Department of Energy
Office of Legacy Management

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11545 Rockville Pike
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Rockville, MD 20852-2738

Subject: *Verification Monitoring Report for the New and Old Rifle, Colorado, Processing Sites*

Dear Mr. Von Till:

Enclosed for your files are two copies of the 2006 *Verification Monitoring Report for the New and Old Rifle, Colorado, Processing Sites.*

Please contact me at (970) 248-6073 if you have any questions.

Sincerely,

Richard P. Bush
Site Manager

Enclosures (2)

cc w/o enclosures:
R. Dayvault, Stoller
Project File RFN 110.02 (Thru D. Roberts)

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DOE–LM/1306–2006

Verification Monitoring Report for the Old and New Rifle, Colorado, Processing Sites

September 2006

U.S. Department of Energy

Office of Legacy Management

Work Performed Under DOE Contract No. DE–AC01–02GJ79491
for the U.S. Department of Energy Office of Legacy Management.

DOE-LM/1306-2006

Verification Monitoring Report for the Old and New Rifle, Colorado, Processing Sites

September 2006

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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Acronyms and Abbreviations

CDPHE	Colorado Department of Public Health and Environment
COC	constituent of concern
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ft	foot (feet)
GCAP	Ground Water Compliance Action Plan
ICs	institutional controls
MCL	maximum concentration limit
mg/L	milligram per liter
NRC	U.S. Nuclear Regulatory Commission
RRM	residual radioactive material
SOWP	Site Observational Work Plan
UMTRA	Uranium Mill Tailings Remedial Action (Project)

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1.0 Introduction

1.1 Purpose of Report

The purpose of this Verification Monitoring Report is to evaluate and interpret ground water monitoring data collected at the Old and New Rifle, Colorado, Uranium Mill Tailings Remedial Action (UMTRA) Project processing sites (Figure 1 and Figure 2) and to assess the progress of meeting the compliance strategy for ground water cleanup. Detailed information for the Old and New Rifle sites and water quality data through 1998 and 1999 are found in the Final Site Observational Work Plans (SOWPs) (DOE 1999a and 1999b) for the sites.

1.2 Compliance Strategy

The proposed compliance strategy for both the New and Old Rifle sites is natural flushing in conjunction with continued ground water and surface water monitoring, and institutional controls (ICs) that would restrict access to contaminated ground water (DOE 2005 and 2001). Also, the U.S. Department of Energy (DOE) and the State of Colorado constructed an alternate domestic water supply system in 2003 to service users near and downgradient of the New Rifle site (Figure 2). This compliance strategy will be protective of human health and the environment.

1.3 Site Status

The Old Rifle SOWP (DOE 1999a) and Ground Water Compliance Action Plan (GCAP) (DOE 2001) are complete and have received concurrence from the U.S. Nuclear Regulatory Commission (NRC) and the Colorado Department of Public Health and Environment (CDPHE). The conditions are to maintain ICs over the site and conduct a monitoring program until levels of contaminants of concern (COCs) decrease to acceptable levels. An Environmental Checklist was completed and accepted for the Old Rifle site. The Old Rifle site is currently owned by the City of Rifle.

The New Rifle SOWP (DOE 1999b) and the GCAP (DOE 2006) have been submitted to NRC and CDPHE. Final concurrence of the GCAP by NRC and the State will occur when all issues of their reviews are resolved and the GCAP is revised accordingly. The conditions are to maintain ICs over the site and downgradient areas (Figure 3) and continue a monitoring program until concentrations of COCs decrease to acceptable levels. An Environmental Assessment resulting in a Finding of No Significant Impact was completed and distributed to stakeholders (DOE 2003). The annual verification monitoring proposed in the GCAPs for these sites is currently being implemented and results of late 2004/2005 are presented in this report.

2.0 Site Conditions

2.1 Hydrogeology

The former Old Rifle processing site is 0.3 mile southeast of the City of Rifle, in a floodplain on the north side of the Colorado River (Figure 1). Ground water occurs under unconfined conditions in the uppermost aquifer that consists of river alluvium and the upper weathered surface of the Tertiary Wasatch Formation. The uppermost aquifer is 5 to 25 feet (ft) thick;

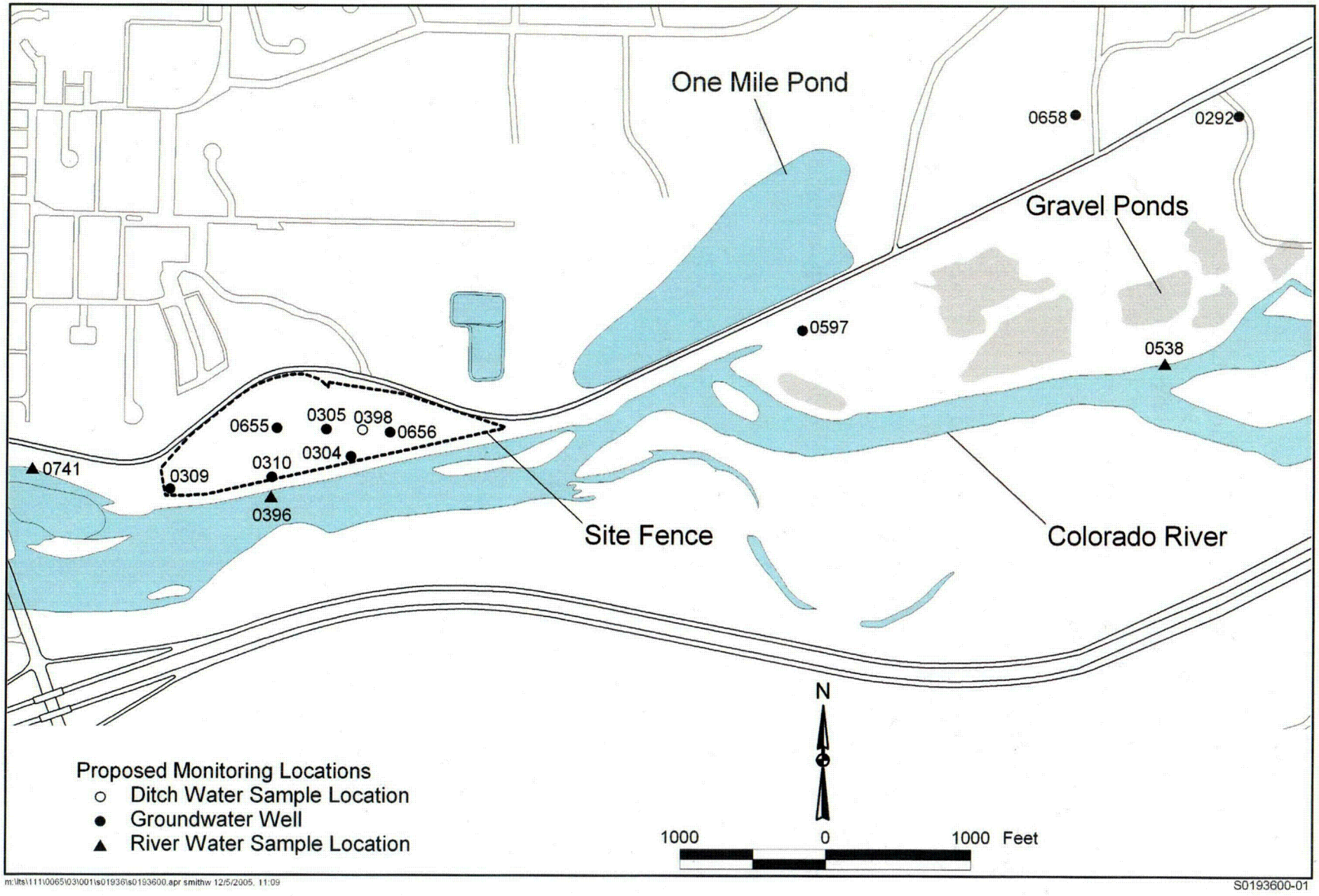

Figure 1. Location of the Old Rifle Millsite with Sample Locations and Site Boundary

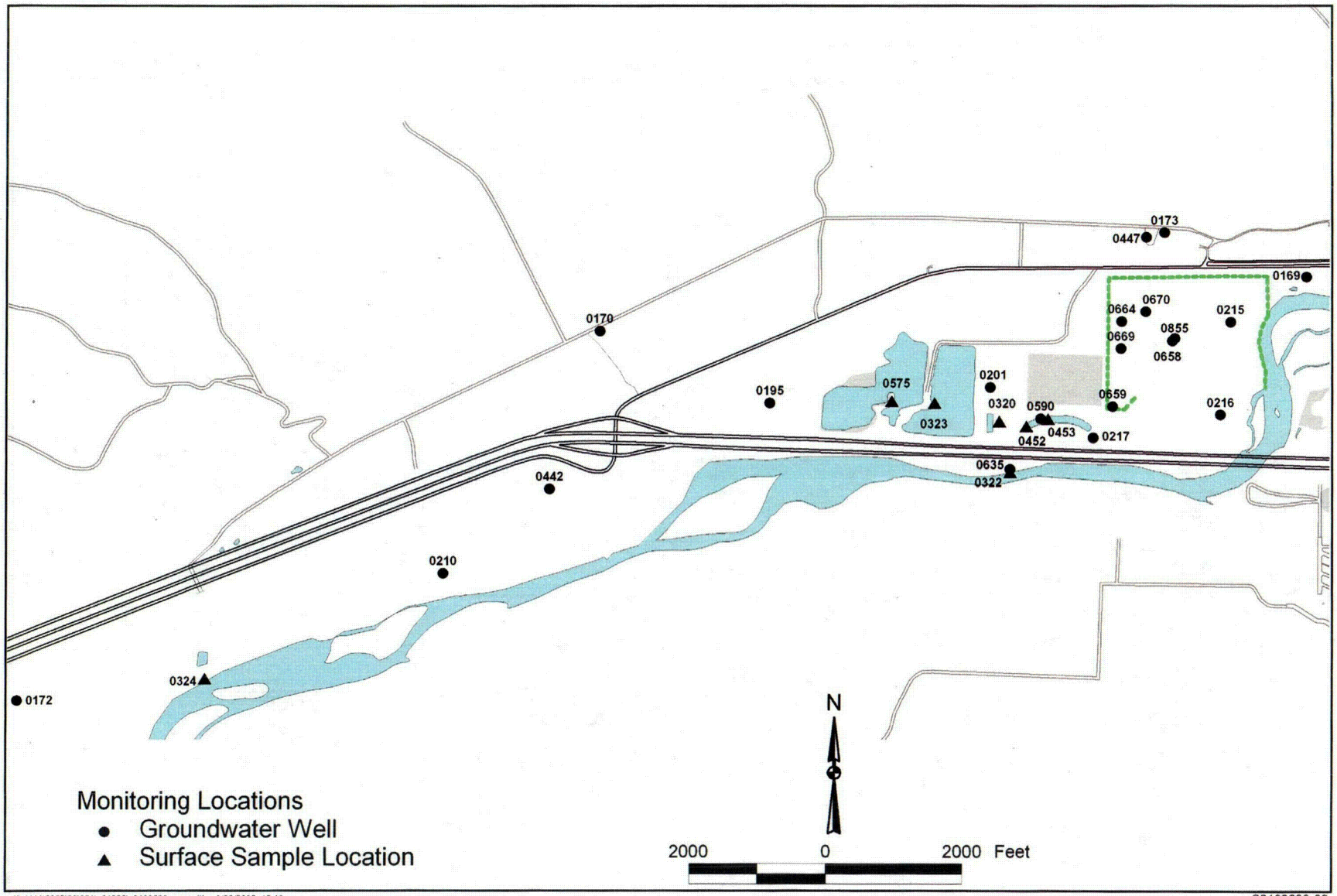

Figure 2. Location of the New Rifle Millsite Monitoring Locations

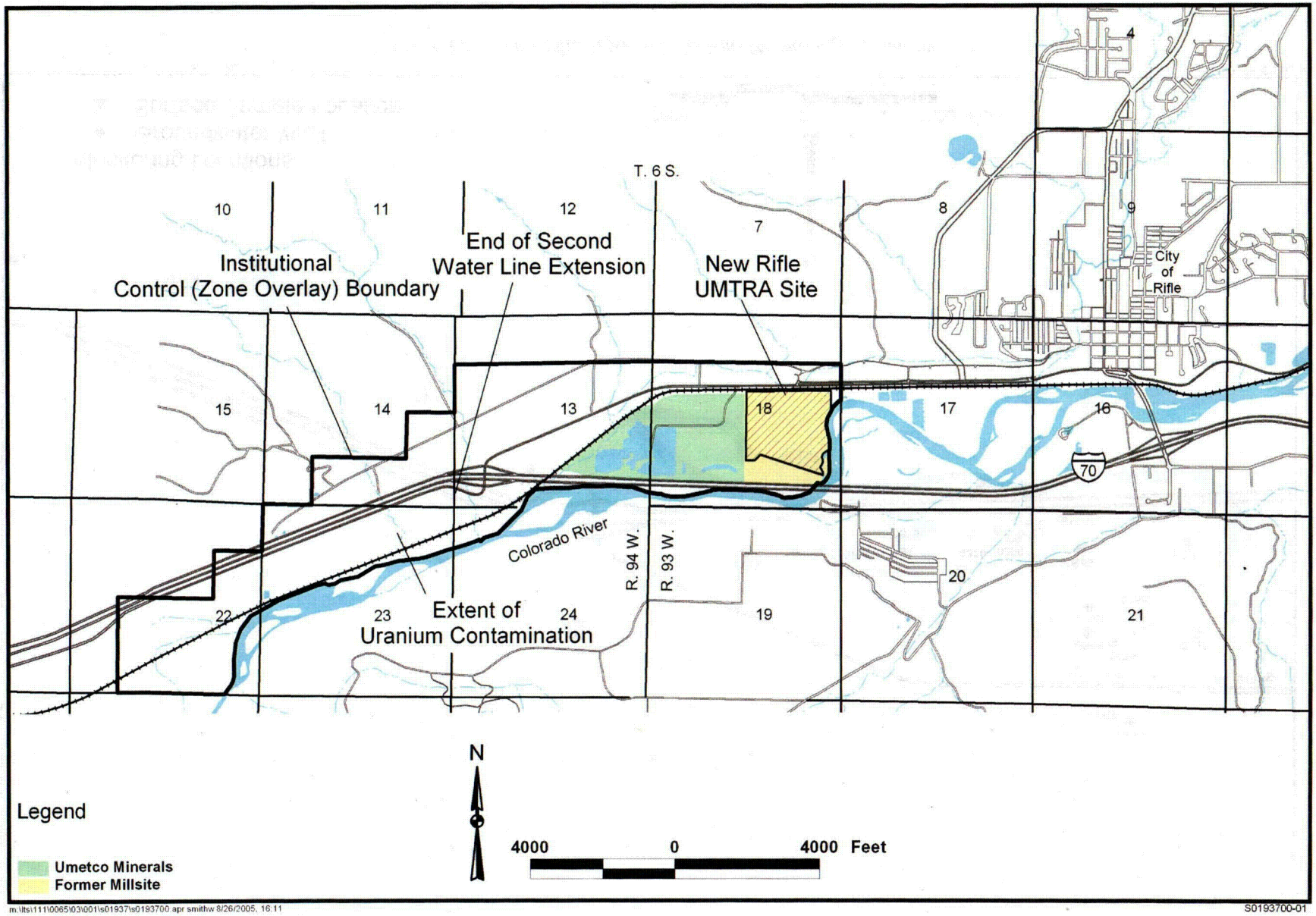

Figure 3. Location of the New Rifle Millsite With IC Boundary

saturation occurs from 5 to 10 ft below ground surface. The uppermost aquifer is composed of poorly sorted sediments ranging from clay-sized material through gravel, with cobbles and occasional boulders. Ground water in the alluvial aquifer generally flows to the west-southwest; hydraulic conductivity ranges from 1.2 ft/day in the alluvium to 0.02 ft/day in the weathered Wasatch. Recharge is from ground water ephemeral seeps above the millsite, precipitation, and from an unlined irrigation return ditch that flows across the middle of the site. The Colorado River can briefly recharge the millsite ground water during periods of maximum flow associated with spring runoff. Ground water discharge is mainly to the Colorado River; another source of discharge is by evapotransporation. At Old Rifle, alluvium pinches out against bedrock outcrops at the downgradient end of the site. The Old Rifle site has no hydrological connection to the New Rifle site. Additional data regarding the hydrogeology of the Old Rifle site is contained in the SOWP (DOE 1999a).

The former New Rifle processing site is located about 1.5 miles west of the City of Rifle and is also situated on the north floodplain of the Colorado River (Figure 2). As with the Old Rifle site, the uppermost aquifer consists of river alluvium and the weathered Wasatch Formation. Other hydrologic properties are similar to those at the Old Rifle site (DOE 1999b). Alluvium is thickest along the western and southern portions of the site and is continuous for at least 4 miles downgradient of the site. The alluvium provides a source for domestic water in the area. Recharge is from ephemeral streams from the north and precipitation; ground water discharge is to the Colorado River and evapotransporation.

At one time Roaring Fork Resources operated a gravel mine on the property adjacent to and downgradient of the New Rifle site. Water was pumped from an active onsite mining pit where excavation was occurring to another onsite pit for storage and infiltration. (These pits have been referred to previously as the "Roaring Fork ponds.") During its period of operation the pumping did have an effect on ground water flow downgradient of the New Rifle site creating both a cone of depression in and a ground water mound on the alluvial aquifer water table (DOE 1999b). Operation of the gravel mine ceased in early 2003 and natural ground water flow conditions have been reestablished in the alluvial water system.

2.2 Ground Water Quality

Background water quality of the alluvial aquifer in the vicinity of the Rifle sites has been found to have concentrations of selenium and uranium that are above applicable standards (DOE 1995b). Sulfate levels in background locations have also been relatively high, far exceeding the secondary drinking water standard of 250 milligrams per liter (mg/L) (nonenforceable; based on aesthetic considerations). However, it has been demonstrated that ground water in the uppermost aquifer beneath the Old Rifle site and beneath and downgradient of the New Rifle site was contaminated by site-related activities.

Table 1 presents historical data for COCs in ground water at both sites prior to completion of surface remediation. A comparison of historical data with benchmarks provided indicates that criteria were exceeded for a number of constituents; contamination at the New Rifle site was much greater than at the Old Rifle site. Additionally, while ground water was not being used in the vicinity of the Old Rifle site, several private wells were present in the alluvial aquifer downgradient of the New Rifle site (DOE 1995b).

Table 1. Historic Ground Water Chemistry for Old and New Rifle Site COCs

COC (all units mg/L)	Benchmark	Old Rifle Site		New Rifle Site	
		Historical Range[a] Aug. 1990–Aug. 1994	Median	Historical Range[a] Aug. 1990–Aug. 1994	Median
Ammonia as NH_4[b]	na	na	na	506–1,750	1,030
Arsenic	0.05[c]	na	na	0.97–1.3	1.1
Molybdenum	0.01[c]	na	na	2.3–3.7	2.9
Nitrate as N	10[c]	na	na	124–251	177
Selenium	0.036[d]	0.007-0.085	0.072	<0.002–0.3	<0.05
Uranium	0.067[d]	1.6-2.1	1.8	0.24–0.37	0.29
Vanadium	na	0.51-0.75	0.55	0.59–2.8	1.3

[a]Ranges and median values are from the Baseline Risk Assessment (DOE 1995a), Table 3.1.
[b]No longer considered as a COC; included to understand nitrate behavior
[c] EPA UMTRA ground water standard (40 CFR 192)
[d]Maximum background value, cleanup goal
na=not applicable

During surface remediation, mill tailings and other residual radioactive materials (RRM) were removed; surface remediation was completed by 1996 and tailings were stabilized in an engineered repository located about 15 miles north of Rifle. RRM was removed down to and, in some cases, just below the ground water surface. Clean gravel and soil were used to fill the excavations and the surface was given 6 inches of topsoil and sown with seed mixtures.

Subsequent characterization completed at the New Rifle site as part of a pilot study for removal of vanadium from the ground water (DOE 2000) indicated that some residual soil contamination remains at that site below the water table. Analyses showed elevated concentrations of vanadium; several samples also showed residual concentrations of molybdenum, uranium, and arsenic. Most of these soils are associated with the location of a former disposal pond, and, to a lesser extent, with former tailings pile locations. Soil characterization was not conducted at the Old Rifle site except to confirm that radiological cleanup criteria were met.

2.3 Land and Water Use

The former Old Rifle processing site was acquired by the City of Rifle from the State of Colorado in 2000. Because all ground water contamination is contained on the millsite and discharges into the Colorado River, adjacent property is not sampled. The city has not decided what it will do with the recently acquired property. The former New Rifle processing site was transferred from the State of Colorado to the City of Rifle in 2004. The adjacent downgradient property is principally owned by Umetco Minerals Corporation (Figure 3); other private parties own parcels downgradient of the site. Domestic wells are present downgradient of the New Rifle site and are used for drinking water. Any domestic well users impacted by millsite-related contamination have been provided alternate water supplies or treatment units. The Roaring Fork gravel pit ceased operation in 2003 and the ponds have filled and equilibrated with the local ground water table since that time. The banks of the ponds have been contoured and seeded. Per an agreement between Umetco and the State of Colorado, use of the ponds by livestock will be restricted, probably by fencing. No immediate plans are in place for this property.

3.0 Monitoring Program

3.1 Monitoring Network

Sampling locations comprising the monitoring network at the Old Rifle processing site are listed in Table 2. The monitoring network consists of seven monitor wells, six onsite and one background; and four surface water locations, one upgradient of the site, two at the site, and one downgradient of the site (Figure 1). Selenium, uranium, and vanadium are monitored at most of these locations.

Table 2. Summary of Monitoring Requirements for Old Rifle

Location	Monitoring Purpose	Analytes	Frequency
RFO–0305, –0655	Center of plume west side of ditch	Se, U, V	Twice yearly for 5 years; at least every 5 years thereafter until 2030[a]
RFO–0656	Center of plume east side of ditch	Se, U, V	Twice yearly for 5 years; at least every 5 years thereafter until 2030
RFO–0304, –0309, –0310	Most downgradient location; leading edge of plume	Se, U, V	Twice yearly for 5 years; at least every 5 years thereafter until 2030
RFO–0292, –0658, –0597	Background ground water quality; upgradient monitor well	Se, U, V	Twice yearly for 5 years; at least every 5 years thereafter until 2030
RFO–0398	Monitor surface water background U recharging aquifer; onsite ditch	U	Twice yearly for 5 years; at least every 5 years thereafter until 2030
RFO–0538, –0396, –0741	Upgradient, adjacent to site, and downgradient locations on Colorado River; monitor effect of site on river	Se, U, V	Twice yearly for 5 years; at least every 5 years thereafter until 2030

[a]Annual monitoring will be reinitiated (during the 5-year monitoring program) when a contaminant concentration decreases to or below a respective compliance standard. Monitoring will be discontinued when/if the contaminant concentrations have remained below the compliance levels for 3 consecutive years.

Monitoring requirements for the New Rifle site are listed in Table 3. The monitoring network consists of 20 monitoring wells at various locations and five surface sampling sites. The analytes monitored vary with sample location.

3.2 Results of Monitoring Program

3.2.1 Old Rifle Site

3.2.1.1 Surface Water

Results of surface water monitoring in the Colorado River indicate that water quality of the river adjacent to and downgradient from the Old Rifle site is indistinguishable from background water quality. This confirms the calculations included in the SOWP (DOE 1999a) demonstrating that ground water discharged to the river would immediately undergo rapid mixing with river water. Sampling of the site ditch, which serves as a source of recharge to the alluvial aquifer, indicates that measurable amounts of uranium (typical concentrations approximately one-half the ground water standard of 0.044 mg/L) are present in that surface water body.

Table 3. Summary of Monitoring Requirements for New Rifle

Location	Monitoring Purpose	Analytes	Frequency
0170, 0172, 0210, 620	Monitor middle and leading edge of molybdenum, uranium, and nitrate plumes.	Ammonia, molybdenum, uranium, nitrate	All wells and locations, annually until 2010. Monitoring requirements will be reevaluated at that time.
0195, 0201, 0215, 0216, 0217, 0590, 0635, 0658, 0659, 0664, 0669, 0670, 0855	Monitor flushing in main body of plumes.	Ammonia, molybdenum, nitrate, uranium	
0320, 0322, 0323, 0324, 0452, 0453, RFO-538, 0575	Monitor surface water to determine impact of ground water discharge to surface water and ecological receptors; 0538 is background location shown on Figure 1.	Ammonia, molybdenum, nitrate, uranium, vanadium	
0442/0446	Private wells before and after reverse osmosis treatment; 0442 is pre-treatment, 0446 is post-treatment. Until domestic users connect to municipal water	Ammonia, molybdenum, nitrate, uranium	
0215, 0216, 0217, 0590, 0658, 0659, 0664, 0669, 0670, 0855	Monitor behavior of vanadium plume.	Vanadium	Semiannually through 2007. Monitoring will likely become same as for other COCs after that time.

[a]Monitoring for a COC will be discontinued if concentrations are below its standards for 3 consecutive years.
[b]Until 2007.

3.2.1.2 Ground Water

Spot plots showing the distribution of COCs in ground water at the Old Rifle site are presented in Figure 4 through Figure 6. Time/concentration graphs for wells sampled at both the Old and New Rifle site are presented in Appendix A. Table 4 presents statistics for monitoring results for the Old Rifle site for two time periods—1998/1999, shortly after completion of surface remediation, and the most recent monitoring results from April 2006. Comparison of these two groups of data should provide some indication of the progress of natural flushing since surface cleanup ended.

Table 4. Post-Remediation Ground Water Monitoring Results for the Old Rifle Site

COC (all units mg/L)	Benchmark	Range 1998-1999	Mean 1998-1999	April 2006	April 2006
Selenium	0.05[a]	<0.0001-0.122	0.023	0.00002–0.042	0.011
Uranium	0.044[b]	0.0268-0.270	0.0997	0.018–0.23	0.105
Vanadium	0.33[c]	<0.0006-0.799	0.2337	<0.00078–0.41	0.128

Data for wells 0304, 0305, 0309, 0310, 0655, 0656
[a]EPA Safe Drinking Water Act Standard and approved ACL
[b]EPA UMTRA ground water standard (40 CFR 192)
[c]Risk-based concentration

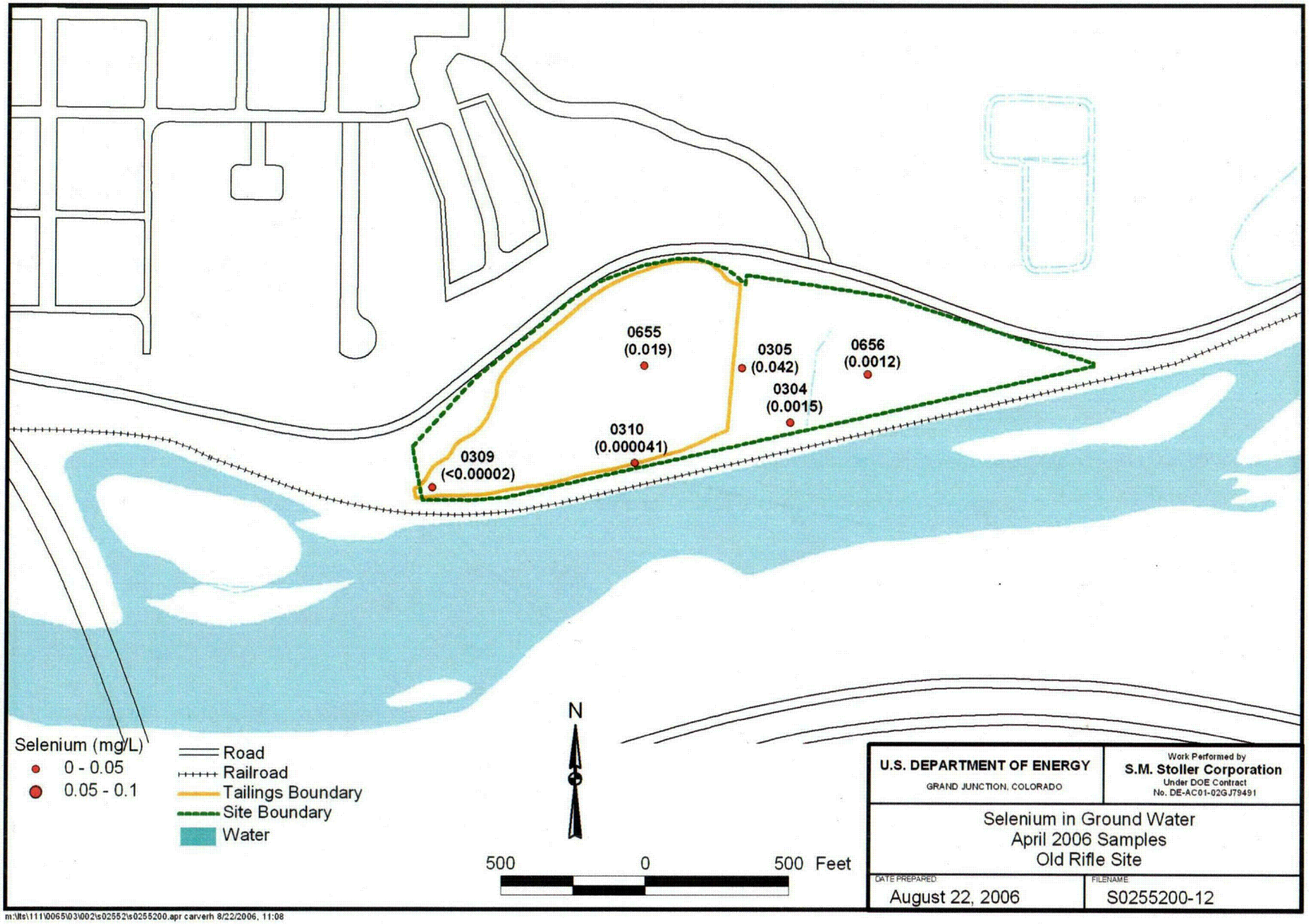

Figure 4. Selenium in Ground Water at the Old Rifle Site

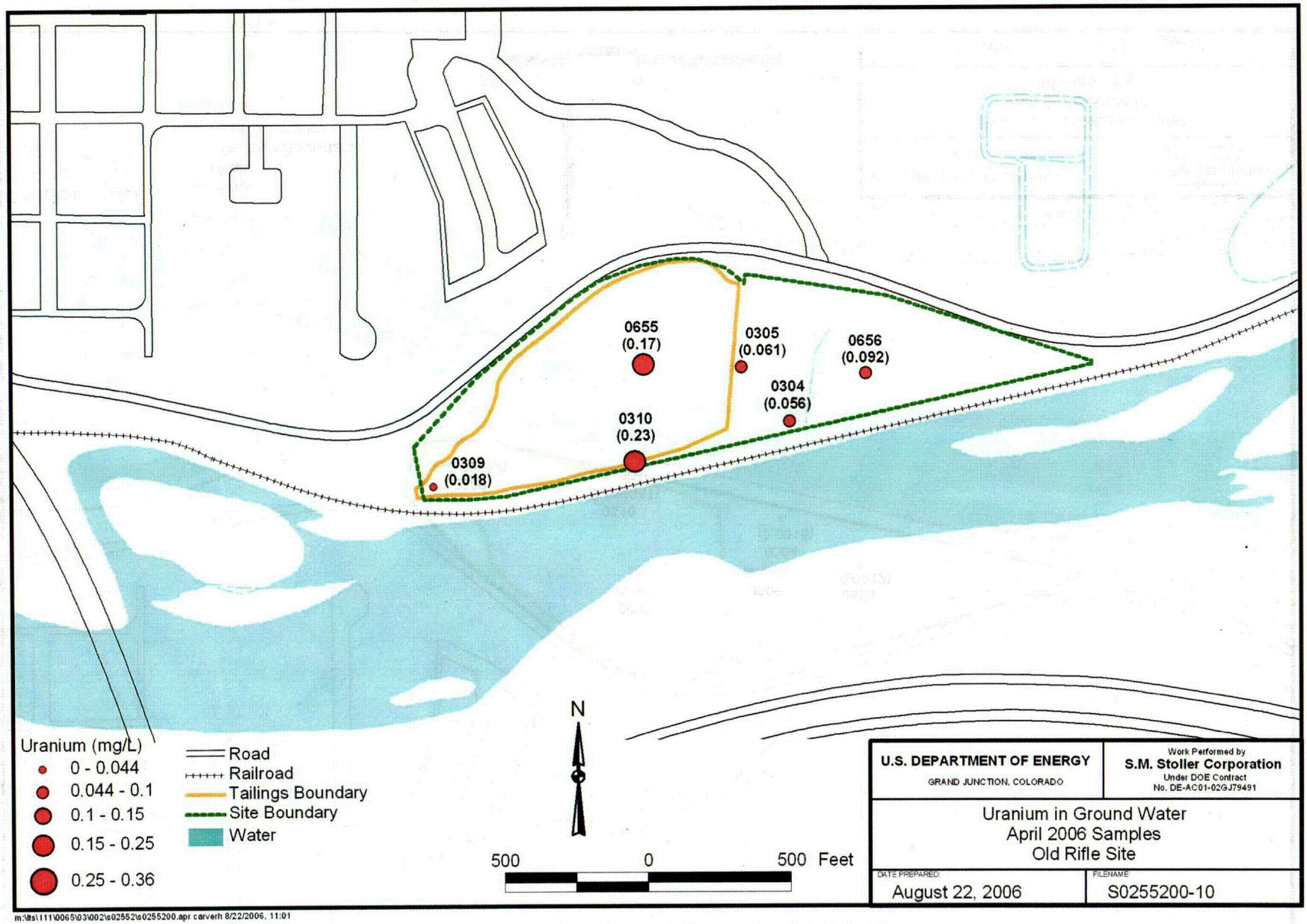

Figure 5. Uranium in Ground Water at the Old Rifle Site

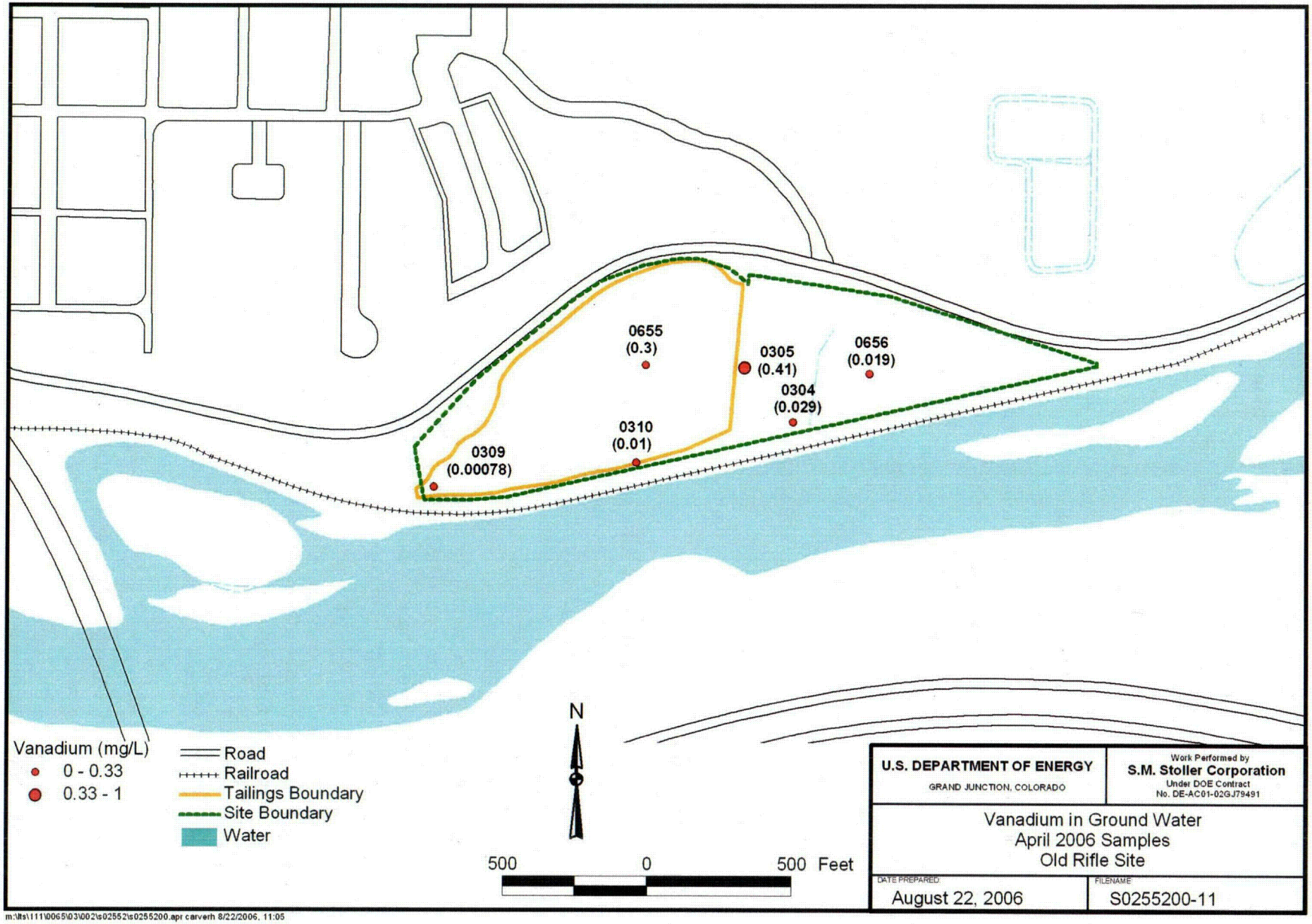

Figure 6. Vanadium in Ground Water at the Old Rifle Site

Data in Table 4 indicate that currently the average concentrations of selenium and vanadium in Old Rifle alluvial ground water are below the benchmark values of 0.05 and 0.33 mg/L, respectively. All locations were below the selenium benchmark for 2006 and only a single location (0305) exceeded the vanadium benchmark. In contrast, all locations except one (0309) exceeded the uranium standard. A comparison of 1998/1999 data with recent data indicate that average concentrations of vanadium and selenium have decreased by about half over time, while the average concentration for uranium is actually slightly higher at present. Maximum observed concentrations for all COCs have decreased

Spot plots in Figures 4 through 6 indicate that selenium and vanadium contamination is very limited in distribution in comparison to uranium, which is much more pervasive. Selenium and vanadium are much less mobile than uranium and more likely to adsorb to subsurface materials. It is likely that the limited distribution and stronger decreases in concentration displayed by selenium and vanadium compared to uranium can be attributed to adsorptive mechanisms.

On the other hand, uranium is a highly mobile constituent. The fact that large changes in uranium concentrations have not occurred at the site may indicate that ground water is not moving through the subsurface as rapidly as was previously thought. This could be, in part, due to drought conditions that have dominated over the last several years, resulting in low rainfall and reduced river flows. Time concentration plots in Appendix A-1 show that while some locations appears to show a decline in uranium concentration, others display no discernible trend.

3.2.2 New Rifle Site

3.2.2.1 Surface Water

Two surface water locations at the New Rifle site (locations 0322 and 0324) represent Colorado River water. The other surface locations were samples collected from the wetland area and former Roaring Fork gravel pond; as such, these samples are more representative of ground water in the area. Samples collected at location 0322 have had detectable levels of ammonia and nitrate, which have exceeded concentrations in background, though ammonia was not detected in 2006. However, concentrations of most constituents are indistinguishable from background and orders of magnitude less than concentrations observed in the adjacent wetlands. No surface water standards were exceeded in the river. The samples collected thus far at surface location 0324 have had results comparable to background. Sampling results confirm the calculations performed as part of the SOWP (DOE 1999b) that indicate discharging ground water undergoes significant mixing with river water and that rapid attenuation of contaminants occurs.

Elevated levels of site-related constituents do occur in the wetland area and in the Roaring Fork gravel pond. As natural flushing results in declining contaminant concentrations in the alluvial aquifer (see Section 3.2.2.3), corresponding declines should occur in these surface waters as well.

3.2.2.2 Ground Water

Ground water beneath the New Rifle site was contaminated by former vanadium and uranium ore-processing operations that were ongoing from 1958 through 1972, from lignite ash processing from 1964 to 1967, and from vanadium processing (which did not produce tailings but may have produced milling solutions) from 1973 to 1984. Site field investigations have

shown that the alluvial aquifer is the only aquifer affected by the former milling operations. Previously identified contaminants of concern (COCs) in the alluvial aquifer with concentrations that exceed ground water standards of 40 CFR 192 are arsenic, molybdenum, nitrate, selenium, and uranium. Fluoride has exceeded the Safe Drinking Water Act (SDWA) standard of 4 mg/L. Concentrations of ammonia, manganese, and vanadium have exceeded risk-based concentrations based on use of ground water for domestic purposes in a residential setting (DOE 1999). Based on discussions with Colorado Department of Public Health and the Environment (CDPHE), it has been determined that ammonia, fluoride, and manganese are of little concern at the site based on their relatively low concentrations and limited distribution. Therefore only the remaining COCs and ammonia are discussed further in this document. Ammonia is included only to the extent that it influences nitrate behavior.

Spot plots showing the distribution of constituents monitored in New Rifle alluvial ground water are presented in Figure 7 through Figure 13. In general, the contaminant plumes for the less mobile constituents, such as arsenic, selenium, and vanadium, are restricted in areal extent and are still centered around the former millsite. Plumes for more mobile constituents (ammonia, nitrate, molybdenum, uranium) are more extensive. For purposes of evaluating the progress of natural flushing for the New Rifle site, monitor wells were assigned to one of three groupings—onsite, adjacent to site, and downgradient—for the purposes of computing statistics for analytical results. Onsite wells are those physically within the site boundary. As noted above, residual soil contamination does exist at the New Rifle site below the water table. This contamination is most likely to affect water quality of ground water in contact with those soils (thus serving as a persistent source of contaminant flux to ground water) and would thus influence water quality of onsite wells.

While onsite wells are grouped for the purposes of computing statistics for ground water at the site and comparing them to historical trends, three subgroups of onsite wells can be recognized based on patterns of time-concentration plots for the wells (time-concentration plots are included in Appendix A). Wells 0169, 0215, and 0216 are located adjacent to the Colorado River and are upgradient from the main source of site ground water contamination—the former raffinate pond and tailings pile. Concentrations of most constituents in these wells are generally low and display limited variability. Locations 0855, 0658, and 0659 are in the footprint of the former raffinate ponds and tailings pile. Soil sampling conducted during the pilot study for vanadium at the site indicate that residual contamination exists in these areas and may have local influence on ground water quality. These locations are characterized by time-concentration plots with the highest concentrations of most constituents and the greatest degree of variability over time. For the most part, no clear trends are observed in these wells. It is likely that adsorption/desorption reactions between ground water and soils occur in this area and that ground water concentrations are sensitive to fluctuations in the water table. The remaining onsite wells—0669, 0664, and 0670—are outside of the residual contaminated area. Trends displayed by time-concentration plots for these locations are more similar to those for offsite locations. They display some variability, but are typically decreasing (with some exceptions) for constituents with concentrations above benchmarks.

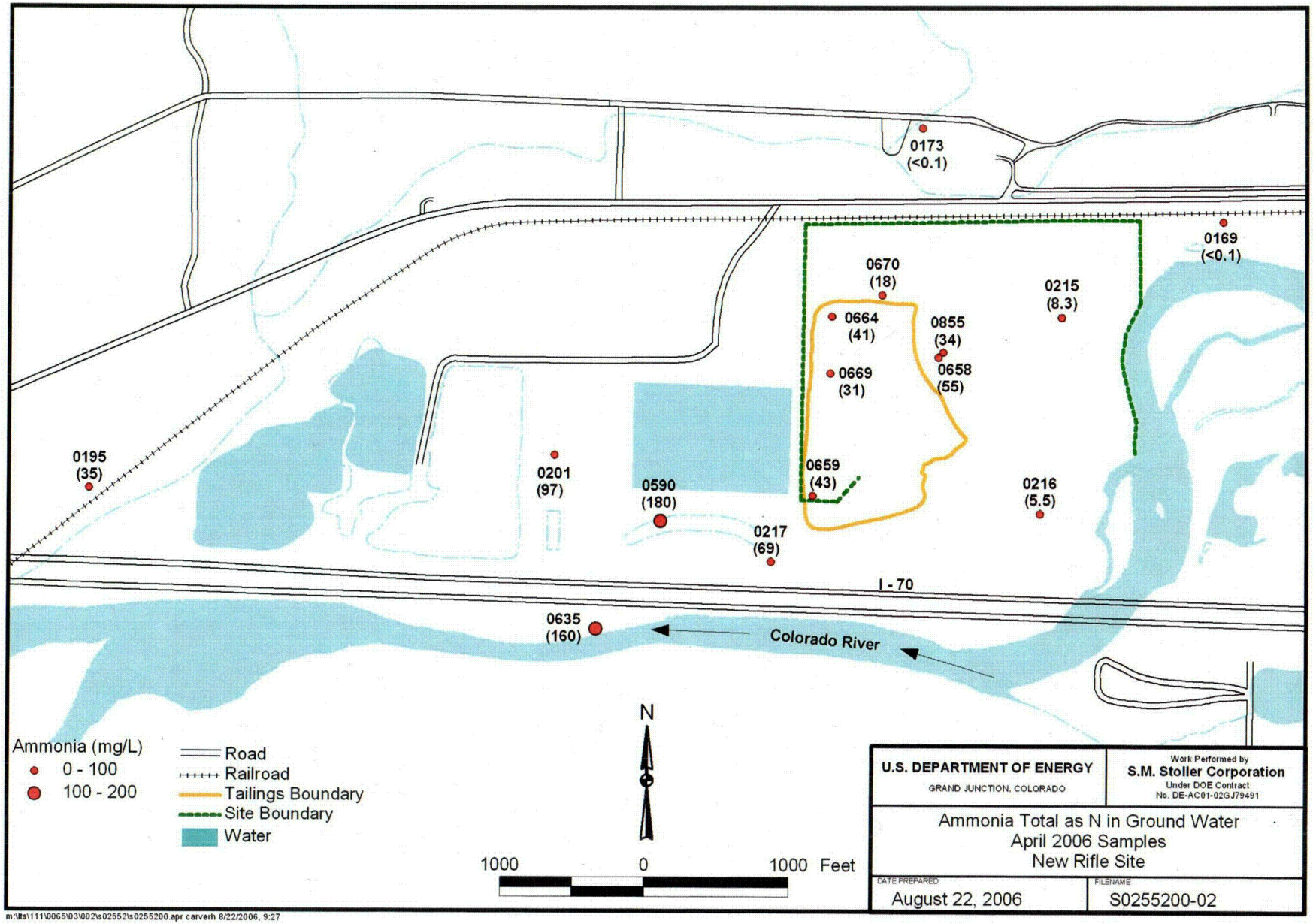

Figure 7. Ammonia in Ground Water at the New Rifle Site

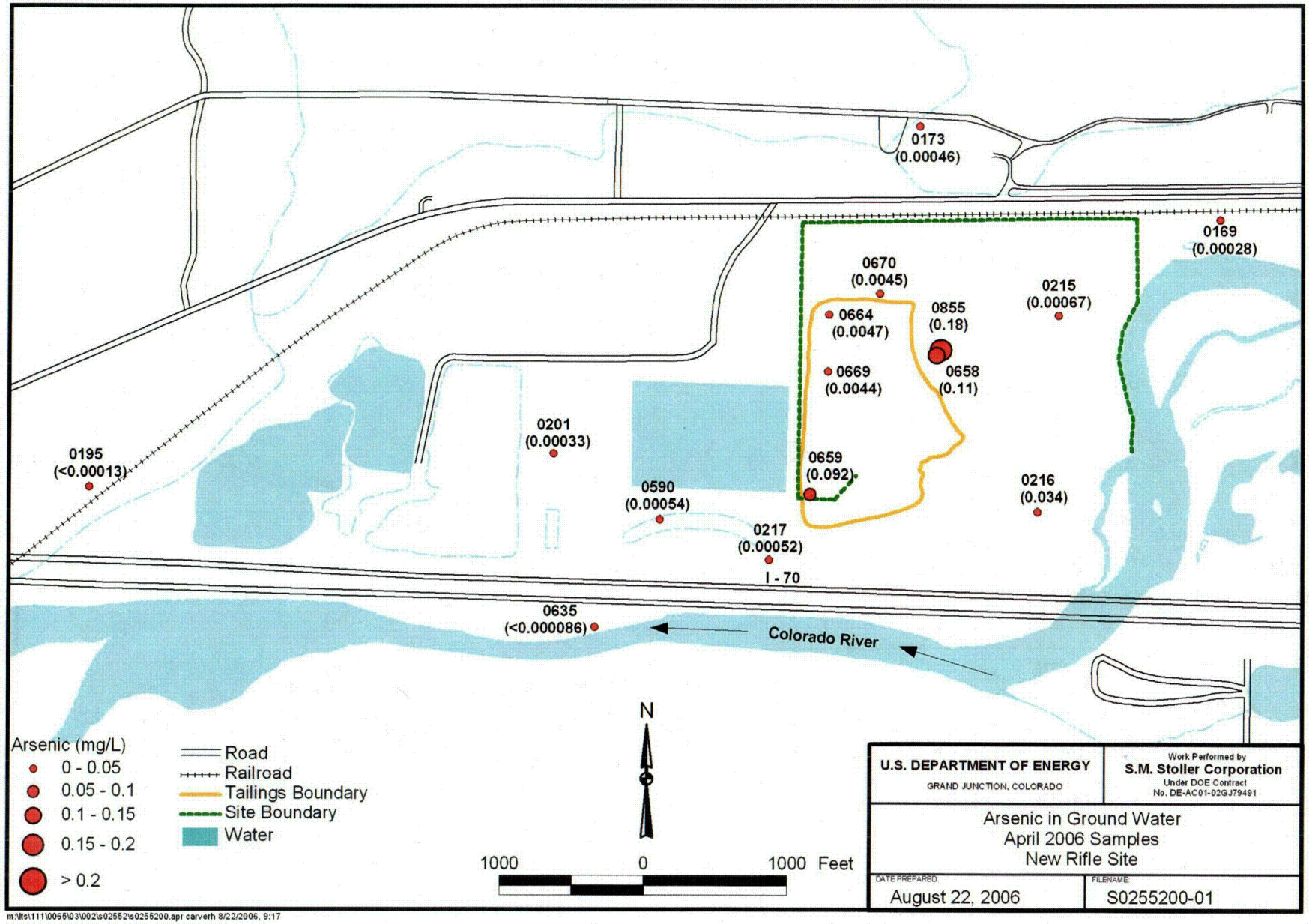

Figure 8. Arsenic in Ground Water at the New Rifle Site

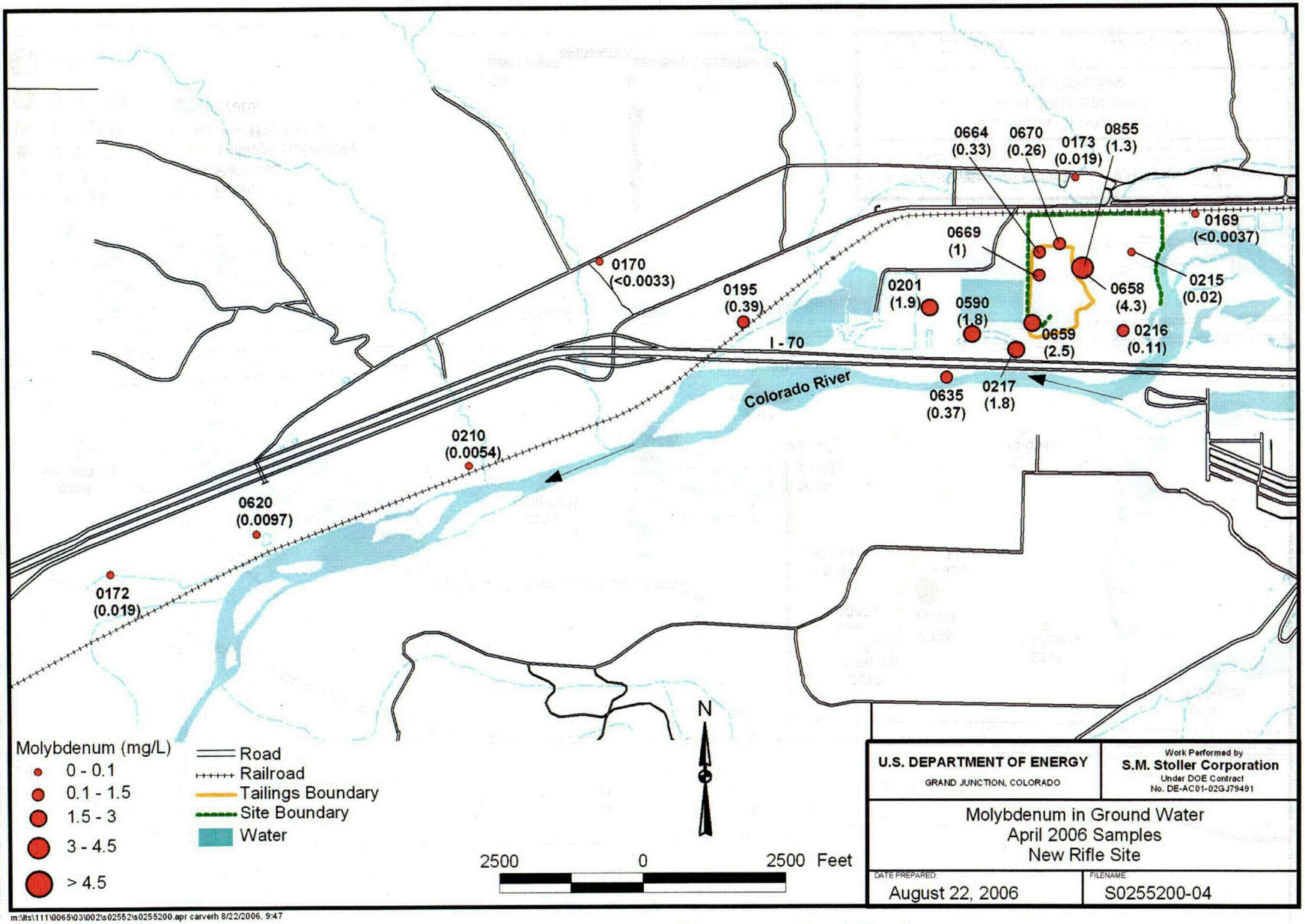

Figure 9. Molybdenum in Ground Water at the New Rifle Site

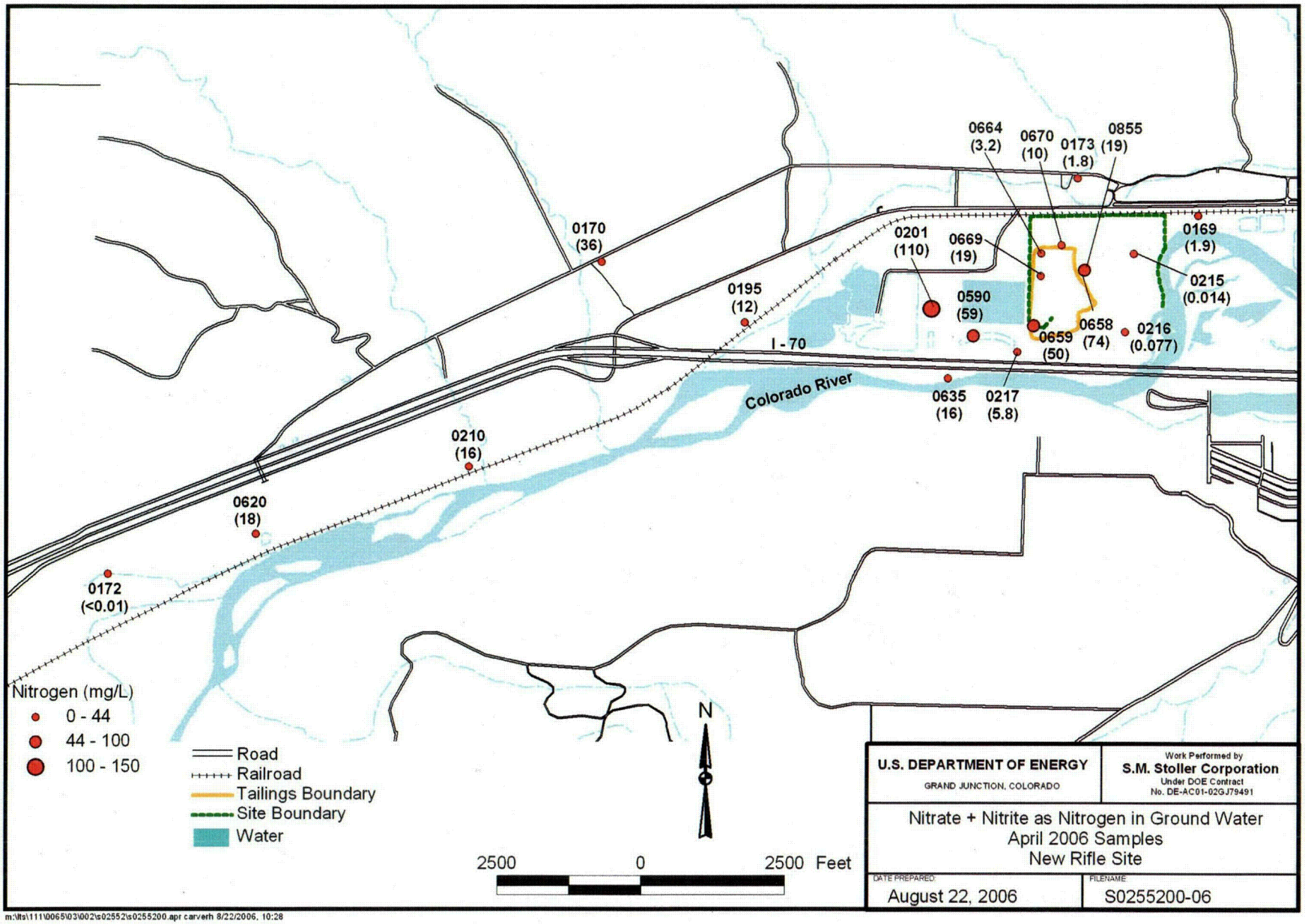

Figure 10. Nitrate + Nitrite as Nitrogen in Ground Water at the New Rifle Site

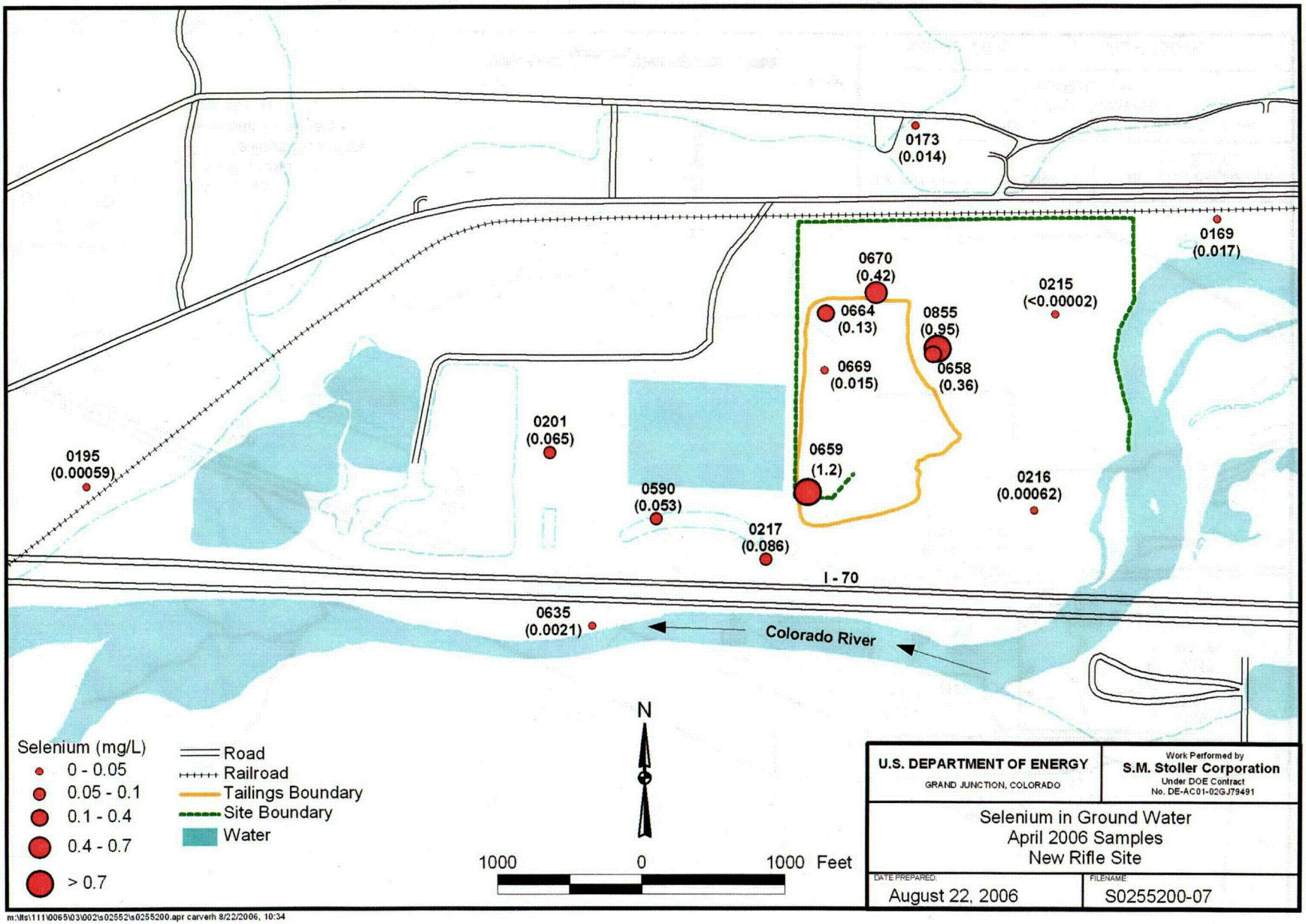

Figure 11. Selenium in Ground Water at the New Rifle Site

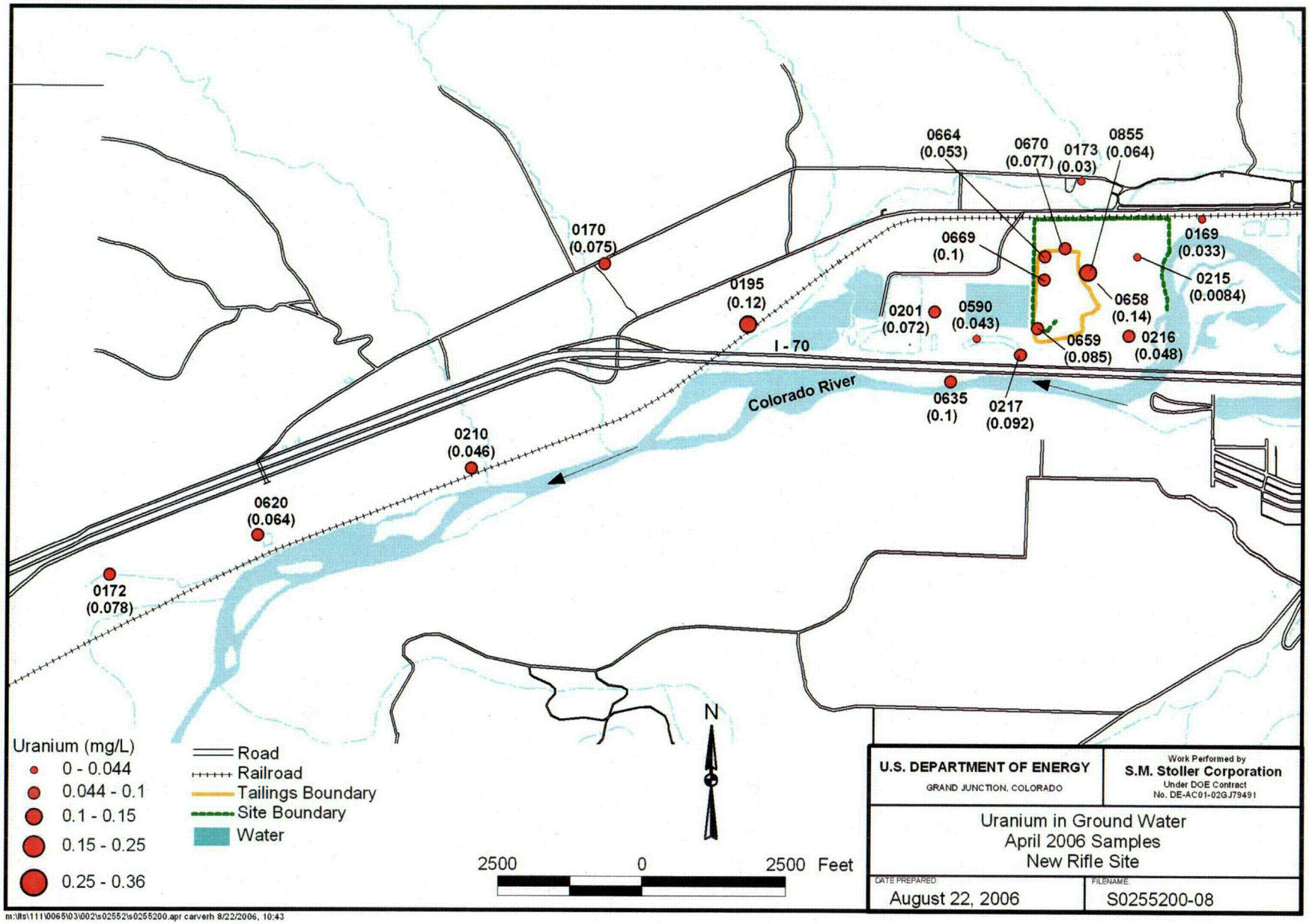

Figure 12. Uranium in Ground Water at the New Rifle Site

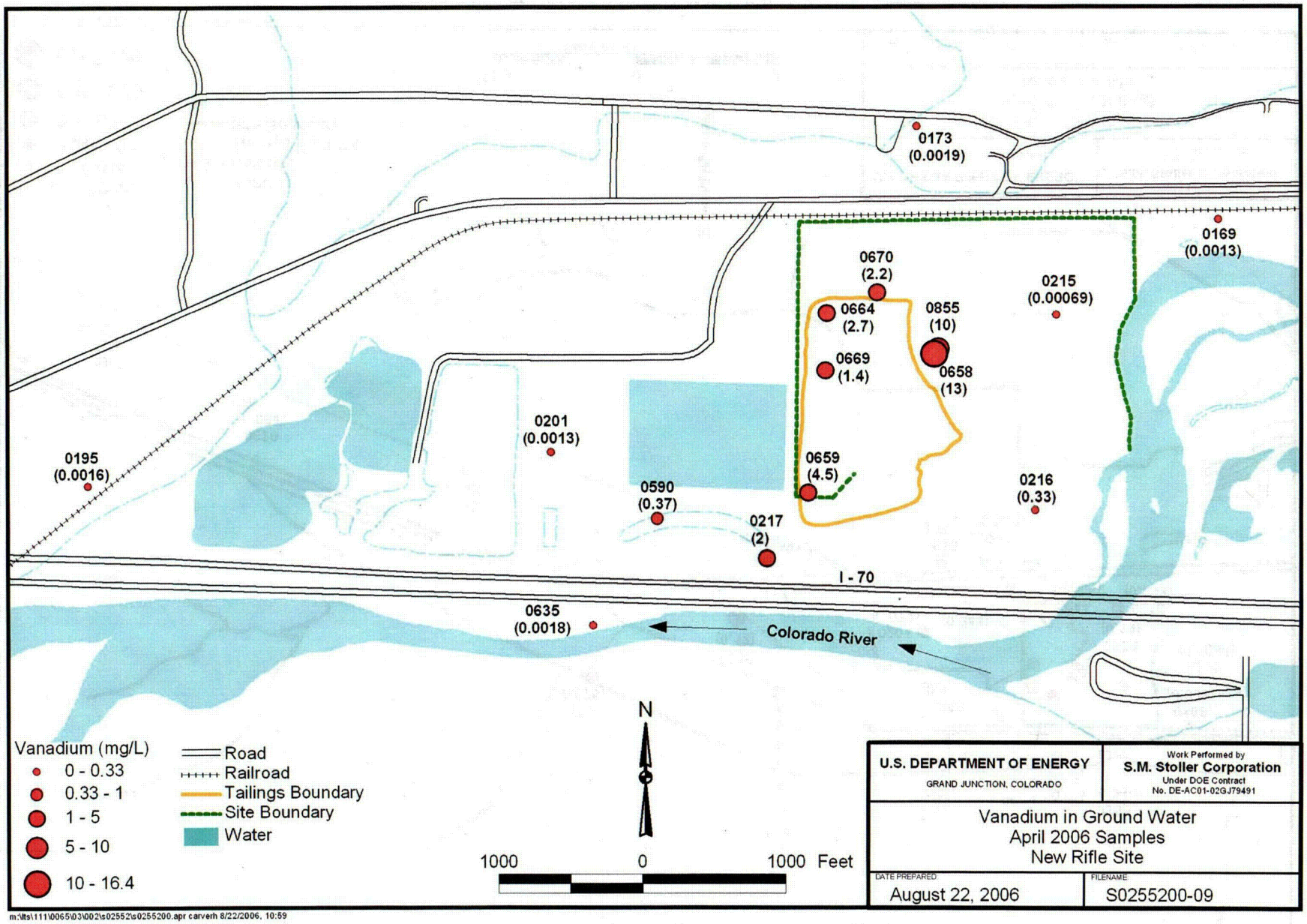

Figure 13. Vanadium in Ground Water at the New Rifle Site

Contamination in offsite wells is attributed solely to the migration of contaminated water downgradient and not from direct contact with a residual source. The wells downgradient of the New Rifle site were split into two groups which are separated by the Roaring Fork gravel ponds. As described previously, the ponds affected ground water flow direction during operation, thus hydraulically separating those two groups of wells to some extent. Additionally, activities associated with wetland construction were more likely to influence water quality of the wells adjacent to the site compared with those farther downgradient. Table 5 and Table 6 provide statistics for the three groups of wells. Water quality benchmarks are provided in Table 5 for comparison. Historic data provided in Table 1 are based on combined results of data from wells on and adjacent to the site. Time-concentration plots for the New Rifle wells are also included in Appendix A.

Table 5. Mean Concentrations in Ground Water—1998/1999 and April 2006 for the New Rifle Site

Contaminant	Benchmark (mg/L)	Onsite[a]		Adjacent to Site[b]		Downgradient[c]	
		1998-99 mean (mg/L)	April 2006 mean (mg/L)	1998-99 mean (mg/L)	April 2006 mean (mg/L)	1998-99 mean (mg/L)	April 2006 mean (mg/L)
Ammonia, total as NH_4	na	124	29	448	127	7.87	7.08
Arsenic	0.05[d]	0.061	0.036	<0.001	0.00037	0.00058	0.0007
Molybdenum	0.1[d]	2.498	1.22	1.928	1.47	0.035	0.17
Nitrate as N	10[d]	61.13	51.9	230	48	75.8	16.4
Selenium	0.036[e]	0.135	0.30	0.0096	0.052	0.0012	0.0015
Uranium	0.067[e]	0.1012	0.073	0.097	0.077	0.0752	0.077
Vanadium	na	5.68	3.45	0.367	0.59	<0.0001	0.0034

[a]Includes wells 0215, 0216, 0658, 0659, 0664,0 669, 0670, 0855
[b]Includes wells 0201, 0217, 0590, 0635
[c]Includes wells 0170, 0172, 0195, 0210
[d]EPA UMTRA ground water standard (40 CFR 192)
[e]Maximum background value, cleanup goal

Table 6. Range of Concentrations in Ground Water—1998/1999 and April 2006 for the New Rifle Site

Contaminant	Onsite[a]		Adjacent to Site[b]		Downgradient[c]	
	1998-99 range (mg/L)	April 2006 range (mg/L)	1998-99 range (mg/L)	April 2006 range (mg/L)	1998-99 range (mg/L)	April 2006 range (mg/L)
Ammonia, total as NH_4	4.01-367	5.5-55	276-669	69-180	<0.003-59.6	< 0.1-35
Arsenic	<0.0001-0.186	0.00067-0.036	<0.0001-0.0041	0.00008-0.00054	<0.0004-0.0014	0.00013-0.0015
Molybdenum	0.0237-6.84	0.020-4.3	0.661-3.15	0.37-1.9	0.0041-0.231	0.0033-0.39
Nitrate as N	0.013-368	0.014-74	0.393-836	5.8-110	0.0522-377	<0.01-36
Selenium	<0.001-0.782	<0.00002-1.2	0.0018-0.0197	0.0021-0.086	<0.0001-0.0039	0.00003-0.0036
Uranium	0.0103-0.284	0.0084-0.14	0.0837-0.120	0.043-0.10	0.054-0.177	0.046-0.12
Vanadium	<0.001-25.3	0.00069-13	<0.001-2.69	0.0013-2.0	0.00065-0.0018	0.0015-0.0093

[a]Includes wells 0215, 0216, 0658, 0659, 0664, 0669, 0670, 0855
[b]Includes wells 0201, 0217, 0590, 0635
[c]Includes wells 0170, 0172, 0195, 0210

Observations regarding the concentrations and distribution of each ground water COC for the New Rifle site are provided below.

Ammonia. Highest ammonia concentrations have moved offsite and downgradient, indicating that natural attenuation is progressing. Offsite concentrations of ammonia are lower than those observed historically.

Arsenic. In recent years, arsenic has only exceeded the MCL in the three locations where residual soil contamination exists on site. Only one of these locations (0855) has consistently exceeded the UMTRA MCL; the other two have occasionally had concentrations below the MCL and appear to display overall decreasing trends in arsenic. Arsenic at location 0216 has been in the range of about 0.025 mg/L and is higher than the other "background" locations. Concentrations here have remained relatively constant. Soil sampling during the vanadium pilot study for the site indicates that some minor residual soil contamination may exist in this area (DOE 2000).

Molybdenum. For the most part, molybdenum appears to be flushing from the ground water system. This is perhaps best evidenced in time-concentration plots from locations immediately adjacent to the site. Farther downgradient location 0195 showed an increase in molybdenum from 1998 through 2004, followed by a steep decline during the 2005 sampling event. While not conclusive, this may be an indication that the center of the molybdenum plume has passed here and that levels are generally on the decline. Molybdenum is generally one of the more mobile constituents associated with uranium mill tailings and does provide a useful indicator regarding the progress of natural flushing.

Nitrate. Nitrate at the site has generally been attributed to the degradation of ammonia. This is supported by time-concentration plots for certain locations that showed decreasing concentrations of ammonia coincident with increasing levels of nitrate. The distribution of nitrate also somewhat parallels that of ammonia, with highest concentrations immediately adjacent to the site, where the main ammonia plume has migrated. More recently, the overall concentrations of nitrate have begun to decline, indicating that ammonia may have decreased to levels where natural flushing has a greater effect on nitrate concentration than degradation of ammonia.

Selenium. No clear trends exist with respect to selenium. Concentrations, on average, have not changed significantly since the 1998-1999 sampling period. Some locations have shown large fluctuations (as much as one order of magnitude) in concentration from one sampling event to the next. Concentrations exceeding the maximum background benchmark of 0.036 mg/L are generally confined to the site, although location 0590 has exceeded that value during a couple of recent sampling rounds.

Uranium. Uranium is elevated above the UMTRA ground water standard (0.044 mg/L) and the maximum background value of 0.067 mg/L throughout the contaminant plume, though onsite "background" locations and a location north of the site are below the standard. With a few exceptions, uranium time-concentration plots do not display any clearly increasing or decreasing trends. Drought conditions that have existed over the last several years may have served to mask any changes in uranium levels that can be attributed to natural flushing.

Vanadium. The only locations where vanadium is elevated are located onsite in the vicinity of the residual soil contamination and one location immediately adjacent to the site. Some wells do appear to be showing decreases in vanadium concentration (e.g., 0216, 0669), though others either tend to remain relatively constant or to show considerable cyclical variation. Vanadium shows a strong tendency to sorb to soils. It is likely that the vanadium plume will continue to attenuate through this mechanism and shrink through time.

3.2.2.3 Mann-Kendall Test for Trend

Another method of data evaluation is the nonparametric Mann-Kendall test for trend (Gilbert 1987). The test does not require any particular data distribution and will accommodate missing values and data reported as less than the detection limit. Essentially, it analyzes a series of data by subtracting the values of data collected earlier from those of later data. The method results in a test statistic that is a positive or negative (meaning increasing or decreasing trend) and is used to estimate the probability that the trend is real. Appendix D-1 of the GCAP (DOE 2006) provides a description of the Mann-Kendall test for trend.

As a preliminary analysis, several wells from the New Rifle Site were selected for application of the Mann-Kendall test statistic based on their locations with respect to the uranium and molybdenum plumes. The test was applied to uranium and molybdenum concentrations because these constituents are the most widespread and the most mobile. Additionally, they are not affected by geochemical transformation processes as are ammonia and nitrate. Wells 0664 and 0669 are from two onsite locations near the original plume source areas (raffinate ponds and tailings piles). Well 0201 is located immediately downgradient of the site and upgradient of the Roaring Fork ponds; well 0195 is located immediately downgradient of the ponds. Results of application of the Mann-Kendall test statistic to uranium and molybdenum results for these wells are included in Appendix B. Results show that the onsite wells 0664 and 0669 show strongly decreasing trends (at the 95% confidence level) for both uranium and molybdenum. Likewise, well 0201 displays a decrease in molybdenum (95% confidence level). However, downgradient well 0195 shows a lesser degree of decrease in uranium (90% confidence level), but a strongly increasing trend in molybdenum (95% confidence level).

These results support the conclusions that natural flushing for these two constituents is progressing and that the main portion of the uranium and molybdenum plumes is moving offsite into the adjacent downgradient area. It also illustrates that different portions of the plume would be expected to display differing characteristics over time and space depending on site-specific characteristics (e.g., source location, hydrologic features). This is an important factor in evaluating long-term trends and assessing the attainment of remediation goals.

3.2.2.4 Domestic Wells Downgradient from the New Rifle Site

Concentrations of COCs before treatment by the reverse osmosis system in the domestic wells 0442 and 0447 at the New Rifle are shown in spot plots. For well 0442, nitrate was 48 mg/L (maximum concentration limit [MCL] = 44 mg/L as NO_3) and uranium was 0.068 mg/L (MCL = 0.044 mg/L) in the last sampling round. The concentrations of nitrate and uranium after treatment are 4.6 mg/L and 0.00009 mg/L, respectively, indicating safe drinking water is being provided. No constituents in domestic well 0447 exceeded a standard or benchmark. However, treatment of water from this well further reduced concentrations of constituents that were detected, thereby improving drinking water quality.

4.0 Results and Conclusions

Maximum and mean concentrations of selenium and vanadium at the Old Rifle site are generally decreasing with time. The mean uranium concentration is decreasing, but not as quickly as expected based on modeling results in the SOWP, which indicated uranium would meet its ground water standard site wide within a 30-year period. The average concentrations of selenium and vanadium meet site benchmarks (both alternate concentration limits). The vanadium benchmark is currently exceeded only marginally at one well; all wells currently meet the selenium benchmark.

As expected with natural flushing, contaminant plumes for a number of constituents associated with the New Rifle site have been decreasing in general and moving downgradient over time. Ammonia concentrations have decreased dramatically compared to historical values and the plume is now centered over the downgradient property adjacent to the site. Arsenic values are down compared to historical levels. While the highest concentrations of molybdenum and uranium are still found on site, concentrations are elevated above standards throughout the length of the plume, indicating downgradient movement and dispersion. Time-concentration plots for some constituents show erratic fluctuations in recent years for some constituents. This may be the result of a number of factors. The Roaring Fork gravel pit was operating during the 1998/99 sampling period and has since shut down, eliminating ground water withdrawal and infiltration. Additionally, recharge to the aquifer has been limited in recent years due to drought and may have resulted in increased concentrations of dissolved constituents in ground water. Nitrate concentrations, which had been increasing in response to ammonia degradation, appear now to be on the decline.

In addition to the above, the pilot study for the New Rifle site was conducted during calendar year 2001, between the 1998/1999 and the April 2006 sampling periods. This study involved pumping and treating of ground water near the center of the vanadium plume on site—the area that also showed the highest concentrations of arsenic, selenium, and molybdenum. Stressing of the aquifer in this area (with reinjection of treated water near the southwest corner of the site) may also have had some effect on aquifer flow and soil/ground water interactions.

With the number of variables that can affect distribution of contaminants in the alluvial aquifer at New Rifle, it is probably too early to determine the effectiveness of natural flushing at the site. However, data collected for the site provide indications that some constituents are flushing, even if trends do not exactly match predictions. Generally speaking, ground water contamination is decreasing. While some individual wells may display increasing concentrations for certain constituents, this is to be expected as the plume centers migrate downgradient away from the site. Based on combined spatial and temporal data in Table 5 and Table 6, it appears that plume centers for ammonia, molybdenum, and nitrate have already moved off site and continue to dissipate downgradient. Arsenic and selenium, having little mobility, will probably remain confined to site ground water. Vanadium, also relatively immobile, has migrated off site, but only to a very limited degree.

Surface water in the Colorado River is not being adversely affected by ground water discharge at either the Old or New Rifle sites. At the present time, the selected compliance strategies at both sites appear to be adequately protective. A more definitive evaluation may be possible after more

monitoring data is collected and after conditions at the New Rifle site have stabilized to some degree. No serious reevaluation of the compliance strategy for either site is warranted at this time.

5.0 References

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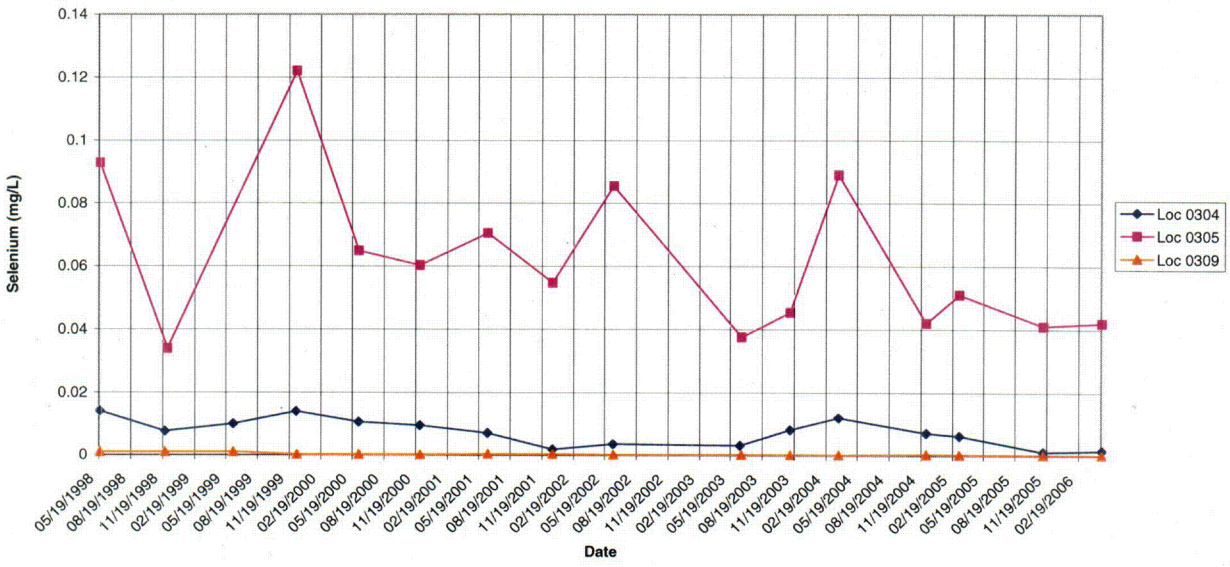
Appendix A–1

Time Concentration Plots for Wells at Old Rifle

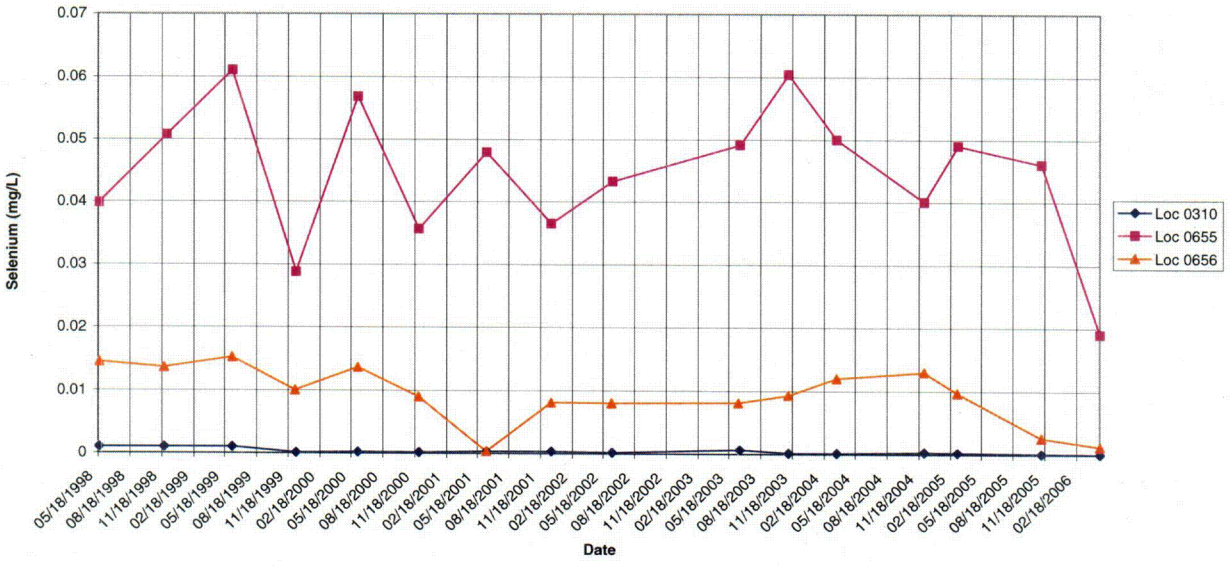
Rifle Old Processing Site (RFO01)

Selenium Concentration



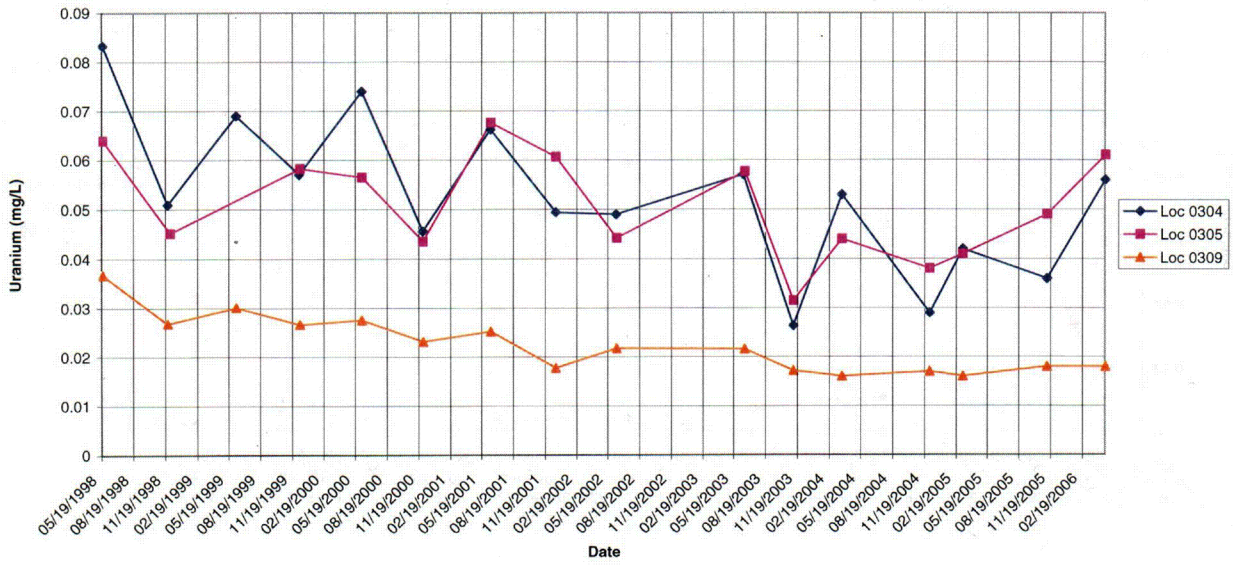
Rifle Old Processing Site (RFO01)

Selenium Concentration



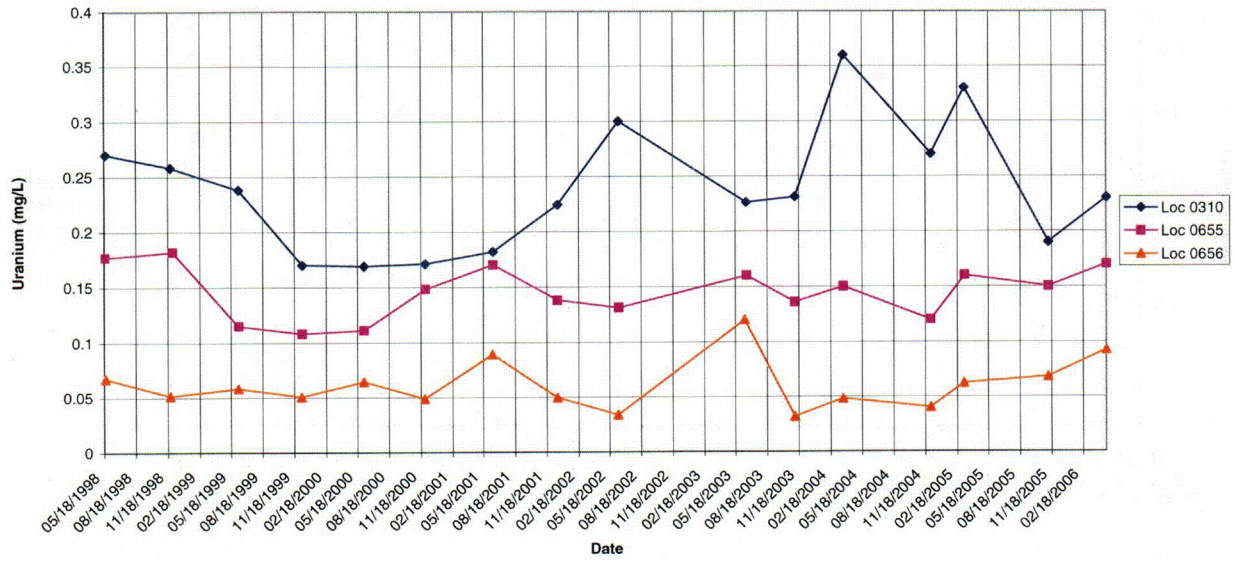
Rifle Old Processing Site (RFO01)

Uranium Concentration



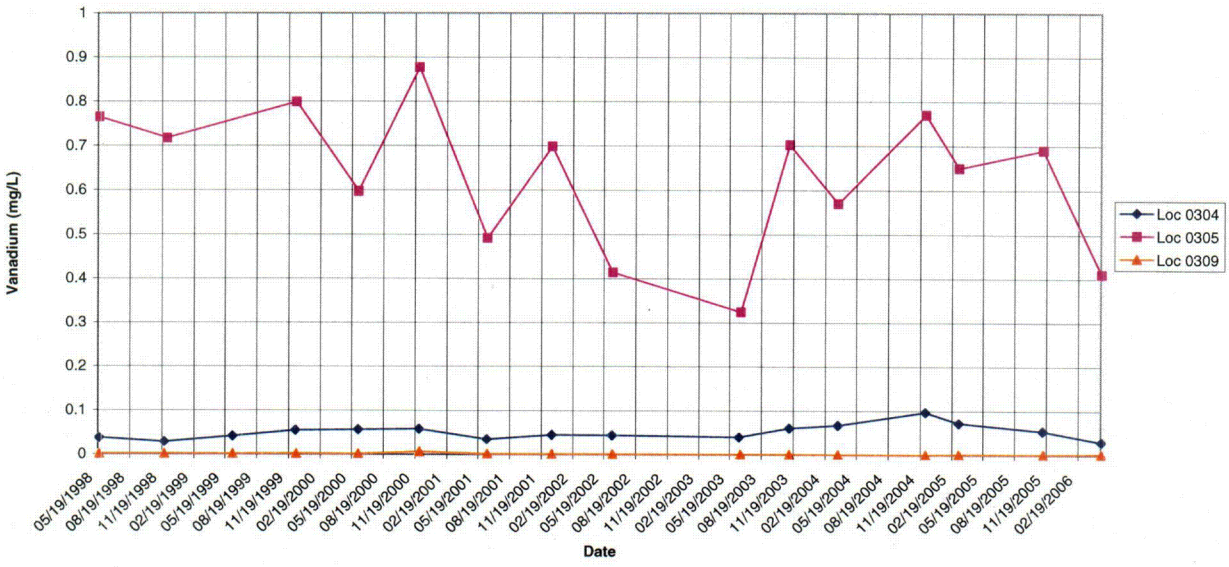
Rifle Old Processing Site (RFO01)

Uranium Concentration



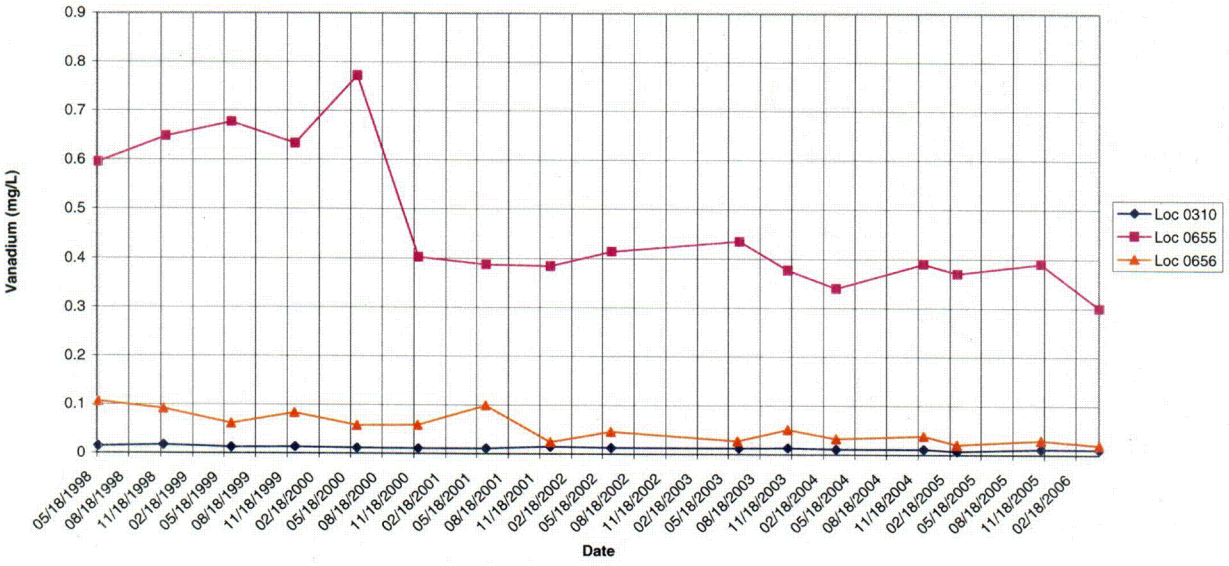
Rifle Old Processing Site (RFO01)

Vanadium Concentration



Rifle Old Processing Site (RFO01)

Vanadium Concentration



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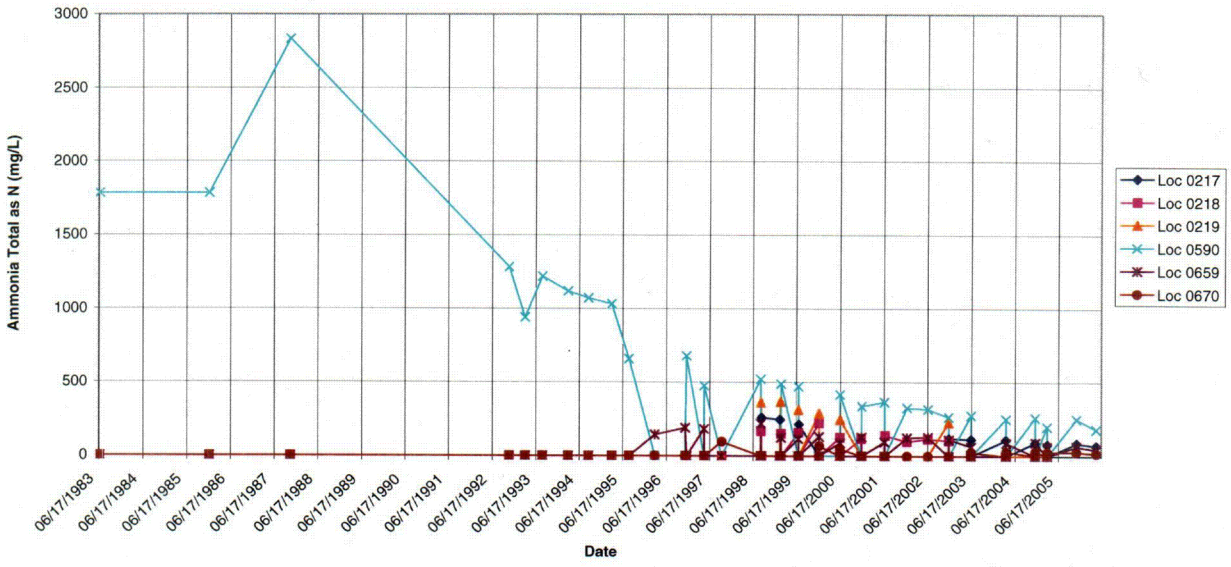
Appendix A–2

Time Concentration Plots for Wells at New Rifle

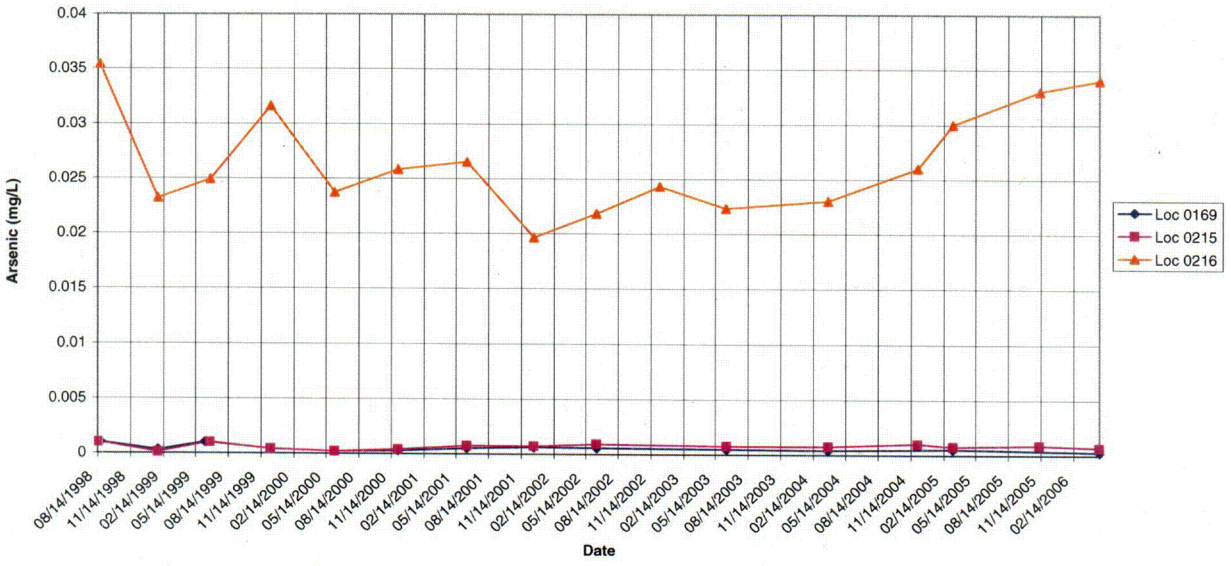
Rifle New Processing Site (RFN01)

Ammonia Total as N Concentration



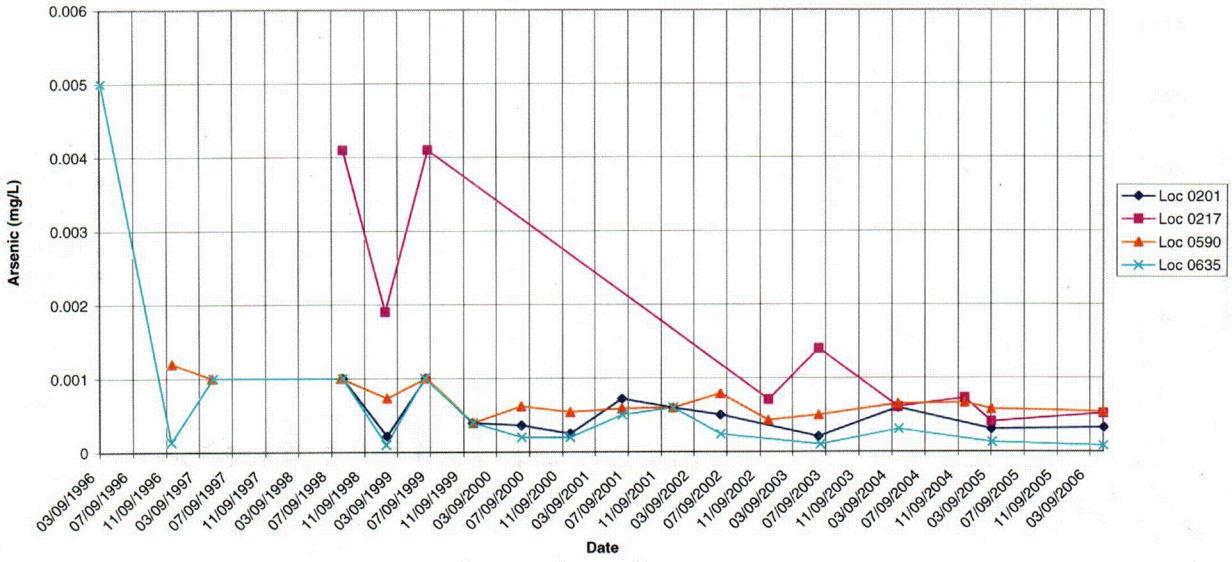
Rifle New Processing Site (RFN01)

Arsenic Concentration



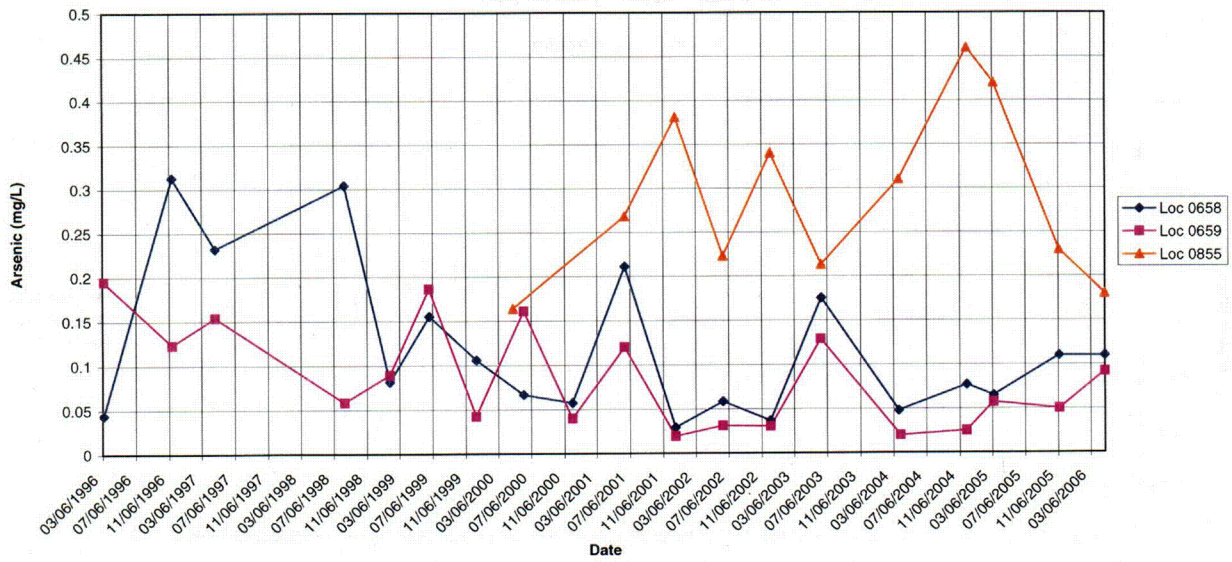
Rifle New Processing Site (RFN01)

Arsenic Concentration



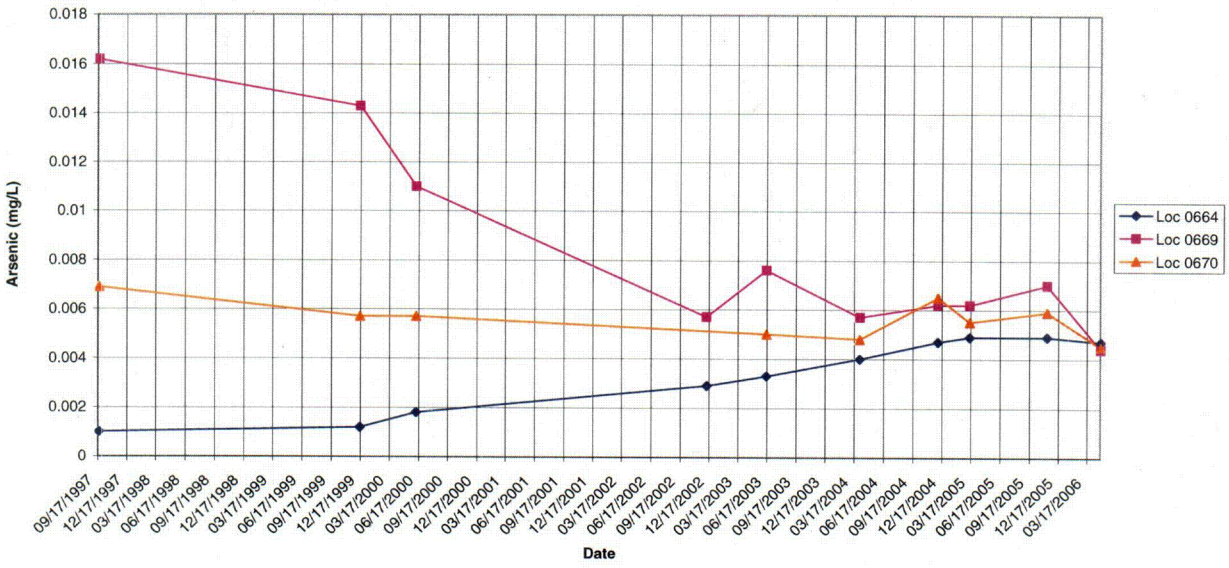
Rifle New Processing Site (RFN01)

Arsenic Concentration



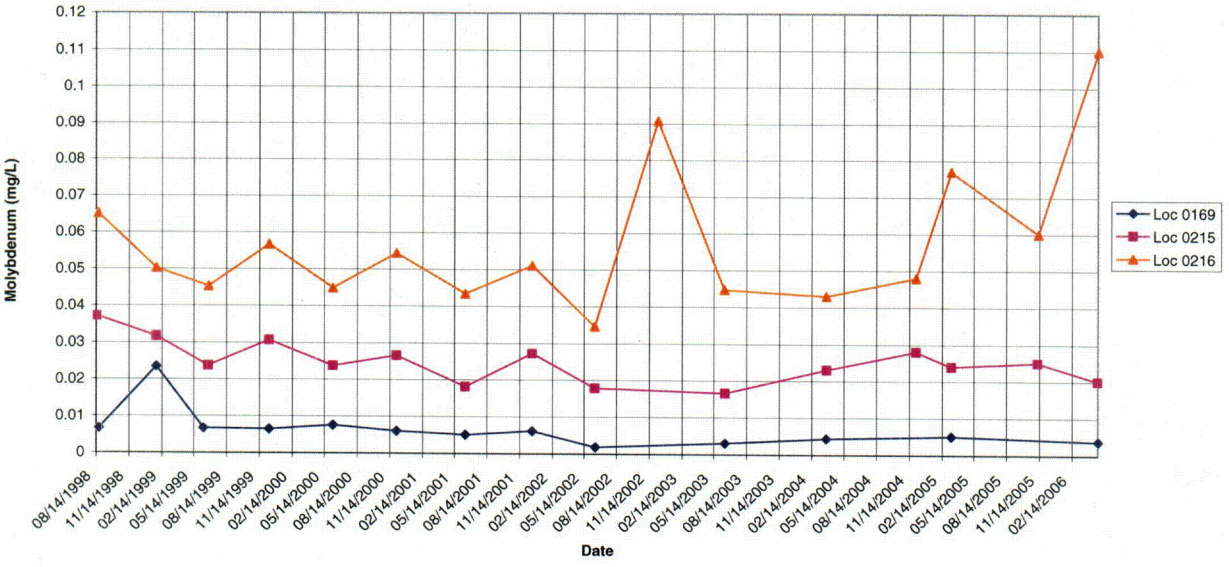
Rifle New Processing Site (RFN01)

Arsenic Concentration



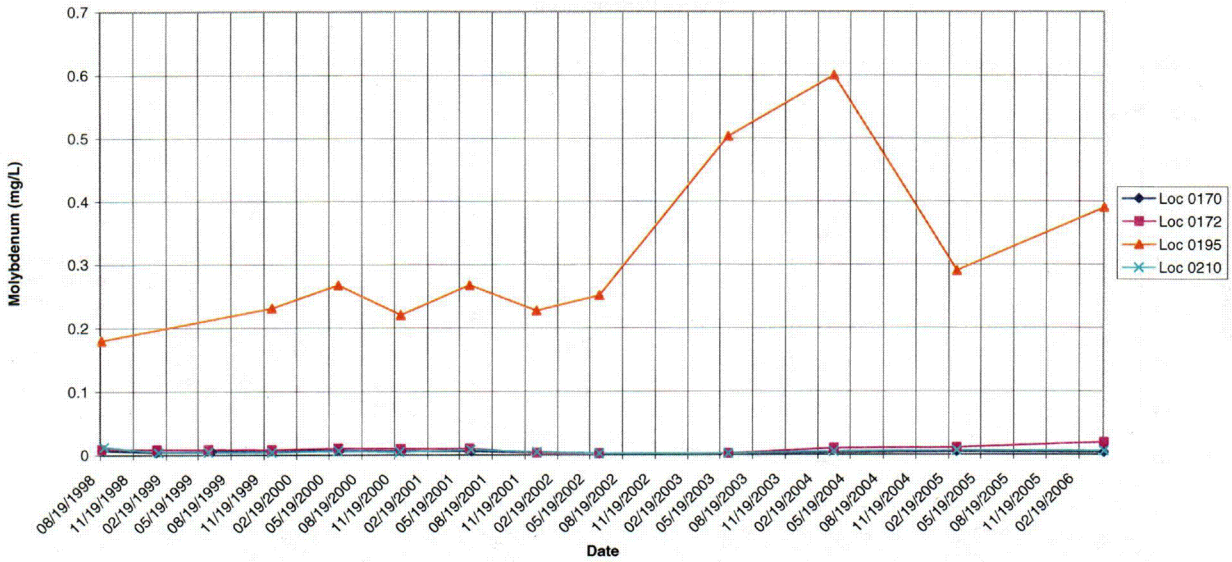
Rifle New Processing Site (RFN01)

Molybdenum Concentration



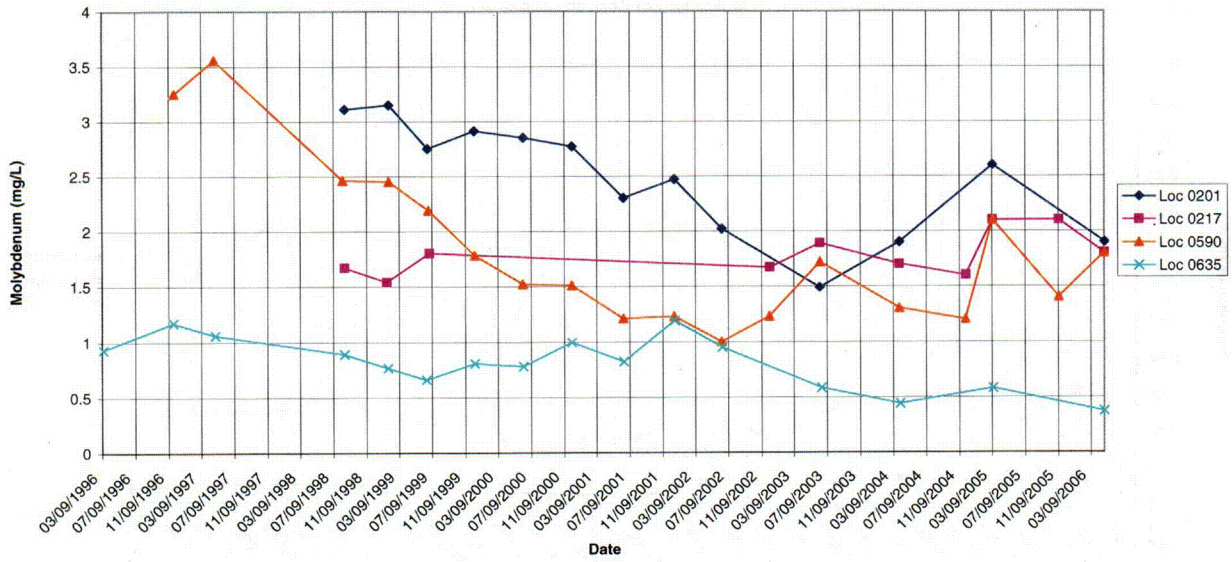
Rifle New Processing Site (RFN01)

Molybdenum Concentration



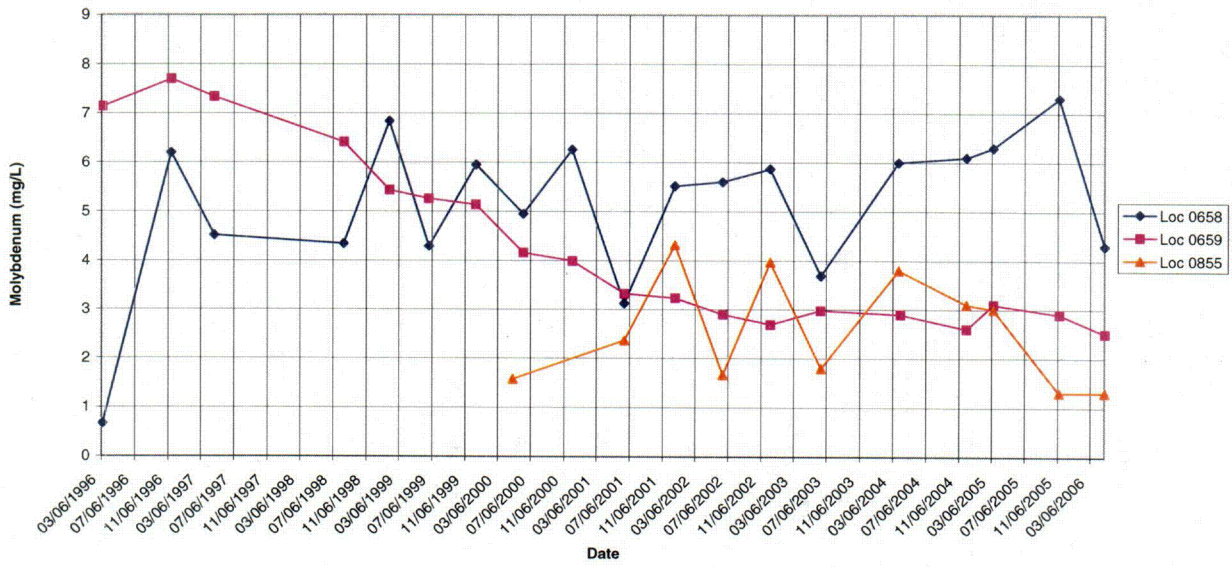
Rifle New Processing Site (RFN01)

Molybdenum Concentration



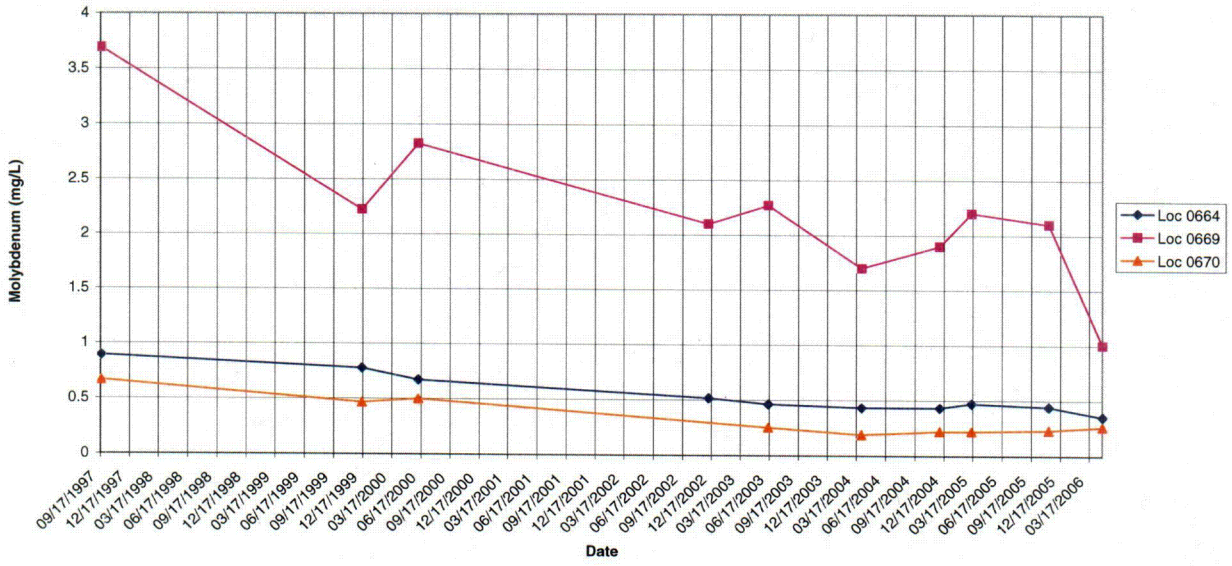
Rifle New Processing Site (RFN01)

Molybdenum Concentration



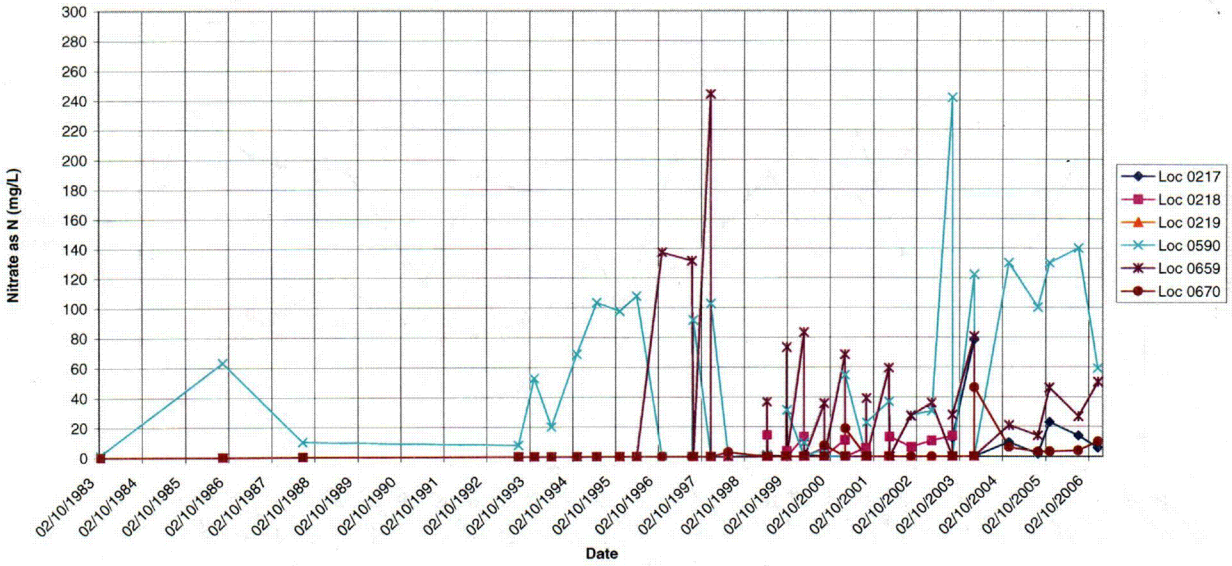
Rifle New Processing Site (RFN01)

Molybdenum Concentration



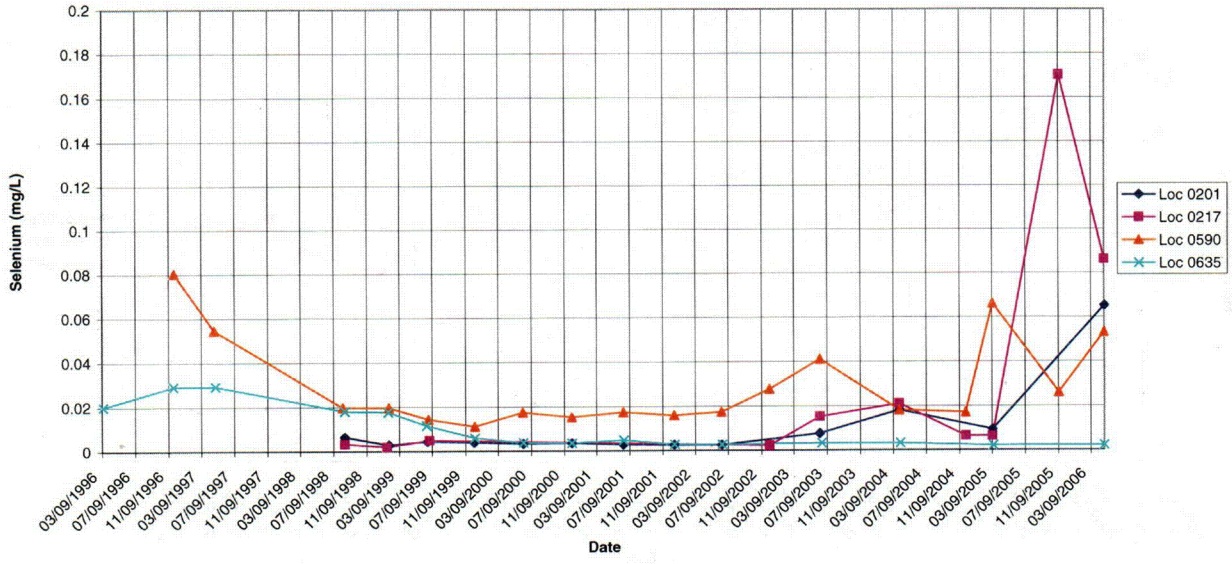
Rifle New Processing Site (RFN01)

Nitrate as N Concentration



Rifle New Processing Site (RFN01)

Selenium Concentration



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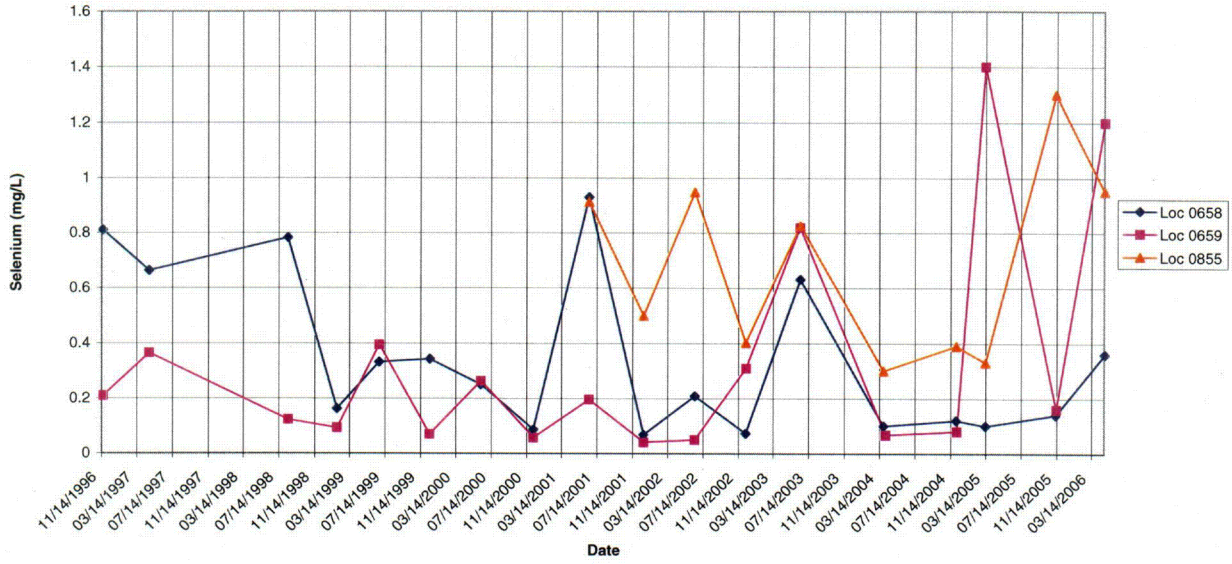
Selenium Concentration



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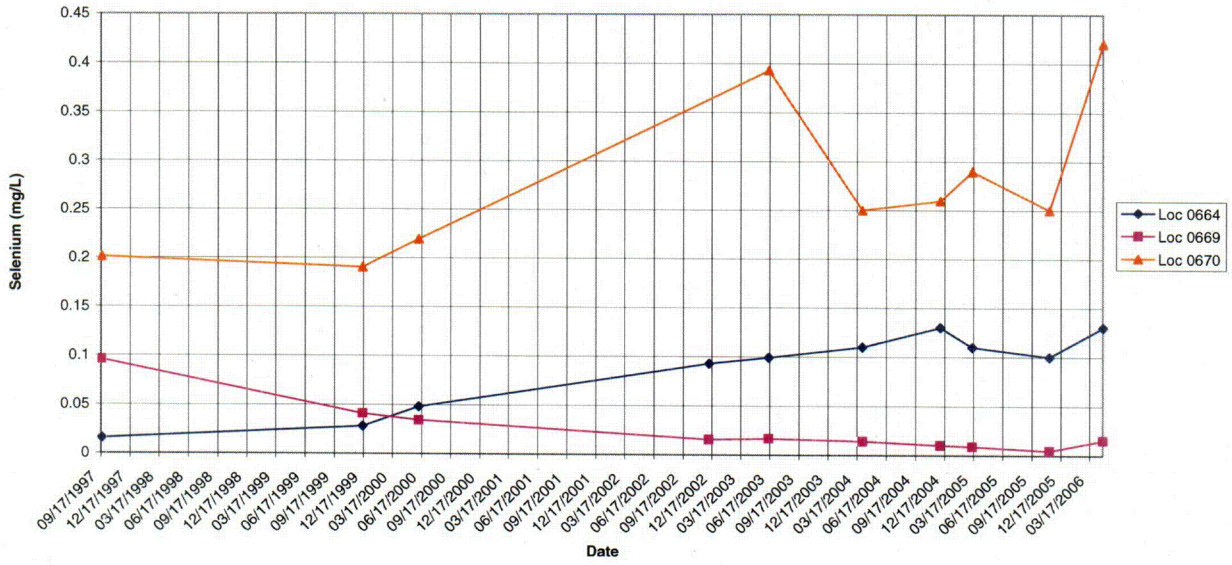
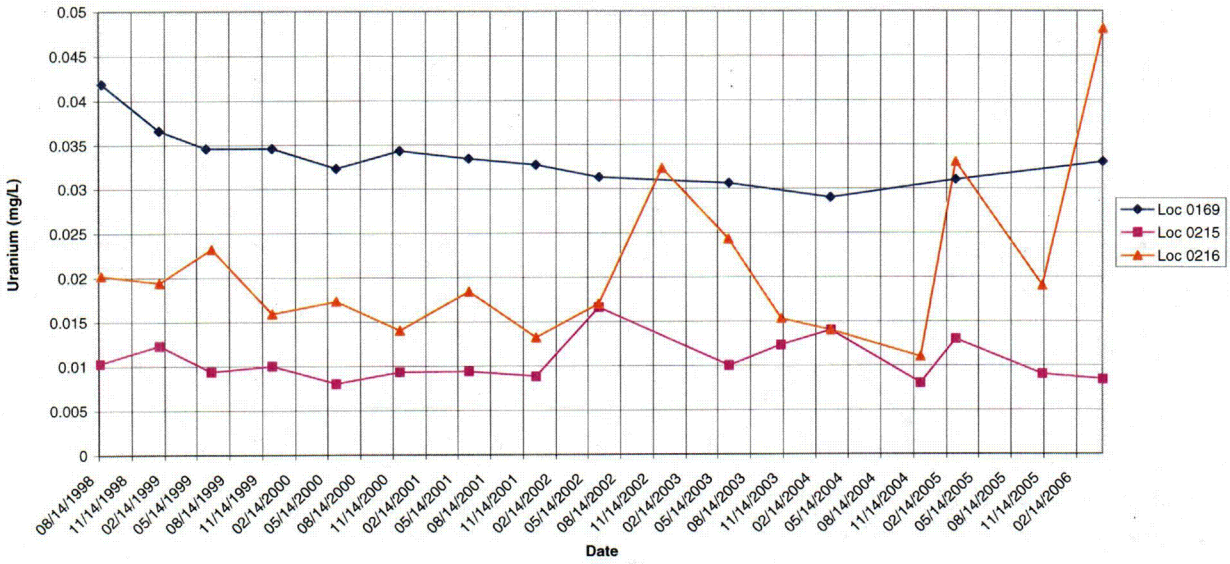
Selenium Concentration



Rifle New Processing Site (RFN01)

Uranium Concentration



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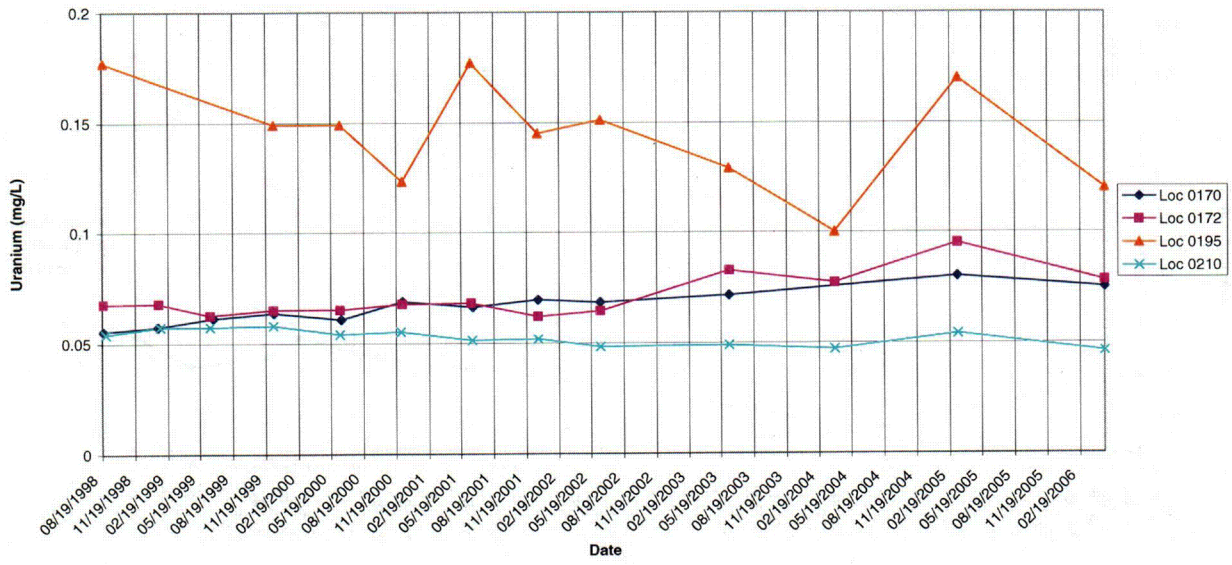
Uranium Concentration



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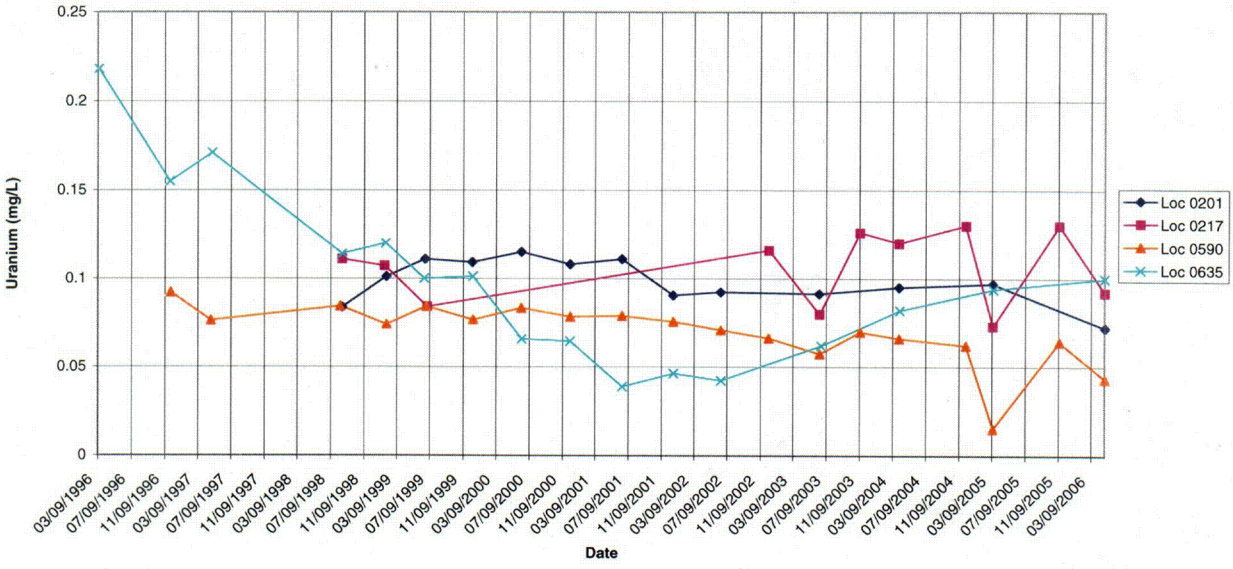
Uranium Concentration



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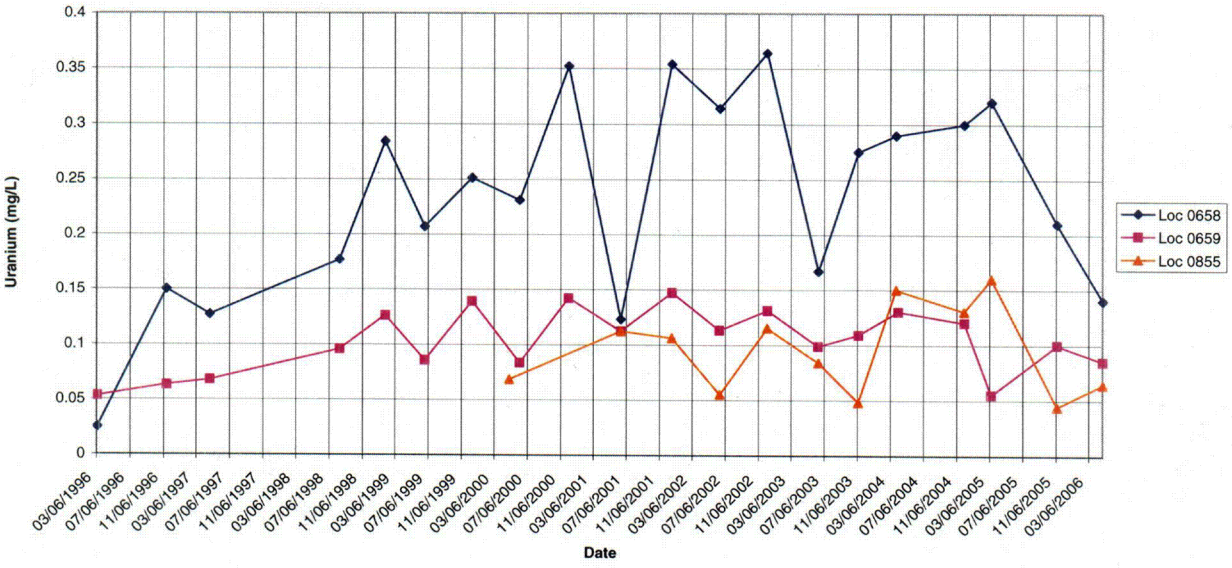

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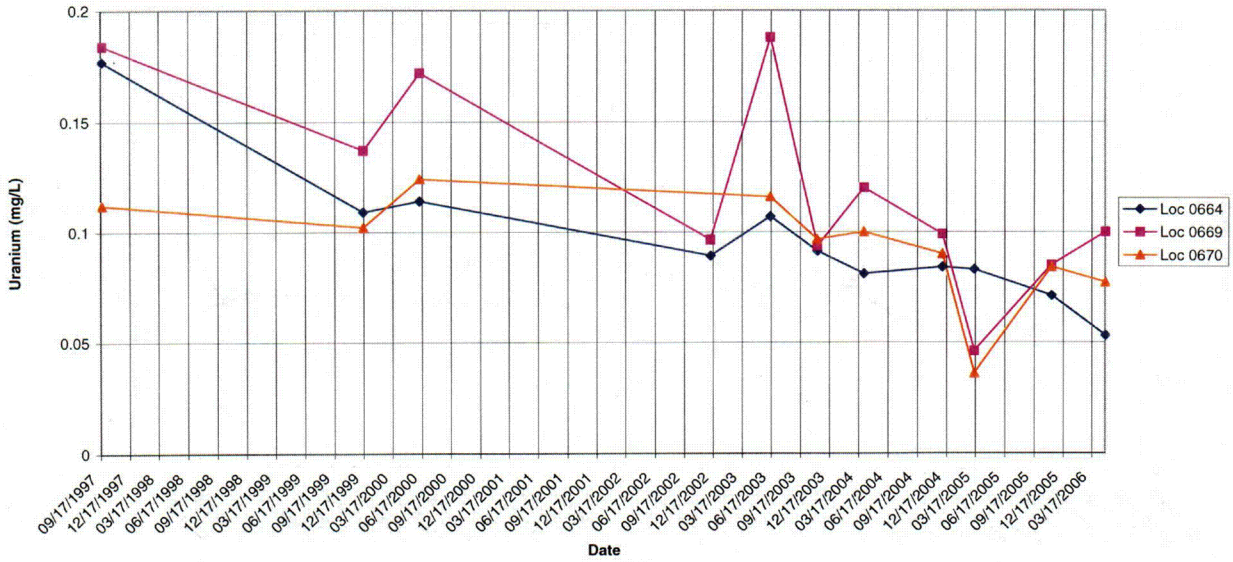
Uranium Concentration



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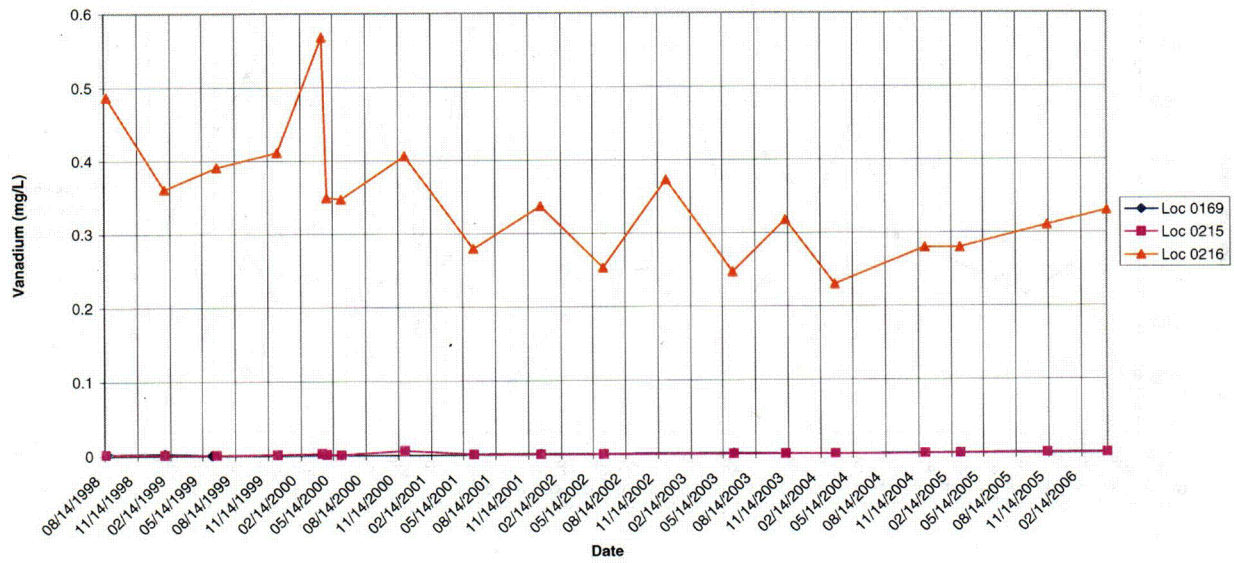
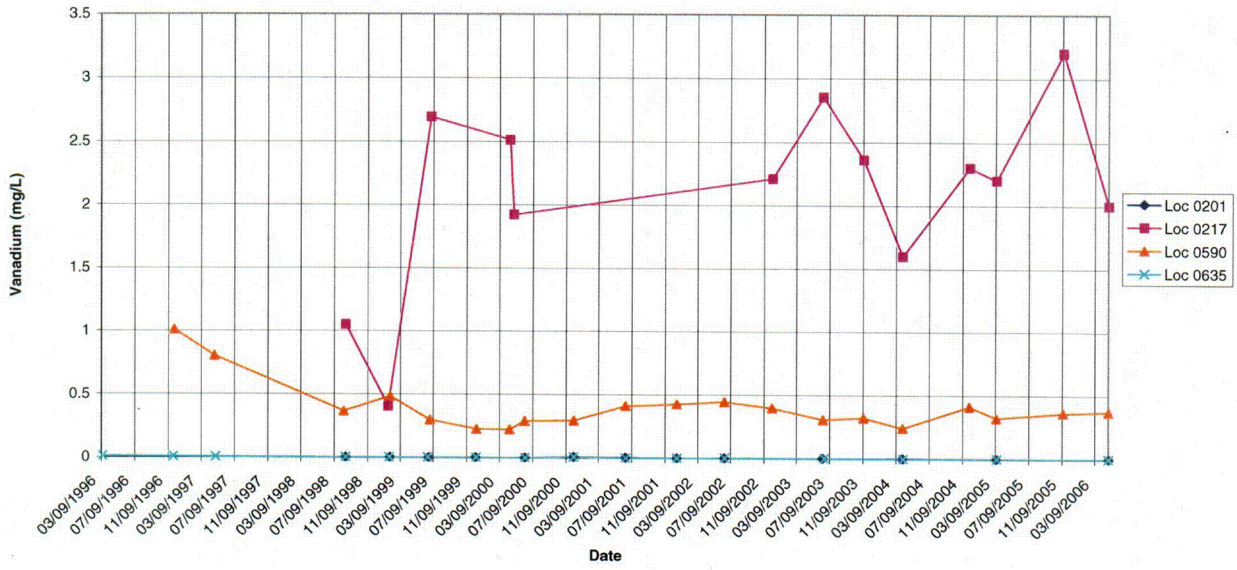
Vanadium Concentration



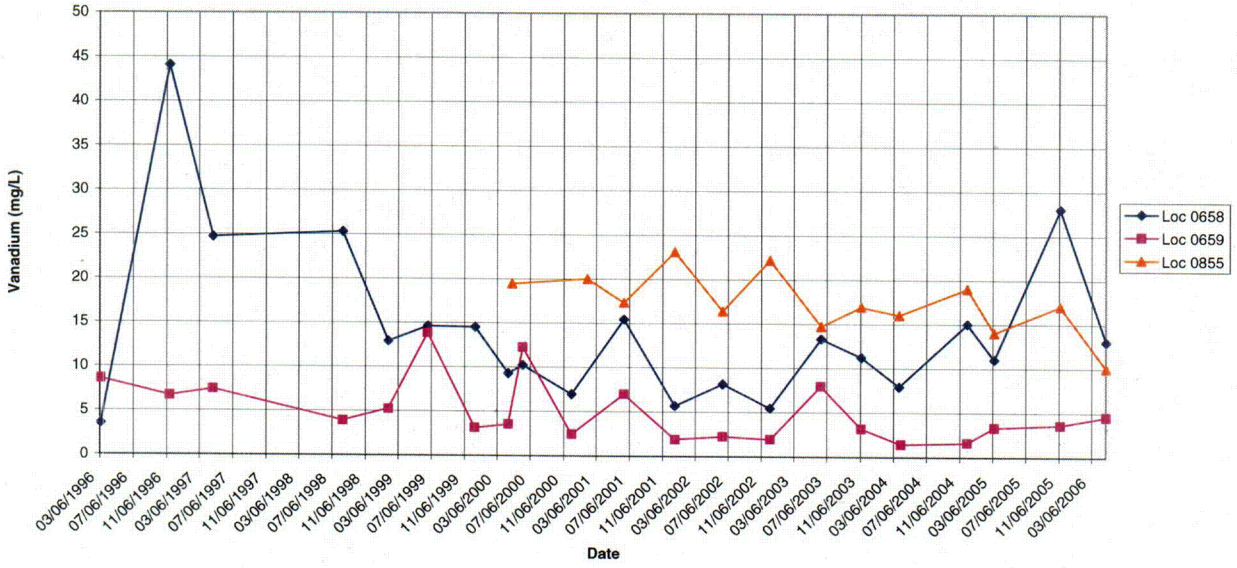
Rifle New Processing Site (RFN01)

Vanadium Concentration



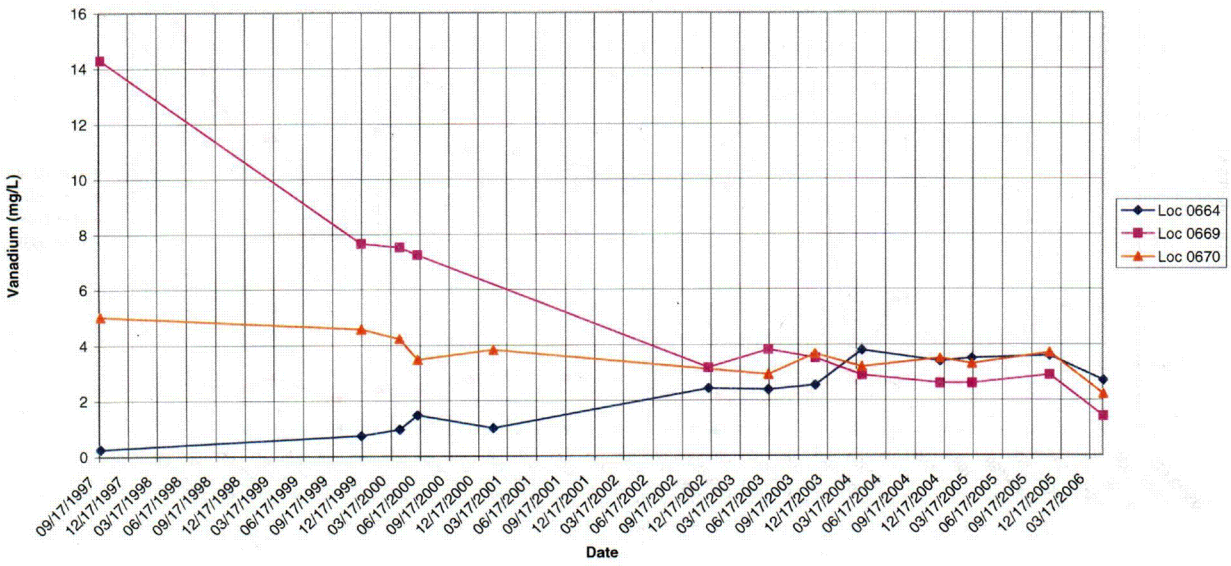
Rifle New Processing Site (RFN01)

Vanadium Concentration



Rifle New Processing Site (RFN01)

Vanadium Concentration



Appendix B

Preliminary Mann-Kendall Test Results

for Selected Locations at the New Rifle Site

The Visual Sample Plan computer module used for the trend analysis is the nonparametric Mann-Kendall test for trend (Gilbert 1987). In this procedure missing values are allowed and the data need not conform to any particular distribution. In this Mann-Kendall test only the relative magnitudes of the data are used rather than the measured values.

A one-tailed test is used because it is desired to test the null hypothesis, H_O, of no trend against the alternative hypothesis, H_A, of a downward trend. If no trend is detected, then it is desired to test the null hypothesis, H_O, of no trend against the alternative hypothesis, H_A, of an upward trend.

Alpha (α) is often called the level of significance. It is also referred to as a Type I error. For $\alpha = .05$, this would be a 5% probability of rejecting the null hypothesis when the null hypothesis is true, i.e., there is a 5% probability of concluding there is a trend when no trend is present. In table format the Type I and Type II errors can be expressed as shown in Table B–1.

Table B–1. Type I and Type II Errors

	Hypothesis is correct	Hypothesis is incorrect
Hypothesis is accepted	Correct decision	Type II error (β)
Hypothesis is rejected	Type I error (α)	Correct decision

Table A18 (Gilbert 1987) gives probability values only for n less than or equal 10. An extension of this table up to n = 40 is given in Table A.21 in Hollander and Wolfe (1973) and has been incorporated within VSP.

The VSP module was used to analyze monitoring data collected from four wells at the New Rifle site. Results are based on data collected since surface remediation was completed (1998 time frame). Data for both uranium and molybdenum were used in the analysis. Results are summarized in Table B–2.

Table B–2. Summary of Mann-Kendall Test Results for Selected Wells at the New Rifle Site

Location	Uranium trend	Alpha[a]	Molybdenum trend	Alpha[a]
RFN-0195	down	10%	up	5%
RFN-0201	down	15%	down	5%
RFN-0664	down	5%	down	5%
RFN-0669	down	5%	down	5%

[a]The alpha of 10% for uranium in RFN-195 indicates a 90% chance that a downward trend exists by this method. A 5% for molybdenum for RFN-195 indicates a 95% chance that an upward trend exists by this method.

End of current text