DOE/EA-1388

Environmental Assessment of Ground Water Compliance at the Shiprock Uranium Mill Tailings Site

Final

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Prepared by
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Acronyms and Abbreviations

CFR	Code of Federal Regulations
cfs	cubic feet per second
DOE	U.S. Department of Energy
EA	Environmental Assessment
EPA	U.S. Environmental Protection Agency
ft	foot (feet)
gpm	gallons per minute
mg/L	milligrams per liter
NECA	Navajo Engineering and Construction Authority
PEIS	Programmatic Environmental Impact Statement (for the UMTRA Ground Water Project)
SOWP	Site Observational Work Plan
UMTRA	Uranium Mill Tailings Remedial Action (Project)
UMTRCA	Uranium Mill Tailings Radiation Control Act
USFWS	U.S. Fish and Wildlife Service

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Executive Summary

This Environmental Assessment (EA) addresses the environmental effects of a proposed action and a no action alternative that have been developed to remediate ground water contaminated by the processing of uranium and vanadium ore within the Navajo Nation at Shiprock, New Mexico. These ores were processed at the Navajo Mill from 1954 to 1968. Milling operations produced tailings that contained radioactive materials and other constituents. In 1986, The U.S. Department of Energy (DOE) completed surface cleanup at the site by encapsulating the tailings in a disposal cell. Large quantities of water used to process the ores during milling introduced contamination into ground water underlying the millsite area and the adjacent floodplain of the San Juan River.

Topographic and hydrologic features divide the site into two regions known as the floodplain and the terrace. A shale cliff referred to as the escarpment separates the floodplain and terrace areas. Alluvial ground water in the floodplain is in hydraulic contact with the San Juan River and receives inflow from the terrace ground water system. The terrace is further divided into terrace east and terrace west areas, reflecting different degrees of contamination and different sources of ground water recharge. Ground water contaminants in the floodplain are in the uppermost aquifer, which consists of alluvium and weathered Mancos Shale. Ground water contaminants in the terrace are in the terrace ground water system, which occurs in alluvium and weathered Mancos Shale.

Floodplain ground water constituents of potential concern for human health are manganese, nitrate, selenium, sulfate, and uranium; ammonium and strontium are of potential concern to the ecology in this area. Constituents of potential concern in the terrace ground water system are ammonium, manganese, nitrate, selenium, strontium, sulfate, and uranium.

Interim actions to protect humans and ecological receptors from contaminated ground water that surfaces at several seeps and washes were completed in November 2000. The interim actions consisted of fencing, placing riprap in the washes to eliminate access to ponded water, and placement of netting to reduce access to contaminated water by birds and burrowing animals.

The proposed action consists of three compliance strategies:

Floodplain—Natural flushing supplemented by active remediation. Mill-related constituents should be removed by natural flushing within 100 years. The effectiveness of the flushing will be determined by long-term monitoring (see Section 3.2). During the initial 10 to 20 years, active remediation will consist of pumping contaminated ground water from one or more extraction wells in the most contaminated part of the floodplain. This water will be piped to a single-lined pond up to 10 acres in size and evaporated. During the natural flushing period (up to 100 years), use of ground water and drilling of new wells would be prohibited.

Terrace East—Active remediation using french drains and extraction wells to collect contaminated water, which would be piped to one or more single-lined evaporation ponds on the

terrace. Ground water moving from the terrace system down to the floodplain would be collected along the base of the escarpment by means of a slurry wall impermeable barrier and an adjacent french drain. This water along with water collected from four extraction wells in the sump area of the terrace and water from a french drain in Many Devils Wash would be piped to a pond up to 10 acres in size in the radon cover borrow pit area and evaporated. Two french drains just west of Many Devils Wash would collect ground water moving eastward toward the wash; this water would be piped either to the pond in the radon cover borrow pit or to a small, lined pond nearby and evaporated. These treatments would continue until the terrace ground water system is hydrologically disconnected from the washes and from seeps along the escarpment. DOE proposes to monitor and sample ground water in selected wells and surface water locations (see Section 3.3) semiannually for 5 years after the start of remedial action to evaluate the possibility that residual moisture is draining from the disposal cell and providing a continuing source of contamination.

Terrace West—No further remediation and application of supplemental standards based on the criterion of limited use ground water. DOE would continue to monitor and sample ground water semiannually in this area for at least the next 5 years with periodic reevaluations to ensure that current beneficial use of the ground water is not being affected by contaminants from the former millsite.

These proposed actions would reduce concentrations of mill-related constituents in the floodplain and terrace east ground water and minimize any potential for risk to human health and the environment. The compliance strategies for all three areas would result in compliance with U.S. Environmental Protection Agency standards in 40 CFR 192 or risk-based concentrations.

DOE would implement administrative actions and field activities to minimize any risk to human health and the environment during and after active remediation. These would include institutional controls oversight, wildlife management, and waste management.

On the basis of comments received on the draft EA, this final EA has been modified to reflect changes in the proposed action and in the consequences of the proposed action. The most significant change to the final EA is that it initially focuses remedial action in the terrace east area and its ground water; the draft EA focused on initial remediation of the floodplain ground water.

1.0 Introduction

The U.S. Department of Energy (DOE) is proposing three ground water compliance strategies for the Shiprock, New Mexico, Uranium Mill Tailings Remedial Action (UMTRA) Project site. These proposed strategies were derived through consultation with representatives of the Navajo UMTRA Program, the Navajo Environmental Protection Agency, and other agencies. The strategies are designed to minimize risk to human health and the environment that result from mill-related constituents in ground water and surface water.

1.1 Background

The Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA) (42 USC 2022 *et seq*.) was enacted to control and mitigate risks to human health and the environment from residual radioactive material that resulted from processing uranium ore. Residual radioactive material includes stockpiled, unprocessed ore and the sandy tailings material that remains after the milling process. These materials contain uranium and its radioactive decay products and also nonradioactive constituents such as metals, nitrate, sulfate, and ammonia that have leached from the tailings and ore into the underlying soil. UMTRCA authorized DOE to perform remedial action at 24 inactive uranium-ore processing sites. The Shiprock site is one of four former processing sites located within the Navajo Nation.

U.S. Environmental Protection Agency (EPA) regulations in Title 40 of the *Code of Federal Regulations*, Part 192 (40 CFR 192): "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings," were established to implement the requirements of UMTRCA. The regulations establish procedures and standards for cleanup of residual radioactive material in land, buildings, and ground water. The regulations also require that selection and performance of remedial action be completed with full participation of affected states, in consultation with affected Indian tribes, and with the concurrence of the U.S. Nuclear Regulatory Commission. DOE and the Navajo Nation entered into a cooperative agreement on the UMTRA Ground Water Project in February 1999. The cooperative agreement defines the scope, schedule, and budgets for activities on Navajo Nation land and is consistent with DOE's American Indian Policy.

DOE completed remedial action of surface and near-surface contamination at the site in 1986. As part of this remediation, the two tailings piles were combined and stabilized on site in a disposal cell that covers about 76 acres. The disposal cell was designed to encapsulate and isolate the contaminated material for 200 to 1,000 years. The cell cover consists of a thick radon barrier composed of windblown clayey and silty soil (loess) derived mainly from Mancos Shale placed over the tailings; an erosion protection layer of resistant rock cobbles covers the radon barrier. The radon barrier is designed to reduce radon emissions and to prevent precipitation from percolating through the contaminated materials into the underlying soil. The erosion protection layer is the outside cover of the cell; it promotes rapid runoff of precipitation to minimize the amount of water infiltrating the cell.

After the source of ground water contamination (i.e., the tailings) is removed or contained, EPA regulations require that the site be evaluated to determine if contaminant concentrations in ground water of the uppermost aquifer meet the EPA ground water standards in 40 CFR 192.

The *Final Programmatic Environmental Impact Statement for the Uranium Mill Tailings Remedial Action Ground Water Project* (PEIS) (DOE 1996) is the umbrella National Environmental Policy Act document for ground water cleanup and provides a general discussion of ground water contamination at the 24 former processing sites. The PEIS also provides a framework for selecting site-specific ground water compliance strategies that comply with EPA regulations. The regulations outline several criteria for determining compliance with ground water standards:

- A characterization/monitoring program to determine background ground water quality.
- Identification of residual radioactive material present and whether the constituents exceed background or maximum concentration limits. These limits are EPA's maximum allowable concentrations of constituents listed in Table 1 of 40 CFR 192.04 that may be present in ground water at UMTRA Project sites.
- The extent of contamination resulting from residual radioactive material.
- Potential risks to human health and the environment.

To comply with these criteria, DOE completed the *Final Site Observational Work Plan for the Shiprock, New Mexico, UMTRA Project Site* (SOWP) (DOE 2000a), which includes results of a comprehensive site characterization and an update of the original Baseline Risk Assessment (DOE 1994). The Baseline Risk Assessment evaluated potential human health and ecological risks that could result from exposure to residual radioactive material. Results of the fieldwork completed in 1999 and 2000 and the recommended compliance strategies, which are the basis for the proposed action in this environmental assessment (EA), are documented in the final SOWP.

1.2 Site Location and Description

The Shiprock site is within the Navajo Nation in northwestern New Mexico, about 28 miles west of Farmington (Figure 1). From the center of the town of Shiprock at the junction of U.S. Highways 64 and 666, the disposal cell in the site is about 1 mile to the south. The site area is south of the San Juan River and extends from the disposal cell about 1 mile to the southeast and 1.5 miles to the northwest. This arid area in the southeast part of the Colorado Plateau has generally low local relief and is characterized by broad, desolate uplands and wide, sparsely vegetated valleys. Elevation at the site is about 5,000 feet (ft). Ship Rock, the prominent landmark about 10 miles southwest of the site, is a volcanic neck that rises about 1,700 ft above the upland area.

Topographic and hydrologic features divide the UMTRA Project site into two regions known as the terrace and the floodplain (Figures 2 and 3, and Plate 1 [pocket map]). The terrace is further divided into terrace east and terrace west areas (Figure 7), reflecting different degrees of contamination and different sources of ground water recharge. The disposal cell and adjacent former millsite are in the terrace east area. About 50 to 60 ft below the terrace, the San Juan

River floodplain lies between the millsite and the river. A northwest-trending shale cliff (known as the escarpment) several hundred feet north of the disposal cell forms the boundary between the floodplain and the nearly flat terrace. Ground water in the floodplain is hydrologically connected to the San Juan River and receives inflow from the terrace ground water system. Bob Lee Wash and Many Devils Wash are two north-northeast trending drainages that cut through the terrace. Figure 2 depicts the layout of the land and prominent features near the site; Figure 3 is a 1986 aerial photograph of the Shiprock site as surface remediation neared completion.

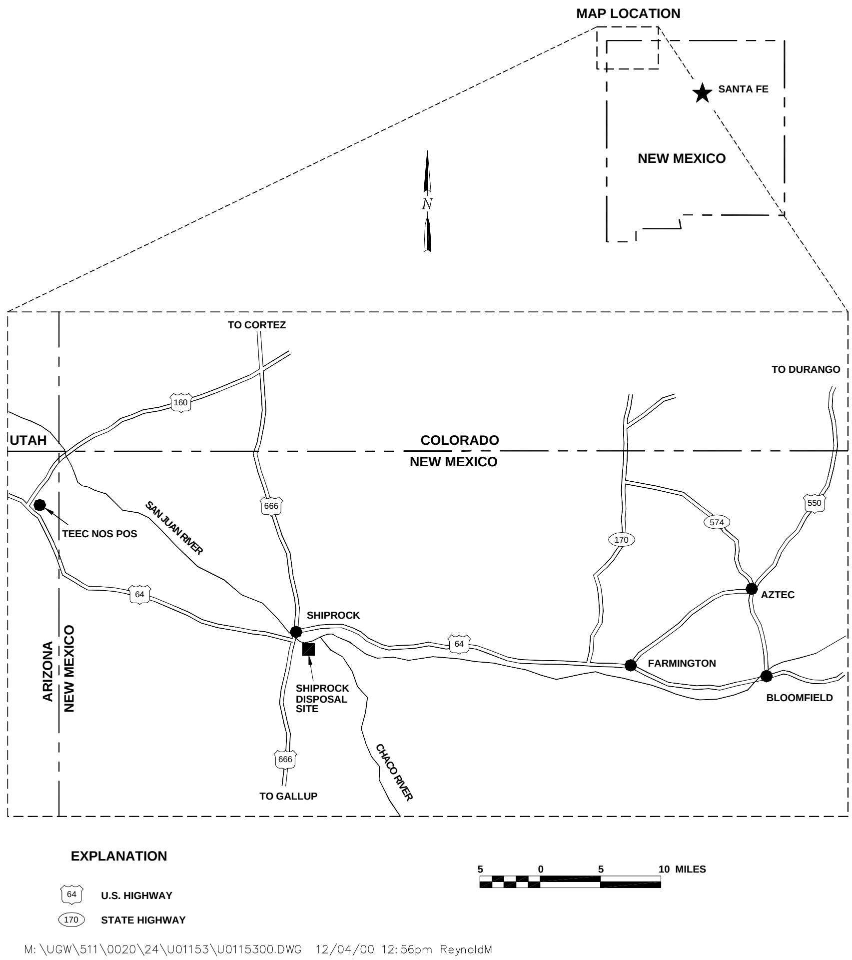

Figure 1. Location of the Shiprock Site

1.3 Site History

Much evidence suggests that the terrace alluvium was unsaturated in the Shiprock area south of the San Juan River in the 1930s and early 1940s before the start of irrigated farming, housing developments, business developments, a helium processing plant, and a uranium mill. Significant quantities of helium were found along with nitrogen in oil and gas fields in the area in the early 1940s. In 1944, the U.S. Bureau of Mines constructed a helium processing plant about 0.75 mile northwest of the former uranium mill. The helium plant was later dismantled, and the Shiprock Shopping Center currently occupies that location.

The uranium mill, known as the Navajo Mill, was operated by Kerr-McGee from November 1954 to March 1963 when it was sold to the Vanadium Corporation of America (VCA). VCA operated the mill until August 1967 when the company merged with Foote Mineral Company, which continued operation until milling ended in August 1968. Before and during the milling operations, the site was leased from the Navajo Nation. In 1973, the lease expired and the site ownership reverted to the Navajo Nation.

Throughout the 14-year milling period, the Shiprock area south of the San Juan River and west of the Navajo Mill gained population, and agricultural use increased. In 1956, the Bureau of Indian Affairs completed construction of an irrigation project in the terrace area west of the Navajo (helium) Plant. Irrigation water was brought from the Hogback Canal (diverted from the San Juan River about 8 miles east of Shiprock) southward and distributed to the terrace area by means of the Helium Lateral Canal. By 1960, irrigated farming was well established in this area.

In 1961, a well was drilled as an oil and gas test to a depth of 1,850 ft on the terrace about 0.4 mile northwest of the mill. Known in the UMTRA Project as artesian well 648 (Navajo tribal well 12T-520), the well was not capped and has since flowed from a screened zone in the Morrison Formation below any mill-related contamination.

Some of the mill buildings and most of the equipment were dismantled and placed in the west tailings pile from the time that milling ended in 1968 to the expiration of the Foote Mineral Company lease in 1973. In about 1972, Shiprock Community Development completed several large housing projects on the terrace about 0.75 mile to 1 mile southwest of the millsite. Municipal water and sewer lines to support this development increased the amount of water available to the shallow ground water system south and west of the millsite.

Ground water at the Shiprock site is present in alluvial sediments of the terrace and the San Juan River floodplain. The terrace ground water system consists of saturated sand and gravel at the base of the alluvium and the upper, weathered portion of the underlying Mancos Shale. The presence of terrace ground water is thought to be a result of human activity in the area. Drilling in geologically similar material in a terrace background area indicated that both the base of the alluvial material and the weathered part of the Mancos Shale were dry. Also, considered alone, natural rates of recharge in the millsite terrace appear to be insufficient to sustain a water table (DOE 2000a).

The creation of a terrace ground water system is probably tied to multiple events, including (1) pumping of San Juan River water to the terrace for production and processing of helium at the former Navajo (helium) Plant, (2) pumping of San Juan River water to the terrace for processing uranium ore at the Navajo Mill, (3) spraying water for dust control during disposal cell stabilization, (4) siphoning of San Juan River water to the terrace for irrigation through the Helium Lateral Canal, and (5) leaking municipal water supply and sewer lines and domestic sewer systems.

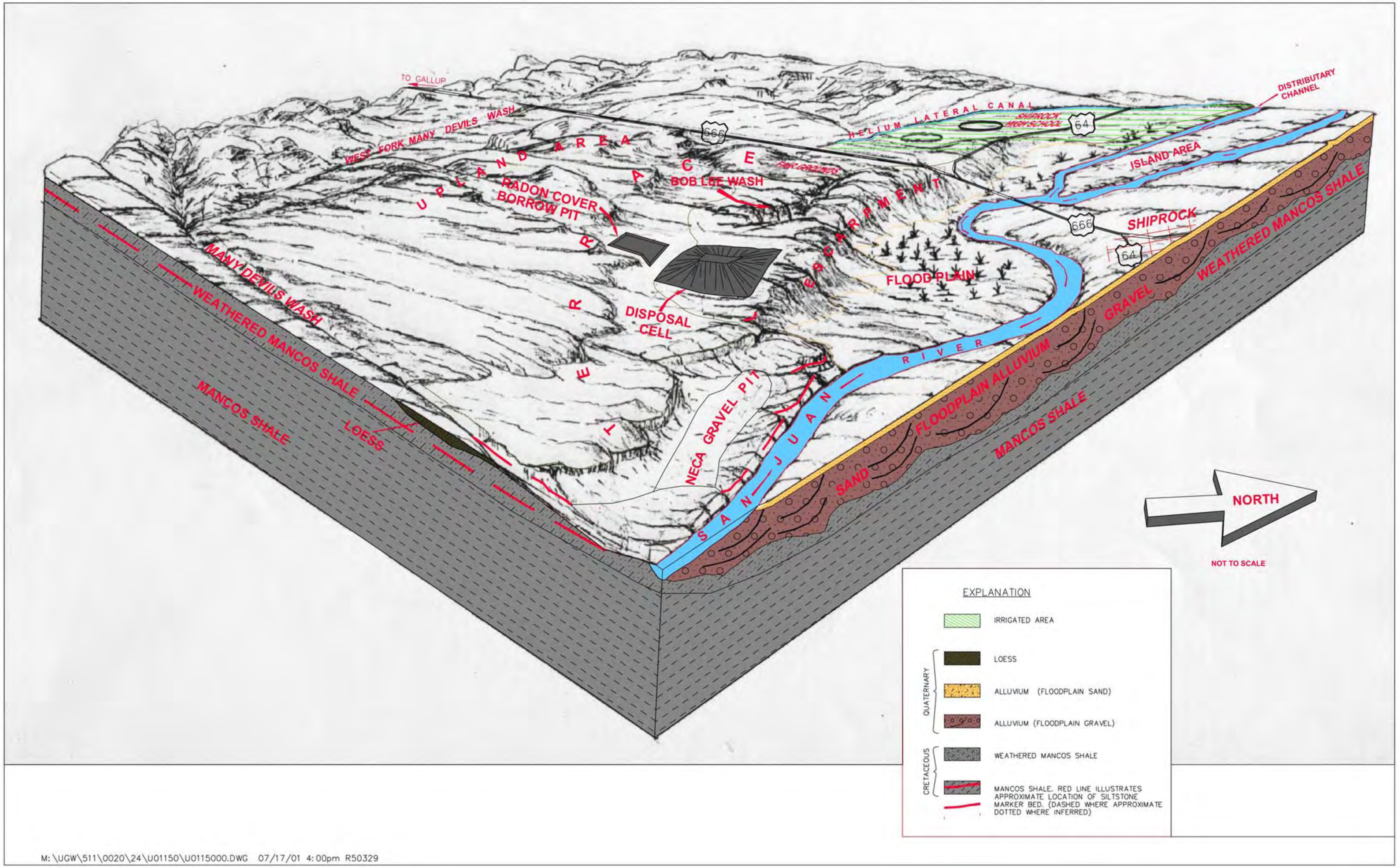

Figure 2. Physiographic Block Diagram of the Shiprock Site

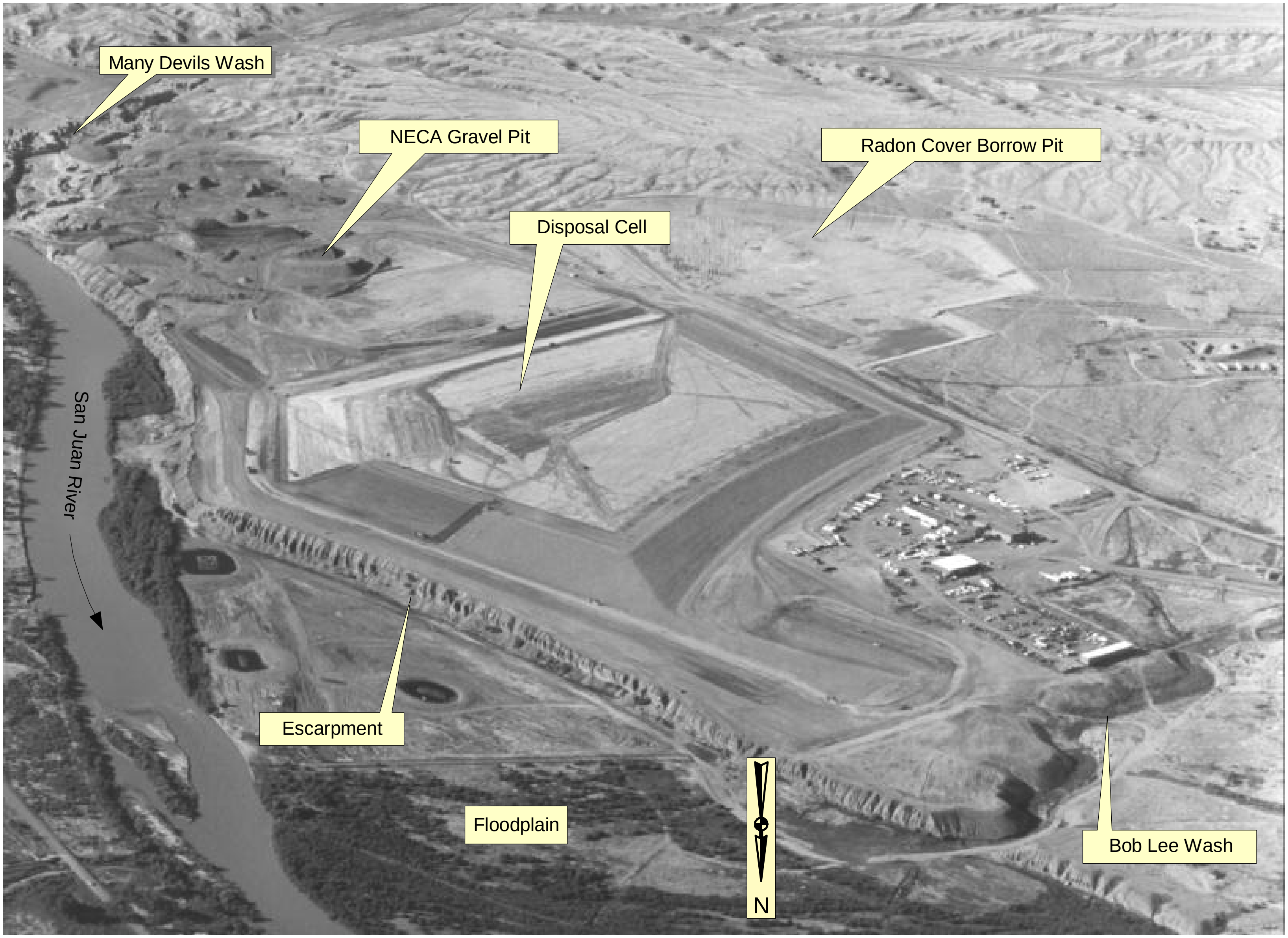

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Figure 3. July 1986 Aerial Photograph Looking Southeast at the Shiprock Site.

1.4 Overview of Contamination

Historical processing of uranium ore at the site has resulted in contaminated ground water. DOE collected ground water, surface water, soil, salt deposit, and sediment samples from the floodplain and terrace areas from September 1985 to fall 2000. Analytical data from these samples are extensive and are included in Appendixes B through E of the SOWP (DOE 2000a). Section 4.4 of the SOWP presents a detailed summary of these analyses.

Monitoring over the past 15 years has shown that concentrations of several ground water chemicals that were historically elevated, such as antimony and cadmium, have decreased to levels below instrument detection limits. Section 6.0 of the SOWP provides a comparison of data collected since December 1998 with UMTRA Ground Water Project standards, Navajo Nation surface water standards, and ecological and human health risk benchmarks. On the basis of these analyses, DOE identified nitrate, uranium, sulfate, selenium, and manganese as posing a potential human health risk in floodplain ground water, assuming use as drinking water in a residential scenario. Ammonium and strontium are also of potential concern for ecological risks. Concentrations of these same constituents are elevated in the terrace ground water system and would pose human health or ecological risks if ingested. Therefore, DOE is continuing to monitor both the terrace and floodplain ground water systems for ammonium, manganese, nitrate, selenium, strontium, sulfate, and uranium.

Highest concentrations of mill-related constituents in terrace ground water are generally in samples obtained near the former millsite, the disposal cell, and Bob Lee and Many Devils Washes. Ground water near the former millsite has a northerly flow toward Bob Lee Wash. Because the contaminated ground water discharging into upper Bob Lee Wash would be a potential risk to livestock if it were consumed as the only source of drinking water over a long term, DOE has implemented interim actions to reduce possible exposure of these receptors to the water. Interim actions are short-term actions taken to mitigate or eliminate release of a hazardous substance or prevent contact with contaminated media. These actions are described in Section 1.5.

South of the disposal cell, terrace ground water is present in a buried ancestral channel of the San Juan River. Flow of this ground water in the ancestral channel is mainly to the northwest toward the area irrigated by the Helium Lateral Canal; some flow is also to the east toward Many Devils Wash. Because a probable livestock exposure point exists where the ground water discharges into Many Devils Wash, DOE also established interim actions to cover the exposed water in this wash.

The floodplain alluvial aquifer is bounded by the escarpment along its southern margin and by the San Juan River along its northern margin. It is believed that the terrace ground water system continues to discharge into the floodplain aquifer. Transport modeling suggests that mill-related contaminants in the floodplain aquifer would flush within 100 years if no contaminant source existed (DOE 1999a).

1.5 Interim Actions

Contaminated ground water from the terrace system discharges to the surface at several locations. These surface expressions of ground water are the only complete exposure pathways to terrace system ground water at the site. Potential risk is greatest to biological receptors. To minimize potential risks to human health and ecological receptors, DOE completed several interim actions, including grazing restrictions, fencing, and netting to eliminate access to contaminated seeps and surface water. Areas affected by the interim actions are upper Bob Lee Wash, lower Many Devils Wash, and seeps 425 and 426 (Plate 1 in map pocket). The long-term remediation strategy for both washes and seeps 425 and 426 is to remove ground water from the terrace east area to the point that the seeps are dried up. Improvements added to the area as a result of interim actions will be inspected at least annually and, if necessary, will be modified or restored.

The following interim actions in Bob Lee Wash, Many Devils Wash, and seeps 425 and 426 were completed in late summer and fall 2000.

Interim Actions at Bob Lee Wash

- A fence was installed around the perimeter of the upper part of the wash to keep livestock and large animals from entering the wash and to minimize human access.

- A layer of 2- to 6- inch-diameter rocks (riprap) was placed in low areas of the main drainage where water had ponded. A woven geotextile (a synthetic fabric) was first placed on the surface in the ponded areas to stabilize the soil under riprap loading. Small aggregate was placed over the geotextile, and a geogrid (a plastic mesh) was placed over the aggregate to provide a barrier that prevents small-animal access to the water. Larger riprap (8–12 inch diameter) was then placed over the geogrid.

Interim Actions at Many Devils Wash

- A fence was installed in the main wash at the confluence of the East Fork, along the west side of the wash on the terrace above, and along the east side of the wash at access points. The fencing prevents livestock from entering the wash area. A fenced corridor was placed on the siltstone bed at the knickpoint of the wash to allow livestock to cross the wash. (A knickpoint represents a break in the slope of a stream, or an abrupt change in its profile.)

- A drainpipe was installed in a shallow trench cut through the siltstone bed at the knickpoint to prevent livestock from drinking the contaminated water while using the fenced corridor.

- Riprap was placed in the bottom of the wash in all areas above and below the knickpoint where water has ponded. A woven geotextile was first placed on the surface in the ponded areas to stabilize the soil under riprap loading. Small aggregate was placed over the geotextile, and a geogrid was placed over the aggregate to provide a barrier that prevents small-animal access to the water. Large riprap was then placed over the geogrid.

Interim Actions at Seeps 425 and 426

A fence was constructed around both seeps, and netting was placed over the top of each fenced area to prevent birds from accessing the seep water.

Field Evaluation of Interim Actions

On July 19, 2001, DOE, Navajo UMTRA, and the U.S. Fish and Wildlife Service (USFWS) jointly conducted a field evaluation of the interim actions. Because of heavy rain a few days earlier on July 14 (estimated to be a 25-year event), about 20–25 percent of the interim actions in the two washes had been damaged or washed out. Interim actions at the seeps were unaffected. DOE is currently evaluating the extent of repairs needed.

2.0 Purpose and Need for Action

The purpose of the UMTRA Ground Water Project is to protect human health and the environment at abandoned ore-processing sites by complying with the final EPA ground water standards in 40 CFR 192 Subpart B. DOE proposes to implement the compliance strategy outlined in the SOWP (DOE 2000a), which uses the framework established in the PEIS (DOE 1996). Figures 4, 5, and 6 show the compliance selection framework as it applies to each of the three project areas at the Shiprock site.

3.0 Proposed Action and Alternatives

Only the proposed action and no action alternatives are presented in this EA. The PEIS provides several alternatives for complying with EPA's ground water standards and assesses in general terms the effects associated with each compliance strategy. Section 7.0 of the SOWP provides the rationale for selecting the compliance strategies proposed in this EA, and Section 8.0 of the SOWP discusses active remediation alternatives. The strategies are consistent with the compliance selection framework in the PEIS.

DOE would work with the Navajo Nation UMTRA Program and other agencies to implement institutional controls or other controls where needed to restrict use of areas that may be affected by contaminated ground water during the remedial action period. Institutional controls are controls that prohibit or limit access to contaminated media. At the Shiprock site, these may include access controls, grazing restrictions, a drilling moratorium, permit restrictions, and other administrative measures.

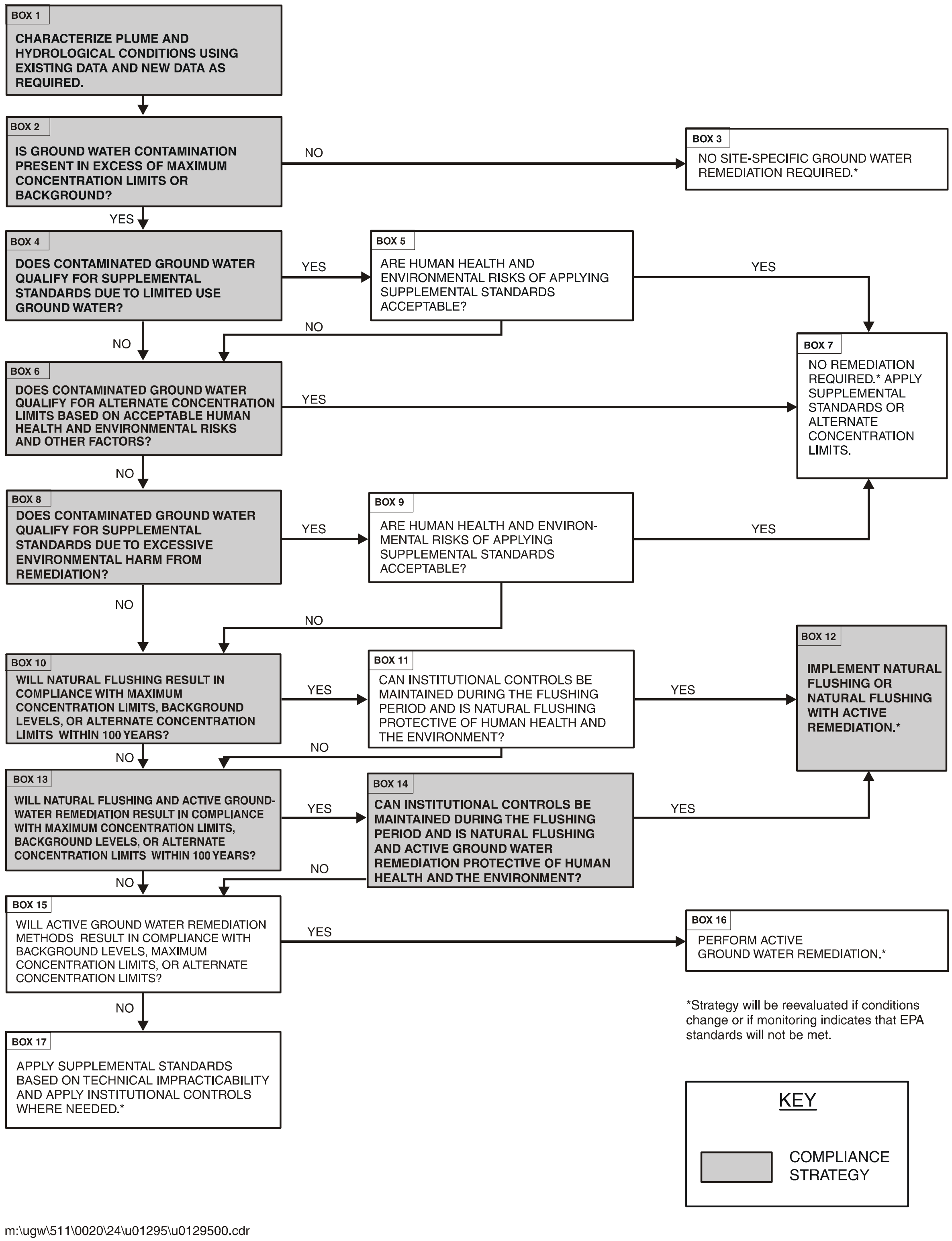

Figure 4. Ground Water Compliance Selection Framework for the Floodplain

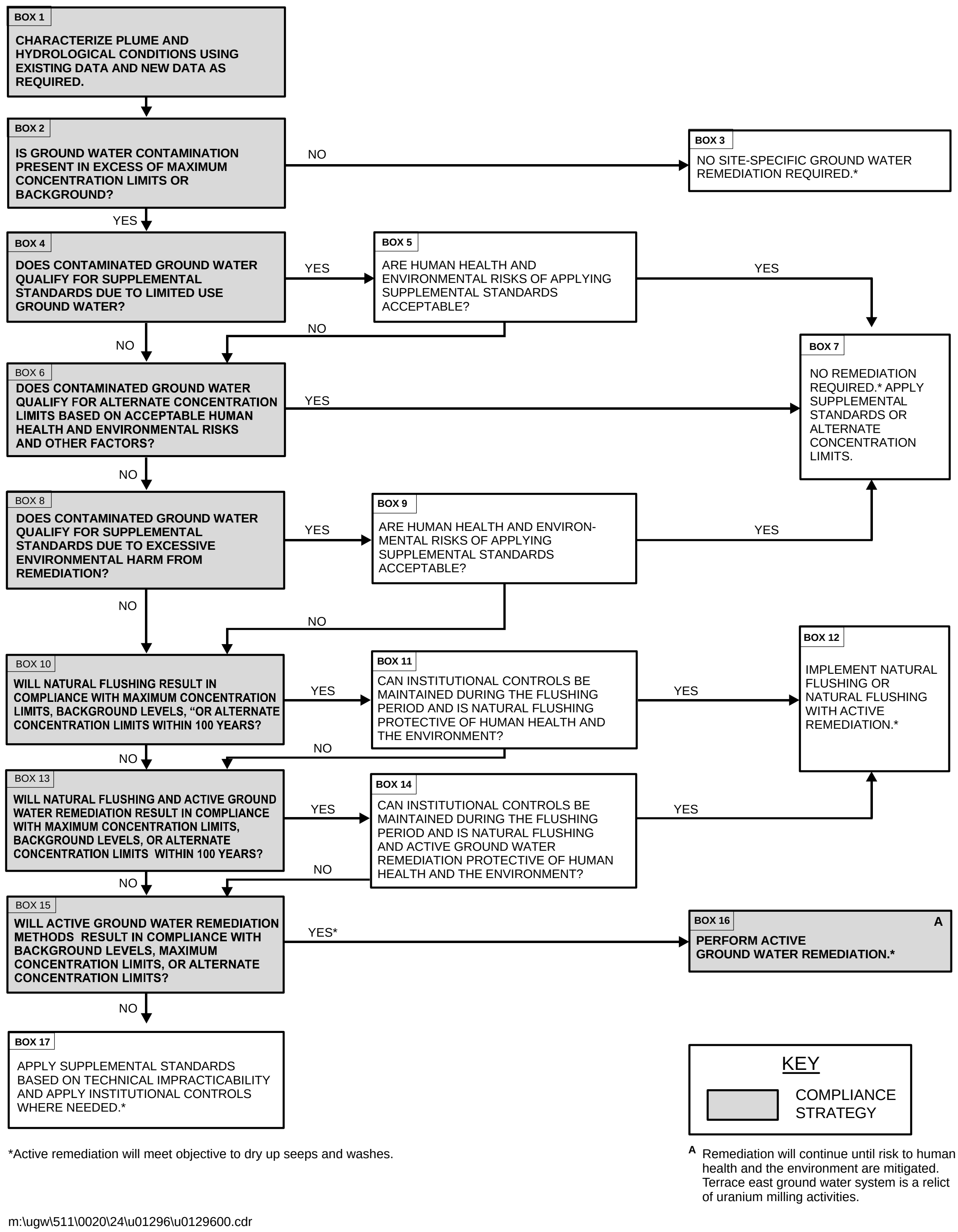

Figure 5. Ground Water Compliance Selection Framework for the Terrace East Area

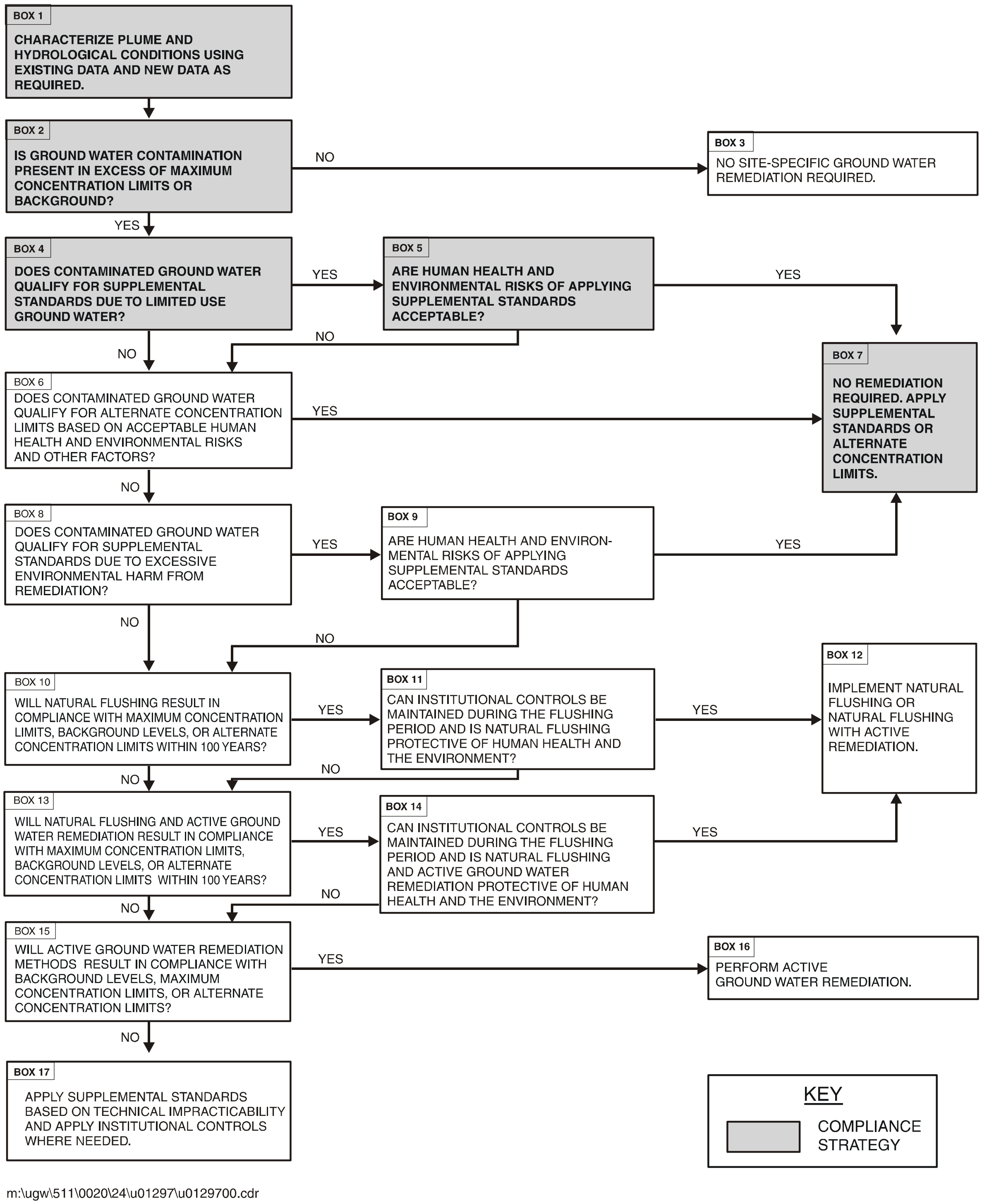

Figure 6. Ground Water Compliance Selection Framework for the Terrace West Area

3.1 Compliance Strategy Selection

This EA presents information from the SOWP that describes the scope of the compliance strategies and related human health and environmental effects. Table 1 summarizes the proposed strategy for each of the three project areas. Table 2 shows the EPA numerical ground water standards. Also, an applicable Navajo Nation standard for uranium in surface water used for domestic purposes is 35 milligrams per liter (mg/L).

Table 1. Summary of Proposed Compliance Strategies

Project Area	Ground Water Constituents	Compliance Strategy	Rationale
Floodplain	Ammonium, manganese, nitrate, selenium, strontium, sulfate, and uranium	Natural flushing with monitoring supplemented with some active remediation	During the initial 10 to 20 years, active remediation from one or more wells will remove constituents form the most contaminated area of the floodplain. Natural flushing will remove mill-related constituents within 100 years.
Terrace East		Active remediation with monitoring	Active remediation at the base of the escarpment will intercept and remove contaminated water moving from the terrace east area to the floodplain. Active remediation on the terrace will reduce the concentrations of constituents entering the washes and seeps and will dry up the seeps.
Terrace West		Supplemental standards with monitoring (40 CFR 192)	Widespread ambient contamination not related to uranium milling processes. Alluvial ground water is partly a result of irrigation practices and partly a result of past milling operations.

Table 2. Ground Water Constituents and EPA Maximum Concentration Limits

Constituent	Maximum Concentration Limit (40 CFR 192)
Ammonium	NA; see discussion of risk-based concentrations in Section 4.8
Manganese	NA; see discussion of risk-based concentrations in Sections 4.8
Nitrate (as N)	10 mg/L (equivalent to 44 mg/L as NO_3)
Selenium	0.01 mg/L
Strontium	NA; see discussion of risk-based concentrations in Section 4.8
Sulfate	NA; see discussion of risk-based concentrations in Sections 4.8
Uranium (234+238)	30 pCi/L (equivalent to 0.044 mg/L assuming secular equilibrium)

Notes: NA means that the constituent does not have a maximum concentration limit in 40 CFR 192.
pCi/L = picocuries per liter

3.2 Floodplain Compliance Strategy

3.2.1 Active Remediation Phase

The proposed action for the floodplain aquifer is natural flushing with monitoring supplemented by some active remediation at one or more wells to remove constituents from the most contaminated area of the floodplain. In the natural flushing strategy, natural geochemical and biological processes and ground water movement decrease ground water contaminant concentrations through time. Included in the proposed action are institutional controls, which consist of prohibiting grazing, prohibiting drilling of new wells for use of ground water, and ensuring that artesian well 648 continues to flow and that its water continues to discharge down Bob Lee Wash to the floodplain. Approximately 150 million gallons (460 acre-feet) of ground water in the floodplain is believed to be affected by past ore-processing activities. The active remediation phase of the strategy would consist of drilling from one or more extraction wells, withdrawing water from the well, and pumping it through underground piping to a lined pond in the terrace east area where it would be evaporated.

Figure 7 shows the proposed location of the first extraction well, which is in the area of highest contaminant concentrations in the floodplain ground water. The one or more extraction wells would be designed to pump up to 10 gallons per minute (gpm) for a period of 10 to 20 years, but pumping from these wells would not be continuous. At times when the evaporation pond becomes dry because of lack of water from other sources, the one or more floodplain extraction wells would be pumped. Monitor well 854, which is near the proposed initial extraction well, will be designated the point of compliance well. The designated point of exposure will be location 940, which is a surface water sampling location along the San Juan River (Plate 1).

Compliance standards for uranium and nitrate are their UMTRA Project standards of 0.044 mg/L and 44 mg/L, respectively. If monitoring indicates that leaching of Mancos Shale in the irrigated area of terrace west is contributing uranium and selenium contamination to the floodplain, the cleanup standards for both constituents may be reevaluated and an alternate concentration limit may be proposed. An alternate concentration limit may be applied only with the concurrence of the U.S. Nuclear Regulatory Commission and in situations where it can be determined that the constituent will not pose a substantial present or potential hazard to human health and the environment as long as the alternate concentration limit is not exceeded (40 CFR 192.03). For manganese, the cleanup objective is the maximum background concentration, which is currently 2.74 mg/L. This value may change if higher background values are found in future sampling.

Detailed modeling will be conducted to optimize the location of the one or more extraction wells and to ensure that natural flushing will reduce contaminant concentrations to acceptable levels within 100 years. Details of this strategy will be included in the Ground Water Compliance Action Plan. Piping from the one or more extraction wells would be placed in areas that would not affect local activities and sensitive resources, including cultural resources and plant and

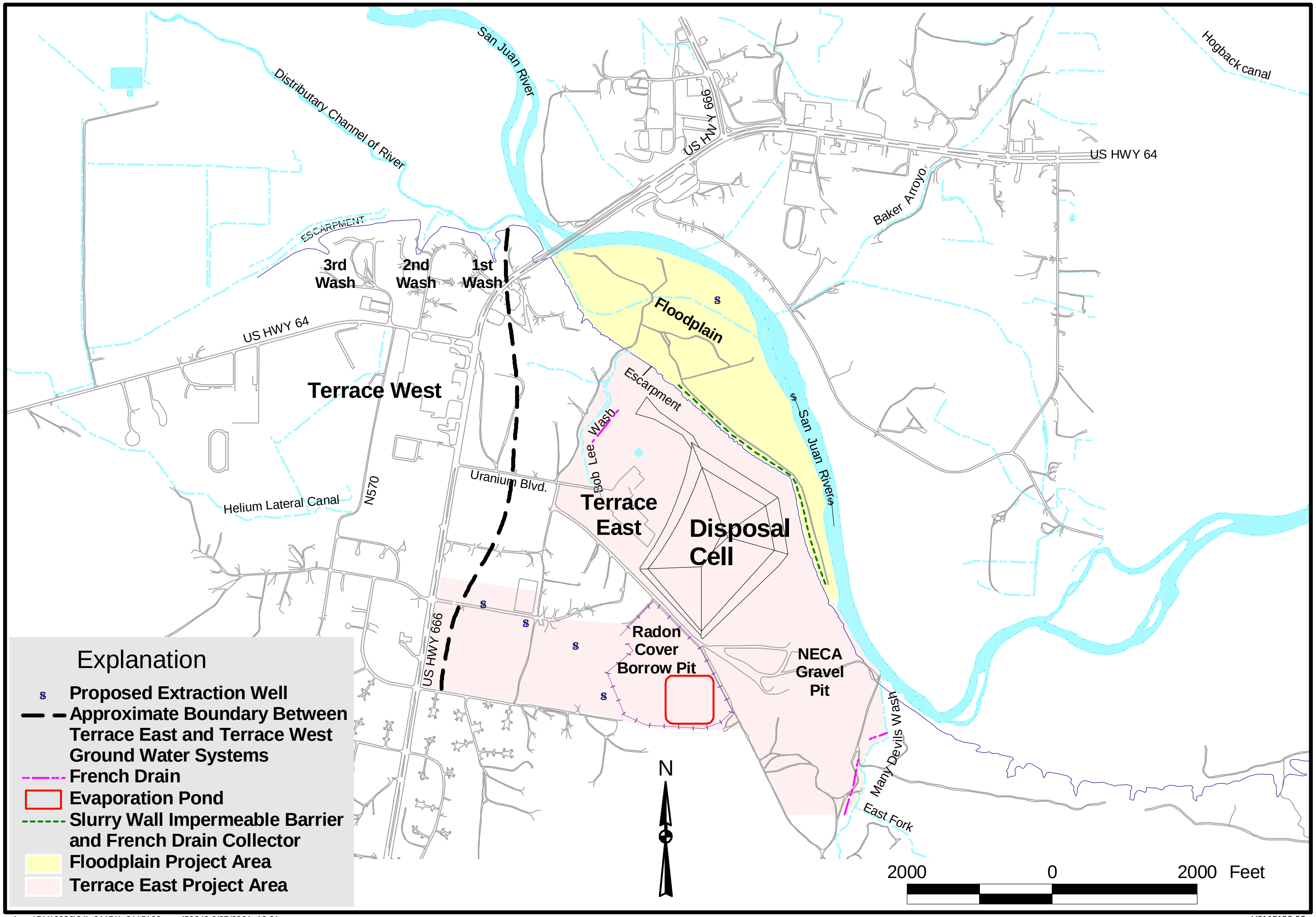

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Figure 7. Approximate Location of Proposed Extraction Wells, French Drains, Evaporation Ponds, and Slurry Wall Impermeable Barrier in the Terrace East and Floodplain Project Areas

animal species protected by federal and tribal regulations. DOE would be required to obtain approval from the New Mexico State Engineer's Office if it is determined that water rights in the San Juan River could be affected. DOE would conduct ground water and surface water monitoring during the 10- to 20-year period of pumping contaminated ground water from the floodplain. Plate 1 shows the monitoring locations; Table 3 identifies the analyses and monitoring parameters.

The proposed monitoring would be conducted semiannually for 5 years after pumping commences. During the initial 5-year period, DOE would evaluate the success of the active remediation phase of the floodplain compliance strategy based on decreasing concentrations of mill-related constituents. For the second 5-year period (through year 10), monitoring would be conducted annually, followed by sampling every 5 years or as necessary.

Table 3. Summary of Monitoring Requirements for the Floodplain

Location	Monitoring Purpose	Analyses	Frequency
Wells 608, 614, 615, 618, 619, 735, 797, 850, 854	Compliance action levels (40 CFR 192)	Manganese, nitrate, selenium, sulfate, uranium (and ammonium and strontium based on ecological concerns) Water chemistry: calcium, chloride, magnesium, potassium, sodium On-site field analyses: alkalinity, conductivity, oxidation-reduction potential, pH, water level (in wells)	Semiannually for the first 5 years, then annually through year 10, and every 5 years thereafter
Surface 898	San Juan River, background		
Surface 897, 940, 1205	San Juan River, background		
Surface 897, 940, 1205	San Juan River on site		
Surface 956	Intake on north side of San Juan River, risk		
Surface 957	San Juan River, downgradient, risk		
Surface 655	Floodplain drainage channel, risk		
Surface 887	Distributary channel, risk		
Surface 959	Distributary channel, risk		

3.2.1.1 Institutional Controls

UMTRCA authorizes the use of institutional controls to minimize the potential for risk to human health and the environment. DOE completed a Range Management Plan (DOE 2000b) that restricts grazing in the floodplain for a 5-year period during initial remediation. The Navajo Nation and affected grazing allottees entered into an agreement with DOE (DOE 1999b), whereby DOE would compensate affected parties for loss of grazing rights during this period. Access to the floodplain is also controlled by the Navajo Nation and DOE for activities that may affect or be affected by UMTRA Project actions.

DOE would enter into an agreement with the Navajo Nation to prohibit drilling new wells or using ground water in the floodplain until remediation is completed. DOE would also request that the Navajo Water Code Administration ensure that artesian well 648 be allowed to continue flowing directly into Bob Lee Wash, which discharges to the floodplain through a wetland area.

The past 40 years of continuous flow from well 648 to the floodplain has flushed contamination from much of the floodplain to the north and northwest of the wetland at the mouth of Bob Lee Wash. Success of the proposed remediation for the floodplain will depend on well 648 continuing to flow. Appendix A presents an assessment of the floodplain and wetland. The time frame for institutional controls is projected to be between 10 and 30 years from the time the U.S. Nuclear Regulatory Commission concurs with the Ground Water Compliance Action Plan.

3.2.1.2 Waste Management

Remediation of floodplain ground water would produce the same types of waste as the terrace east remediation. Section 3.3.1 describes the strategy for waste management. Process wastes would be co-managed with similar wastes from terrace east in a centralized evaporation pond.

3.2.1.3 Wildlife Management Provisions

DOE would develop a wildlife management plan in consultation with USFWS and the Navajo Fish and Wildlife Department that targets protection of sensitive species subject to federal and tribal regulations. The essential elements of the plan would include identifying species likely to occur in the area, monitoring requirements and, if necessary, mitigation measures such as fencing and other appropriate controls that would reduce or eliminate wildlife contact with the pond.

3.2.2 Natural Flushing Phase

If the active remediation phase is successful and removes the highest concentrations of constituents, natural flushing would remove the balance of contamination. Without a source of residual moisture from the terrace, it is predicted that mill-related contaminants in the floodplain ground water will flush naturally within 100 years. Active remediation, consisting of pumping contaminated water from one or more extraction wells, will occur during the first 10 to 20 years of the flushing period. The one or more wells will remove constituents from some of the most contaminated part of the floodplain. Contaminant distribution maps, consistent water levels around the disposal cell, and estimated water flow directions from wells between the disposal cell and the floodplain indicate that a residual moisture source from the disposal cell may be present. A geotechnical investigation will be conducted to evaluate the saturated conditions in the disposal cell and its potential to act as a continuing source. Results of monitoring during this investigation and during remediation will be shared with stakeholders and regulators, and additional compliance strategies will be evaluated as necessary.

3.3 Terrace East Compliance Strategy

The proposed compliance strategy for terrace east is active remediation using french drains and extraction wells to collect contaminated water, which will be piped to one or more evaporation ponds. Figure 7 shows the elements of terrace east remediation. Ground water that moves from the terrace system down to the floodplain will be collected along the base of the escarpment in a french drain at least 3,000 ft long. Water in the french drain is expected to collect at a rate of about 10–12 gpm. A slurry wall impermeable barrier will be placed parallel to the french drain several feet away on the floodplain side. The slurry wall will prevent contaminated terrace ground water from entering the floodplain ground water system.

About 40 million gallons (123 acre-feet) of contaminated water is believed to remain in the terrace alluvial material as a result of past milling operations. Remediation on the terrace will consist of four extraction wells, french drains, and one or more evaporation ponds. The objective is to pump mill-related water out of the base of the alluvial material and weathered Mancos Shale. The purpose of this action is to eliminate the exposure pathways that existed at the washes and seeps before the interim actions were in place. Success would be measured by demonstrating that the seeps have dried up. DOE would establish a system for measuring the flow from seeps draining into Bob Lee and Many Devils Washes, seeps 425 and 426 in the lower part of the escarpment, and seep 786 below the U.S. Highway 666 bridge. Baseline data collection would begin in 2001. Afterward, data would be collected two times per year during normal water sampling. Flows in the washes and from the escarpment seeps are anticipated to decline toward the end of the 5-year period.

The extraction wells will be west of the radon cover borrow pit in the sump area where the saturated thickness at the base of the alluvial material is greatest. These wells are expected to pump water at a rate of about 1 to 2 gpm. In much of the remainder of the terrace east area, the saturated thickness is small (about 1 ft or less) and is impractical to remediate.

One french drain will be constructed just east of Bob Lee Wash, and two french drains will be placed just west of Many Devils Wash (Figure 7). These drains will be constructed as interceptor trenches and will be excavated below the ground water surface to competent Mancos Shale to intercept water flowing through alluvial material and weathered Mancos Shale. The trenches will likely have a perforated pipe at the bottom and will probably be partially backfilled with gravel or small rock to prevent soil from plugging the perforations and to provide a flow path to the pipe. These three french drains are expected to collect water at a total rate of about 4 gpm.

Water withdrawn from the terrace and floodplain wells and from the french drains at the base of the escarpment and in Bob Lee Wash will be pumped through underground piping to a single-lined evaporation pond covering up to 10 acres in the southeast part of the radon cover borrow pit. Water collected from the french drains in the Many Devils Wash area will be piped underground either to the pond in the radon cover borrow pit or to a small, single-lined evaporation pond near the wash. The subsoil under both evaporation ponds would be amended with bentonite and compacted to achieve low permeability. Location of the piping network will be determined during completion of the Ground Water Compliance Action Plan. The main evaporation pond would initially use natural evaporation only, based on an estimated evaporation rate of 2 gpm per acre and a 20 gpm water supply. Enhancing evaporation by use of spray would produce more extraction capacity, and this method may be used later if adverse environmental effects can be avoided. The evaporation ponds and piping would be placed in areas that would not affect humans and sensitive resources, including cultural resources and plant and animal species protected by federal and Navajo Nation regulations.

DOE would conduct ground water and surface water monitoring concurrently with pumping contaminated ground water from the terrace area. Table 4 identifies the target chemicals and monitoring parameters, and Plate 1 shows the monitoring locations.

The time needed for completing terrace east remediation is estimated at 5 to 10 years. During this period, DOE would continue to monitor and evaluate the success of the active remediation phase. Results of analyzing for mill-related constituents and major elements would be used to evaluate the extent and nature of any continuing source from the disposal cell. These results would be shared with stakeholders and regulators, and additional compliance strategies would be evaluated as necessary.

A buffer zone of at least 100 ft around the proposed evaporation pond would be needed to provide room for maintenance and for removal of residue from evaporation. This area would be fenced and posted to control access.

Table 4. Summary of Monitoring Requirements for Terrace East and Terrace West

<table>
<tr><th>Location</th><th>Purpose</th><th>Analyses</th><th>Frequency</th></tr>
<tr><td>Well 648</td><td>Cleanup standards for floodplain</td><td rowspan="2">Ammonium, manganese, nitrate, selenium, sulfate, uranium; strontium for ecological risk concerns

Water chemistry: calcium, chloride, magnesium, potassium, sodium

On-site field analyses: alkalinity, conductivity, oxidation-reduction potential, pH, water level</td><td>Semiannual flow measurements; sample for chemical analyses every 2 years (last sampled in February 2001)</td></tr>
<tr><td>Terrace east wells: 603, 812, 813, 816, 817, 818, 826, 827, 828, 1004, 1007, 1057, 1059

Terrace west wells: 832, 835, 836, 838, 839, 841, 846, 847, 1060</td><td>Water level and ground water chemistry</td><td rowspan="2">Semiannually for the first 5 years, then annually through year 10, and every 5 years thereafter</td></tr>
<tr><td>Terrace east wells: 727, 728, 819, 829, 1065, 1066, 1067, 1068, 1069

Terrace west wells: 814, 815</td><td>Monitor lowering of water levels</td><td>Water level</td></tr>
<tr><td>Terrace east surface water: 425, 426, 786, 885, 886, 889

Terrace west surface water: 884, 933, 934, 936, 942, 958</td><td>Monitor for ecological risks and lowering of water levels</td><td>Ammonium, manganese, nitrate, selenium, sulfate, uranium; strontium for ecological risk concerns

Water chemistry: calcium, chloride, magnesium, potassium, sodium

On-site field analyses: alkalinity, conductivity, oxidation-reduction potential, pH, water level

Water level for 885, 886, and 889

Flow rate for 425, 426, and 786</td><td>Sample 958 for chemical analysis once every 2 years (last sampled in February 2001)</td></tr>
</table>

3.3.1 Waste Management

Two main types of waste would be generated from constructing the slurry wall and french drains: (1) secondary wastes generated from drilling, developing, and monitoring extraction wells and trenches, and (2) process wastes generated from evaporation of contaminated ground water. Wastes generated during installation of extraction wells and buried piping and during excavation and construction of the evaporation pond would include soil, drill cuttings, well development water, field test kits, and miscellaneous solid wastes such as disposable gloves and sampling equipment. These wastes would be only in the site area and would not affect the off-site environment.

All drill cuttings would be spread on the ground around each well. In the unlikely event that they contain radium-226 in excess of 5 picocuries per gram above background, cuttings would be buried in a shallow trench at least 6 inches below ground surface. Ground water brought to the surface during installation and development of the extraction wells may be dispersed over a predetermined area until the evaporation pond is in place. After that time, any new well development water would be discharged to the pond. All miscellaneous solid wastes and debris would be removed from the site on a regular basis until construction activities are completed. Recyclable and salvage material such as paper, wood, PVC pipe, and plastic would be managed accordingly. Secondary wastes would be managed at the time of generation according to DOE's general approach to managing wastes at UMTRA Project sites described in the *Management Plan for Field-Generated Investigation-Derived Wastes* (DOE 2000c).

Process wastes would be co-managed with similar wastes from the floodplain area in a lined evaporation pond. At the end of active remediation, management of sludge in the evaporation pond would require haul trucks and excavating equipment. These activities would produce a short-term increase in the amount of noise and the number of large vehicles and general construction equipment during sludge and liner removal. After active remediation ends, the process wastes (e.g. sludge and pond lining) would be removed and transported to an appropriately licensed DOE disposal facility, possibly the Cheney repository near Grand Junction, Colorado.

3.3.2 Wildlife Management Provisions

Before the start of ground water remediation, a wildlife management plan would be developed that targets protection of sensitive species and critical habitat subject to federal and tribal regulations. Concerns would include noise levels, avoidance of critical habitat, seasonal uses by sensitive species such as the southwestern willow flycatcher, buffer zones, and necessary restrictions. Essential elements of the plan would include identification of species likely to occur in the project area, development of provisions to avoid effects to these species, and any necessary monitoring measures. The plan would be developed in consultation with the U.S. Fish and Wildlife Service (USFWS) and the Navajo Fish and Wildlife Department.

3.4 Terrace West Compliance Strategy

The application of supplemental standards with monitoring is proposed for the terrace west. Supplemental standards are regulatory standards that are used instead of background concentrations, maximum concentration limits, or alternate concentration limits in situations where ground water meets at least one of eight criteria in 40 CFR 192.21. The criterion proposed for terrace west is that of limited use ground water. Limited use means ground water that is not a current or potential source of drinking water because (1) widespread ambient contamination not related to milling activities exists that cannot be cleaned up using treatment methods reasonably employed in public water systems, (2) concentrations of total dissolved solids are in excess of 10,000 mg/L, or (3) the surficial aquifer will not consistently produce 150 gallons per day (0.1 gpm).

After about 7 years of active remediation in the terrace east system, recharge from terrace east to terrace west should be hydraulically cut off, and the source of mill-related contamination will no longer affect the terrace west area. After this period, irrigation water from the Helium Lateral Canal will continue to provide a source of ground water recharge for most of the terrace west ground water system. This should result in flushing mill-related constituents from most of the area. However, it is highly probable that some constituents in the ground water—notably uranium, selenium, and sulfate—are derived from natural leaching of Mancos Shale rather than from former milling operations. Therefore, criterion 1—widespread ambient contamination not related to milling activities—can be applied to the ground water system in the terrace west area. Section 4.4.8 of the SOWP provides documentation of elevated naturally occurring levels of selenium, sulfate, and uranium in the Mancos Shale.

The types and duration of monitoring and rationale for the proposed monitoring in the terrace west area are the same as those for the terrace east area and are described in Section 3.3. Plate 1 shows the monitoring locations, and Table 4 identifies the analyses and monitoring parameters. Monitoring would be conducted to ensure that mill-related constituents do not affect water quality in terrace west and to confirm that certain constituents continue to be present as a result of leaching from Mancos Shale.

3.5 No Action Alternative

The no action alternative provides a baseline for comparing the effects of the proposed action (10 CFR 1021.321[c]). Under the no action alternative at the Shiprock site, no further site activities would be performed at any of the three areas, including well monitoring and implementation of the proposed compliance strategies. DOE would take no action to bring contaminant concentrations in the floodplain and terrace east areas into compliance with EPA ground water standards and would not apply or justify the use of supplemental standards in the terrace west area. Completed interim actions would remain in place, but DOE would perform no monitoring or maintenance and would take no further interim actions.

4.0 Affected Environment and Environmental Consequences

This section describes the environmental media and resources that the proposed action and no action alternatives may affect. Cultural and visual resources, air quality, noise levels, and transportation would not be affected by the alternatives and are not discussed.

4.1 Ground Water

4.1.1 Affected Environment

Ground Water in the Floodplain

Section 4.4.2.1 of the SOWP (DOE 2000a) describes the floodplain contamination in detail. Constituents that are of concern in floodplain ground water based on potential human health or ecological risks are ammonium, manganese, nitrate, selenium, strontium, sulfate, and uranium. Table 5 compares concentrations of these constituents to background levels based on the June 1999 and February 2000 data. Figures 8 through 14 show the areal extent and concentrations of constituents in ground water.

Table 5. Floodplain Alluvial Ground Water Data Summary

Floodplain Contaminant	Frequency of Detection[a]	Background[b] mg/L	Range mg/L	Mean mg/L	UCL_{95}[c] mg/L
Ammonium	32/32	0.045	0.009–70.38	13.14	20.92
Manganese	32/32	1.24	0.0014–10.4	3.20	4.04
Nitrate	32/32	0.12	0.01–3,480	593	943
Selenium	28/32	<0.001	<0.0002–1.04	0.084	0.153
Strontium	32/32	2.26	0.51–20.1	7.82	9.50
Sulfate	32/32	1,432	138–25,300	6,533	8,731
Uranium	32/32	0.007	0.0025–3.77	0.756	1.109

[a]Number of samples in which the constituent was detected/number of samples analyzed.
[b]Background floodplain concentrations: wells 850, 851, and 852; average of concentrations of June 1999 and February 2000 samplings.
[c]95% upper confidence level on the mean.

Note: Samples were collected from floodplain locations 610, 612, 614, 615, 616, 617, 619, 620, 624, 626, 628, 630, 631, 632, 732, 733, 734, 735, 736, 766, 768, 773, 775, 779, 782, 783, 784, 853, 854, 855, 856, and 857.

The floodplain alluvial aquifer consists of unconsolidated medium- to coarse-grained sand, gravel, cobbles, and small boulders and is hydraulically connected with the San Juan River. Borehole evidence indicates that a sandy gravel unit is overlain in most places by a layer of silty sand several feet thick. Both the sandy gravel and silty sand layers appear to be laterally continuous.

In April 2000, filled drainages along the edge of the escarpment were investigated to determine if residual tailings existed and if the drainages presented a preferred pathway for ground water to travel from the terrace to the floodplain. The filled drainages did not contain tailings and did not appear to be primary pathways for contamination to reach the floodplain.

The floodplain ground water receives recharge from several sources. The largest component, historically about 60 percent, is provided by artesian well 648 that drains into Bob Lee Wash and empties into the floodplain. The San Juan River provides recharge to the system at the southeast (upstream) end and accounts for perhaps 15 percent of the total, but generally drains the floodplain along the northern edge. Precipitation at the site is about 7 inches/year; after evaporation and transpiration, it is estimated to contribute about 10 percent of the total ground water budget. The remaining water, about 15 percent of the total, is derived from terrace ground water that seeps onto or into the floodplain. Flow into the underlying, relatively impermeable unweathered Mancos Shale is minimal.

Hydraulic conductivity (i.e., the rate that ground water can flow) of the floodplain ground water ranges from about 70 to 150 ft/day and averages 110 ft/day in the portion of the aquifer affected by mill-related constituents. The direction of ground water movement in some of the floodplain area is influenced by water from artesian well 648 that enters the floodplain at the mouth of Bob Lee Wash. This water produces a ground water mound that flushes a broad area between the mouth of the wash and the San Juan River to the north. A small wetland has formed just east of the mouth of the wash as a result of this discharge. At the east end of the wetland area, floodplain ground water that would normally flow northwest has been deflected northward by the ground water mound caused by discharge from well 648. Surface flow to Bob Lee Wash also exits from a small pond through the subsurface. Any changes in the flow path from the well could affect the configuration of the wetland and could reduce the volume of water forming the ground water mound.

Ground Water in the Terrace

For compliance strategy purposes, the terrace has been divided into two areas: terrace east and terrace west (Plate 1). The terrace contains unconsolidated alluvial and windblown sediments overlying Mancos Shale. Unconsolidated sediments average about 20 ft thick and consist of San Juan River sand, gravel, cobbles, and small boulders overlain by fine-grained sand and silt deposited by the wind. An elongate, northwest-trending area south of the disposal cell contains a thicker sequence of alluvial sediments (as much as 35 ft thick at well 818), which were deposited by an ancestral channel of the San Juan River. This elongate area is termed the sump and contains a greater thickness of saturated sediments than anywhere else on the terrace.

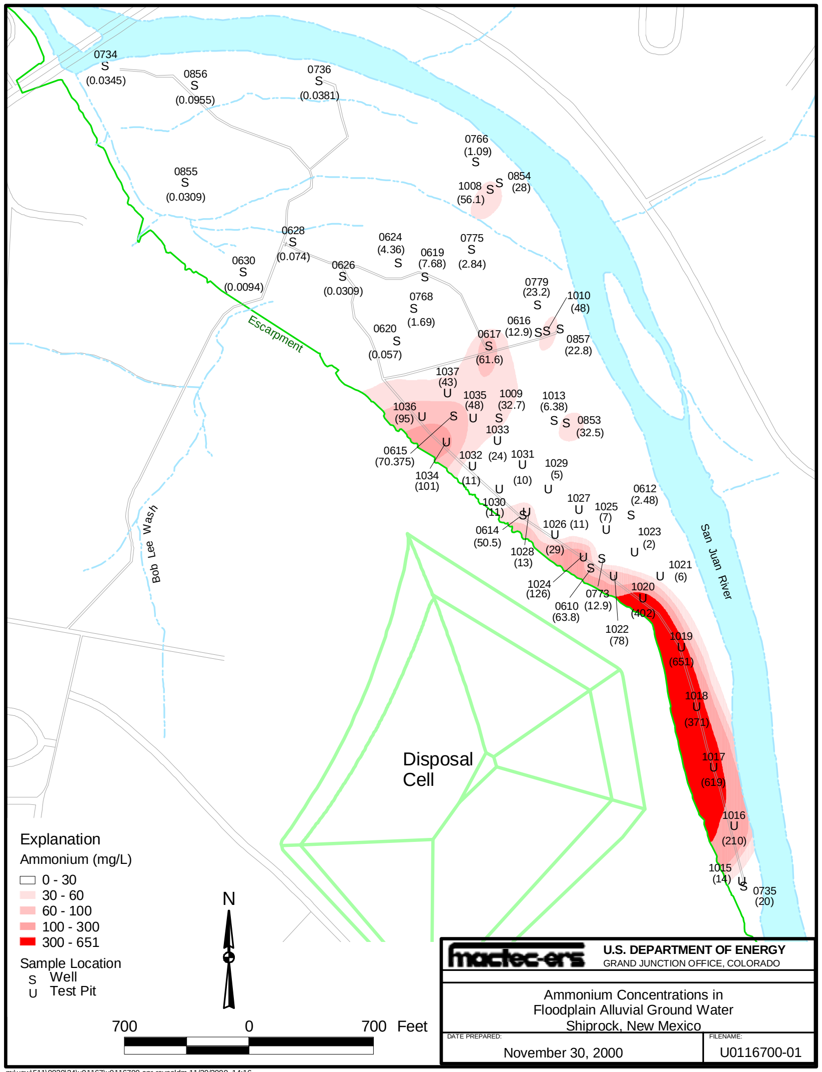

Figure 8. Ammonium Concentrations in Floodplain Ground Water (March 1999 through April 2000 data)

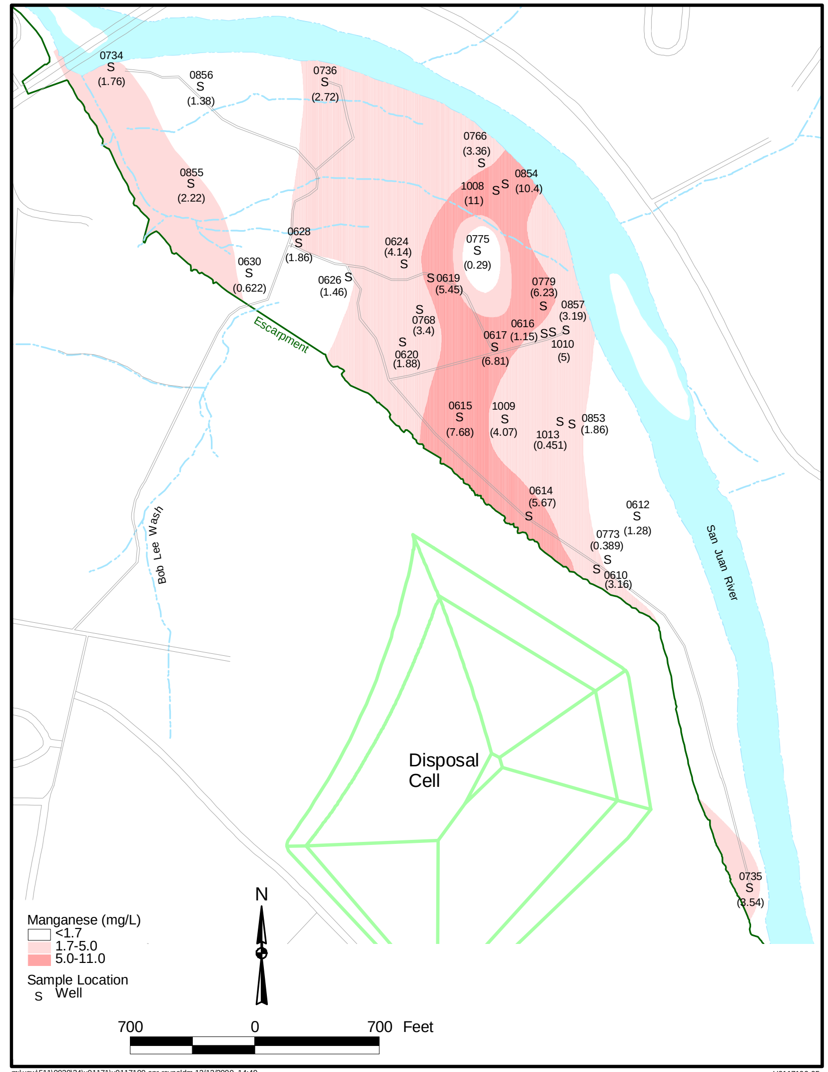

Figure 9. Manganese Concentrations in Floodplain Ground Water (March 1999 through April 2000 data)

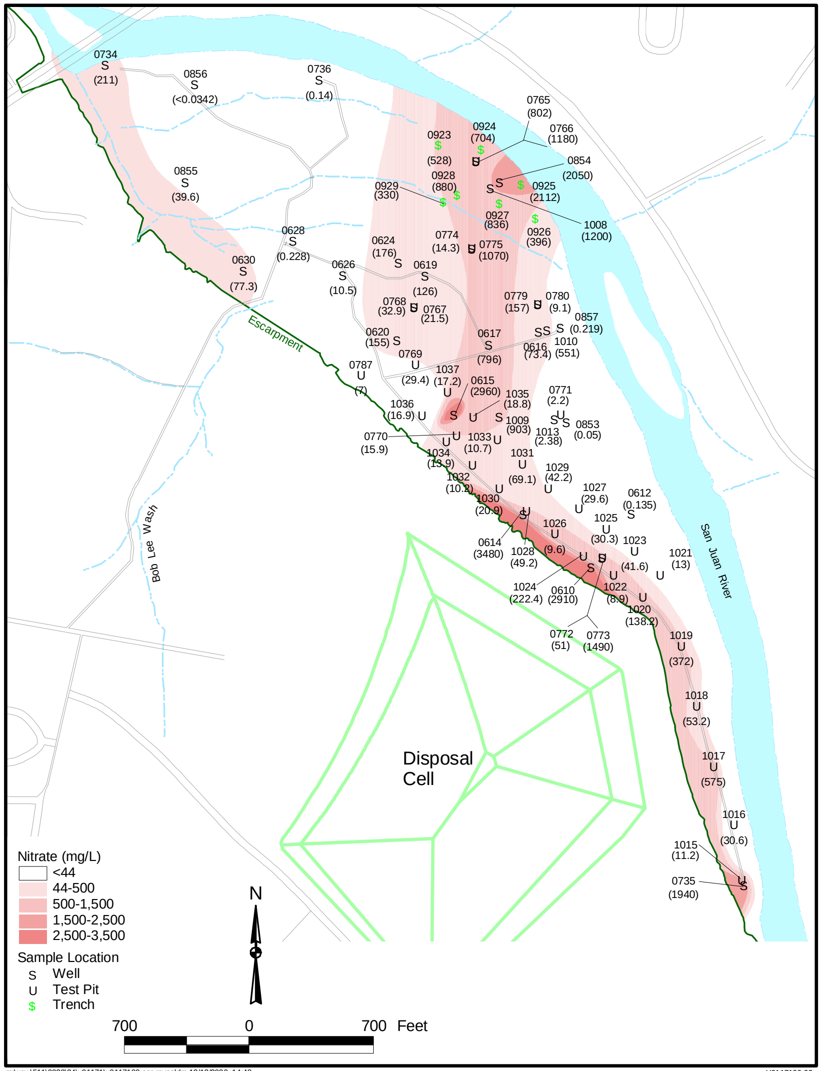

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Figure 10. Nitrate Concentrations in Floodplain Ground Water (March 1999 through April 2000 data)

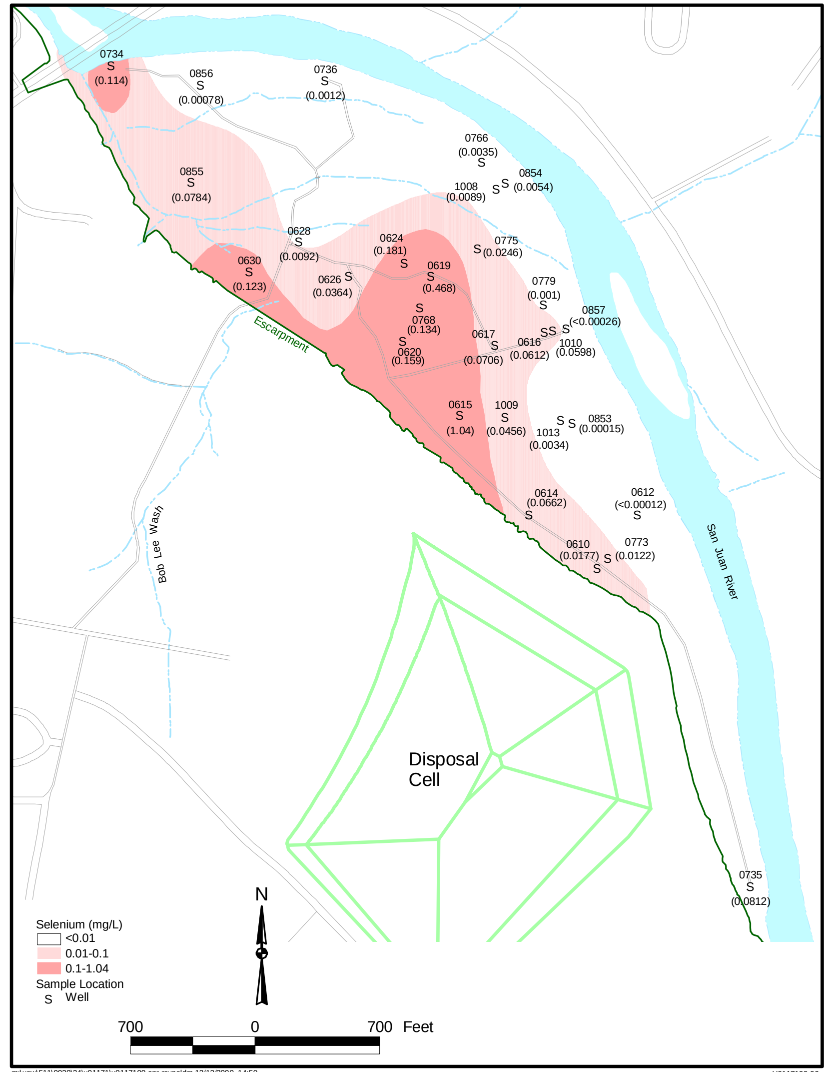

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Figure 11. Selenium Concentrations in Floodplain Ground Water (March 1999 through April 2000 data)

Final

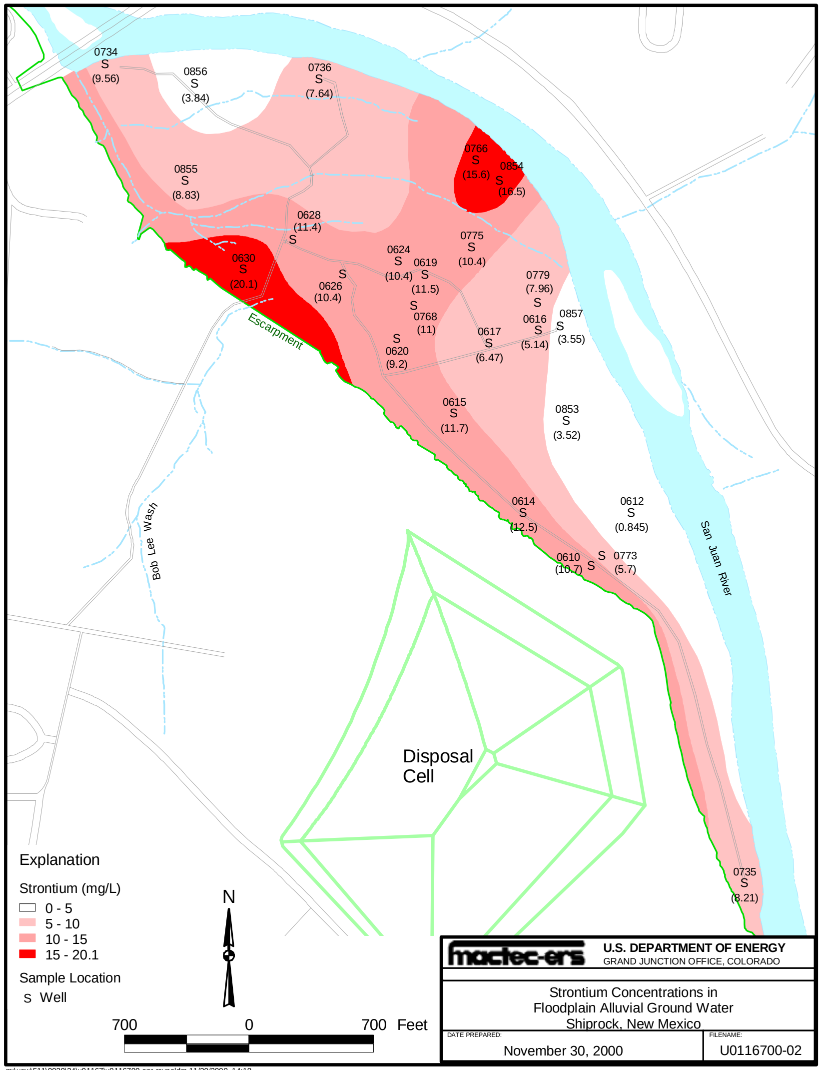

Figure 12. Strontium Concentrations in Floodplain Ground Water (March 1999 through April 2000 data)

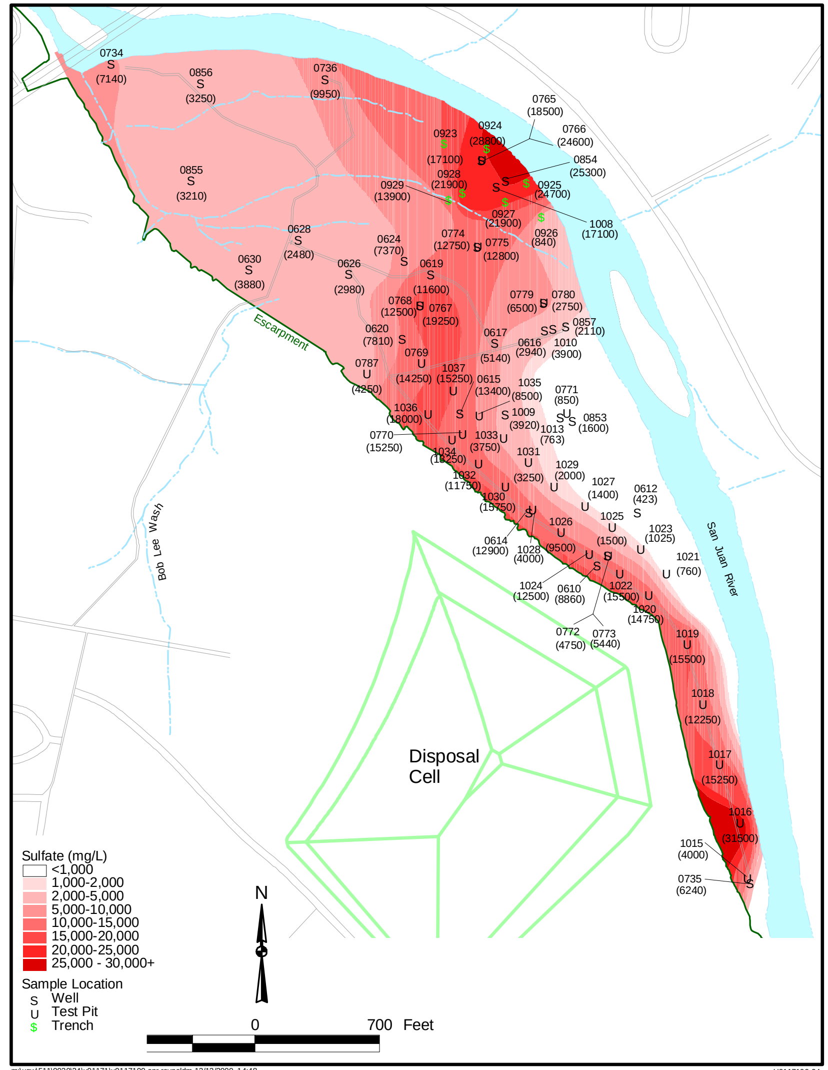

Figure 13. Sulfate Concentrations in Floodplain Ground Water (March 1999 through April 2000 data)

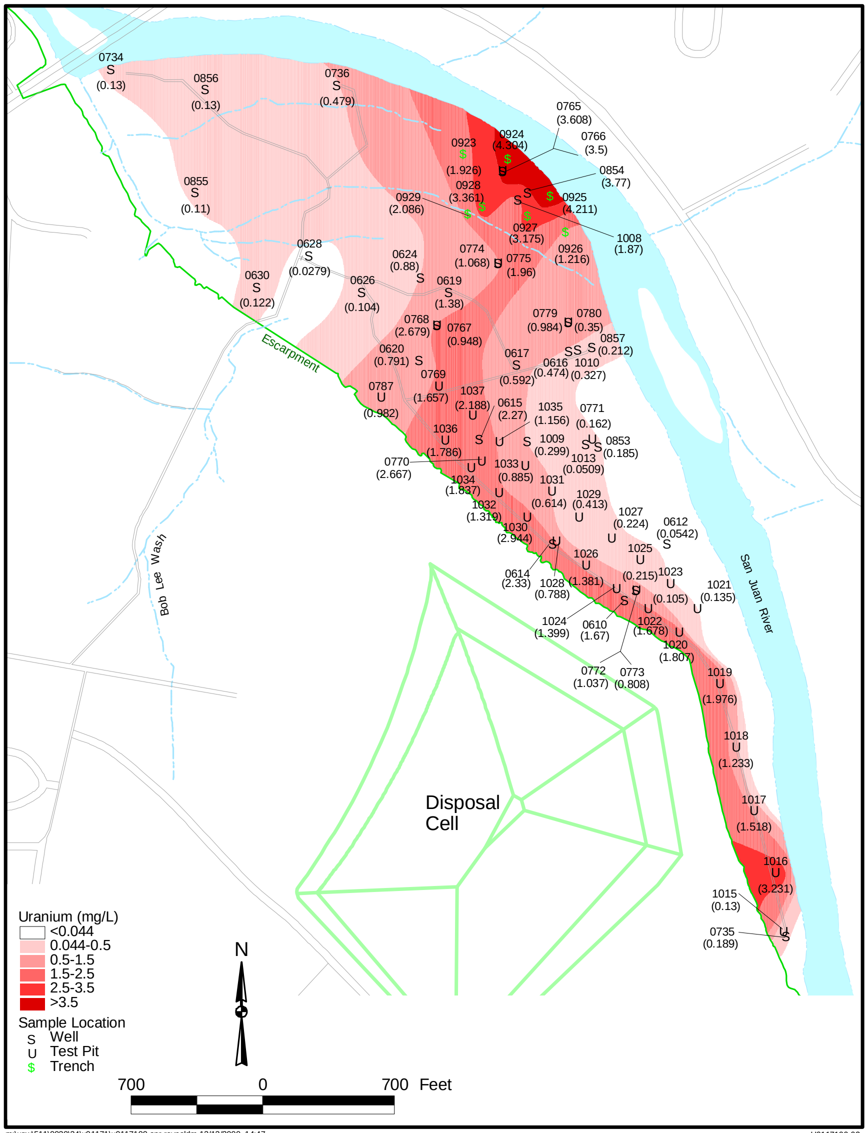

Figure 14. Uranium Concentrations in Floodplain Ground Water (March 1999 through April 2000 data)

The Mancos Shale bedrock surface lies below the unconsolidated sediments. It is generally weathered near the contact of the sediments and, when saturated with water, has the appearance of gray mud. Below this weathered zone, it becomes harder and forms dark gray, tight shale that has low permeability. The disposal cell is built on a bedrock high, and ground water generally moves away from it in all directions. The Mancos Shale also contains thin bentonite (volcanic ash) layers that provide more permeable pathways for migrating ground water, as observed in seep 427 along the escarpment. Another feature of the bedrock is a continuous, hard siltstone bed about one foot thick that is exposed in the escarpment and dips gently toward the east. It is present beneath the disposal cell and crops out to the east in Many Devils Wash, where it forms a knickpoint about 1,200 ft upstream from the confluence with the San Juan River. Ground water that percolates down through the Mancos Shale and reaches the top of this impermeable, resistant siltstone bed is transported downdip to the east and southeast.

Two aquifer tests were conducted in the terrace ground water system. One test was performed in the terrace gravel, in which the average hydraulic conductivity is about 15 ft/day based on this one test. Another test performed in the weathered Mancos Shale indicated a hydraulic conductivity of about 0.4 ft/day. Annual precipitation and evaporation are not adequate to saturate the alluvium overlying the Mancos Shale; therefore, the saturated areas of alluvium are thought to contain some combination of drainage of residual moisture from the disposal cell, recharge from irrigation in the terrace west area, and the recharge component from annual rainfall.

The terrace ground water system is believed to be a result of human activity and probably did not exist before milling and agriculture began in the site area. This conclusion is supported by the lack of ground water in a terrace background area about 1 to 2 miles east that is an analog of terrace east and west. Most of the water in terrace east is a result of past ore-processing activities and subsequent drainage from mill tailings, and ground water in this area consequently has higher levels of contamination. Most of the ground water in terrace west has relatively lower concentrations of ground water contaminants; this water is a result of recharge by annual precipitation, irrigation (in the western part), and drainage from past milling operations (in the eastern part). Section 4.4.2.2 of the SOWP describes the nature and extent of the contamination.

Since 1998, numerous monitor wells have been drilled to further define the extent of contamination and to establish background conditions in terrace east and west ground water. Although no water representing background conditions was found, an estimate of background water quality was developed and is provided in Section 4.4.8 of the SOWP. That section presents a description of how water contacting Mancos Shale can acquire relatively high concentrations of selenium, sulfate, and uranium. Irrigation water in the alluvium west of U.S. Highway 666 is in contact with weathered Mancos Shale and might be expected to leach these constituents from the shale. Table 6 shows the concentration ranges of these three constituents and ammonium, manganese, nitrate, and strontium in samples of terrace alluvial ground water. Figures 15 through 21 are distribution maps of these constituents.

Table 6. Terrace East and West Alluvial Ground Water Data Summary, February 2000

Terrace Contaminant	Frequency of Detection[a]	Range (mg/L)	Mean (mg/L)	UCL_{95}[b] (mg/L)
Ammonium	16/28	<0.0066–1,740	25	147
Manganese	24/28	<0.0006–31.4	2.54	5.16
Nitrate	28/28	0.01–8,790	1,618	2,413
Selenium	25/28	<0.0006–6.52	0.836	1.38
Strontium	28/28	2.75–18.3	8.14	9.53
Sulfate	28/28	1,300–17,800	7,359	9,431
Uranium	28/28	0.0021–3.08	0.247	0.463

[a]Number of samples in which contaminant was detected/number of samples analyzed.
[b]95% upper confidence level on the mean.

Notes: No background values were available; attempts to establish background locations were unsuccessful because the terrace alluvium has no saturated zones outside the area influenced by human activities. This was determined by the spatial distribution of a number of dry holes drilled during characterization.

Terrace alluvial sampling locations are 603, 725, 728, 730, 731, 812, 813, 814, 815, 816, 826, 827, 828, 832, 833, 835, 836, 837, 838, 839, 841, 843, 844, 846, 847, 848, 1048, and 1049

Ground Water Use

Ground water in the floodplain area is not currently used for any purpose. The only known use of ground water from the terrace system in the site area is from well 847 at the north edge of the Shiprock High School property (Plate 1). Water from this well is used for irrigating the school grounds. Testing has shown that use of water for this purpose is safe.

4.1.2 Environmental Consequences

Proposed Action Alternative

Floodplain Ground Water

The active remediation part of the proposed action would reduce concentrations of ground water contaminants in part of the most highly contaminated area of the floodplain. The treatment goals during the natural flushing and active remediation would restore the quality of the ground water to a condition such that contaminant levels would not exceed EPA ground water standards in 40 CFR 192 or risk benchmarks for constituents without maximum concentration limits. All ground water extracted during the active remediation would be discharged to a lined evaporation pond in the terrace east area. Although this reduction in ground water volume could lower the water table during the short term, water in the San Juan River would replace existing ground water. Following the active remediation phase, ground water monitoring would verify that continued natural flushing reduces concentrations of mill-related constituents.

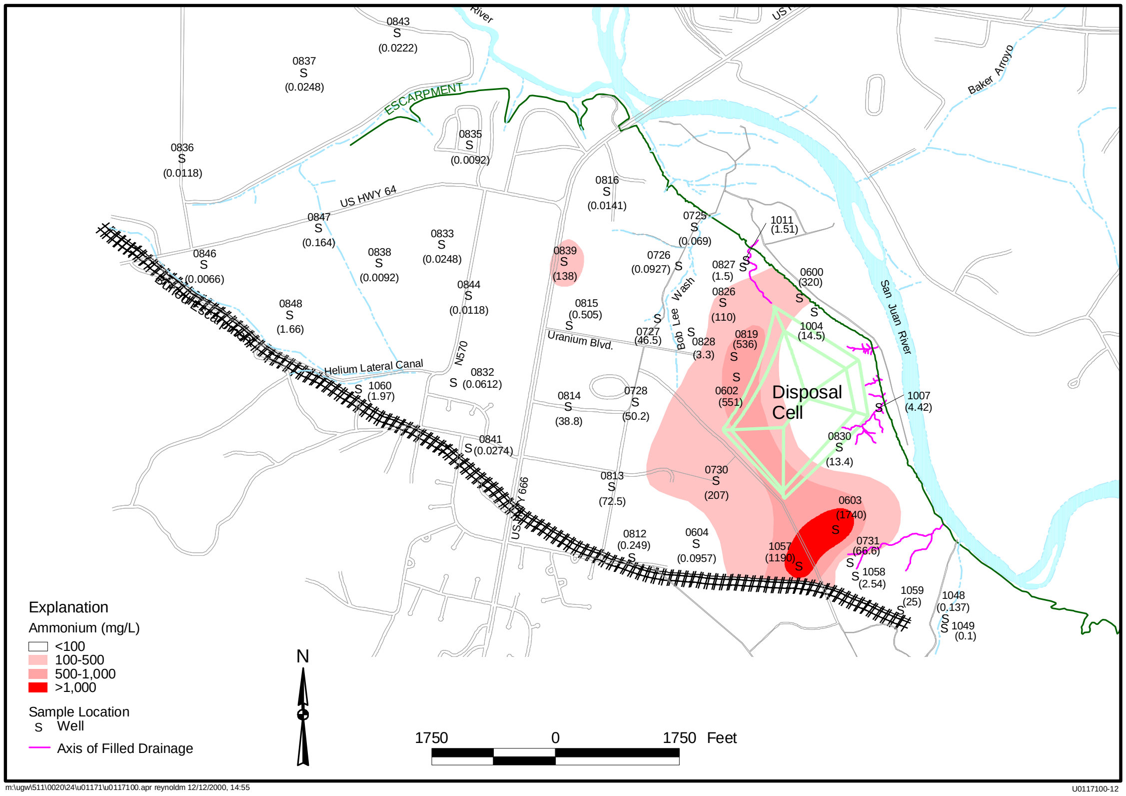

Figure 15. Ammonium Concentrations in Terrace Ground Water (March 1999 through April 2000 data)

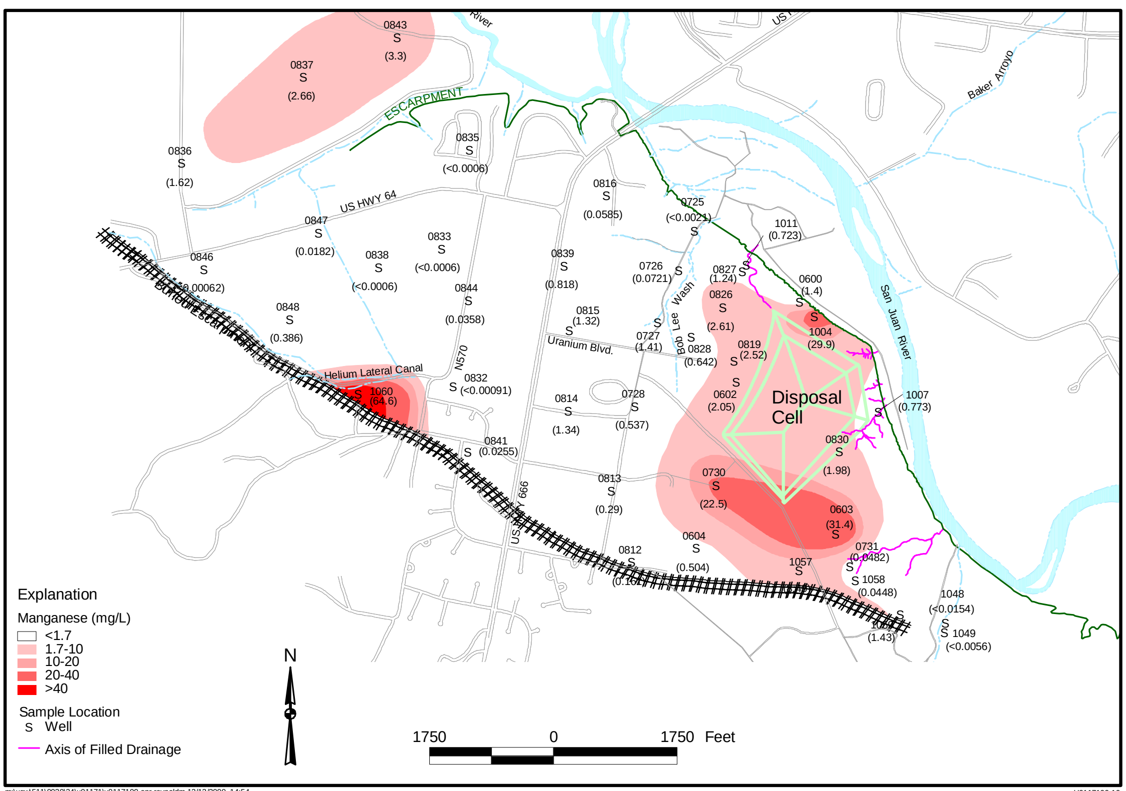

Figure 16. Manganese Concentrations in Terrace Ground Water (March 1999 through April 2000 data)

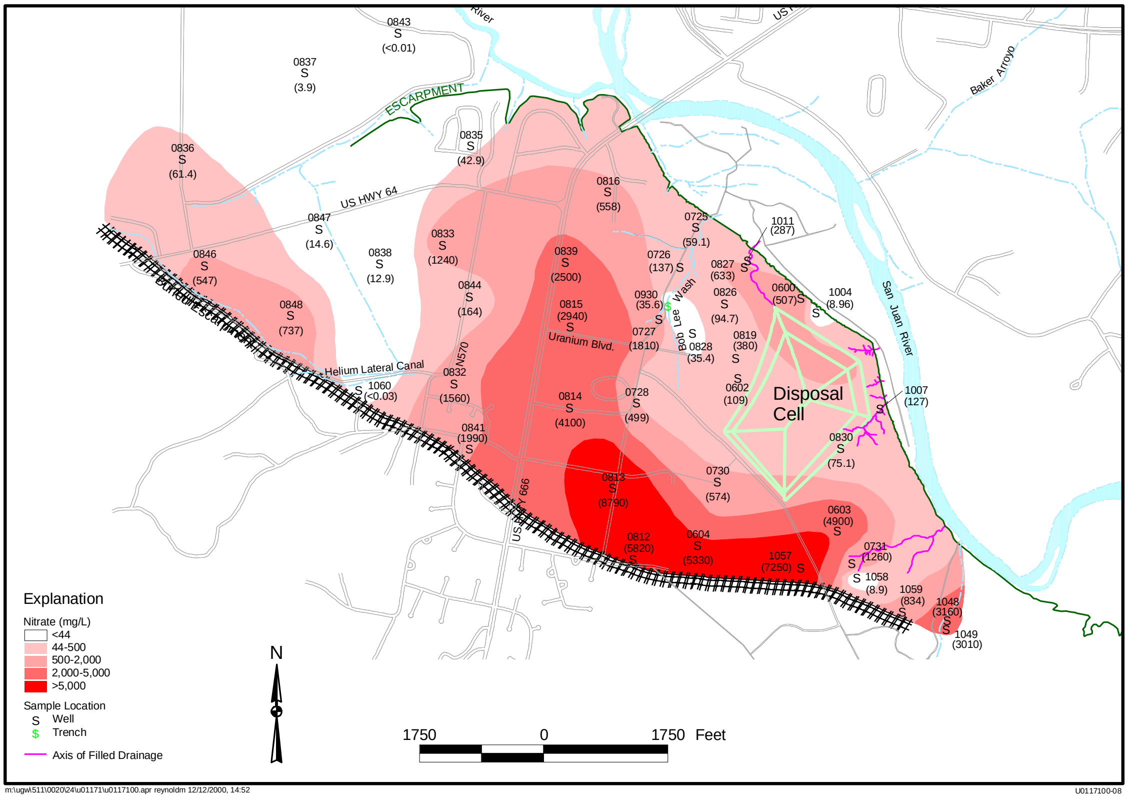

Figure 17. Nitrate Concentrations in Terrace Ground Water (March 1999 through April 2000 data)

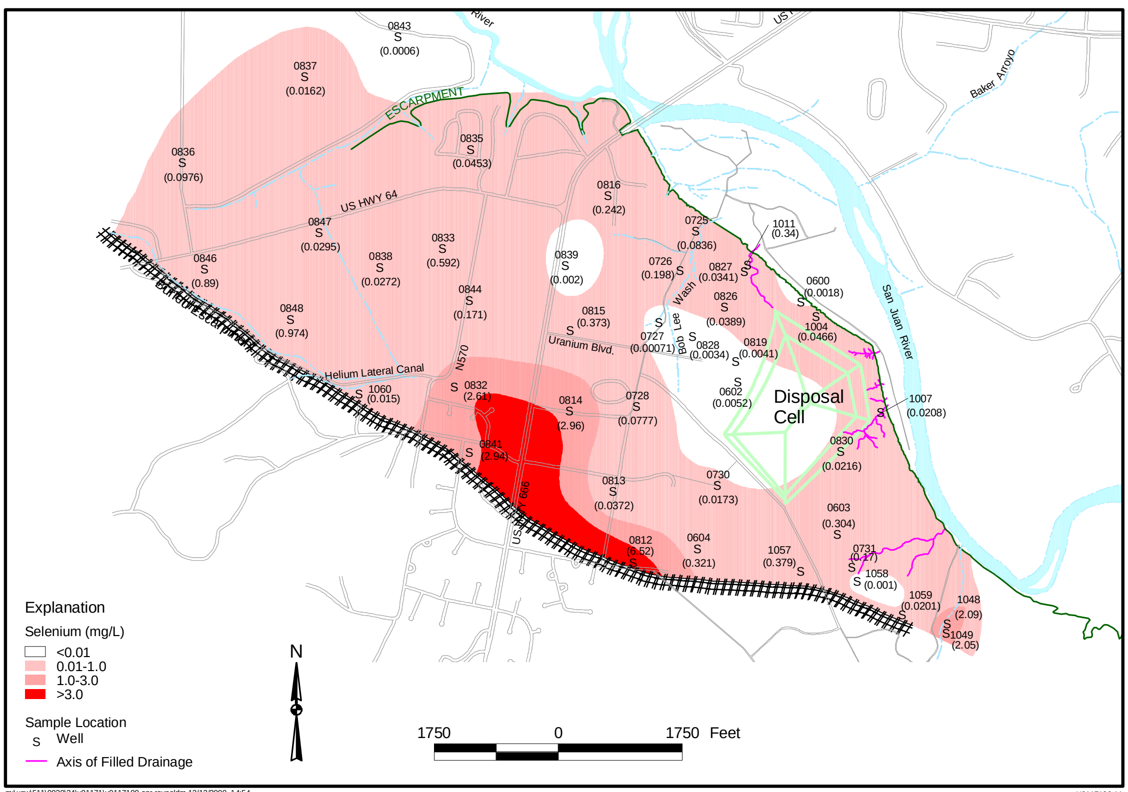

Figure 18. Selenium Concentrations in Terrace Ground Water (March 1999 through April 2000 data)

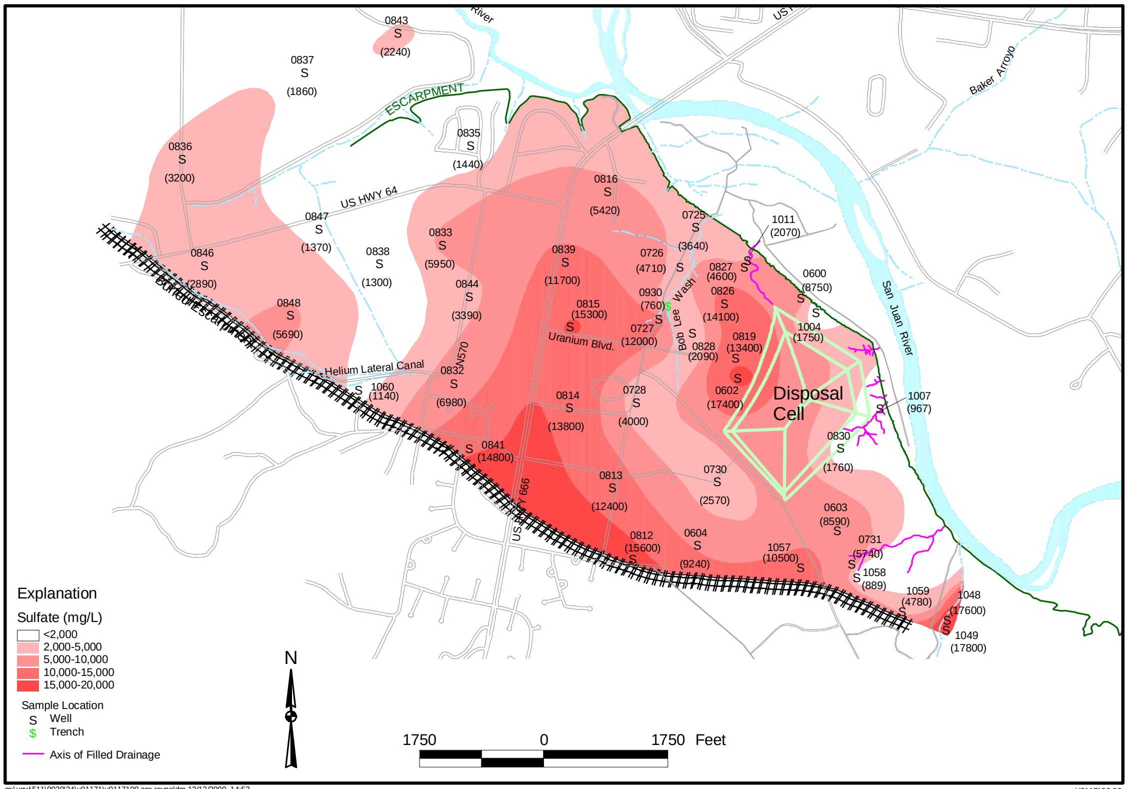

Figure 19. Sulfate Concentrations in Terrace Ground Water (March 1999 through April 2000 data)

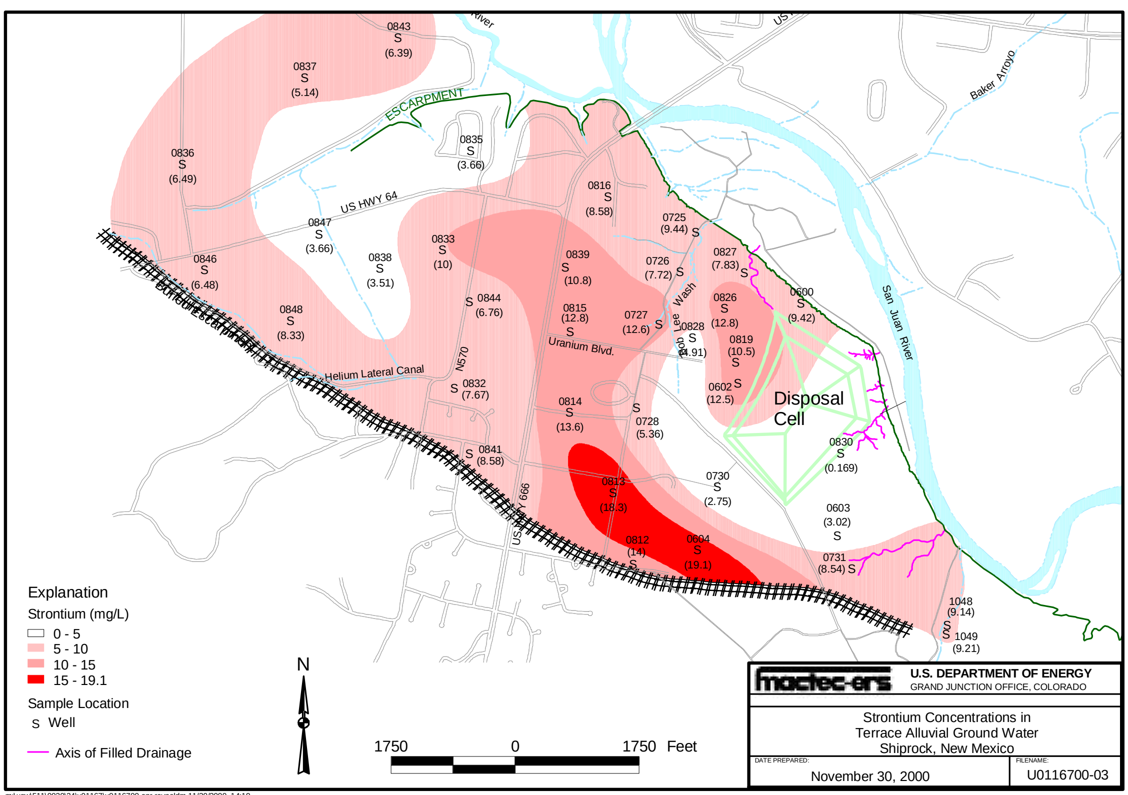

Figure 20. Strontium Concentrations in Terrace Ground Water (March 1999 through April 2000 data)

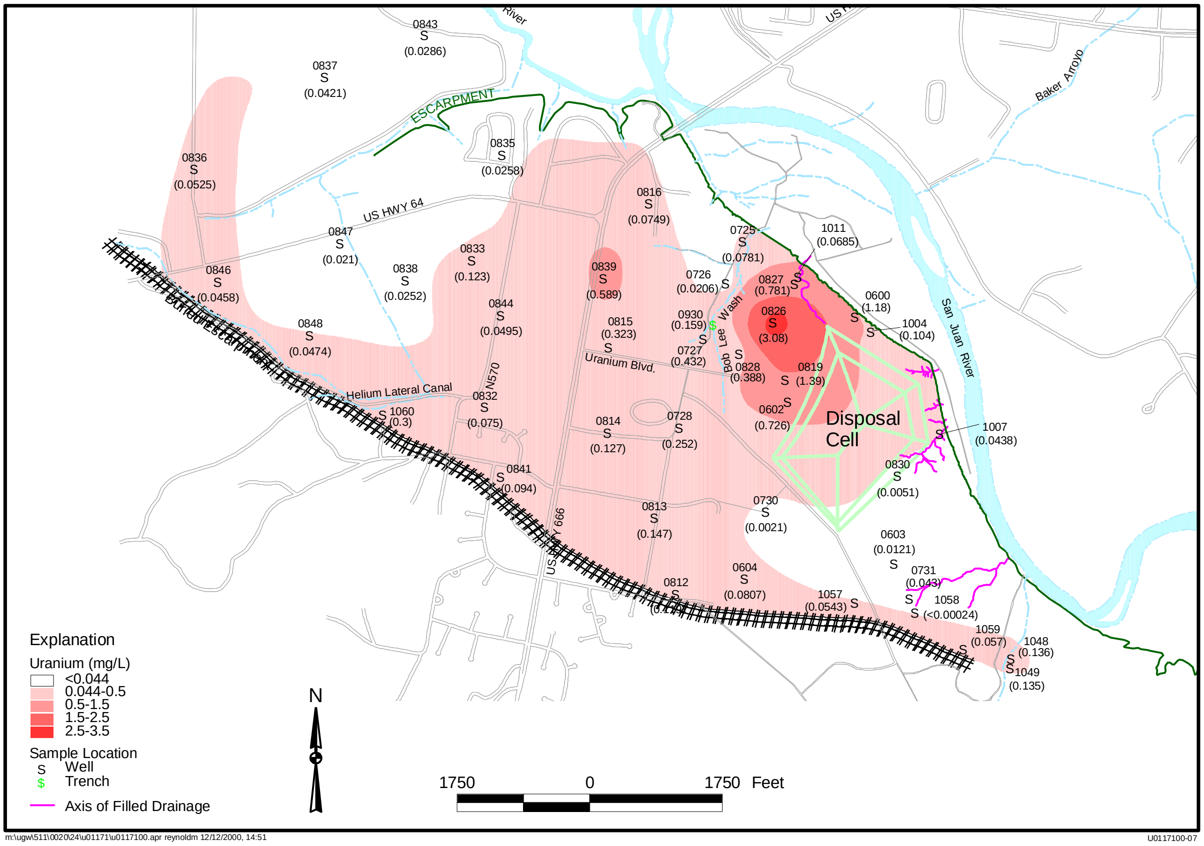

Figure 21. Uranium Concentrations in Terrace Ground Water (March 1999 through April 2000 data)

Terrace Ground Water

As discussed in Section 1.3 and in SOWP Section 4.3, much evidence supports the hypothesis that no ground water was present in the terrace alluvium before milling and irrigation began in the area. Under the proposed action, terrace east ground water would be intercepted and collected at the base of the escarpment, and this water would be piped to a pond and evaporated. Also, terrace east ground water would be hydraulically separated from ground water in terrace west, then the volume of ground water in terrace east would be depleted, and flow to the seeps and washes where ground water has surfaced would be stopped. Mill-related constituents in ground water in the terrace west system would flush naturally, and most of the ground water system would continue to receive recharge from irrigation provided by the Helium Lateral Canal.

No Action Alternative

Under the no action alternative, no pumping of floodplain ground water would occur. Ground water contaminants in the floodplain would not be expected to flush to acceptable concentrations within 100 years. Ground water in the terrace east system would not be extracted to deplete the system and dry up seeps and washes, and the slurry wall impermeable barrier would not be constructed to prevent contaminated terrace system ground water from entering the floodplain aquifer. The completed interim actions would continue to prevent exposure to wildlife and livestock. However, terrace ground water would continue to surface in these areas, and no future interim actions would be taken; DOE would conduct no monitoring or maintenance of the current interim actions and would not monitor ground water or collect data to evaluate the possibility of a continuing source of ground water contamination. Mill-related ground water would continue to flow to the terrace west area. DOE would not apply supplemental standards or collect and analyze data to evaluate the contribution of constituents leached naturally from Mancos Shale. Ground water in the terrace east and floodplain areas would remain contaminated into the foreseeable future. No institutional controls or other controls would be placed on use of ground water in the floodplain.

4.2 Surface Water

4.2.1 Affected Environment

Surface water from the floodplain drains into the adjacent San Juan River. Two river locations upgradient of the millsite floodplain (898 and 888, Plate 1) were sampled to provide water quality data representing background. Ground water from the terrace system surfaces as seeps in the washes and along the escarpment.

Table 7 is a summary of surface water data for samples collected in February 2000 from terrace and floodplain locations. Results from samples collected along the San Juan River are included with those from floodplain samples in the summary.

Table 7. Summary of Surface Water Chemistry for the Shiprock Site

Constituent	Location	FOD[a]	Background[b] mg/L	Range mg/L	Mean mg/L	UCL_{95} mg/L[c]
Ammonium	San Juan River	10/10	0.013	0.022–0.173	0.054	0.08
	Other floodplain	6/6		0.032–1.02	0.24	0.55
	Escarpment seeps	5/5	NA[d]	0.0213–0.847	0.201	0.52
	Other terrace	11/11		0.0425–0.220	0.0844	0.1157
Manganese	San Juan River	10/10	0.001	0.005–05	0.017	0.03
	Other floodplain	6/6		0.0421–0.697	0.397	0.633
	Escarpment seeps	4/5	NA	0.0006–0.065	0.0208	0.52
	Other terrace	11/11		0.0018–0.0568	0.0135	0.0232
Nitrate	San Juan River	10/10	1.52	1.74–22.50	4.3	8.27
	Other floodplain	6/6		5.63–203	89	146
	Escarpment seeps	5/5	NA	129–515	265	397
	Other terrace	11/11		1.02–3,520	657	1,414
Selenium	San Juan River	10/10	0.001	0.0006–0.0012	0.001	0.00
	Other floodplain	6/6		0.0119–0.152	0.076	0.120
	Escarpment seeps	5/5	NA	0.0446–0.428	0.18	0.31
	Other terrace	9/11		<0.001–2.32	0.45	0.94
Strontium	San Juan River	10/10	1.35	0.86–1.09	0.90	0.94
	Other floodplain	6/6		5.18–14.8	10.9	14.4
	Escarpment seeps	5/5	NA	5.70–10.3	7.84	9.65
	Other terrace	11/11		4.18–13.5	8.48	10.3
Sulfate	San Juan River	10/10	120	182–504	229	290
	Other floodplain	6/6		2,160–4,200	3,208	3,885
	Escarpment seeps	5/5	NA	2,640–5,670	3,918	4,906
	Other terrace	11/11		1,670–20,100	5,392	9,234
Uranium	San Juan River	10/10	0.002	0.0020–0.0469	0.007	0.02
	Other floodplain	6/6		0.0393–0.112	0.078	0.103
	Escarpment seeps	5/5	NA	0.0433–0.330	0.17	0.31
	Other terrace	10/11		<0.0001–1.71	0.21	0.50

[a]FOD: frequency of detection; number of samples in which constituent was detected/number of samples analyzed.
[b]Background floodplain concentration is an average for samples from locations 888 and 898 collected in June 1999 and February 2000 from the San Juan River upgradient of the millsite floodplain.
[c]95% upper confidence level on the mean.
[d]Not applicable; terrace alluvium has no ground water in background locations.

Notes: San Juan River locations: 546, 548, 553, 555, 893, 895, 896, 897, 940, 941
Other floodplain locations: 655, 657, 658, 887, 894, 939
Escarpment seeps: 425, 426, 786, 935, 936
Other terrace locations: 662, 884, 885, 886, 889, 933, 934, 942, 1263, 1264, 1265
Analytical data are from the February 2000 sampling round.

Constituents in San Juan River samples were generally within the range of background. The floodplain samples with the highest concentrations came from locations within the floodplain (658, 655, and 894; Plate 1) and from a side channel (known as the distributary channel) of the San Juan River.

The highest contaminant concentrations were detected in terrace surface water; these samples represent the surface expression of ground water with little or no dilution.

Floodplain Area

The San Juan River has a drainage area of about 12,900 square miles upstream from the town of Shiprock. Discharge records for the river at Shiprock are nearly continuous since February 1927. Data from the river gauge indicate that before 1963, extreme low and high flows ranged from less than 8 cubic feet per second (cfs) to about 80,000 cfs, respectively. After construction of the Navajo Reservoir (located 78 river miles upstream of Shiprock) in 1963, the minimum and maximum flows moderated to about 80 cfs and 15,000 cfs, respectively. Average flow in the San Juan River at Shiprock is 2,175 cfs (Stone et al. 1983). Surface water from Many Devils Wash and Bob Lee Wash and ground water from the floodplain all flow into the San Juan River.

The Navajo Nation has implemented water quality standards for surface water within the Reservation. The San Juan River is classified as a domestic water supply suitable for primary and secondary human contact, livestock and wildlife watering (including migratory birds), irrigation, and a cold-water fishery. The U.S. Geological Survey monitors water quality at river gauge 09368000, which is also the location of a water intake structure along the north bank of the river just east of the U.S. Highway 666 bridge. The intake structure is used for emergency water supply for the town of Shiprock. The Navajo Tribal Utility Authority also monitors water in compliance with the Safe Drinking Water Act. Monitoring has shown that concentrations of chemicals in river water at the intake structure are below Navajo EPA surface water quality standards for the San Juan River. DOE also monitors the San Juan River upstream, downstream, and on site at the Shiprock millsite (Plate 1) to determine if mill-related constituents are affecting water quality.

With the exception of a sample collected from on-site location 940, analytical results indicate no significant variation in samples from upstream, downstream, and on-site locations (SOWP Section 4.4.1.1). River water samples collected during a low-flow period (February 2000) were taken near the riverbank in slow-flowing parts of the river. Data from that sampling event indicate that contaminant concentrations at location 940 are higher than at other locations in the river along the floodplain and suggest millsite influence. The highest uranium concentration at location 940 was 0.047 mg/L. Although there is no federal surface water quality standard for uranium, the concentration at location 940 slightly exceeds EPA's maximum ground water concentration limit of 0.044 mg/L. The high uranium concentration at location 940 also exceeds the Navajo Nation surface water quality standard for dissolved uranium of 0.035 mg/L for domestic use. Uranium concentrations in samples collected downgradient of the former millsite at location 893 were less than 0.002 mg/L. Although these data suggest a limited millsite influence on the San Juan River, DOE's monitoring indicates that mill-related constituents are not affecting water quality in the river or in Shiprock's emergency water intake.

Terrace East Area

Water from artesian well 648 flows to the east in an outflow ditch into Bob Lee Wash and accounts for most of the surface water in this wash. Discharge from well 648 was measured with a flow meter at approximately 64 gpm. Although the well water is from the Morrison Formation, which is below any mill-related contamination, ground water samples from the well contained elevated levels of several naturally occurring constituents, including sulfate (2,000 mg/L).

Bob Lee Wash discharges into a 5-acre floodplain wetland at the mouth of the wash. Water in the wetland flows west to northwest along a drainage channel (abandoned distributary channel) on the floodplain. Ultimately, water from the wetland and all ground water discharges to the San Juan River. The wetland is discussed in Section 4.3. In Bob Lee Wash south of the confluence of the outflow ditch from well 648, seeps form several small pools and supply a flow of several gallons per minute in the winter months but are dry or only moist during the rest of the year. These seeps, especially on the east side of Bob Lee Wash, are contaminated with millsite effluent, and all seeps contain constituents leached from weathered Mancos Shale. As part of the interim actions in the summer of 2000, these seeps were covered with riprap and mesh, and the area was fenced to minimize exposure to human and ecological receptors. A storm event in July 2001 scoured most of the wash, leaving primarily cobbles within the drainage.

Surface water in Many Devils Wash occurs in the northernmost 1,200 ft of the channel, which discharges into the San Juan River. The most likely source of water in the wash is to the west in the saturated terrace alluvium and underlying weathered Mancos Shale. Where a siltstone bed in Mancos Shale is exposed and forms a knickpoint in Many Devils Wash about 1,200 ft upstream from its confluence with the San Juan River, the soil and shale are covered with a white granular salt crust along the east bank of the wash, and to a lesser extent along the west bank. This crust is similar to salt crust found along washes cut into Mancos Shale elsewhere on the Colorado Plateau. Normal discharge at the mouth of Many Devils Wash is estimated to be about 0.3 gpm. Large runoff flows from infrequent storm events can dissolve the precipitated salts in the wash and transport them to the San Juan River. Selenium is the contaminant of potential concern present in the greatest abundance in the salts. To evaluate the effect dissolved selenium from a storm event in Many Devils Wash may have on water quality in the San Juan River, several assumptions were incorporated to derive a reasonable scenario. Results of this simulation are provided in Appendix C. The calculations indicated that average concentrations of dissolved selenium in Many Devils Wash storm water discharging into the San Juan River would be about 0.001 mg/L. This concentration is less than the Navajo Nation surface water standard for selenium of 0.002 mg/L and similar to background concentrations detected in water samples from the San Juan River. Therefore, it is unlikely that dissolution of salt deposits in Many Devils Wash would affect water quality in the river. Also, riprap and mesh installed as part of the interim actions cover most of the water in the wash and reduce the amount of crust exposed and the quantity of contaminants available for transport to the river during storm water discharges. A flow-activated sampler was installed in August 2001 to collect samples for selenium analysis and determine actual concentrations during a high-flow event.

Nitrate concentrations up to 3,520 mg/L in surface water samples from Many Devils Wash and uranium concentrations up to 1.71 mg/L in surface water samples from Bob Lee Wash indicate millsite contamination. Most of the surface water on the terrace is believed to be a surface expression of terrace ground water. Interactions between terrace surface water and the terrace ground water system are discussed in Section 4.4.2.2 of the SOWP.

The escarpment along the San Juan River between Bob Lee and Many Devils Washes contains several active seeps that discharge from the Mancos Shale. The seepage flow is small and normally appears as damp zones along the cliff face. White salt crust at other locations, that are now dry, suggests that seepage along the cliff face has been common in the past or continues below talus slopes. Seep flow is also apparent at several other locations, particularly at seeps 425 and 426 (Plate 1), where discharges total about 1 gpm, and at location 786 under the U.S. Highway 666 bridge, where the flow is estimated at about 1.5 gpm.

Terrace West Area

Three washes drain the terrace area west of the U.S. Highway 666 bridge. These washes have no formal names and are designated from east to west as 1st, 2nd, and 3rd Wash, respectively (Plate 1). The 1st and 2nd Washes each support minor surface water discharge near the base of the terrace alluvium. The escarpment along the San Juan River distributary channel east and west of 1st Wash contains numerous active seeps that discharge from the Mancos Shale. The seep at location 935 just west of the mouth of 1st Wash has an estimated flow of 1.5 gpm. The seep at location 936 between 1st and 2nd Washes has a significant flow, but the flow has not been measured. As with terrace east, the presence of white granular salt crust suggests that seepage along the cliff face has been common in the past or continues below the ground surface. Water from 1st and 2nd Washes discharges to the distributary channel of the San Juan River. In the winter of 1999, the base flow was estimated to be about 1.5 gpm in 1st Wash and about 0.2 gpm in 2nd Wash. No flow has been seen in 3rd Wash.

Surface water has been sampled at several locations in an area of former gravel pits north of Shiprock High School. Two of the locations (1063 and 1064) are in small potholes that contain stagnant water; those have been sampled only once. The most significant spring in the area is at location 942, which flows at several gallons per minute; this flow drains northward and supplies perennial water to the irrigation return flow ditch, which drains east-northeast and eventually enters the distributary channel of the San Juan River.

Surface Water Use

The Navajo Tribal Utility Authority maintains the water supply for the town of Shiprock; the principal supplier is the City of Farmington, which obtains its water from Farmington Lake. Alternative drinking water sources for Shiprock are from the San Juan River and consist of the Hogback Canal and the intake structure just upstream from the U.S. Highway 666 bridge. The Navajo Agricultural Products Industries Irrigation Canal and the proposed Navajo-Gallup Pipeline Project (Molzen-Corbin & Associates 1993) are in the planning stages and may offer future water sources. Water in the Hogback Canal is drawn from the San Juan River about 11 miles upstream from Shiprock and provides irrigation water to agricultural users. River water from the intake structure at Shiprock is used only as an emergency source of water. Surface water sample location 956 was established in June 2000 at the intake structure to monitor this source. Samples collected in June 2000 at this location during relatively high river flow had no anomalous concentrations of constituents. Samples collected during relatively low river flow in February 2000 at location 548, just upstream from the intake, also had no anomalous concentrations of constituents.

Although water in the floodplain is not currently used for any purpose, it has been used historically for watering livestock. Interim actions identified in the Range Management Plan (DOE 2000b), including fencing around the washes and seeps, significantly reduce the potential for livestock watering. Most livestock watering would occur in the San Juan River. Water from seeps along the escarpment is not currently used for any purpose.

4.2.2 Environmental Consequences

Proposed Action Alternative

Under the proposed action alternative, concentrations of surface water constituents (primarily uranium at location 940) in the San Juan River would decrease. Surface water contaminant levels in the most highly contaminated area of the floodplain would also decrease as a result of several factors. Primary among these is the drying up of the seeps that surface in Bob Lee Wash and along the escarpment. The strategy of drying up the seeps assumes that all water from well 648 will continue to discharge into Bob Lee Wash. If well 648 were turned off, its historical diluting effect on contaminants would decrease. This could result in short-term buildup of contaminant concentrations in the wetland at the mouth of Bob Lee Wash. Also, the wetland would slowly dry up. The reduction in ground water contaminant concentrations in the floodplain as a result of active remediation would also reduce contaminant levels in surface waters that are hydraulically connected to ground water.

Ground water in the terrace east and terrace west areas would be hydraulically disconnected. After the terrace east water levels are lowered, concentrations of constituents in terrace west ground water should remain the same or decrease, and the potential for surface expression would be eliminated. If terrace east ground water is removed through the extraction wells and intercepted and removed through the french drains, surface water flow from ground water seeping into the washes would cease.

No Action Alternative

Under the no action alternative, surface water in all areas would be available for domestic, agricultural, or industrial use. Surface water in the floodplain would continue to be influenced by contaminated ground water and by seeps that discharge from the terrace. The San Juan River would continue to receive trace amounts of mill-related constituents. The no action alternative in the terrace east area would result in a continuing source of contamination to Bob Lee Wash, Many Devils Wash, the escarpment seeps, and the floodplain alluvial aquifer.

Surface water in the terrace west area would continue to have higher concentrations of mill-related constituents as ground water from the milling operations continues to flow into the terrace west ground water system. DOE would not conduct monitoring and data analysis to evaluate the presence of a continuing source of contamination.

4.3 Floodplain/Wetlands

4.3.1 Affected Environment

The Shiprock site encompasses a portion of the San Juan River floodplain and a small wetland (Figure 22). No floodplains or wetlands are in the terrace east area. Appendix A is an assessment of the floodplain and jurisdictional wetland. (A jurisdictional wetland is a wetland that has been delineated according to the method in the *Army Corps of Engineers Wetlands Delineation Manual* [Corps of Engineers 1987].)

Floodplain Area

The portion of the San Juan River floodplain associated with the Shiprock site comprises about 124 acres. This floodplain area begins about 1,500 ft downstream from the confluence of Many Devils Wash and the San Juan River and extends downstream to the U.S. Highway 666 bridge. Downstream from the U.S. Highway 666 bridge, the floodplain south of the river resumes, but its southern edge is mainly defined by a distributary channel of the river.

Wetland

In June 1998, about 5.1 acres of jurisdictional wetland near the mouth of Bob Lee Wash and in its discharge path across the floodplain were delineated according to methods in the *Corps of Engineers Wetlands Delineation Manual* (U.S. Army Corps of Engineers 1987). The wetland area is characterized by narrowleaf cattail, hardstem bulrush, inland saltgrass, and common reed. Surrounding riparian and higher-elevation areas are dominated by tamarisk, Russian olive, and inland saltgrass. Scientific names of wetland plant species are in Appendix D. Vegetation cover is well developed in all these areas. A heavy rain in July 2001 reduced the wetland area to about 4 acres by depositing cobbles and gravel at the mouth of Bob Lee Wash.

The wetland and surrounding riparian areas provide habitat for birds, small mammals, deer, furbearers, and other wildlife. Above Bob Lee Wash, flow from well 648 provides most of the water for the wetland. No federal, state, or tribal threatened or endangered plants or animals have been identified in the wetland.

In fall 1999, the flow from well 648 was altered by the construction of a small pond above Bob Lee Wash. Before the pond was constructed, all the water flowed directly east in an outflow ditch into the wash. Flow was diverted to the small pond where it infiltrated the ground under the pond. The water flowed below the ground surface and entered Bob Lee Wash as springs, and some of the water discharged as springs directly onto the floodplain just west of the mouth of Bob Lee Wash. This situation continued throughout 2000. In early 2001, the original flow eastward in the outflow ditch was restored, but the small pond and some flow into it remains. Over time, the variation in flow to the wetland could change the current configuration. The area on the floodplain west of the mouth of Bob Lee Wash where some of the water is now pooling consists of tamarisk and bare ground and is not jurisdictional wetland. Surface water discharge in this location may eventually establish wetland characteristics.

4.3.2 Environmental Consequences

Proposed Action Alternative

The main long-term effect of the proposed action would be the removal of ground water contaminants from the floodplain and wetland areas. Interim actions now in place and the proposed institutional controls would be eliminated once remediation was complete. Section 4.8 addresses ecological risk as it relates to the proposed action.

Construction activities associated with installation of the slurry wall and french drain would have short-term effects in the floodplain. Pumping of ground water from one or more extraction wells on the floodplain would lower the water table temporarily, but river water would recharge the aquifer proportionately within a short time. The estimated 10 gpm maximum extraction rate is insignificant compared to typical river flow (450,000 gpm, or 1,000 cfs) and would have no noticeable effect on water levels. Installation of the slurry wall and french drain would disturb up to 5 acres along the base of the escarpment.

Extraction wells and the associated piping and construction activities would avoid the jurisdictional wetland. Because most of the wetland's water comes from the artesian well discharge, pumping of the floodplain and terrace east should not affect wetland hydrology.

No Action Alternative

The no action alternative would allow contaminated ground water to continue to flow into the floodplain and wetland areas.

4.4 Soils, Sediments, and Salts

In 1998 and 1999, DOE conducted studies of sediments and soils at the site to determine if soils were a continuing source of contamination to ground water or surface water and if sediments had become contaminated in certain areas. One study evaluated sitewide concentrations of constituents. The sampling locations (Figure 23) were biased toward those that were more likely to contain higher levels of contamination based on ground water sampling, sample coloration, or higher radiometric measurements. A second study evaluated soil from 24 test pits at the base of the escarpment below the disposal cell. That study showed soil in that area is not a continuing source of contamination. Section 4.4.3 of the SOWP discusses both studies in detail.

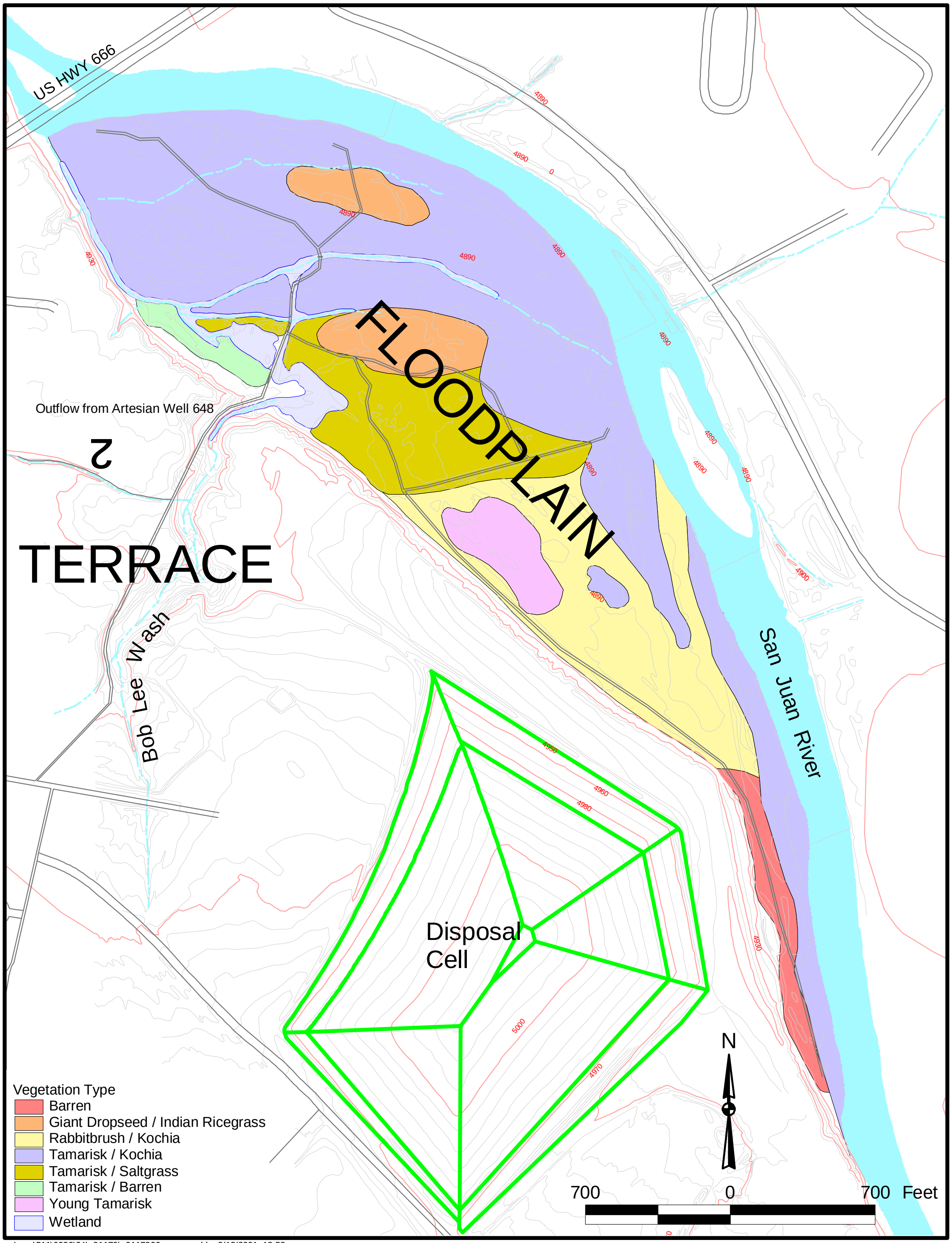

Figure 22. Wetland and Vegetation Locations at the Shiprock Site

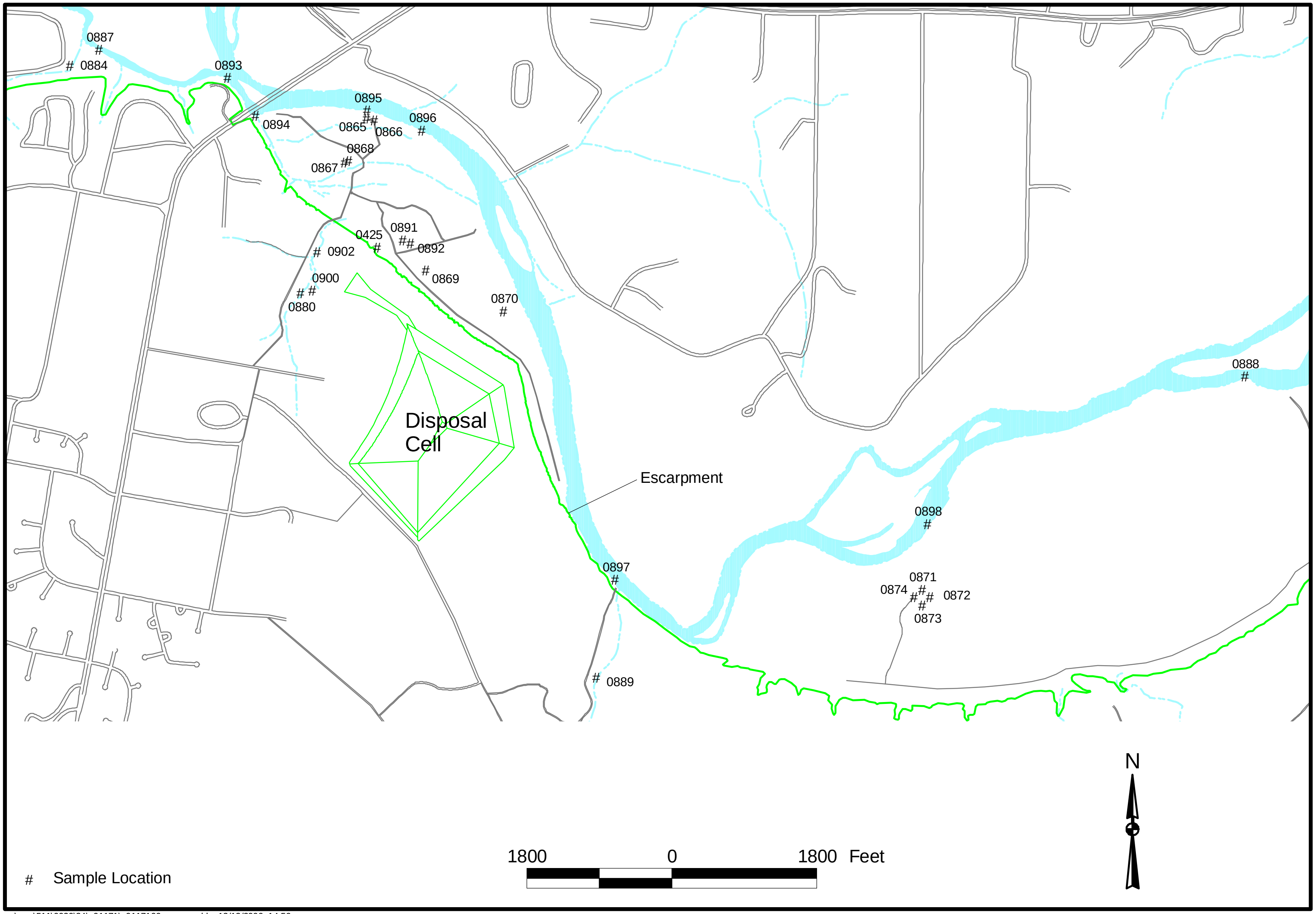

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Figure 23. Soil and River Sediment Sample Locations

The studies also identified areas where soil constituents may be at concentrations that could affect biological receptors such as benthic (bottom-dwelling, aquatic) organisms and plants.

Analysis of salt deposits was recommended during discussions with site stakeholders at a meeting in Tucson, Arizona, on March 4, 1999. DOE began a study of the deposits shortly afterward; results of this study are in Section 4.4.5 of the SOWP and the *Composition of Salt Deposits, UMTRA Ground Water Project, Shiprock, New Mexico, Site* (DOE 1999c). Sample locations for the salt deposit study are shown in Figure 24.

4.4.1 Affected Environment

Soils and Sediments

Investigations targeted 12 constituents—ammonium, antimony, arsenic, cadmium, magnesium, manganese, nitrate, selenium, sodium, strontium, sulfate, and uranium—that could be associated with past milling activities. Concentrations of a few constituents were slightly above background but were not significantly elevated above the range of natural variation. The surface remediation program completed in 1986 effectively removed most, if not all, mill-related contamination.

Concentrations of all 12 constituents in the five on-site and downgradient San Juan River sediment samples are similar to those in samples from the two upgradient locations, suggesting that millsite effluents have not contaminated the river sediments.

Salt Deposits

Salt deposits on the ground surface occur on the floodplain, the escarpment, and in Bob Lee and Many Devils Washes. The deposits are thickest and most extensive in Many Devils Wash. These deposits consist of translucent white or yellow-tinted crystalline minerals up to 0.25 inch thick that often encrust soil or vegetation. Some salt deposits on the floodplain are crystalline, but many occur as white powders that coat the ground. The crusts and powders are often concentrated in tire tracks, perhaps because the sediment had been compacted, causing an increase in upward capillary water movement. In upland areas, the salt deposits typically occur as thin layers of white powder, similar to salt deposits on weathered Mancos Shale elsewhere in the region.

Salt deposits along the escarpment are thickest and most extensive where seeps occur. Before completion of the interim actions in Many Devils Wash, the deposits were visible on most of the wash bottom and are still common on the east wall of the wash. Infrequent rains dissolve the crust, but it reappears by evaporation after several days of dry conditions. This was evident in Many Devils Wash on March 28, 2000, when the crust disappeared after a rain of about 0.75 inch. Dry conditions reestablished the crust within a week as ground water seeped to the surface and evaporated. Evangelou and others (1984) describe the salt deposits that commonly occur naturally in the Mancos Shale as containing a mixture of calcium, sodium, and magnesium sulfate evaporite minerals. Concentrations of most constituents in the deposits are within the range of background. Uranium and nitrate were the only constituents that had consistently elevated concentrations; these concentrations are probably attributable to mill-related contamination.

4.4.2 Environmental Consequences

Proposed Action Alternative

About 15–20 acres of soil would be disturbed during construction activities associated with installing the extraction well system, one or more evaporation ponds, a slurry wall, and other construction activities.

In the floodplain soils and sediments, active remediation would reduce concentrations of mill-related constituents in the most contaminated areas. If no continuing source of contamination is present, natural flushing would reduce contaminant levels over time. Active remediation on the terrace east ground water system should dry up the seeps and reduce the occurrence of salt deposits attributable to ore processing. Once the seeps have dried up, contaminant concentrations in sediment and soil affected by seep water should be close to natural conditions. Topsoil excavated for the evaporation pond would be stockpiled and seeded to prevent erosion. The excavated soil would be used to backfill the pond after completion of active remediation. All roads and disturbed areas would be returned to their previous state to the extent practicable. The proposed action would not affect soil and sediment in the terrace west area.

No Action Alternative

The no action alternative would not alter present conditions at the site.

4.5 Vegetation

4.5.1 Affected Environment

Vegetation in the floodplain area was mapped and sampled during characterization work in 1998 through 2000. Section 4.6 of the SOWP (DOE 2000a) presents a description of the plant ecology characterization for floodplain areas east of U.S. Highway 666. The floodplain area west of U.S. Highway 666 was characterized only qualitatively because of difficulty of access. Vegetation types west of the highway were similar to those mapped on the east. Appendix D provides the scientific names of vegetation associated with the Shiprock site.

Floodplain Area

Floodplain vegetation reflects a history of disturbances in the form of surface remediation in 1986 and the traditional use of the floodplain as a grazing area. Characterization in 1998 included a description of the changes in floodplain vegetation after surface remediation.

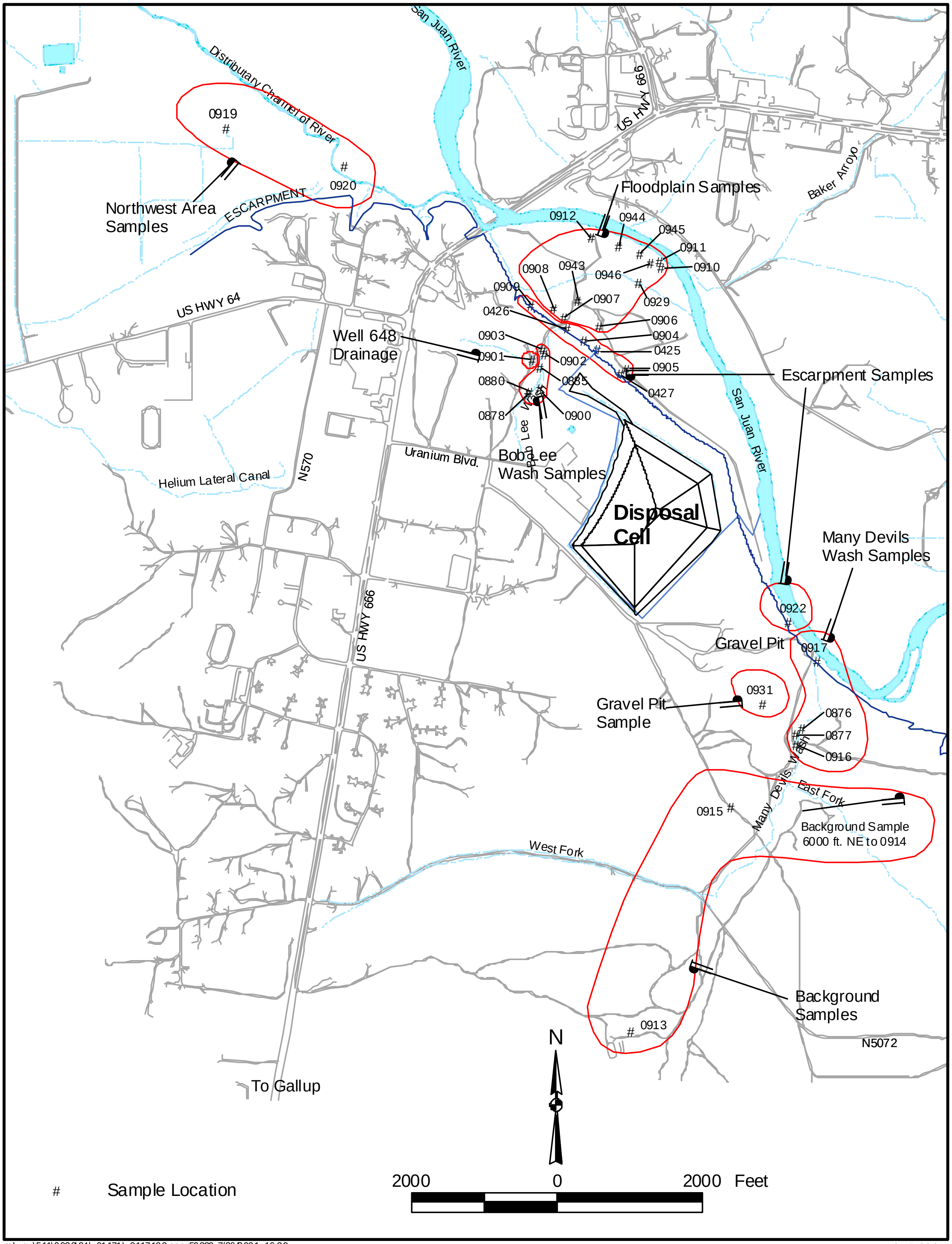

Figure 24. Sample Locations for the Salt Deposit Study

Several plant communities are present on the floodplain, as shown in Figure 22. Tamarisk (both mature and saplings) with an understory of kochia covers close to half the area. Both of these are introduced weedy species that minimize the ecological value of this community type. Rabbitbrush and kochia cover a large part of the floodplain's south half, which also includes large bare patches and some remnants of perennial grasses. Saltgrass and scattered mature tamarisk occur adjacent to the wetland in the west central portion, indicating the high water table in this area. An association of Indian ricegrass and giant dropseed occurs on stabilized sandy areas of the floodplain.

Marshland species dominated by cattail, bulrush, saltgrass, and common reed are at the base of Bob Lee Wash and along its drainage path across the floodplain. This vegetation is supported almost solely by flow from artesian well 648. In 1999, the construction of a small pond in the outflow ditch above Bob Lee Wash changed the flow pattern of the water. A new area of ponded water is currently located against the escarpment just west of the delineated wetland. If the current situation continues, it is likely that the location of the wetland will shift westward to reflect this new drainage pattern; portions of the current wetland will become drier. This issue is discussed further in Appendix A, "Shiprock Floodplain and Wetland Assessment."

Terrace East Area

Vegetation in the terrace east area reflects a history of disturbance and consists of desert grassland and pioneer species on disturbed land. The 1984 Environmental Assessment (DOE 1984, Appendix F) lists Indian ricegrass, sand dropseed, galleta grass, saltbush species, and rabbitbrush as the dominant vegetation in less disturbed areas. The disturbed areas adjacent to the disposal cell and gravel pit are sparsely vegetated by a few perennial grasses and annual weeds such as cheatgrass, Russian thistle, and kochia.

Recent biological surveys (DOE 2000d) confirmed the presence of one federally listed threatened species, the Mesa Verde cactus. Several populations of this species on the terrace contain from one to more than 100 per group. These are located in a fenced preserve just south of the Navajo Engineering and Construction Authority (NECA) gravel pit (Plate 1). The cactus is also present in several areas in the southeast part of the site south of the fenced preserve.

Terrace West Area

The terrace west area is dominated by human activity, and vegetation consists of sparse desert flora and disturbed land species scattered throughout residential, commercial, and agricultural land. Irrigated fields on the terrace west area grow mostly alfalfa.

4.5.2 Environmental Consequences

Proposed Action Alternative

Floodplain Area

Installation of wells and piping, and construction activities associated with the slurry wall impermeable barrier and french drain would temporarily disturb about 5 acres of vegetation in the construction areas. Any disturbances in floodplain nonjurisdictional wetland areas would be minimal, and those areas should revegetate naturally in a short time because of the presence of a shallow water table. Because livestock grazing is not allowed on the floodplain, effects to newly established vegetation would be negligible. Pumping ground water from one or more extraction wells in the contaminated area of the floodplain would create a cone of depression in the water table around each well. This may be detrimental to some of the shallow-rooted herbaceous plants near each well but would not noticeably affect phreatophytes (plants that have roots in the water table) such as tamarisk, the roots of which can extend to a depth of 20 ft or more. Once the extraction process is completed, any conditions changed by the extraction would be restored by the return of natural ground water levels. The locations of the extraction wells would be far enough from the wetland that the pumping would have no influence on wetland vegetation.

Terrace East and West

About 10–15 acres of vegetation would be disturbed by construction of the extraction well system, french drains, and one or more evaporation ponds. Vegetation is sparse in the terrace areas, and construction is not expected to produce any noticeable changes in plant cover or composition.

Extraction of ground water on the terrace is expected to dry up seeps 425 and 426, thus eliminating them as potential exposure pathways to ecological receptors. In doing so, the vegetation growing in these seeps would be altered. Currently, the terrace cover is composed of low-growing grasses. When the terrace ground water levels drop sufficiently, the vegetation would gradually change to match that of the surrounding escarpment areas. The proposed action would have no effect on the Mesa Verde cactus.

Because most of the water flowing in Bob Lee Wash comes from well 648, terrace ground water extraction should have minimal effects on the wetland vegetation there. Removal of institutional controls and the return of grazing to the floodplain and wetland would alter vegetative cover and diversity; the effects would depend upon grazing management. Changes in the flow rate of well 648 have the most potential for altering wetland vegetation.

No Action Alternative

The no action alternative would not affect the current condition of site vegetation and would have no effect on the Mesa Verde cactus.

4.6 Wildlife

A baseline inventory of wildlife species likely to inhabit the site area was documented in the *Environmental Assessment of Remedial Action at the Shiprock Uranium Mill Tailings Site, Shiprock, New Mexico* (DOE 1984). That EA assessed the effects of surface remediation. Further investigations and meetings with the Navajo Fish and Wildlife Department and the USFWS took place between 1997 and 2000 to update the baseline. Two surveys, conducted in August 1998 and November 1999 (Ecosphere Environmental Services 1998 and 1999), evaluated the potential presence of sensitive species. Sensitive species include those that are protected under tribal or federal regulations, including the Endangered Species Act, Eagle Protection Act, and Migratory Bird Treaty Act. The 1998 survey identified 14 sensitive species that could occur at the site. That survey included a letter (dated August 3, 1998) from the Navajo Fish and Wildlife Department identifying 18 Navajo Nation species of concern, including threatened and endangered species. The survey also included a current listing of all wildlife anticipated to be found near the site. On the basis of the 1998 survey, the 1999 survey was undertaken to respond to USFWS concerns for threatened and endangered species that may inhabit the San Juan River, the floodplain and jurisdictional wetland, and Bob Lee Wash. Appendix D provides the scientific names of wildlife species that may inhabit the site.

4.6.1 Affected Environment

Floodplain Area

The floodplain area has the most diverse habitat of the three areas and supports a variety of wildlife species. Riparian habitats exist along the San Juan River, at the mouth of Bob Lee Wash, and in drainage channels that cross the floodplain. Figure 22 shows a jurisdictional wetland that is also in the floodplain.

Table 8 lists the species of concern most likely to inhabit the floodplain area. The floodplain area has suitable habitat for the southwestern willow flycatcher, although that species has not been sighted during surveys. An aquatic survey was not conducted, but the San Juan River in the site area is federally designated critical habitat for the Colorado pikeminnow and razorback sucker. The roundtail chub is also known to be present in the river.

Terrestrial mammals sighted in the floodplain include foxes, coyotes, skunks, raccoons, deer, and rodents, which all use the area for foraging, resting, denning, and other activities. Beaver use is also evident near the San Juan River, and muskrats may be present but have not been sighted.

Riparian vegetation attracts a variety of resident and migratory birds. Crows, ravens, magpies, and flickers are common to the area. Birds of prey such as the American kestrel and turkey vulture have also been observed. Migratory and seasonal birds are likely to use the floodplain and wetland, and waterfowl such as ducks, geese, herons, and egrets have been observed in the aquatic habitat of the San Juan River.

Table 8. Wildlife Species of Concern Likely To Inhabit the San Juan River and Adjacent Floodplain

Species	Federal Status[a]	Navajo Status[b]	Observed	Comments
Bald eagle	MBTA, EPA	Group 2	No	ESA threatened. Known winter resident but no nests observed.
Southwestern willow flycatcher	MBTA, ESA	Group 2	No	ESA endangered. Suitable habitat exists in two areas of the floodplain.
Roundtail chub	None	Group 2	No	Suitable habitat exists in the San Juan River.
Colorado pikeminnow	ESA	Group 2	No	ESA endangered. Suitable habitat exists in the San Juan River. Formerly Colorado squawfish.
Razorback sucker	ESA	Group 2	No	ESA endangered. Suitable habitat exists in the San Juan River.
Northern leopard frog	None	Group 3	No	Known to occur within 3 miles of the site.

[a]ESA = Endangered Species Act; MBTA = Migratory Bird Treaty Act; EPA = Eagle Protection Act
[b]Navajo Endangered Species List (NESL); Groups 2 and 3 are protected under the Endangered Species Act.

Reptiles observed in drier areas of the floodplain include collared lizards, side-blotched lizards, and bull snakes. Although no amphibians have been sighted in the floodplain, frogs are expected to inhabit this area. The wetland and the distributary and main channels of the San Juan River support a diverse aquatic community, including fish, snails, and a variety of insects.

Terrace East Area

The terrace east area has a less diverse habitat than the floodplain and would not be expected to support a variety of wildlife species. Except in Bob Lee Wash, vegetation in most of the terrace east area is sparse and typical of a desert ecosystem. Bob Lee Wash and the outflow ditch from well 648 support a relatively diverse aquatic community, including minnows, frogs, and a variety of insects. Many Devils Wash supports little vegetation. Almost no wildlife activity (including sign) is evident at the wash; however, a red fox has been observed within 100 yards of the wash.

Cover is very limited in the terrace east area, and birds and terrestrial mammals such as foxes, coyotes, skunks, raccoons, deer, and rodents would likely use this area only on a limited basis. Bird species likely to be seen are primarily resident species. Birds of prey such as the western burrowing owl, barn owl, American kestrel, red tailed hawk, and turkey vulture have been observed in the terrace east area.

Reptiles observed or expected in this area include collared lizards, side-blotched lizards, rattlesnakes, and bull snakes. Amphibians (primarily frogs) have been seen in Bob Lee Wash and the outflow ditch from well 648 but not in the Many Devils Wash area. It is not known if this is due to water quality in the wash or lack of habitat.

Table 9 lists the species of concern most likely to occur in the terrace east area. The western burrowing owl is the only one of these species that has been observed in that area. Other raptors listed in the table may use the area for feeding, but nesting and roosting habitat is almost nonexistent. Habitat is suitable for the mountain plover, pronghorn antelope, and black-footed ferret, but human disturbances and grazing limit use of the area by those species.

Table 9. Wildlife Species of Concern Most Likely To Be Present in the Terrace East Area

Species	Federal Status[a]	Navajo Status[b]	Observed	Comments
Rough-legged hawk	MBTA	None	No	Known winter resident in the Shiprock area. May hunt in the site area.
Western burrowing owl	MBTA	None	Yes	Regularly observed during site visits. Nesting sites also observed.
Golden eagle	MBTA, EPA	Group 3	No	No observations to date. May hunt in this area.
Ferruginous hawk	MBTA	Group 3	No	Known to occur in the region. May hunt in this area.
Mountain plover	MBTA	Group 4	No	No observations to date. Known to occur in the region. May be limited by human disturbances.
Peregrine falcon	MBTA	Group 3	No	No observations to date. Known to occur in the region. May hunt in this area as an occasional visitor. Delisted from ESA in August 1999
Pronghorn antelope	None	Group 3	No	No observations to date. Known to occur in the region. Unlikely to occur locally due to human disturbances.
Black-footed ferret	ESA	Group 2	No	ESA endangered. No observations to date. Based on the size of the prairie dog town, none are anticipated to be in this area; therefore, no effect is anticipated.

[a]ESA = Endangered Species Act; MBTA = Migratory Bird Treaty Act; EPA = Eagle Protection Act
[b]Navajo Endangered Species List (NESL); Groups 2 and 3 are protected under the Endangered Species Act, Group 4 does not require protection under the Endangered Species Act.

Terrace West Area

The terrace west area is a combination of habitats found in the floodplain and terrace east areas. The significant difference between this area and the other two is the predominance of human activity, such as residential, agricultural, and commercial development. Irrigation ditches and the main and distributary channels of the San Juan River are drinking water sources. However, only the northernmost section of the terrace west area has limited potential as wildlife habitat.

Table 10 lists the species of concern most likely to occur in the terrace west area. An aquatic survey was not conducted, but the San Juan River in the site area is known to be federally designated critical habitat for the Colorado pikeminnow and razorback sucker. The roundtail chub is also known to be present in the river. Raptors listed in Table 10 may use the area for feeding, but nesting and roosting habitat is almost nonexistent. Habitat is not suitable for the pronghorn antelope and the black-footed ferret.

Table 10. Wildlife Species of Concern Likely To Inhabit the Terrace West Area

Species	Federal Status[a]	Navajo Status[b]	Observed	Comments
Rough-legged hawk	MBTA	None	No	Known winter resident in the Shiprock area. May hunt in this area.
Ferruginous hawk	MBTA	Group 3	No	Known to occur in the region. May hunt in this area.
Bald eagle	MBTA, EPA	Group 2	No	ESA threatened; known winter resident but no nests observed. Would hunt in this area along the river.
Roundtail chub	None	Group 2	No	ESA endangered. Suitable habitat exists in the San Juan River.
Colorado pikeminnow	ESA	Group 2	No	Suitable habitat exists in the San Juan River. Formerly Colorado squawfish.
Razorback sucker	ESA	Group 2	No	Suitable habitat exists in the San Juan River.
Northern leopard frog	None	Group 3	No	Known to occur within 3 miles of the site. Could occur in the floodplain next to the river.

[a]ESA = Endangered Species Act; MBTA = Migratory Bird Treaty Act; EPA = Eagle Protection Act
[b]Navajo Endangered Species List (NESL); Groups 2 and 3 are protected under the Endangered Species Act.

Terrestrial mammals would likely be limited to those adapted to human activity, such as coyotes, skunks, raccoons, and rodents. Wildlife cover is very limited in the southern half of this area. Bird species likely to be sighted in the northern section of the terrace west area are similar to those that would be seen in the floodplain, although use of this area would be minimal compared to use of the floodplain area. Riparian vegetation along the distributary channel and San Juan River would attract birds for feeding, nesting, perching, roosting, and other activities. Migratory and seasonal birds and waterfowl such as ducks, geese, herons, and egrets are likely to use the aquatic habitat along the San Juan River. However, this area has not been studied extensively. It is anticipated that the same reptiles, amphibians, and fish likely to be in the floodplain section would be present in the area along the San Juan River.

4.6.2 Environmental Consequences

Proposed Action Alternative

Floodplain Area

Active remediation consisting of one or more extraction wells and a slurry wall/french drain on the floodplain would disturb about 5 acres of habitat. Short-term disturbances would be associated with installing a power supply, pumps, one or more extraction wells, a slurry wall impermeable barrier and french drain, and buried PVC pipe for collecting water from one or more extraction wells. Installation of the extraction system would take about 4 months and is projected to be completed between the months of April and October 2002. Following installation, disturbed areas would be recontoured and revegetated with recommended seed mixes. The reduction of contaminant concentrations at the completion of remedial action would reduce or eliminate any risk that contaminants pose to wildlife.

Construction activities are not anticipated to have any noticeable effects on amphibians, fish, or reptiles. Installation of the extraction system and slurry wall/french drain could result in some mortality to small burrowing mammals with small home ranges. Short-term displacement or disturbances of resident small mammal populations and birds would also be likely during the installation phase, although it should not affect larger mammals. Disturbances from the presence of humans and the use of operating equipment could temporarily disturb nesting, roosting, breeding, foraging, and hunting activities of resident birds, migratory birds, and birds of prey. Because of the wildlife management provisions, no effects to sensitive species are anticipated from implementing the remedial action.

Terrace East Area

The active remediation in the terrace east area would disturb about 10–15 acres of habitat. Short-term disturbances would be associated with excavating one or more evaporation ponds, installing a power supply, constructing french drains, and installing extraction wells, pumps, and buried PVC pipes for collecting water from extraction wells. Installation of one or more ponds and the extraction system would take about 4 months and is projected to be completed between the months of April and October 2002. Following installation, disturbed areas would be recontoured and revegetated with recommended seed mixes. The reduction of contaminant concentrations at the completion of remedial action would reduce or eliminate any risk that contaminants pose to wildlife.

No effects to amphibians or fish are anticipated during installation because none are present in the project area. Installation of the extraction system could result in some mortality to reptiles and small burrowing mammals with small home ranges. Short-term displacement or disturbances of resident reptiles, small mammal populations, and some birds would also be likely during the installation phase, although no effects to larger mammals are expected. Disturbances from the presence of humans and the use of operating equipment during the installation phase could limit nesting, roosting, breeding, foraging, and hunting activities of some resident birds and birds of prey in the short term. Effects to migratory birds during installation are not a concern in the terrace east area because of limited habitat and existing human activities that are not project related. Because of the wildlife management provisions, construction activities are not anticipated to affect sensitive species.

After remediation equipment is installed, the remaining potential effects to wildlife are associated with one or more evaporation ponds. Evaporation of water pumped from the extraction wells and french drains into one or more ponds would concentrate dissolved solids, which could result in toxic concentrations of some constituents. Actions such as barriers and fencing identified in the wildlife management plan would limit the potential for adverse effects to most wildlife. If a small evaporation pond is constructed near Many Devils wash to hold water collected and piped from the two french drains, the pond would be fenced and netted to effectively exclude wildlife. Sensitive species that could be affected if they are present and using the area would likely include waterfowl, some migratory birds, the western burrowing owl, bald eagle, rough-legged hawk, and ferruginous hawk. No effects to the southwestern willow flycatcher are anticipated in this area because of the lack of suitable habitat.

Terrace West Area

Because supplemental standards would be applied in this area, no surface disturbing activities or other sources of disturbance would occur. Therefore, the proposed action would not affect wildlife or habitat.

No Action Alternative

Under the no action alternative, no field activities or human disturbances would occur. Therefore, no adverse effects would result from physical disturbances in any of the three areas. However, constituents that may pose a risk to wildlife would be left in place.

4.7 Human Health Risk

4.7.1 Affected Environment

Contaminated ground water from both the floodplain and the terrace east systems is not currently used for any purpose, and no grazing takes place in contaminated areas. The only potentially complete pathways are for exposure to surface water in the washes and seeps. However, the recently completed interim actions (see Section 1.5) greatly reduced these potential points of exposure.

The Navajo Tribal Utility Authority provides treated water to most of the residents south of the San Juan River through a municipal water supply system that purchases water from the Farmington system. An intake structure on the north bank of the San Juan River just east of the U.S. Highway 666 bridge is only used to take water out of the river during emergency situations.

Section 6.1 of the SOWP contains the updated human health Baseline Risk Assessment. The update evaluated potential risks associated with incidental exposure to surface water and with using terrace and floodplain ground water as drinking water in a residential scenario. The evaluation showed that the greatest potential risks were associated with use of both terrace and floodplain ground water as drinking water, although both exposure pathways are incomplete, and the ground water systems do not currently pose actual human health risks. Some potential risk exists in areas of terrace west where ground water has not been influenced by irrigation.

4.7.2 Environmental Consequences

Proposed Action Alternative

Floodplain Area

As part of the proposed action, DOE would enter into an agreement with the Navajo Nation to prohibit drilling of wells or using ground water until remediation is complete. This approach, combined with the interim actions already implemented, would restrict ground water use until ground water quality meets applicable standards, thus eliminating potential future risks.

The proposed action would not affect workers or the public. The greatest risks associated with the proposed action would be to workers during construction of the slurry wall/french drain treatment system. The use of standard safety precautions and practices would reduce the risks inherent in operating drilling and excavating equipment. Risk from ingesting ground water applies to long-term ingestion in a residential setting rather than short-duration activities such as construction and monitoring. Risks to the public during the construction and operation of the system would be negligible because access would be restricted.

Terrace East Area

DOE would consult the Navajo Nation to determine actions necessary to discourage use of ground water. Actions may include prohibiting installation of new wells or the use of ground water until remediation is complete. These actions mitigate potential future risks because of restrictions on ground water use. As with the proposed action for the floodplain, risks would be associated with the occupational hazards inherent in construction and operation of the active treatment system. However, these risks would be minimal, and they would be further reduced by the use of appropriate health and safety practices.

Terrace West Area

The supplemental standards proposed for ground water in the terrace west area would not affect human health. DOE would consult the Navajo Nation to determine actions necessary to discourage use of ground water to irrigate crops consumed by humans. Actions may include prohibiting installation of new wells for drinking water purposes until mill-related constituents have flushed. Use of ground water for agricultural irrigation would be permissible in areas where the water yield is sufficient.

No Action Alternative

Potential risks to human health could increase under the no action alternative. Because no formal institutional controls or other controls would be used, domestic wells could be installed and create access to contaminated ground water for drinking water purposes. The Baseline Risk Assessment update in the SOWP (DOE 2000a) indicates that use of ground water from the floodplain and terrace east as the primary source of drinking water would result in unacceptable risks to human health. The most significant risks would occur from manganese, nitrate, selenium, sulfate, and uranium; infants are a sensitive subpopulation for exposure to nitrate and sulfate.

4.8 Ecological Risk

4.8.1 Affected Environment

Data gathered in September 1998, June 1999, September 1999, and March 2000 at the Shiprock site were used to update the 1994 Baseline Risk Assessment (DOE 1994). This summary of ecological risk at the site is taken from the more comprehensive evaluation in Section 6.2 of the SOWP.

Based on differences in media type, ecological communities, and receptors, the Shiprock site was divided into six areas to assess ecological risks. These areas are shown as Areas A through F on Plate 2. Each area was evaluated with respect to ground water constituents, key ecological receptors, and potential exposure pathways. Contaminant concentrations in surface water, sediment, and soil from the six areas were compared with data from reference areas. Risk estimates were derived from exposure and benchmark values. For aquatic and benthic organisms and plants, exposures are equivalent to media concentrations (surface water for aquatic organisms and sediment or soil for benthic organisms and plants). For wildlife and livestock, exposures were modeled from multiple pathways, such as direct ingestion, direct contact, and ingestion of forage or prey.

Constituents that present no risk were dropped from further consideration, and those with low risks were also dropped if the potential receptors did not include threatened or endangered species. Because conservative assumptions were incorporated into the risk exposure models and toxicity benchmarks, the actual risks posed by these constituents are probably overestimated. Therefore, risks that are considered low are expected to be protective of ecological populations and communities but may not be protective of individuals in the cases where threatened or endangered species may be exposed. Table 11 summarizes the constituents of potential ecological concern at each of the six evaluated areas. These constituents are considered to be of potential concern because their concentrations in environmental media indicate a potential for adverse toxicological effects to biological receptors.

Table 11. Constituents of Ecological Concern Based on Risk Screening Results

Area A: Distributary Channel and Tributaries	Area B: San Juan River	Area C: Shiprock Floodplain	Area D: Bob Lee Wash	Area E: Many Devils Wash	Area F: Upland Terrace
Ammonium Manganese Nitrate Selenium Strontium Sulfate Uranium	Manganese Selenium Strontium Sulfate Uranium	Ammonium Manganese Nitrate Selenium Strontium Sulfate Uranium	Ammonium Nitrate Selenium Sulfate Uranium	Ammonium Nitrate Selenium Strontium Sulfate Uranium	None

Floodplain Area

Potential ecological risks at Area B (the San Juan River) are mainly risks to aquatic receptors, that is, to organisms that live entirely or primarily in the water. In recent sampling rounds, concentrations of selenium, sulfate, and uranium at isolated locations have exceeded the water quality benchmarks. However, the estimated risks do not represent the general water quality conditions of the river. Selenium concentrations in samples from all but two of 60 locations were not only less than the water quality benchmark, they were also less than the maximum selenium concentration from the background river samples (0.0018 mg/L).

Manganese, selenium, sulfate, and uranium are the principal risk drivers in surface water at Area C (the floodplain). Current concentrations of manganese, selenium, and uranium concentrations in sediments and soil could pose risks to wetland and upland plant communities. Minor risks to land-dwelling organisms that feed on plants may exist on the floodplain from selenium and manganese exposures, and potential risks to wetland predators may exist from exposures to selenium in the food chain.

Risk to Livestock Grazing on the Floodplain

The San Juan River floodplain area is not currently grazed; however, it is part of a grazing allotment managed by the Navajo Nation and could potentially be used for livestock grazing at a future date. Additional forage sampling was conducted in June 2000 to assess the risk to livestock grazing on the floodplain. A complete discussion of risk is included as Appendix B of this EA. Results of the assessment indicated that livestock should not be at risk if allowed to graze on the floodplain.

Terrace East Area

Areas D and E and most of Area F lie within the terrace east area (Plate 2). Before the interim actions, it was determined that water in Bob Lee and Many Devils Washes (Areas D and E, respectively) had sufficiently elevated concentrations of several constituents to pose potential ecological risks. However, upon completion of the interim actions, these exposure pathways have diminished and current risks are negligible.

In Area F, summary statistics were calculated for each analyte evaluated in the samples of greasewood leaves and stems collected from the (millsite) upland terrace area and a reference terrace area. Risk estimates indicate that concentrations of these constituents in the aboveground tissues of these plants are not sufficient to pose a risk to wildlife on the terrace.

Terrace West Area

Area A and a small portion of Area F are in the terrace west area (Plate 2). Potential risks from selenium exposure may exist for aquatic and benthic organisms, wetland plants, and wildlife (especially predators) that are associated with the wetland habitats. Risks to terrestrial wildlife and livestock that may use the area (principally being exposed through drinking water) are minimal. Ammonium, manganese, nitrate, strontium, sulfate, and uranium are also of potential risk to aquatic organisms in this area.

Salt Crust—All Areas

Samples of salt deposits were collected from Areas A, C, D, and E. Nitrate, sulfate, ammonium, and uranium were evaluated for ecological risk because they were present most consistently and at highest concentrations. Wildlife may be exposed to these salts through incidental ingestion with soil and sediment. Based on the maximum concentrations of nitrate and uranium, the potential for increased risk by the incidental ingestion of salt crusts in these areas by wildlife and livestock is considered low.

As discussed in Section 4.2, infrequent heavy rainfall in the area can produce runoff in Many Devils Wash (Area E) that dissolves the salt deposits in the wash and transports them into the San Juan River. Results of simulations indicate that salt crusts in Many Devils Wash are not likely to have a detrimental effect on the quality of water in the river. Appendix C provides a description of the assumptions and calculations. In August 2001, a flow-activated sampler provided by USFWS was installed in the wash to collect samples of surface water during a flood event in the wash. The samples will be analyzed for selenium to provide data on salt crust dissolution and its effect on the San Juan River.

Summary

DOE received several letters from the USFWS between February 2000 and August 2001, which outlined their concerns related to potential ecological risks at the site. Many of the concerns were addressed by interim actions and additional sampling in the San Juan River. DOE is continuing to consult with all agencies, including the USFWS and Navajo Fish and Wildlife Department, concerning risk and potential effects on sensitive species.

4.8.2 Environmental Consequences

Proposed Action Alternative

The proposed action would further reduce contaminant concentrations in the terrace east area, the San Juan River, its distributary channel, and the floodplain. Remediation would also eliminate the mill-related source of surface water in the seeps along the escarpment and in Bob Lee and Many Devils Washes. Ecological effects of the proposed action would probably not differ noticeably from present conditions because no adverse ecological effects have been observed to date. The decreased concentrations of mill-related constituents in the San Juan River following remedial action would have a positive effect on all aquatic receptors, including fish listed in the Endangered Species Act. Likewise, reduction in constituent concentrations in other areas would reduce or eliminate any risk contaminants might pose to wildlife species, including the southwestern willow flycatcher if its presence is confirmed. If monitoring indicates an increase in contaminant concentrations in any media or forage samples, risks to ecological receptors, including livestock, could increase.

No Action Alternative

Under the no action alternative, contaminant concentrations would not be reduced to acceptable levels. DOE would discontinue monitoring. Although ecological risks in Bob Lee and Many Devils Washes are currently minimized by the interim actions, the netting, riprap, and fencing would not be maintained to ensure their integrity. The potential for ecological risks and risks to livestock would not be monitored, evaluated, or mitigated. Therefore, ecological risks could potentially increase over the long term.

4.9 Land Use

4.9.1 Affected Environment

Land near the Shiprock site is used for a variety of purposes because of its proximity to the town of Shiprock. There is no current development within the floodplain area, which has historically been used for grazing. Once DOE completes remediation in this area, it would likely be returned to grazing and would also continue to be a riparian floodplain and open space area. Once grazing occurs, the value of the existing wetland area would be questionable. Grazing would also diminish the current wildlife habitat.

The eastern and southernmost portion of the terrace east area is characterized as sparsely developed with scattered residences and grazing. The terrace area directly south of the floodplain has industrial development and includes the disposal cell and NECA facility, which includes offices, equipment repair shops, and equipment and material storage. Also within the fenced NECA facility is an Indian Health Service office of the U.S. Public Health Service and the Shiprock Field Office of the Navajo Abandoned Mine Lands Reclamation Department. Several of the NECA facility buildings were former millsite buildings that were decontaminated during surface remediation. Southeast of the disposal cell is the fenced NECA gravel pit, which extends nearly to the mouth of Many Devils Wash and includes equipment for mining and crushing gravel. South of the disposal cell is the fenced radon cover borrow pit. West of the fenced NECA facility is the Shiprock Fairgrounds area, which is the site of the annual (in October) Northern Navajo Shiprock Fair.

Commercial and administrative developments line both sides of U.S. Highway 666 south of the San Juan River. The largest commercial facility in the area (and in the entire town of Shiprock) is the TsJ Bit ' aR (Shiprock) shopping center in the terrace west area. Included in the shopping center is the Shiprock Regional Business Development Office that administers business lease tracts. East and northeast of the shopping center are several fast food restaurants and small businesses. South of the shopping center are a few small businesses, a senior citizens center, the post office, a day care center, and a large office building under construction for the Bureau of Indian Affairs. Two schools, Shiprock High School (and its stadium and athletic fields) and Stokely Elementary School, are in the irrigated area south of U.S. Highway 64.

Land use in the northernmost portion of the terrace west area is predominantly agricultural, and alfalfa is the main crop. These irrigated areas are east of the high school, the DinJ College farm area, and the Blueeyes Ranch north of the irrigation return flow ditch. Water for these irrigated areas is supplied by a buried siphon (constructed in 1956) that takes water from the Hogback Canal north of the San Juan River and discharges it into the Helium Lateral Canal.

Planned land use changes in the Shiprock site area include:

- Return of the millsite floodplain north of the disposal cell to grazing use after floodplain remediation is completed.
- Possible expansion of the NECA gravel pit westward to the area of the radon cover borrow pit after terrace east remedial action is completed.
- Movement of the fairgrounds facility by about 2002 or 2003 to a location about 4 miles to the south.
- Construction of a hotel and several other new businesses in the area of the former fairgrounds.
- Construction of a multipurpose cultural center south of the new Bureau of Indian Affairs office. The center is currently in the planning stage and will include a library, welcome center, youth center, small museum, auditorium, amphitheater, gymnasium, and sports fields.
- Construction of a new Diné College facility in the tract east of the Shiprock High School.
- Construction of the Tabaaji Recreational Vehicle Park on the floodplain just north of the San Juan River and west of U.S. Highway 666.

4.9.2 Environmental Consequences

Proposed Action Alternative

The proposed action would allow the floodplain area to be returned to grazing, its historical use, in a shorter time than the no action alternative, and with minimal risk to livestock and wildlife. The proposed action in the terrace east and terrace west areas would not affect existing or future land uses, with the exception of the areas that would be used for an evaporation pond up to 10 acres in size and possibly a small additional evaporation pond near Many Devils Wash.

No Action Alternative

Under the no action alternative, the Navajo Nation could allow grazing in the floodplain in unrestricted areas. DOE would not impose restrictions in any areas. As is the case with the proposed action, land use in the terrace east and west areas would not be affected by the no action alternative. This is primarily due to the availability of a municipal water supply to serve land use and development needs.

4.10 Socioeconomics

4.10.1 Affected Environment

The town of Shiprock is unincorporated and has no defined city limits. Population and socioeconomic data apply to the Shiprock Chapter, a 196-square-mile area that includes the residential and business areas of the town and also the sparsely populated surrounding areas. The estimated total 1997 population of the Shiprock Chapter was 8,881, of which 8,615 (97 percent) are Native American (Navajo Nation 1997). Shiprock is not only the largest community in the Navajo Nation, it is the largest Native American town in the United States.

4.10.2 Environmental Consequences

Proposed Action Alternative

Installation of the extraction wells, slurry wall impermeable barrier, french drains, piping system, and one or more evaporation ponds could provide temporary employment for up to 10 local laborers and heavy equipment operators for several months. Operation of the pumps and water distribution system could employ one or more local technicians for the duration of active remediation. The proposed action would not affect local businesses or residences and would have no long-term effect on employment or population.

No Action Alternative

No activities would take place, and the no action alternative would not affect the socioeconomic characteristics of the area.

4.11 Environmental Justice

4.11.1 Affected Environment

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,* states that federal programs and actions shall not disproportionately affect minority or low-income populations. Because 97 percent of the population in the area is Native American, contamination resulting from activities at the site has the potential to affect members of the Navajo Nation almost exclusively.

4.11.2 Environmental Consequences

Proposed Action Alternative

Under the proposed action alternative, DOE would attempt to improve ground water quality to acceptable standards. The proposed action would not result in a disproportionately high or adverse effect to the tribal population.

No Action Alternative

The no action alternative could have a disproportionate effect on a minority population if contaminated ground water were used as a domestic water supply.

4.12 Cumulative Impacts

The Council on Environmental Quality defines "cumulative impact" as the "impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions" (40 CFR 1508.7). No actions other than those proposed by DOE are anticipated at or near the Shiprock site. The proposed action would produce a beneficial cumulative effect to ground water quality because contamination in the ground water from past activities would be cleaned up to applicable standards.

No other resources discussed in Section 4.0 would be affected cumulatively from the proposed action or the no action alternatives. Therefore, the proposed action alternative would not result in cumulatively adverse impacts.

5.0 Persons or Agencies Consulted

Persons and agencies consulted are listed below. DOE held several meetings between 1992 and 2001, including a public meeting in May 2001 in which DOE presented the proposed compliance strategies. A 60-day public comment period preceded the meeting. At the beginning of the public comment period, DOE distributed copies of the draft EA to stakeholders and local libraries. DOE received 127 comments from federal and Navajo agencies and individuals. In July 2001, DOE held a meeting with representatives from Navajo UMTRA, Navajo EPA, and other interested parties to resolve comments and determine a final proposed action. Appendix E presents a summary of the 127 comments and provides responses; Appendix F provides full text of the comments received by DOE.

Name	**Agency or Company**
Madeline Roanhorse Ray Russell Harlen Charlie	Navajo UMTRA Program Window Rock, Arizona
David Mikesic John Nystedt	Navajo Fish and Wildlife Department Window Rock, Arizona

Name	Agency or Company
	Navajo Environmental Protection Agency
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Steve Austin	Shiprock, New Mexico
Wilma Becenti	Window Rock, Arizona
Charmaine Hosteen	Shiprock, New Mexico
Eric Rich	Tuba City, Arizona
Deb Misra	Window Rock, Arizona
David Burbank	Shiprock Chapter Grazing Committee Shiprock, New Mexico
Denise Copeland	Shiprock Chapter (Capital Improvements) Shiprock, New Mexico
Dennis Siefert	School District No. 22 Shiprock, New Mexico
Roy Waters	Central Consolidated School District No. 22 Shiprock, New Mexico
Ted Charles	Navajo Land Office Shiprock, New Mexico
Marilyn King Johnson	Department of Youth Community Services Shiprock, New Mexico
Randy Sells Doreen Hammond	Navajo Nation Division of Economic Development, Regional Business Development Office, Shiprock, New Mexico
Ron Everson Jonathan James	Navajo Engineering and Construction Authority Shiprock, New Mexico
Lynn Benally Perry Charley	Navajo Abandoned Mine Land Reclamation Program Shiprock, New Mexico
Alfred Dehiya	Navajo Nation Project Review Window Rock, Arizona
Allen Downer	Navajo Natural Heritage Program (Cultural Resources) Window Rock, Arizona

Name	Agency or Company
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Herb Beyale James Manybeads Marlin Saggboy	Navajo Tribal Utility Authority Shiprock, New Mexico
Bennie Williams	Navajo Water Code Administration Fort Defiance, Arizona
Elvis Jodie	Natural Resources Conservation Service Shiprock, New Mexico
Jerry Thomas	Bureau of Indian Affairs Shiprock, New Mexico
David Leal Russ McRae Patricia Zenone	U.S. Fish and Wildlife Service New Mexico Ecological Services Albuquerque, New Mexico
Rick Kruger Barb Osmondson	U.S. Fish and Wildlife Service Grand Junction, Colorado
Sarah Rahman	U.S. Army Corps of Engineers Albuquerque, New Mexico
Jim Walker	EPA Region IX Farmington, New Mexico
Shannon Fitzgerald	EPA Region IX San Francisco, California
Jim Sizemore	New Mexico State Engineers Office Santa Fe, New Mexico
Bill Enenbach	New Mexico State Engineers Office Aztec, New Mexico
Barbara Hoditshek Steve Pierce	New Mexico Surface Water Quality Bureau Santa Fe, New Mexico
George Trosky	DLR Group Farmington, New Mexico

Name	**Agency or Company**
Steve Semken, Ph.D.	Diné College Shiprock, New Mexico
Jim McKinley	Pacific Northwest Laboratory Richland, Washington
David Bleakly	Bleakly Botanical & Biological, LLC Albuquerque, New Mexico

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Glossary

Alluvium: Clay, silt, sand, gravel, or similar material deposited during comparatively recent geologic time by a stream or other body of running water, as a sediment in the bed of the stream or in its floodplain.

Alternate concentration limits: Concentrations of constituents that may exceed the maximum concentration limits; or, limits for those constituents that do not have maximum concentration limits. If DOE demonstrates, and the U.S. Nuclear Regulatory Commission concurs, that human health and the environment would not be affected, DOE may use an alternate concentration limit.

Aquatic receptors: Organisms that live entirely or primarily in the water.

Benthic: Benthos, bottom-dwelling aquatic organisms.

Bentonite: A soft, porous, light-colored rock composed of clay-sized grains. The rock is somewhat greasy and soaplike to the touch and commonly has the ability to absorb large quantities of water accompanied by as much as an eightfold increase in volume.

Distributary channel: One of the channels of a braided stream. At the Shiprock site, the distributary channel downstream of the U.S. Highway 666 bridge is nearly dry during low-flow stages of the San Juan River; during high-flow stages, the channel carries a considerable volume of water.

Geogrid: A plastic mesh that allows water to drain through but retains gravel and larger rocks. Geogrid (specifically, microgrid) material was used during interim actions at the Shiprock site in Many Devils and Bob Lee Washes. The geogrid was placed over the 3- to 6-inch-diameter rock, and large cobble rock was placed over the geogrid.

Geotextile: A synthetic woven fabric used during interim actions at the Shiprock site in Many Devils and Bob Lee Washes. The fabric was laid down on the bottom of the washes to stabilize the underlying soil. Rock of 3- to 6-inch diameter was placed over the geotextile.

Hydraulic conductivity: A calculation describing the rate at which water can move through a permeable medium, usually expressed in distance divided by time.

Institutional controls: Controls prohibiting or limiting access to contaminated media; may consist of means such as deed restrictions, use restrictions, or permitting requirements.

Interim actions: A short-term action taken to mitigate or eliminate the actual release or threat of a release of hazardous waste or hazardous waste constituents at a facility. Generally, interim actions are taken while a long-term, comprehensive corrective action is being developed.

Jurisdictional wetland: A wetland that has been delineated according to the method in the *Army Corps of Engineers Wetlands Delineation Manual*.

Knickpoint: A break in slope or point of abrupt change in the profile of a stream or its valley.

Maximum Concentration Limit: EPA's maximum concentration of ground water constituents listed in Table 1 to Subpart A of 40 CFR 192.04 that may be present in contaminated ground water at UMTRA Project sites.

Natural flushing: A compliance strategy in which natural geochemical and biological processes and ground water movement decrease ground water contaminant concentrations through time.

Receptors: Organisms that may be exposed to contaminants.

Residual radioactive material: Uranium mill tailings that DOE determines to be radioactive that have resulted from the processing of uranium ore, and other wastes at a processing site that DOE determines to be radioactive and that relate to the processing. EPA has interpreted this to include nonradioactive constituents in the tailings that may pose a risk to human health or the environment.

Supplemental standards: Regulatory standards applied instead of background concentrations, maximum concentration limits, or alternate concentration limits that meet at least one of the eight criteria in 40 CFR 192.21. DOE proposes to apply the criterion of limited use ground water for the terrace west area of the Shiprock site.

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Appendix A

Shiprock Floodplain and Wetland Assessment

MAC-GWSHP 11.10-2

UMTRA Ground Water Project

Shiprock Floodplain and Wetland Assessment

Final

September 2001

Prepared by
U.S. Department of Energy
Grand Junction Office
Grand Junction, Colorado

Project Number UGW–511–0020–27–000
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Introduction

As the lead agency, the U.S. Department of Energy (DOE) is proposing to remediate ground water contaminated by residual radioactive material that resulted from historical processing of uranium ore at the Shiprock site. This material is regulated by the Uranium Mill Tailings Radiation Control Act (UMTRCA) of 1978. The Shiprock site (Figure A-1) is within the Navajo Nation. DOE has determined that contaminant concentrations in ground water warrant remedial action at the site to comply with U.S. Environmental Protection Agency standards in 40 CFR 192 and to minimize the potential for adverse effects to human health and the environment. This Floodplain and Wetland Assessment was prepared simultaneously with the *Environmental Assessment of Ground Water Compliance at the Shiprock Uranium Mill Tailings Site* (EA) and is included as an appendix to the EA.

Background

The Shiprock Uranium Mill Tailings Remedial Action (UMTRA) Project site is in San Juan County in the northwest corner of New Mexico (Figure A-1). In the early 1950s, the Shiprock area experienced dramatic growth resulting from uranium and oil and gas exploration. In January 1952, the U.S. Atomic Energy Commission established a uranium-ore buying station at the Shiprock site. In 1954, Kerr-McGee Oil Industries, Inc., completed construction of a uranium mill just east of the buying station. The uranium mill, known as the Navajo Mill, operated from November 1954 to March 1963 when it was sold to the Vanadium Corporation of America (VCA). VCA operated the mill until August 1967 when the company merged with Foote Mineral Company, which continued operation until milling ended in August 1968. Before and during the milling operations, the site was leased from the Navajo Nation. In 1973, the lease expired and the site ownership reverted to the Navajo Nation. During its life, the mill processed about 1.5 million tons of ore. Some of the mill buildings and most of the equipment were dismantled and placed in a tailings pile from the time that milling ended in 1968 to the expiration of the Foote Mineral Company lease in 1973.

Soon after acquiring the site in 1973, the Navajo Nation asked the U.S. Environmental Protection Agency and other federal agencies for assistance in stabilizing the two tailings piles at the site. Some moving of the tailings and filling of drainages had already occurred by June 1974. Remedial action criteria in UMTRCA made it necessary to prepare a revised site engineering assessment, followed by surface and ground water characterization studies. These characterization studies resulted in an EA proposing remedial action for surface contamination. DOE was assigned the role of lead agency under UMTRCA. Cleanup of surface soils and buildings took place in late 1985 and 1986 and consisted of consolidating the two tailings piles into one disposal cell. A photographic record of remediation and disposal cell construction during 1985 through 1987 is archived at the DOE Grand Junction Office. The U.S. Nuclear Regulatory Commission issued a license in September 1996 to the Grand Junction Office for long-term care of the disposal cell.

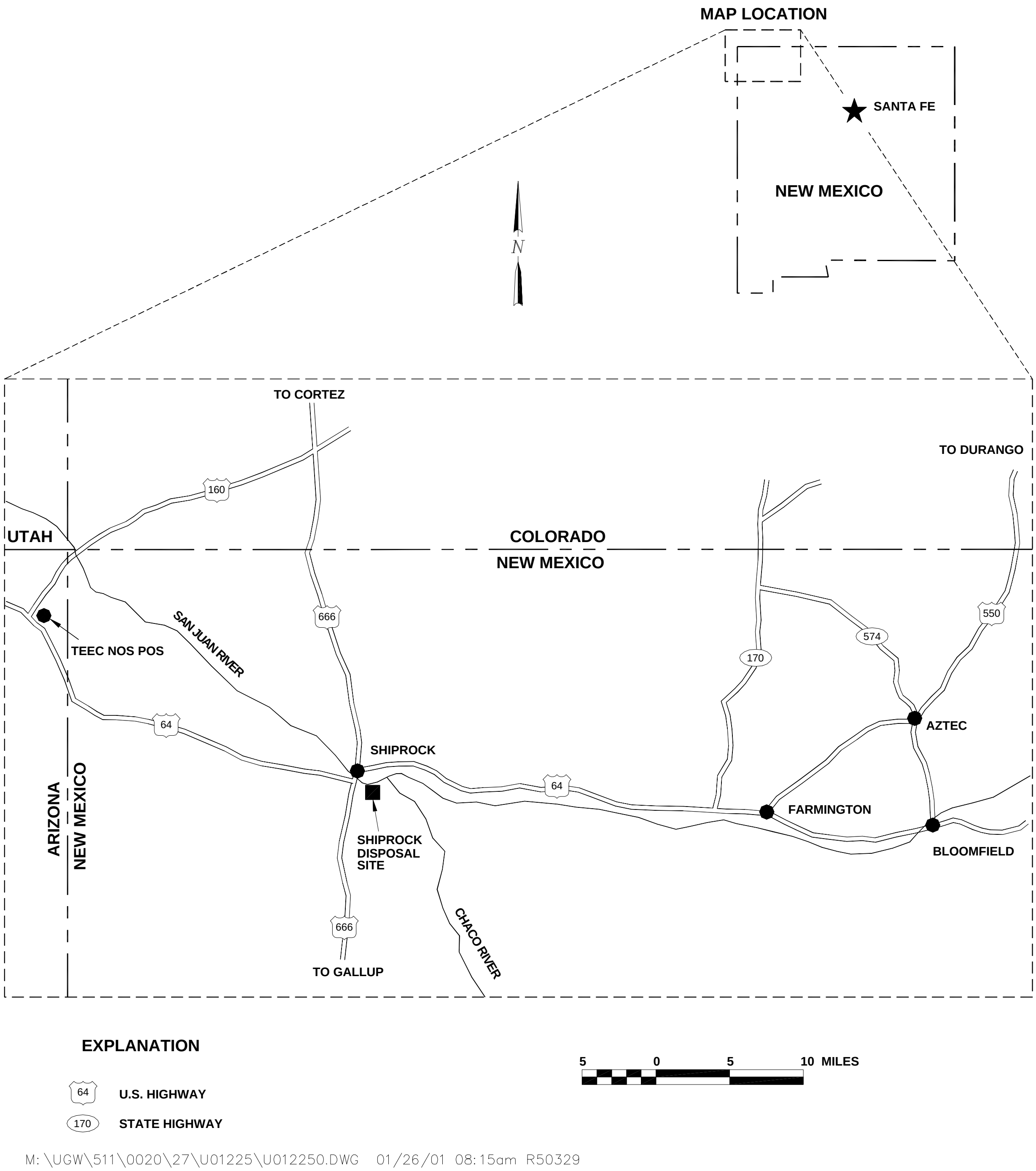

Figure A-1. Location of the Shiprock Site

Following surface remediation, DOE characterized the site to evaluate whether ground water had become contaminated from residual radioactive material leaching through soils. To comply with regulatory requirements for characterization, DOE completed the *Final Site Observational Work Plan for the Shiprock, New Mexico, UMTRA Project Site*, Revision 2 (SOWP) (DOE 2000), which includes monitor well locations, contaminants of potential concern, a site evaluation and findings, and an updated ecological risk assessment. The U.S. Fish and Wildlife Service provided comments to the draft SOWP by letter dated February 29, 2000, and to the draft EA by letters dated June 14, July 3, and August 3, 2001.

The land surface at the Shiprock site consists of a floodplain on the south side of the San Juan River and a terrace area, which is elevated 50 to 60 feet (ft) above the floodplain. The terrace area and the floodplain are separated by a shale cliff known as the escarpment (Figure A-2). To facilitate site characterization and development of a ground water compliance strategy, the Shiprock site was divided into three areas: terrace east, terrace west, and the floodplain. The terrace areas are not included in this floodplain and wetland assessment but are discussed in detail in the EA.

Project Description

Contaminants that are of potential concern in floodplain ground water are ammonium, manganese, nitrate, selenium, strontium, sulfate, and uranium. Ground water monitoring has shown that the contaminants have similar distribution patterns. The highest concentrations are along the base of the escarpment in the southern half of the floodplain and across the middle of the floodplain. Figures 8 through 14 in the EA depict contaminant distributions in the floodplain.

The ground water compliance strategy for the floodplain is active remediation in the most contaminated area combined with natural flushing and institutional controls. One or more extraction wells (Figure A-2) would be installed and would be pumped sporadically rather than continuously. Ground water from the well would be piped through an underground line up to an evaporation pond on the terrace. Section 3.2 of the EA provides a more detailed description of this compliance strategy. Computer modeling of ground water flow and transport indicates that contaminant concentrations in the portion of the plume where concentrations are highest would decrease to acceptable levels in 10 to 20 years, depending on the rate of ground water withdrawal. Afterwards, modeling predicts that contaminants would continue to flush naturally, and concentrations would decrease to acceptable levels within 100 years, assuming no continued source exists that would release contaminants in the ground water from the terrace area. Ground water would be monitored during the natural flushing phase to ensure that concentrations are decreasing as predicted.

The ground water extraction rate from the wells could be as high as 10 gallons per minute (gpm). To evaluate the success of remediation, DOE would collect samples for laboratory analysis, monitor water levels, and perform field analyses of the samples semiannually for the first 5 years after pumping begins, then annually through year 10, and once every 5 years or as necessary after year 10 for up to 100 years as authorized in EPA's ground water standards.

A slurry wall impermeable barrier at least 3,000 ft long and a french drain adjacent to it will be constructed in the floodplain along the base of the escarpment. This remediation, considered as part of the remediation of terrace east ground water, is designed to intercept ground water from the terrace system that flows down to the floodplain and prevent terrace contaminants from entering the floodplain aquifer.

Detailed location and design of the slurry wall impermeable barrier and french drain paralleling it, as well as piping configuration from the extraction well to the evaporation pond will be shown in the Ground Water Compliance Action Plan. Construction activities for the slurry wall, french drain, and extraction well would avoid sensitive environmental areas such as the wetland and areas of wildlife habitat.

Specific construction activities on the floodplain include

- Installing one or more extraction wells.
- Installing a pumping system and underground PVC pipe to transport extracted ground water from the well to a lined evaporation pond on the terrace.
- Constructing vehicle access routes for installing a well and piping. Existing roads would be used for monitoring and sampling existing ground water wells and surface water locations.
- Operation and maintenance of the pumping and piping systems.
- Installing the slurry wall impermeable barrier and french drain adjacent to it along the base of the escarpment.

Floodplain Description

The portion of the San Juan River floodplain associated with the Shiprock site comprises about 124 acres. This floodplain area begins about 1,500 ft downstream from the confluence of Many Devils Wash and the San Juan River and extends downstream to the U.S. Highway 666 bridge. Downstream from the U.S. Highway 666 bridge, the floodplain south of the river resumes, but its southern edge is mainly defined by a distributary channel of the river. DOE’s proposed remedial action would affect the portions of the floodplain area shown in Figure A-2.

The surface of the floodplain is about 5 to 10 ft above the river. The alluvial aquifer in the floodplain consists of medium- to coarse-grained sand, gravel, and cobbles; alluvial ground water discharges into the river. Borehole evidence indicates that the sandy gravel fraction of the alluvium is overlain in most places by a layer of silty sand several feet thick. Floodplain deposits range from 10 to 20 ft in thickness, and the saturated thickness of the alluvial aquifer averages about 12 ft.

During a 100-year flood, flow in the San Juan River would be about 110,000 cubic ft per second and would reach the 4,900-ft elevation, which is 12 ft above baseline (U.S. Army Corps of Engineers 1966). On the south and west side of the river, the water would cover the floodplain and extend to the base of the escarpment. Figure A-2 shows the area of the 100-year floodplain.

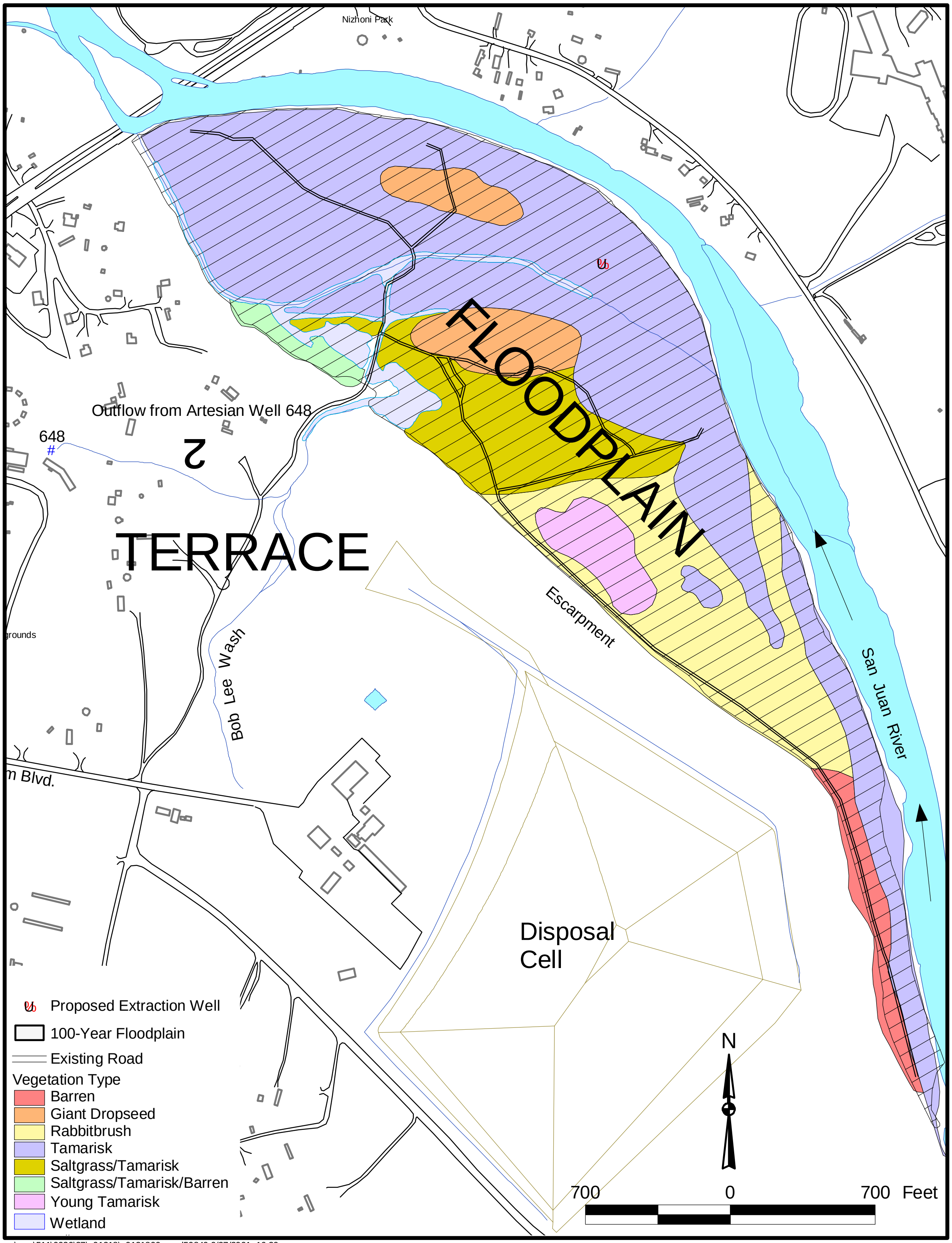

Figure A-2. Floodplain and Wetland at the Shiprock Site

Removal of contaminated soils from the floodplain in 1985 and 1986 slightly enlarged the 100-year river-flood channel and increased the cross-sectional area by 2 percent (DOE 1984). This action had a negligible effect on expected flood levels and velocities. Construction of the Navajo Dam on the San Juan River about 75 miles upstream of the site in 1963 moderated extremes in river flows and made flood events rare. A flood in June 1995 covered a portion of the floodplain for a few days. Scouring of the floodplain is infrequent, and vegetation reestablished quickly after surface remediation.

Although grazing has been prohibited on the floodplain since 1986, the area is part of a grazing allotment managed by the Navajo Nation and could be used for livestock grazing in the future. In summer 2000, DOE conducted sampling and analysis of floodplain vegetation to assess potential risk to livestock that ingest the vegetation. Results of the screening-level assessment indicated that livestock should not be at risk from grazing. However, even though the estimates of exposure to contaminants in vegetation incorporated several conservative assumptions, the results represent only one point in time. Because exposure to individual livestock over an extended period on the floodplain could exceed the estimates, DOE entered in to an agreement in 2000 to restrict grazing until potential risks are minimized or eliminated. The assessment of risks to livestock from grazing on floodplain vegetation is included as Appendix B in the EA.

Floodplain Effects

Long-term effects of ground water remediation are expected to be beneficial. Once the contaminants are removed from the aquifer, and monitoring shows that the ground water meets water quality standards, institutional controls could be removed. After the initial 5 years of active remediation, use of ground water and resumption of grazing on the floodplain would be evaluated.

Disturbances to the floodplain during construction would be minimal. Well and piping installation and construction of the slurry wall and french drain would avoid sensitive areas such as nesting sites of threatened and endangered species. Disturbed areas are expected to revegetate naturally in a short time because of a shallow water table and the proximity of mature vegetation. Although susceptibility to flood erosion would increase for a short time because of surface disturbance, erosion is unlikely because floods are rare and the disturbed areas would be small. Erosion control measures would be used near work areas as necessary.

Pumping ground water from a floodplain extraction well would lower the water table temporarily, but river water would recharge the aquifer within a short time. The extraction rate of up to 10 gpm is insignificant compared to the typical total river flow of 450,000 gpm (1,000 cubic feet per second) and would have no noticeable effects on water levels. Ground water flow patterns would be altered during extraction as San Juan River water is drawn in to replace the contaminated ground water, but this process should have positive effects to the floodplain.

Wetland Description

In June 1998, approximately 5.1 acres of wetland near the mouth of Bob Lee Wash and in its discharge path across the floodplain were delineated according to procedures in the *Army Corps of Engineers Wetlands Delineation Manual* (U.S. Army Corps of Engineers 1987). The three diagnostic environmental characteristics of a wetland—a predominance of hydrophytic vegetation (plants that prefer waterlogged soil), hydric soil (soil that is saturated or ponded long enough to develop conditions that favor the growth of hydrophytic vegetation), and wetland hydrology—were recorded throughout the wetland areas (DOE 1998). Figure A-2 shows the location of the wetland.

The wetland area is characterized by narrowleaf cattail, hardstem bulrush, inland saltgrass, and common reed. Surrounding floodplain and higher-elevation areas are dominated by tamarisk, Russian olive, and inland saltgrass. Vegetation cover is well developed in all these areas. The wetland and surrounding floodplain areas provide potential habitat for birds, small mammals, deer, and other wildlife. No federal, state, or tribal threatened or endangered plants or animals have been identified in the wetland.

Above and to the west of Bob Lee Wash, flowing artesian well 648 provides a large portion of the water for the wetland. The size of the wetland area, therefore, has been and will continue to be affected by the amount of water flowing from the well. In fall 1999, the flow path of water from well 648 in the existing outflow ditch was altered by the construction of a small pond adjacent to the ditch. Rather than flowing directly east in the outflow ditch into the wash as it had been, the water infiltrated the ground under the pond. Although most of the water continued to flow below the ground surface and entered Bob Lee Wash as springs, some of the water discharged as springs directly onto the floodplain just west of the mouth of Bob Lee Wash. This flow situation continued throughout 2000. In early 2001, the original flow eastward in the outflow ditch was restored, but the small pond and some flow into it remains. Flows from the springs continue to supply water to the floodplain area west of the mouth of Bob Lee Wash. Currently, this area contains tamarisk and bare ground and is not jurisdictional wetland. This continued discharge will probably result in wetland vegetation and soils around the ponded water and will change the shape of the wetland.

As surface water from well 648 discharged into the floodplain at the mouth of Bob Lee Wash, it created a ground water mound that deflected the flow of contaminated ground water through the floodplain aquifer. It is believed that this mounding effect and consequent deflection of ground water flow is the reason the area of higher contaminant concentrations in the floodplain aquifer bends northward in an arc toward the river rather than continuing northwest through the wetland and down the long axis of the floodplain.

Field investigations in 1998, 1999, and 2000 assessed the potential for contaminant exposure pathways in the wetland by sampling and chemical analysis of wetland plants. The results, summarized in Section 4.8 of the EA, indicate minimal risk to ecological receptors in the wetland. Appendix B of the EA discusses potential risks to livestock that graze in the floodplain.

On July 14, 2001, heavy rainfall, probably the equivalent of a 25-year rainfall event, reduced the area of the wetland by an estimated 25 percent. Cobbles and pebbles scoured from the terrace area were transported by the flood water down Bob Lee Wash and deposited in a fan at the mouth of the wash, covering some of the wetland.

Wetland Effects

The proposed location of the extraction well and the underground piping for it, as well as the proposed slurry wall and french drain, are not within jurisdictional wetland areas. Hydrology of the wetland is controlled mostly by the flow from well 648; therefore, the extraction of ground water should have minimal effect. No sensitive species of plants or animals are within the wetland. Construction activities in areas near the wetland may temporarily displace some of the animal residents. Vegetation would be expected to regenerate naturally in a short time because of the proximity of mature vegetation, ample water, and small size of the disturbed areas.

Potential adverse effects of the compliance strategy on the wetland would be mitigated by avoiding sensitive environmental areas. Erosion control measures would be employed as needed if construction removes vegetation from the area and creates the potential for erosion. In addition, the proposed remedial action in the terrace above the wetland would decrease or stop the flow from seeps 425 and 426. This would slightly diminish the volume of water flowing into the southern portion of the wetland.

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Appendix B

Assessment of Risk to Livestock Grazing on the Floodplain at the Shiprock Site

UMTRA Ground Water Project

Assessment of Risk to Livestock Grazing on the Floodplain at the Shiprock Site

September 2001

Prepared by
U.S. Department of Energy
Grand Junction Office
Grand Junction, Colorado

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Additional forage sampling was conducted in June 2000; analytical results were not available to include in the Site Observational Work Plan (DOE 2000). This appendix presents the evaluation of risks to livestock grazing on the floodplain at the Shiprock site.

The evaluation indicates that livestock should not be at risk if allowed to graze on the San Juan River floodplain. Although the results incorporate several conservative assumptions in the estimation of potential exposure, the vegetation sampling results represent only one point in time. The potential exposure to individual livestock over an extended period on this site could exceed these estimates.

The San Juan River floodplain area is not currently grazed; however, it is part of a grazing allotment managed by the Navajo Nation and could potentially be used for livestock grazing in the future. In 2000, DOE entered into an agreement with the Navajo Nation that restricts grazing until potential risks are minimized or eliminated.

Forage grass samples were collected to minimize uncertainties associated with modeling plant concentrations from soil concentrations. Fifteen samples (plus one field duplicate) of range grasses were collected from the floodplain area on June 14, 2000, and were analyzed for 10 metals (antimony, arsenic, cadmium, copper, manganese, molybdenum, selenium, strontium, uranium, and vanadium,) and 2 anions (nitrate, and sulfate). Concentrations of these analytes were reported in milligrams per kilogram (mg/kg) dry weight. The percent weight loss on drying was also measured and reported.

The grass samples were aboveground tissues that consisted mostly of leaves and stems but also included flowers if present. These were clipped no closer than one inch above the ground surface. Dead plant material was removed from the sample at the time of collection. The samples were not washed to remove soil particles because it was observed that the inland saltgrass often had salt particles on the leaf surfaces. Removal of this material could lead to underestimation of exposure in a grazing animal. However, direct ingestion of soil by the sheep was still included in the exposure estimation to account for other sources of ingested soil, such as grooming.

Sampling locations for the range grasses, shown as the 1300 series on Plate 2 of the EA, were scattered over the entire floodplain area. Samples were collected from each of the identified range sites except those where thick, wooded growth suppresses grass growth or prevents use by livestock. At the time of the sampling, the Shiprock area (and a large portion of the Southwest) was undergoing drought conditions. Plant growth on much of the floodplain was limited by the drought. As a result, the grass sampling locations and the grass species sampled were adjusted according to availability. These conditions may be beneficial to the risk assessment, because the grasses that were found with green growth were commonly near seeps or in low points such as drainages, where they are more likely to be in contact with ground water. Inland saltgrass was the species typically found in these areas. Green grasses that were in upland sites were typically large giant dropseed and alkali sacaton, which could have roots extending deep enough to contact ground water. Table B-1 presents the results of the range grass sampling and analyses. In this table, the maximum concentration from the regular and duplicate sample analyses is presented for Sample 1322.

Table B-1. Results of Range Grass Analysis from the Shiprock Floodplain Area (Area C)

Sample No.	Species[a]	Loss on Drying (%)	Sb (mg/kg)	As (mg/kg)	Cd (mg/kg)	Cu (mg/kg)	Mn (mg/kg)	Mo (mg/kg)	NO_3 (mg/kg)	Se (mg/kg)	Sr (mg/kg)	SO_4 (mg/kg)	U (mg/kg)	V (mg/kg)
1327	Alkali sacaton	57.6	0.032	0.12[b]	0.089	3.5	24.6	0.51	44.9	0.30	15.8	13,100	0.37	0.27[b]
1318	Giant dropseed	60.8	0.027	0.12[b]	0.099	4.2	8.7	1.7	13.8[b]	0.38	25.8	6,290	0.086	0.27[b]
1323	Giant dropseed	61.2	0.027	0.47	0.090	4.7	12.5	2.0	102	0.66	36.8	7,270	0.19	0.27[b]
1329	Giant dropseed	73.8	0.040	0.38	0.14	4.5	9.2	1.2	13.8[b]	0.18	32.1	6,620	0.27	0.27[b]
1319	Indian ricegrass	36.8	0.026	0.50	0.24	1.1	13.3	1.7	329	0.83	54.2	3,580	0.28	0.27[b]
1316	Inland saltgrass	55.5	0.047	0.37	0.057	2.3	14.9	0.43	13.8[b]	0.51	45.5	6,400	0.12	0.27[b]
1320	Inland saltgrass	49.6	0.022	0.48	0.074	2.9	18.9	0.57	84.4	1.6	22.7	6,180	0.17	0.27[b]
1321	Inland saltgrass	50.7	0.025	0.12[b]	0.051	3.2	11.4	0.36	30.2	0.38	34.0	7,100	0.46	0.27[b]
1322[c]	Inland saltgrass	48.5	0.026	0.56	0.18	2.9	64.3	0.93	90.7	1.7	23.5	3,390	0.11	0.27[b]
1324	Inland saltgrass	52.7	0.030	0.46	0.062	2.9	99.1	0.64	37.9	0.81	64.1	4,650	0.18	0.27[b]
1325	Inland saltgrass	44.7	0.034	0.66	0.095	8.2	23.1	0.40	13.8[b]	1.5	42.6	5,170	0.41	0.27[b]
1326	Inland saltgrass	54.8	0.033	0.51	0.092	3.7	17.6	0.33	13.8[b]	0.40	14.8	5,970	0.34	0.27[b]
1328	Inland saltgrass	53.3	0.031	0.32	0.072	2.9	8.8	0.62	13.8[b]	0.08[b]	16.1	8,140	0.18	0.27[b]
1330	Inland saltgrass	49.1	0.031	0.31	0.12	4.9	30.1	0.35	82.2	0.23	26.1	4,040	0.20	0.27[b]
1331	Inland saltgrass	47.1	0.030	0.12[b]	0.062	3.2	17.6	0.54	41.8	0.58	22.7	7,780	0.21	0.27[b]
Mean of non-saltgrass species		58.0	0.030	0.32	0.132	3.6	13.7	1.42	100.7	0.47	32.9	7,372	0.24	0.27
Mean of saltgrass		50.6	0.031	0.39	0.087	3.7	30.6	0.52	42.2	0.78	31.2	5,882	0.24	0.27
Mean of all species		53.1	0.031	0.37	0.102	3.7	24.9	0.82	61.7	0.68	31.8	6,379	0.24	0.27
95% Upper Confidence limit of mean for all species		56.9	0.034	0.45	0.125	4.4	36.2	1.07	98.3	0.91	38.4	7,456	0.29	0.27

[a]Alkali sacaton = *Sporobolus airoides*; giant dropseed = *Sporobolus giganteus*; Indian ricegrass = *Oryzopsis hymenoides*; inland saltgrass = *Distichlis stricta*.
[b]Analyte not detected. Value is one-half the detection limit.
[c]Duplicate of this sample was also collected and analyzed. Concentrations presented here are the maximums between the sample and the duplicate.

Summaries of the means for all samples, the means for all inland saltgrass samples, and the means for all non-saltgrass samples are presented in this table, along with the 95 percent upper confidence level on the mean (UCL_{95}) of all samples. In general, the UCL_{95} provides a conservative estimate of the mean concentration of constituents in the range grasses and was therefore used in the risk assessment. However, in some cases it was found that the mean of the non-saltgrass samples exceeded the UCL_{95}. Because it is not known whether some livestock may avoid grazing on saltgrass if other grasses are available, the non-saltgrass mean was used in the risk assessment when it was greater than the UCL_{95}. Insufficient non-saltgrass samples were available to calculate a separate UCL_{95}. Table B-2 presents a summary of the surface water, soil, and range grass data used in this assessment.

Table B-2. Summary of Surface Water, Soil, and Range Grass Data from the Floodplain (Area C)

Contaminant of Potential Concern	Surface Water (mg/L)		Soil (mg/kg)		Range Grass (mg/kg)	
	Maximum	UCL_{95}[a]	Maximum	UCL_{95}[a]	Maximum	UCL_{95}[a]
Antimony	0.00560[b]	0.00222[b]	0.380	0.253	0.047	0.034
Arsenic	0.00720[c]	0.00200[c]	4.20	2.61	0.66	0.45
Cadmium	0.00160[c]	0.000507[c]	1.17	0.706	0.24	0.13[d]
Copper	0.0105[b]	0.0105[b]	ND[f]	ND[f]	8.2	4.4
Manganese	16.4[c]	1.36[c]	723	398	99.1	36.2
Molybdenum	0.0140[b]	0.0110[b]	ND[f]	ND[f]	2.0	1.42[d]
Nitrate	2,460[c]	280[c]	1,010	444	329	100.7[d]
Selenium	0.137[c]	0.0361[c]	2.00	1.13	1.7	0.91
Strontium	19.8[c]	12.6[c]	349	188	64.1	38.4
Sulfate	17,100[c]	4,790[c]	42,300	31,400	13,100	7,460
Uranium	0.682[c]	0.231[c]	35.6	14.6	0.46	0.290
Vanadium	0.00560[c]	0.00460[b]	ND[f]	ND[f]	0.27[e]	0.27[e]

[a]Upper confidence limit (one-tailed). One-half the detection limit used for nondetects. Confidence limit only presented when less than the maximum measured concentration.
[b]Based on unfiltered water samples.
[c]Based on filtered water samples, which exceeded concentrations measured in unfiltered samples.
[d]Mean of the five sample of non-saltgrass species, which was greater than the UCL_{95} of all grass samples.
[e]Analyte not detected. Concentration is one-half the detection limit.
[f]ND = no data

The pathways for this exposure are similar to those for terrestrial wildlife receptors on the floodplain; the primary route of exposure is ingestion of food, water, and soil containing the contaminants.

A sheep was selected as the livestock receptor for this assessment. The estimation of potential exposure of the sheep to contaminants follows the modeling approaches used for terrestrial (specifically mammalian) wildlife receptors, such as the deer mouse. Exposure to each contaminant (as milligrams of the constituent per kilogram body weight per day [mg/kg-day]) was estimated as the sum of the individual exposures derived through the ingestion of food (range grasses), water, and soil. Contaminant concentrations in each medium (in milligrams per kilogram for food and soil, and milligrams per liter for water) were multiplied by the ingestion rate of that medium by the sheep (in kilograms per day for food and soil or liters per day for water) and divided by the body weight of the sheep in kilograms to obtain the exposure rate in milligrams per kilogram per day. As with the wildlife receptors, the exposure of the sheep to site contaminants through inhalation and dermal absorption were considered to be insignificant. Conservative assumptions incorporated in the estimation of exposure through the direct ingestion of soil and water are expected to more than compensate for the small amount of additional exposure that might occur as a result of the inhalation of dust or the absorption through the skin from direct contact with soil or water.

A body weight of 50 kg was used for the sheep. Based on information from the International Atomic Energy Agency (IAEA 1994), a 50-kg sheep (considered a lamb) is expected to eat from 0.5 to 2.0 kg/day of dry forage and drink from 3 to 5 L/day of water. The upper ends of these ranges (2.0 kg/day dry forage and 5 L/day water) were used to conservatively estimate the exposure to the sheep in this assessment. Soil ingestion rates are typically measured as a percentage of the food ingestion rate. Measured values of soil ingestion for the sheep were not available; therefore, the soil ingestion rate of a bison (6.8 percent of the food ingestion rate), as measured by Beyer et al. (1994), was used as a surrogate value. Like sheep, bison feed on range grasses and are therefore likely to have similar soil ingestion rates.

The concentrations of constituents used in this assessment for the evaluation of potential risks to grazing livestock are based on site-specific data, including data specific to soil, surface water, and forage grasses. Exposure and risk estimates were based on both the maximum concentrations in these media and on the UCL_{95} of these concentrations. Surface water concentrations used in this assessment were the greater of the two values from filtered and unfiltered samples. Although the unfiltered water samples are expected to have higher concentrations of most constituents because they include suspended sediments, the majority of analytical results used for this assessment were from filtered samples. As a result, the maximum or the UCL_{95} value of the filtered samples exceeded that of the unfiltered samples. Because an unknown fraction of the "soil" ingested by these animals may be sediment ingested with drinking water, the use of the higher concentration ensures that the exposure is not underestimated, although in some cases it may be overestimated by including both incidental soil ingestion and incidental sediment ingestion.

Toxicity benchmarks for the sheep were derived from mammalian toxicity studies using the body weight scaling procedure described for the terrestrial wildlife receptors. These benchmarks are presented in Table B-3. Although ammonium and boron were included as target analytes for ecological risk, these constituents were not considered to be potential risk drivers for livestock. Ammonium is readily used by plants and other organisms and poses less risk of toxicity than nitrate. Boron is also of relatively low toxicity to mammals, and appears to be limited to the areas of the seeps, which are currently fenced to exclude livestock. Antimony, arsenic, cadmium, and copper were included as analytes for the range grasses even though they were not identified as ecological contaminants for the floodplain area. These constituents have relatively low toxicity benchmarks, and therefore may pose a risk to livestock if concentrations are elevated in soil, vegetation, or water; however, it would be questionable whether such elevated concentration could be mill-related. Sulfate was also included in the analysis of the grasses, although no toxicity benchmark is available.

Table B-3. Toxicity Benchmarks for Ecological Contaminants

Constaminant	Mammalian Test Data[a]			Mammalian Receptor (Sheep)
	Test Species	Body weight (kg)	NOAEL[b] (mg/kg-day)	NOAEL[b] (mg/kg-day)
Antimony	Mouse	0.03	0.125	0.0801
Arsenic	Rabbit[b]	4.40[c]	0.396[c]	0.342
Cadmium	Rat	0.303	1.0	0.736
Copper	Sheep[d]	31.7[d]	0.47[c]	0.457
Manganese	Rat	0.35	88.0	65.3
Molybdenum	Mouse	0.03	0.26	0.167
Nitrate	Guinea pig	0.86	507	397
Selenium	Rat	0.35	0.20	0.149
Strontium	Rat	0.35	263	195
Sulfate	ND[e]	ND[e]	ND[e]	ND[e]
Uranium	Mouse	0.028	3.07	1.96
Vanadium	Rat	0.26	0.21	0.153

[a]From Sample and others (1996), except where noted.
[b]NOAEL = No observed adverse effects level
[c]From Nemec and others (1998).
[d]From Buckley and Tait (1981).
[e]ND = no data

Table B-4 presents the hazard quotients (HQs) that resulted from comparisons of the estimated potential exposure in sheep to the toxicity benchmark for each of the target analytes. The hazard quotient is a ratio of the exposure value to the benchmark value.

Table B-4. Hazard Quotients for Livestock Receptors (sheep) at the Floodplain (Area C)

Contaminant	Sheep Hazard Quotients	
	Based on maximum concentrations	Based on UCL_{95} concentrations
Antimony	0.0434	0.0281
Arsenic	0.113	0.0736
Cadmium	0.0176	0.00985
Copper	0.719	0.387
Manganese	0.116	0.0408
Molybdenum	0.489	0.348
Nitrate	0.660	0.0836
Selenium	0.587	0.291
Strontium	0.0281	0.0170
Sulfate	NB	NB
Uranium	0.0936	0.0380
Vanadium	0.0742	0.0735

NB = no (toxicity) benchmark

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Appendix C

Selenium Concentration in Many Devils Wash from Dissolution of Salt Deposits in Storm Runoff

UMTRA Ground Water Project

Selenium Concentration in Many Devils Wash from Dissolution of Salt Deposits in Storm Runoff

September 2001

Prepared by
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As described in the Shiprock Site Observational Work Plan (DOE 2000) and the Environmental Sciences Laboratory report (DOE 1999), salt crusts are present in the Shiprock site area and are widespread in Many Devils Wash, especially on the east side. The crusts range from fine powder to granular crystals in texture and are presumably the result of salt-laden ground water that surfaces and evaporates. In the past, crusts also formed on the bottom of Many Devils Wash; however, the interim action has covered approximately 90 percent of the wash in riprap and has probably significantly decreased salt formation.

The salts are composed primarily of sulfate, sodium, magnesium, nitrate, and calcium (DOE 1999). Selenium is the contaminant that is of greatest concern to wildlife; concentrations range up to 45 milligrams per kilogram (mg/kg) in samples collected from Many Devils Wash. A background sample contained the highest concentration of selenium detected in the salt crusts—approximately 67 mg/kg.

The salt crusts are of potential concern if they dissolve during a storm or rain event and discharge with storm water runoff from Many Devils Wash into the San Juan River. Selenium tends to accumulate in aquatic life to levels that can be toxic to those organisms and to organisms that may consume them, including humans. To evaluate the effect that dissolved salts may have on water quality in the San Juan River, the following assumptions were used in an attempt to represent a reasonable scenario:

- The area of concern in Many Devils Wash is 1,200 feet long (from the knickpoint to the San Juan River).
- The bottom of Many Devils Wash averages 20 feet wide.
- Salts cover the 10 percent of Many Devils Wash that is not covered with riprap. Limited salt formation may occur beneath the riprap. The extent for this salt formation is estimated as another 10 percent over the bottom of the wash, for a total of 20 percent coverage.
- On the east side of Many Devils Wash, it is estimated that salt formation occurs on an average of 5 feet vertically along the length of the wash.
- Salt deposits average 0.25 inch in thickness.
- On average, the salt deposits in Many Devils Wash contain 8 percent insoluble material.
- The average selenium concentration in Many Devils Wash salts is 39 mg/kg.
- The salts have an average estimated density of 1.5 grams per cubic centimeter.
- Discharge in Many Devils Wash is estimated at 500 cubic feet per second (ft^3/s) for a brief, intense storm event. Although discharge data are not available for Many Devils Wash, the estimate was based on streamflow data for other small streams in New Mexico. This estimate seems reasonable based on observations made in the field during storm events.
- For a brief rainfall, approximately 75 percent of the salts would dissolve; it is assumed this would occur evenly over this time period and would mix with the total volume of water flowing through Many Devils Wash. The remainder of the salt would probably dissolve and infiltrate into underlying soils or, in the case of highly crystalline crusts, would not dissolve completely.
- For a lesser or longer storm event, dissolution would occur less rapidly and more water would infiltrate into the subsurface; therefore it is assumed that the estimation provided here is a reasonable worst-case scenario.

Calculations in Table C-1 indicate that the average concentration of selenium in Many Devils Wash storm water discharging to the San Juan River would be approximately 0.001 mg/L. This is less than the surface water selenium standard for the river of 0.002 mg/L and is essentially the same as background concentrations detected in San Juan River water. Therefore, it is not likely that salt crusts in Many Devils Wash would have a detrimental effect on the quality of San Juan River water.

Table C-1. Calculations for the estimate of Selenium Concentration in Many Devils Wash

Scenario: 4-hour Intense Rainfall	
Volume of salt in Many Devils Wash Bottom of wash = Side of Wash = Total =	 1,200 ft 3 20 ft 3 0.25 inch = 99.8 ft^3 1,200 ft 3 5 ft 3 0.25 inch = 124.8 ft^3 224.6 ft^3
If 75 % of salt dissolves, soluble portion =	168.43 ft^3 = 4,782,700 cm^3
If density of salt = 1.5 g/cm^3, total mass of salt =	7,174,050 g = 7,174 kg
If selenium concentration in salt averages 39 mg/kg, total selenium mass =	279,787.95 mg
If flow in Many Devils Wash is 500 ft^3/s for 4 hours, and soluble salt dissolves evenly over that time, average concentration would be:	500 ft^3/s 3 14,400 s = 7.2 3 10^6 ft^3 or 2.04 3 10^8 liters; and 279,788 mg/2.04 3 10^8 L = 0.00137 mg/L Se

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Appendix D

Scientific Names of Plant and Animal Species Associated with the Shiprock Site

Plants

Common Name	Taxonomic Name
Alkali bulrush	*Scirpus maritimus*
Alkali grass	*Puccinellia airoides*
Alkali sacaton	*Sporobolis airoides*
American 4-square	*Scirpus americanus*
Blazing star	*Mentzelia pumila*
Broom snakeweed	*Guitterezia sarothrae*
Cheatgrass	*Brommus tectorum*
Cocklebur	*Xanthium strumanrium*
Common reed	*Phragmites australis*
Cottonwood	*Populus fremontii*
Curly dock	*Rumex crispus*
Evening primrose	*Oenothera albicaulis*
Four-wing saltbush	*Atriplex canescens*
Foxtail barley	*Hordeum jubatum*
Galleta	*Hilaria jamesii*
Giant dropseed	*Sporobolis gigantea*
Greasewood	*Sarcobatus vermiculatus*
Green rabbitbrush	*Chrysothamnus viscidiflorus*
Hard stem bulrush	*Scirpus acutus*
Hoary aster	*Machaeranthera canescens*
Indian ricegrass	*Oryzopsis hymenoides*
Inland saltgrass	*Distichlis spicata*
Kochia	*Kochia scoparia,*
Mesa Verde cactus	*Sclerocactus mesae verdae*
Narrowleaf cattail	*Typha domingensis*
Rabbitsfoot grass	*Polypogon monspeliensis*
Rubber rabbitbrush	*Chrysothamnus nauseosus*
Russian olive	*Eleagnus angustifolia*
Russian thistle	*Salsola kali*
Saltbush	*Atriplex Sp.*
Sandbar willow	*Salix exigua*
Spikerush	*Eleocharis palustris*
Squirreltail	*Sitanion hystrix*
Tamarisk	*Tamarix ramosissima*
Western wheat	*Pascopyron smithii*
Whitetop	*Cardaria draba*
Whitetop	*Cardaria draba*
Wild lettuce	*Lactuca serriola*
Yellow sweet clover	*Melilotus officionale*

Birds

Common Name	Taxonomic Name
American kestrel	*Falco sparverius*
Bald eagle	*Haliaeetus leucocephalus*
Barn owl	*Tyto alba*
Black-billed magpie	*Pica pica*
Brewer's blackbird	*Euphagus cyanocephalus*
Common nighthawk	*Chordeiles minor*
Common raven	*Corvus corax*
Ferruginous hawk	*Buteo regalis*
Golden eagle	*Aquila chrysaetos*
Horned lark	*Eremophila alpestris*
House finch	*Carpodacus mexicanus*
Mountain plover	*Charadrius montanus*
Mourning dove	*Zenaidura macroura*
Northern flicker	*Colaptes auratus*
Peregrine falcon	*Falco peregrinus*
Pinyon jay	*Gymnorhinus cyanocephalus*
Red-tailed hawk	*Buteo jamaicensis*
Robin	*Turdus migratorius*
Rough-legged hawk	*Buteo lagopus*
Scrub jay	*Apelocoma coerulescens*
Southwestern willow flycatcher	*Empidonax trailii extimus*
Sparrow hawk	*Falco spaverius*
Starling	*Sturnus vulgaris*
Turkey vulture	*Cathartos aura*
Western bluebird	*Sialia mexicana*
Western burrowing owl	*Speotyto cuniculaia hypugea*
Western meadowlark	*Sturnella neglecta*
White-crowned sparrow	*Zonotrichia leucophrys*

Reptiles

Common Name	Taxonomic Name
Bull snake	*Pitulophis melanoleucus*
Collared lizard	*Crotaphytus collaris*
Prairie rattlesnake	*Crotalus viridis*
Sagebrush lizard	*S. graciousus*
Short-horned lizard	*Phrynosoma douglassi*
Side-blotched lizard	*Sceloporus stansburiana*

Amphibian

Northern leopard frog	*Rana pipiens*

Mammals

Common Name	**Taxonomic Name**
American elk	*Cervus elaphus*
Bannertail kangaroo rat	*Dipodomys spectobilis*
Bat	*Myotis sp.*
Black-footed ferret	*Mustela nigripes*
Blacktail jackrabbit	*Lepus californicus*
Coyote	*Canis latrans*
Desert cottontail	*Sylvilagus auduboni*
Mule deer	*Odocoileus hemionus*
Porcupine	*Erethizon dorsatum*
Pronghorn antelope	*Antilocapra americana americana*
Red fox	*Vulpes vulpes*
Sheep	*Ovis aries*
Silky pocket mouse	*Perognathus flavus*
Spotted ground squirrel	*Spermophilus spilosoma*
Striped skunk	*Mephitis mephitis*
Whitetail antelope squirrel	*Ammospermophilus leucurus*

Fish

Common Name	**Taxonomic Name**
Colorado pikeminnow	*Ptychocheilus lucius*
Razorback sucker	*Xyrauchen texanus*
Roundtail chub	*Gila robusta robusta*

Appendix E

Summary of Comments on the Draft EA and Responses to Comments

Appendix E. Responses to Comments on the April 2001 Shiprock Draft Environmental Assessment of Ground Water Compliance

	EA Comments[a]	Issue Type[b]	Status[c]	Response/Resolution
	Navajo Nation Comments received 6/8/01			
	EA and SOWP Comments (Page 1)			
1	1: Contaminant sources may not be properly defined. Contamination from the disposal cell and in the vadose zone may need to be redefined in the conceptual and transport models.	T	NC	DOE believes that a thorough site characterization was conducted and that most sources of contamination are identified. However, it is impossible to eliminate all uncertainty. SOWP Sections 4.4, 4.5 and 5.0 describe the sources of contamination and how they were incorporated into the site conceptual model. Evaluations of the drainage of residual moisture from the disposal cell are planned; when data from these investigations are available, the conceptual model may need to be revised.
2	2: Documents contain no compliance plan; difficult to verify compliance with regulatory requirements.	R	NC	Section 2.0 of the SOWP identifies key regulatory drivers. Section 2.6 specifically identifies agencies consulted and requirements. DOE continues to work with federal and tribal agencies to accomplish compliance with federal and tribal regulations. Section 5.0 of the EA identifies the key agencies. In addition, work plans for each field activity incorporate a compliance plan that identifies compliance requirements. The Navajo UMTRA Project Office has reviewed the work plans.
3	3: The results of the risk assessment are not linked to the establishment of remedial goals.	R	NC	Remediation goals are set forth only for ground water in 40 CFR 192 and specify four options: background, MCLs, ACLs, or supplemental standards. Risk assessment under UMTRA was conducted at each site to establish a baseline of current risks. Determining the degree of risk assists DOE in determining the compliance strategy for each site. At the Shiprock site, DOE, in consultation with Navajo UMTRA and other agencies, implemented interim actions based on risk to humans and ecological receptors. The long-term compliance strategies for each area of the site are intended to eliminate exposure pathways and reduce concentrations of key contaminants. However, due to other “non-DOE” contributions to contaminant concentrations, it is extremely difficult to establish prescriptive remediation goals for humans and ecological receptors.
4	4: The current design of the evaporation pond may pose environmental risks due to aerial dispersion of liquid contaminants and evaporites.	T	C	To address Navajo Nation concerns, DOE is not considering spray evaporation as part of the remediation plan at this time. Instead, solar evaporation using side-drip entry is the initial plan for remediation. At a later time, enhanced evaporation methods will be evaluated. The EA will be revised to reflect the remediation plan using solar evaporation with side drip.
	General Comments (Page 1)			
5	1: What method was used to determine dewatering from the disposal cell…please elaborate. Cell drainage is essential to the remedial action plan. Tailings dewatering can be a very slow process without active or passive drainage systems.	T	NC	Agree with comment but no change is required in the EA. The drainage of residual moisture from the cell was obtained from flow model calibration and consequently is dependent upon other estimated parameter values, including areal recharge, terrace hydraulic conductivity, and Mancos Shale hydraulic conductivity. The flow model is sensitive to each of these parameters. Water levels in the flow model are more sensitive to areal recharge, Mancos Shale hydraulic conductivity, and terrace hydraulic conductivity than they are to drainage from the disposal cell. Because chemical mass is introduced to the transport model via drainage from the disposal cell, however, this component is of equal importance with the parameters.

[a]Comments are paraphrased for summary and include SOWP comments that were submitted relative to the EA. The entire text of the comment is attached as Appendix F.
[b]**T** = technical issue; **R** = regulatory issue; **S** = stakeholder concern that is not technical or regulatory in nature;
[c]**A** = agree with comment, EA will be revised as necessary; **C** = DOE determined changes to the EA were appropriate. **NC** = no changes, EA context and content is sufficient.

Appendix E. Responses to Comments on the April 2001 Shiprock Draft Environmental Assessment of Ground Water Compliance

EA Comments[a]		Issue Type[b]	Status[c]	Response/Resolution
6	2: Sequestering the flow from well 648 may be very unpopular with locals.	S	NC	Success of the proposed remediation for the floodplain depends on artesian well 648 continuing to flow. DOE requests that the outflow from this well continue eastward in the outflow ditch that empties directly to Bob Lee Wash. This would not hinder the historical use of this well water by the local population.
7	3: Will the terrace east area stay dry once active remediation is complete? Consider a land use restriction that will limit activities (e.g., irrigation) that may remobilize contamination.	T	NC	Remediation in the short term is intended to dry up the seeps in the washes and along the escarpment. The extraction wells pumping from the axis of the buried channel will lower ground water levels but will not remove all the ground water in the terrace system. Some residual water will remain in the system as a result of limitations of pumping and the water-holding capability of the clayey, weathered Mancos Shale and coarse alluvial material. Water levels in the extraction wells will be monitored after active remediation; if water levels rise, the need for additional action would be evaluated.
8	4: Is there an exposure pathway from salt deposits to ecological receptors? Do fauna use deposits as salt licks?	S	NC	For the purposes of risk assessment, it was assumed that terrestrial wildlife and livestock receptors could directly ingest salt crusts. Section 6.2.3.7 of the SOWP and Section 4.8 of the EA discuss the risks associated with salt crusts, and it was determined that the risk to wildlife and livestock is low. The actual existence of this pathway, however, has not been confirmed.
9	5: The spray evaporation system may be undersized. Retention ponds with hazardous materials must be properly designed. A study needs to be conducted to ensure the design is correct.	T	C	As stated in the response to comment 4, spray evaporation is not being considered at this time. The remediation plan is to construct a 10-acre pond for solar evaporation using side-drip entry. The pond would accommodate a relatively low pumping rate of 20 gallons per minute.
10	6: Meteorological data should be evaluated to see if the evaporation system can be operated 78% of the time without affecting humans and the environment.	T	NC	Meteorological data (primarily wind speed and net evaporation) will be used for the final design of the pond.
11	7: There is a concern with recontaminating surrounding areas when operating the spray evaporation system. Studies should be conducted to ensure that evaporites will not pose risk to humans and the environment.	T	NC	As stated in the response to comment 4, spray evaporation is not being considered at this time.
12	8: More specific information is needed to support the proposed compliance strategies (e.g., locations and numbers of background wells and point of compliance wells). Recommend summarizing from data in the draft GCAP.	T	A	Tables 3 and 4 will be updated to list background wells and other wells and surface locations planned for sampling. These changes will be reflected in the draft GCAP, in preparation.
	Specific Comments, Environmental Assessment (pp 2–4)			
13	Executive Summary: Mention that success of the compliance strategy is dependent upon rapid dewatering of the disposal cell. This must be explained.	S	NC	For the next 5 years DOE will be evaluating the effect of drainage of residual moisture from the disposal cell. Review of this after 5 years may result in modifications to the remediation strategy.
14	Table 1: An additional column “Remediation Goal” should be added to the table. This information should also be incorporated into the selection framework process.	R	A	Remediation Goal will be added to the Rationale column in Table 1 of the EA. A statement on the goal for each area will be made there but will not be carried into the selection framework (Figures 4, 5, and 6).

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Appendix E. Responses to Comments on the April 2001 Shiprock Draft Environmental Assessment of Ground Water Compliance

EA Comments[a]		Issue Type[b]	Status[c]	Response/Resolution
15	Table 2: Remediation goals for human health and ecological receptors should be provided in separate tables. Goals for human health should be based on 40 CFR 192, and goals for ecological receptors should be back-calculated 95% UCLM values based on an HQ of 1.0.	S	NC	DOE is required under UMTRCA to remediate to the standards established by 40 CFR 192 and to be protective of human health and the environment. HQs are calculated to determine if an ecological risk may be present. HQs greater than 1 do not necessarily indicate risk to any particular receptor populations. DOE's primary concern is threatened and endangered species, and DOE has committed to work with the U.S. Fish and Wildlife Service to address contaminants that may pose a risk to these species. Requested calculations would not change the proposed action.
16	Section 1.5: A monitoring plan should be in place to ensure interim actions remain effective. Inspections are recommended.	R	A	A sentence will be added to page 10 indicating that the improvements added to the areas as a result of interim actions will be inspected annually and, if necessary, modifications will be made.
17	Section 3.2.1: Provide calculations used to determine the sufficiency of a 100-foot buffer.	T	NC	As stated in the response to comment 4, spray evaporation is no longer being considered.
18	Section 3.4, paragraph 2: The no action alternative for the west terrace must be dependent upon dewatering of the east terrace. State this in Section 3.4.	R	NC	During the remediation period water levels and samples will be collected at six wells. Surface water samples and water levels will also be collected. Evaluation of these data will determine the effect of terrace east remediation. If lower contaminant concentrations and lower water levels are not occurring, then the remediation strategy will be modified accordingly.
19	(1) Section 3.2.1: ACLs may be developed for nitrate and uranium. DOE should try to determine background concentrations of these constituents prior to a lengthy ACL petition process. Background levels should become remediation goals. (2) Manganese: Discuss rationale for selecting maximum value instead of other statistical data. (3) Also discuss rationale for selecting 100 years as the remediation time frame.	R T R	NC NC NC	(1) DOE agrees that background should be determined as remediation progresses. DOE should be able to better identify contributions related to ore-processing activities. If it is determined that background is higher than MCLs, then it is feasible that background or ACLs could become remediation goals. (2) UMTRCA allows DOE to choose background, MCL, or ACL concentrations for a cleanup standard. The maximum background value for manganese was selected because it may never be possible to achieve levels lower than this. (3) The 100-year time frame is the maximum period allowed for natural flushing according to EPA's UMTRCA regulations.
20	Section 4.3.2: Show capture zones for floodplain pumping. Recommend a map of simulated drawdowns.	T	NC	Section 4.3.2 presents a description of present conditions. Because there is presently no active pumping occurring on the floodplain, there are no drawdowns to plot; therefore, no map is required. Pages 4-243 through 4-245 in the SOWP describe a pumping scenario for the terrace. Projected drawdowns for that scenario are presented on SOWP Figure 4-73 (a) and (b). Capture zones and drawdowns for pumping wells planned in the floodplain will be included in the modeling as part of the preparation of the GCAP.
21	Section 4.4: High soil contamination in the floodplain should be considered in modeling because contaminated soils will contaminate the aquifer.	R	NC	Under the surface program, soils that had radium concentrations exceeding UMTRCA cleanup standards were removed in 1985 and 1986. This eliminated the possibility that soils are a continuing source of contamination.
22	Section 4.8: Use maximum concentrations to determine risks to livestock in non-saltgrass samples.	R	NC	Maximum concentrations would represent an overly conservative approach due to the "roaming" nature of livestock. In addition, ecological risk assessment guidelines encourage risk management when a potential risk may occur. DOE has entered into an agreement with the Navajo Nation to restrict livestock grazing during ground water remediation.

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	SOWP Comments(pages 5–8)			
23	The entire floodplain may discharge to the river, thus removing a significant mechanism for flushing. Add a discussion of river stage to support the theory that a portion of the floodplain is gaining from the river.	T	NC	The plume maps in the SOWP (Figures 4-20 and 4-21) support the hypothesis that the terrace is recharging the panhandle of the floodplain east of the disposal cell. The absence of the chemical plume in the crescent area north-northwest of the panhandle is where San Juan River water is believed to enter the floodplain. The crescent region coincides with the area shown in Figure 4-13 (floodplain flow components) of the SOWP where San Juan River water is shown entering the floodplain.
24	The value used for precipitation infiltration may be high. Cite the reference for the higher 30%.	T	NC	Several factors combine to warrant the choice of 30 percent, including the granular character of the surficial deposits, the contributions of runoff from the terrace, and the shallow depth to ground water. Of all the heavy rainstorms we observed on the floodplain, overland flow was never observed. Because no recharge measurements exist for the floodplain, the 30 percent value is simply an estimate.
25	Explain why evapotranspiration was not accounted for in the flow from well 648 to the wash. It is assumed that total flow from 648 reaches the floodplain aquifer.	T	NC	Some of the flow percolates into the underlying terrace alluvial material (cobbles, gravel, sand) and weathered Mancos Shale. This flow eventually finds its way to the floodplain near the mouth of Bob Lee Wash.
26	The change in units to ft^3/year is confusing; keep units consistent.	T	A	All future reports of water budget will use the units ft^3/day. The ft^3/yr terms can be multiplied by 1 yr/365 days to convert them to ft^3/day. Also, the terms were converted to an equivalent set of units in Table 5-1 of the SOWP.
27	Cite the source for the value of 4.4 inches per year.	T	NC	As described in the SOWP, this value was obtained from modeling studies. The calibration of the numerical flow model was accomplished using this value.
28	Determine point of compliance. If the point of compliance is location 940, recommend action to prevent violation.	R	C	The EA has been revised to reflect the point of compliance. Location 940 is a surface water sampling location. Although uranium has been detected in the San Juan River, concentrations exceeded the surface water standard of 35 mg/L on only one occasion. The proposed action will reduce concentrations of contaminants at this location.
29	The mean is higher than the UCL_{95}. Fix.	T	A	Four numbers were in error in Table 4-12 of the SOWP. UCL_{95} for ammonium for Escarpment Seeps should be changed from 0.0448 to 0.52. Mean for nitrate for Other Floodplain should be changed from 0.40 to 89. UCL_{95} for nitrate from Other Floodplain should be changed from 0.63 to 146. UCL_{95} for nitrate from Escarpment Seeps should be changed from 132 to 397. These changes were made to Table 7 in the EA.
30	Concentrations of SO_4 and U are high at location 880. Storm events could mobilize contamination and hit the floodplain with a slug of COCs.	T	NC	Salt crusts are more prevalent in Many Devils Wash than in Bob Lee Wash where samples were collected at location 880. A sampler has been installed at the mouth of Many Devils Wash to collect samples during a storm event. The analyses of these samples will be used to determine what levels of contaminants are being contributed to the San Juan River by dissolution of salt crusts during a storm event.
31	If an R_d has been determined, what is the applicability of a leaching test?	T	NC	Column leaching tests often provide more realistic portrayal of contaminant release than R_d tests because they incorporate a dynamic (flowing) situation. Also, Rd is more applicable to trace elements (e.g. U) but can be inaccurate for major ions (e.g. nitrate and sulfate) that may transport by mechanisms other than adsorption.

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EA Comments[a]		Issue Type[b]	Status[c]	Response/Resolution
32	There is no discussion of Mancos Shale as a source of nitrate. Very high nitrate concentrations have migrated from the raffinate ponds, and could reach the Shiprock school or the seep in 1st Wash. Explain fate and transport of nitrate in this area to justify no action.	T	NC	Nitrate has been found to leach from pelitic rocks in other areas and could be leached from the Mancos Shale. Nitrate fate and transport are discussed in section 4.4.7.8 of the SOWP.
33	What studies support a porosity of 0.3? It's at the high end of alluvial materials.	T	NC	The range in porosity for unconsolidated deposits is 25 to 40 percent for gravel, 25 to 50 percent for sand, 35–50 percent for silt, and 40–70 percent for clay (Freeze, R.A. and J.A. Cherry GROUNDWATER , Prentice-Hall 1979, pg 37). We believe that 30 percent is adequately within those ranges for the terrace alluvium.
34	The model simulation for nitrate concentrations is lower than actual field data. This could influence the simulation of nitrate flushing, and it may take longer to flush in the floodplain.	T	NC	The model simulates nitrate as nitrogen. Therefore, the simulated values are scaled down by a factor of 10 below what you're used to seeing. See page 4-233 (SOWP) second to last paragraph for an explanation. The actual duration of the flushing of nitrate as nitrogen might exceed the predicted times, but not for the reasons stated in the comment.
35	The model simulation for uranium concentrations is below actual field values.	T	NC	The comment is in agreement with the points listed in the last two paragraphs of page 4-234 in the SOWP. By honoring the laboratory-derived values for K_d, the plume has a smaller dimension than it would have if a lower K_d were used. Use of a lower K_d is perhaps justified in this case. This would cause the uranium plume to spread farther and flush more readily.
36	SOWP Section 6.1 should include a human health conceptual site model, including plausible exposures pathways associated with the evaporation system. A quantitative risk assessment should be added to assess the effect to human receptors downwind from the evaporation pond.	S	NC	As stated in the response to comment 4, spray evaporation is no longer being considered. This will eliminate the risk to human receptors downwind from the evaporation pond.
37	Justify why arsenic was eliminated as a human health COPC. List the criteria for eliminating COPCs that were identified in the BLRA.	T	NC	As stated in section 6.1.2.1 of the SOWP, arsenic concentrations have been at or below the detection limit since about 1995. This justifies eliminating it as a COPC.
38	Explain the statements "if the maximum concentration of a constituent was much higher than the rest of the measured values, a more representative calculation is also provided," and "maximum surface water concentrations are used to provide worst-case risk estimates for these possible exposures." They appear to be inconsistent with the calculation of RME using a UCL_{95} of the mean.	T	NC	The first statement means that if a very high outlier was present for a data set, this value was eliminated from use and the second highest value used. For the terrace area, UCL_{95} values were not used because of the uncertainty of the areal extent of the site-related plume. For information purposes and to determine relative importance of each constituent in contributing to hypothetical risk, maximum values were generally used. Surface water in the terrace represents the only currently complete exposure pathway (assuming it was possible to access the site). Because the surface water tends to pool in spots, it would be possible for a receptor to be exposed at specific points. The maximum contaminant values were used to be conservative. The UCL_{95} values were used for floodplain locations, where the extent of the plume is more well-defined.
39	Cancer and noncancer risks should be based on UCL_{95} rather than mean concentrations. Compare to the lower end of the risk range at $1.0\ 3\ 10^{-6}$.	T	NC	The UCL_{95} values were used where data made this practical. Where means are used, these are provided for information purposes only. The maximum values in some calculations were used for the purposes stated in response to comment 38.

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40	Explain the rationale for categorizing risk from "low" to "very high." This categorization is misleading. A discussion of conservatism should be provided in the Uncertainty section of the Ecological Risk Assessment. Table 6-53 should be revised to include numerical HQ values for aquatic and benthic organisms, plants, wildlife, and livestock. Discuss the conservative nature of HQ calculations in the Uncertainty section of the document.	T	NC	The HQ values for each receptor/COPC pair are presented in the SOWP earlier in Section 6.2.3. It is not the purpose of Table 6-53 to repeat these values, but to qualitatively summarize them based on the relative magnitudes of these HQs to highlight the COPCs and media of greatest concern in each of the five areas for risk management purposes. The definitions of the categories used in this summarization and the factors associated with the conservative nature of the HQs are described in the SOWP, Section 6.2.3.11.
	Navajo Nation EPA Comments			
	General Comments			
41	The EA and SOWP emphasize irrigation water and other sources of ground water contamination and downplay the areal extent of mill-related ground water and contamination—despite strong evidence that the major source of both water and contamination in the terrace can only be from the area of the former millsite. Specifically:			
	(1)The raffinate ponds, where highly contaminated water was stored in unlined areas…were located above a portion of the buried relic San Juan River floodplain… Thus a significant portion of the water that infiltrated into the terrace would have flowed toward the buried escarpment and relic river channel south and west of the disposal cell. In contrast, irrigation water was only present during 6 months of the year. Also, irrigation water was spread out over a large area….	T	A	(1) DOE agrees generally with this comment. The EA will be revised to clarify that the raffinate ponds were a significant contributor of milling water to the terrace east and terrace west ground water systems. Irrigation from the Helium Lateral Canal system was more widespread from the late 1950s to the mid 1980s than it is presently. Prior to construction of the high school and elementary school in the mid to late 1980s, irrigated fields covered that area.
	The subsurface contours of the impermeable layer beneath the area of irrigation show a strong gradient to the northwest; thus, any irrigation water infiltrating the terrace area would have to flow contrary to this gradient.			The "impermeable layer" referred to is the Mancos Shale bedrock surface in Figure 4-7 in the SOWP. The surface is not impermeable—saturation extends downward for varying depths into the weathered Mancos Shale. Irrigation water from the Helium Lateral Canal would percolate downward from the ground surface in a somewhat radial pattern, creating a local mounding effect as it travels through the vadose zone. Upon reaching the ground water (potentiometric) surface, flow would be to the northwest, as shown in Figure 4-9 of the SOWP.
	(2) Under the irrigation area, the equipotential lines in SOWP Figure 4-9 indicate that ground water flow is to the northwest, with a strong gradient north of US Hwy 64. Ground water originating near the high school would have to flow across or up this gradient to affect the area immediately west of and under US Hwy 666.	T	NC	(2) Agree generally with this comment. The irrigated area shown on Plate 1 in both the SOWP and EA is that area affected by irrigation water from the Helium Lateral Canal and its subsidiary ditches. Water from this canal system enters the ground surface and percolates downward, eventually reaching the saturated ground water surface. From its initial point at the ground surface, some flow is radial in a lateral sense, and the effect of this descending ground water extends laterally for some distance. It is unlikely that lateral flow from the east edge of the Helium Lateral Canal system would go east far enough to influence the U.S. Highway 666 area.

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41 (cont.)	(3) Contaminated ground water is predominantly from the milling operation. Irrigation water may have slowed down and even redirected mill-related ground water around the irrigated fields but has not contributed to ground water or contamination in the terrace in any other meaningful way. The nitrate plume, which most closely mirrors ground water flow from the former millsite, suggests that most of the water currently in the terrace came from mill operations and/or surface remediation at the site.	T	NC	(3) Agreed
	(4) Although selenium concentrations are attributed to leaching of Mancos Shale, concentrations in the irrigated area are lower than those in almost all other parts of terrace west. The elevated concentrations of constituents attributed to natural leaching are also due to the presence of mill-related water, not irrigation water. The conclusion that uranium concentrations are due to natural leaching of Mancos Shale is not supported by the evidence presented here [see original text attached]. The irrigation water is flowing toward the north/northwest and is not present long enough to leach significant amounts of contaminants, as evidenced by the low concentration in ground water in the irrigated area. Only water that has been sitting in the Mancos Shale for long periods of time, such as the mill-related water, can leach out the U, Se, and SO_4 in concentrations found throughout the terrace away from the irrigated fields. DOE needs to take more responsibility for the ground water in the terrace west area and should take a more active role in cleaning up the contaminated water in this area.	T	NC	(4) DOE agrees that the longer water is in contact with weathered Mancos Shale, the longer it has to leach U, Se, and SO_4 from it. The areas of the terrace that have been irrigated in recent times (e.g., terrace west) generally have lower concentrations of these constituents than do areas of terrace east. The higher ^{234}U:^{238}U ratios in these areas generally lower in total uranium suggest that water is not in equilibrium with respect to the isotopes and may represent non-milling-related water or a mixing of irrigation and milling-related water.
	Specific Comments			
42	Sec. 1.1, first line: The citation in the USC given for UMTRCA is incorrect. The one provided is for NEPA.	R	A	The EA will be revised to show the correct citation as 42 USC 2022.
43	p.9, Sec. 1.4: The buried ancestral channel of the San Juan River is located well south of Bob Lee Wash, and terrace ground water in this channel flows west toward the Helium Lateral Canal (SOWP Figure 4-7). Also, the equipotential lines (SOWP Figure 4-9) indicate that some ground water does flow east toward Many Devils Wash.	T	A	The text will be clarified to reflect this.
44	Figure 3: The view is to the south or southeast, not northwest as the caption states.	S	A	Agree. The caption will be changed.
45	Table 2 should list the cleanup goals for constituents that do not have specific EPA maximum concentration limits.	S	NC	Cleanup goals for ammonium, manganese, strontium, and sulfate are not mandated by 40 CFR 192. For these constituents, we are looking at a risk-based standard, if available; also, SDWA standards may be applicable.
46	Figure 5: The same symbol (*) references two different notes, making this figure confusing unless both notes are supposed to be referenced each time.	S	A	Agree. This will be changed in the EA. Remove the "* Strategy will be reevaluated if conditions change or if monitoring indicates that EPA standards will not be met."

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47	Sec. 3.2.1, para. 1, p.21: ACLs must also consider water quality standards for surface waters that are hydrologically connected to the contaminated ground water. Large exceedences of Navajo Nation Water Quality Standards are not acceptable to the Navajo EPA, and any ACLs established should not be set at levels that would allow these exceedences to continue.	R	NC	The regulations require that ACLs consider effects to surface waters. Therefore, DOE agrees that Navajo Nation surface water quality standards must be considered. ACLs will be developed in consultation with Navajo and federal regulatory agencies during the GCAP and implementation phase of the project.
48	Sec. 3.2.1, last sentence, para. 3, p.21: The New Mexico State Engineer's Office has no jurisdiction over withdrawal of water from the San Juan River on the Navajo Reservation. Approval must come from the Navajo Nation Water Code Administration.	R	NC	DOE has communicated with the Office of the State Engineer and has been informed that a permit from their office will be required. However, they have informed DOE (by letter dated May 24, 2001) that 1,200 acre-feet of water was filed for by the Navajo Nation. They have expressed willingness to work with DOE and the Navajo Nation to address this issue when the time is appropriate. It is DOE's understanding that the State of New Mexico does have jurisdiction over surface water rights flowing in the San Juan River.
49	Sec. 3.2.1, para. 1, p.22: (1) The SOWP states that monitoring will be conducted quarterly during the remediation period. Why was this changed to semiannually; during which seasons will sampling be conducted; and how will that decision be made?	S	NC	(1) From December 1998 to February 2001, ground and surface water sampling at the Shiprock site occurred at a near-quarterly frequency. Many new wells and surface water sampling locations were established during this period of site characterization. Data from frequent sampling during all seasons and at high and low river flows provided an understanding of the extent of contamination and its seasonal variation. With this framework of site data, site conditions can be monitored using fewer, well-chosen, representative locations that are sampled less frequently. Future sampling is planned semiannually to occur in late winter and late summer.
	(2) It is unclear how DOE can determine if terrace west is contributing uranium and selenium to the floodplain when no monitoring of wells is proposed for the area between the floodplain and terrace west. Also, as discussed in detail [see original text attached], it is difficult to see how the irrigation water will flow upgradient from the irrigated area to the floodplain.	T	A	(2) Ground water in the floodplain (north of the disposal cell) receives inflow from the terrace ground water system, as stated on page 2 of the EA, but that inflow is from the terrace east area. The statement on pages 21 and 22 of the EA that leaching of Mancos Shale in the irrigated area of terrace west contributes uranium and selenium to the floodplain aquifer is not correct. As correctly pointed out, ground water from terrace west would have to flow upgradient to reach the floodplain. The EA text will be corrected to reflect this.
	(3) The last line in this paragraph states that interim actions "prevent" exposure to contaminated ground water at the seeps. Though the interim actions substantially reduce exposure, it is misleading to state that exposure is prevented, since water flows out from under the netted and fenced seeps, and ponded water is still visible in places around the rip-rap.	T	A	(3) The wording in the EA will be changed to state "… interim actions are substantially reducing exposure to contamination…." for the interim actions on page 22, first paragraph.

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50	Sec. 3.3:			
	(1) It is unclear whether the compliance strategy for terrace east is simply to pump the ground water down until the washes and seeps dry up as stated in this section and a note in Figure 5, or if all water in this area is to be removed as the SOWP states (p.7-2).	T	NC	(1). The compliance strategy for terrace east is to pump the ground water down until the seeps dry up. Water will probably not be completely removed from the terrace. See the response to comment 7.
	(2) Since the MCLs are "irrelevant" as the SOWP states on p.7-2, and no ACLs or other cleanup goals are mentioned, what EPA standards are referred to in the note under Box 16 of Figure 5?	R	A	(2) The * footnote stating "Strategy will be reevaluated if conditions change or if monitoring indicates that EPA standards will not be met" will be removed from Figure 5.
	(3) Unless all mill-related water (i.e., all water) in the terrace east area is going to be removed, it must be assumed that supplemental standards have been instituted, because no cleanup concentration goals are mentioned. DOE needs to state what these supplemental standards are and justify their selection under 40 CFR 192.21, because it is not clear how DOE came to the conclusion that this compliance strategy is acceptable under EPA regulations. If supplemental standards have been chosen, 40 CFR 192.22 states that the alternate remedial action taken to meet these standards must come as close to meeting the otherwise applicable standard in 40 CFR 192.02(c)(3) as is reasonably achievable.	R	NC	(3) The supplemental standards criterion that will be invoked under 40 CRF 192.11 paragraph (e) "Limited use ground water means ground water that is not a current or potential source of drinking water because [criterion 2] widespread ambient contamination not due to activities involving residual radioactive materials from a designated processing site exists that cannot be cleaned up using treatment methods reasonably employed in public water systems." In other words, if the ground water is of naturally poor quality such that levels of one or more constituents exceed UMTRA MCLs, and it is not currently or projected to be a source of drinking water, then it can qualify for this criterion. This can be invoked even if the millsite contributed additional contamination to the ground water.
	(4) The compliance strategy does not address the seeps between the [US Hwy 666] bridge and 1st Wash, which are hydrologically connected to the mill-related ground water. As presented above, the evidence for this connection is provided by the Mancos Shale contours, the equipotential surface, and the nitrate plume.	T	A	(4) Seeps in 1st Wash (933), 2nd Wash (934), and between the two washes (936) will be sampled semiannually and analyzed to evaluate ecological risk concerns. Also, the flow rate of seep 786 below the U.S. Highway 666 bridge will be measured along with sampling for ecological risk concerns; and a new location (959) in the distributary channel at the mouth of 1st Wash will be sampled for ecological risk concerns. This sampling is shown in the revised Table 4 of the EA. After about 5–10 years of active short-term remediation in the terrace east system, the remnant milling-related water supplying the seeps should be depleted and the seeps would be drying up.
51	Sec. 3.4			
	(1) Para. 2, p.25: It is unclear how irrigation water will flush contaminants upgradient from the irrigated area—especially since the only irrigated area (besides lawns) will soon be north of US 64.	T	A	(1) The EA text will be revised to indicate that the irrigation water will continue to flush that part of the terrace west area downgradient from irrigation. The new Diné College campus may also use water from this irrigation system to water landscaping.

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51 (cont.)	(2) Para. 2, pp25–26: The nitrate plume is the primary evidence that ground water in this area comes from the millsite, since natural sources cannot be that high. The Kjeldahl nitrogen study ruled out septic/sewer leaks, and fertilizer would have to migrate upgradient great distances to reach most of the highly contaminated areas where natural leaching is supposed to be due to irrigation water.	T	A	(2) The distribution of nitrate does seem to indicate the extent of the millsite-derived contaminant plume. Elevated nitrate concentrations in well 1060 from more recent data (June 2000 and February 2001) than the results shown in Figure 17 of the EA indicate that the contaminant plume moves westward around the south edge of the area irrigated by the Helium Lateral Canal. The EA text will be revised to indicate this.
	(3) As with the terrace east area, DOE needs to clearly state what the supplemental standards are. Text in 40 CFR 192.22(c) indicates that DOE is to periodically inform EPA of the determinations made regarding the use of supplemental standards. Has this been done, and is EPA in agreement with DOE decisions?	R	NC	(3) DOE states in the EA that "limited use ground water" is the selected supplemental standard. DOE will continue to notify EPA periodically of the determinations.
	(4) More wells should be regularly monitored in this area to accurately determine how the ground water and contaminants are going to respond to both terrace east remediation and reduction in irrigation in terrace west.	T	A	(4) The number of wells from which samples and water levels will be taken will be increased to 11. Table 4 in the EA will be revised to show these changes.
52	Sec. 4.1.1, para. 1, p.37: How could bentonite be more permeable than the other layers within the Mancos Shale? Bentonite is essentially impermeable when wet.	T	A	Seepage has been observed along thin (less than 1-inch thick) bentonitic layers in the Mancos Shale along the escarpment, particularly at seep 427. This will be noted in the text of the EA on page 37. Rather than flowing through the bentonite, water movement may be along horizontal discontinuities bordering the bentonite layers.
53	Sec. 4.1.1, para. 2, p.37: It is difficult to see how irrigation water could migrate such great distances upgradient.	T	A	The text will be modified to state that irrigation water is one component of saturation in the west part of the terrace west alluvial material.
54	Sec. 4.1.1, para. 3, p.37: The lower concentrations of ground water contaminants are downgradient from the irrigated area. There are very high levels of contamination in terrace west upgradient from the irrigated area, along the east side where the main portion of the contaminant plume is moving north along US Hwy 666.	T	A	Clarification will be made in the text.
55	Sec. 4.1.1, para. 4, p.37: Although the discussion in the SOWP shows how relatively high concentrations of U, SO_4, and Se can be leached out of the Mancos Shale, it does not show:			
	(1) that the water is not mill related.	T	NC	(1) DOE assumes that some contribution to the contamination in terrace west is millsite related.
	(2) that concentrations of SO_4 or Se anywhere near those found in the southeast portion of terrace west can be leached from the Mancos Shale.	T	NC	(2) Concentrations of Se and SO_4 are probably higher in the southeastern part of terrace west than can be accounted for by leaching Mancos Shale. This is thought to be a contribution from milling-related contamination.

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55 (cont.)	(3) how the nitrates got there.	T	NC	(3) DOE assumes that most of the nitrates could be from milling-related activity, but some could also be from septic systems or from fertilizer. Having said this, DOE maintains that levels of Se and U in ground water associated with weathered Mancos Shale would be expected to be higher than MCLs for these constituents. DOE did not find background ground water on the terrace and has instead used the surrogate argument that these levels would be expected to be higher based on published information about the formation and on information from other DOE sites.
56	Ground Water Use, p.38: What is well 848 used for?	T	NC	Well 848 on Shiprock High School property is not being used. At the time the UMTRA Ground Water Project received permission to open the well and take samples in the fall of 1998, the well cap was welded shut. The last time the well was sampled was in February 2001.
57	Terrace Ground Water, p.47: Again, how is irrigation water supposed to flush mill-related contaminants out of terrace west when the only significant irrigation will be north of US Hwy 64 once the college construction begins?	T	NC	Irrigation water will flush mill-related contaminants from a large part of the terrace west area. After the new Diné College campus is completed, it is assumed that some landscaping will be irrigated, and that would promote flushing.
58	It would be nice if Table 7 also included the cleanup concentration levels.	R	NC	The table shows the summary for surface water chemistry on the floodplain and terrace. Cleanup concentration levels are listed and described in Table 2 of the EA.
59	Sec. 4.2.1, para 3, p.49: (1) The Navajo Nation surface water quality standard for dissolved U is 35 µg/L for waters with domestic water supply as a designated use. This would include the San Juan River.	R	A	(1) The Navajo Nation surface water quality standard for domestic use will be included in the EA.
	(2) Though the distributary channel is lumped in with terrace west, it is part of the San Juan River. Thus, contrary to the last sentence of this paragraph, DOE's monitoring does indicate that mill-related constituents are affecting the water quality in the river.	T	NC	(2) The distributary channel itself is included with the floodplain, not terrace west. The San Juan River stage has to be high before flow passes through the distributary channel. This flow threshold is estimated to be about 3,000 cfs. Locations 887 and 939 in the distributary channel sampled during a high river flow in June 1999 had very low uranium concentrations (below detection limit). At other sampling times of low river flow, uranium concentrations at locations 887 and 939 have exceeded or nearly exceeded the EPA ground water standard of 0.044 mg/L. At these times, the high concentrations are believed to be related to ground water seepage containing some mill-related constituents from the escarpment area west of the US Highway 666 bridge (1st and 2nd Washes and nearby seeps).

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60	Sec. 4.2.1, para. 2, p.50: The scenario depicted in Appendix C is not very reasonable. A 4-hour storm is not going to produce a hydrograph that starts at 500 cfs, lasts exactly 4 hours, and ends at 500 cfs. The hydrograph will have rising and falling limbs where flow is much lower. This lower flow (particularly on the rising limb) will be moving in and around the rocks, flushing out the salts and dumping into the San Juan River with very high concentrations of the evaporites.	T	NC	Calculations used simplistic assumptions that were a best guess. A sampling device has been installed at the mouth of Many Devils Wash to collect samples during a storm event. Analyses of these samples will provide actual concentrations of contaminants being discharged to the San Juan River.
61	Sec. 4.2.1, Terrace West Area, para. 2, p.51: The water quality data for surface water sites 0942, 1063, and 1064 seem to indicate that different ground water sources are feeding them. Site 0942 is located along the edge of the plume that has migrated around the upper irrigated area and has water chemistry similar to that in wells 0848, 0846, and 0836. Sites 1063 and 1064 are located in abandoned gravel pits and clearly have no connection with the contaminated ground water. This is reflected by the similarity of water chemistry between these sites and nearby wells within the currently irrigated area (e.g., 0847 and 0838). Thus, it would be useful to maintain either 1063 or 1064 for long-term monitoring along with 0942.	T	NC	Paragraph will be rewritten for clarity. Sampling of 942, the major spring in the area, will be sampled semiannually for chemistry. Sample locations 1063 and 1064 were sampled only once during the winter of 1999 and are small potholes from an old gravel extraction area that contained stagnant water.
62	Sec. 4.3.1, para. 1, p.53: It is unclear whether Bob Lee Wash would be considered part of terrace east, but portions of that wash other than those delineated in EA Figure 22 would likely be considered jurisdictional wetlands, in contrast to the statement made in this paragraph.	R	NC	The jurisdictional wetlands was delineated in accordance with Corps of Engineers criteria. Due to potential conflicts with historical grazing rights, DOE has suggested to Navajo regulatory agencies that the wetlands be provided protected status if the Navajo Nation wishes to promote wetland values. To date a final response has not been received.
63	Sec. 4.4.2, Terrace West Area, p.71: Is the water clean enough for people to eat food such as beans, leaf lettuce, or fruit from an orchard (without washing first) if those plants have been watered with a sprinkler irrigation system? What if the yield is sufficient for agricultural uses in the highly contaminated portions along the east side of terrace west? Any water that may be used for irrigation or watering of food crops will need to meet standards similar to drinking water standards.	T,R	A	Concentrations of selenium are high enough in terrace west ground water that they could accumulate in certain types of plants to levels that are higher than recommended for dietary intakes of some animal species. Selenium is the constituent present in terrace west ground water that has the greatest potential for bioaccumulation. Selenium is an essential nutrient for humans, though it can be toxic at higher than dietary levels. Selenium uptake by plants and fruits is highly variable and it is impossible to say, in the absence of site-specific and plant-specific data, whether the ground water is safe for irrigation use. It is recommended that some other source of irrigation water be used for watering food crops.
64	Sec. 4.8.1, Floodplain Area, p.72: The estimated risks are high in the distributary channel, which is part of the San Juan River and which is where young endangered fish are likely to reside.	R	NC	The distributary channel (Area A) is considered part of terrace west area for risk assessment purposes because it is potentially influenced by RRM from this area. Potential risk to aquatic receptors in this area is acknowledged and discussed under the subsection "Terrace West Area." on page 73. DOE has agreed to continue working with the U.S. Fish and Wildlife Service, Navajo Fish and Wildlife, and Navajo EPA to address this concern under the consultation process in 50 CFR 402. A new sample location in the distributary channel at the mouth of the 1st wash will be established to provide additional data for ecological risk assessment.

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65	Section 5.0: Window Rock should be added to the list of Navajo EPA locations—Patrick and Wilma both work out of that office.	S	A	Changes will be made to Section 5.0 of the EA.
	Navajo Nation Water Code Administration Comments			
	Overview			
66	The EA could benefit from greater description of the major remediation technique of spray evaporation—its design, specific location, operation, and efficacy. The EA, as a public document with a legally defined public mission, should be able to stand largely on its own.	T	A	The EA will be revised to reflect a remediation plan that uses solar evaporation and drip evaporation initially and will evaluate the possibility of enhanced evaporation at a later time.
	Comments on Individual Sections			
67	Section 3 should include information on the spray evaporation strategy, as discussed in *Overview* above.	T	A	As stated in the response to comment 4, spray evaporation is no longer being considered.
68	How was the size of the 100-ft buffer zone around the evaporation pond chosen?	T	NC	As stated in the response to comment 4, spray evaporation is no longer being considered.
69	p.21, para. 3, last sentence: We recommend that DOE coordinate any relevant State contacts with the Navajo Nation Department of Justice before making any such contacts.	R	NC	See response to comment 48. DOE agrees that the Navajo Water Code Administration will be a key regulatory agency in resolving water rights issues. DOE will rely on the judgement of the Navajo UMTRA Program and the Navajo Water Code Administration as to the level of involvement required by the Navajo Nation Dept. of Justice.
70	p.22 last sentence and top of p.23: A few sentences of clarification are needed here concerning dispersing ground water brought to the surface, since at least some of the ground water will be contaminated.	R	NC	Dispersing ground water during well development has been common practice at all UMTRA sites. Calculations have been completed to ensure that concentrations will not recontaminate the surface.
71	Sec. 3.2.2: It would be useful to briefly describe what possible "additional compliance strategies" will be evaluated if the disposal cell proves to be a continuing contaminant source.	T	NC	DOE would rather not discuss this at the present time because additional information will be gathered and evaluated during the next 5 years to address this possibility. DOE will be open to any number of possibilities should the disposal cell prove to be a continuing source of contamination.
72	Sec. 3.3, p.24: It is unclear whether DOE plans to pump terrace east ground water only to the point at which the seeps dry up, or to the point where DOE can no longer reasonably extract the contaminated ground water.	T	NC	See comment 50
73	Sec. 3.4, p.25, regarding the 7 years of remediation: We want to underscore the importance of eliminating uncertainty about whether contaminants in the terrace west area are naturally occurring or result from mill-related contamination in terrace east.	T	NC	See comment 41
74	p.47, first para., "…no water was present in the terrace…": The Navajo WCA has reservations about that statement and suggests that the presumption not be completely relied on.	T	A	Some rewording of the first sentence in first paragraph on p. 47 of the EA will be made.

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75	The Navajo WCA supports DOE's wish to allow well 648 to flow and may request assistance from AML/UMTRA and DOE regarding the best way to proceed with questions such the need for signs, fencing, special water use permit, periodic inspections, and periodic maintenance.	T	NC	Continued flow from well 648 is integral to the success of the proposed remediation for the floodplain. DOE appreciates the ongoing support of Navajo UMTRA and the Navajo Water Code Administration to resolve this issue.
	Din■ College/Navajo Dryland Environments Laboratory			
76	Why was 5 years chosen as the time period for semiannual monitoring? The EA indicates that the terrace east active remediation will require 5–7 years. Semiannual monitoring should continue until the levels of the seven COCs in the terrace east monitoring wells and seeps fall below MCLs or within background; or until it can be clearly demonstrated that any elevated contaminant levels are unrelated to the former mill or disposal cell; or until the terrace east monitoring wells and seeps no longer produce water.	T	NC	DOE will monitor the system for longer than 5 years. This number was chosen because DOE will reevaluate the strategy after 5 years and make changes if necessary. DOE plans to monitor terrace east until it is demonstrated that the seeps have dried up.
	Tufts University			
77	The EA should be amended to include a discussion in more detail to convince the reader that the cell is not serving as the source for contamination, especially with respect to uranium.	T	NC	DOE plans a number of monitoring activities over the next 5 years after remedial action has begun (see Section 7.6 in the SOWP) and is committed to determining if "drainage of residual moisture" is coming from the disposal cell. DOE contends that it is better to start remedial action and remove contaminated ground water from the floodplain and terrace than to continue simply studying the system. The remedial actions planned would have to be performed regardless of whether or not the disposal cell is leaking.
78	It is puzzling that uranium decay products were not reported among the contaminants. It is hard to believe that there is not appreciable radium and thorium on site.	T	NC	The 1994 BLRA evaluated the concentrations and health risk implications of uranium daughter products. Total carcinogenic risks from radionuclides were within EPA's acceptable risk range of 1 3 10^{-4} to 1 3 10^{-6}. Ground water from several terrace wells west of the disposal cell have consistently exceeded the UMTRA MCL of 5 pCi/L for Ra-226 plus Ra-228. These wells were sampled frequently from fall 1998 to June 2000. To determine the carcinogenic risk for radium for the area east of US Highway 666 (generally terrace east), the recent radium data from wells in this area were averaged and the risk calculated. The resulting risk was 2.77 3 10^{-5}, which is well within the EPA's acceptable risk range. The calculation was somewhat conservative because the wells with high radium concentrations were sampled more frequently than the other terrace wells. Therefore, from a risk perspective, no problem with radium exists. Also, this ground water just west of the disposal cell is not accessible and, over time, flushing will improve the water quality by lowering concentrations.

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79	The Shiprock emergency water intake is in a bad location. Despite assurances in the EA that levels of contaminants are not elevated at the site, this seems like an accident waiting to happen. Monitoring should be conducted before every use of the intake, and plans should be made to move the intake upstream from the site.	T	NC	Sample location 956 was established on the San Juan River at the intake structure during the June 2000 sampling. The location was subsequently sampled in July 2000, November 2000, and February 2001. Very low concentrations of uranium, similar to upstream background concentrations, have been found in all samplings at this location. The sample in July 2000 was collected at the time of an extremely low river flow (approximately 250 cfs). Similarly low uranium concentrations have been found in earlier samplings from location 548 about 100 yards upstream from the intake structure. From these numerous samplings, we conclude that uranium concentrations are not significantly above background for river water at the present location of the intake.
	Navajo Nation Department of Water Resources			
80	p.ix, Executive Summary, first sentence in para. 1: Change “Navajo Indian Reservation at Shiprock” to “Navajo Nation at Shiprock.”	S	A	Change will be made to the text.
81	p.1, para. 3, fourth sentence: Change from “thick radon barrier …fine-grained soil..” to “thick radon barrier composed of mixed clay soils….”	T	A	Partly agree—sentence will be reworded.
82	p.2, first sentence in para. 1: Description of site location is incorrect because the three areas (floodplain and terraces) can be referenced to different distances.	T	A	Information will be expanded and clarified into two sentences.
83	p.4, para. 1, first sentence: For more clarity, add the number of milling years to the first sentence : “Throughout the 14-year milling period….”	T	A	Change will be made to text.
84	p.4, para. 2, second sentence: The term “plugged” is used incorrectly, since the well has never been abandoned. Change to “capped.”	T	A	Change will be made to text.
85	p.4, second sentence in para. 3: Change “City” to “municipal,” since Shiprock is not considered a city.	S	A	Change will be made to text.
86	p.4, second sentence in para. 4: Remove “saturated,” since the first sentence refers to both terrace and floodplain alluvial sediments; at the end of the paragraph the author refers to insufficient recharge to saturate the terrace sediments.	T	A	Partly agree. Saturation in the terrace system does occur in the lower part of the alluvial material and in the weathered part of the Mancos Shale. Clarification will be made to the last sentence indicating that natural recharge, considered alone, would not sustain a water table.
87	p.4, para. 5: Fluids leaching from processing ponds during milling operations, water used for dust control during the cell stabilization, and residential septic tanks and leach fields may also have contributed to the shallow aquifer recharge.	T	A	These will be added/combined to those events listed in the text.
88	Plate 1 and maps: If prominent locations are listed, then please list the Nataani Nez Shiprock Elementary School and the police station. Both are located directly north of the floodplain across the San Juan River.	S	NC	Emphasis was south of the San Juan River; only a few locations were shown north of the river.

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89	p.5, Figure 2: The map may not be to scale, but the cross-section showing the geologic features should be somewhat realistic. Alluvial sediments generally do not lie flat when deposited; rather, the stream profile should indicate the flow characteristics from channeling caused by erosion and deposition.	T	A	Some bedding surfaces will be added to Figure 2 in an attempt to show the channeling in the alluvial material.
90	p. 6: There is no page 6.	S	NC	Page 6 is the back of page 5. All color figures are printed separately on a color printer. Running the figures through again to print the even page numbers on the reverse side would add considerable time and expense to the preparation of the report. Also, if pages with color figures are used for two-sided printing, the text tends to burn through onto the figure.
91	p.7, Figure 3: Change caption to "Looking Southeast from Northwest."	T	A	The caption will be changed.
92	p.9, para. 1, first sentence: "Monitoring over the past 15 years…." Please indicate which wells or areas were sampled, since those wells located near the river may have been sampled during low river flows and re-sampled during high flows, causing the concentrations to dilute.	T	NC	Concentrations of antimony and cadmium were plotted historically for wells 732 through 736 along the San Juan River. For Sb, concentrations were consistently low after 1996 in low- and high-flow times of year. For Cd, concentrations were consistently low after 1994 in both low- and high-flow times of the year.
93	p.9, para. 1, second sentence: Is DOE still using both EPA and Navajo EPA standards? If both, then indicate with citations throughout the document when Navajo ground water standards were considered.	R	A	DOE will revise the EA to include "Navajo surface water standards." The Navajo Nation does not currently have ground water standards other than those applied by 40 CFR 192. DOE appreciates the Navajo Department of Water Resources bringing this error to our attention.
94	(1) p.9, para. 3: It is likely that several buried ancestral channels are present, and these channels could explain the contaminant flow pathways throughout the terrace areas. An extensive seismic refraction survey could identify fractures, offsets, gravel/boulder contacts with the shale, and topographic features of the shale. Terrace fractures are likely the conduits to the buried ancestral channels. Once these pathways have been identified, DOE could properly place extraction wells for an effective remediation program.	T	NC	Numerous boreholes and wells have provided a fairly clear understanding of the top of bedrock profile for the terrace area. The conclusive drilling data has in many cases differed significantly from 1996 refraction survey data interpretations.
	(2) Also, it is believed that contaminated ground water in the terrace is following the more resistant layer that overlies the weathered Mancos Shale about 20–25 ft below the surface. It is highly unlikely that contaminants are being transported through the remaining Mancos Shale.	T	NC	The comment is unclear. As stated, it refers to a resistant layer that overlies the weathered Mancos Shale. This would be in the terrace alluvial material. No boreholes have shown such a layer in the alluvial material. A resistant layer known in the Mancos Shale is the east-dipping siltstone bed, which contaminated water is likely perched upon and moves on it downdip.

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95	p.9, paragraph 4: What assumptions did the transport model make? Did the model consider a scenario with no flows from well 648? Given the 100-year project period, it is highly unlikely that the Navajo Nation will grant institutional controls so that well 648 could remain free flowing for that time period.	T	NC	Details of the numerical modeling are beyond the scope of the EA; they are presented in the final SOWP, Section 4.5. The effects of no flows from well 648 were not simulated because the possible initial conditions for such evaluations are practically limitless, as described in the final SOWP Section 4.5.6. In addition, as discussed in Section 4.5.6 of the SOWP, it would be risky for DOE to proceed with construction of a remediation project if the status of well 648 remains unresolved. The highest chances for a successful remediation would exist if continued flow from well 648 is ensured.
96	p.11, Sec. 2.0: "…by complying with the final EPA ground water standards…." Change sentence to "…by complying with the final EPA ground water standards…and Navajo EPA ground water standards…" Throughout the document several references have been made to EPA's ground water standards, whereas only one statement is listed for Navajo EPA standards. Please list Navajo EPA along with EPA if both will be used.	R	NC	See response to comment 93.
97	p.12, para. 1: Navajo Nation Water Resources does not concur with DOE's dependence on well 648 to increase natural flushing. We would prefer that DOE use the San Juan River to enhance the flushing. We believe that the high concentrations of contaminants on the floodplain below the disposal cell are within the sediments and only receive significant flushing during high river stages. During low flows, the lack of hydraulic head prevents contaminant transport from the base of the terrace; during those times the extraction wells will enhance contaminant movement toward the saturated zone within the floodplain.	T	NC	The DOE believes that ensuring water from well 648 continues to flow onto the floodplain is an integral part of the proposed floodplain remedial action. Using water from the San Juan River to enhance flushing through gradient manipulation was strongly opposed by the USFWS because of its possible effects on endangered aquatic receptors in the San Juan River.
98	p.12, para. 1, fourth sentence: DOE should keep in mind that all wells must be filed with and all water data must be returned to the Navajo Nation Water Code program.	S	NC	The DOE will continue to comply with these conditions.
99	p.12, para. 3, first sentence: According to Figure 7, five extraction wells are proposed. Depending on the location of the wells, a water usage fee may be required. If the well is within the hydrologic barrier and at the base of Bob Lee Wash discharge on the floodplain, a permit would not be necessary if a water use permit for well 648 has been issued previously. Otherwise, all remaining floodplain extraction wells will require a water use permit, since the floodplain receives recharge from the San Juan River. Please clarify which are the first proposed extraction wells.	R,T	A	DOE is finalizing a water use agreement with Navajo UMTRA and Navajo Water Code Administration that covers monitoring and extraction wells for all four sites within the Navajo Nation. Water Use Permits will be submitted for any extraction wells. Proposed locations will be clarified in the final EA.

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EA Comments[a]		Issue Type[b]	Status[c]	Response/Resolution
100	p.21, para. 3, first sentence: Will the detailed modeling incorporate a detailed geologic framework based on drill cores, outcrop measurements, and/or geophysical data.? A detailed geologic framework would help delineate the permeability pathways (via buried channels) that would allow strategic placement of extraction wells.	T	NC	Geologic parameters used in the modeling will include results of extensive characterization conducted from fall 1998 to spring 2001.
101	p.21, para. 3, last sentence: We are checking with legal council to determine if this statement is correct. The water rights given by State of New Mexico to Kerr-McGee before the mill operations were recently returned to the Navajo Nation. Therefore, there is no need for approval from the State Engineer's Office, but there is a need to obtain approval from the Navajo Nation Water Code office.	R	NC	See response to comment 48.
102	p.24 Sec. 3.3, and p.47, Sec. 4.1.2: We do not concur with the institutional controls. We have some concerns that when the terrace extraction wells can no longer extract ground water, residual contamination may be left below the disposal pile. Navajo Water Resources Management cannot control future development south and southwest of the disposal cell, and development could introduce artificial recharge to the terrace and mobilize contaminants in the soil.	R	NC	Institutional controls are a necessary part of the compliance strategy. DOE assumes that the life expectancy of an IC is probably not more than 100 years, and that is why natural flushing must be demonstrated within that period of time. DOE will monitor the disposal cell during the initial phase of remedial action and try to determine if and how much moisture is continuing to drain from it. This information will be shared with stakeholders and a review of the remedial action will be conducted after 5 years. DOE believes it is important to initiate the remedial action and start cleaning up the ground water at Shiprock.
103	pp. 27 and 28, Sec. 4.1.1: "…aquifer consists of unconsolidated medium- to coarse-grained sand, gravel, and cobbles…" DOE well logs indicate boulders, and some boulders can be seen at the ground surface. Please indicate that [descriptions of] the alluvial sediments should refer to sand, gravel, and boulders throughout the document.	T	A	Some alluvial material as large as small boulders is present. Text will be modified to reflect this.
104	p.27, last para., and p.28, 2nd and 3rd para: We believe that the San Juan River is losing water to the floodplain aquifer and provides most of the recharge. The higher water levels observed at the mouth of Bob Lee Wash (from well 648 discharge) create a hydraulic barrier from the base of the wash to the river. The term "ground water mound" is used incorrectly. Perhaps the term "ground water divide" could better explain the hydrologic conditions at the base of Bob Lee Wash.	T	NC	Figures 8–14 show that the San Juan River feeds the floodplain aquifer only along its southeast margin, the area where the aquifer is flushed. The largest component of ground water comes from discharge of well 648. DOE does not share the commenter's suggestion that there is substantive advantage in using the term "ground water divide". A ground water mound is "a mound-shaped elevation in the water table or another potentiometric surface that builds up as a result of the downward percolation of water, through the zone of aeration or an overlying confining bed, into the aquifer represented by the potentiometric surface (Bates and Jackson, Glossary of Geology 2nd Edition and Wilson and Moore, Editors, Glossary of Hydrology). A divide, or ground water divide, is "a ridge in the water table or other potentiometric surface from which the ground water represented by that surface moves away in both directions…" (Bates and Jackson, Glossary of Geology 2nd Edition, and Wilson and Moore, Editors, Glossary of Hydrology). Because the flow radiates outward from the mouth of Bob Lee Wash and does not flow in an opposite direction, there is no divide; there is only a mound.

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105	p.28: "…sediments average about 20 ft thick…" Rather than use the average thickness for the sediments, DOE might want to indicate the range of lithologic thickness of the different sediments to show the variability.	T	A	Some modification will be made to the EA text on page 28; however, most of this detail is in Section 4.2 of the SOWP.
106	p.37, para. 1, 5th sentence: the thin bentonite layers—how deep are these layers?	T	NC	These thin bentonite layers occur throughout the Mancos Shale; several are exposed along the escarpment.
107	(1) The Navajo Nation does not favor any institutional controls for water permits or usage for any length of time. All the statements below [see original text attached] require that the Navajo Nation establish institutional controls for a 100-year period. We are unsure if the Water Code Administration will have the authority and resources to ensure that future employees will have oversight of restricting permits for drilling and water use in and around the UMTRA Project area.	R	NC	(1) DOE is continuing to address this concern with the Navajo UMTRA Program office under the terms of the cooperative agreement between DOE and the Navajo Nation. Although DOE recognizes the validity of this concern, the regulations allow for DOE and Navajo UMTRA to implement institutional controls.
	(2) Since DOE is requesting that artesian well 648 continue to flow for the next 100 years to assist the flushing, is DOE willing to pay for the well water used for flushing?	R	NC	(2) See response to comments 98 and 101.
108	p.49, para. 2, 3rd sentence: "…water intake structure on the north bank…" Change to "…water intake structure located approximately 400 ft from the north bank…"	S	NC	The water intake structure is along the north bank of the river and its position is accurately shown in Plates 1 and 2. The structure is about 400 ft upstream (east) of the U.S. Highway 666 bridge.
109	p.51, para. 1: "…(3) the Navajo Agriculture Products Industries Irrigation Canal and the proposed Navajo-Gallup Pipeline Project." This pipeline project is still in the negotiation phase and hasn't been approved by congress; it could be years before the pipeline is operating. Therefore, DOE should not depend on this pipeline for an alternative municipal water supply for Shiprock if the intake area becomes contaminated.	S	A	This change will be made in the narrative.
110	p.59, Figure 24: Remove the text "US HWY 66" on the northern highway.	S	A	Figure 24 will be revised.
111	p.80: "Dr. Steve Semken" should probably be written as "Steve Semken, Ph.D."	S	A	Revision will be made.
	U.S. Fish and Wildlife Service comments received June 14, 2001			
112	The Service cannot concur with DOE's conclusion that the proposed remedial actions "may affect but are not likely to adversely affect" federally listed species.	R	NC	DOE acknowledges the Navajo Fish and Wildlife and U.S. Fish and Wildlife Service concerns and is committed to working with both agencies to address protection of endangered species. DOE believes that remediation will have a positive effect on endangered species.
113	The Service would like to meet…to continue informal consultation on the project.	R	NC	Since the receipt of comments on the EA, DOE has communicated with the USFWS and Navajo Fish and Wildlife on several issues that still require resolution. DOE has agreed to continue consultation as the project progresses and has committed to determining if additional short-term actions in specific areas require mitigation beyond that already completed as interim actions.

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114	This is a complex site…and will require development of a comprehensive approach to maximize ecological benefits.	R	NC	As a federal agency, DOE is committed to the protection of endangered species and their habitat.
U. S. Fish and Wildlife Service comments received July 3, 2001 (received after the close of the public comment period but included due to ongoing consultation)				
115	Ecological risk calculations indicate substantial risk to T&E species and other wildlife.	R	NC	DOE concurs that the calculations indicate substantial risk. However, the SOWP and the EA state the overly conservative parameters (e.g., 100% exposure) used to assess risk. For instance, hazard quotients calculated to indicate “real” risks to the southwestern willow flycatcher from ingestion of selenium would be significantly reduced. The flycatcher would be exposed only when present in the area. Evidence indicates that the flycatcher may be present, and if present, would likely be exposed in the most contaminated areas less than 3 months of the year. DOE believes that it is in the best interest of all stakeholders to make risk management decisions on the basis of reasonable scenarios and has committed to work with the USFWS to ensure a balance between the degree of potential risk and the level of mitigation. Continued consultation between the agencies and a revised Biological Assessment are included within the scope of DOE’s commitment.
116	USFWS agrees that the proposed remedial actions will result in a net benefit to federally listed species and their habitat. However ground water removal alone is not sufficient to reduce or eliminate short-term historical risks. USFWS strongly recommends immediate consultation on the design to rapidly reduce or eliminate ecological risks…	R	A	DOE considered USFWS and other stakeholders concerns for a more immediate result and has revised the proposed action accordingly.
U.S. Fish and Wildlife Service comments received August 3, 2001 (received after the close of the public comment period but included due to ongoing consultation)				
117	There is no remedial action proposed for the terrace west area. There is ecological risk in this area. Additional ecologically based remediation is necessary.	R	NC	DOE agrees that potential ecological risk is present in the terrace west area. A field meeting held on July 19, 2001, included a visit to this area. Observations at the meeting were that habitat for T&E fish species appears to be marginal, but habitat for the southwestern willow flycatcher appears to be suitable. Therefore, DOE has committed to additional sampling and further consultation with the USFWS to better define the potential risk and determine the need for additional short-term mitigation in this area. This concern will be included in the revised Biological Assessment.
118	The storm event that destroyed interim action mitigation measures demonstrates the need for a more rapid remedial action.	R	A	See response to number 116.
119	Ecological benefits of the proposed action are based on the gradual removal of ground water…USFWS recommends three primary remedial actions within the next 1–10 years.	R	NC	DOE agrees with these concerns and will continue to consult with the USFWS to determine the appropriate level of short-term mitigation required. In some cases the July 2001 storm event appears to have reduced the potential degree of risk (e.g., Bob Lee Wash was scoured, which resulted in the removal of vegetation and standing pools of water that previously had presented potential risk). However, potential risks in some areas still need further assessment. DOE, Navajo UMTRA, Navajo EPA, Navajo Fish and Wildlife, and USFWS are committed to ongoing efforts to assess and mitigate potential risks to T&E species.

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120	Technical comments: DOE should focus on selenium risks throughout the site. Removal of uranium and sulfate should also be considered. Water collected from the french drains should also be treated.	R	NC	DOE agrees with the USFWS concerns and has modified the proposed action to address at least some those expressed. DOE believes that water collected from both Bob Lee Wash and Many Devils Wash will significantly reduce potential short-term risks.
121	Proposed Remedial Actions (Area A): Several constituents pose potential risk based on the HQs DOE presented in the EA. DOE needs to address these potential risks directly, vs. a side benefit of ground water remediation.	R	NC	DOE has agreed with the USFWS to address concerns expressed in this area in ongoing consultation. As stated in previous responses, DOE believes that risk management should be dependent upon the degree of potential risk, and any mitigation should be relative to the potential for real risk. These are issues that DOE agrees required further discussion among all affected stakeholders.
122	Area B (San Juan River): Sediment removal in the San Juan river is not necessary. However, DOE should consider reduction of COPCs in surface waters of the San Juan River and the floodplain expeditiously.	T	A	DOE has revised the proposed action and believes changes in the proposed action will remove millsite-related contaminants more expeditiously. Concentrations of most COPCs in the river are similar to background. Also, see response to comment 124 concerning HQs.
123	Area C (floodplain): Previous soil and sediment removal was based on radiological parameters… This approach does not address nonradiological parameters.	R	NC	DOE has closed out the surface remediation program. However, additional soil characterization was completed in several areas to determine presence of residual radioactive material.
124	Area D (Bob Lee Wash): Areas containing soils and sediments with an HQ above 1 should be removed., or covered…For surface waters and seeps remedial strategies should consider reducing risk to birds…	R	NC	This comment is consistent with other USFWS comments that any risks that result in an HQ greater than 1 should be remediated. HQs are an indication of potential risk, and do not necessarily mean a risk is present. However, DOE also acknowledges and agrees with the concerns raised by the USFWS within the scope of their legislated responsibility. Therefore, DOE, USFWS and other stakeholders will need to continue to address these concerns on a case by case basis to form a defensible position regarding any risk management decisions. DOE and USFWS have worked together to complete short-tem actions (e.g. netting) to reduce the potential risks to ecological receptors in some of the more contaminated areas (e.g., seeps, Bob Lee Wash, and Many Devils Wash).
125	Area E (Many Devils Wash): Concentrations of COPCs could represent risks to wildlife, including migratory birds and their habitat.	R	NC	DOE agrees with USFWS concerns that potential risk occurs in this area. The expedited approach in the revised proposed action, combined with interim actions, are anticipated to reduce concentrations more quickly. DOE has also undertaken some of the sampling proposed by the USFWS (e.g., installation of an ISCO sampler at the mouth of Many Devils Wash), and will continue to work with USFWS on related recommendations.
126	Background COPCs and ACLS: Remedial actions should address selenium and other COPC concentrations. The chemical signature of some COPCs cannot always be explained by Mancos Shale chemistry. Further sampling is necessary to justify supplemental standards or ACLs.	T	NC	DOE has committed to additional sampling and assessment to further characterize the success of remedial action.
127	Disposal cell and conclusions: Remedial actions should consider a water-impermeable cap over the disposal cell…Alternative and/or additional remedial actions are necessary to rapidly reduce risk associated with soils and sediments, and exclude wildlife from highly contaminated areas.	R/T	NC	DOE believes that interim actions and the revised proposed action will accomplish USFWS goals to reduce potential risks as rapidly as possible. DOE is currently conducting studies of the disposal cell to determine its potential as a continuing source and will continue to evaluate the success of remedial actions and make adjustments where necessary.

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Appendix F will be provided upon request. Click Wendee Ryan or Michelle Smith.

Full Text of Comments on the Draft EA