N Conc (mg/L)	Mass Removed (kg)	NH_3-N Conc (mg/L)	Mass Removed (kg)	NH_3-N Conc (mg/L)	Mass Removed (kg)	NH_3-N Conc (mg/L)	Mass Removed (kg)
Apr 2009	890	10	N/A	N/A	640	124	700	157	800	120
Sept 2009	N/A	N/A	N/A	N/A	310	117	310	187	470	81
Oct 2009	290	75	N/A	N/A	250	301	250	67	N/A	N/A
Nov 2009	290	71	N/A	N/A	360	146	N/A	N/A	N/A	N/A
Total		**157**		**N/A**		**688**		**410**		**201**

NH_3-N = ammonia

Month	Well 0775		Well 0776		Well 0777		Well 0778		Well 0779	
	NH_3-N Conc (mg/L)	Mass Removed (kg)	NH_3-N Conc (mg/L)	Mass Removed (kg)	NH_3-N Conc (mg/L)	Mass Removed (kg)	NH_3-N Conc (mg/L)	Mass Removed (kg)	NH_3-N Conc (mg/L)	Mass Removed (kg)
Apr 2009	860	228	990	94	990	231	N/A	N/A	N/A	N/A
Sept 2009	470	36	490	67	450	144	410	125	N/A	N/A
Oct 2009	N/A	N/A	500	190	N/A	N/A	560	277	560	58
Nov 2009	N/A	N/A	490	83	N/A	N/A	500	54	650	22
Total		**264**		**435**		**375**		**456**		**80**

NH_3-N = ammonia

Table D-4. Estimated Uranium Mass Withdrawals at CF4 Extraction Wells During 2009

Month	Well 0770		Well 0771		Well 0772		Well 0773		Well 0774	
	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)
Apr 2009	2.2	0	N/A	N/A	2.2	0.4	2.2	0.5	2.5	0.4
Sept 2009	N/A	N/A	N/A	N/A	2.4	0.9	2.4	1.4	2.8	0.5
Oct 2009	1.7	0.4	N/A	N/A	2.4	2.9	2.5	0.7	N/A	N/A
Nov 2009	1.4	0.3	N/A	N/A	2.5	1.0	N/A	N/A	N/A	N/A
Total		**0.8**		**N/A**		**5.2**		**2.6**		**0.9**

U = uranium

Month	Well 0775		Well 0776		Well 0777		Well 0778		Well 0779	
	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)	U Conc (mg/L)	Mass Removed (kg)
Apr 2009	2.5	0.7	2.5	0.2	2.2	0.5	N/A	N/A	N/A	N/A
Sept 2009	2.8	0.2	1.9	0.3	2.1	0.7	2.2	0.7	N/A	N/A
Oct 2009	N/A	N/A	2.2	0.8	N/A	N/A	2.0	1.0	2.0	0.2
Nov 2009	N/A	N/A	2.2	0.4	N/A	N/A	1.7	0.2	1.7	0.1
Total		**0.9**		**1.7**		**1.2**		**1.9**		**0.3**

U = uranium

Table D-5. Summary of CF1 Ammonia (as N), TDS, and Uranium Ground Water Concentrations (mg/L) During 2009 vs. Historical Range

Location	N	Type	2009 Ammonia Concentration Range (mg/L)	Historical Ammonia Concentration Range (mg/L)	TDS Concentration Range (mg/L)	Historical TDS Concentration Range (mg/L)	Uranium Concentration Range (mg/L)	Historical Uranium Concentration Range (mg/L)
0770	3	Remediation	290 - 300	130 - 1200	19,000 - 23,000	9,000 - 64,000	1.4 - 1.7	0.51 – 2.6
0772	3	Remediation	250 - 360	91 - 960	19,000 - 21,000	5,800 - 81,000	2.0 - 2.5	0.39 – 3.1
0776	3	Remediation	490 - 500	190 - 1900	21,000 - 23,000	8,600 – 73,000	1.9 - 2.2	0.39 – 2.7
0780	7	Observation	120 - 710	77 - 890	3,600 - 22,000	1,000 – 25,000	0.62 - 3.4	0.24 – 3.9
0782	7	Observation	63 -1,000	140 - 750	1,800 - 83,000	10,000 – 90,000	0.3 - 0.85	0.29 – 2.9
0786	7	Observation	41 - 820	27 - 820	950 - 37,000	490 – 56,000	0.13 - 3.0	0.072 – 3.2
0787	7	Observation	99 - 250	32 - 340	3,900 - 90,000	1,100 – 91,000	0.12 - 0.81	0.11 – 0.72
0790	3	Well Point	84 - 720	0.1 - 240	2,200 - 24,000	380 – 12,000	0.35 - 2.9	0.011 – 1.6
0791	3	Well Point	160 - 770	0.71 – 520	4,800 - 26,000	660 – 23,000	0.78 - 2.6	0.017 – 2.7

Appendix E.
Evaporation Pond Additional Information

Table E-1. Important Dates, Evaporation Pond Levels, and Activities Associated with the IA Treatment Systems During 2009

Date	Pond Level (ft)	Activity
Jan 15, 2009	5.9	Successful test on CF1 replumb design
Jan 28, 2009	6.0	CF1 restarted
Feb 9, 2009	6.5	Shut down half of CF1 well to decrease flow to pond
Feb 23, 2009	6.8	RAC started testing sprinkler system
Feb 26, 2009	6.6	Started sprinkler system full time, rest of CF1 started
Mar 12, 2009	5.8	Restarted PW02
Mar 23, 2009	5.0	Restarted CF3, total q ~120 gpm
Mar 26, 2009	5.0	PW02 shut down, no flow showing on meter
Apr 3, 2009	5.5	Well field shut down for drain valve repair @ 15:30
Apr 6, 2009	6.4	Well field restarted with PW02 @14:00, q = 130 gpm
Apr 9, 2009	6.4	CF4 initiated on extraction mode, q = 65 gpm
Apr 13, 2009	7.4	CF4 shut down due to leak in badger meter vault, 774/775 vault @ 15:30
Apr 22, 2009	7.5	Shut down well field @ 13:00, leak in main line
Apr 27, 2009	8.0	CF1 and PW02 back on @ 14:30,
Arp 28, 2009	8.0	CF3 restarted @ 11:20
May 12, 2009	8.6	Shut down CF1 (optimization plan) @ 10:00, only CF3 and PW02 running
May 14, 2009	8.0	PW02 down, breaker tripped
Jun 18, 2009	6.9	Restarted PW02 w/ new motor, ran only a few hrs, need new wire
Jun 23, 2009	7.4	PW02 back on @ 09:00
July 16, 2009	9.0	Shut down CF3 to control pond level
Aug 17, 2009	5.6	Restarted CF1 to protect habitat
Aug 19, 2009	5.6	Restarted CF3
Sept 11, 2009	7.4	CF1 shut down due to high river flow
Sept 14, 2009	8.5	CF4 restarted
Sept 17, 2009	8.5	Shut down CF3
Sept 21, 2009	9.1	Shut down CF1 to control pond level
Sept 24, 2009	9.1	Landshark started evaporating water
Sept 28, 2009	9.1	Portion of CF4 shut down to reduce flow to pond
Oct 1, 2009	9.0	Shut down PW02
Nov 10, 2009	8.4	Shut down CF4 for off-pile cleanup

Q = pumping rate

Appendix F.
Surface Water Monitoring Additional Information

Table F-1. Surface Water Monitoring During Critical Habitat for 2009

Date	River Flow	Location	Ammonia Conc.	Temp.	pH	Habitat?	Acute/Chronic
7/15/09	8,330	CF3	0.37	36.73	8.32	No	4.71
							N/A
		CF2/3	0.76	24.39	8.38	No	3.88
							0.80
		BL Inter.	1.92	33.86	8.30	No	4.71
							N/A
7/16/09	7,810	CF3 Inter.	0.61	18.53	7.78	No	5.72
							1.26
		CF2/3	0.23	21.48	8.17	No	5.72
							1.11
		CF2/3	0.38	21.99	8.34	No	4.71
							0.94
		CF2	0.24	21.16	8.41	No	3.88
							0.91
		CF3	0.22	21.81	8.35	No	3.88
							0.80
		BL Inter.	0.29	20.00	7.98	No	8.40
							1.71
7/20/09	6,520	CF2/3	0.59	21.89	8.34	No	17.0
							2.45
		CF2	0.39	21.57	8.01	Yes	8.40
							1.50
		CF2	0.25	21.82	7.91	Yes	10.1
							1.73
		CF2	0.12	21.53	7.97	Yes	8.40
							0.80
		CF2/1	0.16	22.99	8.50	No	8.40
							1.50
7/21/09	6,200	CF2/3	0.30	22.26	7.36	No	23.0
							2.92
		CF1/2	0.45	19.60	7.97	No	8.40
							1.71

Table F-1. Surface Water Monitoring During Critical Habitat for 2009 (continued)

Date	River Flow	Location	Ammonia Conc.	Temp.	pH	Habitat?	Acute/Chronic
8/18/09	4,410	CF1	2.2	23.64	8.22	No	5.72
							0.97
		CF2	0.21	23.61	8.31	No	4.71
							0.83
		BL	1.4	23.60	8.27	No	4.71
							0.83
		CF1	0.12	23.90	8.40	No	3.88
							0.70
		CF2/3	0.1	18.53	8.17	Yes	5.72
							1.43
		CF3	0.35	21.62	8.29	No	4.71
							0.94
8/19/09	4,030	CF4	1.6	18.62	8.35	No	3.88
							1.03
9/10/09	3,660	CF1	0.08	30.50	8.76	No	1.84
							0.24
		CF4	0.36	27.80	8.57	No	2.65
							0.39
		CF4	7.05	27.94	8.29	No	4.71
							0.64
		CF4	8.45	29.03	7.84	No	12.1
							1.17
		CF4	34.5	30.55	7.89	No	10.1
							1.03

Table F-1. Surface Water Monitoring During Critical Habitat for 2009 (continued)

Date	River Flow	Location	Ammonia Conc.	Temp.	pH	Habitat?	Acute/Chronic
9/11/09	3,630	CF4	3.63	21.00	8.37	No	3.88
							0.91
		CF4	16.60	17.28	8.22	No	5.72
							1.43
		CF4	24.9	17.16	8.24	No	5.70
							1.43
		CF4	2.5	17.16	8.24	No	5.72
							1.22
		CF4	0.19	20.90	8.53	No	3.20
							0.76
		CF4	56	16.81	8.21	No	5.72
							1.63
Diverted freshwater through the CF4 channel; next readings were recorded during freshwater diversion							
		CF4	0.61	24.01	8.51	No	3.20
							0.59
		CF4	1.38	25.00	8.46	No	3.20
							0.50
		CF4	7.26	29.05	8.04	No	8.40
							0.90
		CF4	9.73	27.63	8.10	No	6.95
							0.88
		CF4	8.39	24.78	8.09	No	6.95
							1.14
		CF4	0.48	27.79	8.46	No	3.20
							0.46
		CF4	1.23	23.18	8.25	No	4.71
							0.83
		CF4	0.63	27.00	8.51	No	3.20
							0.46

Table F-1. Surface Water Monitoring During Critical Habitat for 2009 (continued)

Date	River Flow	Location	Ammonia Conc.	Temp.	pH	Habitat?	Acute/Chronic
9/14/09	3,450	CF4	2.74	18.86	7.87	No	12.1
							2.54
		CF4	9.38	19.28	7.26	No	26.2
							3.57
		CF4	2.36	15.95	7.44	No	23.0
							4.30
		CF4	9.95	18.86	7.87	No	12.1
							2.54
		CF4	0.98	20.39	8.12	No	6.95
							1.47
		CF4	30.6	18.32	7.77	No	12.1
							2.54
		CF4	2.34	17.22	8.03	No	8.40
							1.94
9/15/09	4,280	CF4	0.83	20.16	7.97	No	8.40
							1.71
		CF4	1.12	19.95	8.31	No	4.71
							1.07
		CF4	1.99	20.48	8.41	No	3.88
							0.91
		CF4	0.88	19.68	8.40	No	3.88
							0.91
		CF4	0.8	16.50	8.19	No	5.72
							1.63
		CF4	0.3	17.24	7.56	No	19.9
							3.18
		CF4	0.43	16.78	8.21	No	5.72
							1.63
		CF4	1.5	20.87	8.37	No	5.72
							1.63

Table F-1. Surface Water Monitoring During Critical Habitat for 2009 (continued)

Date	River Flow	Location	Ammonia Conc.	Temp.	pH	Habitat?	Acute/Chronic
9/17/09	4,090	CF4	0.30	17.24	8.57	No	17.0
							3.18
		CF4	0.22	16.94	8.10	No	6.95
							1.91
		CF4	0.20	16.50	8.19	No	5.72
							1.63
		CF4	0.21	16.68	8.21	No	5.72
							1.63
		CF4	0.22	16.78	8.21	No	5.72
							1.63
		CF1	0.23	17.03	8.23	No	5.72
							1.43
		River	0.19	17.50	8.22	No	5.72
							1.43
9/21/09	4,220	CF4	0.20	17.03	7.84	No	12.1
							2.54
		CF4	0.15	16.34	8.27	No	4.71
							1.39
		CF1	0.16	21.21	8.53	No	3.20
							0.67

July 13, 2009
River Flow 9,310

Photo 1. Baseline intermediate channel was an isolated pool of water (view to north)

Photo 2. Confluence of CFs 3 and 2 (view to northeast)

Photo 3. CF2 channel (view to south)

July 14, 2009
Flow 8,830 cfs

Photo 4. Baseline intermediate isolated pool of water (view to north)

Photo 5. Confluence of CFs 2 and 3 (view to northeast)

Photo 6. CF2 channel (view to south)

July 16, 2009
Flow 7,810 cfs

Photo 7. Confluence of CFs 3 and 2
(view to northeast)

Photo 8. CF2 channel (view to south)

July 20, 2009
6,520 cfs

Photo 9. Confluence of CFs 3 and 2 (view to northeast)

Photo 10. CF2 channel (view to south)

Photo 11. Confluence of CFs 2 and 1 (view to south)

July 21, 2009
6,200 cfs

Photo 12. Confluence of CFs 3 and 2 (view to northeast)

Photo 13. CF2 channel (view to south)

Photo 14. Confluence of CFs 2 and 1 (view to south)

July 28, 2009
Flow 6,030 cfs

Photo 15. CF2 channel (view to south)

Photo 16. CF2 isolated pools of water (view to north)

Photo 17. CF1 channel (view to south)

September 1, 2009
Flow 4,330 cfs

Photo 18. CF1 channel (view to south)

September 10, 2009
Flow 3,660 cfs

Photo 19. Dry CF1 channel (view to south)

Photo 20. Confluence of CFs 1 and 4 (view to south)

Photo 21. CF4 channel. Note gravel bar in center of channel (view to south)

September 14, 2009
Flow 3,450 cfs

Photo 22. CF1 channel (view to northeast)

Photo 23. CF4 channel (view to south)

Photo 24. CF4 channel (view to north)

Photo 25. CF4 channel and initial action hose (view to northeast)

September 15, 2009
Flow 4,280 cfs

Photo 26. CF4 channel and initial action hose. Note hose moved further north to facilitate dilution on gravel bar (view to north)

Photo 27. CF4 channel south of initial action hose.

Photo 28. After 9/15 storm, river flow increased, and gravel bar was inundated due to higher river level

September 17, 2009
Flow 4,090 cfs

Photo 29. CF4 channel with initial action (view to northeast)

Photo 30. View of CFs 1 and 4 (view to south)

Appendix G.
Mesa State Bench Scale Test Results

Results of Moab UMTRA Project Ammonia Bench Scale Test
Laboratory Work Completed By Mesa State College

Purpose

The purpose of the ammonia bench scale test was to determine how varying pH and temperature effect the ammonia concentration in the ground water. Moab TAC subcontracted the Mesa State Department of Physical and Environmental Sciences to conduct the laboratory test.

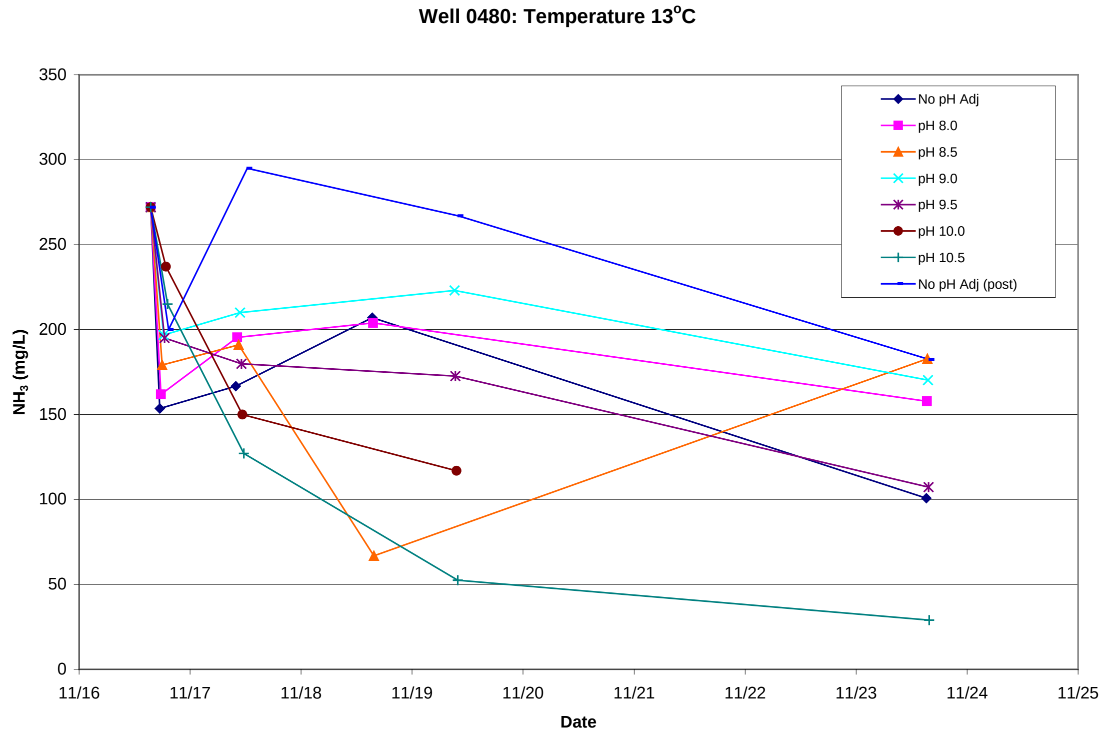
Methods

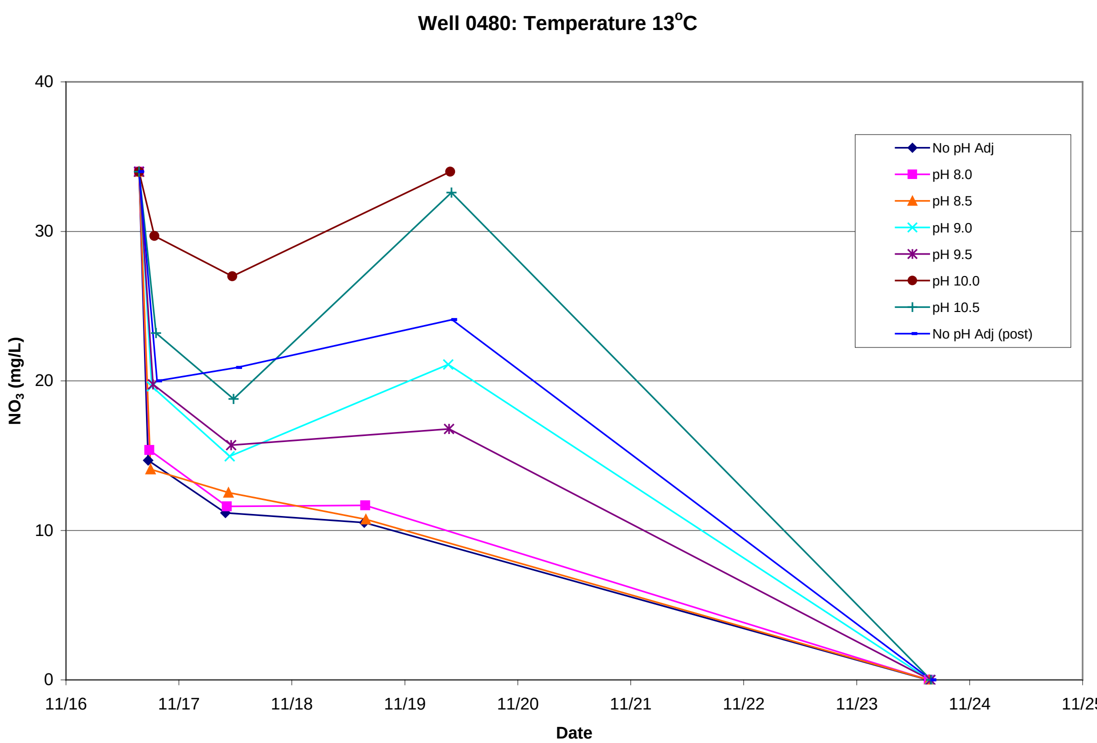
Approximately 4 liters of ground water from wells 0480 (18 ft bgs) and 0782 (34 ft bgs) was divided into 24 beakers with approximately 150 milliliters in each beaker. Sodium hydroxide was titrated into each beaker to adjust the pH to 8.0, 8.5, 9.0, 9.5, 10.0, 10.5 and 11.0 at location 0480 and to 8.0, 9.0, and 10.0 at location 0782. Each beaker was heated or cooled to 13º C, 25º C, or 38º C. The ammonia and nitrate concentration was monitored hourly for the first 3 hours and then on a daily basis. A Hach sensIon ammonia probe was used to measure the ammonia as N and a Hach Model 51920 platinum combination electrode was used to measure the nitrate and both were calibrated prior to operation. The data was recorded and was plotted on an excel spreadsheet.

Data

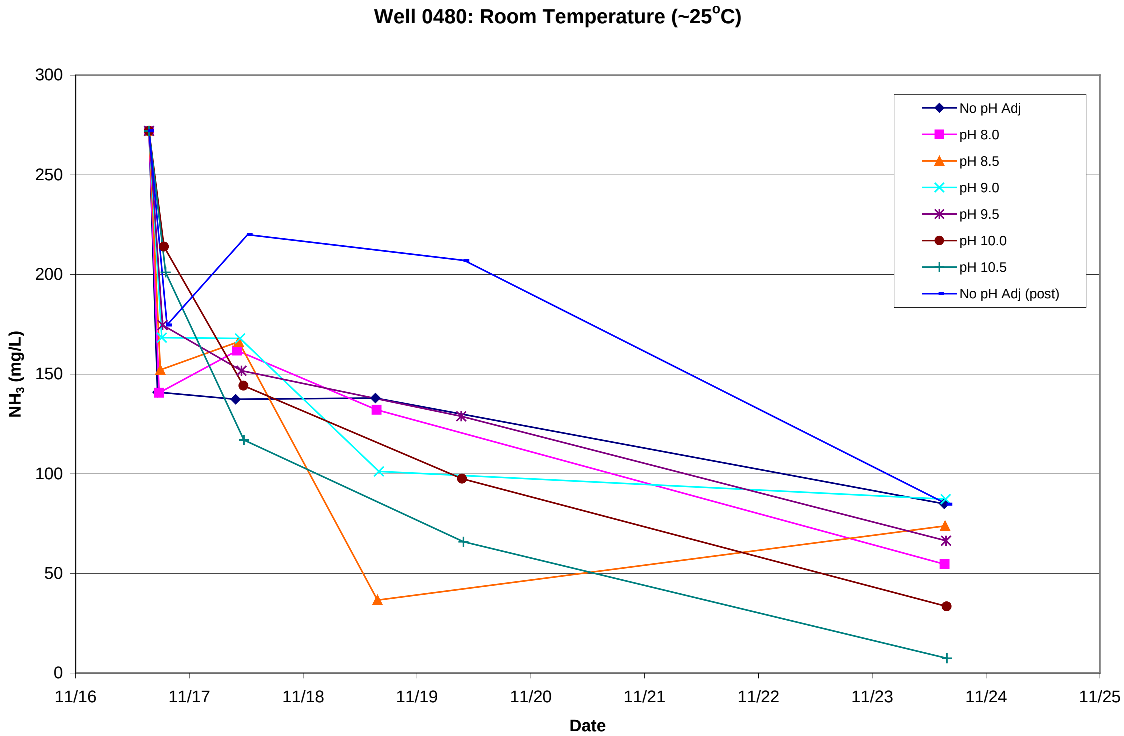
The first test consisted of a ground water sample from 0480 (18 ft bgs). The initial ammonia concentration was 272 mg/L, and the initial nitrate concentration was 34 mg/L. This test was started on November 16 and the last measurement was collected on November 23, 2009 (at which time there as not enough sample volume left to collect further data).

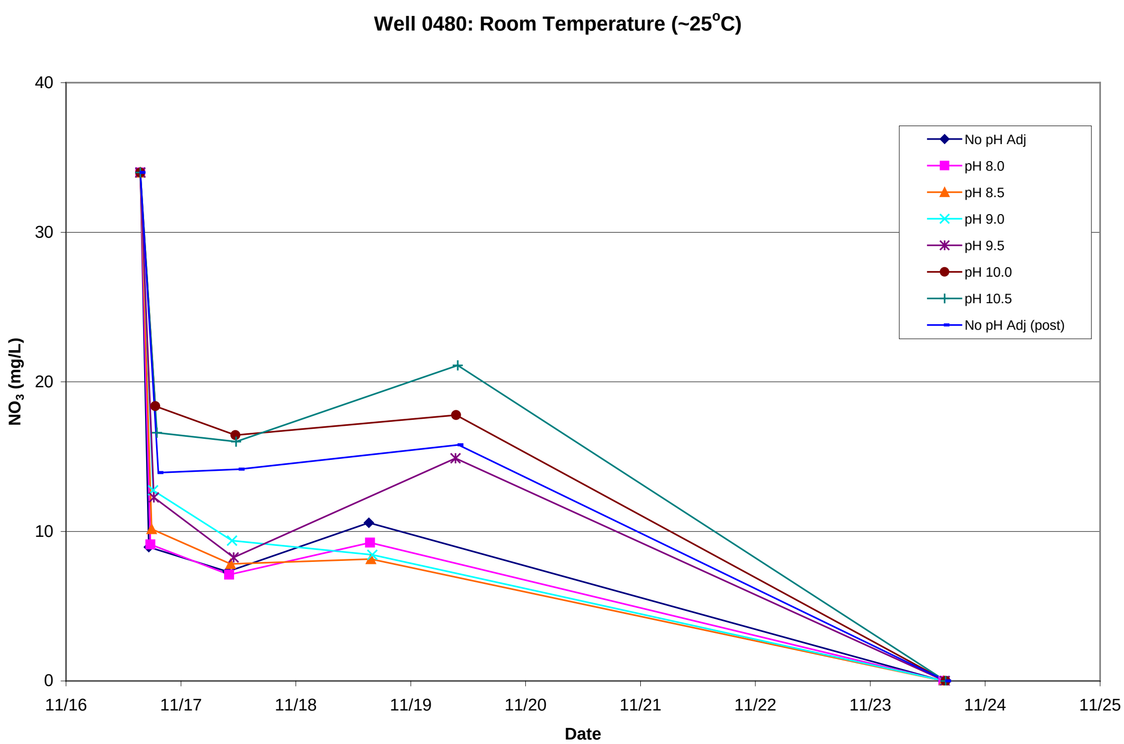
The plots below present the results for the samples left at 13° C:



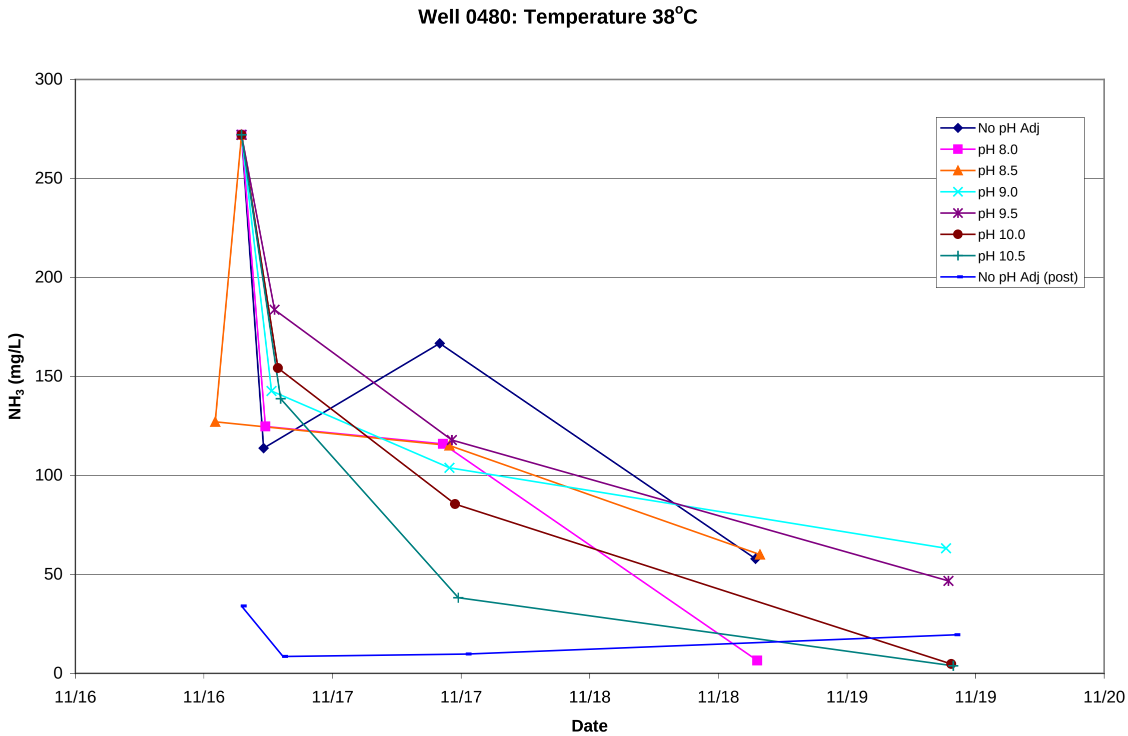


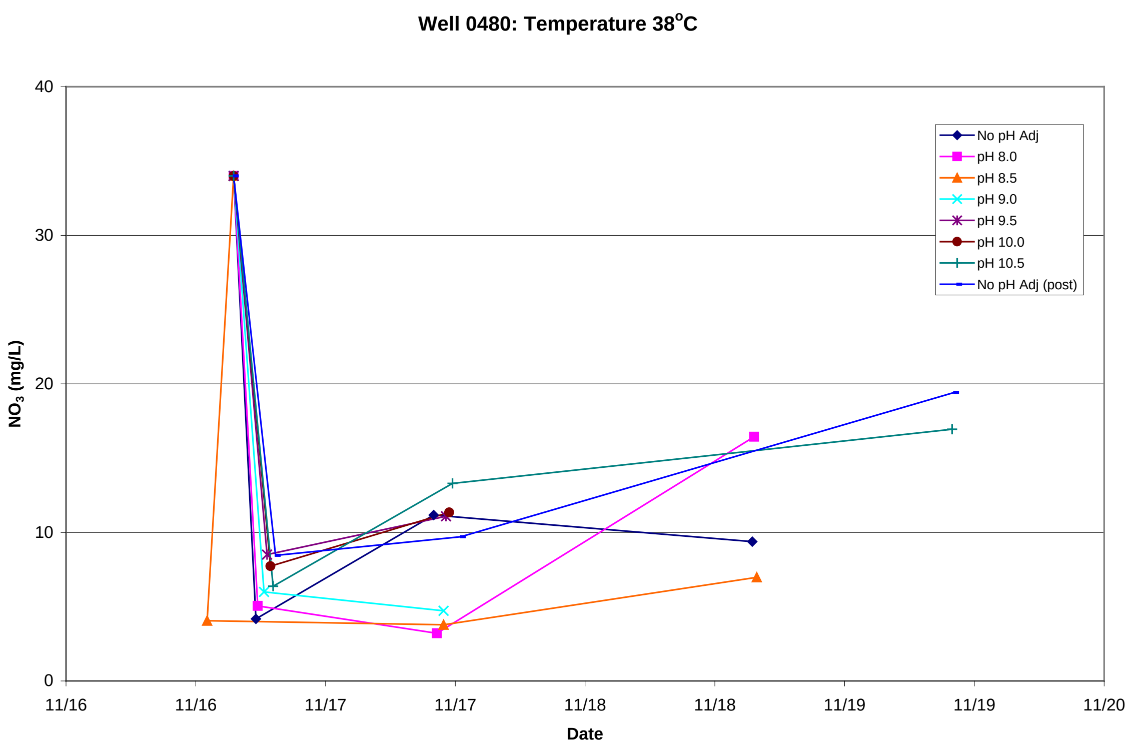
The plots below present the results for the samples left at ~25° C:





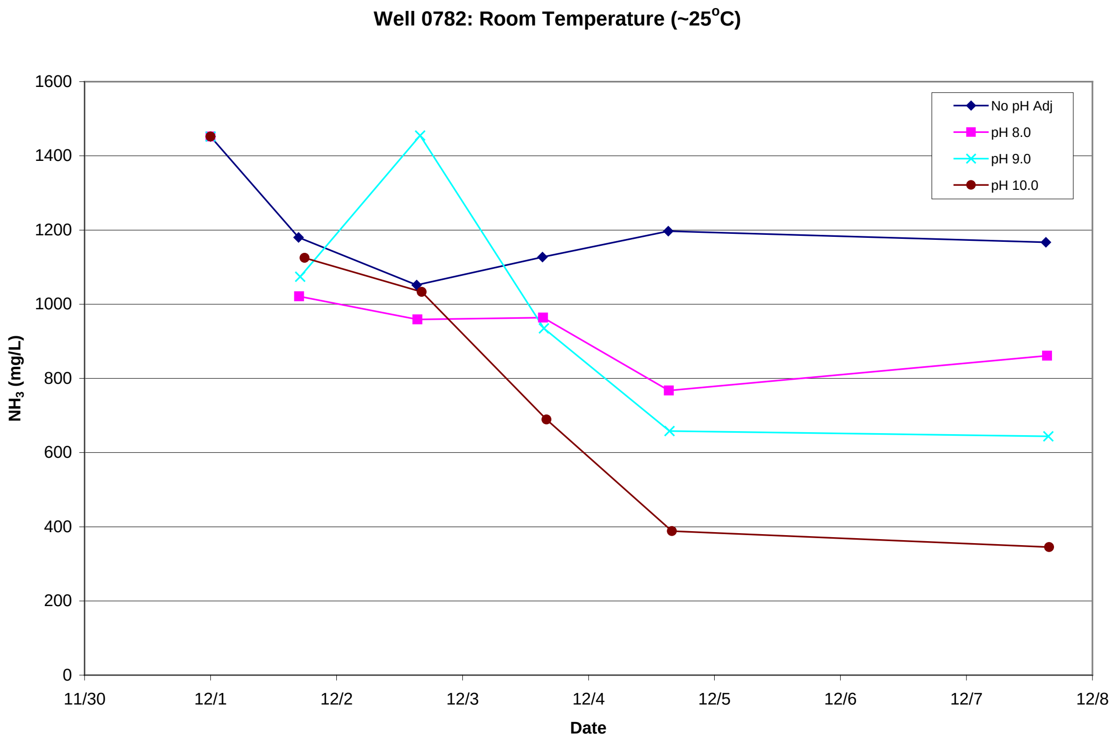
The plots below present the results for the samples left at 38° C:

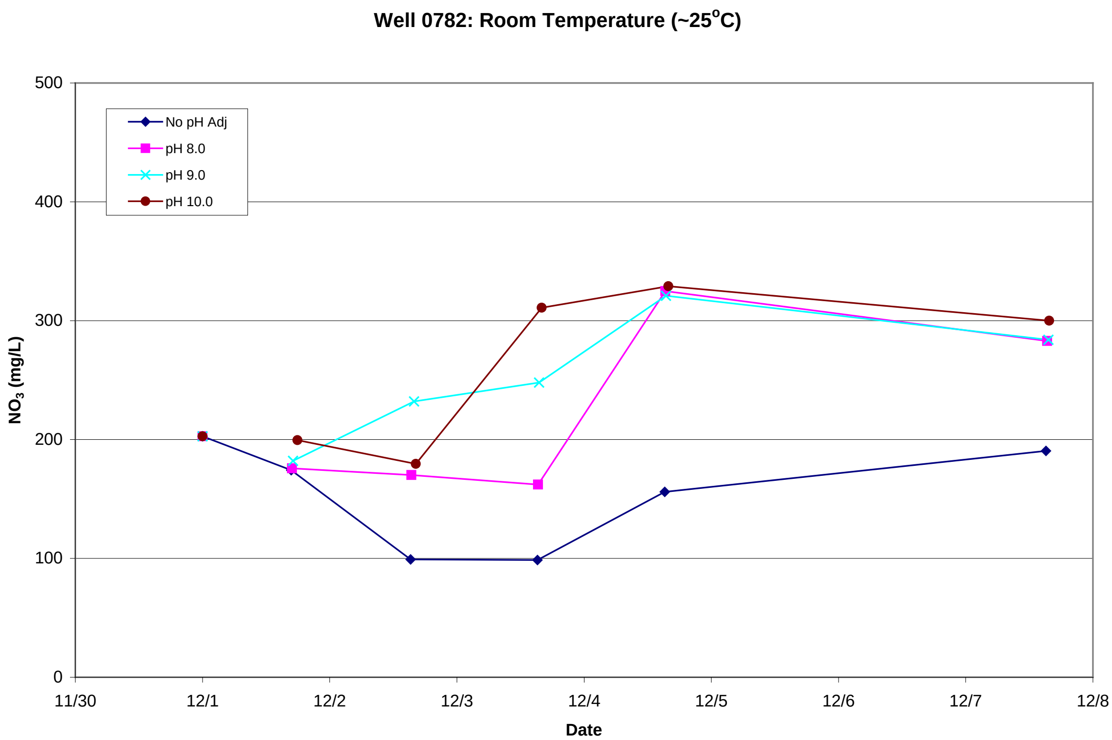


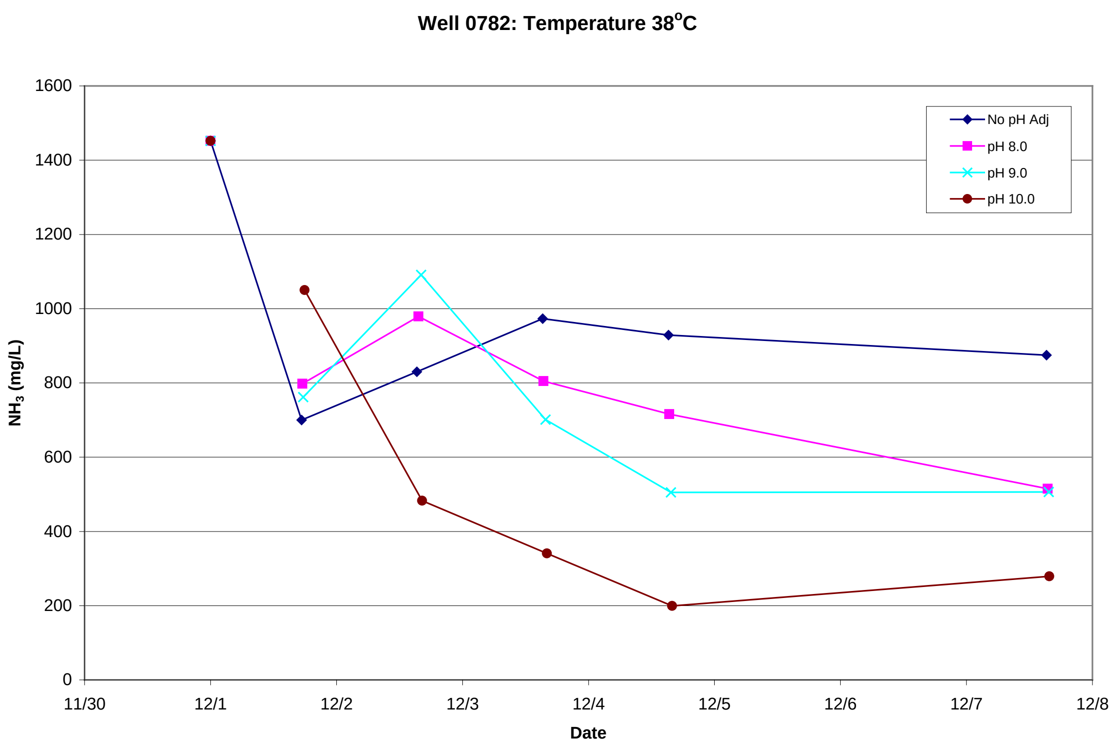


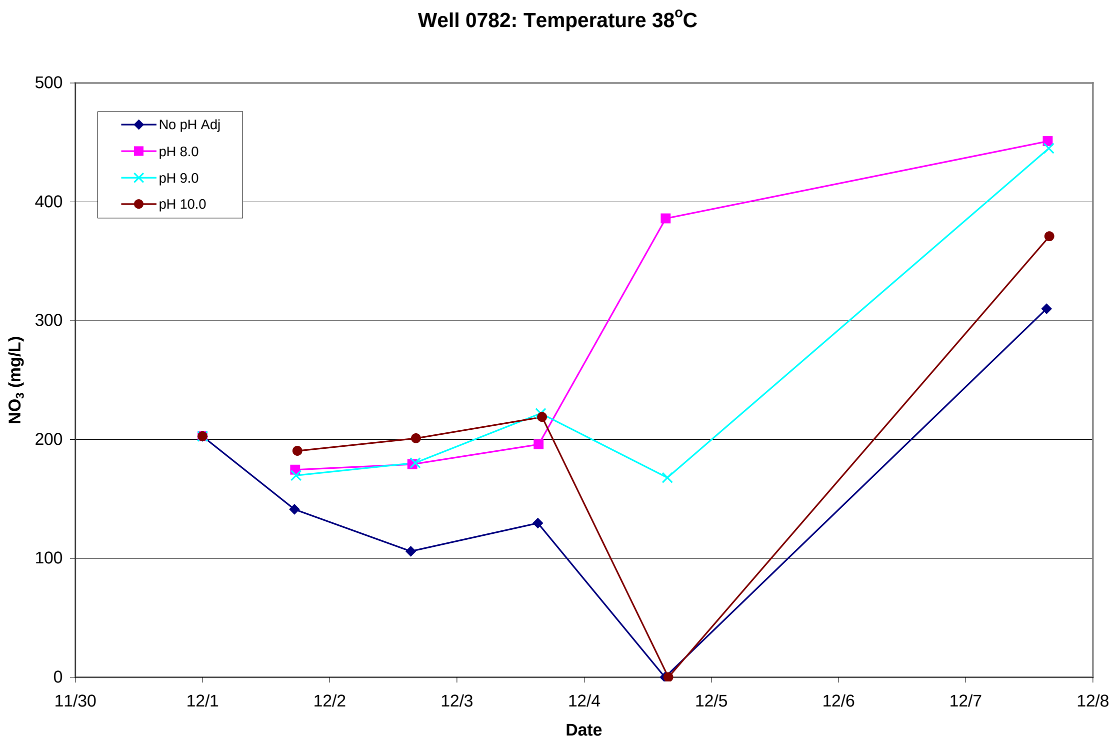
The second test was a sample from 0782 (34 ft bgs). The initial ammonia concentration was 1,452 mg/L, and the initial nitrate concentration was 202 mg/L. This test began on December 1 and the last measurement was recorded on December 7, 2009. Based on results of first test, sample 0782 was only split up into 15 beakers. The pH was adjusted to 8.0, 9.0, and 10 (using sodium hydroxide), and exposed to temperatures of ~25° C and 38° C.

The plots below present the results for the samples left at approximately 25° C:




Well 0782: Room Temperature (~25°C)
500
400
300
200
100
0
NO3 (mg/L)
11/30
12/1
12/2
12/3
12/4
12/5
12/6
12/7
12/8
Date
No pH Adj
pH 8.0
pH 9.0
pH 10.0


Well 0782: Temperature 38°C
1600
1400
1200
1000
800
600
400
200
0
NH3 (mg/L)
11/30
12/1
12/2
12/3
12/4
12/5
12/6
12/7
12/8
Date
No pH Adj
pH 8.0
pH 9.0
pH 10.0



Summary of Results

The results of the bench test on 0480 concluded that the higher the pH, the lower the ammonia concentration over time. Higher temperatures decreased the ammonia concentrations over a shorter period of time. After seven days the samples kept at room temperature had the approximately the same concentration as the samples kept at 38°C reached after only 3 days. Nitrate was not present in the samples kept at 13 °C and 25 °C after 7 days, and in general initially dropped and then increased to approximately one-half the initial nitrate concentration after three days in the sample kept at 38 °C. It was observed that at pH values above 9.5, a white precipitate started to form immediately as the pH was adjusted.

The results of the second test were similar to the first test. Ammonia concentrations decreased more rapidly at higher pH. After 3 days, the pH 10 sample kept at 38°C contained approximately one-half of the ammonia concentration compared to the pH 10 sample kept at room temperature (200 vs 400 mg/L). Nitrate concentrations increased in the samples kept at 25 °C for all various pH values, and initially decreased after 3 days and increased back to the initial concentration in the same with the unadjusted pH. The nitrate concentrations in samples kept at 38 °C gradually increased over the test period.