DOE–EM/GJTAC2202

Office of Environmental Management – Grand Junction

MOAB UTAH UMTRA

UMTRA Project

Moab UMTRA Project
2015 Ground Water Program Report

Revision 0

May 2016

U.S. Department of Energy

Office of Environmental Management

Prepared by the Technical Assistance Contractor under contract number DE-EM0002067
for the U.S. Department of Energy Office of Environmental Management, Grand Junction, Colorado.

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Moab UMTRA Project 2015 Ground Water Program Report

Revision 0

Review and Approval

5/19/16
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Revision History

Revision Number	Date	Reason for Revision
0	May 2015	Initial issue.

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Acronyms and Abbreviations

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

1.0 Introduction

1.1 Purpose and Scope

The purpose of the Ground Water Program Report is to assess the performance measures the U.S. Department of Energy (DOE) has taken to remediate ground water at the Moab Uranium Mill Tailings Remedial Action (UMTRA) Project site and to protect endangered fish habitat in the Colorado River adjacent to the site. This report describes the Ground Water Program activities for the Moab Project during 2015 and evaluates how the ground water system at the Moab site responds to various pumping regimes and fluctuating river flow.

1.2 Site History and Background

The Moab Project site is a former uranium ore-processing facility located approximately 3 miles northwest of the city of Moab in Grand County, Utah (Figure 1). The Moab mill operated from 1956 to 1984. When the processing operations ceased, an estimated 16 million (mil) tons of uranium mill tailings accumulated in an unlined impoundment. A portion of the impoundment is in the 100-year floodplain of the Colorado River. In 2001, ownership of the site was transferred to DOE. Since April 2009, tailings have been relocated by rail to a disposal cell 30 miles north, near Crescent Junction, Utah.

Site-related contaminants, including ammonia and uranium, have leached from the tailings pile into the shallow ground water. Some of the more mobile constituents have migrated downgradient and are discharging to the Colorado River adjacent to the site.

In 2005, DOE issued the *Record of Decision for the Remediation of the Moab Uranium Mill Tailings, Grand and San Juan Counties, Utah* (6450-01-P), which includes the cleanup alternative to continue, and expand as necessary, its ongoing active remediation of contaminated ground water at the Moab site. As an interim action (IA), DOE began limited ground water remediation that involves extraction of contaminated ground water from on-site remediation wells and evaporation of the extracted water in a lined pond. Diverted river water is also injected into remediation wells to protect fish habitat in riparian areas along the Colorado River.

2.0 Ground Water Program Description

The Ground Water Program at the Moab site is designed to limit ecological risk from contaminated ground water discharging to potential endangered fish species habitat areas along the Colorado River. This protection is accomplished by removing contaminant mass with ground water extraction wells and by freshwater injection between the river and the tailings pile to create a hydraulic barrier that reduces discharge of contaminated water to suitable habitat areas. When necessary, surface water diversion takes place in the side channel adjacent to the IA well field when the area is considered a suitable habitat for endangered young-of-year fish species. Ground water and surface water monitoring is performed in conjunction with injection and extraction operations and through water level and analytical data. Surface water diversion performance is measured by analytical data.

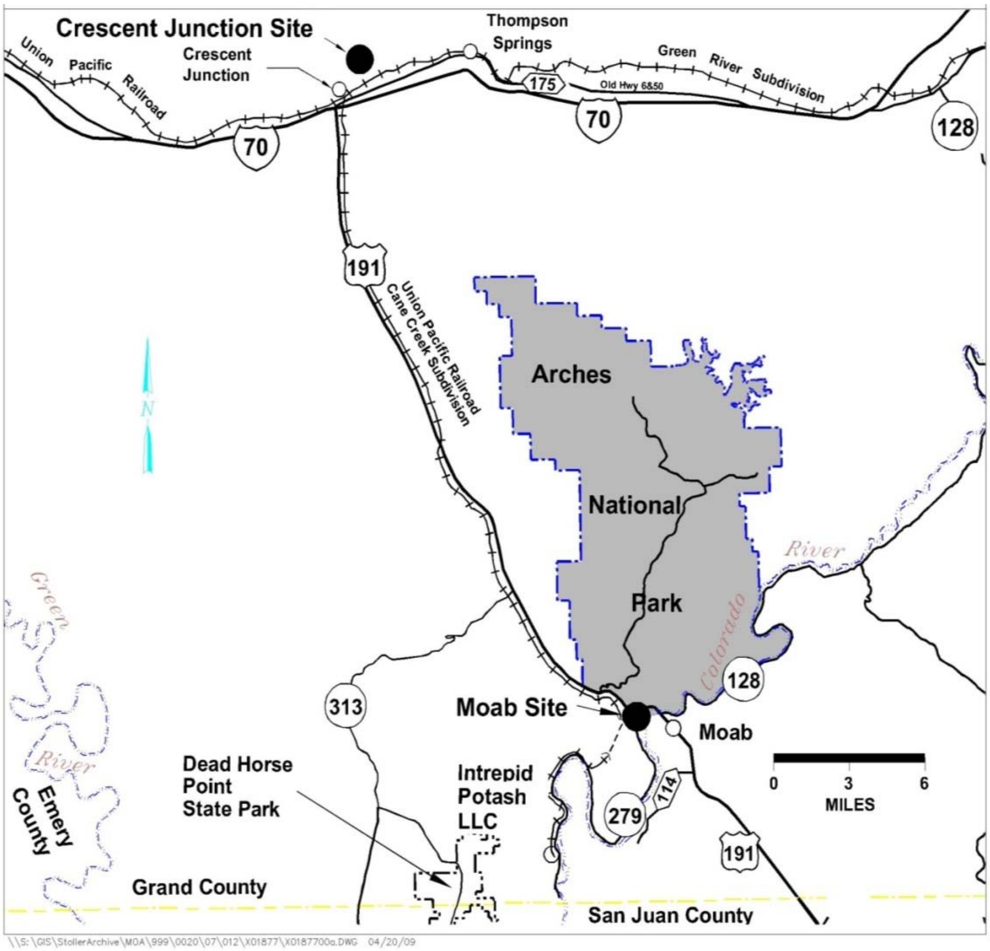


Figure 1. Location of the Moab Project Site

2.1 IA Ground Water System

DOE installed and began operating the first of several configurations (CFs) of extraction/injection wells that comprise the IA ground water system in 2003 (Figure 2). The well field consists of five configurations of wells, an infiltration trench, and a baseline area. The objectives of the IA system are to: 1) reduce the discharge of ammonia-contaminated ground water to side channels that may be suitable habitat for endangered aquatic species, 2) remove contaminant mass through ground water extraction, and 3) to provide performance data for use in selecting and designing a final ground water remedy.

Contaminated ground water from the shallow plume above the brine zone is extracted through a series of eight extraction wells (CF5) and pumped to an evaporation pond or through evaporation units on top of the tailings pile. The IA system also includes injection of diverted river water into the underlying alluvium through remediation wells (CFs 1 through 4) and an infiltration trench installed near the western bank of the river. A surface water diversion system adjacent to the IA well field delivers freshwater to the side channel adjacent to the IA well field. This diversion occurs when the channel is considered a suitable habitat for endangered young-of-year fish species. Monitoring wells are also part of the IA system for evaluation purposes.

Figure 2. Location of IA Wells

2.2 Hydrology and Contaminant Distribution

The primary hydrogeologic unit present at the Moab site consists of unconsolidated alluvium and salt beds of the Paradox Formation. The alluvium at the Moab site is mostly comprised of either the Moab Wash alluvium or the Colorado River basin-fill alluvium. The Moab Wash alluvium is composed of fine-grained sand, gravelly sand, and detrital material that travels down the Moab Wash and interfingers near the northwestern boundary of the site into the basin-fill alluvium deposited by the Colorado River.

The basin-fill alluvium is comprised of two distinct types of material. The upper unit consists mostly of fine sand, silt, and clay and ranges in thickness up to 15 feet (ft) near the saturated zone in some areas. This shallow unit is made of overbank deposits from the Colorado River. The lower part of the basin-fill alluvium consists mostly of a gravelly sand and sandy gravel, with minor amounts of silt and clay. This deeper, coarse alluvium pinches out to the northwest along the subsurface bedrock contact and thickens to the southwest toward the river more than 450 ft near the deepest part of the basin. The upper silty-sand unit typically has a hydraulic conductivity that ranges from 100 to 200 ft/day.

Water table contour maps indicate the ground water in this area discharges into the Colorado River. Figure 3 was generated using data collected in June 2015 and exhibits how ground water underlying the site discharges into the Colorado River. The river flow ranged from 14,600 to 31,000 cubic feet per second (cfs) when the ground water elevation was measured. Figure 4 shows the ground water contours in November/December 2015, when the river flow ranged from 3,130 to 4,710 cfs. The ground water elevation in May was higher due to the bank storage during the above-average peak river flow on the Colorado River.

Most ground water beneath the site contains total dissolved solids (TDS) concentrations greater than 10,000 milligrams per liter (mg/L) (brackish water and brine). A brine interface occurs naturally beneath the Moab site that is delineated at a TDS concentration of 35,000 mg/L, which is equivalent to a specific conductance of approximately 50,000 micromhos per centimeter (µmhos/cm). The interface moves laterally and vertically during the course of each year in response to stresses such as changes in river stage.

The tailings pile fluids contain TDS exceeding 35,000 mg/L, which allows this fluid sufficient density to vertically migrate downward in ground water under previous operating conditions at the site. This former density-driven flow has created a legacy plume of dissolved ammonia that now resides below the brackish water/brine interface. The ammonia beneath the interface represents a potential long-term source of contamination to the upper alluvial ground water system.

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

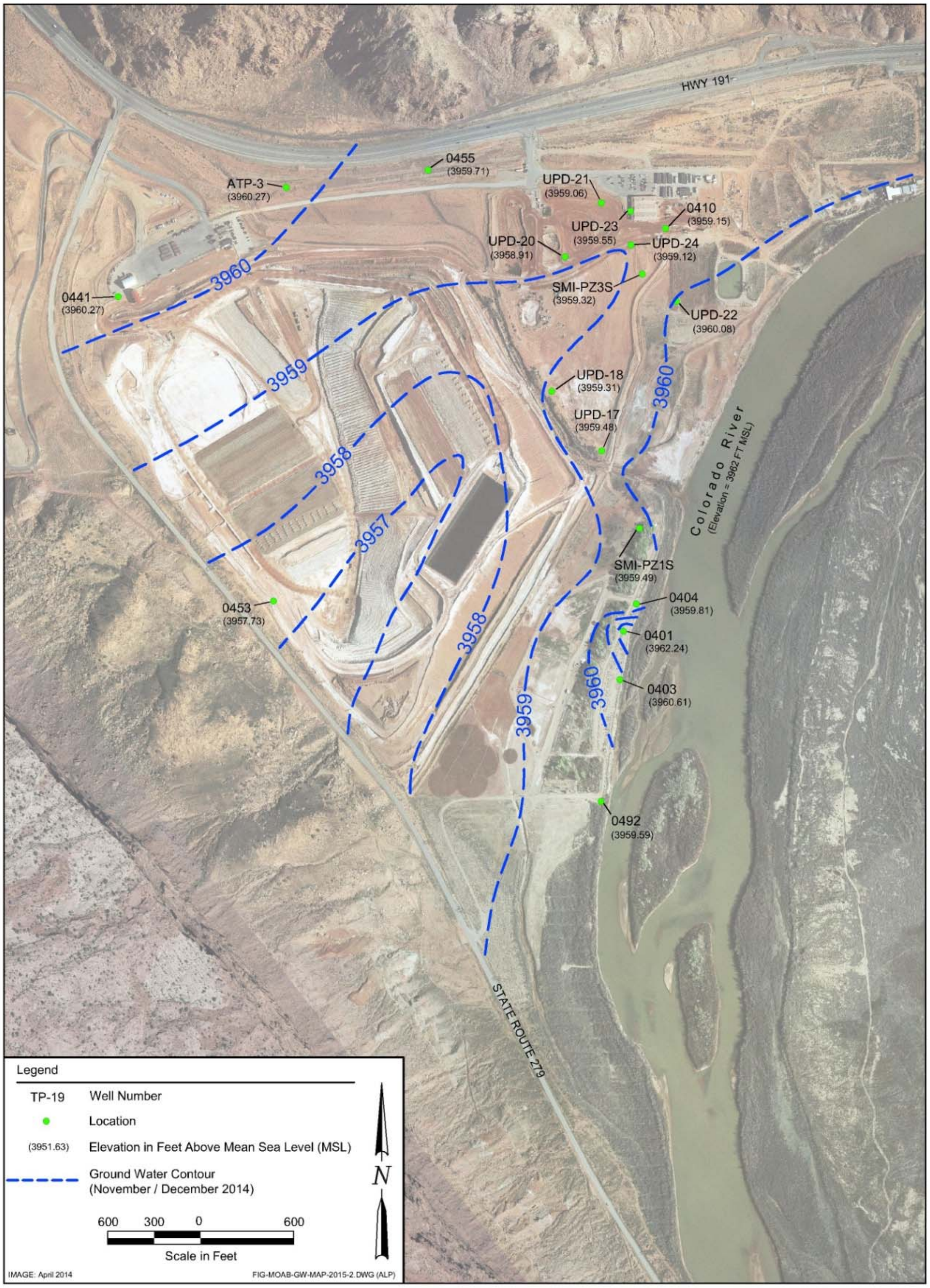


Figure 3. Site-wide Water Contour Map June 2015

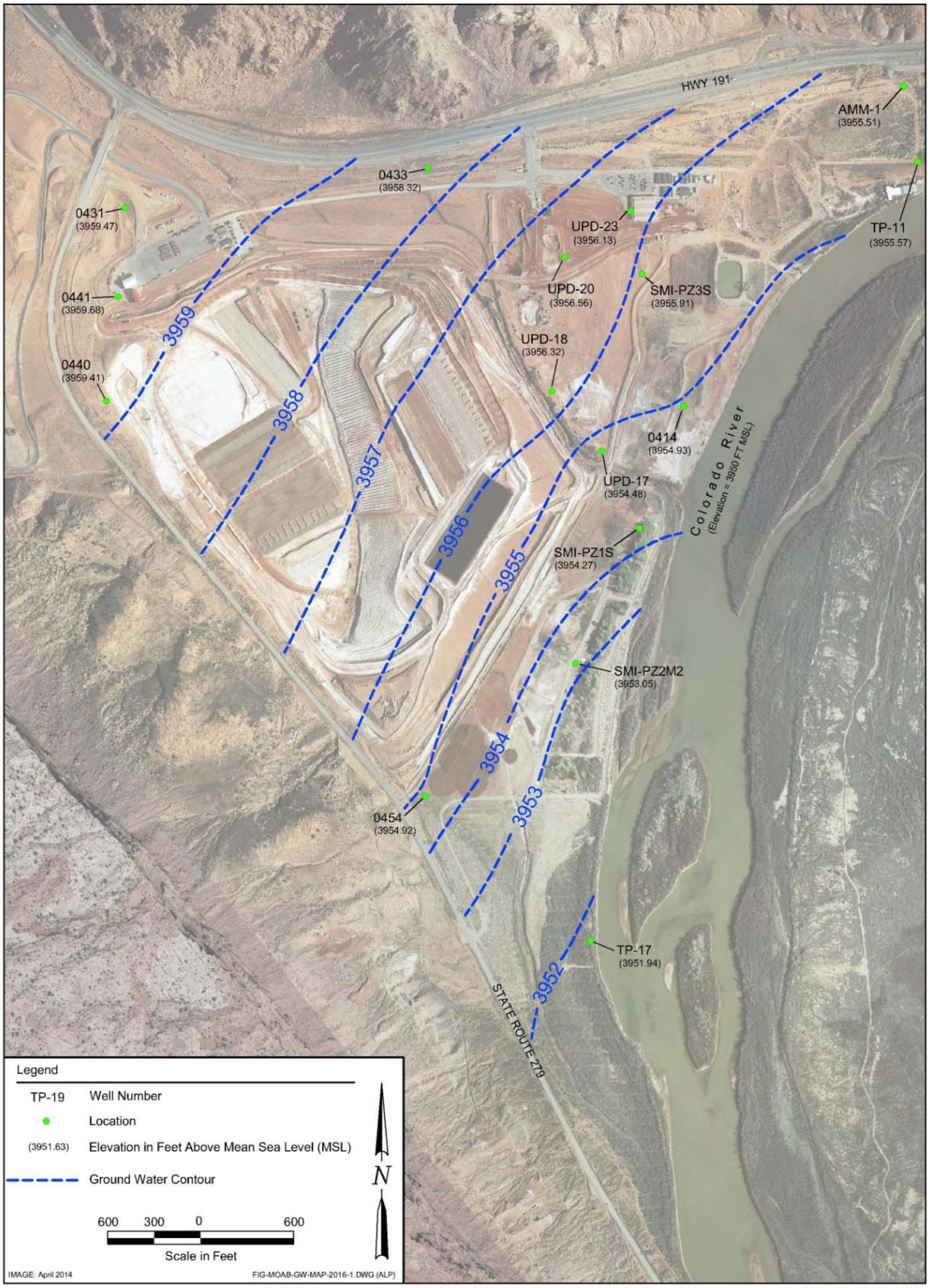


Figure 4. Site-wide Water Contour Map November/December 2015

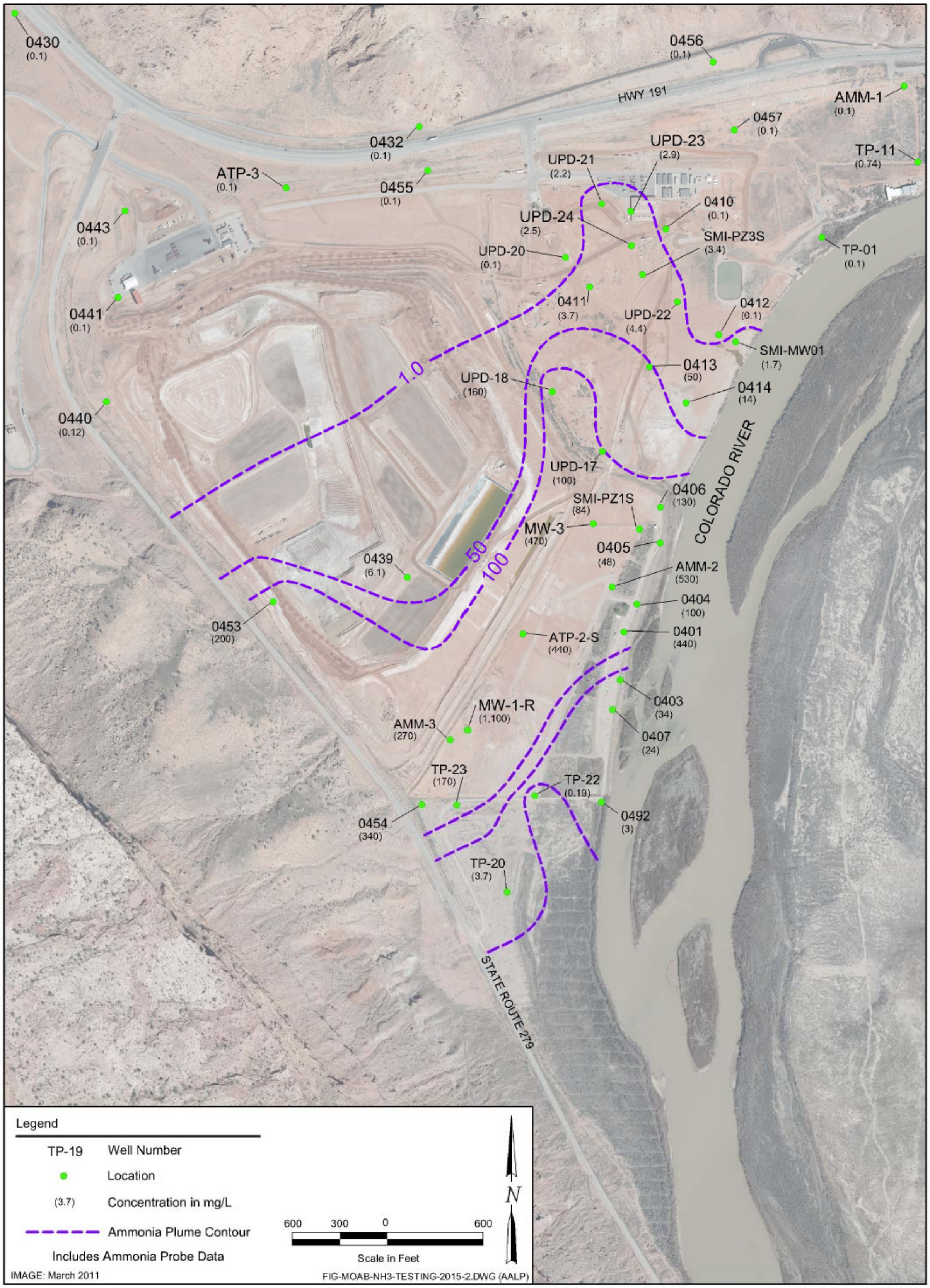


Figure 5. Ammonia Plume in Shallow Ground Water May/June 2015

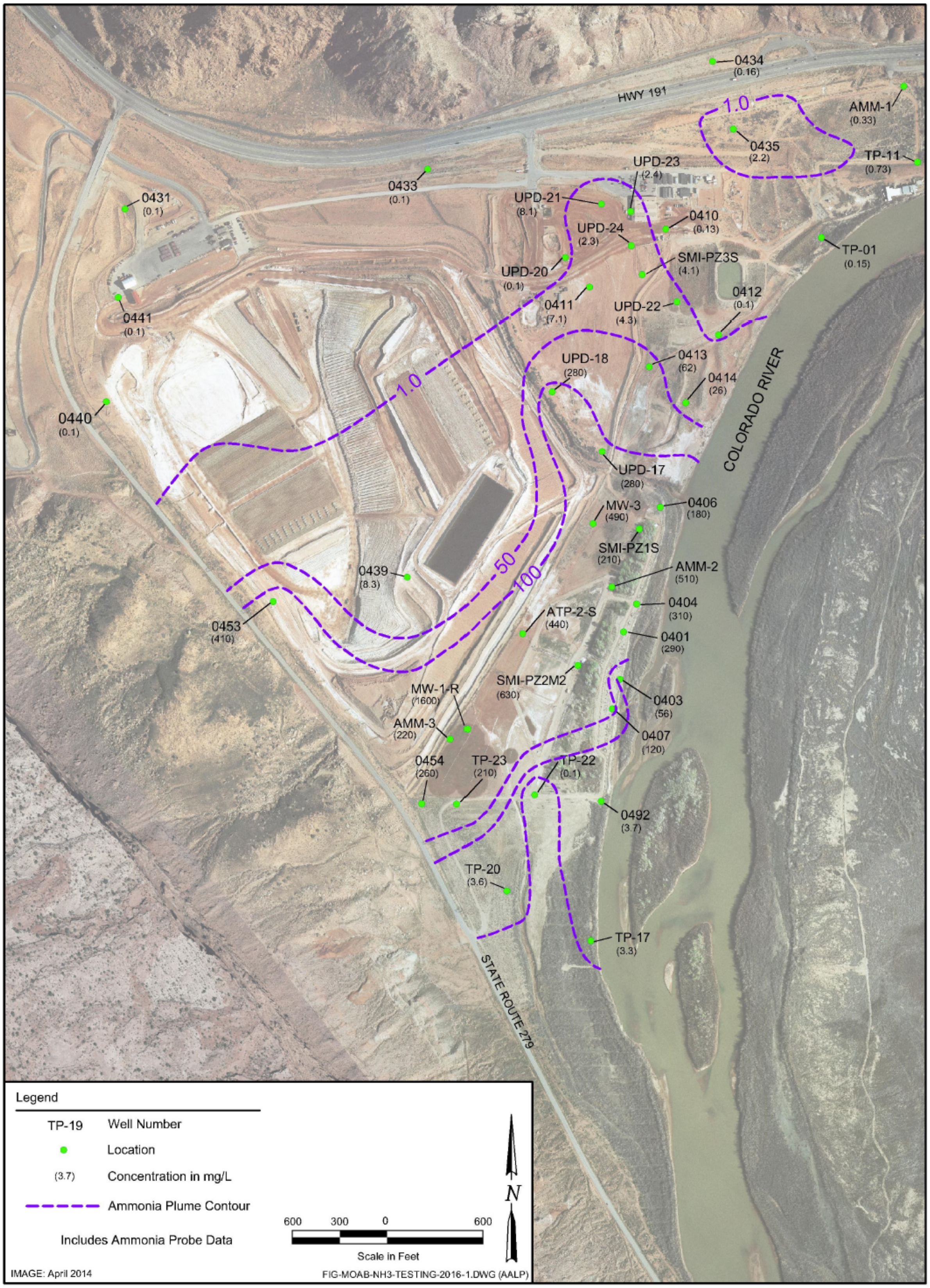


Figure 6. Ammonia Plume in Shallow Ground Water November/December 2015

Oxidation of ammonia to nitrate or nitrogen may also contribute to lower ammonia concentrations observed in the upgradient shallow ground water beneath the tailings pile, where aerobic conditions are more likely; however, there is now flushing of the legacy plume by advective flow of freshwater due to density stratification of the brine zone. Figure 5 shows the ammonia plume in June 2015, and Figure 6 shows the ammonia plume in November/December 2015. The two plume maps are comparable.

There is no standard associated with ammonia, while the uranium ground water standard of 0.044 milligrams per liter is based on Table 1 in Title 40 Code of Federal Regulations Part 192, Subpart A (40 CFR 192A), “Standards for the Control of Residual Radioactive Materials from Inactive Uranium Processing Sites.”

In addition to ammonia, the other primary constituent of concern in ground water is uranium. Figures 7 and 8 show the distribution of dissolved uranium in shallow ground water in 2015. The uranium plume is similar in the spring and winter.

2.3 Surface Water/Ground Water Interaction

Previous investigations have shown that Colorado River flows impact the ground water elevations and contaminant concentrations in the well field. For the majority of the year, when the river is experiencing baseflows (less than 5,000 cfs), ground water discharges into the river (gaining conditions).

As the river flows increase in response to the spring runoff, the river changes from gaining to losing conditions, and a freshwater lens starts to develop in the subsurface underlying the well field. At this time, the ground water gradient direction reverses in the vicinity of the riverbank, and the ground water contaminant concentrations are diluted. Once the river flows subside, the river switches back from losing to gaining, the ground water gradient direction is re-established towards the river (to the southeast), and the freshwater lens recedes.

Figure 9 displays the ground water elevation and the elevation of the Colorado River in 2015. The elevation of the Colorado River was calculated using the river flows from the USGS Cisco gaging station and converting them to an elevation using the site rating curve included in the *Moab UMTRA Project Flood Mitigation Plan* (DOE-EM/GJTAC1640). The 2015 peak flow was 31,800 cfs (on June 13), which corresponds to an elevation of 3963.2 ft mean sea level (msl).

In 2015, the Colorado River was under losing conditions between January and mid-April (when the ground water elevation is greater than the river surface elevation), at which time the river started fluctuating between gaining and losing conditions through mid-May. The river was under losing conditions mid-May through late June (the river surface elevation was greater than the ground water surface elevation), until it switched back to gaining conditions (Figure 9).

3.0 Methods

Well field performance is assessed by measuring extraction/injection rates of remediation wells, measuring water levels, and sampling surface water locations, extraction wells, and monitoring wells. In 2015, the IA well field operations included extraction at CF5 and injection at CF4.

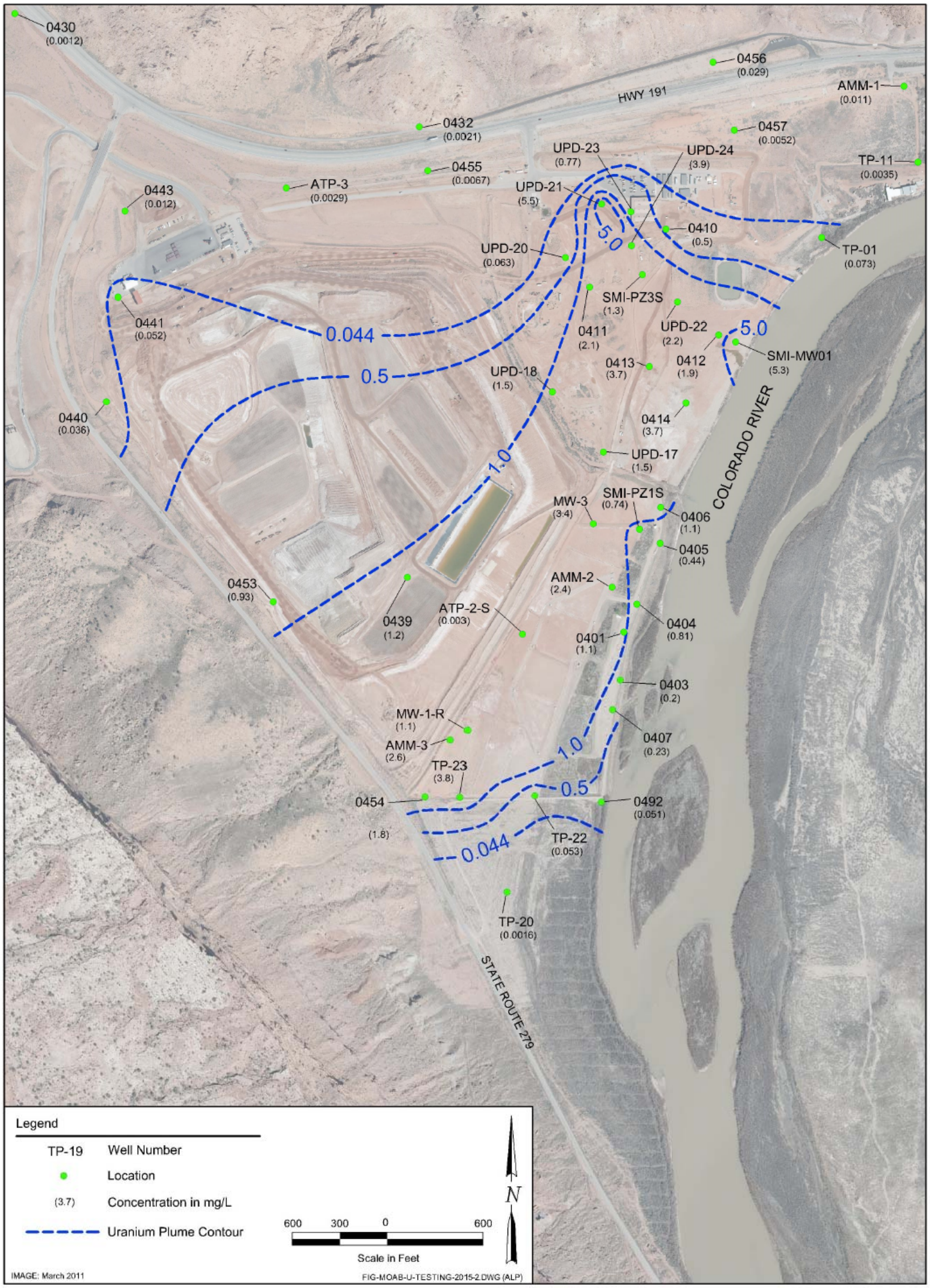


Figure 7. Uranium Plume in Shallow Ground Water May/June 2015

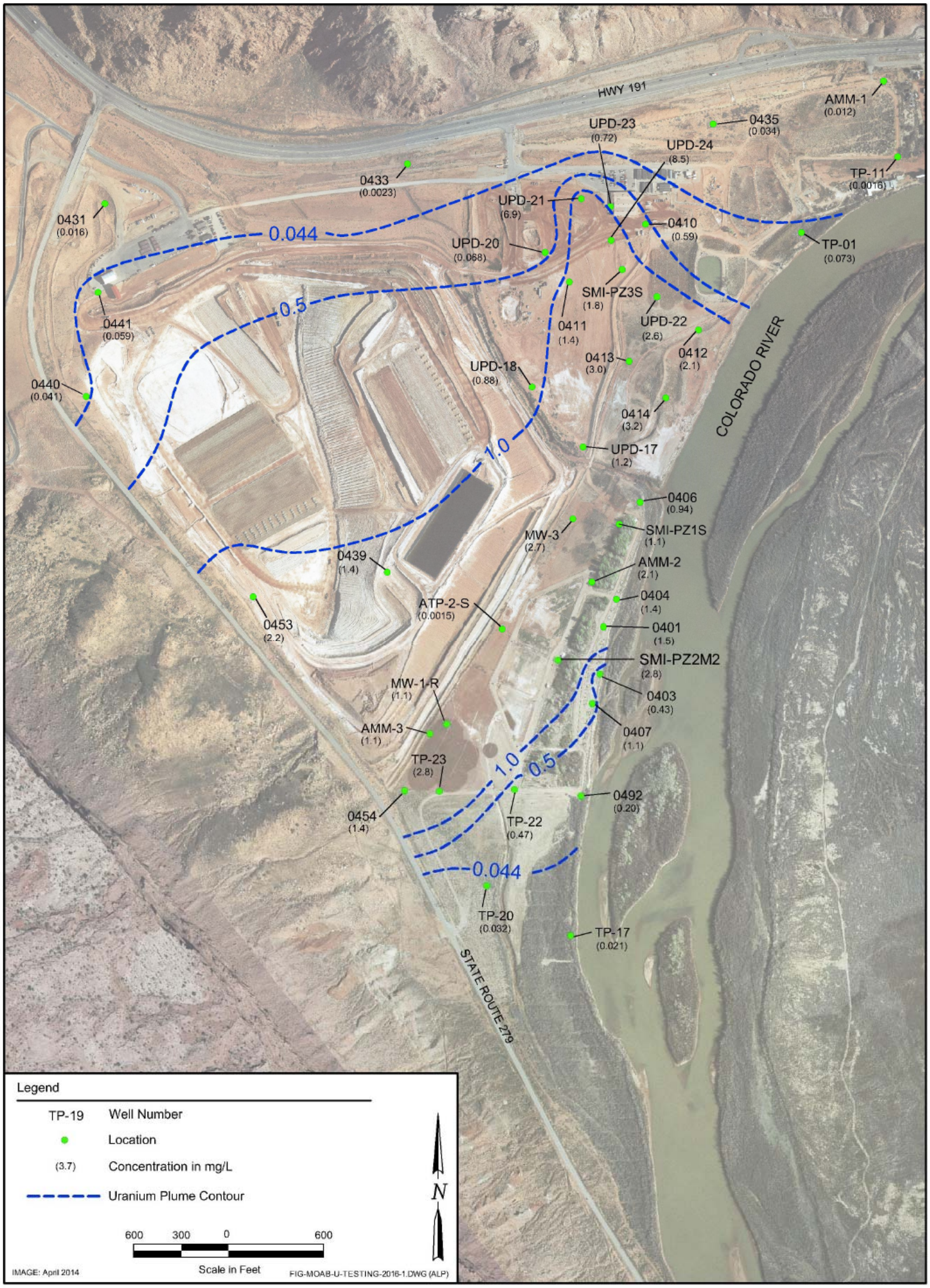


Figure 8. Uranium Plume in Shallow Ground Water November/December 2015

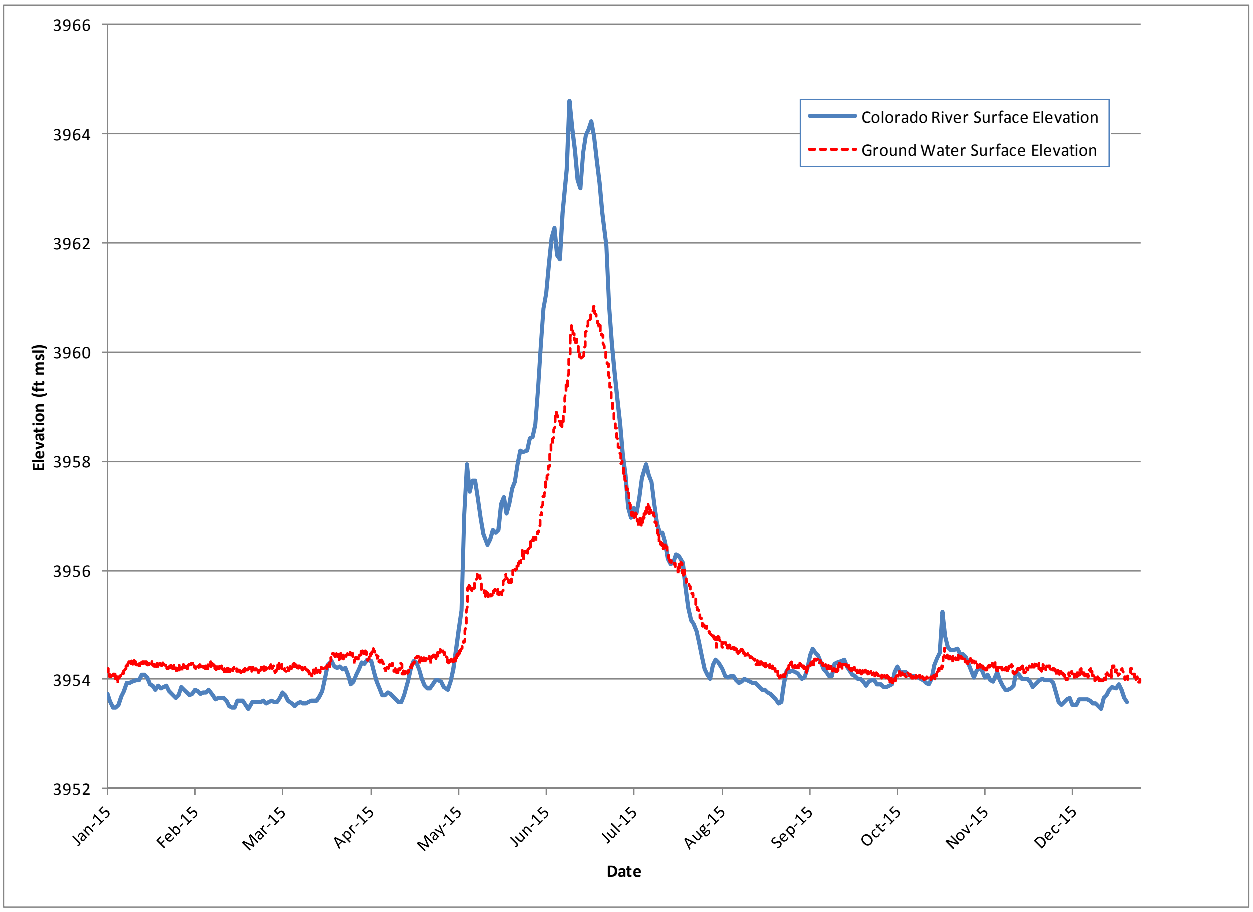


Figure 9. Ground Water Surface Elevation Compared to the Colorado River Surface Elevation 2015

3.1 Remediation Well Extraction

Each extraction well also contains a flow meter that displays the instantaneous flow rate in gallons (gal) per minute (gpm), the cumulative total volume extracted (displayed at "Total 1" on the flow meter), and the net volume since the last reset of the internal memory (displayed as "Total 2" on the flow meter). Flow meter readings are manually recorded on a weekly basis during extraction operations and are used in conjunction with water quality data to evaluate the performance of the system.

When the extraction wells are sampled, the resulting ammonia and uranium concentrations are used to calculate the contaminant mass removal. The contaminated ground water is discharged to the evaporation pond on top of the tailings pile, where it naturally evaporates, is sprayed through the evaporators, or used for dust suppression inside the Contamination Area (CA). Any contaminants that are deposited as salts in the CA will eventually be removed for disposal with tailings and transported to the Crescent Junction disposal site.

3.2 Remediation Well Injection

Each injection well contains a flow meter that displays the instantaneous injection rate in gpm and the total volume. Flow meter readings are recorded manually on a weekly basis during injection operations and are used in conjunction with water level data to estimate the amount of freshwater mounding in each well.

3.3 Water Levels

Ground water levels are recorded in the IA well field on a weekly basis during pumping and injection operations to monitor ground water drawdown and freshwater mounding. A water level indicator is used to measure the depth to ground water (below top of casing). Data logging equipment with pressure transducers are installed at various locations to measure water levels more frequently.

3.4 Water Quality

Selected well and surface water locations are sampled at various times, depending on the purpose of the sampling event. Before sampling, the field parameters, which include temperature, pH, and conductivity are measured and recorded. Observation wells are sampled with dedicated down-hole tubing and a peristaltic pump, while remediation wells are sampled with dedicated submersible pumps. Water samples are collected at various depths and locations to monitor the primary contaminants of concern, ammonia (as N) and uranium. All water sampling was performed in accordance with the *Moab UMTRA Project Surface Water/Ground Water Sampling and Analysis Plan* (DOE-EM/GJTAC1830). Samples are shipped overnight to ALS Global (ALS) in Fort Collins, Colorado, for analysis.

4.0 Ground Water Extraction Operations and Performance

4.1 IA Operations

This section provides information regarding the IA well field extraction performance during the 2015 pumping season. This section also includes a discussion regarding the total ground water extraction rate, hydraulic control, mass removal, and water quality. Appendix A contains tables of well construction information (Table A-1), chronology (Table A-2), pumping volumes (Table A-3), mass removal (Tables A-4 and A-5), and drawdown data (Figures A-1 through A-8).

In 2015, the extraction system operated in the spring and summer months. The evaporator units were used between April and September, as dictated by the weather conditions. The extraction schedule was focused on optimizing ammonia and uranium mass removal and on rotating through each of the CF5 remediation wells.

Extraction operations began in March, with well 0815 at a rate of approximately 25 gpm, and well PW02 was used in April at a rate of 50 gpm. By early May, all eight extraction wells ran on a rotational basis at an average combined rate of approximately 33 gpm.

Throughout the summer, ground water extraction occurred by cycling through seven of the eight CF5 wells. The extraction rate peaked at 70 gpm in April. Extraction was suspended on September 10 to control the evaporation pond level. The extraction wells were winterized on November 5, 2015.

The associated volume of ground water extracted by each well in CF5 is shown in Appendix A, Table A-3. Figure 10 provides a graphic summary of the cumulative volume of ground water extracted from CF5 in 2015. A total of 10.5 mil gal of water were extracted from CF5 during 2015.

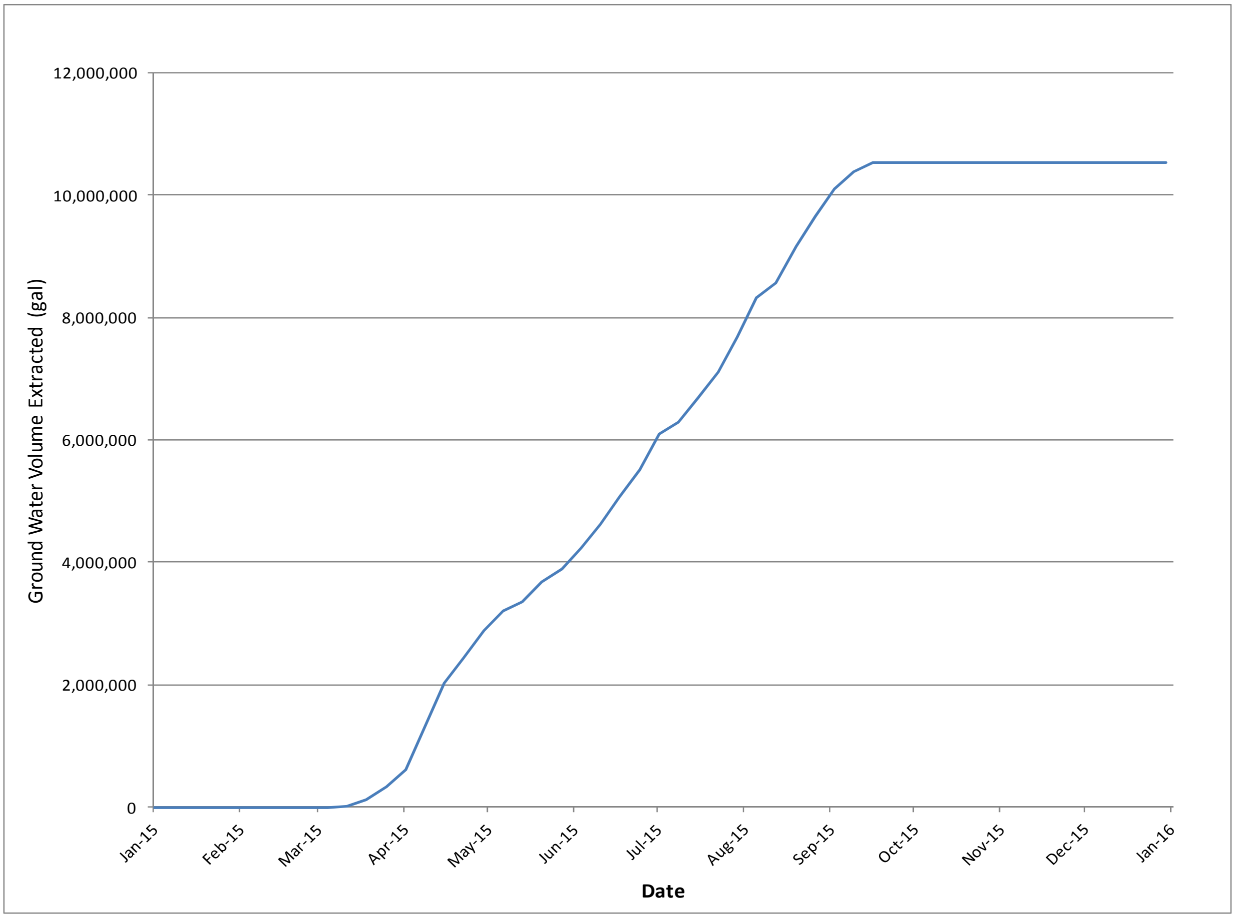


Figure 10. Cumulative Volume of Extracted Ground Water during 2015

4.1.1 CF5 Pumping Rate and Ground Water Extracted Volume

As previously mentioned, CF5 extraction wells 0810 through 0816 and PW02 were used to extract ground water in 2015. The well screens are placed at varying depths (Appendix A, Table A-1) due to varying depths to the brine interface in the CF5 area.

Monthly extraction volumes for each of the eight extraction wells are listed in Table A-3 (Appendix A). The majority of the 2015 extracted water was removed from well PW02 (1.5 mil gal) and 0815/0816 (1.4 mil gal). The remaining CF5 wells extracted between 1.0 and 1.3 mil gal in 2015. Extraction operations were maximized in April and June, when 2.2 mil gal were extracted during both months. The evaporator units and water trucks were used to dispose of the extracted water.

4.2 IA Extraction Performance

4.2.1 Ground Water Levels and Hydraulic Control

Figure 11 shows the average pumping rates and associated drawdown data for each of the CF5 wells. The wells with the highest drawdown (0810, 0811, and 0814) are located on the southern portion of CF5, while the wells on the northern end of CF5 (0813 and 0816) are more productive. This difference is likely due to variation in underlying sediments. The results are similar to those measured in previous years.

Hydrographs were prepared to compare background ground water elevations (from observation well 0405 located in the northern end of the well field) and ground water elevations of the CF5 extraction wells during the pumping season (see Tables A-1 through A-8 in Appendix A). Applicable extraction rates for each well were plotted against the ground water elevations.

Well 0405 water elevation data were adjusted so that both wells were assigned the same non-pumping water level. The difference between the two wells gives a qualitative estimate of drawdown in response to pumping.

Figures A-1 through A-8 (Appendix A) show drawdown during extraction operations for CF5 compared to the background ground water surface fluctuation. The wells had maximum drawdown during higher rates of extraction, and the water levels rebounded quickly after the extraction operations were shut down.

4.2.2 Extraction Well Specific Capacity

Specific capacity is the measure of a well’s performance relative to formation hydraulic characteristics. Individual extraction well drawdown data were used to compute the specific capacity during the 2015 pumping season. While this is not a rigorous method of calculating specific capacity because it does not account for well interference, it provides a qualitative evaluation of the relative performance of each extraction well (Table 1).

The specific capacity varies greatly in the CF5 wells. Remediation wells 0813 and 0816 have the highest specific capacities; up to 125.4 gpm/ft was measured in well 0816. More drawdown is observed in the wells with lower specific capacity values (0811, 0812, and 0814). The data shown in Table 1 are comparable to what has been historically observed.

4.3 Contaminant Mass Removal

The ammonia and uranium mass removed by CF5 extraction wells in 2015 is presented in Tables A-4 and A-5 of Appendix A. These values are based on ground water extraction volumes recorded by individual flow meters. The mass of ammonia and uranium removed from ground water by the extraction wells was calculated by multiplying the extracted volume by the corresponding contaminant mass concentration measured in each well’s discharge.

The concentrations used in these calculations were drawn from analytical data presented in Appendix D (available on the Project’s SharePoint website). To estimate the contaminant mass removed when analytical data were not available for the specific month, concentrations were derived from previous and subsequent months to provide a representative concentration.

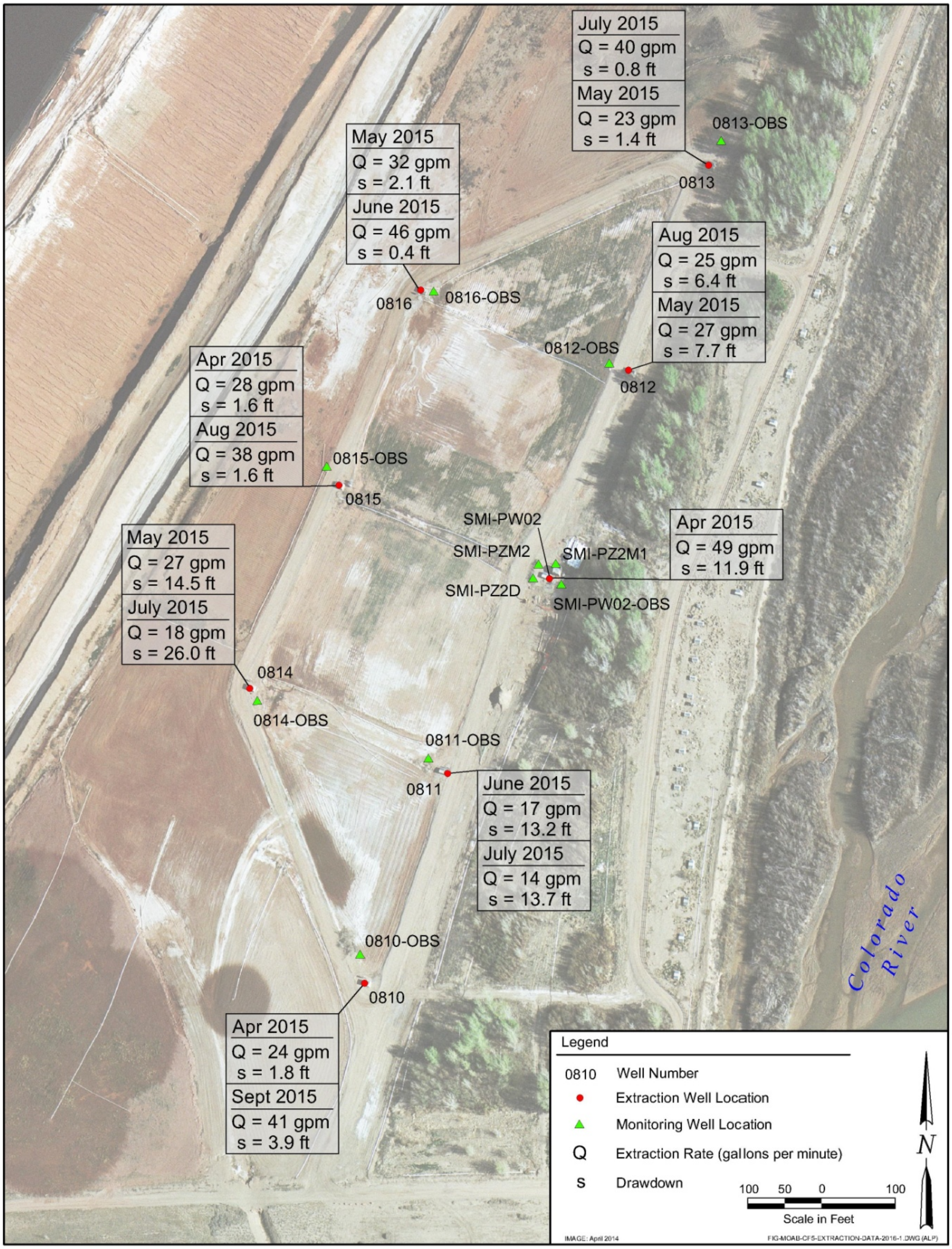


Figure 11. Flow Rates and Drawdowns in CF5 in 2015

Table 1. Drawdown during Extraction Operations

Location	Date	Drawdown (ft)	Extraction Rate (gpm)	Specific Capacity (gpm/ft)
0810	04/29/15	1.8	24	13.2
	09/10/15	3.9	41	10.6
0811	06/10/15	13.2	17	1.3
	07/22/15	13.7	14	0.24
0812	05/12/15	7.7	27	3.5
	08/01/15	6.4	25	3.9
0813	05/13/15	1.4	23	16.6
	07/29/15	0.8	40	50.0
0814	05/27/15	14.5	27	1.9
	07/22/15	26.0	18	0.69
0815	04/22/15	1.6	28	17.07
	08/26/15	1.6	38	24.4
0816	05/13/15	2.1	32	15.4
	06/10/15	0.4	46	125.4
PW02	04/15/15	11.9	49	4.13

In 2015, a total of 27,810 pounds (lb) (12,614 kilograms [kg]) of ammonia and 230 lb (104 kg) of uranium were extracted from the ground water. Table A-4 in Appendix A shows that extraction wells PW02 and 0815 removed the most ammonia mass, at 6,443 lb (2,922 kg) and 4,009 lb (1,818 kg), respectively. Estimated mass withdrawals of uranium at CF5 extraction wells are presented in Appendix A, Table A-5, which shows the greatest mass of uranium was extracted from wells PW02 and 0815 at 42 lb (19 kg) and 38 lb (17 kg), respectively.

4.4 Ground Water Chemistry

Ground water samples were collected from the CF5 extraction wells in May 2015 (Table 2). Ammonia concentrations varied from 160 mg/L (0816) to 520 mg/L (PW02), and the uranium concentration ranged from 1.5 mg/L (0813) to 3.9 mg/L (PW02). Specific conductance ranged from 16,714 µmhos/cm at well 0812 (northern end of CF5) to 35,122 µmhos/cm at well PW02. The specific conductance was higher at PW02 because the pump is set at a lower elevation.

Table 2. CF5 Ammonia and Uranium Concentrations, 2015

Location	Date	Ammonia (mg/L)	Uranium (mg/L)	Specific Conductance (µmhos/cm)
0810	05/12/15	300	3.1	32,151
0811	05/12/15	330	2.6	22,381
0812	05/13/15	330	1.8	16,714
0813	05/13/15	330	1.5	15,310
0814	05/12/15	170	2.8	23,445
0815	05/12/15	210	3.3	25,604
0816	05/12/15	160	2.7	22,933
PW02	05/12/15	520	3.9	35,122

5.0 Evaporation Pond Operations

The evaporation pond, located on the southeastern portion of the tailings pile, stores the ground water that was extracted from the CF5 wells. Water stored in the pond is removed by evaporation, by water trucks for dust suppression on top of the tailings pile, or through the use of evaporator units located on the edge of the pond.

A chronology of the evaporation pond operations can be found in Table B-1 in Appendix B and is summarized here. Table B-2 contains the 2015 evaporation pond level and volume for 2015, and Table B-3 contains the evaporator operations.

The Remedial Action Contractor (RAC) removed water from the pond for dust suppression from February to December.

The evaporation pond will be decommissioned, and the water added to the pond on September 10, 2015, was the last time the evaporation pond will be used. The two evaporator units were dismantled and moved down from the evaporation pond on November 11, 2015.

5.1 Evaporation Pond Water Balance

Water inflows and outflows, along with the pond level, are illustrated in Figure 12. As shown, the outflow varied from month to month, but was highest from March through October.

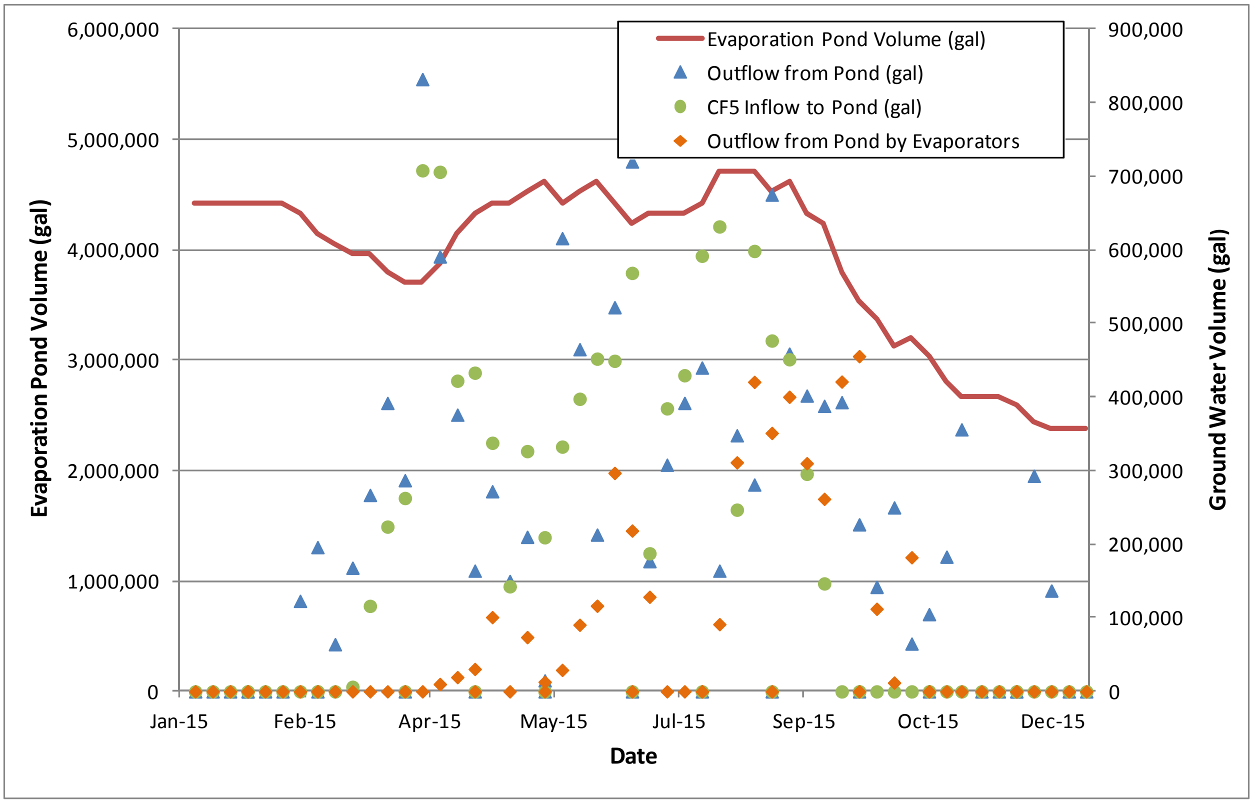


Figure 12. Rates of Water Delivery and Outflow to and from the Evaporation Pond and Pond Volume during 2015

Approximately 12.3 mil gal of extraction water were removed from the evaporation pond by water trucks in the CA. Most of the water was removed during the spring and summer months (April through June) when the evaporation potential is highest (Figure 12). This water is used for dust suppression inside the CA.

Approximately 4.4 mil gal of extracted water were pumped through the evaporators between April and October, when the weather conditions are more conducive to evaporation. On occasion, during favorable weather, the evaporators ran overnight. The total gallons represent what was pumped through the evaporators as opposed to what actually evaporated, which was not possible to calculate.

6.0 Injection Operation and Performance

The main objective of freshwater injection is to form a hydrologic barrier between the tailings pile and the backwater channel that flows adjacent to the well field and to dilute contaminants before ground water discharges into the backwater channel. Freshwater injection into the CF4 wells occurred from January to April and again from August to December.

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

CF4 is located in the southern portion of the IA well field, adjacent to a prominent side channel that typically remains open to the main channel until the river flow drops below 3,000 cfs. The brine/freshwater interface is higher in elevation in this portion of the well field, and sample results have indicated that ground water discharges to the adjacent backwater channel. Approximately 6.9 mil gal of freshwater were injected into CF4 in 2015.

6.1 Injection Performance

Injection into all 10 wells began on January 5 (Table C-2, Appendix C). The system ran into mid-April when it was down for maintenance. The system was left down during the peak river flow, following the *Flood Mitigation Plan*. Operations resumed on August 18, and it was necessary to suspend operations from mid-August through September 23 because of high river turbidity. Injection continued until early October, when it was shut down for maintenance for a week. The system ran through November and most of December until it was winterized on December 23.

6.2 Summary of Chemical Data from Observation Wells

In 2015, ammonia samples were collected from the CF4 observation wells and well points during injection operations to access the effectiveness of the system (Appendix C, Table C-3). Ammonia samples collected were sent to ALS.

Ammonia samples were collected in March and November during injection operations (Appendix C, Table C-3). The results of these samples indicate ammonia concentrations were lowest at 18 ft below ground surface (bgs) (less than 1 mg/L at downgradient wells 0784, 0783, and 0785) and highest between 36 and 46 ft bgs (up to 1,600 mg/L at upgradient well 0781).

The specific conductance at the upgradient wells at a depth of 18 to 33 ft bgs had a specific conductance between 1,131 and 1,290 µmhos/cm except for location 0781, which was at 55,727 to 74,710 µmhos/cm at 46 ft bgs. This implies the brine interface was located between 33 and 46 ft bgs during injection operations in 2015. In the downgradient wells/well points, the specific conductance was between 1,140 and 21,623 µmhos/cm, indicating the brine interface was more than 36 ft bgs during injection operations.

The uranium concentrations were the highest at 46 ft bgs during injection operations. In March, well 0781 (46 ft bgs) had a concentration of 2.2 mg/L, and it increased slightly to 2.4 mg/L in November. The next highest uranium concentration was 0.9 mg/L in downgradient well 0787 (36 ft bgs) in November.

6.3 Freshwater Mounding

Water levels were collected on a near daily basis during injection operations. To determine the amount of freshwater mounding in each well, the collected water levels were plotted against the pressure transducer water levels in background well 0405.

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

Figures 13 and 14 are contour maps showing the CF4 freshwater mounding in March and November 2015, respectively. The highest mounding occurs within 30 ft of the injection system. Maximum mounding occurred in each injection well at varying dates in the spring and fall. The amount of mounding was dependent on the individual well efficiency and the injection rate.

Table 3 presents the maximum mounding measured in each of the 10 injection wells and the corresponding injection rate. The mounding in the observation wells varied from 0.1 to 0.6 ft in the upgradient wells and 0.5 ft in the downgradient wells (Table 4). The amount of mounding observed in 2015 was slightly higher than what was observed in 2014. This is likely because the CF4 injection wells must be developed.

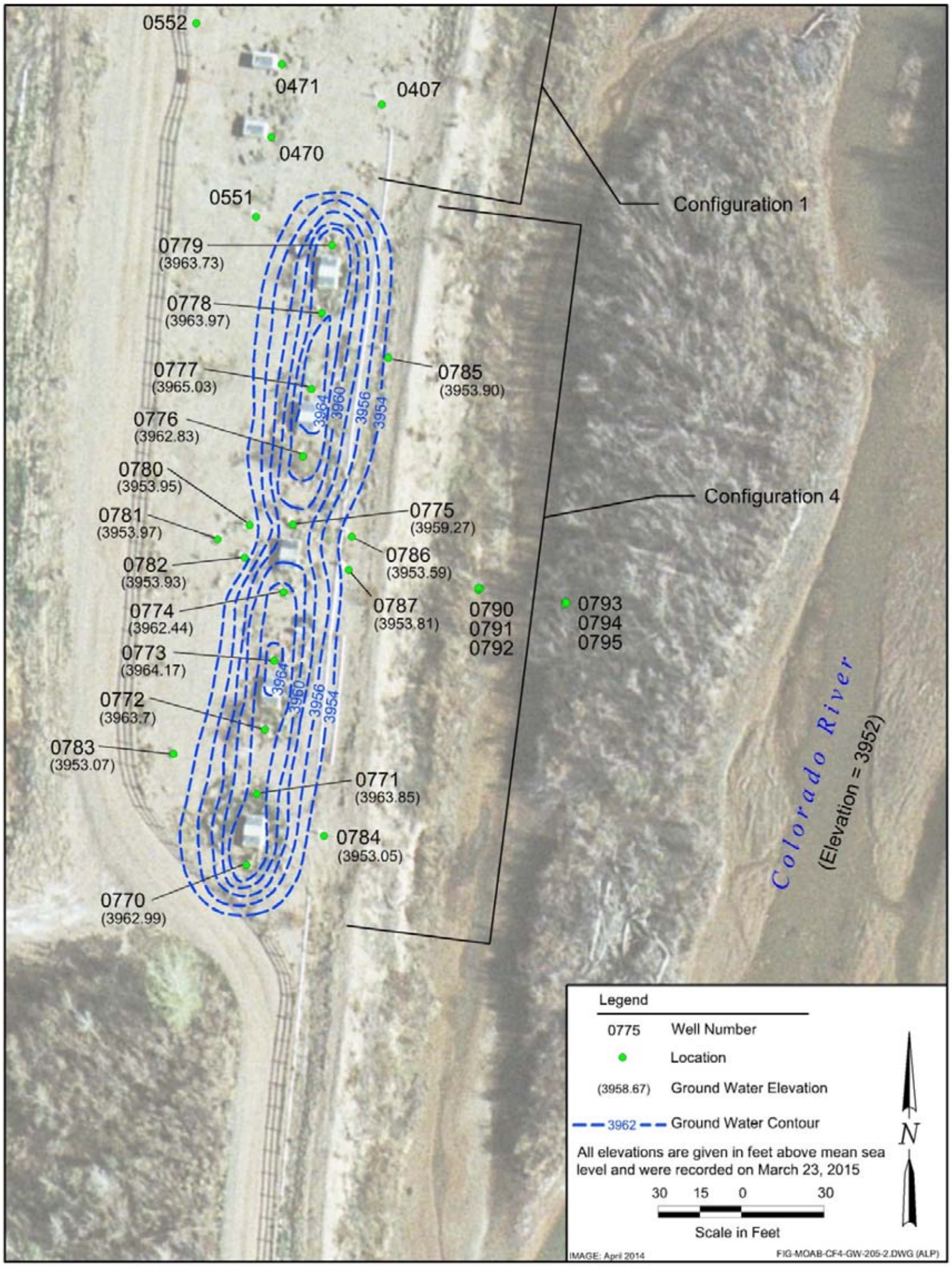


Figure 13. Freshwater Mounding at CF4 during Injection Operations March 2015

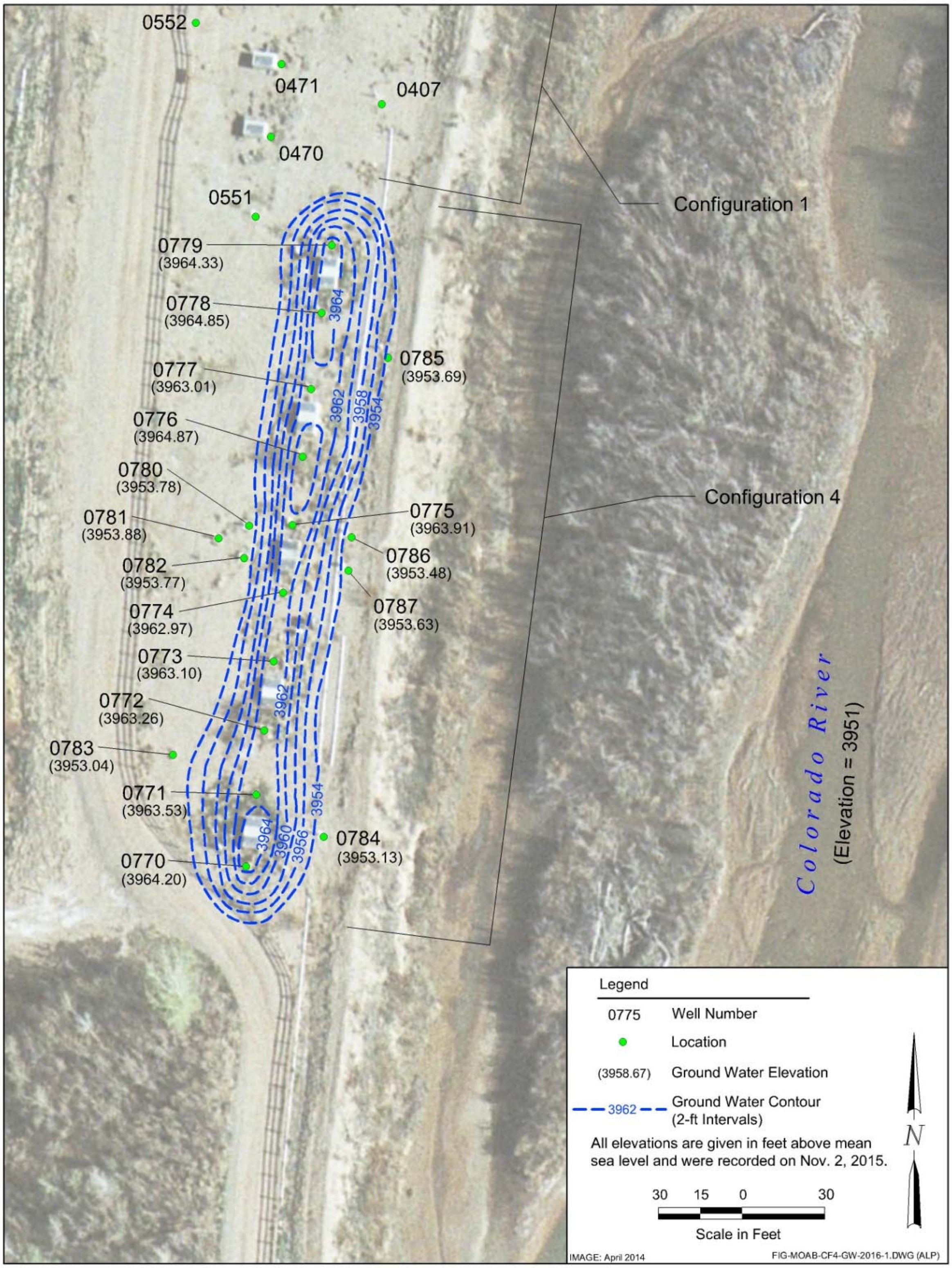


Figure 14. Freshwater Mounding at CF4 during Injection Operations November 2015

Table 3. Maximum Mounding Observed in CF4 Injection Wells

Well	Date	Type	Maximum Mounding (ft)	Injection Rate (gpm)
0770	11/05/15	Injection Well	11.9	4.2
0771	03/31/15	Injection Well	13.2	4.2
0772	04/01/15	Injection Well	12.2	2.4
0773	04/01/15	Injection Well	12.1	3.2
0774	08/25/15	Injection Well	11.9	3.3
0775	11/16/15	Injection Well	11.9	4.8
0776	11/02/15	Injection Well	11.9	3.1
0777	03/25/15	Injection Well	12.1	2.9
0778	04/01/15	Injection Well	12.3	3.4
0779	12/03/15	Injection Well	12.5	1.1

Table 4. Freshwater Mounding Observed in CF4 Observation Wells

Well	Date	Location	Maximum Mounding (ft)	Distance from Injection Source (ft)
0780	03/23/15	Upgradient	0.2	25
0781	03/24/15	Upgradient	0.1	30
0782	03/23/15	Upgradient	0.6	25
0783	11/02/15	Upgradient	0.2	30
0784	11/02/15	Downgradient	0.4	30
0785	03/23/15	Downgradient	0.4	25
0786	11/02/15	Downgradient	0.5	30
0787	03/23/15	Downgradient	0.5	30

7.0 Surface Water Monitoring

In 2015, the river flow ranged from 2,960 to 31,800 cfs from January through December. The channel that flows adjacent to CF4 was not considered a suitable habitat for young-of-year fish during the monitoring season (June through September). During those 3 months, the river flow at the Cisco Gage varied from 3,930 to 31,800 cfs.

Surface water monitoring is completed through site-wide surface water sampling. The site-wide sampling event occurs twice a year, and surface water samples are collected upgradient of the site, on site, and downgradient of the site (Figure 15).

7.1 Site-wide Surface Water Monitoring

Site-wide surface water sampling was conducted adjacent to the well field in June 2015. Locations were sampled in preparation for the post-spring runoff peak flows, when the side channel could potentially develop into a suitable habitat. The data would be used to determine where the highest ammonia concentrations were present in the side channel before peak spring runoff. The results of this sampling event can be found in the *Moab UMTRA Project Ground Water and Surface Water Monitoring January through June 2015* (DOE-EM/GJTAC2183). All of the sample results were below the U.S. Environmental Protection Agency (EPA) acute and chronic criteria

Figure 15. CF4 Side Channel in 2015

Three surface water samples were collected in December when the river was at baseflow conditions. At the time, the channel was very shallow and was not considered a habitat. The results can be found in the *Moab UMTRA Project Ground Water and Surface Water Monitoring July through December 2015* (DOE-EM/GJTAC2197). All of the ammonia concentrations were below EPA acute and chronic criteria.

7.2 Surface Water/Habitat Monitoring

Surface water monitoring adjacent to CF4 is conducted yearly after the spring peak river flow begins to recede. The purpose is to monitor the ammonia concentrations in the side channel adjacent to the site, because the channel is a potential habitat for young-of-year endangered fish species (e.g., Colorado pikeminnow, razorback sucker).

In 2015, a combination of the higher than average peak flow and an active late summer monsoonal season deposited an abundance of silt in the side channel. In 2015, due to the deposit in the side channel, it did not meet the suitable young-of-year habitat criteria (closed off upriver, open downriver). Figure 15 shows the deposition in the CF4 side channel.

7.3 Summary of Surface Water Monitoring

All of the surface water ammonia samples collected in 2015 were below EPA acute and chronic criteria.

The CF4 side channel remained dry after the peak runoff, and several late season storms added silt to the channel. The side channels that extend into the river just east of CF4 that became a habitat in 2014 remained completely open to the river in 2015, so habitat monitoring and surface water diversion was not necessary in 2015.

8.0 Investigations

8.1 Sampling Events

Sampling events occurred throughout the year in 2015. CF4 and observation wells adjacent to the tree plots were sampled in March and April of 2015. CF5 and the tree plot wells were sampled in May 2015. The site-wide sampling event took place in May and June of 2015, during the peak river flow.

Maps of sample locations and the sample results can be found in the *Moab UMTRA Project Ground Water Surface Water Monitoring Report January through June 2015* (DOE-EM/GJTAC2183).

Several sample events took place in Crescent Junction at well 0205 to investigate the source of ground water found in the well in June 2015. The site-wide sampling event occurred in October 2015, along with CF4 and the tree plot wells.

Monitoring wells were sampled in the Matheson Wetlands in November 2015, and the site-wide sampling during baseflow conditions was completed in December 2015/January 2016. Maps of the sample locations and the sample results can be found in the *Moab UMTRA Project Ground Water Surface Water Monitoring Report July through December 2015* (DOE-EM/GJTAC2197).

8.2 Crescent Junction Well Pumping

Four monitoring wells (locations 0202, 0203, 0205, and 0210) were originally constructed at the Crescent Junction site in 2006 to a depth of about 300 ft bgs as part of the site characterization. These wells were recompleted to a depth of approximately 65 ft bgs in June 2011 to monitor possible release of tailings fluids into the subsurface.

Water was first encountered in well 0205 in late June 2015 and has been present in the well since that time. Short-term recovery tests (which measure the well's recovery rate) were conducted bimonthly between November 10, 2015, and March 16, 2016. Based on the test results, the recovery rate increased from 0.064 to 0.084 gpm between early November and early December 2015. The analytical data from July and November 2015 show the water in well 0205 has a high concentration of nitrate/nitrite as N (Table 5). Well 0205 monitoring will continue to determine the source the water and the nitrate.

Table 5. Well 0205 Analytical Data

Analyte	Analyte Concentration in Well 0205 on 7/14/15 (mg/L)	Analyte Concentration in Well 0205 on 7/29/15 (mg/L)	Analyte Concentration in Well 0205 on 11/4/15 (mg/L)
Ammonia as N	16	17	18
Arsenic	0.039*	0.039*	0.039*
Barium	0.027	0.019	0.024
Boron	1.6	1.3	1.4
Bromide	18	20*	20*
Cadmium	0.0033*	0.0033*	0.0035
Calcium	280	400	380
Chloride	5,200	2,000	3,700
Chromium	0.0051*	0.021	0.005
Copper	0.0097*	0.017	0.021
Fluoride	5*	10*	10*
Iron	0.06	0.083	0.049
Lead	0.013*	0.013*	0.016
Magnesium	370	1,100	1,000
Manganese	0.45	0.71	0.570
Molybdenum	0.054	0.022	0.011*
Nitrate/Nitrite as N	710	1,100	970
Potassium	57	59	57
Selenium	4.6	5.4	4.8
Sodium	12,000	11,000	9,900
Sulfate	20,000	20,000	21,000
Total Dissolved Solids	N/A	43,000	48,000
Uranium	0.017	0.000029*	0.025

*At or below detection limit

8.3 Ground Water Modeling

A.D. Laase Hydrologic Consulting was contracted to update the Moab site ground water flow in 2016 to run additional simulations. This SEAWAT transient flow model was originally developed in 2011 and is described in Attachment 3 of the *Moab UMTRA Project 2011 Ground Water Program Report* (DOE-EM/GJTAC2041).

The modeling update focused on modifying the flow model to reflect changes to the site since the model was first developed. Once these changes were made to the recharge zones, especially the zone in the vicinity of the tailings pile, a number of simulations were completed. These simulations focused on changes to the ground water extraction system pumping scheme necessary due to the eventual removal of the evaporation pond. The various scenarios modeled included increased freshwater injection in association with the reduced ground water extraction and the impact on the overall protection of the Colorado River side channel located off CF4. Documentation containing details regarding the model configuration and calibration are contained in Appendix D.

Ground water flow modeling shows that the projected ground water extraction pumping scheme altered due to the removal of the evaporation pond is not significantly different compared to the previous extraction pumping scheme on the ground water flow system, and the level of protection of the Colorado River remains the same.

9.0 Summary and Conclusions

In 2015, the IA operations focused on ground water extraction (from CF5) and freshwater injection (CF4); the surface water diversion system operation was not required during the year, because a suitable habitat did not develop the side channel.

A total of 10.5 mil gal of water were extracted from CF5 in 2015. The extraction rate peaked in April, and operations continued through the fall. Each of the eight extraction wells were utilized in 2015. Figure 16 shows the ammonia and uranium mass removed and the volume of ground water extracted from the CF5 extraction wells in 2015. The volume and mass removed is similar to the past few years. Approximately 230 lb of uranium and more than 27,810 lb of ammonia were removed from the ground water in 2015.

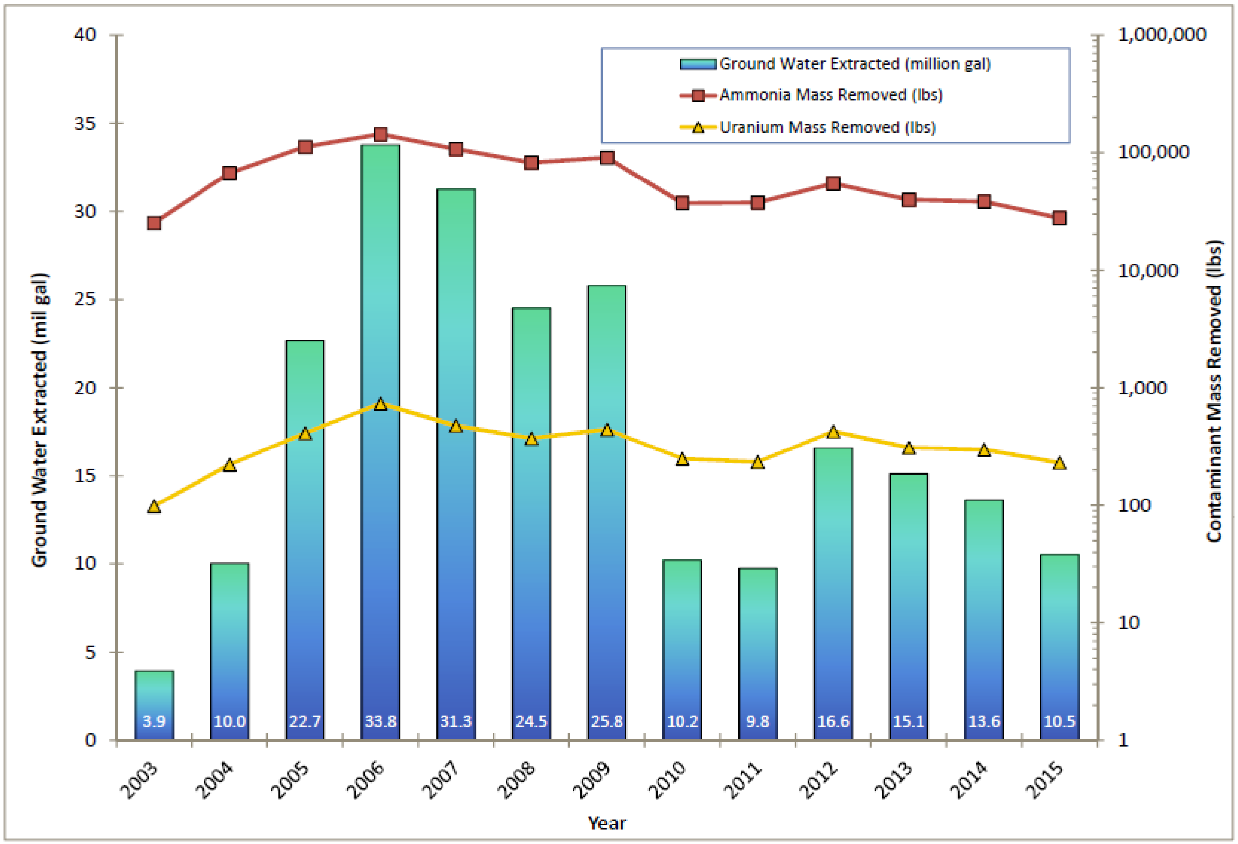


Figure 16. 2015 Mass Removal

Approximately 4.4 mil gal of extracted water were pumped through the evaporators, and 12.3 mil gal of extracted water were used by water trucks for dust suppression in the contaminated area. The evaporators were run overnight when conditions were favorable. More water was pumped through the evaporators in 2015 compared to 2014 due to running the evaporators overnight.

Approximately 6.9 mil gal of freshwater were injected into CF4 in 2015. Laboratory data from the CF4 observation wells during injection operations indicate the system is effective at diluting ammonia concentrations, especially from 28 to 36 ft bgs. Specific conductance also decreases at the downgradient observation wells during freshwater injection.

Site-wide surface water samples indicated the contaminants do not extend past the site boundary. The surface water diversion system was not necessary in 2015 since the side channel adjacent to CF4 did not meet the definition of a suitable habitat for young-of-year endangered fish species. This is the second season the channel has remained dry.

10.0 References

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

DOE (U.S. Department of Energy), *Moab UMTRA Project Ground Water and Surface Water Monitoring January through June 2015* (DOE-EM/GJTAC2183).

DOE (U.S. Department of Energy), *Moab UMTRA Project 2011 Ground Water Program Report* (DOE-EM/GJTAC2041).

DOE (U.S. Department of Energy), *Moab UMTRA Project Ground Water and Surface Water Monitoring July through December 2015* (DOE-EM/GJTAC2197).

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

DOE (U.S. Department of Energy), *Record of Decision for the Remediation of the Moab Uranium Mill Tailings, Grand and San Juan Counties, Utah* (6450-01-P).

Appendix A.
Tables and Data for 2015 Ground Water Extraction

Appendix A. Tables and Data for 2015 Ground Water Extraction

Table A-1. Well Construction for CF5 Extraction Wells

Well	Well Type/Relative Depth	Diameter (in.)	Ground Surface Elevation (ft above msl)	Screen Interval (ft bgs)	Total Depth (ft bgs)
0810	Extraction	8	3,966.56	10.4 – 40.4	40.4
0811	Extraction	8	3,966.59	8.8 – 38.6	38.6
0812	Extraction	8	3,966.62	14.2 – 44.2	44.2
0813	Extraction	8	3,966.67	14.4 – 44.4	44.4
0814	Extraction	8	3,967.02	12.4 – 42.4	42.4
0815	Extraction	8	3,967.13	21.7 – 51.7	51.7
0816	Extraction	8	3,967.38	20.9 – 50.9	50.9
SMI-PW02	Extraction	4	3,965.60	20.0 – 60.0	60.3

In. = inch

Table A-2. Chronology of CF5 Activities in 2015

Date	River Flow (cfs)	Activity
January	3,010 to 4,280	No extraction
February	2,980 to 3,710	No extraction
March	3,060 to 4,830	Re-started extraction on March 11 from well 0815.
April	3,230 to 4,760	Extraction from 0815, PW02, 0810, and 0811. Shut down from April 21 to 23 for electrical repairs.
May	3,710 to 14,100	Extraction from 0810, 0811, 0812, 0813, 0814, 0816. Shut down extraction for May 21 to control the pond level.
June	14,600 to 31,000	Extraction from 0810, 0811, 0812, 0813, 0814, 0816.
July	4,520 to 14,700	Extraction from 0810, 0811, 0812, 0813, 0814, 0816.
August	3,180 to 4,840	Extraction from 0810, 0811, 0812, 0813, 0814, 0815, 0816.
September	3,880 to 5,270	Extraction from 0810, 0811, 0812, 0814, 0815, 0816. Shut down extraction on September 10 to control pond level
October	3,740 to 6,740	No extraction.
November	3,700 to 3,820	Extraction winterized on November 5.
December	3,510 to 3,990	No extraction.

Table A-3. CF5 Extraction Volumes 2015

	Volume Extracted (gal)												
Well	**Jan-15**	**Feb-15**	**Mar-15**	**Apr-15**	**May-15**	**Jun-15**	**Jul-15**	**Aug-15**	**Sep-15**	**Oct-15**	**Nov-15**	**Dec-15**	**Totals**
810	0	0	0	2,285	214,091	314,530	48,345	264,167	461,516	0	0	0	1,304,934
811	0	0	0	26,620	222,261	334,135	162,309	181,844	202,386	0	0	0	1,129,555
812	0	0	0	0	199,832	417,891	225,562	323,916	42,833	0	0	0	1,210,034
813	0	0	0	0	181,513	267,168	364,654	538,013	0	0	0	0	1,351,348
814	0	0	0	0	89,858	319,736	312,945	206,288	115,662	0	0	0	1,044,489
815	0	0	603,063	666,514	4,928	0	0	97,169	71,242	0	0	0	1,442,916
816	0	0	0	0	102,017	546,859	480,143	342,661	0	0	0	0	1,471,680
PW02	0	0	6,051	1,570,989	2,149	0	0	0	0	0	0	0	1,579,189
MONTHLY	0	0	609,114	2,266,408	1,016,649	2,200,319	1,593,958	1,954,058	893,639	0	0	0	10,537,145
TOTAL (gal)													**10,537,145**

Table A-4. CF5 Ammonia Mass Removal 2015

	Ammonia Mass Removed (lbs)												
Well	**Jan-15**	**Feb-15**	**Mar-15**	**Apr-15**	**May-15**	**Jun-15**	**Jul-15**	**Aug-15**	**Sep-15**	**Oct-15**	**Nov-15**	**Dec-15**	**Totals**
810	0	0	0	14	570	553	354	660	1,153	0	0	0	3,304
811	0	0	0	100	833	754	610	500	556	0	0	0	3,535
812	0	0	0	0	632	632	1,136	890	118	0	0	0	3,408
813	0	0	0	0	514	310	1,426	1,478	0	0	0	0	3,728
814	0	0	0	0	210	349	547	292	164	0	0	0	1,561
815	0	0	1,009	2,691	14	0	0	170	125	0	0	0	4,009
816	0	0	0	0	178	729	640	457	0	0	0	0	2,003
PW02	0	0	0	6,435	9	0	0	0	0	0	0	0	6,443
MONTHLY	0	0	1,009	9,239	2,961	3,326	4,713	4,447	2,115	0	0	0	27,810
TOTAL (gal)													**27,810**

Appendix A. Tables and Data for 2015 Ground Water Extraction (*continued*)

Table A-5. CF5 Uranium Mass Removal 2015

Well	Uranium Mass Removed (lbs)												
	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Totals
810	0	0	0	0.1	5.2	5.7	3.7	6.8	11.9	0	0	0	33.4
811	0	0	0	0.6	5.2	5.9	4.8	3.9	4.4	0	0	0	24.9
812	0	0	0	0	3	3.4	6.2	4.9	0.6	0	0	0	18.1
813	0	0	0	0	2.1	1.4	6.5	6.7	0	0	0	0	16.7
814	0	0	0	0	2	5.7	9.0	4.8	2.7	0	0	0	24.3
815	0	0	8.9	23.8	0.1	0	0	2.7	2.0	0	0	0	37.5
816	0	0	0	0	2	12.3	10.8	7.7	0	0	0	0	32.8
PW02	0	0	0	42	0.1	0	0	0	0	0	0	0	42.1
MONTHLY	0	0	8.9	66.6	19.7	34.5	40.9	37.5	21.6	0	0	0	**230**
TOTAL (lb)													**230**

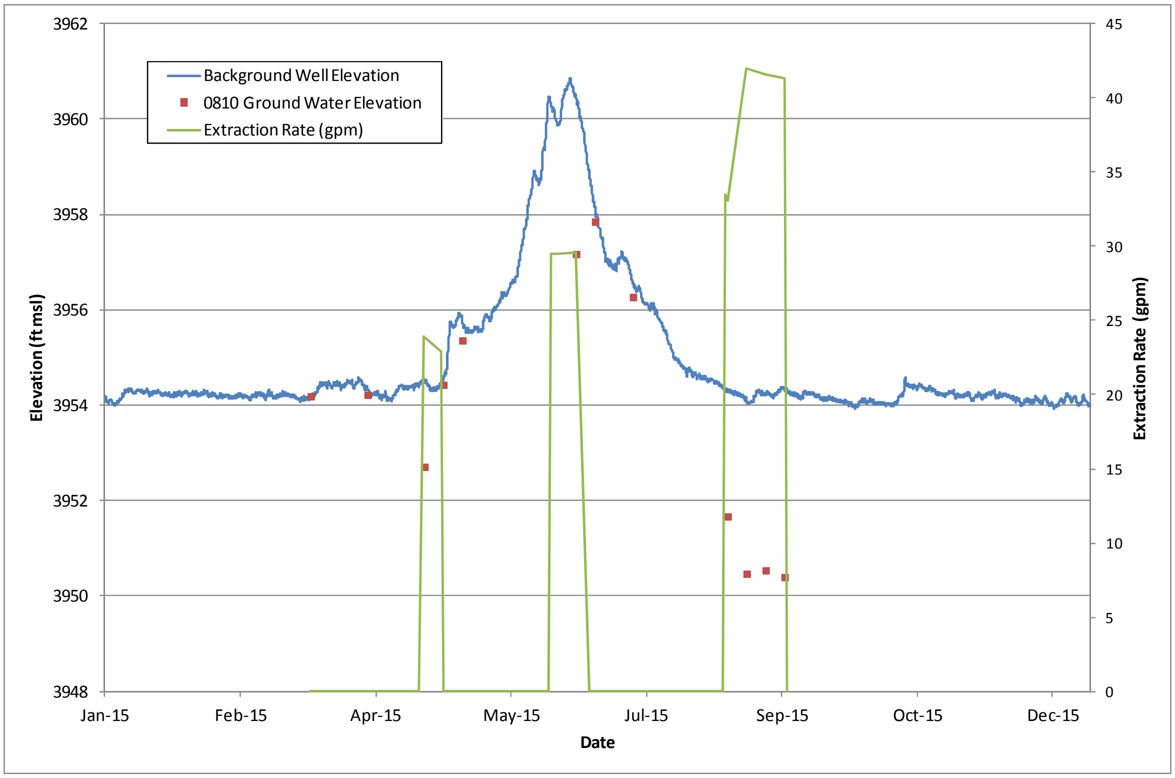


Figure A-1. Drawdown Plot for Well 0810

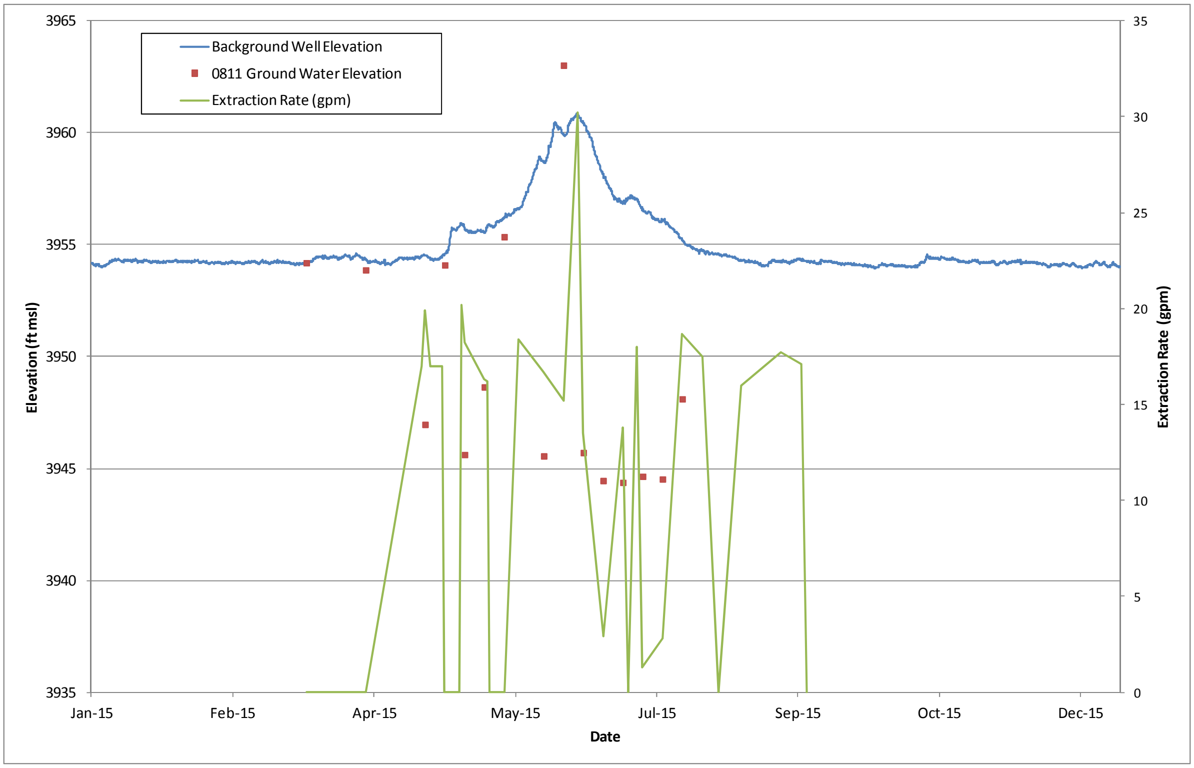


Figure A-2. Drawdown Plot for Well 0811

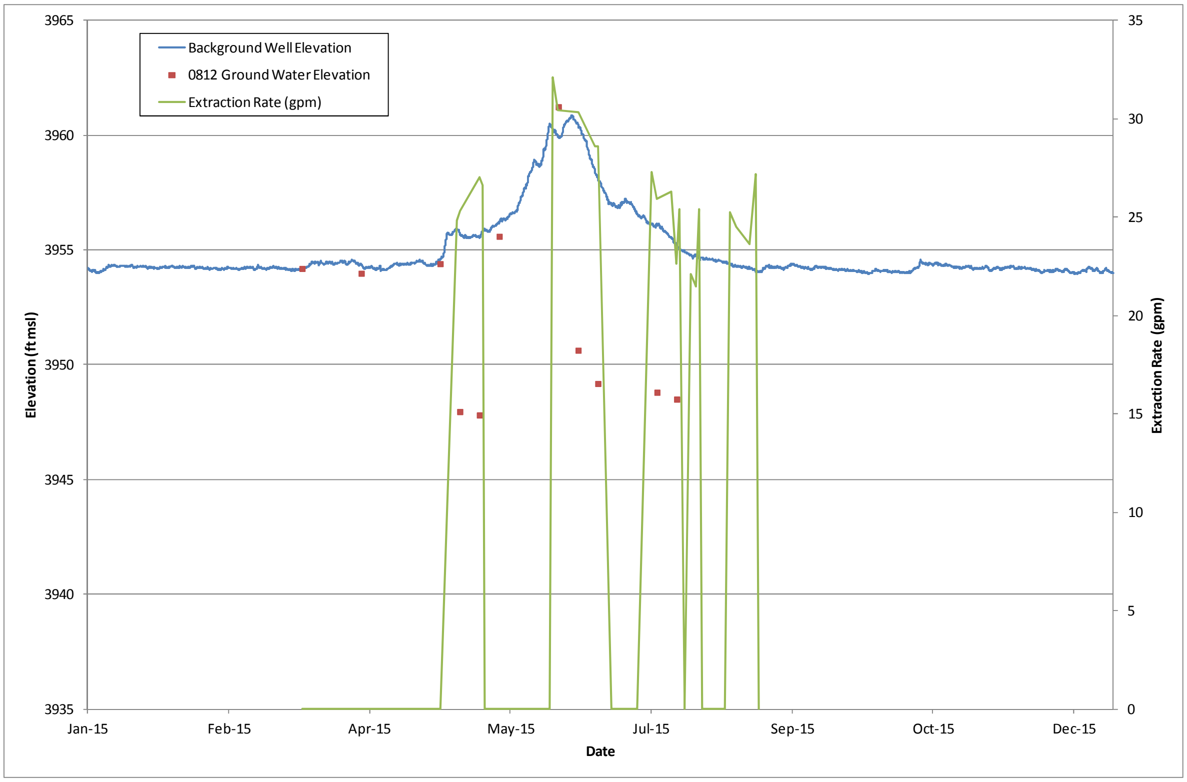


Figure A-3. Drawdown Plot for Well 0812

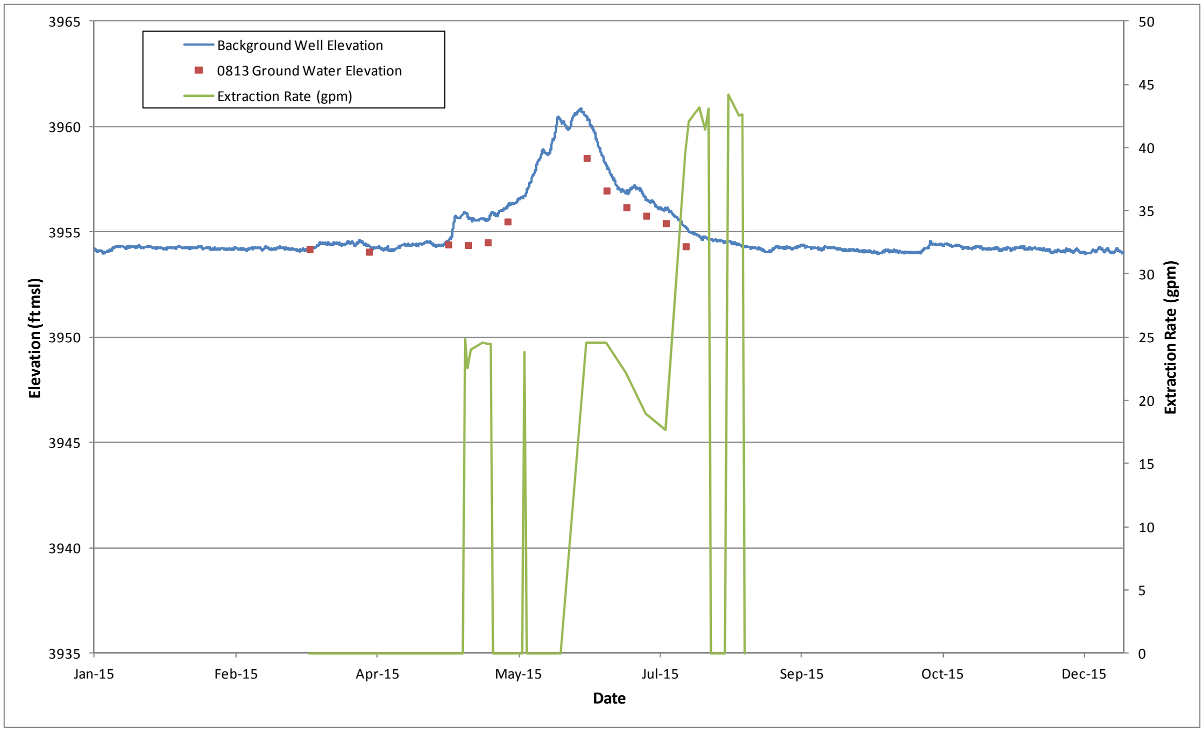


Figure A-4. Drawdown Plot for Well 0813

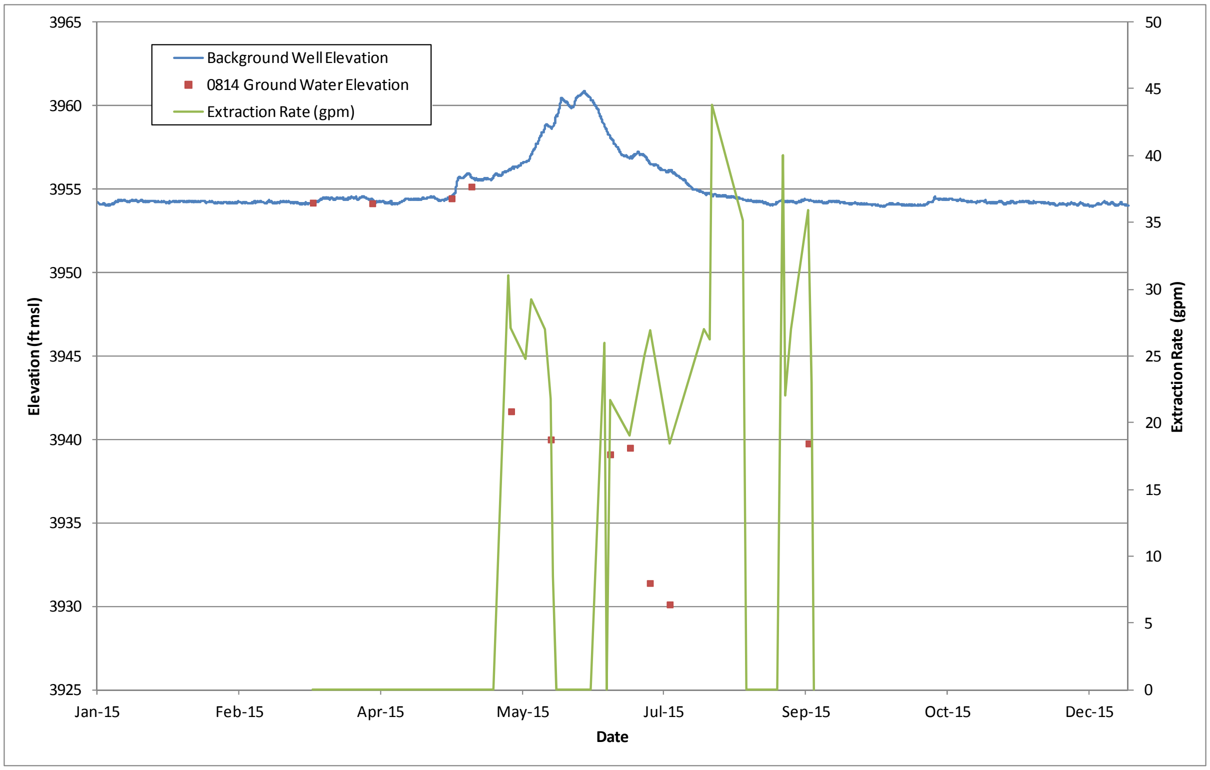


Figure A-5. Drawdown Plot for Well 0814

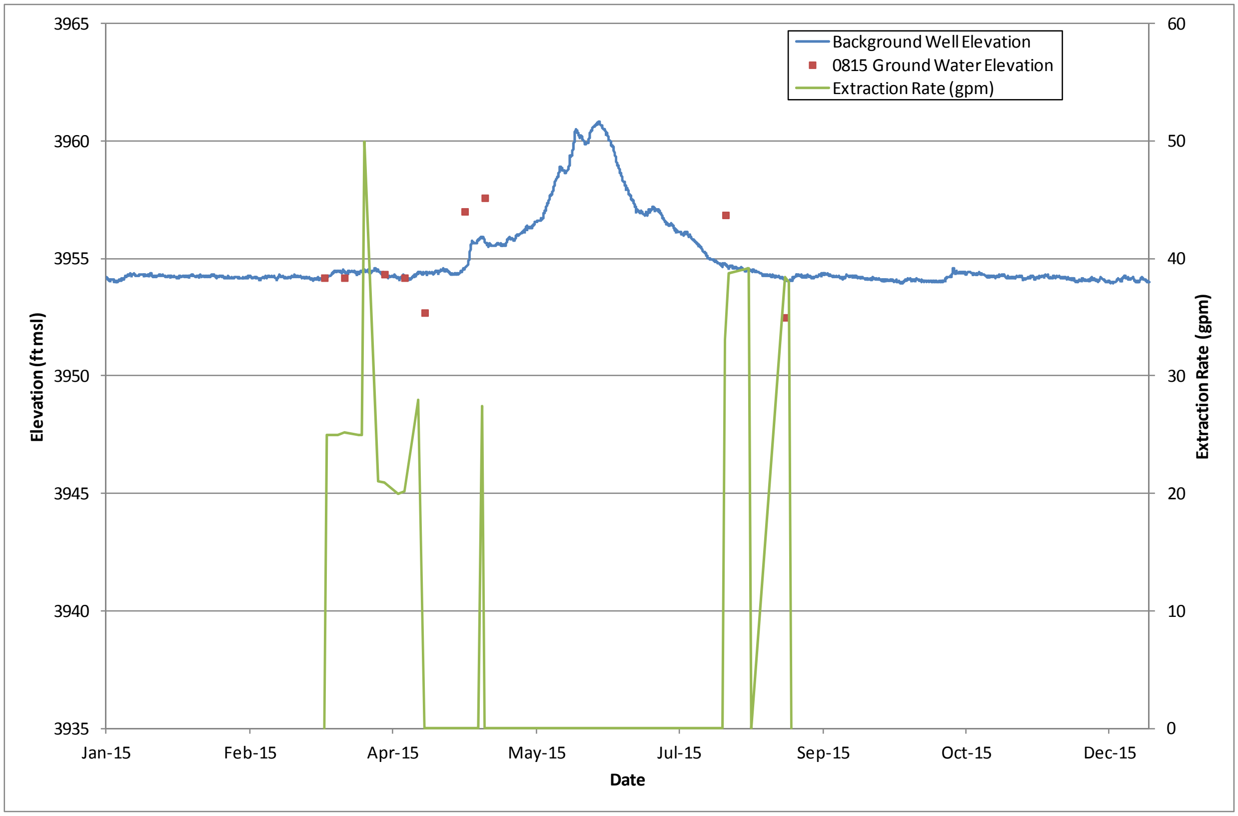


Figure A-6. Drawdown Plot for Well 0815

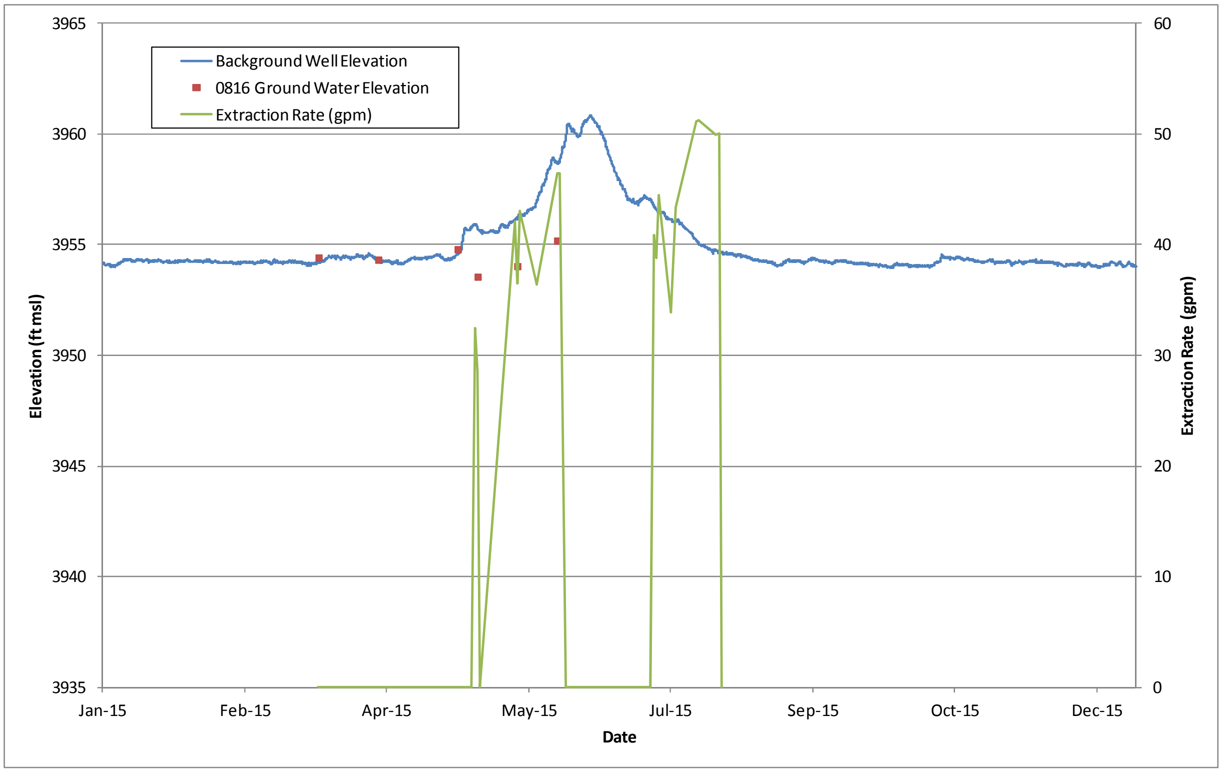


Figure A-7. Drawdown Plot for Well 0816

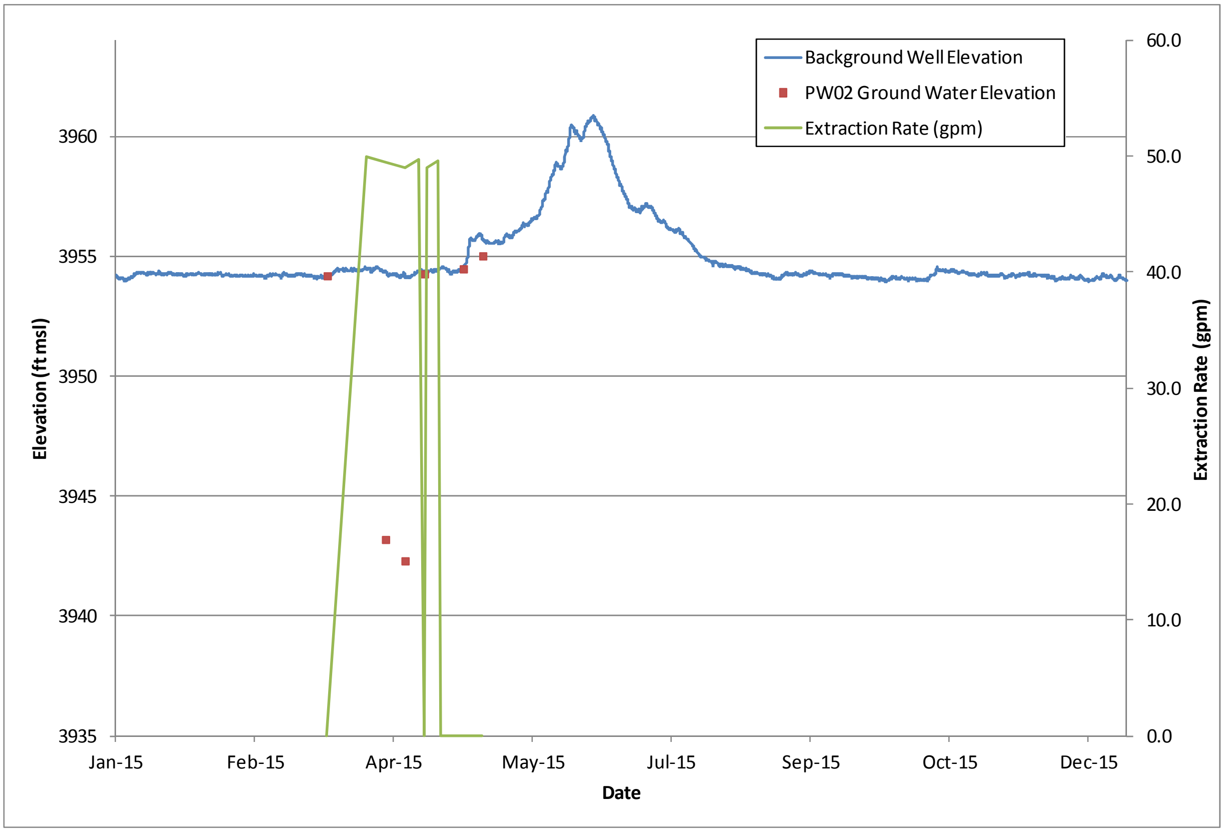


Figure A-8. Drawdown Plot for Well PW02

Appendix B.
2015 Evaporation Pond Data

Appendix B. 2015 Evaporation Pond Data

Table B-1. Evaporation Pond Chronology for 2015

Date	Pond Level (ft)	Activity
03/11/15	8.5	Extraction began
04/04/15	8.2	Began extracting from PW02
04/15/15	8.4	Begin using evaporators
04/21/15	8.7	Extraction shut down for electrical repairs
04/23/15	8.7	Extraction re-started
05/21/15	9.1	Shut down extraction to control pond level
06/04/15	9.0	Evaporators shut down for Health and Safety concerns.
07/08/15	8.9	Evaporators shut down due to electrical Health and Safety issue.
08/04/15	9.3	Re-started evaporators
09/10/15	8.9	Extraction shut down to control pond level
11/03/15	7.1	Evaporators dismantled, moved down from evaporation pond
11/05/15	6.9	Extraction wells are winterized

Table B-2. Pond Level vs. Pond Volume 2015

Date	Pond Level (ft)	Pond Volume (gal)
01/07/15	9.0	4,427,363
01/14/15	9.0	4,427,363
01/21/15	9.0	4,427,363
01/28/15	9.0	4,427,363
02/04/15	9.0	4,427,363
02/11/15	9.0	4,427,363
02/18/15	8.9	4,333,063
02/25/15	8.7	4,147,521
03/04/15	8.6	4,056,279
03/11/15	8.5	3,966,056
03/18/15	3.5	3,966,056

Appendix B. 2015 Evaporation Pond Data (*continued*)

Table B-2. Pond Level vs. Pond Volume 2015 (continued)

Date	Pond Level (ft)	Pond Volume (gal)
03/25/15	8.3	3,788,668
04/01/15	8.2	3,701,503
04/08/15	8.2	3,701,503
04/15/15	8.4	3,876,852
04/22/15	8.7	4,147,521
04/29/15	8.9	4,333,063
05/06/15	9.0	4,427,363
05/13/15	9.0	4,427,363
05/20/15	9.1	4,522,682
05/27/15	9.2	4,629,021
06/03/15	9.0	4,427,363
06/10/15	9.1	4,522,682
06/17/15	9.2	4,619,021
06/24/15	9.0	4,427,363
07/01/15	8.8	4,239,782
07/08/15	8.9	4,333,063
07/15/15	8.9	4,333,063
07/22/15	8.9	4,333,063
07/29/15	9.0	4,427,363
08/05/15	9.3	4,716,379
08/12/15	9.3	4,716,379
08/19/15	9.3	4,716,379
08/26/15	9.1	4,522,682
09/02/15	9.2	4,619,021
09/09/15	8.9	4,333,063
09/16/15	8.8	4,239,782

Appendix B. 2015 Evaporation Pond Data (*continued*)

Table B-2. Pond Level vs. Pond Volume 2015 (continued)

Date	Pond Level (ft)	Pond Volume (gal)
09/23/15	8.3	3,788,668
10/07/15	8.0	3,363,036
10/14/15	7.5	3,119,888
10/21/15	7.6	3,199,918
10/28/15	7.4	3,040,877
11/04/15	7.1	2,809,961
11/10/15	6.9	2,661,113
11/18/15	6.9	2,661,113
11/25/15	6.9	2,661,113
12/02/15	6.8	2,588,218
12/09/15	6.6	2,445,485
12/16/15	6.5	2,375,648
12/23/15	6.5	2,375,648
12/30/15	6.5	2,375,648

Appendix B. 2015 Evaporation Pond Data (*continued*)

Table B-3. Evaporator Use in 2015

Date	Total Gallons
1/7/15	0
1/14/15	0
1/21/15	0
1/28/15	0
2/4/15	0
2/11/15	0
2/18/15	0
2/25/15	0
3/4/15	0
3/11/15	0
3/18/15	0
3/25/15	0
04/01/15	0
04/08/15	0
4/15/15	9,944
4/22/15	19,414
4/29/15	30,467
05/06/15	100,875
05/13/15	0
05/20/15	73,780
05/27/15	12,932
06/03/15	29,218
06/10/15	90,553
06/17/15	116,452
06/24/15	296,897
7/1/15	218,488
7/8/15	128,535
7/15/15	0
7/22/15	0
7/29/15	0
8/5/15	91,318
8/12/15	311,292
8/19/15	420,629
8/26/15	351,155
9/2/15	400,279
9/9/15	310,034
9/16/15	261,553
9/23/15	421,082
9/30/15	455,598
10/7/15	112,235
10/14/15	11,900
10/21/15	182,299
10/28/15	0
11/4/15	0
11/10/15	0
11/18/15	0
11/25/15	0
12/2/15	0
12/9/15	0
12/16/15	0
12/23/15	0
12/30/15	0

Appendix C.
Tables and Data for 2015 Freshwater Injection

Appendix C. Tables and Data for 2015 Freshwater Injection

Table C-1. CF4 Well Construction

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

Appendix C. Tables and Data for 2015 Freshwater Injection (*continued*)

Table C-2. Chronology of CF4 Activities in 2015

Month	River Flow (cfs)	Activity
January	3,010 to 4,280	Injection system was started on January 5.
February	2,980 to 3,710	Injection system operated all month.
March	3,060 to 4,830	Injection system operated most of the month. It was shut down from March 19-21 to replace a valve in CF4. The system was shut down on March 27, and the filter was cleaned. The system was restarted on March 31.
April	3,230 to 4,760	Injection system operated most of the month. It was shut down from April 15 from maintenance and remained off due to high river flow
May	3,710 to 14,100	Injection system remained shut down for high river flow.
June	14,600 to 31,000	No injection operations due to high river flow.
July	4,520 to 14,700	No injection operations due to high river flow.
August	3,180 to 4,840	Injection system was re-started on August 18. It was shut down on August 27 due high turbidity.
September	3,880 to 5,270	Injection operations resumed on September 23.
October	3,740 to 6,740	Was shut down for maintenance from October 7-14 for maintenance.
November	3,700 to 3,820	Injection system operated all month.
December	3,510 to 3,990	Injection system was shut down to repair a leak from December 6-9 and again on December 18, when it was winterized for the season.

Table C-3. Ammonia Sample Results 2015

Location	Date	Ammonia, as N (mg/L)	Uranium (mg/L)	Specific Conductance (µmhos/cm)
0780	03/23/15	0.15	0.018	1,290
	11/02/15	0.1	0.0057	1,131
0781	03/23/15	1,600	2.2	74,710
	11/02/15	1,500	2.4	55,727
0782	03/23/15	1	0.017	1,265
	11/02/15	0.9	0.017	1,178
0783	03/23/15	0.1	0.047	1,222
	11/02/15	1	0.071	1,243
0784	03/23/15	0.1	0.014	1,339
	110/2/15	0.1	0.014	1,179
0785	03/23/15	0.1	0.0075	1,291
	11/02/15	0.13	0.01	1,234
0786	03/23/15	0.19	0.0082	1,270
	11/02/15	0.1	0.007	1,140
0787	03/23/15	41	0.048	1,662
	11/02/15	480	0.9	21,623
0790	04/02/15	0.11	0.038	1,273
0791	04/02/15	160	0.18	5,757

µmhos/cm = micromhos per centimeter

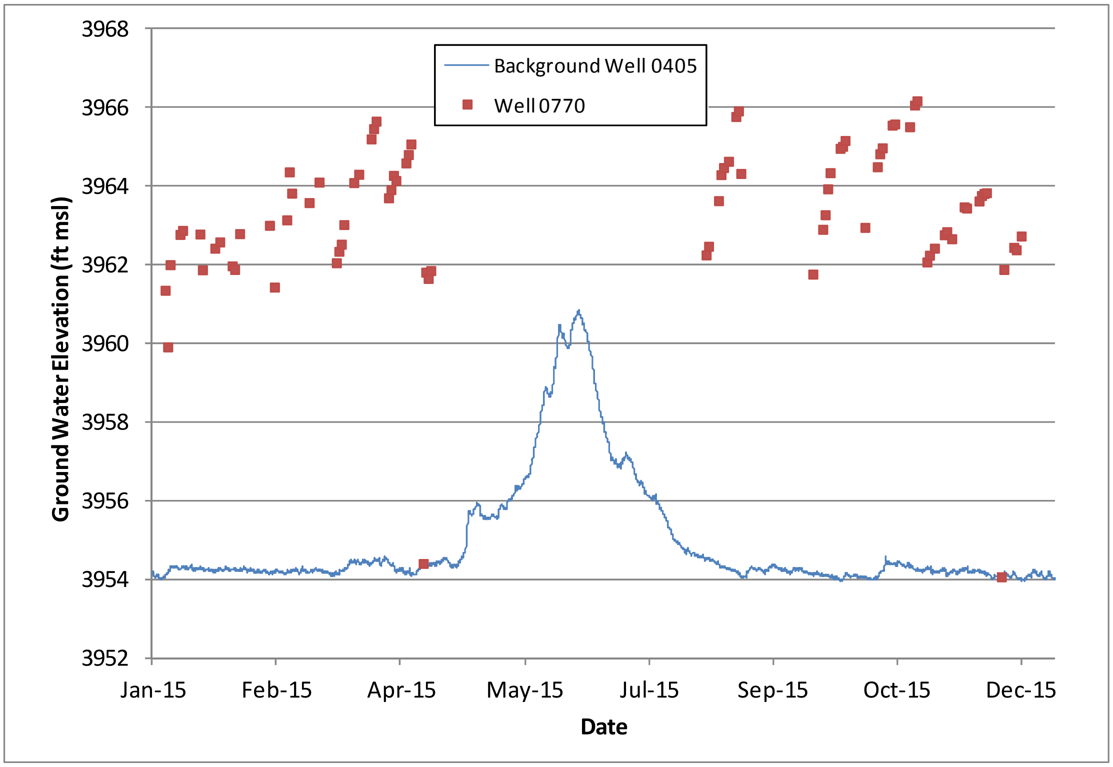


Figure C-1. Freshwater Mounding in Remediation Well 0770 during Injection

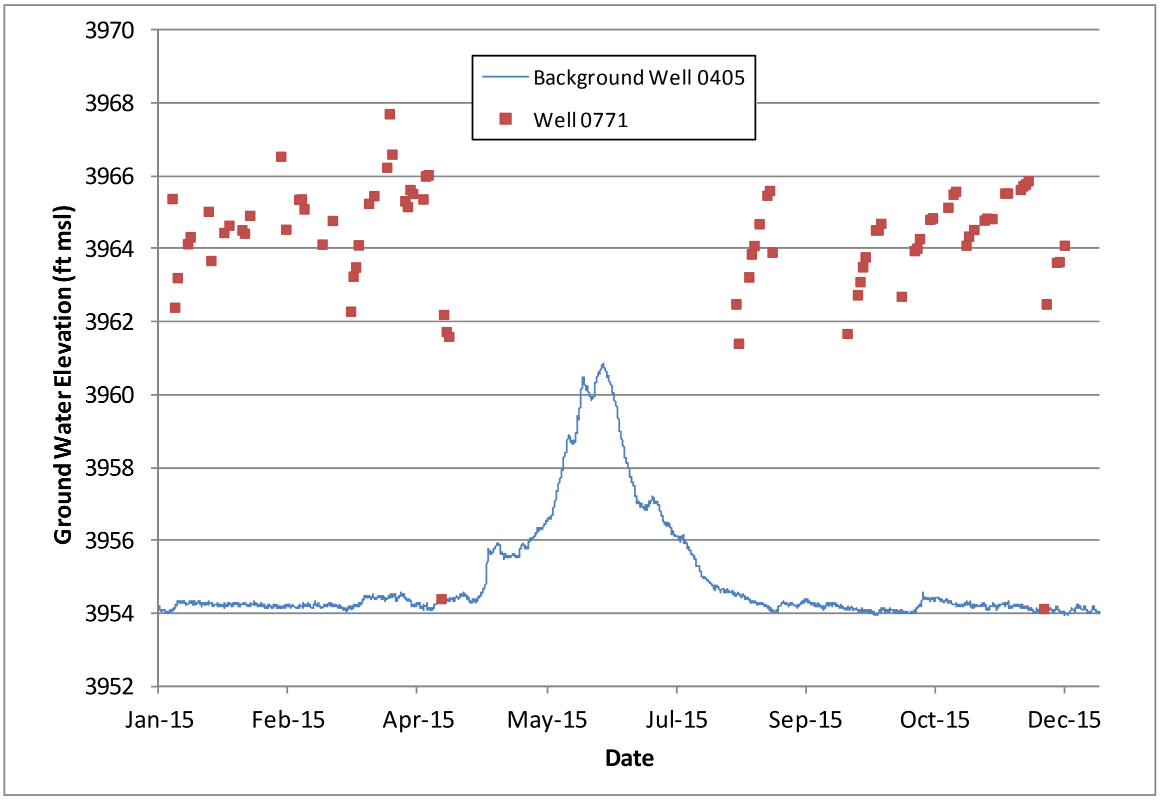


Figure C-2. Freshwater Mounding in Remediation Well 0771 during Injection

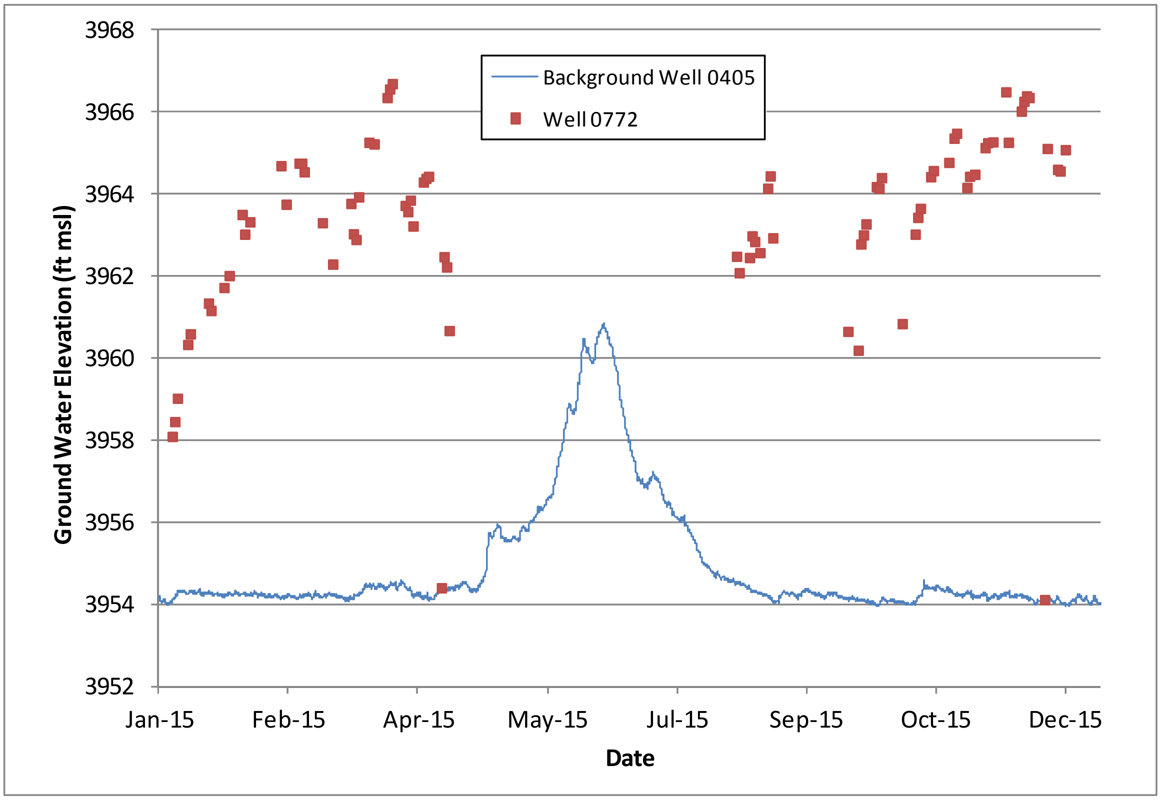


Figure C-3. Freshwater Mounding in Remediation Well 0772 during Injection

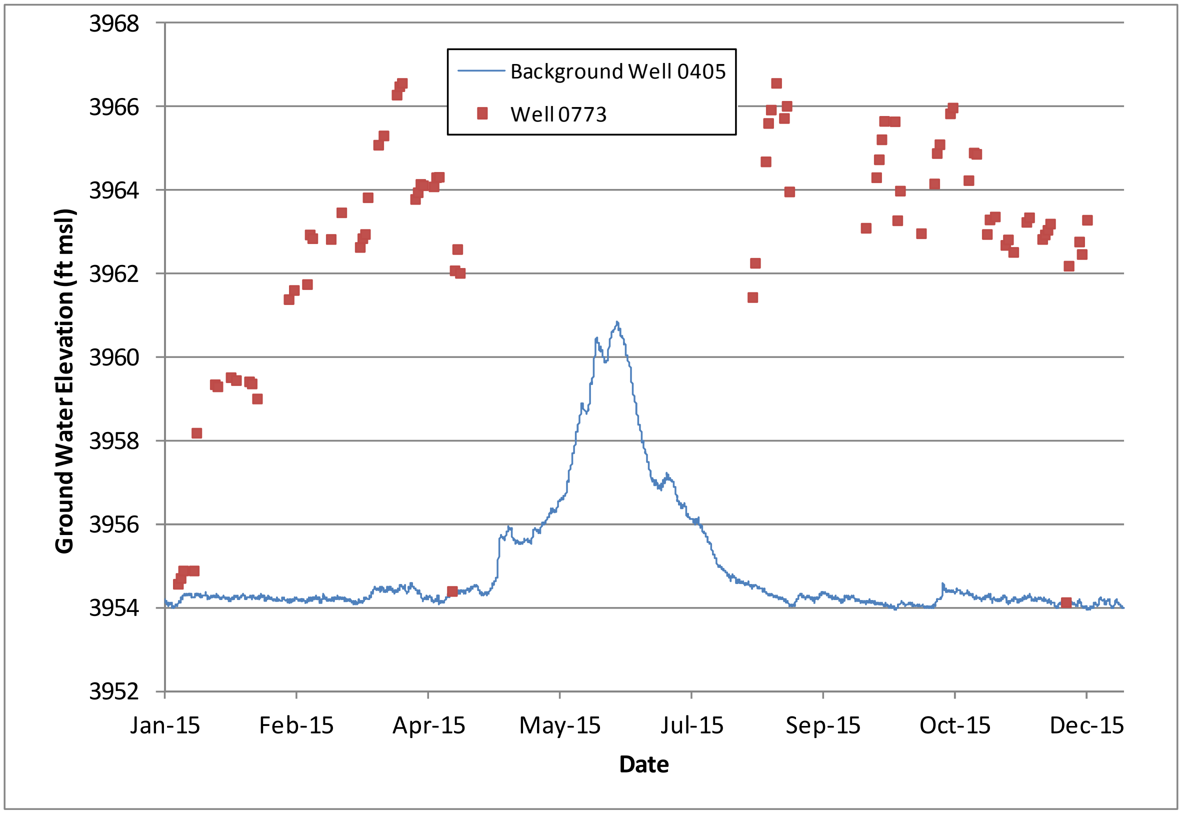


Figure C-4. Freshwater Mounding in Remediation Well 0773 during Injection

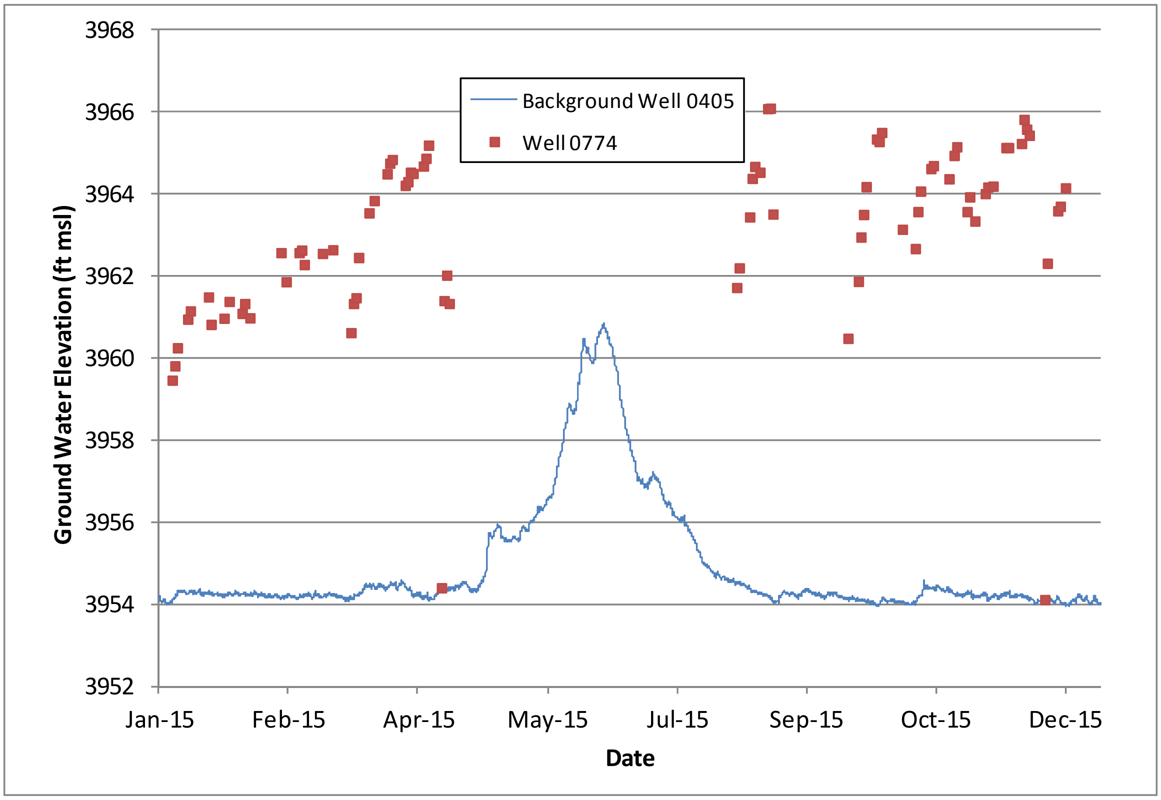


Figure C-5. Freshwater Mounding in Remediation Well 0774 during Injection

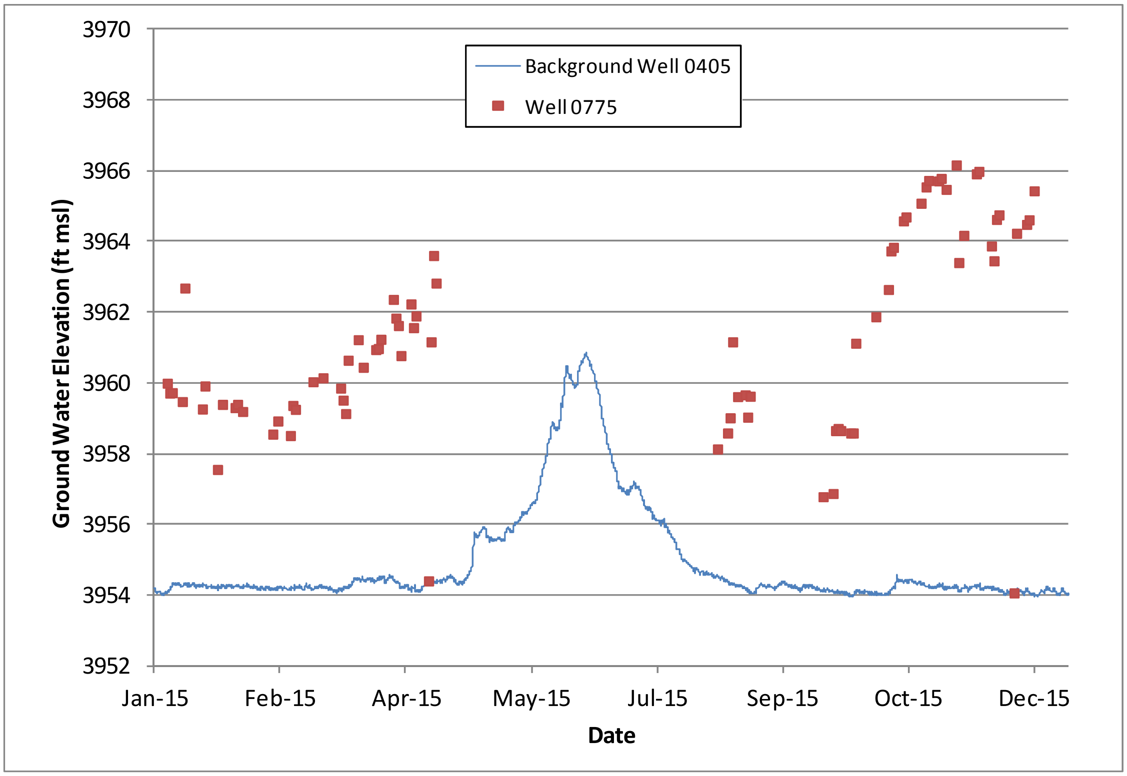


Figure C-6. Freshwater Mounding in Remediation Well 0775 during Injection

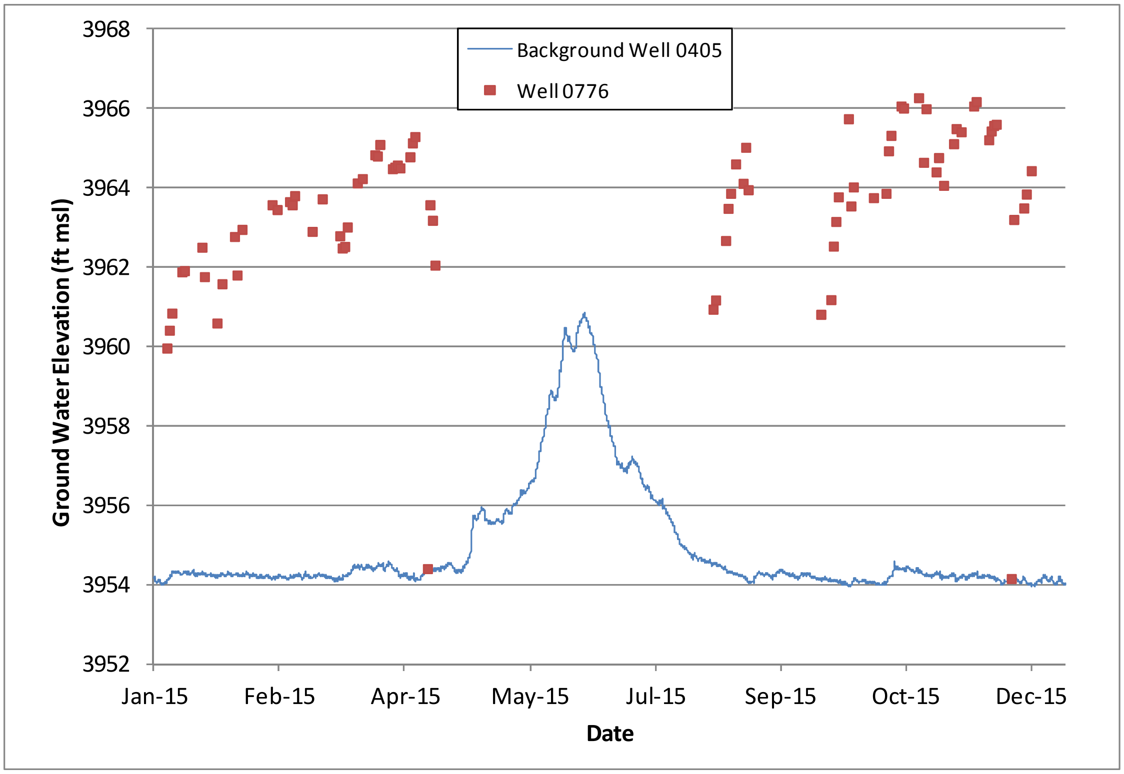


Figure C-7. Freshwater Mounding in Remediation Well 0776 during Injection

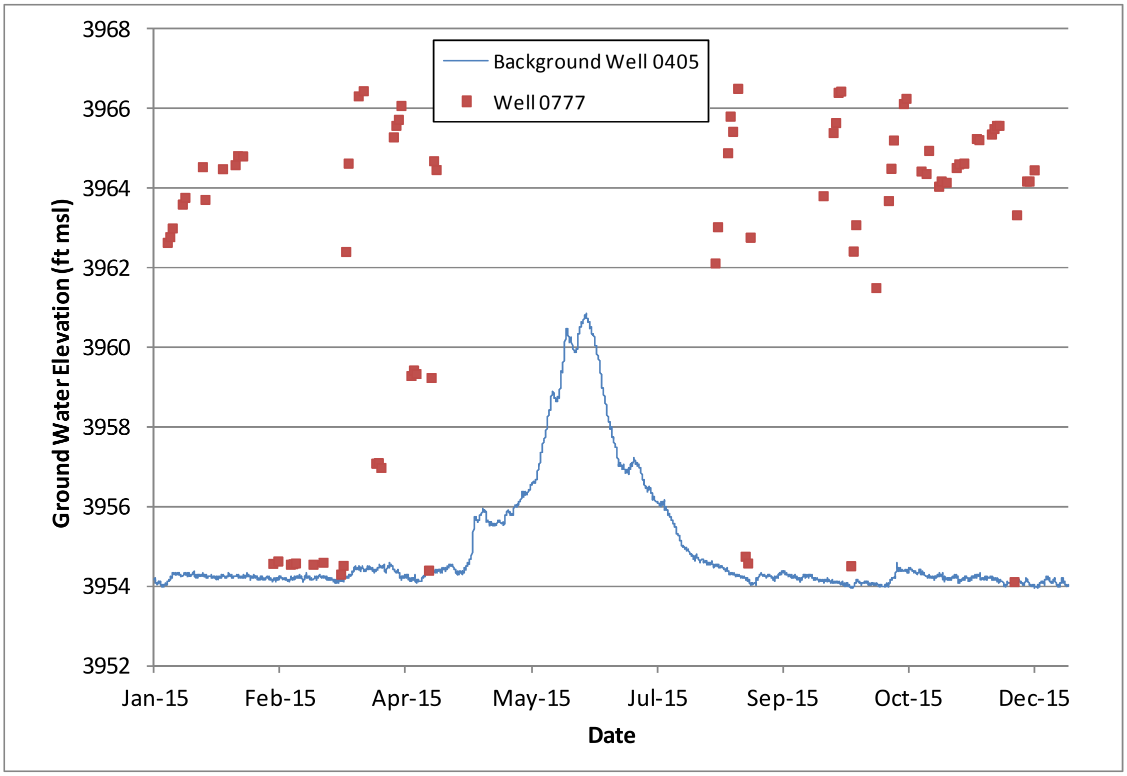


Figure C-8. Freshwater Mounding in Remediation Well 0777 during Injection

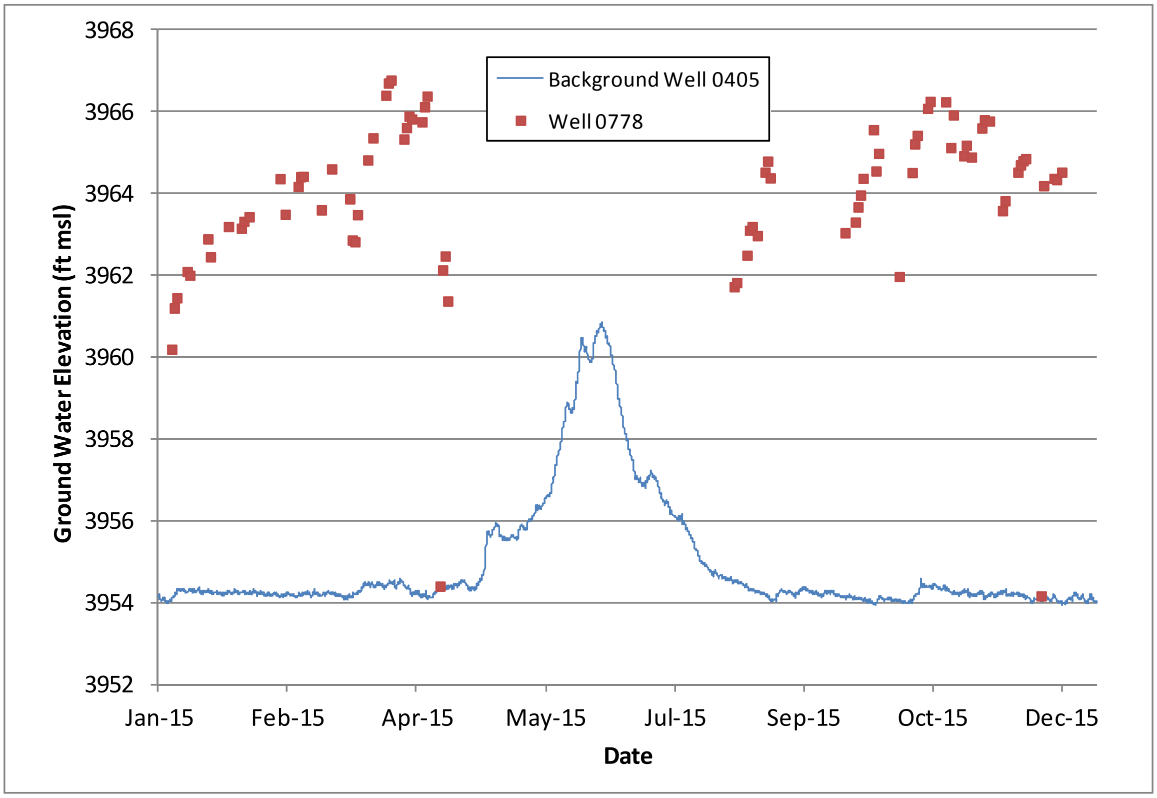


Figure C-9. Freshwater Mounding in Remediation Well 0778 during Injection

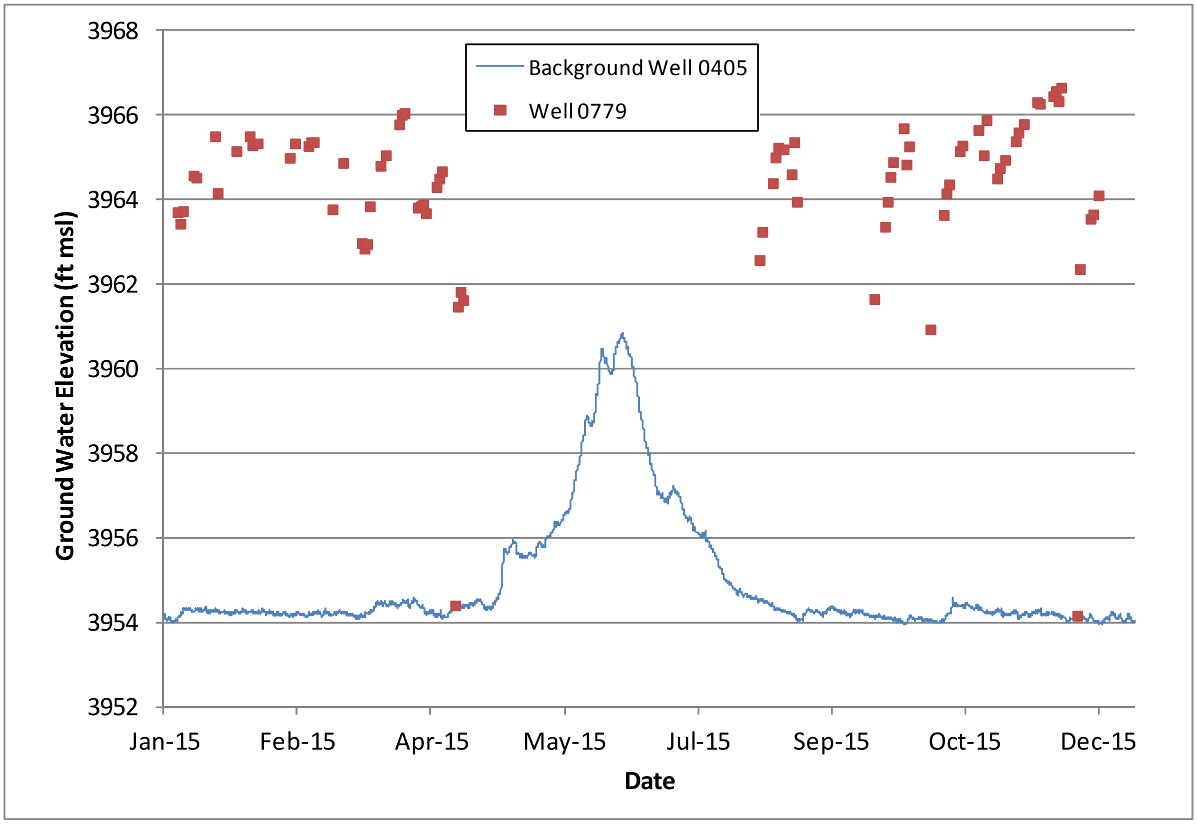
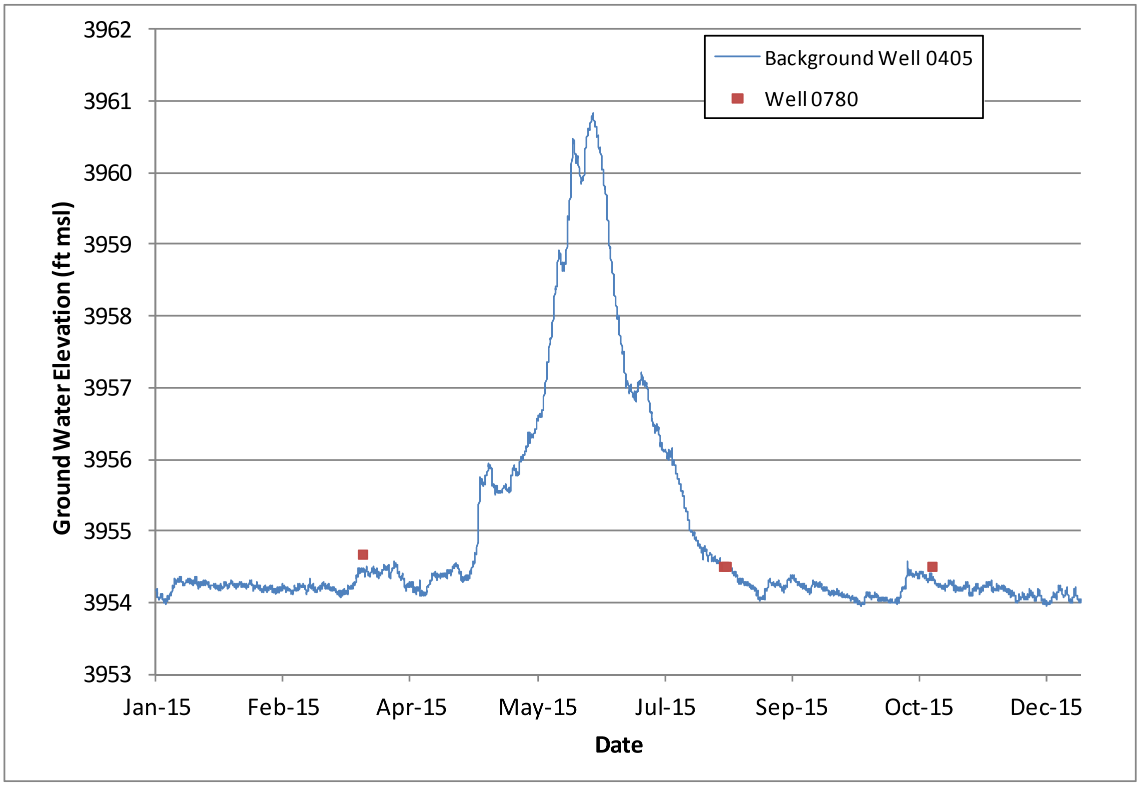
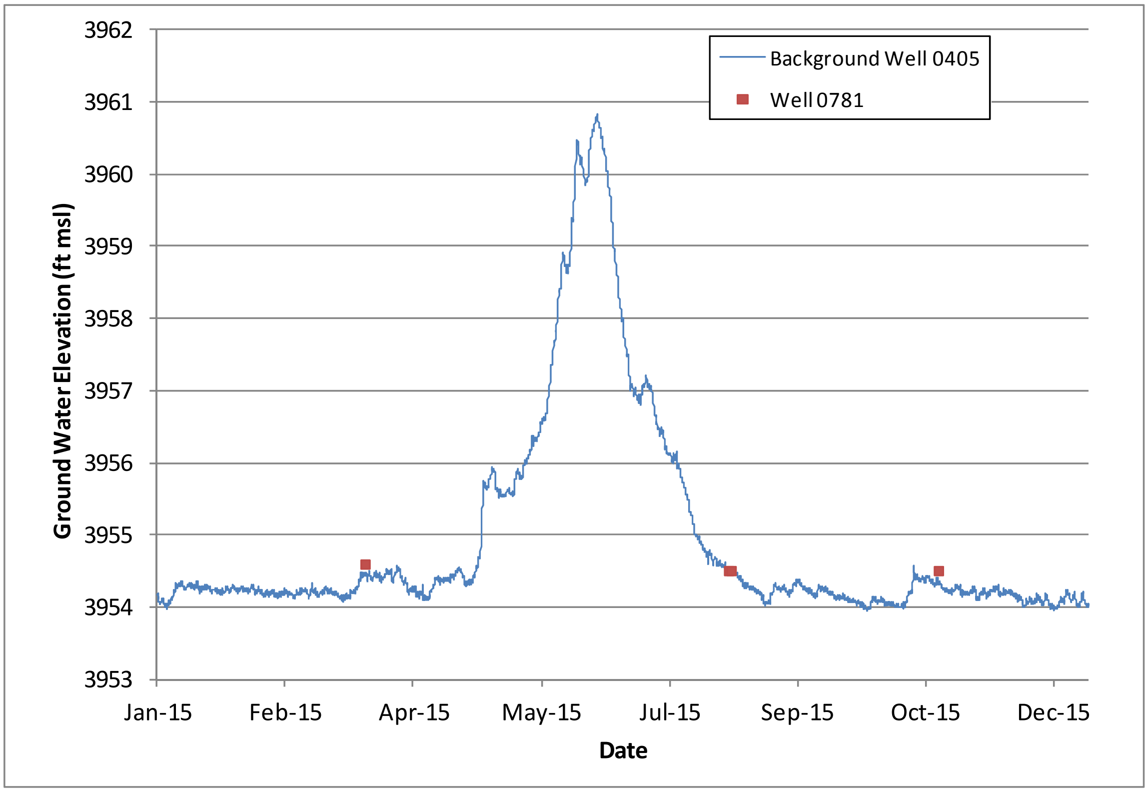


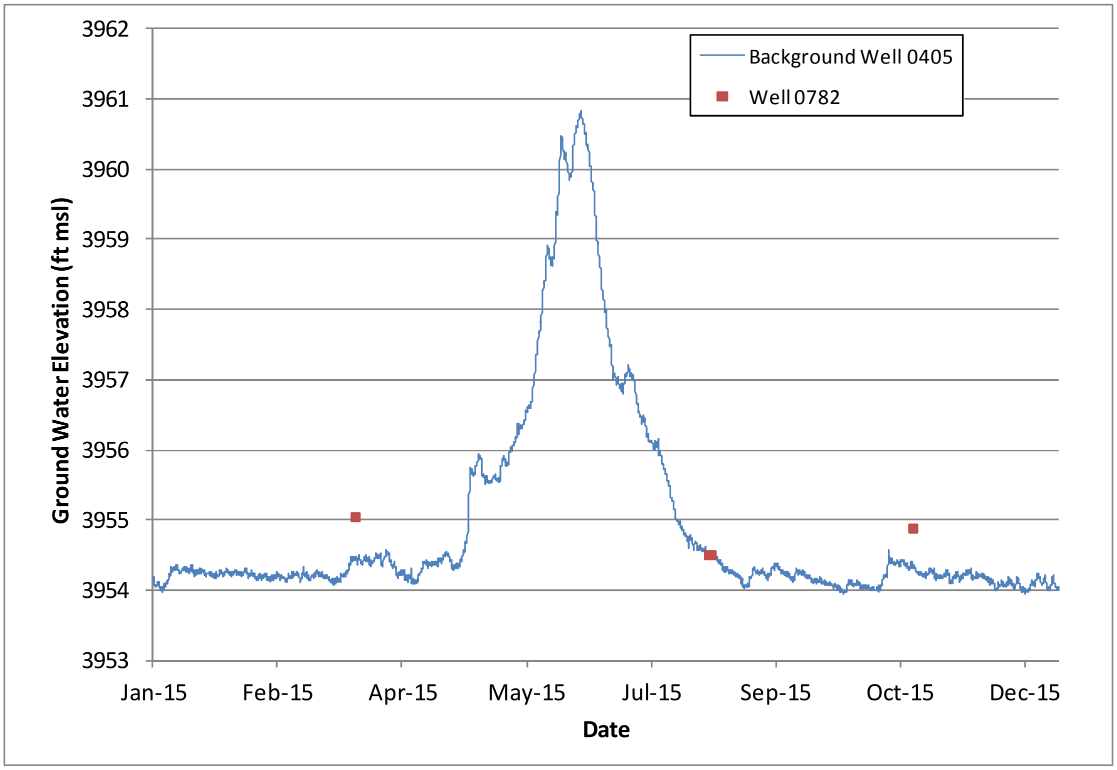
Figure C-10. Freshwater Mounding in Remediation Well 0779 during Injection



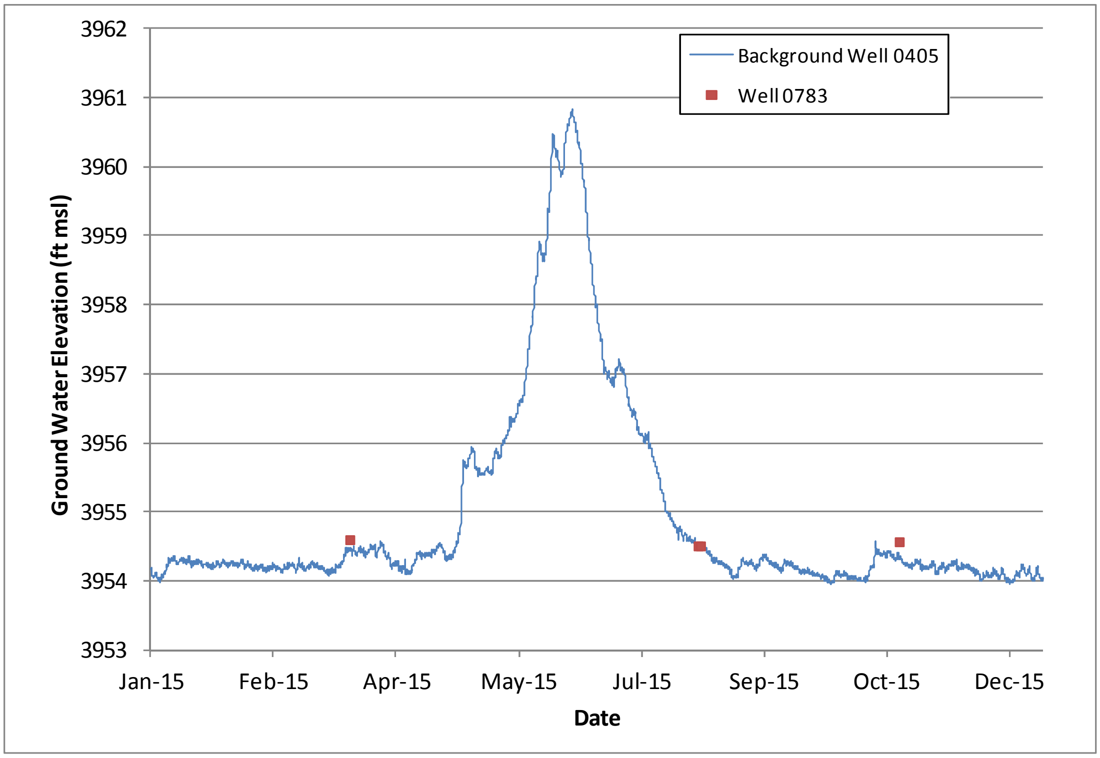
C-11. Freshwater Mounding in Observation Well 0780



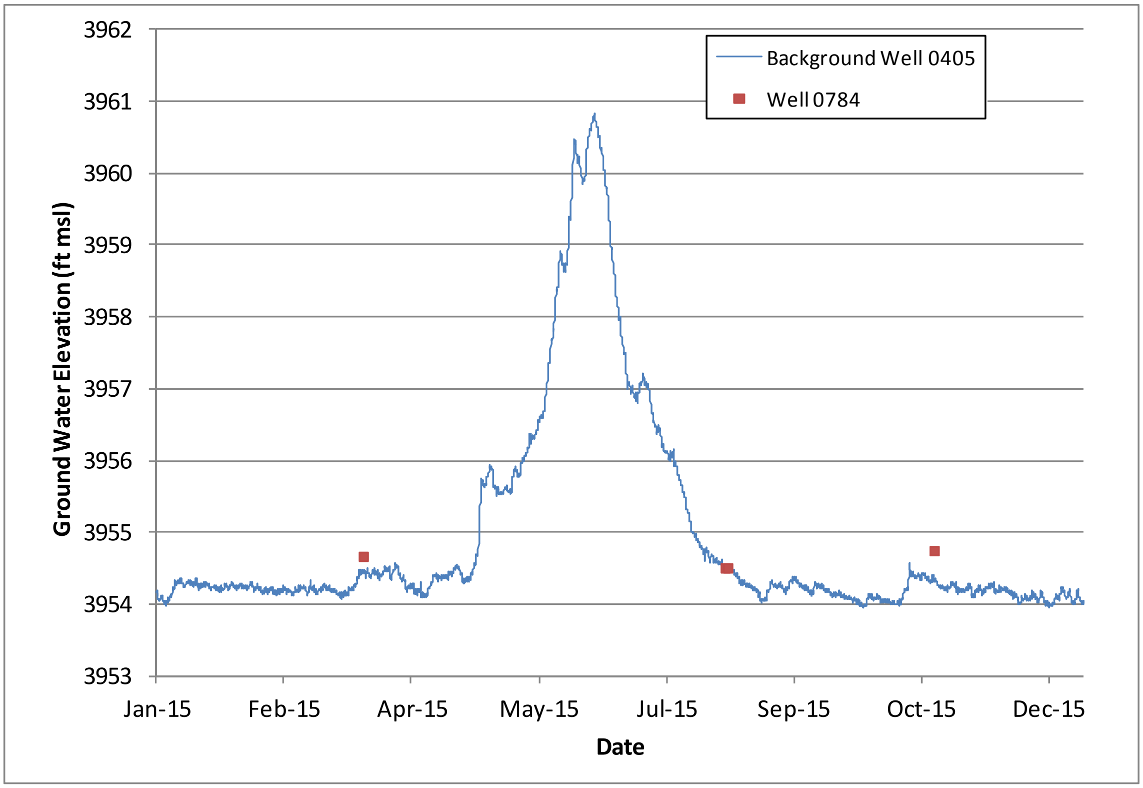
C-12. Freshwater Mounding in Observation Well 0781



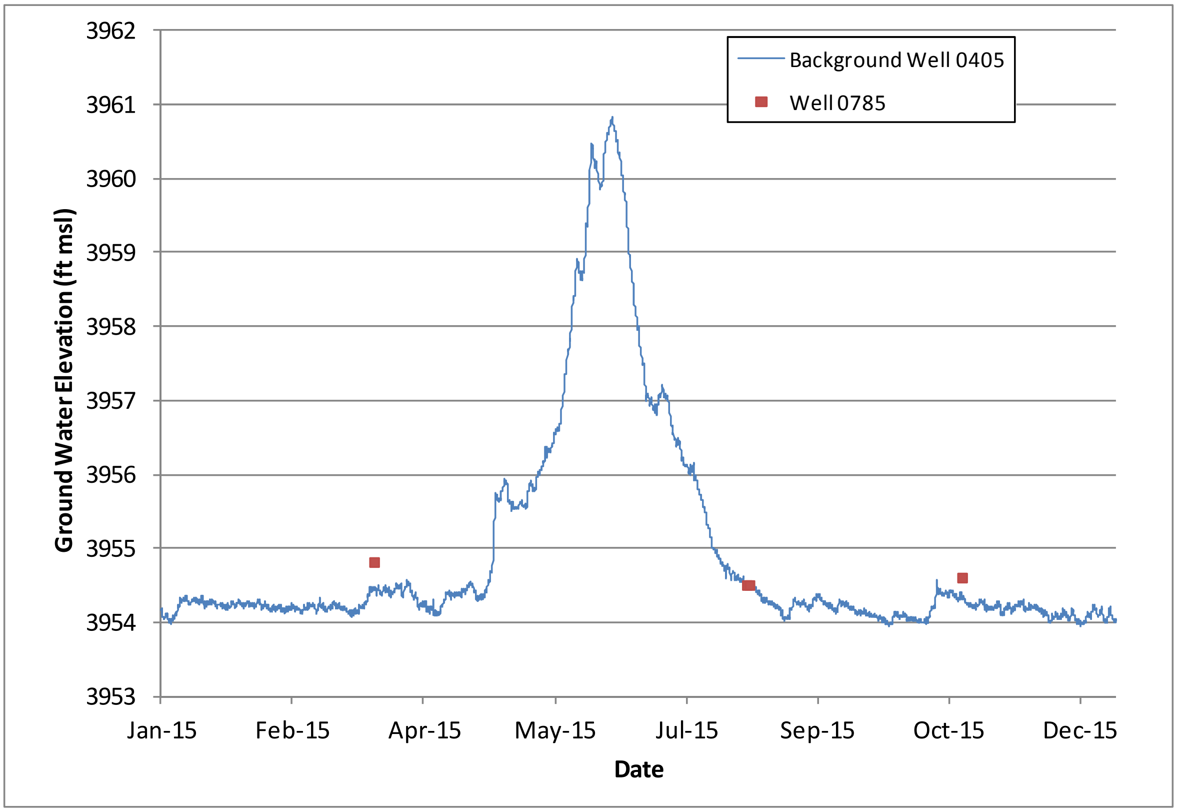
C-13. Freshwater Mounding in Observation Well 0782



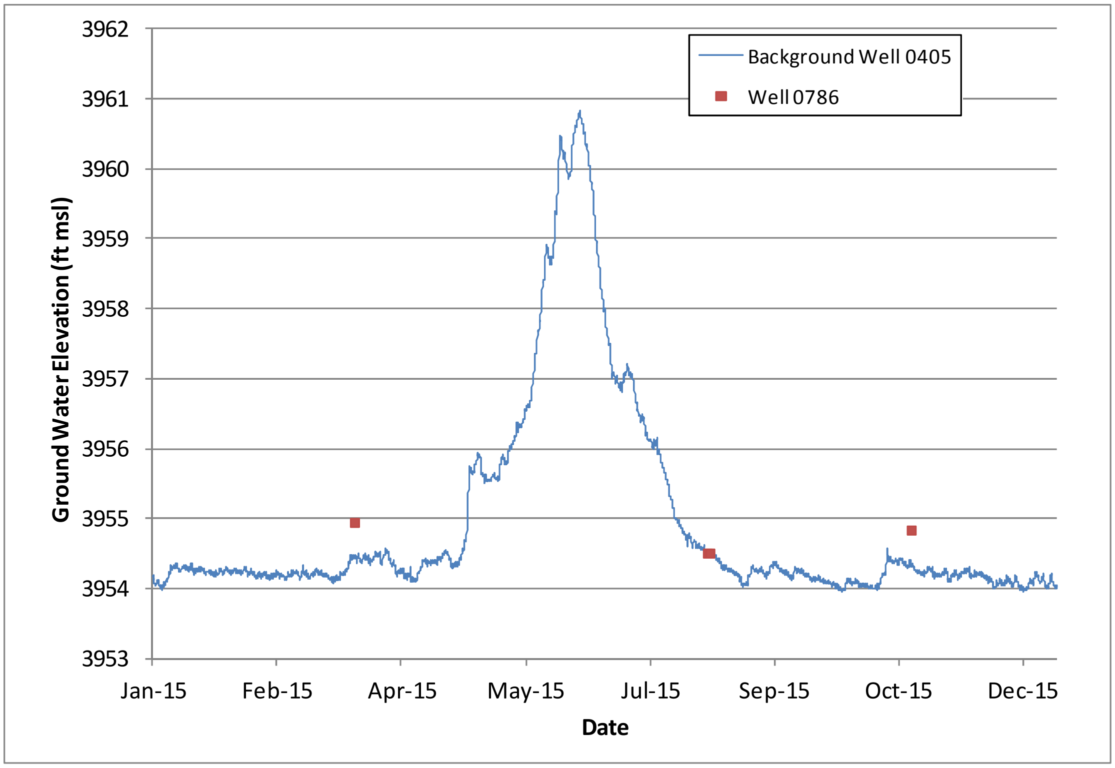
C-14. Freshwater Mounding in Observation Well 0783



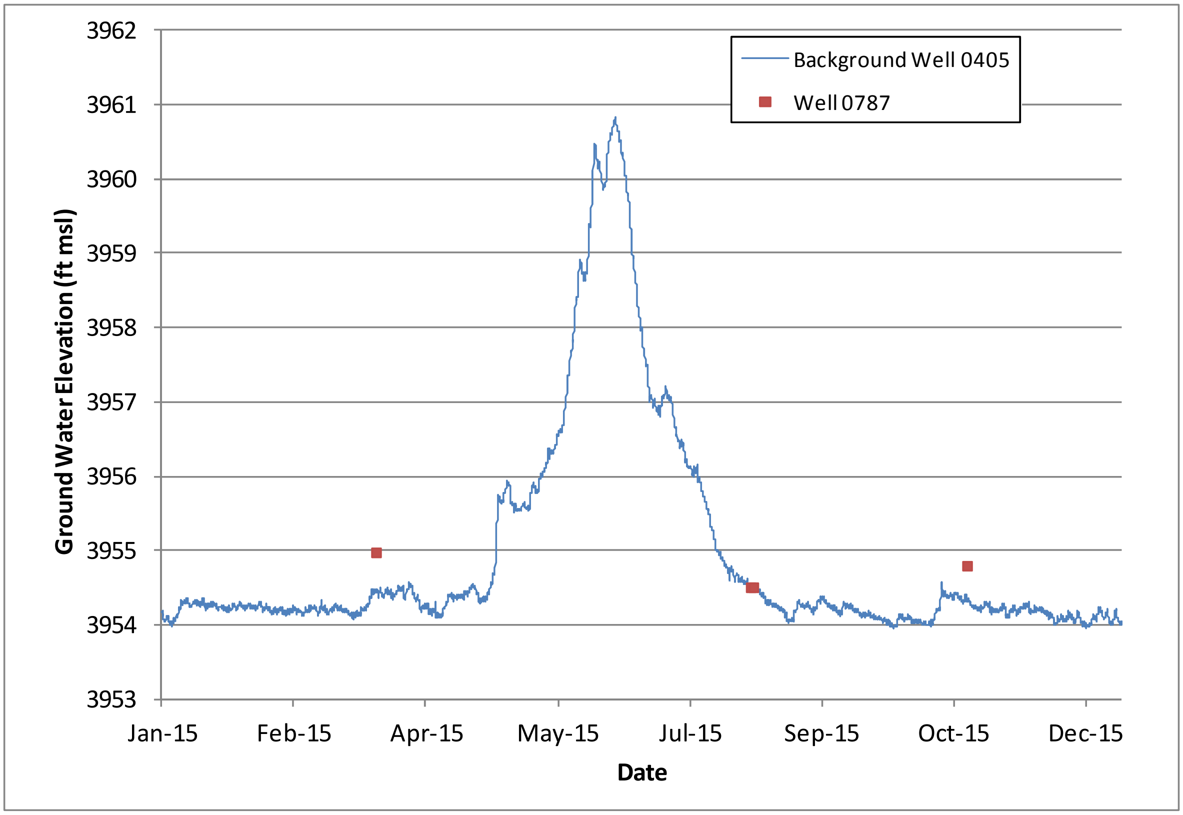
C-15. Freshwater Mounding in Observation Well 0784



C-16. Freshwater Mounding in Observation Well 0785



C-17. Freshwater Mounding in Observation Well 0786



C-18. Freshwater Mounding in Observation Well 0787

Appendix D.
Model Configuration and Calibration

Appendix D. Model Configuration and Calibration

Introduction

The former Moab Mill Site currently uses a series of extraction and injection wells to prevent contaminated ground water discharge to the Colorado River potential suitable habitat area located off the well field (Figure 1). Currently the former Moab UMTRA Site is undergoing transformation that includes removing the tailings pile and eradicating on-site near shore tamarisks and replacing them with combinations of cottonwoods, willows and grasses. It is recognized that removal of the tailings pile will result in increased recharge within the foot print of the former tailings pile and that eradication of tamarisks and revegetation efforts will reduce evapotranspiration at the site, particularly since the replacement plants are young and have not reached full evapotranspiration potential. This modeling effort was undertaken to determine how reconfiguration could potentially impact injection and extraction well performance.

- An ambient simulation representing current conditions was also performed for comparison purposes.
- Injection and extraction well operation (Tables 1 and 2);
- Injection well operation (Table 1);
- Extraction well operation (Table 2);
- Maximum evapotranspiration, which assumes that the cottonwoods and willows are at maximum size but injection and extraction are absent.

An additional simulation was undertaken to evaluate the effects of halting ground water extraction in January, February and December. For this simulation the extraction rates were identical to those described in Table 2, except no extraction occurred in the months of January, February or December (Table 3).

Table 1. Injection Well Rates (gpm)

Month	Injection Well Number										Total (gpm)
	0770	0771	0772	0773	0774	0775	0776	0777	0778	0779	
Jan	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	15.0
Feb	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	28.0
Mar	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	26.0
Apr	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	19.0
May	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	16.0
Jun	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	9.0
Jul	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	12.0
Aug	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	13.0
Sep	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	13.0
Oct	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	20.0
Nov	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	24.0
Dec	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	17.0

Table 2. Extraction Well Rates for Scenario 1 (gpm)

Month	Extraction Well Number								Total (gpm)
	0810	0811	0812	0813	0814	0815	0816	PW02	
Jan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.5	37.5
Feb	0.0	0.0	0.0	0.0	0.0	35.0	0.0	37.5	72.5
Mar	30.0	18.3	27.5	0.0	0.0	35.0	0.0	37.5	148.3
Apr	30.0	18.3	27.5	53.3	0.0	35.0	0.0	37.5	201.6
May	0.0	18.3	27.5	53.3	34.0	0.0	47.0	0.0	180.1
Jun	30.0	18.3	27.5	53.3	34.0	35.0	47.0	37.5	282.6
Jul	30.0	18.3	27.5	0.0	34.0	0.0	47.0	0.0	156.8
Aug	30.0	18.3	27.5	53.3	34.0	0.0	0.0	0.0	163.1
Sep	30.0	18.3	27.5	53.3	0.0	0.0	0.0	0.0	129.1
Oct	30.0	18.3	27.5	53.3	0.0	0.0	0.0	37.5	166.6
Nov	0.0	0.0	27.5	0.0	0.0	35.0	0.0	37.5	100.0
Dec	0.0	0.0	27.5	0.0	0.0	35.0	0.0	37.5	100.0

Table 3. Extraction Well Rates for Scenario 2 (gpm)

Month	Extraction Well Number								Total (gpm)
	0810	0811	0812	0813	0814	0815	0816	PW02	
Jan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Feb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mar	30.0	18.3	27.5	0.0	0.0	35.0	0.0	37.5	148.3
Apr	30.0	18.3	27.5	53.3	0.0	35.0	0.0	37.5	201.6
May	0.0	18.3	27.5	53.3	34.0	0.0	47.0	0.0	180.1
Jun	30.0	18.3	27.5	53.3	34.0	35.0	47.0	37.5	282.6
Jul	30.0	18.3	27.5	0.0	34.0	0.0	47.0	0.0	156.8
Aug	30.0	18.3	27.5	53.3	34.0	0.0	0.0	0.0	163.1
Sep	30.0	18.3	27.5	53.3	0.0	0.0	0.0	0.0	129.1
Oct	30.0	18.3	27.5	53.3	0.0	0.0	0.0	37.5	166.6
Nov	0.0	0.0	27.5	0.0	0.0	35.0	0.0	37.5	100.0
Dec	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Model Configuration

The evaluation was undertaken using the Moab Mill Site transient SEAWAT model developed by A. D. Laase Hydrologic Consulting in 2011. Modeling was performed using the SEAWAT (Langevin, C.D., et. al., and MODFLW/MT3DMS (McDonald, M.G. and Harbaugh, A.W.), codes and Groundwater Vistas (Rumbaugh and Rumbaugh) software as the pre and post processors. Changes to the model included removing the recharge zone associated with the tailings pile and replacing that zone with ambient recharge. The tailings pile was designed to limit precipitation infiltration and as a result recharge from the pile consisted primarily of residual drainage which, given the age of the pile, was minimal compared to precipitation infiltration.

The single evapotranspiration zone representing tamarisks clustered along the shoreline was also modified to represent the plantings of cottonwoods, willows and grasses (Figure 2). Transpiration from cottonwoods and willow plantings is between 0.05 inches/day (in/d) and 0.19 in/d on an annual basis (Shaeffer et al. 2000). For comparison, tamarisks transpire between 0.39 in/d and 0.47 in/d on an annual basis (Shaeffer et al. 2000). For the simulations it was assumed that because the cottonwood and willow plantings are relatively young, transpiration is currently only half of the reported rate. Grasses are relatively short rooted compared to trees and as such transpire much less ground water than cottonwoods and willows.

For the simulations it was assumed that transpiration from grasses was zero. Assigned evapotranspiration rates were scaled to reflect the percentage of cottonwoods, willows and grasses in each planting area. Further, in recognition that evapotranspiration is temporally variable, assigned evapotranspiration rates were scaled similarly to the 2011 model to reflect expected monthly changes in transpiration. To reflect that the remaining tamarisks are doing poorly, evapotranspiration from them was halved during the simulations.

Lastly, injection and extraction wells were added to the model (Figure 1) and assigned the monthly production rates listed in Tables 1 and 2. These rates are the anticipated rates during a normal Colorado River spring runoff.

Model Predictions

Model predictions for ambient conditions and the remedial four scenarios are presented in the following subsections.

Ambient Conditions

Monthly model-predicted ground water surface for a focused area containing the extraction and injection wells and potential suitable habitat for ambient conditions are shown in Figures 3 through 14. January through March ground water surfaces show ground water discharge to the river (Figures 3 through 5). Rising river levels associated with spring runoff are reflected in April’s ground water surface (Figure 6). High river stage in May and June results in river water entering the adjacent subsurface soils which is evident in the model-predicted ground water surfaces (Figures 7 and 8). By July river levels have dropped and the ground water surface shows ground water once again discharging to the river (Figures 9 through 14).

The model predicts under ambient conditions that ground water discharge to the potential suitable habitat at rates between 0.08 gpm and 1.27 gpm for all months except May and June (Table 4). In May and June elevated river stage associated with spring runoff results in river water flowing into the subsurface soils from the river side channel at rates between 2.17 and 2.39 gpm.

Table 4. Potential Suitable Habitat - Ambient Recharge and Discharge Volumes.

Month	Inflows (gpm)	Outflows (gpm)	Inflow – Outflow (gpm)
January	0.00	1.27	-1.27
February	0.00	1.25	-1.25
March	0.00	1.04	-1.04
April	0.00	0.08	-0.08
May	2.17	0.00	2.17
June	2.39	0.00	2.39
July	0.00	0.43	-0.43
August	0.00	1.25	-1.25
September	0.00	1.24	-1.24
October	0.00	1.09	-1.09
November	0.00	1.09	-1.09
December	0.00	1.26	-1.26

Injection and Extraction Wells Operational

To capture ground water contamination and to prevent ground water discharge to the potential suitable habitat area the extraction and injection wells are operated together at the rates listed in Tables 1 and 2. Monthly model-predicted ground water surfaces when the extraction and injection wells are operated together are shown in Figures 15 through 26.

The effects of pumping are illustrated by cones of depressions surrounding the extraction wells that develop in response to pumping. Mounding associated with injection is evident, for the most part, in the model-predicted ground water surfaces adjacent to the potential suitable habitat. As with the previous injection simulations, use if a 1-foot contour interval fails to communicate mounding occurring in June (Figure 20), July (Figure 21) and September (Figure 23). Examination of the modeling output shows that ground water levels are higher than adjacent river levels indicating flow from the injection wells towards the river. Flow at the potential suitable habitat is from the injection wells to the river January through March and August through December (Table 5). Flow from April through July is from the potential suitable habitat to the subsurface soils.

Table 5. Comparison of Potential Suitable Habitat Ambient and Injection and Extraction Well Operation Recharge and Discharge Volumes

Month	Ambient			Injection and Extraction Well Operation		
	Inflows (gpm)	Outflows (gpm)	Inflow – Outflow (gpm)	Inflows (gpm)	Outflows (gpm)	Inflow – Outflow (gpm)
January	0.00	1.27	-1.27	0.00	0.78	-0.78
February	0.00	1.25	-1.25	0.00	1.19	-1.19
March	0.00	1.04	-1.04	0.00	0.52	-0.52
April	0.00	0.08	-0.08	0.90	0.00	0.90
May	2.17	0.00	2.17	3.08	0.00	3.08
June	2.39	0.00	2.39	3.98	0.00	3.98
July	0.00	0.43	-0.43	0.78	0.00	0.78
August	0.00	1.25	-1.25	0.03	0.09	-0.06
September	0.00	1.24	-1.24	0.01	0.15	-0.15
October	0.00	1.09	-1.09	0.07	0.08	-0.01
November	0.00	1.09	-1.09	0.00	0.41	-0.41
December	0.00	1.26	-1.26	0.00	0.60	-0.60

Injection Wells Operational

Injection wells were installed adjacent to the fish spawning area to ensure clean water rather than contaminated ground water discharges to the potential suitable habitat. Monthly injection rates are as listed in Table 1. Monthly model-predicted water-tables show, for the most part, mounding associated with injection (Figures 27 through 38). While mounding isn't readily apparent in the January (Figure 27), April (Figure 30), July (Figure 33) and September (Figure 35) examination of the modeling output shows that ground water levels are higher than adjacent river levels by less than 1 foot, which is also less than the 1-foot contour interval. Consequently, closed contours are not present in the vicinity of the injection wells. Model-predicted ground water surfaces for May and June, a period of high river stage due to spring runoff, shows flow from the potential suitable habitat to the subsurface soils (Figures 31 and 32).

Mass balance analysis shows that with the exception of May and June clean injected water discharges to the potential suitable habitat (Table 6). Note that the volume of water discharging to the potential suitable habitat increases every month except for May and June relative to ambient conditions indicating that injected water rather than contaminated water is discharging to the potential suitable habitat. In May and June, due to elevated river stage, water flows from the river to the subsurface soils at the potential suitable habitat.

Table 6. Comparison of Potential Suitable Habitat Ambient and Injection Well Operation Recharge and Discharge Volumes

Month	Ambient			Injection Well Operation		
	Inflows (gpm)	Outflows (gpm)	Inflow – Outflow (gpm)	Inflows (gpm)	Outflows (gpm)	Inflow – Outflow (gpm)
January	0.00	1.27	-1.27	0.00	1.85	-1.85
February	0.00	1.25	-1.25	0.00	2.17	-2.17
March	0.00	1.04	-1.04	0.00	1.94	-1.94
April	0.00	0.08	-0.08	0.00	0.80	-0.80
May	2.17	0.00	2.17	1.56	0.00	1.56
June	2.39	0.00	2.39	1.99	0.00	1.99
July	0.00	0.43	-0.43	0.00	0.88	-0.88
August	0.00	1.25	-1.25	0.00	1.74	-1.74
September	0.00	1.24	-1.24	0.00	1.73	-1.73
October	0.00	1.09	-1.09	0.00	1.77	-1.77
November	0.00	1.09	-1.09	0.00	1.89	-1.89
December	0.00	1.26	-1.26	0.00	1.89	-1.89

Extraction Wells Operational

The extraction wells are primarily operated to capture contaminated ground water originating from the former tailings pile. Because of the relatively large volumes of water extracted (Table 2) the wells influence the ground water river interaction in the vicinity of the potential suitable habitat. Cones of depression resulting from extraction well operation are present in the model-predicted ground water surfaces for every month (Figures 39 through 50). Pumping influence is less in January and February when only extraction well PW02 is operational (Figure 39 and 40). The cones of depression are much larger in subsequent months when multiple extraction wells are operational (Figures 41 through 50). With the possible exception of January and February, the monthly model-predicted ground water surfaces suggest that ground water extraction results in flow from the river towards the extraction wells in the vicinity of the potential suitable habitat. Mass balance analysis shows that with the exception of January and February, operation of the extraction well field results in flow from the river towards the extraction wells (Table 7). Pumping extraction well PW02 in January and February decreases the volume of ground water discharging to the potential suitable habitat from approximately 1.25 gpm to 0.25 gpm.

Table 7. Comparison of Potential Suitable Habitat Ambient and Extraction Well Operation Recharge and Discharge Volumes

Month	Ambient			Extraction Well Operation		
	Inflows (gpm)	Outflows (gpm)	Inflow – Outflow (gpm)	Inflows (gpm)	Outflows (gpm)	Inflow – Outflow (gpm)
January	0.00	1.27	-1.27	0.00	0.25	-0.25
February	0.00	1.25	-1.25	0.00	0.32	-0.32
March	0.00	1.04	-1.04	0.34	0.00	0.34
April	0.00	0.08	-0.08	1.57	0.00	1.57
May	2.17	0.00	2.17	3.65	0.00	3.65
June	2.39	0.00	2.39	4.35	0.00	4.35
July	0.00	0.43	-0.43	1.20	0.00	1.20
August	0.00	1.25	-1.25	0.39	0.00	0.39
September	0.00	1.24	-1.24	0.31	0.00	0.31
October	0.00	1.09	-1.09	0.64	0.00	0.64
November	0.00	1.09	-1.09	0.36	0.00	0.36
December	0.00	1.26	-1.26	0.05	0.05	0.00

Maximum Evapotranspiration Conditions

Simulations were performed with ambient evapotranspiration rates doubled to mimic the evapotranspiration potential of the recently planted cottonwoods, willows and grasses upon maturation. Evaluations were performed to assess whether water uptake alone from the plantings could halt or significantly lesson ground water discharge to the potential suitable habitat. Monthly model-predicted ground water surfaces for maximum evapotranspiration conditions are shown in Figures 51 through 62. The results are similar to the ambient condition predictions, with the January through March ground water surfaces shows ground water discharge to the river (Figures 51 through 53). Rising river levels associated with Spring runoff are reflected in April's ground water surface (Figure 54). High river stage in May and June results in river water entering the adjacent subsurface soils which is evident in the model-predicted ground water surfaces (Figures 55 and 56). By July river levels have dropped and the ground water surfaces show ground water once again discharging to the river (Figures 57 through 62).

Mass balance analysis shows that the interaction between the subsurface soils and adjacent potential suitable habitat are virtually identical for maximum evapotranspiration conditions and ambient conditions (Table 8). Ground water discharges to the potential suitable habitat January through April and July through December. Rising river levels associated with spring runoff result in flows from the potential suitable habitat to the subsurface soils.

Table 8. Comparison of Potential Suitable Habitat Ambient and Maximum Evapotranspiration Recharge and Discharge Volumes

Month	Ambient			Maximum Evapotranspiration		
	Inflows (gpm)	Outflows (gpm)	Inflow – Outflow (gpm)	Inflows (gpm)	Outflows (gpm)	Inflow – Outflow (gpm)
January	0.00	1.27	-1.27	0.00	1.28	-1.28
February	0.00	1.25	-1.25	0.00	1.26	-1.26
March	0.00	1.04	-1.04	0.00	1.05	-1.05
April	0.00	0.08	-0.08	0.00	0.09	-0.09
May	2.17	0.00	2.17	2.20	0.00	2.20
June	2.39	0.00	2.39	2.43	0.00	2.43
July	0.00	0.43	-0.43	0.00	0.39	-0.39
August	0.00	1.25	-1.25	0.00	1.23	-1.23
September	0.00	1.24	-1.24	0.00	1.23	-1.23
October	0.00	1.09	-1.09	0.00	1.09	-1.09
November	0.00	1.09	-1.09	0.00	1.08	-1.08
December	0.00	1.26	-1.26	0.00	1.26	-1.26

Modified Extraction Pumping Schedule Scenario

Simulations were completed using an alternative extraction pumping schedule, when there is no extraction during November, December, and January (Table 3). This pumping alternative represents the anticipated extraction scheme after the evaporation pond has been removed. As expected, cones of depression resulting from extraction well operation are present in the March through November model-predicted water tables (Figures 63 through 74). Residual effects from pumping can be seen in the January and December model-predicted water table as evidenced by the protrusion of the 3,953-ft contour in-land. By February there is no visual evidence of the influence of pumping. However, the water table is still depressed as a result of nine months of continuous pumping.

The February model-predicted ambient water table (Figure 4) shows the 3,954-ft contour locate adjacent to the Colorado River while the February model-predicted modified pumping scenario water-table (Figure 64) shows the 3,953-ft contour adjacent to the river.

Mass balance analysis shows that during January, February and December ground water discharges to the Colorado River at rates between 0.35 and 0.67 gpm (Table 9). Note that even with the absence of pumping these rates are less than ambient rates. The reduction in discharge volumes to the river relative to ambient conditions is due to storage effects. Simplistically, ground water is “filling” in the cones of depression (adding to storage) resulting from nine months of continuous pumping rather than solely discharging to the river. From March through November flow is from the potential suitable habitat to the subsurface soils. Also note that with the exception of January, February and December, potential suitable habitat inflows and outflows for the modified extraction well pumping scenario are similar to those predicted for the Extraction Wells Operational Scenario (Table 3).

Table 9. Comparison of Potential Suitable Habitat Ambient and Modified Extraction Well Operation Recharge and Discharge Volumes

Month	Ambient			Modified Extraction Well Operation		
	Inflows (gpm)	Outflows (gpm)	Inflow – Outflow (gpm)	Inflows (gpm)	Outflows (gpm)	Inflow – Outflow (gpm)
January	0.00	1.27	-1.27	0.00	0.58	-0.58
February	0.00	1.25	-1.25	0.00	0.67	-0.67
March	0.00	1.04	-1.04	0.22	0.00	0.22
April	0.00	0.08	-0.08	1.50	0.00	1.50
May	2.17	0.00	2.17	3.61	0.00	3.61
June	2.39	0.00	2.39	4.32	0.00	4.32
July	0.00	0.43	-0.43	1.18	0.00	1.18
August	0.00	1.25	-1.25	0.38	0.00	0.38
September	0.00	1.24	-1.24	0.30	0.00	0.30
October	0.00	1.09	-1.09	0.64	0.00	0.64
November	0.00	1.09	-1.09	0.36	0.00	0.36
December	0.00	1.26	-1.26	0.00	0.35	-0.35

Comparison between the Previous and Modified Extraction Pumping Schedule Scenario

A comparison of the previous extraction schedule and the modified extraction schedule and the overall impact to the ground water system is provided in Table 10. The differences between the ambient and the two extraction scenarios are displayed along with the difference between the ground water system inflows and outflows. These differences are also compared to each other, and the results indicate there is not a significant difference between the two extraction scenarios, and the overall protection of the potential suitable habitat area protection is not impacted.

Table 10. Comparison between the Previous Ground Water Extraction Schedule and the Modified Extraction Schedule

Month	Ambient			Previous Ground Water Extraction			Difference Inflow-Outflow (gpm)
	Inflows (gpm)	Outflows (gpm)	Inflow – Outflow (gpm)	Inflows (gpm)	Outflows (gpm)	Inflow – Outflow (gpm)	
January	0.00	1.27	-1.27	0.00	0.25	-0.25	-1.02
February	0.00	1.25	-1.25	0.00	0.32	-0.32	-0.93
March	0.00	1.04	-1.04	0.34	0.00	0.34	-1.38
April	0.00	0.08	-0.08	1.57	0.00	1.57	-1.65
May	2.17	0.00	2.17	3.65	0.00	3.65	-1.48
June	2.39	0.00	2.39	4.35	0.00	4.35	-1.96
July	0.00	0.43	-0.43	1.20	0.00	1.20	-1.63
August	0.00	1.25	-1.25	0.39	0.00	0.39	-1.64
September	0.00	1.24	-1.24	0.31	0.00	0.31	-1.55
October	0.00	1.09	-1.09	0.64	0.00	0.64	-1.73
November	0.00	1.09	-1.09	0.36	0.00	0.36	-1.45
December	0.00	1.26	-1.26	0.05	0.05	0.00	-1.26

Month	Ambient			Modified Ground Water Extraction			Difference Inflow-Outflow (gpm)
	Inflows (gpm)	Outflows (gpm)	Inflow – Outflow (gpm)	Inflows (gpm)	Outflows (gpm)	Inflow – Outflow (gpm)	
January	0.00	1.27	-1.27	0.00	0.58	-0.58	-0.69
February	0.00	1.25	-1.25	0.00	0.67	-0.67	-0.58
March	0.00	1.04	-1.04	0.22	0.00	0.22	-1.26
April	0.00	0.08	-0.08	1.50	0.00	1.50	-1.58
May	2.17	0.00	2.17	3.61	0.00	3.61	-1.44
June	2.39	0.00	2.39	4.32	0.00	4.32	-1.93
July	0.00	0.43	-0.43	1.18	0.00	1.18	-1.61
August	0.00	1.25	-1.25	0.38	0.00	0.38	-1.63
September	0.00	1.24	-1.24	0.30	0.00	0.30	-1.54
October	0.00	1.09	-1.09	0.64	0.00	0.64	-1.73
November	0.00	1.09	-1.09	0.36	0.00	0.36	-1.45
December	0.00	1.26	-1.26	0.00	0.35	-0.35	-0.91

Month	Previous Ground Water Extraction			Modified Ground Water Extraction			Difference (gpm)
	Inflows (gpm)	Outflows (gpm)	Inflow – Outflow (gpm)	Inflows (gpm)	Outflows (gpm)	Inflow – Outflow (gpm)	
January	0.00	0.25	-0.25	0.00	0.58	-0.58	0.33
February	0.00	0.32	-0.32	0.00	0.67	-0.67	0.35
March	0.34	0.00	0.34	0.22	0.00	0.22	0.12
April	1.57	0.00	1.57	1.50	0.00	1.50	0.07
May	3.65	0.00	3.65	3.61	0.00	3.61	0.04
June	4.35	0.00	4.35	4.32	0.00	4.32	0.03
July	1.20	0.00	1.20	1.18	0.00	1.18	0.02
August	0.39	0.00	0.39	0.38	0.00	0.38	0.01
September	0.31	0.00	0.31	0.30	0.00	0.30	0.01
October	0.64	0.00	0.64	0.64	0.00	0.64	0.00
November	0.36	0.00	0.36	0.36	0.00	0.36	0.00
December	0.05	0.05	0.00	0.00	0.35	-0.35	0.35

Summary and Conclusions

Simulation results suggest:

- Ground water discharge to the potential suitable habitat under ambient conditions is between 0.08 gpm and 1.27 gpm. During May and June during spring runoff, under ambient conditions water from the potential suitable habitat enters the subsurface soils at a rate of approximately 2 gpm.
- Operation of the extraction wells at current rates results in flow from the potential suitable habitat to the extraction wells March through December. In January and February operation of extraction well PW02 reduces ground water discharge to the potential suitable habitat from 1.25 gpm to 0.25 gpm.
- Operation of the injection wells at current rates results in clean injection water discharging to the potential suitable habitat January through April and July through December. In May and June increased river levels results in water flowing from the potential suitable habitat to the subsurface soils.
- Pumping and injection at current rates results in injection water discharging to the potential suitable habitat January through March and August through December. From April through July a combination of extraction well pumping and rising river levels due to spring runoff results in flow from the potential suitable habitat to the subsurface soils.
- Ground water discharge and recharge to and from the potential suitable habitat when the recently planted cottonwoods, willows and grasses are fully mature is not expected to be much different than current ambient conditions.
- Model-predicted mass balance evaluation suggests that operation of extraction wells alone, injection wells alone and extraction and injection wells together protects the potential suitable habitat by halting contaminated ground water discharge to the area. An exception is in January and February for the extraction well scenario when only extraction well PW02 is simulated as being operational. During this period ground water discharge to the fish spawning area is reduced from 1.25 gpm to 0.5 gpm. While not simulated, it is likely based on proximity to the potential suitable habitat, that pumping extraction well 811 rather than PW02 in January and February would halt ground water discharge to the potential suitable habitat.
- The modeling shows that the modified ground water extraction pumping scheme altered due to the removal of the evaporation pond is not significantly different compared to the previous extraction pumping scheme on the ground water flow system, and the level of protection of the Colorado River remains the same.

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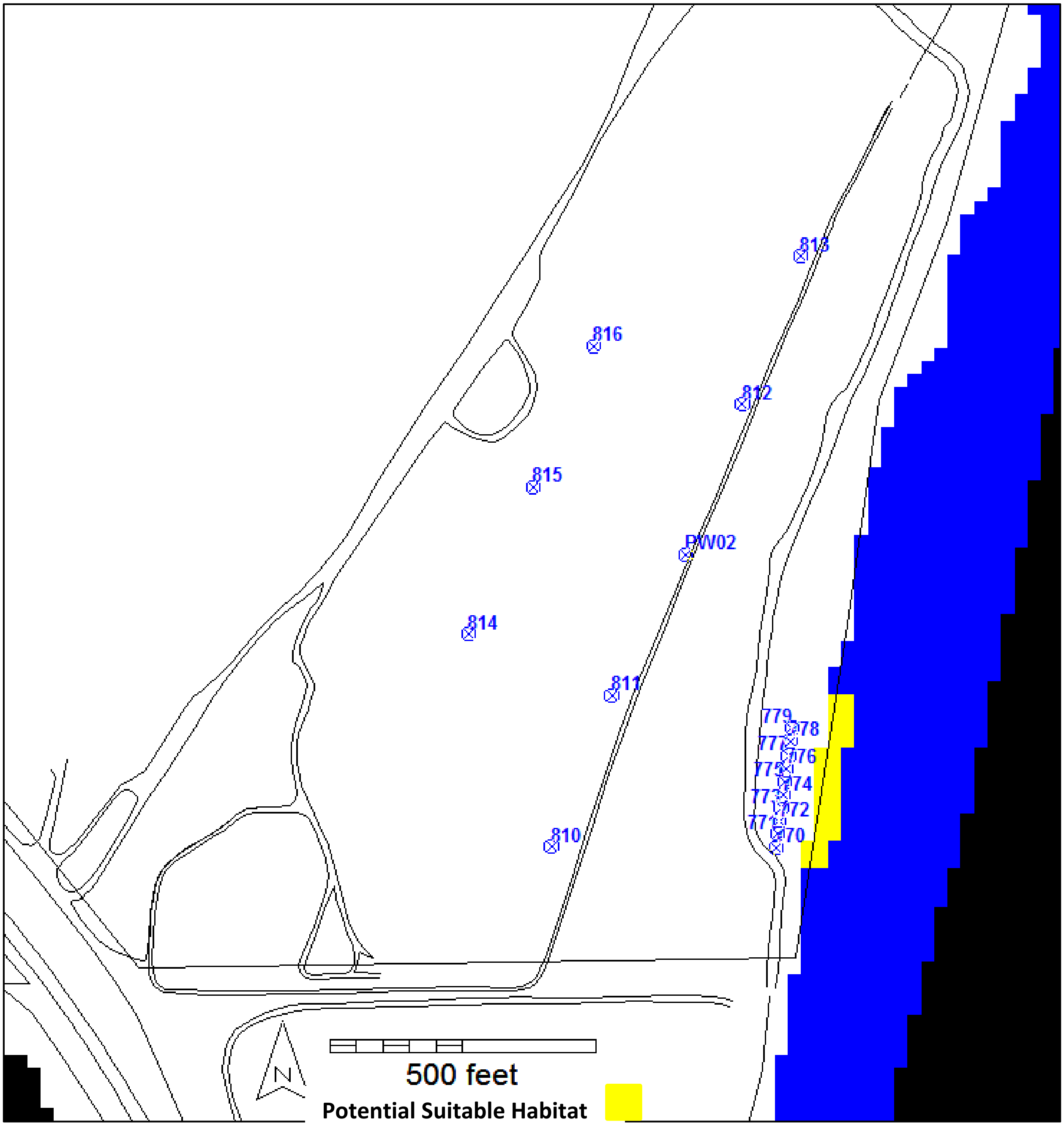
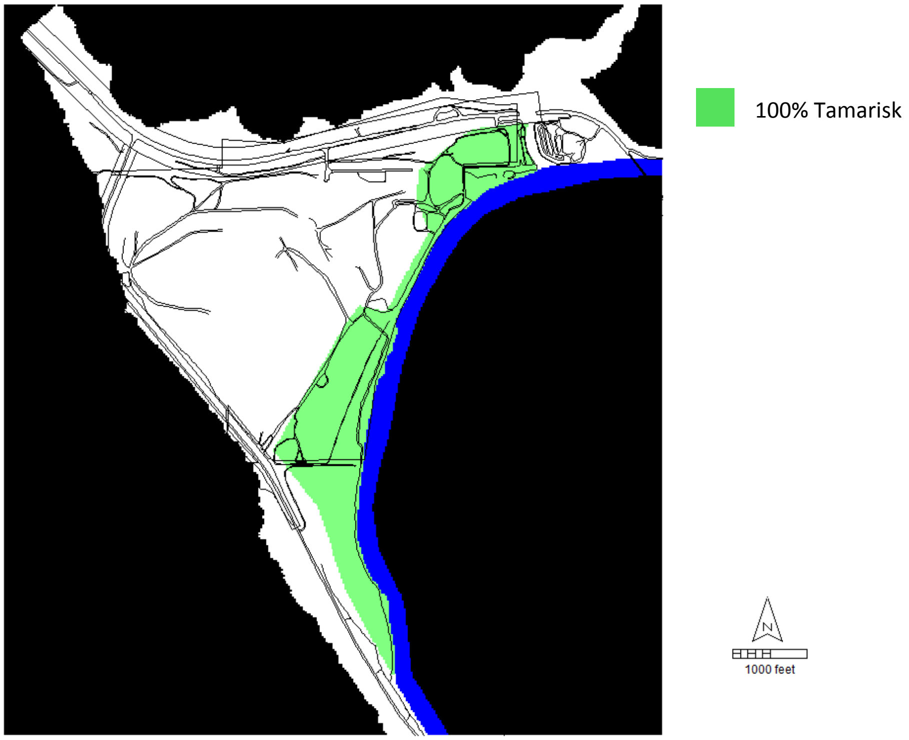
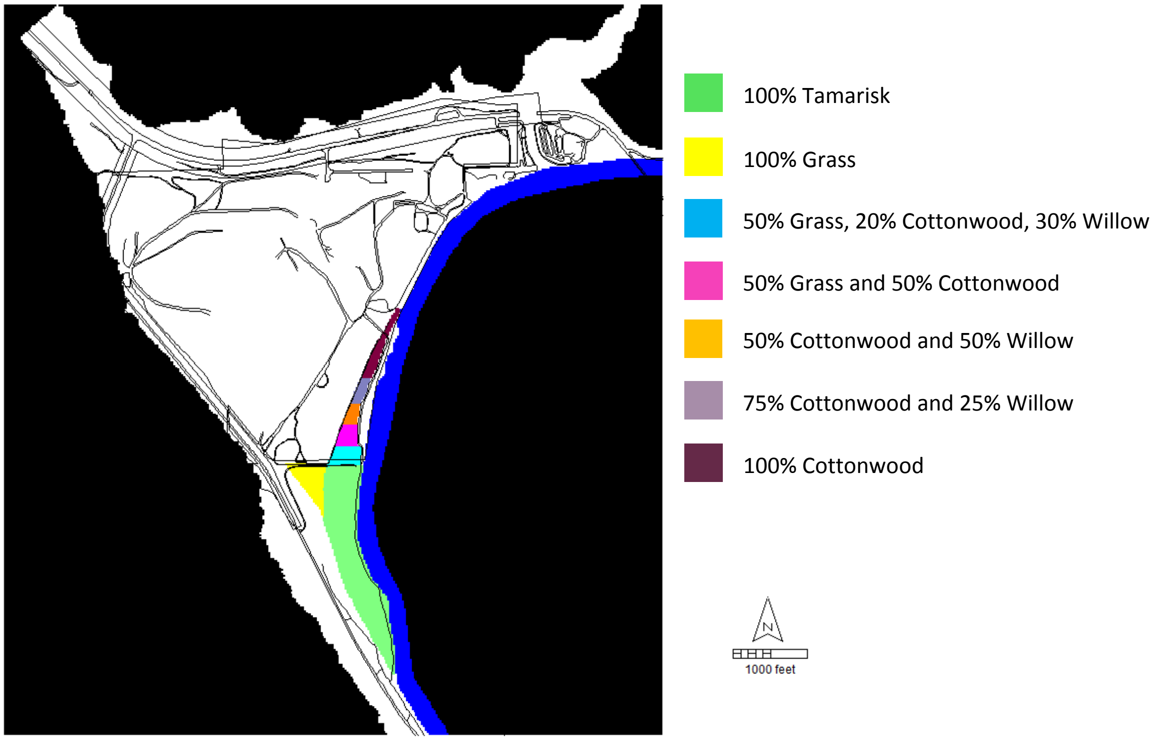


Figure 1. Location of Injection (700 Series), Extraction Wells (0800 Series And PW02), and Fish Spawning Grounds



2010 Configuration



2015 Configuration

Figure 2. Reconfigured Evapotranspiration

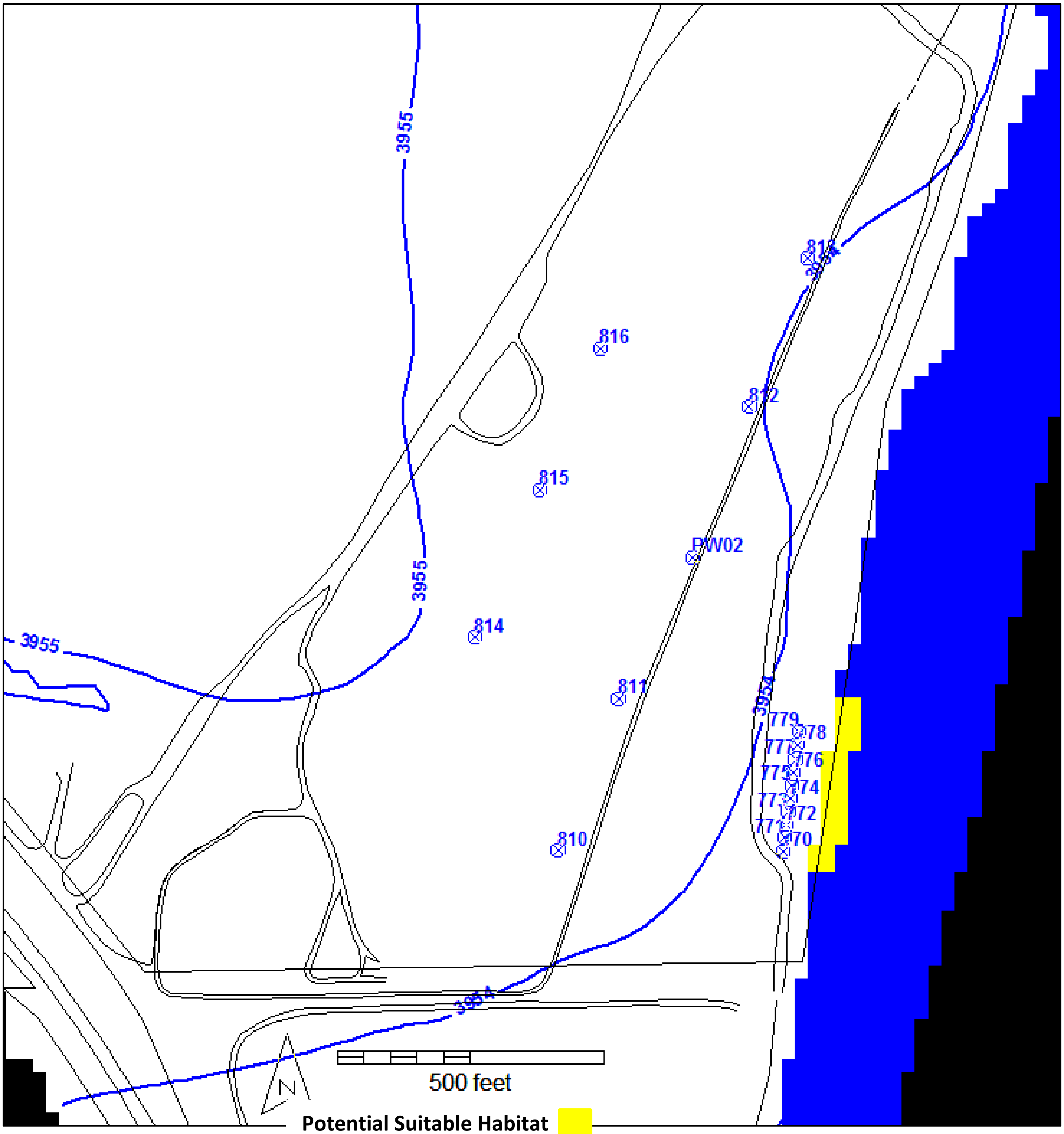


Figure 3. January Model-predicted Water Table, Ambient Conditions

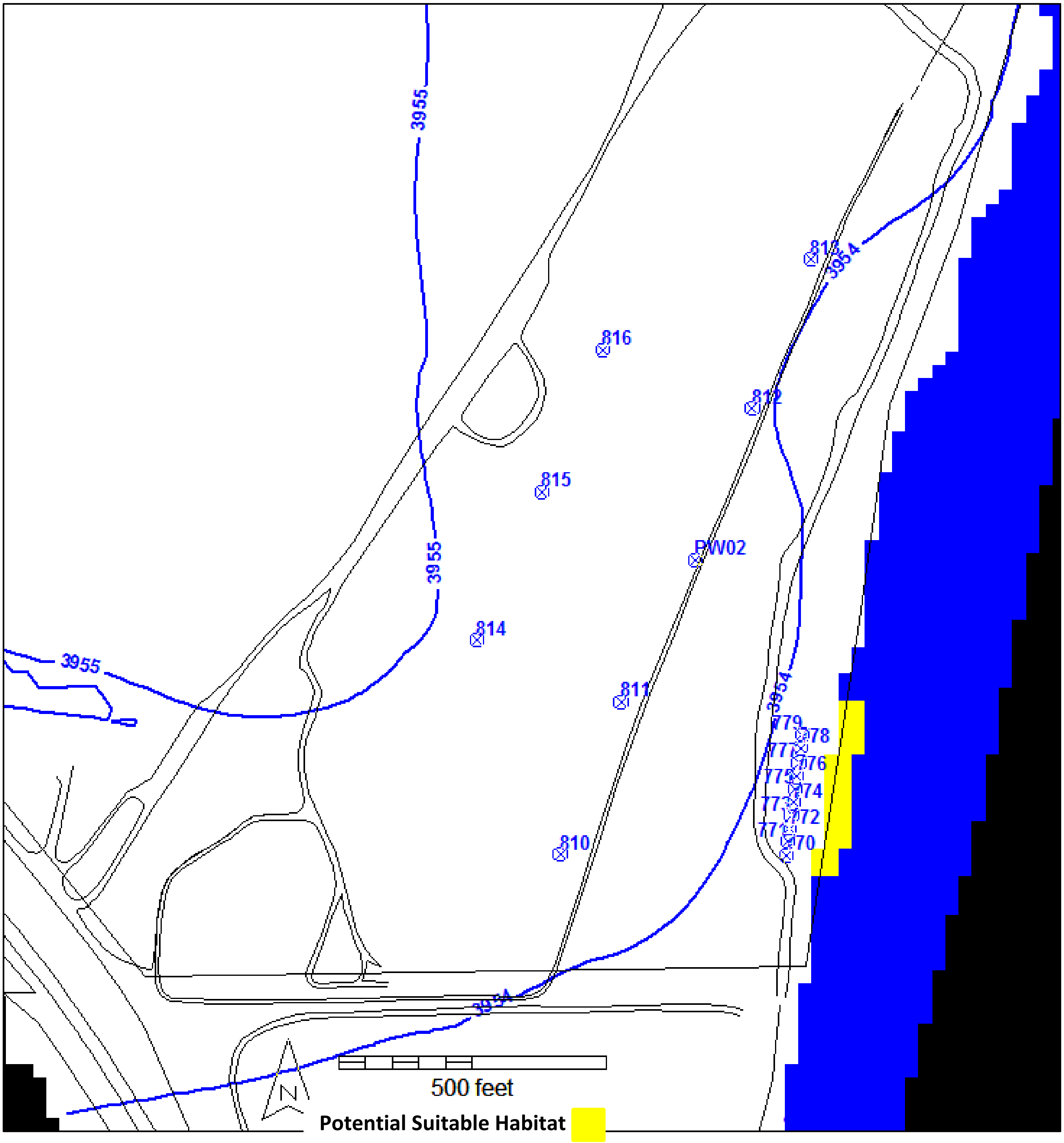


Figure 4. February Model-predicted Water Table, Ambient Conditions

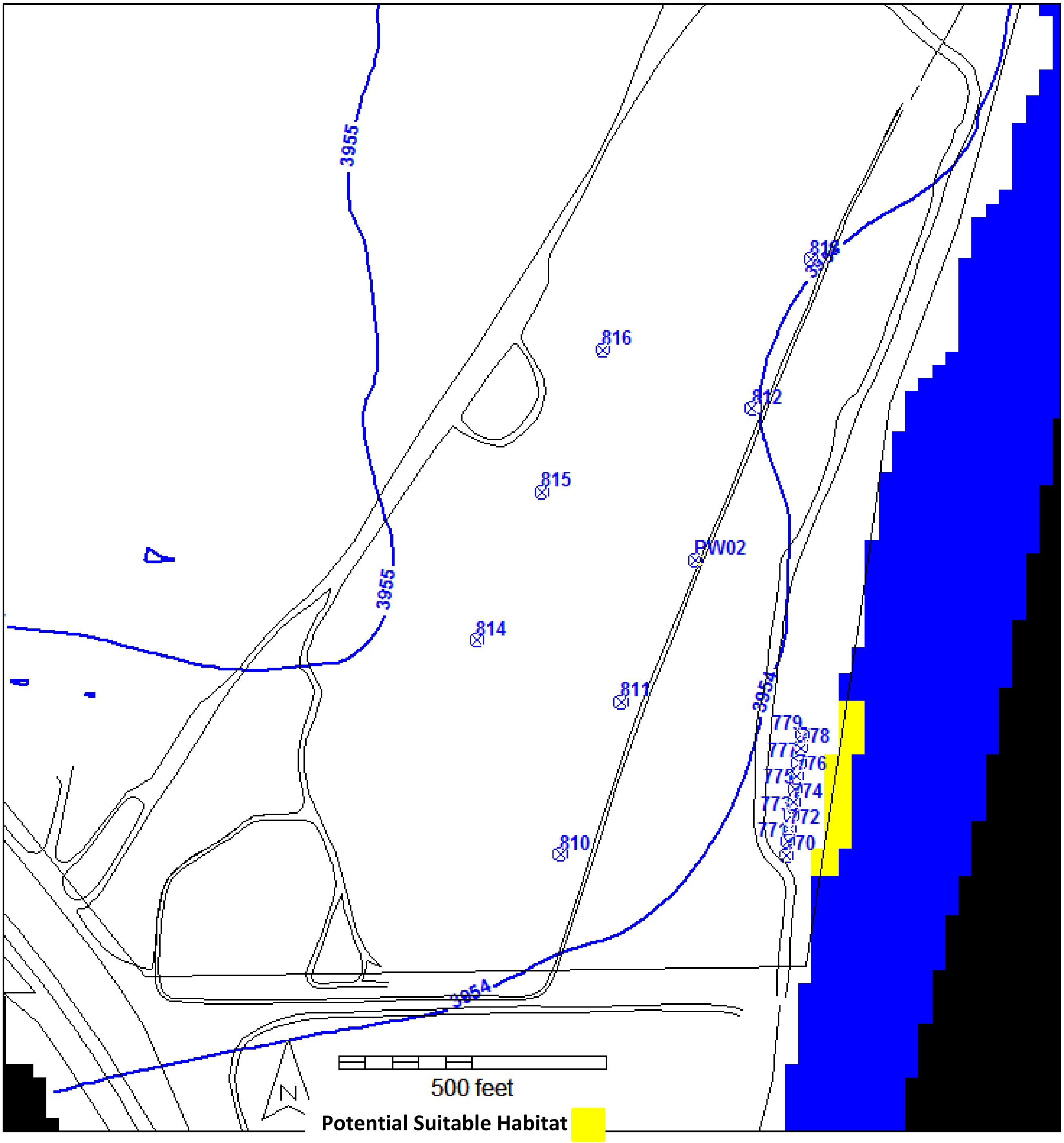


Figure 5. March Model-predicted Water Table, Ambient Conditions

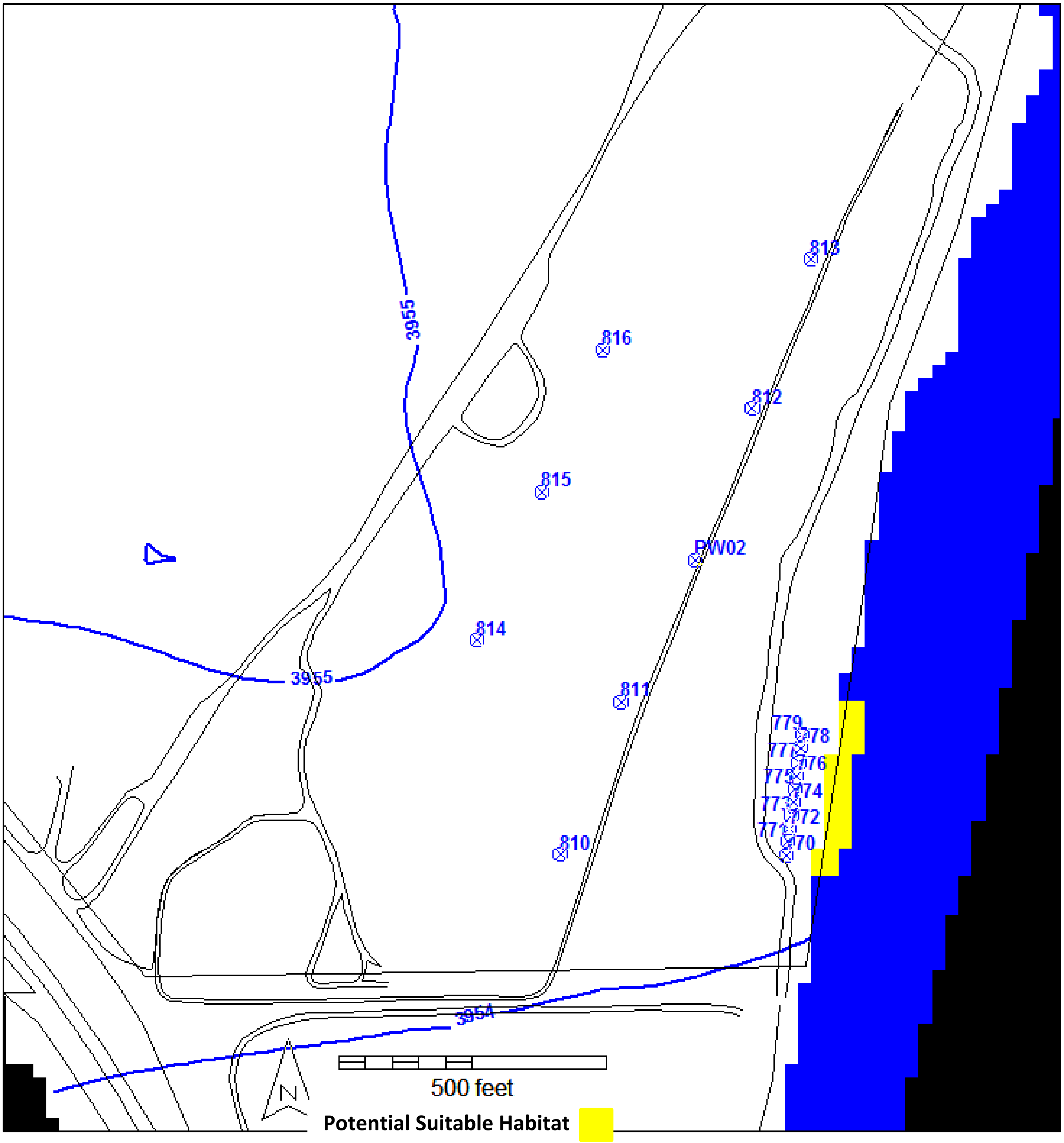


Figure 6. April Model-predicted Water Table, Ambient Conditions

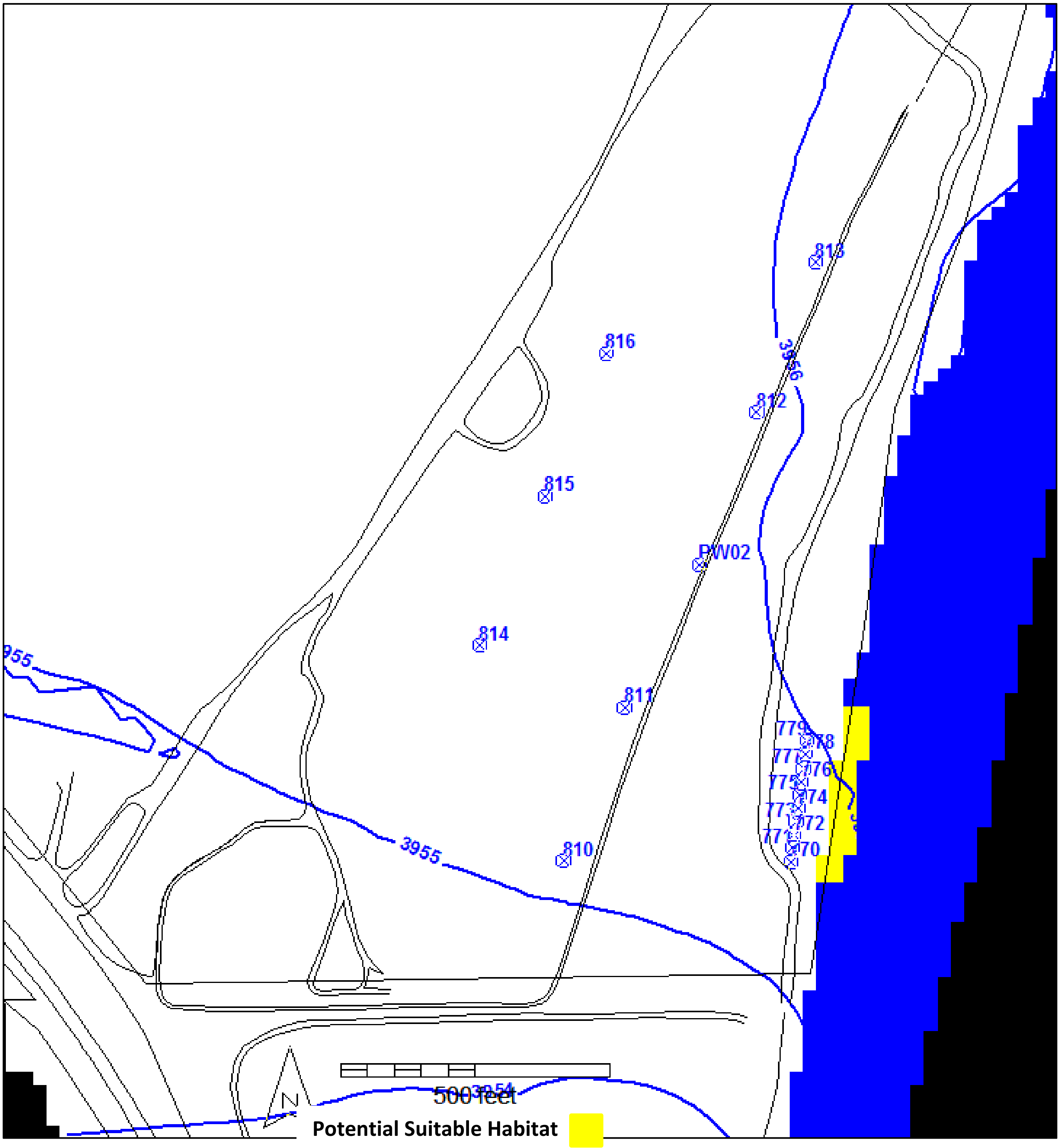


Figure 7. May Model-predicted Water Table, Ambient Conditions

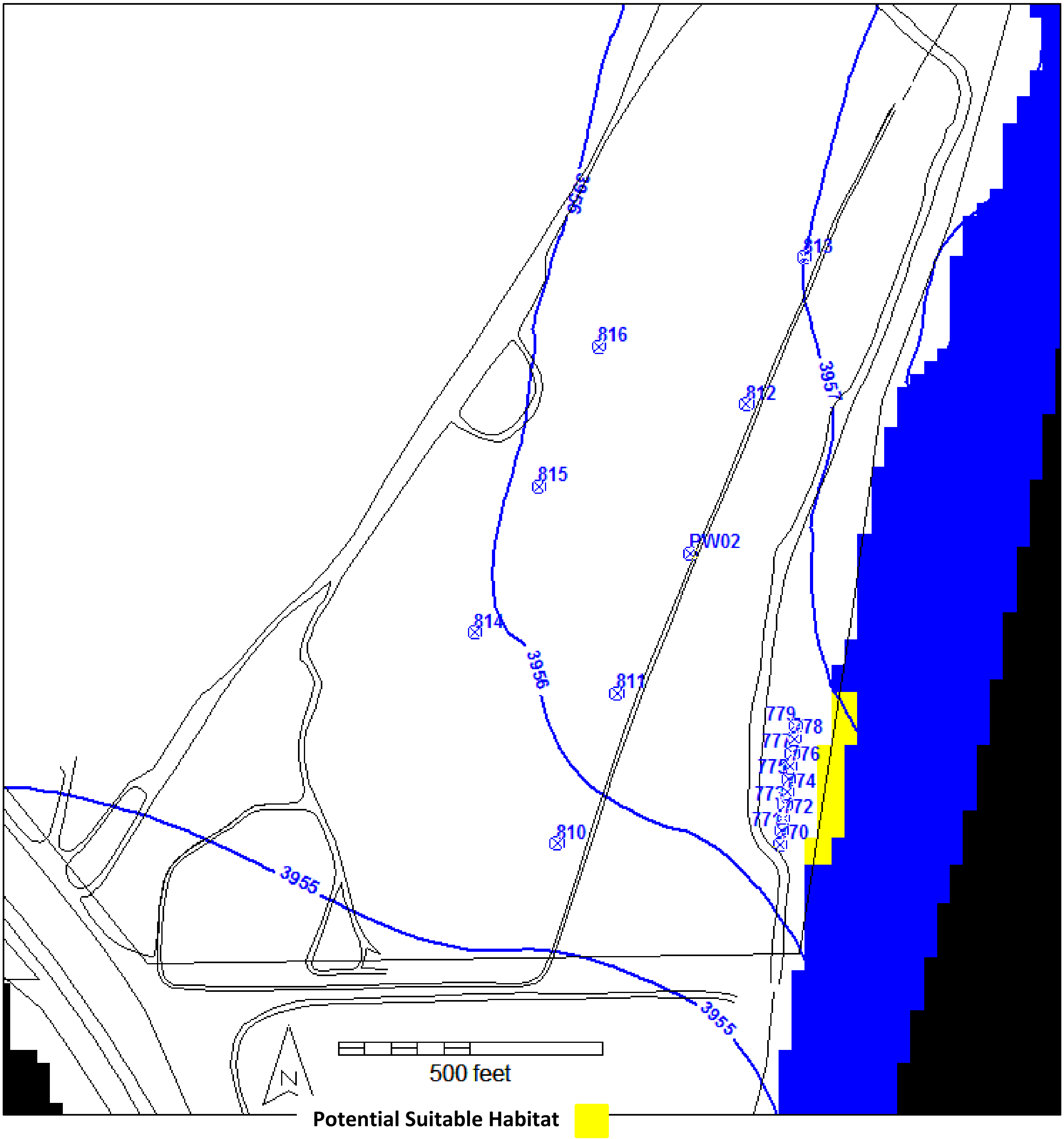


Figure 8. June Model-predicted Water Table, Ambient Conditions

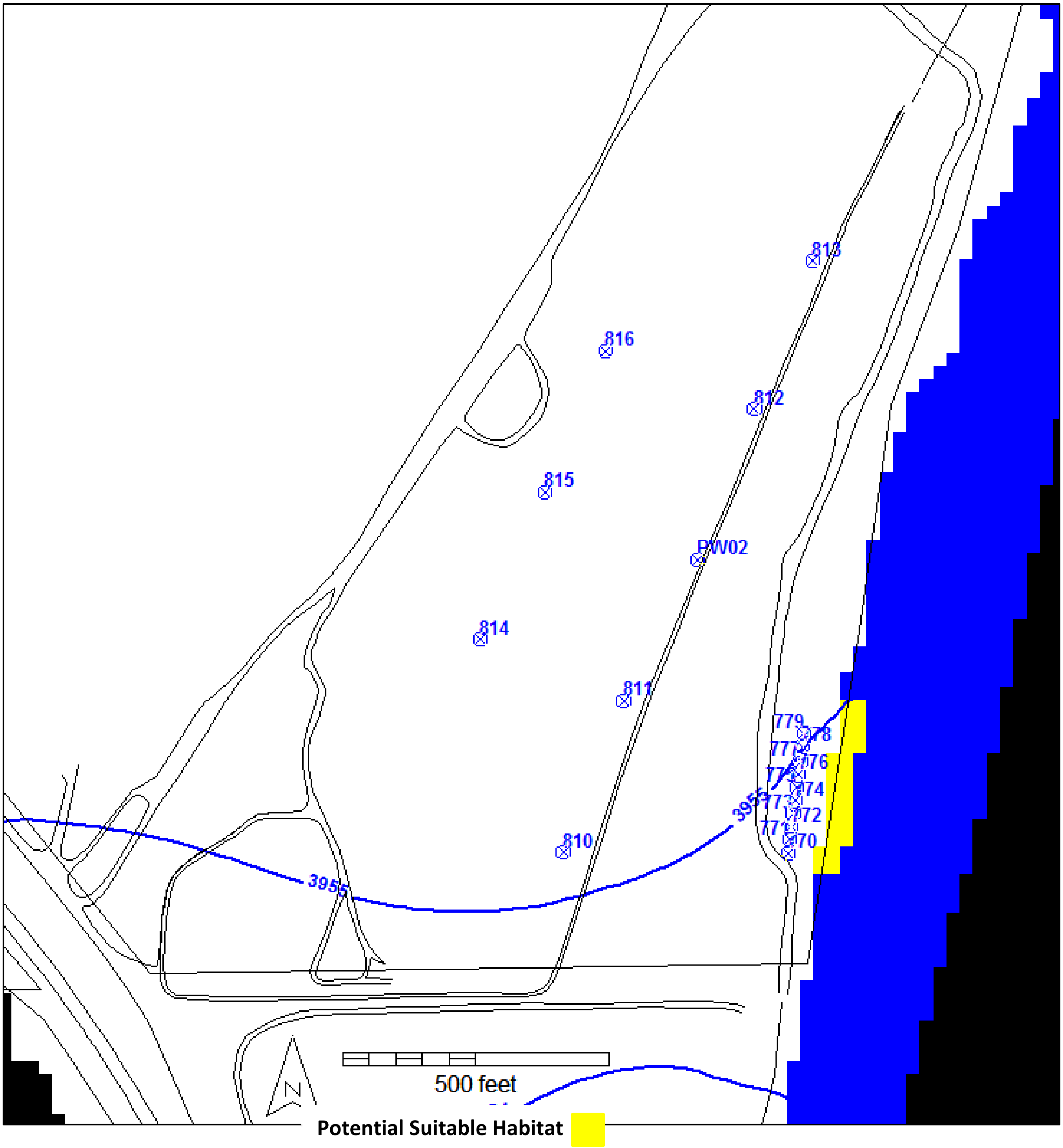


Figure 9. July Model-predicted Water Table, Ambient Conditions

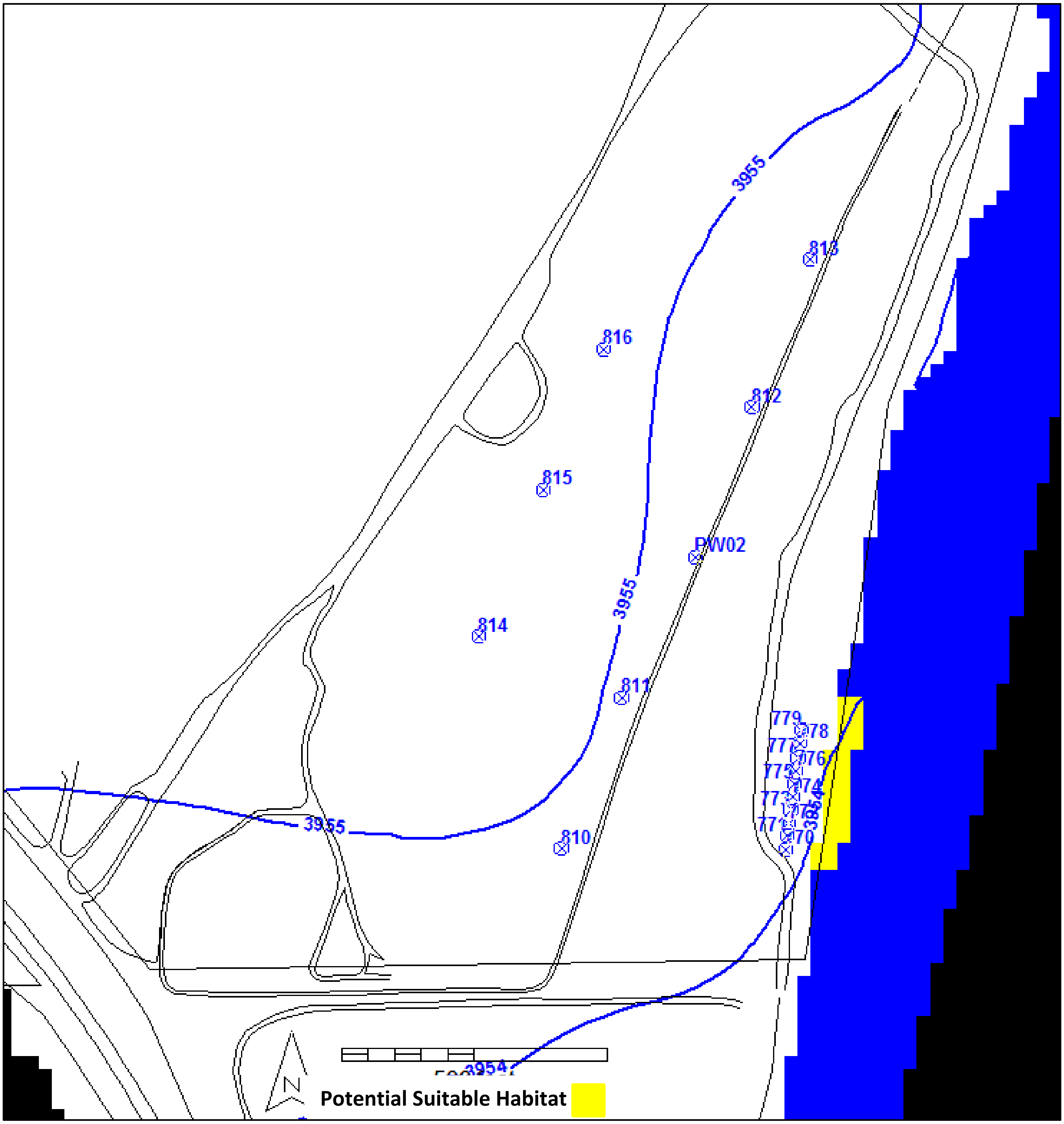


Figure 10. August Model-predicted Water Table, Ambient Conditions

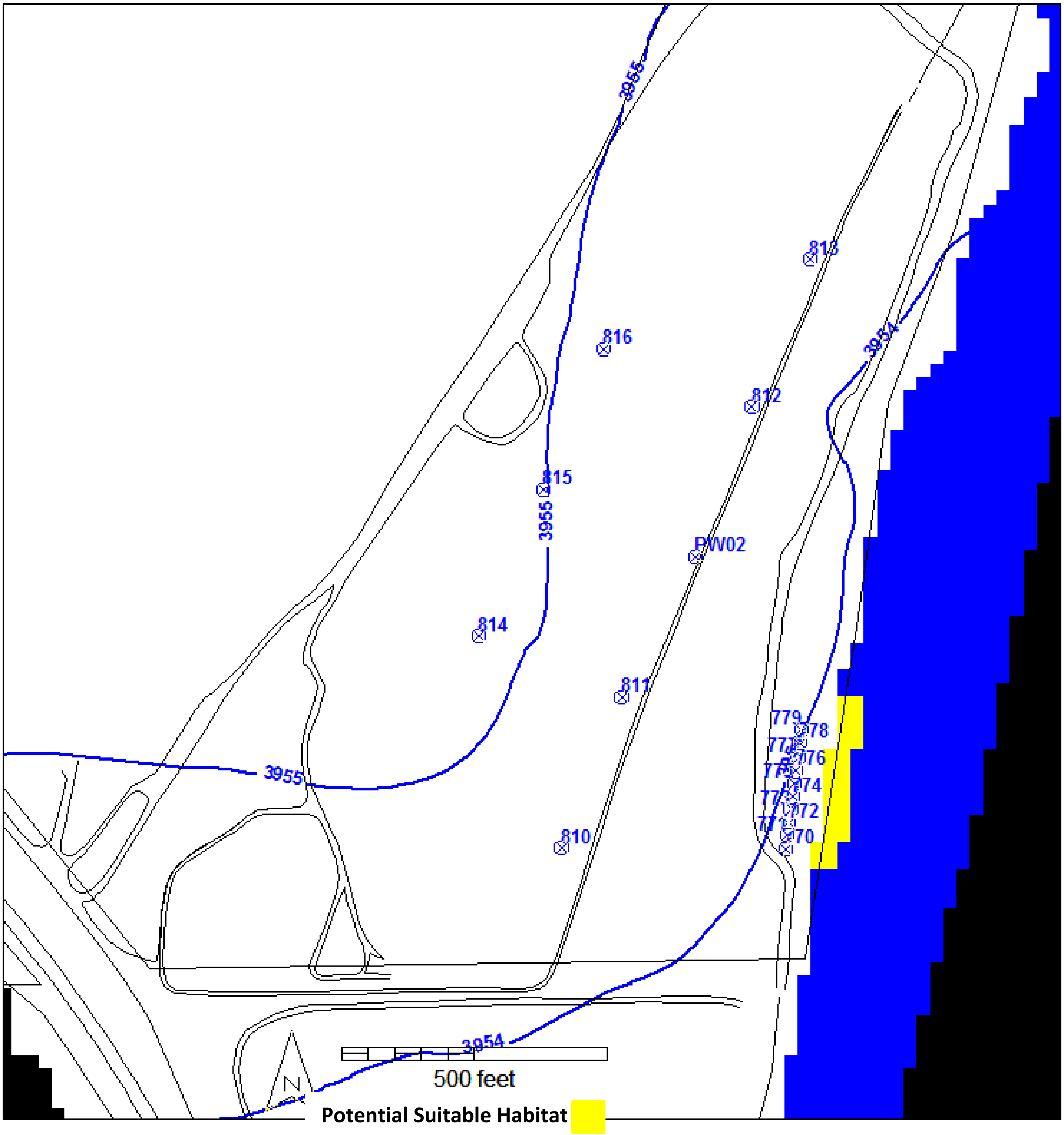


Figure 11. September Model-predicted Water Table, Ambient Conditions

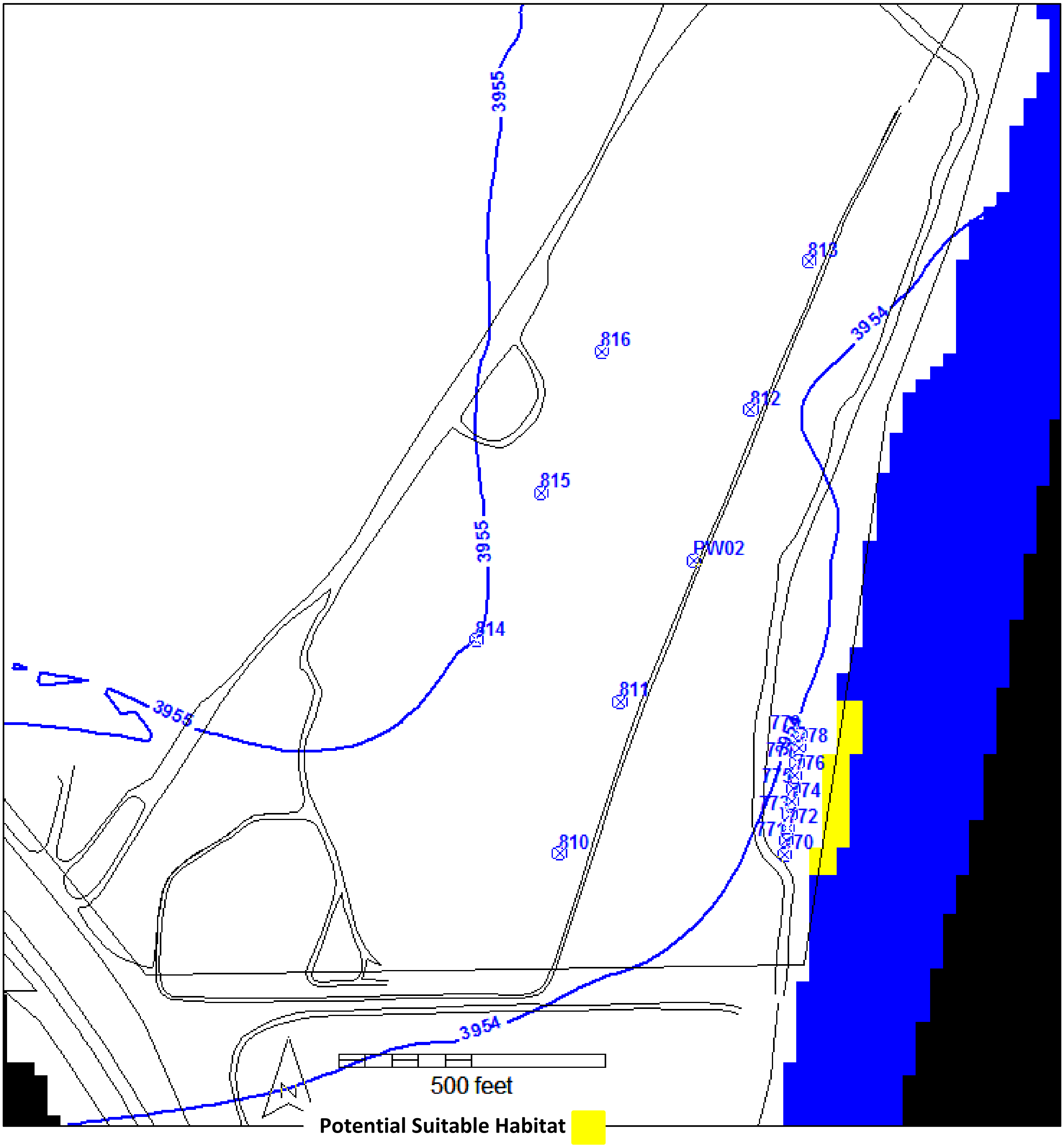


Figure 12. October Model-predicted Water Table, Ambient Conditions

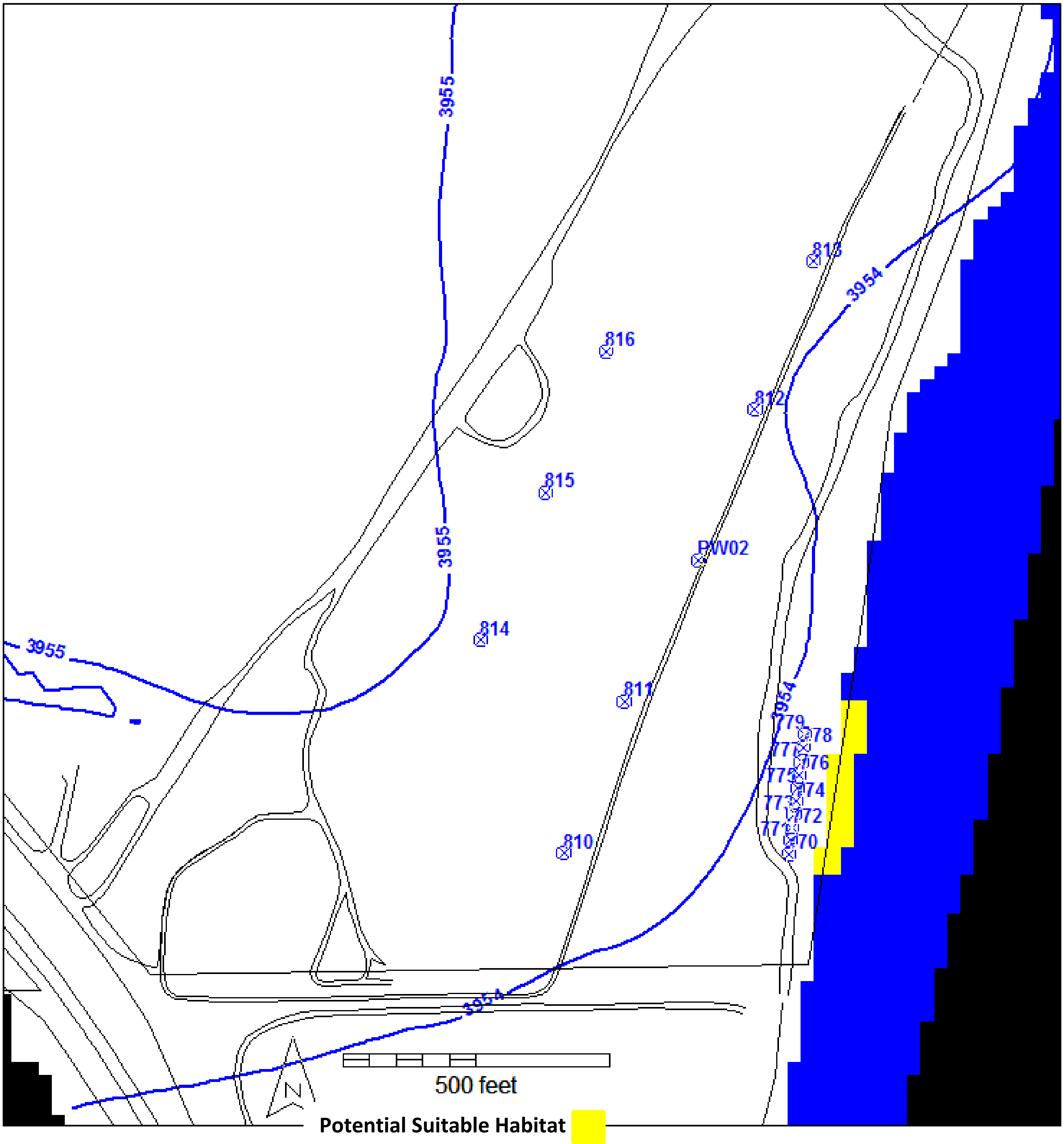


Figure 13. November Model-predicted Water Table, Ambient Conditions

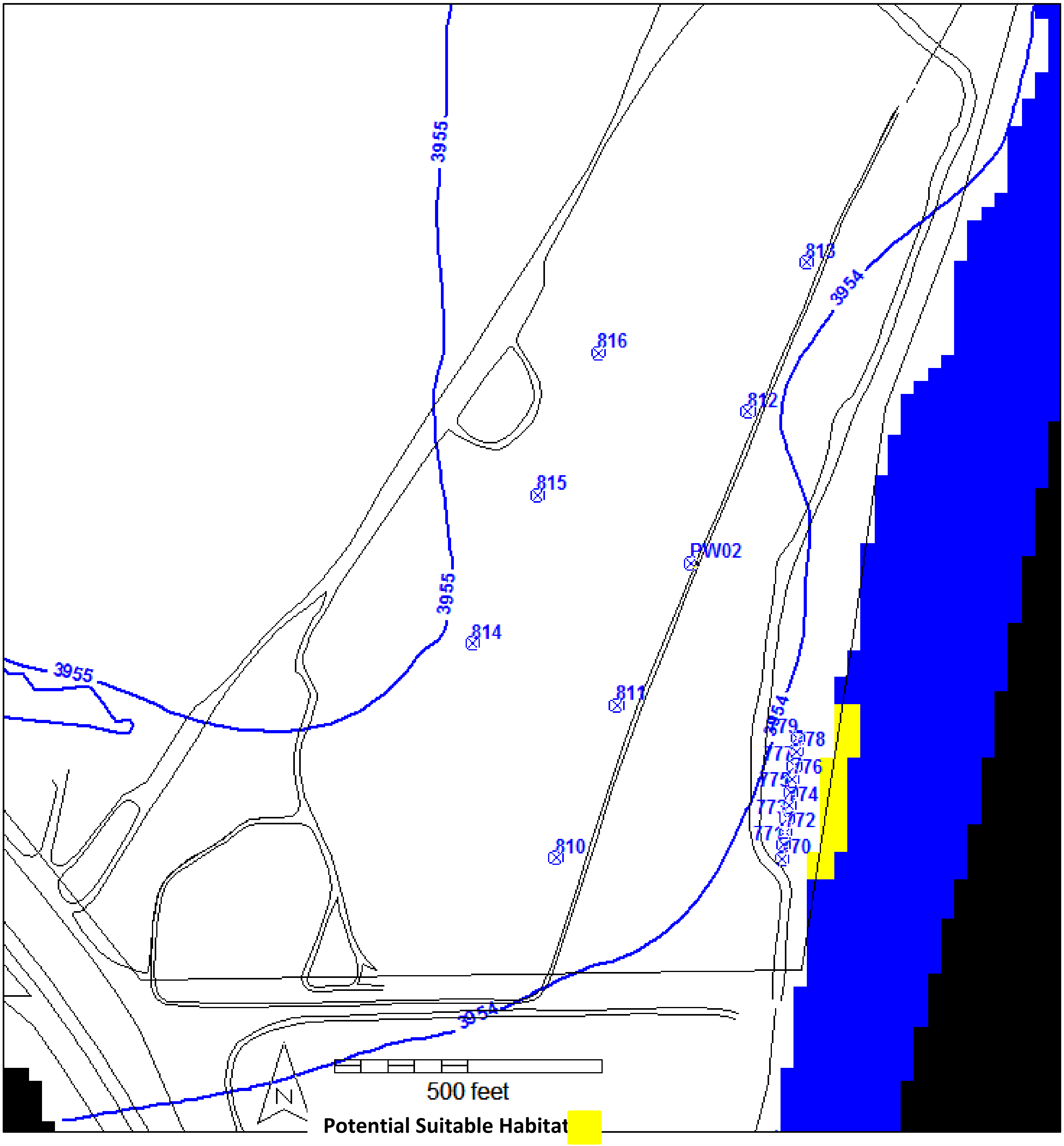


Figure 14. December Model-predicted Water Table, Ambient Conditions

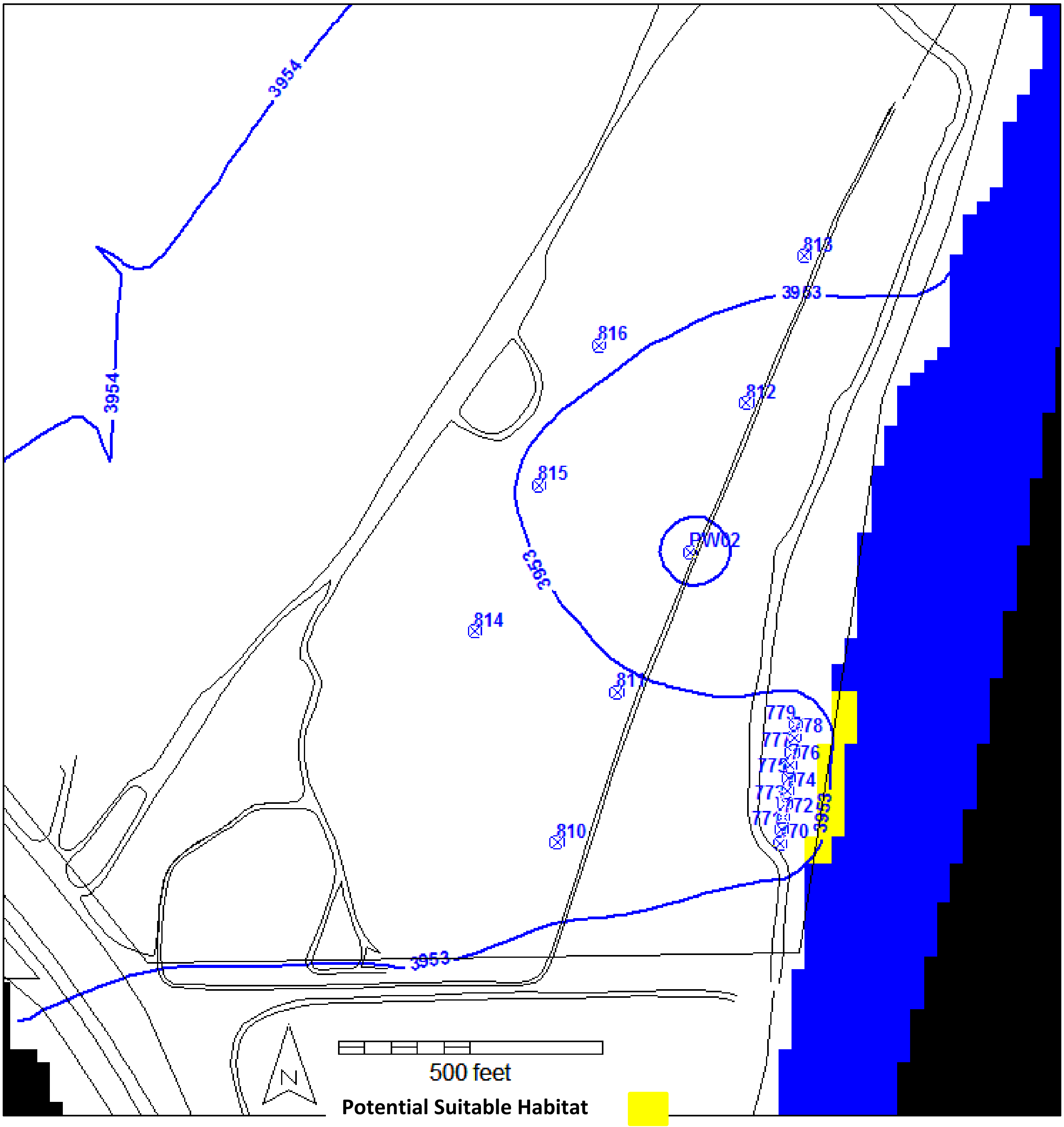


Figure 15. January Model-predicted Water Table, Injection and Extraction Wells Operating

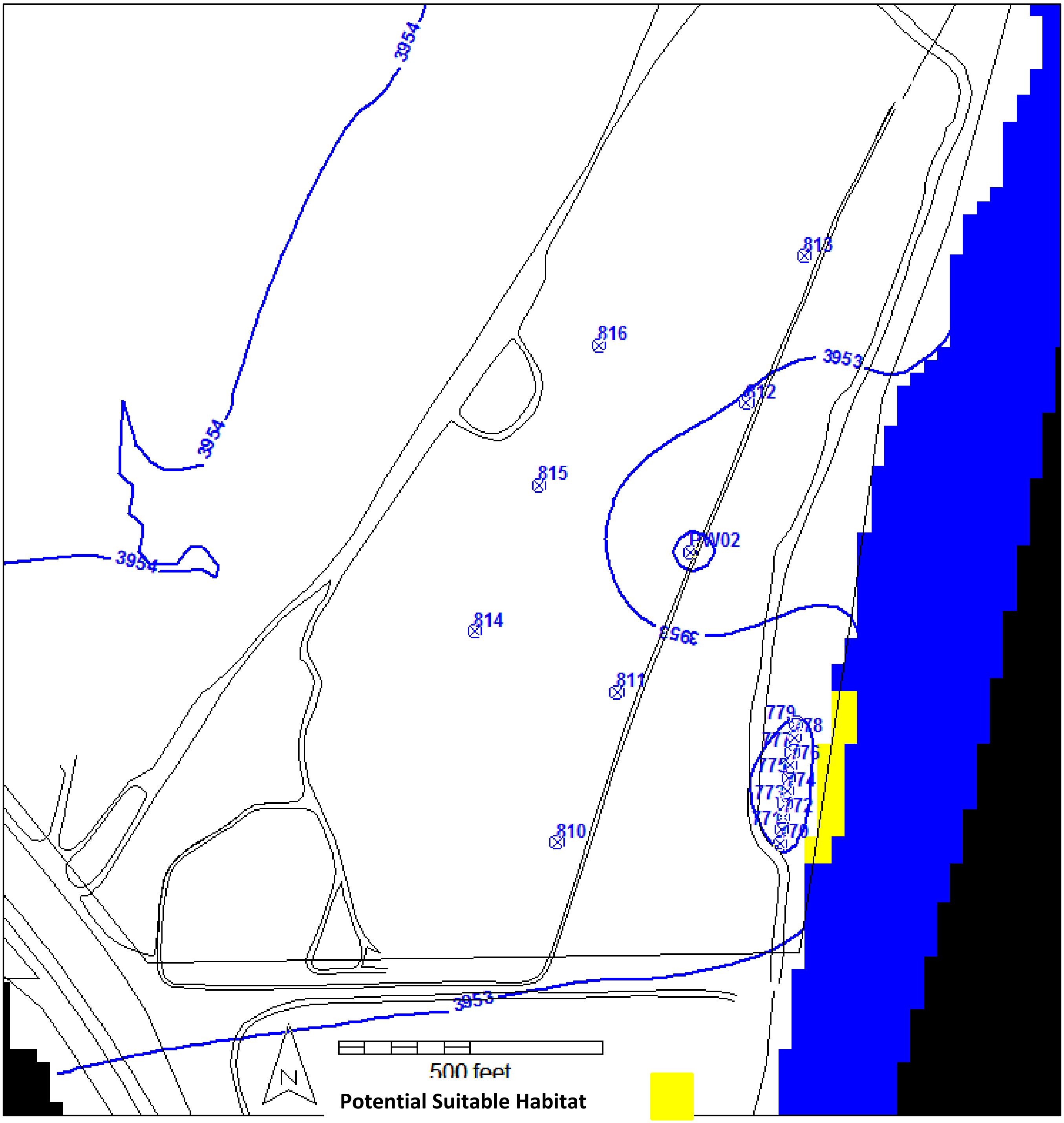


Figure 16. February Model-predicted Water Table, Injection and Extraction Wells Operating

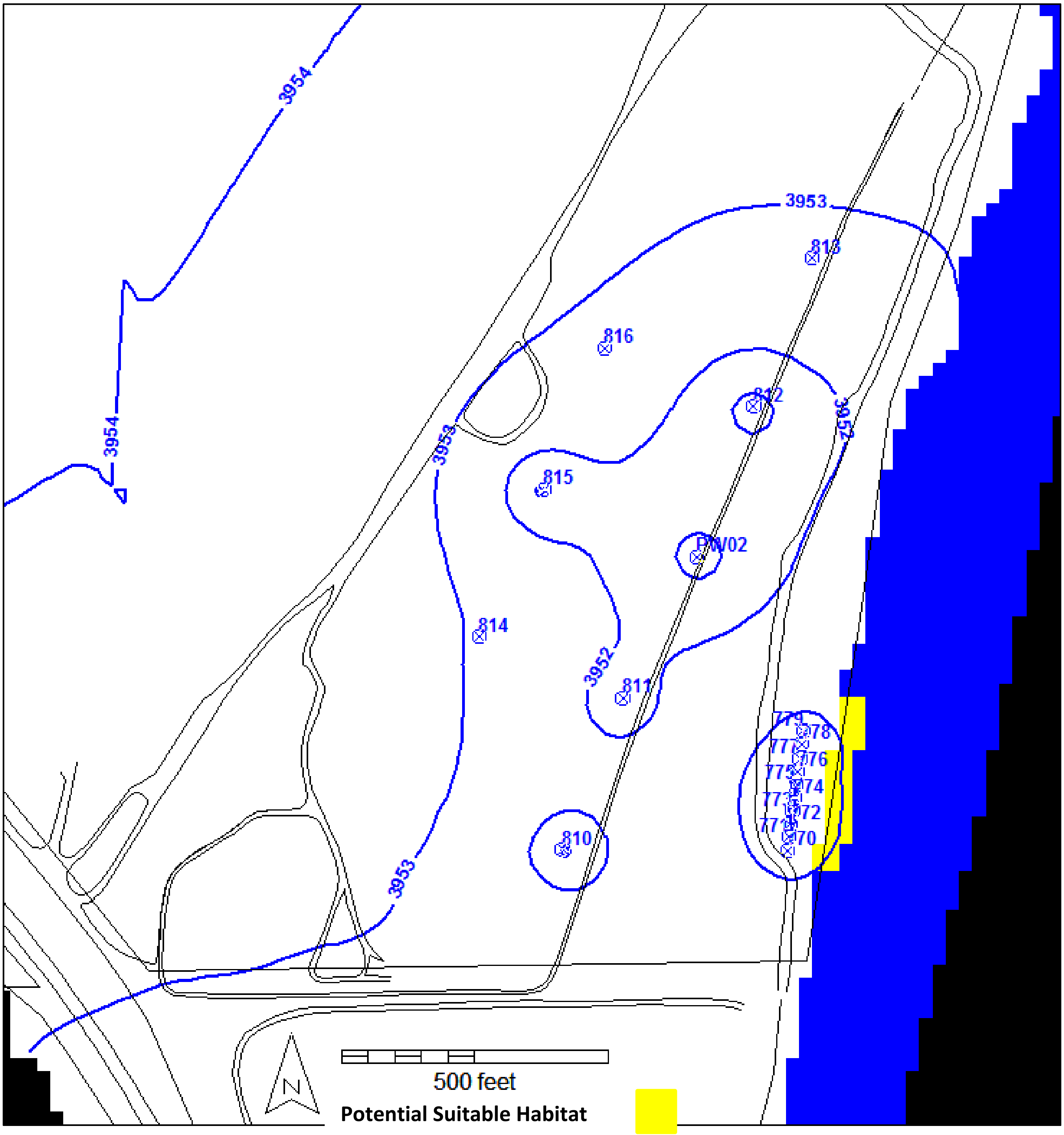


Figure 17. March Model-predicted Water Table, Injection and Extraction Wells Operating

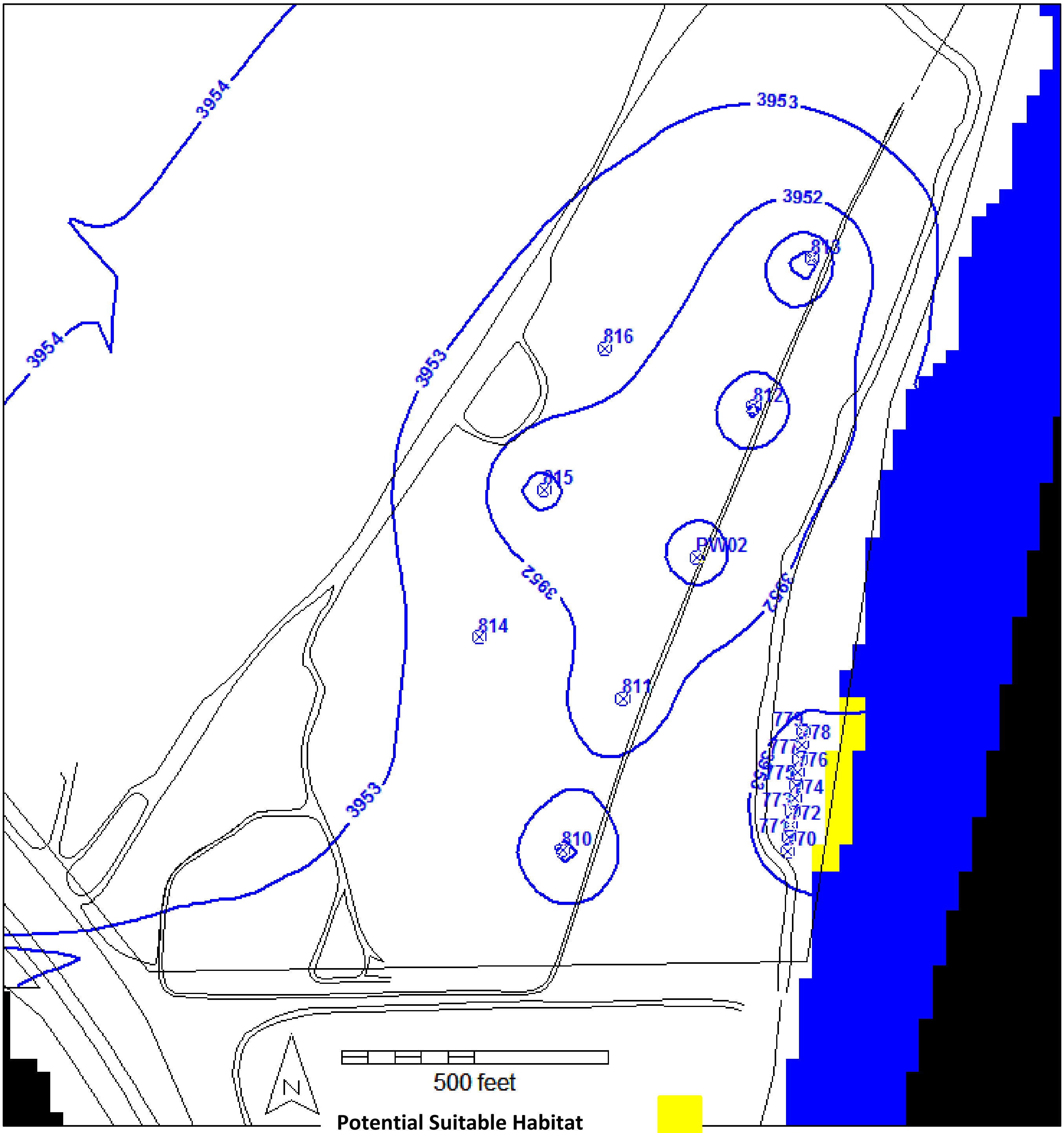


Figure 18. April Model-predicted Water Table, Injection and Extraction Wells Operating

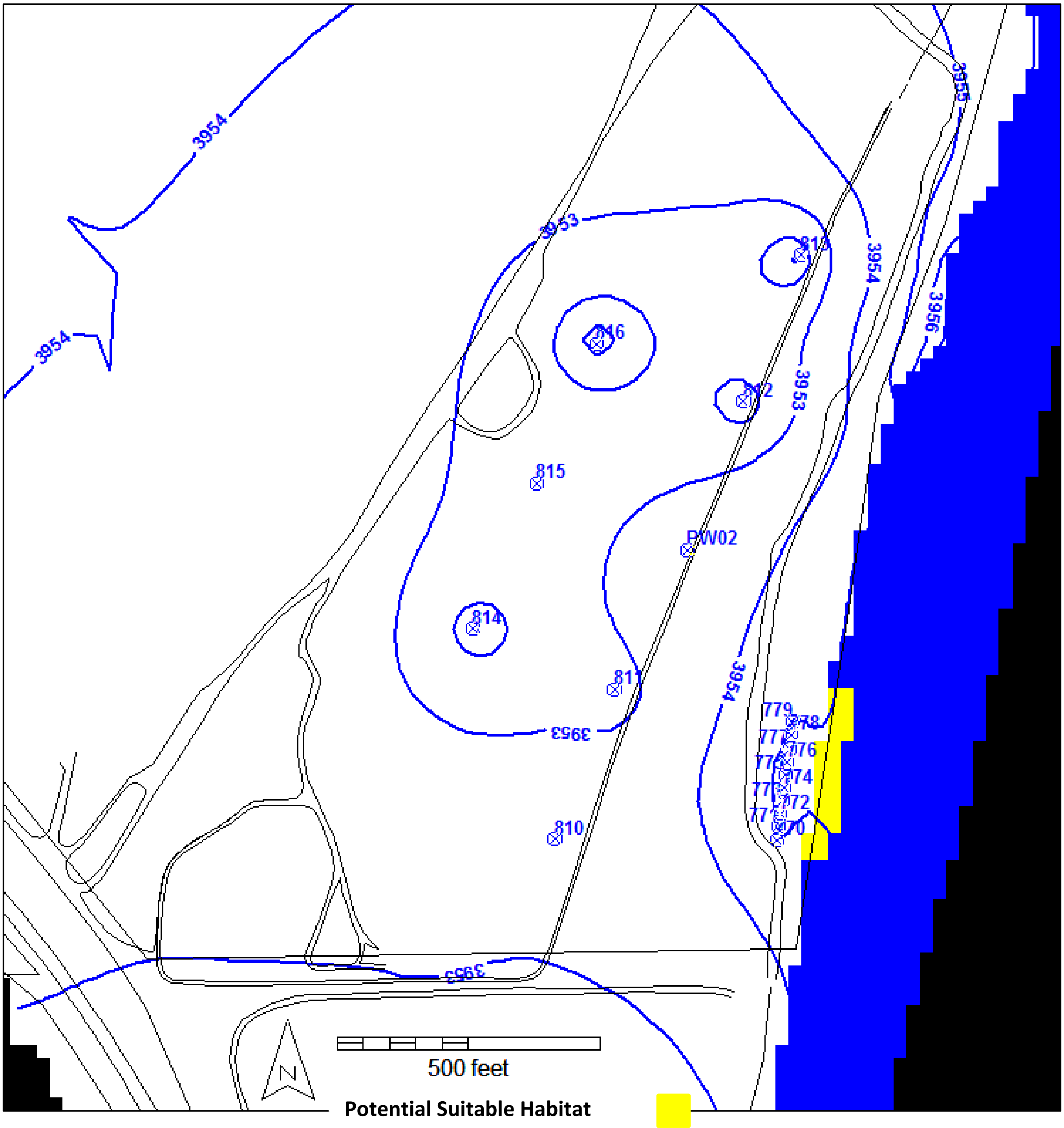


Figure 19. May Model-predicted Water Table, Injection and Extraction Wells Operating

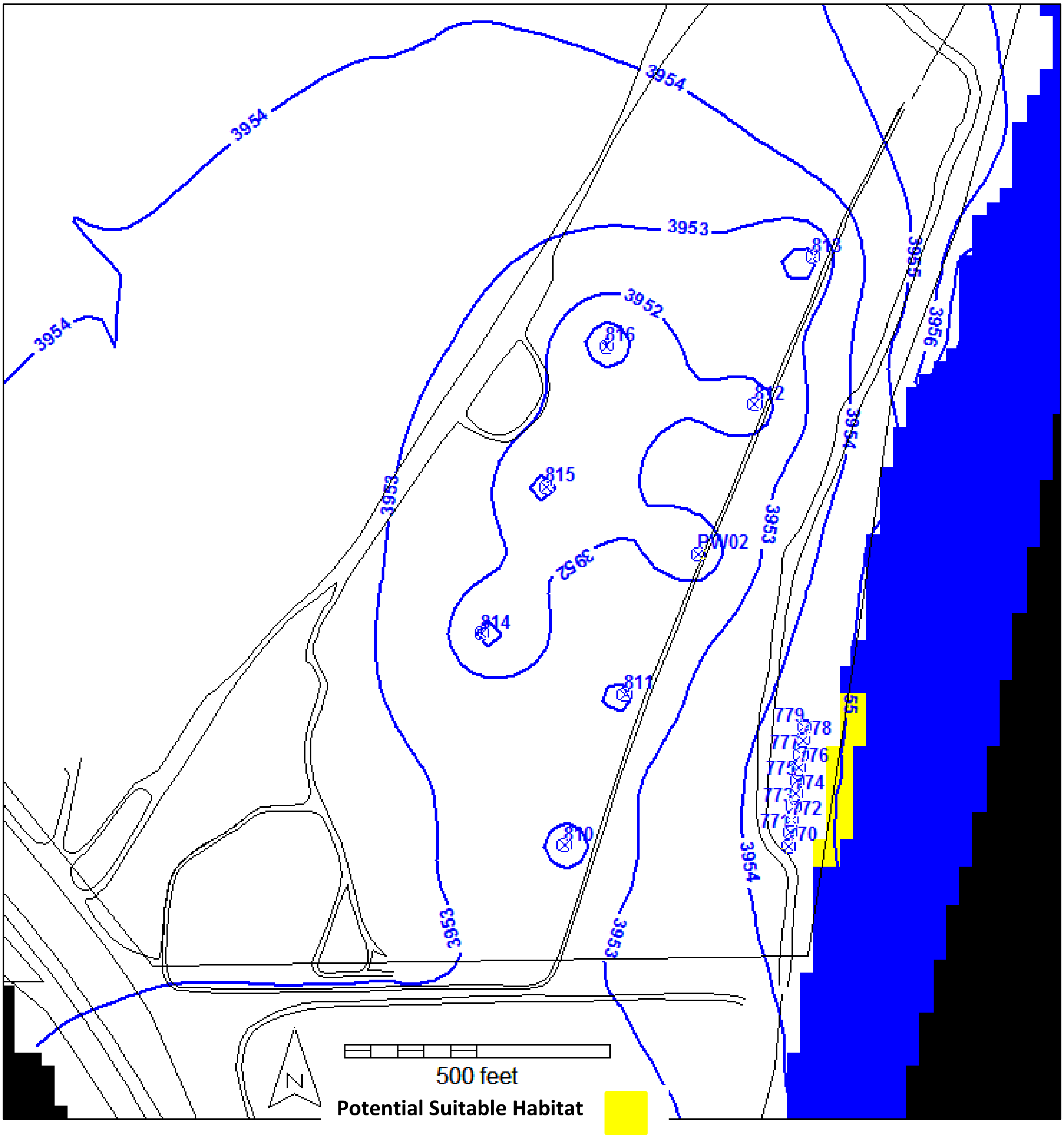


Figure 20. June Model-predicted Water Table, Injection and Extraction Wells Operating

Figure 21. July Model-predicted Water Table, Injection and Extraction Wells Operating

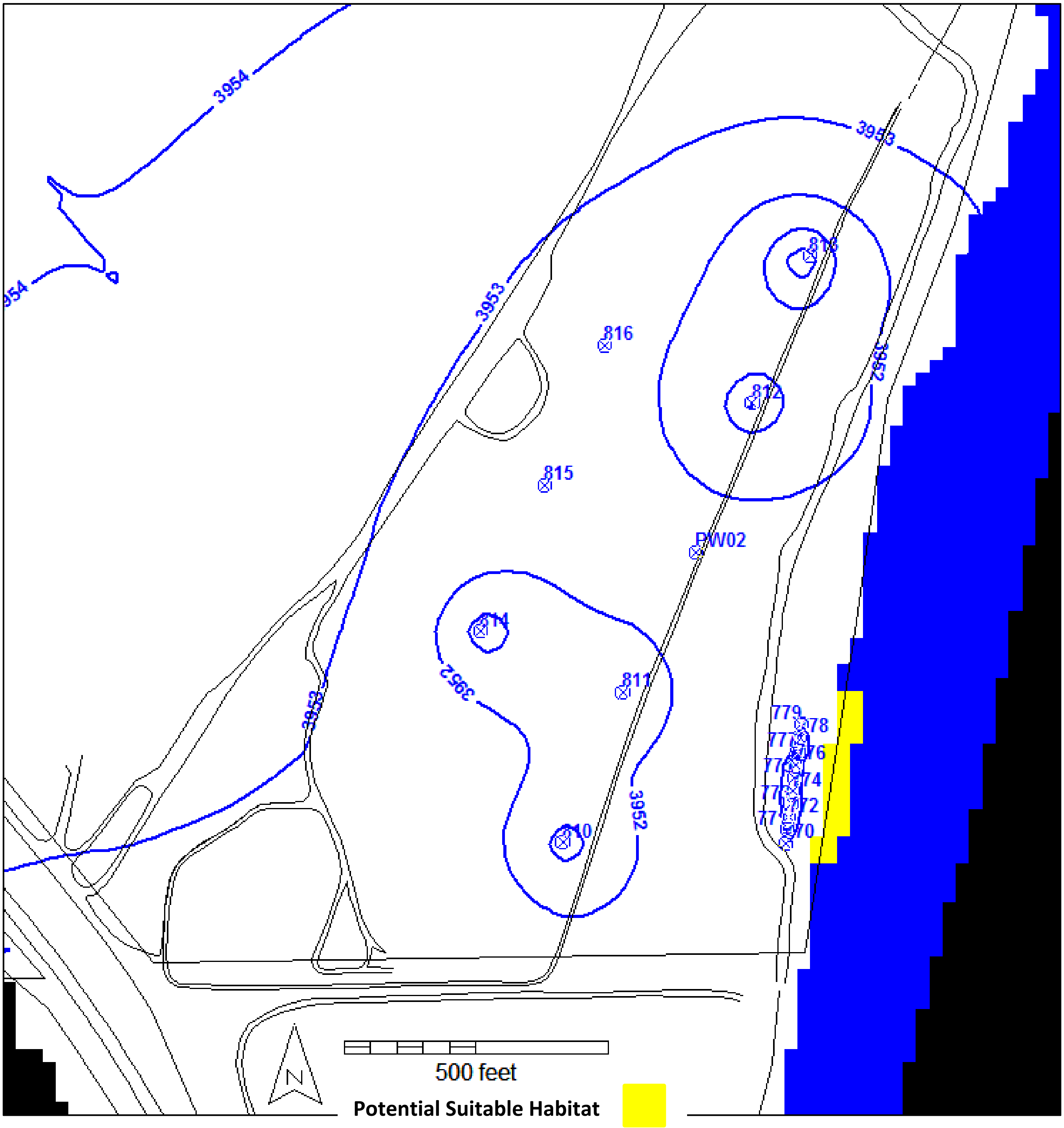


Figure 22. August Model-predicted Water Table, Injection and Extraction Wells Operating

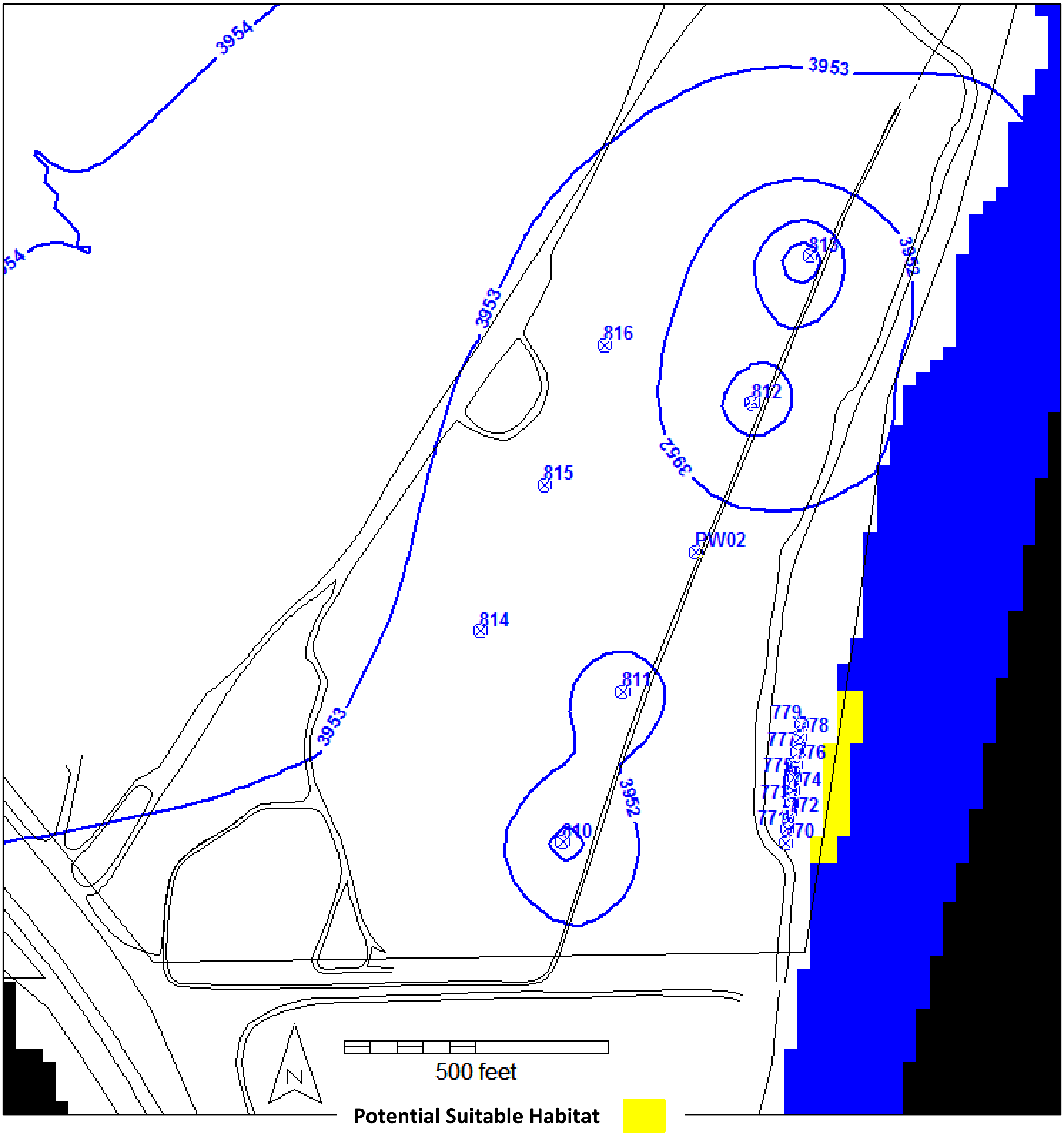


Figure 23. September Model-predicted Water Table, Injection and Extraction Wells Operating

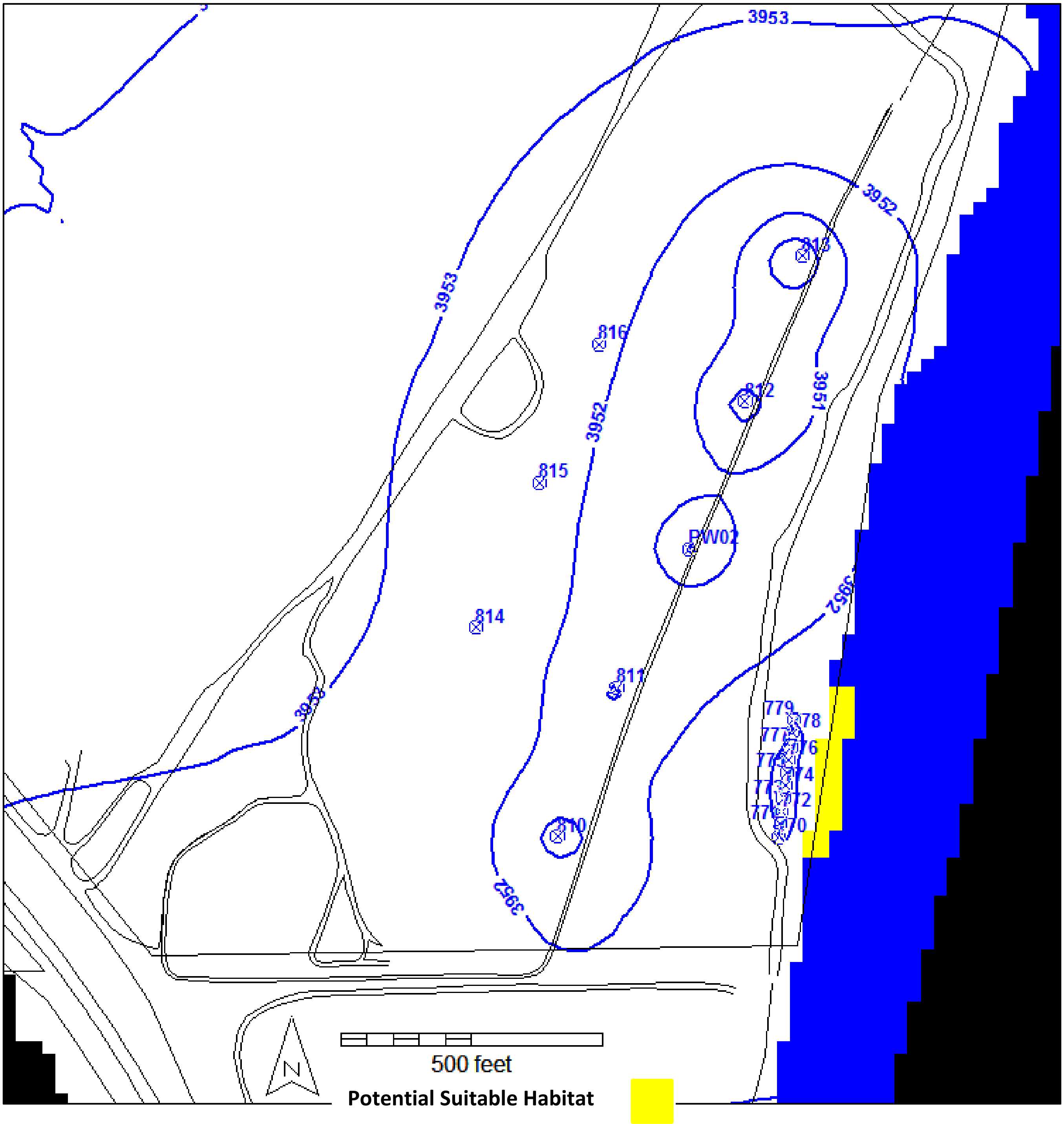


Figure 24. October Model-predicted Water Table, Injection and Extraction Wells Operating

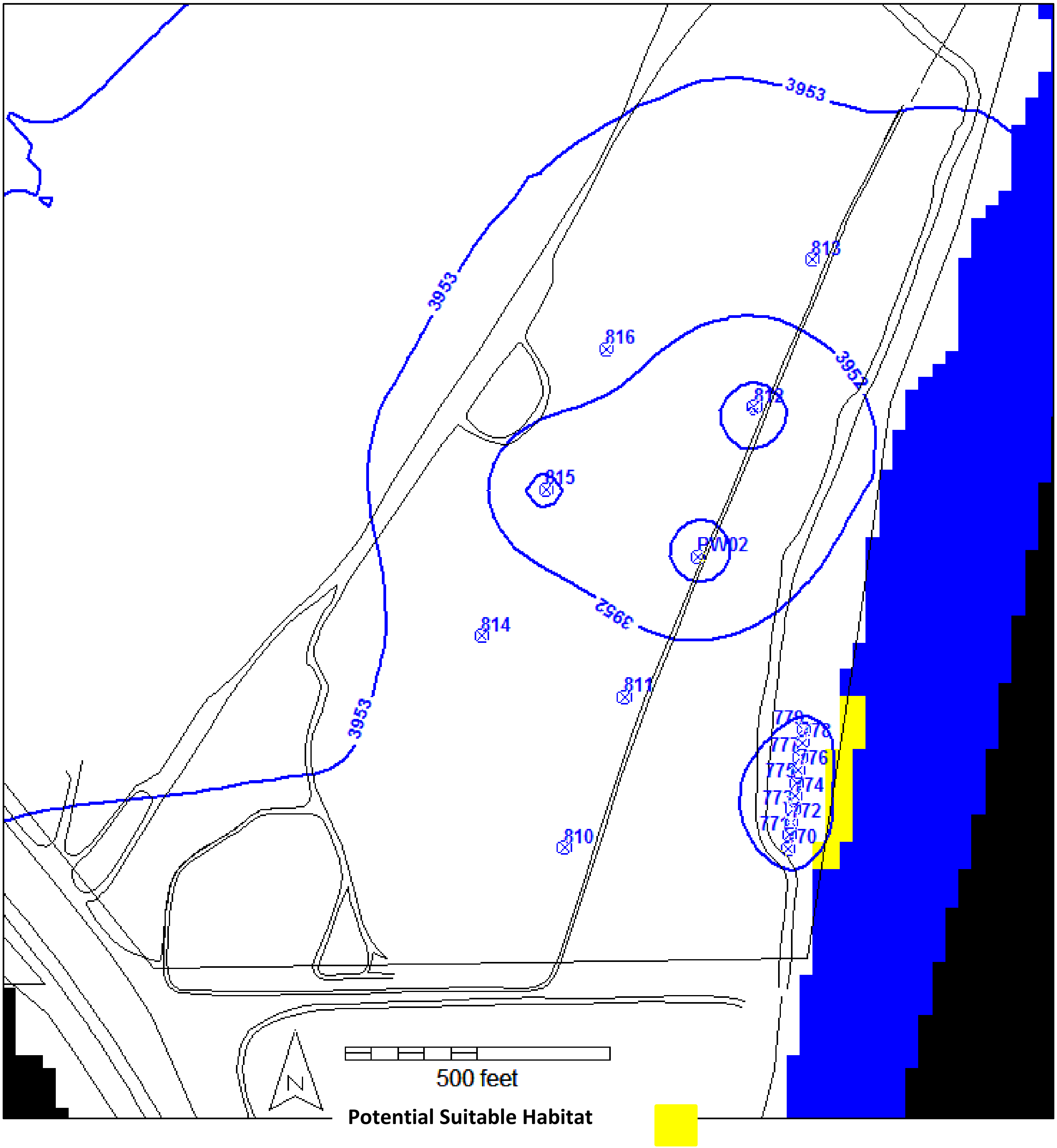


Figure 25. November Model-predicted Water Table, Injection and Extraction Wells Operating

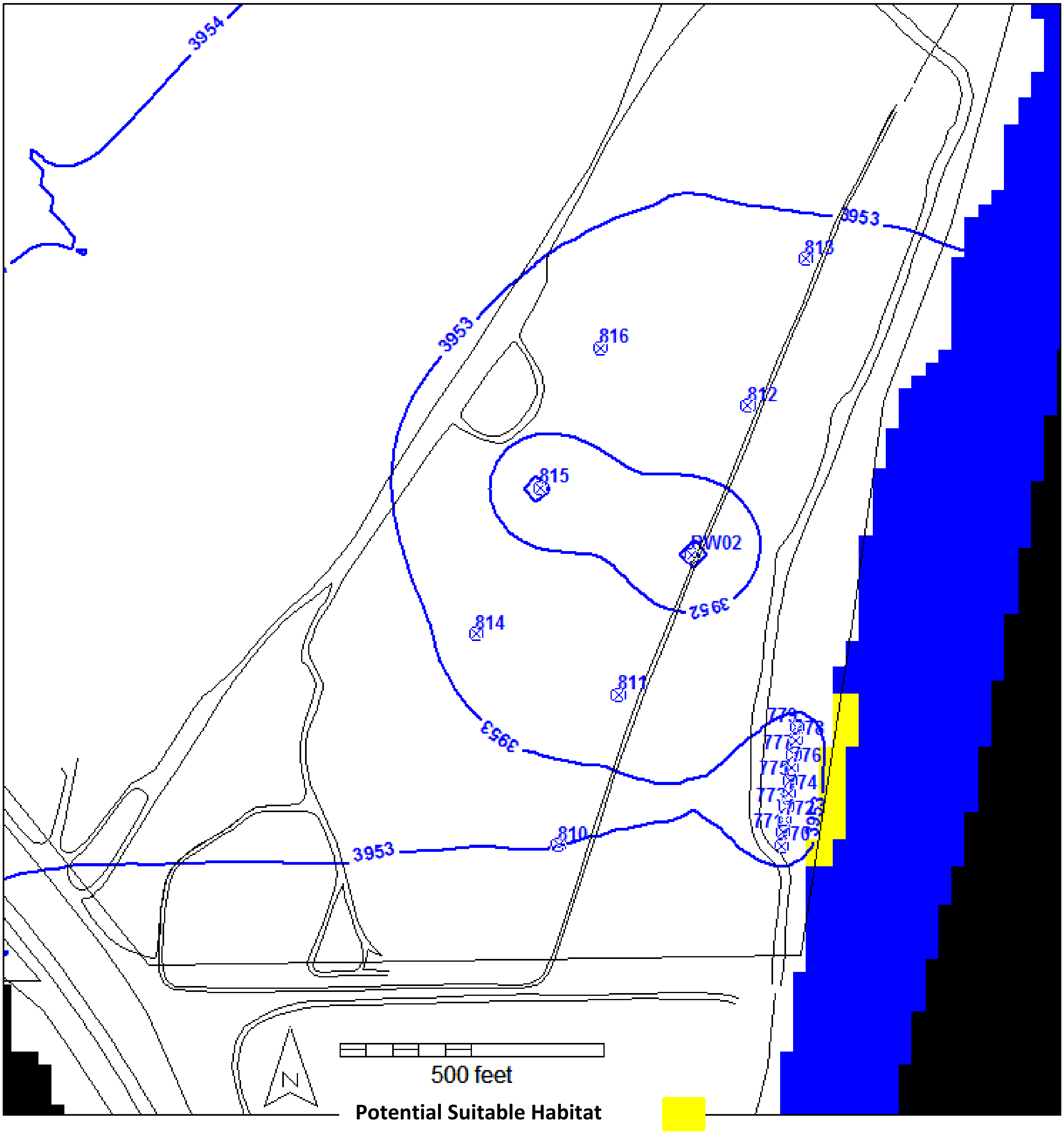


Figure 26. December Model-predicted Water Table, Injection and Extraction Wells Operating

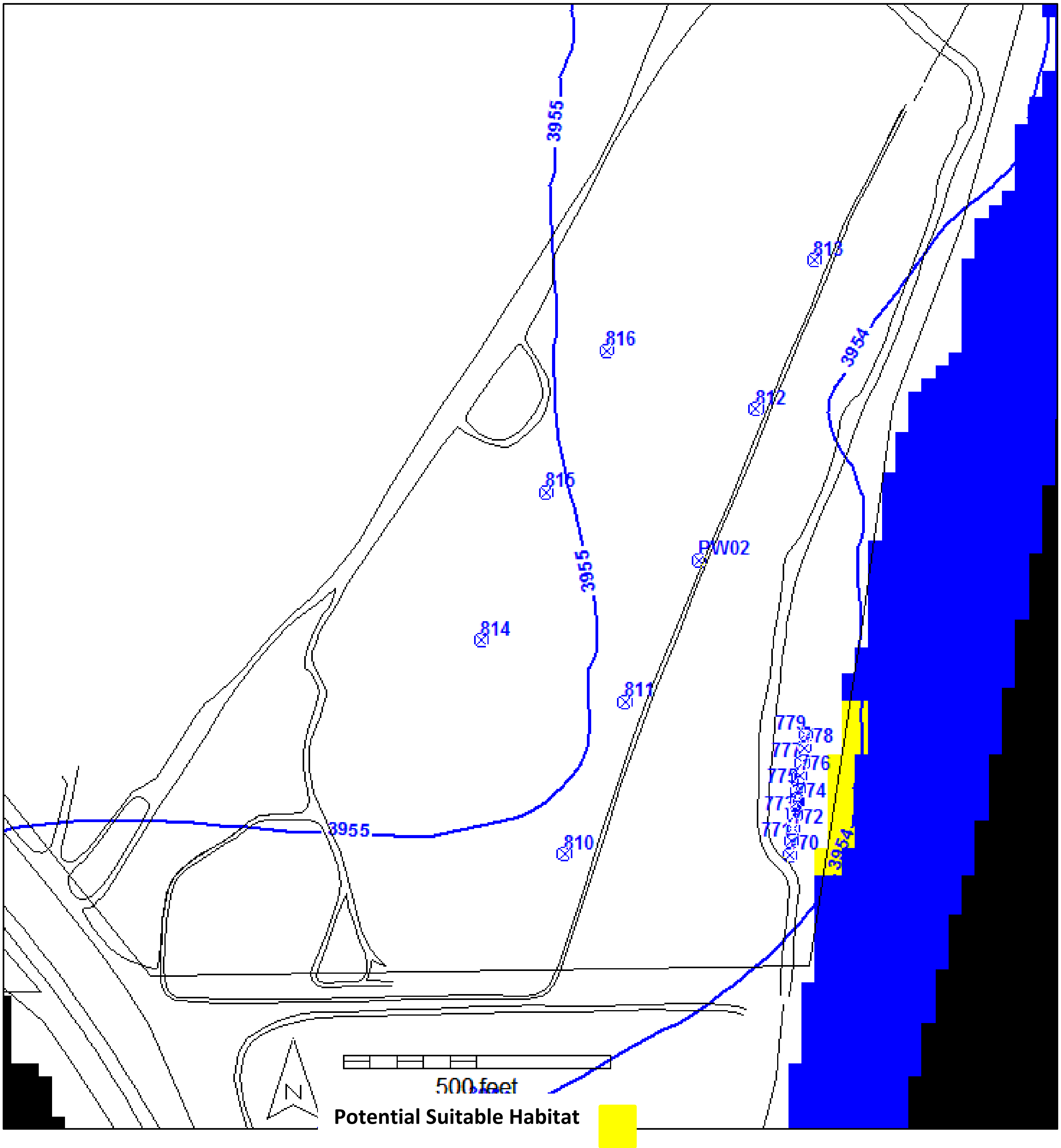


Figure 27. January Model-predicted Water Table, Injection Wells Operating

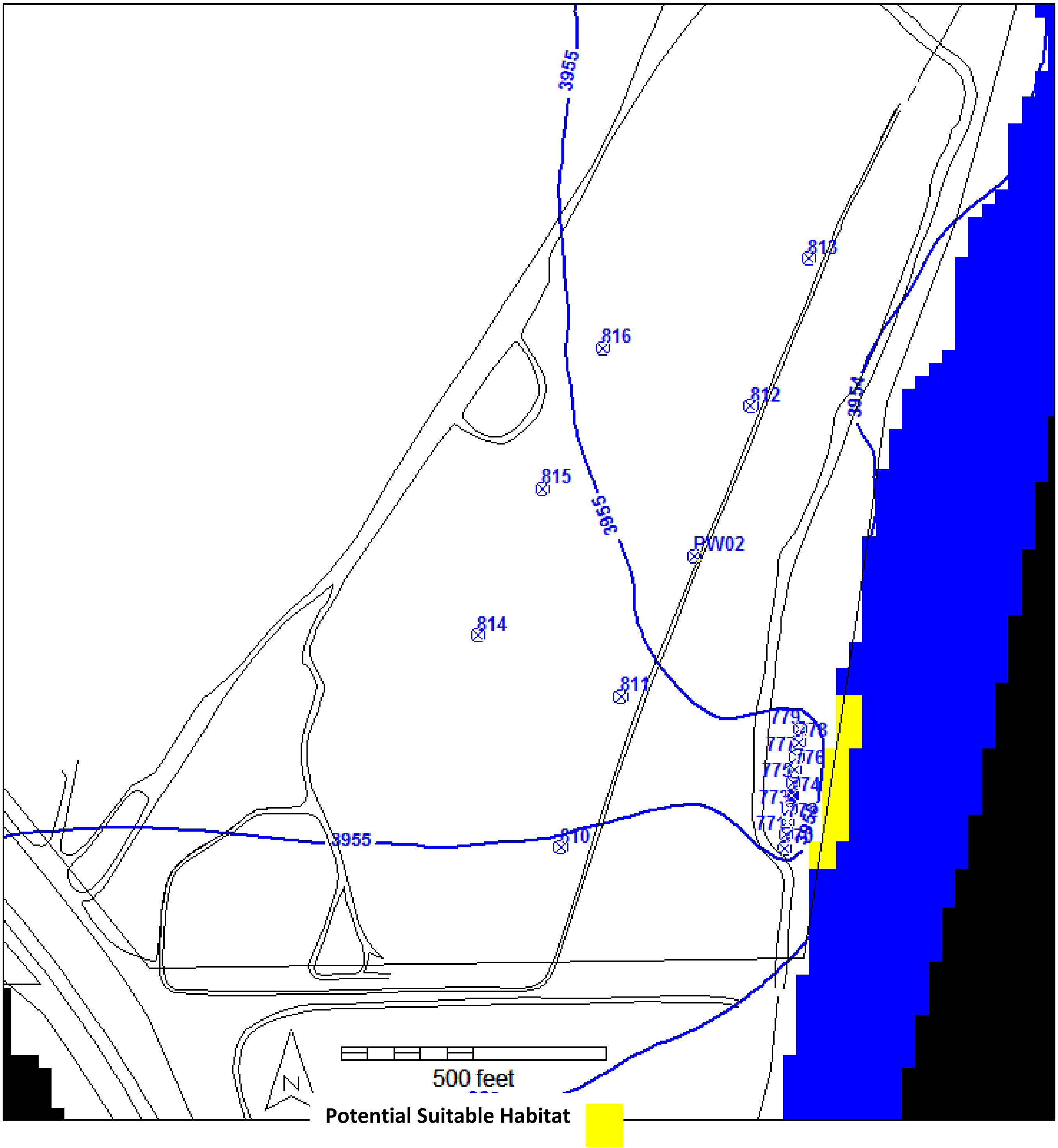


Figure 28. February Model-predicted Water Table, Injection Wells Operating

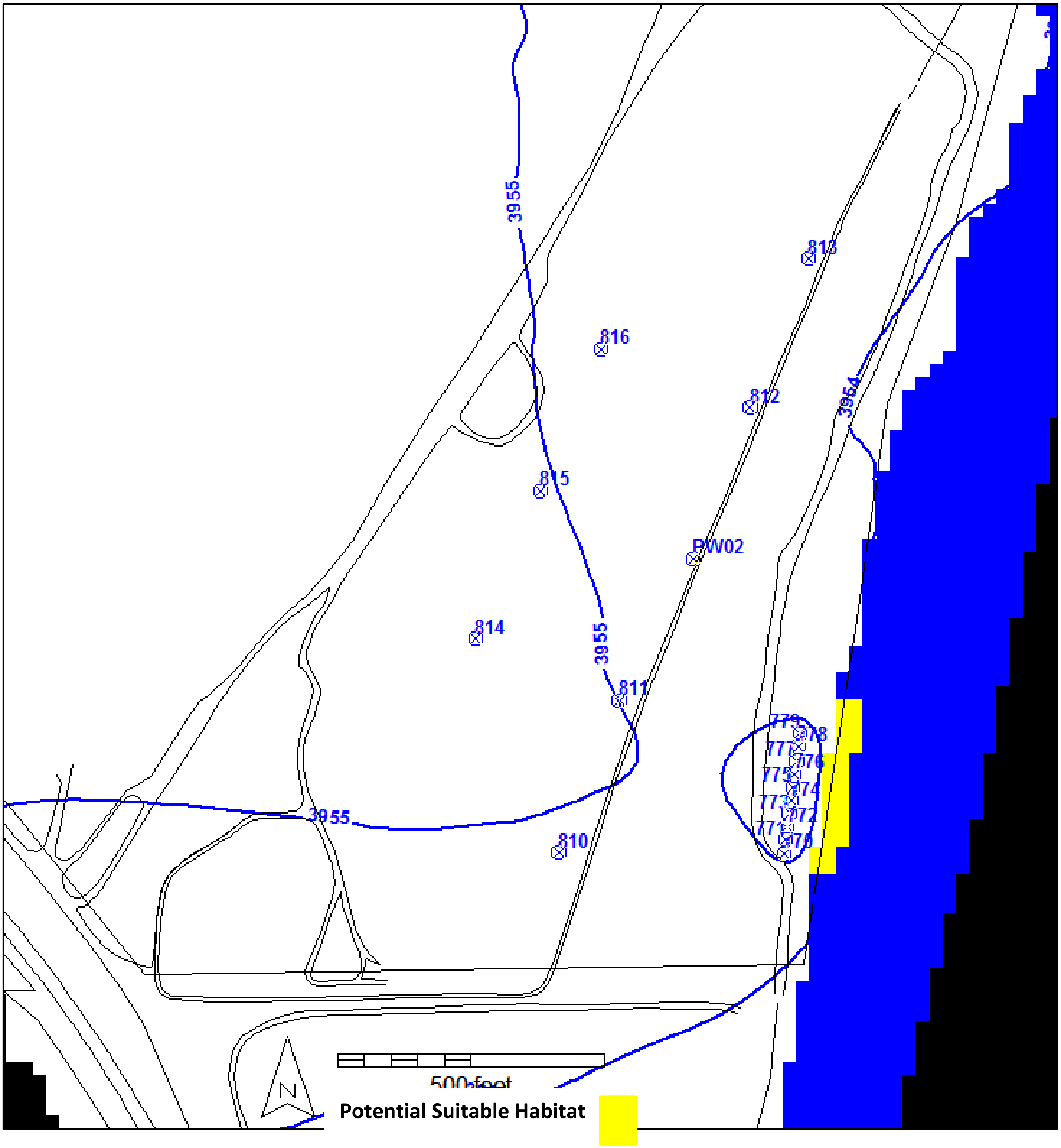


Figure 29. March Model-predicted Water Table, Injection Wells Operating

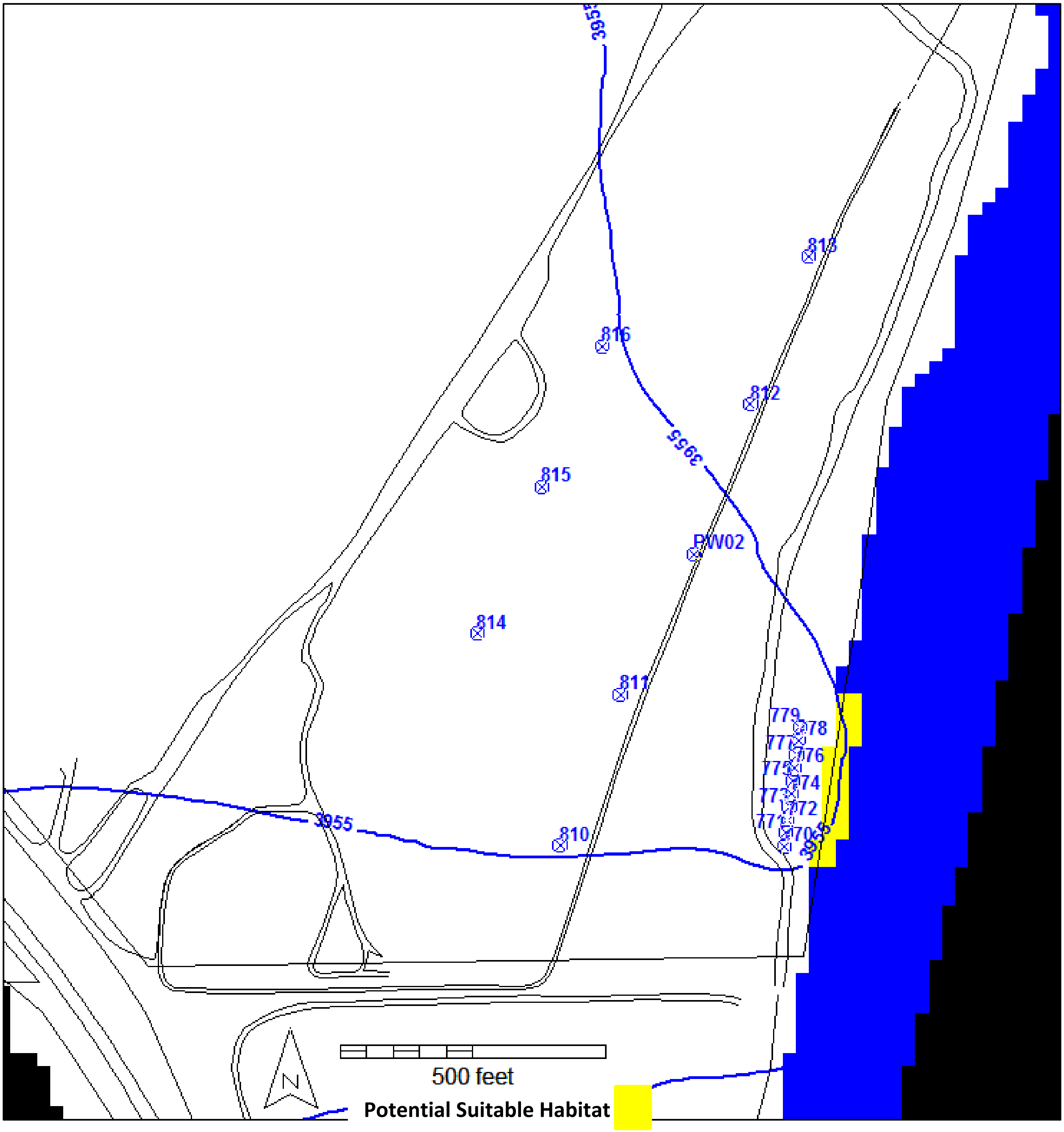


Figure 30. April Model-predicted Water Table, Injection Wells Operating

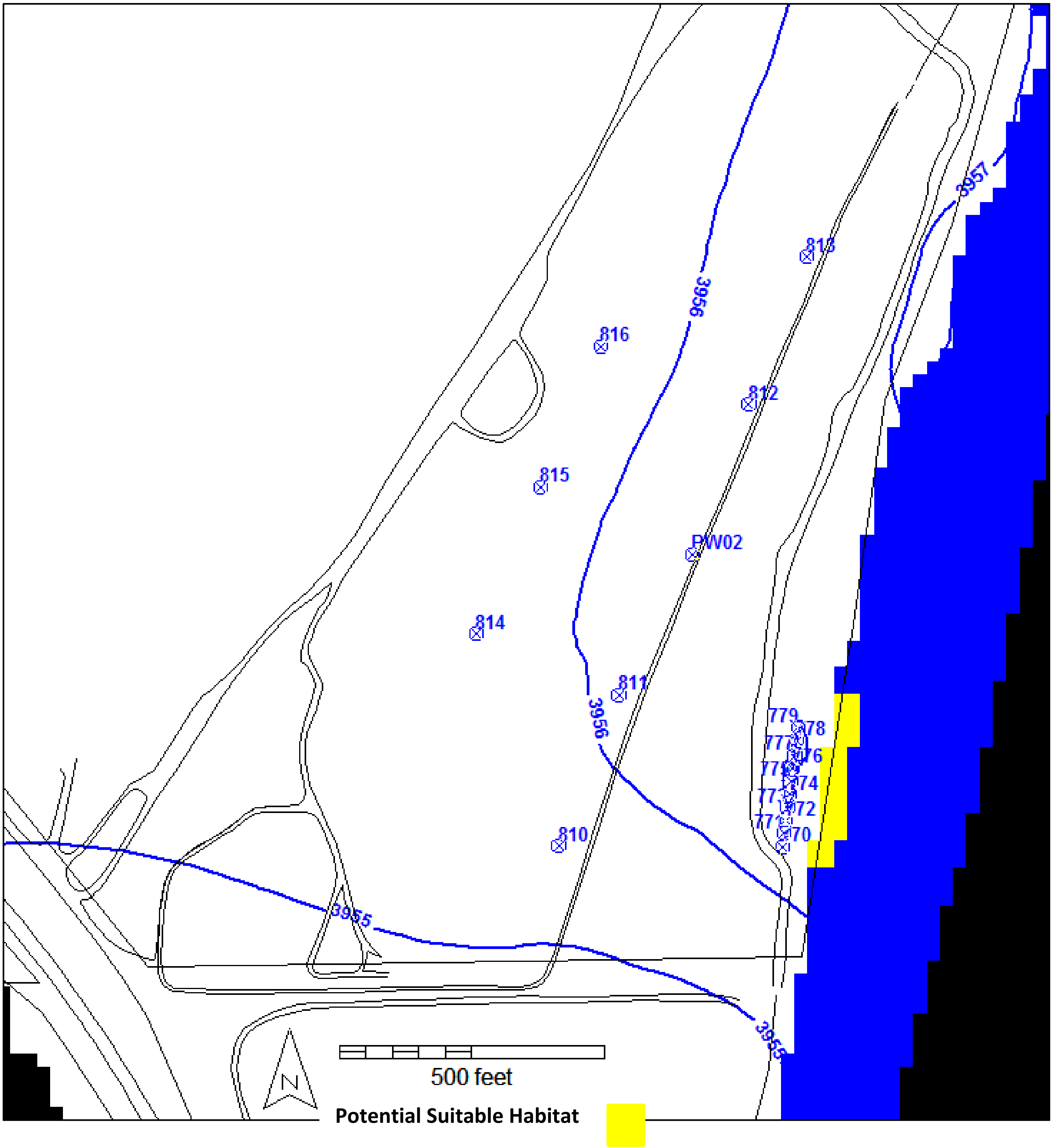


Figure 31. May Model-predicted Water Table, Injection Wells Operating

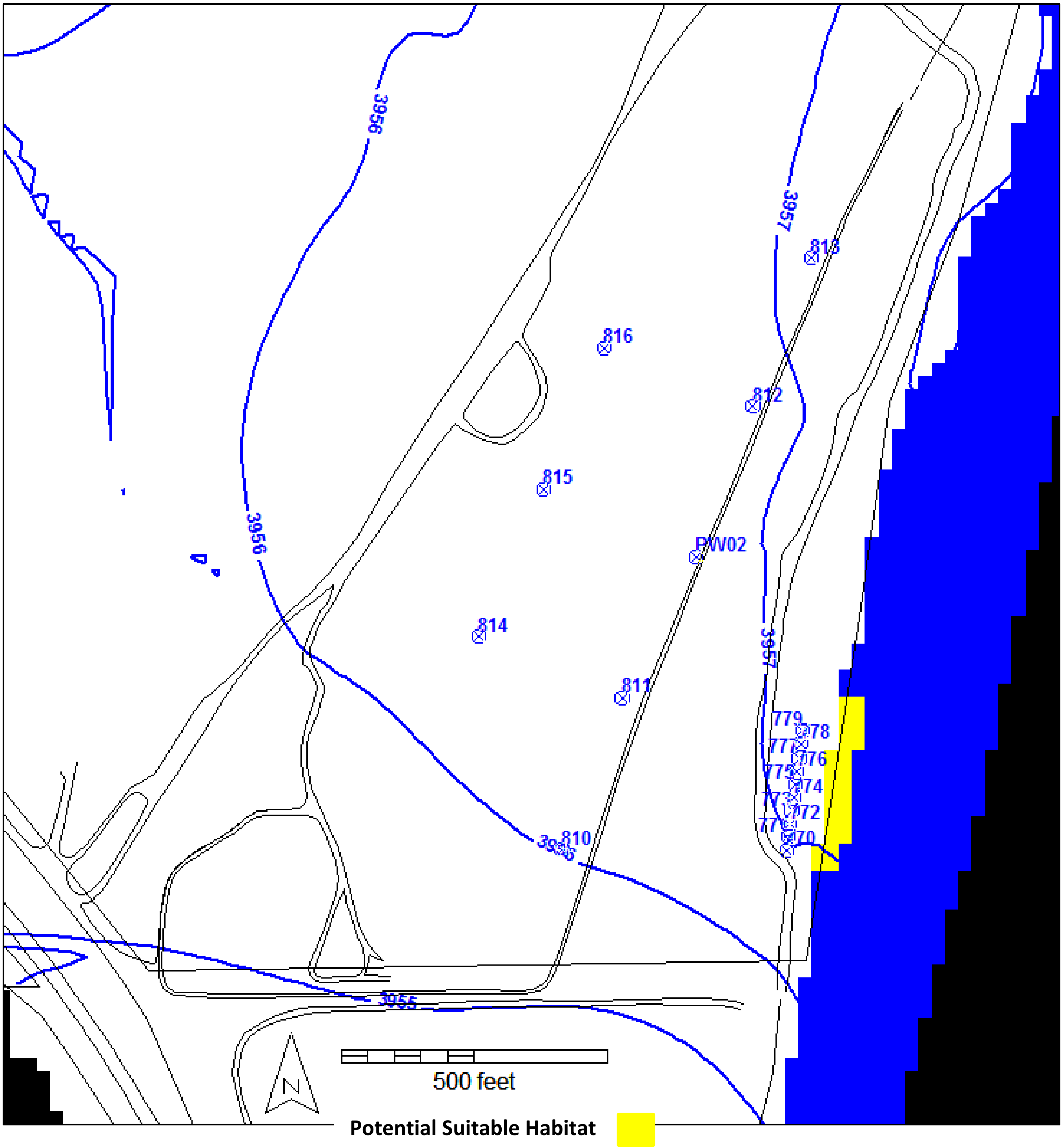


Figure 32. June Model-predicted, Extractions Injection Wells Operating

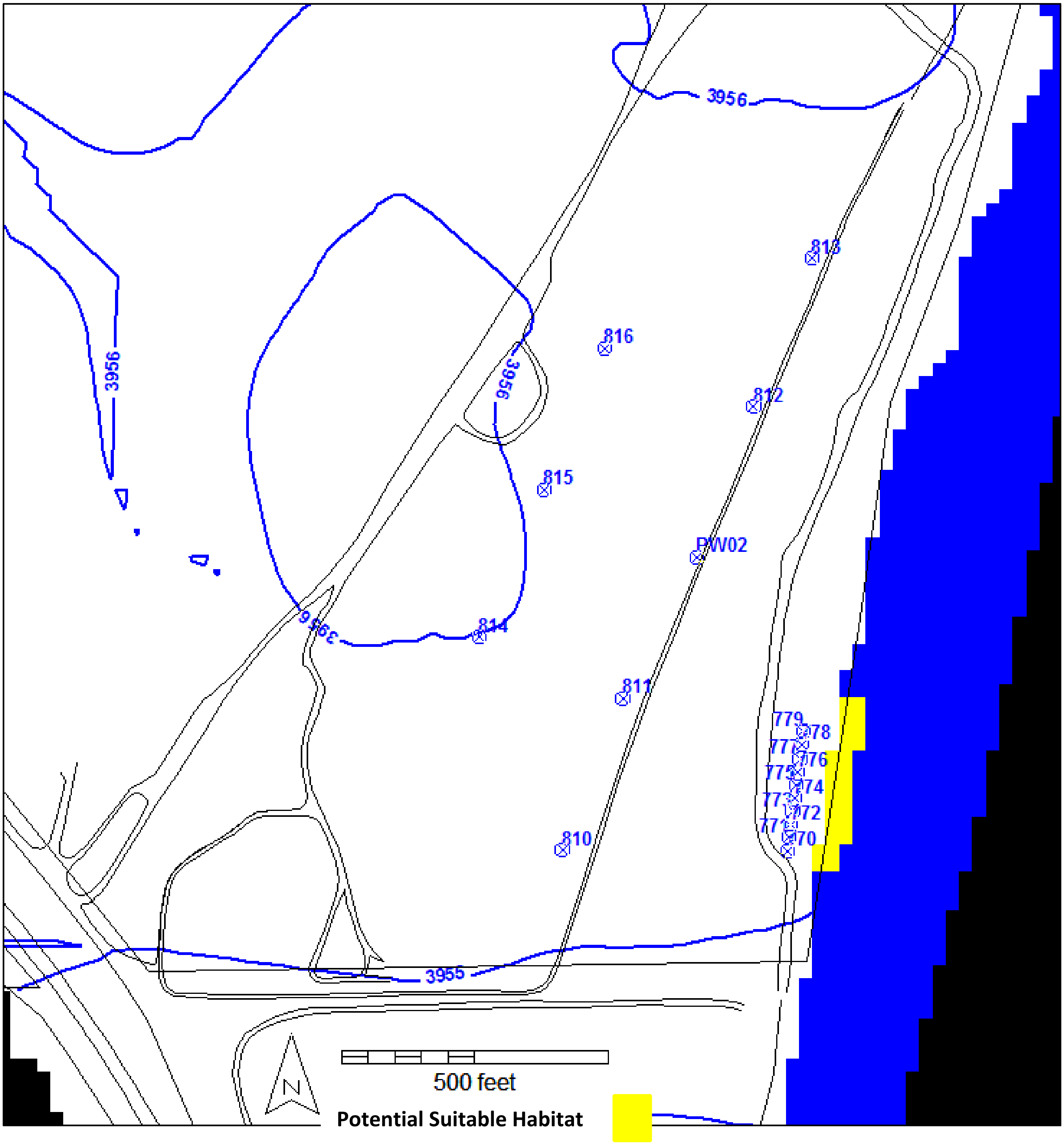


Figure 33. July Model-predicted Water Table, Injection Wells Operating

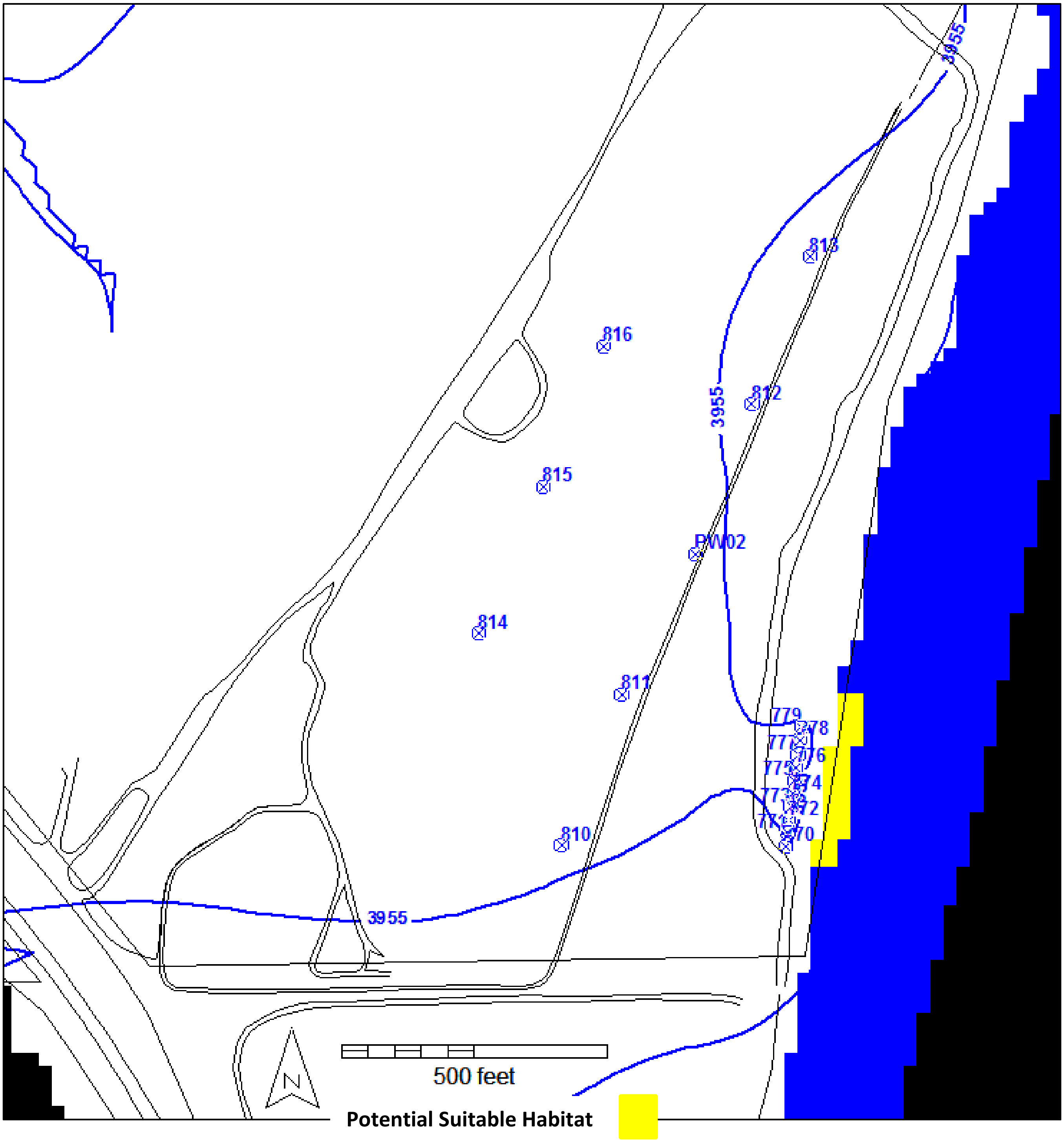


Figure 34. August Model-predicted Water Table, Injection Wells Operating

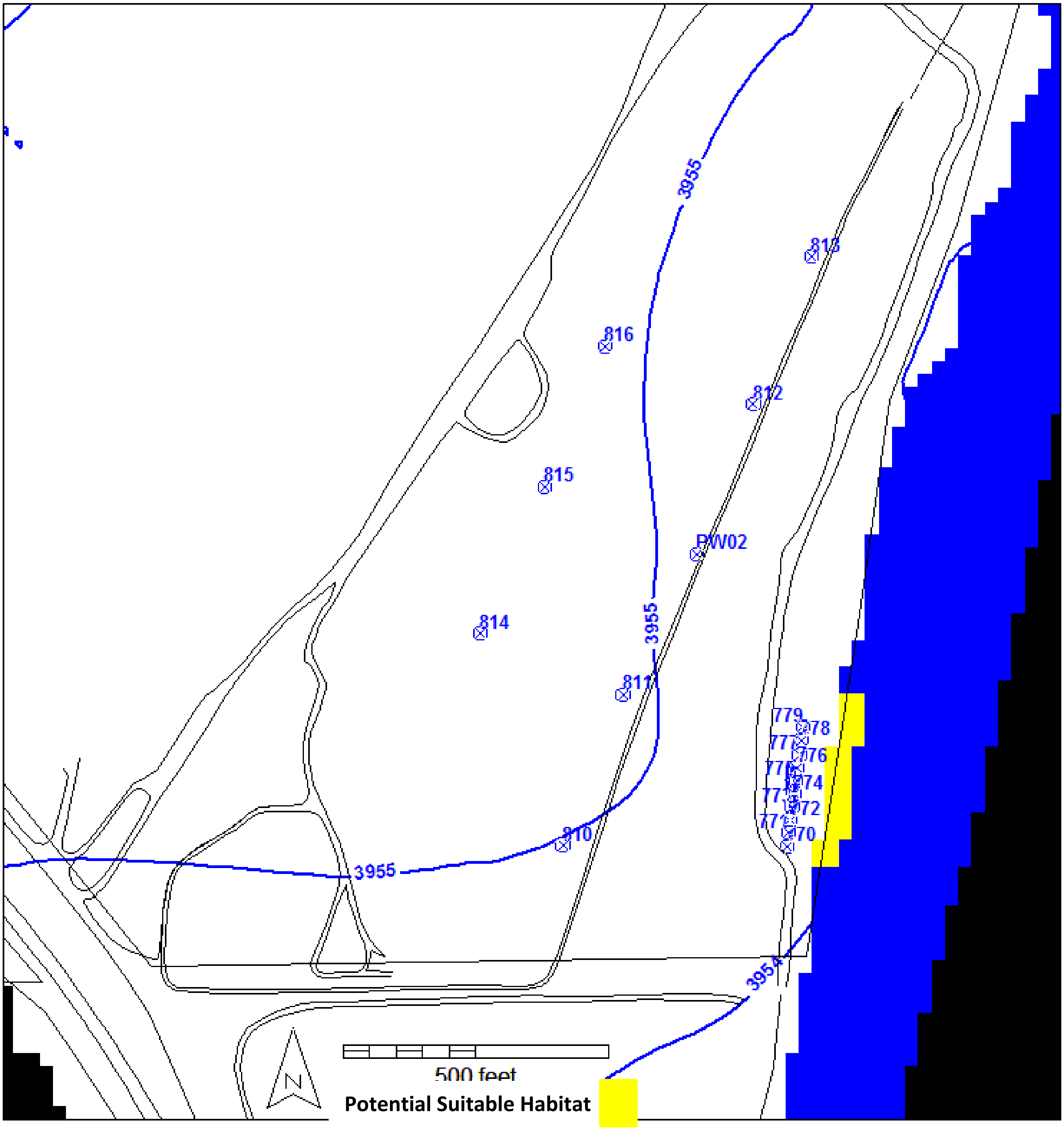


Figure 35. September Model-predicted Water Table, Injection Wells Operating

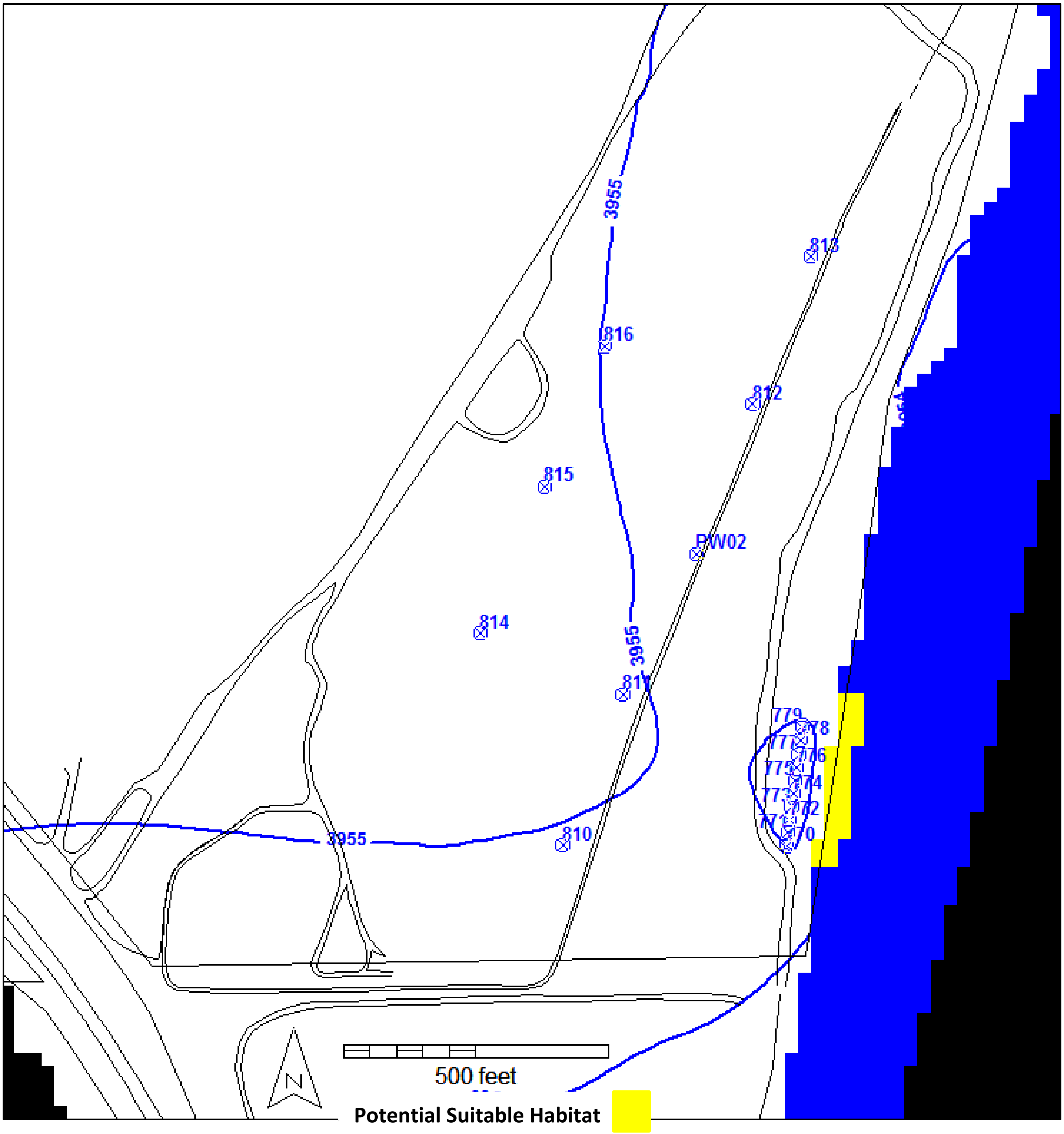


Figure 36. October Model-predicted Water Table, Injection Wells Operating

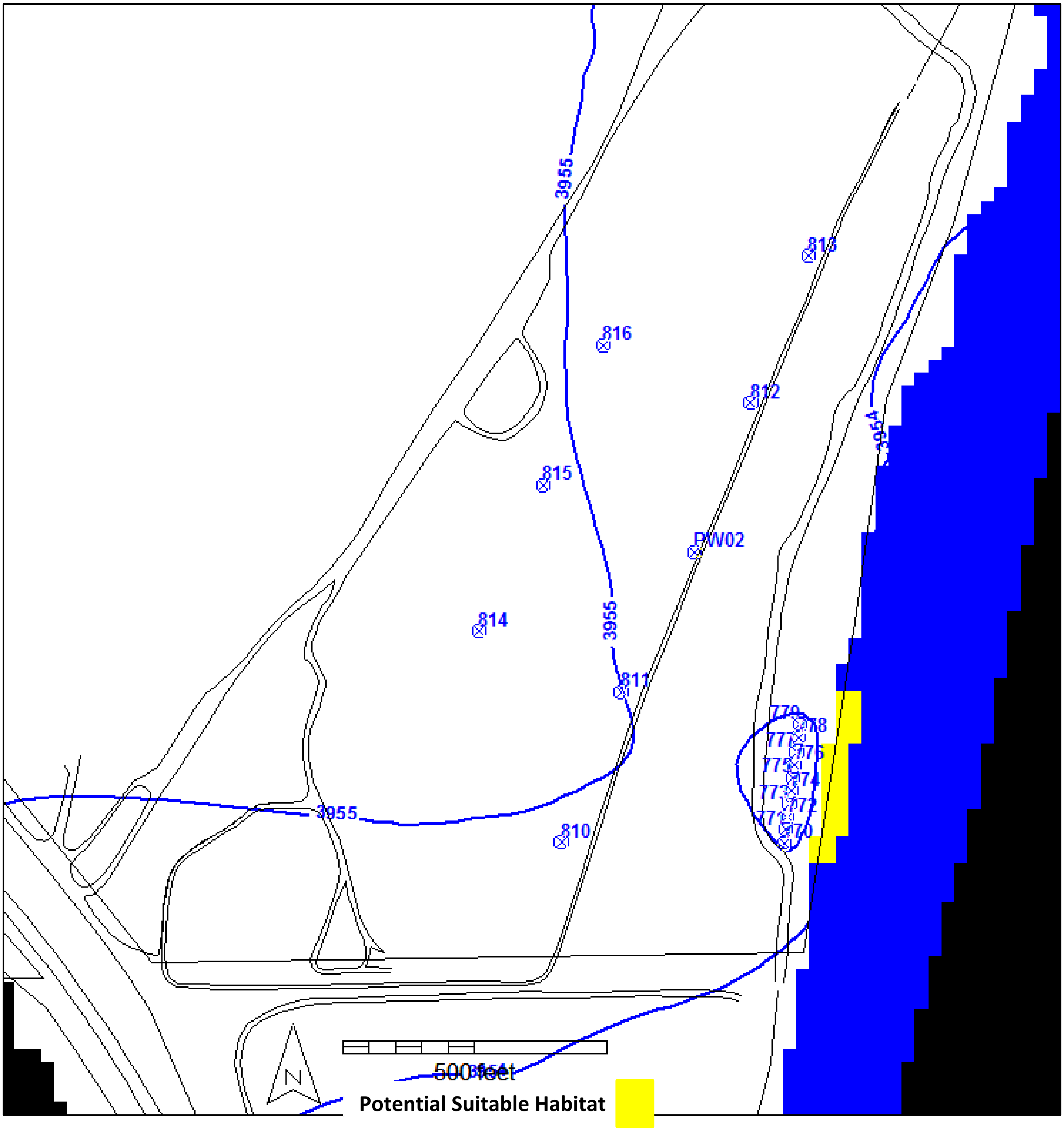


Figure 37. November Model-predicted Water Table, Injection Wells Operating

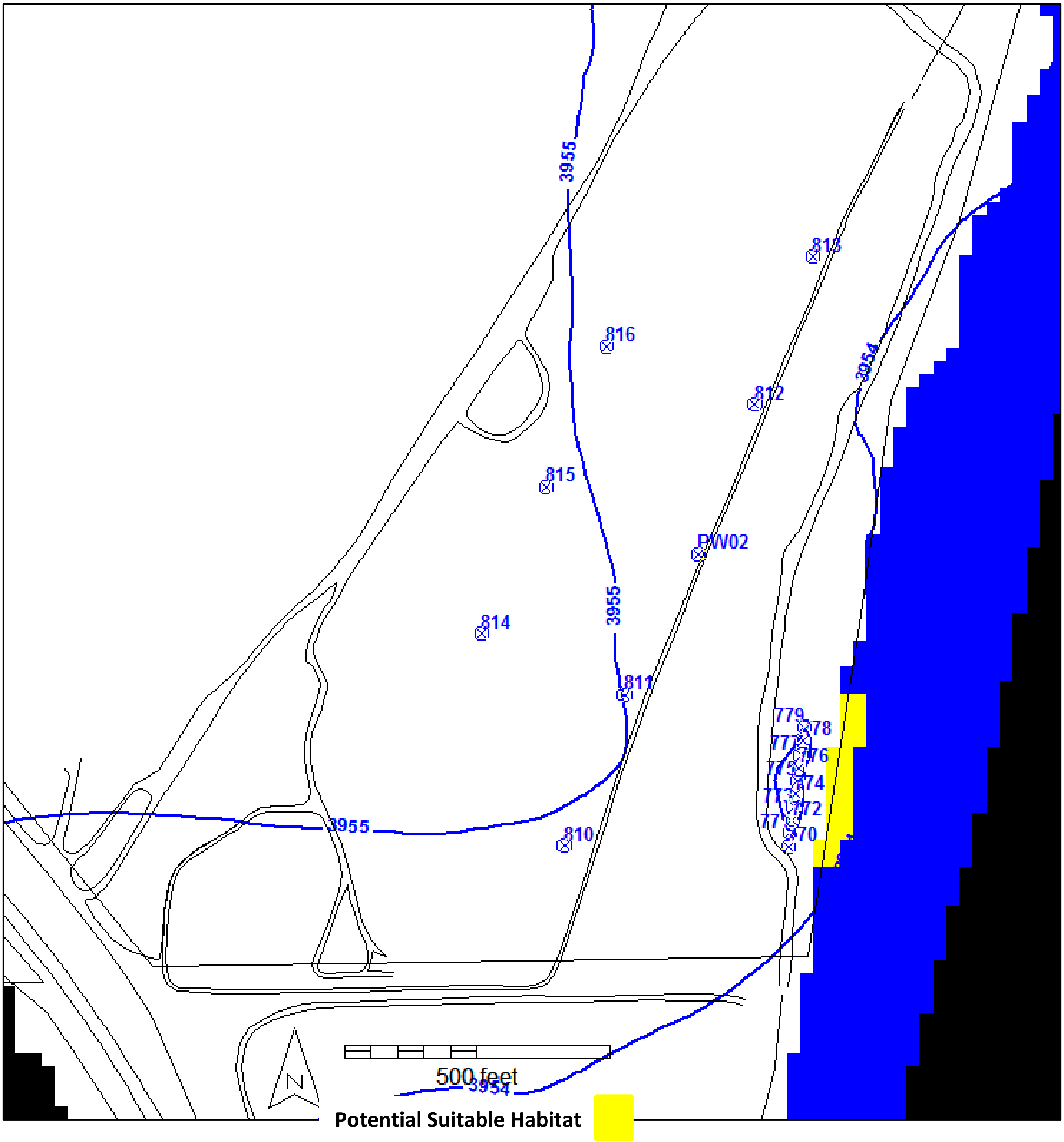


Figure 38. December Model-predicted Water Table, Injection Wells Operating

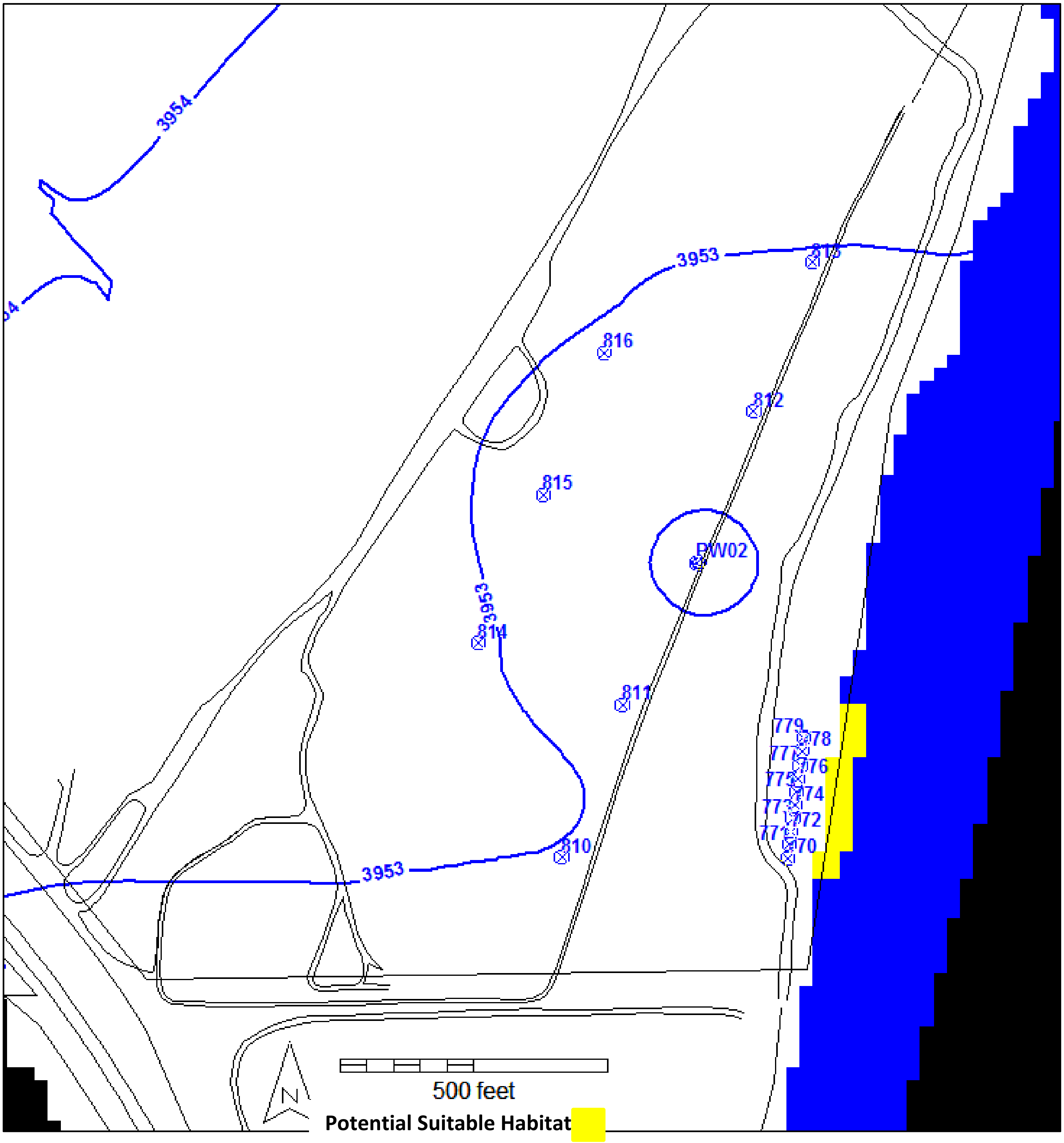


Figure 39. January Model-predicted Water Table, Extractions Wells Operating

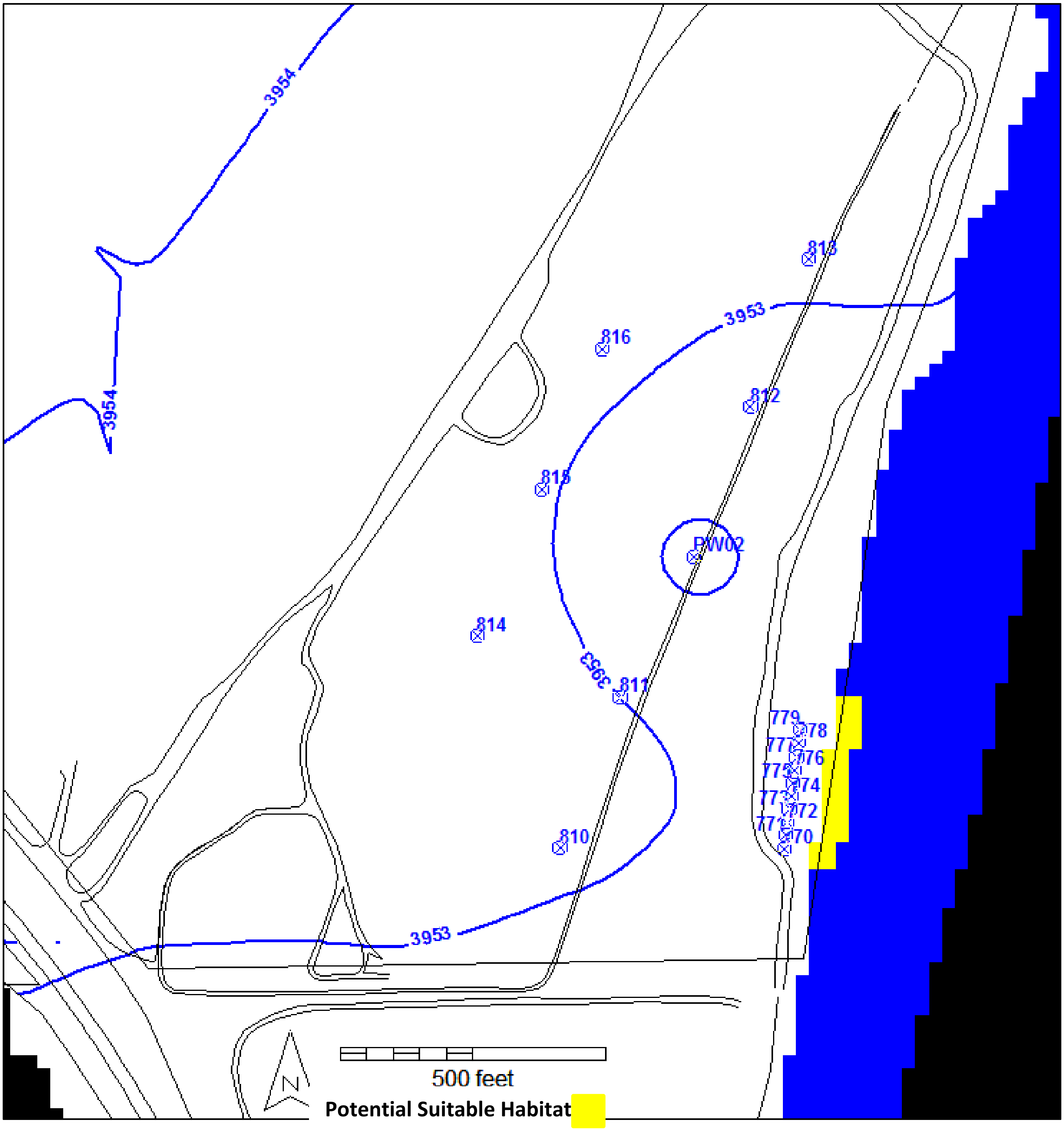


Figure 40. February Model-predicted Water Table, Extractions Wells Operating

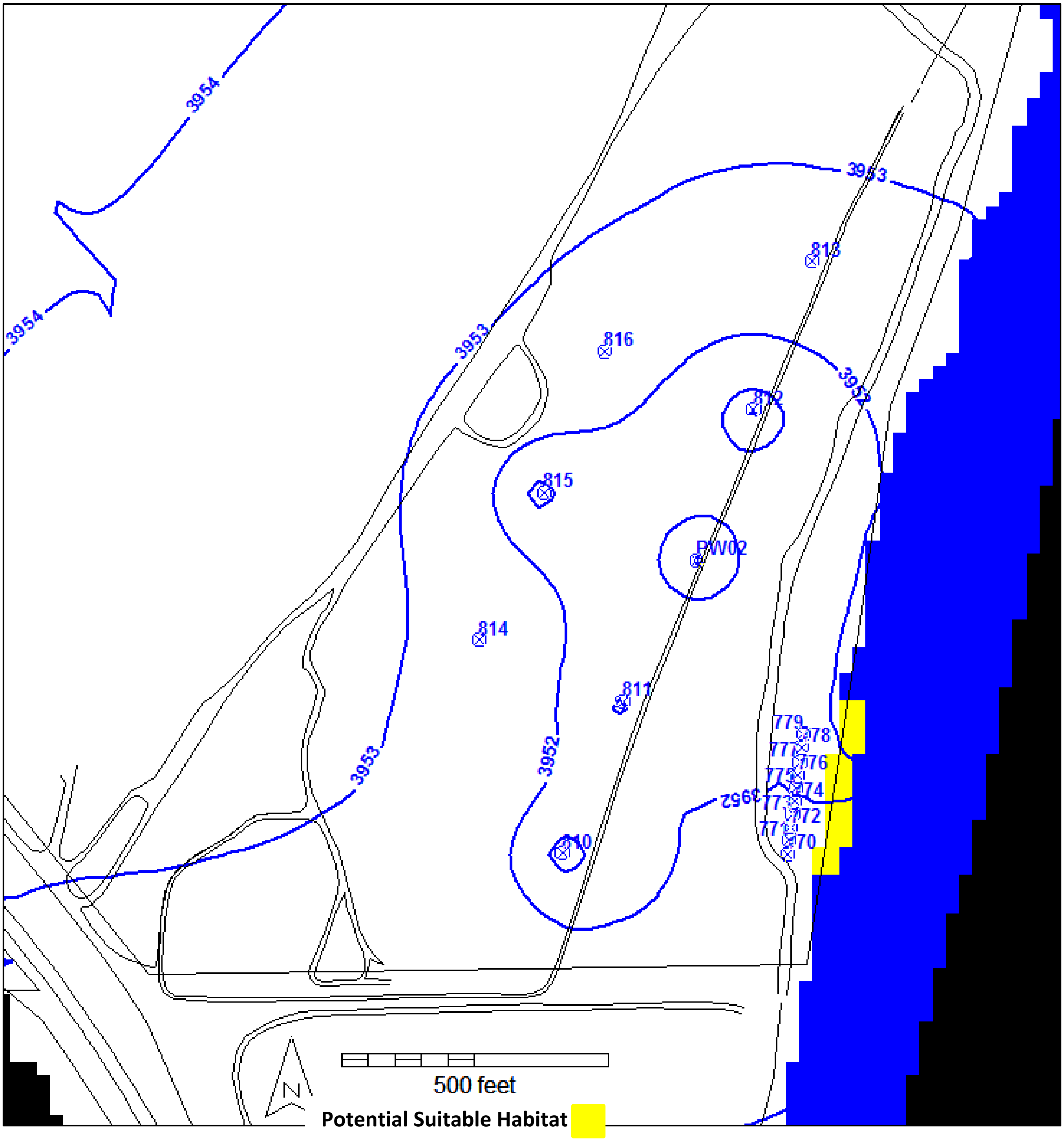


Figure 41. March Model-predicted Water Table, Extractions Wells Operating

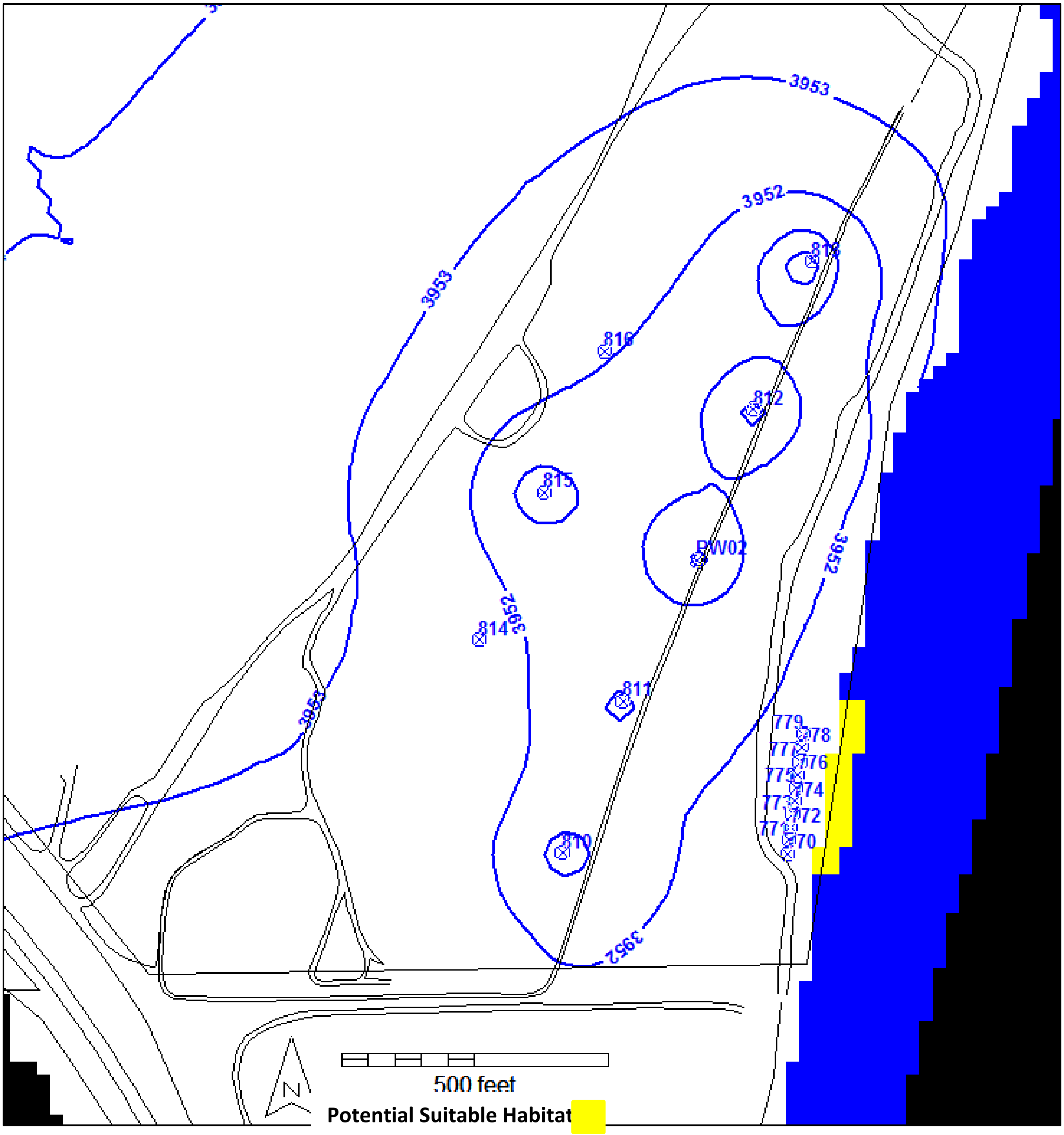


Figure 42. April Model-predicted Water Table, Extractions Wells Operating

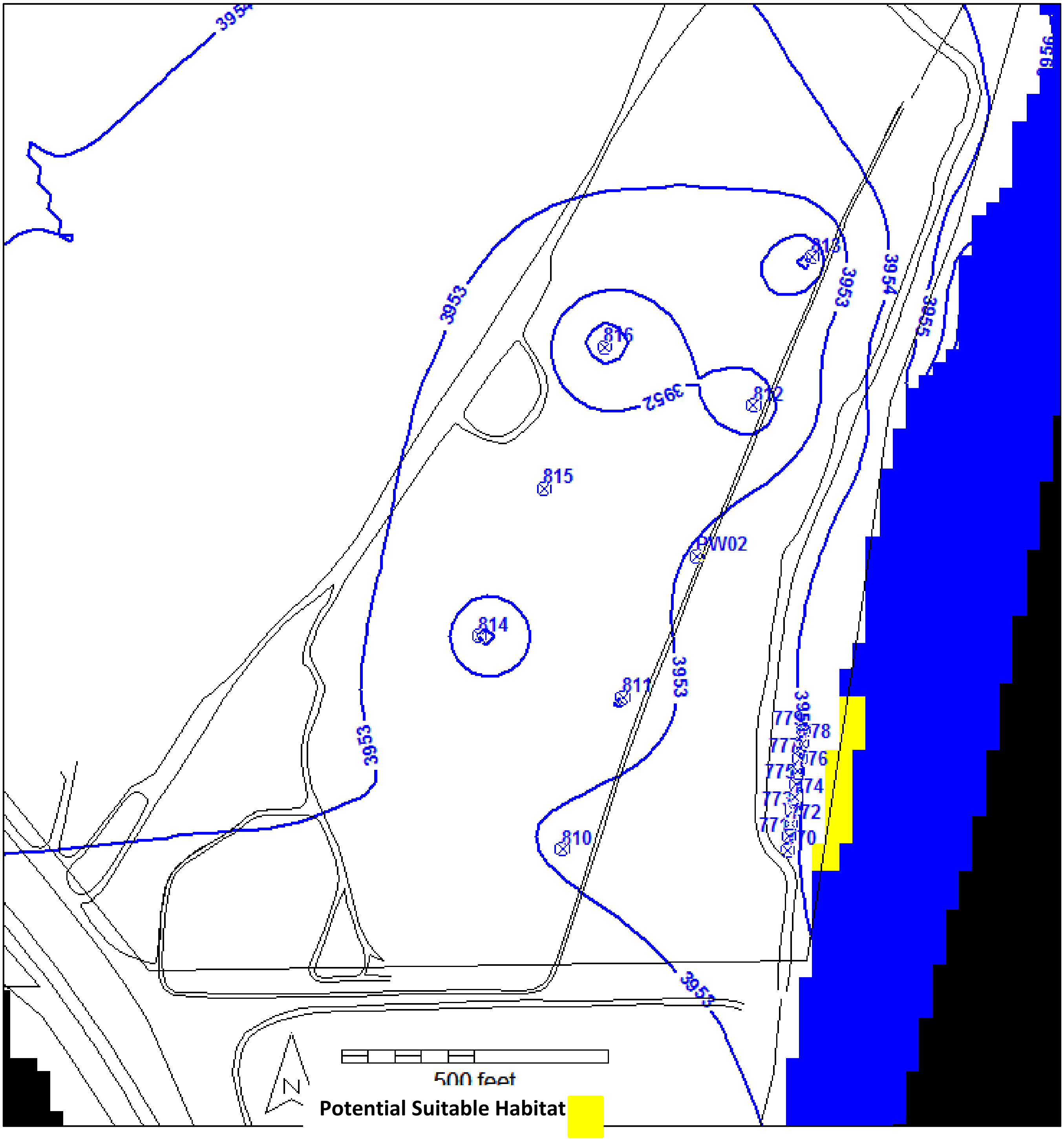


Figure 43. May Model-predicted Water Table, Extractions Wells Operating

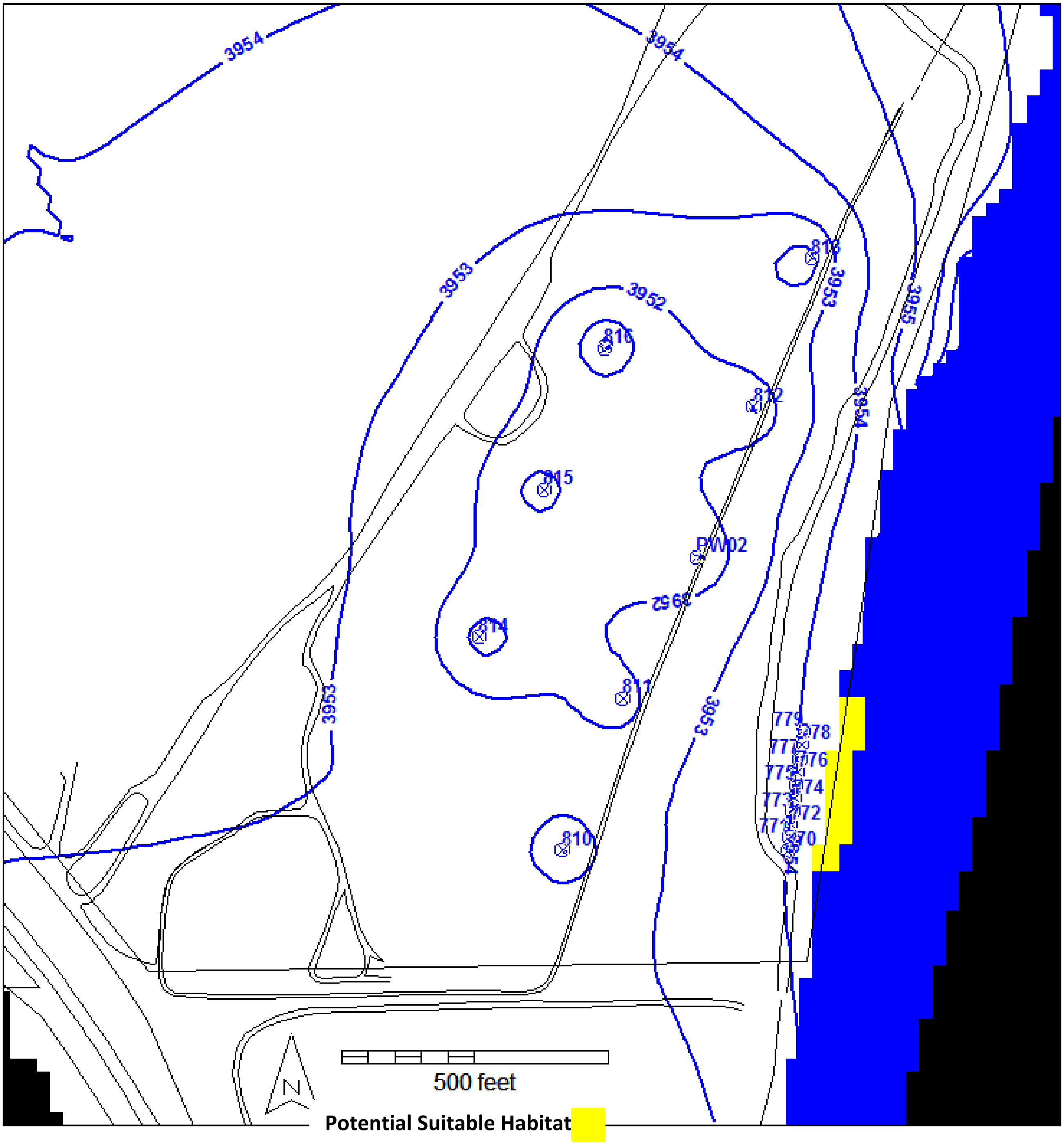


Figure 44. June Model-predicted Water Table, Extractions Wells Operating

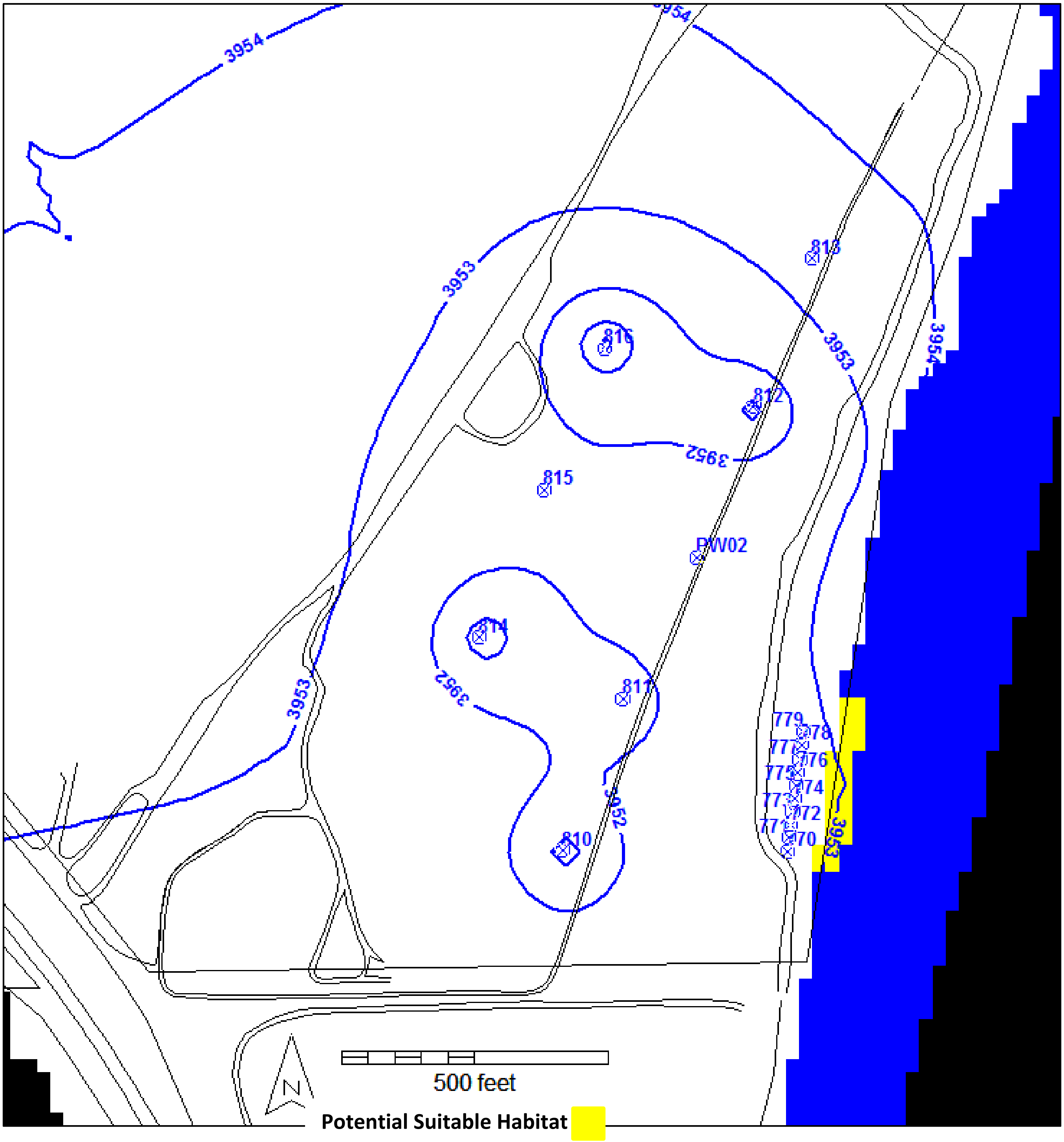


Figure 45. July Model-predicted Water Table, Extractions Wells Operating

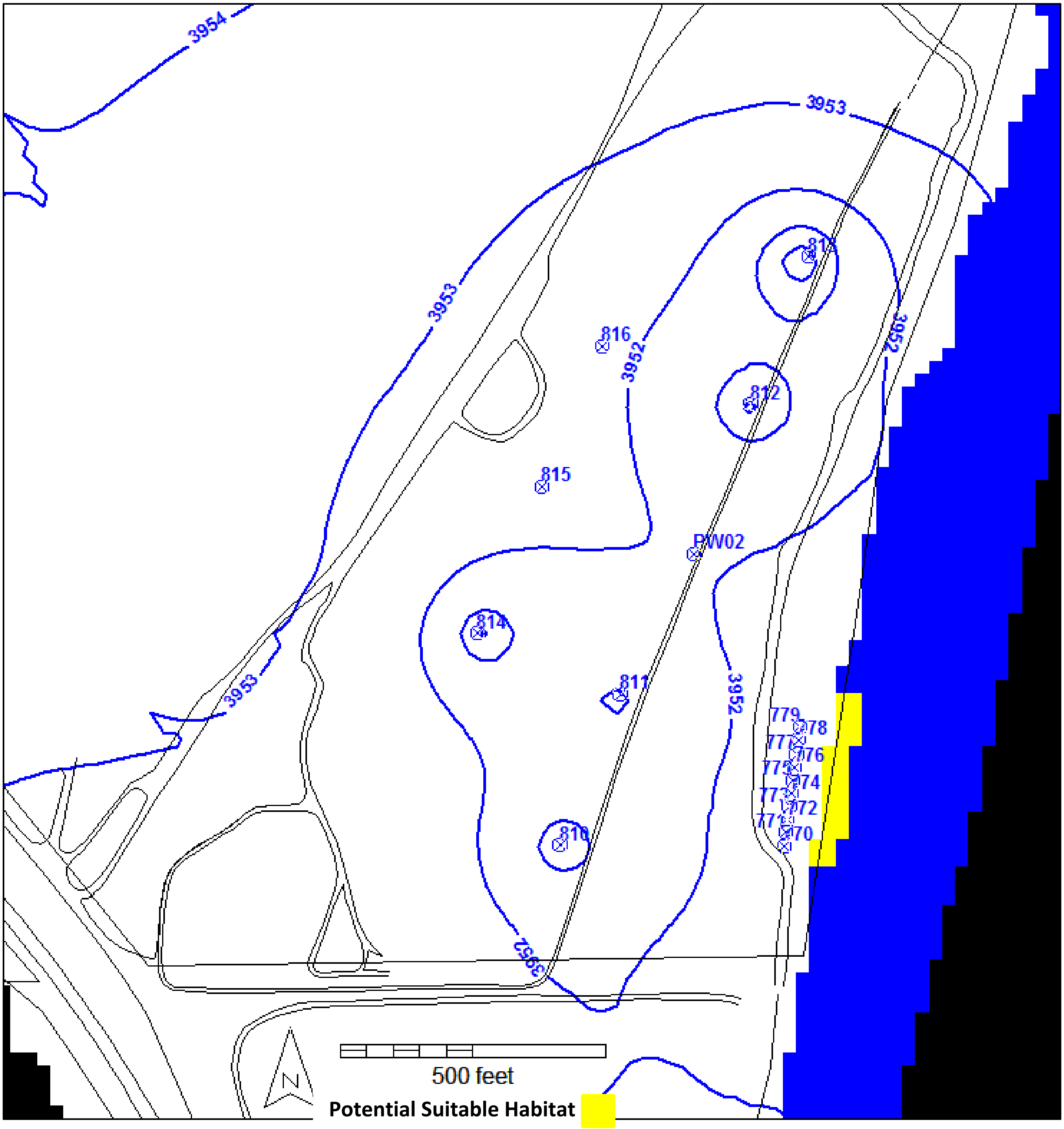


Figure 46. August Model-predicted Water Table, Extractions Wells Operating

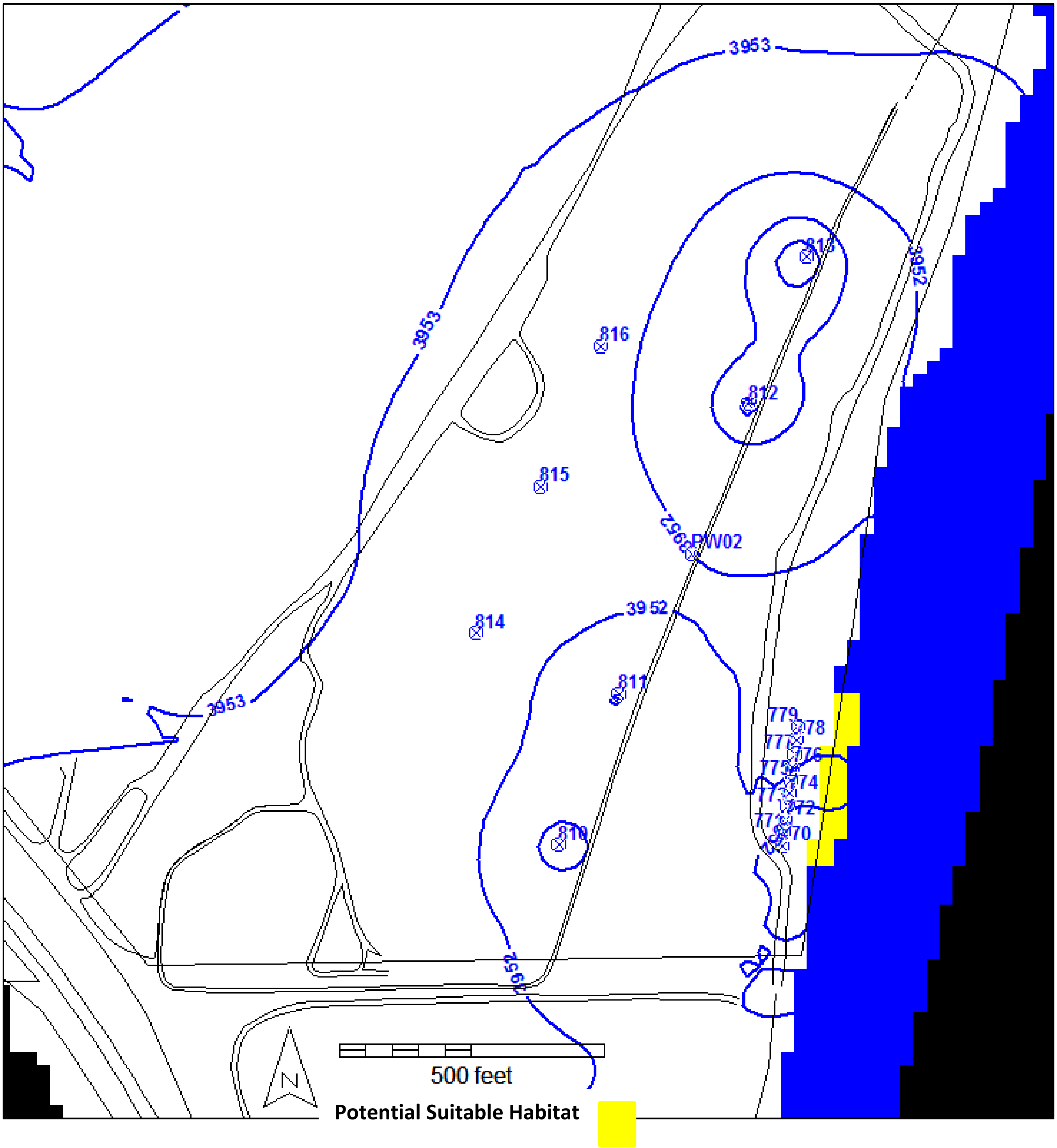


Figure 47. September Model-predicted Water Table, Extractions Wells Operating

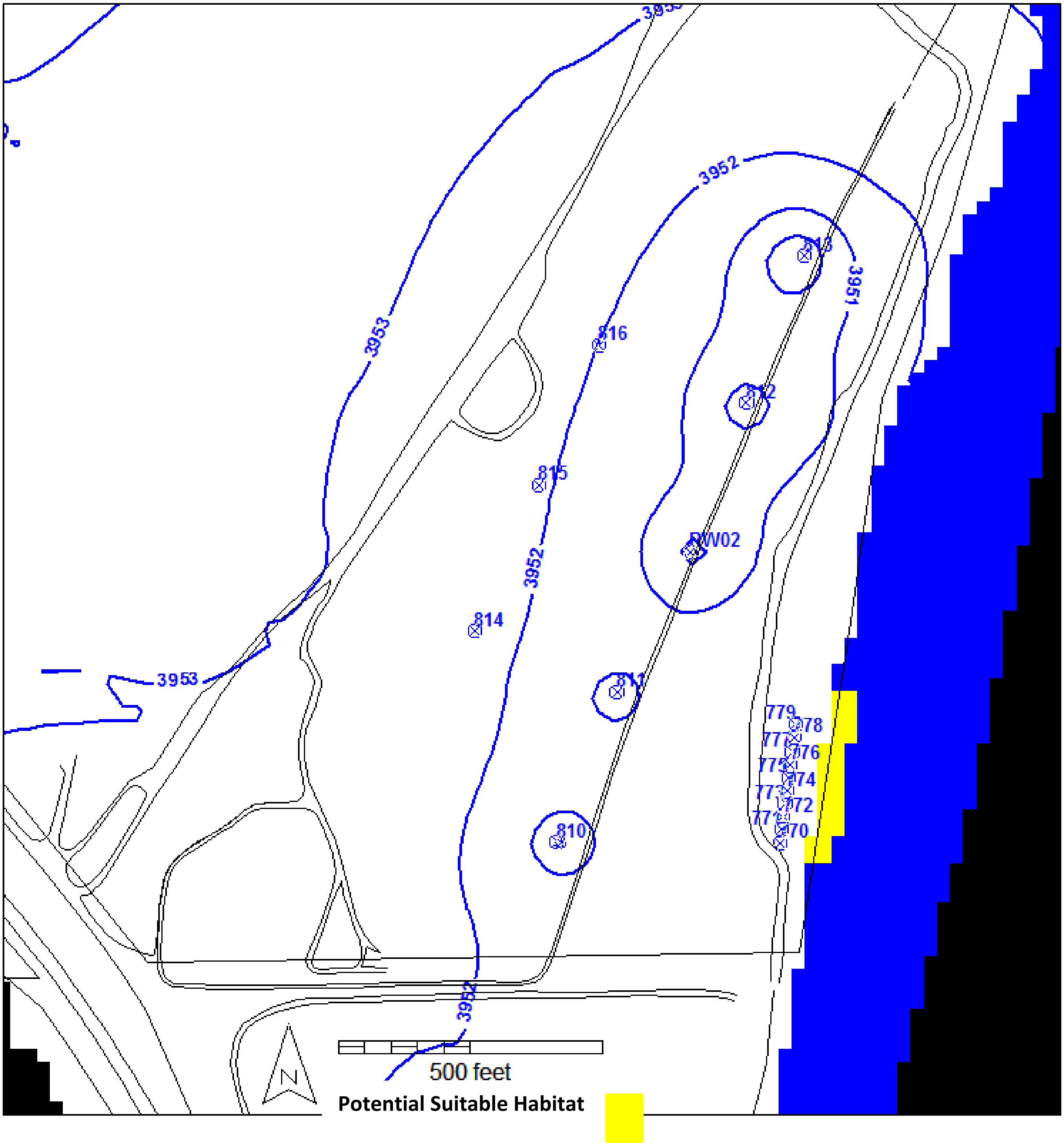


Figure 48. October Model-predicted Water Table, Extractions Wells Operating

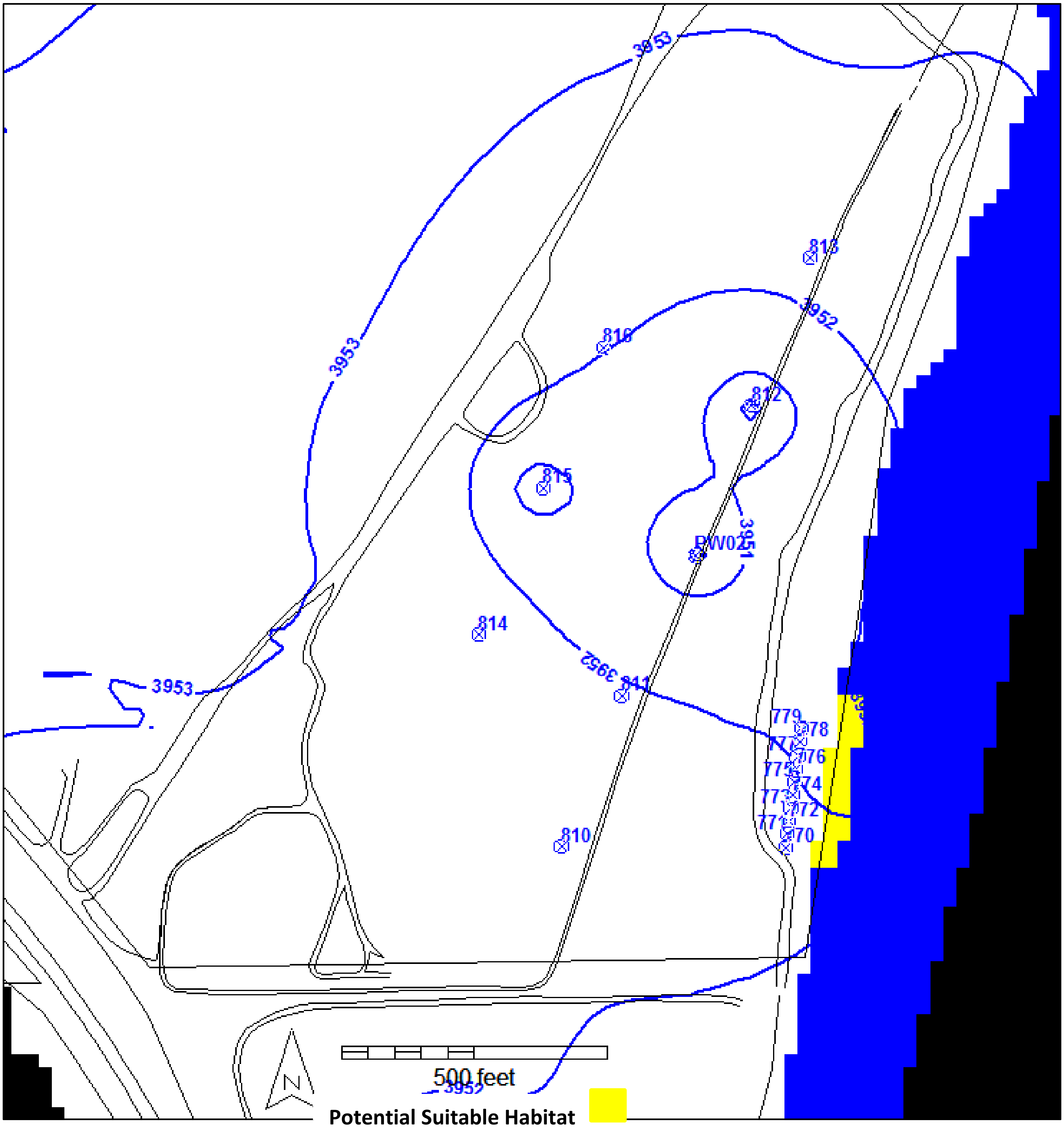


Figure 49. November Model-predicted Water Table, Extractions Wells Operating

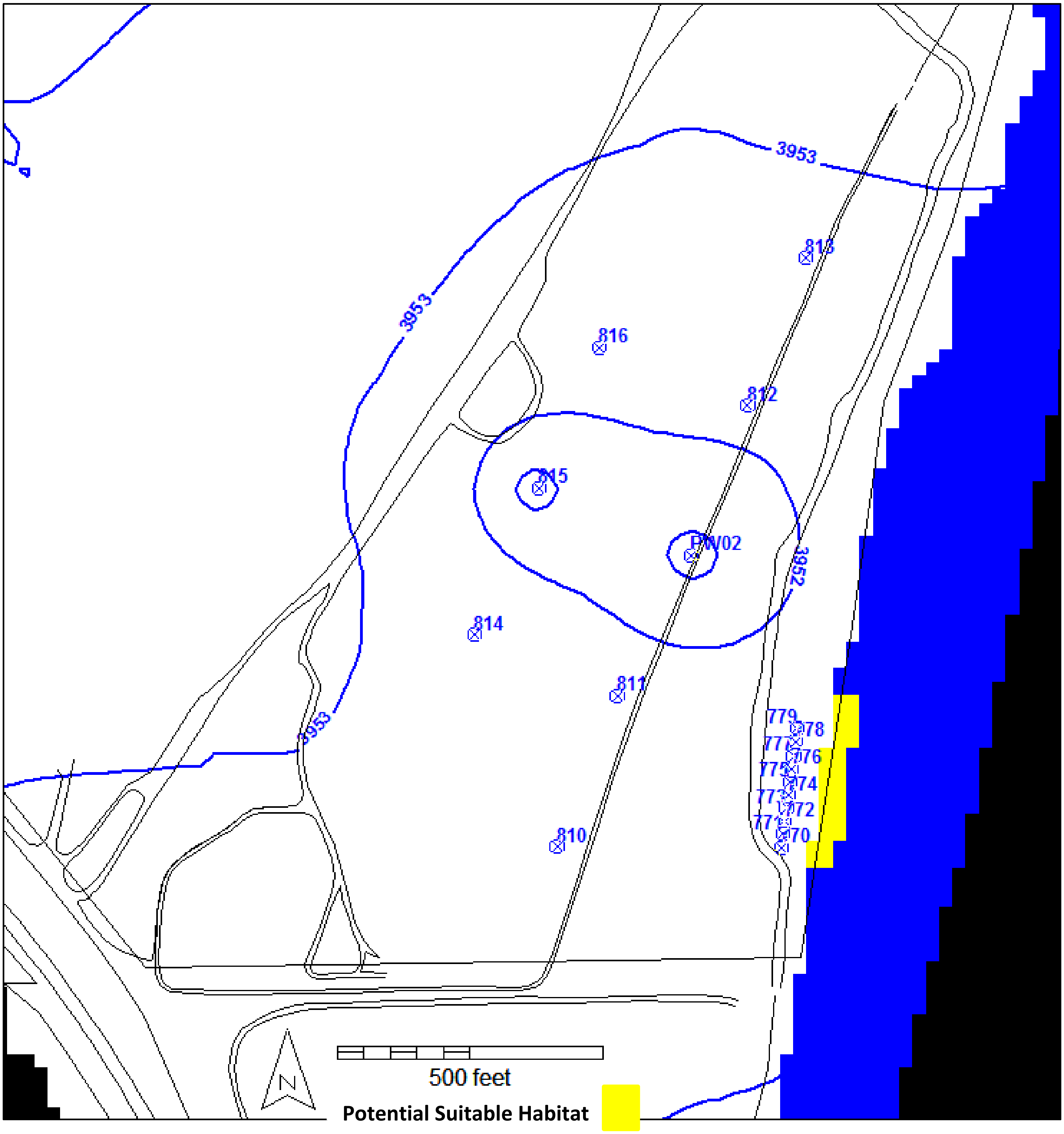


Figure 50. December Model-predicted Water Table, Extractions Wells Operating

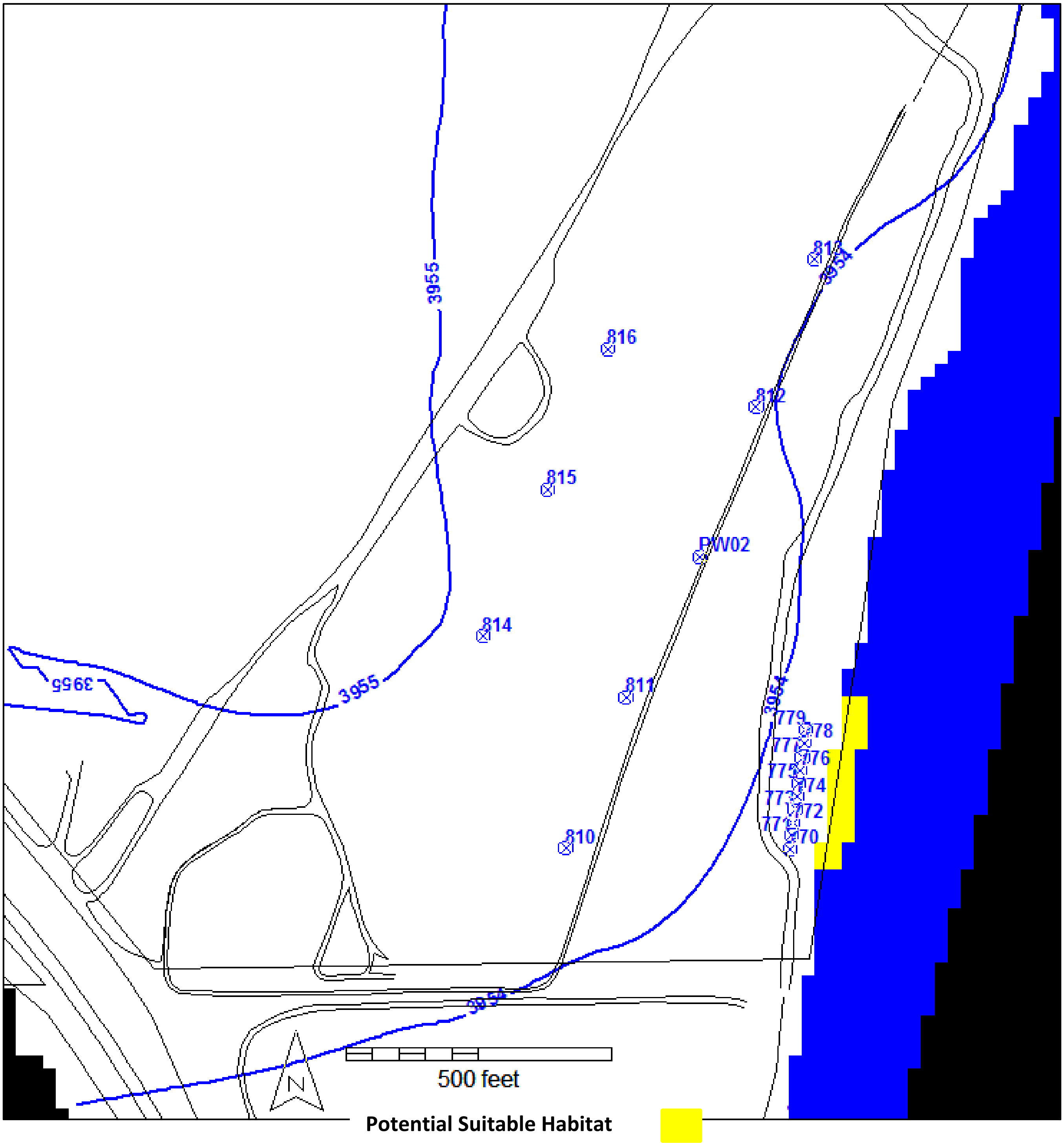


Figure 51. January Model-predicted Water Table, Maximum Evapotranspiration Conditions

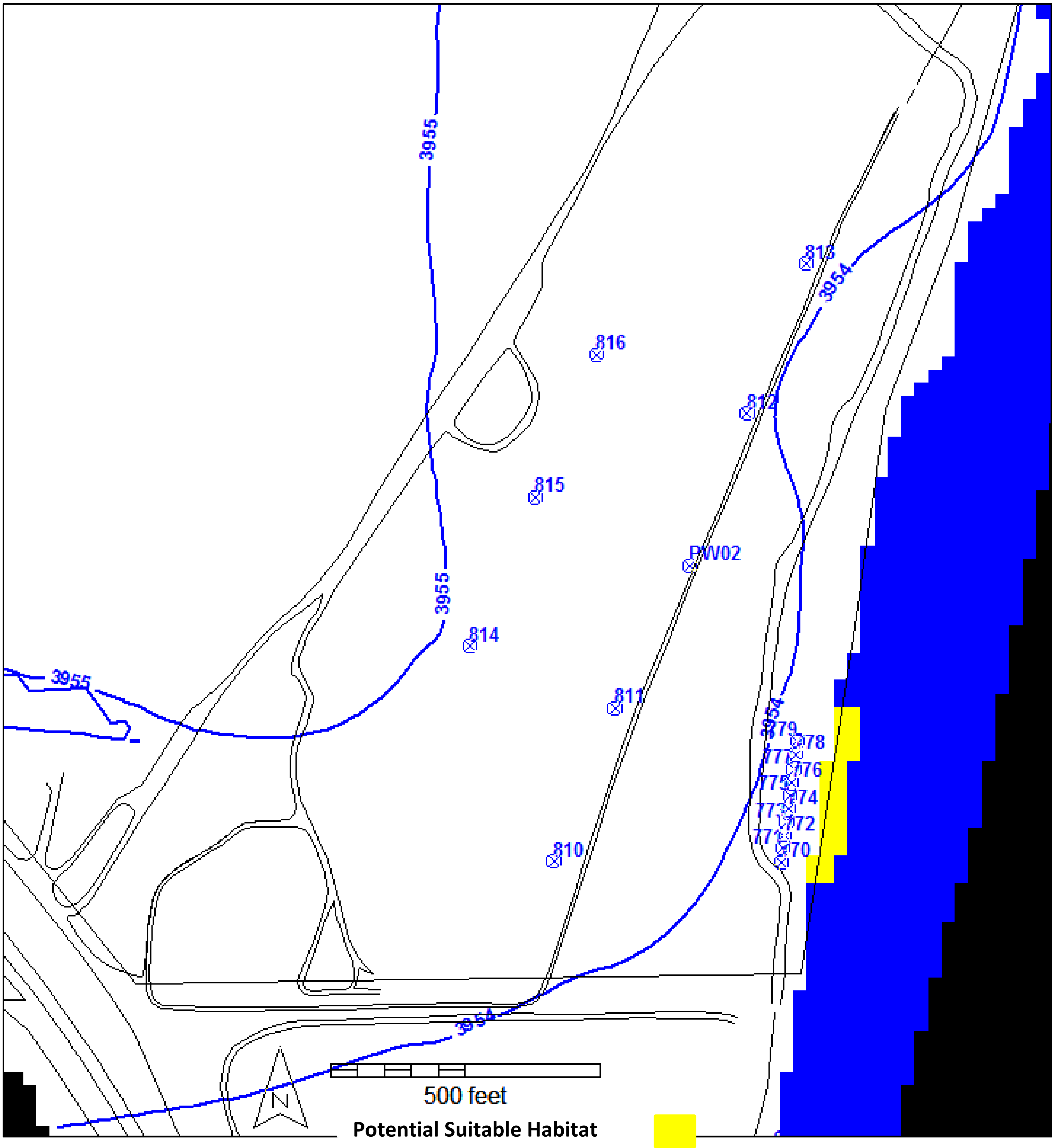


Figure 52. February Model-predicted Water Table, Maximum Evapotranspiration Conditions

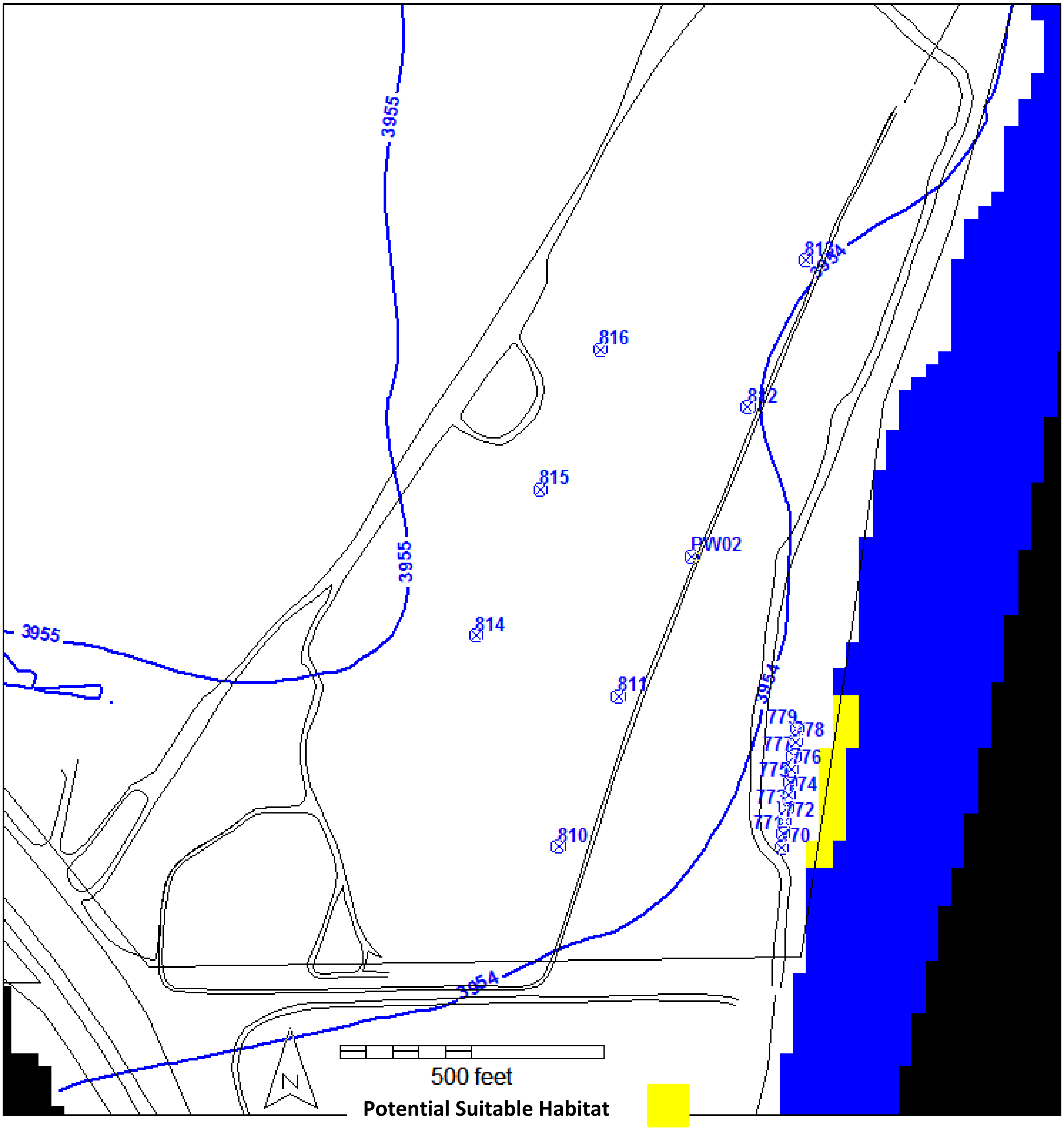


Figure 53. March Model-predicted Water Table, Maximum Evapotranspiration Conditions

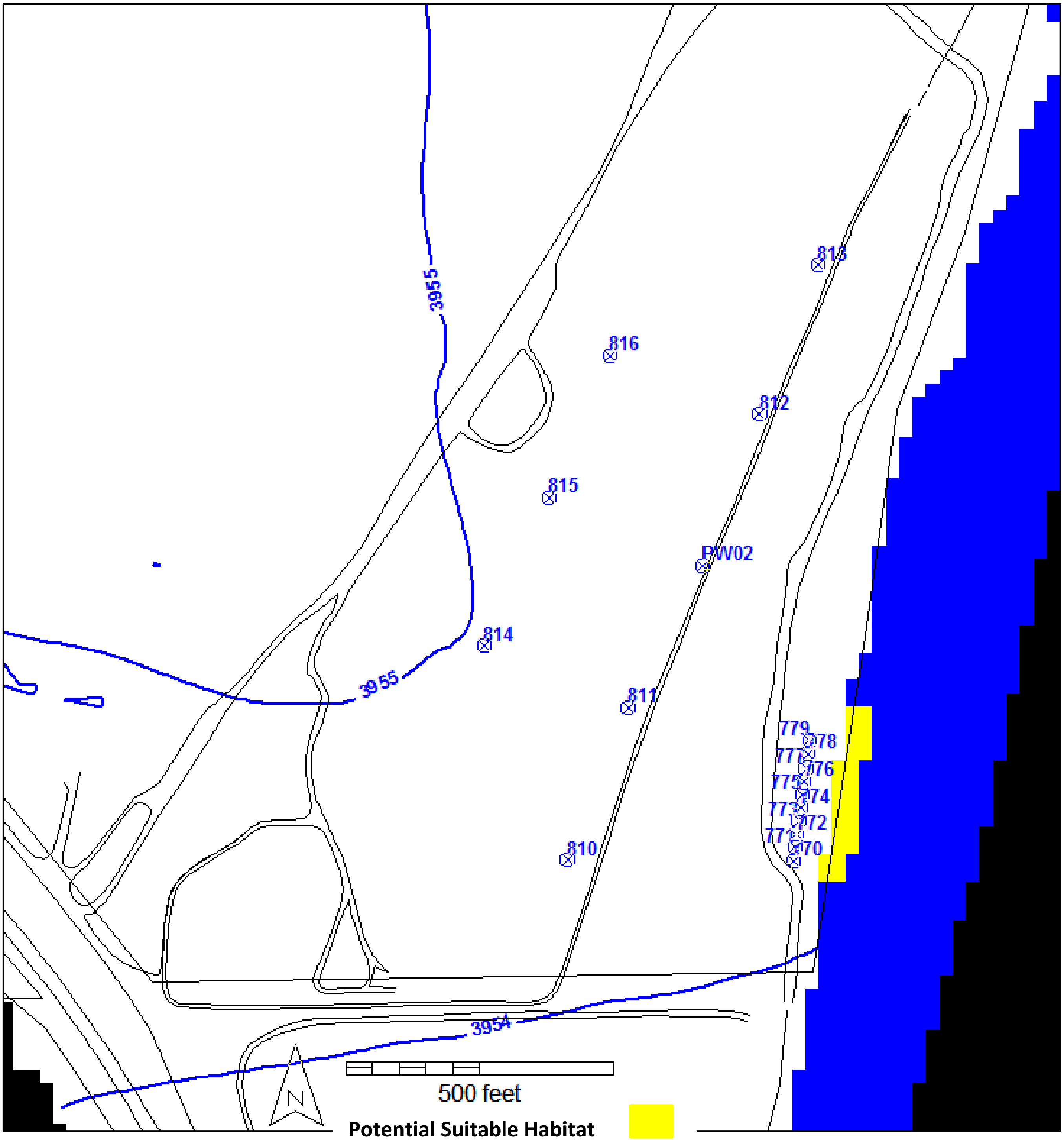


Figure 54. April Model-predicted Water Table, Maximum Evapotranspiration Conditions

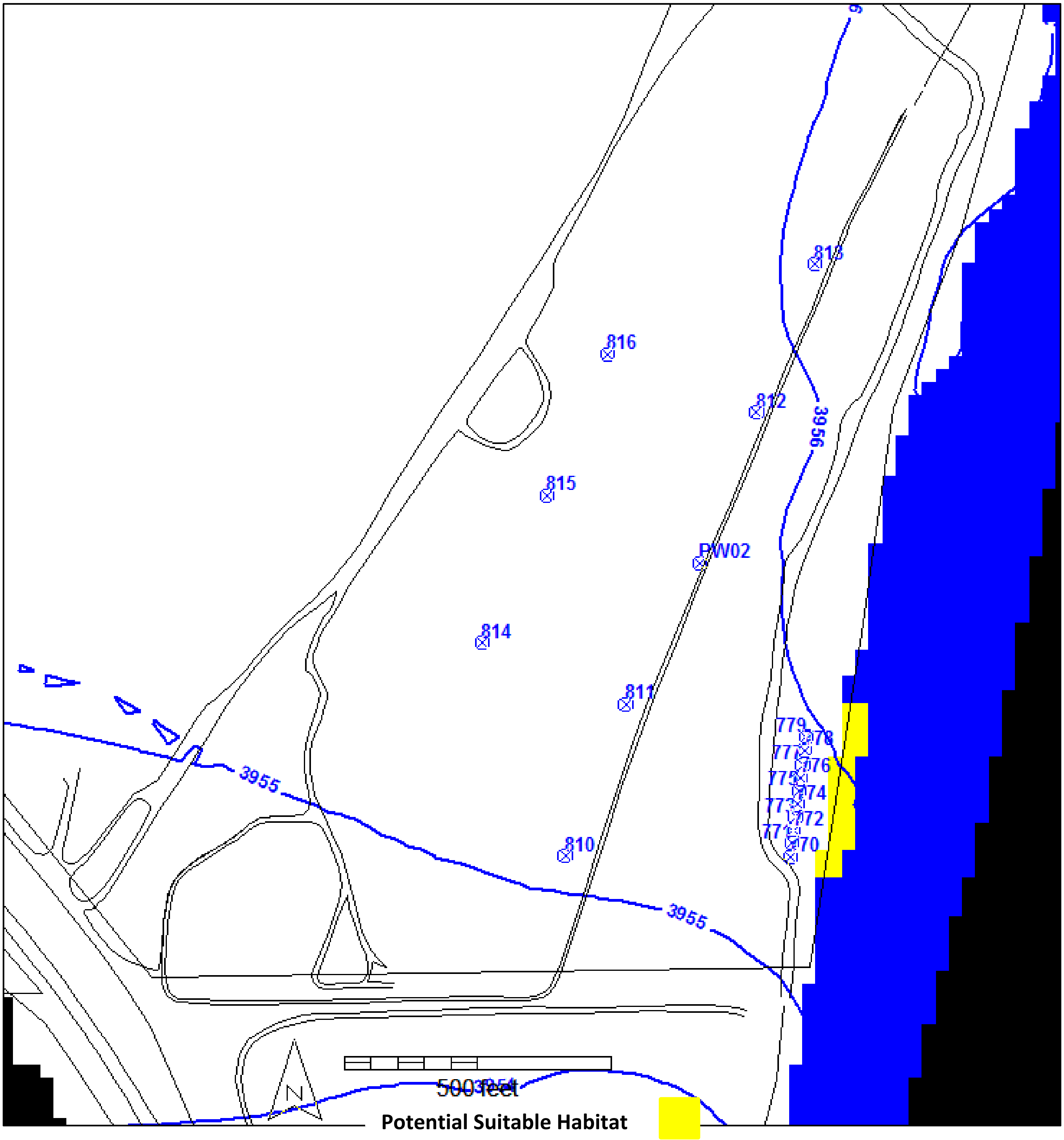


Figure 55. May Model-predicted Water Table, Maximum Evapotranspiration Conditions

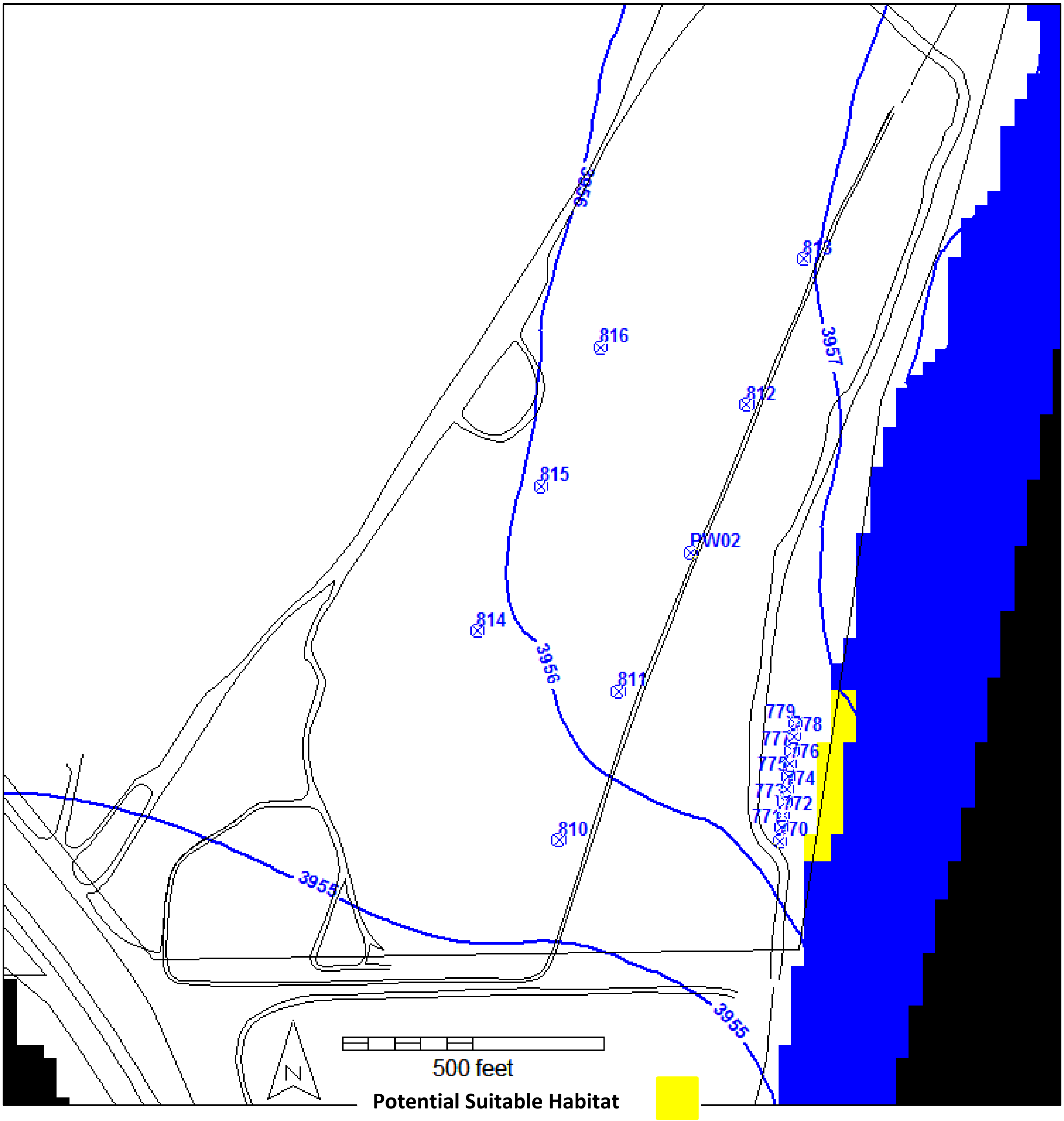


Figure 56. June Model-predicted Water Table, Maximum Evapotranspiration Conditions

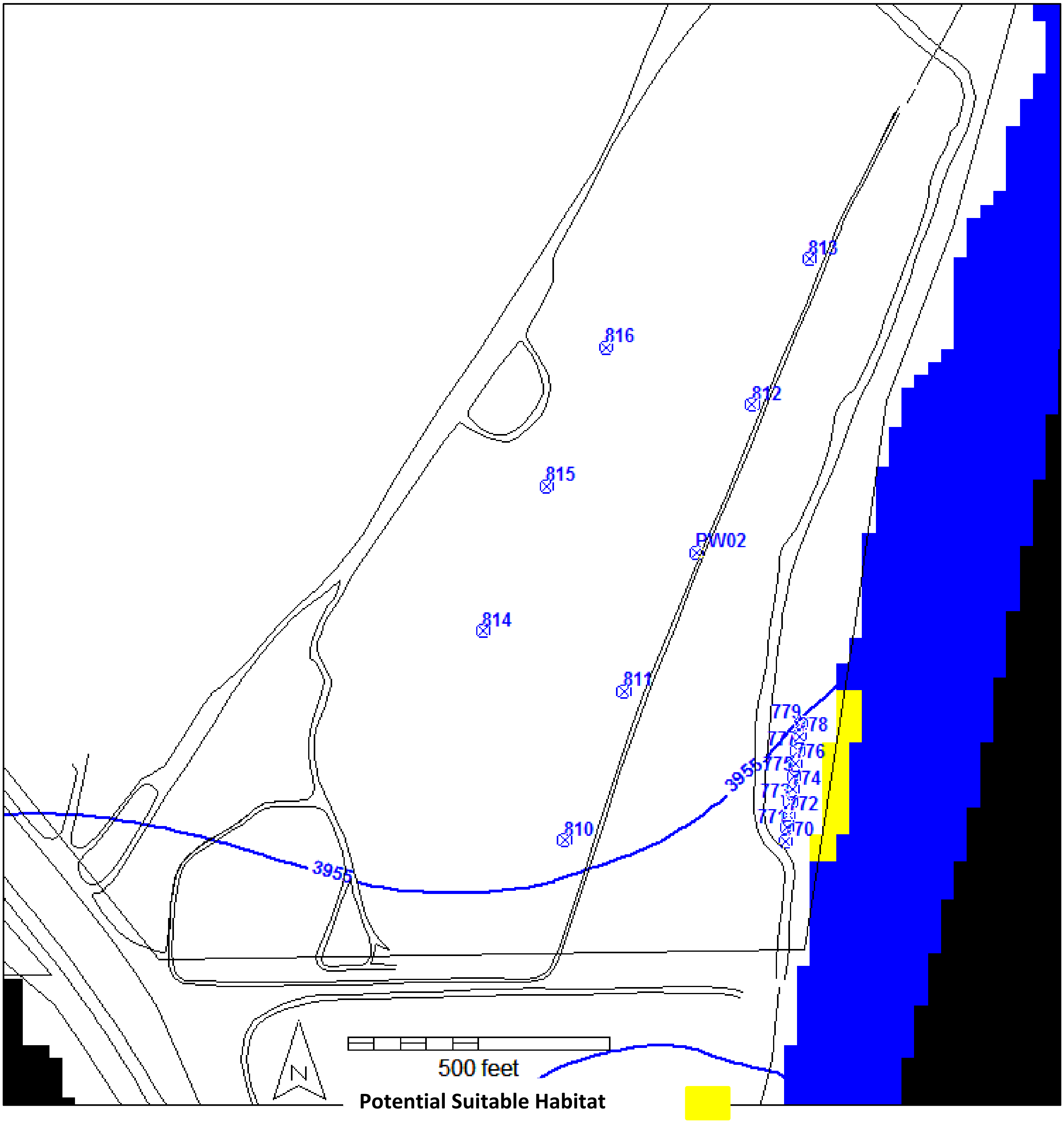


Figure 57. July Model-predicted Water Table, Maximum Evapotranspiration Conditions

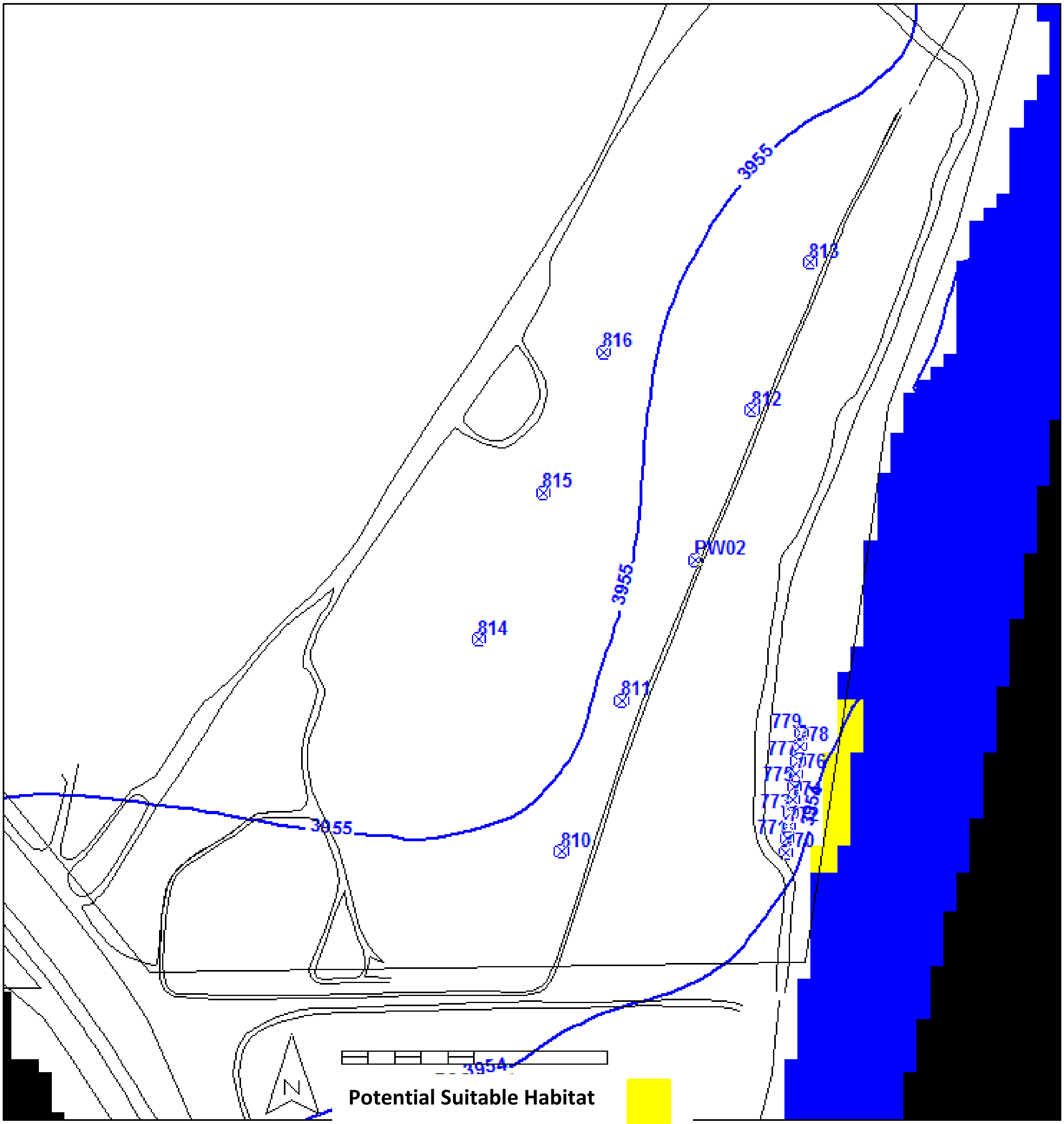


Figure 58. August Model-predicted Water Table, Maximum Evapotranspiration Conditions

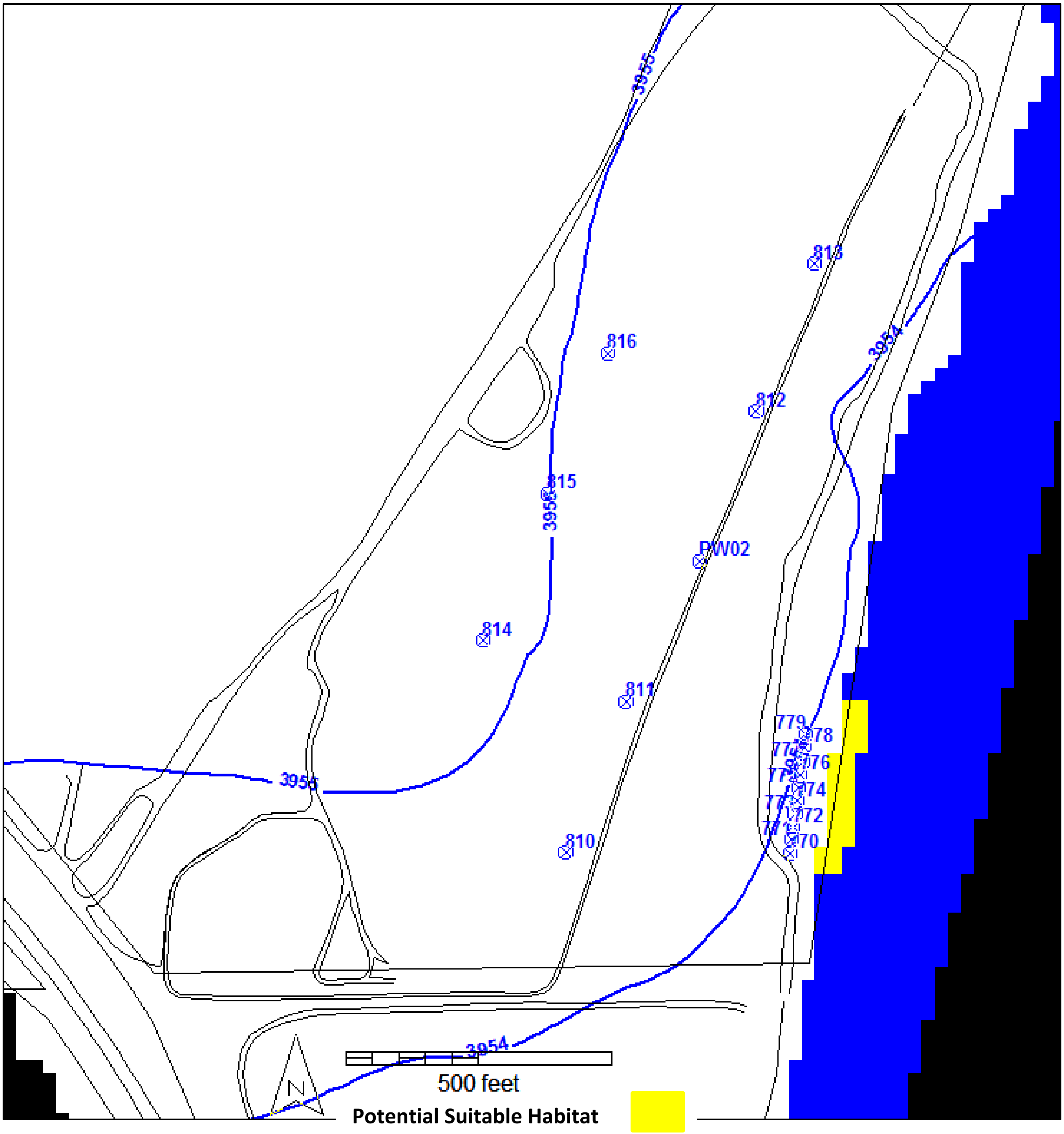


Figure 59. September Model-predicted Water Table, Maximum Evapotranspiration Conditions

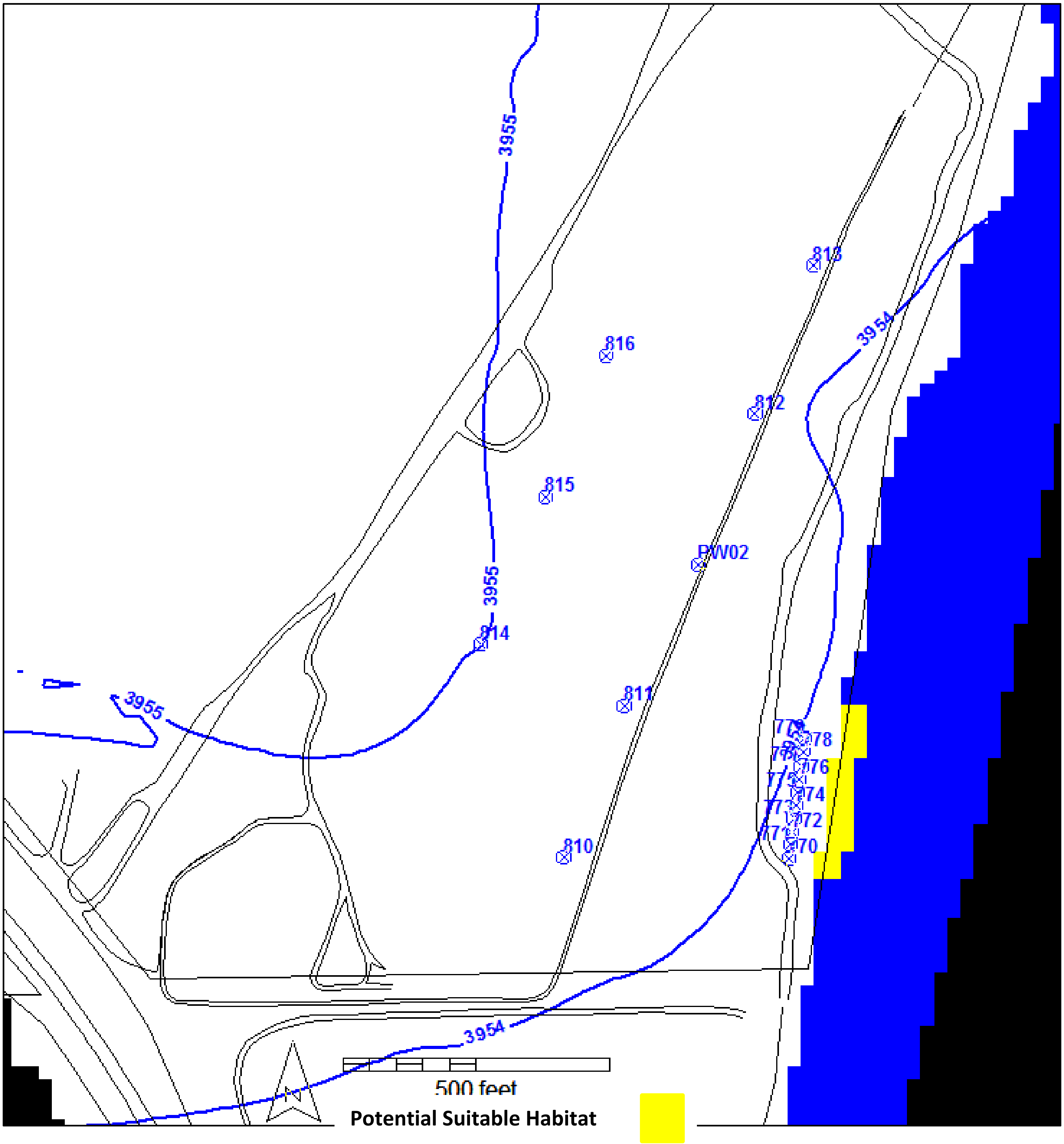


Figure 60. October Model-predicted Water Table, Maximum Evapotranspiration Conditions

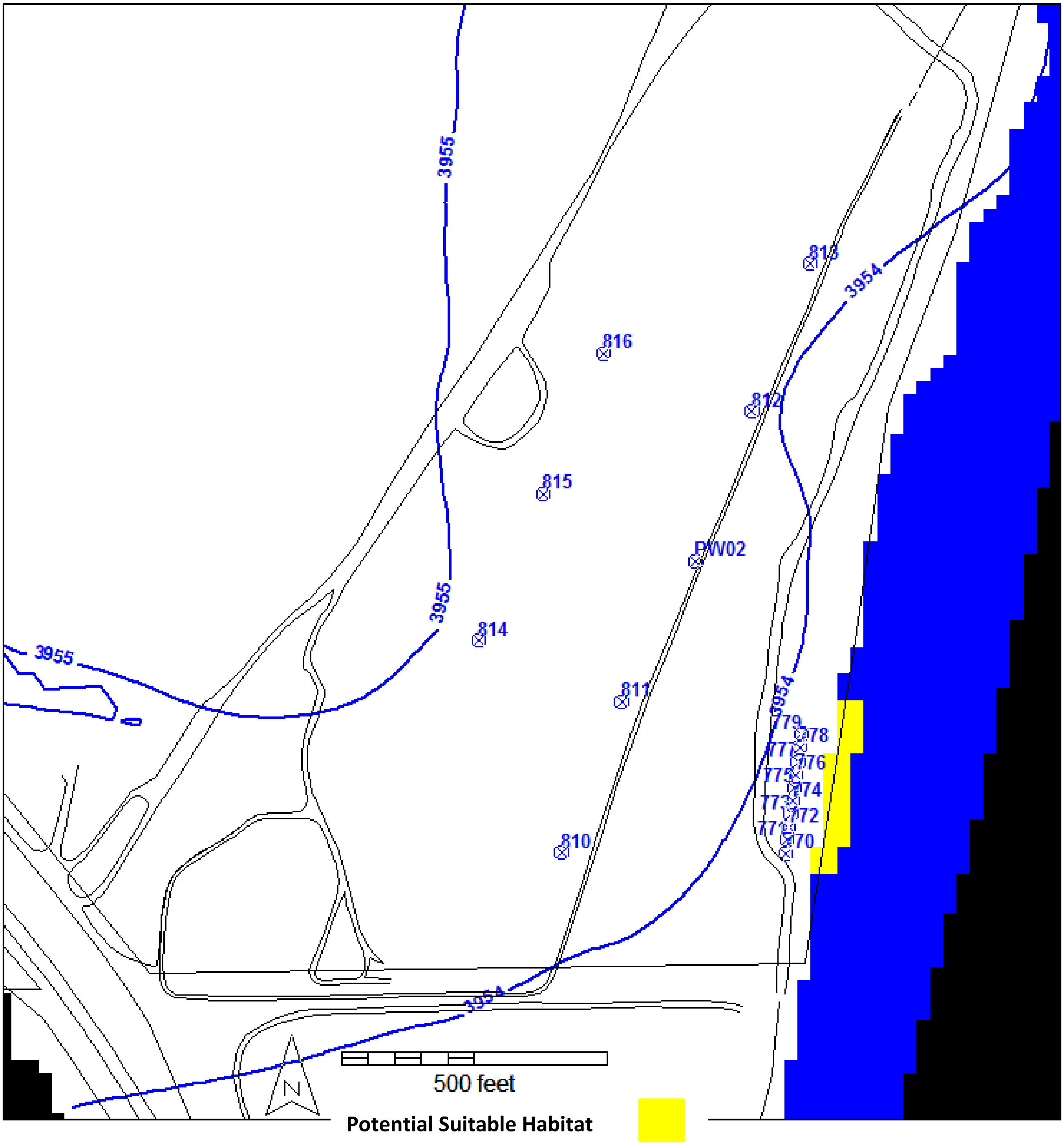


Figure 61. November Model-predicted Water Table, Maximum Evapotranspiration Conditions

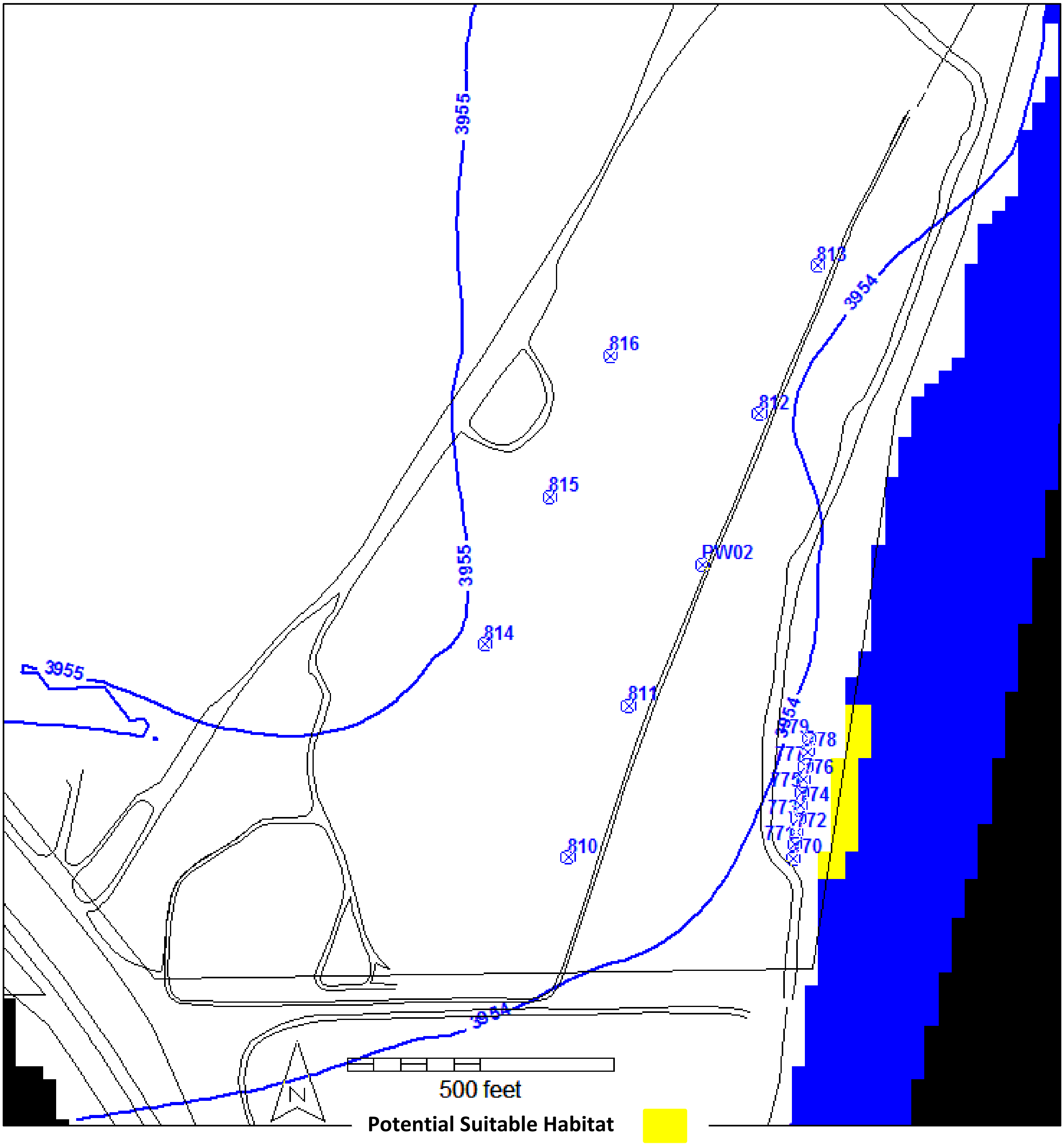


Figure 62. December Model-predicted Water Table, Maximum Evapotranspiration Conditions

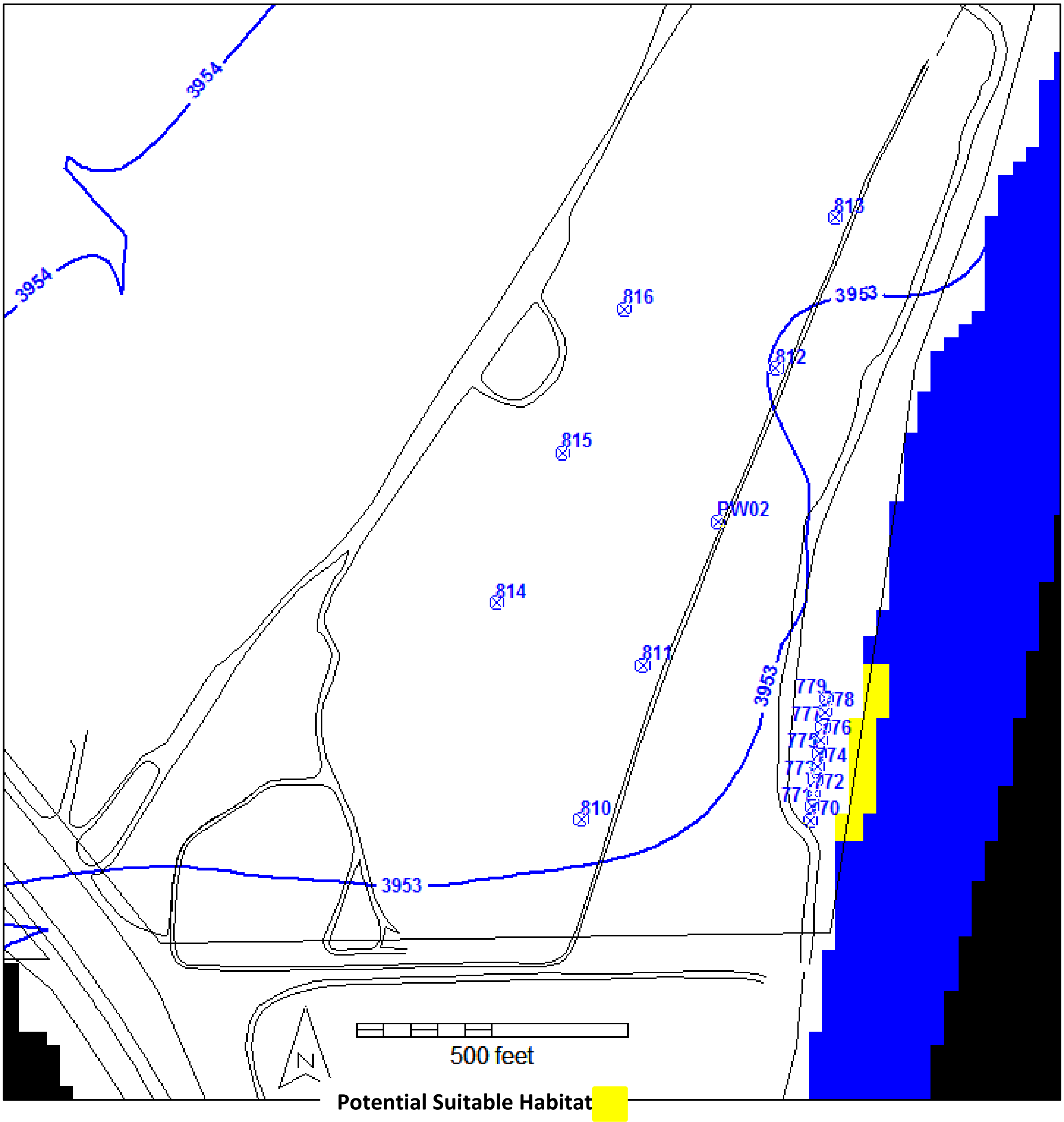


Figure 63. January Model-predicted Water Table, Extractions Wells Operating

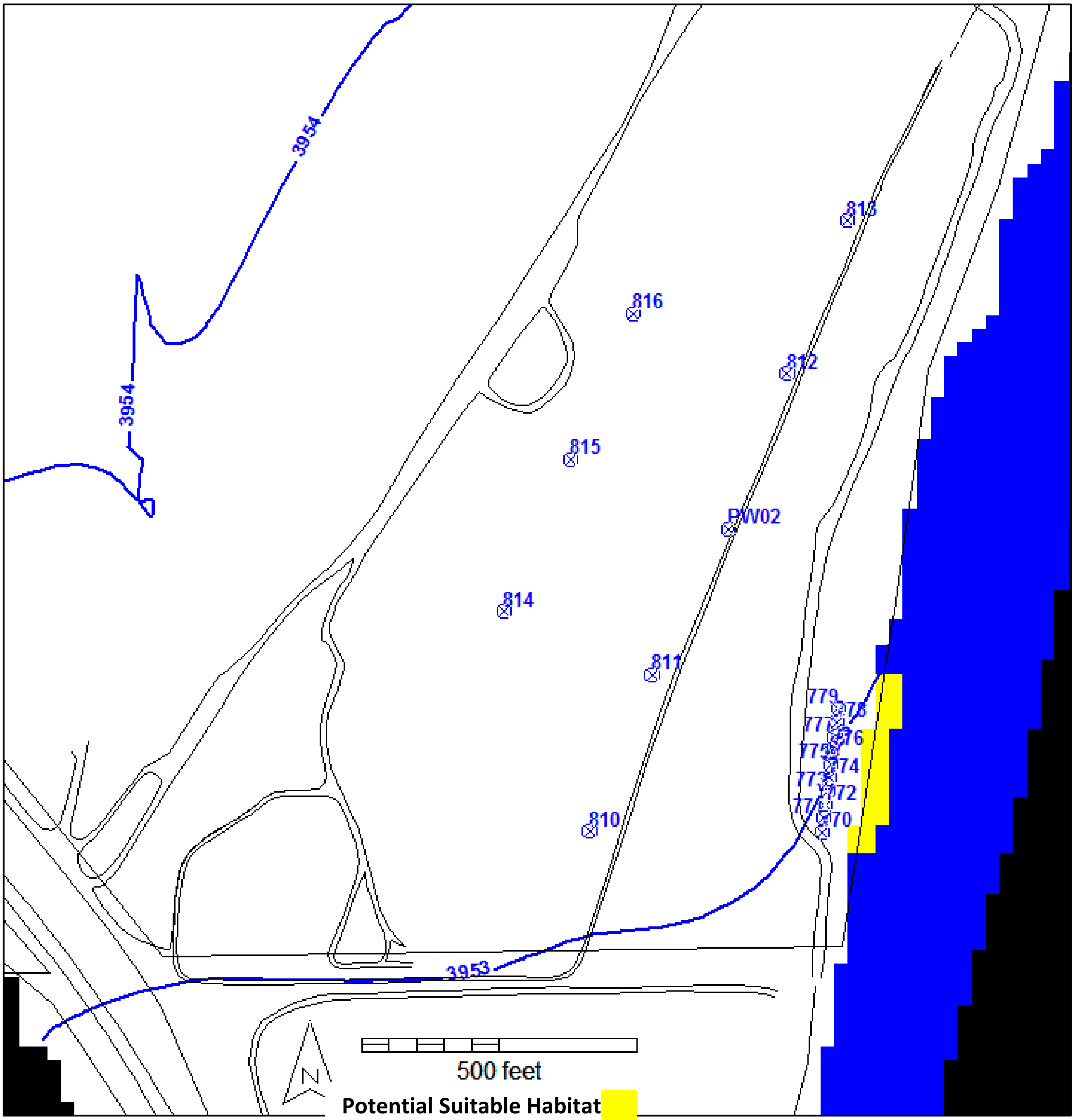


Figure 64. February Model-predicted Water Table, Extractions Wells Operating

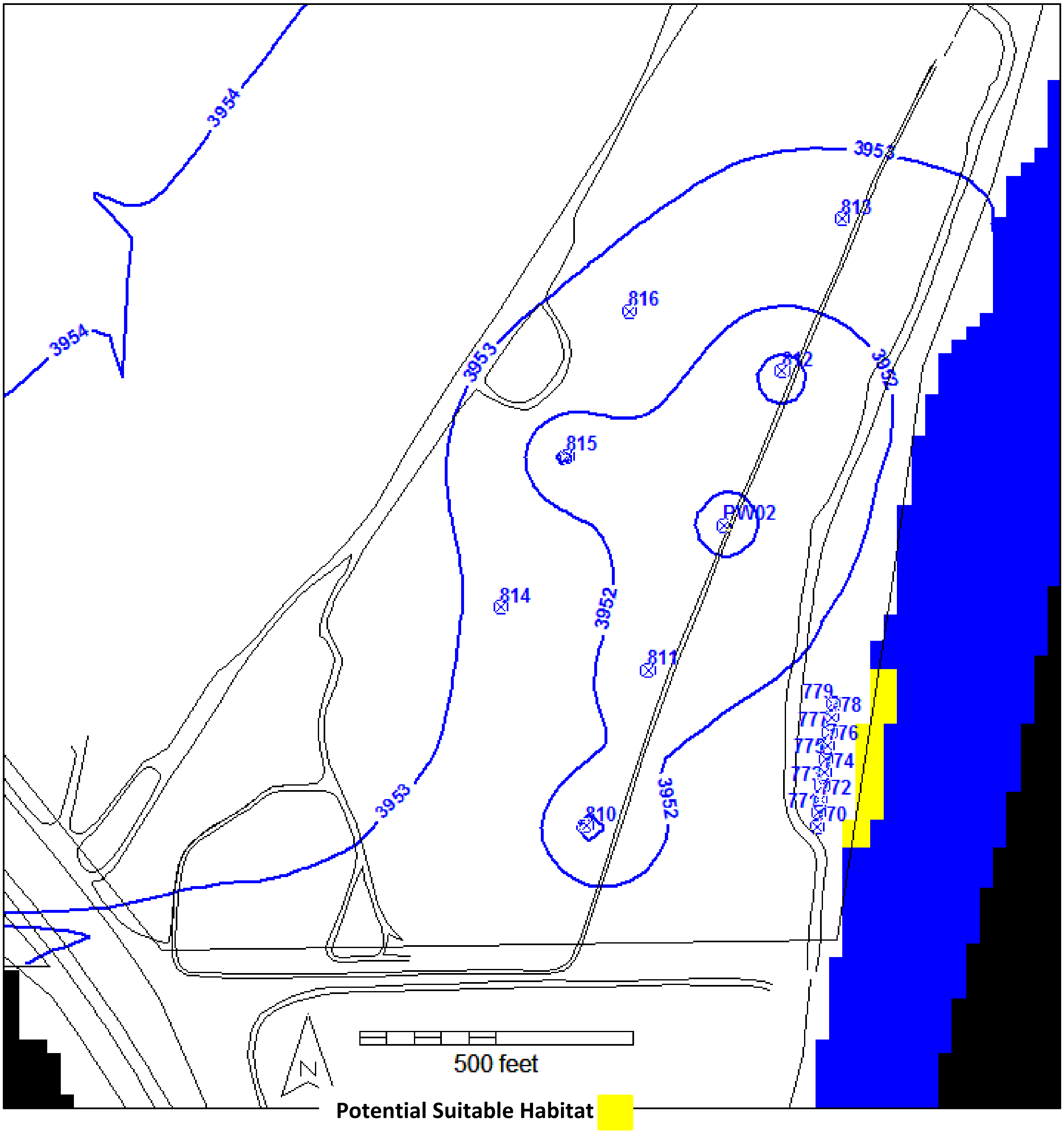


Figure 65. March Model-predicted Water Table, Extractions Wells Operating

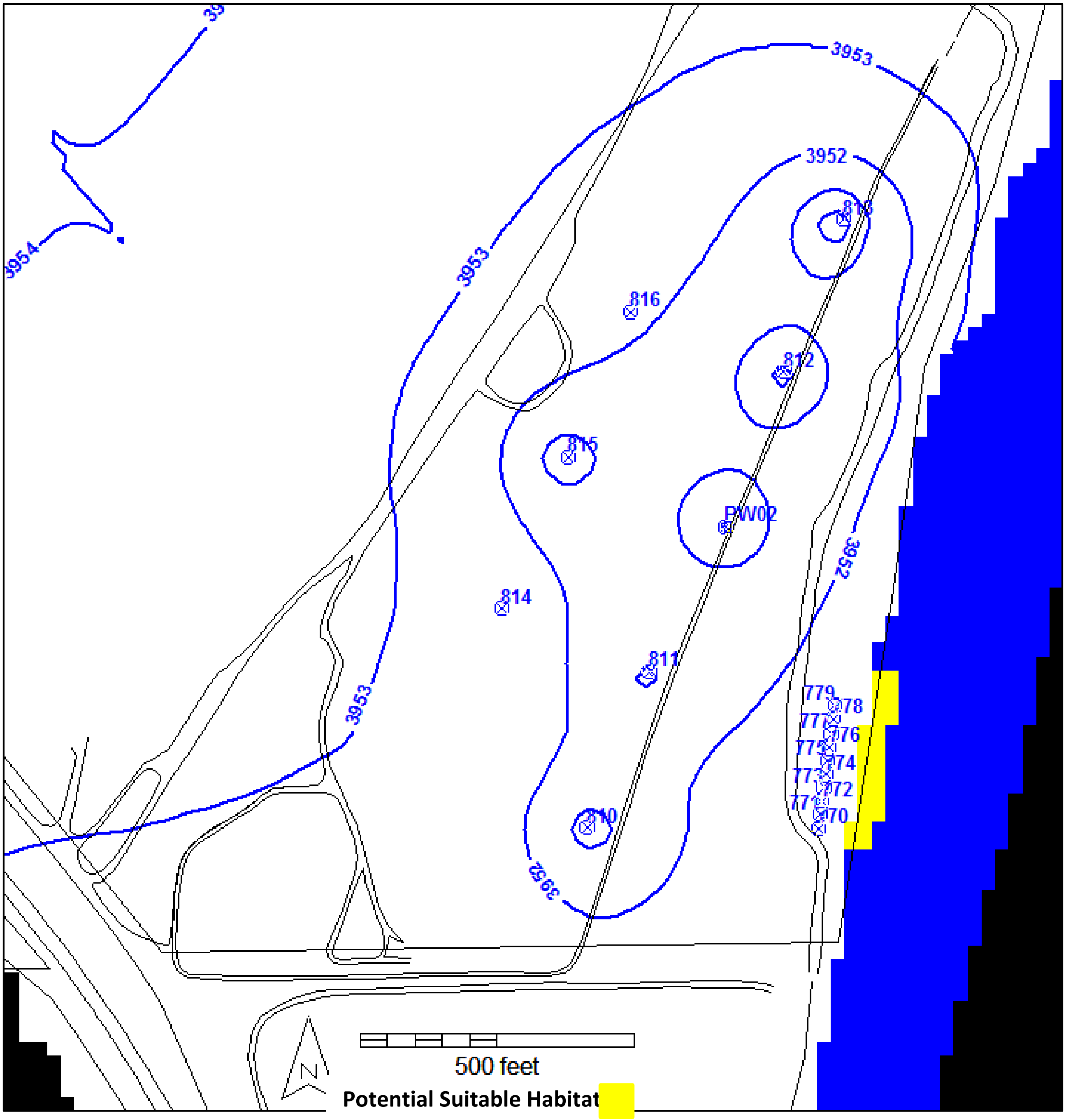


Figure 66. April Model-predicted Water Table, Extractions Wells Operating

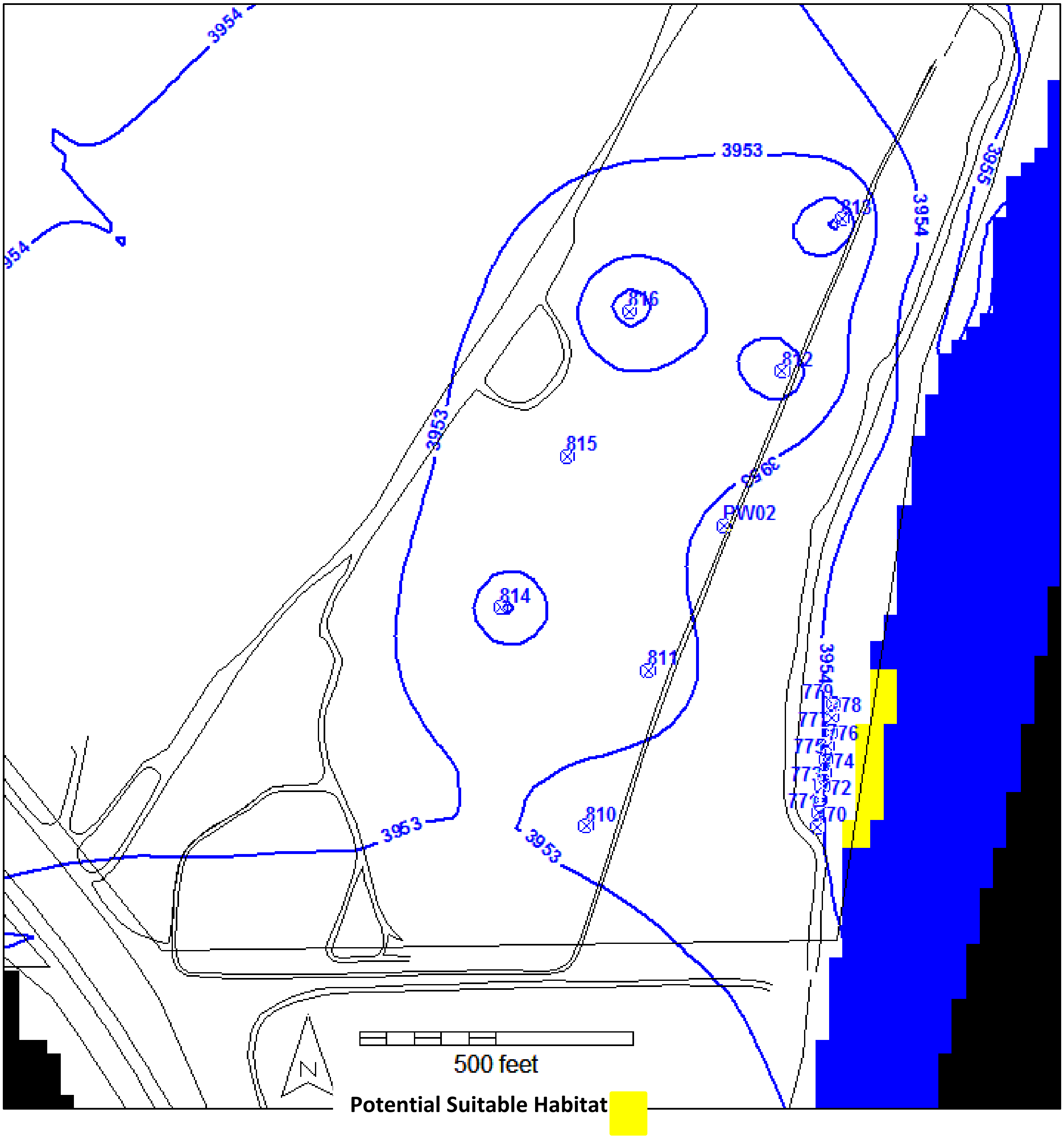


Figure 67. May Model-predicted Water Table, Extractions Wells Operating

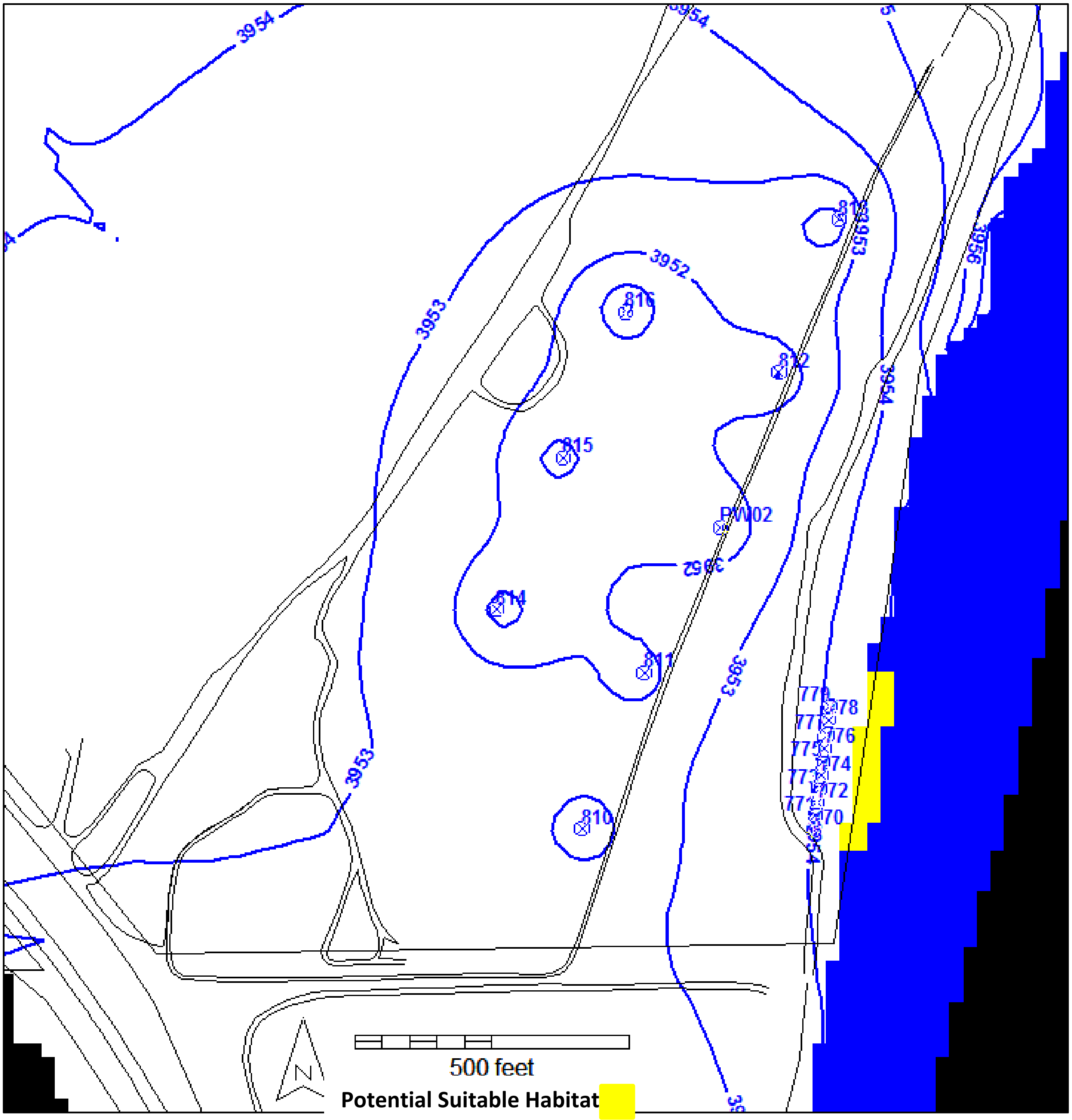


Figure 68. June Model-predicted Water Table, Extractions Wells Operating

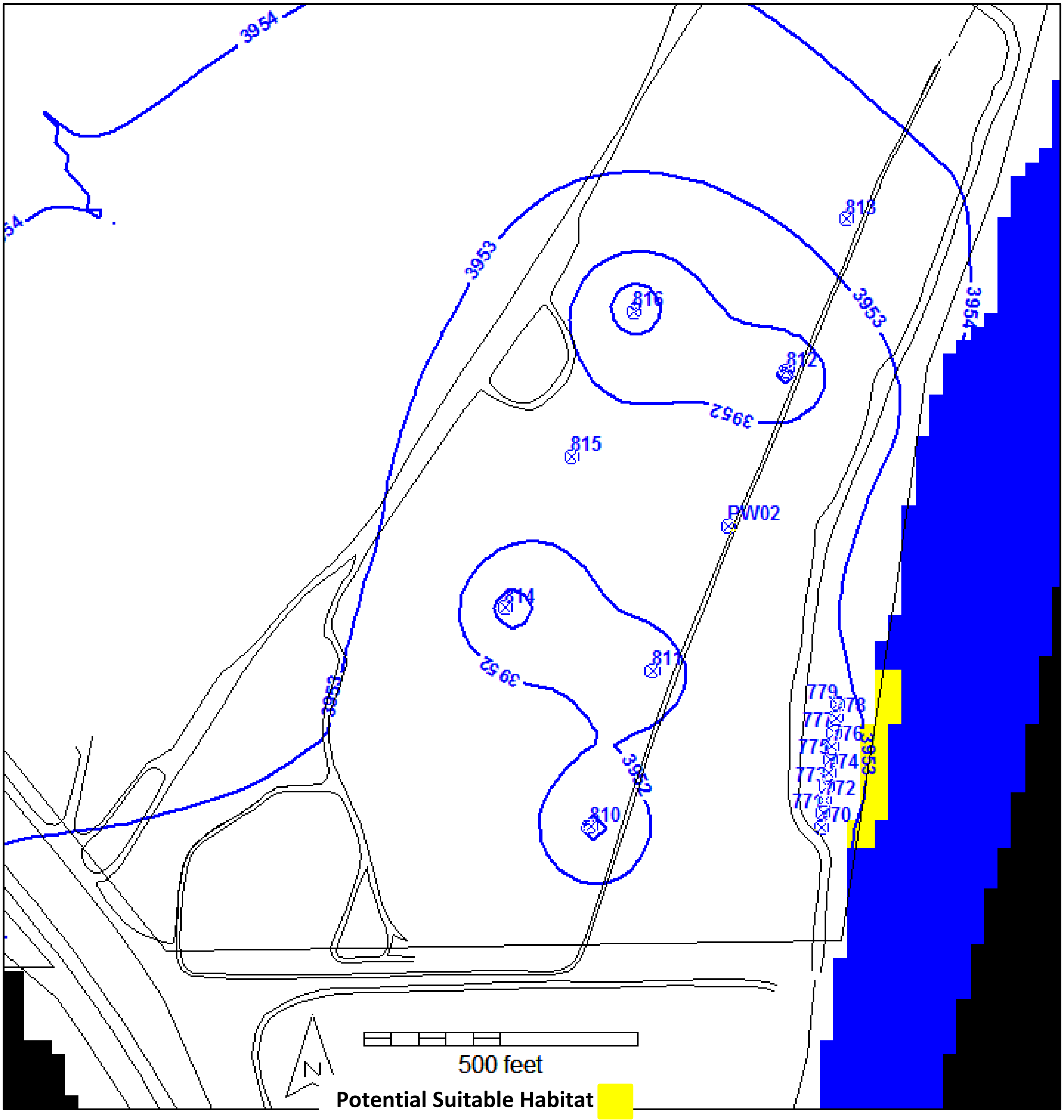


Figure 69. July Model-predicted Water Table, Extractions Wells Operating

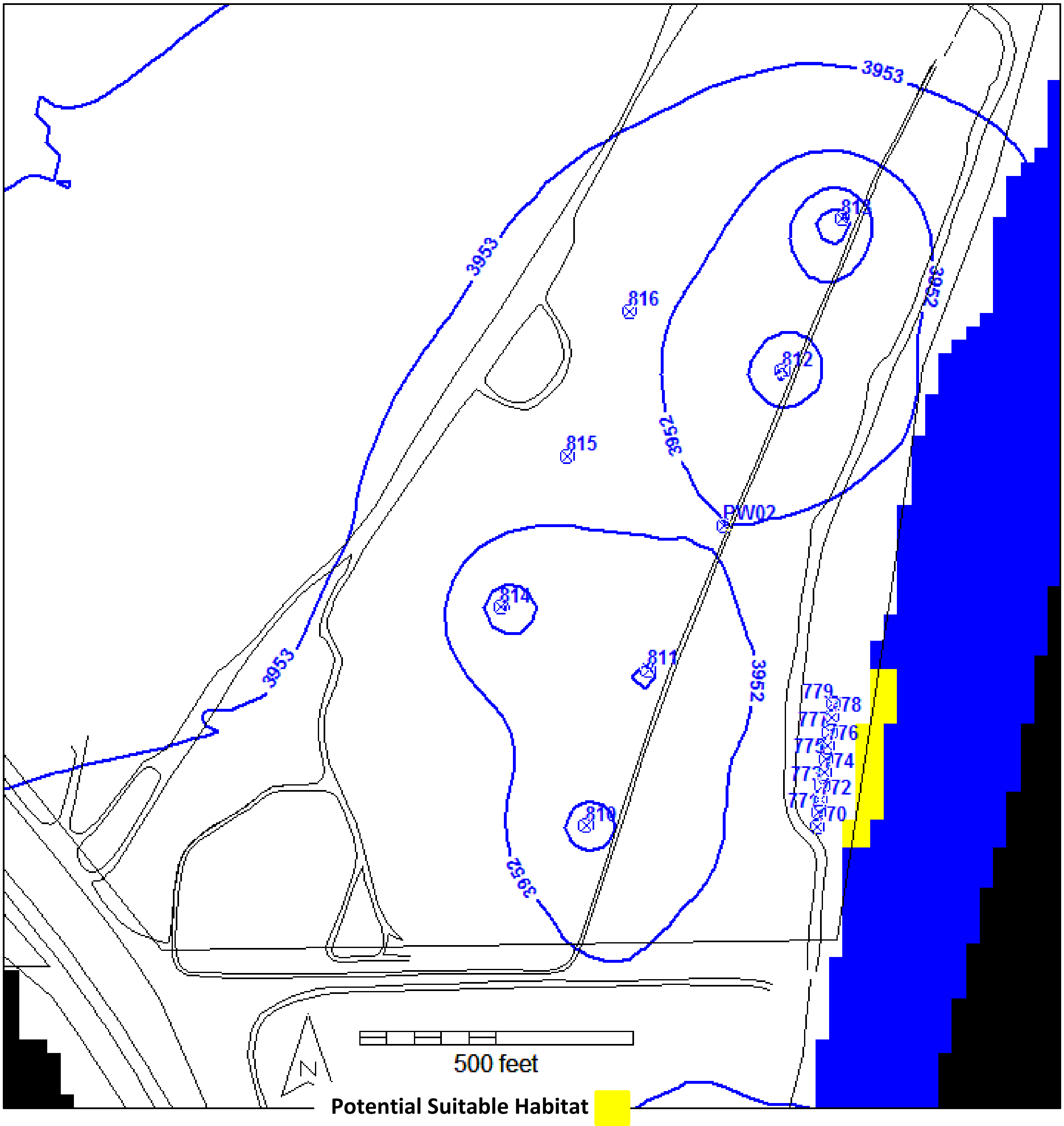


Figure 70. August Model-predicted Water Table, Extractions Wells Operating

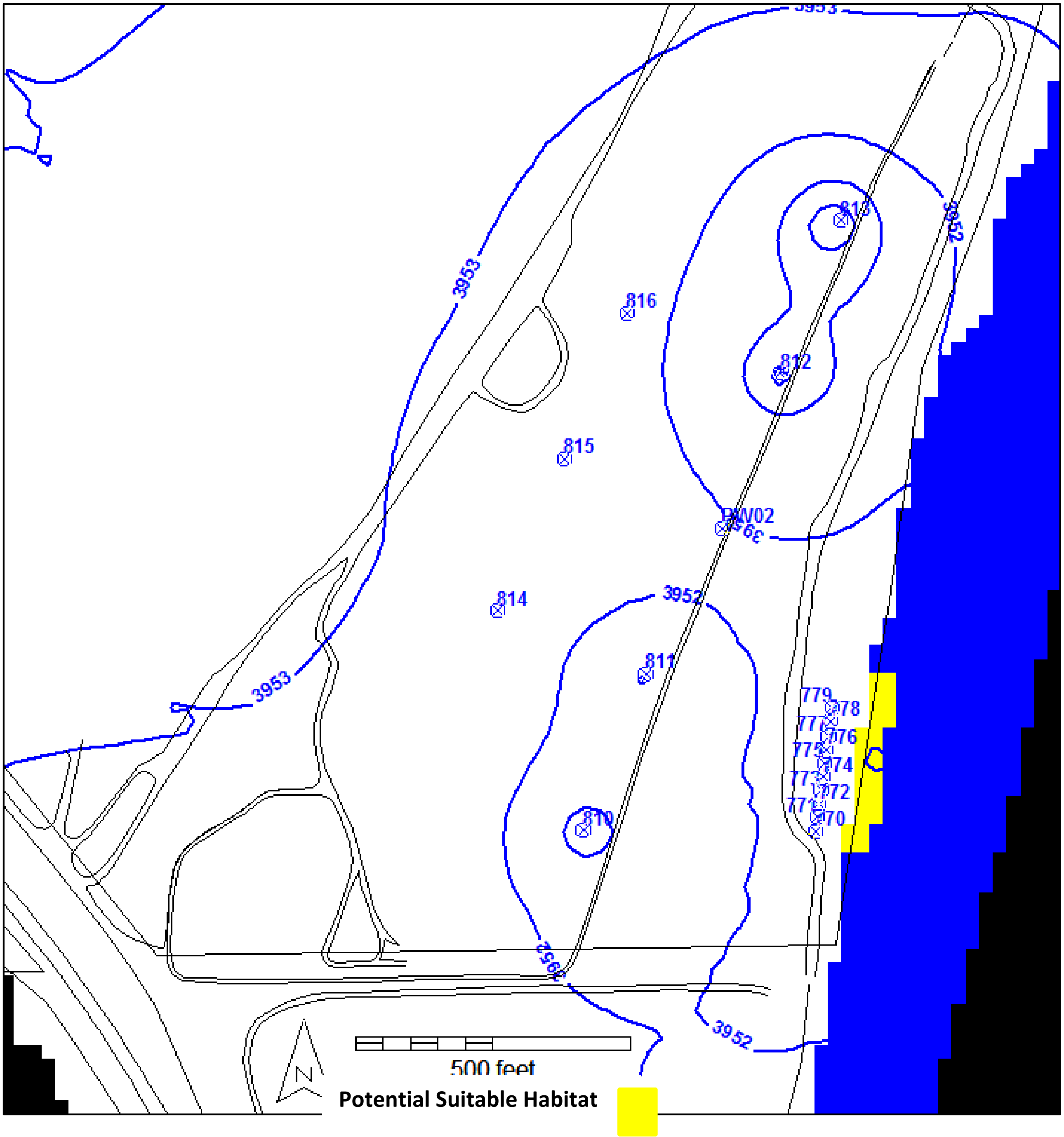


Figure 71. September Model-predicted Water Table, Extractions Wells Operating

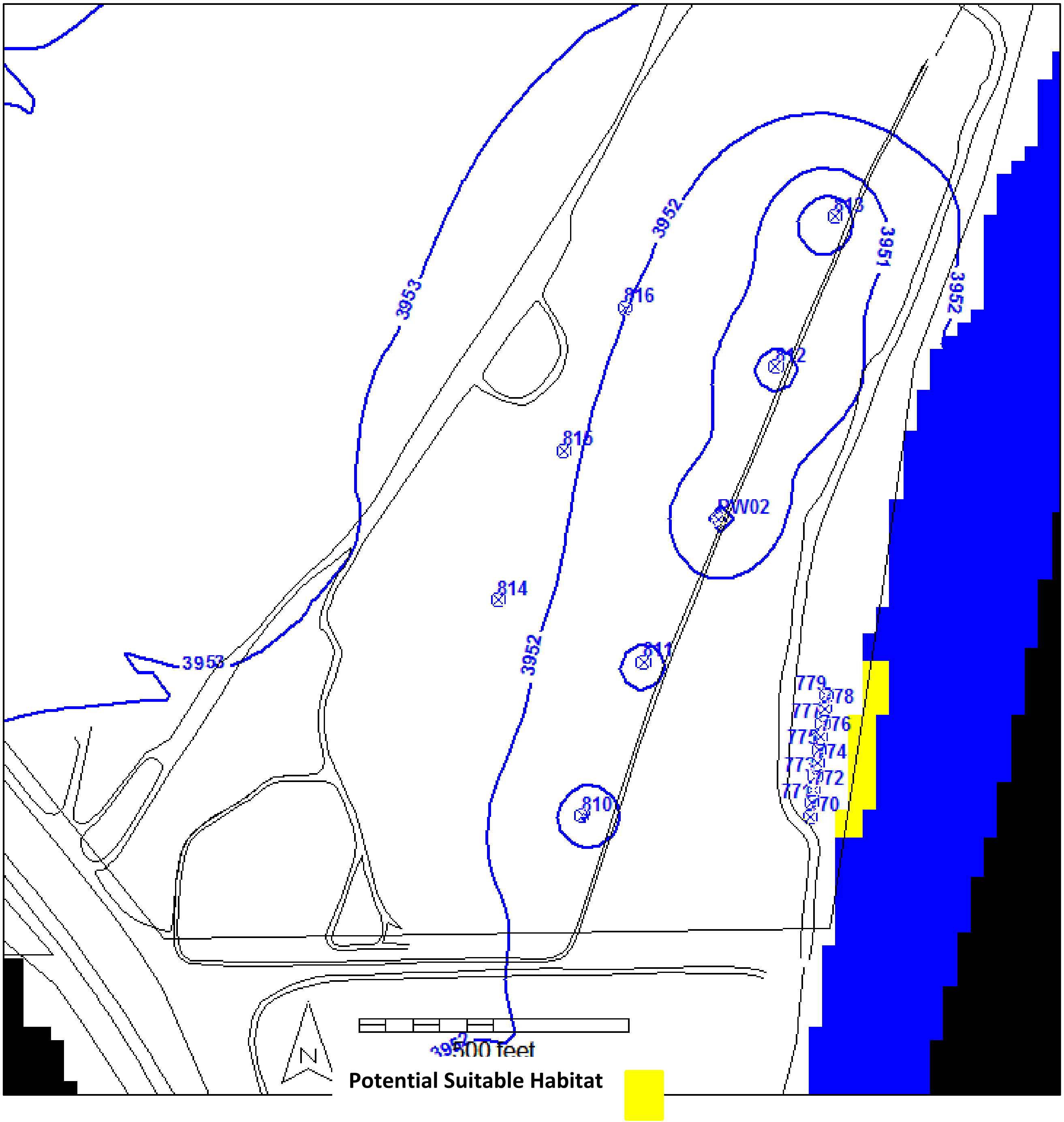


Figure 72. October Model-predicted Water Table, Extractions Wells Operating

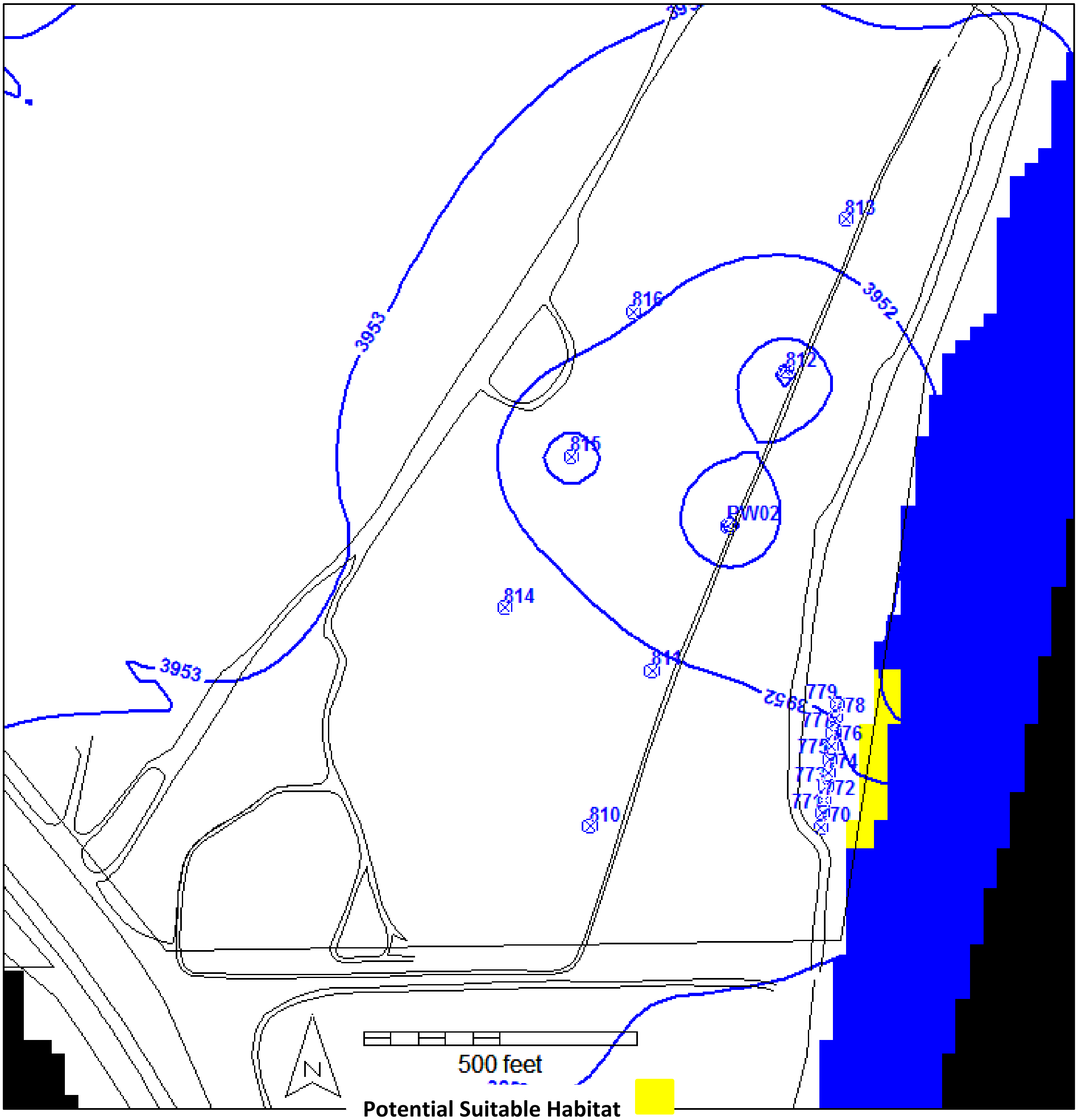


Figure 73. November Model-predicted Water Table, Extractions Wells Operating

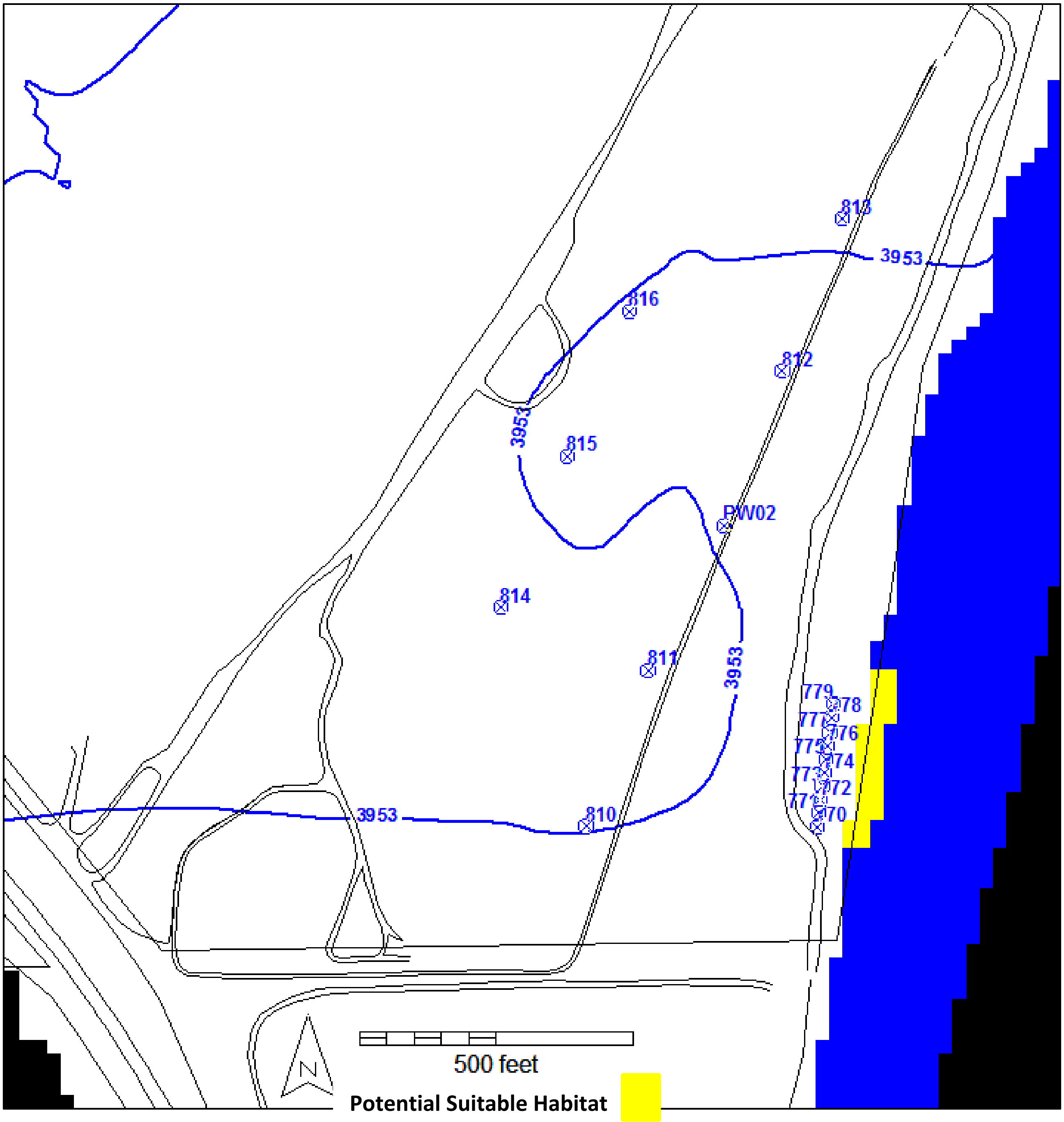


Figure 74. December Model-predicted Water Table, Extractions Wells Operating