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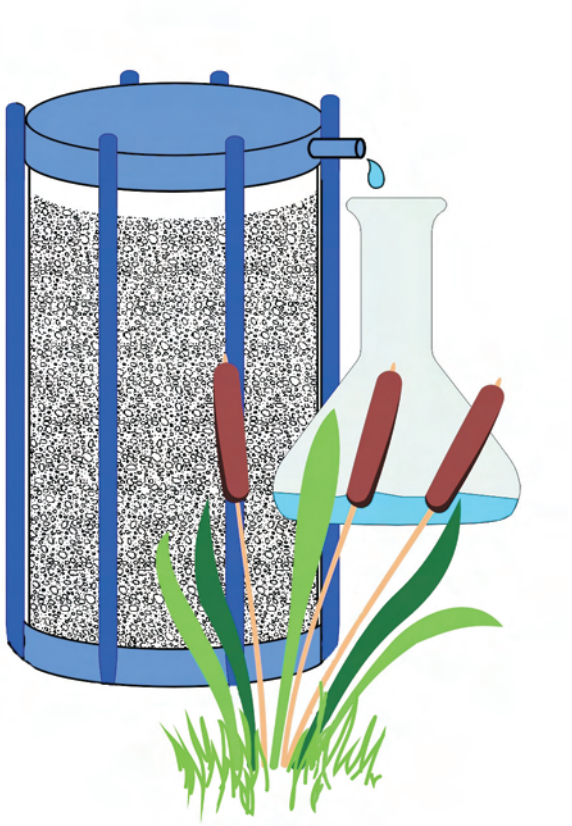
Environmental Sciences Laboratory

Ground-Water Table and Chemical Changes in an Alluvial Aquifer During Sustained Pumping at the Monticello, Utah, Zero-Valent Iron Treatment Cells

January 2008



Prepared for
U.S. Department of Energy
Grand Junction, Colorado

Work Performed by the S.M. Stoller Corporation under DOE Contract No. DE–AC01–02GJ79491 for the U.S. Department of Energy Office of Legacy Management.
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Abstract

This study investigated changes in the ground-water elevation and chemistry during pumping at rates exceeding the flux of the aquifer from a ground-water mound upgradient of the Monticello, Utah, permeable reactive barrier. The data suggest that an average pumping rate of more than 10 gallons per minute (gpm) is needed to significantly reduce aquifer mounding. Currently, only about 6 gpm can be treated at an ex situ treatment system due to limitations of the infiltration gallery to dispose of the clean water. The uranium concentration in the treated water has consistently been less than 10 micrograms per liter (µg/L) even during pumping up to 13 gpm, indicating that the treatment system is capable of treating additional ground water. The ground-water table did not change significantly during the project. The saturated ground-water thickness is significantly less on the south side of the alluvial valley than on the central and north portions. Ground water was sampled five times over a 5-month period. Uranium concentrations in the extraction well EW-1, located in the center of the ground-water mound, varied from about 300 to 400 µg/L. There was no correlation between uranium concentration and pumping rates. The highest uranium concentrations (up to 1,385 µg/L) occurred in a well on the south side of the valley. Major ion compositions were useful in depicting signatures for the ground water. There appears to be at least two areas (north/central, and south) of the valley with distinctly different ground-water signatures.

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1.0 Introduction

This project was undertaken to investigate changes in the ground-water elevation and chemistry during pumping at rates exceeding the flux of the alluvial aquifer at the U.S. Department of Energy (DOE) Office of Legacy Management Monticello, Utah, Site. The purpose of the study was to determine if concentrations of uranium in ground water were affected by high pumping rates. It was thought that uranium concentration could be affected by changing the ground-water flow paths reaching the extraction well. In addition, lowering the ground-water table may result in lower uranium concentrations because of less contact with shallow sediments that may contain more uranium. The project was funded by the U.S. Environmental Protection Agency (EPA) Region 8 through an Interagency Agreement between EPA and DOE. DOE subcontracted to S.M. Stoller through Task Order ST08-08, and this report satisfies a portion of the deliverable for this task order.

A ground-water mound was created as hydraulic conductivity was reduced due to mineralization of a permeable reactive barrier (PRB). This mound was expected to decrease with pumping rates exceeding about 10 gallons per minute (gpm). A treatment system was installed in 2005 to treat the contaminated ground water pumped from the mound. Recently, the capacity of the system was doubled by adding a second treatment cell so that it could treat ground water at a sufficient rate (exceeding 10 gpm) to draw the mounding down. Because of the absence of a suitable means to dispose of the treated water, the required sustained pumping rates were not met, and the sampling was suspended after 5 of the proposed 12 sampling episodes. However, despite the inability to complete the sampling, the data provide detailed information on chemistry and water levels in the mound and upgradient ground-water chemistry. This report describes results of the study, which was conducted from April through November 2007, and includes a description of the ground-water table variation, ground-water chemistry, and treatment system efficiency.

1.1 Site Background

The Monticello mill processed uranium (U) and vanadium (V) ores from the mid-1940s until 1960 (Morrison et al. 2002). Approximately 1 million tons of U ore was processed, and the resultant tailings were impounded at four locations on the 78-acre site. Much of the waste material was slurried to impoundments, and the wastes were in direct contact with the shallow aquifer in some areas, resulting in significant contamination of the ground water.

From July 1997 to September 1999, 3.3 million cubic yards (yd^3) of tailings and contaminated soil was relocated from the site to an engineered repository constructed 0.5 mile south of the mill site. During tailings removal, large areas of the site and the alluvial aquifer were excavated to bedrock to ensure that the site was cleaned up to the mandated regulatory levels. Much of the alluvial aquifer was rebuilt using clean borrow material by December 2000.

The Monticello Mill Tailings Site is located within the valley of Montezuma Creek. Perennial flow in the creek is about 1 cubic foot per second and is regulated at the Monticello Reservoir 1.5 miles west of the mill site. The watershed of the creek includes a portion of the Abajo Mountains that rise to 11,000 feet about 2 miles farther west. Remedial action significantly modified the alignment and elevation of the creek from its original position on the mill site and in the area of the PRB. The present alignment of Montezuma Creek is closer to the original alignment (pre-millsite) than was the alignment during mill operation.

The unconfined aquifer (alluvial aquifer) consists of permeable sand and gravel within the valley of Montezuma Creek. Abundant cobbles and up to 15 percent silt and clay also are present in the alluvium. The paleochannel is about 450 feet wide near the PRB and controls most or all of the ground-water flow from the Monticello mill site. Regional ground water flows east and southeast down the valley from the mill site. The alluvial aquifer pinches out against hillslope colluvium and bedrock flanking the valley. Thin, intermittent lenses of ground water occur in colluvial deposits north of the alluvial aquifer and the PRB. This ground water, which originates from urban runoff, irrigation of farm land, and other sources not related to the mill site flows into the alluvial aquifer.

Low-permeability bedrock containing mudstone and siltstone beds underlies the alluvial aquifer and isolates it from a deeper aquifer. The bedrock erosional surface at the base of the alluvial aquifer near the PRB slopes gently east to southeast and is relatively flat with mild undulations to 3 feet. Saturation in the alluvium ranged from about 3 to 6 feet before remediation of the area; depth to ground water beneath the valley floor ranged from about 6 to 9 feet. Large-scale aquifer dewatering operations and creek diversions between spring 1999 and fall 2000 affected ground-water flow throughout the PRB area. Reconstruction of the alluvial aquifer and creek have been completed and all water diversion has ceased.

1.2 Permeable Reactive Barrier

A PRB was constructed at the Monticello site in 1999 as part of an interim remedial action Record of Decision pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act. The PRB project was funded by DOE's EM-50 program and was intended to help determine if PRB technology was viable. The technology was relatively new, and only a few other PRB demonstration projects were operational at the time. The zero-valent iron (ZVI) component of the PRB was intended to remove U from ground water and to enhance the natural flushing of the downgradient alluvial aquifer. The PRB has a 2-foot-wide (in the direction of ground-water flow) upgradient zone containing a mixture of pea gravel and ZVI (13 volume percent ZVI) and a 4-foot-wide zone of 100 percent ZVI (DOE 2005). Shortly after its installation, ground-water samples collected downgradient of the PRB had significantly lower U concentrations than those collected upgradient, indicating that the PRB was positively affecting ground-water remediation. A more detailed description of the PRB is available in Morrison et al. (2002).

The corrosion of ZVI led to precipitation of calcium carbonate, iron oxide, and other minerals that occluded pore space and restricted flow through the PRB. Hydraulic conductivity of the PRB was calculated from pneumatic slug test data collected from about 40 ground-water wells four times during PRB operation: June 2000, August 2003, November 2004, and November 2005 (DOE 2006). The mean values of hydraulic conductivity in the ZVI zone decreased from $10^{-1.70}$ to $10^{-4.34}$ centimeters per second during this period. This significant decrease in hydraulic conductivity in the ZVI zone caused ground water to mound upgradient of the PRB.

1.3 Ground-Water Compliance Strategy

The current strategy for ground water compliance at the Monticello site is monitored natural attenuation. Calculations from a ground-water model suggest that the aquifer will clean up by about the year 2042. The PRB and treatment systems should decrease the cleanup time.

In the region between the PRB and the mill site, U concentration trends over the past 5 years at three of five monitoring wells indicate that the aquifer should clean up by the year 2021 in this region. This progress is acceptable within the overall 42-year restoration period allotted in the monitored natural attenuation remedy. However, rising concentration trends and relatively high concentrations at some wells in the region may invalidate this prediction. A localized "hot-spot" of contaminated water present at the south end of the south slurry wall may account for these upward trends.

Contamination is likely sorbed to aquifer sediment. It is hypothesized that contamination will be released from the higher-elevation portion of the aquifer as the ground-water table rises. This partially saturated portion of the aquifer may contain an inventory of residual U that has not been thoroughly flushed by flowing ground water. The induced rise and fall of the water table on ground-water contamination has not been considered in current predictions of the ground-water cleanup time. One objective of the current study was to test this hypothesis by monitoring dissolved U concentrations as the water table changes levels due to prescribed pumping regimes. Prior to construction of the second ex-situ treatment system, pumping was limited to 5 gpm, which was inadequate to draw the ground-water level down significantly. There was a short period of time during the current study when the pump-and-treat system operated at up to 13 gpm; however, because of problems discharging the treated water at an infiltration trench, the system is currently operated at no more than 6 gpm.

2.0 Methods

The field program involved 5 rounds of samplings from 7 wells and 24 samplings of the treatment system. Samples were collected from the treatment cells via pipe valves and/or dipping a plastic Nalgene bottle at the treatment cell outflow. Well samples were collected using a peristaltic pump or, on deep wells, using a bailer. For wells that could be sampled with a peristaltic pump, the ground water was pumped through a flow cell instrumented with electrodes for measuring dissolved oxygen, electrical conductivity, pH, oxidation-reduction potential, and temperature (methods AP[DO-1], AP[EC-1], AP[pH-1], AP[ORP-1]; STO 210). Alkalinity was measured in the field by acid titration (method AP[Alk-1]; STO 210). Samples were preserved in 2 percent HNO_3 for analysis of calcium (Ca), iron (Fe), magnesium (Mg), potassium (K), sodium (Na), and U. Calcium, Fe, Mg, K, and Na were analyzed by flame atomic absorption (methods AP[Ca-1], AP[Fe-1], AP[Mg-1], AP[K-1], AP[Na-1]; STO 210). Uranium was analyzed by laser-induced kinetic phosphorescence (method AP[U-2], STO 210). Samples were kept cool but not preserved for analysis of chloride (Cl), nitrate (NO_3), sulfate (SO_4), by ion chromatography (methods AP[Cl-2], AP[NO_3-4], AP[SO_4-4]; STO 210).

Water levels were measured with a hand-held sensor capable of accuracy to about 0.1 inch. A water level transducer with accuracy to about 0.1 inch was used in well 88-85, and these data were recorded on a datalogger.

3.0 Results and Discussion

Figure 1 shows the locations of the PRB, treatment system, and monitoring wells used for ground-water sampling. Well 88-85 is located approximately 24 feet upgradient from the extraction well (EW-1) and is nearly centered in the ground-water mound. Ground-water elevation in well 88-85 gradually increased after installation of the PRB, then decreased after installation of the treatment cells (Figure 2). The five sampling events (May 8, May 29, July 17, August 14, and September 5, 2007) are plotted on Figure 3 along with the pumping rates and the ground-water elevation in well 88-85. The following discussion examines the effects of pumping on the ground-water table elevation and on the chemistry of the ground water. Concentrations of U in effluent from the treatment cells were consistently less than the 44 micrograms per liter (µg/L) target and generally less than 10 µg/L.

3.1 Ground-Water Mounding

Ground water forms a mound upgradient of the PRB as described in previous reports, including DOE (2001). The ground-water elevation varied from 6,791.6 to 6,793.7 feet during the course of this study. The ground-water elevation was increasing just prior to the installation of the second treatment cell (Figure 3, dashed line). Shortly after treatment cell TC-2 was brought on line with TC-1, at a combined pumping rate of more than 10 gpm, the elevation in well 88-85 decreased about 0.6 foot. Following the first sampling episode, the pumping rate was decreased to 6 gpm, and the ground-water elevation in well 88-85 increased by about a foot. Just prior to the second sampling episode, the pumping rate was increased to about 13 gpm, causing the ground-water elevation in well 88-85 to decrease steadily by nearly 2 feet. Following the third sampling episode, the pumping rate fluctuated around about 8 gpm; the ground-water table fluctuated but showed little overall change. These inverse correlations between pumping rate and ground-water elevation suggest that pumping from EW-1 is affecting the ground-water elevation in the mound. After the final sampling episode on September 5 the pumping rate was held nearly constant at 8 gpm and then at 6 gpm. The ground-water elevation had a spike during the 8 gpm period, probably caused by agricultural watering. During the 6 gpm period, the ground-water elevation decreased, going against the trend; this decrease could be due to seasonal change.

The data suggest that an average pumping rate of more than 10 gpm is needed to significantly reduce the aquifer mound. Currently, only about 6 gpm can be pumped due to limitations of the infiltration gallery to dispose of the clean water. DOE is currently seeking concurrence to discharge the treated water to Montezuma Creek, thereby allowing an increased pumping rate. The U concentration in the treated water has consistently been less than 10 µg/L even during pumping up to 13 gpm. Thus, it appears that the treatment system is capable of successfully treating water at higher pumping rates.

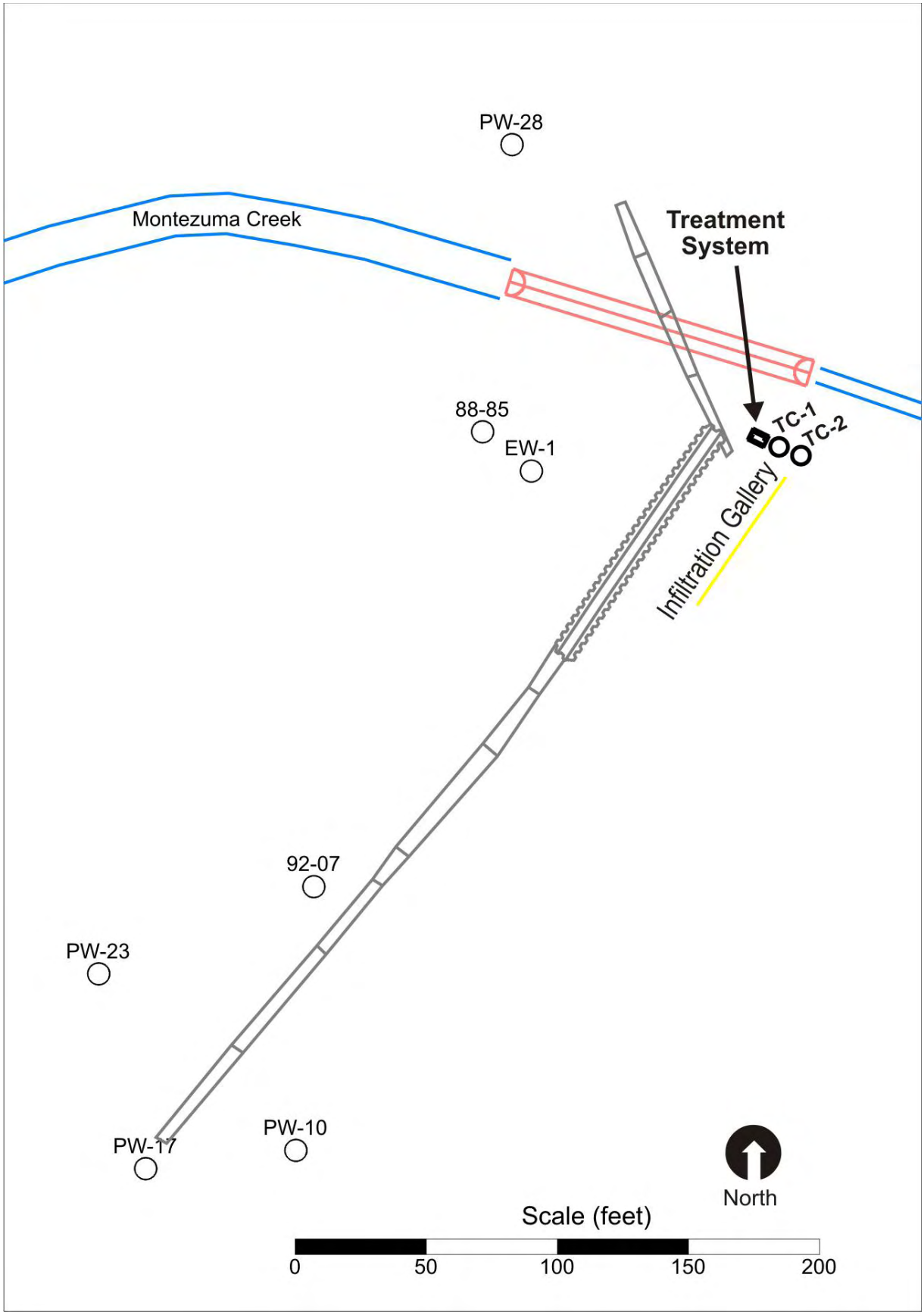

Figure 1. Location Map

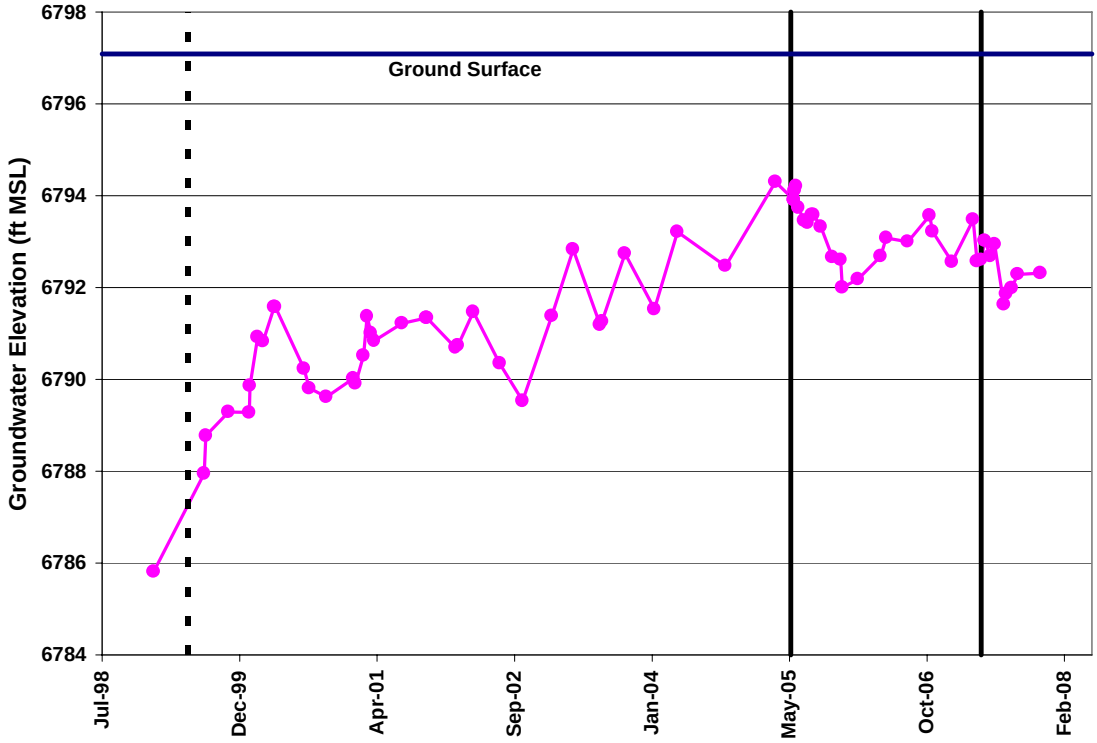

Figure 2. Ground-Water Elevation at Well 88-85 at Installation of PRB (vertical dashed line), and Installation of Treatment Cells TC-1 and TC-2 (two solid vertical lines)

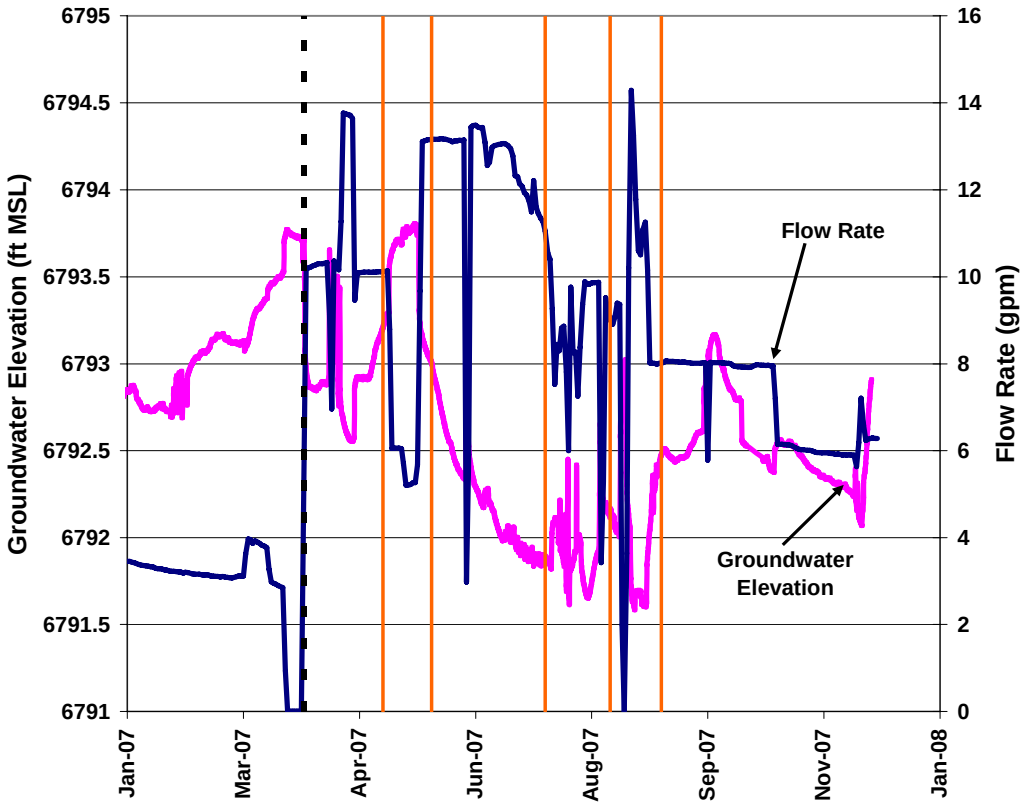

Figure 3. Time Plot of Flow Rate and Ground-Water Elevation. Plot shows combined flow rate (blue) of TC-1 and TC-2, ground-water elevation at Well 88-85 (pink), start of flow through the two treatment cells (vertical dashed line), and sampling events (vertical orange lines) during the study period.

The ground-water table did not change significantly during the project, as indicated by comparing the contour map for April 10, 2007 (Figure 4), near the start of the project, with the map for October 9, 2007 (Figure 5), near the end of the project. The highest elevation of the ground-water mound is near well 88-85. The elevation decreases by about 8 feet at the end of the south slurry wall and by about 3 feet at the northern end (Figure 4). The ground-water table decreases by about 6 feet across the PRB. The contour maps clearly indicate the mounding effect of the PRB. The elevation of the ground-water table decreased by only 0.05 foot at well 88-85 (Figure 5) during the study period, indicating that the pumping rates were insufficient to cause rapid drawdown. As discussed above, the pumping rate would need to exceed 10 gpm to cause significant decrease of the mounding.

One of the initial objectives of the study was to determine if increased pumping rates would pull ground water having the highest U concentrations from the south end of the slurry wall (near well PW-17) into the extraction well to be treated. The ability to pull this water is dependent on the configuration of the bedrock surface. A cross section of the saturated zone using the top of bedrock as the lower aquifer boundary shows the ground-water mound (Figure 6). The saturated zone thickens from well PW-17 in the southern area to well 88-85 in the mound, and a relatively thick saturated section continues across Montezuma Creek to well PW-28 at the northernmost terminus of the slurry wall. The bedrock surface is relatively flat across the valley, hampering the ability to draw the contaminated ground water from well PW-17 into the extraction well; consistent with the previous analysis (DOE 2001). The ground-water mound depicted in the cross section is displayed spatially on an isopach map (map showing thicknesses of saturated ground water) in Figure 7. The location of the mound centered near well 88-85 is clearly demonstrated. The saturated thickness varies from less than 1 foot at well PW-17 to more than 10 feet at well 88-85 and nearly 6 feet at PW-28. In 1998, prior to dewatering on the millsite and installation of the PRB, the saturated thickness at well 88-85 was 5.5 feet (DOE 1998).

3.2 Ground-Water Chemistry

Uranium concentrations in extraction well EW-1 varied from about 300 to 400 µg/L during the study period, and there was no indication that concentrations were decreasing (Figure 8) and no correlation between U concentration and pumping rates. The U concentrations were slightly lower in January 2007 and seem to be decreasing in December, possibly indicating a seasonal change. Summer irrigation watering could cause a decrease in U concentration from dilution, but instead the lower values were recorded before and after the watering season. The U concentration showed a significant increasing trend after installation of treatment cell TC-1 in May 2005 (Figure 9). The ground-water mound was at its maximum extent just prior to installation of TC-1, and it is speculated that U concentrations in the pumped water were affected by irrigation water that infiltrated to shallow depths and mixed with contaminated ground water; ground water was only 1.5 feet below ground surface at that time. As pumping proceeded, the ground-water table lowered, and more of the irrigation water was lost to evapotranspiration, causing U concentrations in the ground water to increase.

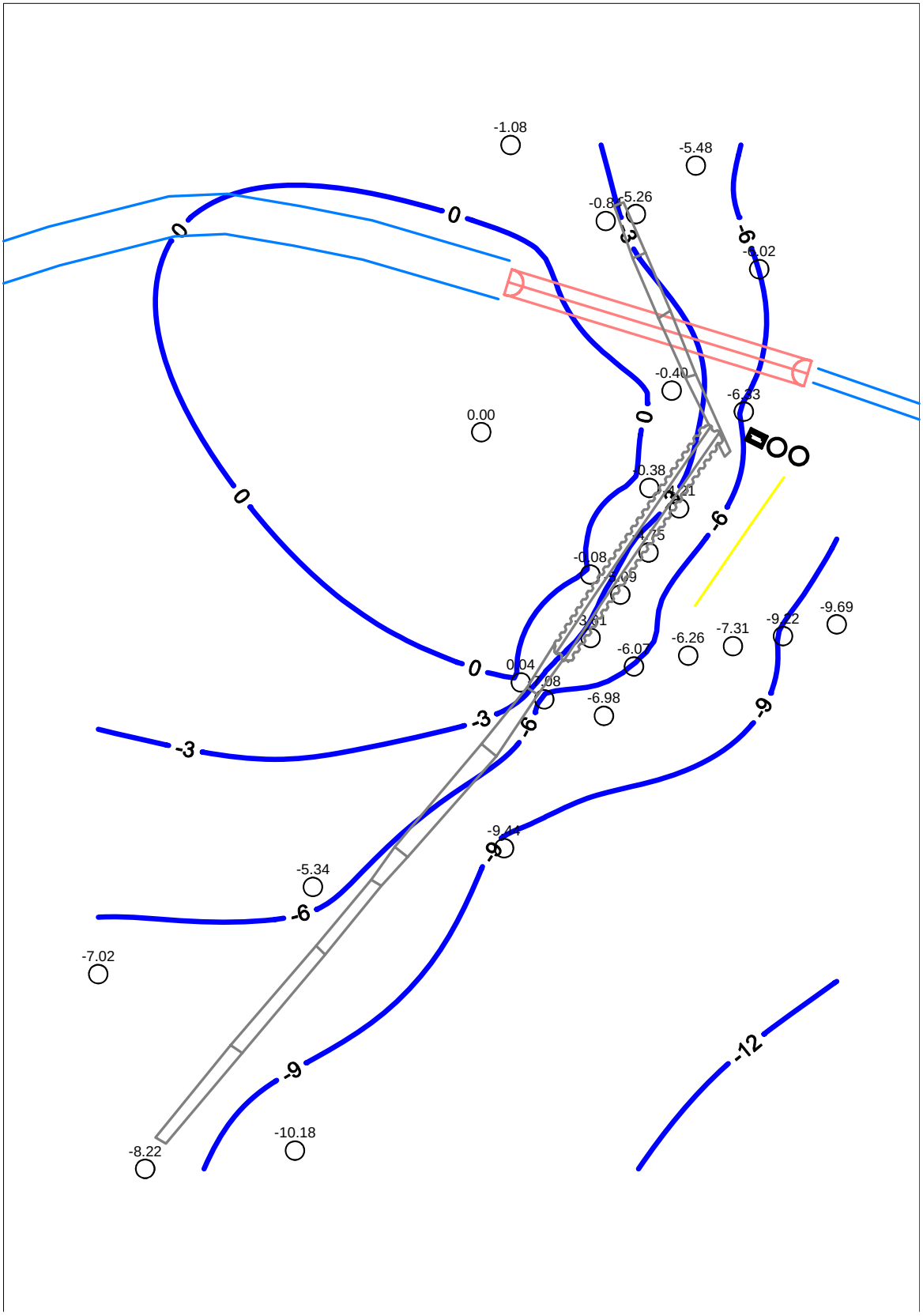

Figure 4. Ground-Water Table Near the Start of the Project, April 10, 2007. Datum is the ground-water elevation at well 88-85 (6792.57 feet).

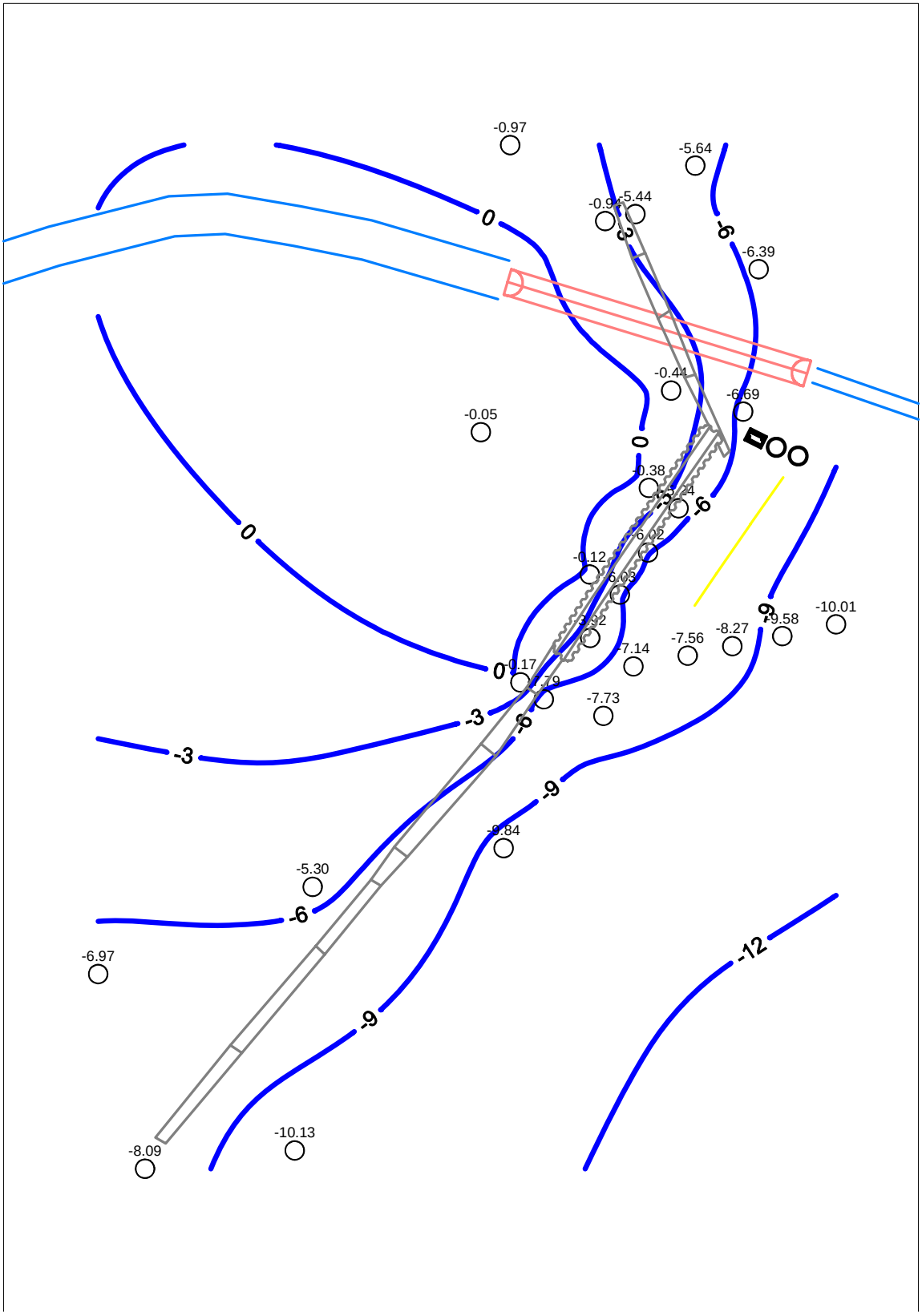

Figure 5. Ground-Water Table Near Completion of Project, October 9, 2007. Datum is the ground-water elevation at well 88-85 on April 10, 2007 (6792.57 feet), same as in Figure 4.

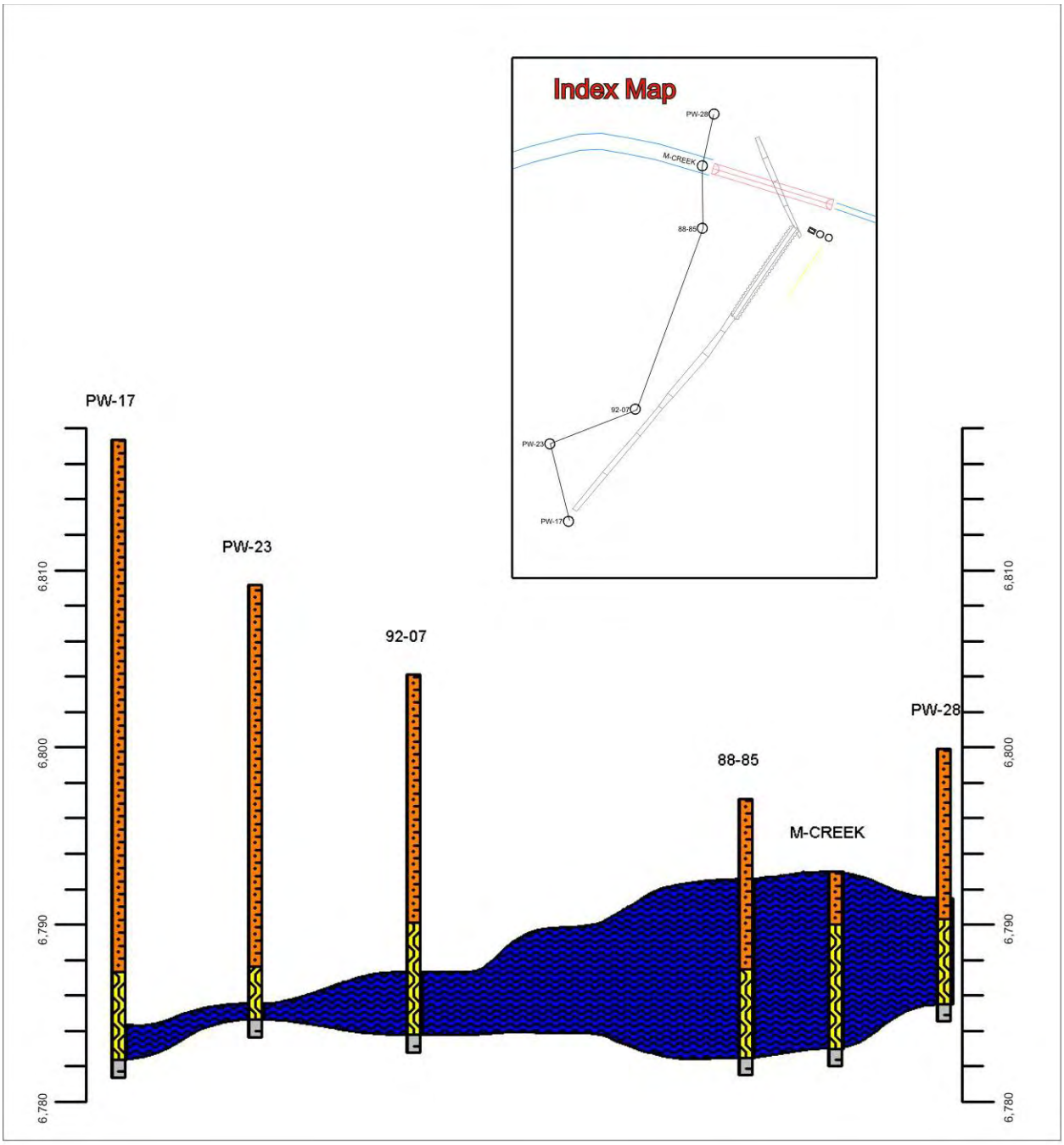

Figure 6. Cross Section Showing Saturated Thicknesses, April 10, 2007. M-CREEK is Montezuma Creek. Geologic units from top to bottom are silt overburden, alluvial gravel, and Dakota bedrock (shale). Vertical exaggeration × 10.

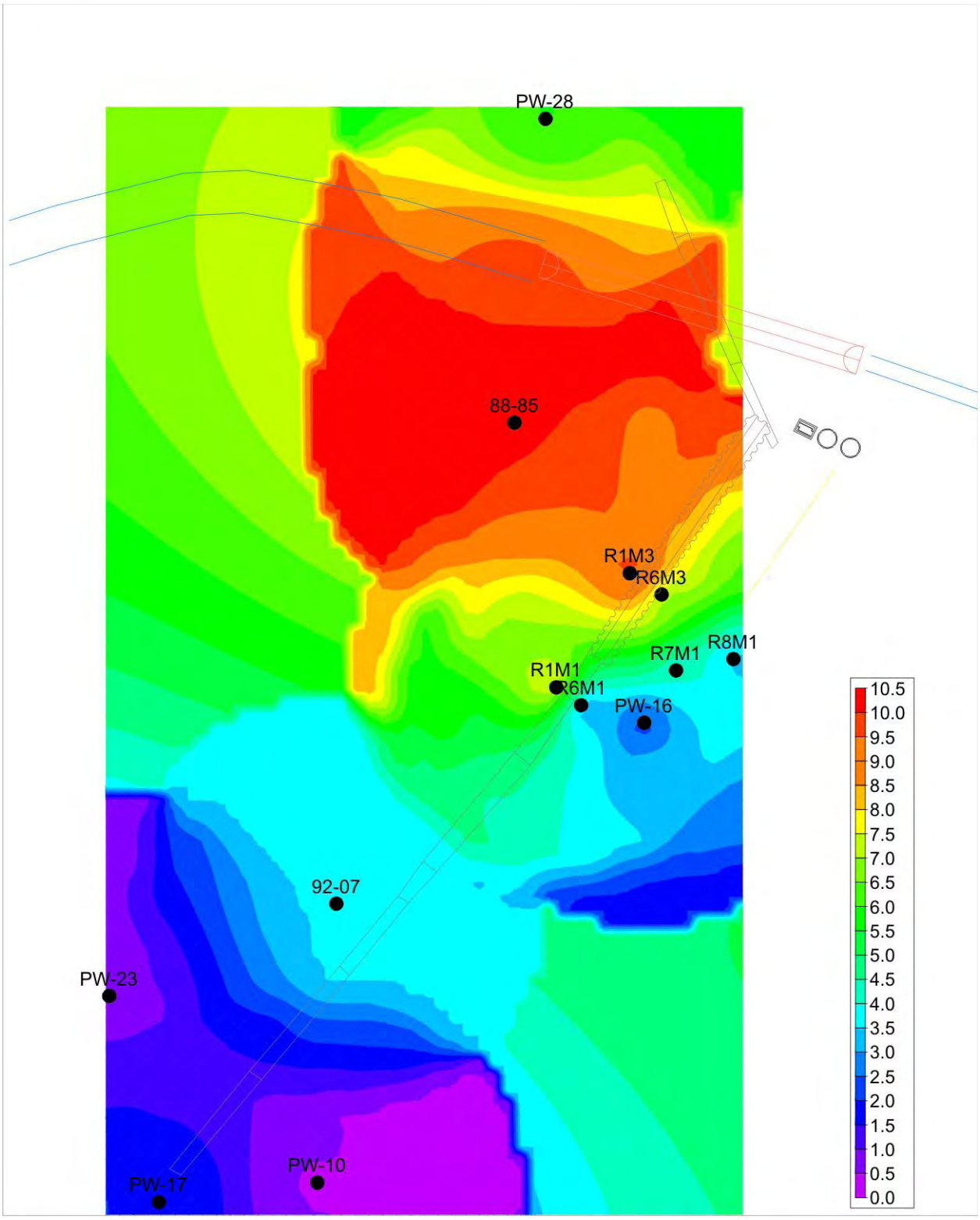

Figure 7. Ground-Water Isopach Map (feet), April 10, 2007. Legend values indicate thicknesses of saturated aquifer.

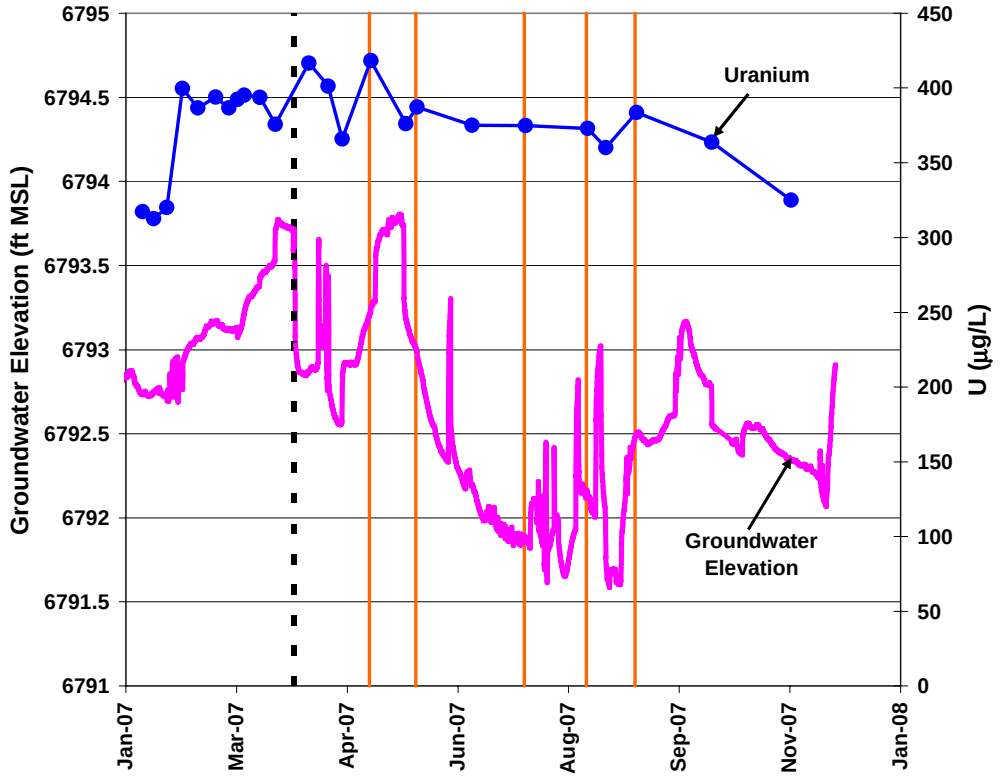

Figure 8. Uranium Concentration in Upgradient Ground Water at Well EW-1. Plot shows U concentrations (blue points) ground-water elevation at well 88-85 (pink), start of flow through the two treatment cells (vertical dashed line), and sampling events (vertical orange lines).

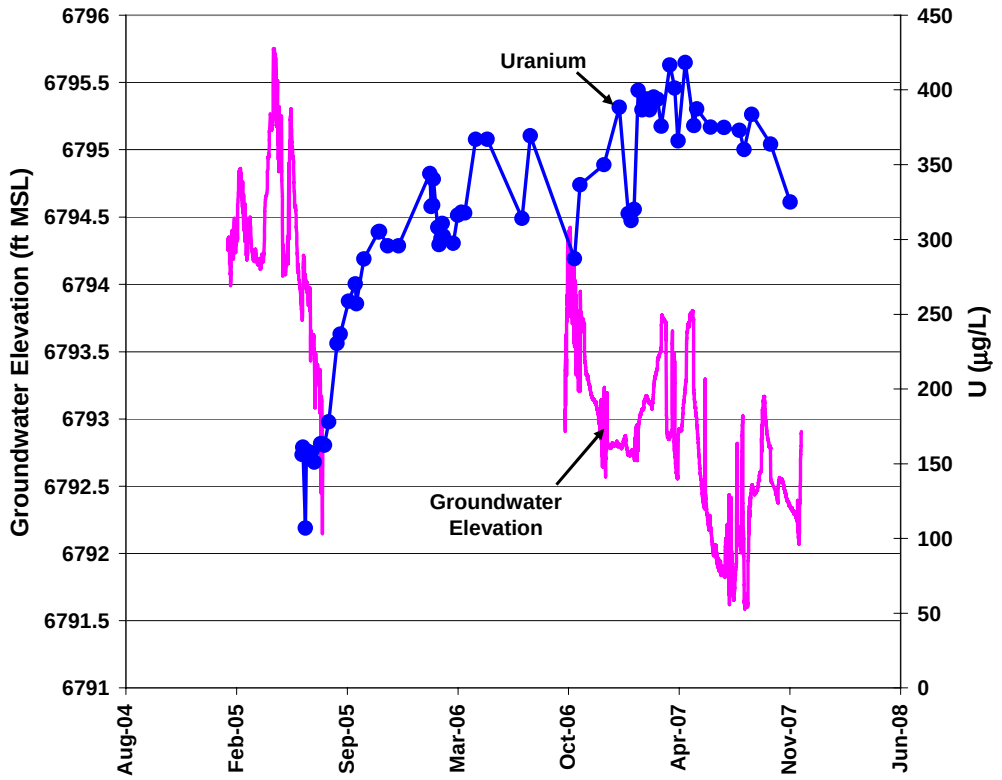

Figure 9. Uranium Concentration (blue dots) During Period of Operation of TC-1 and Elevation in Upgradient Ground Water at Well EW-1

Uranium concentrations show a distinct spatial trend in the upgradient wells. Concentrations in wells PW-10, PW-17, PW-23, and 92-07, located near the south end of the south slurry wall, have consistently had U concentrations several hundred micrograms per liter higher than in wells 88-85, EW-1, and PW-28 in the center and northern portion of the project area (Figure 10). A plot of the spatial distribution of U on September 5, 2007, demonstrates the elevated U concentrations at the south end of the slurry wall (Figure 11) and is consistent with the U concentration trend observed prior to installation of the PRB (DOE 1998, 1999). Reasons for the higher values of U in the southern area may be related to an historic episode in the management of mill process water on the south side of Montezuma Creek. As described earlier, the saturated thickness in the south area is less than 2 feet, and the volume of ground water with the high U concentrations is relatively small compared to the mounded area near well 88-85. Ground water conveyed to the treatment cells is lower in U than ground water in the southern area. It is speculated that extraction well EW-1 is drawing an insignificant amount of ground water from the southern area.

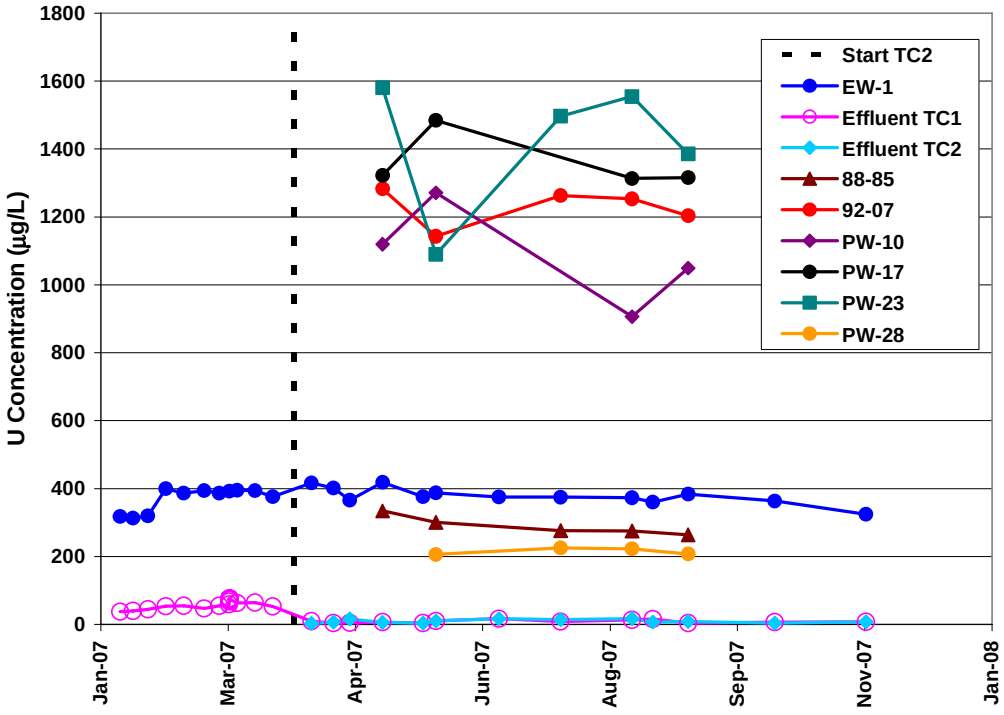

Figure 10. Uranium Concentrations in Treatment Cell Effluents and Upgradient Well Samples Following Installation of Treatment Cell TC-2 (vertical dashed line)

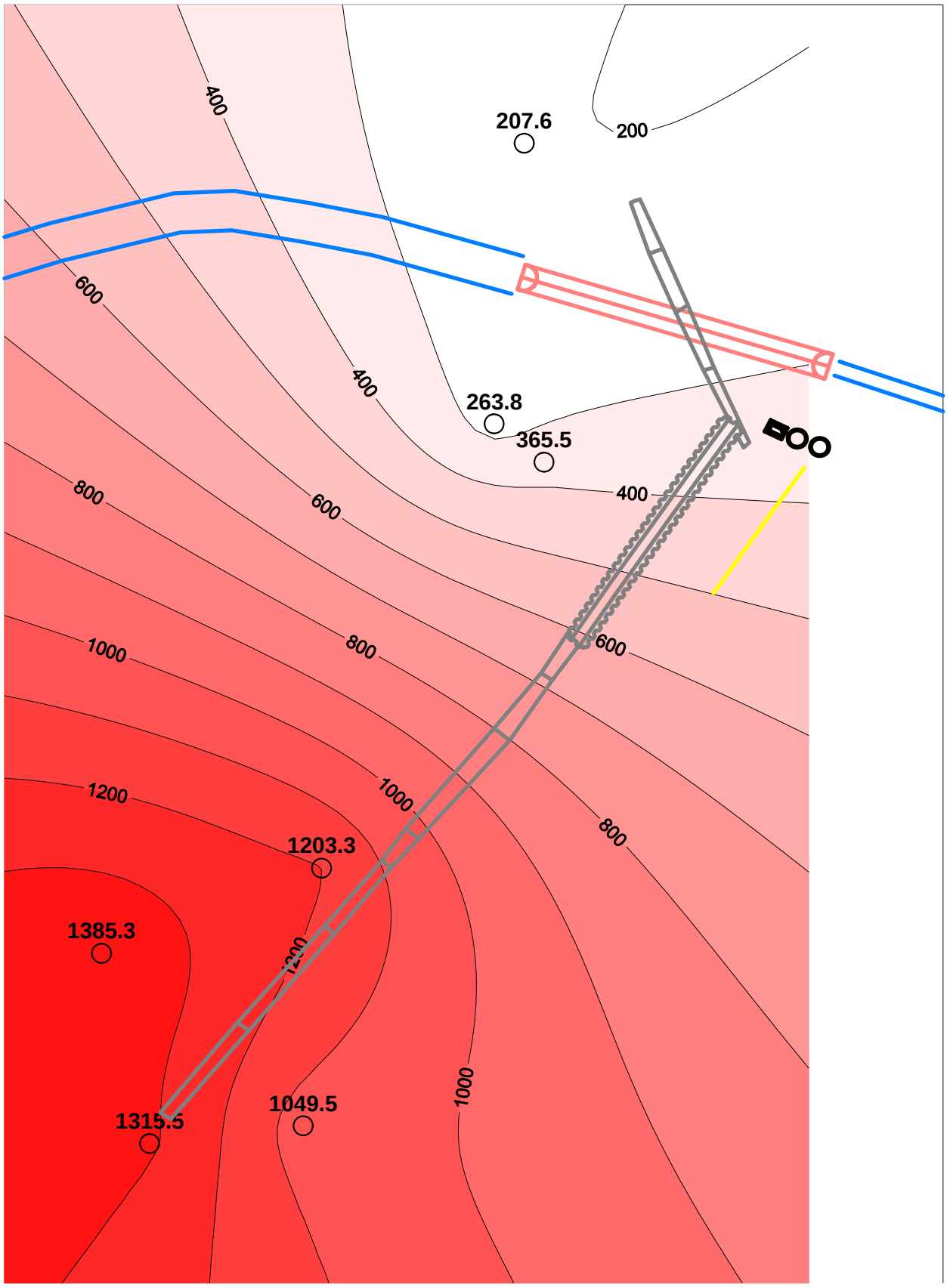

Figure 11. Uranium Concentrations (µg/L), September 5, 2007

In addition to U, major ions were analyzed during the current study to develop geochemical signatures that could be used to help delineate the flow paths of ground water. Figure 12 provides a "starburst" plot of the major cations Ca, Na, K, and Mg. The starburst plot is a useful visualization to portray distributions of multiple constituents. To use the plot, focus on a particular cation such as Na. The red-colored quadrants show that Na is more prevalent in the southern area. On the plots, the well with the highest value of the constituent fills the quadrant, and that with the lowest value has zero area. Potassium (green quadrant) is also more prevalent in the southern area, whereas Ca and Mg are more prevalent in the northern area. The pumping area (wells 88-85 and EW-1) has intermediate concentrations of the cations. However, the higher concentrations of Ca and Mg relative to Na and K in the pumping area suggest that ground water reaching the pump and the northern area are from similar sources. Figure 13 shows a starburst plot of major anions SO_4, Cl, and NO_3. Nitrate and Cl are more dominant in the north. Sulfate is high in both the north and south but low in the central pumping area. The higher proportions of Cl and NO_3 relative to SO_4 suggest that ground water received at the pumping well and the north area have a similar source, consistent with the results of the cation distributions.

There appears to be at least two areas (north/central, and south) with distinctly different ground-water signatures, possibly caused by a subtle ground water “divide” as discussed in Morrison et al. (2002). Extensive earthwork during remediation in this area could have resulted in the physical separation by altering the makeup of the aquifer. Another possibility for the different chemical signatures is different tailing types formerly located on the north (East Tailings Pile) and south (Acid Pile) of Montezuma Creek. Nitrate releases from offsite sources (possibly stock yards) have also been noted for the north side of Montezuma Creek. Both the cation and anion data seem to be well suited to "fingerprinting" the ground water and with greater spatial coverage could be used to more accurately define ground-water origins.

4.0 Conclusions

- Pumping at more than 10 gpm is required to significantly reduce ground-water mounding.
- Pumping is currently limited to about 6 gpm because of constraints on disposal of the clean water.
- The treatment system is capable of treating more than 13 gpm.
- Ground-water saturated thickness is significantly less in the southern portion of the study area than in the pumping well and northern area.
- Uranium concentrations increased upgradient of the PRB immediately following installation of treatment cell TC-1, but the long-term trend is toward lower U concentrations.
- The highest U concentrations occur in ground water on the south side of the valley.
- Major ion concentrations are useful in depicting chemical signatures and suggest a different source for the ground water on the south side of the valley than in the central and northern areas. More detailed analysis of the major ion signatures would better delineate ground-water flow paths.
- The trends in U concentrations and water table elevations during the sustained pumping are similar to the trends observed nearly 10 years ago prior to remediation at the mill site and installation of the PRB (DOE 1998, 1999).

- Based on the response of the water table during variable pumping rates, the total flux of ground water in the aquifer is about 10 to 15 gpm, plus any flux that is bypassing the PRB/slurry wall system.

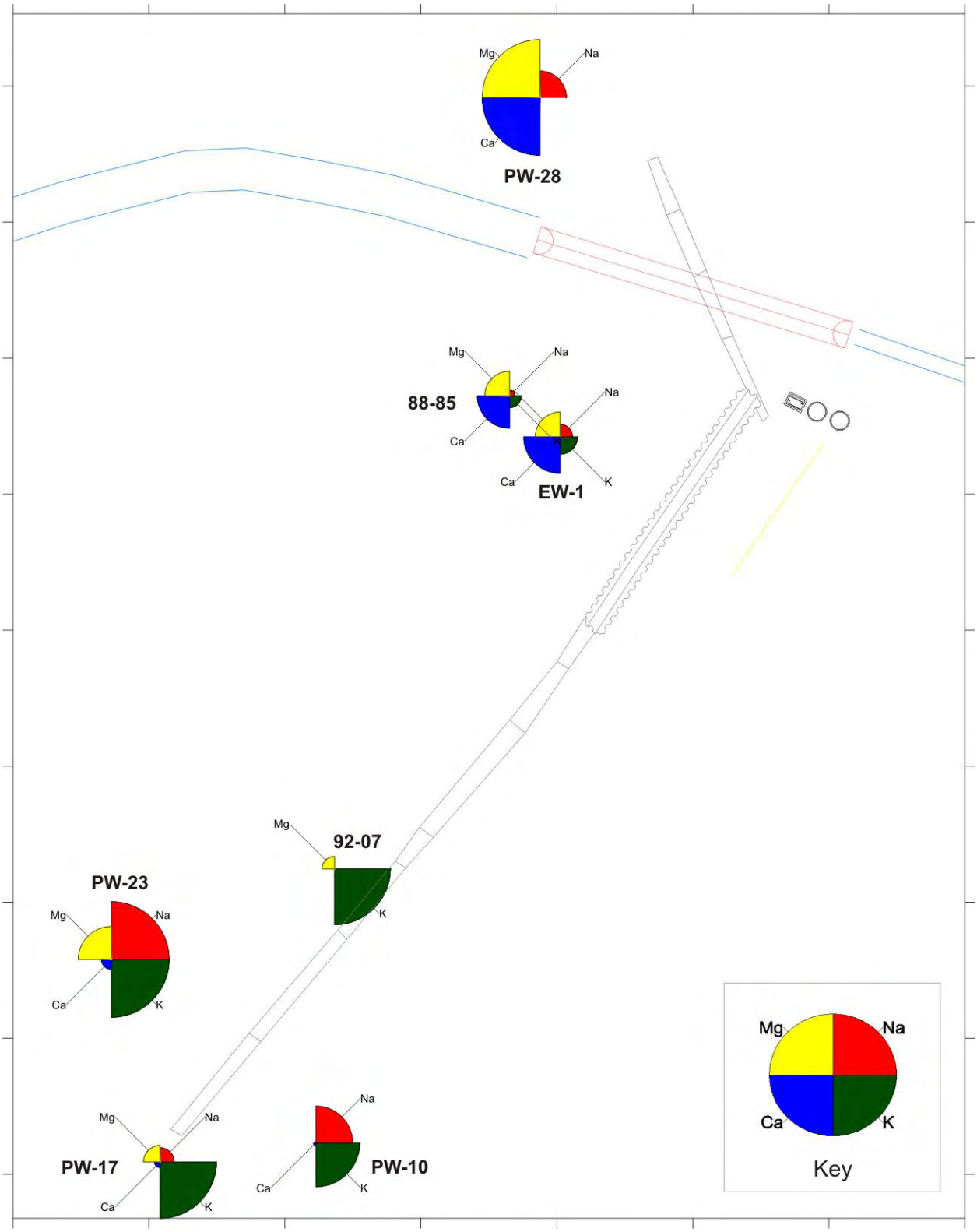

Figure 12. Starburst Plot of Cation Concentrations, September 5, 2007

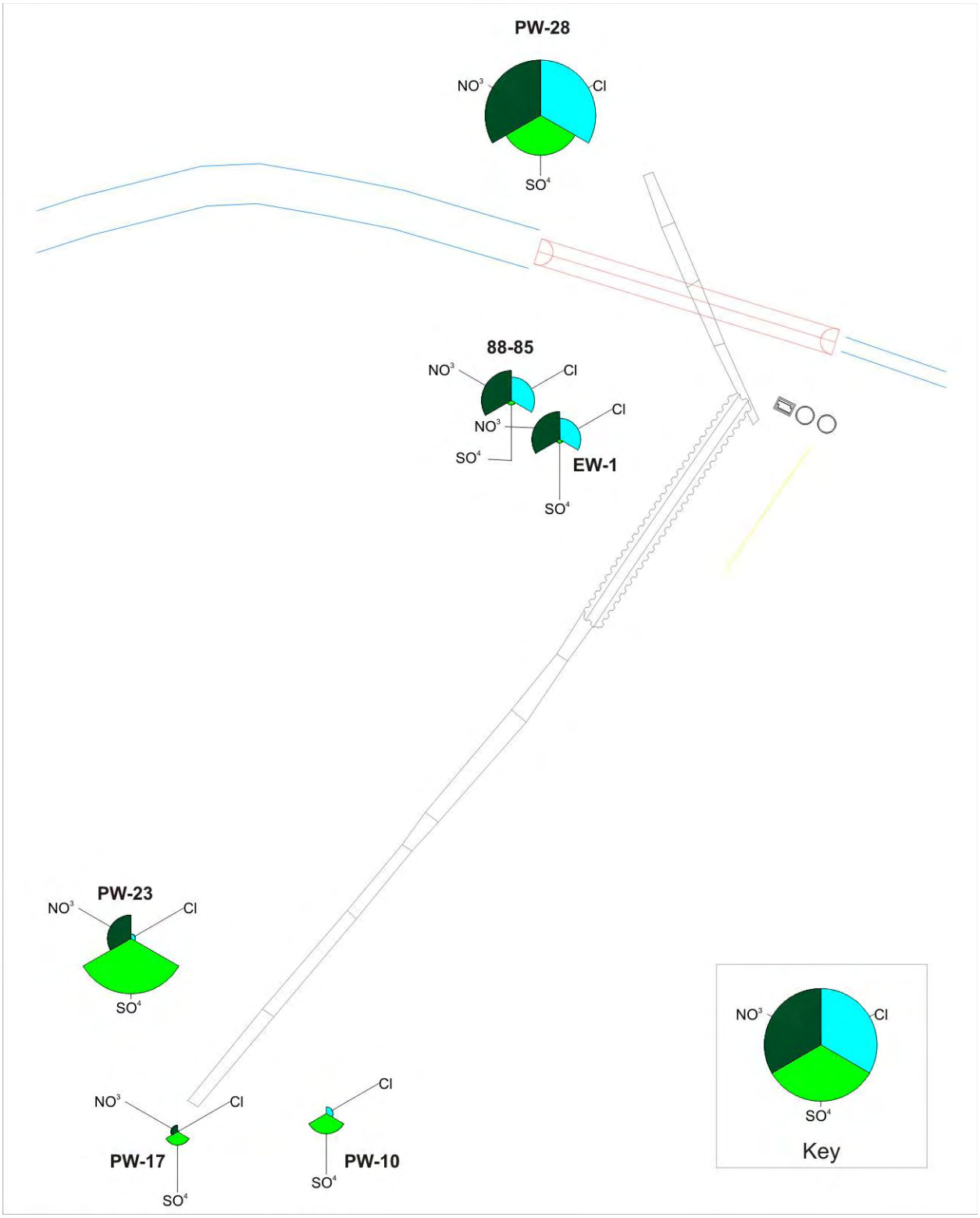

Figure 13. Starburst Plot of Anion Concentrations, September 5, 2007

5.0 Recommendations

- Obtain a means of discharging clean water so that a higher pumping rate is achieved.
- Examine the geochemistry of the area between the PRB and the former Acid Pile to help delineate the source of high uranium concentration in ground water near well PW-17.

6.0 References

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Appendix A

Chemical Data Collected During This Study

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Sample No.	Sampling Date/Time	U (ug/L)	Ca (mg/L)	Fe (mg/L)	Cl (mg/L)	NO3 (mg/L)	SO4 (mg/L)	K (mg/L)	Mg (mg/L)	Na (mg/L)	Cond (uS/cm)	pH	ORP (mV)	Alkalinity (mg/L as CaCO3)	Dissolved Oxygen (mg/L)	Temp (C)
INFLUENT SAMPLES																
TCINF	9-Jan-2007	388.5			84	32	755									
TCINF	25-Jan-2007	317.3														
TCINF	30-Jan-2007	312.7														
TCINF	5-Feb-2007	320.2														
TCINF	12-Feb-2007	399.8			91	32	786									
TCINF	19-Feb-2007	386.7			77	28	677									
TCINF	27-Feb-2007	394														
TCINF	5-Mar-2007	386.8														
TCINF	9-Mar-2007	392.6														
TCINF	12-Mar-2007	395.3														
TCINF	19-Mar-2007	393.9														
TCINF	26-Mar-2007	375.7														
TCINF	10-Apr-2007	416.7			92	29	777									
TCINF	19-Apr-2007	401.4	291	0.16				9		145						
TCINF	25-Apr-2007	366	347	0.13				9.3		145						
TCINF	8-May-2007	418.3	285	**0.1**	99	31	793									
TCINF	24-May-2007	376.2		**0.1**												
TCINF	29-May-2007	387.4	281	**0.1**	89.9	29.7	726.8	9.6	62	142.5						
TCINF	23-Jun-2007	375.2														
TCINF	17-Jul-2007	374.9	285.3	**0.1**	66	19	586	11.7	58	130						
TCINF	14-Aug-2007	373	247	0.14	67	15	651	9.4	60	122.5						
TCINF	22-Aug-2007	360.1	249	0.22	59	16	577	9.3	64	132.5						
TCINF	5-Sep-2007	383.6	295	**0.1**	61	17	624	10.8	64	117.5	1718	6.69	144.4	304	0.73	13.44
TCINF	9-Oct-2007	363.7	300	0.12	62	15	763	11.8	66	112.5						
TCINF	14-Nov-2007	325														
EFFLUENT SAMPLES																
TCEFF1	9-Jan-2007	58.7			85	6	758									
TCEFF1	25-Jan-2007	37.4														
TCEFF1	30-Jan-2007	40.2														
TCEFF1	5-Feb-2007	44.9														
TCEFF1	12-Feb-2007	53.8			91	5	785									
TCEFF1	19-Feb-2007	55			78	4	684									
TCEFF1	27-Feb-2007	46.8														
TCEFF1	5-Mar-2007	54.9														
TCEFF1	9-Mar-2007	59.07														
TCEFF1	9-Mar-2007	74.98														
TCEFF1	9-Mar-2007	74.32														
TCEFF1	9-Mar-2007	74.71														
TCEFF1	9-Mar-2007	68.06														
TCEFF1	9-Mar-2007	76.91														
TCEFF1	9-Mar-2007	75.49														

Sample No.	Sampling Date/Time	U (ug/L)	Ca (mg/L)	Fe (mg/L)	Cl (mg/L)	NO3 (mg/L)	SO4 (mg/L)	K (mg/L)	Mg (mg/L)	Na (mg/L)	Cond (uS/cm)	pH	ORP (mV)	Alkalinity (mg/L as CaCO3)	Dissolved Oxygen (mg/L)	Temp (C)
TCEFF1	9-Mar-2007	73.35														
TCEFF1	12-Mar-2007	63.3														
TCEFF1	19-Mar-2007	64.1														
TCEFF1	26-Mar-2007	53.1														
TCEFF1	10-Apr-2007	9.8			93	19	793									
TCEFF1	19-Apr-2007	4.3	336	45.4				9.1	75	137.5						
TCEFF1	25-Apr-2007	4.7	298	44.8				8.9	66	142.5						
TCEFF1	8-May-2007	7.26	280	43	95	**2.5**	766									
TCEFF1	24-May-2007	4.15		41.9												
TCEFF1	29-May-2007	10	287	32.8	88.4	**2.5**	727.1	9.5	62	142.5						
TCEFF1	23-Jun-2007	16.4														
TCEFF1	17-Jul-2007	8.1	287.1	34.4	66	**2.5**	584	11.4	64	127.5						
TCEFF1	14-Aug-2007	13.5	244	34.4	66	**2.5**	650	9.2	62	122.5						
TCEFF1	22-Aug-2007	15.8	249	27.3	63	**2.5**	596	9.5	64	130						
TCEFF1	5-Sep-2007	3.9	289	36.1	60	**2.5**	615	9.6	64	117.5	1769	7.05	-204.3	356	0.56	14.17
TCEFF1	9-Oct-2007	7.3	291	22.8	63	**2.5**	761	9.5	66	115						
TCEFF1	14-Nov-2007	7.6														
TCEFF2	10-Apr-2007	3.1			92	22	781									
TCEFF2	19-Apr-2007	6.7	275	47				9.2	68	142.5						
TCEFF2	25-Apr-2007	16.3	386	37				9.2	66	137.5						
TCEFF2	8-May-2007	6.15	332	33.7	96	**2.5**	779									
TCEFF2	24-May-2007	4.07		37												
TCEFF2	29-May-2007	10	306	24.1	88.9	**2.5**	728.5	9.4	64	145						
TCEFF2	23-Jun-2007	16.7														
TCEFF2	17-Jul-2007	14.2	291	33.2	68	**2.5**	582	11.2	60	137.5						
TCEFF2	14-Aug-2007	17	246	35.5	66	**2.5**	650	9.4	62	125						
TCEFF2	22-Aug-2007	7.2	249	30.4	60	**2.5**	588	9.3	64	132.5						
TCEFF2	5-Sep-2007	8.7	283	25.3	60	**2.5**	620	9.6	64	117.5	1796	7.2	-200.3	357	0.58	13.92
TCEFF2	9-Oct-2007	4.4	298	25.8	63	**2.5**	760	9.4	66	112.5						
TCEFF2	14-Nov-2007	8														
WELL SAMPLES																
EW-1	8-May-2007	369.8	293	0.1	104	34	792				2155	6.76	136.6	334	2.56	9.75
EW-1	29-May-2007	346.3	258	**0.1**	90	30	715	8.9	64	142.5	2022	6.71	131.5	336	2.44	10.17
EW-1	17-Jul-2007	296.4	293	**0.1**	67	20	590	10.3	60	137.5	1957	6.81	171.2	342	1.87	12.56
EW-1	14-Aug-2007	316.3	252	0.19	68	16	653	8.4	60	125	1697	6.73	47.6	375	2.89	13.4
EW-1	5-Sep-2007	365.5	291	3.6	64	18	630	9.8	66	135	1756	6.67	144.7	281	0.47	14.42
88-85	8-May-2007	334.2	318	0.14	52	18	389				2171	6.78	130.5	344	2.59	9.93
88-85	29-May-2007	301.1	271	2.24	98	34	741	8.8	44	147.5	2096	6.68	129.2	355	2.37	11.59
88-85	17-Jul-2007	276.6	296	**0.1**	73	22	598	9.8	52	132.5	2026	6.79	168.6	353	2.25	14.1
88-85	14-Aug-2007	275.2	254	0.19	72	17	663	7.8	62	117.5	1725	6.77	63.9	251	2.32	14.64
88-85	5-Sep-2007	263.8	287	0.3	66	19	634	8.6	66	125	1771	6.65	144	287	1.27	14.77
92-07	8-May-2007	1282.7	287	0.15	29	3	382				1913	6.77	124.7	278	0.59	8.49
92-07	29-May-2007	1143	242	**0.1**	54	7	739	16.5	62	142.5	1940	6.62	116.7	298	0.59	8.21

Sample No.	Sampling Date/Time	U (ug/L)	Ca (mg/L)	Fe (mg/L)	Cl (mg/L)	NO3 (mg/L)	SO4 (mg/L)	K (mg/L)	Mg (mg/L)	Na (mg/L)	Cond (uS/cm)	pH	ORP (mV)	Alkalinity (mg/L as CaCO3)	Dissolved Oxygen (mg/L)	Temp (C)
92-07	17-Jul-2007	1262.8	272	**0.1**	42	4	636	19	54	125	1915	6.67	139.8	333	1.24	10.49
92-07	14-Aug-2007	1253.1	225	0.23	44	3	669	18.4	46	127.5	1616	6.62	57.2	310	1.76	12.61
92-07	5-Sep-2007	1203.3	257	0.11	45	5	615	17.8	60	117.5	1622	6.6	82.3	269	0.6	12.66
PW-10	8-May-2007	1119.8	246	10.9	66	7	842				2150			356		
PW-10	29-May-2007	1270.8	252	2.17	59	8	802	15.5	60	190				338		
PW-10	14-Aug-2007	906.3	210	6.3	60	**5**	683	15.4	48	180						
PW-10	5-Sep-2007	1049.5	259	0.24	51	5	700	15.3	54	170						
PW-17	8-May-2007	1321.9	248	0.25	66	9	834				2060			318		
PW-17	29-May-2007	1484.5	280	1.22	56	10	801	18	60	185				320		
PW-17	14-Aug-2007	1313.4	233	2.8	50	5	716	20.2	62	150						
PW-17	5-Sep-2007	1315.5	262	0.18	46	8	671	17.9	62	137.5						
PW-23	8-May-2007	1580.8	295	6.3	65	20	1064				2380					
PW-23	29-May-2007	1089.3	273	4.59	59	20	1007	18.2						319		
PW-23	17-Jul-2007	1496.8	311	0.34	61	19	905	20.6	84	245						
PW-23	14-Aug-2007	1554.5	255	8.5	58	13	955	18.6	70	215						
PW-23	5-Sep-2007	1385.3	266	7	49	16	849	18.2	70	200						
PW-28	29-May-2007	205.9	374	**0.1**	137	51	912	5.6	82	180	2465	6.56	64	385	2.1	10.65
PW-28	17-Jul-2007	225.3	321	**0.1**	102	36	736	6.8	80	163	2361	6.68	-154.7	374	3.01	12.68
PW-28	14-Aug-2007	222.7	275	0.25	101	30	787	5.2	76	165	1993	6.68	-41.1	380	3.5	13.09
PW-28	5-Sep-2007	207.6	311	**0.1**	95	31	784	6.2	82	155	2024	6.58	80.5	291	2.23	13.67

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