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Monticello Mill Tailings Site
Operable Unit III
Annual Ground Water Report
October 2005 through April 2006

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1.0 Introduction

This report presents the results of environmental monitoring conducted from October 2005 through April 2006 for Operable Unit (OU) III, surface water and ground water, of the Monticello Mill Tailings Site (MMTS). 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, Grand Junction, Colorado, 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

(1) Present the current extent of contamination in ground water and surface water at the site as compared to the respective remediation goals,

(2) Present contaminant concentration trends that track the progress of natural attenuation toward meeting those goals, and

(3) 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*, Draft Final, January 2004 (DOE 2004c).

Hydrologic data presented in the report, including ground water levels and surface water flow, provide a water budget context for evaluating the concentration trends against both the site conceptual and numerical model 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 primary waste form produced, were impounded at four piles on the site. 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.

The MMTS was placed on the CERCLA National Priorities List (NPL) 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 with cleanup of the millsite occurring 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 until the environmental effects of OUs I and II remedial actions could be determined through a Remedial Investigation (RI) and Feasibility Study (FS). Field studies under the RI began in 1992. A Remedial Investigation report that summarized the OU III study through 1996 was prepared and finalized in 1998 (DOE 1998a) while OU I and II remedial actions continued. To then address further possible change that could affect remedy selection and to 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 the IRA ROD included implementing institutional controls that restrict use of contaminated ground water, comprehensive water quality and hydrologic monitoring, updating OU III baseline human health and ecological risk assessments, and implementing a treatability study of permeable reactive barrier (PRB) technology. Other IRA ROD activities were the continued extraction and treatment of contaminated ground water from millsite excavations, and defining 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 using actual site conditions following OUs I and II remedial actions. Based on that information, the ROD for OU III selected monitored natural attenuation with institutional controls as the remedy. 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 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 occurring 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). Montezuma Creek forms at the confluence of North and South Creeks a short distance upstream of the millsite. A municipal reservoir (Loyd's Lake or Monticello Reservoir), located about 1-mile upstream of the millsite, interrupts the natural flow of South Creek. The municipal water water treatment interrupts the natural flow of North Creek. In the western portion of OU III, the valley of Montezuma Creek is relatively broad and gentle, and used for agriculture. A deep canyon network incised into the local bedrock formations characterizes the east, undeveloped portion of the study area. Montezuma Creek is a limited source of irrigation and livestock watering.

The hydrostratigraphic units within OU III are the shallow alluvial aquifer, the underlying Dakota Sandstone aquitard, and below that, the Burro Canyon sandstone aquifer. Remnants of the 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 within the valley of Montezuma Creek. Depth to 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 surface remedial actions. To reconstruct this portion of the aquifer, sand and gravel obtained from non-contaminated areas of the aquifer was placed in a narrow (30 to 40 ft wide) excavated channel, in places several feet deep into the bedrock. This channel underlies 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 its millsite reach. The creek, and each of the three adjoining wetlands also constructed during site restoration, fully penetrates the alluvium and so are effective ground water sinks. A downstream outlet connects each wetland to Montezuma Creek.

Total flow of alluvial ground water across the eastern boundary of the millsite is estimated to be less than 50 gallons per minute. 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 one 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 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.

3.1 Ground Water Use

In the absence of millsite-related contamination, the Utah Department of Environmental Quality classification of the alluvial aquifer within OU III is Class II, Drinking Water Quality Ground Water. There is no current use of the alluvial aquifer for drinking water, irrigation, or livestock watering. The potential to develop the alluvial aquifer as a domestic source is low because the saturated zone is very thin and generally unproductive. Furthermore, the institutional controls implemented under the IRA for OU III prevent the use of contaminated ground water for domestic purposes. Montezuma Creek is used for crop irrigation and livestock watering.

The city of Monticello has historically distributed water from the Burro Canyon aquifer only for non-domestic purposes (municipal and residential irrigation) but has augmented the culinary supply with this source during recent drought. The 10 municipal extraction wells are scattered within a one-mile radius of the center of town; the total pumping rate for 2002 was about 350 gallons per minute (gpm).

3.2 Permeable Reactive Barrier

In June 1999, a permeable reactive barrier was installed about 750 ft east of the former millsite (see Figure 2) 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 11–13 ft deep by 8 ft wide (parallel to flow). The first zone is 2 ft thick consisting of crushed gravel and 13 percent by volume ZVI. The second zone, 4 ft thick, consists entirely of ZVI. A third zone, 2 ft thick and consisting entirely of crushed gravel, serves to evenly distribute the treated water to the aquifer downgradient of the PRB. Low permeability slurry walls constructed of bentonite-amended soil extend north and south to funnel ground water to the reactive zone. The north slurry wall is 97 ft long by 10–16 ft deep by 3−4 ft wide, and the south slurry wall is 240 ft long by 10–16 ft deep by 3–4 ft wide. The slurry walls and reactive zone are keyed at depth into competent bedrock.

Under 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. In June 2005, DOE Environmental Sciences Laboratory (ESL), Grand Junction, Colorado, constructed an auxiliary, discretionary treatment cell as the PRB showed signs of progressive failure. This second system benefits OU III objectives by alleviating the ground water mound and providing ground water treatment while advancing the development of PRB technology. Operation and maintenance of the auxiliary system is the responsibility of the ESL. Selected wells within the PRB are monitored in conjunction with April and October annual events for OU III.

4.0 Contaminants of Concern and Remediation Goals

Contaminants of concern for OU III surface water and ground water are arsenic, manganese, molybdenum, nitrate, selenium, uranium (and uranium isotopes), 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 (MCL) as established by the U.S. Environmental Protection Agency (EPA), a maximum concentration limit under the Uranium Mill Tailings Remedial Action (UMTRA) program, or were derived from the OU III human health risk assessment. Surface water remediation goals correspond to the available surface 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	-----	-----

[a] Source: DOE 2004b.
[b] µg/L = micrograms per liter; pCi/L = picocuries per liter.
[c] State of Utah standard for surface water.
[d] EPA Maximum Contaminant Level (MCL).
[e] Based on OU III human health risk assessment.
[f] UMTRA maximum concentration limit.
[g] Excluding uranium and radon.
[h] Excluding 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 2005 and April 2006. In the following subsections, water quality results are presented in two formats: (1) spatial distribution as of April 2006, and (2) time-varying concentrations at individual sampling locations since January 2000 (or earlier in some cases), a convenient starting date for this purpose because all construction activities likely to perturb the ground water system had since been completed.

Appendices 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) represents a subset of all locations monitored since January 2000 because project objectives, field conditions, and access restrictions varied during that time, or a given well was decommissioned (see Appendix D for a list of wells decommissioned during the review period). In addition, sampling conducted in October is slightly more comprehensive than the April event (see Figure 3), when several downgradient alluvial wells located beyond the extent of contamination, and numerous bedrock wells, are not sampled.

5.1 Extent of Contamination in the Alluvial Aquifer

Figure 4 to Figure 10 illustrate the extent of contamination in the alluvial aquifer in April 2006, 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 Figure 4 to Figure 10.

Each COC was present in alluvial ground water at one or more location in April 2006 in excess of the respective remediation goal. Uranium (U) remains the most widespread contaminant in ground water, with concentrations that are greater than ten-times the remediation goal at many locations. Uranium contamination extends to 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.

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 therefore 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 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

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, located a short distance beyond the terminus of the current uranium plume. 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. Likely, plume expansion beyond this area is prevented by the hydrologic discharge boundary described in Section 3.0.

Because of the much greater concentration, manganese does not plot on the same scale used in Figure 11; however, the presence of this constituent 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 wells located farthest downgradient 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 Figure 4 to Figure 10 (see PRB inset), despite the progressive loss of hydraulic conductivity, the PRB remains chemically effective in reducing contaminant concentrations to acceptable levels. Some loss of treatment effectiveness of the gravel/ZVI zone is evident for several analytes, however the ZVI zone remains very effective, except for manganese. Concentrations of manganese in ground water increase within the PRB. This trend has progressively decreased such that internal concentrations currently only slightly exceed the remediation goal. Alluvial ground water immediately downgradient of the PRB tends toward acceptable concentrations of manganese.

To date, the auxiliary treatment cell has treated 2 million gallons of contaminated ground water while operating at a rate of 5 gpm. Routine monitoring (approximately monthly) indicates continued treatment of uranium to below the remediation goal (30 µg/L). By analogy to past performance of the PRB, concentrations of the remaining COCs (excepting manganese) are similarly reduced in the treatment cell to meet remediation goals. In August 2006, a permanent infiltration trench was installed to more optimally return the treated water from the cell to the aquifer. Telemetry allows remote real-time monitoring of the system flow conditions. A high-level switch is calibrated to deactivate the extraction pump to prevent an over-flow condition.

5.2 Contaminant Concentration Trends in the Alluvial Aquifer

Figure 12 through Figure 18 illustrate the concentrations of arsenic, manganese, molybdenum, nitrate (as N), selenium, uranium, and vanadium, respectively, as they vary over time at selected monitoring wells located along the 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 is 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 that time, concentrations of arsenic, manganese, molybdenum, uranium, and vanadium have remained 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 monitoring well (MW00-01). As of April 2006, the latest pulse had dissipated to the extent that the nitrate standard was exceeded at only two locations, both 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 II remedial action, particularly in the eastern area of the millsite where an extensive area of carbonaceous and pyritized shale of the Dakota Sandstone was freshly exposed. Naturally abundant selenium in this formation was likely mobilized by oxygenated ground water of the reconstructed alluvial aquifer that was placed on the fresh bedrock surface. Selenium concentrations have in general 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). Selenium-contaminated ground water continues to enter OU III along the northeast margin of the millsite, presumably also from the bedrock source.

5.3 Extent of Contamination in the Burro Canyon Aquifer

Water quality monitoring results for bedrock monitoring wells obtained since January 2000 are included in Appendix B. The Burro Canyon aquifer wells that were sampled during the review period are wells 93-01 and 83-70. The cumulative monitoring data through April 2006 for these and other wells sampled when monitoring was more comprehensive than is current indicates that the Burro Canyon aquifer remains uncontaminated by site-related constituents.

Monitoring results for wells completed in the upper weathered interval of the Mancos Shale (well 200-4) and the Dakota Sandstone (well 92-12) are also included in Appendix B. Ground water sampled at those locations during the reporting period was not contaminated, which is consistent with previous results for those locations. Bedrock ground water sample results for April 2006 are not shown in Figure 4 through Figure 10, however, the corresponding well locations are included in Figure 3.

5.4 Extent of Contamination in Surface Water

Appendix C contains the analytical results for water samples collected from established monitoring sites along Montezuma Creek, at ground water seeps, and from the eastern-most of the constructed wetland areas on the former millsite (Wetland 3). Results for the surface water samples collected in April 2006 are shown in Figure 4 through Figure 10. Surface water sites are identified in Figure 3.

With respect to the applicable surface water standards for OU III (Table 1), there is no contamination of Montezuma Creek by site-related constituents. Because the gross alpha activity standard for OU III excludes the contribution from uranium, which accounts for the alpha activity in OU III waters, the activity standard (15 pCi/L) is not exceeded. There is no separate standard for uranium in surface water. However, owing to the discharge of contaminated ground water, uranium concentrations in Montezuma Creek exceed background values throughout much of OU III (Figure 9). Discharge of ground water also results in relatively high uranium concentrations in Wetland 3, as well as for lesser contamination by arsenic, nitrate, and selenium, but dilution to acceptable levels occurs before the water enters the creek. 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 that 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 of particular relevance to the ongoing biomonitoring task. The figures identify recently decreasing

concentrations of both constituents in surface water, reflecting general water quality improvement. Selenium has decreased to below the remediation goal at all surface water locations on Montezuma Creek.

5.5.1 Ground Water Seeps

A zone of ground water seepage of suspected cultural origin occurs along the north margin of the millsite. Although the seepage is generally perennial, the flows decreased significantly during the recent drought years. Water quality at the locations of Seep 3, 5, and 6 (Figure 3) suggest possible off-site sources of nitrate, selenium, and uranium to OU III. The high nitrate levels present at Seeps 3 and 6 (see Figure 7) likely relate to the previously mentioned livestock operations. Figure 21 shows the contribution of nitrate from this source to vary widely. The occurrence of selenium in ground water and surface water in this area (Figure 8) is of suspected 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 (Figure 21). Selenium concentrations at Seep 3 appear to be declining. High concentrations of uranium in samples from Seep 6 (Figure 9) may be remnant contamination from ore stockpiles formerly located on the hilltop above that seep. Uranium concentrations at Seep 6 have been relatively steady (see Figure 23) since monitoring was initiated at that location in 2002. Seepage from this location may contribute to localized uranium contamination of ground water in the alluvial aquifer.

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 occasionally been too diffuse at Seep 1 to sample; Seep 2 has flowed constantly except throughout much of 2002 during the height of the recent drought. Contaminant concentrations and trends at Seep 2 are similar to those at nearby monitor wells, including a downward trend in selenium, which is also apparent at Seep 3. Samples collected at Seep 1 are much less contaminated, possibly due to greater creek seepage to the wetland in this area (Seep 1 is closer to Montezuma Creek than is Seep 2, see Plate 1 for locations). Although Seep 2 water is contaminated, COC concentrations in Wetland 3 are consistently below remediation goals, as detected at locations W3-03 and W3-04. The receiving water in the immediate area of Seep 2 may occasionally exceed a remediation goal however, as noted in Section 9.0.

6.0 Hydrologic Monitoring Results

Hydrologic monitoring consists of water level measurement and surface water flow measurement. Ground water levels were measured in all monitoring wells at the site during both monitoring events of the review period. Surface water flow was measured at each prescribed location in October 2005 but only at several locations in April 2006 because of poor field conditions. Appendix E contains all water level data collected since January 2000. All corresponding monitoring locations are provided on Plate 1. Figure 3 identifies the locations where water levels were measured in October 2005 and April 2006. Appendix F contains the tabulated results of the stream flow measurements since 1999.

6.1 Alluvial Aquifer

Leakage through the dam at the Monticello reservoir (Loyd's Lake), located approximately 1-mile west of the millsite, and a losing stream condition downstream to the millsite, control 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 monitoring wells (Figure 24), this area is subject to seasonal water table fluctuations of up to about 5 feet. A rising water table trend is apparent over the past several years at the upgradient locations, due to either climatic conditions or additional watering of the golf course following its expansion in 2001.

Water table fluctuations of similar magnitude and direction are not observed in the hydrographs for monitoring wells located on the millsite, which show relatively static conditions over time (Figure 25). This is likely because the creek and wetlands are efficient ground water sinks, as indicated by gaining stream conditions in that reach. Rapid discharge to the creek and wetlands in the western portion of the millsite apparently dampens the water table fluctuations observed farther upgradient such that the saturated thickness of aquifer underlying the millsite the remains consistently between about 2 and 3 feet.

Water level hydrographs for the area downgradient of the millsite are shown in Figure 26. The effect of dewatering during remedial actions is evident as the drop in 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 drains to facilitate tailings excavation and diverted for treatment before being discharge to the creek at the east boundary of the millsite. Water levels at wells 92-11, 88-85, and 92-07 have since rebounded owing to the cessations of dewatering and in part to ground water mounding at the PRB. Operation of the auxiliary treatment cell has not significantly lowered the water table local to the PRB area (see water level hydrographs for wells 88-85 and R1-M4, Figure 25).

East of the PRB, the same period of millsite dewatering may also account for the observed water table decline and subsequent recovery through about 1999 to 2000 at wells 92-08 and P92-06 (Figure 26). This effect is not apparent farther east at well 92-09, possibly having been dampened over that distance through aquifer/creek interaction or sustained discharge of Burro Canyon ground water to the alluvial aquifer.

6.2 Burro Canyon Aquifer

Well pairs 95-01/95-02 and 95-03/95-04 comprise the eastern-most 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. The water table at these locations is shown to be relatively stable over time (Figure 27) with a consistent upward flow gradient from the Burro Canyon aquifer to the alluvial aquifer (see Figure 27). Ground water withdrawal from the Burro Canyon aquifer by the city of Monticello during 2001 to 2004 apparently did not affect water the direction or magnitude of this gradient, nor were water levels at well 95-08 affected (Figure 28), which is a Burro Canyon well located on the mesa above well pair 95-03/95-04. Additional evidence of Burro Canyon ground water discharge in this reach is the

higher ground water elevation at well 95-08 than at well 95-04, in addition to numerous seeps and springs near the exposed base of the formation in the canyon floor.

At Burro Canyon monitoring wells located nearer the municipal well field, for example, wells 83-70, 205 and 93-01 (Figure 28 [Plate 1 identifies the location of well 205]), municipal pumping accounted for as much as 15 to 20 feet of water level drawdown in the Burro Canyon aquifer. Water levels in those affected wells are currently rebounding, presumably because the municipal ground water withdrawal was discontinued following the abundant precipitation in the spring of 2005. The continued discharge of Burro Canyon ground water in the area of the site including well 95-01 and 95-03 is identified as an important natural attenuation mechanism for limiting eastward plume expansion (DOE 2004b).

Private use of Burro Canyon ground water in OU III is currently limited to a single landowner, who in 2004 obtained water rights to well 83-70 for lawn and garden watering. From the well hydrograph, the local effect of ground water withdrawal at well 83-70 is much less than the regional trend owing to cessation of municipal pumping. Use of the well is probably limited to summer months. Over the past year, former upgradient Burro Canyon monitoring 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.

6.3 Stream Flow

Results of periodic measurements of flow at several locations on Montezuma Creek since April 2000 are depicted on Figure 29. 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 Figure 29 refers to the segment of Montezuma Creek between wells 0200 and 92-09 (see Figure 3) where the valley begins to narrow into a steep-walled canyon. Flow measurements for that reach were taken at either of location SW00-03, SW00-06 (Plate 1 and Appendix F), 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 29 clearly shows the effect of drought during 2002 to 2004, culminating in the absence of measurable flow at any location during mid-summer 2003. The reduced stream flows are the result of near depletion of the Monticello reservoir during that time and the consequent reduction in alluvial aquifer base flow. In addition, less water was available for irrigation in the city, thus an important source of aquifer recharge along the north margin of the millsite was significantly reduced. During wetter times, ground water discharge is usually sufficient to sustain flow throughout Montezuma Creek.

Creek flow in general has increased over the past 2 to 3 years. In April 2005, following abundant winter and spring snow, measured creek flow was about 2,000 gpm (April 2005 results are not shown in Figure 29). Peak flow in Montezuma Creek in the spring of 2005 may have reached 30,000 gpm, as reported by city officials, in part from deliberate releases from the reservoir and anomalous flows in North Creek due to heavy runoff from the Abajo Mountains.

7.0 Ground Water Restoration Progress

The ROD for OU III stipulates that, beginning with the water quality results from October 2004, observed concentration trends 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 sub-regions (Figure 30) based on contaminant and hydrogeological conditions. For each region, the average uranium concentration is computed for each sampling event among a prescribed group of monitoring wells within the region. An empirically determined uncertainty range of ±30 percent is then assigned to each computed average (see Appendix B of DOE 2004a for details). If, for any aquifer region, the model-predicted value falls below the lower uncertainty range of the observed values for three consecutive events (beginning with October 2004 results), the progress of aquifer restoration is not meeting expectations and the need for response actions under CERCLA will be determined (DOE 2004b).

Table G-1 in Appendix G summarizes the model-predicted uranium concentrations at the locations of the selected wells. Starting concentrations (model time zero) in Table G-1 are based on the results of October 2002 ground water monitoring. Figure 31 and Figure 32 compare the observed concentration averages and corresponding uncertainty range for uranium since October 2000 to the model-predicted values.

Comparison of model predictions and observed uranium concentrations in ground water are summarized below for the five separate aquifer regions and with reference to Figure 31 and Figure 32.

Region 1 Predicted uranium concentrations are less than 70 percent of the observed average since at least October 2004. 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 consistent with the model prediction.

Region 4 The uranium concentration trend deviates significantly from the model prediction toward a shorter restoration period. Observed concentrations are less than model-predicted values.

Region 5 The uranium concentration trend deviates significantly from the model prediction toward a longer restoration period.

8.0 Water Quality Summary

- Currently, aquifer restoration progress for uranium in Regions 1 and 5 does not meet the performance criteria established in the ROD for OU III. As part of the CERCLA 5-year review for the Monticello NPL sites, to occur in 2007, DOE will re-evaluate the ground water data to determine the best statistical method and best means to determine if restoration progress is acceptable for the aquifer as a whole.
- Arsenic contamination is limited to a small region upgradient of the PRB at concentrations that are less than 2-times the remediation goal.

- Manganese contamination is limited to three isolated, widespread locations. Its distribution does not resemble a ground water plume. At the location immediately downgradient of the PRB, the manganese may originate as an impurity of the ZVI.
- Molybdenum exceeds its remediation goal in ground water at a single location (well PW-17) as of April 2005.
- Nitrate concentrations had decreased below the remediation goal at all locations by October 2003. A pulse of nitrate, possibly related to livestock feedlots immediately north of the millsite, or fertilizer application on the golf course immediately upgradient of the millsite, was detected in ground water samples collected in April 2005. Minor nitrate contamination is limited to two remaining locations along the north margin of the millsite.
- Selenium contamination has decreased over the past year such that it remained only at well 200 and in the alluvium at the upgradient interface of the PRB. The maximum concentration of selenium in ground water is currently less than two times the remediation goal (50 µg/L). Elevated selenium continues to enter OU III from off-site at Seep 3.
- Uranium remains the most widespread contaminant in ground water with concentrations commonly 8 to 10-times the remediation goal.
- Vanadium contamination has decreased such that the remediation goal is exceeded in the area between the millsite and PRB. The maximum vanadium concentration (440 µg/L, maximum) is only 1.3 times the remediation goal (330 µg/L).
- Hydraulic conditions remain effective in preventing eastward (downgradient) expansion of the uranium plume into uncontaminated regions of the aquifer.
- Applicable surface water quality standards are not exceeded at any location in Montezuma Creek.

9.0 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, is 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 feet.

Biomonitoring tasks are implemented in phases according to the conceptual design and scope presented in DOE 2004b. Scope of the biomonitoring activities are determined in consultation with the Biological Technical Assistance Group (BTAG), comprised of qualified representatives of the U.S. Fish and Wildlife Service, EPA, the Utah Department of Environmental Quality, 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 again in April 2006. Sampling and analysis of aquatic and terrestrial insects associated with wetland habitat was conducted in May 2005 and 2006.

Avian surveys were conducted during periodic visits (every other week) in May through August 2005, and May and June 2006. Program Directives MSG-06-01, MSG-06-02, and MSG-06-03 addressed sediment and surface water sampling and analysis, avian surveys, and benthic macroinvertebrate sampling and analysis, respectively, in fiscal year 2006. Tabulated results for all post-ROD biomonitoring samples are provided in Appendix H. Results of the 2005 macroinvertebrate sampling and analysis program (including sediment and surface water results) and the 2005 avian survey are included in DOE 2005a and 2005b, respectively. Results of the biomonitoring sediment, surface water, and macroinvertebrate sampling completed to date are summarized below. Similar reports for the work completed in 2006 are in preparation for distribution among the BTAG within calendar year 2006.

9.1.1 Sediment and Surface Water Results

Selenium results for October 2005 and April 2006 abiotic samples are presented in Figure 33 and Figure 34, respectively. Figure 35 and Figure 36 display the selenium results for surface water and sediment obtained since October 2004 (Note: surface water samples were not filtered prior to analysis). In that time, the only instance of selenium exceeding the toxicity threshold in surface water (5 µg/L) occurred in Wetland 3 at the location nearest Seep 2 (14 µg/L at location W3-S1, October 2004; see Figure 35). Selenium accumulation in sediments may be greatest in Wetland 3 and the Sediment Pond, as compared to the apparent background concentrations present in Wetland 1 and 2 (Figure 36). To date, two instances of selenium exceeding the threshold criteria in sediment (4 mg/kg) have occurred (6.9 mg/kg at location W3-S1 in April 2006, and 4.1 mg/kg at location P-S3 in October 2005). If the replicate mean for a given wetland or pond sampling event is considered, only the surface water threshold at Wetland 3 in October 2004 is exceeded.

9.1.2 Macroinvertebrate Results

Table 2 includes the results for macroinvertebrate samples collected in Wetlands 1−3 and the Sediment Pond by kick nets in Spring 2005 and 2006. Among samples collected by kick net, Wetland 3 has the highest selenium results, with averages for the respective event that slightly exceed or approach the 7 mg/kg dry weight criterion (toxicity threshold) for protection of fish and wildlife species. This criterion is not exceeded in any sample from Wetland 1 and 2, and at the Sediment Pond. Averages for Wetlands 1 and 2 are less than the guideline level of concern (3 mg/kg), whereas the averages for the Sediment Pond slightly exceed that level. At both the Sediment Pond and Wetland 3, the replicate means do not vary appreciably between Spring 2005 and 2006.

Table 3 lists the results for samples collected in the Sediment Pond by Hester-Dendy samplers in Spring of 2005 and 2006. In Spring 2005, macroinvertebrates collected by kick net and Hester-Dendy devices had similar selenium content. However, samples collected by Hester-Dendy devices in Spring 2006 contained 2-times greater selenium than those collected by kick net or Hester-Dendy devices in 2005. An interpretative report that integrates surface water, sediment, and macroinvertebrate results is currently in preparation and will be distributed in Fall 2006 under separate cover to the BTAG.

9.1.3 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).
- State-sensitive species were not identified in either the 2005 or 2006 survey (or in the 1998 baseline ecological risk analysis for OU III).
- 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 definitely 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 all areas with one known nesting pair 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 (Wetlands 2, 3, and the Sediment Pond).
- Several species of ducks are commonly observed at Wetland 3 and the Sediment Pond. Sightings include individual, pairs, and small flocks of up to five or six individuals.
- Waterfowl nesting in 2006 is 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 wastewater lagoons.

Table 2. Selenium Results for Kick Net Samples Collected in Wetlands 1−3 and the Sediment Pond

Location	Sample	Se (mg/kg dry wt)	
		Spring 2005	**Spring 2006**
Wetland 1	1	1.64	—
	2	3.11	—
	3	3.51	—
Replicate Mean (Std Dev)		2.75 (0.98)	—
Wetland 2	1	1.76	—
	2	1.60	—
	3	1.68[a]	—
	4	1.39	—
Replicate Mean (Std Dev)		1.61 (0.16)	—
Wetland 3	1	6.21	6.47
	2	**10.3**	3.69
	3	5.18	5.93
	4	—	**7.98**
Replicate Mean (Std Dev)		**7.23** (2.71)	6.02 (1.78)
Sediment Pond	1	4.26	3.65[b]
	2	3.15	5.15
	3	3.84	4.77[b]
	4	—	3.68[c]
Replicate Mean (Std Dev)		3.75 (0.56)	4.31 (0.76)

[a]mean of field split sample
[b]mean of replicate sample aliquots
[c]mean of triplicate sample aliquots
— = no sample collected

Table 3. Selenium Results for Hester-Dendy Samples Collected in the Sediment Pond

Location	Sample	Se (mg/kg dry wt)	
		Spring 2005	**Spring 2006**
Sediment Pond	1	3.52	**12.65**
	2	4.35[a]	**10.93**
	3	—	5.97
Replicate Mean (Std Dev)		3.94 (0.59)	**9.85** (3.47)

[a] Samples 2 & 3 combined for analysis due to low sample mass
— = no sample collected

9.2 Biomonitoring Status and Schedule

Reports documenting the 2006 avian surveys and the 2006 macroinvertebrate sampling and analysis task will be submitted to the BTAG in Fall or Winter 2006.

- Surface water and sediment sampling of the wetlands and Sediment Pond are scheduled to occur in October 2006 and April 2007 according to the same scope as implemented in 2006.

- All other biomonitoring scope has been completed.
- The semi-annual FFA meeting in February 2007 may provide a convenient opportunity to convene the BTAG for discussion following review of the 2006 reports and receipt of October 2006 surface water and sediment sampling results.

10.0 References

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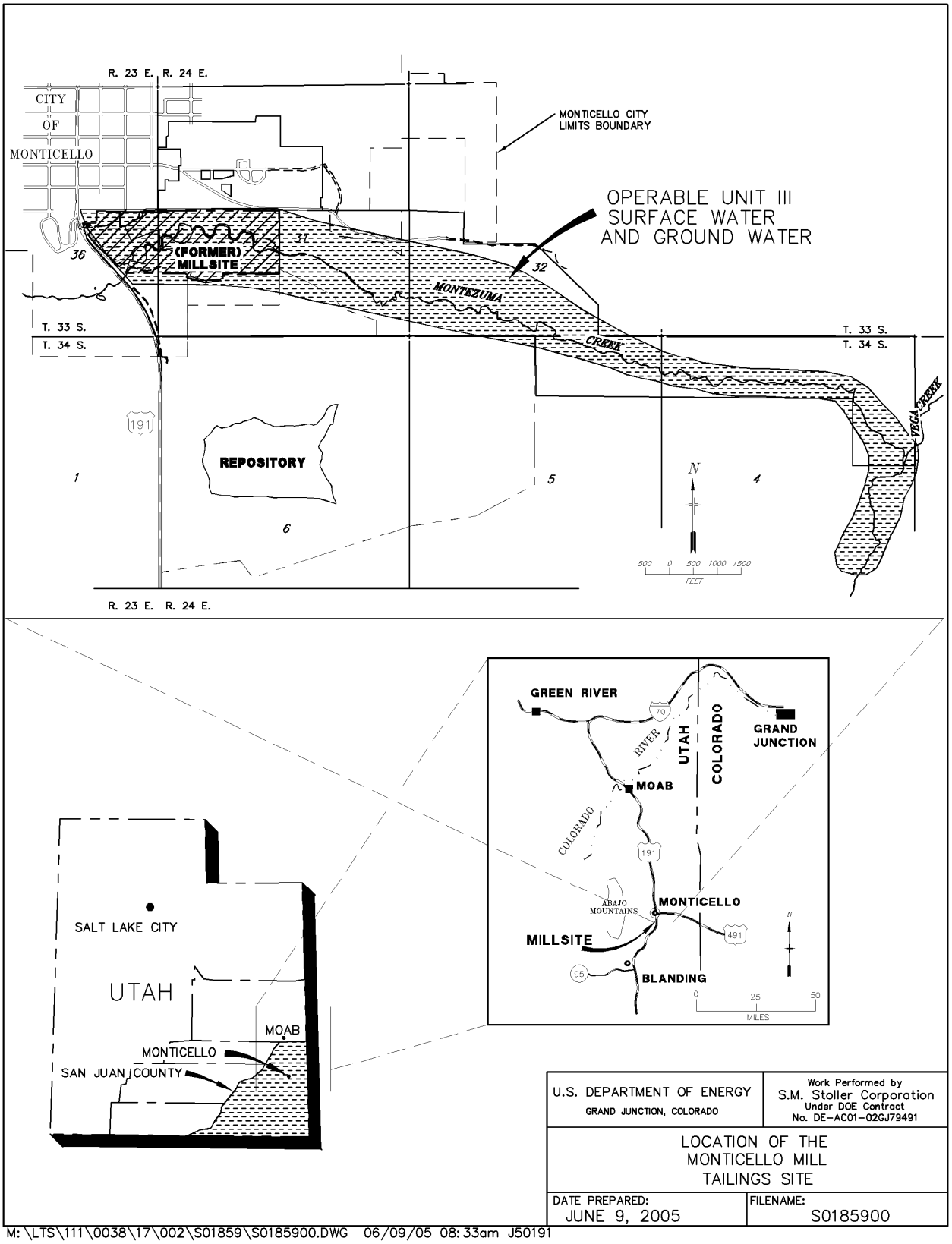

Figure 1. Location of Monticello Mill Tailings Site

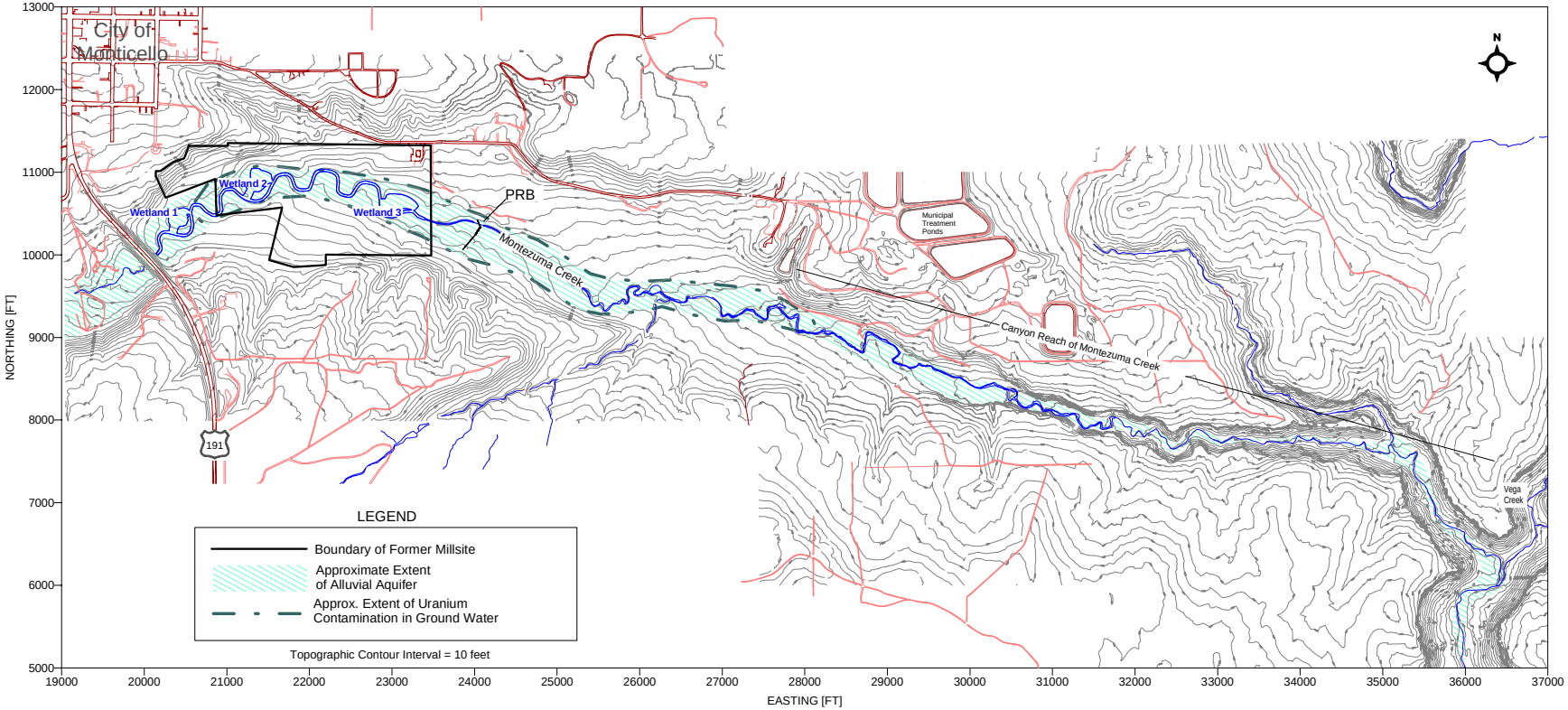

Figure 2. Site Area Features

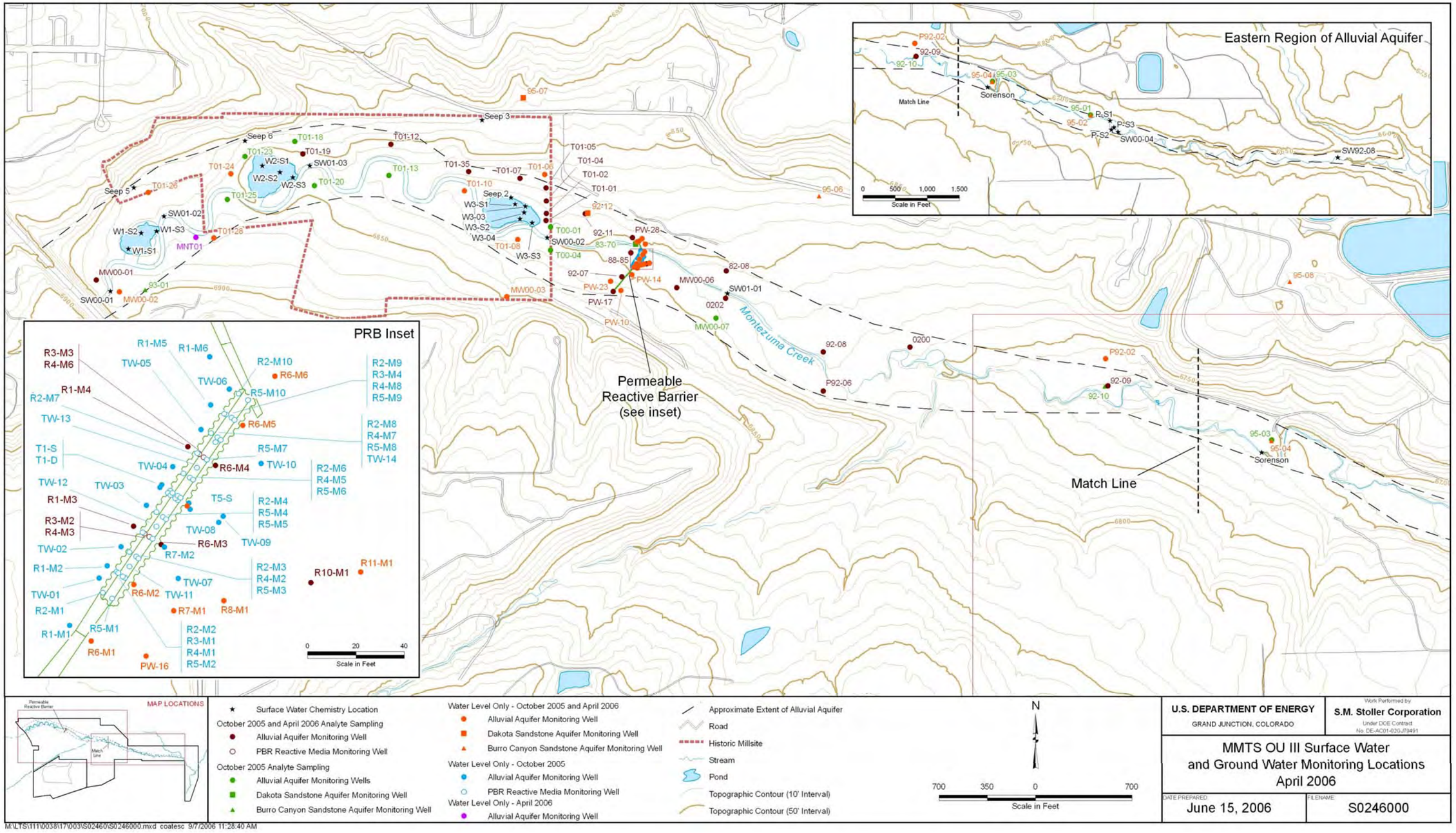

Figure 3. Reference Map for OU III Water Quality Monitoring Locations, April 2006

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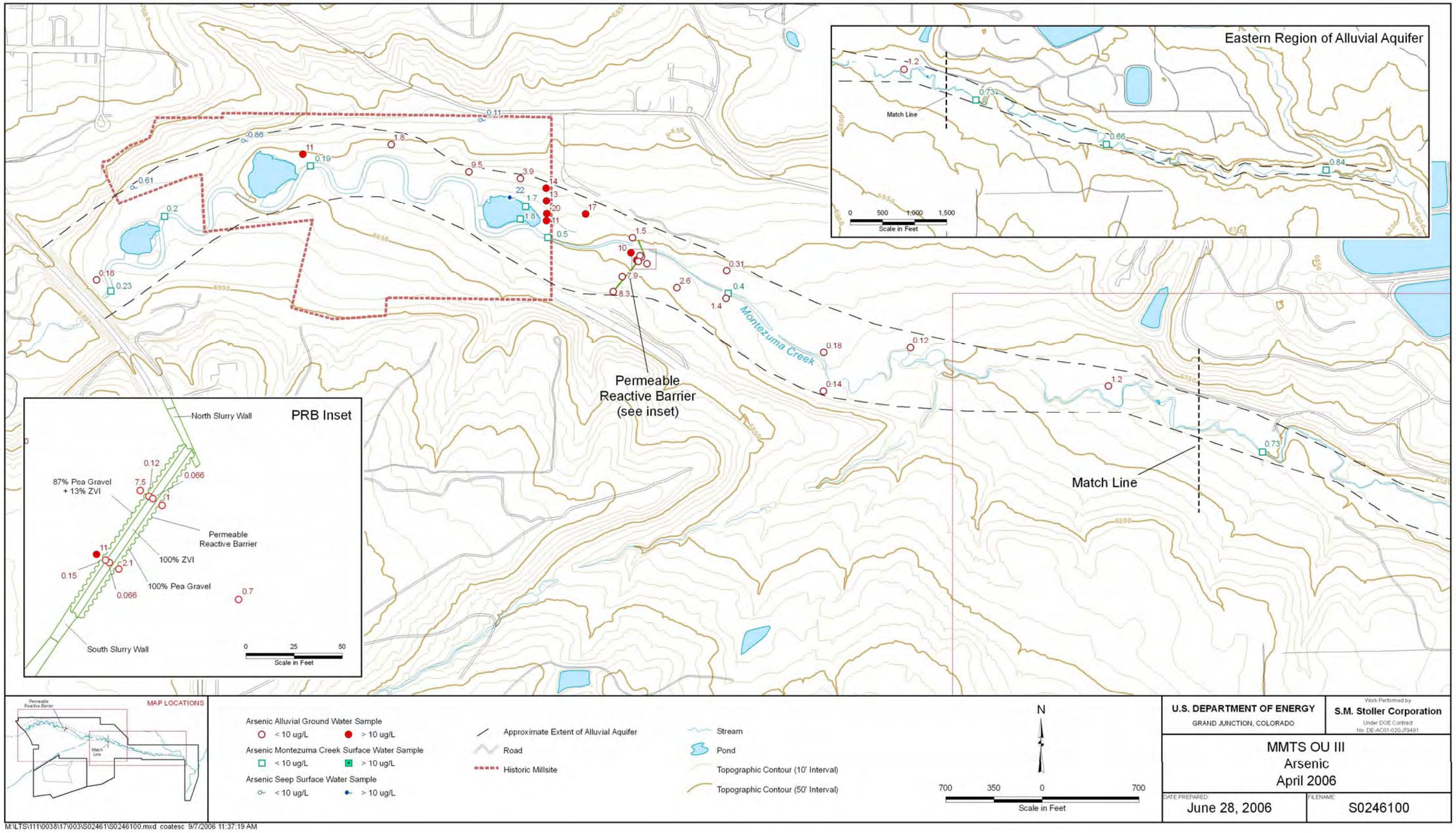

Figure 4. Distribution of Arsenic in Surface Water and Alluvial Aquifer Ground Water, April 2006

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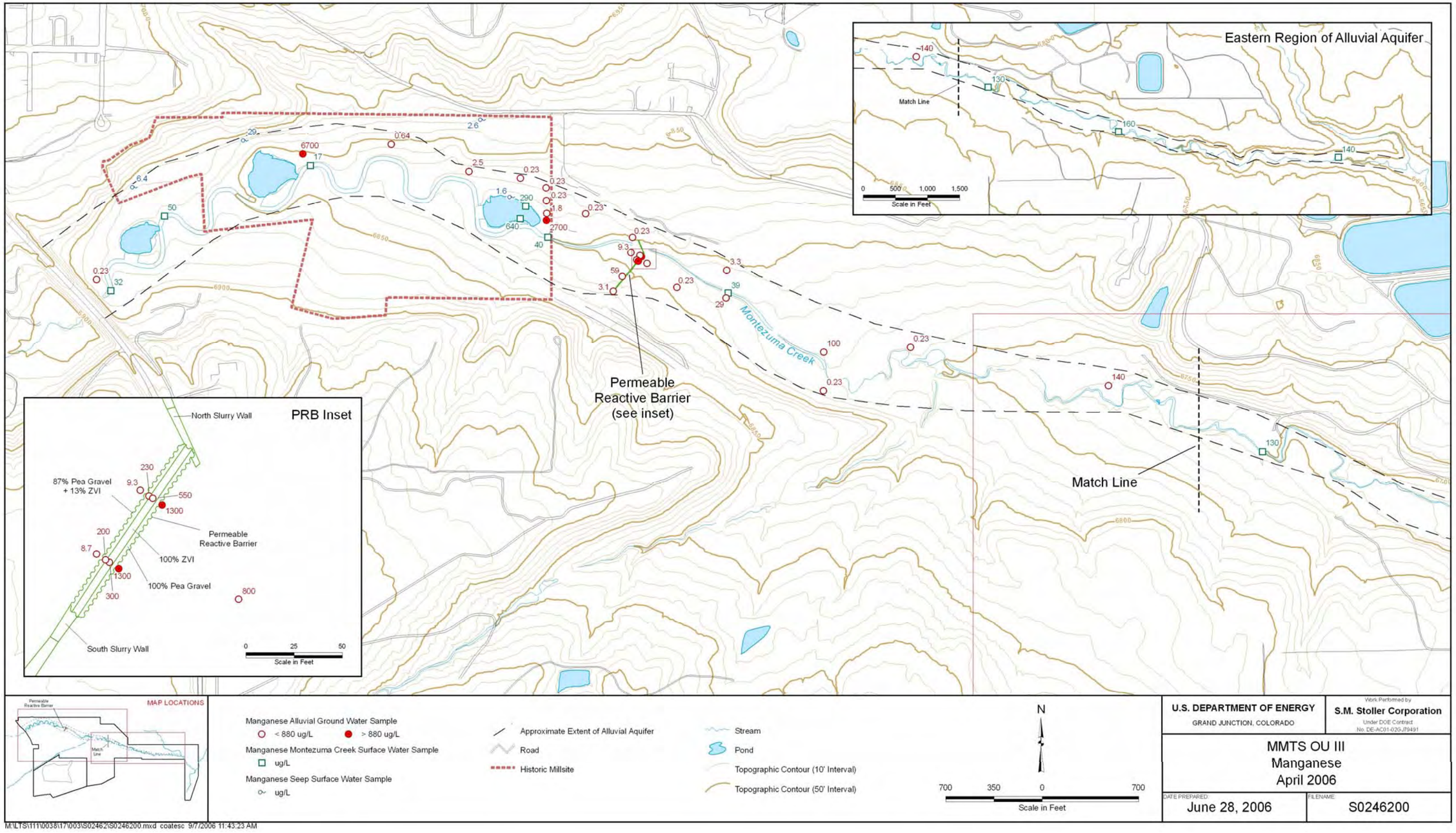

Figure 5. Distribution of Manganese in Surface Water and Alluvial Aquifer Ground Water, April 2006

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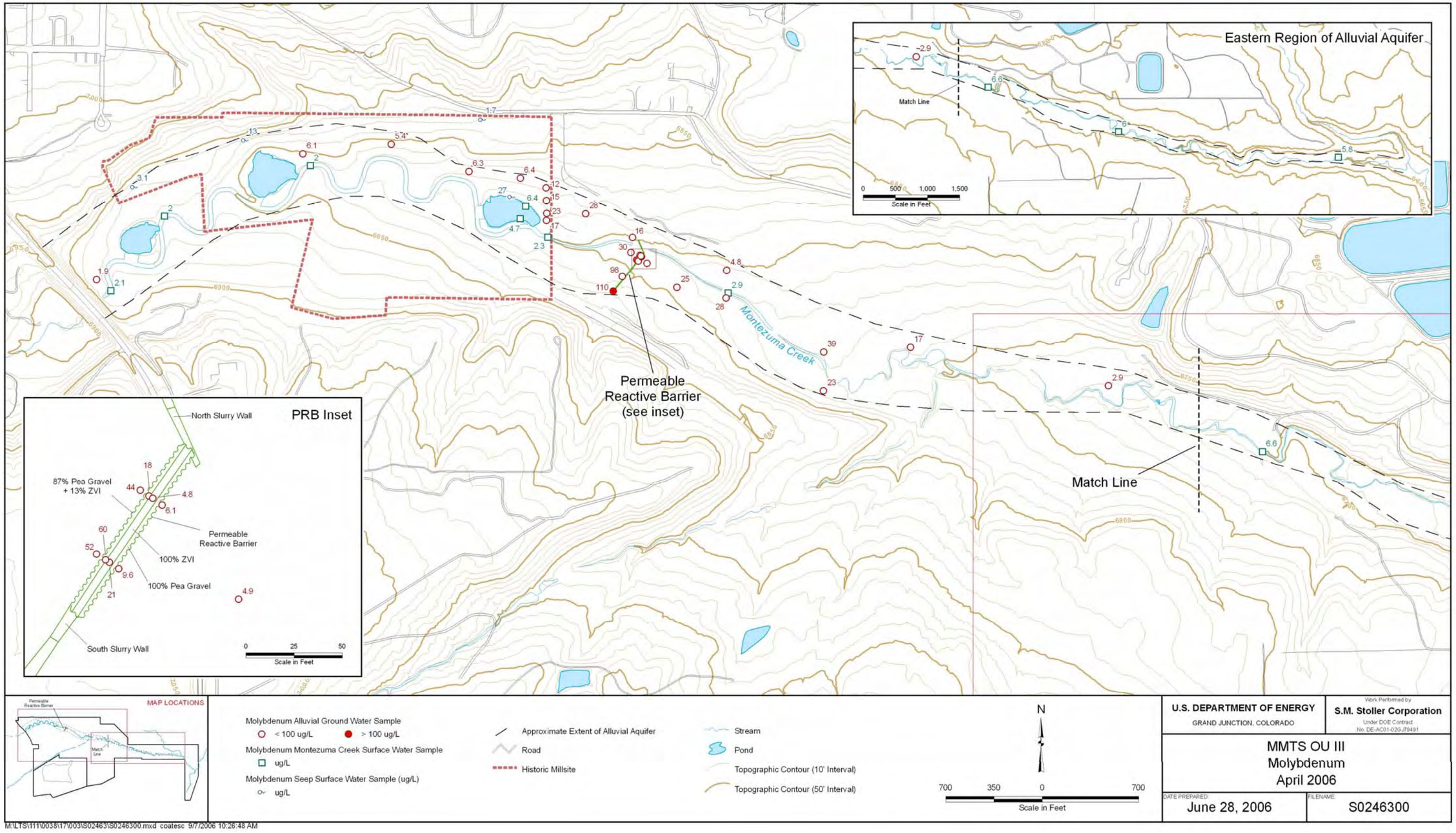

Figure 6. Distribution of Molybdenum in Surface Water and Alluvial Aquifer Ground Water, April 2006

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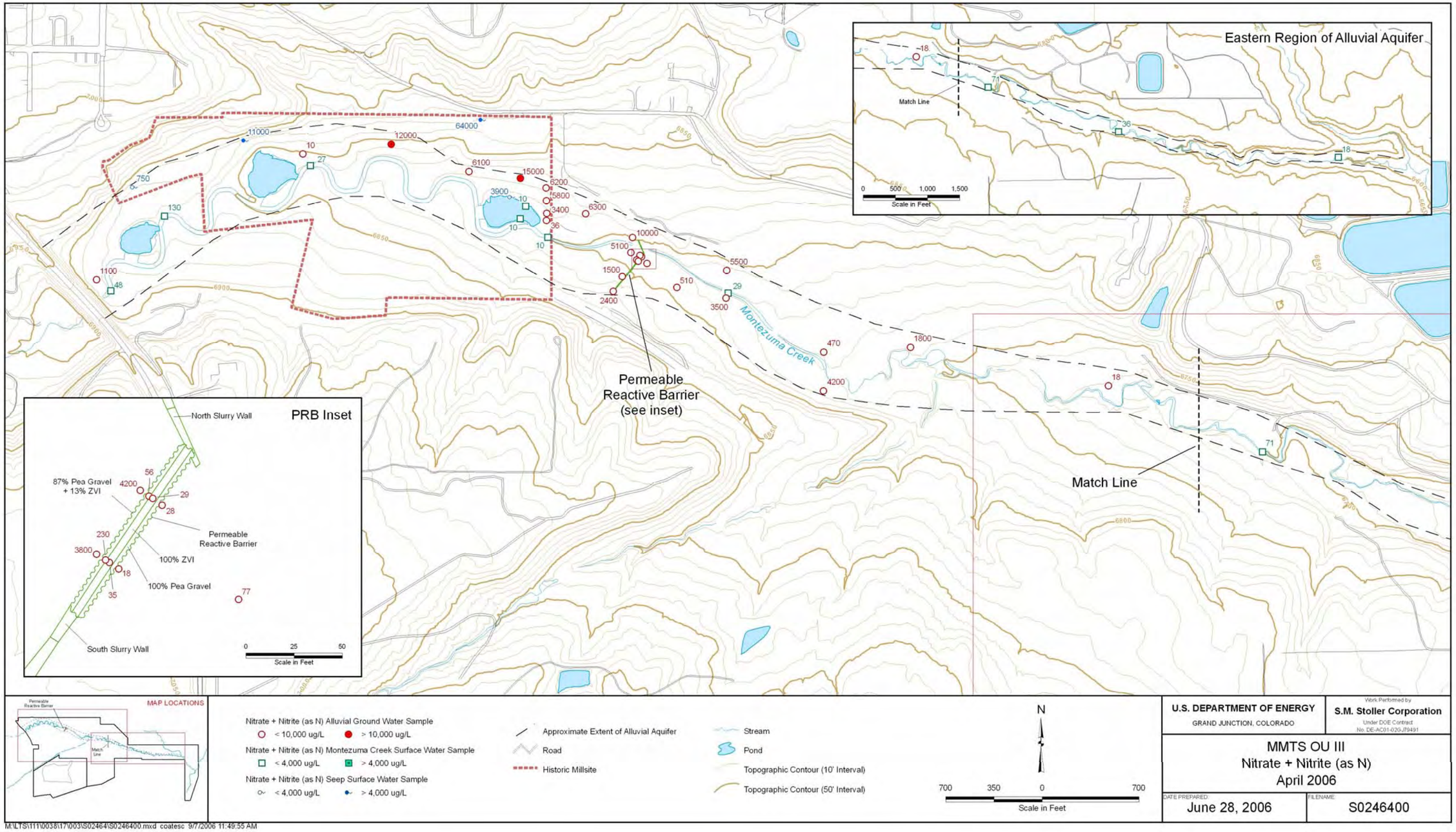

Figure 7. Distribution of Nitrate (as N) in Surface Water and Alluvial Aquifer Ground Water, April 2006

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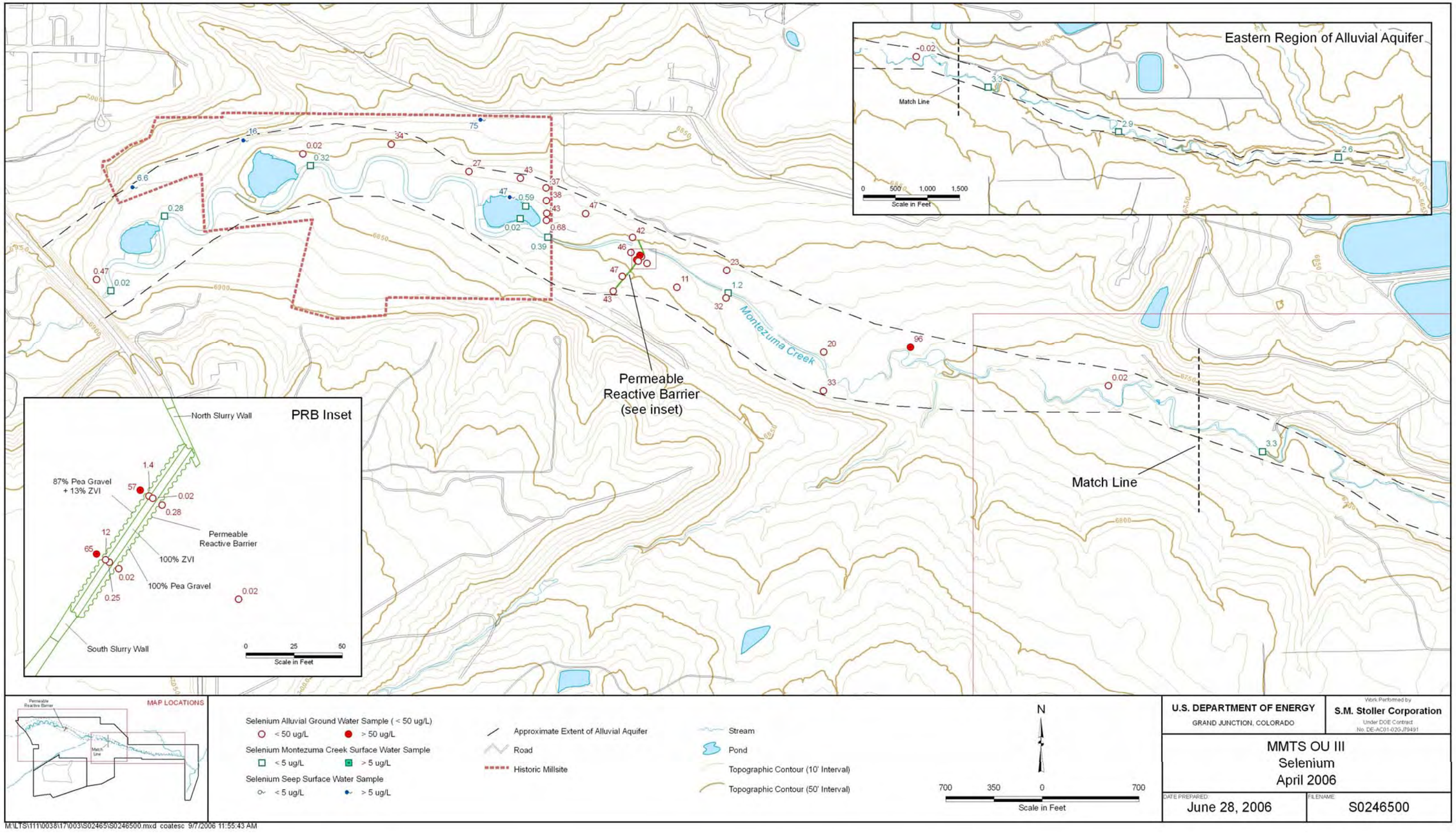

Figure 8. Distribution of Selenium in Surface Water and Alluvial Aquifer Ground Water, April 2006

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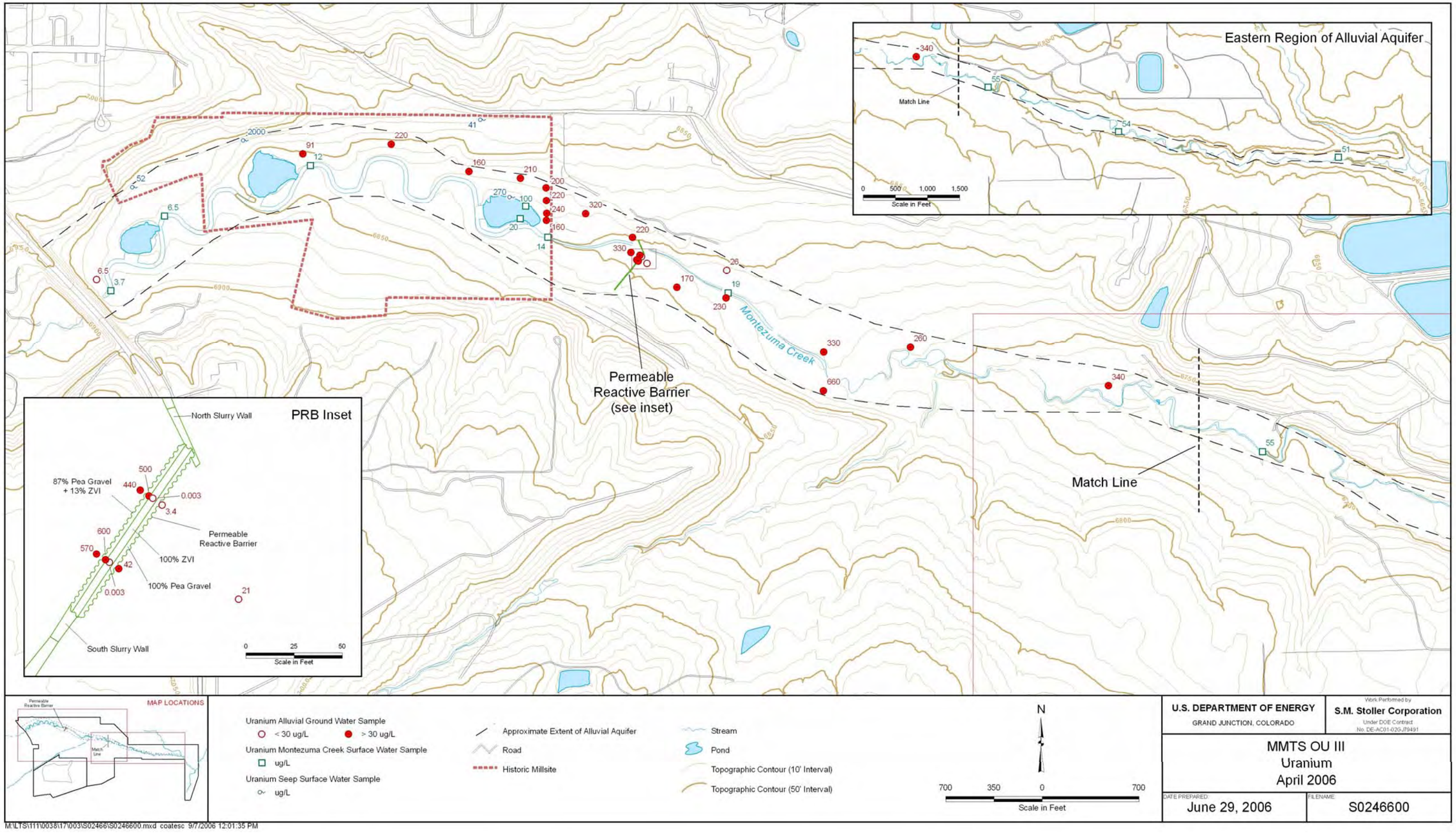

Figure 9. Distribution of Uranium in Surface Water and Alluvial Aquifer Ground Water, April 2006

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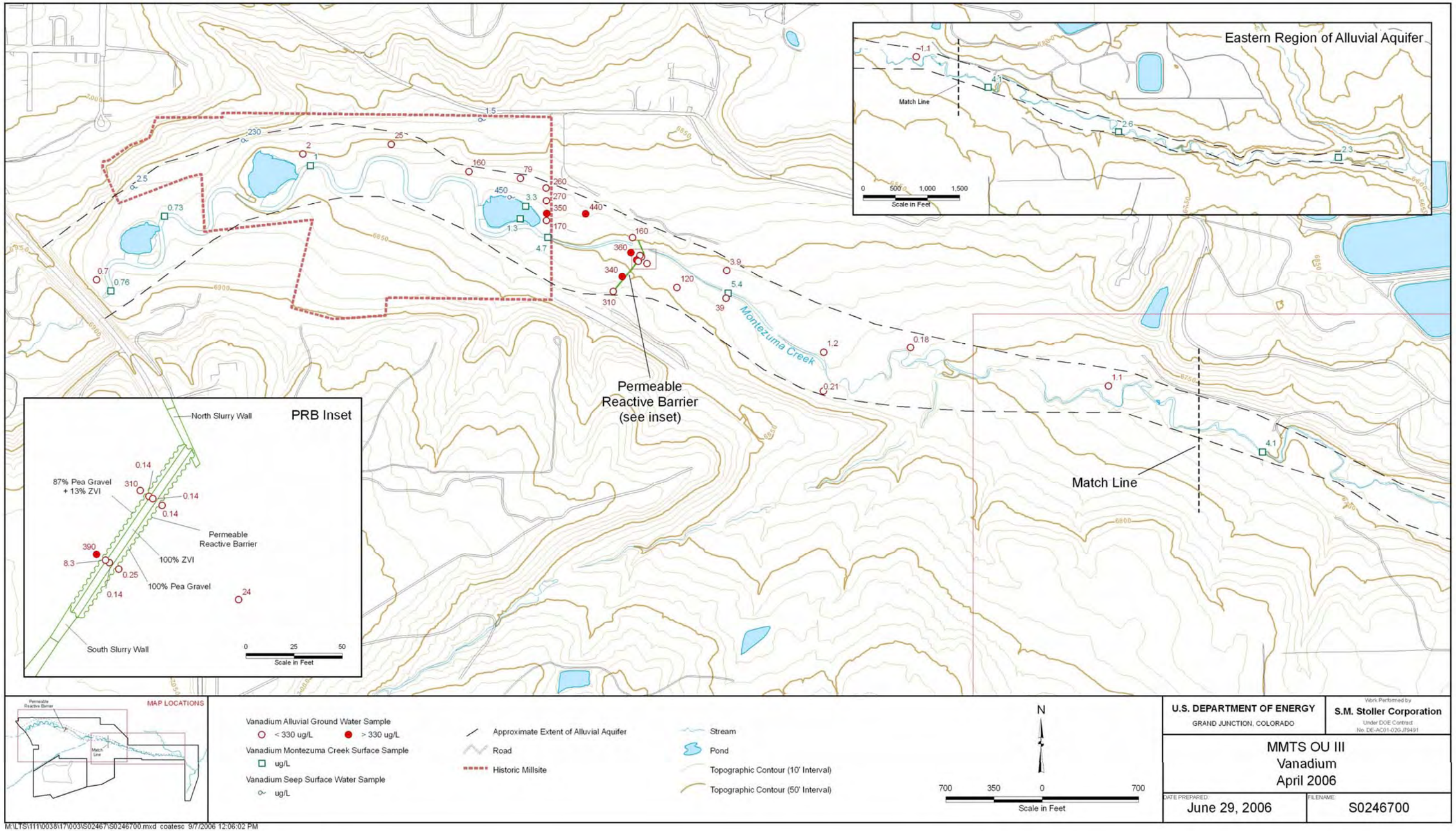

Figure 10. Distribution of Vanadium in Surface Water and Alluvial Aquifer Ground Water, April 2006

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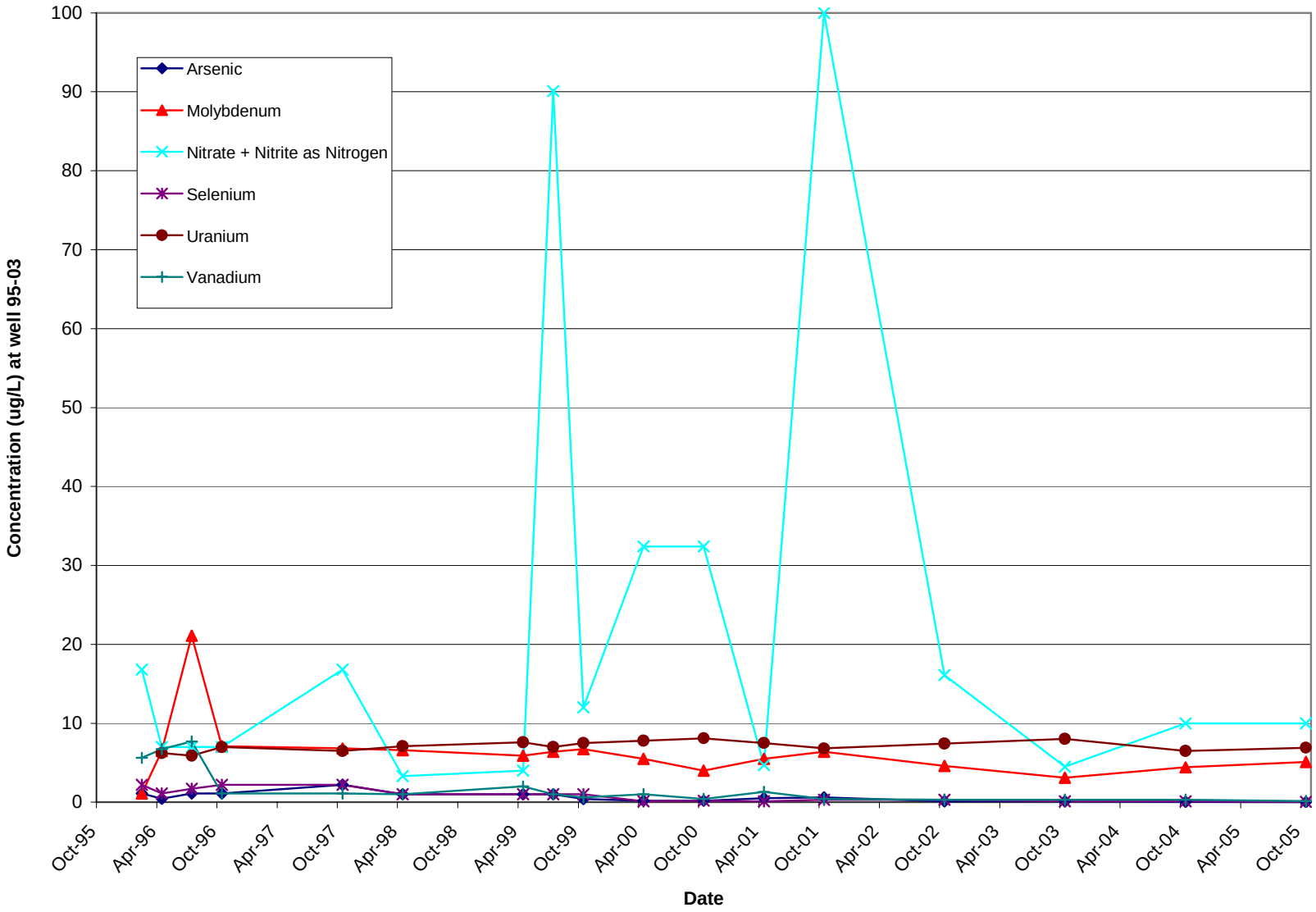

Figure 11. Contaminant Concentrations Over Time at Sentinel Well 95-03

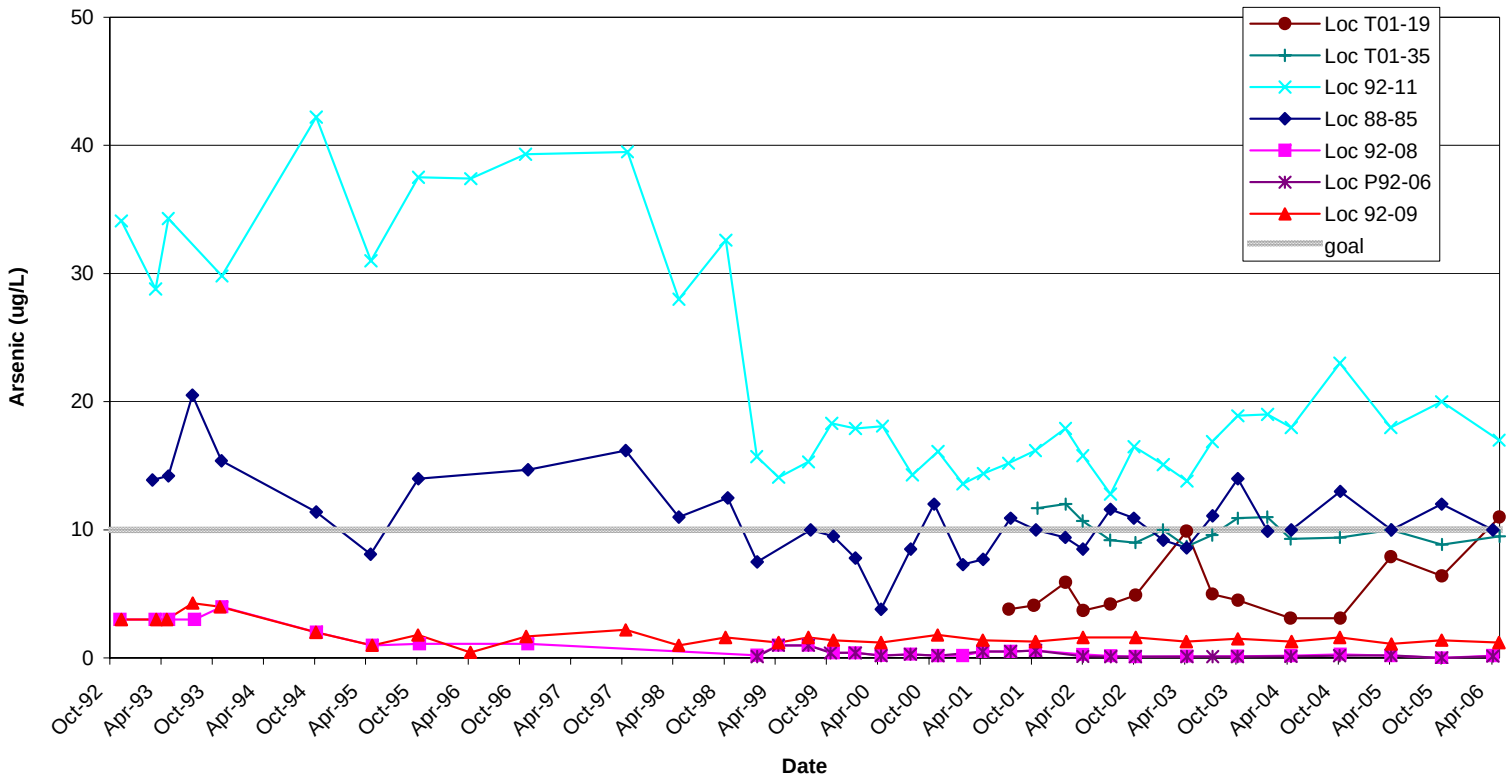

Figure 12. Arsenic Concentration Over Time at Selected Alluvial Aquifer Monitoring Wells

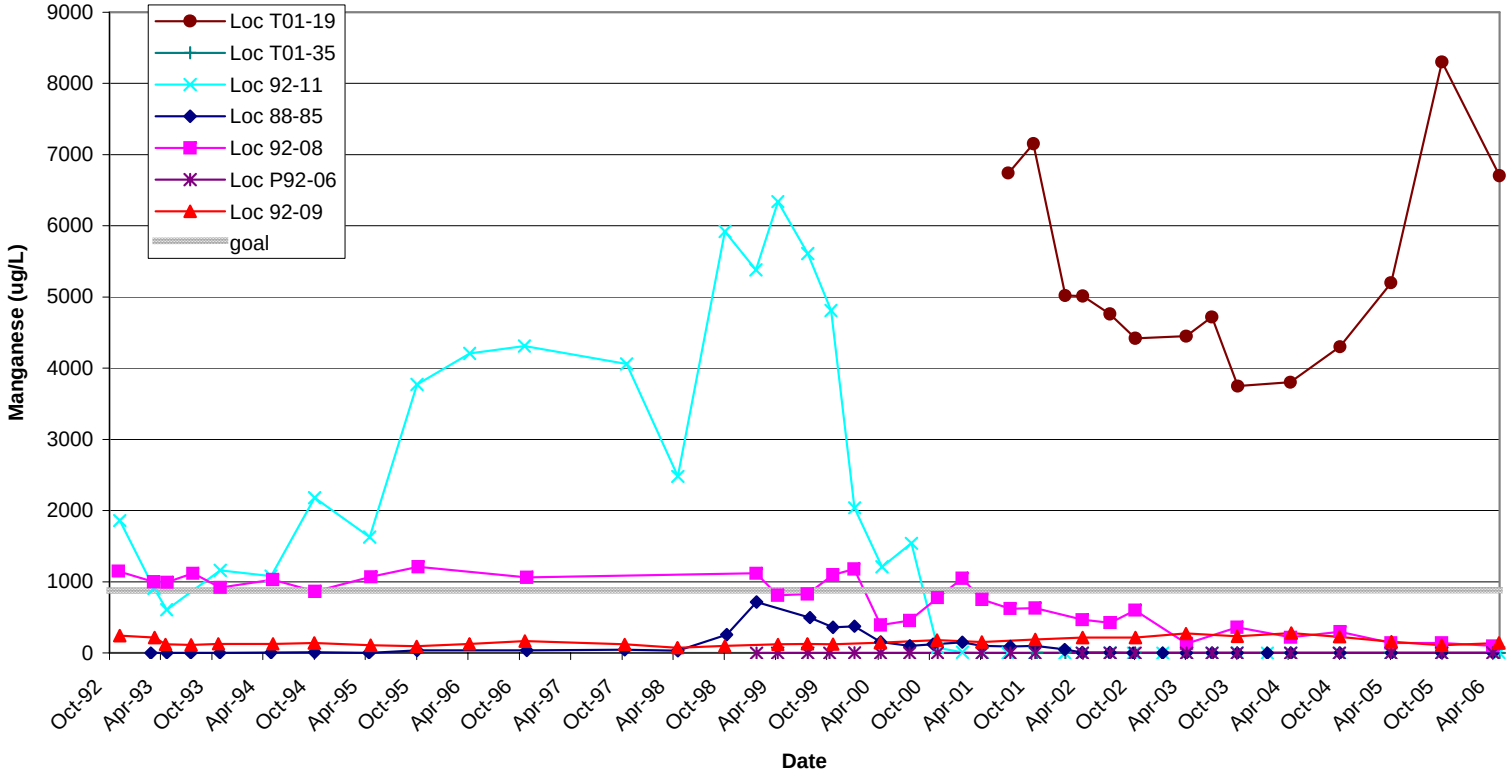

Figure 13. Manganese Concentration Over Time at Selected Alluvial Aquifer Monitoring Wells

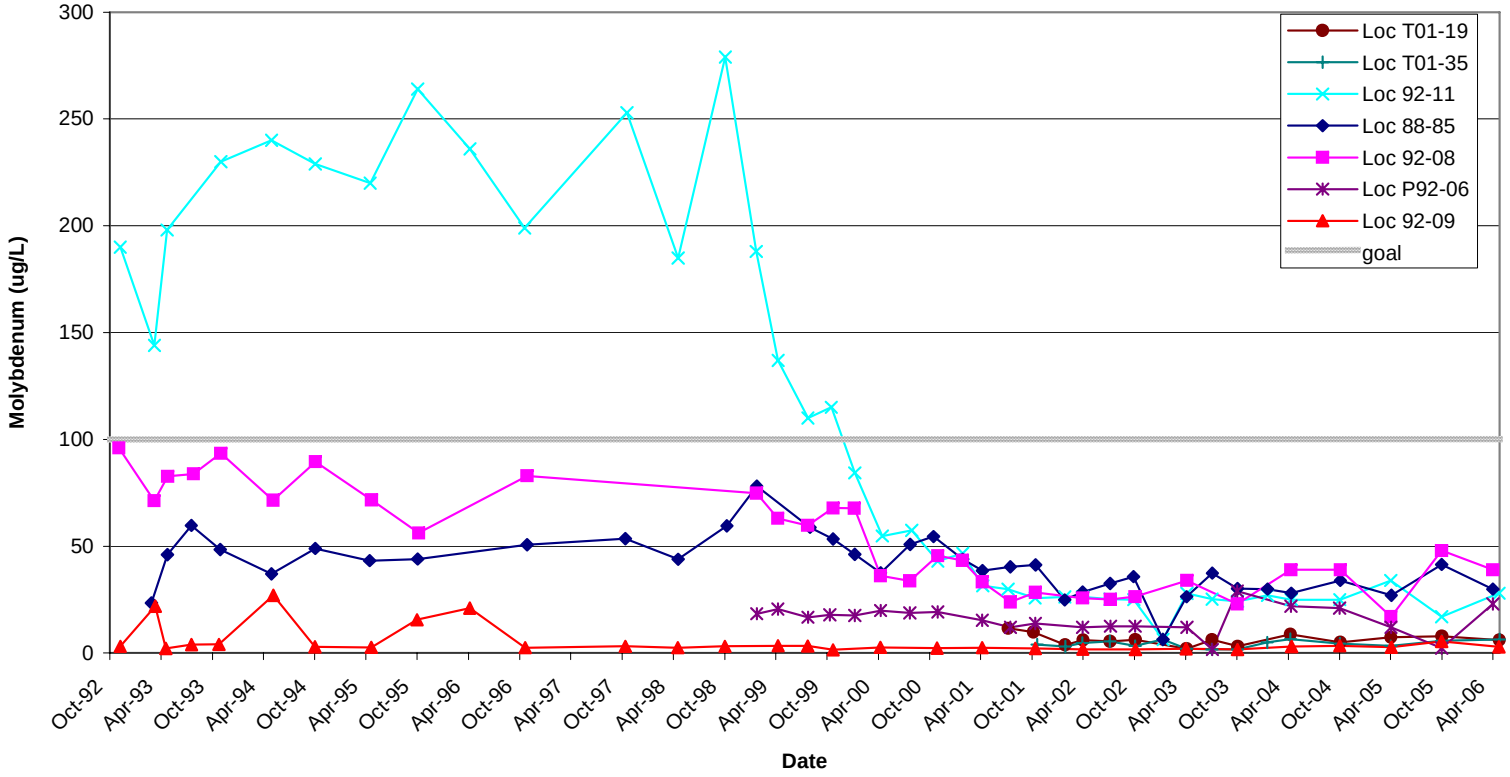

Figure 14. Molybdenum Concentration Over Time at Selected Alluvial Aquifer Monitoring Wells

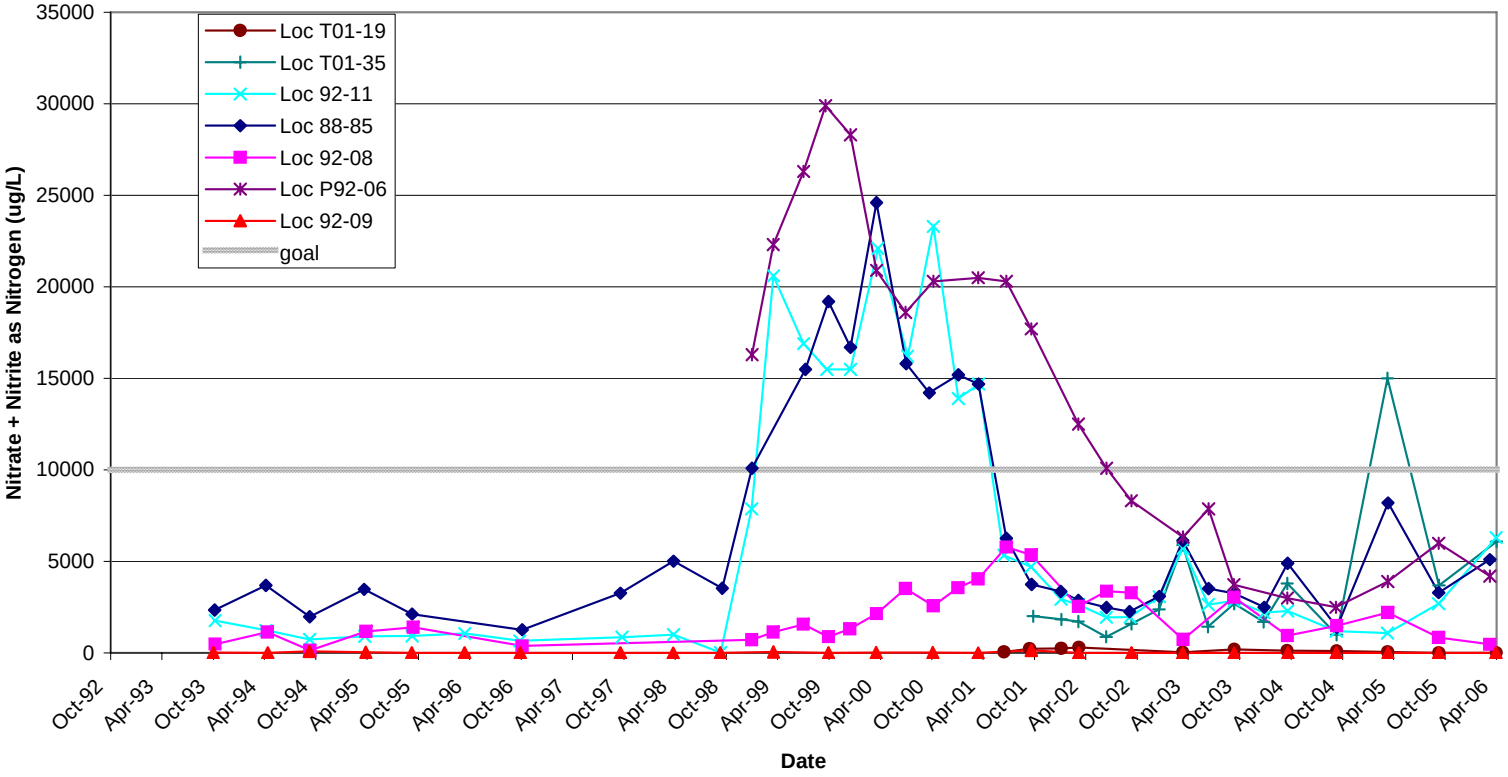

Figure 15. Nitrate (as N) Concentration Over Time at Selected Alluvial Aquifer Monitoring Wells

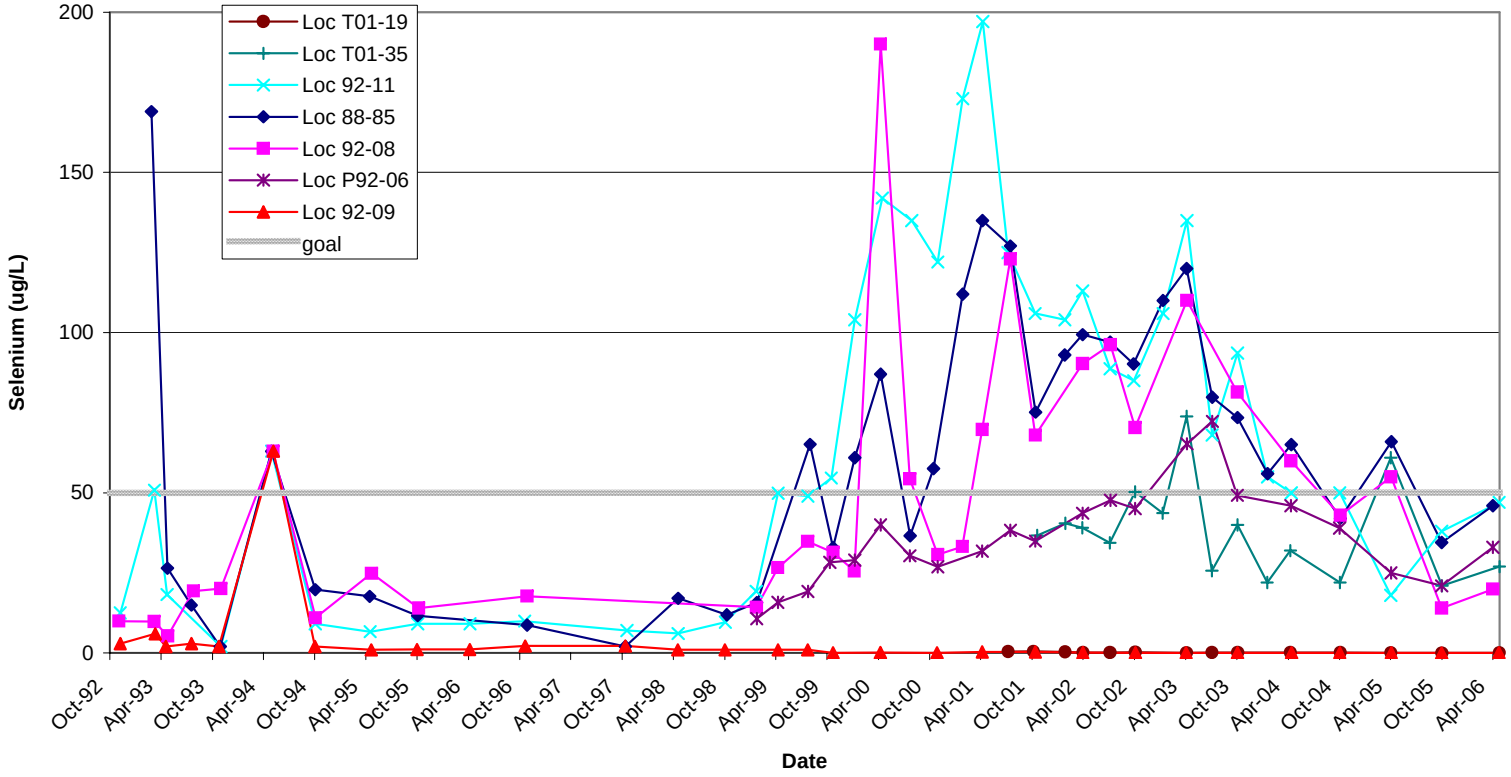

Figure 16. Selenium Concentration Over Time at Selected Alluvial Aquifer Monitoring Wells

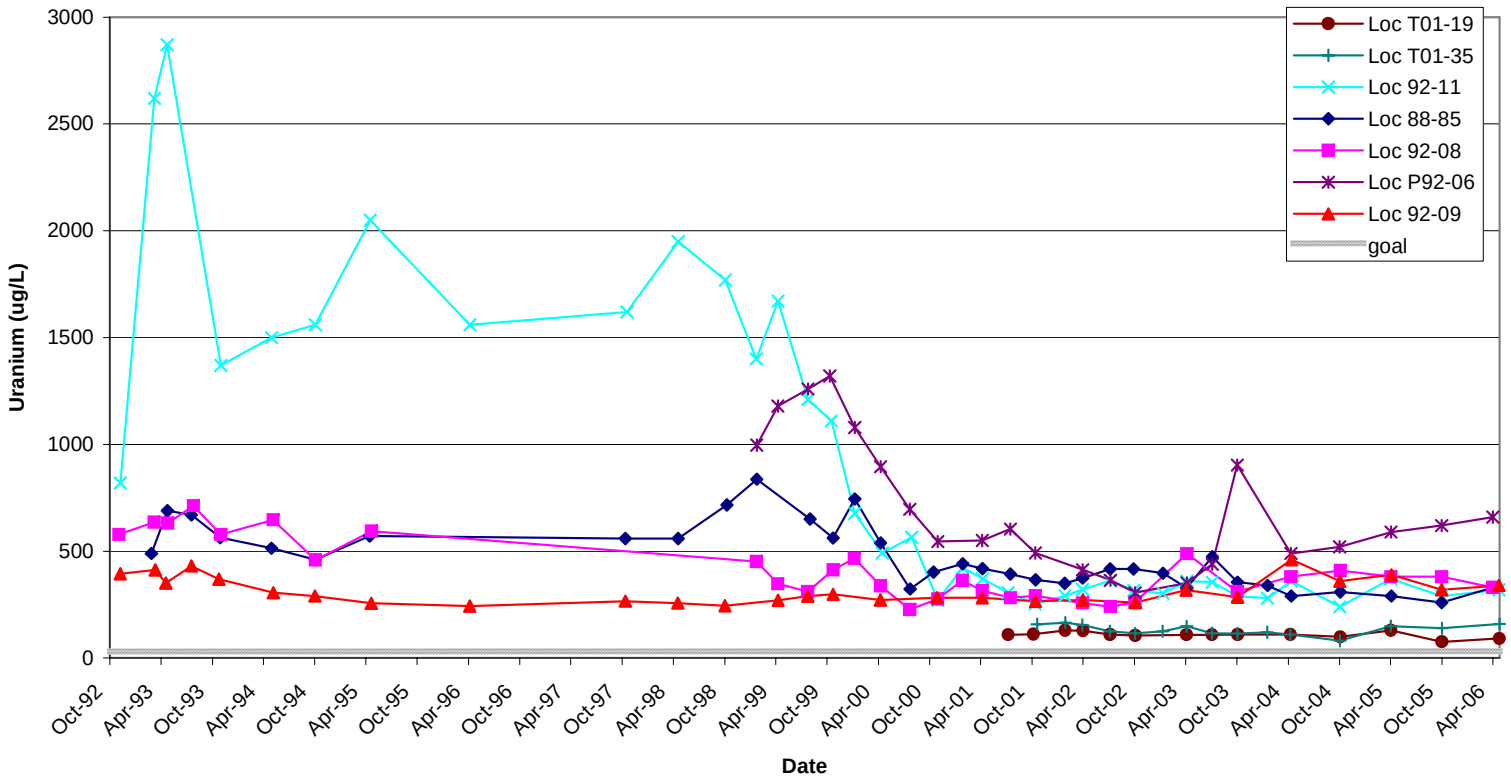

Figure 17. Uranium Concentration Over Time at Selected Alluvial Aquifer Monitoring Wells

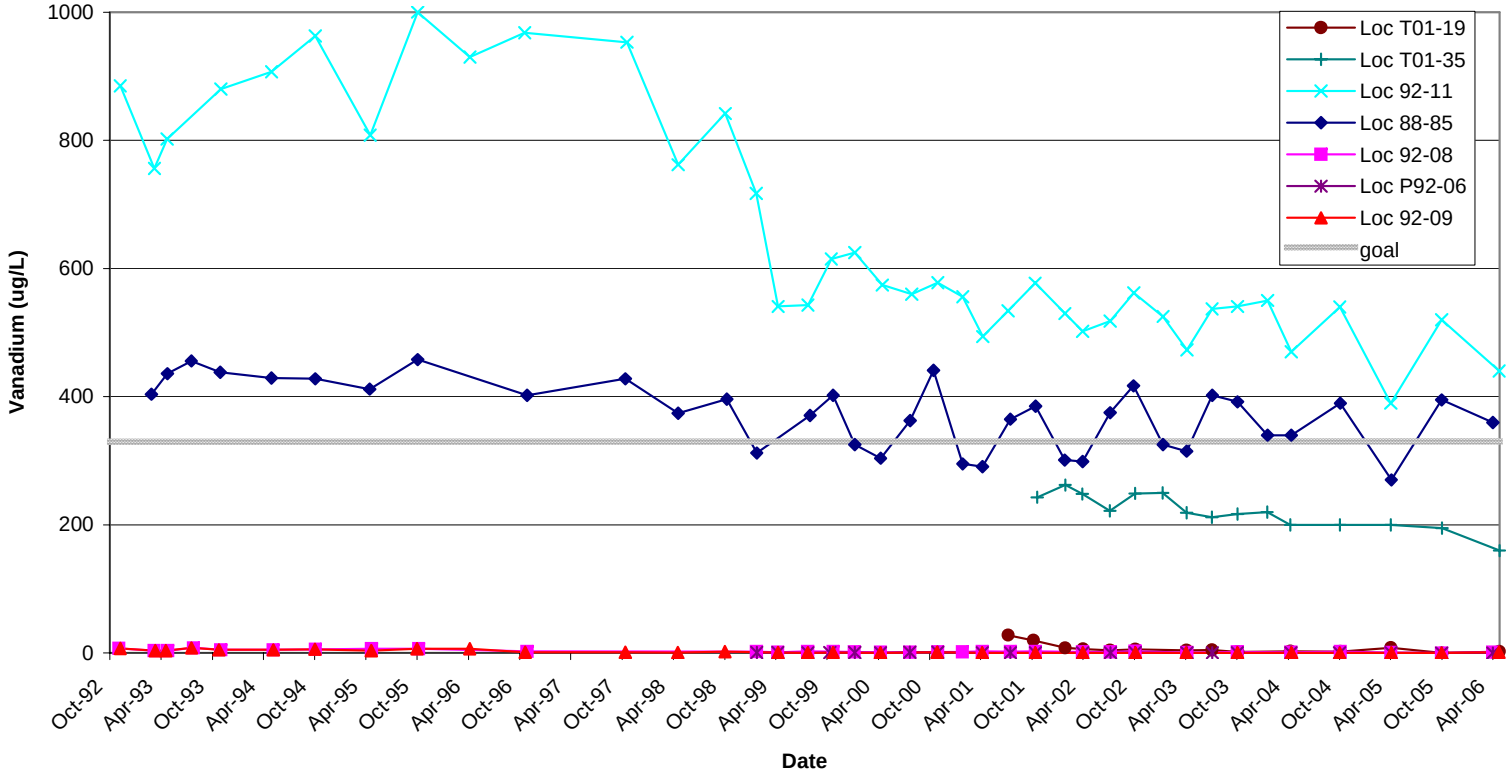

Figure 18. Vanadium Concentration Over Time at Selected Alluvial Aquifer Monitoring Wells

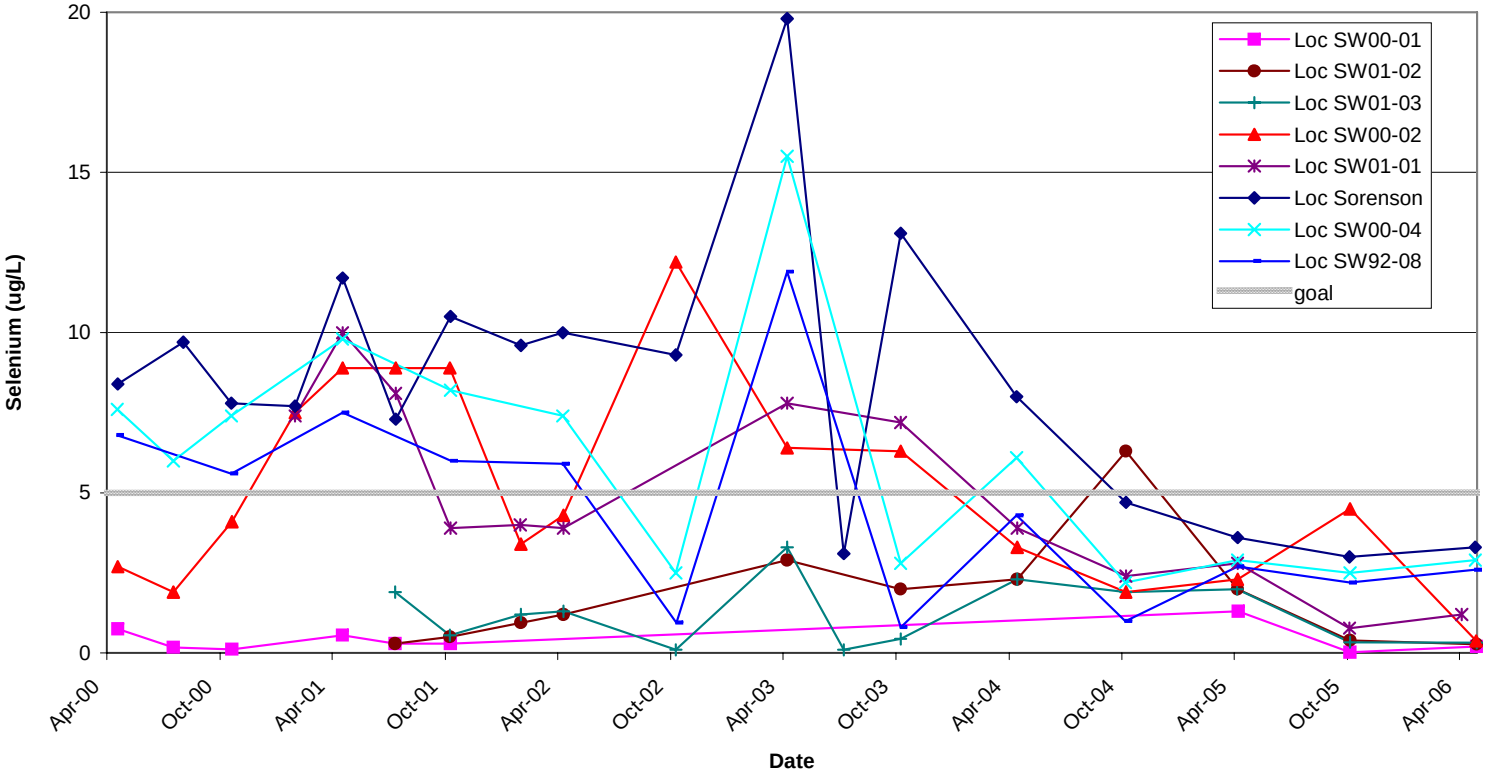

Figure 19. Selenium Concentration Over Time in Montezuma Creek

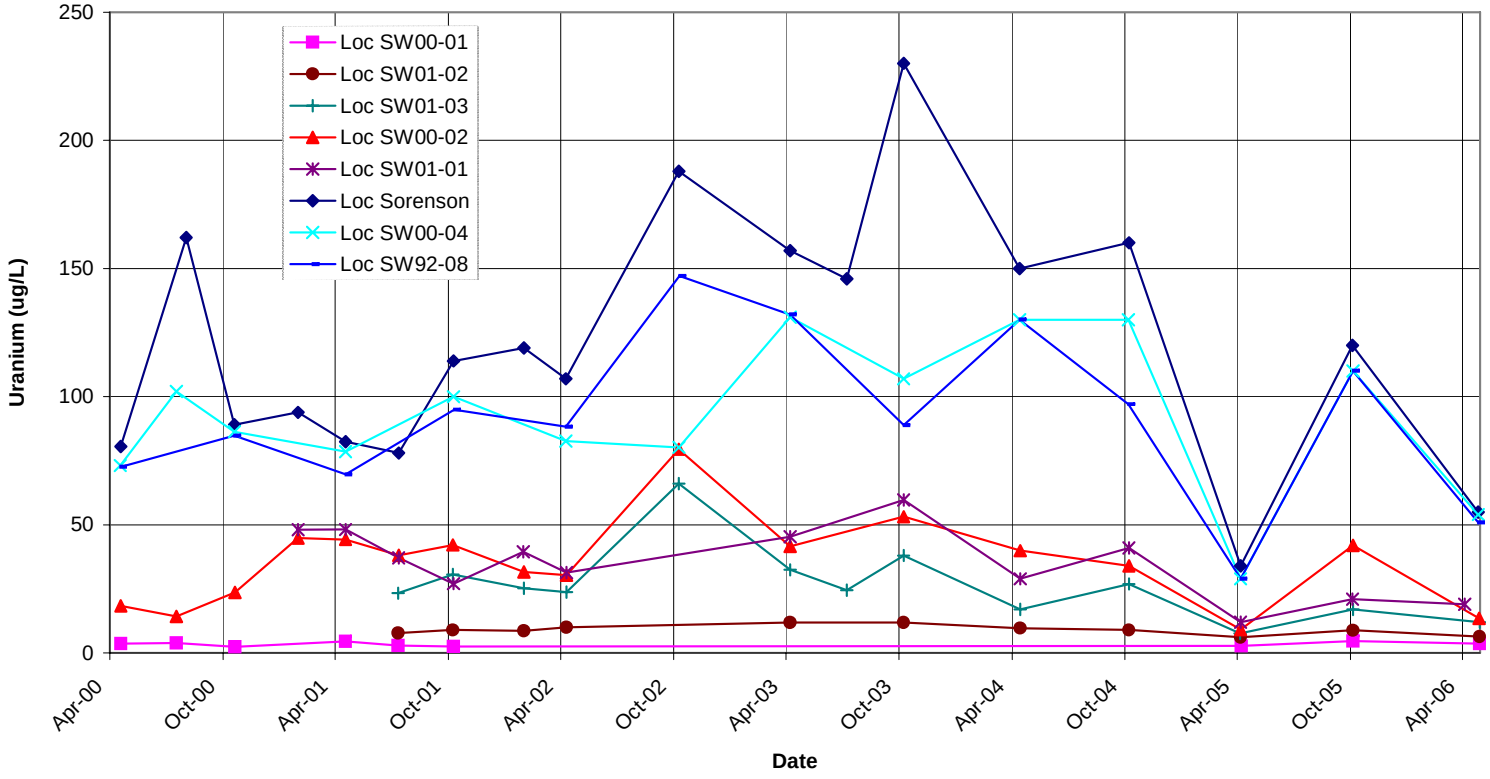

Figure 20. Uranium Concentration Over Time in Montezuma Creek

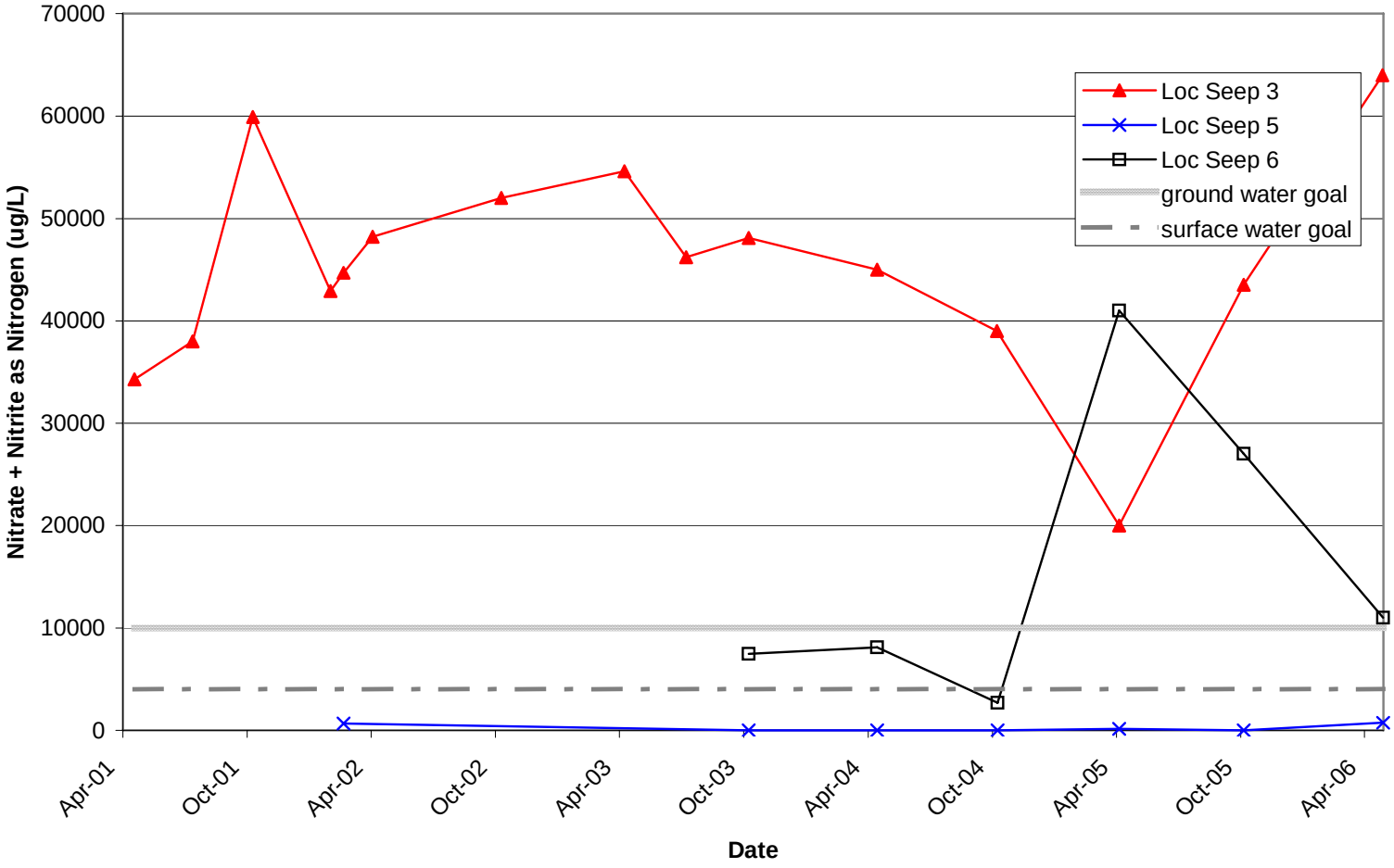

Figure 21. Nitrate (as N) Concentration Over Time at Selected Seep Locations

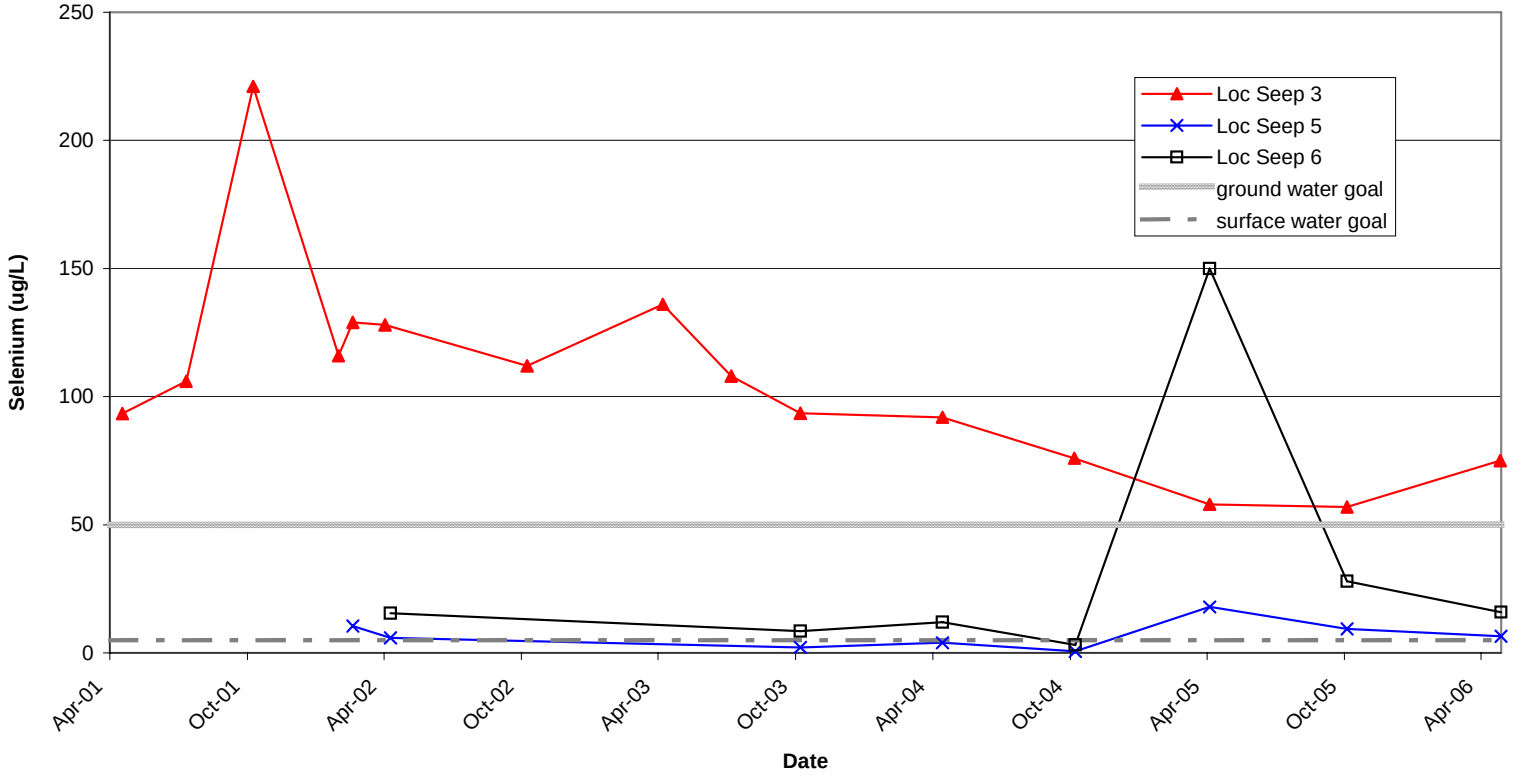

Figure 22. Selenium Concentration Over Time at Selected Seep Locations

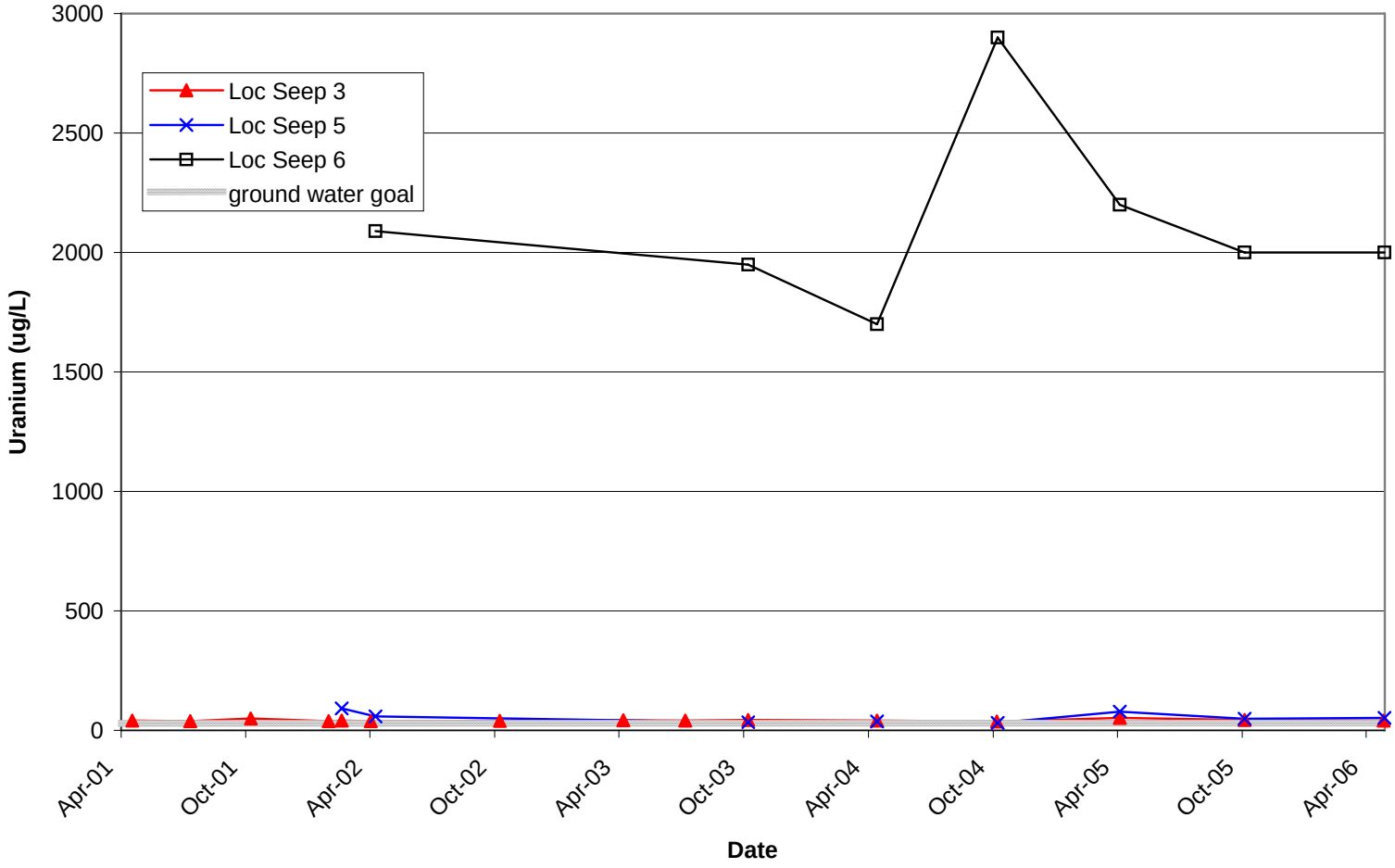

Figure 23. Uranium Concentration Over Time at Selected Seep Locations

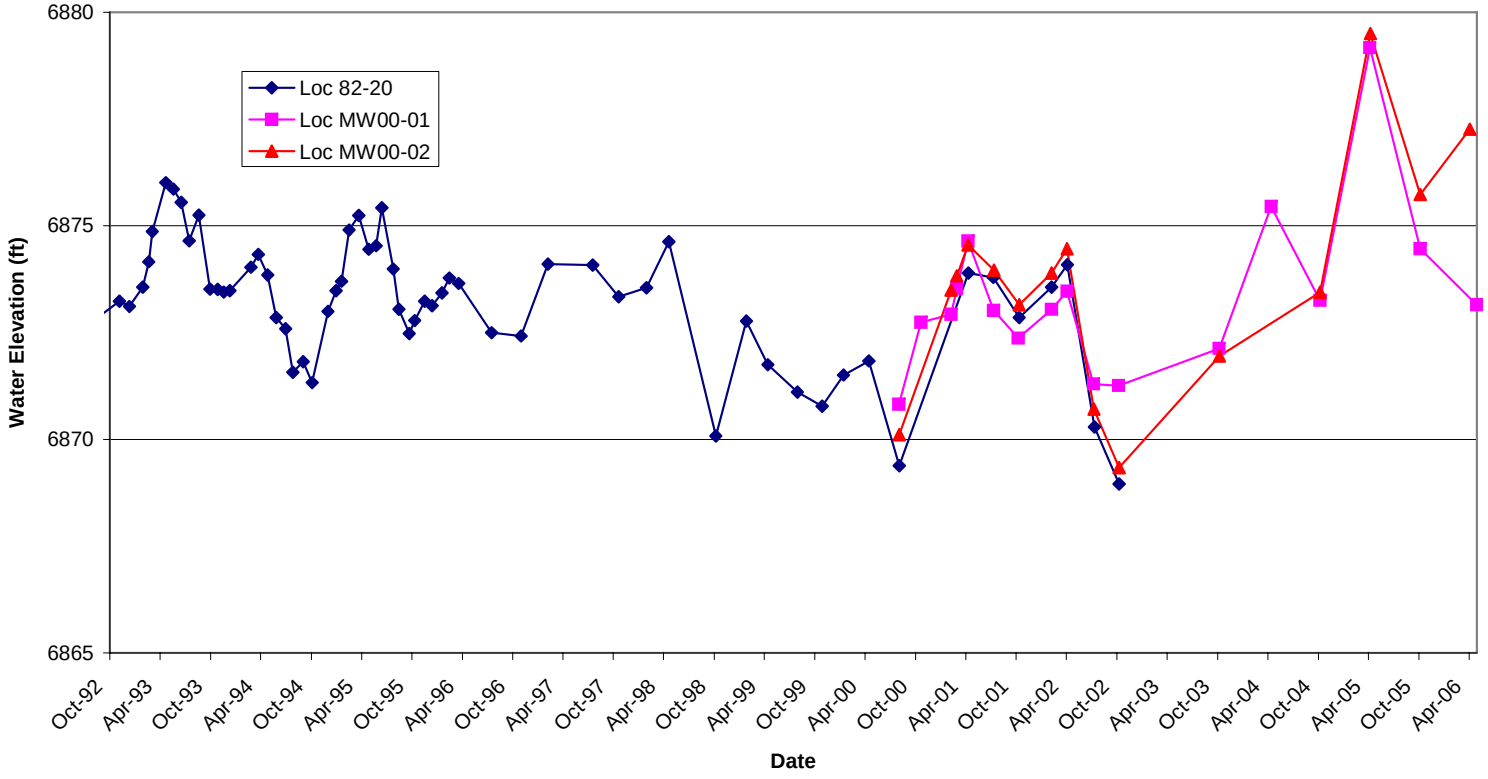

Figure 24. Water Level Hydrographs for Upgradient Alluvial Wells

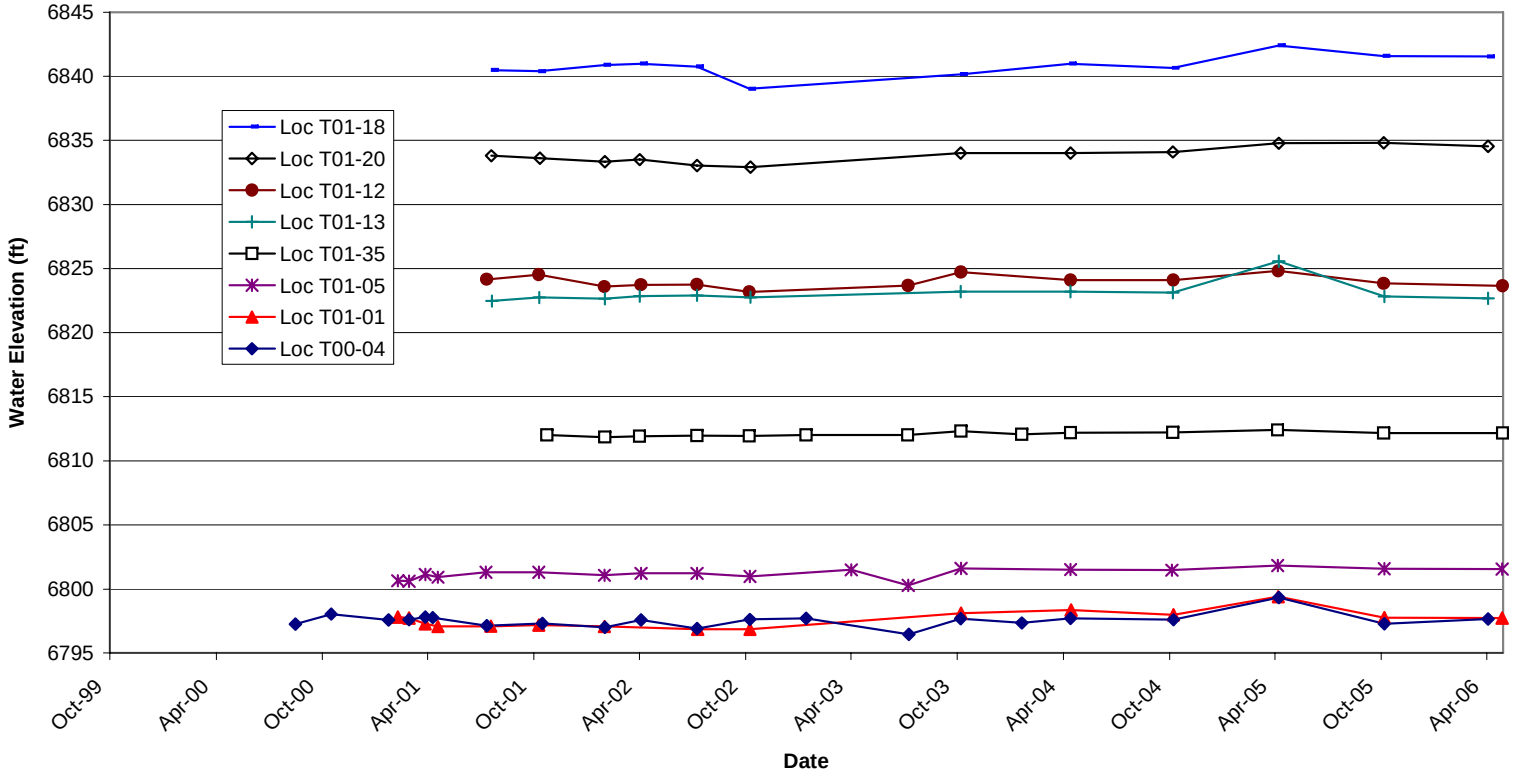

Figure 25. Water Level Hydrographs for Selected Millsite Alluvial Wells

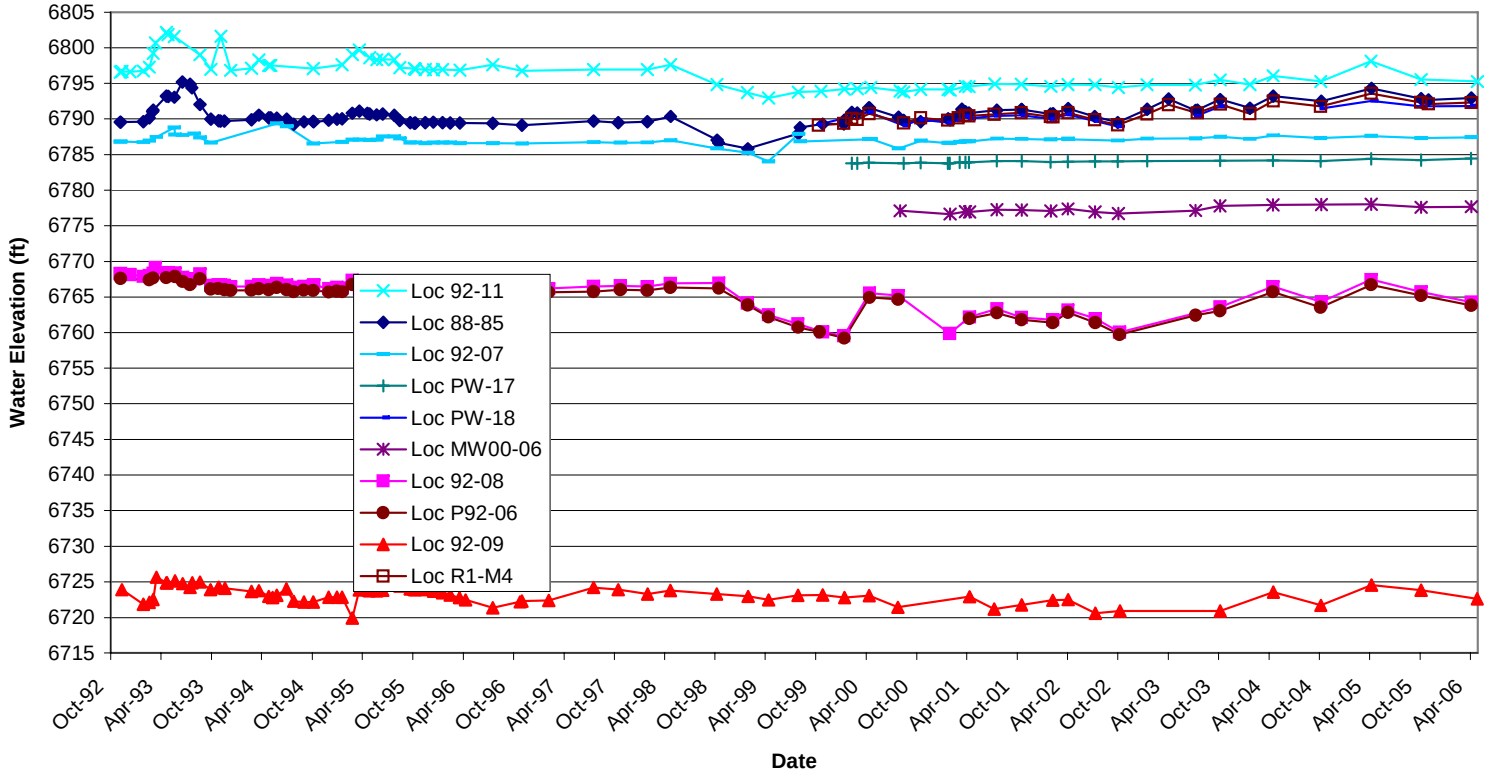

Figure 26. Water Level Hydrographs for Selected Downgradient Alluvial Wells

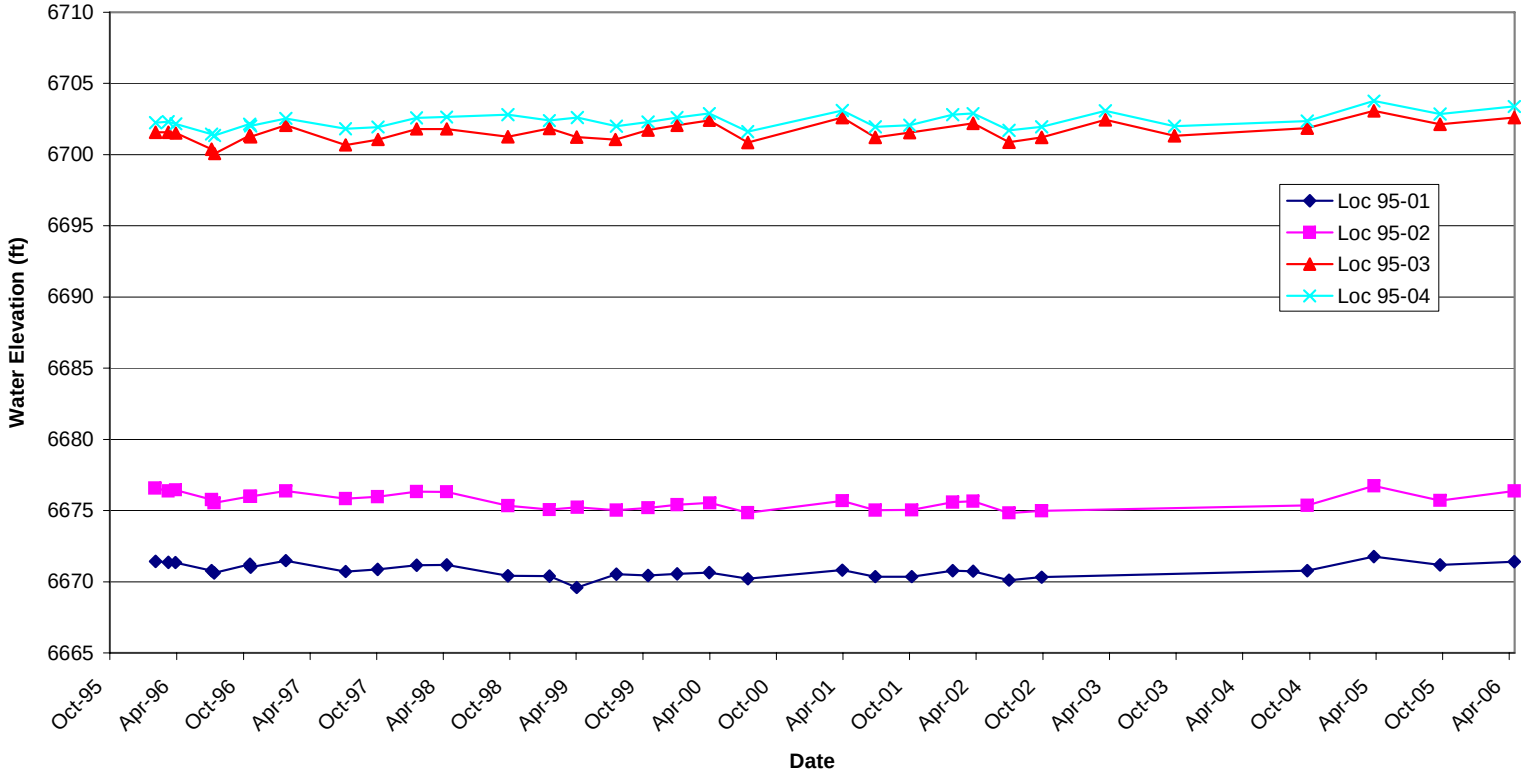

Figure 27. Water Level Hydrographs for Paired Alluvial/Burro Canyon Well Pairs 95-01/95-02 and 95-03/95-04

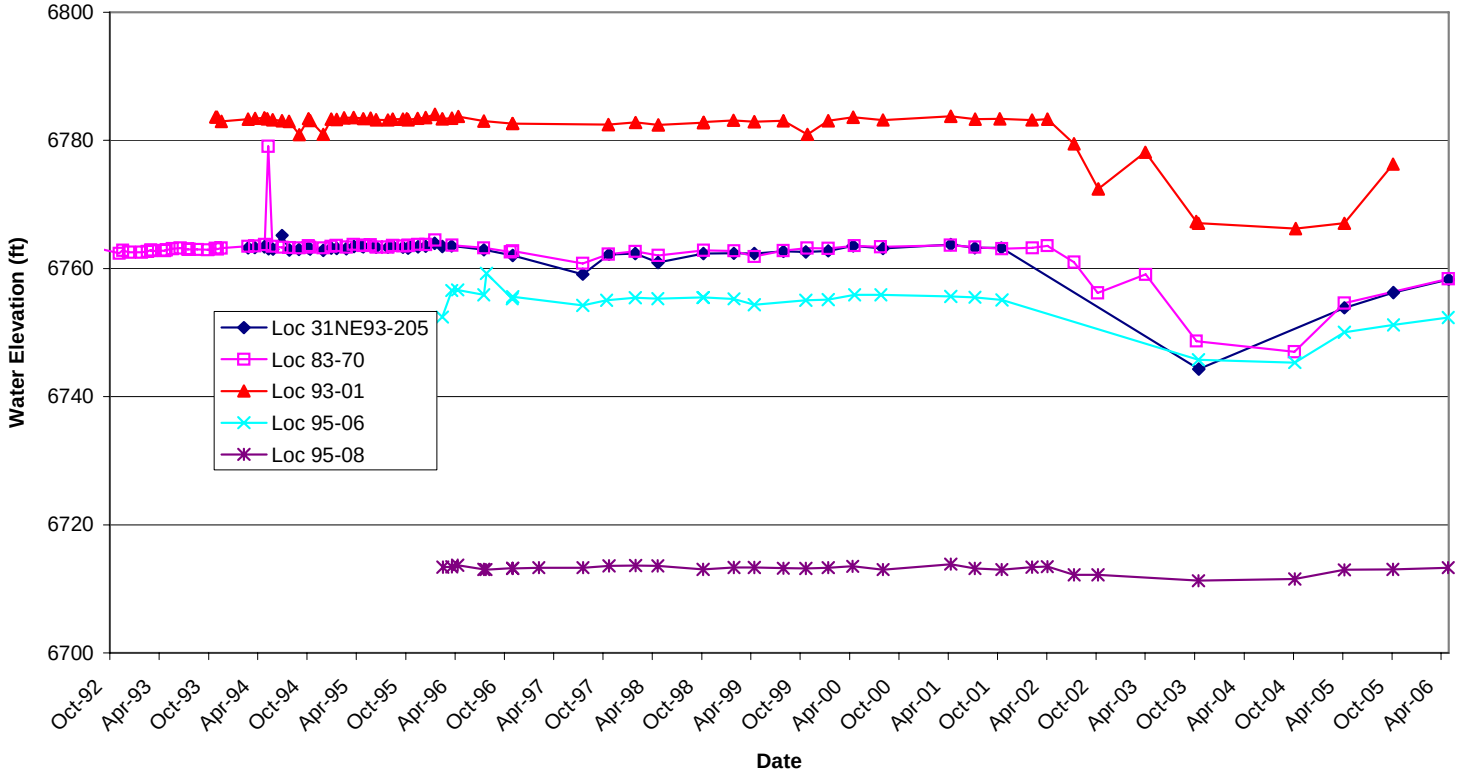

Figure 28. Water Level Hydrographs for Selected Burro Canyon Aquifer Wells

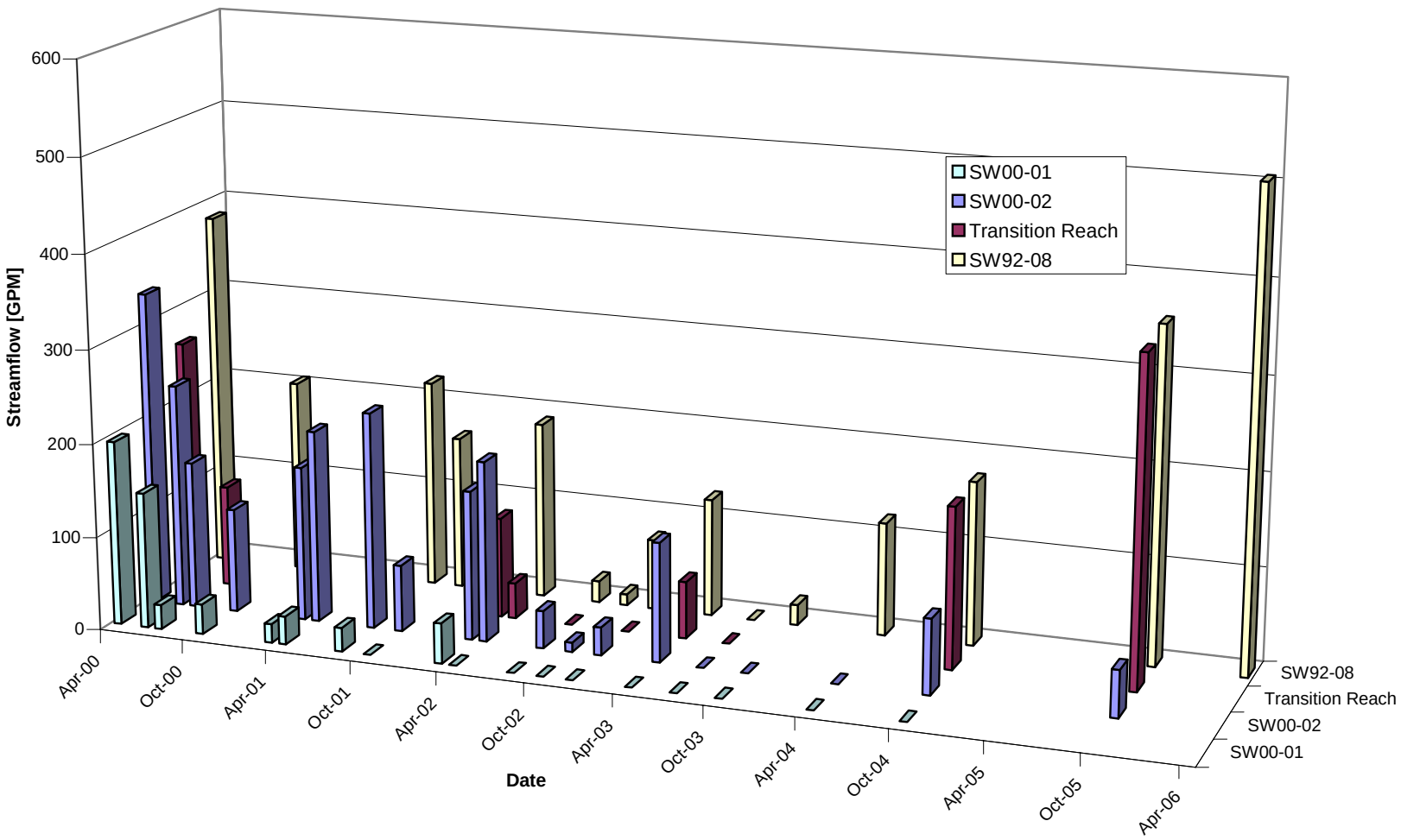

Figure 29. Stream Flow Hydrographs for Selected Sites on Montezuma Creek

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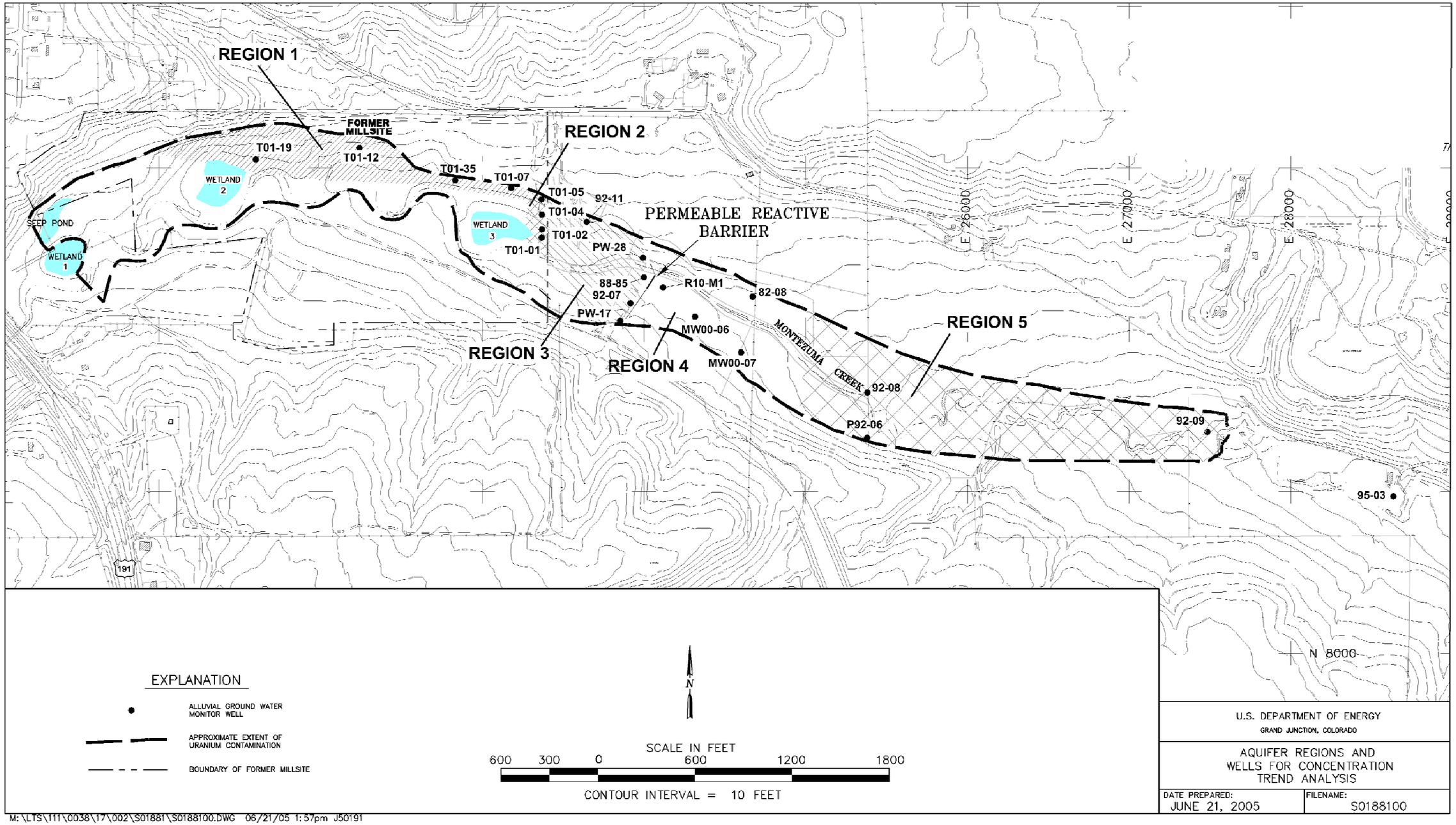

Figure 30. Aquifer Regions and Monitoring Wells Selected for Concentration Trend Analysis

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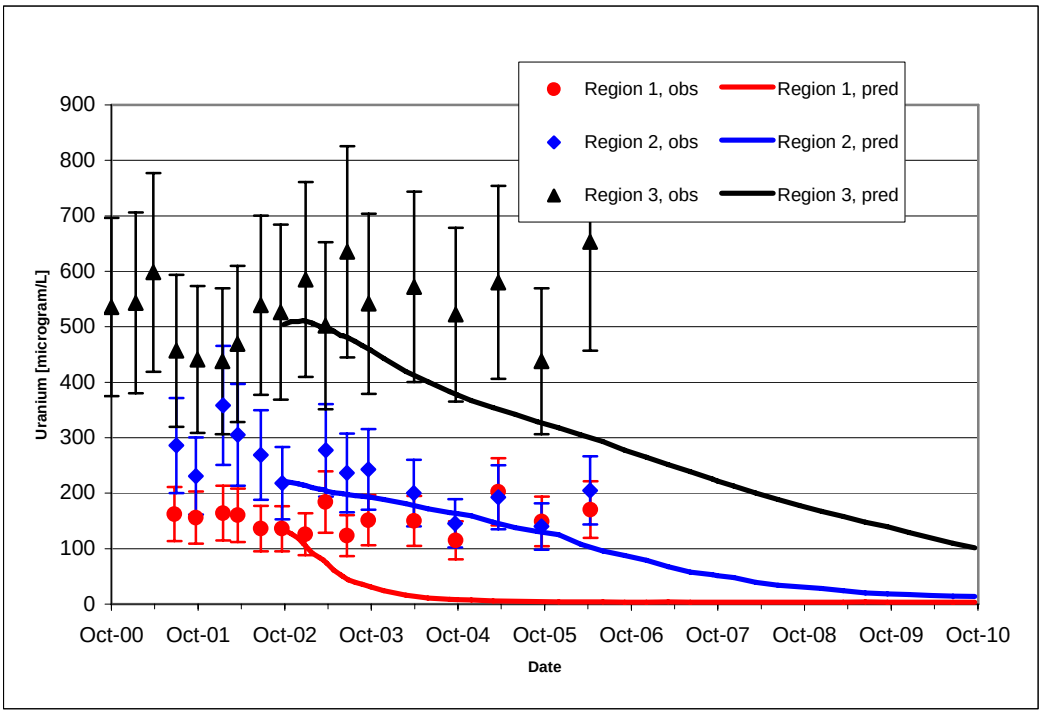

Figure 31. Comparison of Model Prediction to Observed Restoration Progress–Aquifer Regions 1 to 3

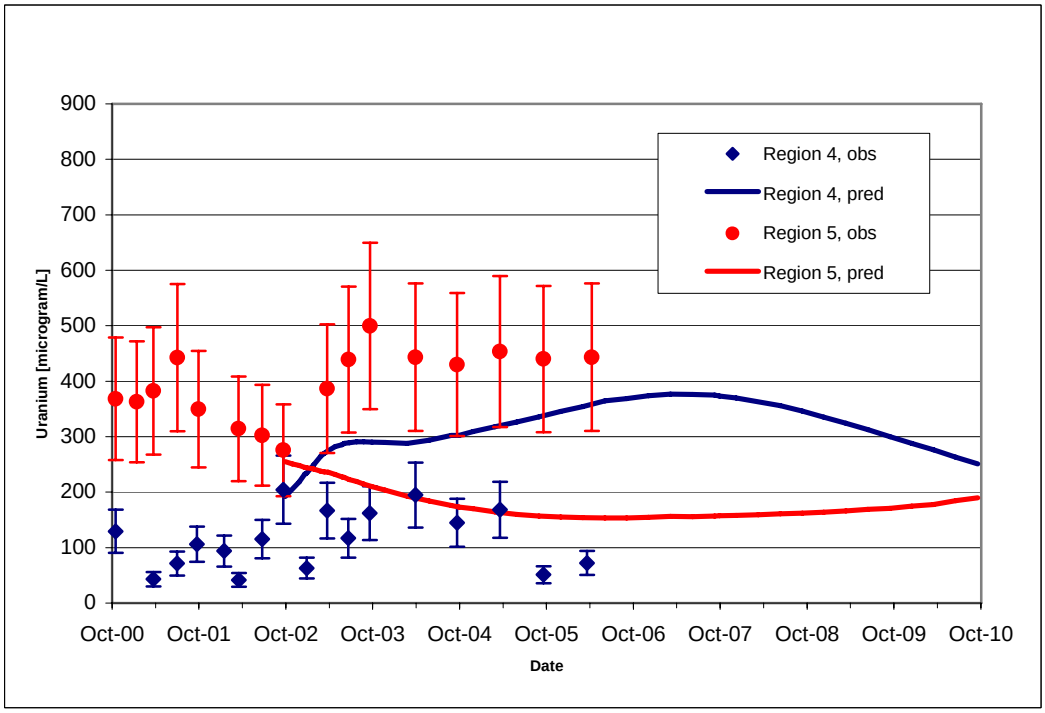

Figure 32. Comparison of Model Prediction to Observed Restoration Progress–Aquifer Regions 4 and 5

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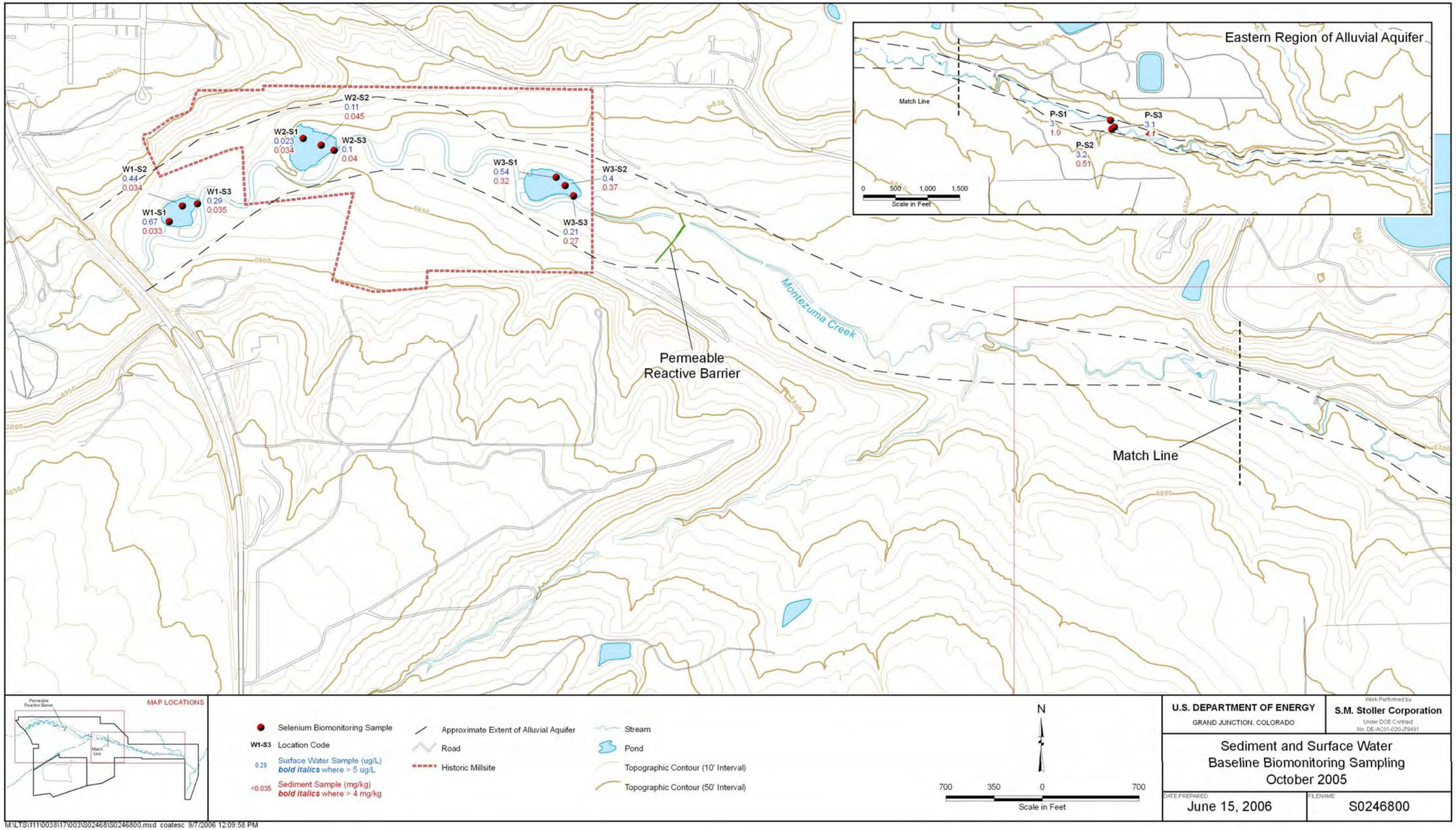

Figure 33. Sediment and Surface Water Sample Locations and Results for Post-ROD Biomonitoring, October 2005 Event

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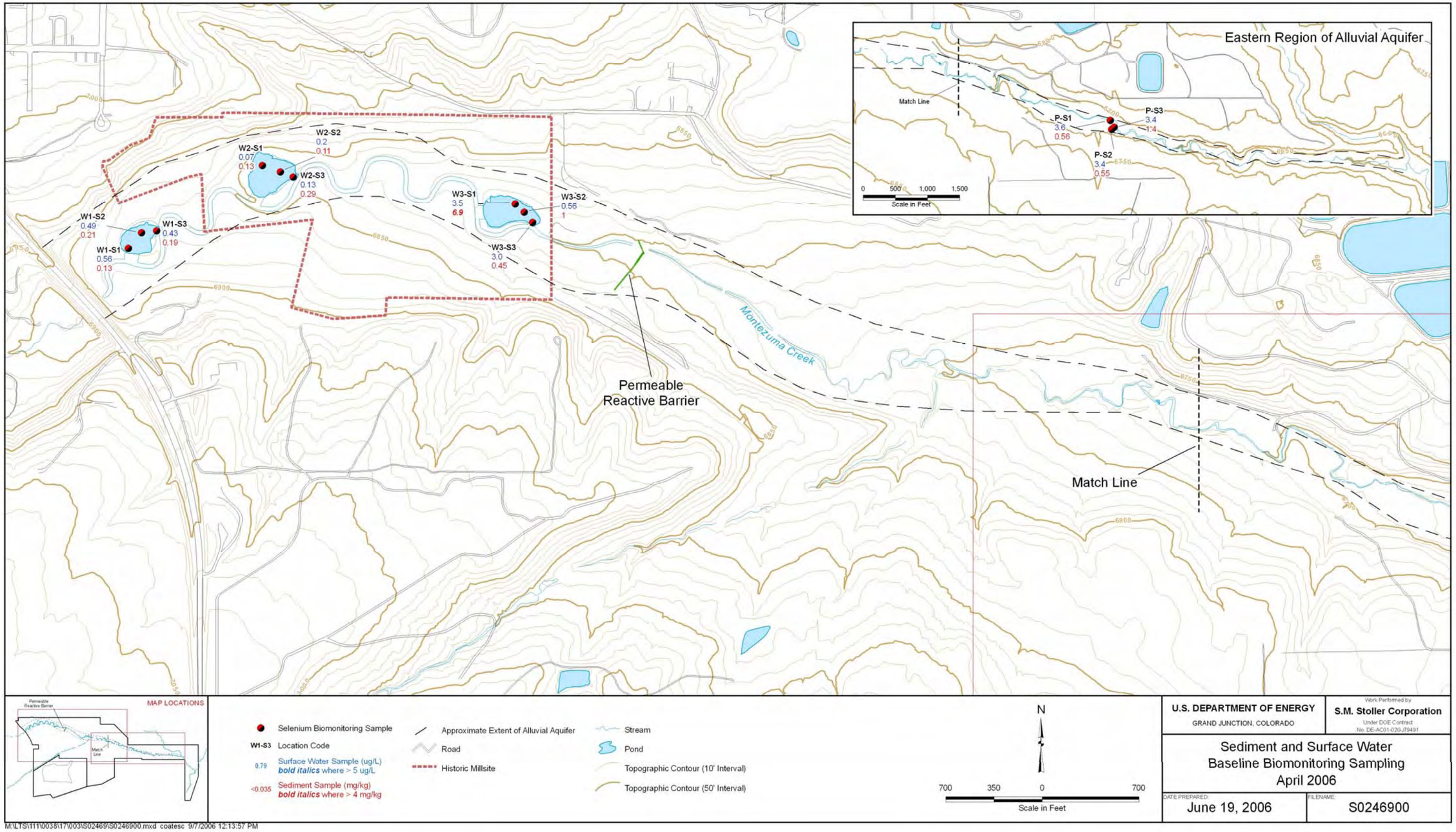

Figure 34. Sediment and Surface Water Sample Locations and Results For Post-ROD Biomonitoring, April 2006 Event

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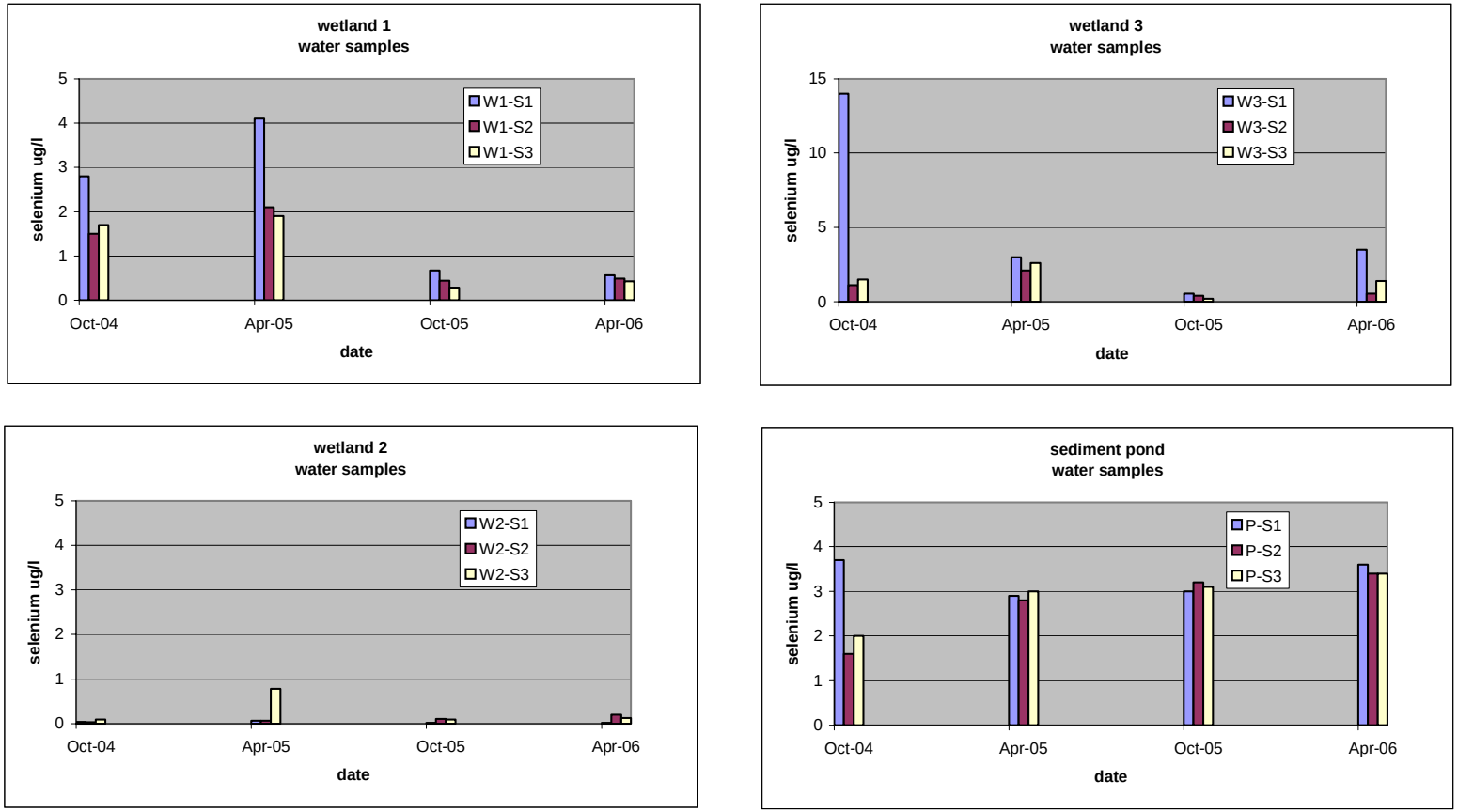

Figure 35. Post-ROD Biomonitoring Results for Selenium in Surface Water

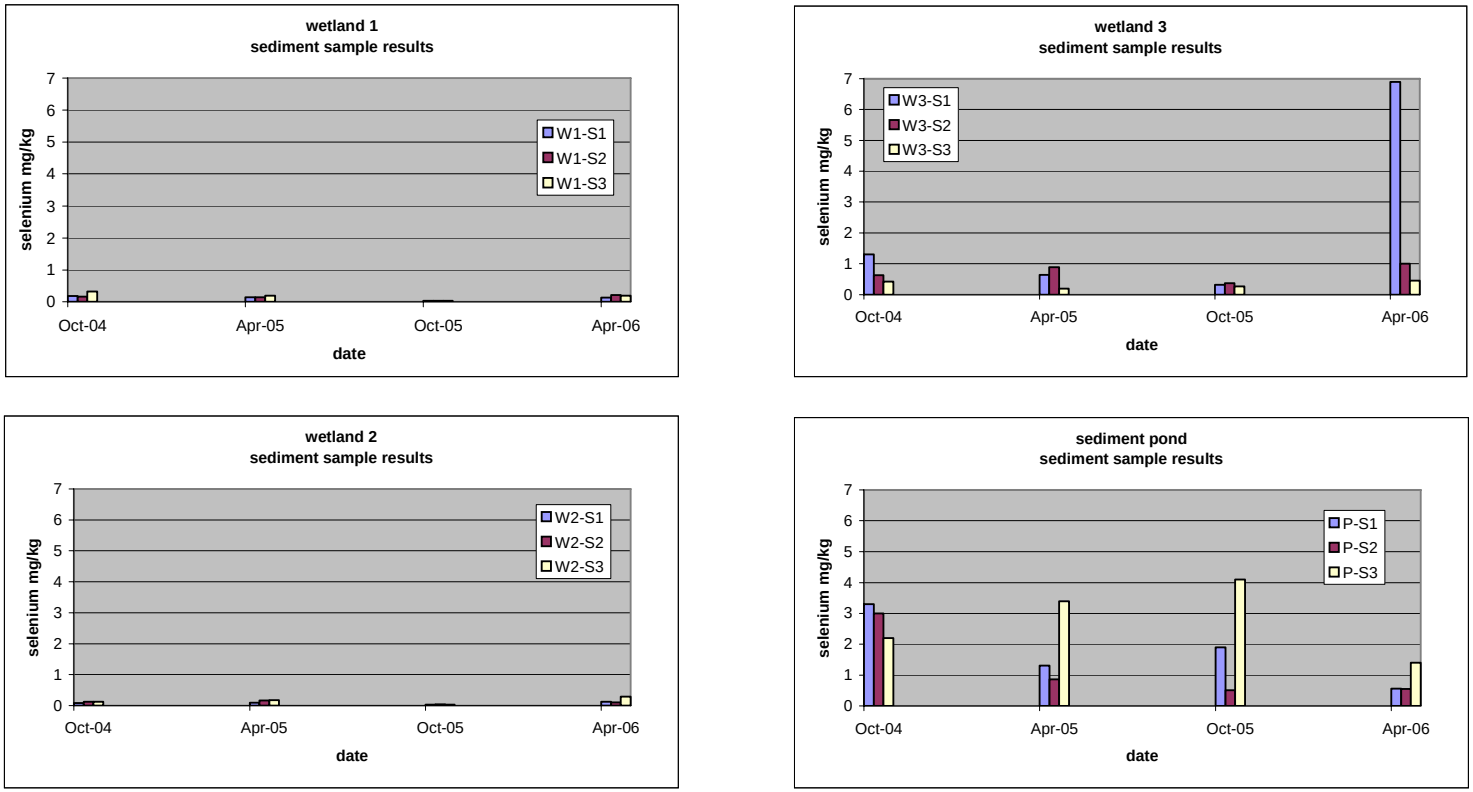

Figure 36. Post-ROD Biomonitoring Results for Selenium in Sediment