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MOAB UTAH
UMTRA Project

Interim Action Expansion Work Plan for Configuration 4

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1.0 Introduction

The Moab Uranium Mill Tailings Remedial Action (UMTRA) Project site near Moab, Utah (Moab 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 plant was constructed in 1956 by the Uranium Reduction Company, which operated the mill until 1962 when the assets were sold to the Atlas Minerals Corporation (Atlas). Operations continued under Atlas until 1984. When the processing operations ceased in 1984, the mill had accumulated an estimated 16 million cubic yards of uranium mill tailings in an unlined impoundment in the floodplain of the Colorado River. The tailings pile covers approximately 130 acres, is about 0.5 mile in diameter, averages about 94 feet (ft) in height above ground surface, and is located about 750 ft west of the Colorado River. Atlas placed an interim cover over the tailings pile as part of decommissioning activities ongoing between 1988 and 1995. In October 2001, the title of the property and responsibility for remediation of the tailings pile and contaminated ground water beneath the site were transferred to the U.S. Department of Energy (DOE).

It has been known for years and indicated by a number of investigations, including one completed by DOE (DOE 2003a), that contaminants have leached from the tailings pile into the ground water. Several site-related contaminants have been identified, but the most pervasive and highest concentration constituent is ammonia. DOE's studies have identified two plumes of ammonia associated with the site: a deep plume beneath the tailings pile and a shallower plume emanating from the toe of the tailings pile to the Colorado River. Ground water from the shallow plume has been demonstrated to discharge to the Colorado River and to have a localized impact on surface water quality. Degradation of surface water quality is of concern because of potential effects on aquatic species in the area, particularly endangered fish.

DOE has been operating an interim action to evaluate two scenarios for treating contaminated ground water and protecting the endangered fish habitat in backwater areas of the river adjacent to the site. One method is to extract contaminated ground water from a series of wells installed in the shallow plume and pump it to an evaporation pond on top of the tailings pile. The other method is to pump diverted Colorado River water into a storage pond, allow time for settlement of fines, and then after sediment filtration, inject this water into these same wells and/or another series of wells installed into the alluvial aquifer.

The current interim action well field consists of three clusters of remediation wells along with numerous observation wells. These well clusters are referred to as Configurations 1, 2, and 3 (Figure 2). Configuration 1, installed in summer 2003, is designed to reduce contaminant mass in the alluvial aquifer by ground water extraction and pumping to the evaporation pond. Configurations 2 and 3 are designed to operate either in extraction mode, the same as Configuration 1, or to create a freshwater hydraulic barrier between the ammonia plume and the river and effect discharge of clean water into potential endangered fish habitat.

An additional area adjacent to the pile, the Baseline Area, has also been monitored. This area is outside the influence of the interim action well field and is intended to provide data regarding natural variation of the ground water and surface water systems in response to changes in river stage. Several performance assessments of the extraction and injection portions of the interim actions to date have been prepared (DOE 2005a, 2005b, 2005c). The results of those assessments and the work detailed in this plan for expanding the interim action to include an infiltration

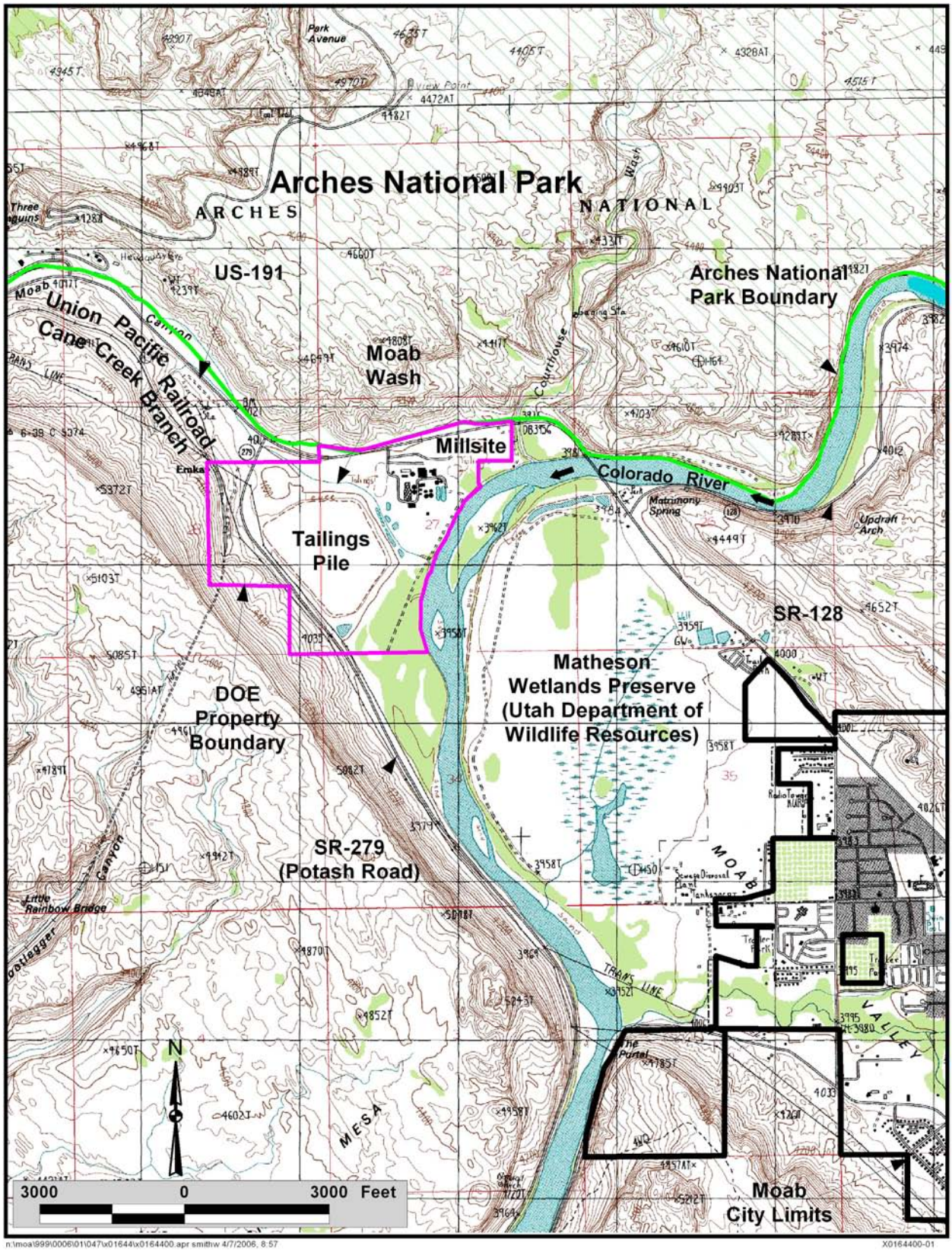

Figure 1. Location Map of the Moab Site and Surrounding Area

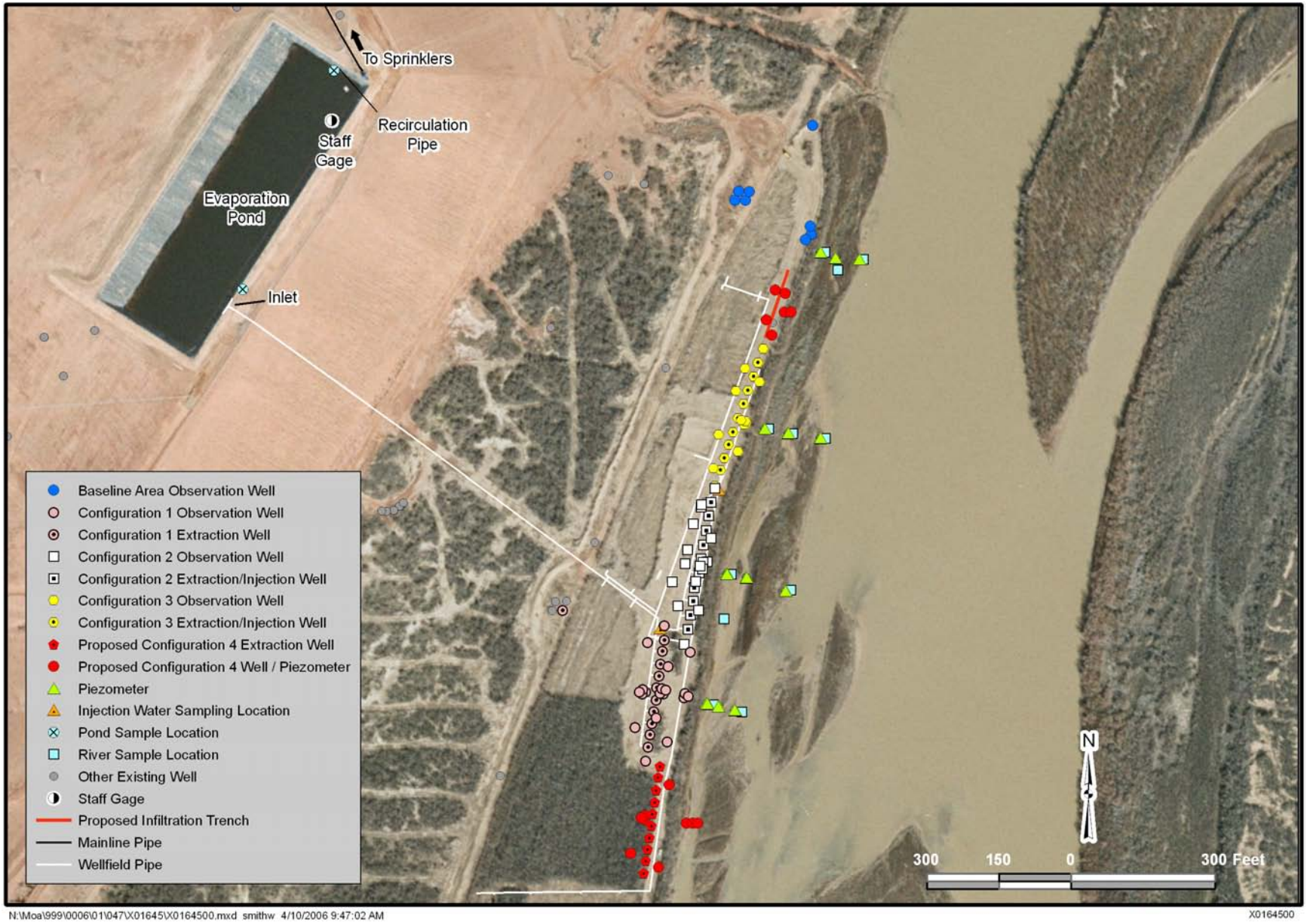

Figure 2. Locations of Existing Configurations 1, 2, and 3, the Baseline Area, and the Proposed Locations for the Infiltration Trench and Configuration 4

trench and Configuration 4 will help guide the implementation of the final remedial action system for ground water. Figure 2 shows the locations of existing well field configurations and the Baseline Area, as well as the proposed location for the Infiltration Trench and Configuration 4 dual-purpose (extraction or injection) wells. Proposed observation wells and river piezometers are also shown on this figure.

2.0 Background

Ground water remediation at the Moab Site is aimed mostly at improving surface water quality, particularly in areas that are potential habitat for endangered fish. Therefore, the most important processes to understand are those that relate to ground water and surface water interactions, such as those occurring in the hyporheic zone that underlies the river. The activities associated with the interim action expansion are focused on improving the understanding of those interactions and on identifying ways in which the interim action can reduce ammonia concentrations in surface water.

A simple cross-section showing important features of the conceptual site model in the area where ground water is presumed to discharge to the Colorado River is shown in Figure 3. This figure represents baseline site conditions in the absence of active ground water remediation. Characterization at the site has identified two different water types in the alluvial aquifer near the river based on total dissolved solid (TDS) concentrations (DOE 2003a). The first is a relatively thin layer of water with a moderate to high salinity (TDS < 35,000 milligrams per liter [mg/L]), which overlies a deeper, thicker layer of brine (TDS > 35,000 mg/L). The boundary between the two layers (the “brine surface”) is relatively sharp and is found at progressively shallower depths from the vicinity of the tailings pile toward the Colorado River. Based on shallow test pit sampling adjacent to the river at the north end of the pile, in which all ground water samples had concentrations of < 35,000 mg/L TDS, it is assumed that the brine surface intersects the river bottom in this area at a short distance from the river’s west shore. The brine surface also generally rises closer to ground surface toward the south end of the pile and is essentially at the surface south of the southernmost extent of the pile. A seep that was observed in January 2003 during a very low stage of the river (1,820 cubic feet per second) indicated the intersection of the brine surface with the steep bank of the river. The seep sample had a TDS concentration of greater than 40,000 mg/L, as estimated from specific conductance data.

The relatively sharp transition from very saline water to brine is believed to be an important feature in the alluvial aquifer for a number of reasons. It appears that the highest concentrations of ammonia—the primary constituent of concern (COC) at the site—are associated with the brine surface (DOE 2003a). Limited sampling of ground water near the river indicates increasing concentrations of ammonia from the water table to a short distance below the brine surface, and decreasing concentrations with continued depth. Because water density increases with increasing salinity, the brine surface tends to act as a barrier to flow from above; there is apparently little flow across the brine surface at locations away from the river. As a result, the two aquifer layers located above and below the brine surface tend to represent two distinct sources of ammonia discharge to the river.

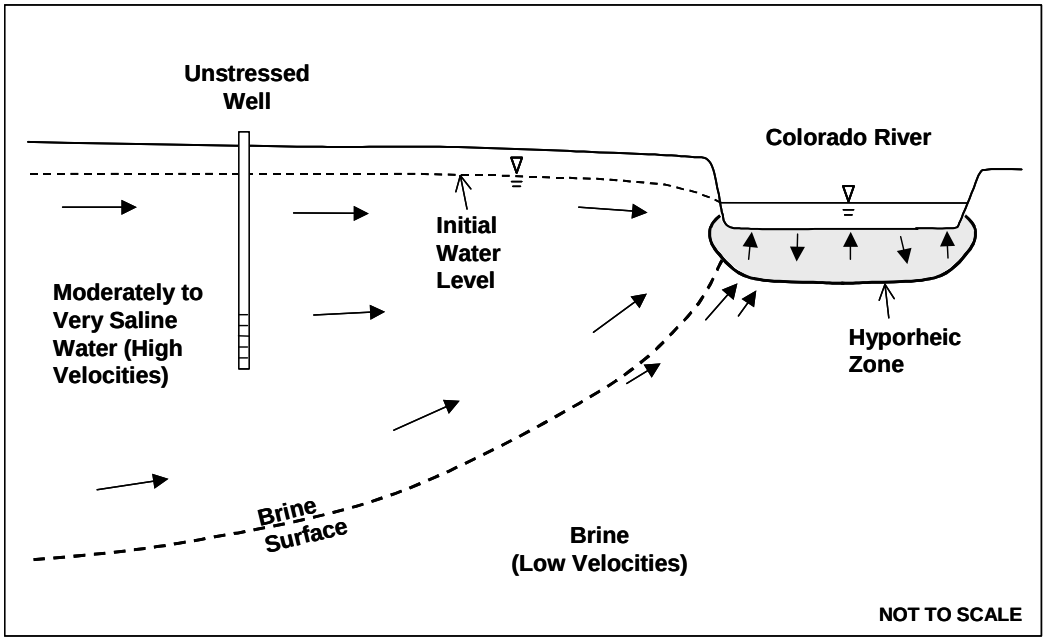

Figure 3. Site Conceptual Model Showing Ground Water Discharge to the Colorado River

Also due to density differences, any active remediation that results in drawdown of the surface of the upper layer could cause upconing of the brine layer and a potential shift in the location of the brine surface. Pumping of the aquifer could therefore bring the brine closer to ground surface and affect phreatophyte vegetation. Pumping can also alter where the brine discharges to the river. One study of vegetation in the Matheson Wetlands Preserve across the river from the Moab Site attributed mortality of cottonwood trees in the preserve, in part, to increases of natural salinity in the ground water (Bellagamba 1997). It has also been hypothesized that pumping of the aquifer could cause higher concentrations of ammonia to discharge to the river at sensitive locations by raising the brine surface. Therefore, it is important to understand how the alluvial system will likely respond to the application of stresses during remedial action, particularly those associated with the interim action.

Limited data were obtained during operation of Configurations 1 and 2 in 2004 regarding response of the brine interface to extraction and injection. Additional data were collected in 2005 and 2006 for the well field remediation wells (including Configuration 3), observation wells, and the riverbed piezometers to further this objective. Some piezometers continue to yield insufficient water quantities for sampling purposes, and some wells that are installed to depths periodically at or below the brine surface reflect erratic concentrations of COCs. Activities proposed as part of this interim action expansion are intended to enhance the ground water flow from the piezometers.

3.0 Purpose and Scope

The main purpose of the interim action is to improve surface water quality in the areas that provide quality habitat to endangered fish species and to reduce contaminant mass in the aquifer until a full-scale remediation system can be designed and installed. It is anticipated that the interim action may operate for as long as a 10-year period before implementation of the final ground water remedy. An alternatives analysis for long-term ground water remediation has been performed (DOE 2006). In that document preferred alternatives are suggested, but a final remedy has not been selected. The tasks described here for expansion of the interim action will continue to build upon the current understanding of ground water and surface water interactions while coinciding with the overall strategy for ground water remediation as described in the Alternatives Analysis (DOE 2006) document.

This work plan describes tasks to evaluate flow and transport in ground water and surface water (i.e., the Colorado River) under four conditions: (1) baseline conditions (no remediation system operating); (2) continued operation of Configuration 1 extraction wells; (3) continued operation of Configuration 2 freshwater injection wells and conversion of Configuration 3 wells to freshwater injection; and (4) operation of a new freshwater Infiltration Trench and new extraction/injection wells (Configuration 4) as part of an expanded well field. Baseline characterization tasks will provide the basis for evaluating the effects of the three active remediation configurations. Tasks associated with Configurations 1, 2, and 3 involve continued system operation and monitoring in accordance with the operations plan (DOE 2005d). This work plan forms the basis for design of Configuration 4 (including an Infiltration Trench); outlines tasks involved in installation of replacement riverbed piezometers for all configurations; and provides the necessary information for sampling, analysis, and data evaluation.

4.0 Baseline Area and Existing Interim Action Well Field System

This section describes the objectives for the different portions of the existing well field system and outlines proposed tasks associated with continued data collection and reporting. As shown on Figure 2, there are numerous observation wells and piezometers located adjacent to the existing configurations of remediation wells. There are several purposes associated with the different areas. The purpose of Baseline Area characterization is to continue to evaluate the effects of the well field system operation. The Baseline Area has been established to monitor the ground water chemistry and water level elevation changes that are not under the influence of remediation activities associated with Configurations 1, 2, or 3.

The primary purpose of operating any of the well field configurations in extraction mode is to intercept ammonia in high-concentration areas, thereby reducing mass loading to the river. Results of system operation and monitoring indicate that extraction can pull river water into the aquifer and reverse the ground water flow gradient, at least locally. Figure 4 shows this reversal conceptually. This reversal should result in reduced discharge of ammonia to near-shore areas. However, it is not clear how ground water extraction affects the brine surface below the river and locations of ammonia discharge to the river.

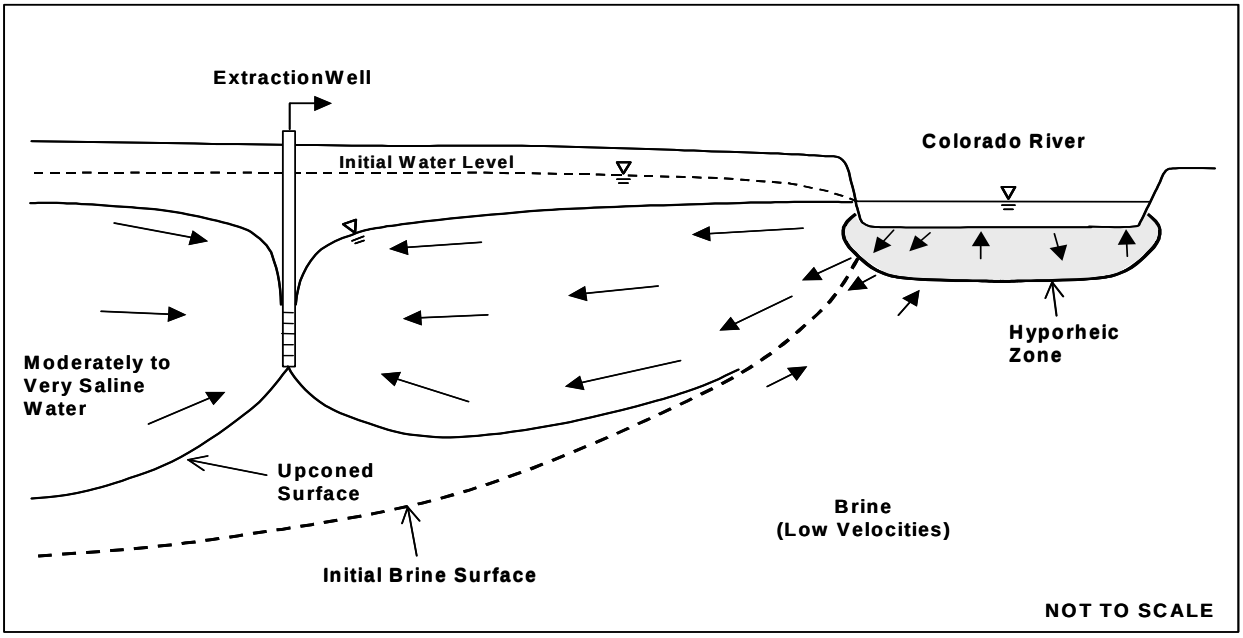

Figure 4. General Effects of Operating Remediation Wells for the Purpose of Contaminant Mass Removal

The purpose of operating Configuration 2 or 3 in injection mode is to determine the feasibility of and capacity for diluting ammonia concentrations in the backwater habitat via injection of freshwater into the aquifer close to the Colorado River. A conceptual depiction of the effects of operating Configuration 2 for freshwater injection is shown in Figure 5. Mounding of freshwater at the injection well helps provide a hydraulic barrier between the ammonia plume and the river near its western shore.

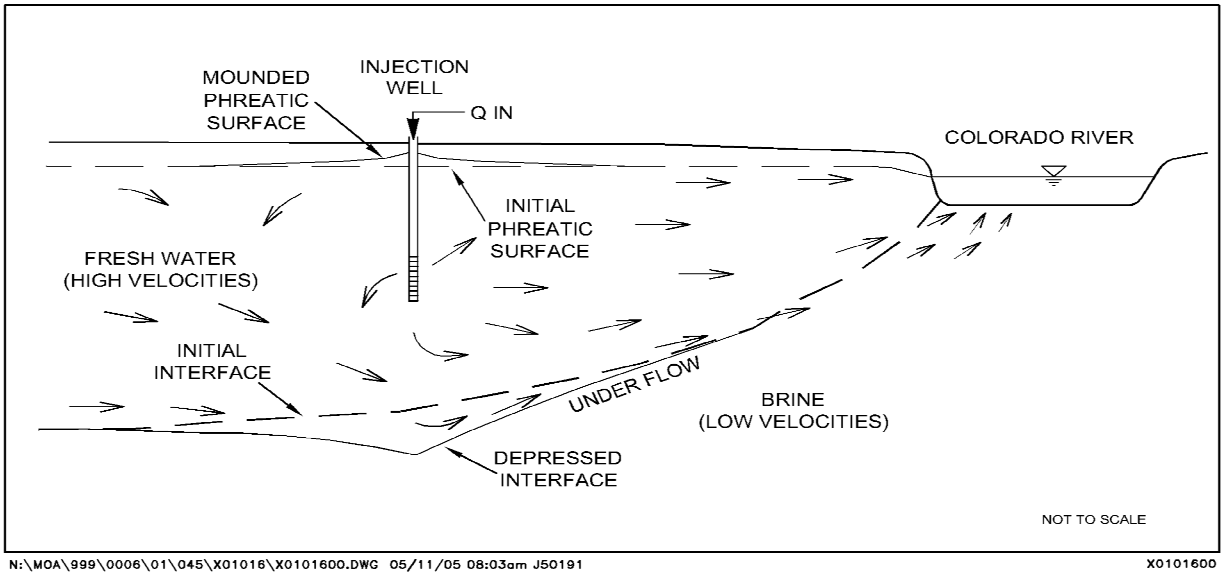

Figure 5. General Effects of Freshwater Injection via Remediation Wells

The Baseline Area is located upstream of the well field configurations and proposed Infiltration Trench, as shown on Figure 2. Sampling will occur to better understand the characteristics and processes in the hyporheic zone shown on Figure 3 (e.g., location of the brine surface, flow paths and hydraulic gradients, ammonia concentrations). Sampling of the baseline monitoring network in 2004 was limited and did not provide adequate data to separate natural system variability (largely due to fluctuations in river stage) from changes caused by operation of the active remediation systems. Monitoring of the Baseline Area in 2005 and 2006 has occurred more frequently, generally monthly, to provide this needed information.

4.1 Specific Objectives

Baseline Area monitoring will continue to be used to refine the understanding of the unstressed ground water system. In particular, the water-quality monitoring network is designed to determine vertical and horizontal distributions of ammonia and TDS concentrations and to determine the significance of the brine surface with respect to ammonia distribution. The alluvial system in the Baseline Area has shown significant natural variability related to changes in river stage. The data collected from the Baseline Area will continue to be used, during evaluation of the well field, to distinguish natural variations in flow processes and water chemistry from the effects of system operation.

The monitoring network for Configurations 1 and 3 (when used in extraction mode) will be used to monitor changes, if any, in the distribution of ammonia and TDS concentrations during continued ground water extraction. It will also be used to monitor: (1) changes in ground water flow paths above and below the brine surface during pumping, and (2) the extent of the cone of depression maintained by the extraction wells.

The monitoring network for Configurations 2 and 3 (when used in injection mode) will be used to determine if these wells are effective in reducing contaminant concentrations in Colorado River backwater areas. An apparent reduction was observed during the past year of operation of Configuration 2. Another objective will be to evaluate how injection affects the position of the brine surface beneath the river and discharge of ammonia to surface water.

4.2 Tasks

4.2.1 Task 1. Install Replacement Riverbed Piezometers

Maps of the existing well field configurations and Baseline Area are provided as Figure 6 through Figure 9. Temporary small-diameter piezometers designed for sampling ground water from specific depth intervals were previously installed adjacent to the backwater channels of the Colorado River opposite the site. These provide: (1) chemical data for the ground water discharging to the river, (2) information regarding flow and transport in the hyporheic zone, and (3) data to measure the vertical flow gradient below the riverbed. When the temporary piezometers were initially installed, it was uncertain if they would provide sufficient data or last longer than one season due to changes in the river morphology. Although they have in general provided beneficial data, there have been limits on the rate or volume of ground water available from some for sampling purposes. Therefore, a design change is proposed which includes installing replacement piezometers. These will be manufactured by Solinst and will feature a 1-ft manufactured screen interval with a cone-shaped tip for ease in driving into the sediment.

Figure 6. Existing Baseline System

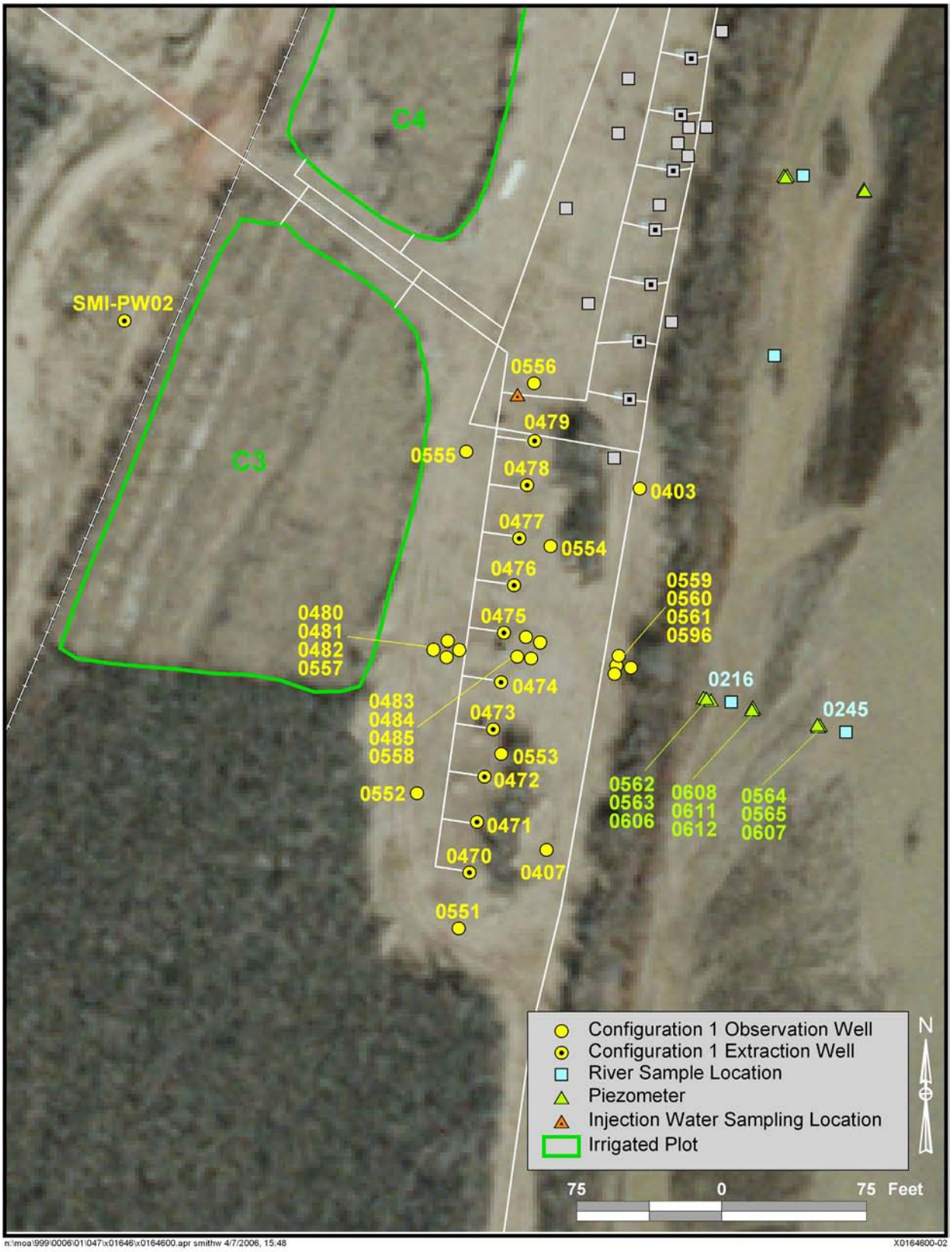

Figure 7. Existing Configuration 1 System

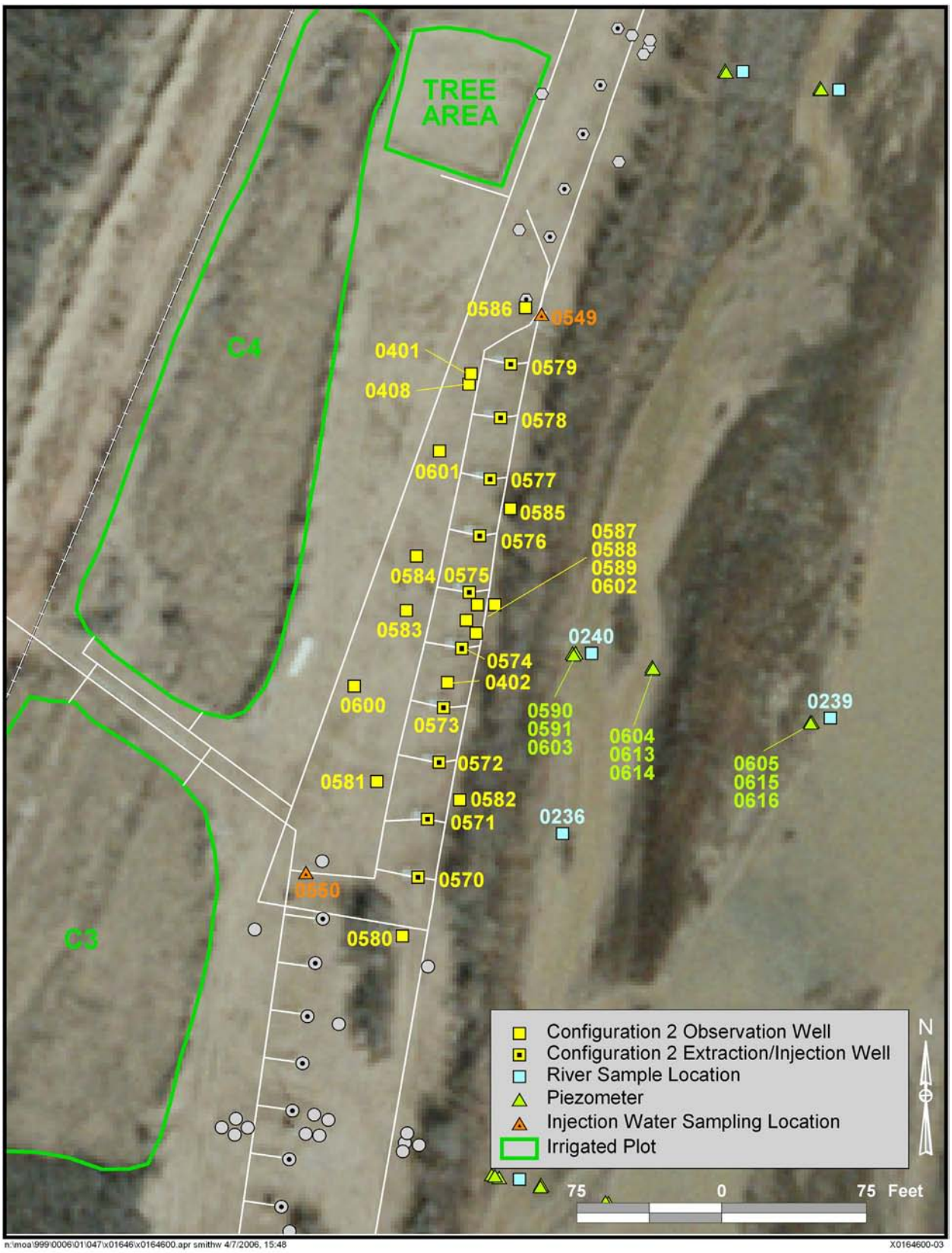

Figure 8. Existing Configuration 2 System

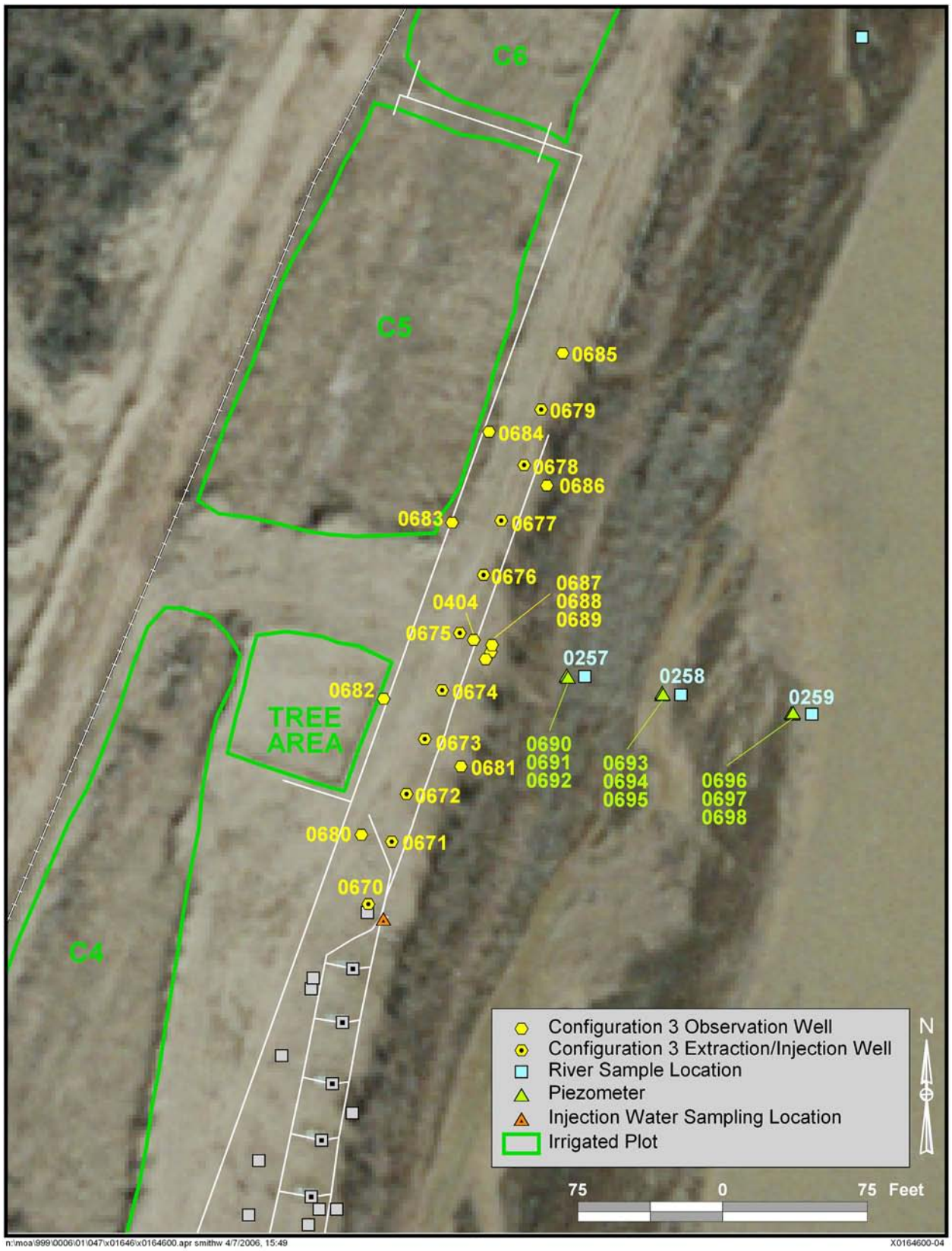

Figure 9. Existing Configuration 3 System

A protective sheath eliminates smearing on the screen during installation and is retracted to expose the screen once the designated depth is reached. The remainder of the piezometer construction consists of standard 1-inch-diameter steel pipe that can be pre-cut into 3- to 5-ft segments that are threaded on each end. These manufactured-screen piezometers should greatly increase the volume of ground water that can be extracted during sampling, which will be a significant improvement over the open-ended pipe piezometers currently in use. Threaded caps are proposed to protect the piezometers during high stages of the river.

The replacement piezometers will be located immediately adjacent the original and will be installed to approximately the same depth. Well numbering will remain the same for consistency of data history. The original piezometers will be removed or abandoned by cutting off the pipe at ground level.

4.2.2 Task 2. Data Collection

Data collected through this sampling will improve the understanding of ground water and surface water interactions and help locate the intersection of the brine surface with the riverbed under background flow conditions for the Baseline Area wells and under active remediation conditions for Configurations 1, 2, and 3 wells. Sample collection will continue from the monitor well and piezometer locations for baseline chemical parameters and hydraulic and chemical performance data. Measurements will include water levels, field parameters, and laboratory analysis. Sampling of the piezometers will be conducted as river conditions permit. Except during near-bank, full-flow conditions, the shoreline piezometers are accessible year-round. A surface water sample will be collected (when present) near the base of each piezometer cluster location to compare local surface water chemistry with underlying ground water chemistry and to monitor the integrity of the piezometer completion. Sampling procedures and analytical requirements for the samples are provided in Section 7. Sampling frequency requirements are summarized in Tables 1 through 4.

Table 1. Monitoring Requirements for the Baseline Area

Location	ID	Purpose	Frequency
Near-shore monitoring well	0405, 0488, 0493	Monitor changes in plume concentrations	Monthly for laboratory analysis
Inland monitoring well	SMI-PZ1M, SMI-PZ1D, SMI-PZ1S, SMI-PW01	Monitor changes in plume concentrations	Quarterly for laboratory analysis
Piezometer[a]	(0494 / 0495 / 0597) **(0496 / 0497 / 0598)** (0498 / 0499 / 0599)	Monitor water chemistry in the hyporheic zone and saline water beneath the river	Monthly for field parameters; quarterly for laboratory analysis
River[b]	0241, 0242, 0243	Monitor changes in surface water quality downgradient of well field at river	Monthly for field parameters; quarterly for laboratory analysis

[a] Piezometers **0496, 0497, and 0598** are scheduled to be sampled monthly for laboratory analysis.
[b]Surface water sample locations in the river may vary as conditions change; one surface water sample adjacent to one piezometer cluster will be sampled monthly for laboratory analysis

Table 2. Sampling Frequency Requirements for Configuration 1

Location	ID	Purpose	Frequency
Extraction well	0470–0479, SMI-PW02	Monitor changes in plume concentrations and brine surface	Twice monthly for field parameters
	0470, 0472, 0474, 0476, 0478	Monitor changes in plume concentrations	Monthly for laboratory analysis
	0471, 0473, 0475, 0477, 0479		Quarterly for laboratory analysis
Observation well[a]	0480, 0481, 0483, 0484, 0557, 0558, 0559, 0560	Monitor changes in plume concentrations	Monthly for laboratory analysis
	0403, 0407, 0482, 0485, 0552, 0555, 0561, 0596		Quarterly for laboratory analysis
	0403, 0407, 0480, 0481, 0482, 0483, 0484, 0485, 0551, 0552, 0554, 0555, 0556, 0557, 0558, 0559, 0560, 0561, 0596	Monitor changes in ground water surface elevations.	Weekly
Piezometer[b]	**(0562 / 0563 / 0606)** (0608 / 0611 / 0612) (0564 / 0565 / 0607)	Monitor the hyporheic zone and saline water beneath river	Monthly for field parameters; quarterly for laboratory analysis
River[c]	0216, 0245	Monitor changes in surface water quality downgradient of well field at river	Monthly for laboratory analysis
Evaporation pond	0547, 0548	Monitor changes in concentrations at inlet and discharge pipe	Weekly for field parameters; monthly for laboratory analysis

[a]Actual locations sampled monthly may vary based on field conditions.
[b]Piezometers **0562, 0563,** and **0606** are scheduled to be sampled monthly for laboratory analysis.
[c]Surface water sample locations in the river may vary as conditions change.

Table 3. Sampling Frequency Requirements for Configuration 2

Location	ID	Purpose	Frequency
Remediation well	0570−0579	Monitor changes in ground water surface elevation	Weekly
	0570, 0572, 0574, 0576, 0578	Monitor changes in plume concentrations (during extraction mode only)	Twice monthly for field parameters; monthly for laboratory analysis
	0571, 0573, 0575, 0577, 0579		Twice monthly for field parameters; quarterly for laboratory analysis
Observation well[a]	0408, 0583, 0584, 0587, 0588, 0589,	Monitor changes in plume concentrations	Monthly for laboratory analysis
	0401, 0581, 0582, 0585, 0586, 0600,		Quarterly for laboratory analysis
	0401, 0402, 0408, 0580–0589	Monitor changes in ground water surface elevation	Weekly
Piezometer[b]	**(0590 / 0591 / 0603)** (0604 / 0613 / 0614) (0605 / 0615 / 0616)	Monitor the hyporheic zone and saline water beneath river	Monthly for field parameters; quarterly for laboratory analysis
River[c]	0236, 0239, 0240	Monitor changes in surface water quality downgradient of well field at river	Monthly for laboratory analysis
Freshwater hydrant	0550	Monitor water quality changes in background injection water	Monthly for laboratory analysis

[a]Actual locations sampled monthly may vary based on field conditions.
[b]Piezometers **0590, 0591,** and **0603** are scheduled to be sampled monthly for laboratory analysis.
[c]Surface water sample locations in the river may vary as conditions change.

Table 4. Sampling Frequency Requirements for Configuration 3

Location	ID	Purpose	Frequency
Remediation well	0670−0679	Monitor changes in ground water surface elevation	Weekly
	0670, 0672, 0674, 0676, 0678	Monitor changes in plume concentrations (during extraction mode only)	Twice monthly for field parameters; monthly for laboratory analysis
	0671, 0673, 0675, 0677, 0679		Twice monthly for field parameters; quarterly for laboratory analysis
Observation well[a]	0682, 0683, 0687, 0688, 0689,	Monitor changes in plume concentrations	Monthly for laboratory analysis
	0404, 0680, 0681 0684, 0685, 0686,		Quarterly for laboratory analysis
	0404, 0680−0689	Monitor changes in ground water surface elevation	Weekly
Piezometer[b]	(**0690** / **0691** / **0692**) (0693 / 0694 / 0695) (0696 / 0697 / 0698)	Monitor the hyporheic zone and saline water beneath river	Monthly for field parameters; quarterly for laboratory analysis
River[c]	0257, 0258, 0259	Monitor changes in surface water quality downgradient of well field at river	Monthly for laboratory analysis
Freshwater hydrant	0549	Monitor water quality changes in background injection water	Monthly for laboratory analysis

[a]Actual locations sampled monthly may vary based on field conditions.
[b]Piezometers **0690**, **0691**, and **0692** are scheduled to be sampled monthly for laboratory analysis.
[c]Surface water sample locations in the river may vary as conditions change.

4.2.3 Task 3. Reporting

Validation Data Packages will be prepared monthly for the ground water interim action well field and also include the Baseline Area wells and piezometers. Quarterly sampling of the Baseline Area wells as part of the Routine Sampling (a site-wide quarterly event) will be addressed in a separate validation data package.

Operational data collected under Task 2 will be used to evaluate the continued performance of the system. Chemical and hydrologic effects of system operation on the aquifer will be evaluated. A performance report will be prepared annually to summarize all water elevation and chemical data.

5.0 Infiltration Trench and Configuration 4

This section describes the objectives for the well field system expansion and outlines proposed tasks. The objective of Configuration 4 wells in extraction mode is to intercept ammonia, thereby reducing mass loading to the river. Results of system operation and monitoring for Configurations 1 and 3 indicate that extraction can pull river water into the aquifer and reverse the ground water flow gradient, at least locally. This reversal should result in reduced discharge of ammonia to near-shore areas.

In concert with the Alternatives Analysis (DOE 2006), Configuration 4 is intended to operate with freshwater injection. Injection of freshwater (diverted Colorado River water) into areas

near the river has been demonstrated to depress the brine surface and possibly move ground water discharge of the ammonia plume farther toward the east than occurs under background conditions. The diverted Colorado River water discharging to the near-shore backwater areas dilutes ammonia concentrations, thereby improving the local surface water quality. Monitoring results indicate that injection can dilute concentrations of ammonia, at least locally, but it is not clear what effects previous injection has had on the brine surface and the site where the ammonia ultimately discharges to the river. The additional work described here is intended to improve the understanding of the effects of additional injection on these processes.

Figure 2 shows the proposed Infiltration Trench, well, and piezometer locations associated with this well field expansion. Based on the recent operational experience of Configurations 1 and 2 versus Configuration 3, well construction details similar to Configuration 3 will be employed for Configuration 4, although the depths will be shorter due to a shallower brine surface beneath this area.

5.1 Specific Objectives

Incorporating the proposed Infiltration Trench and Configuration 4 as an injection system into the well field is designed to answer several questions:

- What is the total sustained injection rate that can be maintained by using the Infiltration Trench versus a configuration of wells, such as Configuration 2 or 3?
- Does the infiltration of freshwater from a shallow depth (as compared to injection into wells) also provide for an apparent reduction in contaminant concentrations in river backwater areas?
- How does injection affect the position of the brine surface beneath the river and the discharge of ammonia to surface water? (The brine surface is believed to be much shallower near to and south of the proposed locations for Configuration 4.)

5.1.1 Task 1. Trench and Well Field Design

The screened intervals for Configurations 1 and 2 remediation wells included fine-grained sediments that overlie the productive sandy gravel unit. Using these finer-grained materials for design, these wells were constructed using 0.010-inch slot screen with a 16/40 sand pack. This small screen size and sand pack may play a role in these wells being historically less productive than anticipated. In order to increase production from Configuration 3, a 0.020-inch slot screen with a 10/20 sand pack was used to construct the remediation wells. These wells also were installed over larger and deeper intervals than used for the other two configurations, and were screened primarily within the sandy gravel unit.

Configuration 4 remediation wells will be similarly designed to Configuration 3, but with total depths of approximately 35 ft (due to shallower brine surface than beneath Configuration 3) and a screened interval between 15 and 35 ft. The top 5 ft of the screened interval may potentially include the overlying finer-grained unit. If encountered, a 0.010-inch slot screen with the 16/40 sand pack will be used within the vertical interval of fine-grained material.

The Infiltration Trench shown on Figure 2 will be designed similar to a septic system leach field. A perforated pipe(s) will be placed approximately 10 to 12 ft deep in a gravel-lined

excavation that is then backfilled with native sediments. It is anticipated that the Infiltration Trench will be excavated down into the top of the sandy gravel unit and that it will be approximately 150 ft in length. It is to be situated between Configuration 3 and the Baseline Area wells.

5.1.2 Task 2. Install Injection and Extraction Wells

The configuration and number of injection and extraction wells is based on experience gained from operating the existing configurations. Ten wells that are dual-purpose (injection and extraction) are proposed for installation as shown on Figure 2. The design proposed for Configuration 4 wells is summarized in Table 5.

Table 5. Screen Intervals and Locations of Dual-Purpose Remediation Wells for Configuration 4

ID	Well Design	Location	Purpose
770	6-inch-diameter PVC dual-purpose pipe. Screened 15 to 35 ft bgs with 20-slot, vee-wire screen and a 10/20 sand pack	Remediation wells located on 30-ft centers along the riverbank road south of Configuration 1	Freshwater injection (expected rate 2 to 20 gpm), hydraulic barrier, and ammonia dilution in river water. Also can be used for ground water extraction (expected rate of 2 to 10 gpm) and mass removal of ammonia from aquifer
771			
772			
773			
774			
775			
776			
777			
778			
779			

The depth of the 10 dual-purpose wells will be approximately 35 ft below ground surface (bgs). Wells in the field will be installed with the top of the screen beginning near the contact between the base of the upper fine-grained unit and the top of the lower gravel unit, which is approximately 15 ft bgs. A 20-ft screen length is recommended for all the wells.

Site characterization data have shown that the ammonia concentrations increase with depth near the Colorado River and attain maximum levels just below the brine surface. Ground water extraction focused on ammonia mass removal is therefore proposed for this horizon. Configuration 4 will initially be operated as an injection system with an anticipated freshwater injection rate of between 2 and 20 gallons per minute (gpm). Introduction of clean water into this portion of the aquifer would deflect the flow paths of ground water that would normally discharge to the river at this location, and replace that water with higher quality ground water.

If the system is operated in extraction mode, pumps will provide a rate of between 2 and 10 gpm each, depending on the available evaporative capacity in the evaporation pond and the conductivity of the aquifer.

5.1.3 Task 3. Install Observation Wells

A combination of a small number of existing wells and several new observation wells is proposed to assess performance of the Infiltration Trench and Configuration 4 system (Figure 2). Small-diameter observation wells are proposed to be installed, using a Geoprobe, to various depths ranging from 20 to 30 ft bgs (based on field conditions) with a minimum of 10-ft

screens. These wells, designed to monitor the mounding from the freshwater injection or the cone of depression generated by the remediation wells in extraction mode, will be constructed using a minimum of 1-inch-diameter PVC pipe to allow for monitoring instrumentation. Locations for these proposed wells are shown on Figure 2 and summarized in Table 6.

Table 6. Observation Wells and Piezometers Proposed for System Expansion

ID	Screen Interval (ft bgs)	Well Type	Location	Purpose
TBD	10 to 20	1-inch-diameter observation well	20 ft upgradient (NW) of Infiltration Trench	Measure changes in plume concentration and Infiltration Trench freshwater injection mound
TBD	10 to 20		20 ft upgradient (SW) of Infiltration Trench	
TBD	10 to 30		20 ft downgradient (NE) of Infiltration Trench	
TBD	20 to 30		20 ft downgradient (SE) of Infiltration Trench	
0409	10 to 20		Existing well downgradient (SE) of proposed Infiltration Trench	
0551	10 to 20		Existing well upgradient (NW) of proposed Configuration 4	Measure changes in plume concentration and extent of Configuration 4 injection mound or cone of depression (when used in extraction mode)
TBD	10 to 20		30 ft upgradient (SW) of Configuration 4	
TBD	10 to 30		20 ft downgradient (NE) of Configuration 4	
TBD	20 to 30		20 ft downgradient (SE) of Configuration 4	
TBD	30 to 40		1000 ft south of Configuration 4	
TBD	30 to 40	6-inch-diameter observation well	Within central portion of Configuration 4	Monitor elevation of brine surface, chemical data
TBD	45 to 55		Within central portion of Configuration 4	
TBD	20 to 30		Within central portion of Configuration 4	
TBD	1 to 2	Small-diameter piezometer	At the base of the riverbank adjacent to the Infiltration Trench	Monitor shallow ground water chemistry and vertical gradients east of the riverbank drop off next to both Configuration 4 and the Infiltration Trench
TBD	4 to 5			
TBD	11 to 12			
TBD	1 to 2		At the base of the riverbank adjacent to Configuration 4	
TBD	4 to 5			
TBD	11 to 12			
TBD	1 to 2		Between riverbank and main river water channel opposite Configuration 4	
TBD	4 to 5			
TBD	11 to 12			

Three observation wells in the central portion of Configuration 4 are proposed to be installed using 6-inch-diameter casing and screen to allow for the upgrade to an extraction well, should the future need arise. One of these wells is designed to provide ground water chemistry data from the 30- to 40-ft bgs interval. Another well is designed to monitor the brine surface and provide ground water chemistry data from the 45- to 55-ft bgs interval, and the third well, screened from 20 to 30 ft, is designed to monitor the ground water chemistry at the freshwater/brine surface interval. Locations proposed for these 6-inch monitor wells for Configuration 4 are shown on Figure 2 and summarized in Table 6.

5.1.4 Task 4. Install Piezometers

Temporary small-diameter riverbed piezometers are proposed to be installed perpendicular to the shoreline to sample shallow ground water at depths of from 1 to 2, 4 to 5, and 10 to 11 ft bgs immediately beneath the riverbed and to monitor ground water discharge and vertical flow gradients there. It is proposed that two sets of three nested small-diameter piezometers be installed opposite Configuration 4, and one set at similar depths opposite the Infiltration Trench. A description of the locations and rationale for the proposed piezometers is presented in Table 6.

5.1.5 Task 5. Data Collection

The monitoring network and procedures to evaluate the performance of the Infiltration Trench and Configuration 4 are designed to ascertain ground water flow directions and contaminant concentrations in relation to the brine surface. Contaminant concentrations during operation will be compared to pre-startup concentrations in the area and to baseline area concentrations to evaluate this system expansion effectiveness. Monitoring will be conducted using monitor wells and several sets of piezometers similar to those used in Configuration 1 and the Baseline Area; however, because the distance to the edge of the Colorado River is subject to transient changes, a replication of the monitoring geometry at the existing sites might not be achievable.

Water level data, field parameters, and samples for laboratory analysis will be collected at the monitor wells, piezometers, and remediation wells before the system is started and during operation.

Sampling of the piezometers will be conducted as river conditions permit. Except during near-bank, full-flow conditions, the shoreline piezometers are accessible year-round. A surface water sample will be collected (when present) near the base of each piezometer cluster location to compare the surface water chemistry to the ground water chemistry and to monitor the integrity of the piezometer completion. Data collected through this sampling will improve the understanding of ground water and surface water interactions and help determine the areal extent over which either injection or extraction is influencing river water quality.

The system will be initially operated for injection only. The need to operate the system as an extraction field will be evaluated in the future. The observational approach will be used to establish and adjust operating parameters as necessary to evaluate the specific objectives for this configuration. Sampling and analysis requirements are presented in Section 7. Sampling frequency requirements for operation of Configuration 4 and monitoring both this configuration and the Infiltration Trench are presented in Table 7. As with some of the other site wells, once a trend has been established (minimum of 6 months), laboratory analyses may be reduced to a quarterly basis for some wells.

Table 7. Sampling Frequency Requirements for Infiltration Trench and Configuration 4

Location	Field Parameters	Laboratory Analysis	Water Levels
Remediation wells	Twice monthly (during extraction mode only)	Monthly (during extraction mode only)	Weekly
Monitor wells	Monthly	Monthly	Weekly
Piezometers	Monthly	Monthly	Monthly
Surface water (location numbers to be added)	Monthly	Monthly	N/A

6.0 Project Requirements

6.1 Personnel and Equipment

Sampling will be conducted according to standard sampling protocols and procedures (see Section 7.1). Standard equipment and methods will be employed.

6.2 Environmental Compliance

Additional information (from that given in this section) on environmental compliance, waste management, and emergency response is in the Moab Health and Safety Plan (HSP) (DOE 2005e). Low volumes of wastewater will be generated from sampling activities. Purge water from sampling will be managed by spreading the ground water evenly on the ground surface around the well. Water will not be dispersed onto surface areas that will enable it to flow into Moab Wash or the Colorado River. Other regulatory requirements are summarized in Table 8.

Table 8. Regulatory Requirements for Field Activities

Task/Activity	Regulation	Requirement
All field activities	NEPA	Categorical Exclusion
Wells greater than 30 ft deep	State water well drillers (UAC Title 655)	• Well construction performed by Utah licensed driller • Permit required
Injection well installation and operation	State UIC program	Permit by rule; notify State with description of proposed well
Wells less than 30 ft deep and shallow piezometers	None	None
Use of clean water for injection	Colorado River water rights	Use existing non-consumptive water right (01 to 40)

6.3 Health and Safety

Information on health and safety, and emergency response is in the Moab HSP (DOE 2005e). The site-specific HSP has been prepared for the Moab Project in accordance with the requirements of *U.S. Code of Federal Regulations* (29 CFR 1910.120). All activities performed in association with well drilling, sampling, and monitoring of ground water and surface water will be performed according to the site-specific health and safety requirements developed for this task (DOE 2005e).

7.0 Sampling and Analysis

Water samples will be submitted to a commercial laboratory for analyses of the constituents listed in Table 9. In addition to the chemical constituents listed in Table 9, standard field parameters will be measured. Ground water samples from selected piezometers will be analyzed for biogeochemical parameters on a monthly and quarterly basis. The piezometer sampling frequency is listed in Tables 1 through 4, and the chemical constituents are listed in Table 10. This table lists all constituents that could be analyzed, but given the low volume of ground water that is available from some piezometers, not all are included during each sampling event.

Table 10 also lists the relative priority of each analyte or group for sample collection during each biogeochemical sampling event.

Table 9. Analytes and Methods for Ground Water and Surface Water Samples

Analyte	Sample Container	Preservation	EPA Method	Detection Limit	Line Item Code (LIC)
Ammonia-N	125 mL poly	HNO_3, pH < 2	350.3	0.1 mg/L	WCH-A-005
Chloride	500 mL poly	Cool, 4 °C	9056	0.5 mg/L	MIS-A-039
Bromide			9056	0.5 mg/L	MIS-A-038
Sulfate			9056	0.5 mg/L	MIS-A-044
TDS	125 mL poly	Cool, 4 °C	160.1	10 mg/L	WCH-A-033
Uranium	500 mL poly	HNO_3, pH < 2	GJO-01	0.1 µg/L	GJO-1

Field parameters include: alkalinity, dissolved oxygen, redox potential, pH, specific conductance, turbidity, and temperature.

Table 10. Biogeochemical Analytes and Methods for Ground Water Samples

Analyte	Sample Container	Preservation	EPA Method	Detection Limit	Line Item Code (LIC)	Relative Priority
Nitrate / Nitrite-N	125 mL poly	HNO_3, pH < 2	MCAWW 353.2	0.1 mg/L	WCH-A-005	High
Fe (II)	40 mL glass	HCl, pH<2	Mod 7199	0.5 mg/L	GJO-54	
Mn (II)	40 mL glass	HCl, pH<2	Mod 7199	0.5 mg/L	GJO-53	
Dissolved Gasses	40 mL glass	BAK	AM20GAX	0.1 mg/L	GJO-52	
Biological Oxygen Demand	1 L poly	Cool, 4 °C	MCAWW 405.1	2 mg/L	WCH-A-007	
Chloride	500 mL poly	Cool, 4 °C	MCAWW 300.0A	0.5 mg/L	MIS-A-039	
Bromide			MCAWW 300.0A	0.5 mg/L	MIS-A-038	
Sulfate			MCAWW 300.0A	0.5 mg/L	MIS-A-044	
TDS	125 mL poly	Cool, 4 °C	160.1	10 mg/L	WCH-A-033	
Sulfide	1 L poly	NaOH/ZnOAc	376.1	2 mg/L	WCH-A-038	
Orthophosphate	250 mL poly	H_2SO_4, 4 °C	365.1	0.01 mg/L	WCH-A-028	
Ammonia-N	125 mL poly	HNO_3, pH < 2	MCAWW 350.1	0.1 mg/L	WCH-A-005	
Dissolved Organic Carbon	250 mL glass	Cool 4 °C	MCAWW 415.1	1.0 mg/L	WCH-A-024	
Total Inorganic Carbon	250 mL glass	Cool 4 °C	MCAWW 415.1	1.0 mg/L	GJO-49	
Fe	500 mL poly	HNO_3, pH < 2	6010B	50 mg/L	GJO-16	
Mn	500 mL poly	HNO_3, pH < 2	6010B	5 mg/L	GJO-17	
Se	500 mL poly	HNO_3, pH < 2	6020A	0.1 mg/L	GJO-14	
U	500 mL poly	HNO_3, pH < 2	6020A	0.1 µg/L	GJO-1	
Total Organic Carbon	250 mL glass	Cool 4 °C	MCAWW 415.1	1.0 mg/L	WCH-A-025	
Chemical Oxygen Demand	250 mL poly	H_2SO_4, 4 °C	MCAWW 410.4	5 mg/L	WCH-A-010	
Phosphate	250 mL poly	H_2SO_4, 4 °C	MCAWW 365.2	0.01 mg/L	WCH-A-029	
Total Kjeldahl Nitrogen	250 mL poly	H_2SO_4, 4 °C	MCAWW 351.2	0.2 mg/L	WCH-A-039	Low

Field parameters include: alkalinity, dissolved oxygen, redox potential, pH, specific conductance, turbidity, and temperature.

7.1 Sampling Procedures

Water sampling will be performed in accordance with the *Ground Water and Surface Water Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites* (DOE 2005f) and the *Environmental Procedures Catalog* (STO 6). Deviations from these procedures will be noted in a field variance log with an explanation and a description of its possible impacts on data quality. The following specific procedures from the *Environmental Procedures Catalog* (STO 6) will be used for water sampling:

- GT-1(P), "Standard Practice for Field Documentation Processes."
- GT-2(P), "Standard Practice for Sample Labeling."
- GT-3(P), "Standard Practice for Chain-of-Sample-Custody and Physical Security of Samples."
- LQ-2(T), "Standard Test Method for the Measurement of Water Levels in Ground Water Monitoring Wells."
- LQ-3(P), "Standard Practice for Purging Monitoring Wells."
- LQ-4(T), "Standard Test Method for the Field Measurement of pH."
- LQ-5(T), "Standard Test Method for the Field Measurement of Specific Conductance."
- LQ-6(T), "Standard Test Method for the Field Measurement of the Oxidation-Reduction Potential (Eh)."
- LQ-7(T), "Standard Test Method for the Field Measurement of Alkalinity."
- LQ-8(T), "Standard Test Method for the Field Measurement of Temperature."
- LQ-9(T), "Standard Test Method for the Field Measurement of Dissolved Oxygen."
- LQ-10(P), "Standard Practice for the Use of a Flow Cell for Field Measurements."
- LQ-11(P), "Standard Practice for the Sampling of Liquids."
- LQ-12(P), "Standard Practice for the Collection, Filtration, and Preservation of Liquid Samples."
- LQ-19(P), "Standard Practice for the Inspection and Maintenance of Ground Water Monitoring Wells."
- LQ-24(T), "Standard Test Method for Turbidity in Water."

7.2 Sample Quality Assurance and Control

The objective of sample quality assurance and control measures is to provide systematic control of the tasks to maximize accuracy, precision, comparability, and completeness. All procedures will be checked for accuracy through internal laboratory quality control checks such as the analysis of blind duplicates, splits, and known standards. Analytical methods to be used for the water samples are summarized in Table 9 and Table 10. Sample preservation will consist of storing the samples in a cooler with ice during field sampling, sample packaging, and shipping.

To maintain evidence of authenticity, the samples collected must be properly identified and easily discernible from other like samples. A label will be attached to the sample container

specifying the sample identification number, location, date collected, time collected, and the sampler's name.

Water samples will be kept under custody from the time of collection to the time of analysis. Chain-of-custody records will be used to list all transfers in the possession of the samples. The chain-of-custody form will show that the sample was in constant custody between collection and analysis. While the samples are in shipment to the analytical laboratory, custody seals will be placed over the cooler opening to ensure that the integrity of the samples have not been compromised. The receiving laboratory must examine the seals on arrival and document that the seals are intact. Upon opening the container, the receiving laboratory will note the condition of the sample container (e.g. broken bottles, leaking bottles, etc.).

All sample shipments will be made in compliance with Department of Transportation regulations (49 CFR 171-179) governing shipment of hazardous materials and substances. These regulations govern the packaging, documentation, and shipping of hazardous material, substances, and waste. Special care will be taken to ensure the integrity of the sample through proper packaging and shipping. To determine the proper identification of a hazardous sample, field personnel will review field measurements data and field notes for relevant information concerning the sample material in a container. This information will include field radiological scans and any other information that might be useful in classifying the sample for shipment. If a sample is known or suspected to contain a specific hazardous material, the sampler will note its presence on the sample label. This information is important to the receiving laboratory to determine the proper handling of the sample prior to its analysis.

8.0 Routine Reporting

After laboratory analysis is complete, results of each sampling event will be reported in a data validation package. This package will include trip reports. Evaluation and interpretation of the data can be reported in calculation sets, annual reports, as supplements to data validation packages, or some other reporting mechanism(s), as deemed appropriate.

9.0 References

29 CFR 1910.120. U.S. Department of Labor, Occupational Safety and Health Standards, "Hazardous Waste Operations and Emergency Response."

49 CFR 171-179. U.S. Department of Transportation, "Hazardous Materials Regulations."

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STO 6. *Environmental Procedures Catalog*, U.S. Department of Energy, Grand Junction, Colorado, continuously updated.