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UMTRA Ground Water Project

Work Plan for Characterization Activities at the UMTRA Grand Junction Project Site

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Abbreviations

AOAC	Association of Office Analytical Chemists
AOC	area of contamination
BLRA	*Baseline Risk Assessment*
BOR	U.S. Bureau of Reclamation
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CESQG	Conditionally Exempt Small Quantity Generators
CFR	Code of Federal Regulations
COCs	constituents of concerns
COPCs	Contaminants of Potential Concern
CRs	concentration ratios
DOE	U.S. Department of Energy
DOT	Department of Transportation
DQO	Data Quality Objective
EHPA	bis(2-ethylhexyl)phosphate
EPA	U.S. Environmental Protection Agency
ESC	Expedited Site Characterization
ft	feet (foot)
ft/s	feet per second
gal/yr	gallons per year
GJ	Grand Junction
GJO	Grand Junction Office
gpm	gallons per minute
HA	health advisories
HIs	Hazard Indices
HSP	Health and Safety Plan
IDW	investigation-derived waste
in.	inch (inches)
Kd	distribution coefficient
km	kilometers
lbs	pounds
LNAPL	light nonaqueous phase liquids
m	meters
m^3/yr	cubic meters per year
MCLs	maximum concentration limits
mg/Kg	milligrams per kilogram
mg/L	milligrams per liter
mi	miles
mL	milliliter
NEPA	National Environmental Policy Act

NRC	Nuclear Regulatory Commission
pCi/L	picocuries per liter
PEIS	*Programmatic Environmental Impact Statement*
PID	photo-ionization detector
ppb	parts per billion
PPE	personal protective equipment
PVC	polyvinyl chloride
QC	quality control
RCRA	Resource Conservation and Recovery Act
Regional Center	Grand Junction Regional Center for Developmental Disabilities
RRM	residual radioactive material
SOWP	Site Operational Work Plan
T&E	Threatened and Endangered
TBP	tributyl phosphate
TDS	total dissolved solids
UMTRA	Uranium Mill Tailings Remedial Action
VP	vicinity properties
WRR	work readiness review

1.0 Introduction

The Grand Junction site is one of 24 Uranium Mill Tailings Remedial Action (UMTRA) project sites being remediated by the U.S. Department of Energy (DOE). The former millsite (often referred to as the Climax site) is located in Mesa County, Colorado, along the southern side of the City of Grand Junction in an industrial area (Figure 1–1). The site lies on the northern bank of the Colorado River about 1 mile east of its confluence with the Gunnison River. The UMTRA site at Grand Junction consists of approximately 114 acres that underwent remedial action from 1989 to 1994. Approximately 3.1 million yards of contaminated tailings and other radioactive materials were transported to the Cheney disposal site located about 10 miles south of Grand Junction.

A discussion of the additional background information and data needs is presented in Sections 2.0 through 5.0. A site conceptual model for the site is summarized in Section 6.0. Data quality objectives are defined in Section 7.0. The specific procedures that will be used to satisfy the data requirements are presented in Section 8.0. Results of the site characterization and a recommended final ground-water remediation technology will be presented in the final Site Operational Work Plan (SOWP) upon completion of the field work.

1.1 Purpose and Scope

Ground water impacted by uranium ore processing at the Grand Junction UMTRA site contains constituents in concentrations that exceed the ground-water protection standards established for uranium and thorium mill tailings (U.S. Code of Federal Regulations [CFR], Title 40, Part 192). Impacted ground water is located in an alluvial aquifer that is hydraulically connected to the Colorado River. The purpose of this document is to describe a plan for field investigations to collect data that would help with the selection of a corrective remedy for the site. The data will be sufficient to evaluate whether supplemental standards are applicable for ground-water protection and whether natural flushing is appropriate in case supplemental standards cannot be applied.

Vicinity properties are homes and businesses in the Grand Junction area that used the tailings for construction purposes such as landfill and foundations. Over 4,000 vicinity properties have been remediated under the UMTRA program. The DOE and the Colorado Department of Public Health and Environment (CDPHE) are interested in determining the potential for ground-water contamination from vicinity properties located in the Grand Junction area. Appendix C addresses the issue of ground-water contamination due to vicinity properties. To evaluate the potential for ground-water contamination from the vicinity properties, a single worst-case vicinity property will be characterized. Using the criteria listed in Appendix C, the Grand Junction Regional Center for Developmental Disabilities (Regional Center) was selected as the study site.

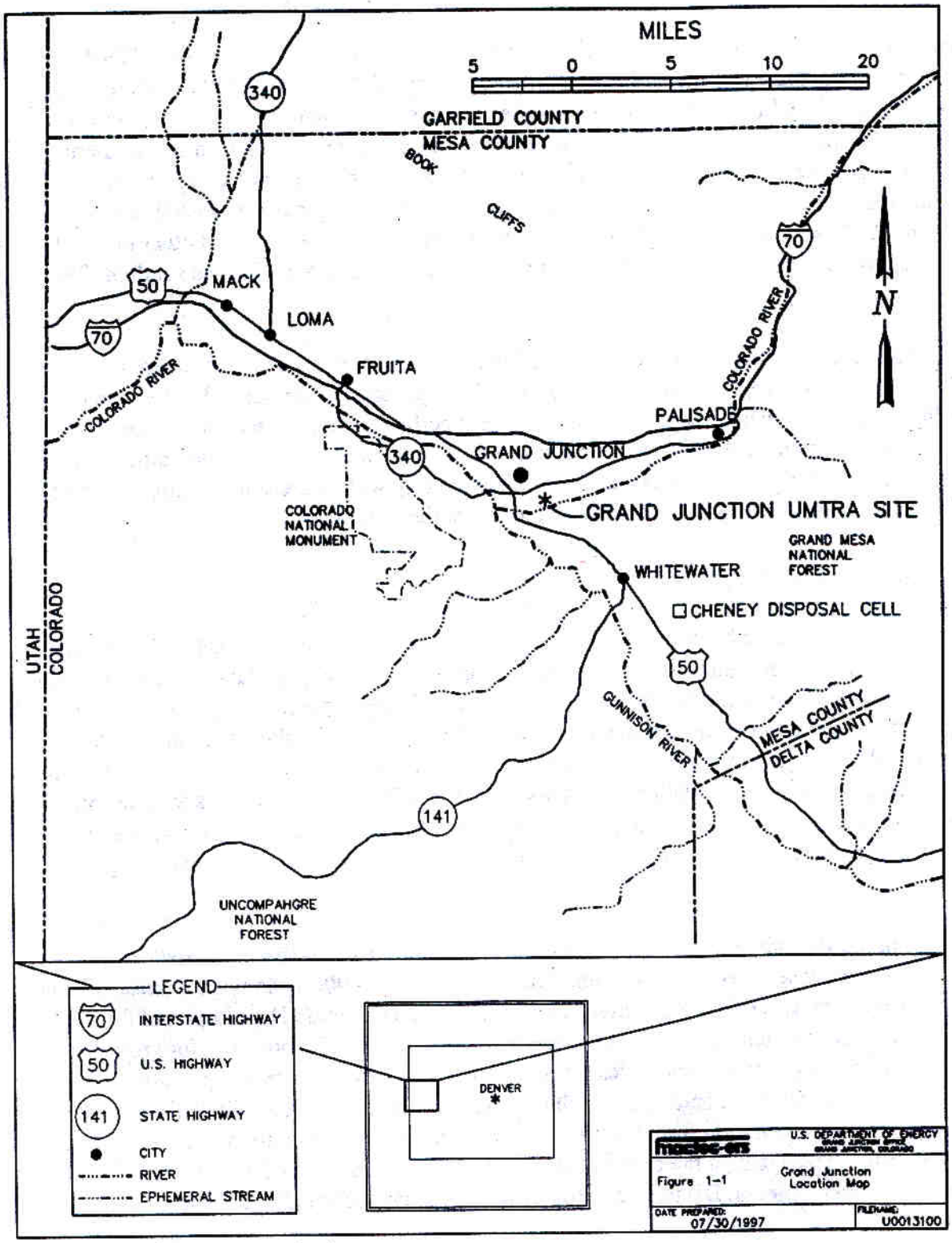

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Figure 1–1. Grand Junction Location Map

1.2 Site Background

The Grand Junction site was used to mill ores for recovery of uranium and vanadium from 1951 through 1970. Ores were processed using both acid and carbonate milling circuits. A total of about 2.3 million tons of ores was milled. Tailings removal was completed in 1994. The site is now owned by the City of Grand Junction which is developing a master plan for future land use. Contaminants from the milling operation have contributed to ground-water contamination beneath the site.

1.2.1 Milling History

This site and the main uranium milling building were originally part of the Holly Sugar Company processing plant. The site was reconfigured for uranium ore processing and opened as the Climax mill in June 1951. It was constructed and operated by the Climax Uranium Company, a subsidiary of Climax Molybdenum Corporation. In 1960, Climax was incorporated into American Metals Climax, Inc., who operated the mill until closure in March 1970. The Climax mill had an initial production rate of 330 tons per day until 1955 when modifications increased capacity to 500 tons per day, which was maintained until closure (Merritt 1971; Orr 1954). This mill was the first in the United States designed for uranium production with vanadium as a byproduct. The mill was fed with sandstone ores composed mostly of primary uranium/vanadium oxide and silicate minerals. Some oxidized ores containing carnotite and tyuyamunite were also milled. Most of the mill feed came from about 20 company-owned mines in the Uravan Mineral Belt; the remainder came from independent producers (Merritt 1971).

Ore was crushed and ground before treatment. Uranium was initially acid leached and neutralized before sands and slimes were separated. Sands were acid leached again. After separation, the slime fraction was salt roasted and water leached to remove vanadium, and finally acid leached again to remove uranium and water-insoluble vanadium. A solvent extraction process separated uranium from vanadium. The solvent extraction raffinate solution and other intermediate products were retreated with acid again to remove additional uranium and vanadium (Merritt 1971). Tailings from the washing circuit and raffinate from the solvent extraction operation were sent to one or two small holding ponds near the mill where fines settled out before the waters were sent to one of the three separate holding ponds where liquids were allowed to evaporate. The tailings piles were stabilized with vegetation during operation and erosion of tailings into the Colorado River was minimized. This complex milling process required a relatively large number of different chemicals. Inorganic chemicals included sulfuric acid, hydrochloric acid, sodium chlorate, ammonia, sodium chloride, sodium carbonate, hydrogen peroxide, and powered iron metal; organic chemicals included number 2 fuel oil, di (2-ethylhexyl) phosphoric acid, tributyl phosphoric acid, and tertiary amines (DOE 1995).

A total of 2,281,614 tons of ore averaging 0.28 percent U_3O_8 and 1.41 percent V_2O_5 were milled. A total of 11,698,736 pounds (lbs) of U_3O_8 were produced with a 93 percent recovery and 46,050,877 lbs of V_2O_5 were produced with a 72 percent recovery over the history of the operation (Albrethson and McGinley 1982). An estimated 2.2 million dry tons of tailings in the form of fine sands and slimes were produced during the life of the mill. From 1951 to the early 1960's, tailings were available to private citizens and contractors who used them for fill and other construction activities (e.g., concrete production).

1.2.2 Remedial Action History

From 1970 to 1971, slimes in the bottom of the northern-most tailings pond (Pond 1) were sold to Union Carbide as ore. The bottoms of the ponds were plowed, 8 of the 12 mill buildings were demolished and placed into the settling ponds, dikes surrounding them were leveled, and ponds were filled with tailings, covered with soil, and the area was returned to original ground level. Concurrently, the remaining tailings pile was stabilized.

During the UMTRA cleanup in the late 1980's, portions of the site were subsequently used as the temporary or “state” repository for UMTRA vicinity property tailings. UMTRA cleanup of the site was conducted in two phases. Phase I, completed in 1989, consisted of fencing, demolition of remaining buildings except the old sugar mill, constructing lined retention ponds, and preparing the wastewater treatment plant foundation at the Cheney disposal cell located about 10 miles south of Grand Junction. Phase II, begun in 1990, included constructing or filling the Cheney disposal cell and assembling the wastewater treatment plant. By the end of 1994 all contaminated materials from the old processing site and the vicinity property materials temporarily stored at the site had been transported to the Cheney disposal cell. The only building left is the original brick sugar mill (also used as the main Climax mill building) that was cleaned, fitted with a new roof, and sold to the private sector in 1995. It is now located outside of the fenced enclosure of the old Climax site.

1.2.3 Current Status

The area has been covered with 6 inches (in.) of soil and sown with vegetation. Part of the original remedial action involved constructing wetlands including eight ponds along the southern boundary of the property adjacent to the Colorado River. Flooding in 1994 eroded the ponds and reconfigured the southern boundary.

The Climax site was deeded to the City of Grand Junction in 1996. The City is developing a master plan for the use of the land. Possible uses include a city park, recreational areas, sports arenas, and engineered holding ponds and wetlands for handling storm flow. The City has recently named the land occupied by the former millsite "Las Colonias Park", from an earlier Latino community that lived in this part of town.

A pedestrian bridge was built in 1997 adjacent to the southeastern boundary of the site. In 1995 and 1996, the Army Corps of Engineers constructed a flood control levee through the southern part of the site. A concrete sidewalk built in 1997 on top of the levee is part of the city’s riverfront trail corridor connecting the north side of the Colorado River to the south side via the foot bridge. East of the site, the Western Colorado Botanical Society, in coordination with the city, is constructing the Western Colorado Botanical Gardens. The gardens are located at the southern end of 7th Street at the access to the Watson Island section of the Colorado River Trail.

1.2.4 Sources of Ground-Water Contamination from Milling Operation

Contamination of ground water at the site is from original processing of uranium ore and from subsequent leaching of the uranium mill tailings. During active milling, slimes and water from the

operation were sent to several evaporation ponds that totaled 35 acres (Merritt 1971). The ponds did not supply enough surface area for complete evaporation of the water and some liquids seeped into the shallow alluvial aquifer. An estimated 22.5 million gallons per year (gal/yr) (85,500 cubic meters per year [m^3/yr]) seeped from the ponds into the shallow aquifer from 1951 to 1955 and 48 million gal/yr (180,000 m^3/yr) from 1955 to 1970. Based on this estimate, the total amount of process water that seeped into the shallow aquifer over the history of the milling operation was approximately 780 million gallons or 2,400 acre-feet (ft) (3.0 million m^3) (DOE 1996d).

1.3 Target Compliance Strategy

A framework for determining the appropriate strategy for achieving compliance with the U.S. Environmental Protection Agency's (EPA's) ground-water protection standards is presented in the *Programmatic Environmental Impact Statement for the Uranium Mill Tailings Remedial Action Ground Water Project* (PEIS) (DOE 1996c). This framework was used in the Grand Junction SOWP Rev. 0 (DOE 1996d) to select the ground-water compliance strategy for the site. The ground-water compliance strategy currently under consideration is application of supplemental standards based on limited use of the aquifer. If the data collected during this study do not support a supplemental standard strategy, then natural flushing will be evaluated. Data will be collected to support both supplemental standards and natural flushing strategies. An evaluation of the compliance strategy based on current knowledge is presented in Appendix A.

In order to apply the supplemental standards strategy, the ground water must be considered *limited use* which applies to ground water "that is not a current or potential source of drinking water because (a) the concentration of total dissolved solids is in excess of 10,000 mg/l, or (2) widespread, ambient contamination not due to activities involving residual radioactive materials from a designated processing site exist that cannot be cleaned up using treatment methods reasonably employed in public water systems, or (3) the quantity of water reasonably available for sustained continuous use is less than 150 gallons per day."

If one or more of these requirements are not met, the natural flushing strategy will be evaluated to determine if the contaminant concentrations will be reduced to below MCLs or ACLS within 100 years.

In addition, under both strategies institutional controls may be required to limit access to or use of the ground water until such time as the concentrations are below acceptable limits considered protective of human health and the environment.

2.0 Geologic Setting

The Grand Junction site is at an elevation of approximately 4,600 ft (1,400 meters [m]) in the broad, arid Grand Valley of the eastern Colorado Plateau. The site is just north of the west-flowing Colorado River, which, along with its major tributary - the Gunnison River -, cut the Grand Valley. About 0.75 miles (mi) (1.2 kilometers [km]) west of the site, the north-flowing Gunnison River joins the Colorado River. The Grand Valley is bounded by the Book Cliffs to the northeast, about 9 mi (15 km) from the site; the Grand Mesa to the east, about 16 mi (26 km) from the site; and the Uncompahgre Plateau to the southwest, about 5 mi (8 km) from the site.

In the site area, unconsolidated Quaternary deposits consisting of sand, silt, gravel, and cobbles laid down by the Colorado River cover sedimentary bedrock formations of Late Cretaceous age. In places, the Quaternary material is covered by soil or fill material placed or altered during surface remediation activities. Bedrock exposures closest to the site are to the south in the escarpment about 75 ft (23 m) high along the south side of the Colorado River. Approximately 15 ft (5 m) of Quaternary sand, silt, gravel, and cobbles overlies the bedrock and forms the top of the escarpment. This alluvial terrace material was deposited by the ancestral Colorado River and the surface formed on the terrace is known as Orchard Mesa. Bedrock in the subsurface of the site and along the escarpment strikes northwest and dips gently northeast at 2 to 3 degrees (Lohman 1965). This strike is parallel to the axis of the Uncompahgre Uplift to the southwest, and the dip is away from the uplift toward the Piceance Basin to the northeast.

2.1 Stratigraphy

Bedrock underlying the site and exposed within 1 mi (1.6 km) of the site is of Late Cretaceous age and consists of Dakota Sandstone and the overlying Mancos Shale. These formations and the overlying Quaternary material are shown in a southwest-to-northeast cross section just west of the site in Figure 2–1. Characteristics of the unconsolidated Quaternary material and fill, Mancos Shale, and Dakota Sandstone are described below.

2.1.1 Quaternary Sediments and Fill

Unconsolidated alluvial material and fill, in places, underlies the site north of the Colorado River and ranges in thickness from 10 ft (3 m) to about 30 ft (10 m) (DOE 1996d). The thickness generally increases northward from the river and reaches its greatest thickness locally in an east-trending area about 2 mi (3.2 km) north of the site around North Avenue (U.S. Bureau of Reclamation [BOR] 1986). About 3 mi (5 km) east of the site, the alluvial material is thicker, as determined from borehole data. The thickest alluvium found in these boreholes was 78 ft (24 m) in hole 717 about 2 mi (3.2 km) north of the river (DOE 1996d). Quaternary material south of the site and south of the Colorado River caps the escarpment as a layer about 15 ft (5 m) thick and is a terrace deposit composed of cobbles and gravel with a sand and silt matrix.

Quaternary material north of the river may generally be divided into two types of deposits, bedload cobbles and gravel of the alluvial or cobble aquifer and overlying floodplain deposits of sand, silt, and clay. The “cobble aquifer” was first recognized by Schneider (1975), who proposed that the Colorado River was formerly about 3 mi (5 km) north of its present channel and the cobble aquifer was deposited as bedload during lateral migration of the river to its present position. As part of the Colorado River Basin salinity control project in the late 1970s and 1980s, the Bureau of Reclamation investigated the cobble aquifer and produced an isopach map of its thickness (Bureau of Reclamation 1986). The cobble aquifer is as much as 40 ft (12 m) thick in the Clifton area and is from 5 to 15 ft (1.5 to 5 m) thick in the site area. Description of the material composing the cobble aquifer in the site area includes silty gravel, and silty gravel and sand.

Fine-grained floodplain deposits generally from 5 to 10 ft (1.5 to 3 m) thick composed of sandy clay, clayey sand, sandy silt, and silty sand overlie the cobble aquifer in the site area. Cahn and others (1988) noted that in places the base of the floodplain deposits consisted of clay in discontinuous lenses. Where continuous, this clay could confine the underlying cobble aquifer.

2.1.2 Mancos Shale

Approximately 4,000 ft (1,200 m) of Mancos Shale deposited in the interior epicontinental seaway are present in the Grand Valley in the Grand Junction area. Only the lowermost part of the Mancos Shale, the nonresistant Tununk Member (about 200 ft [62 m] thick), is present less than 1 mile north of the site area. The lower part of the Tununk Member consists of calcareous, medium- to dark-gray shale and silty shale that weathers to yellowish brown or olive gray. The lower 20 ft (6 m) contains a zone of abundant oysters (*Pycnodonte newberryi*) (Willis 1994). Bentonite beds up to a few inches thick that have altered to montmorillonite (swelling) clay are common in the lowermost shales.

An in-place exposure of lowermost Mancos Shale was found in only one area along the escarpment south of the site area. This exposure (Plate 1) is just east of the slide area in the upper part of the escarpment slope immediately below the Quaternary terrace material. Here erosional “pillars” of olive-gray, calcareous, gypsiferous shale and silty shale are present starting about 25 ft (8 m) above the level of the Colorado River and extending up about 20 ft (6 m) to the contact of the Quaternary terrace material. Just south of the pedestrian bridge, a thin, calcareous, fine-grained sandstone bed may also mark the lowermost Mancos.

An outcrop of Mancos Shale along the south bank of the Colorado River just northwest of the lower Mancos “pillars” was reported in the SOWP (DOE 1996d). This outcrop of dark-gray shale contained some *Pycnodonte newberryi*, a bentonite bed several inches thick, and was calcareous, placing it in the lowermost part of the Mancos. However, outcrops of carbonaceous, noncalcareous siltstone along the river just to the west and the presence of slump blocks in the slide area just to the south indicate that this Mancos outcrop is probably part of the slide area and not in place.

Recognition criteria used to distinguish Mancos from Dakota include: calcareous content (HCl causes effervescence), common silty clay grain size, marine environment, gypsum, presence of the oyster *Pycnodonte newberryi*, and presence of bentonite derived from volcanic ash. These recognition criteria were applied to core from five boreholes near the site on the north side of the Colorado River.

None of the core had these characteristics of Mancos Shale, indicating that the subcrop of Mancos is some distance north of the site, probably within a mile.

2.1.3 Dakota Sandstone

The Dakota Sandstone is about 150 ft (46 m) thick in the Grand Junction area, as determined by Lohman (1981) and Young (1959). Young proposed these rocks be named the Naturita Formation. In the project area, the Dakota consists of approximately one-third sandstone and two-thirds shale and siltstone. Unconformably underlying the Dakota are fluvial-lacustrine sandstones and siltstones of the Burro Canyon Formation of Early Cretaceous age. The Dakota, which represents the last terrestrial deposition before transgression of the Mancos sea, in this area has been subdivided into three informal members based on lithology (Young 1959; Willis 1994). The lower member is resistant and consists mainly of crossbedded sandstone and conglomeratic sandstone. The middle member is nonresistant and consists of interbedded carbonaceous shale and sandstone, mudstone, impure coal, and bentonitic clay. The upper member is resistant and consists of fine-grained sandstone.

The lower and middle members are present in the escarpment along the south side of the Colorado River and were cored in boreholes east, west, and north of the site. The upper member was not observed in the area within 1 mi (1.6 km) of the site.

Several sandstone beds, each several feet thick, crop out as ledges in the area of the south end of the railroad bridge across the Colorado River. The south bridge abutment rests on one of these sandstone layers. These sandstone beds occur along the south bank of the Colorado River eastward for about 500 ft (150 m) east of the U.S. Highway 50 bridge. It is believed that these sandstone beds are part of the lower member of the Dakota.

Dark gray rocks of the middle Dakota are exposed above the lower member sandstones in many places along the escarpment from the railroad bridge to the new pedestrian bridge. Thin (less than 2 ft [0.6 m] thick) beds of impure coal (with a lignitic appearance) occur in this member. Remains of old underground coal workings occur just west of the south end of the U.S. Highway 50 bridge (Lohman 1965). Carbonaceous shale and thin, carbonaceous, fine-grained sandstone along with mudstone are the most common rock types exposed along the escarpment.

The middle Dakota was deposited in paludal or deltaic marginal marine environments and appears similar when viewed in isolated outcrops to Mancos Shale. Recognition criteria used to distinguish the Dakota from the Mancos include: carbonaceous material and impure coal, marginal marine environment, common sandy/silty grain size, noncalcareous matrix, presence of pyrite, bioturbated bedding, and bentonitic clay in which the volcanic ash has altered to kaolinite (nonswelling).

Sandstone of the upper member is rarely exposed along the escarpment and this member may be only a few feet thick or absent in places. Several sandstone slabs less than 1 ft (0.3 m) thick, possibly representing an offshore beach environment, occur in the upper part of the slide area in the Columbine Elementary School nature trail area. Also, a thin, calcareous, fine-grained sandstone bed occurs near the top of the escarpment just south of the pedestrian bridge, possibly marking the top of the Dakota or base of the Mancos.

Exposed members of the Dakota along the escarpment south of the Colorado River and their projected dip at 2 to 3 degrees northeastward beneath the site indicate that Dakota Sandstone rather than Mancos Shale, as stated in the SOWP (DOE 1996d), is the first bedrock formation present beneath the site area. The cross section in Figure 2–1 shows the geologic relationships found in boreholes in the area just west of the site. Recognition criteria for Dakota Sandstone were applied to core from five boreholes near the site on the north side of the Colorado River. All of the core had characteristics of Dakota Sandstone; the deepest parts of holes 724 and 725 may have penetrated the upper part of the underlying Burro Canyon Formation.

In the subsurface of the site area north of the Colorado River, the top 5 ft (1.5 m) of the Dakota Sandstone just below the Quaternary material is soft, weathered, and fractured gray shale. This weathered zone can be as much as 10 to 15 ft (3 to 5 m) thick and contains abundant calcite and gypsum in joints.

2.2 Summary of Data Needs

Geologic data needs summarized below are necessary to refine the site conceptual model and to provide parameters for use in ground-water remediation.

2.2.1 Quaternary Stratigraphy

The composition of the cobble aquifer and continuity (if it occurs) of clay layers or lenses separating the cobble aquifer from the overlying floodplain deposits needs to be determined in the site area. A detailed description of the cobble aquifer and floodplain deposits is also necessary during drilling of the proposed background wells east of the site. This information will be used to establish hydrologic continuity in the site area.

2.2.2 Bedrock Identification

Identification of the bedrock formation below the Quaternary material is important both in wells drilled on the site and in the proposed background wells. Mancos Shale will likely be the first bedrock formation found below the Quaternary material in background wells drilled more than 1 mi (1.6 km) east of the site. Wells should penetrate at least 10 ft into the bedrock to determine if an aquitard is present.

Figure 2–1. Cross Section A–A' Grand Junction, CO

Figure 2-1 will be provided upon request. Click Wendee Ryan or Michelle Smith to request.

3.0 Hydrogeology

The major components of the hydrologic system at the Grand Junction site include the Colorado River and irrigation canals north of the site, and three hydrogeologic units: the alluvial aquifer (cobble aquifer is a subset), the underlying shale aquitard composed mainly of shale units in the Dakota Sandstone, and, below it, the confined aquifer in sandstones of the Dakota Sandstone (Figure 2–1). Past data collection activities have revealed that virtually all the contamination associated with site activities is limited to ground water within the alluvium of the unconfined alluvial aquifer. Data collection activities during past investigations have consequently emphasized the alluvial aquifer, and will do so again during this investigation. Flow direction in the alluvial aquifer is from the southwest to west as shown in Figure 3–1. The various components of the hydrologic system are described in the following sections.

3.1 Surface-Water Hydrology

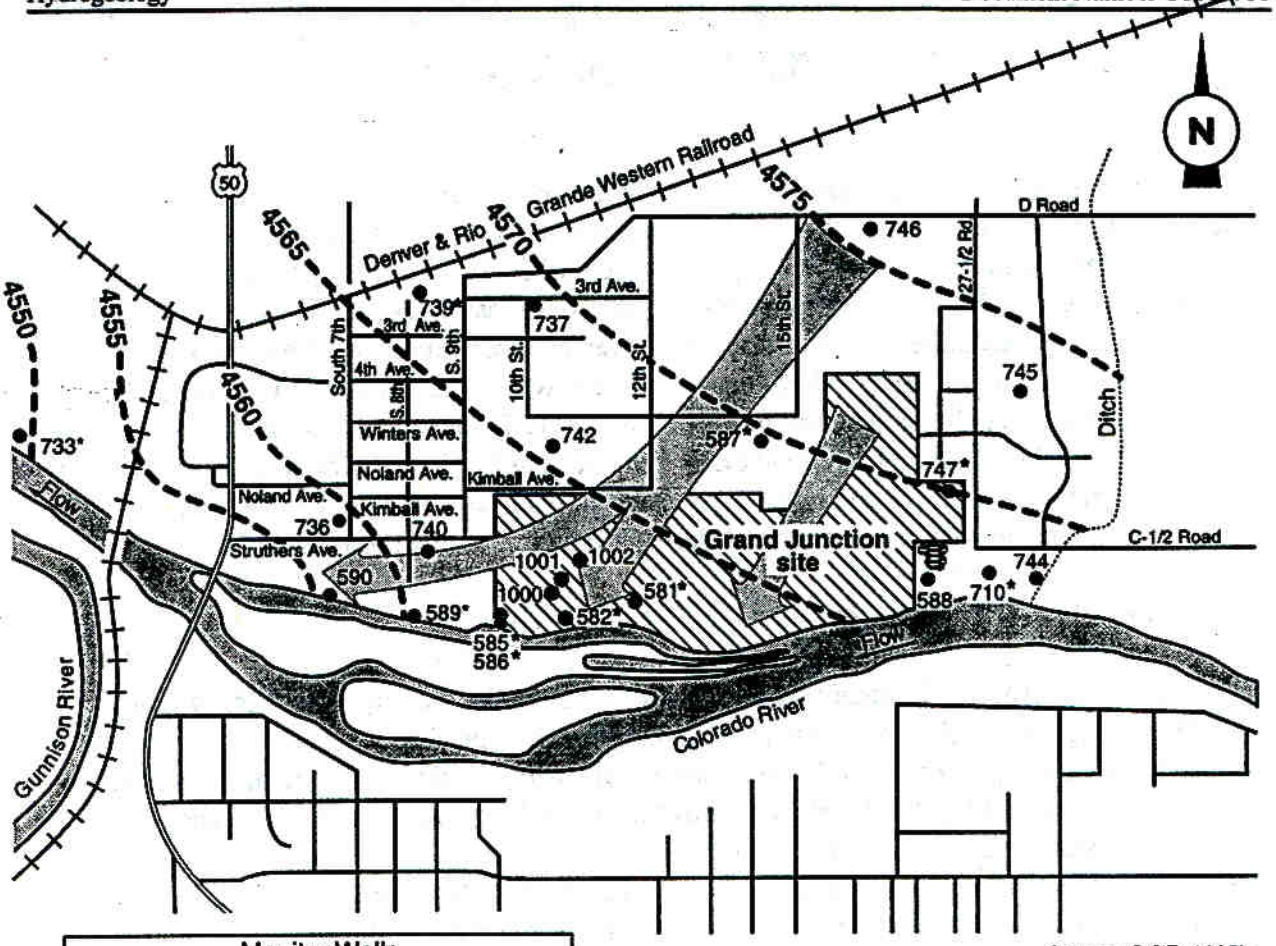
The Colorado River is the dominant surface water feature in the vicinity of the Grand Junction site. The river forms the southern boundary of the site and drains from east to west. River stage fluctuates dramatically in response to snowmelt runoff, which typically occurs between April and July. Data collected during 1994 and 1995 showed an 8 ft difference between high and low water levels in the river during a 24 month recording period. The large stage fluctuations cause the river to behave as the main point of ground-water discharge from the alluvial aquifer during low water periods and as a major source of recharge to the alluvial aquifer during high water periods. During high river stage, large portions of the site along the southern boundary are commonly flooded when the river crests its bank.

Precipitation falling on the site drains to the south, directly into the river and east into a surface drainage ditch that borders the eastern edge of the site (Plate 1).

During surficial remedial action activities on the site, several small ponds were constructed to provide wetlands environments along the southern portion of the site. However, sedimentation during flood events has filled in these shallow ponds and they are no longer present. Other important surface water features in the vicinity include several major irrigation canals to the north and a small pond located immediately east of the site boundary. The irrigation canals are unlined and, during the irrigation season, these canals act as a major source of recharge to the alluvial aquifer. The history and nature of the pond east of the site is unknown, although it is not likely lined and is therefore suspected to be in communication with the ground water of the alluvial aquifer.

3.2 Alluvial Aquifer

The alluvial aquifer is the uppermost hydrologic unit at the Grand Junction site. It is composed of unconsolidated clays, silts, sands, gravels, and cobbles and flows to the southwest. The name “cobble aquifer,” which is commonly used in literature about the valley’s hydrology, is informal and was coined by the BOR (1986). This cobble aquifer underlies most of Grand Junction and covers the Dakota Sandstone and Mancos Shale in a 1.5- to 3-mi-wide strip between Loma



Source: DOE, 1995b.

Notes: 1. Decommissioned monitor wells are indicated by an asterisk.
2. On-site ponds are not shown.

Monitor Wells and Water Table Elevations (ft)			
581	4564.43	737	4568.9
582	4563.32	739	NA
585	4562.43	740	4562.03
586	4562.77	742	4567.78
587	NA	744	4567.07
589	4562.09	745	4572.57
590	4555.44	746	4576.57
710	4567.65	747	NA
731	NA	1000	NA
732	NA	1001	NA
733	4549.95	1002	NA
736	4559.20		

Legend

4575	Inferred line of equal water table elevation (ft above msl)
NA	Data not available
	Predominant ground water flow direction
● 740	Alluvial monitor well
	Pond
50	U.S. highway

0.25 0 0.5 Mile

0.25 0 1.0 Kilometer

O\ g\ ugw\ sowps\ grd_jct\ watrtabl.cdr

Figure 3–1. Water Table Contour Maps (Alluvial Aquifer)

and Palisade. Most of the cobble aquifer extends north of the Colorado River, although some parts occur to the south. The name “cobble aquifer” may be misleading; the composition can range from 90 percent gravel, 9 percent sand, and 1 percent fines to 1 percent gravel, 91 percent sand, and 9 percent fines (Bureau of Reclamation 1986). In many places in the valley, the cobble aquifer is overlain by a silty-clay unit. The base of this unit consists of discontinuous lenses of clay. Where intact, the clay layer confines the cobble aquifer. Together the cobble aquifer and overlying silty clay lenses are called the alluvial aquifer. The alluvial sediments above the clay are variable, and range from sand to silt or clay. Typically, the uppermost layers are low in hydraulic conductivity, which results in a high water table.

During periods of high water in the Colorado River, recharge enters the alluvial aquifer from the river along its southern boundary, flattening hydraulic gradients and creating a more westerly ground-water flow orientation. Seasonal fluctuations in water levels beneath the site range from 2 to 5 ft in response to changes in river stage.

Depths to ground water in the alluvial aquifer range from zero near the river to approximately 20 ft at the northern end of the site. Saturated thicknesses for the alluvium range from approximately 5 to 15 ft.

Recharge to the alluvial aquifer occurs as infiltration of precipitation directly on the site, leakage from upgradient irrigation canals and ditches, and infiltration of river water during spring runoff in the Colorado River. Limited amounts of recharge also likely occur as upward leakage of ground water from the underlying Dakota Sandstone and Mancos Shale. Discharge is primarily limited to drainage into the river during low stage. Some discharge also likely occurs as evapotranspiration from vegetation growing in areas of shallow ground water depth near the river. There are no known wells in the cobble aquifer used for the production of water for domestic, municipal, or industrial purposes.

Hydraulic conductivity in the cobble aquifer is estimated to be 1×10^{-3} feet per second (ft/s) based on prior pumping and slug tests. Based on previously measured hydraulic gradients ranging from 0.003 ft/ft to 0.008 ft/ft, the average linear velocity for ground water in the cobble aquifer is approximately 0.2 to 0.7 ft/day.

3.3 Shale Aquitard

Underlying the alluvial aquifer is a shale aquitard composed of low-permeability shale units in the Dakota Sandstone formation. Previously collected lithologic data indicate the contact between the alluvium and the shale dips westward at approximately 10 to 20 ft per mi. A subtle bedrock high has tentatively been mapped near the western boundary of the site and this local feature may contribute to the apparent increased westerly hydraulic gradient in the cobble aquifer in this area. The uppermost portions of the shale aquitard have been logged during previous investigations as “highly weathered” and may behave as part of the cobble aquifer. Thicknesses of the shale aquitard in the Dakota may be as much as 50 ft (Figure 2–1). Depths to the top of the aquitard range from less than 10 to more than 75 ft below ground surface.

Although this shale unit is regarded as an aquitard, wells completed within the unit indicate that it is saturated with ground water. Horizontal hydraulic conductivity estimates for the aquitard range from 2×10^{-7} ft/s to 1×10^{-3} ft/s (DOE 1996d). The lower end of this range likely characterizes the

unweathered sections of the aquitard. Vertical hydraulic conductivities are likely one to several orders of magnitude less than the horizontal values.

Several wells were installed in the shale aquitard to form paired installations with wells in the cobble aquifer. Although these wells have all since been destroyed or decommissioned, previously collected data (DOE 1996d) indicate that vertical hydraulic gradients are generally directed upwards, with a few exceptions noted during high water levels in the cobble aquifer associated with high river stages.

3.4 Dakota Sandstone

Underlying the shale aquitard is the confined aquifer of sandstones in the Dakota Sandstone (Figure 2–1). This aquifer has not been extensively characterized during previous investigations because of the presence of the overlying aquitard and vertically upward hydraulic gradients that minimize the likelihood of any contaminant infiltration.

Recharge to the Dakota Sandstone occurs as infiltration of precipitation on outcrops to the south. Although not sufficiently mapped by onsite wells, ground-water flow directions beneath the site likely follow regional gradients, which vary between a northeast orientation and a northwest orientation.

Hydraulic conductivity estimates are limited in number, ranging from 2×10^{-7} ft/s to 1.5×10^{-6} ft/s.

3.5 Summary of Hydrology Data Needs

Hydrologic data needs are summarized below. Additional hydrologic data collected will be used to help evaluate the suitability of the supplemental standards alternative and/or the natural flushing alternative.

3.5.1 Surface Water

The recharge/discharge relationship between the Colorado River and the alluvial aquifer has not been quantified. To quantify this relationship, upstream and downstream stage-discharge data for the river will be obtained from the U.S. Geological Survey. These data, together with site-specific stage data obtained during this study adjacent to the site, will be used to estimate seasonal gain and/or loss rates for the reach of river bordering the site. Seasonal losses and gains estimated from surface water data will be compared with estimates obtained from ground-water data collected during the study.

3.5.2 Ground Water

Data defining the water table topography, saturated thickness, lithology, and hydraulic conductivity of the alluvial aquifer are limited. Additional onsite and offsite monitoring/aquifer test wells will be installed to provide water level data, lithologic data, and hydraulic conductivity estimates from pumping tests. Water level measurements will be made in all onsite and background wells. Aquifer tests will be conducted in all newly installed onsite wells and in background wells 745 and 746. Continuous water level logging will be performed on at least three alluvial wells, and the existing Dakota Sandstone well located west of the site. Slug withdrawal tests will be performed at select background well locations P012, P019, and P020. A tracer test to estimate aquifer dispersivity will be considered.

During the installation of on-site monitoring wells, 2-ft split-barrel samples will be collected every 5 ft through the alluvial aquifer to characterize the lithology. Borehole advancement and split-barrel sampling will be continued until the top of the shale aquitard is encountered. Depth to bedrock data will be combined with water level elevation data to define the saturated thickness of the alluvial aquifer.

4.0 Geochemistry

DOE collected ground-water quality data from the processing site and vicinity from 1983 through 1997. Existing wells are currently being sampled annually. Geochemical data are accessible in the SEE_UMTRA database. The most recent information was used to assess ground-water and surface-water quality. Ground water and surface water were last sampled in December 1996–January 1997.

4.1 Contaminants of Potential Concern

Contaminants of Potential Concern (COPCs) are contaminants that could cause adverse health effects if human exposure occurs. To select COPCs for the Grand Junction site, chemical constituents were first screened to determine if they exceeded background. If the maximum detected concentration of a constituent exceeded background but was within the acceptable nutritional requirement levels, it was not retained as a COPC. If the maximum detected concentration was in the high end of dietary ranges, but was of low toxicity, it was not retained. This screening was conducted as part of the *Baseline Risk Assessment of Ground Water Contamination at the Uranium Mill Tailings Site at Grand Junction, Colorado* (BLRA) (DOE 1995). The fourteen constituents considered to be COPCs include: arsenic (As), cadmium (Cd), cobalt (Co), fluoride (F), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni), nitrate (NO_3^-), radium-226 (^{226}Ra), sulfate (SO_4^{2-}), uranium (U), vanadium (V), and zinc (Zn). Nitrate was not considered to be a COPC in the BLRA but was added in response to review comments from CDPHE. UMTRA maximum concentration limits (MCLs) for arsenic, cadmium, nitrate, selenium, and uranium are 0.05, 0.01, 44, 0.01, and 0.044 milligrams per liter (mg/L), respectively (Table 4–1). Ground water used as a sole source of drinking water was determined to be the exposure pathway of greatest potential risk.

Table 4–1. Maximum Concentration Limits (MCL), Health Advisories (HA) for 10–kg Child, 10–day Exposure, and Maximum Observed Concentrations in Alluvium in Most Recent Sampling for Contaminants of Potential Concern (mg/L)

Constituent	UMTRA mg/L	Health Advisory mg/L	Maximum Concentration mg/L
Arsenic	0.05	no HA	0.14
Cadmium	0.01	0.04	0.142
Cobalt	no MCL	?	0.13
Fluoride	no MCL	no HA	4.4
Iron	no MCL	?	16
Manganese	no MCL	no HA	4.9
Molybdenum	0.1	0.04	0.74
Nickel	no MCL	1.0	0.38

Table 4–1 (continued). Maximum Concentration Limits (MCL), Health Advisories (HA) for 10–kg Child, 10–day Exposure, and Maximum Observed Concentrations in Alluvium in Most Recent Sampling for Contaminants of Potential Concern (mg/L)

Constituent	UMTRA mg/L	Health Advisory mg/L	Maximum Concentration mg/L
Nitrate	44	44	1,080
Radium-226	5 pCi/L	no HA	8.3 pCi/L
Sulfate	no MCL	no HA	4,860
Uranium	0.044	no HA	0.473
Vanadium	no MCL	no HA	13.8
Zinc	no MCL	6.0	4.14

4.2 Contaminant Source Areas

All of the COPCs are derived either from the ores or the compounds used in the milling. Arsenic, cadmium, molybdenum, radium-226, uranium, vanadium, and zinc occur in the ores. Nitrate was probably used to strip uranium from the ion exchange agents. Some nitrate may have been derived from the microbial breakdown of ammonia which was used to adjust the pH of the mill liquors. Sulfate was generated from sulfuric acid used to partially dissolve the ores. Iron and manganese are major components of many rocks, including ores, and will become mobile if ground water is chemically reducing. Reducing conditions associated with the milling process probably caused a release of iron and manganese to the ground water. The presence of anomalously high concentrations of fluoride, cobalt, and nickel is surprising since they are not usually associated with the sandstone-type ores that were milled at the site, nor were they used in the milling process.

Processing waters from the acid milling and solvent extraction circuits have entered the ground water at the site. The mill operated on the northern portion of the site (Plate 1). Mill effluent was placed in tailings and raffinate ponds ("former tailings area" and former Ponds 1, 2, and 3 on Plate 1). Tailings were relocated to the Cheney disposal site in 1994. The depth of removal during the relocation of the tailings was based on radium-226 concentrations in the soils as determined from radiometric gamma measurements. Since uranium and most COPCs are not gamma emitters, it is possible that a source of contamination could have been left in place below the excavation depths due to leachate adsorbing or precipitating in the soil layers. Samples will be collected and analyzed to evaluate the potential of a continuing source in the soils.

4.3 Contamination in the Alluvial Aquifer

A well location map for the alluvial aquifer with the most recent sampling dates is shown in Figure 4–1, and maps showing the distribution of the COPCs are shown in Figures 4–2 through 4–15 (arranged alphabetically). Wells in these figures are screened in the cobble aquifer section.

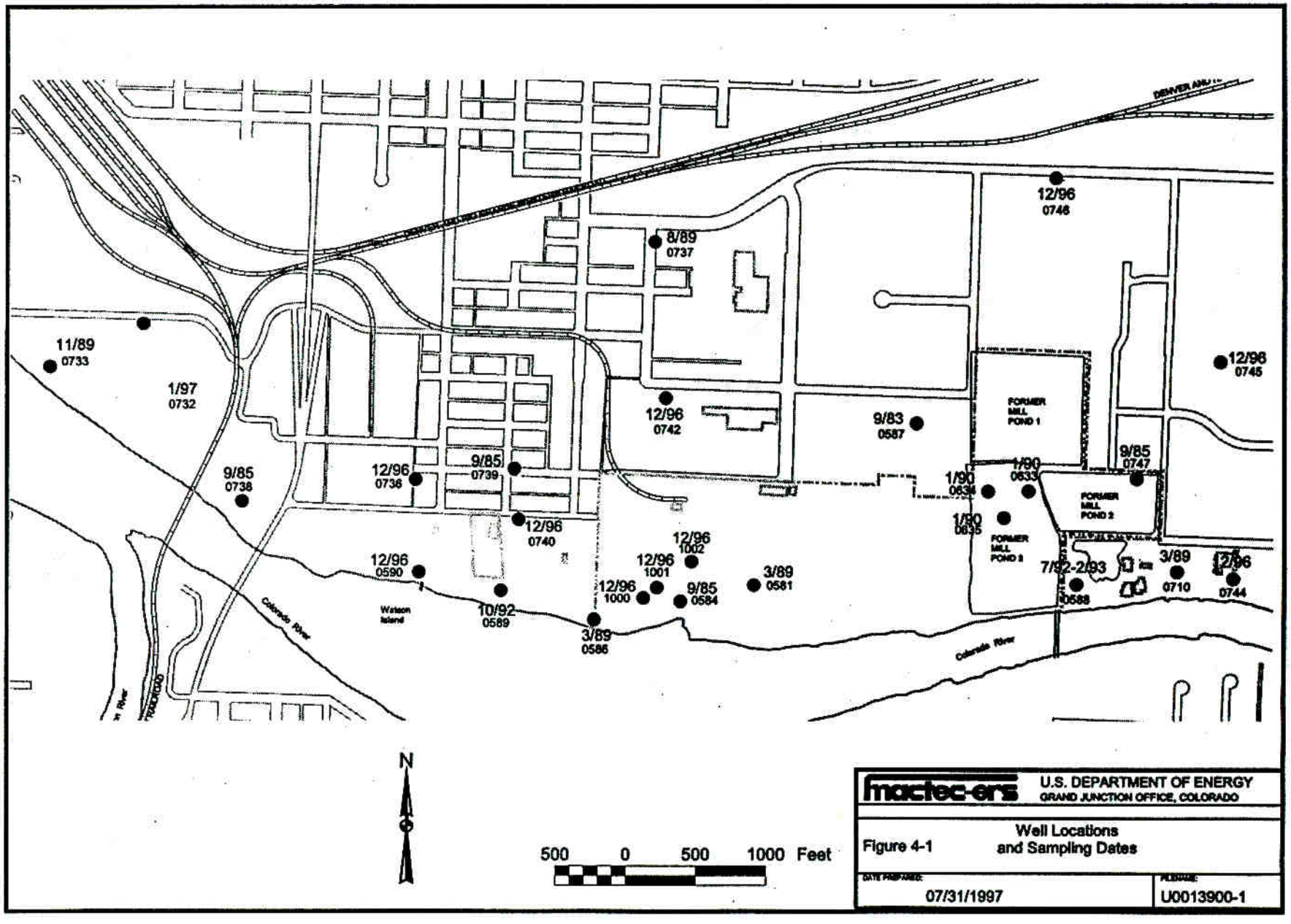


Figure 4–1. Well Locations and Sampling Dates

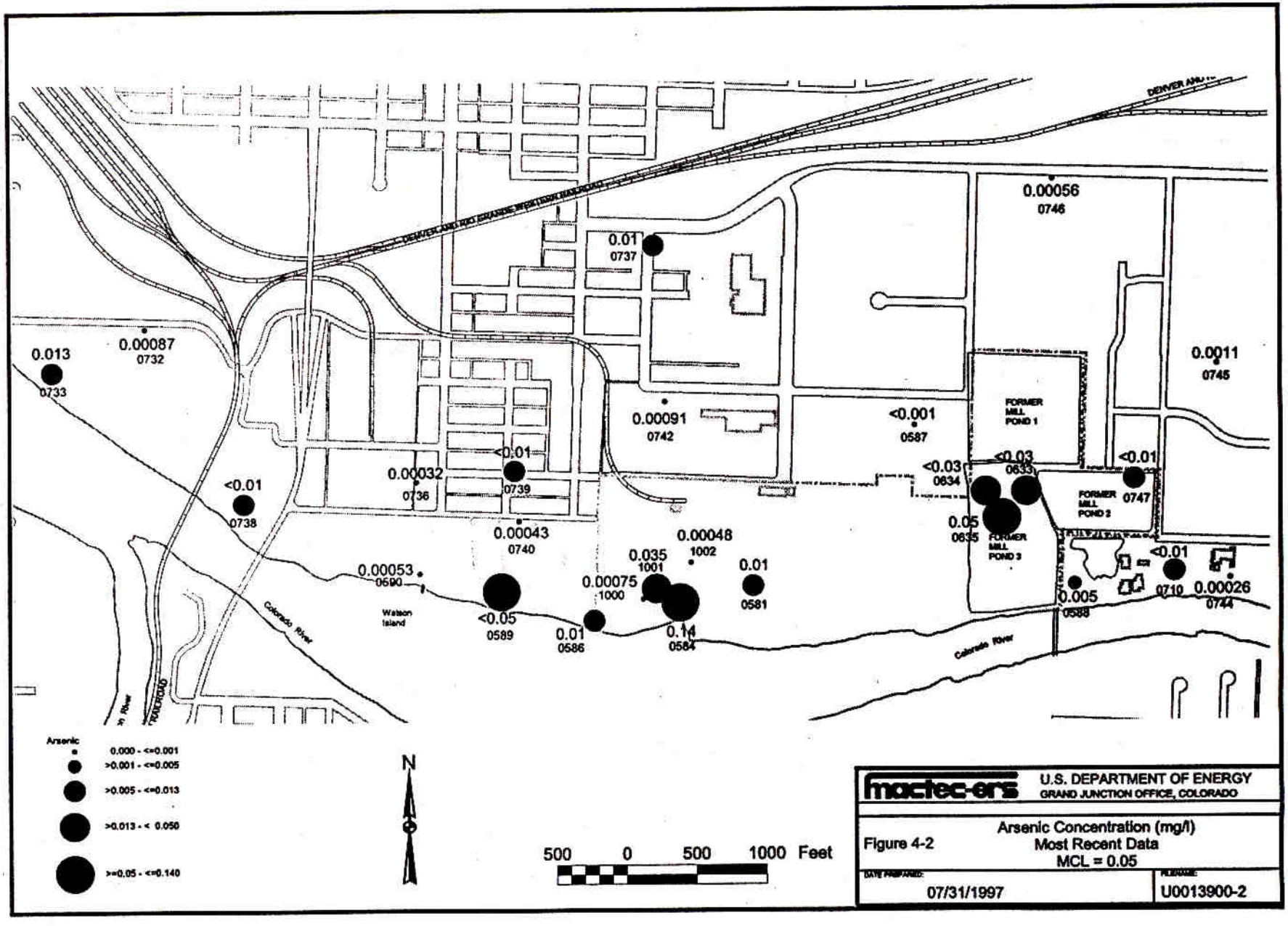


Figure 4-2. Arsenic Concentration (mg/l) Most Recent Data

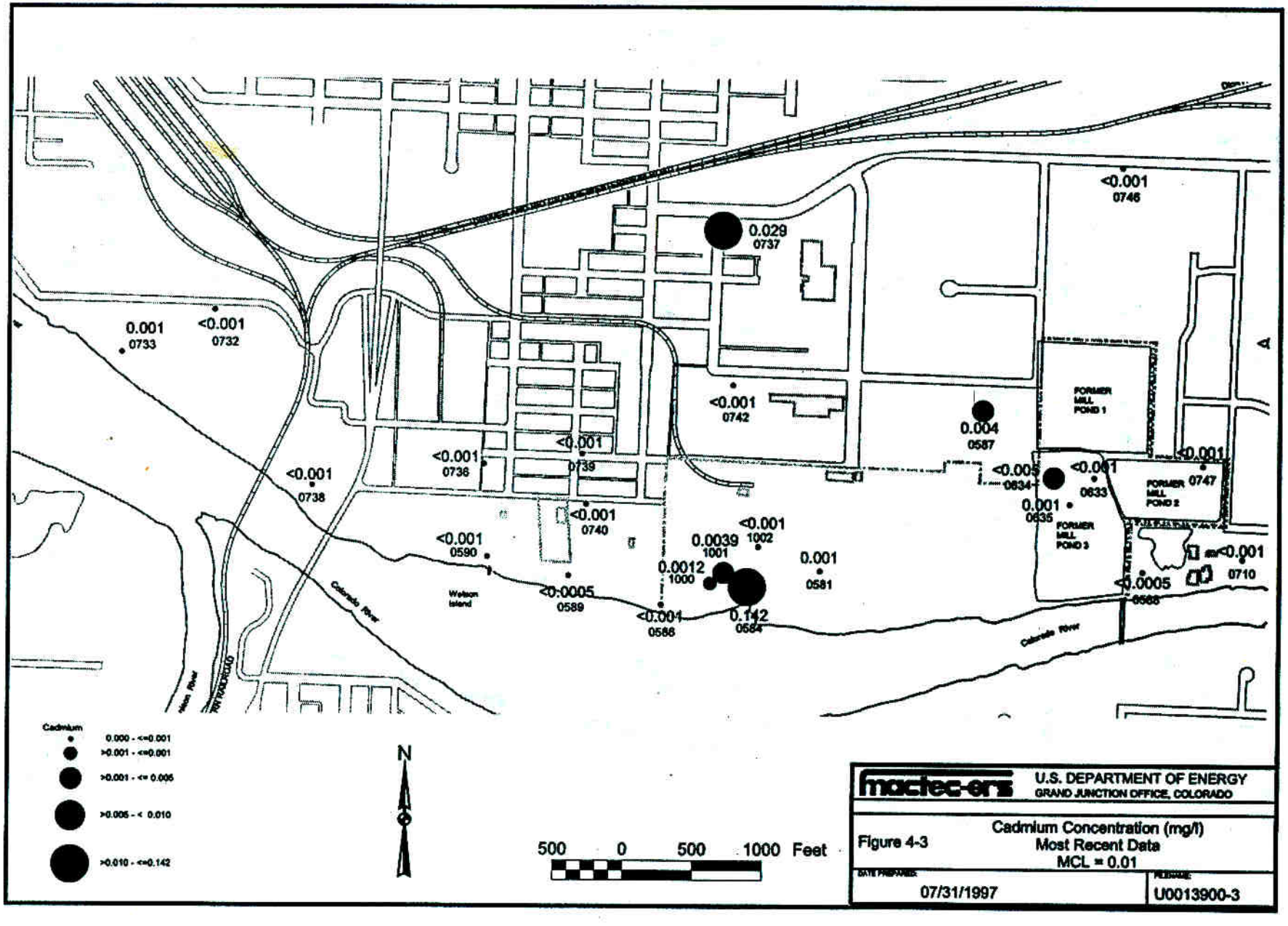


Figure 4-3. Cadmium Concentration (mg/l) Most Recent Data

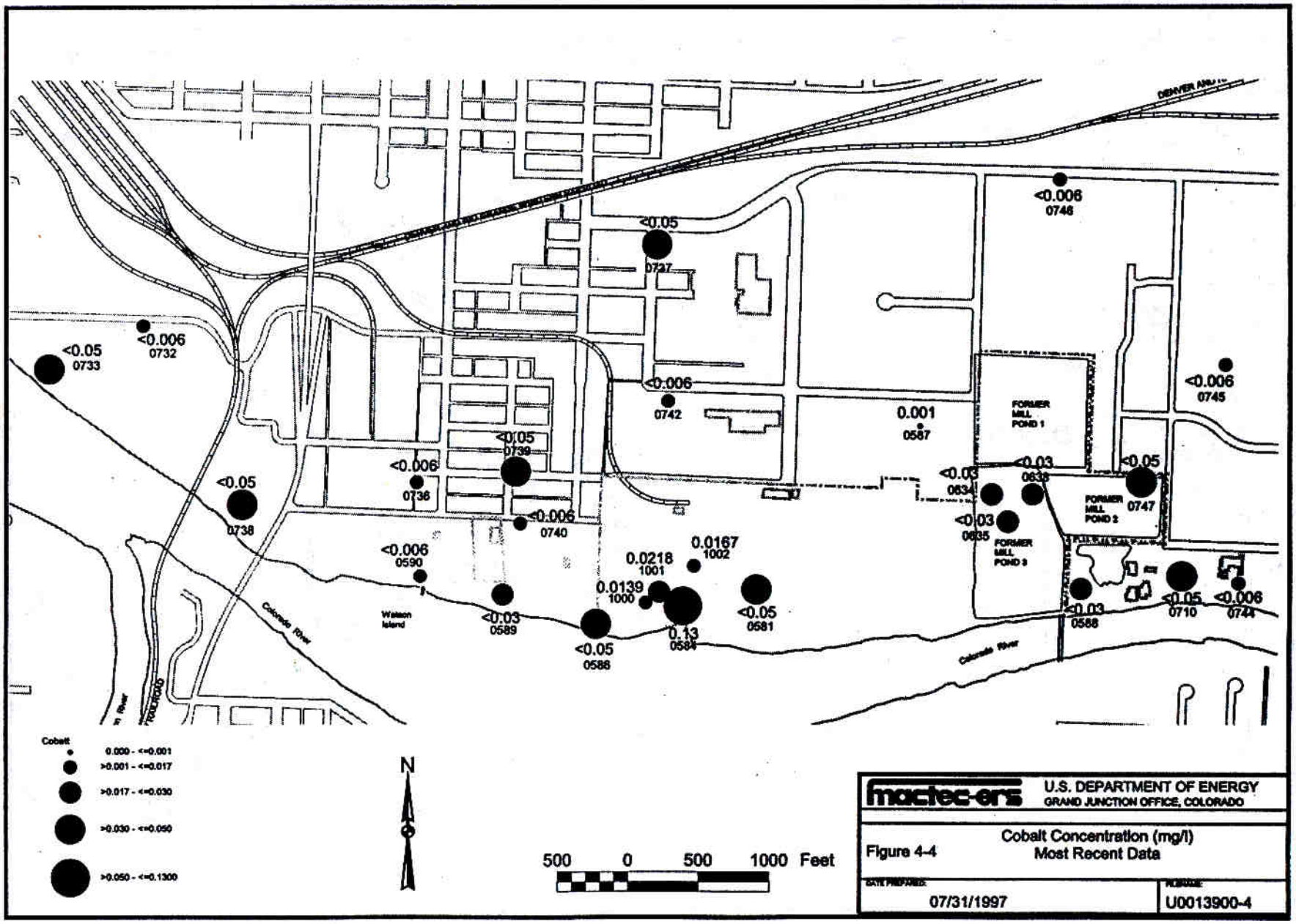


Figure 4–4. Cobalt Concentration (mg/l) Most Recent Data

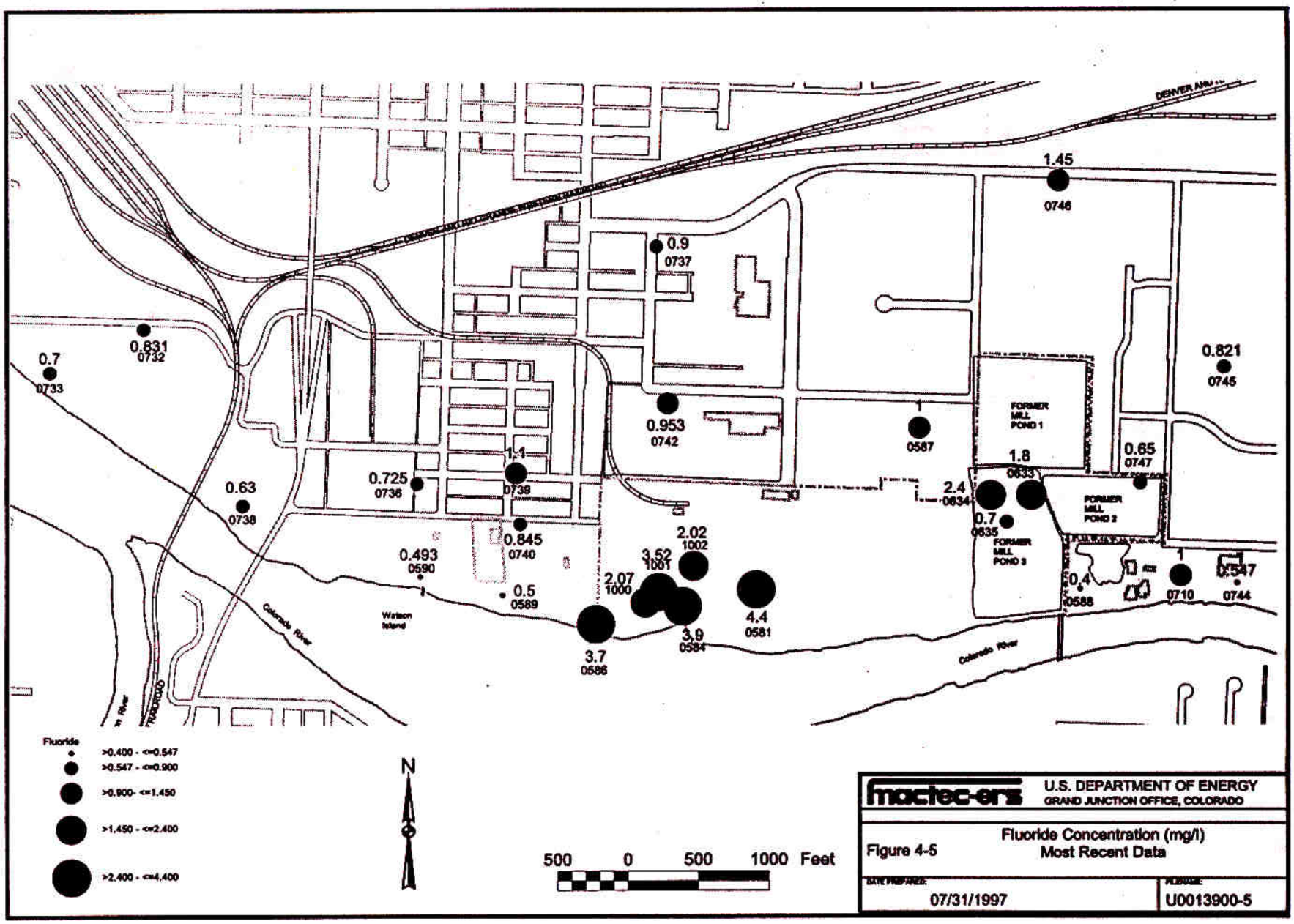


Figure 4–5. Fluoride Concentration (mg/l) Most Recent Data

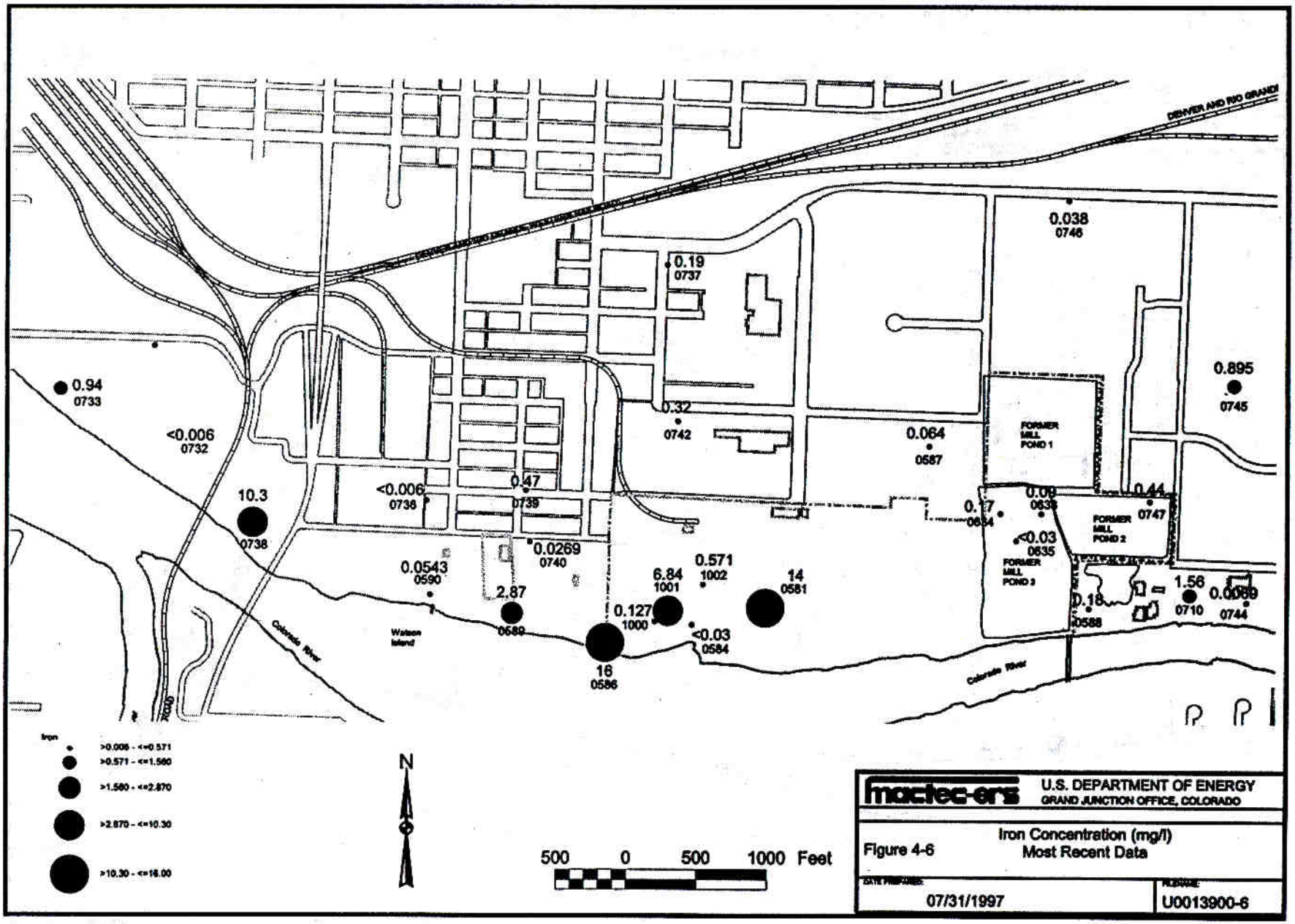


Figure 4–6. Iron Concentration (mg/l) Most Recent Data

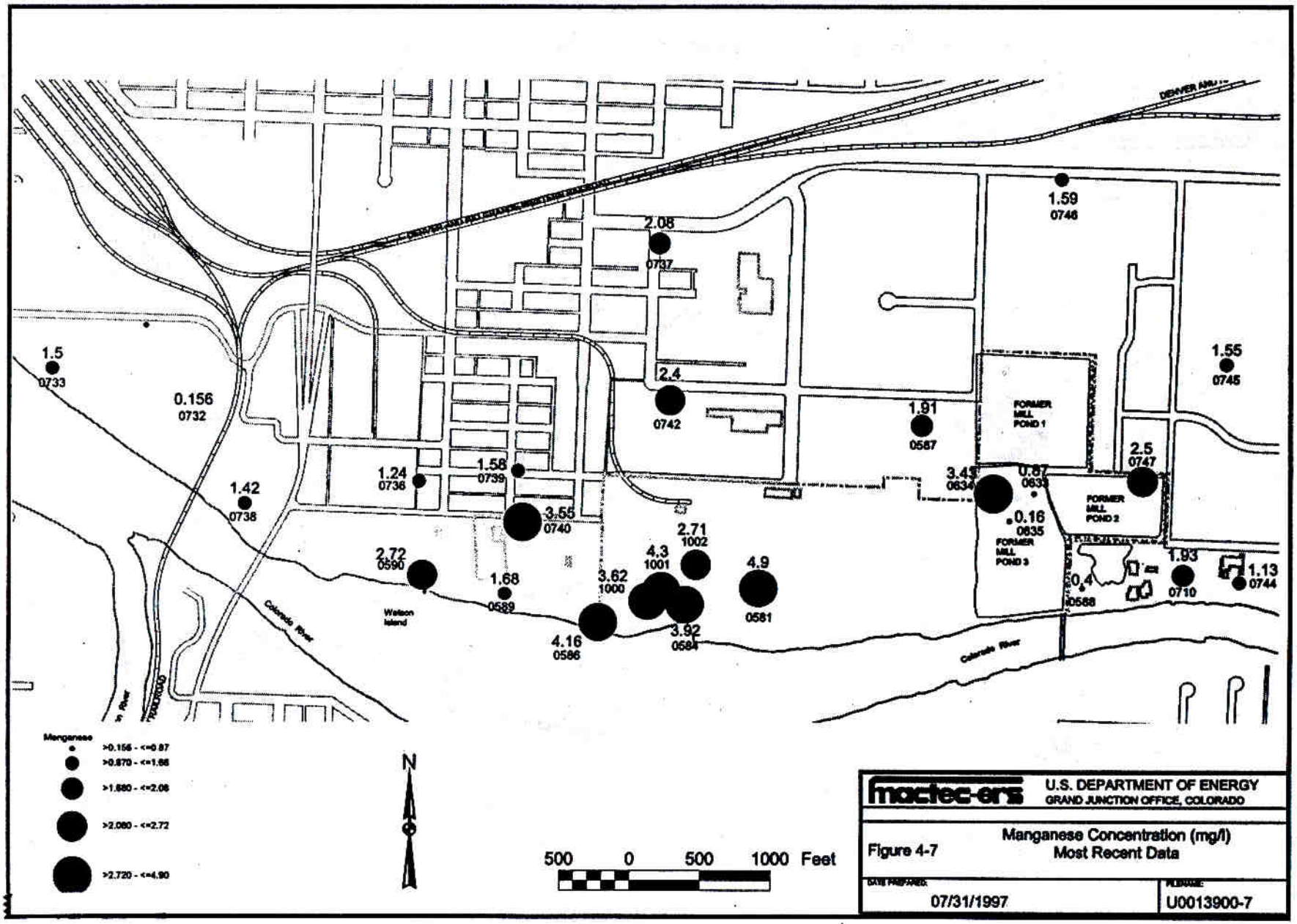


Figure 4–7. Manganese Concentration (mg/l) Most Recent Data

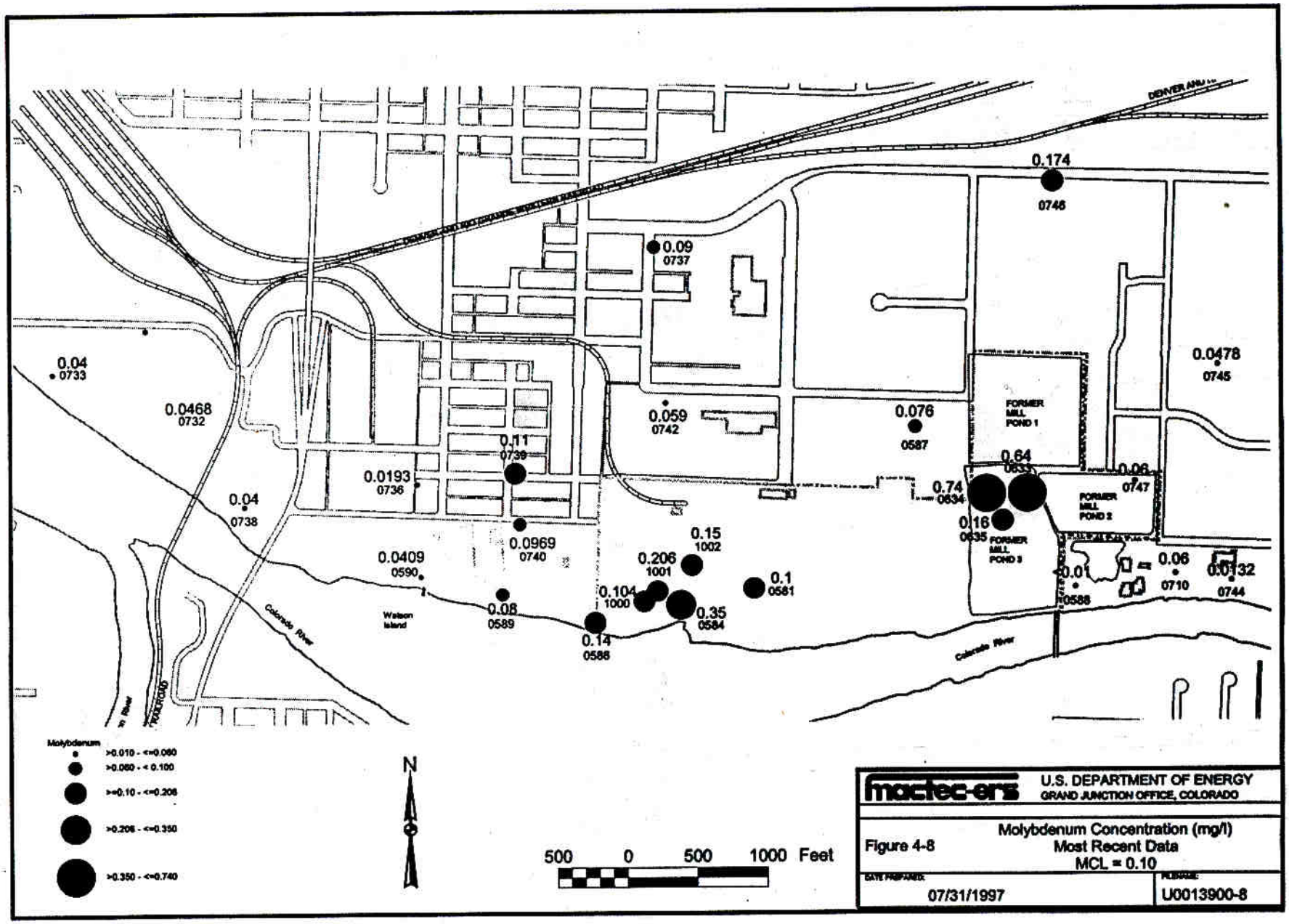


Figure 4–8. Molybdenum Concentration (mg/l) Most Recent Data

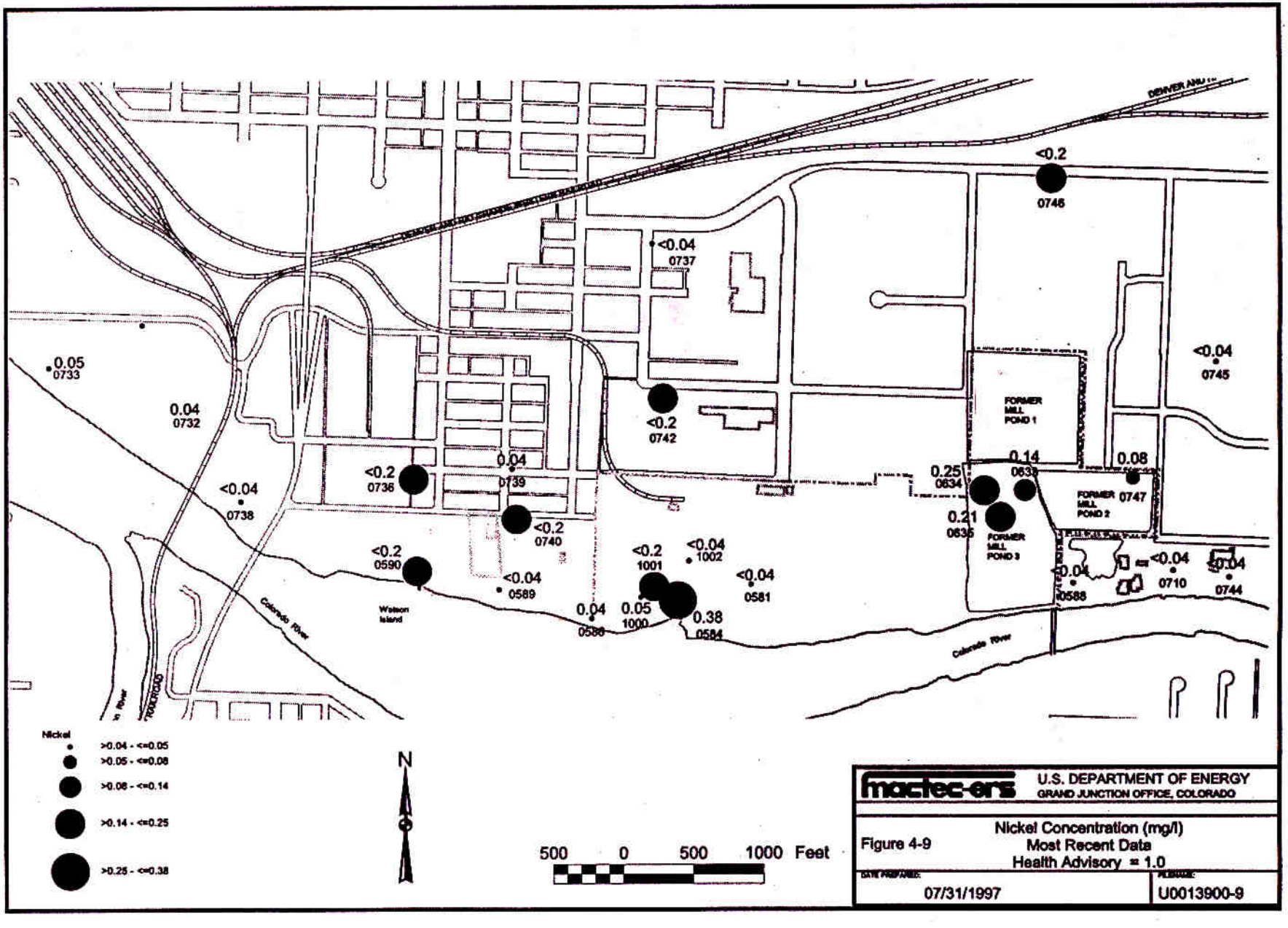


Figure 4–9. Nickel Concentration (mg/l) Most Recent Data

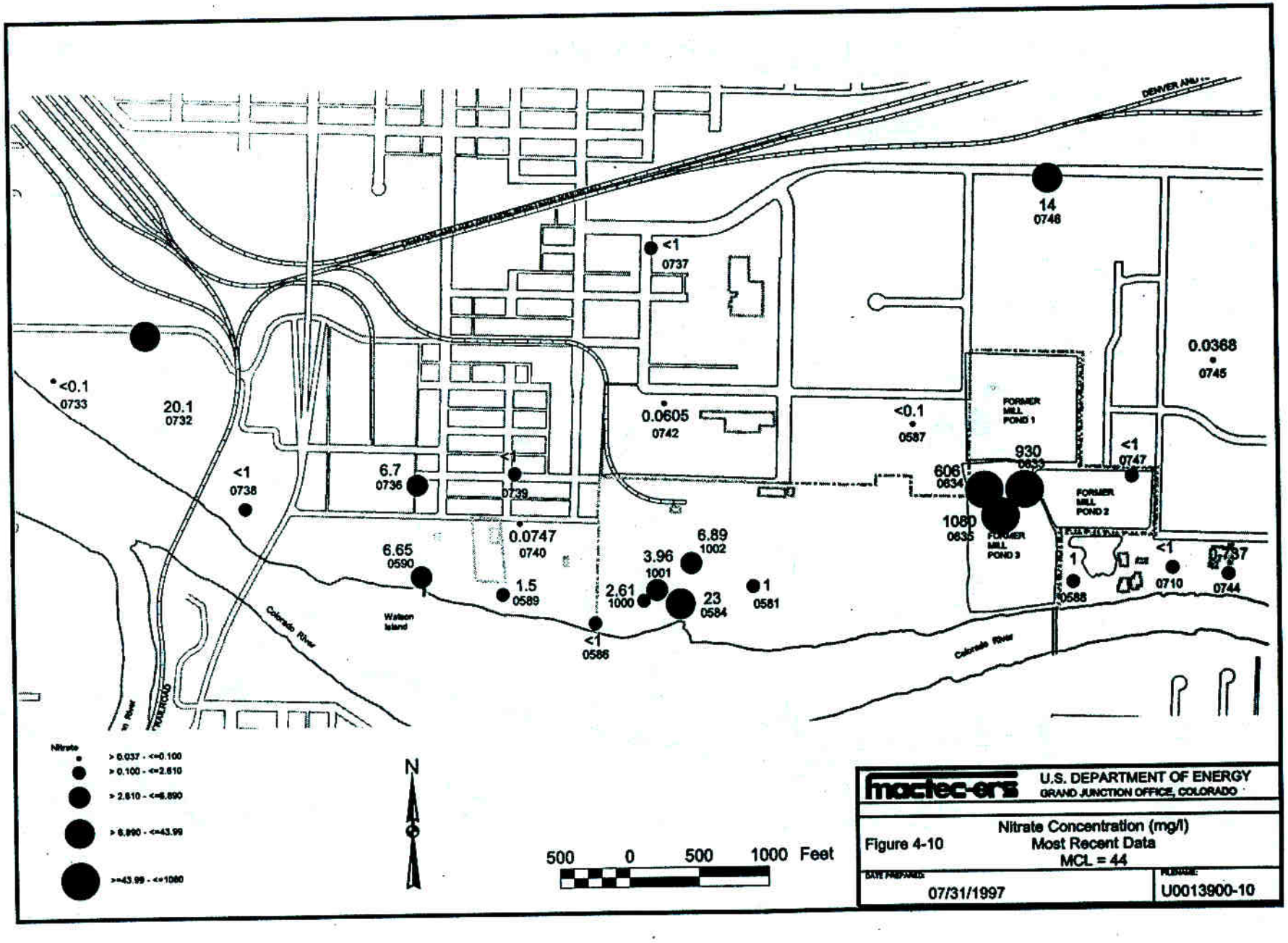


Figure 4–10. Nitrate Concentration (mg/l) Most Recent Data

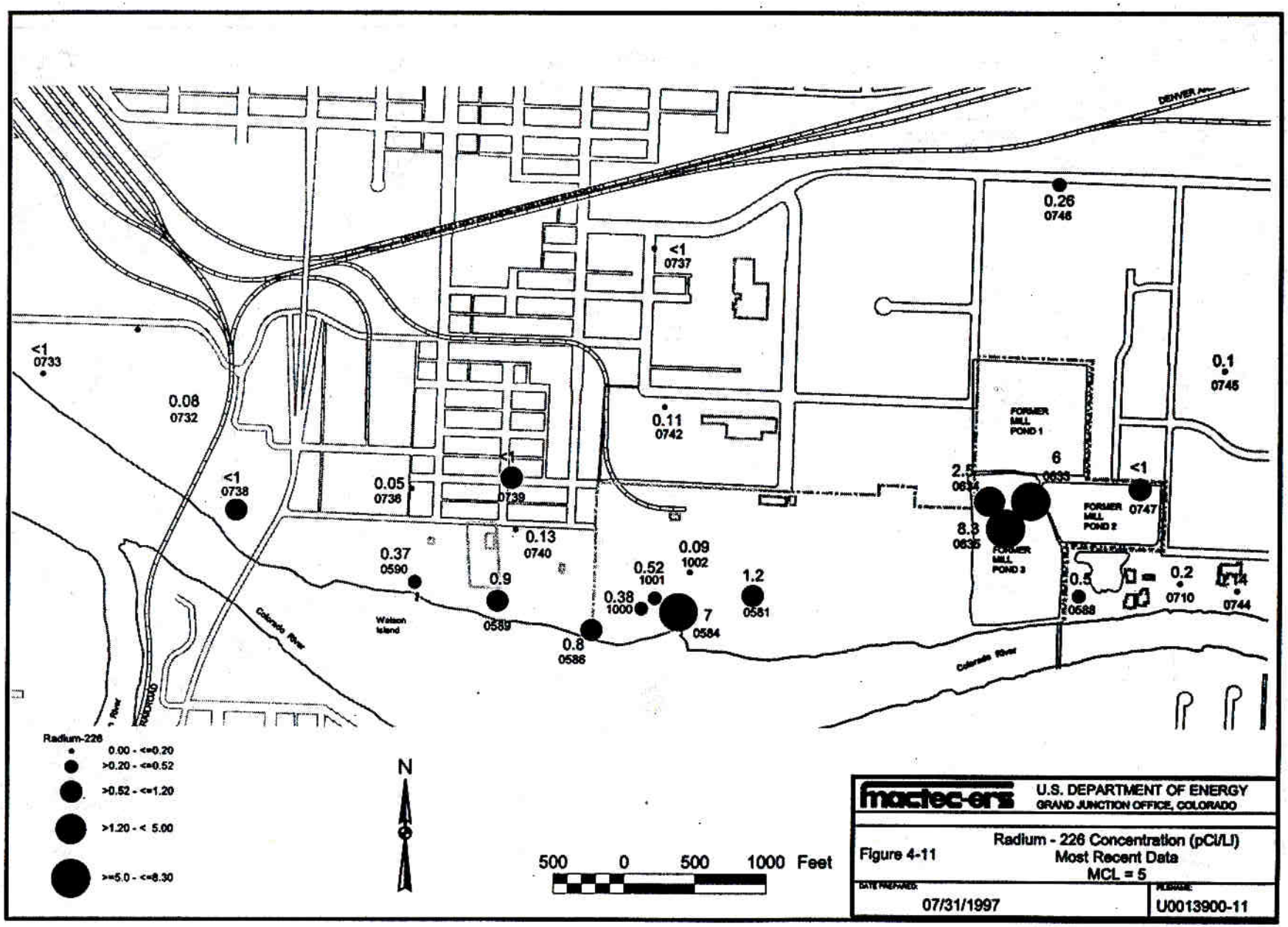


Figure 4–11. Radium-226 Concentration (mg/l) Most Recent Data

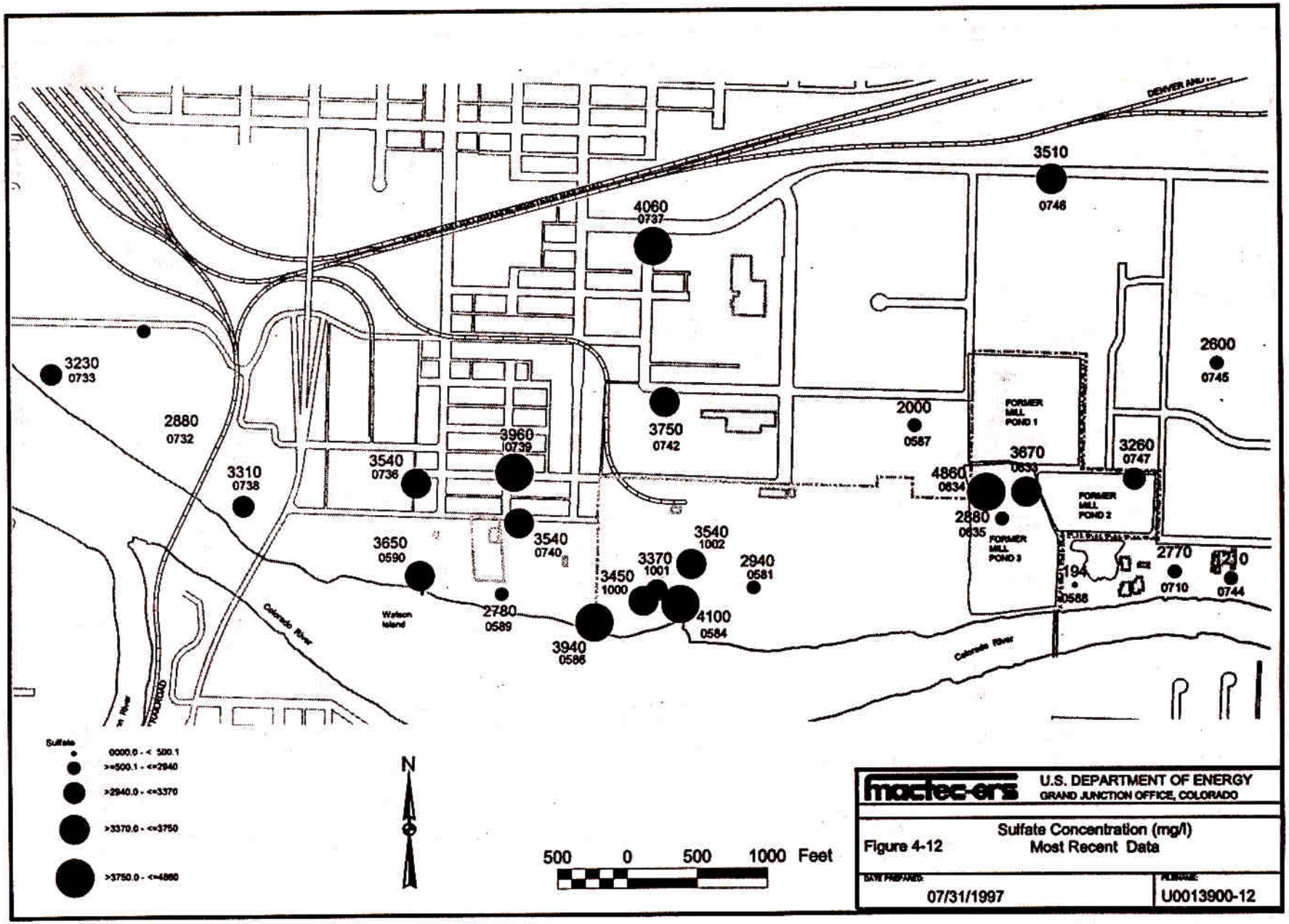


Figure 4–12. Sulfate Concentration (mg/l) Most Recent Data

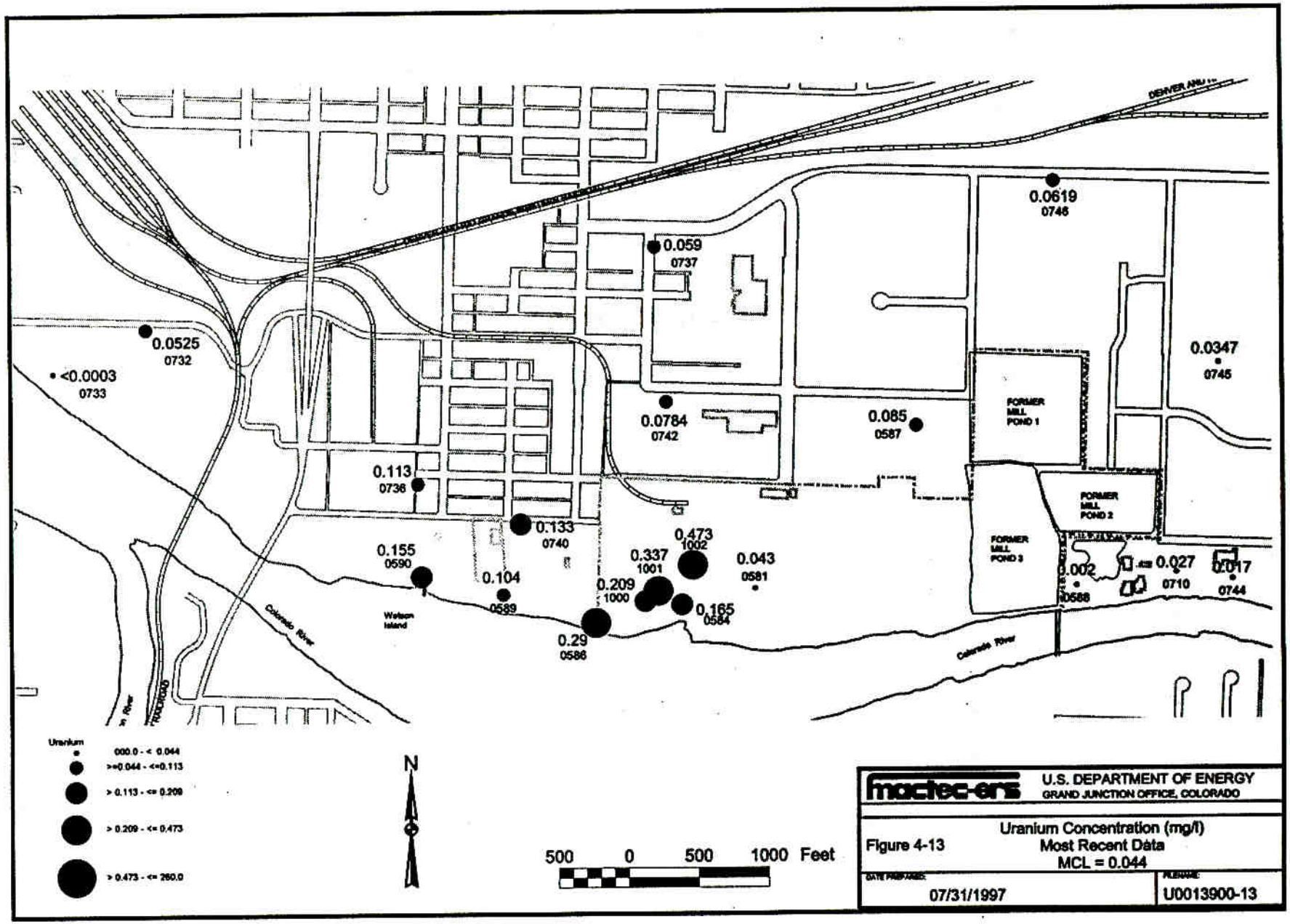


Figure 4–13. Uranium Concentration (mg/l) Most Recent Data

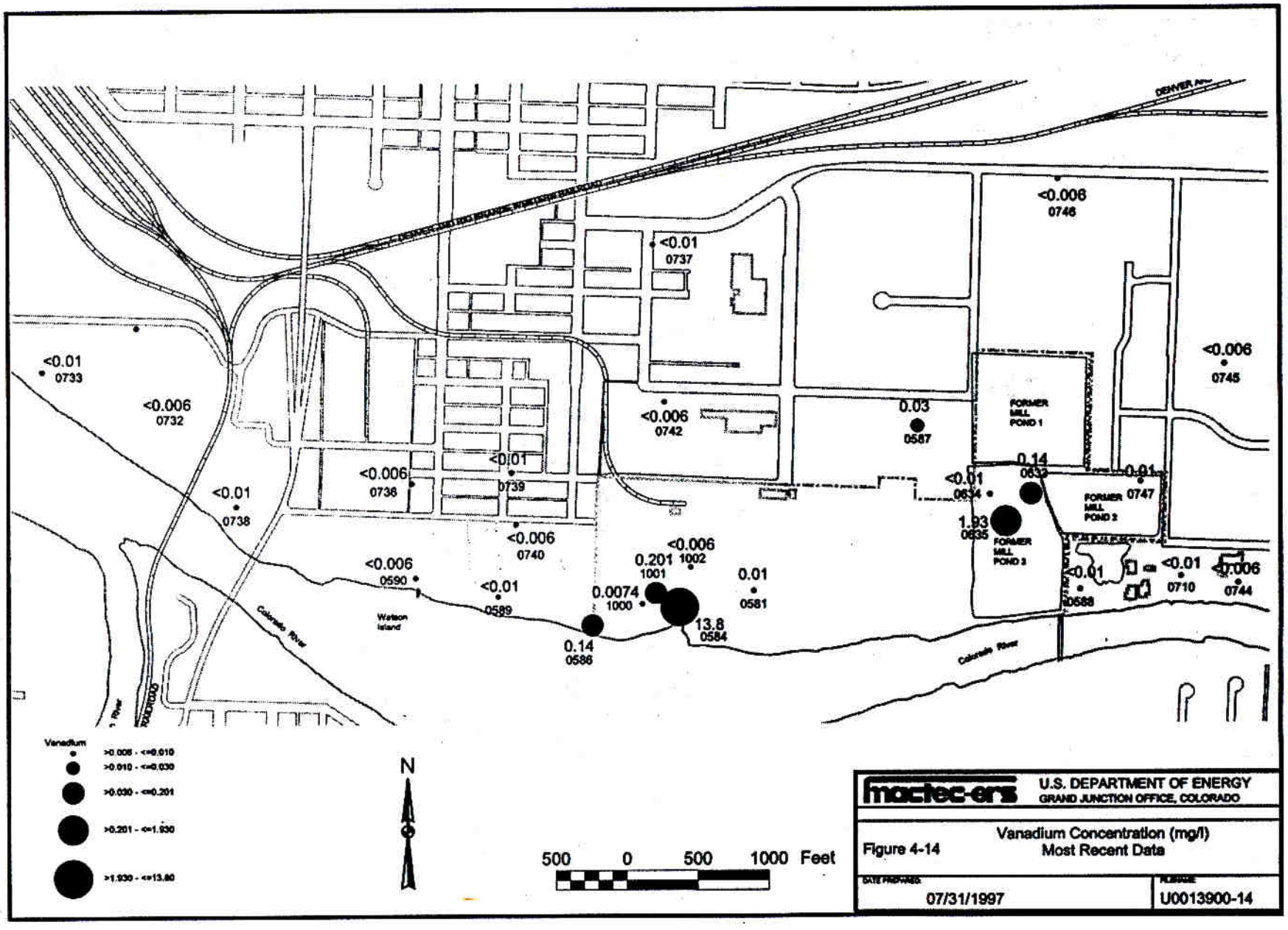


Figure 4–14. Vanadium Concentration (mg/l) Most Recent Data

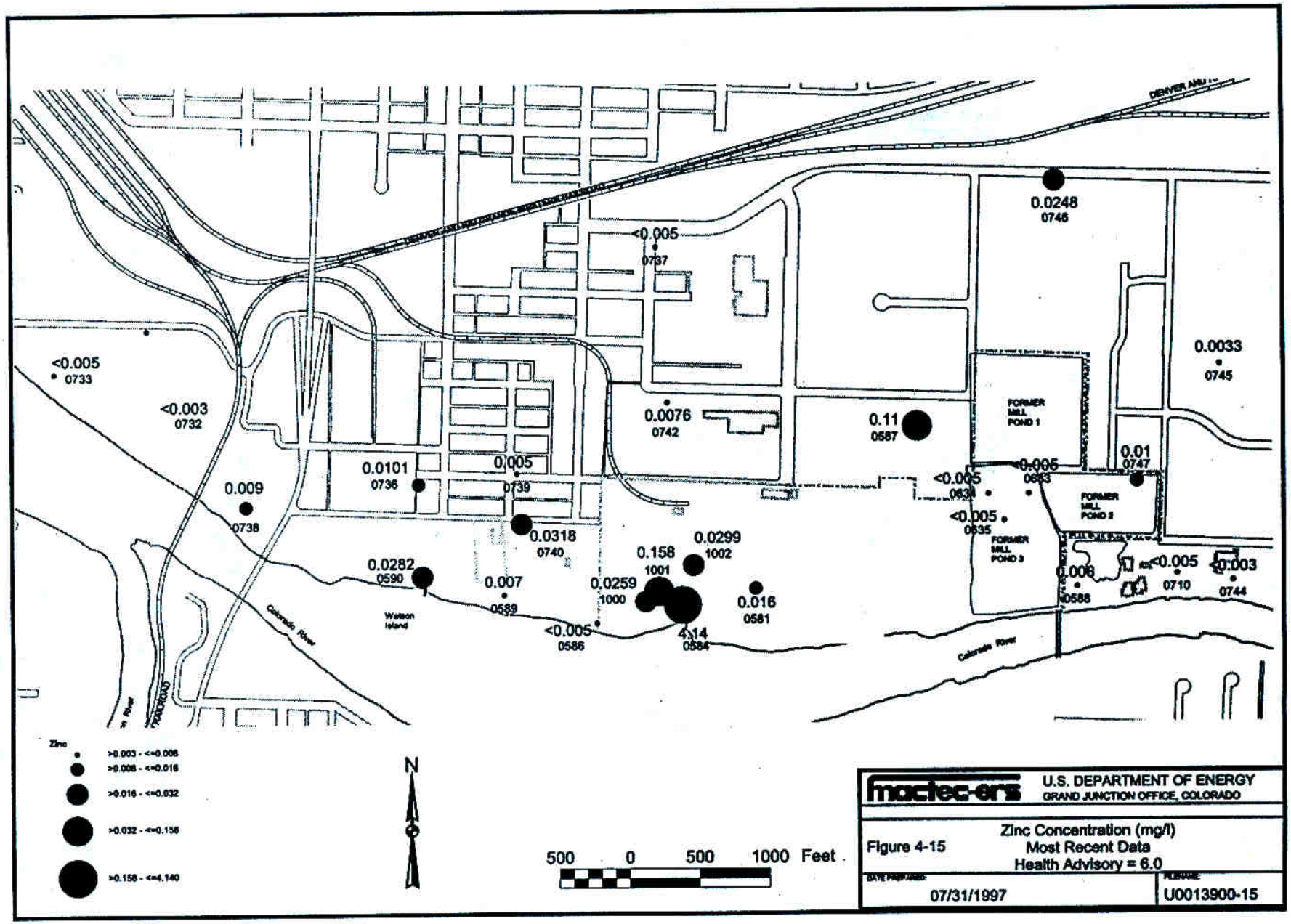


Figure 4–15. Zinc Concentration (mg/l) Most Recent Data

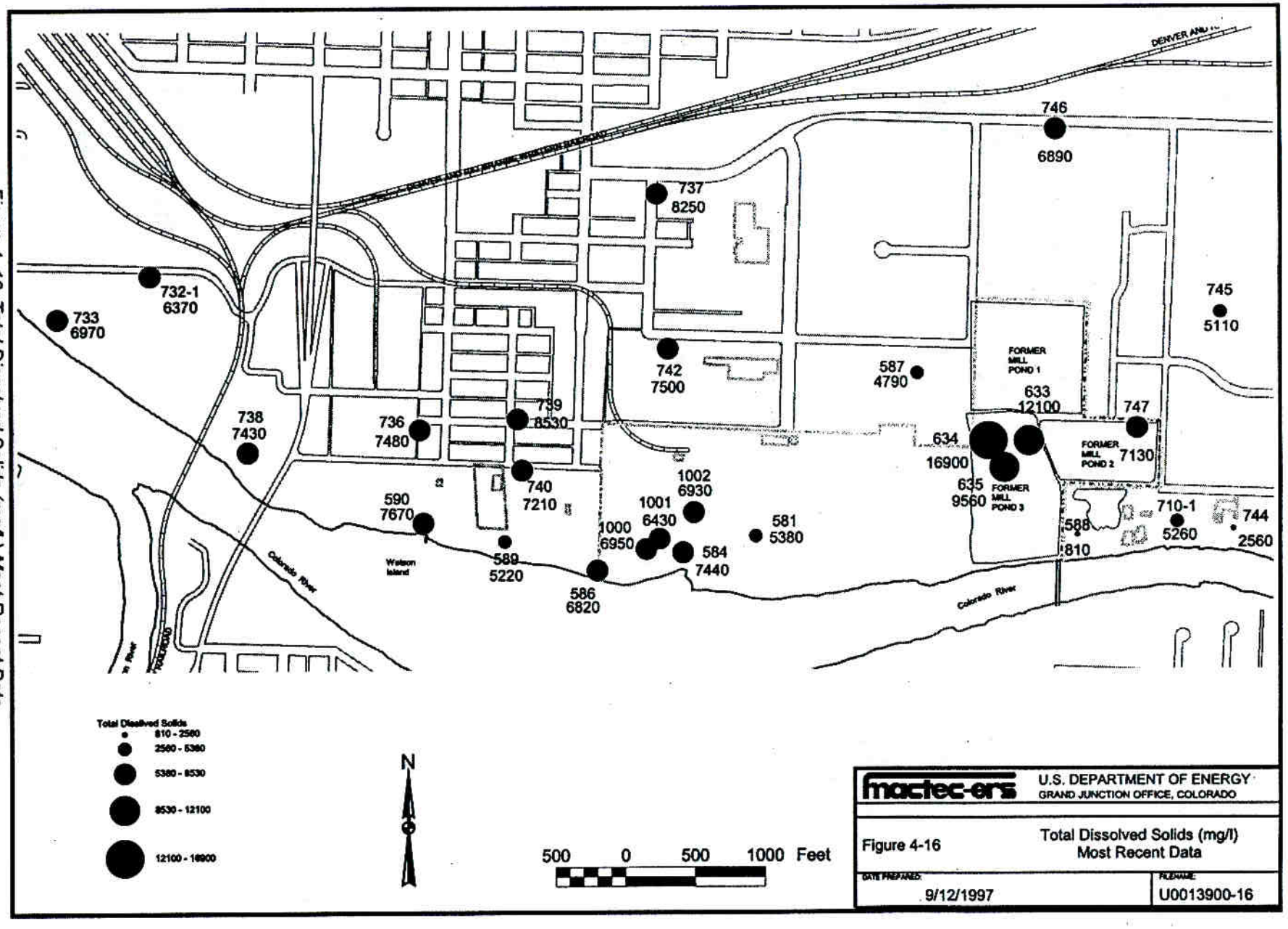


Figure 4–16. Total Dissolved Solids (mg/L) Most Recent Data

The cobble aquifer is contaminated with uranium and other COPCs. For clarity on the concentration plots, well clusters are represented by a single well, thus; cluster 582, 583, 584 is represented by 584; cluster 581, 755 is represented by 581; cluster 585, 586 is represented by 586. Concentrations that are at or below the detection limit are represented by the value of the detection limit.

Ground water flows across the site from northeast to southwest toward the river (Figure 3–1). The ground water may flow subparallel to the river near the western property boundary causing contamination in downgradient wells 589, 590, 740, and 732–1. Alternatively, the contamination in these downgradient wells may be due to the numerous vicinity property tailings that were present (but have since been removed) in this area. Contaminated ground water is likely to be discharging to the Colorado River at the site.

Background concentrations of contaminants are not well known. Wells 745 and 746 have been used for background, but they may be influenced by the presence of numerous large vicinity properties closeby and upgradient. Because of the ubiquitous presence of vicinity properties in and near the City of Grand Junction, it is necessary to examine ground-water quality farther upgradient to establish background.

Well 584 had anomalously high concentrations of metals 12 years ago. This well has the highest concentrations of arsenic, cadmium, cobalt, nickel, vanadium, and zinc of any of the cobble aquifer wells. This is particularly unusual considering that an alluvial well located just 12 ft away has much lower concentrations (Table 4–2).

Table 4–2. Comparison of selected COPC concentrations, from the most recent sampling (September 1985), in two closely-spaced wells (mg/L).

COPC	Well 583	Well 584
Arsenic	0.01	0.14
Cadmium	0.001	0.142
Cobalt	<0.05	0.13
Nickel	0.04	0.38
Vanadium	0.01	13.8
Zinc	0.005	4.14

Organic solvents were used at the site. Samples from wells 581, 583, 732, 736, 737, and 747 collected in 1985 and from wells 583, 736, and 746 collected in 1989 were analyzed for Appendix IX organic contaminants. There were no detections of organic contaminants of potential concern in these samples, however, not all organic chemicals used in the milling operation would have been detected by the analytical techniques used. Organic compounds were not considered in the evaluation of COPCs because it is unlikely that they still exist in unacceptable concentrations (DOE 1997b).

The spatial distribution of each COPC in the alluvial aquifer is discussed below.

New monitoring wells should be drilled on the site and upgradient of the site to more accurately delineate the distribution of arsenic, so that the health and ecological risks can be refined.

4.3.1 Arsenic

The MCL for arsenic is 0.05 mg/L. Other than the anomalous concentration in well 584 (Table 4–2), all arsenic concentrations measured on the most recent samples are at or below the MCL (Figure 4–2). From these results, it is likely that arsenic does not currently exceed the MCL in the alluvial aquifer.

Consistent sampling and preservation procedures should be used so that comparisons of background and on-site concentrations will be reliable.

4.3.2 Cadmium

The MCL for cadmium is 0.01 mg/L. Cadmium exceeds the MCL in water from well 584 sampled last in 1985 (Table 4–2) and in water from upgradient well 737. The most recent samples had cadmium concentrations of 0.142 and 0.029 mg/L in wells 584 and 737, respectively. Since well 584 has not been sampled since 1985 and nearby wells (1000, 1001, and 1002) sampled in December 1996 have cadmium concentrations below the MCL, cadmium may not currently exceed the MCL on the millsite.

4.3.3 Cobalt

The concentration of cobalt that is protective of livestock is 1.0 mg/L and the concentration in irrigation water that is protective of plants is 0.05 mg/L (DOE 1995). The highest concentration (0.13 mg/L) of cobalt was observed in well 584 (Figure 4–4). Cobalt concentrations in all other wells were 0.05 mg/L or less for the latest sampling. Well 584 was last sampled in 1985 and is anomalous in several other metals (Table 4–2). Cobalt concentrations in water from nearby wells (1000, 1001, and 1002), which were sampled in December 1996, are much lower (maximum 0.0218 mg/L). Cobalt is unlikely to have been a significant component of the ores or the processing fluids. These observations indicate that cobalt may not currently be present in concentrations that are of risk to human health or the environment.

4.3.4 Fluoride

Although there is no MCL or health advisory (HA), fluoride is known to cause dental mottling and skeletal fluorosis in humans (DOE 1995). Fluoride is not typically a component of uranium ores or the processing fluids. Some ores, such as in the Marysvale district of Utah, were mined from fluorite veins, however, it is not likely that such ores were milled at Grand Junction. However, there appears to be higher concentrations of fluoride in the water from millsite wells than in water from other wells (Figure 4–5). Concentrations range up to 4.4 mg/L.

4.3.5 Iron

Although there is no MCL, iron is known to cause skin pigmentation, cirrhosis, and acute severe poisoning in humans at elevated concentrations, but is an essential nutrient at lower concentrations (DOE 1995). Iron concentrations range from 0.03 to 16 mg/L from ground water beneath the site with no obvious pattern (Figure 4–6). Water from downgradient well 738 has an iron concentration of 10.3 mg/L, whereas the highest concentration in an upgradient well is 1.56 mg/L in well 710–1. No trends are apparent in the distribution of iron concentrations. Iron concentrations are difficult to interpret due to the abundance of naturally occurring iron, its sensitivity to oxidation potential fluctuations, and problems with sampling and preservation.

Iron is a common constituent of rocks and sediments. Iron mobility is largely a function of the oxidation potential of the ground water. Low oxidation potential will dissolve iron-containing minerals and mobilize iron. Ground-water contamination by iron is probably due to a lower oxidation potential rather than to a high iron content of the tailings. Iron concentrations can also be influenced greatly by sampling and preservation procedures. Dissolved iron can readily precipitate out of solution when exposed to air which will cause false low determinations. Conversely, false highs can occur if colloidal iron is present; the colloids being solubilized by sample acidification. If the colloidal fraction is mobile in the ground water, it is desirable to include it in the analysis, however, colloids can be an artifact of the sampling technique.

4.3.6 Manganese

Although there is no MCL or HA, manganese is known to cause toxicity in humans at elevated concentrations, but is an essential nutrient at lower concentrations. Manganese concentrations in the alluvial aquifer range up to 4.9 mg/L (Figure 4–7). Water from wells on the site (e.g., 581, 584, 586, 1000, 1001, and 1002) and downgradient of the site (e.g., 590 and 740) appear to have higher concentrations than water from upgradient wells (e.g., 587, 710–1, 744, 745, and 746). Manganese concentrations, like iron concentrations, are difficult to interpret due to the abundance of naturally occurring manganese, its sensitivity to oxidation potential fluctuations, and problems with sampling.

Like iron, manganese is a common constituent of rocks and sediments. Manganese mobility is probably due to a lower oxidation potential of the ground water rather than to a high manganese content of the tailings.

4.3.7 Molybdenum

The MCL for molybdenum is 0.10 mg/L and the HA is 0.04 mg/L. Molybdenum concentrations from water from the site range up to 0.74 mg/L for the most recent samplings (Figure 4–8). Nine of the ten wells on the site intercept ground water with molybdenum concentrations exceeding the MCL. Water from upgradient well 746, which has a molybdenum concentration of 0.174 mg/L, also exceeds the MCL, however, ground water in this well may have been contaminated from upgradient vicinity properties.

4.3.8 Nickel

Nickel does not have an MCL but has an HA of 1.0 mg/L. No water from wells exceed the HA for the most recent samplings (Figure 4–9). Concentrations range up to 0.38 mg/L on the site. There are no clear trends in the data that would indicate whether nickel was added to the ground water by the mill. Nickel is not typically concentrated in uranium ores nor is it a component of the processing fluids. These observations suggest that nickel probably does not constitute an increase in health or environmental risk from the milling operation.

4.3.9 Nitrate

The MCL and HA for nitrate is 44 mg/L. Water from three wells (633, 634, and 635) sampled in January 1990 have nitrate concentrations of 930, 606, and 1,080 mg/L, respectively, all of which exceed the MCL. These three wells are in the area of former Pond 3 (Figure 4–10 and Plate 1). This pond may have received nitrate-bearing solutions from the milling process. No other ground water from the most recent sampling had nitrate concentrations that exceeded the MCL.

4.3.10 Radium-226

The MCL for radium-226 is 5 pCi/L. Radium-226 exceeded the MCL in water from three wells (633, 635, and 584) on the site (Figure 4–11). The highest concentration observed was 8.3 pCi/L in water from well 635. Wells 633 and 635, last sampled in January 1990, are in the area of former mill Pond 3. Well 584 was last sampled in 1985. Water from three wells near well 584 (1000, 1001, and 1002), sampled more recently (December 1996), have radium-226 concentrations below the MCL. These results indicate that ground water at the site may not currently have concentrations above the MCL for radium-226.

However, new monitoring wells should be drilled on the site and upgradient of the site to more accurately delineate the distribution of radium-226, so that the health and ecological risk can be determined.

4.3.11 Sulfate

There is no MCL or HA for sulfate. Drinking water standards of 250 or 500 mg/L have been considered by the EPA but no standard has yet been adopted. Ingestion of sulfate is known to produce a laxative effect in adults and severe dehydration in infants. Drinking water sulfate concentrations in the western United States in 1978 ranged from 0 to 820 mg/L, with a mean concentration of 99 mg/L. Sulfate concentrations range up to 4,860 mg/L in the most recent ground-water data (Figure 4–12). There is no clear distribution of sulfate concentrations that indicate a significant contribution from the milling operation. Sulfate concentrations in ground water at the former millsite range from 2,880 to 4,860 mg/L. However, concentrations nearly this high are present in upgradient wells; water from wells 746 and 737 having concentrations of 3,510 and 4,060 mg/L, respectively.

4.3.12 Uranium

The MCL for uranium is 0.044 mg/L. Uranium concentrations in water from the site range up to 0.437 mg/L in the most recent data (Figure 4–13). (Note that no uranium data are available for water from wells 633, 634, and 635 in the former Pond 3 area). Elevated uranium concentrations in water from beneath the site are due to the milling process. Concentrations of uranium in water from four upgradient wells (587, 737, 742, and 746) are 0.085, 0.059, 0.0784, and 0.0619 mg/L, respectively. These values suggest that uranium may be naturally above MCL in the area, however, water from these wells may have been affected by vicinity properties. The SOWP for Grand Junction suggests a plume of water containing concentrations of uranium above MCLs has migrated up to 3,000 ft west of the site (DOE 1996d). Water from other upgradient wells (588, 710–1, 744, and 745) have uranium concentrations below the MCL.

4.3.13 Vanadium

There is no MCL or HA for vanadium. Vanadium is known, however, to cause cholesterol drop, cramps, and green tongue in humans (DOE 1995). Vanadium concentrations in ground water range up to 13.8 mg/L in the most recent data (Figure 4–14). Vanadium is more concentrated in the area of the former millsite indicating that the processing was the source of contamination.

The concentration of 13.8 mg/L was measured in water from well 584 while the next highest value was 1.93 mg/L. Water from wells 1000, 1001, and 1002, located near well 584, have concentrations of 0.0074, 0.201, and 0.006 mg/L, respectively. These values were measured in December 1996 and are indicative of recent conditions.

4.3.14 Zinc

There is no MCL for zinc but there is an HA of 6.0 mg/L (Table 4–1). The highest concentration of zinc in ground water beneath the site is 4.14 mg/L for the most recent samplings (Figure 4–15). This value is from well 584 which was last sampled in 1985. Water from nearby wells 1000, 1001, and 1002, which were sampled in December 1996, had a maximum concentration of 0.158 mg/L. There are insufficient spatial data to accurately determine the distribution of zinc although no wells currently exceed the HA.

4.3.15 Total Dissolved Solids

There is no regulated standard for TDS under the UMTRA Ground Water Project. The highest TDS concentration measured on site during the most recent sampling was 16,900 mg/L in well 634 (Figure 4–16). This well has not been sampled since 1990 and no longer exists. The highest concentration of TDS in the 3 wells sampled in 1996 (wells 1000,1001, and 1002) was 6950 mg/L which is similar to most of the wells in the Grand Junction area (compare with well 745 with 6890 mg/L and 742 with 7500 mg/L).

4.3.16 Organics

Although organics are not currently included in the COPC, organic solvents used in the milling

operations could have entered the ground water. Ground water in eight wells was analyzed for the Appendix IX organic compounds. Two of the wells (581 and 583) are on the former millsite, two are downgradient (732 and 736) and four (737, 744, 746, and 747) are upgradient of the site. Organic COPCs were not detected in any of these wells (DOE 1997b). Based on these analyses, organic contamination, if present, is probably not widespread in the ground water at the Grand Junction site (DOE 1997b).

The analytical methods used to obtain the organic data presently available may not have detected some of the organic COPCs even if they had been present. In evaluating the potential for organic contamination, it is important to collect samples from the top of the water table so that any floating product will be included. Organic contamination, if present at the site, is most likely to be encountered near solvent extraction facilities and/or near solvent storage areas (DOE 1997b).

To more completely evaluate the likelihood of organic contamination due to milling, two additional samples should be collected from wells that are screened across the water table. One should be located slightly downgradient from the solvent extraction and/or solvent storage facilities and the second should be from beneath the raffinate ponds. These samples should be analyzed for organic compounds (bis(2-ethylhexyl)phosphate [EHPA], tributyl phosphate [TBP], and kerosene) that were used for solvent extraction.

4.4 Surface-Water and Sediment Contamination

The Colorado River has been sampled since 1991 to evaluate the influence of contaminated ground water from the former millsite on river water quality. Collection sites are located adjacent to the site and upstream and downstream of the site. The locations are shown on Plate 1. Sites 423, 424, 425, and 427 continue to be sampled annually. Some of the sampling events were at low flow stage and thus represent the maximum effect on river water quality.

The results indicate that, for most constituents, the downstream river water concentrations are no higher than the upstream concentrations. Ammonium, copper, iron, radium-226, uranium and vanadium have had concentrations slightly above upstream concentrations, however, the differences are not statistically significant.

Sediment samples were collected in September 1993 from surface sampling locations 423, 424, 425, 427, and 428 (Plate 1). Samples were analyzed for molybdenum, selenium, strontium, sulfate, and uranium. Results from this sampling event are presented in Table 4–3. Strontium and sulfate concentrations are likely to be affected more by the amount of detrital carbonate and sulfate minerals incorporated in a sample than by any influence from contamination related to the site. Of the other three COPCs analyzed, only the uranium data suggest a possible relationship to site contamination because of the elevated concentration (4.9 milligrams per kilogram [mg/Kg]) observed in the downgradient sample. This value, however, is within the range of normal concentrations in the earth's crustal sediments.

Table 4–3. Results of 1993 Sediment Sampling (mg/Kg).

Location	Mo	Se	Sr	SO_4	U
423 (upgradient)	4	<0.5	160	105	1.5
424 (upgradient)	<1	<0.5	127	273	<1.0
425 (on site)	<1	<0.5	108	500	2.0
427 (downgradient)	<1	<0.5	107	56.2	4.9
428 (on site)	<1	<0.5	108	158	1.2

4.5 Chemical Retardation in the Alluvial Aquifer

The alluvial aquifer is composed of mineral and rock grains from a wide variety of lithologies. There is potential for these grains and the finer-grained matrix material to adsorb contaminants. No laboratory tests have been conducted to evaluate the adsorption of contaminants in the alluvial aquifer. These data will be needed in evaluating natural flushing.

4.6 Summary of Geochemical Data Needs

Additional monitoring wells are needed to determine the nature and extent of contamination in the shallow alluvium beneath the former millsite. Additional wells are needed upgradient of the site to determine background concentrations of all COPCs. Two ground-water wells are needed to evaluate the potential for organic solvent contamination. These wells should be located near the area in which the solvent extraction process occurred and in the area of a former raffinate pond. The samples should be analyzed for organic solvents specific to the milling process. Chemical data are needed from soils on the site to determine if there is a continuing source of contamination that can enter the alluvial aquifer. Colorado River water needs to be sampled more thoroughly to determine if contaminants are entering the river from the site. Samples are required to determine if any contamination resides in the river sediment.

Little is known about the chemical interaction between the ground water and the aquifer minerals. No distribution coefficients (the equilibrium ratio of a chemical concentration in ground water to the concentration in the aquifer solid particles) have been measured. Distribution coefficients for all COPCs on alluvial gravels need to be determined. These results can be used to help model the mobility of COPCs in the alluvial aquifer.

5.0 Ecology

Characterization of the ecology of the former millsite at Grand Junction and of surrounding areas is needed to complete the assessment of ecological risks associated with site-related contaminated ground water. A defensible ecological risk assessment will support the development of risk-based compliance strategies.

The purpose of any ecological risk assessment is to evaluate the likelihood that adverse ecological effects are occurring or may occur as a result of exposure to contamination or other stressors (EPA 1992). For ecological risks to occur at the Grand Junction site, now or at some time in the future, pathways must exist for exposure of biological receptors to contaminated ground water. A screening-level assessment of ecological risks at the site evaluated potential pathways, receptors, and adverse effects (DOE 1995; DOE 1996d). This section summarizes the results of the screening-level assessment and identifies ecological characterization activities needed to complete the risk assessment.

5.1 Summary of the Screening-Level Risk Assessment

The screening-level risk assessment evaluated the potential exposure of terrestrial and aquatic organisms to contaminated ground water, and to surface water or sediment contaminated by ground water. Concentrations of ecological COPCs in ground water, surface water, and sediment were compared to toxicity standards and guidelines for various ecological receptors.

5.1.1 Potential Receptors

This section summarizes information from the screening-level risk assessment on ecological receptors that are potentially exposed to site-related contaminants. The information was derived from qualitative surveys and observations made before tailings were removed and, therefore, is not necessarily indicative of current conditions or future land use.

Before tailings were removed, the ecology of the site consisted of an interspersion of riparian and aquatic habitats. Riparian vegetation dominated by salt cedar thickets covered several small islands and shorelines formed by Colorado River side channels and back waters. Cottonwood, Russian olive, and willow, which broke up the salt cedar thickets in some places, were less abundant. The understory vegetation consisted of several dense, open stands of reed canary grass, spotted knapweed, and giant reed with rushes, sedges, spikerushes, bullrush, and arrowhead common along the shores of side channels and in small wetlands on the islands. Yellow warbler, mourning dove, song sparrow, and black-billed magpie were observed in the salt cedar and willow stands. Mallard and great blue heron were common on the water or on the shore. Evidence of beaver, muskrat, raccoon, and skunk was also common, as was evidence of bull frog and leopard frog. Bald eagle, the only endangered terrestrial species potentially exposed to site contaminants, are known to winter in the area.

The following aquatic organisms were observed in the vicinity of surface water sampling locations in the Colorado River: mayfly nymphs, damselfly nymphs, dragonfly nymphs, water striders, backswimmers,

and Cyprindae minnows. Game fish known to occur in the area include green sunfish, bluegill, largemouth bass, black crappie, black bullhead, and channel catfish. Bluehead sucker, flannelmouth sucker, common carp, roundtail chub, red shiner, sand shiner, and fathead minnow also occur in the area. Threatened or endangered fish potentially exposed to site contaminants include the humpback chub, bonytail chub, Colorado squawfish, and razorback sucker.

After the removal of tailings in 1994, the site was seeded with a mixture of grasses, forbs, and shrubs and eight ponds were constructed along the southern boundary of the site between the flood control levee and the Colorado River. The ponds were constructed as part of a U.S. Army Corps of Engineer effort to reestablish wetland habitat destroyed as a consequence of site remediation. The ponds were fed by contaminated ground water from the site. Colorado River flooding during the late spring and early summer of 1995 almost destroyed the eight wetlands mitigation ponds.

5.1.2 Ecological Contaminants of Potential Concern

Ecological COPCs were defined in the screening-level risk assessment as those constituents that exceeded background concentrations (Table 5–1). Background ground-water chemistry was defined as the quality of ground water that would exist if milling had not taken place; the water quality of upgradient wells was considered to be representative of background conditions (DOE 1995). Two categories of surface water were defined: Colorado River water and water in ponds constructed as part of a wetlands mitigation project. Colorado River COPCs were those constituents with higher concentrations downstream than upstream. COPCs in the wetlands mitigation ponds were determined by comparing concentrations in the ponds and in the upgradient ground-water wells (DOE 1996d). Sediment COPCs were determined by comparing data from Colorado River sediment sampled upstream, downstream, and adjacent to the site (DOE 1995).

5.1.3 Potential Adverse Effects

The following exposure pathways were evaluated in the screening-level assessment:

- Plant uptake of ground water,
- Use of ground water to water livestock or irrigate crops,
- Exposure of aquatic life in Colorado River water and sediments,
- Livestock and terrestrial wildlife ingestion of surface water from ponds fed by site ground water,
- Exposure of aquatic life in ground water-fed ponds, and
- Use of pond water for crop irrigation.

Table 5–1. Summary of Ecologic Contaminants of Potential Concern in Ground Water, Surface Water, and Sediments

Constituents Above Background in Ground Water	COPC in Ground Water	Ecologic COPC in Colorado River Surface Water	Ecologic COPC in Water in Wetlands Mitigation Ponds	Ecologic COPC in Colorado River Sediment
Ammonium		X		
Arsenic	X		X	
Cadmium	X		X	
Cobalt	X		X	
Copper		X		
Fluoride	X		X	
Iron	X	X	X	
Manganese	X		X	
Molybdenum	X		X	X
Nickel	X		X	
Radium-226	X	X	X	
Selenium				X
Strontium	X			X
Sulfate	X		X	X
Uranium	X	X	X	X
Vanadium	X	X	X	
Zinc	X		X	

Phreatophytes, plants that have the potential to root in contaminated ground water, were not sampled. Concentrations of COPCs in plant tissue were estimated using published soil-to-plant concentration ratios (CRs) (DOE 1995). The potential for adverse effects was evaluated by comparing the tissue estimates to published benchmark concentrations that can result in phytotoxicity (Will and Suter 1994). Hazard indices (HIs) were calculated by dividing the plant tissue concentration by the benchmark concentration; an HI greater than 1 indicates a possible phytotoxic effect. HIs for arsenic, manganese, vanadium, and zinc ranged from 3.5 to 34. HIs for cobalt and copper were only slightly greater than 1 (DOE 1996d).

Ground water pumped from the most contaminated area of the plume may be toxic if used to water livestock or wildlife or to irrigate crops. Sulfate and total dissolved solids (TDS) exceed levels that may be toxic if ingested by livestock or wildlife. Comparisons of ground-water concentrations with toxicity

benchmarks indicate that cobalt, fluoride, iron, manganese, molybdenum, vanadium, and zinc exceed levels that may have adverse effects on irrigated crops.

The two wetlands mitigation ponds at the southwestern edge of the site were the most highly contaminated; higher than in nearby upgradient ground-water wells (DOE 1996d). For example, in 1995, the surface water in the western-most pond (Pond 2000) contained 0.473 mg/L of uranium while the ground water 60 m upgradient (well 1000) contained 0.096 mg/L of uranium. The higher concentration in the pond was attributed to evaporation. Water chemistry data for samples taken from the wetlands mitigation ponds before they were destroyed by floods, when compared to water quality standards, indicate that cadmium (Cd), manganese (Mn), and vanadium (V), exceeded chronic toxicity benchmarks for aquatic life and manganese (Mn), molybdenum (Mo), sulfate (SO_4^{2-}), and vanadium (V) exceeded toxicity benchmarks for livestock watering, crop irrigation, and ingestion by wildlife.

5.2 Summary of Ecological Data Needs

The screening-level risk assessment for Grand Junction (DOE 1995; DOE 1996d) indicated that adverse effects could occur if plants were rooted in ground water, if ground water was pumped to water livestock or wildlife or to irrigate crops, or if ponds fed by ground water were constructed for wildlife habitat, to water animals, or to irrigate crops. Pathways currently exist for all of these potential exposures. Phreatophytes such as salt cedar, willow, and cottonwood may be rooting in contaminated ground water downgradient from the site. The remnants of a wetlands mitigation pond occurs near the southwest corner of the site. The Western Colorado Botanical Society is pumping ground water from a well approximately 600 m down river from the site into ponds that will be used to irrigate a public arboretum.

The following ecological characterization activities are needed to evaluate these exposure pathways:

- Meet with City of Grand Junction riverfront development staff to determine possible future land use both on the millsite and down river from the millsite as far as ground-water contamination attributable to millsite activities extends. Review revegetation/landscaping activities planned for the millsite. Review any plans for possible future wetlands, ponds, or irrigation wells within this area.

- Characterize current plant ecology in the contaminated ground water area and project future plant ecology based on future land use scenarios. Identify phreatophyte species rooted in the portion of the plume with the highest contaminant concentrations. Project changes in phreatophyte populations based on future land use scenarios.

- Establish geological, hydrological and ecological criteria for selecting ecological reference areas. Conduct a reconnaissance for reference areas.

- Compare ecological COPC concentrations in tissue taken from phreatophytes growing in the most contaminated onsite ground water and from phreatophytes growing in reference areas. Calculate incremental HIs and HI ratios for phytotoxicity.

- Compare dry-season surface water concentrations in the one remaining pond with a reference area pond. Calculate incremental HIs and HI ratios for aquatic life, ingestion by livestock and wildlife, and irrigation of crops.

- Sample the arboretum water supply and arboretum ponds to determine if levels exceed toxicity benchmarks for irrigating crops or watering livestock or wildlife.

6.0 Site Conceptual Model

Available geological, hydrogeological, and geochemical characterization data for the Grand Junction site and nearby area were evaluated and used to develop the site conceptual model. Details of the conceptual model and supporting information are presented in Sections 2.0 through 4.0. The model presented here is a synthesis of available site data. Improvement or refinement of the model will take place as data needs are fulfilled by the proposed additional characterization.

The near-surface geology of the Grand Junction site consists of fill materials and Quaternary alluvium. These unconsolidated deposits range from about 10 to 30 ft thick beneath the site. Ground water occurs under unconfined conditions in the alluvium and generally flows southwest, toward the Colorado River, although the ground water flows west-southwest immediately west of the site at times of peak river flow.

Shales and coals of the Dakota underlying the alluvium form an aquitard which restricts vertical flow between the alluvium and deeper units. In addition to the physical barrier imposed by the Dakota, its chemically reducing nature is likely to restrict the passage of some redox-sensitive contaminants. Arsenic, cadmium, cobalt, molybdenum, nickel, sulfate, vanadium, uranium, and zinc form low-solubility minerals in a reduced environment. Nitrate reacts to form nitrogen gas in a reducing environment.

Based on current understanding of the regional hydrologic regime, it is likely that there is an upward vertical hydraulic potential from deeper hydrostratigraphic units, such as sandstones in the Dakota, to the alluvium. Thus, it is unlikely that contamination from the site could have migrated to aquifers underlying the alluvium at the site.

The alluvium, or uppermost aquifer, in the Grand Junction area consists of three units. The "cobble aquifer" is present close to the Colorado River and includes unconsolidated sands, gravels, and cobbles. The cobble aquifer is overlain by and interfingers with the "clayey alluvium", a complex interbedding of clay, silt, and sand derived primarily from the Mancos Shale and alluvial-derived gravel sequences. The clayey alluvium grades westward into colluvium derived from the Mancos Shale. The cobble aquifer underlying the site is recharged by water infiltrating the clayey alluvium and colluvium upgradient of the site.

The major sources of recharge to the alluvial aquifer are from seasonal runoff, precipitation, and seepage from local irrigation canals and ditches. Areas of the site immediately adjacent to the Colorado River also receive recharge from the river during high river stage. Ground-water levels in the alluvial aquifer range from 0 to 20 ft below land surface, becoming shallower closer to the river. Ground-water levels beneath the site fluctuate from about 2 to 5 ft annually and are lowest during the fall and winter months. The irrigation season is from April through November, with high river stage occurring in mid- to late-June, and low river stage in September.

Throughout the Grand Valley, water quality from the unconsolidated alluvial aquifer, including the cobble aquifer, is poor due to high TDS (BOR 1986). Ground water leaches calcium sulfate and other

salts from the Mancos Shale as it infiltrates into the alluvium. The Mancos Shale also has naturally high concentrations of trace elements such as uranium, selenium, thorium, and potassium. Because the water quality in the alluvium is poor, agriculture in the Grand Valley has long relied on a series of irrigation canals to supply water for crops. This, in turn, has required the installation of a complex series of drainage ditches to dissipate high ground-water levels caused by seepage from unlined irrigation canals. Seepage from irrigation canals has also resulted in transport of large amounts of soluble salts to the Colorado River. Some of the canals have been lined by the BOR. It is believed that lining the canals will cause water quality in the alluvial aquifer to decline because the infiltration, a source of fresher water, will be eliminated (BOR 1986). Two large canals, Highline and Grand Valley, are present upgradient of the former millsite (Plate 2). The Highline Canal is not lined in the area between 16 and 32 Roads (which includes the area upgradient from the former millsite) and currently there are no plans to line it. The Grand Valley Canal is not lined and there are no plans to line it either. Therefore, it is unlikely that water quality in the alluvial aquifer in the vicinity of the former millsite will change in the near future due to canal lining projects (BOR 1986).

It is necessary to rely on regional background ground-water quality to assess the extent of contamination beneath the site because upgradient ground water in the site vicinity may have been impacted by the large number of vicinity properties in the Grand Junction area.

Tailings leachate seeped into the alluvial aquifer beneath the site and constituents subsequently migrated downgradient from the site. It is known that contamination is found approximately 3,000 ft west of the site. The plume geometry is uncertain, however, due to the presence of vicinity properties downgradient from the site. Much of the ground water in the eastern portion of the site probably discharges into the river without crossing the western site boundary. Contamination that migrates past the western site boundary will eventually discharge into the river as well. Sampling of the Colorado River indicates that contamination has not impacted the river. There is currently no known use of ground water crossgradient or downgradient of the site in the area impacted by uranium processing activities.

Currently no route exists for contaminated ground water to impact surface water other than the Colorado River. The City of Grand Junction may eventually develop wetlands on the former millsite. The Western Colorado Botanical Society is currently developing wetlands on the north side of the river dike between the Watson Island bridge and the Fifth Street bridge. These wetland areas are likely to receive some ground water from the alluvial aquifer.

7.0 Data Quality Objectives

The Data Quality Objective (DQO) process is "a scientific and legally defensible data collection planning process to help users decide what type, quality, and quantity of data will be sufficient for environmental decision making. DQOs are qualitative and quantitative statements derived from the outputs of each step of the DQO process that (1) clarify the study objective; (2) define the most appropriate type of data to collect; (3) determine the most appropriate conditions from which to collect the data; and (4) specify acceptable levels of decision errors that will be used as the basis for establishing the quantity and quality of data needed to support the decision" (EPA 1993).

The purpose of the site characterization effort at the Grand Junction site is to collect the data required to: (1) determine if the alluvial aquifer qualifies for supplemental standards based on widespread ambient contamination, (2) evaluate the incremental risk imposed by mill-related contamination in the alluvial aquifer, and (3) determine if ground water in the alluvial aquifer will naturally flush in 100 years or less. The DQOs are governed by the decisions necessary to determine appropriate responses at the site and will be achieved through implementation of the procedures specified in Section 8.0. Specific DQOs for this project are summarized in the following subsections.

7.1 Subpile and Alluvium Characterization

Data Quality Objective: COPCs may have been sorbed in the upper few feet of the aquifer matrix (subpile soil) beneath the area of the former tailings piles and raffinate ponds. Shallow soil contamination was removed during the surface remediation completed in 1994. The criteria for soil excavation and removal was based on a radiometric standard, however, and non-radioactive contamination may have been left in place. Evaluation of remediation strategies requires a reliable estimate of residual amounts of sorbed contaminants in the subpile soil that may be available as a continuing source of ground-water contamination. Soils that are below the surface of the former tailings piles and raffinate ponds should be tested to determine if regulated COPCs are present that could be providing a continuing source of ground-water contamination to the alluvial aquifer, and that could contribute to human and ecological risk (Sections 4.2 and 5.0).

Samples should be selected from areas of the site that are most likely to have contaminated subpile soils. Chemical extraction and analysis methods should be capable of detecting small amounts of contamination (e.g., less than 0.5 mg/L of uranium). Because most COPCs occur naturally in sediment, the results from the millsite must be compared to similar results from background areas. Leaching of soil and contamination to ground water can occur from several mechanisms such as: (1) infiltration of precipitation, (2) a rising water table, or (3) changing chemical conditions due to land use changes (e.g., fertilizer application). A conservative leaching test should examine the most severe of these mechanisms. The location of a contaminating source will impact the remediation strategy used at the site and affect potential modeling parameters.

Data Collection Strategy: Samples of soils directly beneath the former tailings piles and raffinate ponds will be sampled and analyzed. All wells will be sampled by collecting one 2-ft split barrel for every 5 ft of drilling. These samples will be used to determine lithology/stratigraphy and moisture content, and for various leaching tests. The eight on-site borings will have analyses performed on samples collected at two depths in the alluvial aquifer, for a total of 16 analyses. Analyses will be performed on samples collected during the drilling of monitoring wells P003, P004, P005, P006, P007, P008, P009, and P010. Three borings are proposed for the raffinate ponds, four for the tailings area, and one in the vicinity of the former mill buildings (Plate 1). All samples will be collected below the contact between fill material (placed after the tailings remedial action) and the subsoil (soil that was beneath the tailings or raffinate ponds during the milling operation).

Natural background soil concentrations of COPCs will be determined by analyzing samples from two background locations (P011 and P012). The two locations coincide with proposed monitoring well locations. Both background locations are upgradient of the site. Analyses will be performed on two samples collected from different depths, similar to the on-site sampling.

Each sample will be subjected to a 5-percent nitric acid extraction and analyzed for the COPCs that have UMTRA ground-water standards (arsenic, cadmium, molybdenum, radium-226, and uranium). Five-percent nitric acid will dissolve most amorphous oxides that are likely to contain adsorbed contaminants as well as any water-soluble constituents. As such, it is likely to extract more contamination than would rain water or ground water that may come in contact with the soils. As desired, 5-percent nitric acid will not remove contaminants locked in recalcitrant minerals such as apatites or other heavy mineral grains.

7.2 Bedrock Characterization

Data Quality Objective: Shales in the Dakota Sandstone are assumed to act as an aquitard and will be used as an impermeable boundary in a ground water flow model. This uppermost bedrock surface needs to be defined because its orientation will affect model predictions. It is also important to confirm that shales, and not permeable sandstones that could leak contamination to lower horizons, underlie the site. An evaluation of chemical reduction potential is needed to determine if contaminants are likely to be retarded in the Dakota shale/coal beds.

Data Collection Strategy: All proposed wells on site, downgradient of the site, and background wells will be drilled to intercept the bedrock to determine the depth to top of bedrock (Plate 1). Bedrock lithology will be determined from cuttings or, if required, by split-barrel sampling of these bedrock borings. Chemical reduction will be qualitatively assessed by observing the amount of carbonaceous debris and coal in and the coloration of the samples.

7.3 Alluvial Water Quality Characterization

Data Quality Objective: Only three monitoring wells (1000, 1001, and 1002) currently exist on the site. These are inadequate to evaluate the nature and extent of ground-water contamination on the site. A more comprehensive understanding of the nature and extent of contamination in the alluvial aquifer is necessary to refine the site conceptual model and to evaluate remediation strategies. Water quality data

need to be sufficient to: (1) determine if the alluvial aquifer qualifies for supplemental standards based on widespread ambient contamination, (2) evaluate the incremental risk imposed by mill-related contamination in the alluvial aquifer, and (3) determine if ground water in the alluvial aquifer will naturally flush in 100 years or less.

Due to the seasonality of irrigation practices, influence from the Colorado River, and high rates of evaporation, the alluvial aquifer has a high degree of variation in water quality. A sufficient distribution of sampling locations is needed to adequately evaluate the variation in background water quality. For comparisons with site ground water to be statistically significant, the background wells must be located where the ground-water quality is similar to the ground-water quality that would have existed in the area of the site if no mill had operated.

Data Collection Strategy: A more complete ground-water monitoring network will be established by drilling eight new wells on-site. Three wells (P008, P009, and P010) will be located in the eastern portion where raffinate ponds were formerly located, two wells (P006 and P007) in the former tailings areas, one well (P005) immediately downgradient from the former solvent extraction facility, and two wells (P003 and P004) along the western boundary of the site. The locations of these proposed wells are shown on Plate 1.

Four wells will be drilled downgradient of the site. Three are located between the former millsite and 5th Street and will be used to determine the near-field advancement of the ground-water plume (Plate 1). One well (P002) is located in an area formerly used as stockyards, just east of the site. Another well (P017) is located south of the termination of 7th Street near the Western Colorado Botanical Society's building, and a third well (P001) is located in the future botanical garden area farther to the west. The fourth well (P024) is in the American Auto Salvage area about 1.4 mi downgradient of the site (Plate 2). Well P024 will be used to assess the distribution of contamination at a location where the aquifer may be influenced by ground water from the millsite and from large vicinity properties. All onsite and downgradient monitoring wells will be drilled to bedrock with screens installed over the full saturated thickness of the cobble aquifer.

There are currently no suitable monitoring wells to evaluate background water quality. Establishing the variation in background water quality will require five new monitoring wells (P011, P012, P018, P019, and P020). One well (713–1), that was installed by the BOR near 30 Road, will be used as a sixth background well (Plate 2). The five new wells will penetrate the cobble aquifer north of, and within 1,800 feet of, the Colorado River. (1,800 feet is the distance from the river to the proposed on-site well P010). Field checks revealed that physical access and wetlands designations limit the available locations for drilling near the Colorado River. Proposed drilling sites P011, P012, P018, P019, and P020 were field checked and drilling could be done at these sites (Plate 2). The large circles on Plate 2 have diameters of about 1,800 feet and indicate the proposed drilling areas are consistent distances from the Colorado River as are the proposed on-site wells. We will place the background wells as close as possible to the centers of these circles so that background data can be compared with data from the central portion of the millsite. Well locations were selected that were likely to be unaffected by contamination from vicinity properties and have similar geology and geohydrology as the site (Plate 2). Background wells will be installed with screens extending through the upper 20 ft of the saturated zone in the cobble aquifer.

In summary, a total of 20 new wells will be drilled. Seventeen will be used to evaluate contamination in the alluvial aquifer at the former millsite (eight on site, four downgradient, and five background) and three wells will be drilled at the Regional Center. Water samples from the new wells and all existing wells will be collected twice during FY 1998 and analyzed for COPCs, selenium, and TDS.

7.4 Chemical Retardation in the Alluvial Aquifer

Data Quality Objective: To evaluate natural flushing, the interactions of contaminants between the ground water and aquifer sediments need to be understood. For example, if a contaminant binds tightly to the sediment it will be less likely to flush than one that is unbound. Numerical models are used to calculate the length of the flushing period. Parameters that describe contaminant interactions are experimentally determined and must be compatible with the numerical algorithms. The lithology of the sediment will influence the interaction potential, thus, a variety of lithologies should be tested.

Data Collection Strategy: The most common approach to predicting chemical interactions between ground water and aquifer sediment is to employ a distribution coefficient (Kd). Kd is the ratio between the concentration of a constituent in the sediment to its concentration in the ground water. In a natural flushing strategy, it is likely that pH and other chemical conditions will be reasonably constant for the 100 year period. Thus, changing solution chemistry will not likely have a large impact on Kd values. Most of the variation in Kd values is due to the spatial variation in concentrations of adsorbent minerals in the sediments.

Kd values can vary (for the same sediment sample) if different dissolved concentrations are used. For those COPCs that have maximum ground-water concentrations over 10 times the MCL, Kds will be determined for at least three concentrations.

Kd measurements will be made on samples collected from the five new background wells to avoid the interference imposed by using contaminated samples. Two samples from each well, one from the clayey alluvium and one from the cobble aquifer, will be selected to test samples of varying lithology. Kds will be determined by ASTM procedure D 4646–87 (ASTM 1987). Kds will be determined for all regulated COPCs (arsenic, cadmium, molybdenum, radium-226, and uranium).

7.5 Water Contamination in River and Ponds

Data Quality Objective: Contaminated ground water from the site can potentially enter the Colorado River and ponds or wetlands that border it. The Western Colorado Botanical Society is currently withdrawing water from a sump near the river and using this water for irrigation. In order to assure protection of human health and environment, the potential for contamination of these surface waters should be known.

Additional samples of both water and sediments would be useful to establish the influence from the site. Analysis of “key analytes” like uranium will allow better special resolution of contamination.

Data Collection Strategy: This objective will be addressed by measuring present day concentrations in surface water at locations where it is most likely to be affected by contaminated ground water and

compare these data to data from background areas. Using the principles developed for "Expedited Site Characterization" (ESC), concentrations of a key contaminant indicator will be determined in the river, in ponds, and from the Botanical Society inlet. Uranium is selected as the "key indicator" because: (1) it is an important COPC at the site, (2) the ratio of median concentration in the plume area to the UMTRA MCL is higher than for any other regulated COPC, (3) it is easily measured in the field with detection limits below 1 parts per billion (ppb), and (4) it is one of the most mobile COPCs.

Using the ESC principles, many samples can be collected and analyzed over a short period of time, thus, hydrologic conditions will be relatively constant for all samples. Because data are immediately available, anomalous values can be followed up to determine the areal extent of the contamination. Collection areas will be chosen where contamination is most likely, based on observations of the ground water flow system. At least 15 samples of Colorado River water and 15 samples of pond water (including the Botanical Society intake area) will be collected and analyzed. Approximately one-third of these will be from background areas. About 12 samples will be analyzed in the laboratory for other ecological COPCs (arsenic, cadmium, cobalt, copper, fluoride, iron, manganese, vanadium, and zinc). About five of these samples will be from background areas. Selenium, although not an ecological COPC, will also be analyzed because concentrations are often above the MCL in surface waters throughout the Grand Valley.

7.6 Sediment Contamination in River and Ponds

Data Quality Objective: Contaminated ground water from the site can potentially enter the Colorado River and ponds or wetlands that border it. This ground water could contaminate subaqueous sediments which, in turn, could be harmful to benthic organisms. In order to assure protection of environment, the potential for contamination of these sediments should be known.

Additional samples of both water and sediments would be useful to establish the influence from the site. Analysis of “key analytes” like uranium will allow better special resolution of contamination.

Data Collection Strategy: This objective will be addressed by measuring present day concentrations in river and pond sediments at locations where it is most likely to be affected by contaminated ground water and compare these data to data from background areas. Using the ESC principles, concentrations of a key contaminant indicator will be determined in river and pond sediments. Uranium is selected as the "key indicator" because: (1) it is an important COPC at the site, (2) the ratio of median concentration in the plume area to UMTRA MCL is higher than for any other COPC that has an UMTRA MCL, (3) it is easily measured in the field with detection limits below 1 ppb, and (4) it is one of the most mobile COPCs. The sediments will be leached with nitric acid and uranium analyses will be made in the field.

Using the ESC principles, many samples can be collected and analyzed over a short period of time, thus hydrologic conditions will be relatively constant for all samples. Because data are immediately available, the extent of contamination surrounding any anomalous values can be determined. Collection areas will be chosen where contamination is most likely, based on observations of the ground water flow system and results of surface water analysis. At least 15 samples of Colorado River sediment and 15 samples of pond sediment (including the Botanical Society intake area) will be collected and

analyzed. Approximately one-third of these will be from background areas. About 12 samples will be analyzed in the laboratory for other ecological COPCs (arsenic, cadmium, cobalt, copper, fluoride, iron, manganese, vanadium, and zinc). About five of these samples will be from background areas. Selenium, although not an ecological COPC, will also be analyzed because concentrations are often above the MCL in surface waters throughout the Grand Valley.

7.7 Hydrologic Parameters

Data Quality Objective: To characterize ground-water flow and contaminant migration rates, and to support ground-water modeling if it is deemed necessary, the ground-water elevations and the hydraulic conductivity distribution for the alluvial aquifer materials are required. Ground-water elevations will be used to map water table topography; to determine ground-water flow directions and to estimate ground-water flow rates; and determine vertical gradients between the cobble aquifer, shale aquitard, and Dakota Sandstone. Seasonal fluctuations in water levels will also be used to evaluate recharge from and discharge to the Colorado River. Hydraulic conductivity and lithologic data with hydraulic gradients will be used to estimate ground water and contaminant migration velocities and recharge to and discharge from the Colorado River. If ground-water modeling is performed for the site, water-level elevation and hydraulic conductivity data will be used as input parameters for the model. A value for chemical dispersivity is needed for ground- water transport modeling.

Data Collection Strategy: This objective will be met by making manual water-level measurements at all existing and new on-site, background, and vicinity property wells on a monthly basis for 1 year. Data loggers will also be used to record water-level elevations every 4 hours at selected monitoring wells. Data loggers will be used to record water-level elevations throughout the duration of the field investigation and SOWP preparation activities. Data loggers will be maintained for 1 year in existing wells 1001, 1002, 1003, 746, 724, 743, 744, and in new wells P008 and P017.

New monitoring wells installed on-site and downgradient of the site will be installed with well screens penetrating the entire saturated thickness of the cobble aquifer to allow full characterization from the aquifer tests. Boreholes for the wells will be installed with 2-ft split barrel samples collected every 5 ft for lithologic logging. Lithologic data will be used to aid the characterization of the aquifer for potential modeling purposes.

Hydraulic conductivity will be estimated using single well aquifer tests and slug tests. Single well aquifer tests will be performed at all on-site monitoring wells and at upgradient wells 745 and 746. Tests will include 1 to 2 days of step-drawdown testing to determine suitable pumping rates for the actual aquifer test. The aquifer tests will then be run for 3 to 5 days on each well, during which time drawdown will be measured in the pumping well only using pressure transducers and data loggers. Discharge rates will be measured with electronic flow meters that display instantaneous flow rate and cumulative volumes discharged. Water-level recovery will be monitored after pumping ceases to provide a hydraulic conductivity estimate from recovery data as well as drawdown data.

Slug withdrawal tests will be conducted on three background wells; P012, P019, and P020. These tests will be conducted by instantaneously removing a known volume of water and then recording the water-level recovery by means of a pressure transducer and a data logger. Like the aquifer tests, the

slug tests will provide an estimate of hydraulic conductivity, although slug tests estimates do not characterize as much of the aquifer as do the aquifer tests.

To provide data for quantifying surface water and ground water interactions, staff gauges will be installed at the Colorado River and the drainage dike east of the site. The staff gauges will be established by surveying an elevation for either an existing fixed reference point or a reference point installed specifically for this purpose. Location will be determined after further field investigation. Staff gauge data will be used with upstream and downstream gauging-station discharge data to estimate river losses and gains to and from the cobble aquifer.

Because hydrodynamic dispersivity can be an important parameter in characterizing contaminant transport via analytical or numerical models, a natural gradient tracer test will be considered for the purpose of quantifying site-specific dispersivity. The decision whether or not to proceed with a tracer test will be made after further evaluation of existing data. The decision will be based on an assessment of the importance of obtaining a field estimate of dispersivity, and the time and resources required to complete a natural gradient tracer test.

7.8 Plant Ecology and Land Use

Data Quality Objective: Characterization of present and potential land use, plant communities within the plume area and in a reference area, surface water in ponds fed by the plume and in a reference area, and ground water pumped for a public arboretum are all needed to complete the screening-level risk assessment (Section 5.0).

Data Collection Strategy: Surface and ground-water sampling described in Sections 7.3 and 7.6 are sufficient for the ecological investigations. A qualitative survey of the composition and abundance of riparian and wetlands plant communities currently in the vicinity of the site, that are likely to inhabit the site depending on future land use, and in the reference area will be conducted. Tissue samples of plants rooted in ground water will be submitted for laboratory analysis of ecologic COPC concentrations (Table 5–1). Sample sizes for tissue analyses will be calculated to satisfy a standard error within ± 20 percent of the mean at a confidence level of a = 0.10.

8.0 Site Investigation Procedures

As described in Section 7.0, data required to meet the DQOs include well drilling, ground-water sampling, soil leaching, determination of distribution coefficients, aquifer testing, land surveys, vegetation sampling, and chemical analysis. The following sections present the procedures that will be used to collect these data.

8.1 Ground-Water Monitor Well Installations

Wells will be completed by placing sand pack around the annular space from the bottom of the borehole to a level of 2 ft above the top of the well screen. The well will be installed by using 4-in. internal diameter, flush-joint, threaded polyvinyl chloride (PVC) casing and a PVC screen. The screened intervals will be near the mid portion of the saturated zone, except for two wells screened across the water table that will be used for organic sampling. A 3-ft bentonite seal will be placed to within 2 ft of the ground surface with an expanding grout mixture. Concrete will be used to fill the remaining annulus space to the ground surface and to install the well-cover pad. Construction details for the monitor wells are presented in the Drilling Statement of Work (Appendix B).

Details of the procedures that will be used for monitoring well installation are found in LQ–14(P), "Technical Comments on ASTM D 5092**S**Standard Practice for Design and Installation of Ground-Water Monitor Wells in Aquifers," and GN–13(P) "Standard Practice for Equipment Decontamination."

8.1.1 Auger and Split-Barrel Sampling of Unconsolidated Soils and Sediments

Split-barrel samples will be collected every 2 ft of 5 ft drilled to obtain samples for soil studies, determine distribution coefficients, and to provide lithologic information on the nature of the alluvial aquifer. Auger cuttings will be observed and sampled if the drilling supervisor sees something of interest. For split-barrel sampling, a truck-mounted hollow-stem auger rig is centered over the sample location and the auger advanced to the desired sampling depth. After reaching the desired sampling depth, a 140-lb drop hammer, or equivalent hydraulic driver, is used to collect samples of the unconsolidated material. A 3-in. outside diameter by 24-in. long split-barrel sampler is lowered to the top of the interval to be sampled. With a 140-lb drop hammer having a 30-in. drop, the split barrel is driven for the length of the sample or until 6 in. or less of penetration is achieved after 50 blows.

Once the split barrel is full, or no further penetration is possible, the barrel is carefully removed from the borehole and separated from the drive-rod assembly. The barrel is laid flat on an uncontaminated surface and the head and drive shoe removed. One-half of the split barrel is removed to expose the sample. The uppermost portion of sample in the split barrel is inspected for slough and the slough discarded, if present. The remaining sample is considered representative. The sample is placed in a stainless steel or aluminum pan. The site geologist will describe the material using Unified Soil Classification System terminology in Section SL–24(P) of the *Environmental Procedures Catalog* (1997).

All sediment and soil sampling will be performed in accordance with the following procedures from the *Environmental Procedures Catalog* (1997):

- SL–6(P), “Technical Comments on ASTM D 1452–80(90)**S**Standard Practice for Soil Investigation and Sampling by Auger Borings,”

- SL–7(P), “Technical Comments on ASTM D 1586–84(92)**S**Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils,”

- SL–19(P), “Technical Comments on ASTM D 2488–93**S**Standard Practice for Description and Identification of Soils,”

- GN–8(P) “Standard Practice for Sample Labeling,”

- GN–9(P) “Standard Practice for Chain-of-Sample-Custody Control and Physical Security of Samples,” and

- GN–13(P) “Standard Practice for Equipment Decontamination.”

8.1.2 Subpile Alluvium and Bedrock Investigation

Sample Collection: As described in Section 7, samples will be collected to meet DQOs. They will be double bagged in clean plastic bags. Bags will be transported in 5-gallon plastic buckets to the laboratory.

Lithologic logs of the soil material will be prepared in the field. The upper 1 to 3 ft is likely to be fill material that has been placed on the surface and graded after the removal of the tailings. This fill material is not representative of the subpile soils and should be distinguishable by visual examination. Samples will be collected below the fill.

Sample Preparation: Samples will be air-dried (no oven heat). If the samples contain a significant number of large pebbles, they will be screened with a No. 4 (4.76 mm) sieve to yield a sample suitable for the laboratory tests. The fine-grained material is likely to contain the most contamination so this sieving will bias the analysis toward higher concentrations of contaminant. If sieved, weights of each fraction will be recorded.

Nitric Acid Extraction Method: The specific steps in the extraction procedure are as follows:

- Two grams of soil (accurately weighed) is placed in a 100-milliliter (mL) centrifuge tube (or divided between two 50-mL tubes).

- 100 mL of 5-percent nitric acid is added and the contents are shaken on an end-over-end shaker for 4 hours.

- Contents are centrifuged to remove particles less than 2 microns. Supernatant is decanted into a 200-mL volumetric flask.

- Additional 5-percent nitric acid (about 100 mL) is added. Contents are shaken for 15 minutes, centrifuged, and decanted into the same 200-mL flask. This step will remove most of the constituents present in the residual fluid.

- The 200-mL flask is filled to volume with deionized water and filtered (0.45 µ filter). Alkalinity, pH, and Eh are measured. The remaining solution is preserved and sent to the analytical lab for analyses.

- All samples will be analyzed for the regulated COPCs (As, Cd, Mo, ^{226}Ra, and U).

8.2 Hydrologic Tests

As described in Section 7.0, several types of hydrologic measurements are required to meet the DQOs. Procedures for collecting these data are presented in this section.

8.2.1 Measurements of Water Levels Using a Data Logger

During the water-level monitoring period, an absolute-pressure transducer will be setup to monitor changes in atmospheric pressure. Pressure transducers from In-situ, Inc. (or equivalent) will be used to measure water levels. The transducers will be positioned 5 ft above the bottom of the wells. Transducer setup parameters, installation depth, model, and serial number will be recorded in a field log book prior to the start of baseline data collection.

Water-level and barometric-pressure data will be recorded continuously, at 1-hour intervals, by using either the In-situ, Inc. HERMIT model data logger, and/or the In-situ, Inc. SENTINEL model, and/or the Geoguard Tuber Model. The clocks of the data loggers will be synchronized to a common time, and each logger will be programmed to display and record data in the “depth-to water” mode relative to the top of the casing. To verify the accuracy of the transducers during the monitoring period, the “depth-to water” displayed on the logger will be compared with manual readings taken with a water-level sounder. User manuals from In-situ, Inc. and/or Geoguard will be followed for logger setup, calibration, and programming procedures.

After completion of data collection, water levels will be downloaded to a laptop computer. Files will be named and stored in accord with the conventions described in the *Data Logger Data Management Plan* (DOE 1996b).

Manual water-level measurements will be performed according to procedure LQ–2(T) “Standard Practice for the Measurement of Water Levels in Groundwater Monitoring Wells.”

8.2.2 Step-Drawdown Aquifer Test

Field Procedure: The step-drawdown test will be performed by pumping the well at a low constant discharge until drawdown within the well stabilizes. The likely initial extraction rate for a well completed in the alluvial aquifer will be 1–2 gallons per minute (gpm). The pumping rate will be increased to a higher constant-discharge rate, and the ground water will be pumped until drawdown in the well stabilizes. The process will be repeated until the maximum sustainable yield for the well has been determined.

Flow will be measured by using an instantaneous flow meter such as a Great Plains Industrial flow meter, or equivalent. Flow rates will be logged on a data form or in a field log book. After downloading baseline water-level data, the data loggers will be reprogrammed for a logarithmic sampling schedule. Water-level data will be continuously recorded by a data logger as the test proceeds. Proper operation of the transducer and data logger will be confirmed by taking manual water-level measurements at 1-hour intervals and by comparing the results with data logger output. Recorded data will be transferred to a laptop computer via applicable hardware interfaces and software and will be converted to working files by using the appropriate software.

Data Analysis: Various methods are available to analyze step-drawdown test results for an unconfined aquifer (alluvial aquifer). The step-drawdown data will be analyzed by using either the Hantush-Bierschenk method (Kruseman and deRidder 1990), the Rorabaugh straight line method (Kruseman and deRidder 1990), or Sheanhan's curve-fitting method (Kruseman and deRidder 1990), or up to all three of the methods. These methods are also applicable for analysis of step-drawdown data for a confined or semi-confined aquifer (bedrock aquifer). Additionally, step-drawdown data from testing the bedrock aquifer can be analyzed by using the Eden-Hazel method (Kruseman and deRidder 1990).

8.2.3 Aquifer Tests

Baseline Data: Baseline water-level data will be collected from selected monitoring wells prior to aquifer testing. The baseline water-level data will be used to determine if rising or falling water levels exist prior to the start of the aquifer test(s). Baseline water levels will be collected at half-hour intervals for at least 5 days.

Procedure: The aquifer tests will be performed by pumping the well at a constant discharge for at least 48 hours. As reported by Todd (1980), the minimum pumping time required to attain a delayed-yield response in an unconfined aquifer of predominately fine- to very-fine-grained sand is 30 hours. The pumping rate required to propagate a drawdown cone through the alluvial ground water will be determined from the results of the step-drawdown tests. Recovery of ground-water levels (residual drawdown) will be measured until 95 percent of the maximum drawdown has dissipated.

Flow will be measured by using an instantaneous flow meter such as a Great Plains Industrial flow meter, or equivalent. Flow rates will be logged on a data form or in a log book. After downloading baseline water-level data, the data loggers at the wells to be tested will be reprogrammed for a logarithmic sampling schedule. Water levels in the observation wells will be continuously recorded by a data logger as the test proceeds. Proper operation of the transducer and data logger will be confirmed

by taking manual water-level measurements at 1-hour intervals and comparing the results with data logger output. Recorded data will be transferred to a laptop computer via applicable hardware interfaces and software and will be converted to working files by using the appropriate software.

Data Analysis: Although numerous methods are available for analysis of aquifer test results, all pumping and observation wells partially penetrate the respective aquifers, which limits the number of suitable methods for interpreting data. For the alluvial aquifer, assuming unconfined and unsteady conditions, either Neuman's or Moench's curve-fitting methods (Kruseman and deRidder 1990; Moench 1995), or both, will be used to reduce data.

Aquifer tests and data analysis will be conducted in general accordance with the following ASTM procedures:

- D4043–91 "Standard Guide for the Selection of Aquifer-Test Method in Determining of Hydraulic Properties by Well Techniques";
- D4050–91 "Standard Test Method (Field Procedure) for Withdrawal and Injection Well Tests for Determining Hydraulic Properties of Aquifer Systems";
- D5472–93 "Standard Test Method for Determining Specific Capacity and Estimating Transmissivity at the Control Well";
- D5473–93 "Test Method (Analytical Procedure) for Analyzing the Effects of Partial Penetration of Control Well and Determining the Horizontal and Vertical Hydraulic Conductivity in a Nonleaky Confined Aquifer."

8.3 Land Surveys

At the conclusion of the drilling, physical coordinates and elevations for each monitor well, soil boring, and physical features will be determined by a registered Land Surveyor. The survey team will follow standard contractor survey practices and procedures.

8.4 Ground-Water Sampling

Each new monitor well will be allowed to set undisturbed for a minimum of 40 hours after final completion before it is developed. Development will be performed according to the Drilling Statement of Work (Appendix B). Ground-water sampling will be performed in accordance with the *Addendum to the Sampling and Analysis Plans for the UMTRA Ground Water Project* (DOE 1996a) and the *Environmental Procedures Catalog* (1997). Ground-water samples will be collected from the new monitor well network and selected existing wells and submitted to the Grand Junction Office (GJO) fixed-based Analytical Laboratory for analyses.

The following specific procedures from the *Environmental Procedure Catalog* (1997) will be used for ground-water sampling:

- GN–8(P), “Standard Practice for Sample Labeling,”
- GN–9(P), “Standard Practice for Chain-of-Sample-Custody and Physical Security of Samples,”
- GN–13(P), “Standard Practice for Equipment Decontamination,”
- LQ–2(T), “Standard Test Method for the Measurement of Water Levels in Ground-Water Monitor Wells,”
- LQ–3(P), “Standard Practice for Purging Monitor Wells,”
- LQ–4(T), “Standard Test Method for the Field Measurement of pH,”
- LQ–5(T), “Standard Test Method for the Field Measurement of Specific Conductance,”
- LQ–6(T), “Standard Test Method for the Field Measurement of the Oxidation-Reduction Potential (Eh),”
- LQ–7(T), “Standard Test Method for the Field Measurement of Alkalinity,”
- LQ–8(T), “Standard Test Method for the Field Measurement of Temperature,”
- LQ–9(T), “Standard Test Method for the Field Measurement of Dissolved Oxygen,”
- LQ–10(T), “Standard Test Method for Turbidity in Water,”
- LQ–11(P), “Standard Practice for Sampling Liquids,” and
- LQ–12(P), “Standard Practice for the Collection, Filtration, and Preservation of Liquid Samples.”

8.5 GJO Analytical Laboratory Sample Analyses

Ground-water and soil samples will be submitted to the fixed-based GJO Analytical Laboratory. All procedures will be checked for accuracy through internal laboratory quality-control checks (i.e., the running of blind duplicates, splits, and known standards). Table 8–3 lists the analytical methods to be used for analysis of soil and ground-water samples. Sample preservation will consist of storing the sample vials in an ice chest with Blue Ice to cool samples during field sampling, packaging, and shipping.

Table 8–3. GJO Analytical Laboratory Sample Requirements

Measurement Parameter	Analyte	Sample Container	Analytical Instrument/Method	Detection Limit
Ground Water	Total uranium	2 each 120 mL	ICP/MS EPA 6020	1.0 µg/L
	Other Inorganics	See Supplemental Water Sampling and Analysis Plan for all UMTRA Sites and Addendum to the Sampling and Analysis Plans for the UMTRA Ground Water Project.		

8.6 Vegetation Sampling and Analysis

The species composition and relative abundance of plant communities will be characterized using a modified releve' method (Bonham 1989). This will involve subjectively selecting representative stands of each vegetation type, walking through the stands and compiling a list of all species encountered, and assigning species to cover classes. Cover will not be measured precisely. A species will be placed in one of six cover classes (<1 percent, 1–5 percent, 6–25 percent, 26–50 percent, 51–75 percent, and 75–100 percent).

Samples of species rooting into ground water will be analyzed for ground water COPCs (Table 5–1). Samples will be collected from areas underlain by contaminated ground water as well as in reference areas. Analytical methodologies may include those of the Association of Official Analytical Chemists (AOAC), EPA SW–846, EPA CLP Special Analytical Services, or combinations thereof. Acceptance criteria for laboratory analysis, including calibration of laboratory equipment and internal laboratory quality control (QC) checks (i.e., reagent blanks, duplicates, matrix spikes, etc.) are specified by the analytical method. Laboratory documentation will be maintained for all analytical results. Approximately 20 samples will be analyzed.

8.7 Quality Assurance and Quality Control

The objective of quality-assurance and QC measures is to provide systematic control of all tasks so as to maximize accuracy, precision, comparability, and completeness. The following describes the measures that will be used for sampling and analysis.

8.7.1 Sampling Procedures

Basic sampling procedures are presented in the *Environmental Procedures Catalog* (1997). Deviations from these procedures will be noted in a Field Variance Log with an explanation and a description of its possible impact on data quality.

8.7.2 Sample Control

To maintain evidence of authenticity, the samples collected must be properly identified and easily discernible from other like samples. Samples collected at the Grand Junction site will be identified by a

label attached to the sample container specifying the sample identification number, location, date collected, time collected, and the sampler's name.

Soil and ground-water samples for laboratory analyses will be kept under custody from the time of collection to the time of analysis. Chain-of-custody forms will be used to list all sample transfers to show that the sample was in constant custody between collection and analysis.

While the samples are in shipment to the GJO Analytical Laboratory, custody seals will be placed over the cooler opening to ensure that the integrity of the samples has not been compromised. The receiving laboratory must examine the seals on arrival and document that the seals are intact. Upon opening the container, the receiving laboratory will note the condition of the sample containers (e.g., broken bottles or leaking bottles).

All sample shipments will be made in compliance with Department of Transportation (DOT) regulations (49 CFR 171–179) governing shipment of hazardous materials and substances. These regulations govern the packaging, documentation, and shipping of hazardous material, substances, and waste. Special care will be taken to ensure the integrity of the sample through proper packaging and shipping.

To determine the proper identification of a hazardous sample, field personnel will review field measurement data and field notes for relevant information concerning the sample material in a container. This information will include organic vapors detected, pH, explosive potential determinations, and any other information that might be useful in classifying the sample for shipment. If a sample is known or suspected to contain a specific hazardous material, the sampler will note its presence on the sample label. This information is important to the receiving laboratory to determine the proper handling of the sample prior to its analysis.

8.7.3 Laboratory Quality Control

Laboratory QC will follow what is specified in relevant EPA (SW–846) or the contractors *Handbook of Analytical and Sample-Preparation Procedures Volumes I, II, III and IV* (WASTREN–GJ, undated). Quality control will include analysis of blanks, duplicates, spikes, and check samples.

8.7.4 Field Quality Control

Approximately 10 percent of the samples collected and analyzed will be field QC samples. QC samples will include equipment blanks, trip blanks, check samples, and duplicates. These samples will be analyzed for the same analytes as other samples.

9.0 Environmental Compliance Requirements/Actions

The actions described below are based on a review of the requirements under federal, state and local laws and regulations.

9.1 Environmental Assessment

All actions proposed under this work plan will be assessed under DOE's National Environmental Policy Act (NEPA) regulations. On the basis of initial review, it appears that the proposed work will meet the requirements for categorical exclusion in accordance with DOE's NEPA regulations, 10 CFR Part 1021. Therefore, an environmental checklist will be prepared and a recommendation for categorical exclusion transmitted to the DOE–Albuquerque (DOE–AL) for approval.

9.2 Well Installation/Water Use

Colorado state regulations are intended to regulate wells installed for characterization activities under the UMTRA Ground Water Project. Permits will be obtained for all new wells. Access agreements with landowners will be prearranged and in place prior to initiating work on private land. These permit and agreement processes will begin as soon as the locations are finalized through DOE.

9.3 Cultural Resources Issues

Cultural resources will be protected in accordance with federal and state regulations. During the MACTEC–ERS Grand Junction (GJ) site inspection and review of available literature, no cultural resources were identified on the GJ site or in the upgradient background well locations.

9.4 Wetlands/Floodplain

Site visits were conducted in areas where background wells are to be placed. Most of the locations selected have been previously disturbed. The wells were placed to eliminate the possibility of disturbing any nearby wetlands areas. A review of floodplain maps was conducted and proposed well locations were verified to be outside of the 100-year floodplain. Reviews will be conducted on any additional wells proposed, prior to field mobilization.

9.5 Threatened and Endangered Species

Threatened and Endangered (T&E) species are discussed in the *Final Environmental Impact Statement for Remedial Actions at the Climax Uranium Millsite, Grand Junction, Colorado* (DOE 1986). Two T&E species have been identified near the site. These include the bald eagle, which winters along the river, and the Colorado squawfish, which may occur in the side channels of the Colorado River near the site. Habitat of T&E species will not be disturbed by installation of the wells or access to the wells.

9.6 Off-Road Activities

Existing dirt roads and trails (including previous routes used to access wells) will be used wherever possible. Any “off-road” activities, routes, and access will be conducted in a manner that minimizes adverse impact to soils, vegetation, and other natural resources. In any event, particularly during periods of inclement weather, the MACTEC–ERS field supervisor is responsible for determining the conditions under which off-road travel will be permitted. Any adverse impacts created as a result of off-road travel, including rutting, will be mitigated. Mitigation will be coordinated with the State and may include recontouring and reseeding.

9.7 Transportation of Samples and Reagents

Transportation of samples and hazardous materials (i.e., analytical reagents and sample preservatives) are addressed under Section 7.0 and Appendix C of the *Management Plan for Field-Generated Investigation Derived Waste*, (IDW Plan) (DOE 1997a). Transportation of all hazardous materials will be managed in accordance with DOT regulations, and any EPA, State, local, or facility-specific protocols applicable.

9.8 Waste Management

The strategy for the management of investigation-derived waste (IDW) generated from well drilling/boring, development, and monitoring is tiered to the IDW Plan. Proper implementation of this strategy will ensure that IDW is managed in a manner that is protective of human health and the environment and is in accordance with regulatory requirements.

The IDW to be generated during this site investigation and subsequent monitoring activities will consist of both liquid and solid media. Examples of liquid IDW include well development water, equipment/personal protective equipment (PPE) decontamination water, well purge water, excess sample material, and field-generated, analytical process waste. Water from pump tests will also be generated and is discussed in Section 9.8.2.2. Examples of solid IDW include drill cuttings, bore hole soil, PPE, excess sample material, and field test kits and calibration standards.

It is DOE’s intention to dispose of IDWs that cannot be disposed of on-site (i.e., residual radioactive material [RRM]-classified PPE, disposable sampling equipment, and miscellaneous debris) at the Cheney Repository. Prior approvals from DOE–AL, the State of Colorado, the Mesa County Commissioners, and the Nuclear Regulatory Commission (NRC) shall be obtained for the site prior to initiating off-site shipments to the repository.

9.8.1 Regulatory Requirements for Waste Management

IDW generated during this site investigation will be managed in accordance with all applicable state and federal requirements. A summary of the key regulations applicable to the management and disposal of these wastes is delineated in the IDW Plan and should be reviewed as a part of the IDW disposition process. Brief descriptions of regulations pertaining to this site are provided in the following paragraphs.

The UMTRA remediation standard for ground water represents the value below which there are no regulatory requirements for the management of the radioactive content in liquid IDW including sample residuals and analytical process wastes associated with the UMTRA Ground Water Project. Liquid IDW in the form of sample residuals and analytical process wastes, which meet the UMTRA remediation standard of less than 30 picocuries per liter (pCi/L) U-234 & U-238 (0.044 mg/L, assuming secular equilibrium), and are not otherwise regulated (or meet the criteria of Resource Conservation and Recovery Act [RCRA]-exempt waste) may be solidified, managed as solid waste, and disposed of at a RCRA, Subtitle D landfill. The UMTRA surface remediation standard (5 pCi/gram Ra-226 & Ra-228) is applicable to surface-contaminated material. Those solids contaminated in bulk will be tested for radioactivity in accordance with the IDW Plan and/or the process delineated by this document.

The UMTRA Ground Water Project is not a generator of RCRA regulated wastes. If, during the course of site investigation activities, small quantities (i.e., <100 kilograms/month) of waste materials are encountered which do not meet the definition of RRM or by-product material, these waste materials will be managed in compliance with 40 CFR 261.5, *Special Requirements for Hazardous Waste Generated by Conditionally Exempt Small Quantity Generators* (CESQG), and in accordance with applicable state-specific regulations. Under RCRA, a CESQG's hazardous wastes are not subject to regulation under parts 262 through 266, 268, and parts 270 and 124 of 40 CFR, and the notification requirements of section 3010 of RCRA.

EPA developed a fact sheet guidance document in 1992 to insure that management of IDW generated by Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) field investigations ensures the protection of human health and the environment and complies with applicable regulatory requirements. Since the goals of UMTRA IDW management are consistent with this guidance, some of the management options may be applicable.

EPA's fact sheet describes the allowable disposal of IDW within an 'area of contamination' (AOC) as follows: "Storing IDW in a container within the AOC and then returning it to its source is allowable without meeting the specified Land Disposal Restrictions treatment standards." ... "Therefore, returning IDW that has been stored in containers within the AOC to its source does not constitute land disposal as long as containers are not managed in such a manner as to constitute a RCRA storage unit as defined in 40 CFR 260.10. In addition, sampling and direct replacement of waste within an AOC do not constitute land disposal." Although RCRA does not apply to UMTRA RRM IDW, this management scenario is a viable option for the UMTRA Ground Water Program as long as best professional judgement and available information indicate that the disposal of IDW purge waters in or around the area of the well will not present a risk to human health or the environment. Criteria to determine risk to human health and the environment for the surface dispersion of well water is defined in detail in the IDW Plan.

9.8.2 Disposition of IDW

To the extent allowable under the specific screening procedures identified in the sections below, the following RRM IDW materials will be disposed on-site or beneath the surface of the ground: well development waters, well purge waters, pumping test waters, equipment decontamination waters,

borehole drill cuttings and soils, and excess field samples. As stated in the IDW Plan, water, soil, and excess samples from drilling, developing, and/or routine monitoring of background wells will be dispersed on the ground in the area around the well.

9.8.2.1 On-Site Disposal of Liquid IDW

The surface-dispersion of purge water IDW from routine well monitoring at this site was evaluated based on the potential for the purge water to present a risk to human health or the environment. The results of this evaluation are documented in the IDW Plan. The study indicated that no impact to agricultural crops or humans would result from applying ground-water contaminated with the site's maximum levels of constituents of concerns (COCs) at a rate of 30 gallons per application, over the life of this project (organic contaminants were not a consideration in this study). Consequently, well water generated as a result of well development, monitoring activities, and/or sampling will be dispersed in the area around the well in a manner that will not disturb the surface soil.

If the well is suspected to be contaminated with organics, a field organic vapor analyzer using a photo-ionization detector (PID) will be used to examine the well for evidence of organic contamination. If it is determined that there is not significant evidence of organic contamination (i.e., less than two times the background concentration), the water will be dispersed on the ground. If, based on the use of portable field screening instrumentation, it is determined that the water may contain evidence of organic contamination, the water will be evaporated in stock tanks.

Like the development/purge waters, excess water samples collected for field analyses will be added to the drum and managed in the same manner. The sample bottles will be rinsed with water and scanned for radioactive contamination. Decontaminated bottles will be disposed of as solid waste at a local landfill. In the unlikely event that the bottles cannot be decontaminated, they will be managed as RRM, and disposed at the Cheney Repository.

Aquifer tests will be conducted on eight wells on or adjacent to the site. Water resulting from the pumping test well will be disposed of on the ground surface on site, away from the test well and other injection wells. This will provide an environmentally sound and cost effective means of managing pump test waters.

9.8.2.2 Pump Test Water

There are two options for disposing of water from pump tests: (1) disposing of the water in a trench located in close proximity to the well from which the water is pumped, and (2) discharging the water directly to the surface. CDPHE will be contacted prior to the pump test to determine which option would comply with state regulatory requirements. It is not anticipated that either option would require a state-discharge permit.

<u>Option 1</u>

The water from each pump test will be disposed of in a trench that will be greater than 6 in. Deep but less than 30 in. deep. This will ensure that contaminated ground water will not adversely affect human

health or the environment. The trench will allow the water to percolate back into the aquifer from which it originated without impacting remediated soils. When the pump tests have been completed, the trench will be refilled with the topsoil that was removed.

Option 2

The water from each pump test will be discharged to the surface of the ground. To ensure protection of human health and the environment, the volume of water involved in all of the pump tests to be conducted (~500,000 gallons total) has been put through the calculations used in the IDW Plan. No significant impacts were found.

9.8.2.3 On-Site Disposal of Solid IDW

Drill cuttings and borings brought to the surface as a result of drilling activities will be placed on plastic sheets as they are brought to the surface of the ground. As a precautionary measure, for bore holes and wells that are to be developed in areas where residual radioactivity may remain, the drill cuttings and soils will be scanned with a hand-held scintillometer to determine if there is any indication of detectable radioactivity. If the results of the scan are negative, i.e., less than twice background, the soils and cuttings will be spread around the area of the well from which they were excavated. If the results of the scan are positive, the drill cuttings will be buried 6 in. beneath the surface of the soil in the area of the well.

If the well is suspected to be contaminated with organics, a field organic vapor analyzer will be used to examine the well headspace for evidence of organic vapors. If it is determined that there is no evidence of organic contamination, using two times the background concentration as a positive result (information as to the types of detectors for various organic compounds and expected detection limits is being provided. This section and the liquid IDW may change as a result of that information), the cuttings will be dispersed on the ground around the well.

If, based on the use of portable field screening instrumentation, it is determined that the cuttings contain organic contaminants, the soils will be containerized and disposed of in an onsite burial pit or at an approved landfill.

9.8.2.4 Off-Site Disposal of IDW

The following IDW materials will be disposed off-site: excess sample material associated with off-site analyses, field test kit waste, field calibration standards, and PPE. Excess liquid sample material and any analytical laboratory process waste generated as a result of off-site sample analyses will be managed and disposed of by the off-site laboratory. Soil samples analyzed by the GJO Laboratory will be stored at the GJO until the established retention period expires. At that time, the samples will be disposed of at the municipal landfill or the Cheney Repository, as appropriate.

The UMTRA Ground Water Project is not a generator of hazardous waste. Therefore, small quantities of wastes that may contain regulated constituents will be managed in accordance with the allowances under 40 CFR 261.5, as a conditionally exempt small quantity generator. Subsequently, unless

field-generated wastes (i.e., field calibration standards, used portions of field test kits, and sample residues) are determined to be radiologically contaminated, they will be disposed of at a RCRA Subtitle D facility (municipal landfill) as general refuse, at the conclusion of the site investigation activities. All field-generated wastes determined to be contaminated with radioactivity will be managed as RRM and disposed of at the Cheney Repository.

All PPE used during the site investigation will be disposable. PPE will be decontaminated in the field and disposed of at the local county landfill. In the event that PPE cannot be decontaminated, it will be managed as RRM, and disposed of at the Cheney Repository.

IDW that is expected to be generated during site investigation activities associated with ground-water contamination at the Grand Junction site, the estimated volumes and the approach for their management and disposal are summarized in the IDW Plan.

9.8.3 Management of Spills

Since the only significant equipment used for characterization are trucks and drill rigs, should a spill occur it will most likely be a petroleum product, such as fuel. Actions that prevent spills and overfills should be used when refueling drill rig generators or trucks in the field.

For example, the volume available in the tank should be greater than the volume of fuel in the transfer container, and close attention should be given to all refueling operations, watching constantly to prevent spills and overfills.

In the event of a spill, the following actions should be taken:

- Take immediate action to stop and contain the spill;
- Report petroleum spills exceeding 25 gallons to the regulatory authority (e.g., state, tribe, EPA regional administrator) within 24 hours;
- Ensure that the spill poses no immediate hazards by removing all potential fire hazards;
- Avoid vapor inhalation and skin contact with the spilled material.

Spill clean-up of petroleum products should entail:

- Removal of all of the stained soil, over-excavating a few inches,
- Placement of the excavated material on a plastic tarpaulin, and
- Periodic mixing of the soil with a shovel or by lifting the corners of the tarp and alternating ends to roll the material and remove organic contamination.

When the soil no longer contains a flammable concentration of organic material, the material can be disposed of at a municipal landfill, or at the Cheney Repository if it qualifies as RRM.

For spills of other regulated materials the general rules are similar. Workers should stop and contain the spill, ensure that the spill poses no immediate hazards by removing all potential fire hazards, and avoid vapor inhalation and skin contact with the spilled material. For all spills, field personnel must contact the

UMTRA Project Environmental Compliance Point-of-Contact for the regulatory requirements pertinent to specific types of spill clean-up and notifications, as soon as possible.

9.8.4 Waste Transportation and Disposal

Regulated wastes will be transported in accordance with DOT regulations and disposed of in compliance with federal and state regulations and the permit and/or licensing requirements of the receiving facility. See Section 7 of the IDW Plan for more detailed information. Any questions regarding the off-site shipment of regulated wastes should be directed to the Environmental Compliance Transportation Coordinator or the Environmental Compliance Point of Contact.

10.0 Health and Safety

The site-specific Health and Safety Plan (HSP) has been prepared for the Grand Junction UMTRA Project site in accordance with the requirements of 29 CFR 1910.120, the contractor's health and safety policies, the UMTRA Project Environmental, Health and Safety Plan, UMTRA–DOE/AL–150224.006, and the DOE Headquarters Environment, Safety, and Health/Office of Environmental Management interim document *Handbook for Occupational Health and Safety During Hazardous Waste Activities*, DOE/EH–0478. The health and safety policies, procedures, and hazard analysis referenced in this plan incorporate and take precedence over previous health and safety documentation.

All fieldwork will be performed according to the site specific health and safety requirements developed for this task.

11.0 Logistics and Schedule

11.1 Work Readiness Review

A work readiness review (WRR) will be conducted by MACTEC–ERS at the Grand Junction Office (GJO) before the field team mobilizes for the drilling campaign. The purpose of the WRR is to assure that all personnel, facilities, systems, and processes are ready prior to the start of the fieldwork to minimize the possibility of delays and problems due to incomplete planning and preparations.

11.2 Schedule

A summary of the proposed schedule for the field investigation is as follows:

Task	Completion Date
Final work plan to DOE	**Sept. 12, 1997**
Work readiness review	Oct. 1, 1997
Award drilling contract	Oct. 17, 1997
Initiate fieldwork	**Oct. 17, 1997**
Well Installation	Dec. 12, 1997
Complete elevation and location surveys	Dec. 30, 1997
Complete well development	Jan. 14, 1998
Complete Kd and subpile studies	Jan. 22, 1998
Complete first quarterly well sampling	Feb. 10, 1998
Complete second quarterly well sampling	May 20, 1998
Complete third quarterly well sampling	August 28, 1998
Complete fourth quarterly well sampling	December 10, 1998
Complete aquifer tests	Mar. 18, 1998

12.0 Deliverables

Major deliverables for this project are: (1) Data Reports and (2) Calculation Sets.

Data Reports will provide lithologic logs, completion diagrams, screen depths, sampling locations, dates, field methods used, and other field information. Calculation Sets will provide the results and interpretations from aquifer pump tests, soil analyses, surface water and sediment sampling, plume nature and extent, background samples, and other pertinent results. The Data Reports and Calculation Sets will provide the basis for the revision of the SOWP in FY 1999.

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