



Monticello Mill Tailings Site Operable Unit III Annual Ground Water Report October 2006 through April 2007

September 2007



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of Energy

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Operable Unit III
Annual Ground Water Report
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Work Performed by S.M. Stoller Corporation under DOE Contract No. DE-AC01-02GJ79491
for the U.S. Department of Energy Office of Legacy Management, Grand Junction, Colorado

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1.0 Introduction

This report presents the results of environmental monitoring conducted from October 2006 through April 2007 for Operable Unit (OU) III, surface water and ground water, of the Monticello Mill Tailings Site (MMTS). The MMTS is a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List Superfund Site (CERCLIS ID Number UT3890090035), located in and near the City of Monticello, San Juan County, Utah (Figure 1). The U.S. Department of Energy (DOE) Office of Legacy Management currently administers the site as the Monticello Disposal and Processing Site.

The Record of Decision (ROD) for OU III, signed in June 2004 (DOE 2004a), stipulates environmental monitoring to facilitate annual evaluation of the progress of the selected remedy, monitored natural attenuation with institutional controls. The environmental monitoring for OU III consists of twice-yearly collection and analysis of hydrologic and water-quality data from an established network of observation wells and surface water locations. In addition, the selected remedy includes a phased approach to monitor and evaluate potential impacts of selenium accumulation on ecological receptors. Procedural and other specifications that direct the post-ROD monitoring activities are documented in *Monticello Mill Tailings Site Operable Unit III Post-ROD Monitoring Plan*, Draft Final, August 2004 (DOE 2004b).

1.1 Report Scope and Objectives

This annual ground water report was prepared in accordance with the *Performance Evaluation Plan for Monitored Natural Attenuation at Monticello Mill Tailings Site Operable Unit III*, included as Appendix B of the OU III ROD. The objectives of this report are to:

- Present the current extent of contamination in ground water and surface water at the site as compared to the respective remediation goals,
- Present contaminant concentration trends that track the progress of natural attenuation toward meeting those goals, and
- Compare the observed concentration trends to those predicted by the site numerical model as documented in *Monticello Mill Tailings Site, Operable Unit III—Remedial Investigation Addendum/Focused Feasibility Study* (DOE 2004c).

Hydrologic data, including ground water levels and surface water flows, collected during the semiannual monitoring events are also presented in this report. The hydrologic data provide water budget information that is used in comparing the observed progress of water quality restoration to the site conceptual and numerical models of ground water flow and contaminant transport. The final section of this report summarizes results of ecological monitoring for selenium accumulation.

2.0 Historical Information

The MMTS comprises a 78-acre tract of parkland where the former Monticello mill was located, and about 1,700 acres of private and City-owned peripheral property. Mill activities generated approximately 2.5 million cubic yards of low-level radioactive waste resulting from uranium-

and vanadium-ore processing between 1942 and 1960. Mill tailings, the solid by-product of milling, and the primary waste product, were impounded at four piles on the site of the former mill (millsite). Wind and surface water distributed some contaminated material, and limited amounts were used for local construction, resulting in contamination of more than 400 separate properties in addition to the millsite. Ground water and surface water contamination also resulted as mobile radioactive and other inorganic constituents leached from the tailings piles into the underlying alluvial aquifer.

The MMTS was placed on the CERCLA National Priorities List in 1986. OU III is one of three OUs comprising MMTS. The ROD for OU I (millsite) and OU II (peripheral properties), signed in September 1990 (MMTS ROD), stipulated that all contaminated material from OUs I and II be removed and placed in an on-site repository. Remedial actions under the MMTS ROD were completed in August 2001, and cleanup of the millsite occurred from mid-1997 through mid-1999. The repository is located on DOE-owned property about 1 mile south of the former millsite.

The MMTS ROD also designated OU III to address contaminated surface water and ground water but deferred remedy selection pending completion of site characterization through a Remedial Investigation (RI) and Feasibility Study. Field studies under the OU III RI began in 1992. An RI report that summarized the OU III study through 1996 was finalized in 1998 (DOE 1998a) as OU I and OU II remedial actions continued. To account for further possible changes to the ground water setting because of continuing remedial actions, and to proactively mitigate potential risk associated with the contaminated ground water, the Interim Remedial Action (IRA) ROD for OU III (DOE 1998b) was implemented in September 1998.

The main activities completed under this IRA ROD included implementing institutional controls to restrict use of contaminated ground water, performing comprehensive water quality and hydrologic monitoring, updating the OU III baseline human health and ecological risk assessments, and implementing a field-scale treatability study of permeable reactive barrier (PRB) technology. In addition, IRA ROD activities included the continued treatment of contaminated ground water from the dewatering of OU I excavations on the millsite; quantifying site-specific contaminant transport properties in soil and ground water through field and laboratory investigation; and updating the site conceptual and numerical models of ground water flow and contaminant transport.

Complete results of the IRA are documented in DOE 2004c, as is an evaluation of OU III remedial alternatives for ground water based on site conditions following OUs I and II remedial actions. On the basis of that information, the ROD for OU III selected monitored natural attenuation with institutional controls as the remedy for ground water and surface water. A condition of the ROD was to collect sufficient environmental data to allow annual evaluation of the progress of water-quality restoration within OU III, which is the primary focus of this report.

3.0 Hydrogeological Setting

The area encompassing OU III is sparsely populated and used primarily for livestock ranching and dry farming. The northwestern portion of OU III lies within the city limits of Monticello (population 1,900). The regional setting comprises the broad, nearly flat surface of the Great

Sage Plain, which is about 7,000 feet (ft) in elevation. Average annual precipitation is 15 inches, most of which occurs during late summer and early fall storms.

Montezuma Creek is the main surface water feature in OU III, flowing west to east through the center of the study area (see Figure 2). It is a small perennial stream with headwaters in the Abajo Mountains, which rise to nearly 11,000 ft approximately 5 miles west of Monticello. Typical flow in the creek is about 0.5 cubic feet per second (225 gallons per minute [gpm]). Montezuma Creek forms at the confluence of North and South Creeks a short distance upstream of the millsite. The municipal reservoir (Loyd's Lake, also called Monticello Reservoir), located about 1 mile upstream of the millsite, interrupts the natural flow of South Creek. North Creek, interrupted by the municipal drinking water treatment plant, joins South Creek a short distance below the earthen dam holding Loyd's Lake. Leakage through the dam contributes to the baseflow of Montezuma Creek. In the western portion of OU III, the valley of Montezuma Creek is relatively broad and gentle and is used for agriculture. Farther east, in the undeveloped portion of the study area, the creek has incised a deep canyon network into the bedrock formations. Montezuma Creek is a limited source of irrigation and livestock watering and is a net gaining stream within the boundary of OU III.

The hydrostratigraphic units within OU III are the shallow alluvial aquifer, the underlying Dakota Sandstone aquitard, and the deeper Burro Canyon sandstone aquifer. Remnants of Mancos Shale overlie the Dakota Sandstone at some peripheral locations in the western portion of OU III. Ground water contamination is limited to the alluvial aquifer; the Burro Canyon aquifer is not contaminated. The alluvial aquifer comprises silty sand and gravel channel-fill deposits in the valley of Montezuma Creek. Bedrock is generally within 15 ft of ground surface in the valley floor, and the saturated thickness of the aquifer averages about 5 ft or less. Ground water flow is predominantly west to east following the slope of the valley.

On the millsite, particularly on the east half, much of the native alluvium was excavated to bedrock during remedial actions to remove mill tailings and contaminated soil and sediment. To reconstruct this portion of the aquifer and the creek, sand and gravel obtained from non-contaminated areas of the aquifer was placed in a narrow (30- to 40-ft-wide) corridor, in places excavated several feet into the bedrock. This corridor underlies present Montezuma Creek and contains most of the ground water flow on the millsite. In addition to underflow from the west, the alluvial aquifer receives considerable recharge from anthropogenic sources along the north margin of the millsite, where perennial seeps and wetland vegetation are common. Most of this water likely is captured by Montezuma Creek in the millsite reach. The three adjoining wetlands constructed into bedrock during site restoration are also ground water sinks. A downstream outlet connects each wetland to Montezuma Creek. The eastern portion of the easternmost wetland (Wetland 3) rests on native alluvium and recharges the aquifer locally.

Total flow of alluvial ground water across the eastern boundary of the millsite is estimated to be less than 50 gpm. At this location, where the artificial channel ends, the alluvial aquifer is several hundred feet wide (north to south). The aquifer then narrows considerably about 1 mile east where the valley transitions to a steep-walled canyon (see Figure 2). A losing stream condition generally prevails in the reach between the millsite and this transition zone. As the canyon and aquifer then narrow to the east, alluvial ground water discharges to the creek. In addition, the Dakota Sandstone aquitard is absent in this reach, allowing for the discharge of ground water from the Burro Canyon aquifer to the overlying alluvium and subsequently to Montezuma Creek.

This hydrologic discharge boundary prevents further advancement of contaminated ground water. The alluvial aquifer pinches out entirely in the rugged portion of the canyon within about one-half mile downstream of the OU III boundary.

3.1 Ground Water Use

In the absence of millsite-related contamination, the Utah Department of Environmental Quality (UDEQ) classification of the alluvial aquifer within OU III is Class II, Drinking Water Quality Ground Water. However, there is no current or historical use of the alluvial aquifer for drinking water, irrigation, or livestock watering. The potential to develop the alluvial aquifer for these purposes is low because the saturated zone is thin and generally unproductive. Local private and municipal wells tap the Burro Canyon aquifer. As part of the OU III ground water remedy, institutional controls are in place to formally restrict the use of contaminated ground water for domestic purposes.

The city of Monticello has historically distributed water from the Burro Canyon aquifer only for non-domestic purposes (municipal and residential irrigation) but has recently augmented the culinary supply with this source during recent drought. The 10 municipal extraction wells are distributed within a 1-mile radius of the center of town; pumping rates during peak seasons are on the order of 350 gpm (example year 2002).

3.2 Permeable Reactive Barrier

In June 1999, a PRB was installed about 750 ft east of the former millsite (see Figure 2 for location) as a full-scale treatability study under the OU III IRA. The PRB is constructed of two separate zones containing a reactive medium (zero-valent iron [ZVI]) capable of immobilizing dissolved contaminants at the site. The PRB measures 103 ft long (perpendicular to flow) by about 13 ft deep by 8 ft wide (parallel to flow). The first zone is 2 ft wide consisting of crushed gravel and 13 percent by volume ZVI. The second zone, 4 ft wide, consists entirely of ZVI. A third zone, 2 ft wide and consisting entirely of crushed gravel, distributes the treated water to the aquifer downgradient of the PRB. The PRB is keyed 1 or 2 ft into bedrock. Low permeability slurry walls constructed of bentonite-amended soil extend north and south to divert ground water to the reactive zone. The north slurry wall is 97 ft long; the south slurry wall is 240 ft long. Each is about 15 ft tall, keyed into bedrock, and 3 to 4 ft wide.

In accordance with the ROD for OU III, DOE may operate the PRB without modification or replacement until treatment is no longer effective or ground water mounding becomes excessive, at which time DOE may decommission the PRB. DOE monitors and evaluates the performance of the Monticello PRB as a continuation of the treatability study of ground water remediation using ZVI. Such study has revealed a progressive loss of hydraulic conductivity of the ZVI through precipitation of reaction corrosion products, primarily calcium carbonate minerals. In June 2005, through the DOE Environmental Sciences Laboratory, Grand Junction, Colorado, with support from the U.S. Environmental Protection Agency (EPA) Region VIII, an auxiliary ex situ treatment system was constructed near the PRB to further study ZVI treatment technology and to alleviate the ground water mound at the upgradient interface of the PRB. A second treatment cell was added to the system in March 2007. Ground water is pumped in parallel through two cells from an extraction well located about 40 ft upgradient of the PRB (See Figure 3 for location of ex situ treatment system and extraction well [EW-1]). The total pumping

rate is about 12 gpm. Treated water is returned to the ground water system by way of an infiltration trench and infiltration gallery.

4.0 Contaminants of Concern and Remediation Goals

Contaminants of concern (COCs) for OU III surface water and ground water are arsenic, manganese, molybdenum, nitrate, selenium, uranium, vanadium, gross alpha activity, and gross beta activity. Table 1 lists the respective remediation goals for these constituents in ground water and surface water. The ground water goals correspond to either a maximum contaminant level as established by EPA, a maximum concentration limit under the Uranium Mill Tailings Remedial Action (UMTRA) program, or derive from the OU III human health risk assessment. Surface water remediation goals correspond to the available water quality standards established by the State of Utah. Gross beta does not have remediation goals because there is no activity-based standard for this constituent among the applicable or relevant and appropriate requirements for OU III, and risk factors to derive a risk-based goal are isotope-specific.

Table 1. Contaminants of Concern, Ground Water Remediation Goals, and Surface Water Remediation Goals

COC ^a	OU III Ground Water Remediation Goal ^{a,b}	Surface Water Remediation Goals ^{a,c}
Arsenic	10 µg/L ^d	10 µg/L
Manganese	880 µg/L ^e	-----
Molybdenum	100 µg/L ^f	-----
Nitrate (as N)	10,000 µg/L ^d	4,000 µg/L
Selenium	50 µg/L ^d	5 µg/L
Uranium—metal toxicity	30 µg/L ^d	-----
Vanadium	330 µg/L ^e	-----
Uranium-234/238—radiological dose	30 pCi/L ^f	-----
Gross alpha activity	15 pCi/L ^{d,g}	15 pCi/L ^h
Gross beta activity	-----	-----

^aSource: DOE 2004b.

^bµg/L = micrograms per liter; pCi/L = picocuries per liter.

^cState of Utah standard for surface water.

^dEPA maximum contaminant level (MCL).

^eBased on OU III human health risk assessment.

^fUMTRA maximum concentration limit.

^gExcluding uranium and radon.

^hExcluding uranium and radon for MMTS OU III.

5.0 Water Quality Monitoring Results

Semiannual water-quality monitoring events for the review period occurred in October 2006 and April 2007. In the following subsections, water quality results are presented in two formats: (1) spatial distribution as of April 2007, and (2) time-varying concentrations at individual sampling locations since January 2000 (or earlier in some cases) by which time all large-scale construction activities likely to impact the ground water system had been completed.

Appendixes A, B, and C contain the tabulated analytical results for samples of alluvial ground water, bedrock ground water, and surface water, respectively, collected since January 2000. The

corresponding sampling locations are provided in Plate 1. The current monitoring network (see Figure 3) is a subset of all locations monitored since January 2000 because project objectives, field conditions, or access restrictions have changed, or a given well was decommissioned (see Appendix D for a list of wells recently decommissioned). Sampling conducted in October is slightly more comprehensive than the April event (see Figure 3). Several downgradient alluvial wells located beyond the extent of contamination and numerous bedrock wells that are sampled in October are not sampled in April.

5.1 Water Quality of the Alluvial Aquifer

Figures 4 through 10 illustrate the extent of contamination in the alluvial aquifer in April 2007 for arsenic, manganese, molybdenum, nitrate (as N), selenium, uranium, and vanadium, respectively, showing only those wells sampled on that occasion. Symbol coding (circles for ground water and squares for surface water) identifies whether the remediation goal for the respective COC was exceeded (closed symbol) or not (open symbol) at a given location. The fact that fewer wells are sampled in April does not change the overall depiction of contaminant distribution in Figures 4 through 10 because all alluvial wells located within the contaminant plume are sampled in April.

Each COC was present in alluvial ground water at one or more location in April 2007 in excess of the respective remediation goal. Uranium (U) remains the most widespread contaminant in ground water, with concentrations that are greater than 10 times the remediation goal at many locations. Uranium contamination extends about 4,000 ft downgradient of the millsite. The remaining COC metals are present generally at much lesser concentrations relative to their remediation goal and are limited in distribution to the area near and upgradient of the PRB:

- Arsenic contamination is limited to the area between the millsite and PRB; concentrations are less than 2 times the remediation goal.
- Manganese contamination is now limited in extent to one location on the millsite.
- Molybdenum contamination occurs only at two wells located at the outer end of the slurry wall of the PRB.
- Nitrate contamination occurs only at several locations along the north margin of the valley on or immediately downgradient of the millsite. Nitrate contamination may originate from known livestock feedlots in those areas.
- Selenium contamination (very minor) occurs at a single well located near the outer end of the south slurry wall of the PRB (51 micrograms per liter [$\mu\text{g/L}$] at well 92-07) and farther downgradient at well 0200 at about 2 times the remediation goal of 50 $\mu\text{g/L}$.
- Vanadium contamination has a distribution very similar to that of arsenic. Vanadium concentrations do not exceed 2 times the remediation goal of 330 $\mu\text{g/L}$.

Previous review of site data identified U-234 and U-238 as the sole contributors to gross alpha activity measured in OU III ground water (DOE 1998a). Radon-222 is present throughout in OU III ground water and is a significant alpha emitter but is intentionally expelled during the analytical procedure for gross alpha activity. The remediation goal for gross alpha activity, which excludes uranium and radon, is not exceeded in OU III ground water.

Analyses were not performed to determine activities of U-234 and U-238 in alluvial ground water during the current review period and will not be done in the near future. This is because the mass-concentration goal (30 µg/L), based on the toxicity of metallic uranium, is equivalent to about 20 picocuries per liter (pCi/L) as U-234 plus U-238 and is therefore more stringent than the radiation dose-based goal of 30 pCi/L. As aquifer restoration approaches the mass-concentration goal, sample analysis will then include U-234 and U-238 to confirm that the activity-based goal is also achieved.

5.1.1 Plume Expansion in the Alluvial Aquifer

Uranium contamination extends downgradient to well 92-09 but not farther downgradient to “sentinel” well 95-03. The OU III ground water model predicted only slight increases in uranium concentrations east of the current extent of contamination but never to exceed the remediation goal at well 95-03. Figure 11 illustrates that contaminant levels observed at well 95-03, including uranium, are not increasing, and therefore plume expansion into uncontaminated regions of the aquifer is not significant at this time. Plume expansion into this area is prevented by the hydrologic discharge boundary described in Section 3.0 (Burro Canyon aquifer discharge and gaining stream condition).

Because of the much greater concentration, manganese does not plot on the same scale used in Figure 11; however, the presence of manganese at well 95-03 remains steady at concentrations well below the remediation goal. The relative enrichment of manganese in alluvial ground water at the several downgradient-most wells signifies the discharge of Burro Canyon ground water, which is naturally more abundant in this element.

5.1.2 Permeable Reactive Barrier and Treatment Cell

As shown in Figures 4 through 10 (see PRB inset), despite the progressive loss of hydraulic conductivity, the PRB remains effective in reducing contaminant concentrations (except manganese) to acceptable levels. Some loss of treatment effectiveness of the gravel/ZVI zone is evident for several analytes; however, the ZVI zone remains highly effective. Dissolved concentrations of manganese, an impurity of the iron filings, increase within the PRB. Alluvial ground water immediately downgradient of the PRB is trending toward acceptable concentrations of manganese, probably in response to decreased flow through the PRB.

The auxiliary treatment system has treated about 5 million gallons of contaminated ground water. Treatment influent and effluent are monitored approximately monthly. Except for several isolated instances, ground water treatment by the ex situ cells has been to acceptable levels. Because of reduced treatment effectiveness, the reactive media of the initial cell was replaced in March 2007 after treating approximately 1.2 million gallons.

In August 2006, a permanent infiltration trench was installed to more optimally return the treated water from the cell to the aquifer. As a failsafe for the infiltration trench, DOE is currently applying for a permit to discharge treatment cell effluent to Montezuma Creek. Water level and pressure information collected at various points in the system are relayed by telemetry to the DOE Grand Junction office for remote real-time monitoring of flow conditions and rates within the system. The system is also equipped for remote-manual or automated deactivation of the extraction pump in the event of malfunction or flow blockage.

5.2 Contaminant Concentration Trends in the Alluvial Aquifer

DOE completed a formal analysis of uranium concentration trends using non-parametric statistical methods in August 2007 (DOE 2007a). Statistically significant downward trends were recognized at many of the OU III monitor wells used in the assessment of ground water restoration progress. Non-trending was identified at most of the remaining wells. Upward trending was recognized at several wells, reflecting the expected downgradient transport of a localized ground water “hot spot.” The reader is referred to DOE 2007a for a detailed summary of the statistical analysis and results. Only a qualitative summary of contaminant concentration trending is included in this annual ground water report. Comparison of trends to uranium concentration trends predicted by the OU III ground water model (DOE 2004c) is presented in Section 7.0 of this report.

Figures 12 through 18 illustrate the concentrations of arsenic, manganese, molybdenum, nitrate (as N), selenium, uranium, and vanadium, respectively, as they vary over time at selected monitor wells located along the west-to-east axis of the ground water plume. Ordering of the wells in the legend of these figures is from west (upgradient) to east (downgradient). Monitoring data since 1992 are included in the figures to show the effect of millsite cleanup, evident at many locations as the sharp decrease in the concentration of several COCs in 1998 and 1999. Since then, concentrations of arsenic, manganese, molybdenum, uranium, and vanadium have remained generally static or have gradually decreased. The sharp increase of nitrate in ground water from 1999 through 2001 is attributed to fertilizer applications during site restoration. Dissipation of this plume was complete by 2004, but in April 2005, order-of-magnitude increases occurred at many locations, including the upgradient monitor well (MW00-01). As of April 2007, this latest pulse had dissipated to the extent that the nitrate standard was exceeded at three locations along the north margin of the millsite. This recent input of nitrate is possibly from fertilizer applications on the 18-hole golf course bounding Montezuma Creek immediately west (upgradient) of the millsite or from livestock feedlots just north of the millsite.

Selenium concentrations in ground water also increased significantly following OU I remedial action, particularly in the eastern area of the millsite where an extensive area of carbonaceous, pyritized shale of the Dakota Sandstone was freshly exposed. Naturally abundant selenium in this formation was likely mobilized by oxygenated ground water of the newly reconstructed alluvial aquifer placed over the fresh bedrock. Selenium concentrations in ground water have decreased significantly since this initial effect. Several locations where selenium concentrations increased in April 2005 coincided with those of increased nitrate concentration. This correlation, also apparent with the nitrate release in 1999, may be associated with the ability of nitrate to oxidize and mobilize selenium from bedrock formations similar to those underlying the millsite (Wright 1999; Wright and Butler 1993; Weres et al. 1990).

5.3 Water Quality of the Burro Canyon Aquifer

Water quality data for bedrock monitor wells since January 2000 are included in Appendix B. The Burro Canyon aquifer wells that were sampled during the review period are wells 83-70, 92-10, 93-01, 93-205, 95-06, and 95-07. Among these locations, only wells 93-01 and 83-70 are monitored annually (October events); beginning with the October 2006 event, the remaining wells are sampled every 5 years (see Plate 1 for bedrock well locations not routinely sampled).

Well 93-01 provides background water quality data for the Burro Canyon aquifer. Well 83-70 is completed beneath the main region of contamination in the alluvial aquifer.

Table 2 lists COC concentrations for the bedrock wells sampled in October 2006. Arsenic and uranium were detected at wells 205 and 95-06, respectively, slightly in excess of the remediation goals. These analytes have been detected at similar concentrations since monitoring began at the respective locations since 1994 and 1996. Their occurrence has been attributed to localized natural sources in previous OU III site characterization documents. The cumulative monitoring data through April 2007 for Burro Canyon monitor wells indicates that the Burro Canyon aquifer is uncontaminated by site-related constituents.

Table 2. COC Concentrations in Burro Canyon Ground Water, October 2006

Well	Concentration, October 2006 ^a						
	Arsenic	Manganese	Molybdenum	Nitrate ^b	Selenium	Uranium	Vanadium
83-70	0.3	260	3.2	15	0.02U ^c	0.0048U	0.21U
92-10	0.01	410	1.8	10U	0.02U	0.11	0.21U
93-01	0.31	70	0.13	24	0.02U	0.12	0.21U
93-205	31	650	14	10U	0.02U	0.16	0.21U
95-06	0.01	450	0.13	10U	0.02U	46	0.21U
95-07	0.07	61	0.13	10U	0.02U	1.1	0.21U

^aConcentrations expressed as microgram per liter (µg/L)

^bNitrate + nitrite as nitrogen

^cUndetected at listed value

5.4 Surface Water Quality

Appendix C contains the analytical results for water samples collected from established monitoring sites along Montezuma Creek, at ground water seeps, and from the easternmost of the constructed wetland areas on the former millsite (Wetland 3). Results for the surface water samples collected in April 2007 are shown in Figures 4 through 10. Surface water sites are identified in Figure 3.

With respect to the applicable surface water standards for OU III adopted in the ROD (Table 1), there is no contamination of Montezuma Creek by site-related constituents other than the occurrence of selenium at a concentration equal to the standard (5 µg/L) at the Sorenson location. Gross alpha activity in some surface water samples exceeds 15 pCi/L; however, the Monticello OU III standard (15 pCi/L) excludes the contribution of uranium and radon. Uranium has been shown to account for all alpha activity in OU III waters.

At the time the OU III ROD became effective, there was no state standard for uranium in surface water. Utah has since adopted a 30 pCi/L (approximately 44 µg/L) standard for domestic use surface water (Class 1C), which applies to Montezuma Creek. Discharge of contaminated ground water accounts for uranium concentrations in Wetland 3 that exceed this standard, and for lesser contamination by arsenic, nitrate, and selenium. Dilution to acceptable levels occurs before the water enters the creek. The uranium standard is exceeded at several locations on Montezuma Creek, beginning with the Sorenson location and including those farther downstream (see next section for additional discussion).

Among the remaining COCs that do not have a surface water standard, manganese, molybdenum, and vanadium are present at low concentrations that exceed background values but are much less than the respective ground water standard.

5.5 Contaminant Concentration Trends in Surface Water

Figure 19 and Figure 20, respectively, present selenium and uranium concentrations in surface water samples collected from numerous sites along Montezuma Creek since April 2000. Ordering of the sampling sites in the legend of these figures is from west to east in the direction of creek flow. These analytes were selected for presentation because uranium contamination is most extensive in OU III ground water, and selenium concentrations in surface water are particularly relevant to the ongoing biomonitoring task. Since April 2000, selenium has decreased to levels at or below the remediation goal at all surface water locations on Montezuma Creek. Uranium concentrations in Montezuma Creek exceed the new domestic use standard at the Sorenson location and those farther downgradient. Concentrations of selenium, uranium, and molybdenum increase (historically and at present) to peak concentrations between sites SW01-01 and Sorenson. The limited extent of selenium and molybdenum contamination in ground water in this area suggests that the increased loading to the creek is not from ground water discharge. Instead, the increase in contaminant concentration at the Sorenson location may be from a local deposit of stream-transported mill tailings in the subsurface or creek banks.

5.5.1 Ground Water Seeps

A zone of ground water seepage of suspected cultural origin occurs along the north margin of the millsite. Seepage faces are generally associated with the contact of Mancos Shale and overlying soil. Whether from leaking water lines or irrigation, water percolates through the soil layer and migrates downslope toward Montezuma Creek along the bedrock surface or within a shallow weathered zone. This contact is exposed at several of the prominent seeps. Although the seepage is generally perennial, the flow decreased significantly during the recent drought years. Water quality at the locations of Seeps 3, 5, and 6 (see Figure 3 for seep locations) suggests possible off-site sources of nitrate, selenium, and uranium to OU III. The high nitrate levels present at Seeps 3 and 6 likely relate to the livestock operation that drains to the millsite from the north. Figure 21 shows that the maximum contribution of nitrate from this source coincided with the very wet spring of 2005. The source of selenium in ground water and surface water in this area is likely of bedrock origin, and the recent, relatively large increase in selenium at Seep 6 (Figure 22) may again be related to the corresponding increase in nitrate at that location. Selenium concentrations at Seep 3, which discharges directly to Montezuma Creek just upstream of Wetland 3, appear to be declining since monitoring at that location began in April 2001.

The origin of high uranium contamination at Seep 6 is not certain. The seep is located topographically above the northern extent of the alluvial aquifer on the millsite in the area of the former mill buildings. Numerous seeps occur farther upslope of Seep 6. Underflow of this water may contact soil remediated to the radium-226 standard but containing residual uranium contamination, resulting in localized surface water and ground water contamination. Uranium concentrations at Seep 6 have been relatively steady (see Figure 23) since monitoring began at that location in 2002.

5.5.1.1 Wetland 3, Seep 1, and Seep 2

Seeps 1 and 2 discharge to Wetland 3 along its northwest bank. Since monitoring began at these locations in 2001, flow has been occasionally too diffuse for sample collection at Seep 1; Seep 2 has flowed constantly except throughout much of 2002 during the height of the recent drought. Contaminant concentrations and trends at Seeps 1 and 2 are similar to those at nearby monitor wells. The data include a downward trend in selenium entering the wetland. A similar trend in selenium is also observed at Seep 3. Uranium and selenium concentrations presently exceed the respective water quality standards for surface water in Wetland 3 (locations W3-03 and W3-04). Surface water quality standards are not exceeded in Montezuma Creek immediately downstream of Wetland 3 at location SW00-02. As noted in Section 5.5, surface water standards are exceeded at several locations farther downstream. Section 9.0 includes further discussion of selenium concentrations in Wetland 3 with respect to ecological receptors.

6.0 Hydrologic Monitoring Results

Routine hydrologic monitoring for OU III comprises water level measurement, surface water flow measurement, and visual inspection of known ground water seeps. Appendix E contains all OU III water level data collected since January 2000. Tabulated results of stream flow measured since 1999 are provided in Appendix F. All water level and stream flow monitoring locations are provided on Plate 1, Figure 3, or are described in the text. Appendix G contains National Weather Service precipitation data collected at the Monticello Port of Entry about 2 miles east of town and snowpack data from the Camp Jackson station in the Abajo Mountains (available through the National Oceanic and Atmospheric Administration). Presentation of the snowpack and precipitation data is by “water year”. A water year (WY) extends from October 1 through September 30 and is designated by the calendar year in which it ends and which includes 9 of the 12 months.

6.1 Precipitation Summary

The progress of water quality restoration is evaluated most effectively after the sources of contamination are removed and all large-scale construction activities with potential impact on the hydrogeologic setting have ceased. January 2000 is the appropriate starting date for this purpose for OU III. Precipitation data graphically represented in Figures 24 and 25 indicate that, including WY 2000, all water years except 2005 have received below average precipitation (30-year average). Through August 2007, WY 2007 (starting October 1, 2006) appears to also be in deficit. Winter snowpacks for WY 2007 and WY 2006 were far below average (30 percent or less of average). WY 2005 was abnormally wet (about 2.5 times the average snowpack and 1.6 times the normal precipitation in Monticello). Snowpack in the remaining years was low; only in 2001 was the normal condition approached. In general, the period in review (January 2000 to present) is one of below average precipitation.

6.2 Alluvial Aquifer Ground Water Levels

Leakage through the Monticello reservoir (Lloyd’s Lake) dam and seepage from North Creek are important controls of ground water baseflow in the alluvial aquifer west of the millsite. Golf

course watering may also contribute to aquifer recharge in this area. As indicated in water level hydrographs for upgradient monitor wells (wells MW00-01 and MW00-02, Figure 26), this area is subject to seasonal water table fluctuations of 2 feet or more. Following the several preceding years of low water, water levels responded to well-above-average precipitation in WY 2005 by rebounding 8 to 10 ft to recent highs in April 2005. Subsequent declines of several feet reflect the less abundant moisture of 2006 and 2007 compared to 2005.

Water levels measured at monitor wells farther east on the millsite (Figure 27) do not display the same degree of seasonal fluctuations as at MW00-01 and MW00-02. This water level dampening is probably an effect of pronounced ground water discharge to the creek and wetlands on the millsite, as noted by a strong gaining stream and numerous seepage faces, separate from the engineered infiltration galleries, on the wetland embankments. The unusually dry year of 2002 and into 2003 produced only minor variation in the water table. Water levels were observed to decrease by a foot or less at some wells, while others showed no change. At a time when recharge to the aquifer was very low such that creek flow was absent, underflow from the west was apparently sufficient to maintain a relatively constant water table within the relatively narrow aquifer corridor on the millsite. The water table responded to the abundant moisture of 2005 by rising at many locations by 1 to 2 ft (Figure 27) but has since declined to pre-2005 levels. The alluvial aquifer on the millsite, which is primarily contained within the reconstructed creek corridor, maintains a saturated thickness between about 2 and 5 ft.

Water level hydrographs for selected monitor wells located downgradient of the millsite are shown in Figure 28. The effect of dewatering during remedial actions is evident as the declining water levels at wells 92-11, 88-85, and 92-07 from mid-1998 through mid-1999. During that time, nearly all ground water underlying the millsite was captured at interceptor trenches and diverted to the creek at the east boundary of the millsite to facilitate tailings excavation (much of the diverted water required treatment at an on-site treatment plant prior to discharge). After dewatering ceased, the water table in the upgradient area of the PRB rebounded within about 6 months to levels approaching pre-remediation conditions (wells 88-85 and 92-07 for example). A similar response did not occur at well 92-11, probably because the ground water mounding associated with the PRB affected the area of wells nearest the PRB but not at the distance of well 92-11.

East of the PRB, the same period of millsite dewatering likely accounts for the observed water table decline and subsequent recovery at wells 92-08 and P92-06 (Figure 28). Because of the greater distance from the dewatering activities, the effect at these locations is delayed by several months or more. The effect of dewatering is not apparent farther east at well 92-09, possibly because of greater dampening with distance or through aquifer/creek interaction.

6.2.1 Ground Water Mound at the PRB

Ground water levels in the area immediately upgradient of the PRB trend downward (Figure 29) since installation of the ex situ treatment system, in contrast to the static or slightly rising water levels at wells located upgradient along the east boundary of the millsite. These contrasting trends indicate that ground water extraction at the PRB has lowered the water table in the immediate area by about 1 to 2 feet. This has increased the depth to water from about 3 ft below land surface to about 5 ft below land surface locally. This desired outcome prevents damage to the alfalfa crop grown there; however, continued pumping at the current location, even to the

extent of complete local dewatering, is not likely to induce flow of ground water from the contamination “hot spot” at the outer end of the south slurry wall. This is because the top of bedrock at the point of extraction is topographically higher than the water table in the hot-spot area. Ground water flow is affected by a subtle bedrock trough along the southern margin of the aquifer in this section of the valley. With continued pumping, a portion of the hot spot farther upgradient of the end of the south slurry wall may be diverted to the extraction well, but not that portion currently monitored at wells PW-17, PW-23, and 92-07.

The discharge capacity of the treatment system infiltration trench was exceeded with the addition of the second treatment module, resulting in recent saturation of surface soil and minor crop damage. Extraction rates were then lowered, and effluent was diverted to the temporary infiltration gallery. DOE is currently preparing to expand the discharge capacity of the infiltration system in the fall of 2007 in order to discharge all treated water to the aquifer at a more optimal location than is provided by the temporary system.

6.3 Burro Canyon Aquifer

Well pairs 95-01/95-02 and 95-03/95-04 comprise the easternmost ground water monitoring locations in OU III (see Figure 3 for well locations). Ground water is not contaminated at these locations. Wells 95-01 and 95-03 are completed in the alluvial aquifer. Wells 95-02 and 95-04 are completed in the upper 20 ft of the Burro Canyon aquifer. Water levels are monitored at these locations to confirm the long-term stability of the hydrologic barrier in this part of the canyon that prevents farther downgradient migration of the contaminant plume.

The water table at these well pairs is shown to be relatively stable over time with a consistent upward flow gradient from the Burro Canyon aquifer to the alluvial aquifer (see Figure 30). Ground water withdrawal from the Burro Canyon aquifer by the city of Monticello during 2001 to 2004 apparently did not affect the direction or magnitude of this gradient, nor were water levels at well 95-08 affected (Figure 31), which is a Burro Canyon well located on the mesa above well pair 95-03/95-04. The much greater hydraulic head at well 95-08 compared to those at 95-02 and 95-04 is evidence of the driving force of Burro Canyon discharge in the canyon. Additional indications of Burro Canyon discharge are the numerous seeps and springs near the exposed base of the formation along the canyon walls.

At Burro Canyon monitor wells located nearer the municipal well field, for example, wells 83-70, 93-205, and 93-01, municipal pumping accounted for as much as 15 to 20 ft of water level drawdown in the Burro Canyon aquifer (Figure 31). Water levels in those affected wells continue to rebound since municipal ground water withdrawal was recently lessened or discontinued.

Private use of Burro Canyon ground water in OU III is currently limited to a single landowner, who in 2004 obtained water rights to DOE monitor well 83-70 for lawn and garden watering. From the well hydrograph (Figure 31), the regional effect of municipal ground water withdrawal far exceeded the local effect of direct pumping from well 83-70 for household irrigation. In 2006, former upgradient Burro Canyon monitor well 92-13 (see Plate 1 for location) was transferred to the landowner (Burtenshaw), who subsequently submitted a water rights application, which was approved by the State. The claim has not been acted upon to date.

6.4 Stream Flow

Results of periodic measurements of flow at several locations on Montezuma Creek since April 2000 are depicted on Figure 32. The ordering of the flow measurement locations in the legend is from west to east, parallel to the direction of flow. The “transitional reach” identified in the figure refers to the segment of Montezuma Creek between wells 0200 and 92-09 where the valley begins to narrow into a steep-walled canyon. Flow measurements for that reach were taken at location SW00-03, SW00-06, or just upstream of well 92-09, depending on field conditions. Drainage ravines leading into Montezuma Creek are typically dry and have no influence on the flow data.

Figure 32 clearly shows the effect of recent drought, culminating in the absence of measurable flow at any location during mid-summer 2003. At that time, the absence of a gaining stream condition in Montezuma Creek between stations SW00-01 and SW00-02 not only represents reduced baseflow from the reservoir and North Creek, but it also shows that water for residential irrigation was largely unavailable during peak dry years, thus eliminating aquifer recharge along the north margin of the millsite. Creek flow has since increased to approach normal levels. In April 2005, following abundant winter and spring snow, measured creek flow was about 2,000 gpm (April 2005 results are off-scale and not shown in Figure 32). City maintenance officials reported peak flow in Montezuma Creek in the spring of 2005 of 30,000 gpm resulting from deliberate releases from the reservoir and from anomalously high flow in North Creek due to heavy runoff from a 250 percent of normal snowpack in the Abajo Mountains.

Visual observations during the week of August 24, 2007, indicated that flow in Montezuma Creek increased from zero at the west boundary of the millsite to approximately 50 gpm at the diversion structure located between Wetland 2 and 3 (“Millsite Weir,” Plate 1). This flow was being diverted at that time for irrigating alfalfa fields east of the millsite. Stream gain east of the diversion was minor. Very little flow was observed in Montezuma Creek downstream of the millsite to the Sediment Pond. Gaining conditions resumed farther downstream because the canyon becomes narrower and ground water discharges from the Burro Canyon aquifer.

7.0 Ground Water Restoration Progress

The ROD for OU III stipulates that, beginning with the water quality results from October 2004, observed concentrations for uranium will be compared to those predicted by the ground water model for OU III as a measure of restoration progress. For this purpose, the aquifer is conceptually divided into five regions distinguished by contaminant distribution or hydrogeology (see Figure 33). An average uranium concentration is computed for each region and sampling event from among selected wells and graphed to illustrate the average concentration over time per region. An empirically determined uncertainty range of ± 30 percent is applied to each point (the method to determine this range is documented in the ROD). Model-predicted concentrations (provided in Appendix H of this report) for the corresponding well groups are similarly averaged, normalized to calendar date (model time zero is October 2002), and graphed. Results of these comparisons are presented as Figures 34 and 35. In these figures, solid lines represent averaged model-predicted concentrations, and the individual points represent the average of the observed concentrations in the given region.

The ROD for OU III states that as of October 2004, if for any aquifer region the model average falls below the uncertainty range for the observed average over three consecutive sampling events, aquifer restoration is not progressing as expected. Using this measure, and referring to Figures 34 and 35, the status of aquifer restoration as of April 2007 is summarized as follows.

- Region 1 Predicted uranium concentrations are less than 70 percent of the observed average since at least October 2004; therefore, the progress of ground water restoration in this region is less than expected.
- Region 2 The rate of aquifer restoration in this region is consistent with the model prediction.
- Region 3 The rate of aquifer restoration in this region is inconsistent with the model prediction; the progress of ground water restoration in this region is less than expected.
- Region 4 Uranium concentrations deviate significantly from the model prediction; however, observed concentrations are less than model-predicted values.
- Region 5 Uranium concentrations deviate significantly from the model prediction to imply a longer restoration period than expected.

The short-term interest in evaluating ground water restoration is focused on Regions 1, 2, and 3 because these regions should provide the earliest indications of cleanup; also, the predicted cleanup trends are linear or nearly so through the restoration. The relatively heterogeneous trending anticipated for Regions 4 and 5 and their much longer expected period of restoration presents greater uncertainty in evaluating restoration progress, particularly for the brief period of observation to date.

7.1 Uranium Trend Statistical Analysis

The OU III ROD stipulates that if the acceptance criterion defined in the preceding section is not met for any aquifer region, DOE is to perform additional statistical analysis of the uranium concentrations. The definition of acceptable restoration progress cited is clearly not satisfied for Regions 1 and 3. Consequently, DOE has recently completed a second statistical analysis to determine if statistically significant trends are present in the data that project an aquifer cleanup time that is within the overall 42-year period predicted by the OU III ground water model.

The alternate method selected to evaluate uranium concentration data applied the Mann-Kendall test for trend detection, the Sen's estimate of slope, and the Seasonal Kendall test for trend and slope. Each of these tests is applicable for analyzing ground water cleanup trends, as suggested in *Methods for Monitoring Pump-and-Treat Performance* (EPA 1994). Details in applying these tests are provided in *Statistical Methods for Environmental Pollution Monitoring* (Gilbert 1987). The Monticello uranium concentration data were evaluated by these methods on a well-by-well basis, as regional averages, and under the separate assumptions of cyclical and noncyclical seasonal variation.

With EPA and UDEQ concurrence, the methods, results, and discussion of the second statistical tests are presented in *Monticello Mill Tailings Site Operable Unit III Analysis of Uranium Trends in Ground Water* (DOE 2007). Summary findings are:

- Current trends indicate that the model-predicted period of aquifer restoration for Regions 1 and 3 (within about 15 years) will not be met. Current trends further indicate that

restoration of these regions will not be met in the overall 42-year period predicted by the model.

- Current trends indicate that aquifer restoration will be complete in Region 2 well within the overall 42-year period.
- Trending for Regions 4 and 5 is not a reliable indicator of restoration progress at this early stage of evaluation because heterogeneous trending is expected as zones of higher contamination move into these regions over time.
- Trend analysis of the region-by-region averages provides results similar to those from the original ROD-specified evaluation method. Well-by-well analysis provides some additional insight in evaluating restoration progress by identifying specific areas of potential concern.
- Seasonal and nonseasonal trend analysis provided very similar outcomes. Seasonal cyclicality is apparently not a major cause of variation in the Monticello ground water data.
- Hydrologic factors (for example, recent drought and PRB effects) and uncertainty in the initial contaminant distribution in ground water (extent of ground water hot spots) may be major causes of disagreement between the model-predicted and observed concentration trends.

7.2 Water Quality Compliance Strategy

DOE, in consultation with EPA and UDEQ, has initiated a response action following the conclusion of the second statistical test to develop a position paper outlining the compliance strategy for ground water restoration for the current CERCLA five-year review period. A draft plan is scheduled for completion during fiscal year 2008.

8.0 Biomonitoring

DOE conducts biomonitoring to evaluate possible risk to ecological receptors from recent increases of selenium in surface water and ground water. Biomonitoring is focused on the constructed wetland areas on the former millsite and the sediment retention pond located on Montezuma Creek about 1 mile downstream of the millsite (“Sediment Pond,” Plate 1). The surface area of Wetland 1, 2, and 3, respectively, is approximately 1, 2, and 1.5 acres. Maximum water depth is about 12 inches. The Sediment Pond is about 1 acre in size. About 60 percent of the pond reaches depths up to about 6 ft.

Biomonitoring is implemented in phases according to the task outline presented in DOE 2004b. The scope of biomonitoring activities is determined in consultation with the Biological Technical Assistance Group (BTAG), which consists of representatives of the U.S. Fish and Wildlife Service, EPA, UDEQ, and DOE. Field activities are directed to DOE contractor personnel through program directives.

The post-ROD biomonitoring task began in October 2004 with the collection of sediment and surface water samples from the wetland and sediment pond for analysis of selenium. This was repeated in April and October 2005 and 2006, and April 2007. Sampling and analysis of aquatic insects was conducted in May 2005, 2006, and 2007. Tabulated results for selenium content of

samples collected during these events are provided in Appendix H. Reports that present and discuss in detail the sediment, surface water, and insect sample results through April 2007 are provided in DOE 2005a, DOE 2007b, and DOE 2007c. Avian surveys were conducted during periodic visits (every other week) in May through August 2005 and in May through June 2006. Presentation and discussion of the bird surveys is provided in greater detail in DOE 2005b and DOE 2006.

8.1 Current Scope

Biomonitoring tasks currently in scope include sediment, surface water, and aquatic insect sampling at Wetland 3 and the Sediment Pond in spring 2008. A bird survey will also be completed during spring 2008 to with particular emphasis on confirming the absence of threatened or endangered species that would be at risk to selenium associated with the wetland habitat. Separate reports will be prepared for the BTAG to present the cumulative findings of the cumulative biomonitoring sampling and analysis and the bird surveys in fiscal year 2008.

8.2 Surface water and Sediment Results

Selenium results by location for sediment and surface water collected in October 2006 and April 2007 are presented in map view in Figures 36 and 37, respectively. Figures 38 and 39 display the selenium results for surface water and sediment as time-series since October 2004. In that time, the selenium toxicity threshold in surface water (5 $\mu\text{g/L}$) was exceeded on two occasions (October 2004 and 2006), both occurring in Wetland 3 at the location nearest Seep 2 (location W3-S1). Remaining samples from the three sampling locations in Wetland 3 occasionally exceeded the level of concern (2 $\mu\text{g/L}$); however, the geometric mean for each sampling event never exceeds the level of concern. Selenium in the Sediment Pond water is generally above the level of concern but does not exceed the toxicity threshold. Selenium in Wetland 1 has decreased to less than the level of concern since April 2005. Selenium in Wetland 2 water has never exceeded the level of concern.

Selenium in sediment collected from Wetland 1 and Wetland 2 is below the level of concern for sediment (2 milligrams per kilogram [mg/kg]). Selenium in sediment samples from Wetland 3 and the Sediment Pond occasionally exceeded the level of concern but rarely exceeded the toxicity threshold for sediment (4 mg/kg). Except for the initial sampling at the Sediment Pond, the geometric mean for selenium in Wetland 3 and the Sediment Pond does not exceed the level of concern for sediment.

8.3 Macroinvertebrate Results

Figure 40 provides bar graphs showing the selenium concentration in aquatic macroinvertebrate samples collected in Wetlands 1, 2, and 3 and the Sediment Pond since spring 2005. Error bars represent one deviation of the geometric mean. Among samples collected by kicknet, Wetland 3 has the highest selenium results, with geometric means that approach or slightly exceed the 7 mg/kg dry weight toxicity threshold for protection of fish and wildlife. At the Sediment Pond, selenium content of individual samples and the geometric mean are consistently above the level of concern. Only one sample from the Sediment Pond (April 2007, approximately 8 mg/kg) exceeded the toxicity threshold. Wetlands 1 and 2 were sampled only in spring 2005 for aquatic insects. Two samples from Wetland 1, containing 3.1 and 3.5 mg/kg selenium, marginally

exceeded the level of concern (3 mg/kg). The geometric mean for the Wetland 1 samples (2.6 mg/kg) did not exceed the level of concern. Wetland 2 samples were each less than the level of concern. All aquatic insect samples collected at the Sediment Pond using artificial substrate devices contained selenium in excess of the level of concern. Two of three samples collected by this method (approximately 11 and 13 mg/kg selenium) in 2006 exceeded the toxicity threshold.

8.4 Summary of Avian Surveys

The avian survey conducted in 2005 focused on all bird species observed in the area of the wetlands and Sediment Pond. The large majority of species identified in the 2005 survey had no direct dependence on the wetlands or Sediment Pond habitat. The survey conducted in 2006 focused on bird types more directly dependent on wetland or open-water habitat. Primary observations from the 2005 and 2006 surveys are:

- Federally listed endangered, threatened, or candidate species were not identified in either the 2005 or 2006 survey (or in the 1998 baseline ecological risk analysis for OU III [DOE 1998a]).
- State-sensitive species were not identified in either the 2005 or 2006 survey (or in the 1998 baseline ecological risk analysis for OU III [DOE 1998a]).
- Several species of migratory birds were identified in the 2005 or the 2006 survey (Canada goose, red-tailed hawk, red-winged blackbird, and common snipe).
- Red-winged blackbirds, in flocks commonly greater than 50 individuals, are the most abundant species and utilize the wetland habitat throughout the spring and summer.
- Killdeer were observed at Wetland 3 during the 2005 and 2006 surveys.
- Soras were heard at each wetland and the Sediment Pond; one known nesting pair was identified at Wetland 1.
- White-face ibis were observed in low abundance or as individuals within the first 2 weeks of May in 2005 (at Wetlands 1, 2, and 3) and 2006 (at Wetlands 2, 3, and the Sediment Pond).
- Several species of ducks were commonly observed at Wetland 3 and the Sediment Pond. Sightings include individuals, pairs, and small flocks of up to five or six individuals.
- Waterfowl nesting in 2006 was limited to two pairs of mallards and Canada goose at the Sediment Pond.
- Far greater abundance and diversity of ducks are observed at the municipal wastewater lagoons, located less than one-half mile northwest of the Sediment Pond, than at the Wetlands or Sediment Pond. Canada geese are also more abundant at the wastewater lagoons.

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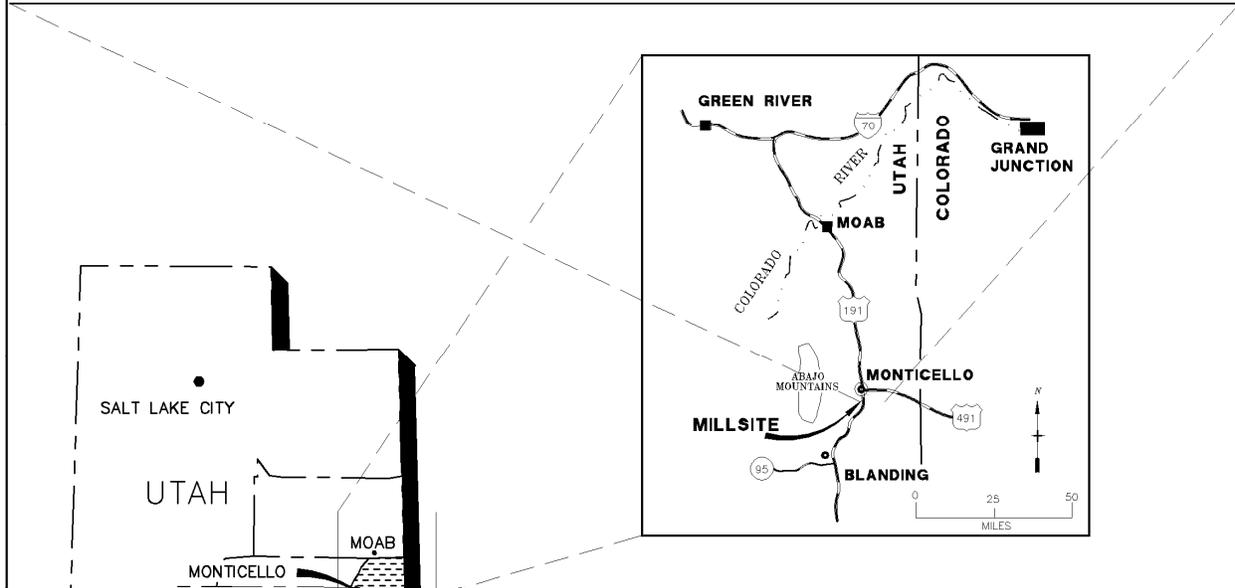
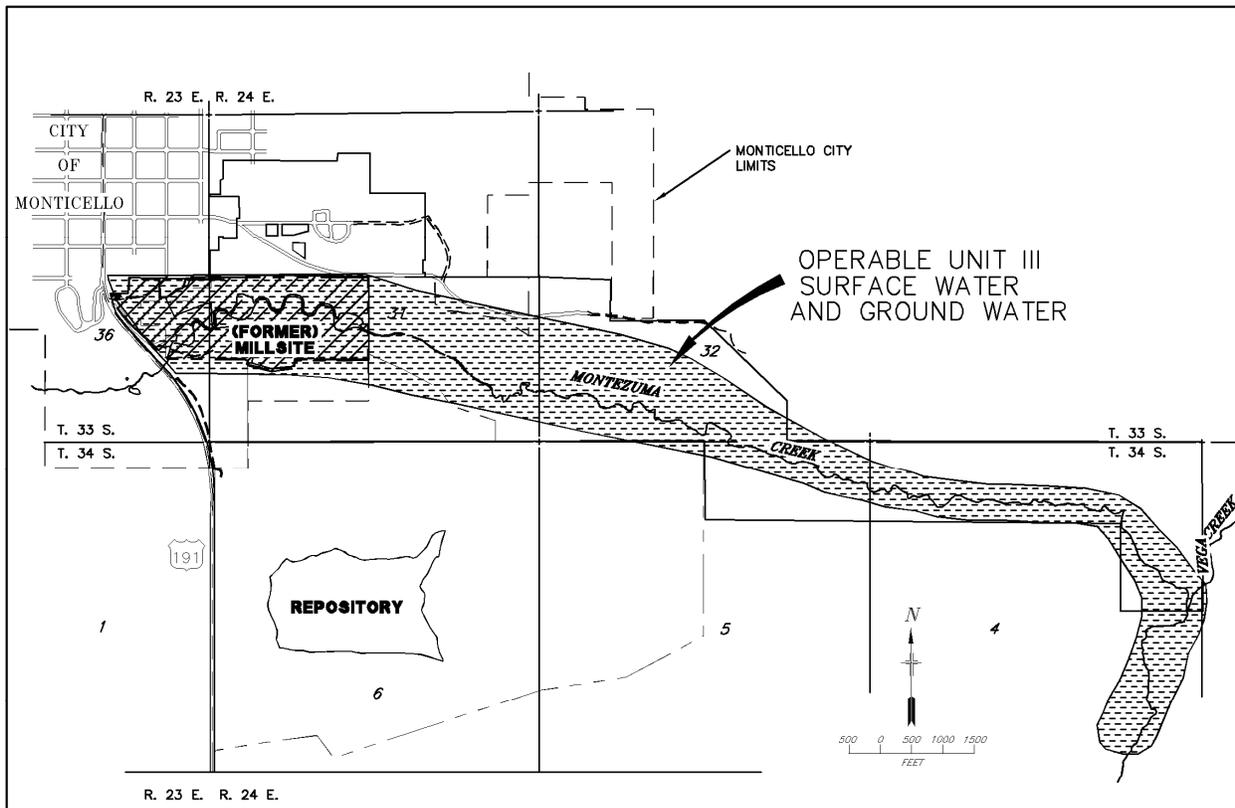
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U.S. DEPARTMENT OF ENERGY GRAND JUNCTION, COLORADO	Work Performed by S.M. Stoller Corporation Under DOE Contract No. DE-AC01-02GJ79491
LOCATION OF THE MONTICELLO MILL TAILINGS SITE	
DATE PREPARED: SEPTEMBER 12, 2007	FILENAME: S0185900

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Figure 1. Location of Monticello Mill Tailings Site

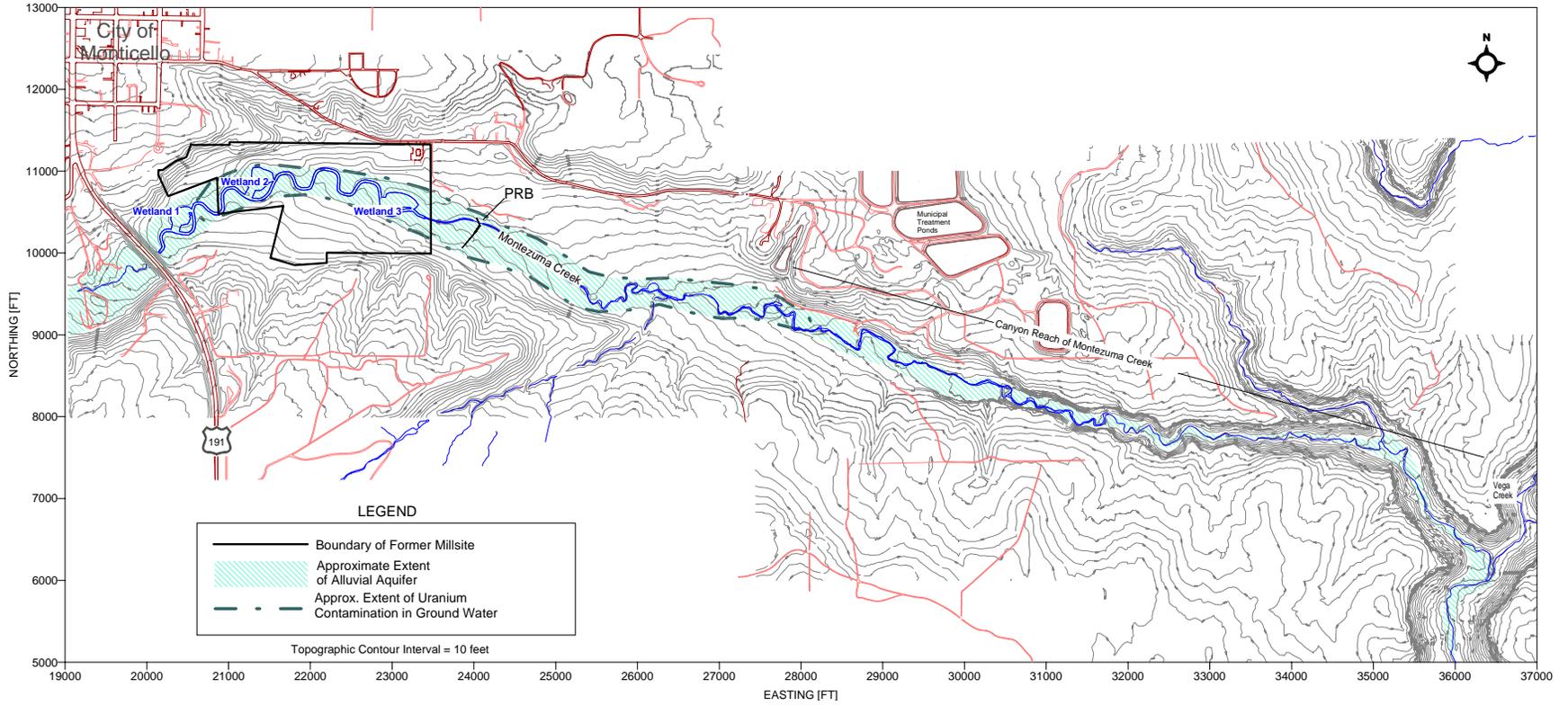


Figure 2. Site Area Features

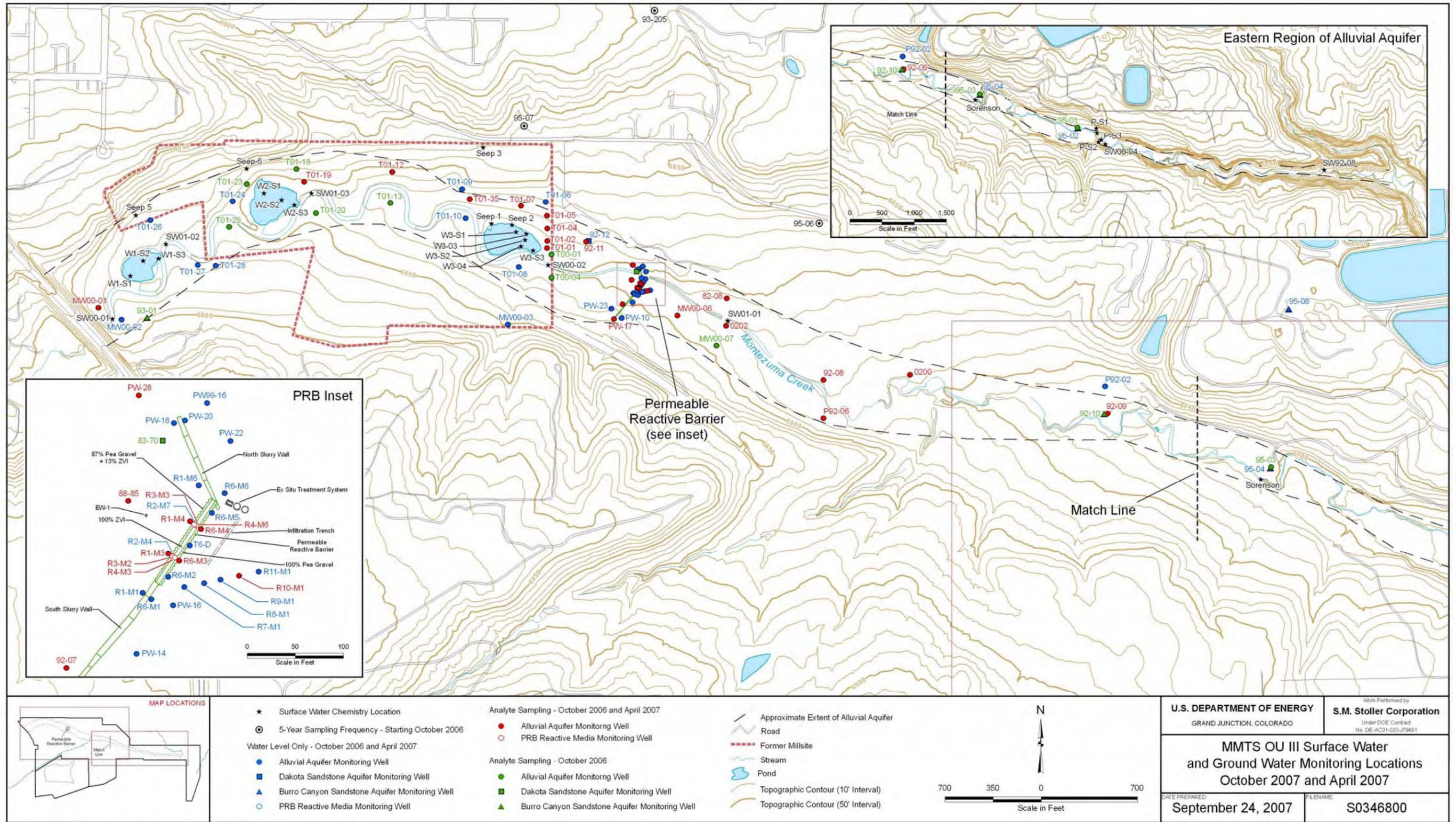


Figure 3. Reference Map for OU III Water Quality Monitoring Locations, April 2007

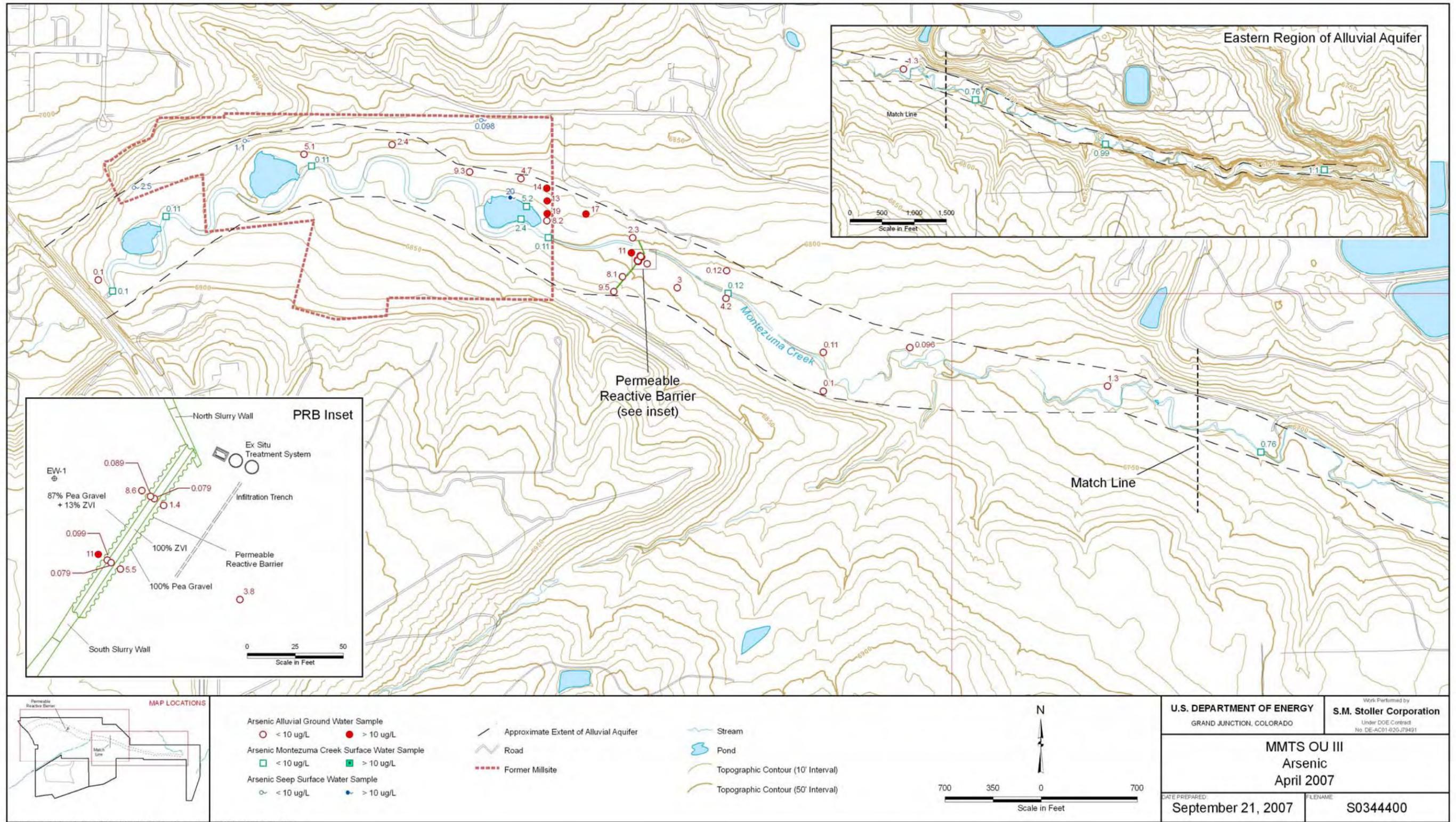


Figure 4. Distribution of Arsenic in Surface Water and Alluvial Aquifer Ground Water, April 2007

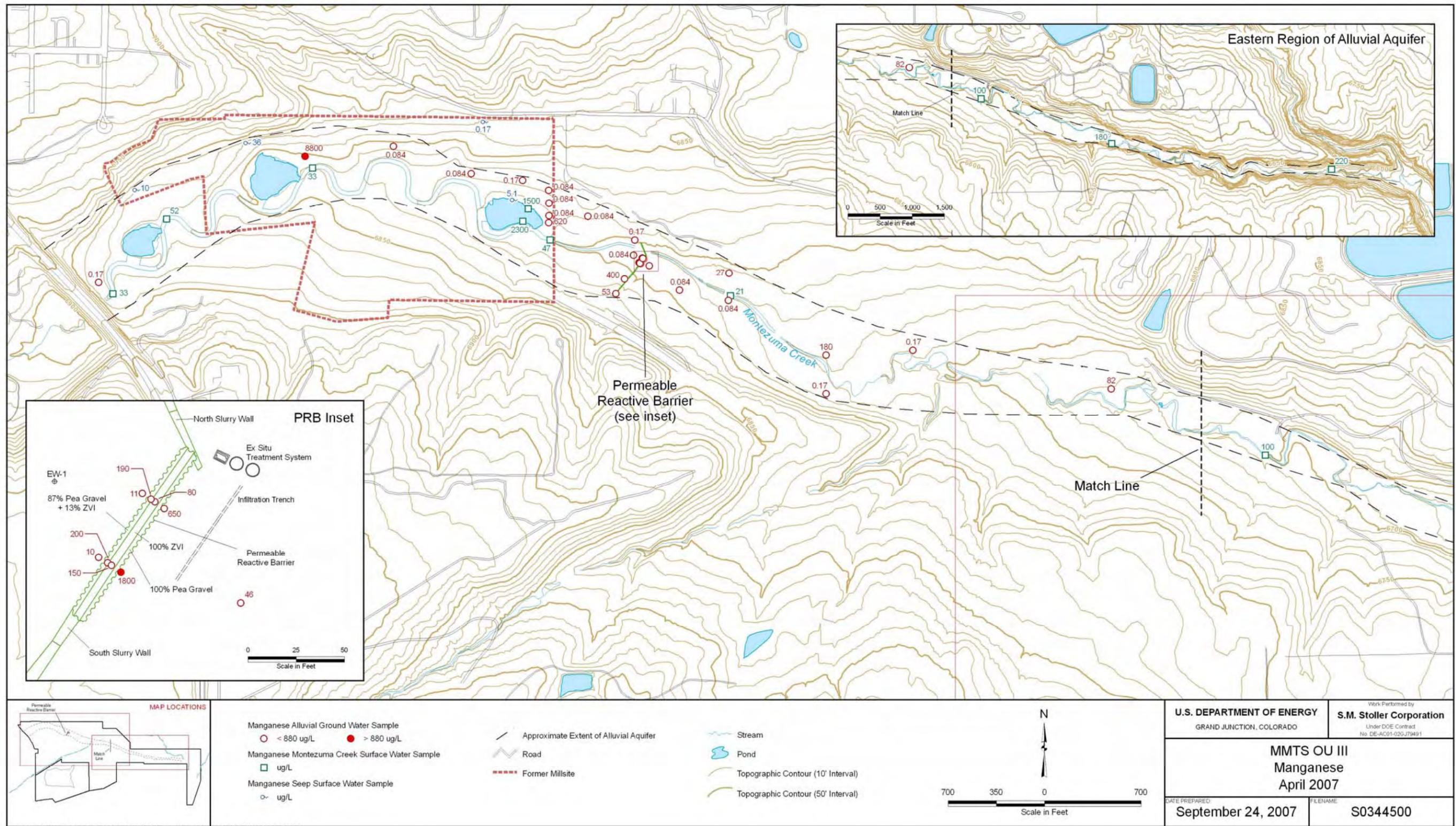


Figure 5. Distribution of Manganese in Surface Water and Alluvial Aquifer Ground Water, April 2007

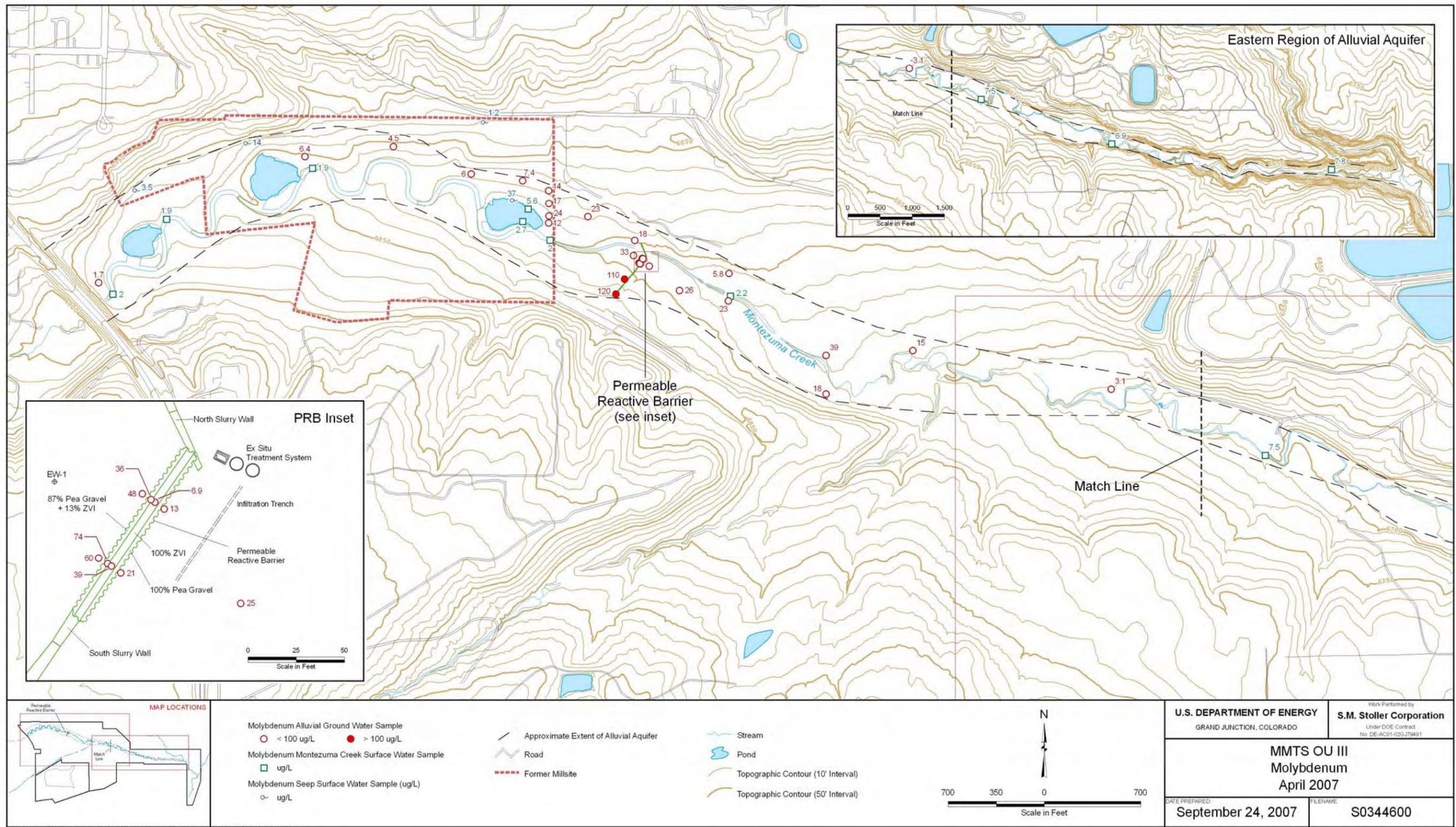


Figure 6. Distribution of Molybdenum in Surface Water and Alluvial Aquifer Ground Water, April 2007

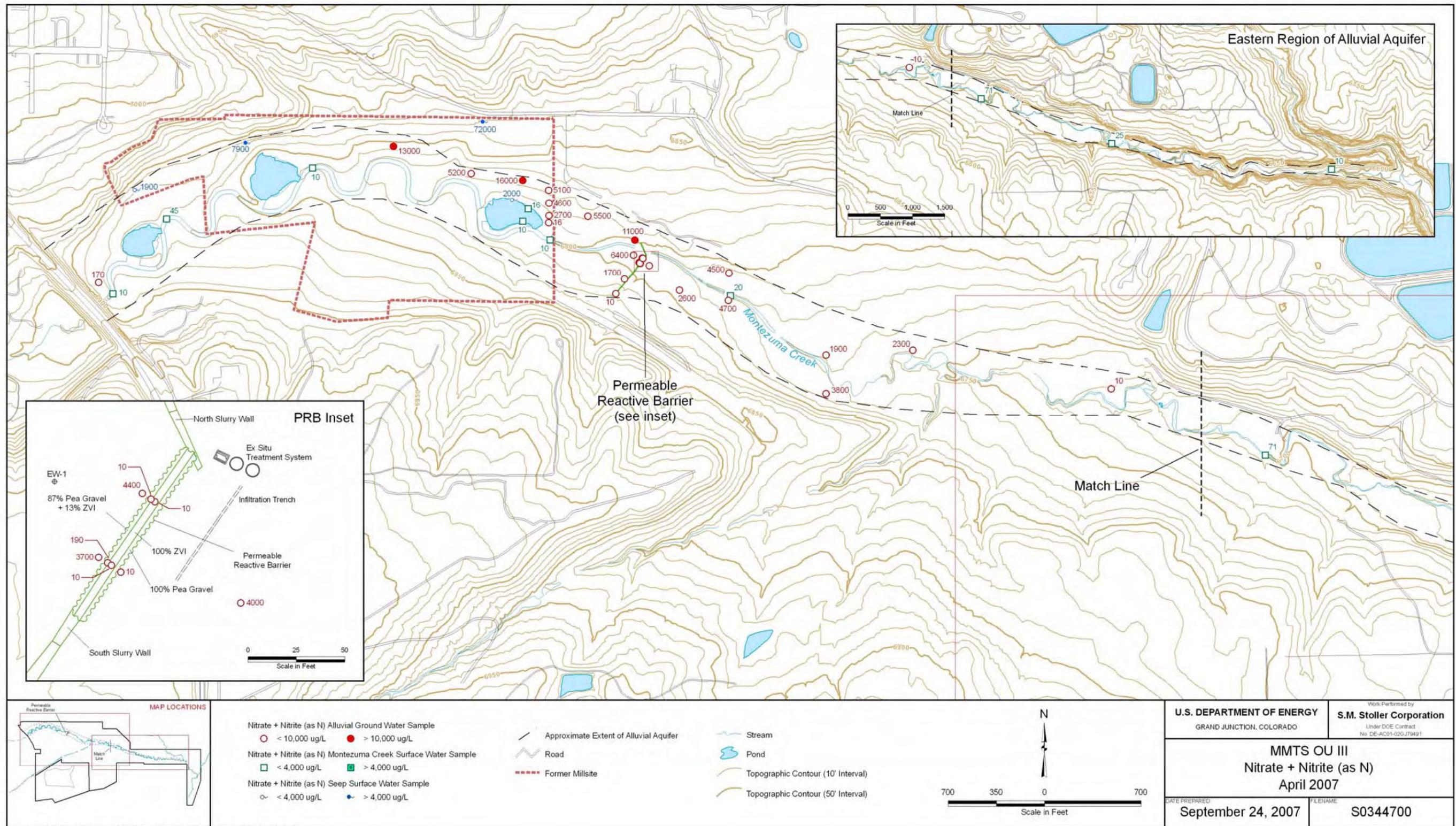


Figure 7. Distribution of Nitrate (as N) in Surface Water and Alluvial Aquifer Ground Water, April 2007

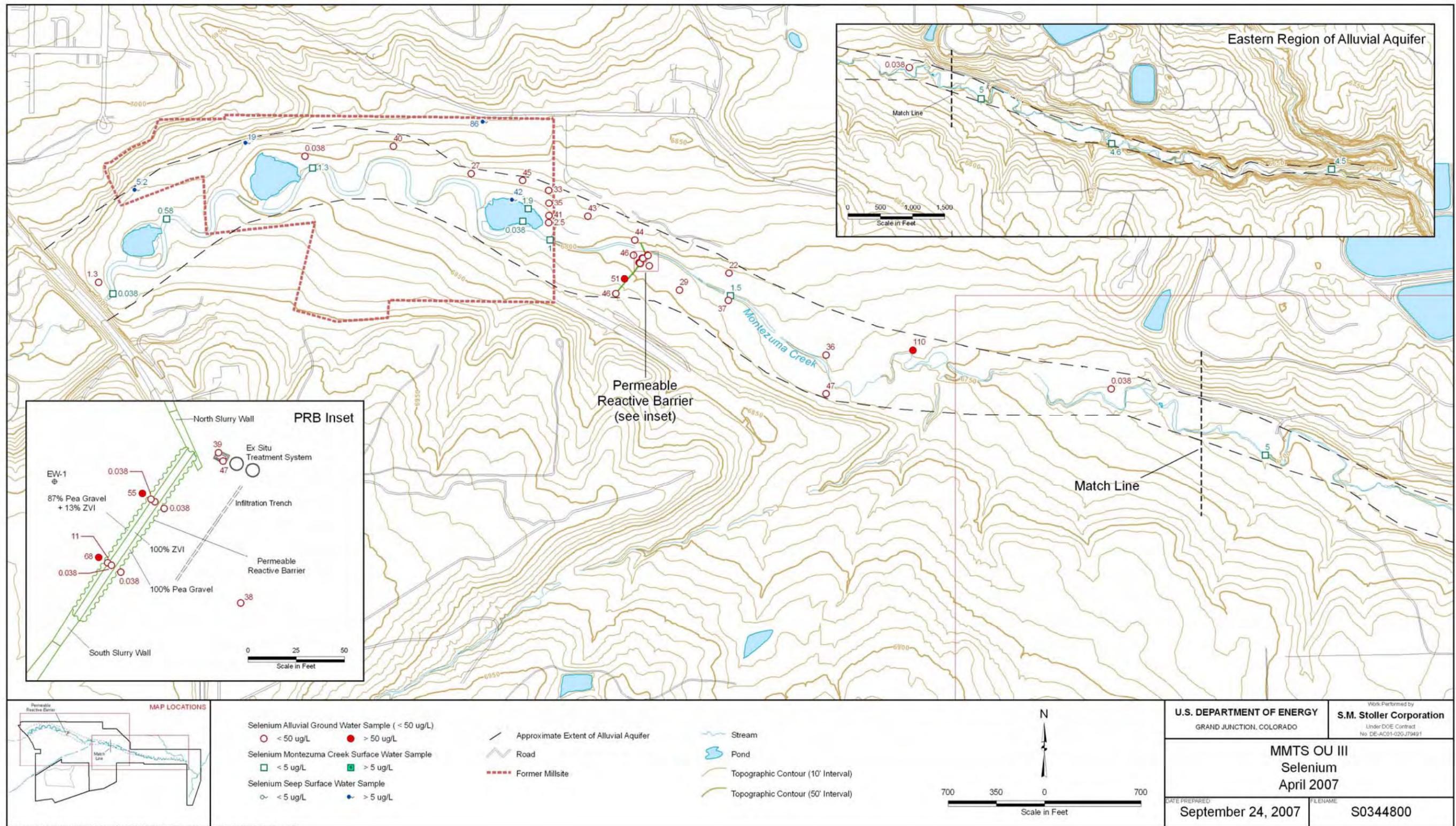


Figure 8. Distribution of Selenium in Surface Water and Alluvial Aquifer Ground Water, April 2007

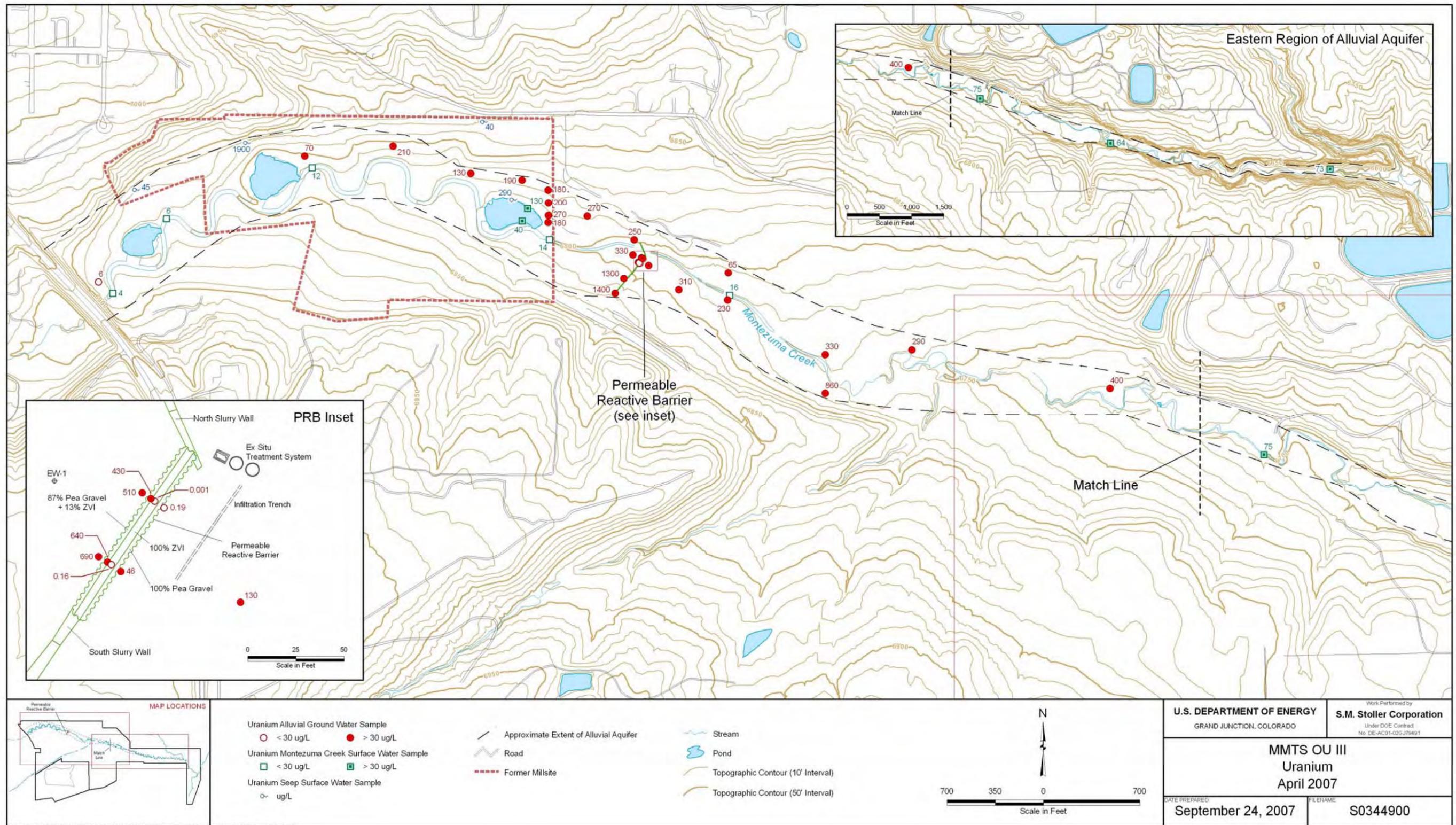


Figure 9. Distribution of Uranium in Surface Water and Alluvial Aquifer Ground Water, April 2007

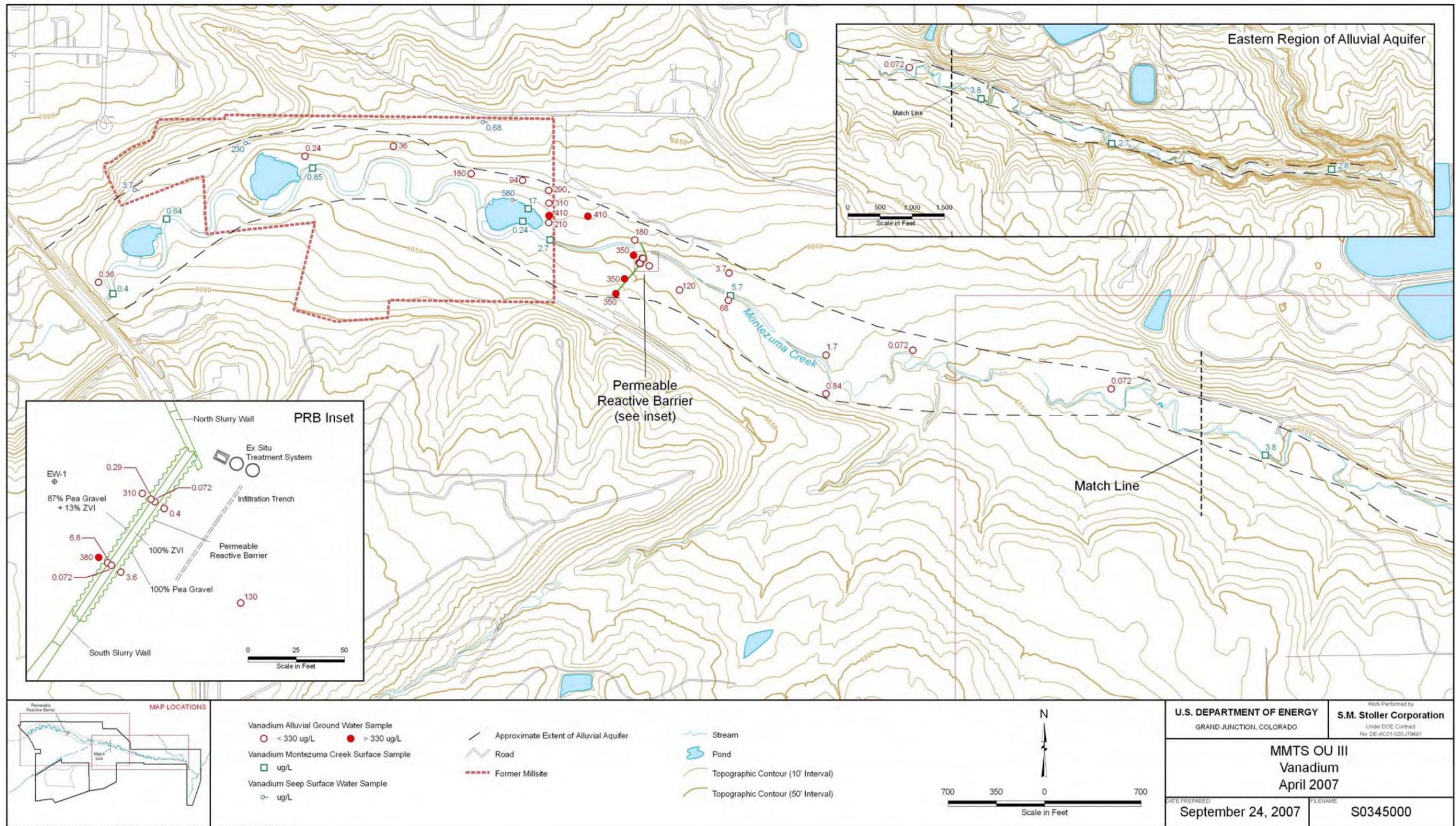


Figure 10. Distribution of Vanadium in Surface Water and Alluvial Aquifer Ground Water, April 2007

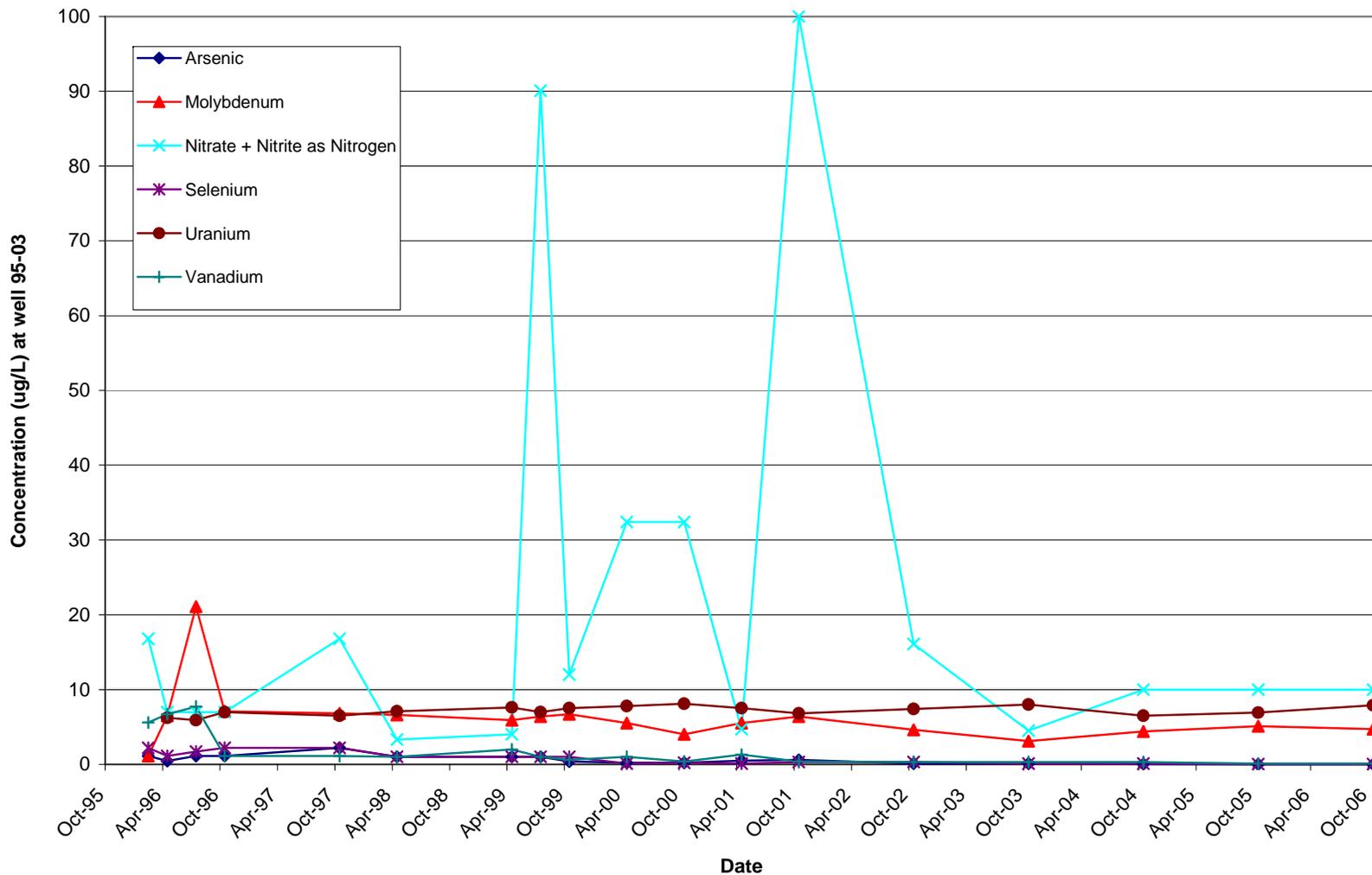


Figure 11. Contaminant Concentrations Over Time at Sentinel Well 95-03

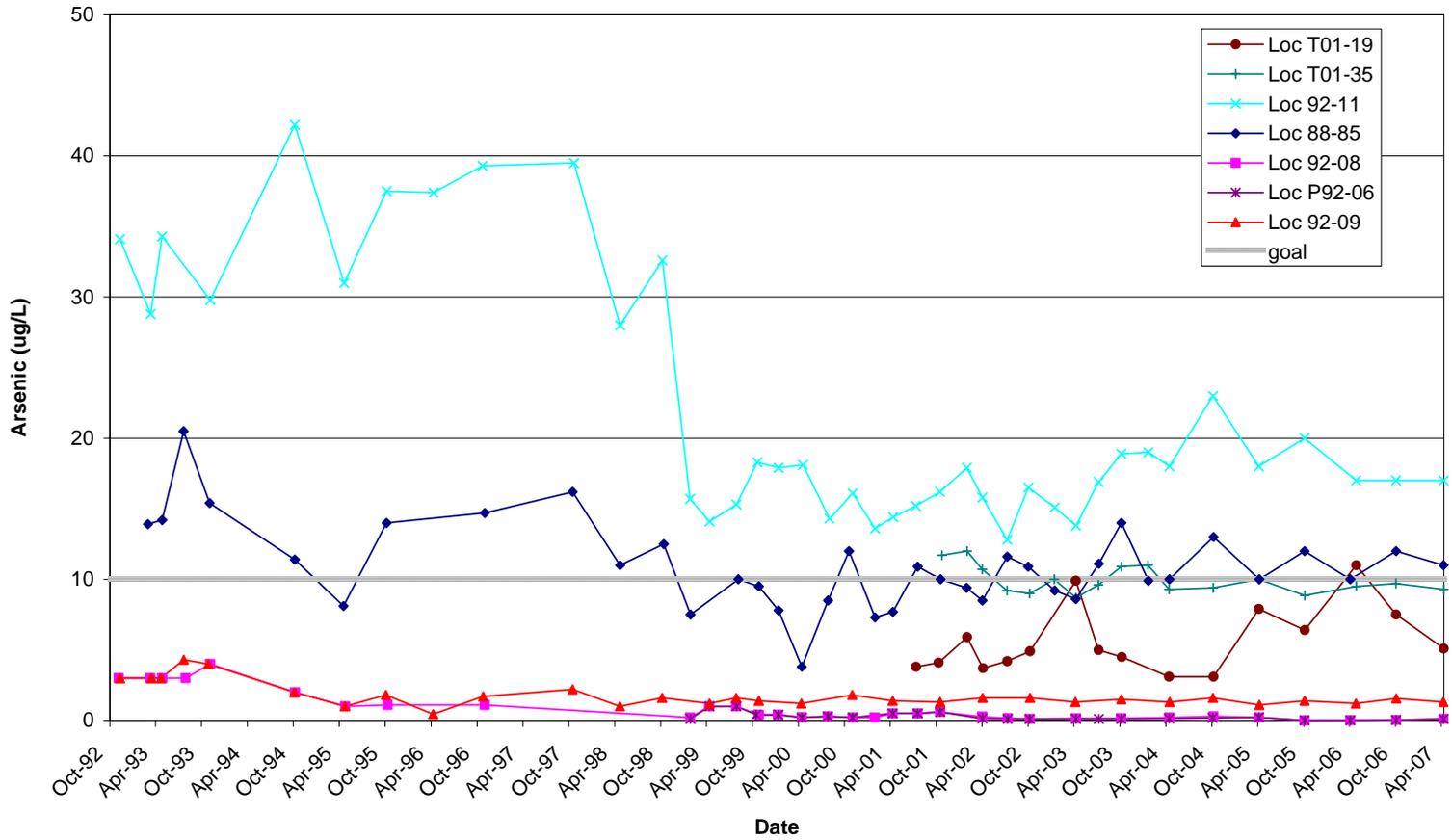


Figure 12. Arsenic Concentration Over Time at Selected Alluvial Aquifer Monitor Wells

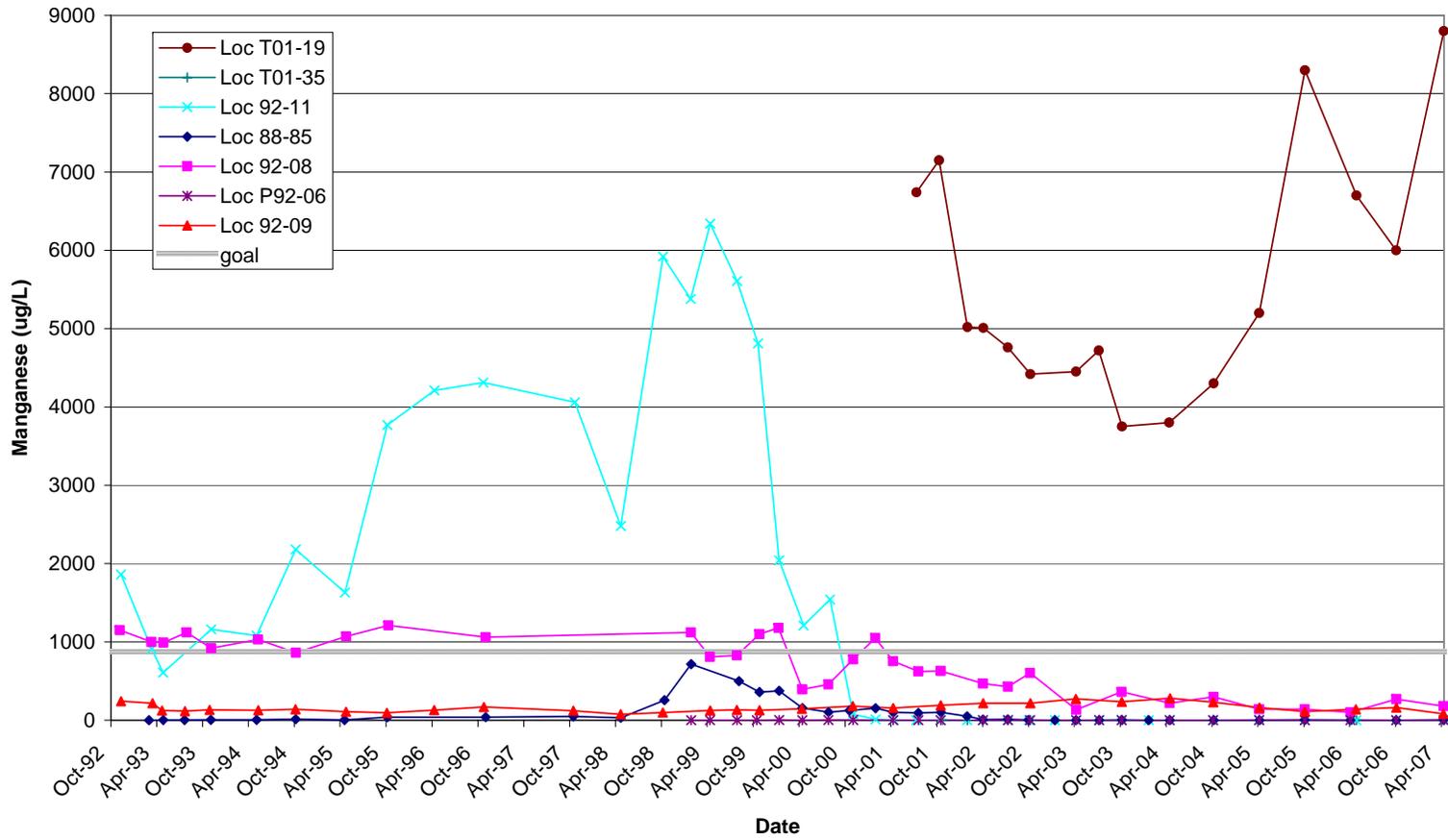


Figure 13. Manganese Concentration Over Time at Selected Alluvial Aquifer Monitor Wells

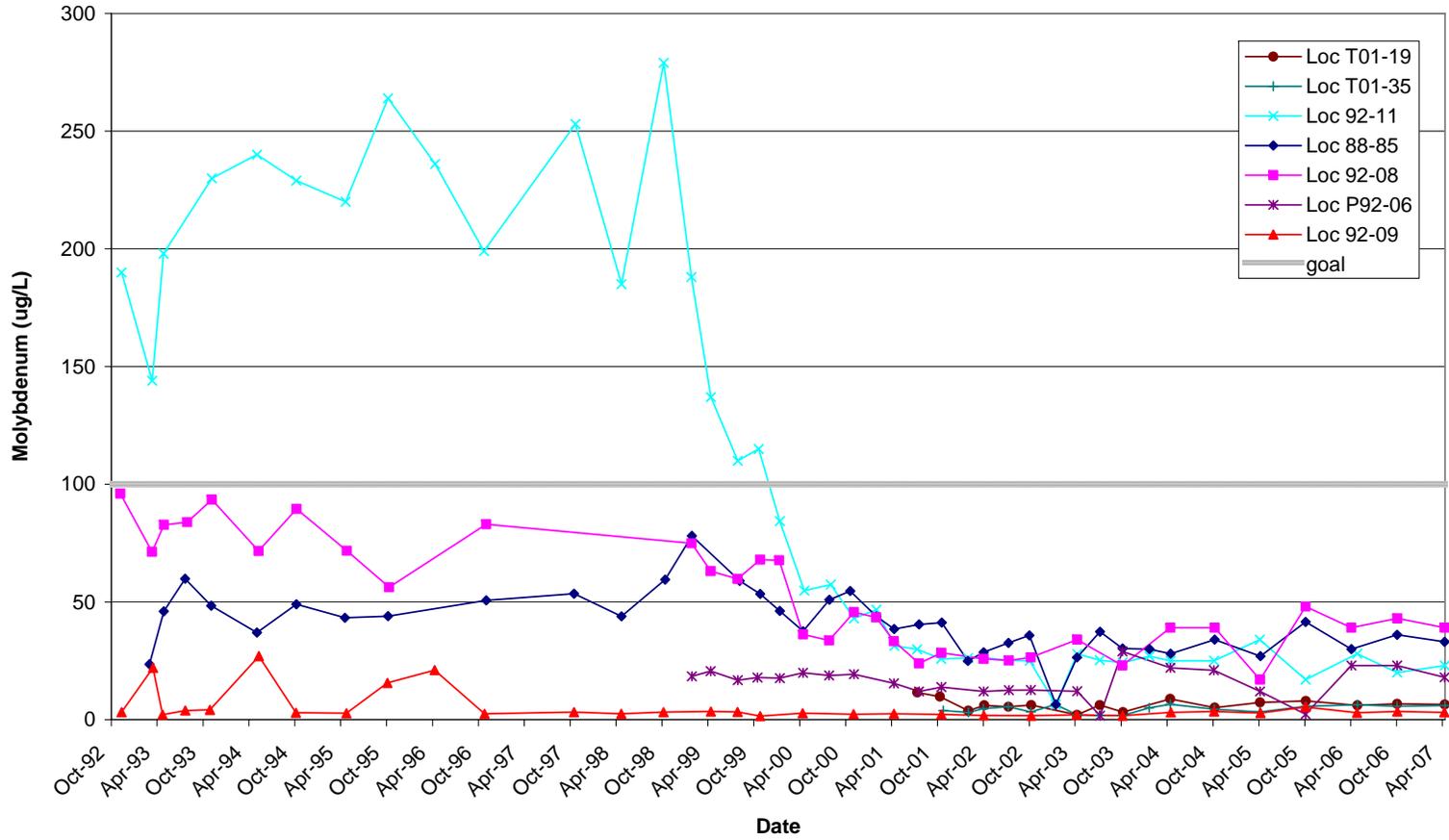


Figure 14. Molybdenum Concentration Over Time at Selected Alluvial Aquifer Monitor Wells

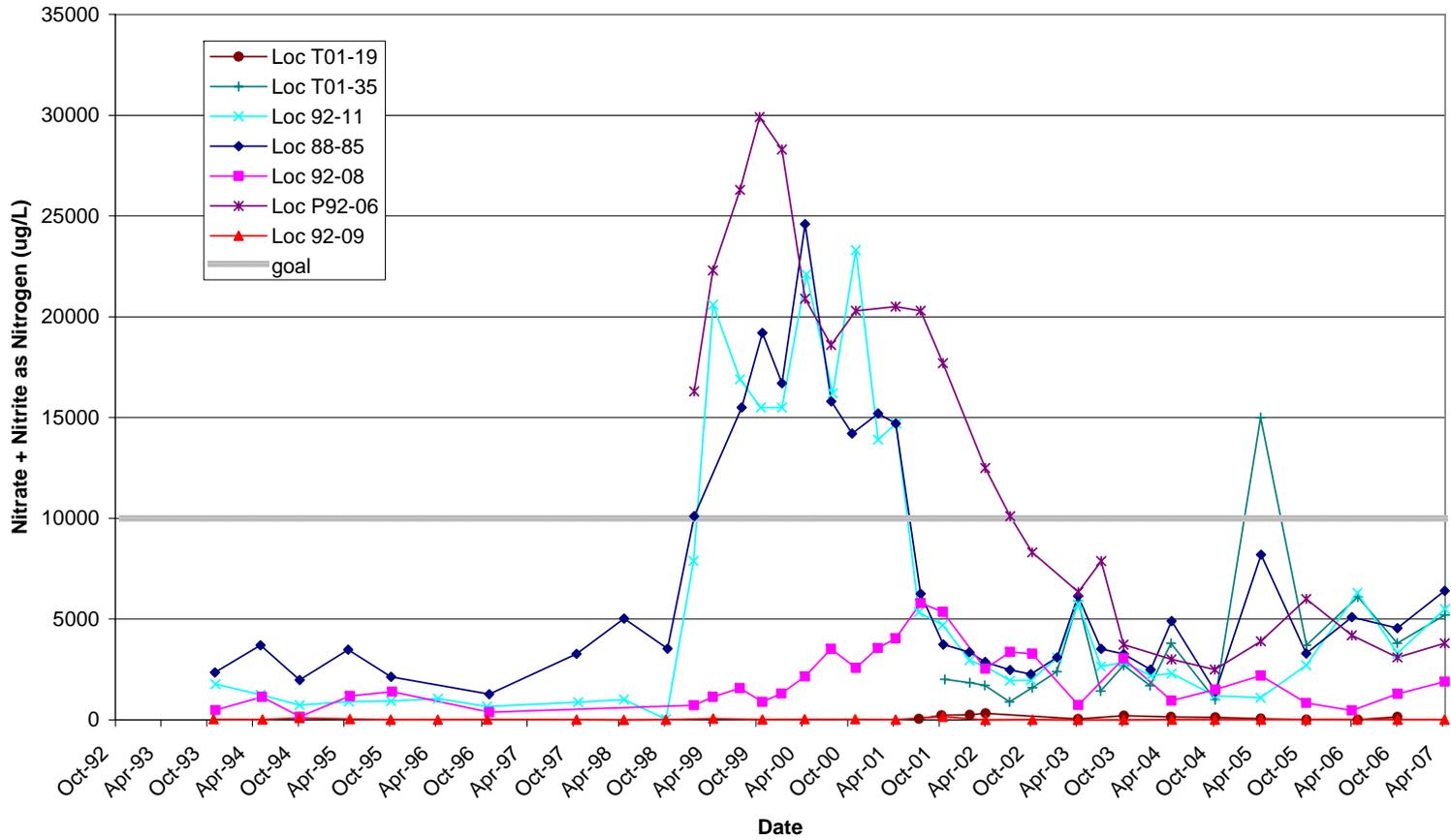


Figure 15. Nitrate (as N) Concentration Over Time at Selected Alluvial Aquifer Monitor Wells

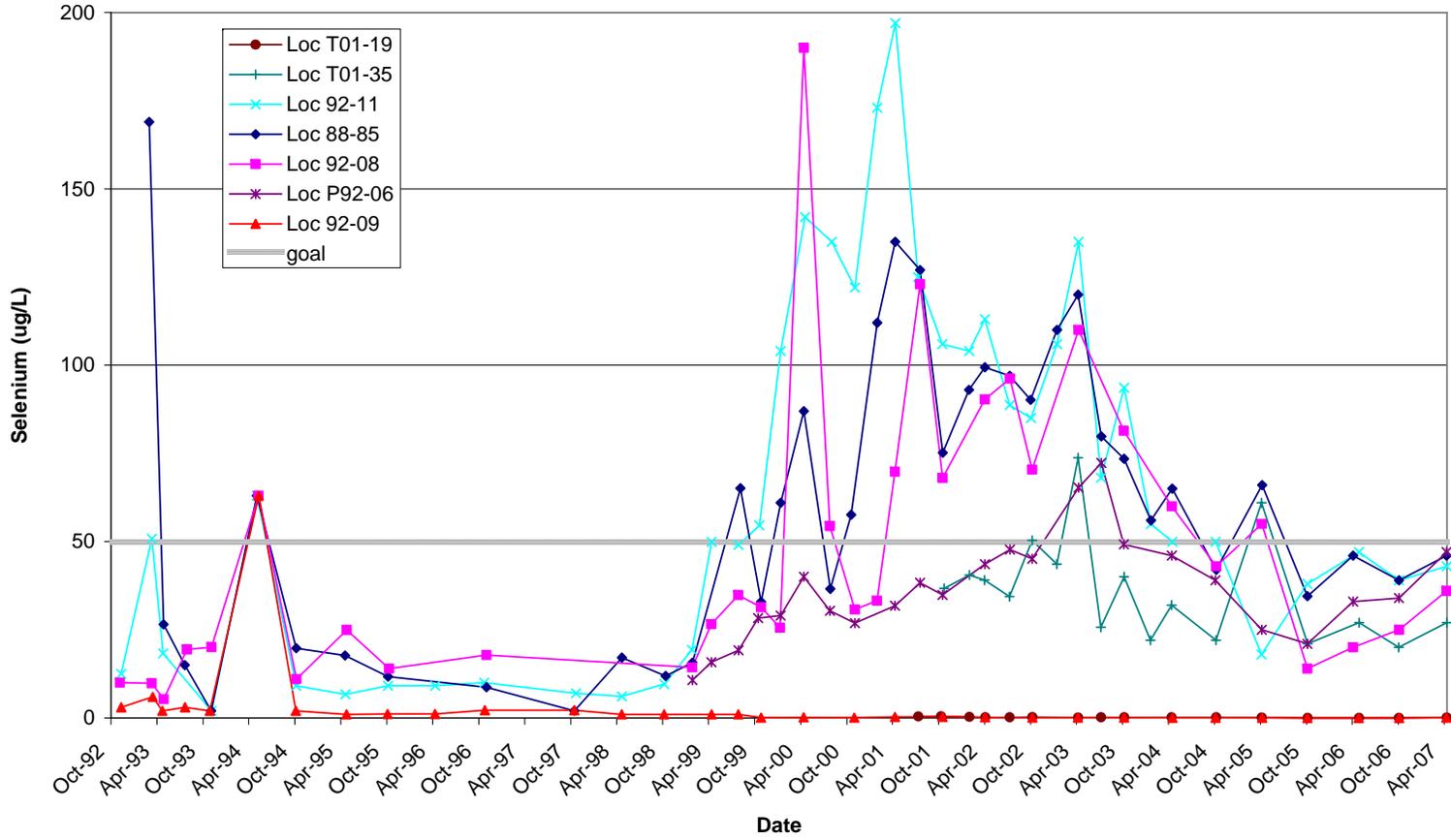


Figure 16. Selenium Concentration Over Time at Selected Alluvial Aquifer Monitor Wells

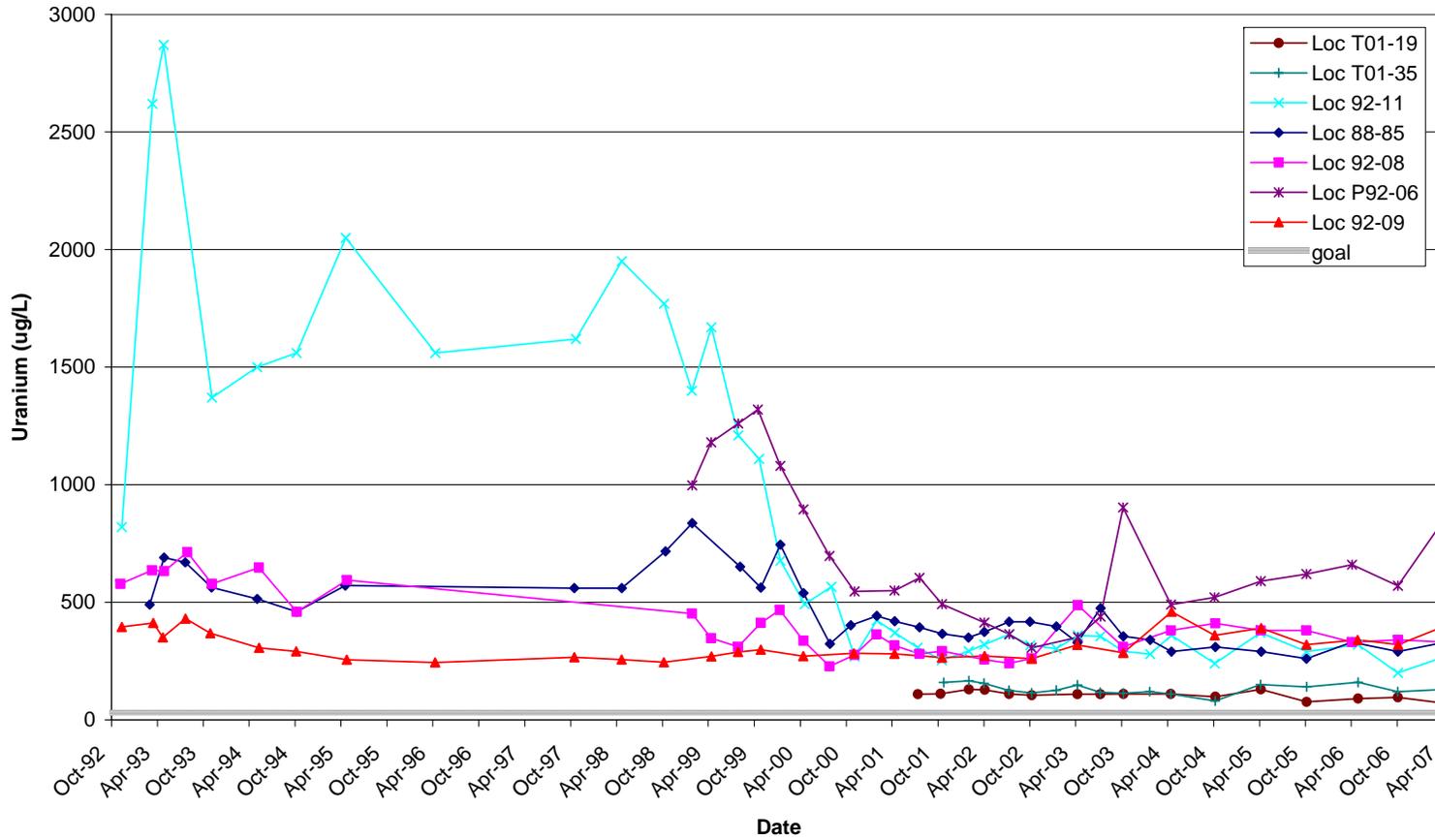


Figure 17. Uranium Concentration Over Time at Selected Alluvial Aquifer Monitor Wells

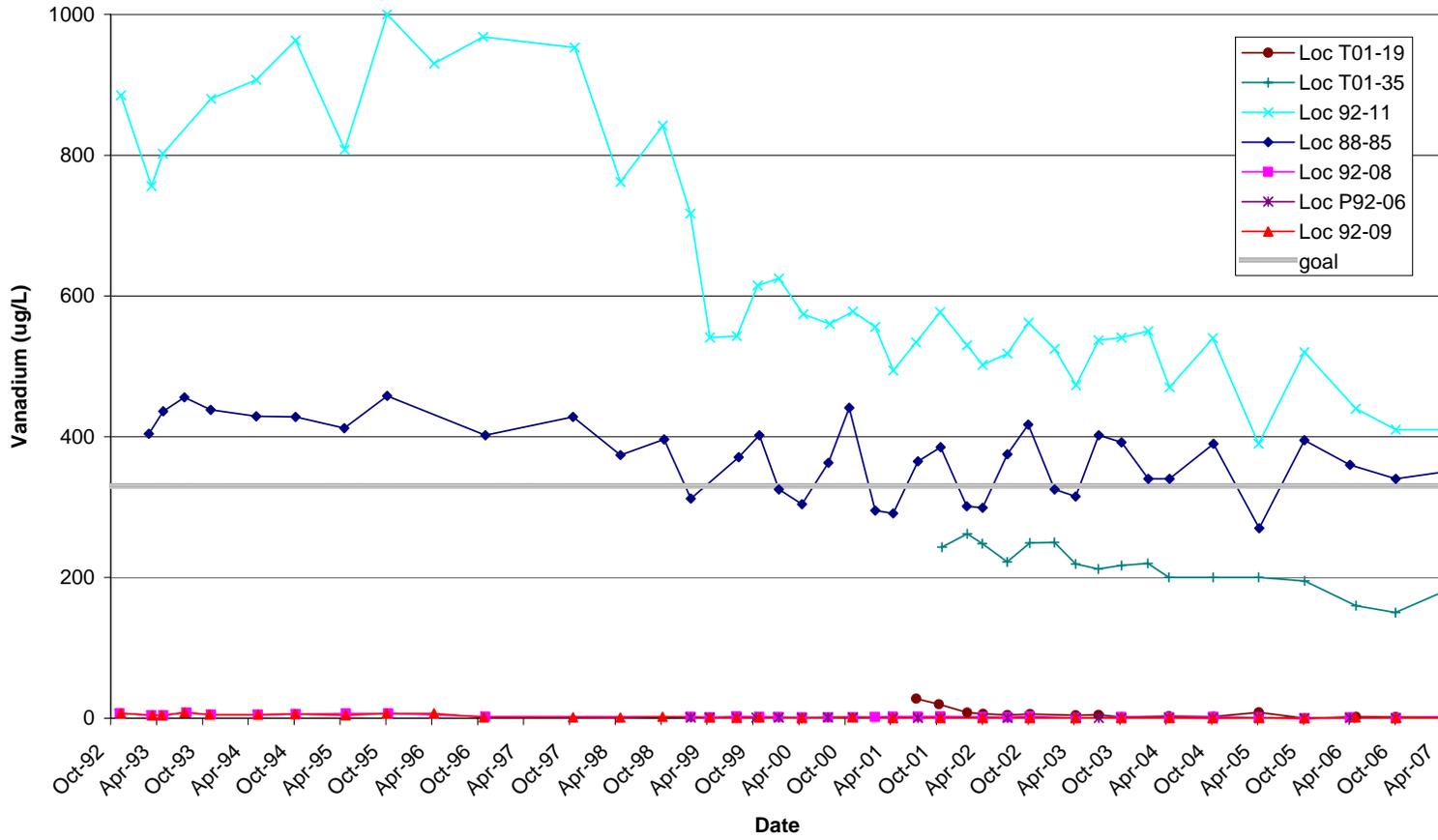


Figure 18. Vanadium Concentration Over Time at Selected Alluvial Aquifer Monitor Wells

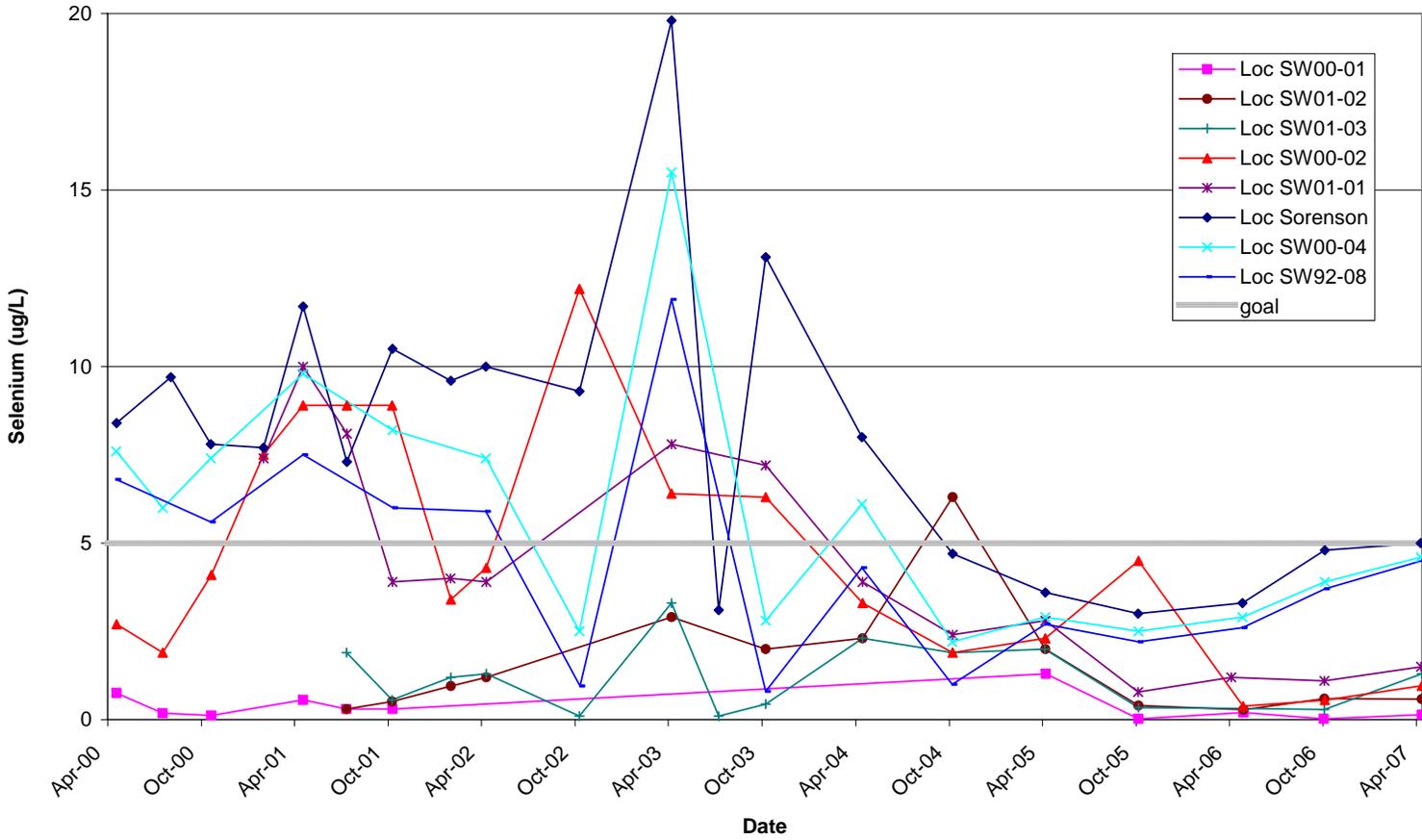


Figure 19. Selenium Concentration Over Time in Montezuma Creek

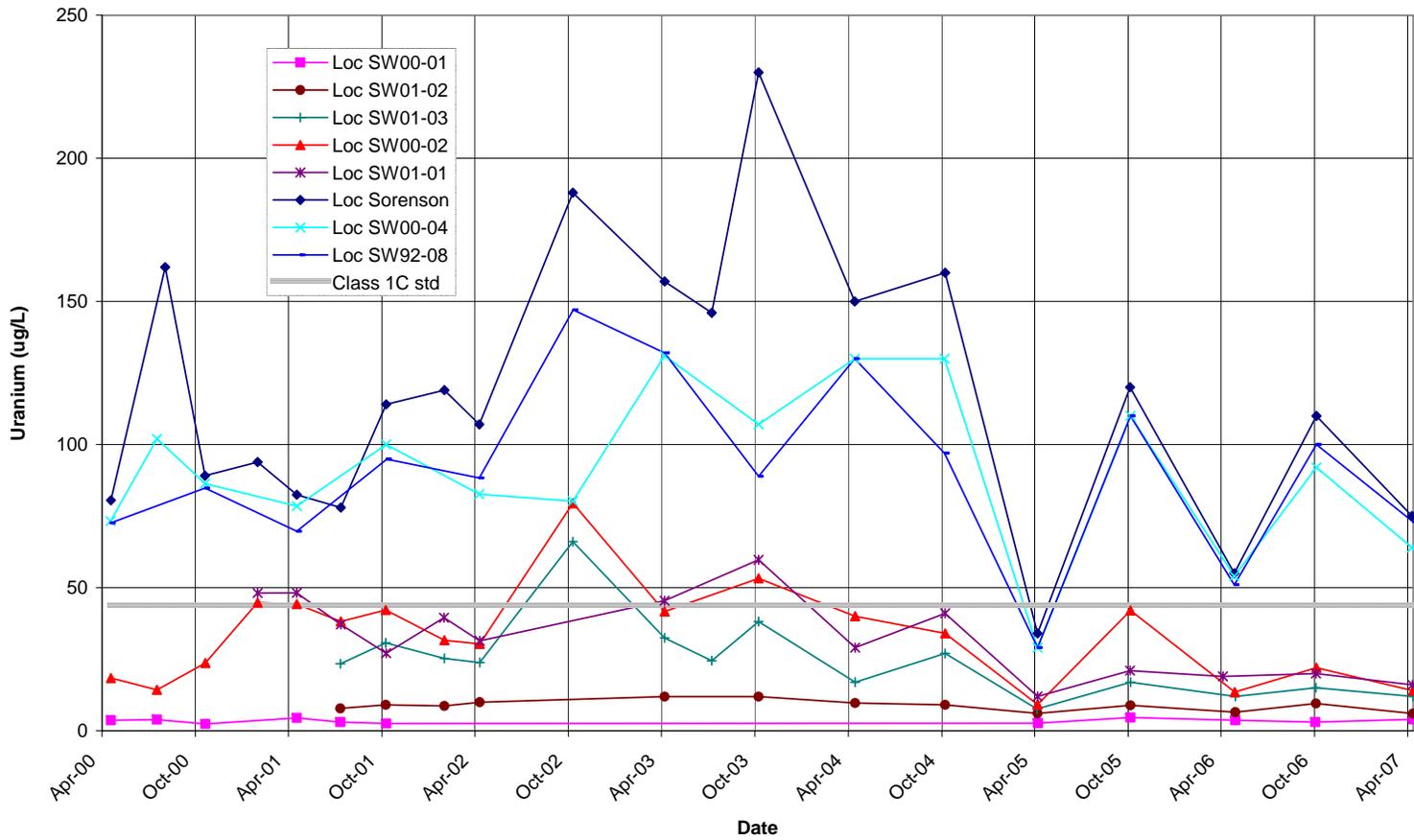


Figure 20. Uranium Concentration Over Time in Montezuma Creek

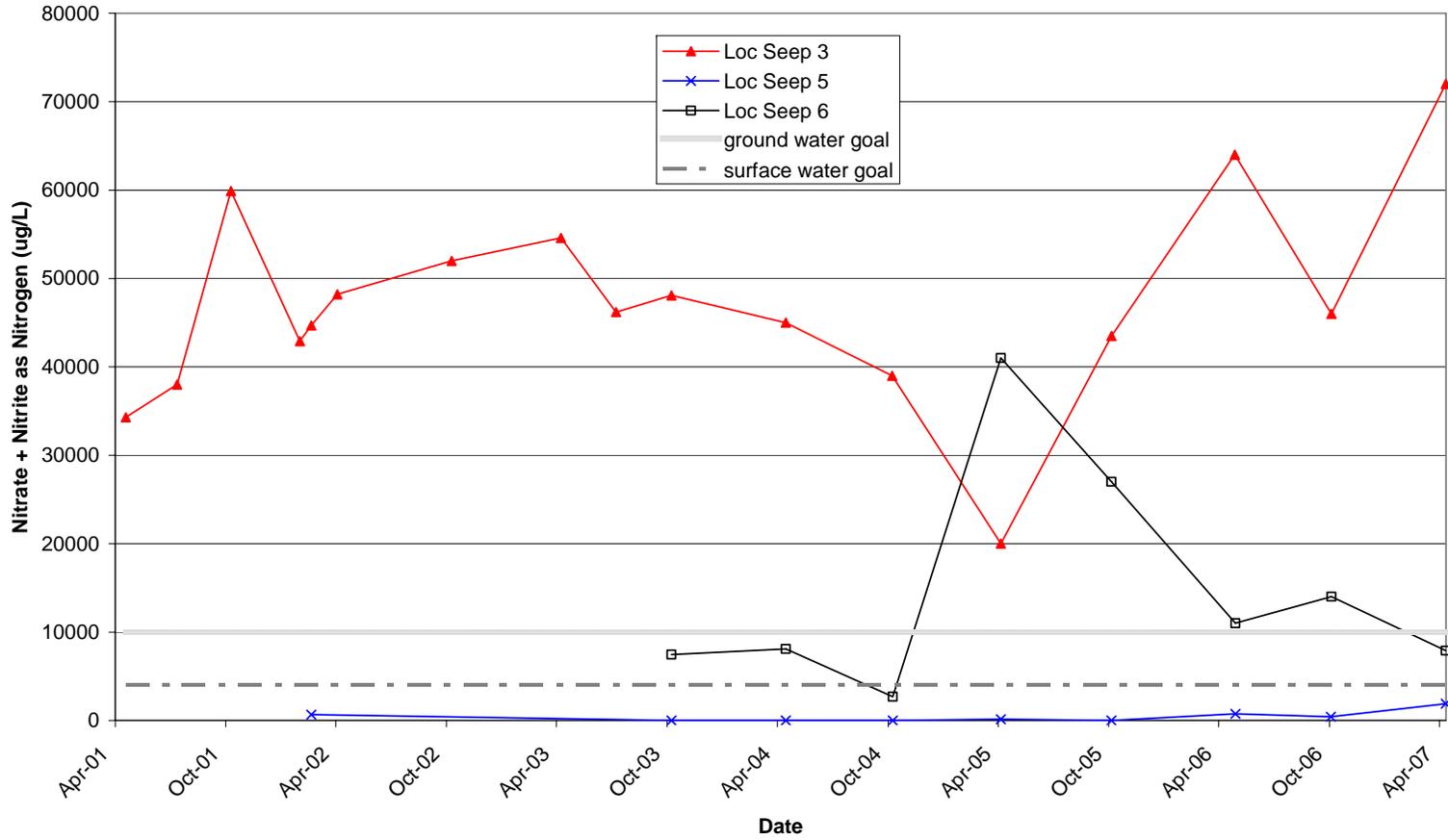


Figure 21. Nitrate (as N) Concentration Over Time at Selected Seep Locations

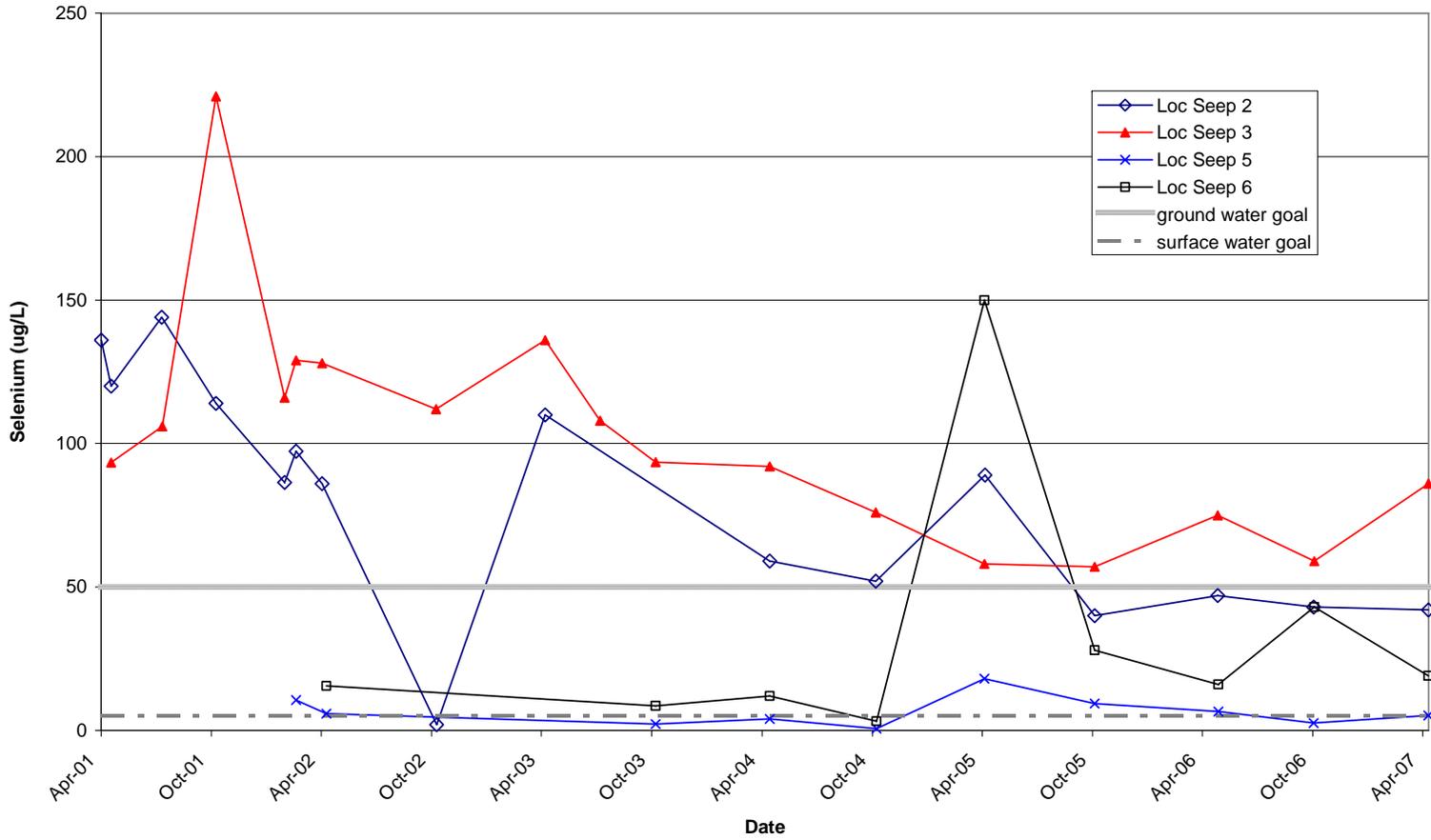


Figure 22. Selenium Concentration Over Time at Selected Seep Locations

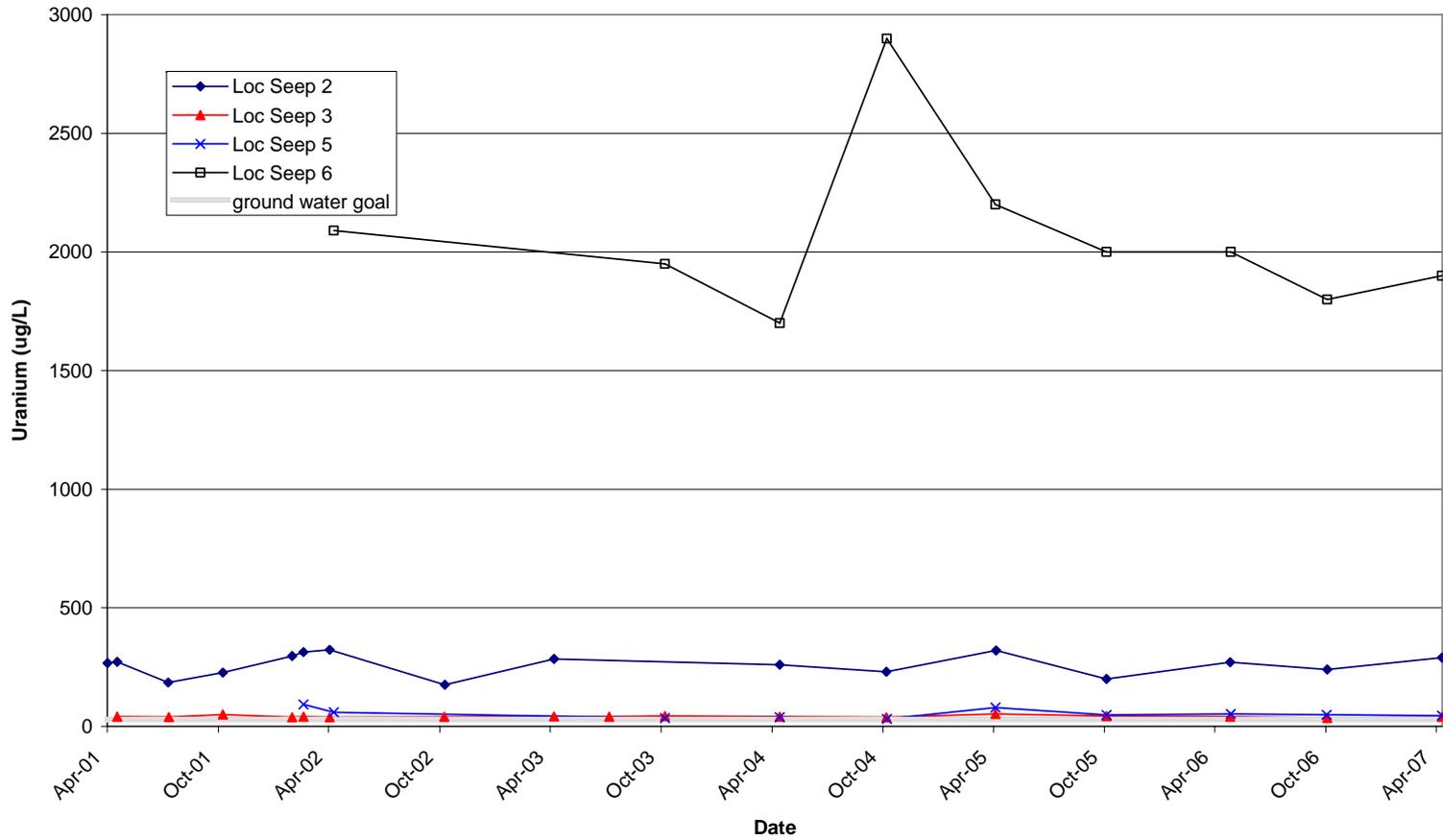


Figure 23. Uranium Concentration Over Time at Selected Seep Locations

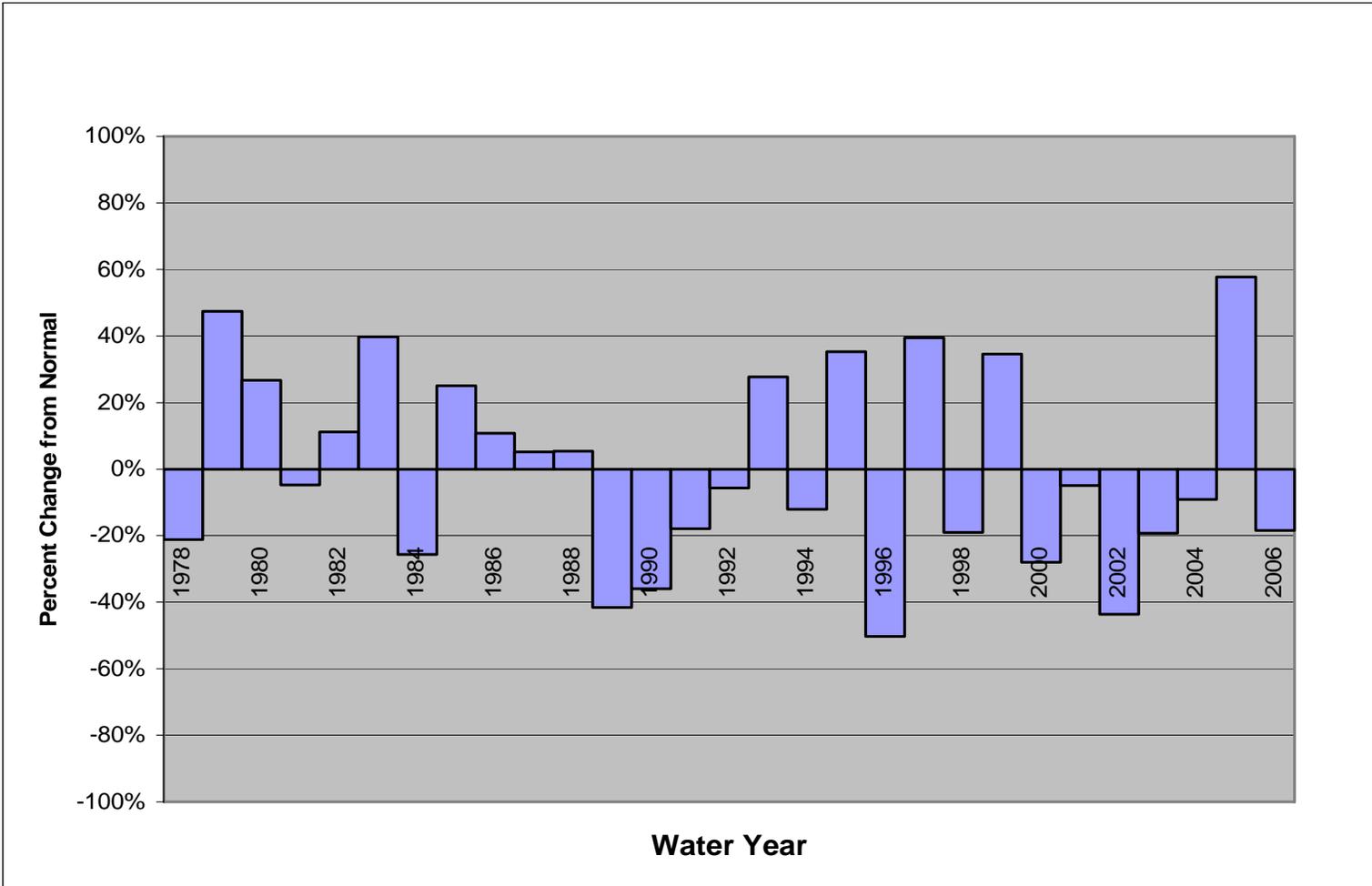


Figure 24. Percent of Yearly Precipitation to 30-Year Average for Monticello, Utah

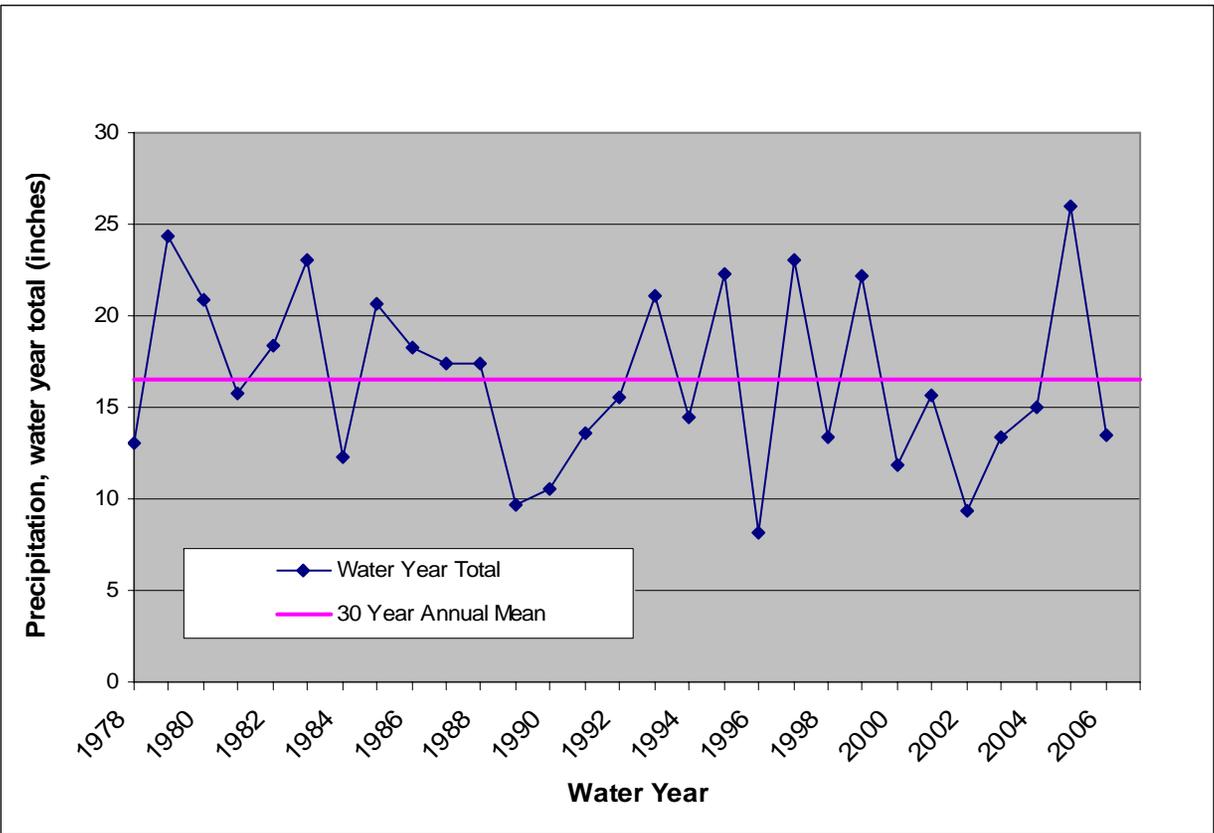


Figure 25. Comparison of Yearly Precipitation to 30-Year Average for Monticello, Utah

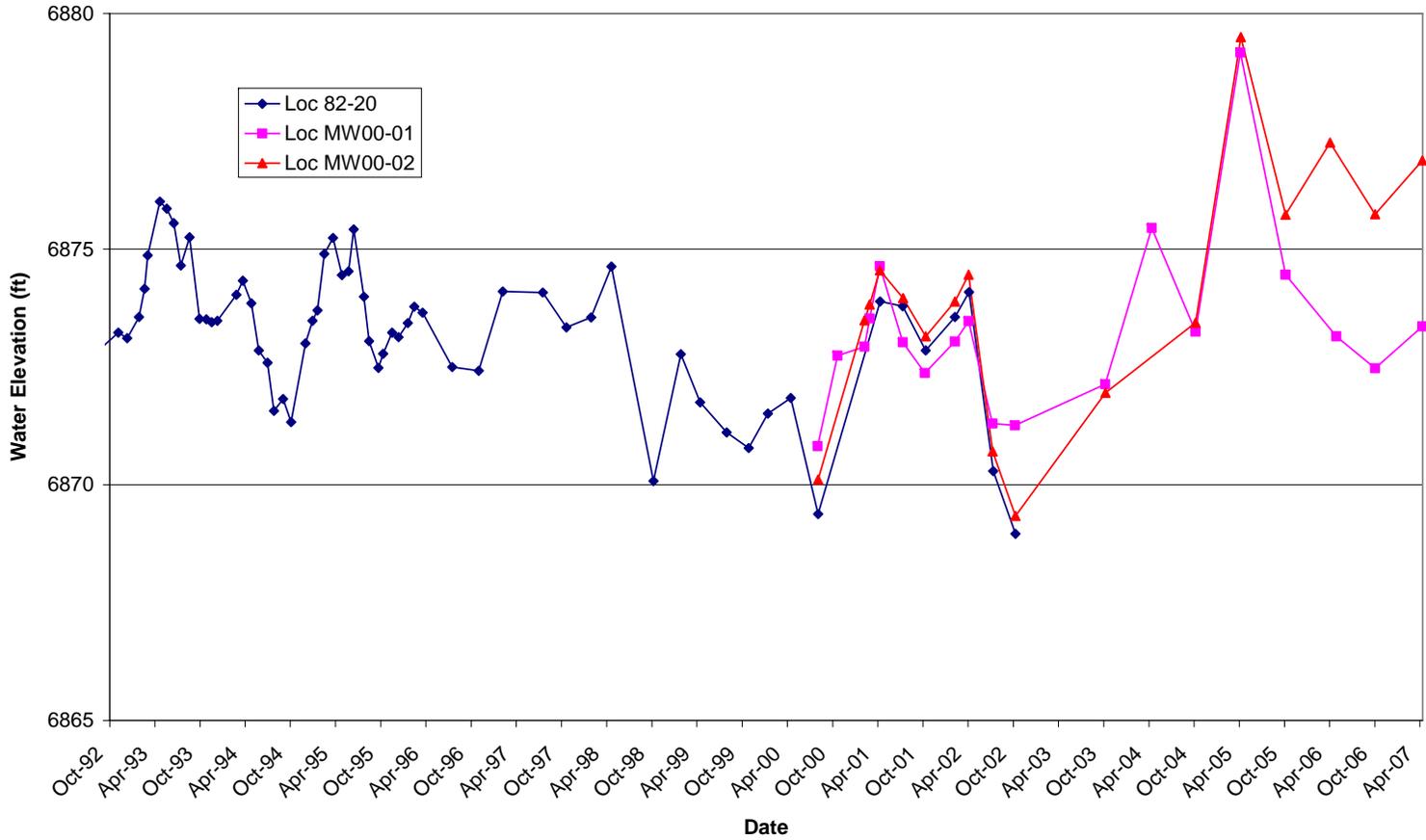


Figure 26. Water Level Hydrographs for Upgradient Alluvial Wells

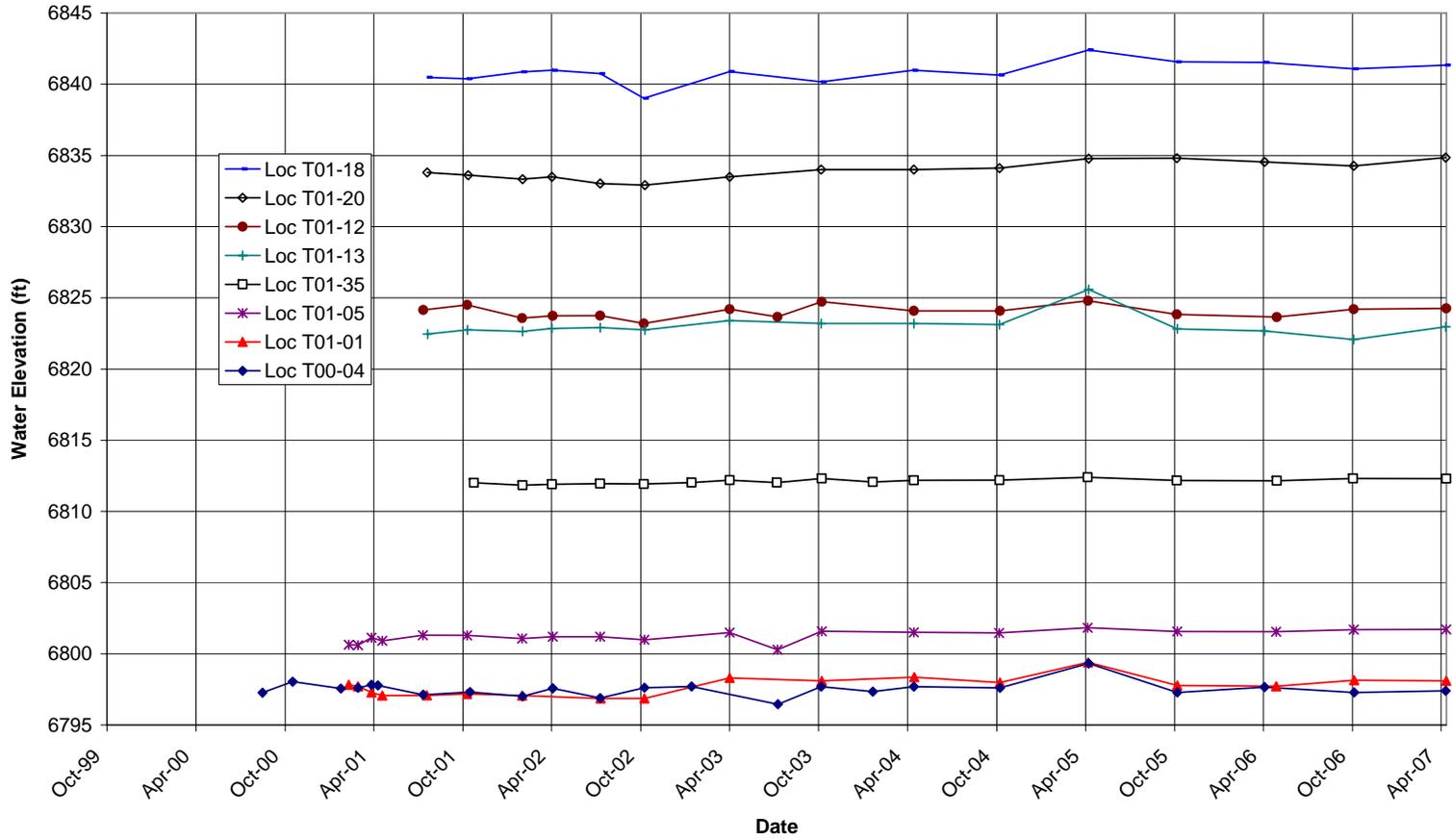


Figure 27. Water Level Hydrographs for Selected Millsite Alluvial Wells

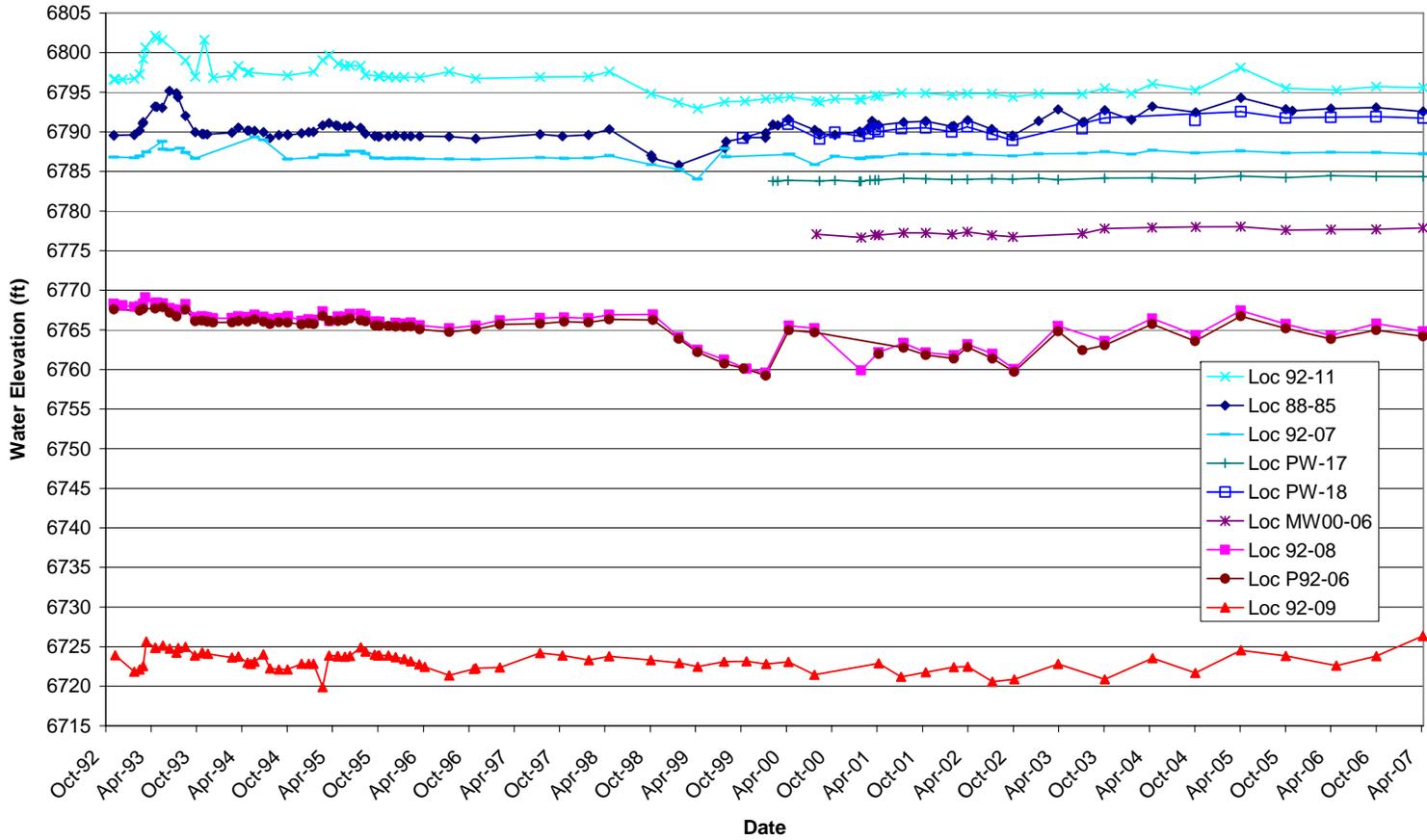


Figure 28. Water Level Hydrographs for Downgradient Wells

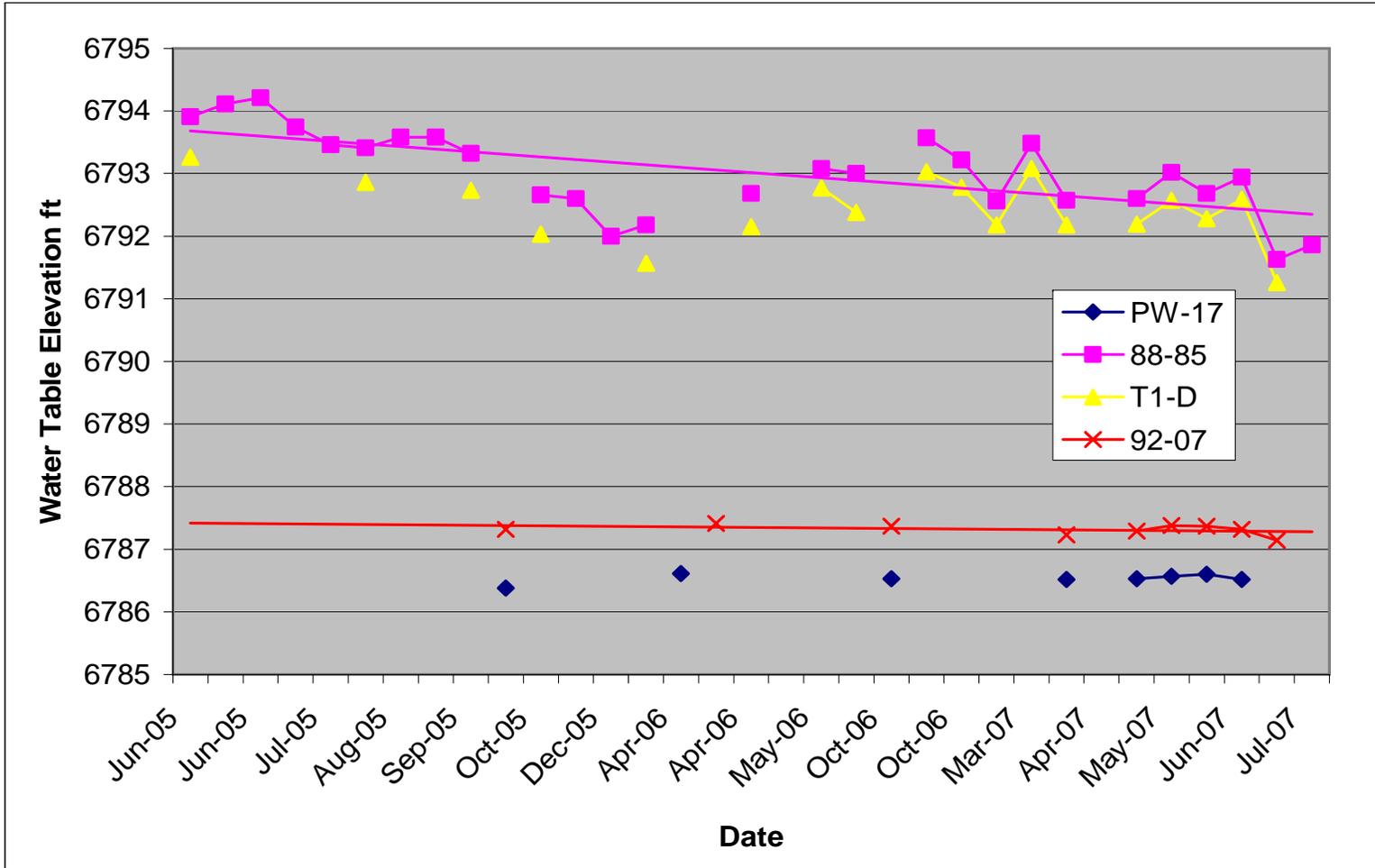


Figure 29. Water Table Trends Near PRB

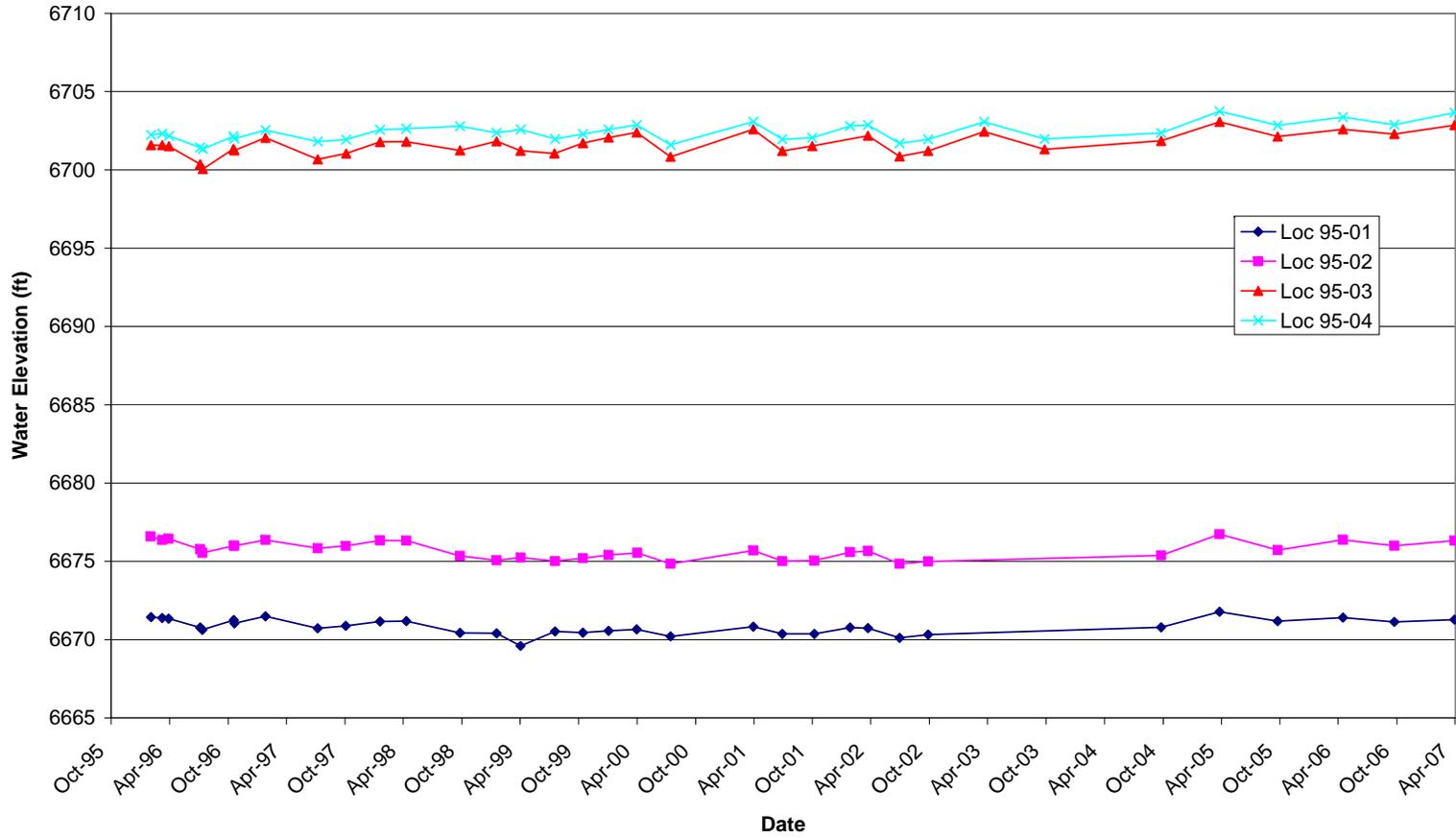


Figure 30. Water Level Hydrographs for Alluvial/Burro Canyon Well Pairs 95-01/95-02 and 95-03/95-04

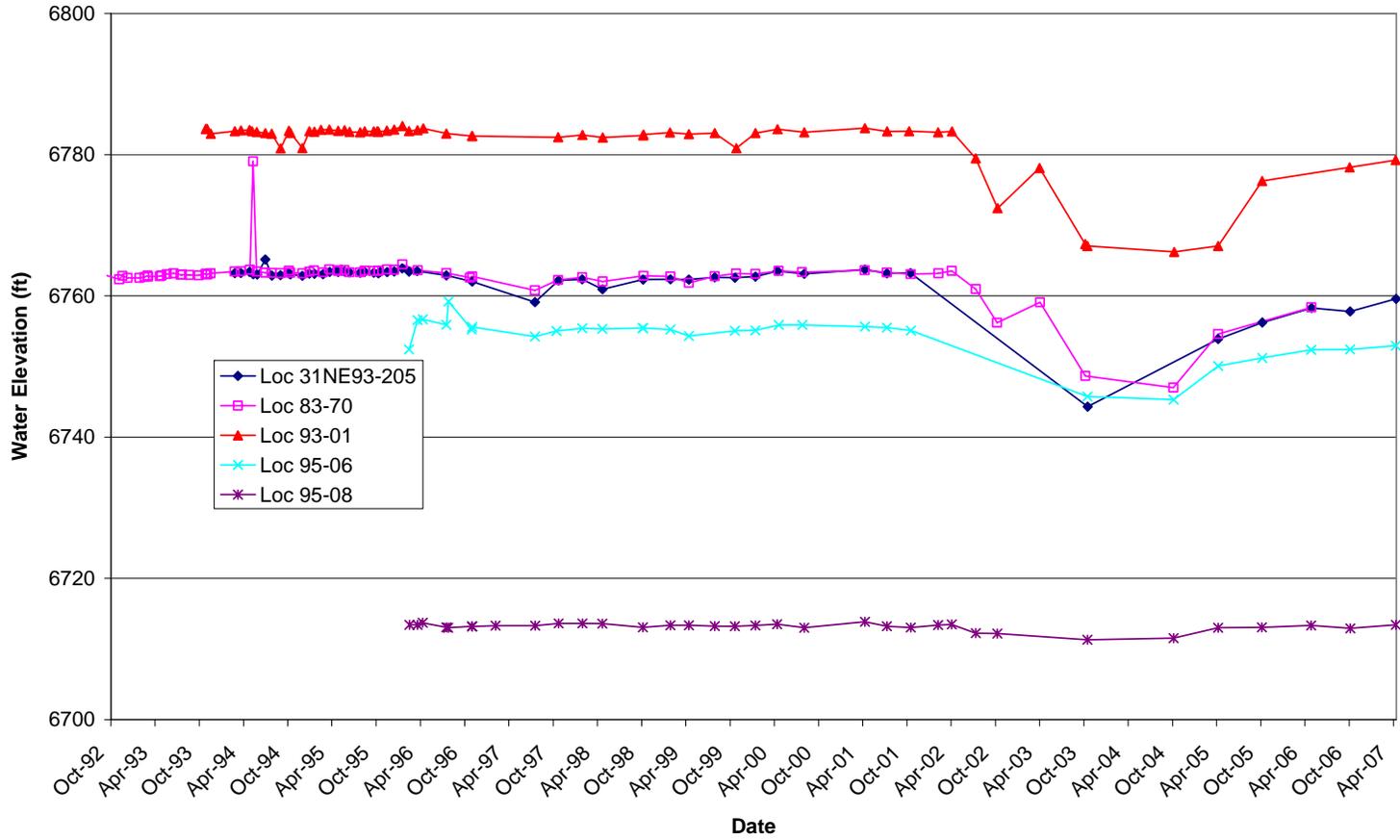


Figure 31. Water Level Hydrographs for Selected Burro Canyon Aquifer Wells

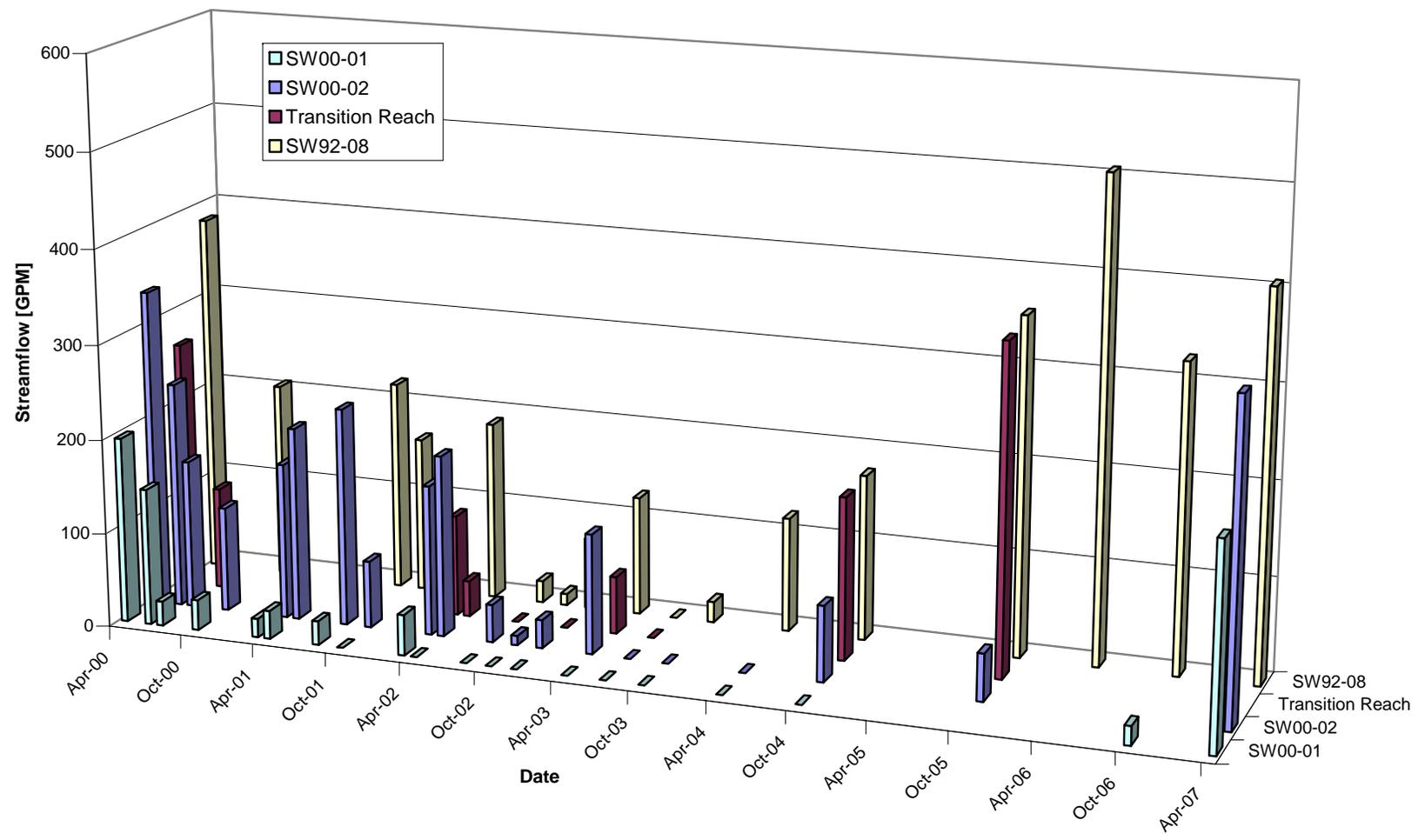
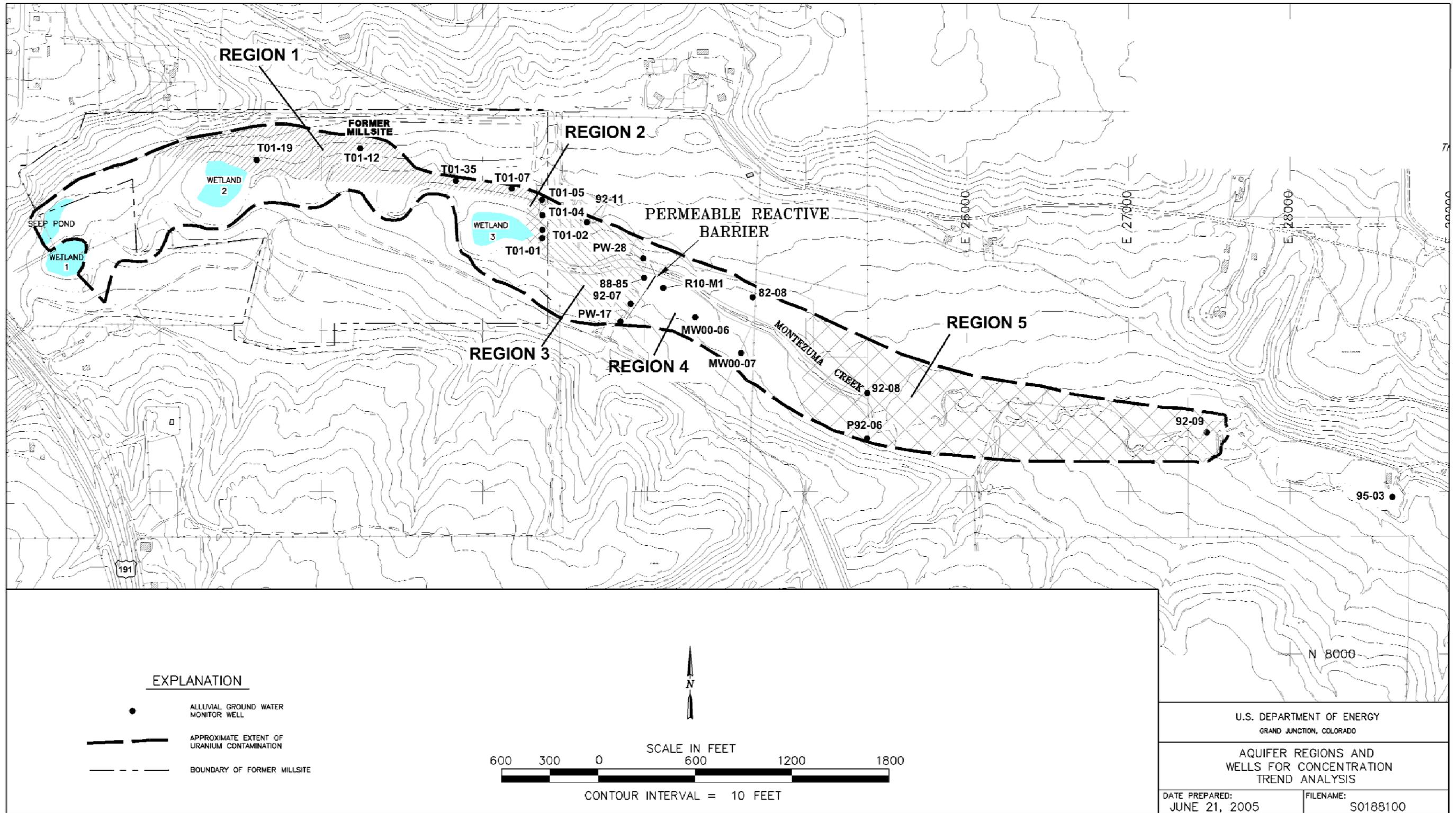


Figure 32. Stream Flow Hydrographs for Selected Sites on Montezuma Creek



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Figure 33. Aquifer Regions and Monitor Wells Selected for Concentration Trend Analysis

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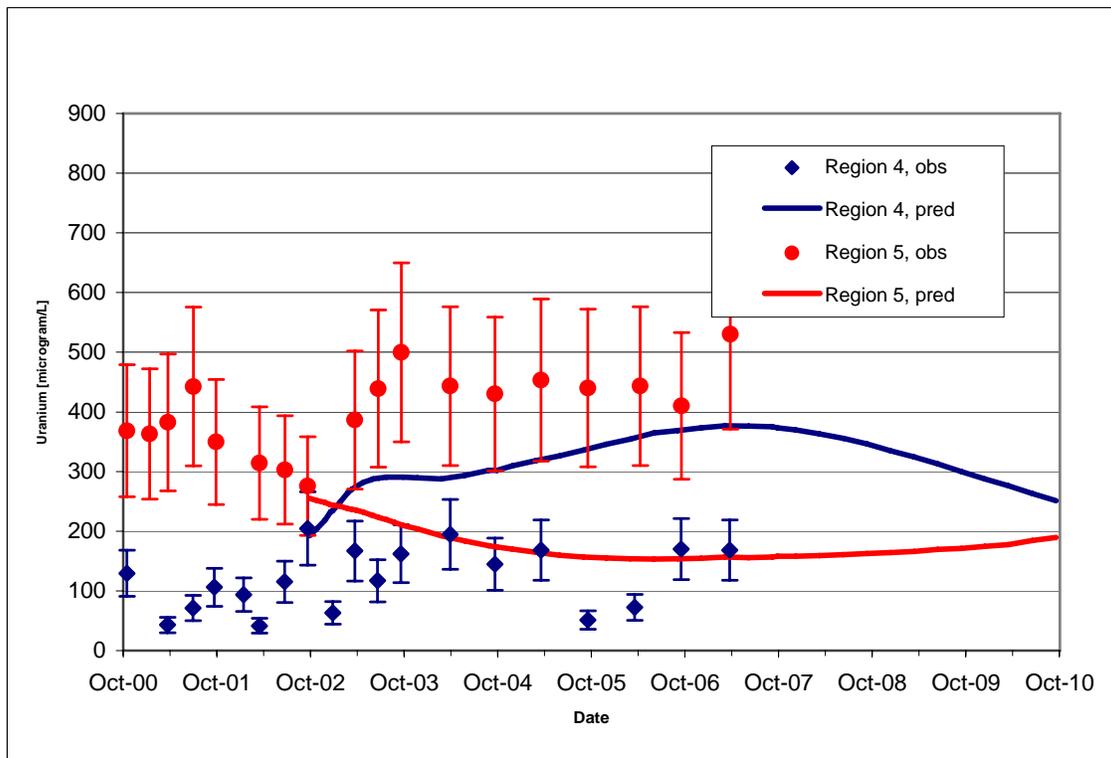


Figure 34. Comparison of Model Prediction to Observed Restoration Progress—Aquifer Regions 1 to 3

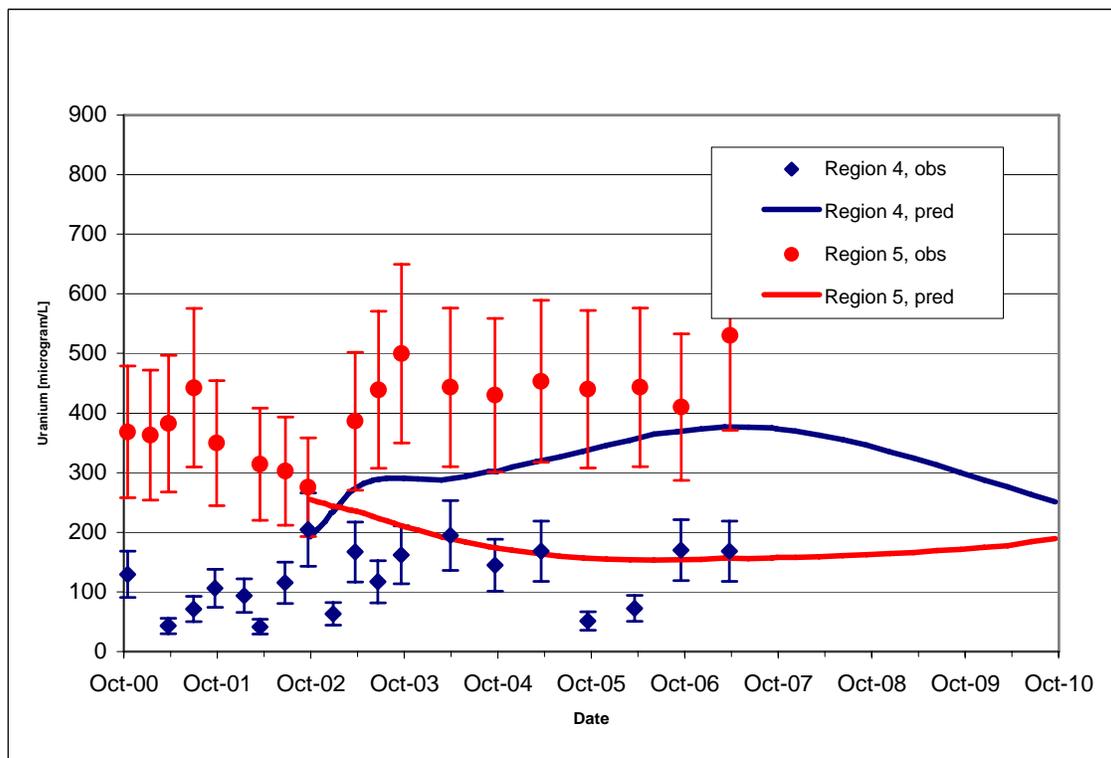
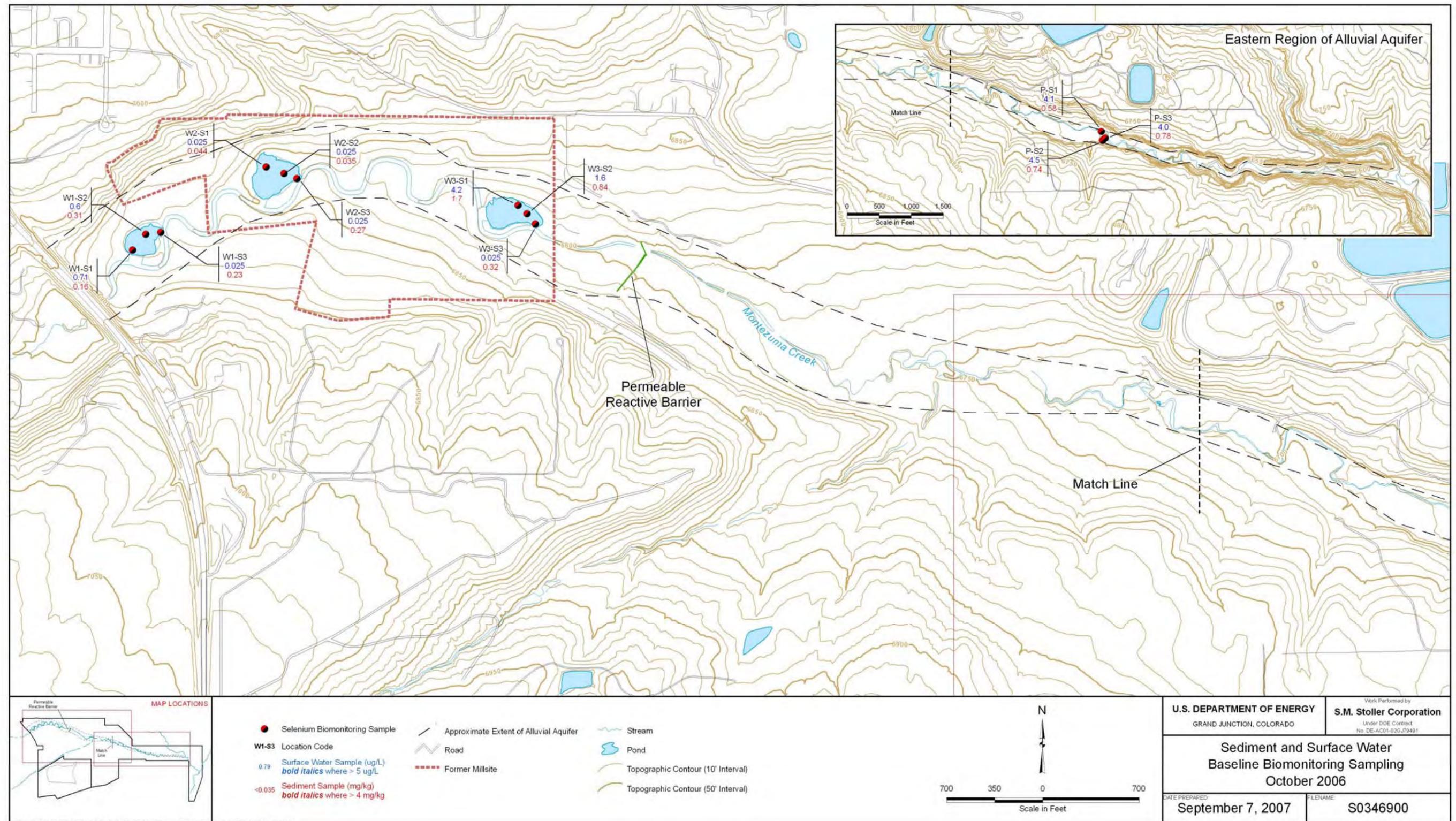


Figure 35. Comparison of Model Prediction to Observed Restoration Progress—Aquifer Regions 4 and 5

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Figure 36. Sediment and Surface Water Baseline Biomonitoring Sampling—October 2006

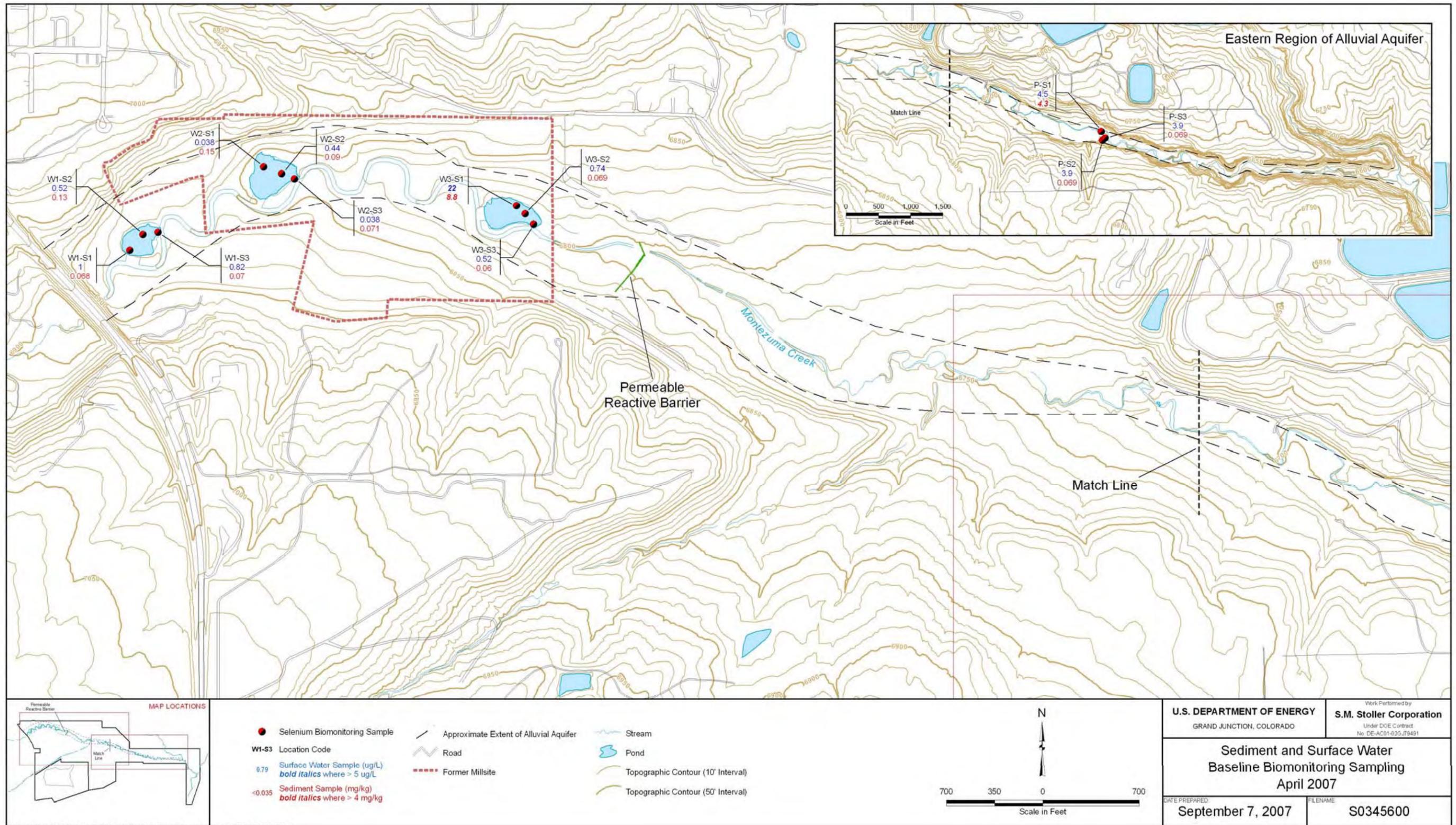


Figure 37. Sediment and Surface Water Baseline Biomonitoring Sampling—April 2007

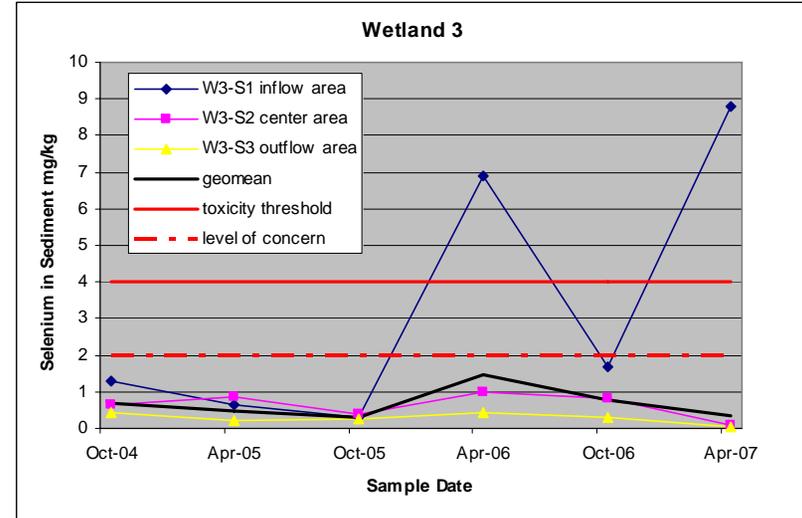
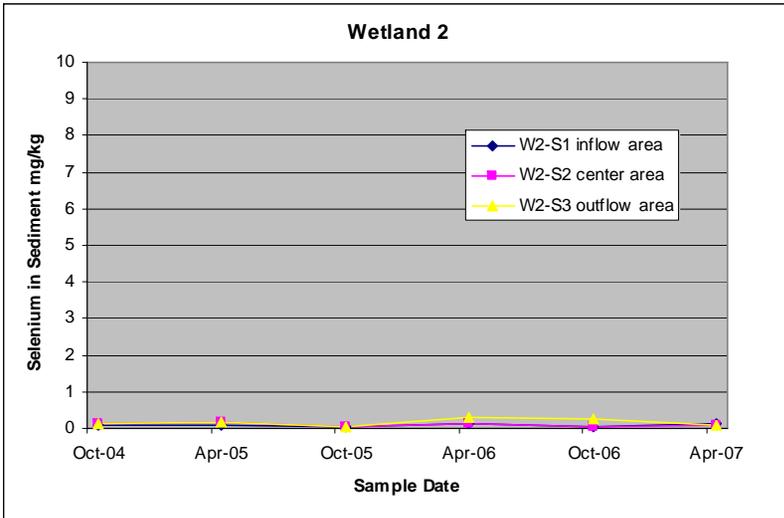
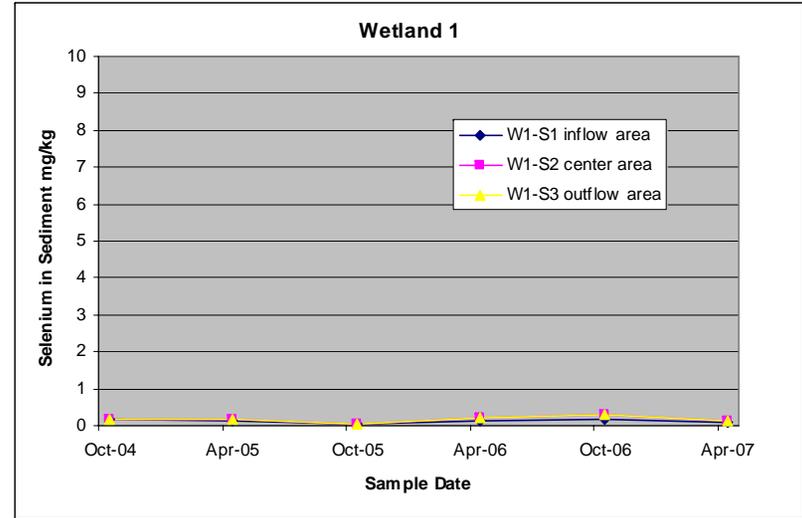
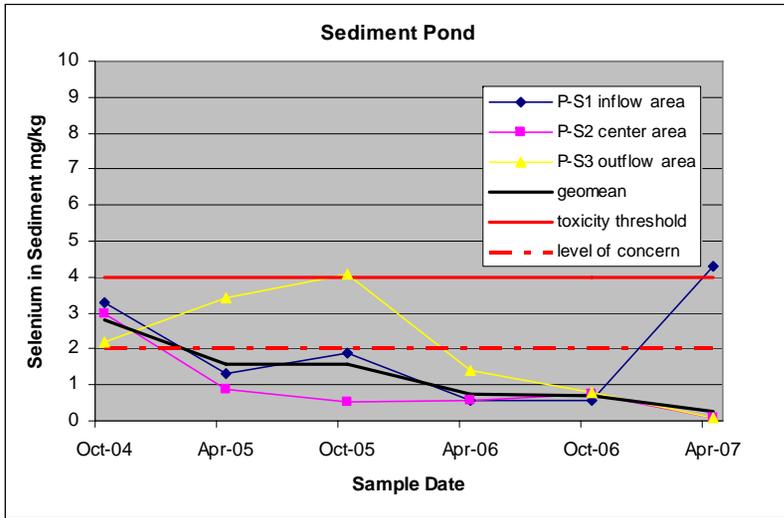


Figure 38. Selenium Concentrations in Sediment

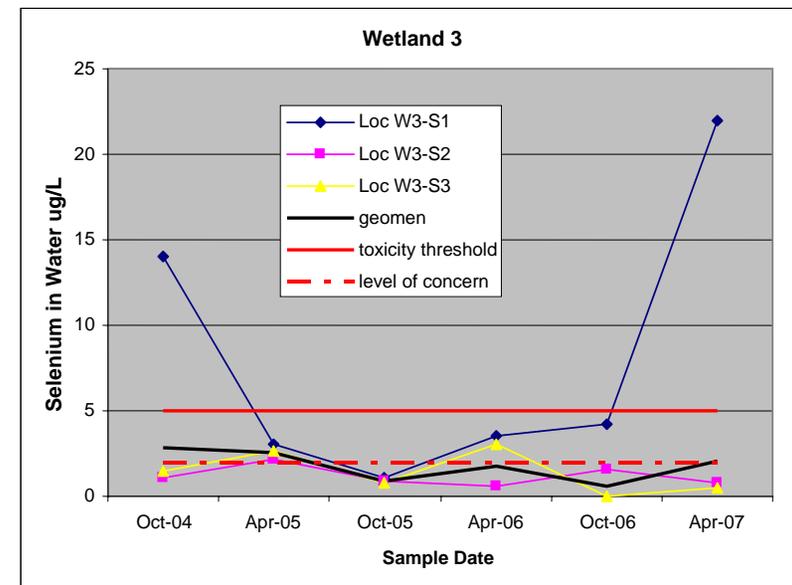
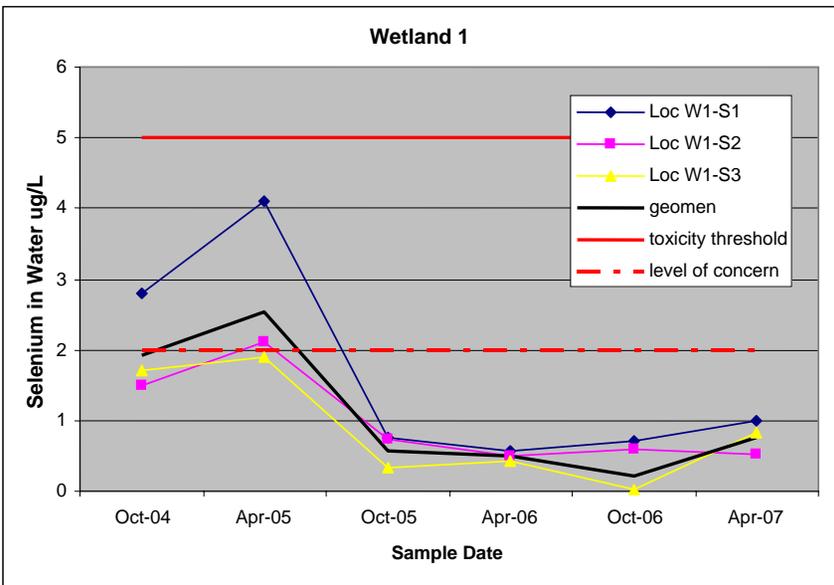
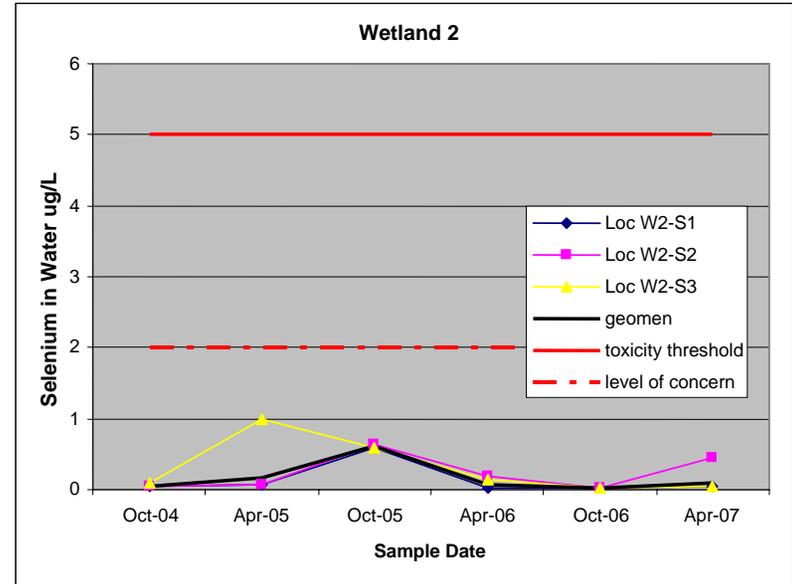
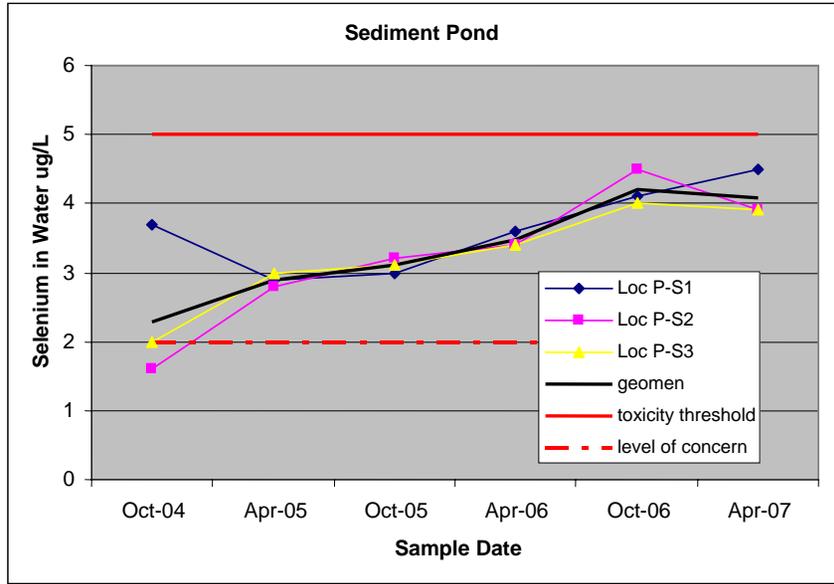


Figure 39. Selenium Concentrations in Surface Water

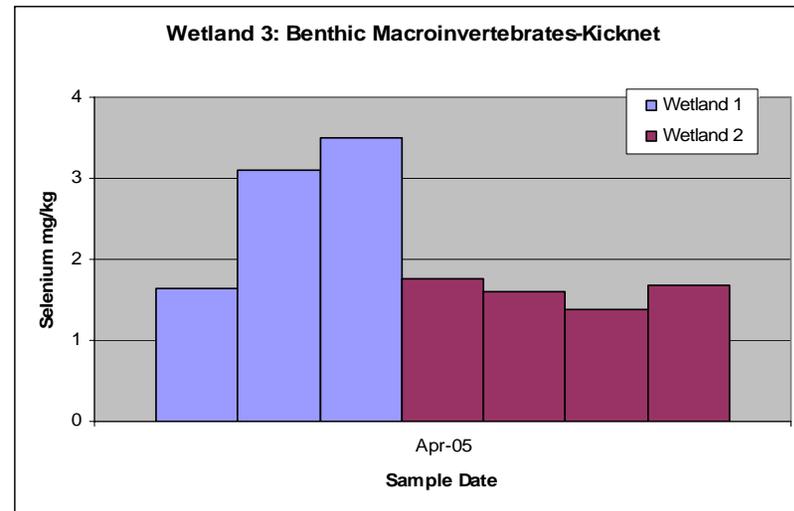
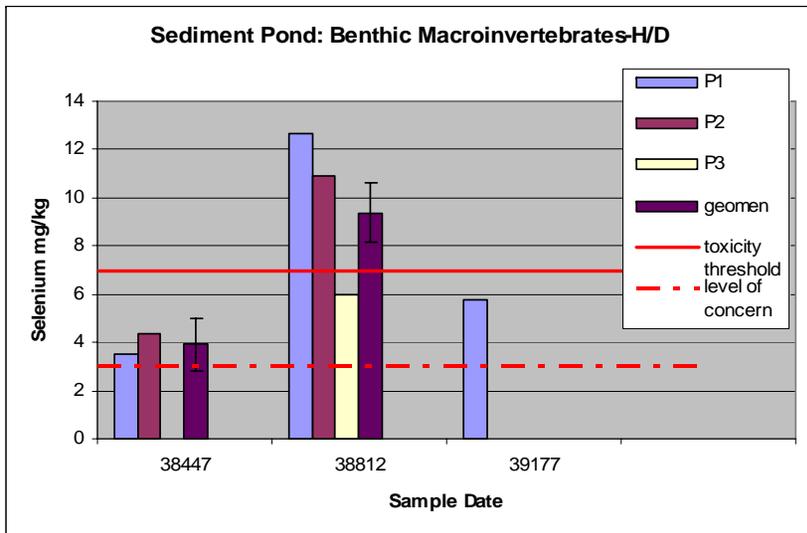
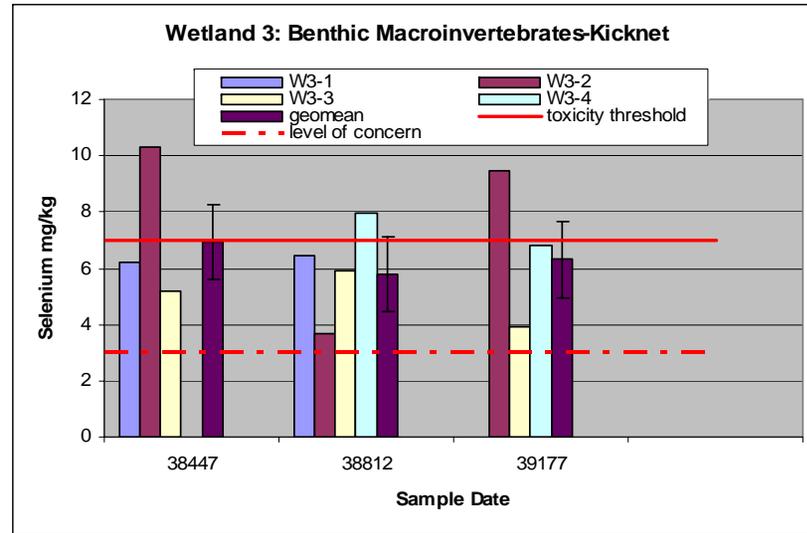
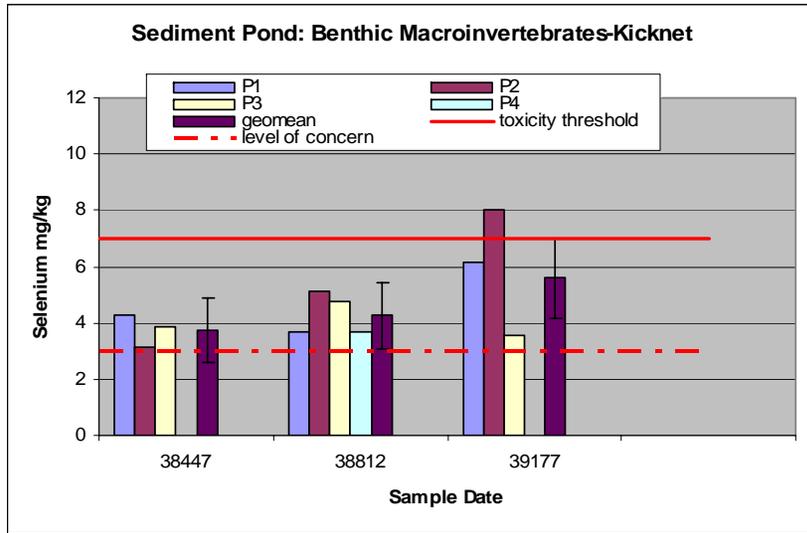


Figure 40. Selenium Concentrations in Aquatic Macroinvertebrate Tissue

End of current text