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UMTRA GROUND WATER PROJECT

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

Draft

September 1999

Prepared by the
U.S. Department of Energy
Grand Junction Office

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

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Plate 1. Geologic Map of the Monument Valley Site

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Acronyms and Abbreviations

BLRA	baseline risk assessment
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
EA	environmental assessment
EPA	U.S. Environmental Protection Agency
ft	feet
gpm	gallons per minute
MCL	maximum concentration limit (established in 40 CFR 192)
mg/L	milligrams per liter
PEIS	Programmatic Environmental Impact Statement
pCi/g	picocuries per gram
^{226}Ra	radium-226
SOWP	site observational work plan
UMTRA	Uranium Mill Tailings Remedial Action (Project)
UMTRCA	Uranium Mill Tailings Radiation Control Act

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Executive Summary

Pursuant to the National Environmental Policy Act, the U.S. Department of Energy, Grand Junction Office (DOE-GJO) has prepared this environmental assessment of ground water remediation alternatives for the Monument Valley uranium mill tailings site. The site is located in northern Arizona within the Navajo Nation. Ground water at the site is contaminated as a result of historical uranium-ore processing activities. Approximately 1,660 acre-feet (540 million gallons) of water may be contaminated. The primary constituents of concern are nitrate and sulfate, and to a lesser extent uranium.

The Monument Valley site is one of 24 former uranium-ore processing sites identified in the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA) for study and potential remedial action. UMTRCA was passed to minimize potential human health and ecological risks from exposure to radiological contamination. The U.S. Environmental Protection Agency has established regulations in 40 CFR 192 for remediation of contaminated surface materials (soils and buildings) and ground water. Contaminated surface materials at the site were removed in 1994 and disposed of at the Mexican Hat disposal cell.

Three distinct water-bearing units are present below the Monument Valley site: the alluvial (surficial) aquifer, the Shinarump aquifer, and the De Chelly aquifer. The alluvial aquifer contains contaminants at levels that could pose an unacceptable risk to human health if the water were used as a long-term source of drinking water. Ground water in the other two aquifers meets most federal standards and Navajo Nation remediation goals. Ground water at the site is not currently being used for domestic purposes.

After an evaluation of alternatives for ground water cleanup, DOE proposes the following remedial action:

Alluvial (surficial) aquifer—Active remediation consisting of distillation combined with phytoremediation (remediation using plants) to remove contaminants.

Shinarump aquifer—No action.

De Chelly aquifer—Natural flushing combined with monitoring.

This environmental assessment discusses the alternatives that were considered and their potential environmental effects.

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1.0 Introduction

The U.S. Department of Energy (DOE) is proposing ground water compliance strategies for three aquifers at the Monument Valley Uranium Mill Tailings Remedial Action (UMTRA) Project site. Although three aquifers are discussed, the focus of this environmental assessment (EA) will be the alluvial (uppermost) aquifer.[1] An estimated 1,660 acre-feet (540 million gallons) of water are contaminated in the alluvial aquifer.

The DOE Albuquerque Operations Office has determined that an EA should be prepared for the proposed action.

1.1 Background

The Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA) (42 U.S.C. 4321 *et seq.*) was enacted to control and mitigate risks to human health and the environment from residual radioactive material that resulted from processing of uranium ore. UMTRCA authorized DOE to perform remedial action at 24 inactive uranium-ore processing sites. The Monument Valley 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: "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 remediation of residual radioactive material in land, buildings, and ground water. UMTRCA defines residual radioactive material as "waste in the form of tailings or other material that is present as a result of processing uranium ores at any designated processing site, and other waste at a processing site which relates to such processing...." The regulations also require that selection and performance of remedial action be completed with full participation of states, in consultation with affected Indian Tribes, and with the concurrence of the Nuclear Regulatory Commission. DOE entered into a cooperative agreement with the Navajo Nation and has held numerous meetings with representatives of the Navajo Nation to address concerns at the Monument Valley site.

DOE completed the *Environmental Assessment of Remedial Action at the Monument Valley Uranium Mill Tailings Site, Monument Valley, Arizona* (Surface EA) (DOE 1989) before conducting surface remediation of the land and mill tailings in 1992. The Surface EA described the affected environment, including surface water and ground water and the effects associated with removal of tailings and debris at the Monument Valley site. Surface materials contaminated with residual radioactive material were disposed of at the Mexican Hat, Utah, disposal cell. Surface remediation was completed in 1994.

[1] The uppermost aquifer consists mainly of fine-grained to medium-grained eolian sand and is referred to as the alluvial aquifer or Quaternary material in this EA.

After the source of ground water contamination (i.e., the tailings) is removed, EPA regulations require that the site be evaluated to determine if contaminant concentrations in ground water of the uppermost aquifer are within 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 1996a) 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 (MCLs) established in 40 CFR 192 (Table 1 to Subpart A).
- The extent of contamination as a result of 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 UMTRA Project Site at Monument Valley, Arizona* (SOWP) (DOE 1999a), which includes the monitor well locations (Plate 1), a site evaluation and findings, and an update of the original Baseline Risk Assessment (DOE 1996b). 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 1997 and 1998 and the recommended compliance strategies, which are the basis for the proposed action in this EA, are documented in the final SOWP. Project documents that provided guidance for the SOWP include the *UMTRA Ground Water Management Action Process (MAP) Document* (DOE 1999b) and the *Technical Approach to Groundwater Restoration* (DOE 1993).

Section 4.0 of the SOWP describes the field investigation approach and results, including surface geophysical surveys, ground water sampling and analysis, soil sampling and installation of monitor wells, aquifer tests, land surveys, and ecological (vegetation) sampling.

Nitrate, sulfate, and uranium are the constituents of concern at the Monument Valley site because they exceed either EPA standards or Navajo Nation remediation goals. EPA has established maximum concentration limits (MCLs) under 40 CFR 192 for nitrate (44 mg/L) and uranium (0.044 mg/L). Because an EPA standard has not been established for sulfate, DOE has agreed to comply with the Navajo Nation remediation goal of 250 mg/L or background.

Remedial action at the Monument Valley UMTRA site would be performed in compliance with EPA and Navajo Nation regulations, the cooperative agreement, and with the concurrence of the U.S. Nuclear Regulatory Commission.

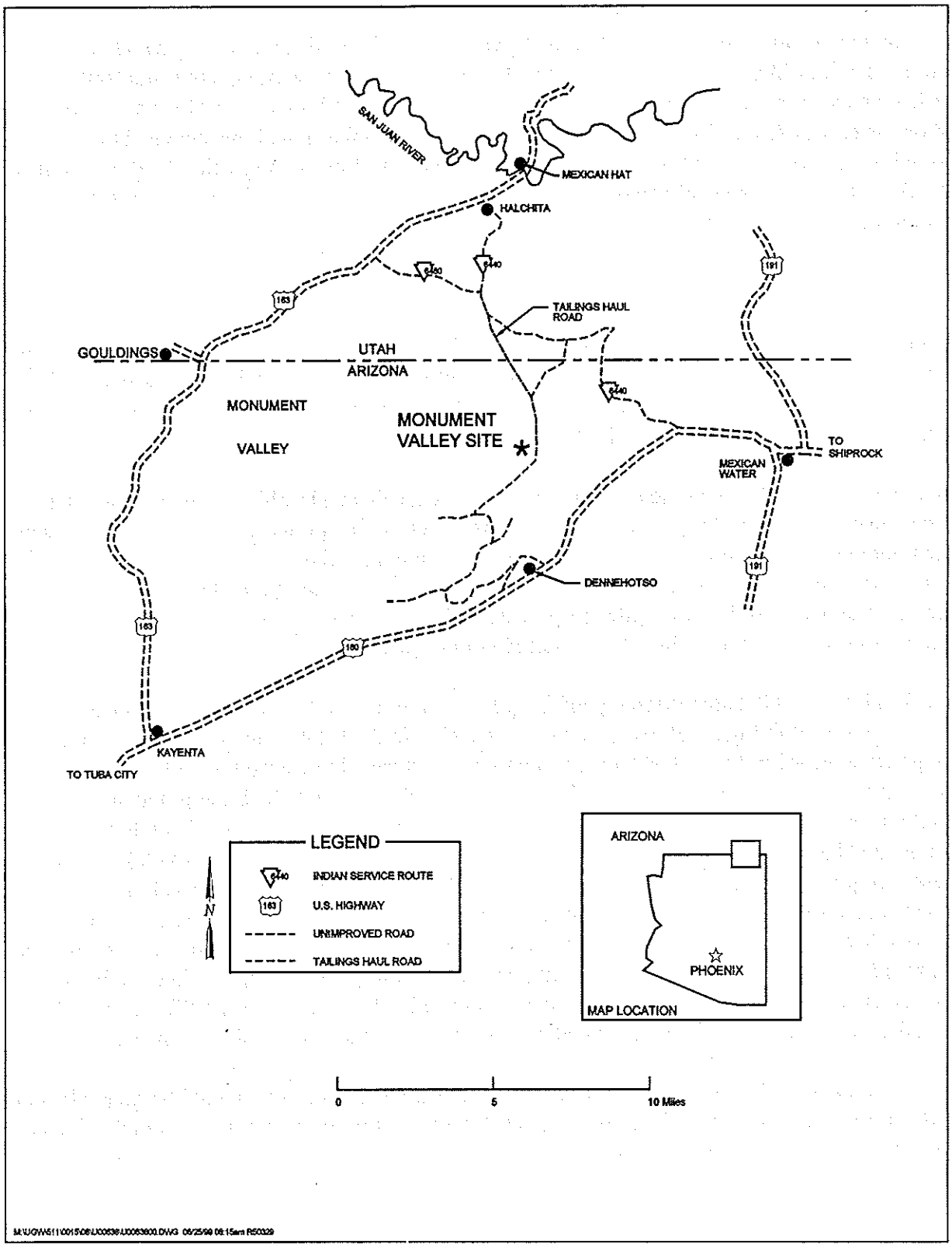


Figure 1. Location of the Monument Valley Site

1.2 Site Description

The Monument Valley site is located in the Navajo Nation in northeastern Arizona, about 15 miles south of Mexican Hat, Utah (Figure 1). The site is on the west side of Cane Valley Wash at an elevation of approximately 4,800 feet and is bordered on the west by Yazzie Mesa and on the east by Comb Ridge (Figure 2). The climate is semiarid, and the site receives approximately 6.4 inches of precipitation annually. May and June are typically the driest months; July, August, and December through February are the wettest months. The Surface EA and Section 3.1 of the SOWP provide detailed descriptions of the site.

1.3 Site History

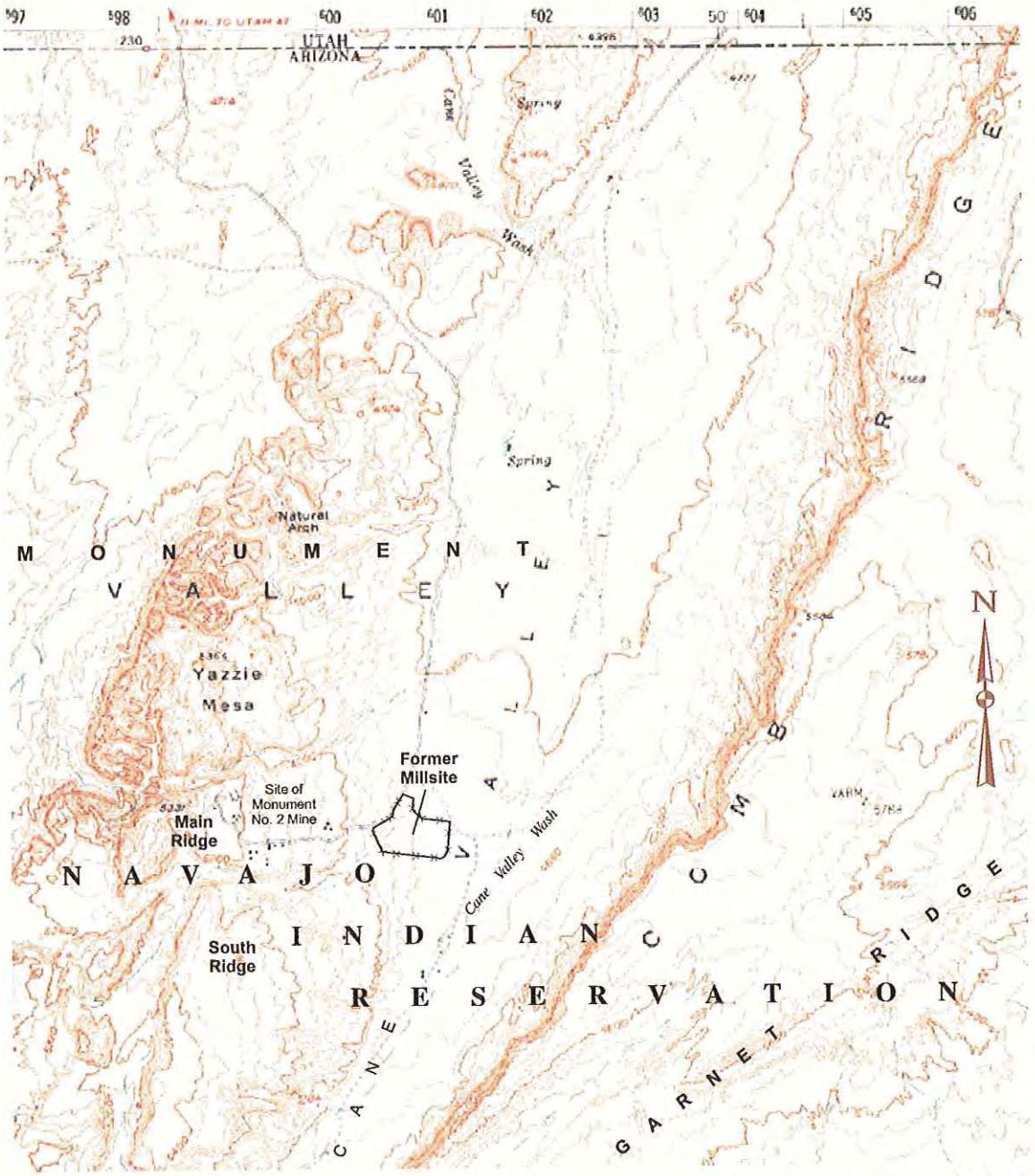
Uranium was first discovered in the Monument Valley area approximately one-half mile west of the former millsite in 1942. A total of 767,166 tons of uranium and vanadium ore was mined between 1943 and 1968, when the mill closed and the lease with the Navajo Nation expired. Most structures were removed shortly thereafter.

From 1955 until 1964, ore at the site was processed by mechanical milling using an upgrader, which crushed the ore and separated it by grain size. During that period the only chemicals used were minor amounts of flocculant.[2] The finer grained material, which was higher in uranium content, was shipped to other mills for chemical processing. Coarser grained materials were stored on site in the "old tailings pile" (Figure 3). Some ground water contamination may have resulted from water draining through the stored tailings piles during that period.

From 1964 until 1968, batch leaching and heap leaching were used to process an estimated 1.1 million tons of tailings and low-grade ore at the site. In the batch-leaching process, sandy tailings were placed in lined steel tanks, and uranium and vanadium were leached by an upward flow of sulfuric acid solution. Heap leaching consisted of placing crushed low-grade ore on polyethylene sheeting and percolating a sulfuric acid solution through the ore. Both heap-leaching and batch-leaching operations used ammonia and quicklime (calcium oxide) to produce a bulk precipitate of concentrated uranium and vanadium. Chemical solutions used in ore processing are believed to have been discharged to the new tailings pile (Figure 3). The new tailings pile contained both sandy tailings and processing solutions. An evaporation pond was on the east side of the new tailings pile. The purpose of the evaporation pond is unknown, but it may have been used to retain seepage from the new tailings pile. Section 3.2 of the SOWP provides a detailed description of the site background and history, including chemical processing.

The former sources of ground water contamination at the site include (1) the old tailings pile and heap-leach area, (2) the new tailings piles, and (3) the evaporation pond. Surface remediation at the site took place from 1992 through 1994 and resulted in the removal of these source materials

[2] A substance used to consolidate particles within a liquid.



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Explanation

Improved Graded Road

Unimproved Road

Fenced Site Boundary

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Figure 2. Regional Setting of the Monument Valley Site

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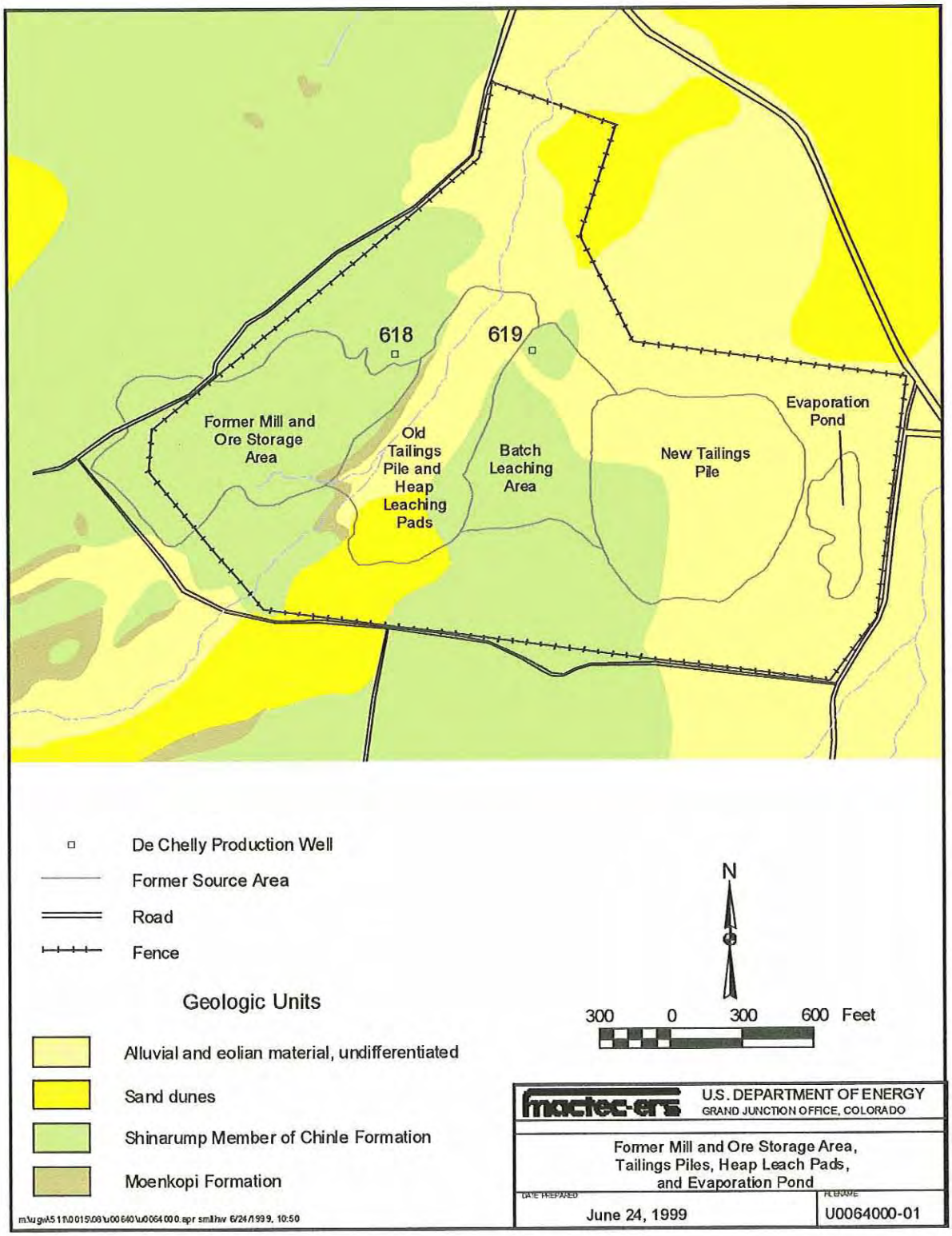

Figure 3. Former Mill and Ore-Storage Area, Tailings Piles, Heap-Leach Pads, and Evaporation Pond

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and other site-related contamination. However, analysis of subpile soil samples (i.e., samples collected from the "footprint" of the former tailings piles) indicates these soils may be continuing sources of ground water contamination. Ammonium in the subpile soil may be contributing to nitrate contamination in ground water.

1.4 Overview of Contamination

Of the three aquifers addressed in the SOWP, contamination is of primary concern in the alluvial (uppermost aquifer) because concentrations of some mill-related constituents exceed background, EPA ground water standards, or Navajo Nation remediation goals. The Shinarump aquifer, which directly underlies the alluvial aquifer, has slightly elevated concentrations of naturally occurring constituents. However, concentrations of these constituents are close to background levels and none exceed EPA ground water standards or Navajo Nation remediation goals. Therefore, site-related contamination has not affected the Shinarump aquifer. This is further supported by evidence of a slightly upward hydraulic gradient from the Shinarump to the alluvial aquifer.

Uranium concentration slightly exceeds the uranium MCL of 0.044 mg/L in an isolated area of the De Chelly aquifer, the deepest of the three aquifers. This contamination is believed to have resulted from pumping of production well 619 during milling operations. Pumping may have drawn contamination downward from the alluvial aquifer. Since well 619 is no longer being pumped for production, and an upward hydraulic gradient has been re-established, evidence in the SOWP has shown that there is no longer a source of contamination reaching the De Chelly aquifer. Uranium concentrations have decreased significantly since the well was pumped during an aquifer test in 1993, indicating that the De Chelly aquifer is diluting uranium concentrations by natural flushing. This dilution is expected to continue through time.

On the basis of the information in the SOWP, DOE will propose ground water compliance strategies for only the alluvial and De Chelly aquifers.

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 and the Navajo Nation remediation goal for sulfate. DOE proposes implementing the compliance strategy outlined in the SOWP, which uses the framework established in the PEIS.

Ground water in the Monument Valley area that has not been affected by past ore-processing activities is generally of good quality and suitable for domestic use. DOE would implement the proposed action in this EA to remediate contaminated ground water to comply with EPA standards and Navajo Nation remediation goals.

3.0 Proposed Action and Alternatives

DOE is proposing a ground water compliance strategy for the alluvial and De Chelly aquifers at the Monument Valley site. Figure 4 shows a regional geologic cross section of the site. Although UMTRA ground water regulations pertain only to the uppermost aquifer beneath UMTRA Title I sites, characterization data and historical knowledge of the Monument Valley site indicate that site activities did result in some contamination of the deeper De Chelly aquifer. Therefore, compliance strategies are proposed for the alluvial and De Chelly aquifers.

The proposed strategies are consistent with the PEIS (DOE 1996a). The PEIS provides options (compliance strategies) for complying with EPA's ground water standards and assesses in general terms the effects associated with each compliance strategy. The Compliance Selection Framework (Figure 5) presented in the SOWP and the PEIS outlines the strategy selection process.

To minimize risks to potential water users in the short term, DOE has agreed with the Navajo Nation to install a water supply system to serve the Monument Valley area. The Navajo Tribal Utility Authority is preparing the appropriate NEPA documentation for the alternate water supply.

3.1 Compliance Strategy Selection

Table 1 presents a summary of DOE's proposed action for ground water compliance at the Monument Valley site.

Table 1. Summary of DOE's Proposed Action

Aquifer	Constituent of Concern	Compliance Strategy	Rationale
Alluvial	Nitrate, Sulfate	Active Remediation:	
		Distillation and Reinjection	Reduce concentrations that exceed MCLs in deeper portions of the aquifer to EPA standards and Navajo Nation remediation goals; reinject clean water to the aquifer.
		Phytoremediation	Reduce concentrations of ammonium in alluvial soils that could be a continuing source of nitrate contamination; reduce concentrations of nitrate in the shallow portions of the alluvial aquifer.
	Uranium	Natural Flushing	Uranium concentration only slightly exceeds the MCL at one monitoring location and is expected to decrease to the MCL within 20 years.
Shinarump	None	None	No evidence of mill-related contamination.
De Chelly	Uranium	Natural Flushing	Uranium concentration only slightly exceeds the MCL in a small isolated area and appears to be decreasing with time. There is no current or short-term human health or ecological risk.

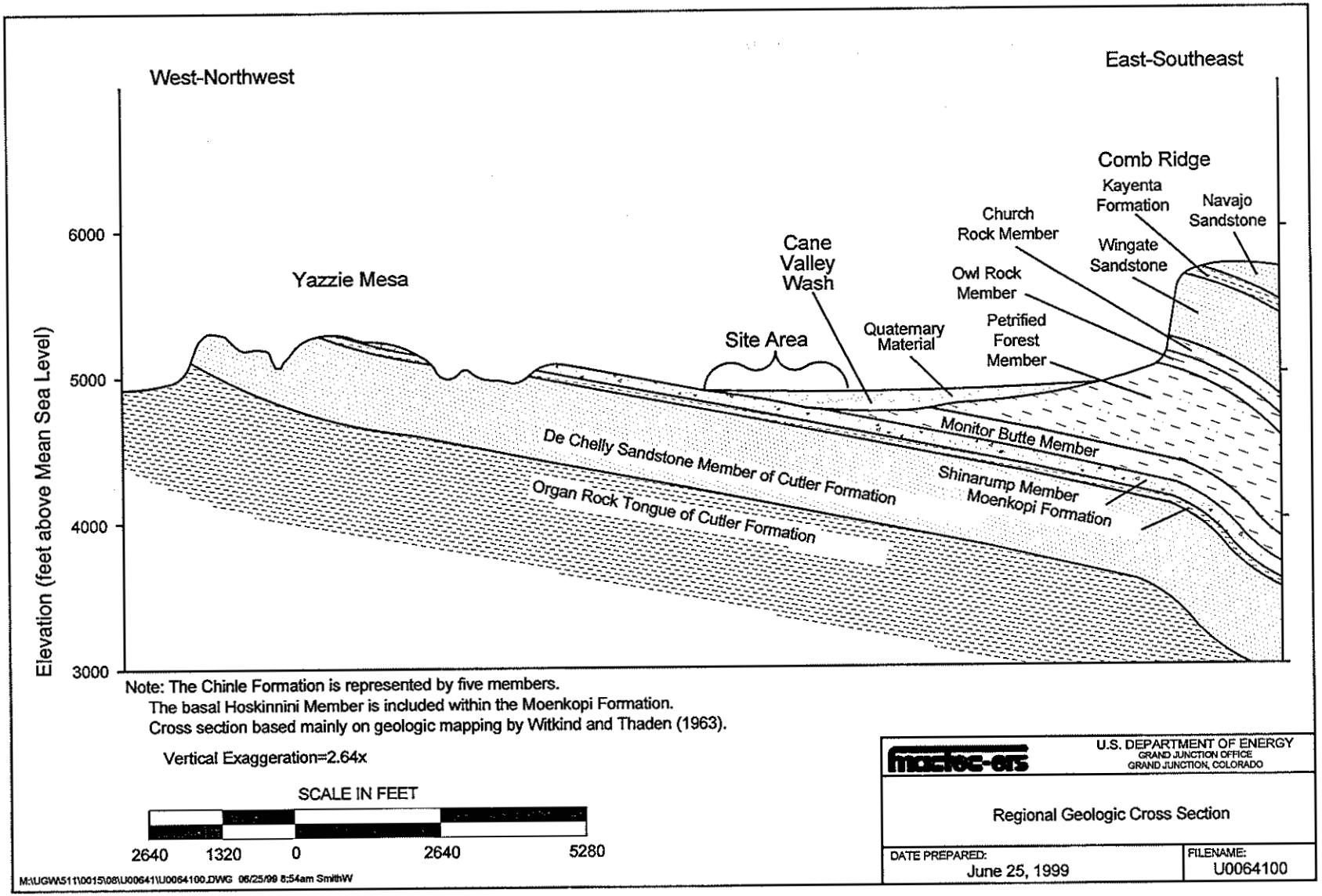

Figure 4. Regional Geologic Cross Section

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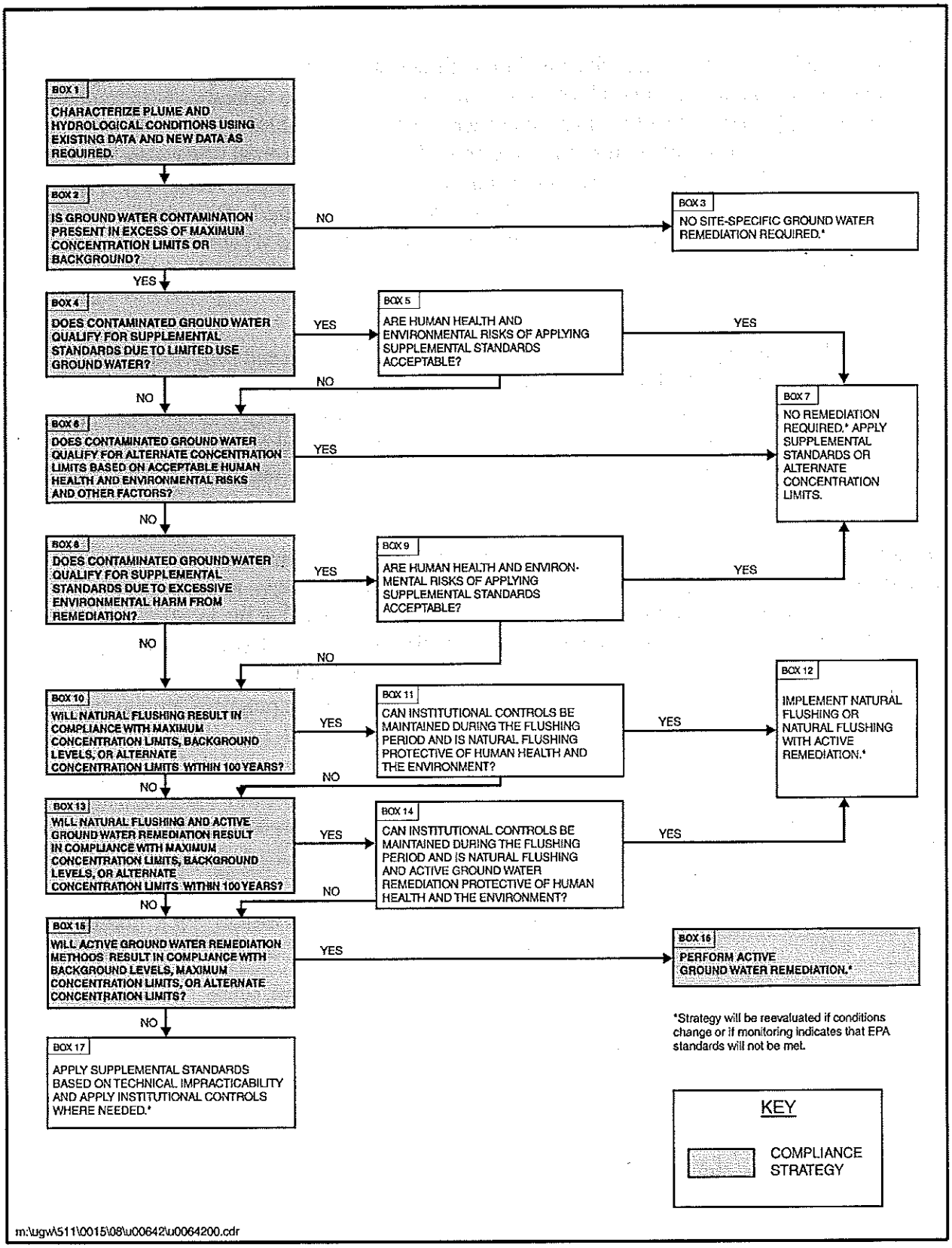

Figure 5. Compliance Selection Framework for the Monument Valley Site

3.1.1 Alluvial Aquifer

Constituents of concern in the alluvial aquifer are nitrate, sulfate, and uranium. Nitrate and uranium concentrations exceed UMTRA ground water standards. No federal or state standards exist for sulfate, but levels in alluvial ground water at the site exceed Navajo Nation remediation goals and may be high enough to result in adverse health effects if ground water were used as a long-term source of drinking water. Uranium concentration at one isolated location near the former source area slightly exceeds the UMTRA standard of 0.044 mg/L. Because the uranium source has been removed and the uranium concentration is near the UMTRA standard, natural flushing is expected to further reduce concentrations to levels below the standard within 100 years.

Because of the relatively high levels and broad distribution of nitrate and sulfate and the estimated ground water velocities, active remediation appears to be the only viable compliance strategy to reduce nitrate concentrations to the UMTRA standard (44 mg/L as NO_3) and sulfate concentrations to the Navajo Nation treatment goal (250 mg/L or background or a sulfate-to-chloride ratio of less than 10). Section 8.1.2.1 of the SOWP explains the rationale for the sulfate-to-chloride ratio.

The proposed compliance strategy for the alluvial aquifer is active remediation of nitrate and sulfate and natural flushing of uranium. Alternatives evaluated for active remediation are discussed in Section 3.2. Ground water monitoring will be conducted at the locations shown in Table 2 to evaluate the progress of the proposed remediation methods. No additional surface water monitoring is proposed because ground water monitoring will give sufficient notice if the contaminant plume will affect Cane Valley wash. Figure 6 shows the proposed monitoring locations.

Table 2. Proposed Sample Locations, Analyses, and Monitoring Frequency for the Alluvial Aquifer

Monitor Well	Monitoring Purpose	Analyte	Frequency
604, 662, 669, 764, 767, 768	lateral boundary of plume	nitrate, sulfate, chloride	annual
760, 761, and 762	leading edge of plume	nitrate, sulfate, chloride	annual
650	most downgradient location	nitrate, sulfate, chloride	annual
655, 656, 770, 771, 765, and 777	vertical contaminant profile	ammonium, nitrate, sulfate, chloride	annual
606, 772, 774	on and near the site	ammonium, nitrate, sulfate, and chloride plus uranium at location MON-774	annual
Group I: 200, 400, and 402	natural background	nitrate, sulfate, chloride	biennial[a]
Group II: 403, 602, and 640	natural background	nitrate, sulfate, chloride	biennial[a]

[a]Group I and II will be alternated with each annual sampling event.

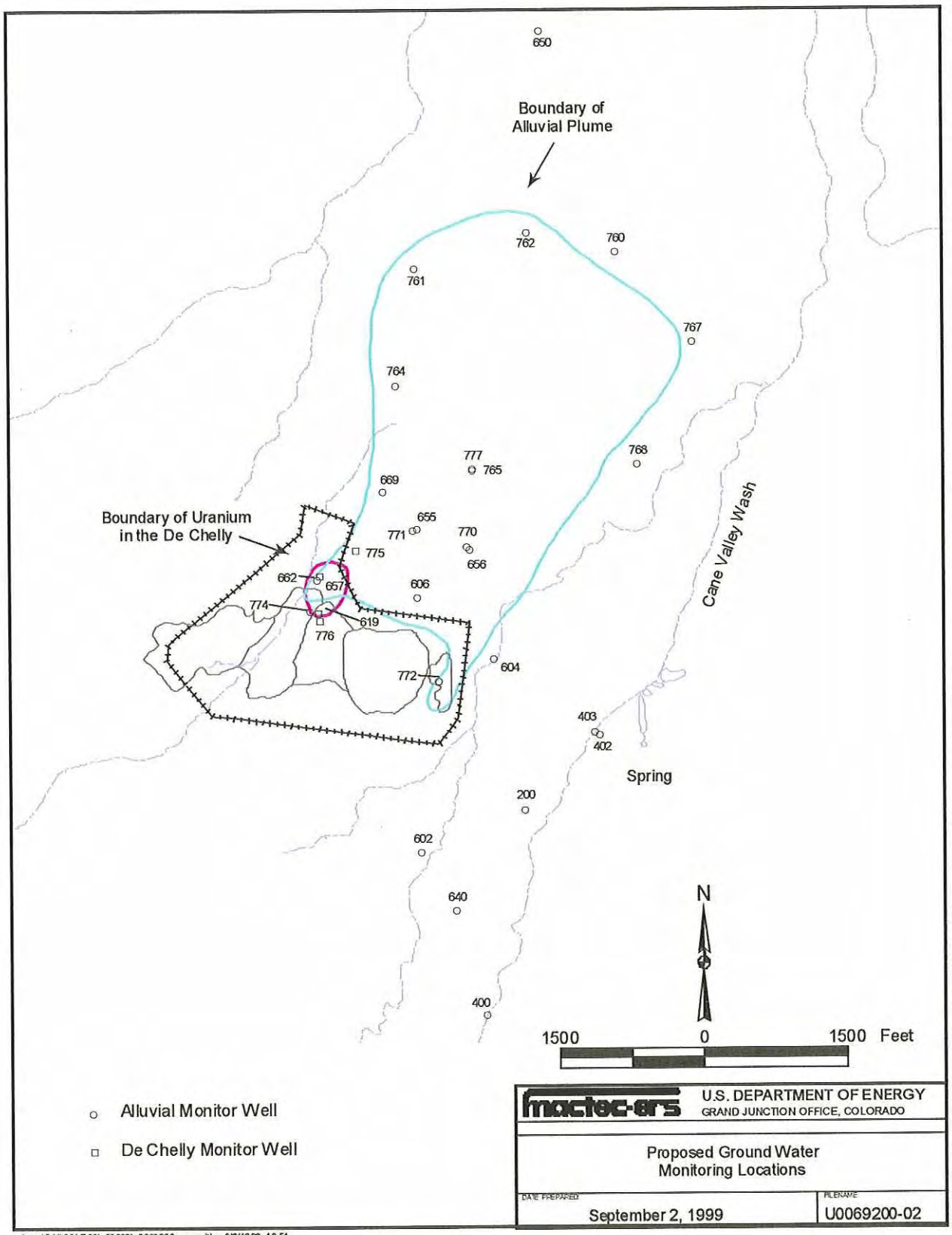

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Figure 6. Proposed Ground Water Monitoring Locations

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3.1.2 Shinarump Aquifer

Historical monitoring (SOWP, Section 5.3.3.2) indicates that milling-related constituents have not adversely affected the Shinarump aquifer. Constituent concentrations in the Shinarump do not exceed EPA ground water standards or Navajo Nation remediation goals. Therefore, no remediation is the proposed compliance strategy; no future monitoring of the Shinarump aquifer would be planned, and existing wells would be decommissioned.

3.1.3 De Chelly Aquifer

Uranium concentration slightly exceeds the UMTRA ground water standard of 0.044 mg/L. However, the affected area of the aquifer is small and isolated, and the carcinogenic risk associated with the use of ground water as drinking water is within EPA's acceptable risk range of 1×10^{-6} to 1×10^{-4}. Concentrations of magnesium and sulfate slightly exceed background but are at levels that are protective of human health and the environment and below EPA standards and Navajo Nation remediation goals. Because the source of uranium contamination was removed (pumping of former production well 619, used during uranium milling operations), natural flushing is expected to decrease uranium concentration to the UMTRA standard within 100 years.

The proposed compliance strategy for the De Chelly aquifer is therefore no remediation of magnesium and sulfate and natural flushing of uranium. Future ground water monitoring will include the wells listed in Table 3. Monitoring would verify that uranium concentrations decrease below the UMTRA standard.

Table 3. Proposed Sample Locations, Analyses, and Monitoring Frequency for the De Chelly Aquifer

Monitor Well	Monitoring Purpose	Analyte	Frequency
619	Location of point-source of uranium in the De Chelly aquifer	Uranium	Annual
776	Upgradient of point-source	Uranium	Annual
657	Leading edge of uranium >MCL	Uranium	Annual
775	Downgradient of leading edge	Uranium	Annual

3.2 Active Remediation Alternatives for the Alluvial Aquifer

3.2.1 Alternatives Considered

The SOWP for the Monument Valley site first evaluated individual technologies in each of three categories: ground water extraction, effluent discharge, and ground water treatment. Several

technologies were screened from further evaluation. The remainder were combined into separate pumping and treatment alternatives and retained for further evaluation. The two pumping alternatives were (1) plume-focused extractions wells without injection and (2) extraction and injection wells.

The four treatment alternatives were (1) plant farming with contaminated ground water, (2) chemical treatment with biological denitrification, (3) distillation, and (4) reverse osmosis. All four treatment options included phytoremediation (remediation using plants) as a component of the treatment system. These treatment alternatives were evaluated against 10 evaluation criteria for effectiveness, implementability, and cost and were compared with one another using these criteria. Section 8.4 of the SOWP presents a detailed discussion of this analysis.

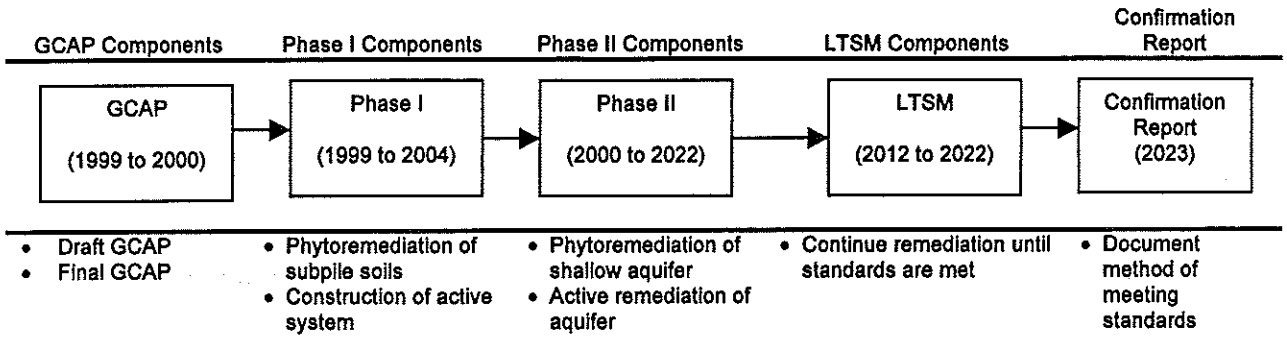
Each of the alternatives considered had advantages and drawbacks, although the chemical treatment with biological denitrification and the reverse osmosis alternatives were clearly inferior in some regards. Distillation was ranked first on the basis of 6 of the 10 criteria but was also the most expensive. Plant farming had several advantages, including lower cost, but also had many uncertainties associated with it. Based on consideration of all evaluation criteria, distillation augmented by phytoremediation was selected as the preferred active remediation alternative for the alluvial aquifer. Clean water that meets cleanup goals would be reinjected into the aquifer, and a concentrated brine would be collected on site in a solar evaporation pond; the sludge would be disposed of at the conclusion of remediation.

3.2.2 Proposed Active Remediation Alternative

DOE is proposing two active remediation methods to reduce concentrations of nitrate and sulfate in the alluvial aquifer. Distillation, which consists of the installation and operation of a distillation treatment unit, is the proposed remediation method for nitrate and sulfate in deeper portions of the aquifer. Phytoremediation is proposed in alluvial soils and shallow portions of the aquifer for ammonium and nitrates to remove potential continuing sources of ground water contamination and accelerate site cleanup. Phytoremediation tests have demonstrated that plants will take up ammonium, which is believed to be a contributor to higher nitrate levels in the alluvial aquifer. Figure 7 shows the schedule for active remediation tasks, and Figure 8 shows the proposed area of remediation. Figure 9 shows the planned locations of the phytoremediation area, well field, and distillation system.

3.2.2.1 Distillation

Of the alternatives considered in the SOWP, distillation would result in the least water lost from the aquifer during treatment, produce the least amount of waste, and produce the highest quality of treated water. Implementation of the alternative would involve (1) installing wells to extract contaminated ground water, (2) constructing a distillation facility to treat the recovered water, and (3) installing additional wells and an infiltration trench to inject the treated ground water back into the aquifer. The objective of the extraction and injection system would be to contain the spread of contaminants while removing contaminants from the ground water to achieve compliance with ground water standards.



Notes: 1. Time periods and components are estimates and may change due to funding constraints, technical considerations, or completion of the NEPA process.
2. LTSM components refer only to ground water remediation activities. LTSM at the site will continue for 200 to 1,000 years.
3. Phase I NEPA review was completed as part of the surface remediation.

Key: GCAP = ground water compliance action plan; LTSM = long-term surveillance & maintenance; LTSP = long-term surveillance plan; O&M = operation and maintenance

Figure 7. Conceptual Implementation Plan

Proposed Extraction System

The extraction system would consist of about 40 extraction wells, varying in depth to a maximum of about 90 ft, depending on the depth of the alluvial aquifer at the well location. The expected flow rate per well is 3 gallons per minute (gpm), which would give the extraction system a peak capacity of 120 gpm once all wells are in service.

A typical extraction well design for the Monument Valley site would consist of an approximately 10-inch diameter borehole with 6-inch diameter PVC pipe and wire-wrapped well screen. The final design of the well and the size of the pump would be based on field conditions.

The extraction wells would be installed at locations within the active remediation area (Figure 9), which encompasses about 180 acres. Installation of the 40 wells would disturb less than 5 acres of surface soil and vegetation. Water from each extraction well would be pumped into a piping system that would discharge into a feed pond.

Proposed Distillation Treatment System

Water from the extraction system would be collected in a feed tank, which would be equipped with a level control system with full instrumentation and controls. Contaminated water would be pumped from the feed tank directly to the distillation system, which would consist of one self-contained unit with a treatment capacity between 100 and 120 gpm. The unit would be instrumented to permit continuous operation with remote monitoring capability.

The concentrated brine from the distillation unit, which is expected to average less than 5 percent of the total feed (DOE 1999a), would be pumped to a solar evaporation pond (Figure 9) for final concentration. The pond would be sized to hold all the sludge produced during the life of the remediation project. The dry sludge from this pond would be removed at the end of the project, which is estimated to be completed by the year 2020.

The treated water from the distillation system, expected to average 95 percent or more of the total feed (DOE 1999a), would be pumped to a holding tank having a capacity of about 10,000 gal. The tank will provide holding capacity so that the injection system can continue to operate during minor upsets in the distillation system. Figure 10 illustrates the distillation process.

The distillation system and pond would be installed in the area shown on Figure 9. Installation of the system would result in surface disturbance of less than 10 acres. Another 2 to 5 acres would be disturbed during installation of the injection wells and trenches used to return treated water to the aquifer. In all, implementing the active remediation phase would result in a surface disturbance of less than 15 acres.

Wildlife Management Plan

Water in the evaporation pond would be of poor quality. Because surface water is scarce in the area, the evaporation pond might attract waterfowl and other migratory species. Protective measures to be used for species that inhabit the area (including temporary inhabitants) would be described in detail in a wildlife management plan, which would be developed following completion of the NEPA process. The plan would include a field survey and monitoring. DOE would consult with the Navajo Nation's Natural Heritage Program, Fish and Wildlife Department, and state and federal agencies to determine the best methods for protecting sensitive species.[3] Options may include the use of fencing, nets, silhouettes, reflectors, or combinations of these and other methods.

Limitations of the Distillation Alternative

Although ground water extraction and ex situ treatment, also known as pump and treat, was found to be the best method to meet cleanup goals in the aquifer, the effectiveness of pump-and-treat systems has been limited. Few sites with contaminated ground water have been restored to drinking water standards; however, the vast majority of sites where pump and treat is now being used are treating organic contaminants, which differ from the inorganic constituents associated with the Monument Valley site. The main factors that influence the effectiveness of ground water extraction systems are hydraulic inefficiencies, heterogeneity of the aquifer, and contaminants sorbing (adhering) to the aquifer material. Hydraulic inefficiencies account for the diffusion of contaminants into low-permeability sediments and hydrodynamic isolation (stagnation points) within a well field. Heterogeneities of the aquifer (e.g., changes in the hydraulic conductivity and effective porosity) affect the ability to extract ground water from all areas of the aquifer. Sorption of contaminants to the aquifer material retards the movement of the

[3] Sensitive species are those that are protected by federal or Navajo Nation laws and regulations.

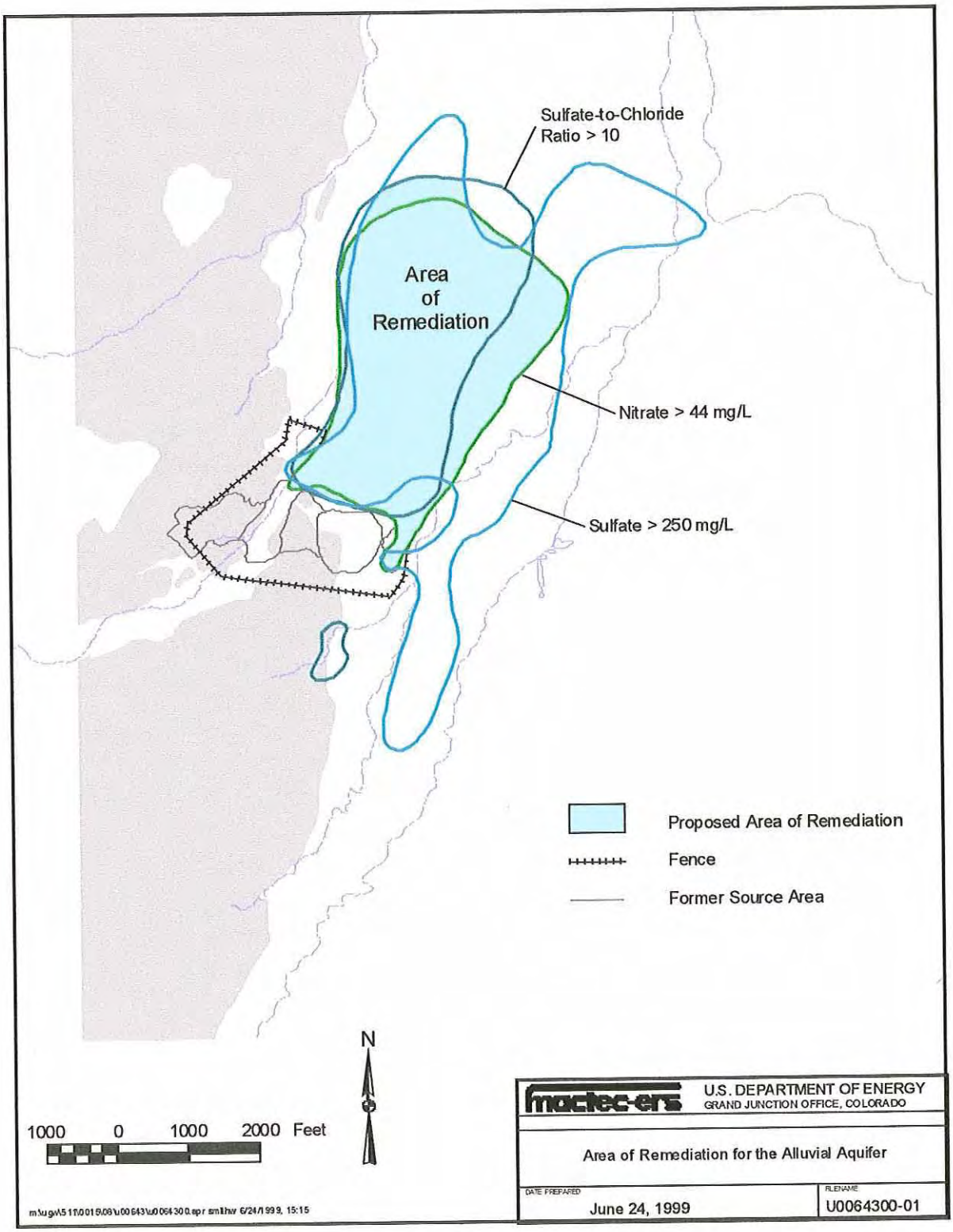


Figure 8. Proposed Area of Remediation

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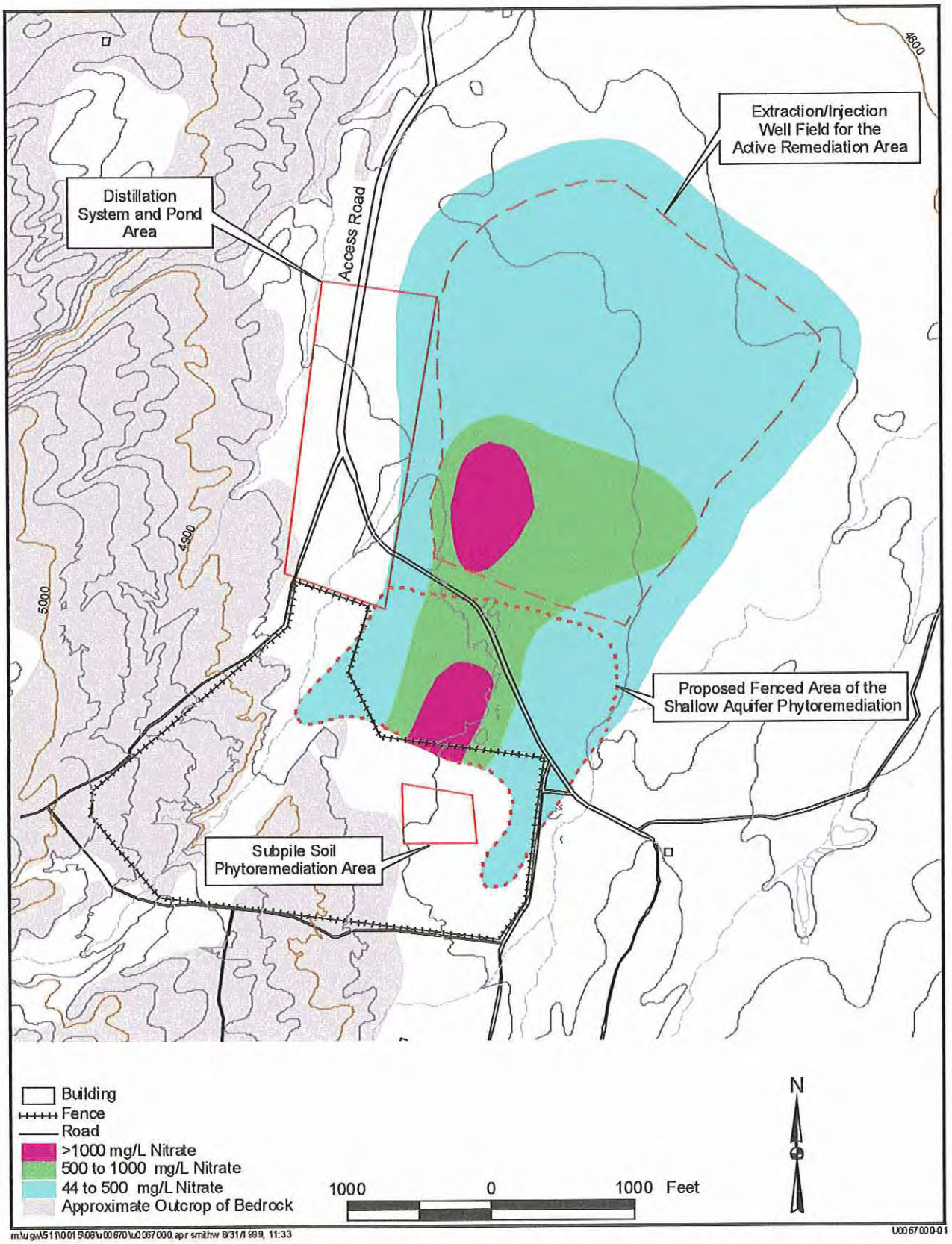

Figure 9. Planned Locations of the Phytoremediation Area, Well Field, and Distillation System

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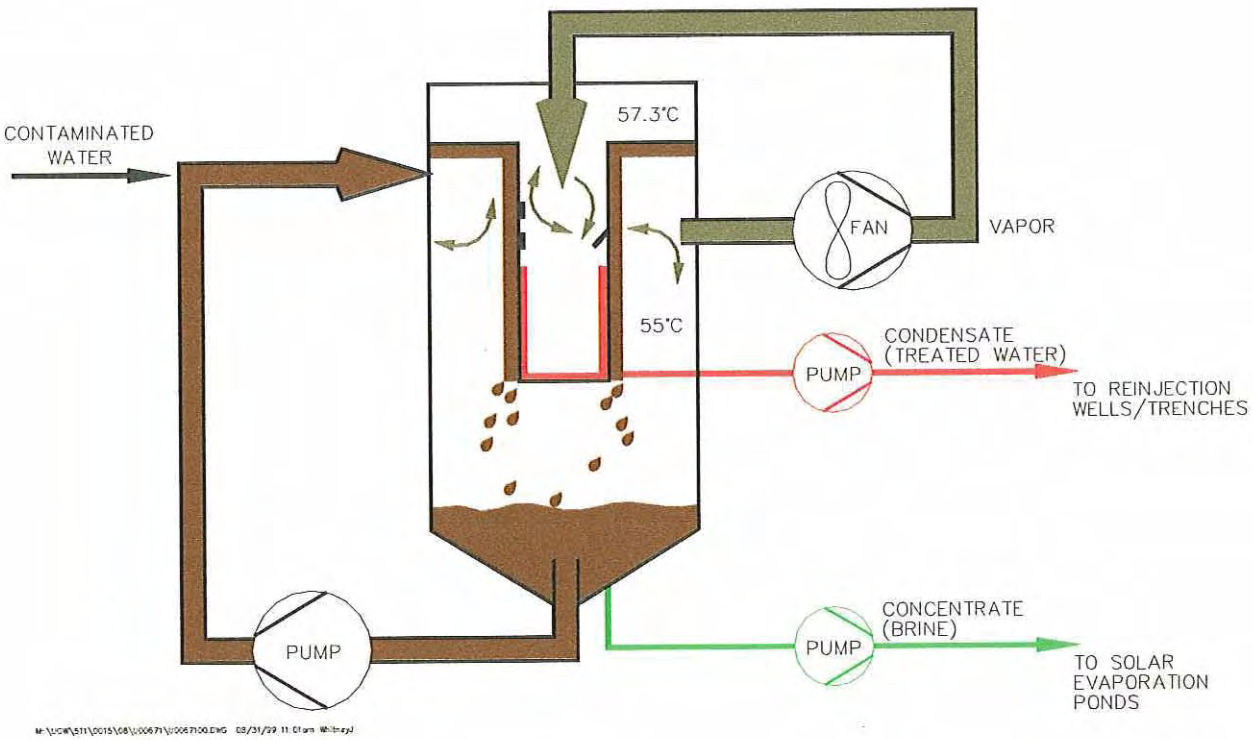

Figure 10. Distillation Process Flow Diagram

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contaminants in the ground water. The more a contaminant sorbs to the aquifer matrix, the more ground water must be extracted to remove the contaminant.

If active remediation cannot achieve the cleanup levels, other methods of protecting human health may be pursued. A provision in 40 CFR 192 allows the use of alternate concentration limits that would be set at higher concentrations than the current cleanup goals but would still be protective of human health. The use of alternate concentration limits may require institutional controls in areas of the plume that could not be remediated to the cleanup levels. Using alternate concentration limits and institutional controls would only be considered if active remediation could no longer effectively reduce contaminant levels in the aquifer.

3.2.2.2 Phytoremediation

The Monument Valley Ground Water Remediation Work Plan: Native Plant Farming and Phytoremediation Pilot Study (Plant Study) (DOE 1998) was completed to determine the feasibility of using phytoremediation (plants that remove contaminants) to remediate shallow subpile soils and ground water at the site. The study determined that phytoremediation is a viable method of augmenting active remediation and is consistent with revegetation plans for the site. Plant farming was considered as a separate active remediation treatment method but was eliminated during alternatives evaluation. Section 2.3 of the Plant Study and Section 4.7 of the SOWP describe the vegetation types, species, and plant associations that exist at the site.

Phytoremediation would use phreatophytes to remove nitrate from the alluvial aquifer and ammonium from subpile soils. Phreatophytes are plants that extract water and nutrients from a permanent ground water supply. Two native phreatophyte populations grow over the plume area: black greasewood (*Sarcobatus vermiculatus*) and fourwing saltbush (*Atriplex canescens*). Greasewood is a phreatophyte that requires a permanent ground water supply and can reach water as deep as 59 ft below the land surface (Nichols 1993). Saltbush is a shrub that takes advantage of ground water when present but can tolerate periods of low water availability. The rooting depth of saltbush may exceed 26 ft (Foxx et al. 1984). Both populations are currently in poor condition from heavy grazing and possibly from herbicide applications.

The success of phytoremediation would be dependent on (1) protecting both populations growing in the plume from grazing and (2) accelerating recovery and expansion of these populations by planting in the plume area. Section 3.2 of the Plant Study (DOE 1998) describes the rationale for using phytoremediation as an active remediation method. The University of Arizona is also conducting an independent (not funded by DOE) greenhouse study that will provide data to maximize the success of phytoremediation. The tasks necessary to implement this remediation method are detailed in the Plant Study.

The phytoremediation area would encompass about 50 acres. An area northeast of the existing fence (Figure 9) would be fenced for a 2- to 3-year period to allow the plants to become established. After removing the fence, DOE would work with the Navajo Nation to determine what level of livestock grazing is permissible.

Limitations of Phytoremediation

Because the greasewood and saltbush populations overlying the nitrate plume have been decimated by heavy grazing and the use of herbicides, these populations may have to be rehabilitated with a combination of transplanting and grazing exclosures if they are to be useful for nitrate remediation. The feasibility of the phytoremediation alternative may be dependent on rapid establishment and growth of greasewood and saltbush transplants in the areas overlying the plume.

3.2.3 Natural Flushing

Because uranium concentration only slightly exceeds the UMTRA standard of 0.044 mg/L at one location, natural flushing is proposed as the compliance strategy for this contaminant. Natural flushing would allow residual uranium to disperse over time.

Upon completion of this EA, a final Ground Water Compliance (remedial) Action Plan will be developed to implement the proposed action in compliance with EPA regulations. EPA regulations require concurrence of the plan by the U.S. Nuclear Regulatory Commission before implementation of remedial action.

3.3 No Action Alternative

DOE requires that an environmental assessment evaluate the no action alternative to provide a baseline for comparing the effects of the proposed action (10 CFR 1021.321[c]). Under the no action alternative at the Monument Valley site, no further site activities would be performed, including well monitoring and implementation the proposed compliance strategies. DOE would take no action to bring contaminant concentrations in the alluvial aquifer into compliance with EPA ground water standards and Navajo Nation remediation goals.

4.0 Affected Environment and Environmental Consequences

The Shinarump aquifer does not appear to be adversely affected by past milling activities, and natural flushing of the De Chelly aquifer would not result in any surface-disturbing activities. Therefore, this section describes the environmental issues and resources that are associated with only the alluvial aquifer at the Monument Valley site and the effects that the proposed action and no action alternatives may have on them. DOE has determined that some environmental resources are not present at the site, or if present, would not be affected by the alternatives. These resources include wetlands, floodplains, and recreational resources. Therefore, these are not discussed further. Sections 4.2 through 4.16 discuss the resources or issues that may be affected by the alternatives.

4.1 Waste Management

During implementation of the proposed action alternative, two main types of waste would be generated: (1) secondary wastes generated from the drilling, developing, and monitoring of extraction and injection wells, and (2) process wastes generated from the treatment of contaminated ground water. Table 4 presents a summary of the wastes anticipated during ground water remediation at the Monument Valley site, the estimated volumes, and the approach for their management and disposal.

Secondary wastes would consist of both liquid and solid media. Liquid secondary wastes would include well development water, water from the decontamination of equipment and personal protective equipment, well purge water, and small amounts of liquid wastes associated with disposable field test kits. Solid secondary wastes would include drill cuttings, personal protective equipment, and wastes associated with disposable field test kits. Process wastes would include the concentrated brine sludge.

Secondary waste that could not be disposed of on site would be hauled to a licensed landfill or to a facility authorized to accept residual radioactive material (e.g., a privately owned uranium mill tailings disposal site [Title II site] or the Grand Junction disposal site in Grand Junction, Colorado), depending on the types and concentrations of contaminants in the waste. In accordance with a Memorandum of Understanding between DOE and the Mesa County Commissioners, approvals by the State of Colorado and Mesa County Commissioners would be obtained before initiating off-site shipments to the Grand Junction disposal site. Likewise, appropriate approvals would be obtained before shipping wastes to one of the privately owned disposal sites (e.g., UMETCO's disposal site in Uravan, Colorado).

DOE's general approach to managing wastes at UMTRA sites and a summary of the regulations potentially applicable to the management and disposal of wastes are described in the *Management Plan for Field-Generated Investigation Derived Wastes* (DOE 1997). Although this plan specifically addresses investigation-derived wastes, the policy and criteria discussed in the plan are applicable to the management of secondary wastes.

The Navajo Nation Water Quality Codes state that no entity shall be entitled to take any action affecting the use of water within the Navajo Nation, unless such action is authorized by a permit. DOE would apply for well and water-use permits through the Navajo Nation Department of Water Resources. Once approved, the requirements of these permits would guide DOE's management of wastes and treated ground water.

Table 4. Summary of Wastes, Volumes, and Disposal Methods

Type of Investigation-Derived Waste	Estimated Maximum Volume	Disposal Option
Drill cuttings	Seven 55-gallon drums per well x 80 wells = 560 drums	During drilling into subpile soils (i.e. soils within the "footprint" of the former tailings piles), drill cuttings will be scanned for gamma activity to ensure they do not exceed the surface remediation criterion for radioactivity. If below the criterion, the cuttings will be dispersed on the ground. If above the criterion, cuttings will be buried a minimum of 1 ft below the ground surface. Cuttings from non-subpile soils will be dispersed on the ground.
Well development water	16,000 gallons (200 gallons per well x 80 wells)	Before the treatment system is in place, on-site surface dispersion is allowable. After treatment system is in place, all liquid waste will be treated and discharged into injection wells.
Equipment rinse water	850 gallons (10 gallons per well for equipment x 80 wells; and 50 gallons for drill rig after drilling)	Before treatment system is in place, on-site surface dispersion is allowable. After treatment system is in place, all liquid waste will be treated and discharged into injection wells.
Monitor well purge water	8,000 gallons (100 gallons per well x 80 wells)	Before treatment system is in place, on-site surface dispersion is allowable (DOE 1997). After treatment system is in place, all liquid waste will be treated and discharged into injection wells.
Brine sludge (dry solids)	8,480 tons (424 tons/year x 20 years)	Municipal Landfill; or if contaminated with radioactivity, ship to the Grand Junction disposal site or a privately owned disposal site.
Field test kit wastes	16 gallons of absorbed liquids (5 gallons per 25 wells x 80 wells)	Based on 40 CFR 261.5, liquid waste will be absorbed, and wastes will be disposed of at a municipal landfill or in a repository.
	1.6 drums of solids (0.5 drums per 25 wells x 80 wells)	
Personal protective equipment (PPE)	Well drilling and development: 8 drums non-contaminated PPE (1 drum per 10 wells x 80 wells)	Decontaminate as necessary and dispose of as general refuse in a municipal landfill
	Initial well sampling: 8 drums noncontaminated PPE (1 drum per 10 wells x 80 wells)	Decontaminate as necessary and dispose of as general refuse in a municipal landfill
	Contaminated PPE and miscellaneous wastes: 4 drums (1 drum per 25 wells x 80 wells)	Dispose of at the Grand Junction disposal site or a privately owned disposal site

As approved by the Navajo Nation through the water use and discharge permits, and to the extent allowable under the screening procedures identified in DOE's programmatic plan for managing wastes (DOE 1997), the following wastes would be disposed of on site around the well itself or beneath the surface of the ground: well development water, well purge water, equipment decontamination water, and drill cuttings. Empty containers and personal protective equipment would be rinsed with clean water or brushed clean and scanned for radioactive contamination. Decontaminated material would be disposed of as solid waste at a State-authorized municipal landfill. In the unlikely event that containers or personal protective equipment could not be decontaminated, they would be managed as residual radioactive material and disposed of at a facility authorized to accept such material.

The treatment system is anticipated to treat as much as 540 million gallons of ground water over the life of the project. Based on the extraction of two pore volumes[4] of ground water, brine effluent resulting from the treatment process is expected to be less than 5 percent of that volume, or 54 million gallons. This effluent would be discharged to a solar evaporation pond and evaporated. The pond would be designed to hold the entire volume of sludge generated throughout the project. The estimated mass of solids produced by distillation and evaporation is 424 tons per year, or 8,480 tons over the life of the project, a period of about 20 years. This process waste (brine sludge) would be disposed of at a facility authorized to accept residual radioactive material.

4.2 Geology and Soils

The Monument Valley site is in Cane Valley, which is in the eastern part of the larger feature known as Monument Valley that straddles the Monument Upwarp in northeastern Arizona and southeastern Utah. Cane Valley, drained by the north-flowing Cane Valley Wash, is floored by unconsolidated material of Quaternary age that consists of dune sand, alluvial material (sand and gravel), and fine-grained sediments that are probably lakebed deposits (clay or sandy clay). Thickness of the Quaternary material ranges from 0 to about 120 ft. Active and partly stabilized sand dunes up to 15 ft (5 m) high cover much of the valley immediately north-northeast of the site. Several canyons have been incised through the sandstone, exposing older reddish siltstones and sandstones of Triassic and Permian age.

Cane Valley is at an elevation of about 4,800 ft (1,500 m) in the area of the site. To the east, Comb Ridge rises abruptly to an elevation of about 5,600 ft (1,700 m). The slopes that gradually rise to the west to elevations of about 5,400 ft (1,650 m) are, from north to south, Yazzie Mesa, Main Ridge, and South Ridge (Figure 2).

[4] One pore volume is the volume of ground water within the contaminant plume. The term "pore" is used because water exists in the pores, or intergranular spaces, of the alluvial aquifer sediments.

4.2.1 Soils

4.2.1.1 Affected Environment

Most soils at the site are derived from Quaternary sediments and consist of reddish-brown coppice dune sands that are more than 80 percent fine sand. A thin white crust covers the Quaternary material in large areas along the floor of Cane Valley adjacent to Cane Valley Wash. This crust is composed of gypsum (hydrous calcium sulfate) or gypsite (an earthy variety of gypsum containing sand and silt) that form as an efflorescent deposit by evaporation of the shallow (within a few feet of the surface) ground water in this area and deposition (crystallization) of its dissolved salts.

Calcification (formation of hardpan composed mainly of calcium carbonate) has occurred in places just below the surface. This hardpan is exposed along the east bank of the main tributary to Cain Valley Wash about 500 ft north of well 654 (Plate 1). There, the hardpan is white, well indurated, and about 3 ft thick.

4.2.1.2 Environmental Consequences

Proposed Action Alternative

The soil's susceptibility to wind erosion would increase when vegetation is removed from the surface during construction of the distillation system. This increase in erosion potential could result in a loss of soil from the site. During construction, mitigation measures outlined in a storm water runoff plan would be implemented to minimize the amount of soil lost. These measures may include installation of silt fencing, mulch, anchored straw bales, or sediment basins. Plant roots in the phytoremediation area would stabilize soil. Soils would be expected to stabilize 2 to 3 years after construction and reclamation is completed.

No Action Alternative

Because no surface-disturbing activities would take place, the no action alternative would have no effect on soils.

4.2.2 Subpile Soils

4.2.2.1 Affected Environment

The Monument Valley site had several periods of uranium-ore processing. During these periods mill tailings, heap-leach residues, and various processing chemicals were stored in unlined ponds. Tailings and soils with ^{226}Ra concentrations exceeding 15 pCi/g were removed during the surface remediation. However, site-related inorganic constituents detected in relatively high concentrations in pore fluid samples collected from the former source areas suggest that some of these constituents may have leached into the subpile soils beneath the storage ponds and were undetected during the radiometric assessment for the tailings removal.

4.2.2.2 Environmental Consequences

Proposed Action Alternative

It is anticipated that active ground water remediation (phytoremediation) will reduce ammonia and nitrate concentrations in the subpile soils.

No Action Alternative

Ammonia concentrations in subpile soils would likely remain high and provide a continuing source of contamination to ground water.

4.3 Ground Water

4.3.1 Affected Environment

Three sources of ground water contamination were formerly present at the site: (1) the old tailings pile and heap-leach area, (2) the new tailings pile, and (3) the evaporation pond. The old tailings pile was composed of the sandy tailings that were a product of the mechanical upgrading of ore. The upgrading process used water containing minor amounts of flocculent but no other processing chemicals. Thus, tailings solutions in the old pile were water-equilibrated to minerals in the ore. Heap leaching of these old tailings occurred in the area where they were stored. Old tailings were placed on the heap-leach pad and sulfuric acid was added to the tailings. Heap-leach pads were lined to collect the leachate, which contained sulfuric acid. By contrast, the new tailings pile contained sand tailings and processing solutions. The processing solutions contained sulfate, nitrate, and ammonium from the processing chemicals. The evaporation pond was probably used to retain seepage from the new tailings pile.

There is a broad range in the depth to alluvial ground water across the site. The water table varies from 8 ft to 50 ft below ground surface; in the area of the nitrate plume, the water table is 30 to 40 ft below ground surface (DOE 1999a). Alluvial ground water generally flows north in the site vicinity; the aquifer material consists mainly of windblown fine- to medium-grained sand deposits. The gradient is higher in the southern end of the site than in the northern portion.

Recharge to the alluvial aquifer results from infiltration of precipitation and from upward leakage from the underlying aquifers. The area receives approximately 6.4 inches of precipitation annually; most of the precipitation results from isolated thunderstorms during late summer and early fall. An estimated 1.6 inches of the annual 6.4 inches is available for recharge and runoff. However, due to loss from evaporation and plant uptake, only a fraction of the annual precipitation actually enters the aquifer.

Extent of Contamination

The primary source of nitrate contamination in the alluvial aquifer appears to be related to process fluids draining from soils beneath the former location of the new tailings pile; leakage from the evaporation pond to the east and the former old tailings pile and heap-leach areas to the west contribute lesser amounts of contamination.

Approximately 540 million gallons of water are contaminated. Nitrate concentrations were used to represent the boundary of site-related contamination in the alluvial aquifer because nitrate occurs in relatively low concentrations in background ground water (Section 5.3.1.3 of the SOWP) and is highly mobile. Figure 11 shows the nitrate concentrations based on 1998 data. It is apparent from the 44 mg/L nitrate boundary that the leading edge of the plume has migrated approximately 4,500 ft (0.85 mile) north of the former millsite. The northerly direction of plume migration is consistent with the direction of the ground water flow in the alluvial aquifer. The estimated linear ground water flow velocity is 150 ft/year, assuming that nitrate contamination first entered the aquifer at the start of the 1967 milling operation (4,500 ft/30 years). Nitrate concentrations appear to have decreased since 1997 by more than 150 mg/L near the former source area at wells 606 and 792 and increased by more than 10 mg/L in downgradient wells 656, 771, 669, and 764.

Figure 11 shows the area of the nitrate plume starting at the former new tailings pile area and continuing approximately 6,600 ft north to well 650, the most downgradient monitor well. The highest nitrate concentration of 1,030 mg/L occurs in alluvial ground water at monitor well 606 located near the former new tailings pile area. Nitrate concentrations decrease to the 44 mg/L MCL approximately 4,500 ft north (downgradient) near monitor well 762. The A–A' cross section in Figure 12 shows a vertical profile of nitrate concentrations from south to north.

Downgradient lateral dispersion of the nitrate plume to the west of the site is limited by the Shinarump sandstone where the alluvial water intersects the Shinarump in subcrop as shown in Figure 13.

Along this western edge of the plume, for example at well 669, the nitrate concentrations are close to the 44 mg/L MCL. Dilution of the plume water by surface water re-entering the aquifer along the west margin of Cane Valley, where the eastward dipping Shinarump sandstone crops out, probably contributes to these relatively low concentrations.

The lateral downgradient extent of contamination in the alluvial aquifer to the east of the site is identified in cross-section B–B' (Figure 13), where nitrate concentrations were below the detection limit in water samples collected at wells 768 and 860. The fact that nitrate was not detected provides evidence that the plume does not extend under Cane Valley Wash. As shown in cross-section C–C' in Figure 14, a similar relationship exists near the downgradient leading edge of the plume, where nitrate concentrations were below the detection limit in ground water samples collected from eastern wells 760, 698, and 697.

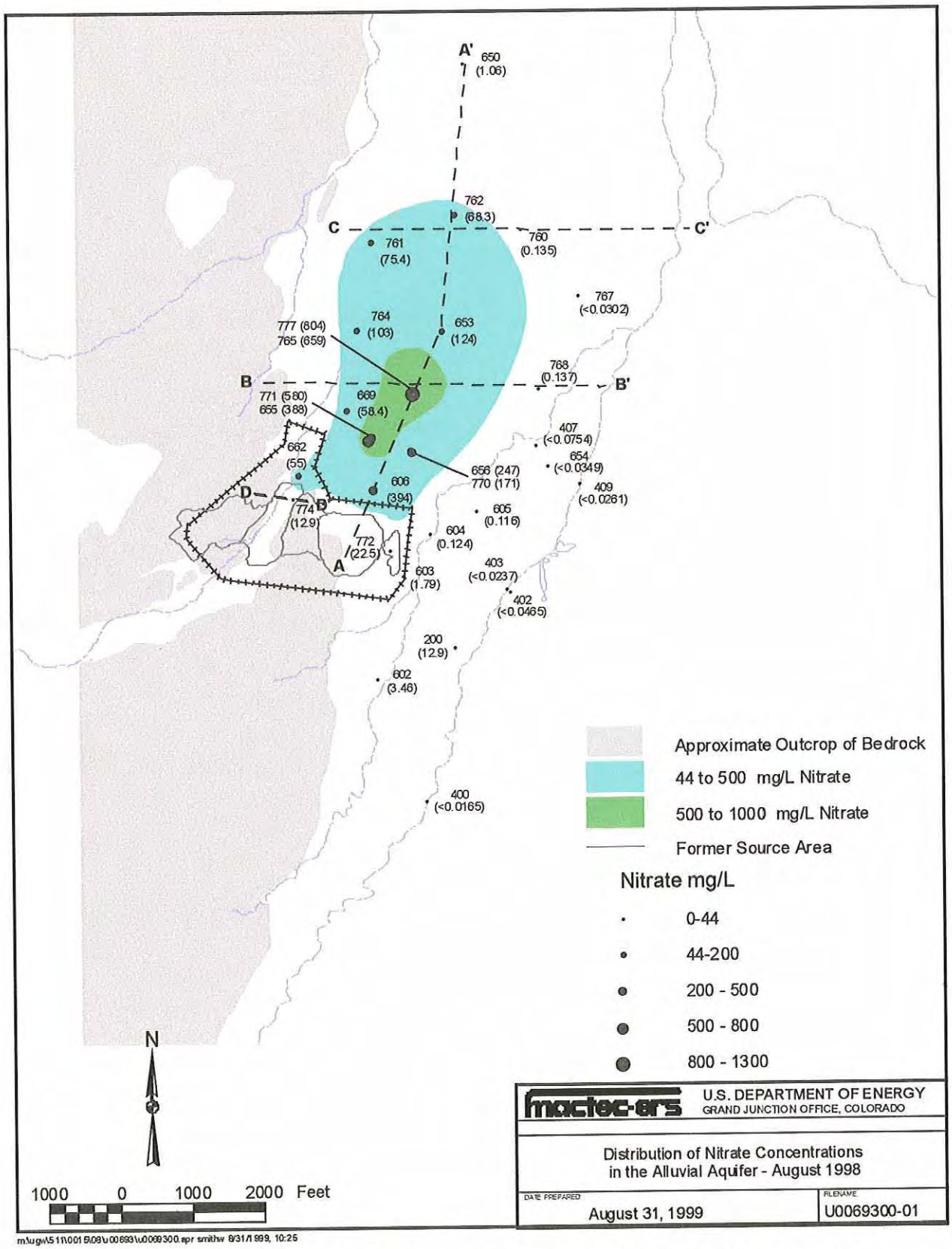

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Figure 11. August 1998 Distribution of Nitrate Concentrations in the Alluvial Aquifer

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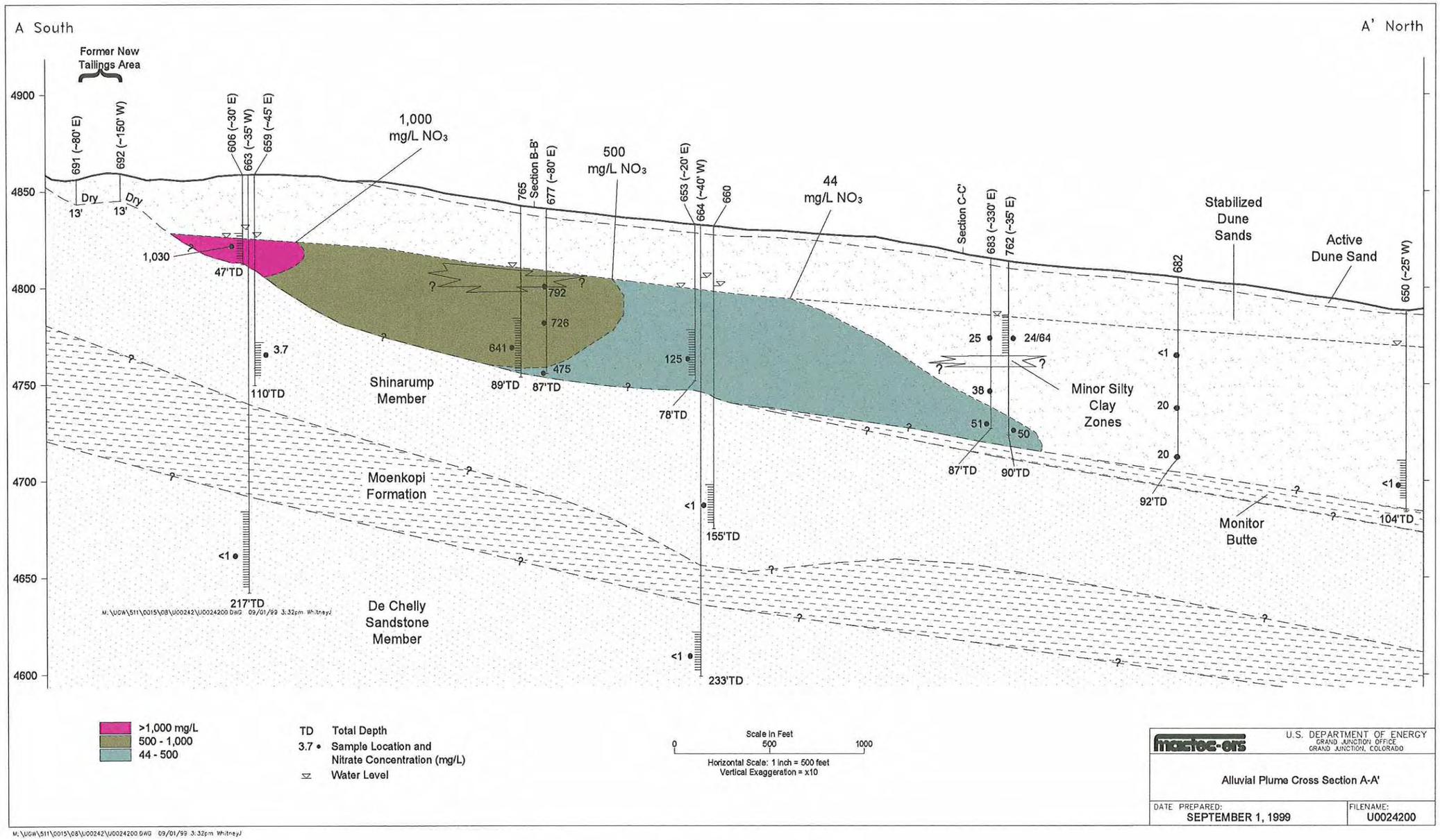

Figure 12. Alluvial Plume Cross Section A–A'

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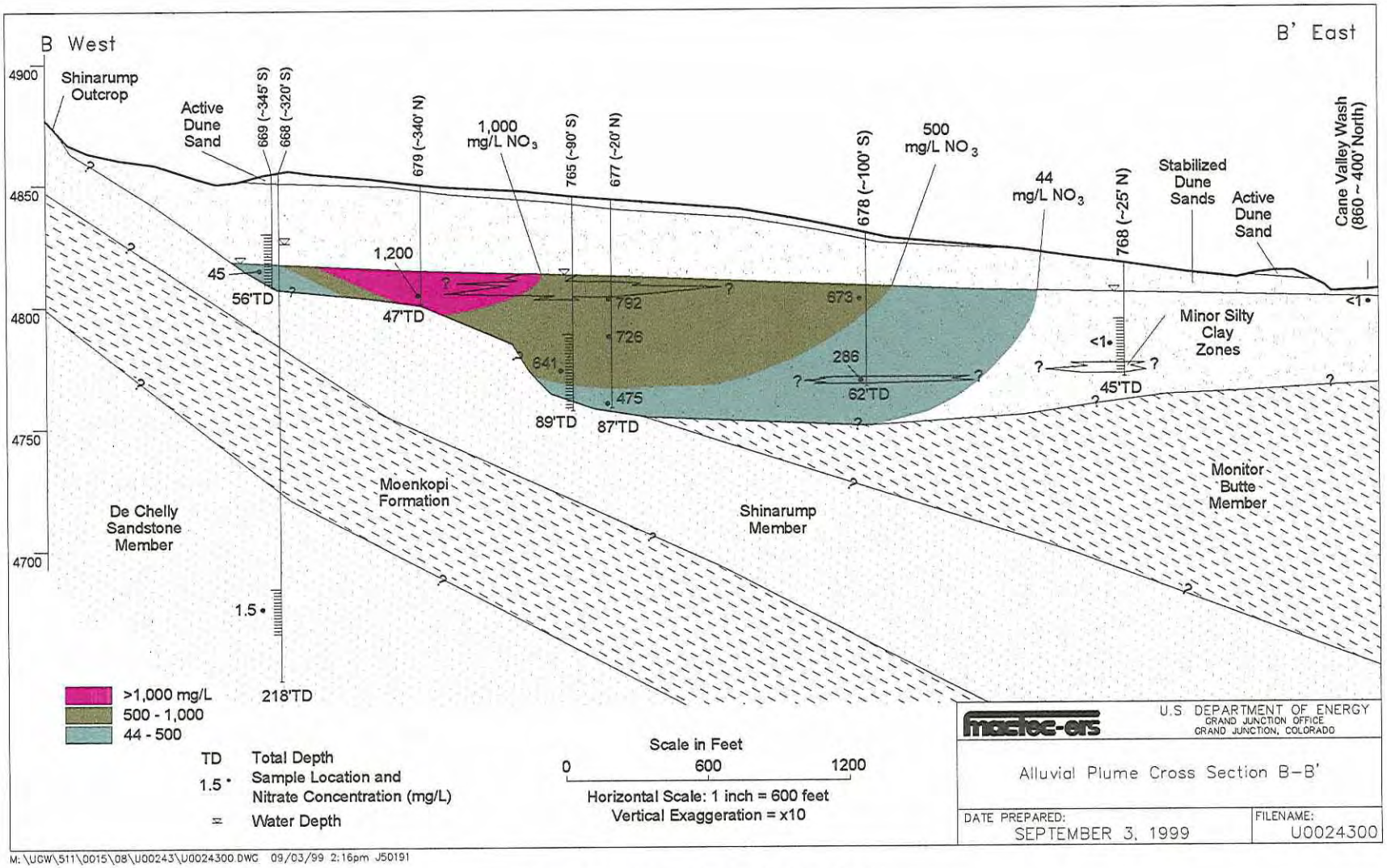

Figure 13. Alluvial Cross Section B–B'

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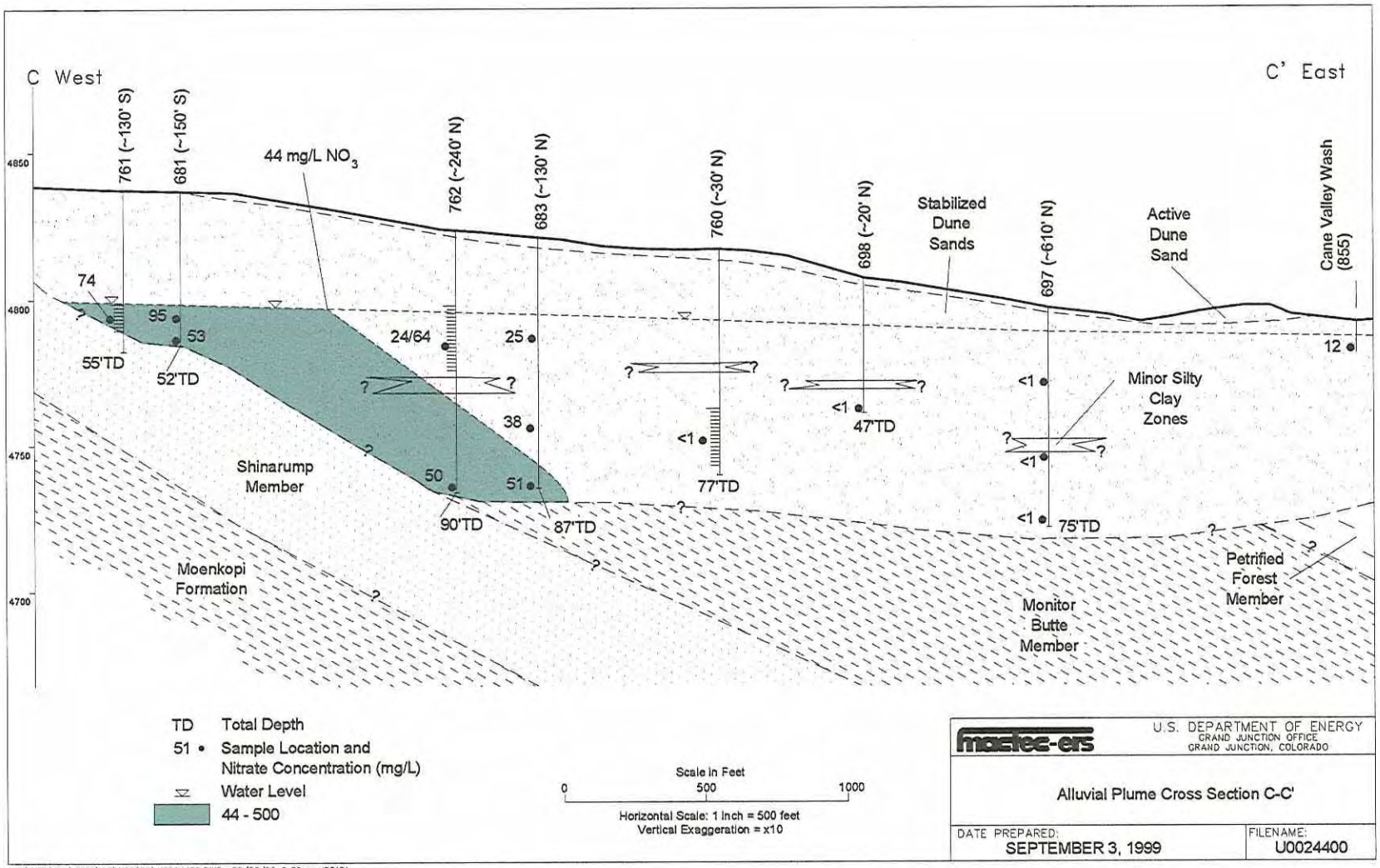

Figure 14. Alluvial Plume Cross Section C–C'

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Sulfate concentrations in the alluvial aquifer have a geochemical dispersion pattern similar to that of nitrate. The sulfate plume as defined by the August 1998 sampling results is shown in Figure 15. Changes in sulfate concentrations also show a trend similar to the trend of nitrate concentrations, with sulfate levels increasing downgradient and decreasing near the former source area.

Uranium also tends to be mobile in the alluvial ground water under the conditions at the site, as indicated by the downgradient concentrations shown in Figure 16.

Background Ground Water Quality

Background water quality in the alluvial aquifer near the former processing site is inferred from results of water samples collected from 1985 through 1997 at upgradient monitor wells 400, 402, 403, 404, 602, and 603 and at upgradient private wells 200, 616, 617, and 640 (Figure 17). Water quality results are summarized in Table 5–6 of the SOWP.

Background alluvial ground water has an average sulfate-to-chloride ratio of 4.9; total dissolved solids (TDS) concentrations average 627 mg/L and range from 294 to 1,590 mg/L. The highest TDS concentrations are associated with the sodium sulfate–type waters, reflecting local evapotranspiration effects. Nitrate concentration averages 6.4 mg/L, which is well below the 44 mg/L standard. On average, the water pH is above neutral (pH 8.0) and the redox condition is oxidizing.

Ground Water Use

Ground water is the sole source of domestic water in the Monument Valley area. Domestic wells upgradient of the site and several domestic wells downgradient of the site have not been affected by the contaminant plume.

4.3.2 Environmental Consequences

Proposed Action Alternative

Under the proposed action alternative, concentrations of contaminants in ground water beneath the Monument Valley site would be reduced. The treatment goals would be to restore the quality of the ground water to a condition such that contaminant levels would be below EPA ground water standards in 40 CFR 192 and would meet the water quality goal presented by the Navajo Nation for sulfate. Current estimates are that the system would require approximately 20 years of operation before ground water standards are met.

The proposed action alternative also would prevent the spread of contamination within the aquifer. The remediation method is designed to achieve containment of the contaminant plume through the creation of (1) a downgradient pressure ridge to prevent further expansion of the

plume, and (2) an upgradient pressure ridge to divert uncontaminated ground water around the plume.

An estimated 95 percent of the water pumped from the aquifer for treatment would be returned to the aquifer through the infiltration trench and injection well system. The remaining 5 percent, or approximately 166 acre-feet, would be discharged to evaporation ponds as brine water as a result of the treatment process. This reduction in ground water volume could lower the water table immediately south of the site during the short term; however, no domestic water supplies would be affected. Once ground water remediation is completed at the site, water tables would return to current levels.

No Action Alternative

Under the no action alternative, ground water quality would change as the contaminant plume expands within the aquifer. The mixing of plume water with adjacent uncontaminated water would result in a decrease in contaminant concentrations within the plume but would also result in an increase in the areal extent of the plume. Future use of ground water on and near the Monument Valley site could be affected by the presence of contaminants.

It is possible that domestic wells could be drilled in areas downgradient of the plume, and as the plume expands, water in certain wells could exceed MCLs.

4.4 Surface Water

4.4.1 Affected Environment

The Monument Valley site is located approximately 1,800 ft west of Cane Valley Wash and the frog ponds (Figure 18), which are the dominant natural surface water features in the area. Cane Valley Wash is an intermittent stream that drains to the southwest into the Little Colorado River.

Most of the surface flow along Cane Valley Wash and other small drainage channels in the vicinity of the site is ephemeral (duration of flow is less than one month) as a direct result of local precipitation. Natural scours created by ephemeral flow along Cane Valley Wash are common and many intersect the shallow ground water, forming small pools that may contain standing water for periods of several weeks or more (intermittent). In response to evaporation and transpiration, the pools get smaller and eventually go dry. These small intermittent pools have been observed just upstream of the frog ponds and downstream for several miles. In the areas where ground water reaches the surface, ponds that form are accessible by people and animals. However, these areas have not been affected by the contaminated ground water; therefore, complete exposure pathways to contaminated ground water discharging to the surface water and sediment do not exist. Figure 5-10 in the SOWP shows the regional watersheds that serve the Cane Valley Wash area.

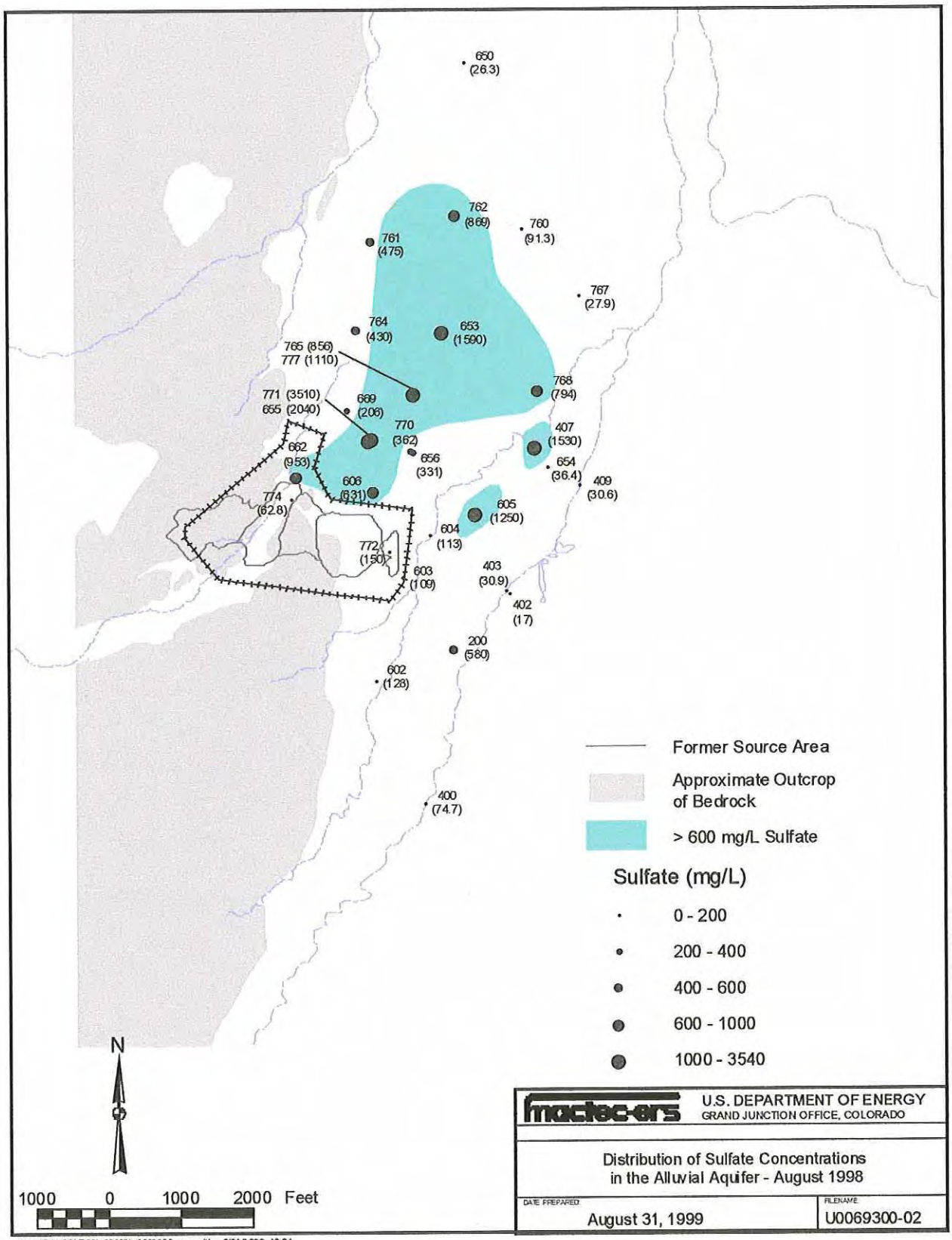

Figure 15. August 1998 Distribution of Sulfate Concentrations in the Alluvial Aquifer

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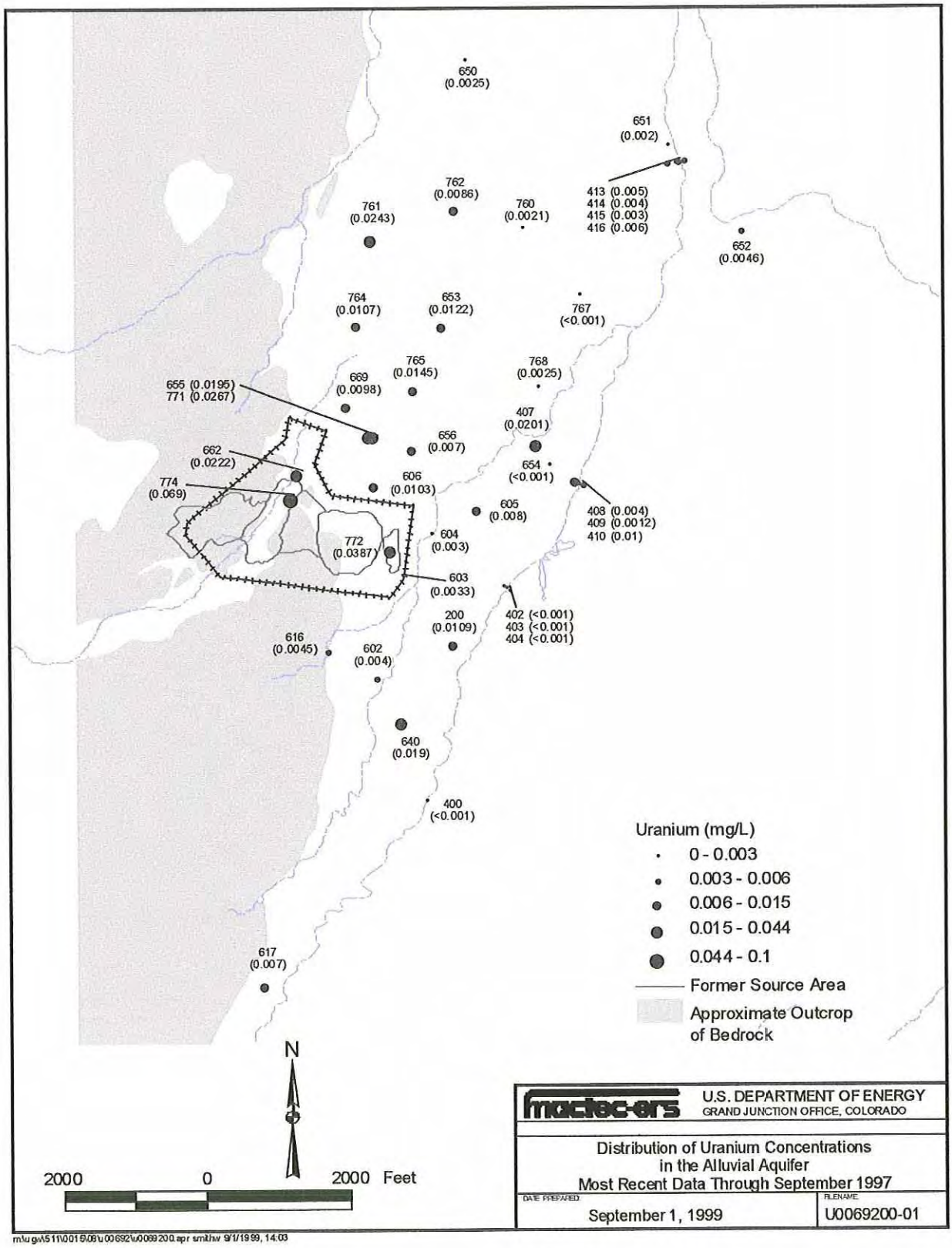

Figure 16. Distribution of Uranium Concentrations in the Alluvial Aquifer—Data through September 1997

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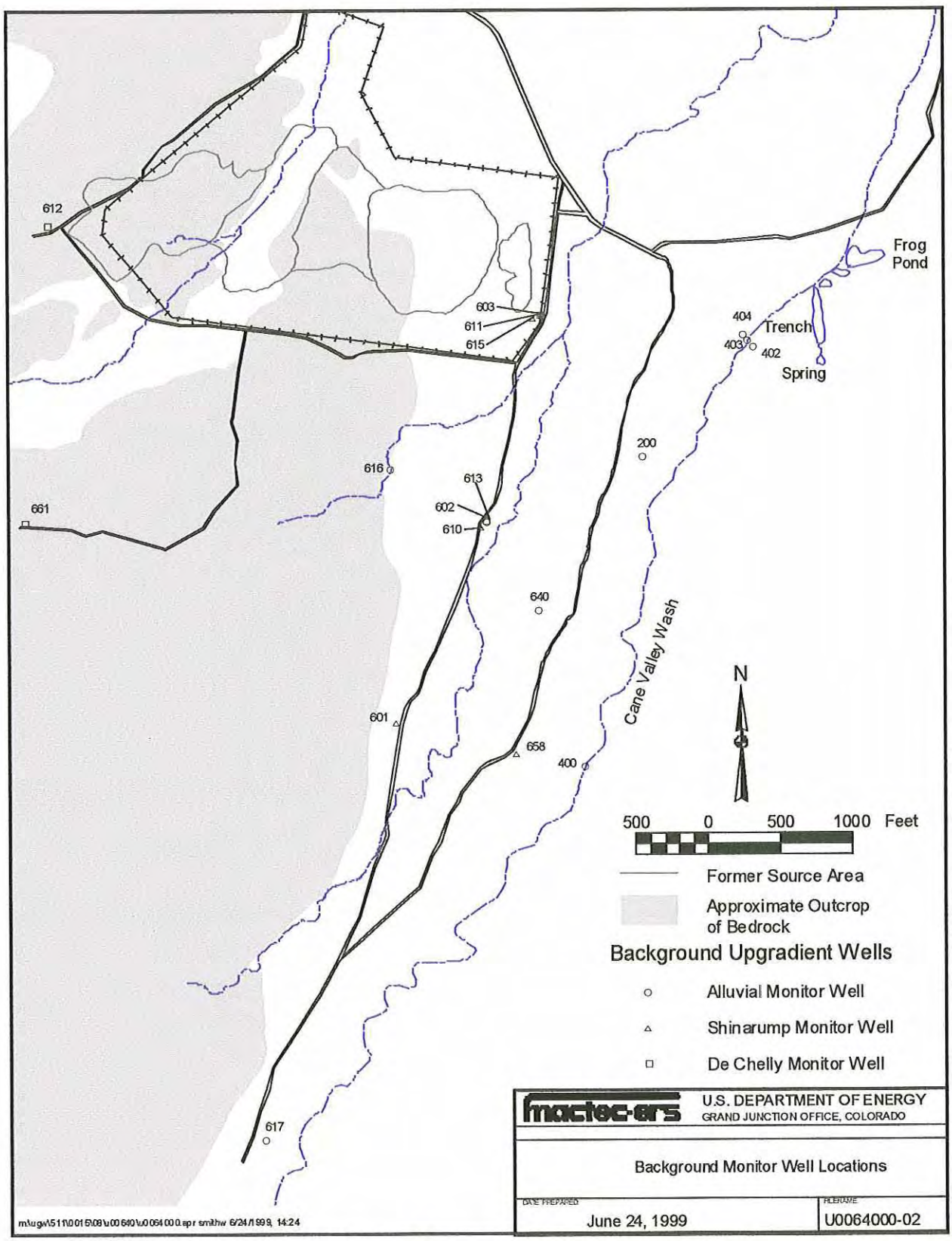

Figure 17. Background Monitor Well Locations

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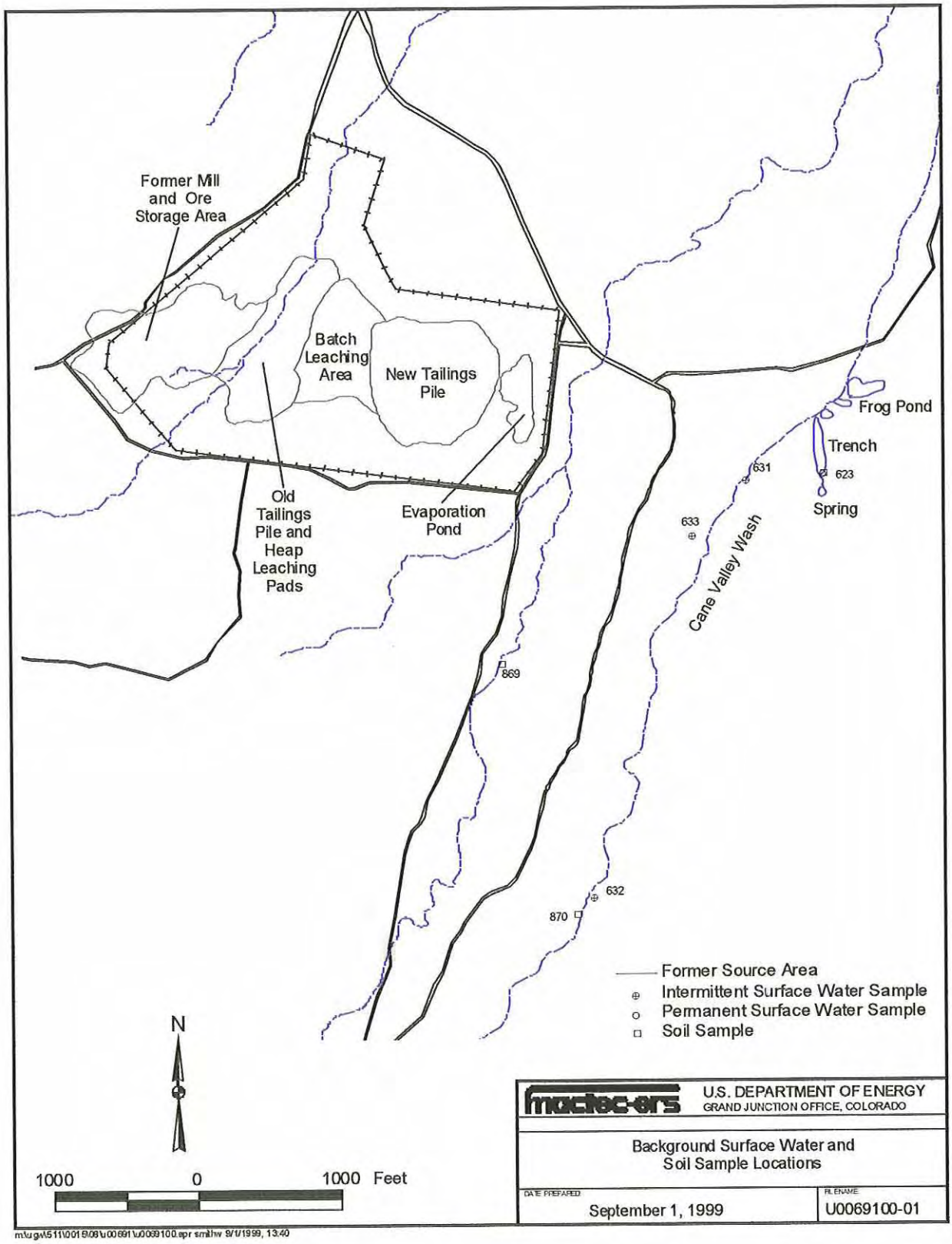

Figure 18. Background Surface Water and Soil Sample Locations

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The only permanent surface water present in the area occurs east of the former millsite in what is referred to as the Cane Valley Frog Ponds. The Frog Ponds consist of two man-made ponds constructed during the 1950s and 1960s when the mill was in operation (Hammack 1993b). Water was supplied by a concrete-lined cistern at the southern pond. The sides of the northern pond were lined with wooden planks braced by ore from the mines. The wooden planks, ore from in and around the northern pond, and evidence of the concrete cistern at the southern pond were removed during surface remediation in April 1994. The ponds are situated roughly in a north-south direction along the drainage axis of Cane Valley Wash. The southern pond is contained in a long, narrow, deep bulldozer cut in a large sand dune. The bulldozer cut intersects the alluvial ground water, which provides some recharge to both ponds throughout the year.

Surface Water Quality and Use

Geochemical similarities between the pond water and ground water from the De Chelly bedrock aquifer water suggest that the ponds may be receiving recharge through former uranium exploration boreholes that penetrated the artesian bedrock aquifer in the immediate area. The exploration boreholes were probably not properly abandoned, thereby allowing artesian flow from the De Chelly aquifer into the alluvium. Water quality analyses for surface water samples collected from 1995 through 1997 are summarized in Section 5.3.1.1 of the SOWP.

Surface water samples collected from intermittent pools along Cane Valley Wash contain naturally occurring high sulfate-to-chloride ratios. Cane Valley Wash and the Frog Ponds appear to be unaffected by site-related contaminants.

Surface water in Cane Valley Wash (when present) and the Frog Ponds is a potential source of water for livestock and wildlife, although the extent of use is unknown. There is no indication that surface water in the area is used for domestic consumption and irrigation.

4.4.2 Environmental Consequences

Proposed Action Alternative

Although there has been no indication that site-related contaminants are entering Cane Valley Wash or the Frog Ponds, the contaminant plume is migrating northeast to the west of Cane Valley Wash. However, even if contaminated ground water were detected in the wash, the proposed action would reduce concentrations in the long term.

The water table would not be noticeably affected as a result of extracting and treating contaminated ground water at the Monument Valley site because about 95 percent of the extracted water would be returned to the aquifer. Therefore, existing surface water uses in the region would not be affected.

No Action Alternative

Under the no action alternative, the contaminant plume would continue to migrate toward Cane Valley Wash, although it is unknown whether ground water discharging to the wash would affect surface water quality. No action would be taken to reduce contaminant concentrations in the aquifer.

4.5 Land Use

4.5.1 Affected Environment

The Monument Valley Site is located in a fairly remote area of the Navajo Reservation that is characterized as open range lands. Vegetation in the area is considered marginal for grazing sheep and cattle. Historically, livestock grazing has been the primary land use. Density of both permanent and temporary housing is sparse. Traditional Navajo homes tend to be located in areas away from towns. Small dryland farms, usually less than 5 acres, are located a mile or more from the site. Currently, contaminated ground water is not being used for irrigation or domestic purposes. The SOWP (Section 8.0) indicates that only one residence is within a mile of the site.

4.5.2 Environmental Consequences

Proposed Action Alternative

Under the proposed action alternative, fences would be placed around the phytoremediation area (about 50 acres) for 2 to 3 years to prevent damage to plants from livestock grazing. Although the distillation unit and evaporation pond would be inside a fenced area, additional measures may be necessary to exclude wildlife and grazing, as discussed in Section 4.8.2. About 5 acres of land would be disturbed in this area, and the disturbed land would be excluded from grazing for the duration of active remediation. Fencing would reduce the acreage of the current grazing allotment.

No Action Alternative

The no action alternative would have no effect on land use.

4.6 Human Health

4.6.1 Affected Environment

Contaminated ground water beneath the Monument Valley site does not currently pose a health risk to humans because it is not used as a drinking water source.

4.6.2 Environmental Consequences

Proposed Action Alternative

Under the proposed action alternative, human exposure to contaminated ground water would be controlled by the Navajo Water Code Administration (NWCA). DOE would encourage the NWCA to deny applications for well permits during the remediation period. The contaminant plume would be contained and limited to the immediate vicinity of the site. On-site activities required for operation and maintenance of the extraction and treatment system would verify that no drinking-water wells are drilled in the area of the plume. The goal of ground water remediation is to meet EPA standards so that eventual unrestricted use of the ground water would be possible.

The greatest health risks resulting from the proposed action alternative would likely be associated with construction and installation of the ground water treatment system and with the subsequent operation of the system. The use of standard safety precautions and construction practices would reduce these risks. Operating procedures would be developed for the treatment unit, and a job safety analysis would be performed for the tasks associated with operation and maintenance. One of the safety attributes of the treatment system is that, if a leak should develop, the leak would discharge toward the interior rather than toward the exterior of the system because the system operates under vacuum. The treatment unit would be equipped with alarms and other protective measures that would serve as indicators of abnormal conditions.

No Action Alternative

Potential risks to human health would be increased under the no action alternative. Because no formal administrative controls would exist to prevent use of contaminated ground water for drinking water, domestic wells could be installed in the area. The Baseline Risk Assessment (DOE 1996b) found that the most significant health hazard from ingestion of ground water at the Monument Valley site would be from nitrate. The primary concern would be for infants, because an infant's stomach absorbs nitrate differently than an adult's. At the concentrations detected in ground water at the Monument Valley site, nitrate could have a lethal effect by interfering with an infant's ability to transport oxygen through the blood.

4.7 Air Quality and Noise

4.7.1 Affected Environment

State of Arizona ambient air quality standards are the same as federal standards defined at 40 CFR 50. The closest air quality sampling station to the Monument Valley site is at Bullfrog Marina, Lake Powell, Utah, approximately 50 air miles to the north. Air quality in the area of the site is within state standards.

4.7.2 Environmental Consequences

Proposed Action Alternative

Construction of the distillation unit and evaporation pond and installation of the extraction and injection wells would disturb the area during the period of construction. Dust picked up and dispersed by traffic and wind could increase the concentration of suspended particulates in the surrounding air. Application of water sprays or other dust suppressants in active work areas would minimize the increase in suspended particulates. These mitigation measures should keep the suspended particulate concentrations within federal and state air quality standards. After vegetation is reestablished at the site through reseeding, dust levels are expected to return to background conditions.

Emissions from the treatment unit would consist of minimal amounts of water vapor and would not affect air quality at the Monument Valley site.

Under the proposed action alternative, noise levels would temporarily increase during well drilling and trenching operations and during excavation for the evaporation pond. Within 50 ft of operating equipment, noise levels would likely range between 75 and 95 decibels. Noise levels would decrease with distance and are expected to be the same as background levels at the nearest residence. On-site workers would be required to wear hearing protection when noise levels exceed the standard of 85 decibels. Noise levels during operation of the treatment unit are expected to be below 85 decibels.

No Action Alternative

Because no on-site activities would take place, the no action alternative would not affect air quality. Current background noise levels at the site would not be affected.

4.8 Wildlife

4.8.1 Affected Environment

Nocturnal rodents and black-tailed jackrabbits (*Lepus californicus*) are probably the principal mammals inhabiting the site. The lack of habitat diversity and natural water sources limits the number of birds likely to visit the site. During spring and fall migrations, a variety of transient bird species may visit the site, and a few species such as the mourning dove (*Zenaida macrousa*), northern mockingbird (*Mimus polyglottus*), horned lark (*Eremophila alpestris*), and the common poorwill (*Phalaenoptilus nutalli*) may nest at the site. The presence of amphibian species is probably minimal, although a few individuals may occur in temporary pools formed during summer rains. Species such as the tiger salamander (*Ambystoma mavortium*) and western spadefoot toad (*Scaphiopus hammondi*) likely reside in the area. The side-blotched lizard (*Uta stansburiana*) and western whiptail lizard (*Cnemidophorus tigris*) are the principal reptile species that inhabit the site.

Species of concern[5] identified by the Navajo Nation Fish and Wildlife Department (Navajo Nation, July 1999, Letter to R. Bleil, MACTEC-ERS) as potentially present in the vicinity of the site include the following: *Aquila chrysaitos* (golden eagle) is known to exist within one mile of the site; *Buteo regalis* (ferruginous hawk), *Cinclus mexicanus* (American dipper), *Empidonax traillii extimus* (southwest willow flycatcher), *Falco peregrinus* (peregrine falcon), *Mustella nigripes* (black-footed ferret), and *Rana pipiens* (northern leopard frog) may exist in the vicinity of the site.

Field observations conducted during 1999 indicate that these species were not present within the area of the proposed action.

4.8.2 Environmental Consequences

Proposed Action Alternative

Approximately 10 acres of habitat for small mammals and birds would be temporarily lost for approximately three years as a result of construction and installation of the water treatment unit and evaporation pond. An additional 5 acres of habitat outside the boundary fence would be temporarily disturbed from the installation of extraction and injection wells and underground pipelines. The noise and human activity associated with construction activities would also temporarily displace wildlife. In most cases, the species would likely return to the disturbed areas once construction was completed and the areas were revegetated. Over the long term, population abundance, distribution, and density of wildlife species would not be noticeably affected.

Because so few surface water sources exist in the Monument Valley area, the evaporation pond at the site might attract waterfowl, other migratory birds, and birds that may be attracted by the presence of waterfowl. Water quality within the ponds is expected to be poor 3 to 5 years after treatment begins. Although the ecological risk assessment conducted for the site did not evaluate the effects of contaminated ground water on wildlife, it is believed that the water in the brine pond could be harmful or lethal to birds if it was ingested over a period of time. Contaminant concentrations are expected to be higher in the brine water than in the ground water plume and thus would be more likely to be harmful or lethal. Barriers such as fencing would be used to prevent livestock from ingesting the brine water.

Field visits conducted during 1999 indicated that habitat for the black-footed ferret, southwest willow flycatcher, and northern leopard frog does not exist within the area of the proposed action.

[5] Species of concern include protected, candidate, and other rare or sensitive species identified by the Navajo Nation, subject to the Endangered Species Act, the Migratory Bird Treaty Act, and Eagle Protection Act.

No Action Alternative

Wildlife species at the Monument Valley site would not be affected by the no action alternative during the short term. Over the long term, the contaminant plume would increase in size. If a water well were drilled into the plume, and ground water was withdrawn and allowed to pond, wildlife could ingest contaminants in the water pumped from the plume. The ecological risk assessment indicated that the use of contaminated ground water as a sole source of drinking water for livestock could result in livestock deaths from the high concentrations of nitrate and sulfate. The same would be expected for most wildlife species that ingested the water. However, species-specific toxicological information does not exist for most wildlife species.

4.9 Vegetation

4.9.1 Affected Environment

Section 2.3 of the Plant Study (DOE 1998) describes plant types and ecology in detail. Black greasewood, fourwing saltbush, broom snakeweed, and soapweed are the predominant vegetation types overlying the contaminant plume at the site. Although the site is relatively void of vegetation, Indian ricegrass and cheatgrass also grow in the area. The Navajo Nation provided a list of plants of interest that may grow at the site. Based on that list, a site field survey in 1999 found no threatened or endangered plants.

4.9.2 Environmental Consequences

Proposed Action Alternative

Well installation and construction activities associated with active remediation would temporarily disturb vegetation. No areas containing threatened or endangered plant species, if they exist at the site, would be disturbed. All disturbed areas would be reseeded upon completion of construction, and vegetation should reestablish after 2 to 4 years.

DOE would remove the distillation treatment unit, water storage tank, evaporation pond, and infiltration trench after completion of the project. The pipelines also would likely be removed. Most of the wells would be decommissioned in accordance with State and tribal regulations. These areas would be regraded, if necessary, and seeded. Vegetation should reestablish within 2 to 4 years.

Plant uptake of ground water contaminants is expected and planned as part of the phytoremediation process. Plants would use the contaminants as they do in the natural environment. No bioaccumulation is expected that would be harmful to other ecological receptors.

Fencing the phytoremediation area to prevent grazing would allow the vegetation to become established more rapidly. As plant density increases, ammonium and nitrate would be taken up at

a faster rate. Eventually these constituents would be returned to the environment through decay and grazing. Once plant density has reached a satisfactory level (2 to 3 years), grazing would be permitted, although regulated to optimize plant growth and root uptake of the nitrogen compounds.

No Action Alternative

Under the no action alternative, the contaminant plume would continue to move downgradient to the north. Plant uptake of ground water contaminants could occur in areas where the water table is closer to the surface, such as in the greasewood plant community. Greenhouse studies (Baumgartner et al. 1996) have shown that the uptake of contaminated ground water would not elevate plant tissue concentrations of the contaminants above maximum tolerable levels and would have little or no effect on the health of the plant.

Because no surface-disturbing activities would take place under this alternative, the vegetation at the site would not be physically disturbed.

4.10 Cultural Resources

4.10.1 Affected Environment

Humans have occupied the Monument Valley area since as early as 9500 B.C. To determine if historical or archaeological sites are present on or near the Monument Valley site, Class III (100-percent coverage pedestrian) cultural resource surveys were conducted by Complete Archaeological Service Associates. No cultural resources were found at the site.

4.10.2 Environmental Consequences

Proposed Action Alternative

Because no historical or cultural resources were found in the site area, the proposed action alternative would have no effect. If those resources are discovered during implementation of the proposed action, DOE would stop work and notify authorities in the Navajo Nation.

No Action Alternative

Because no surface-disturbing activities would take place and no cultural resources are present at the site, the no action alternative would have no effect on those resources.

4.11 Visual Resources

4.11.1 Affected Environment

The eastern boundary of the 30,000-acre Monument Valley Tribal Park is approximately 13 air miles west of the Monument Valley Site. The Tribal Park is considered an important scenic resource that attracts tourists from around the world. Tourists and local residents also use the area for recreation because of its scenic value.

4.11.2 Environmental Consequences

Proposed Action Alternative

The primary effect on visual resources from the proposed action alternative would be the alteration in the foreground view of the Monument Valley site. The treatment unit is expected to be from 20 to 70 ft high and up to 50 ft wide (or long); the pond would be as large as 2 acres. These features would alter the color and texture of the foreground view for approximately 20 years. Because of the site's remote location, it is unlikely that the treatment unit and evaporation pond would create any adverse visual effects. The Tribal Park would not be affected by the proposed action alternative.

Because of the remote location of the site and lack of a major highway, visual effects of the proposed action are unlikely to affect tourism. However, visual effects could be of concern to local residents.

No Action Alternative

Because no surface-disturbing activities would take place, the no action alternative would have no effect on visual resources.

4.12 Socioeconomics

4.12.1 Affected Environment

Dennehotso, Arizona, is about 6.5 air miles east of the site and has a population of approximately 616. The next closest town is Halchita, Utah, which is 17 miles to the north and has a population of about 400. The nearest schools are located in Gouldings, Utah; Kayenta, Arizona; and Halchita. Health care is available through the Navajo Health Service clinic in Kayenta. The Navajo Tribal Police have jurisdiction for law enforcement within the Navajo Nation. Currently no telephone, electrical power, or sewer facilities are available near the site. Tourism in the Monument Valley area is a significant contributor to the local economy but has no direct effect on local residents. Unemployment in the Monument Valley area is relatively high due to the remoteness of the area and historical and cultural preferences for obtaining sustenance from the land.

4.12.2 Environmental Consequences

Proposed Action Alternative

Well installation and construction for the proposed action alternative would employ 5 to 10 local laborers for a period of 3 to 4 months. Once well installation and construction were completed, 4 to 5 local technicians would be employed over a period of approximately 20 years to maintain the wells and treatment unit at the site. These labor requirements are not expected to noticeably affect local unemployment rates. It does not appear that the local increase in laborers would have any effect on housing or the economy, as most laborers would commute or set up temporary residences in the area.

No Action Alternative

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

4.13 Transportation

4.13.1 Affected Environment

Transportation routes near the Monument Valley site are Highway 160, Highway 163, Highway 191, and Indian Service Route 6440. All are unimproved dirt roads. Access to the site is by Indian Service Route 6440 from either Highway 163 or Highway 160.

4.13.2 Environmental Consequences

Proposed Action Alternative

The proposed action alternative would affect transportation primarily during the transport of brine sludge from the Monument Valley site to the disposal facility. The sludge would be removed from the site at the end of the project and would be transported in 30-ton tandem haul trucks. If the sludge were taken to the Grand Junction disposal site in Grand Junction, Colorado, the route would begin on Indian Service Route 6440, north to U.S. Highway 163, north to U.S. Highway 191, and then north to Interstate 70. From Interstate 70, the haul route would extend east to Grand Junction and then southeast on U.S. Highway 50 to the disposal site.

The volume of brine solids that would be generated under the proposed action alternative would be approximately 8,400 tons over the life of the project. If the brine were hauled to a facility once at the end of the project, it could be transported in approximately 280 truckloads. If 10 trucks per day were to haul from the site, the brine sludge could be removed in approximately 28 working days. The transportation activity would be managed to mitigate effects on local traffic; for example, hauling would be conducted during off-peak hours. Transportation of the sludge would

be conducted in concurrence with the Arizona, Utah, and Colorado Departments of Transportation and would comply with federal, state, and Navajo Nation regulations.

Solid wastes such as personal protective equipment and miscellaneous debris would also require periodic hauling to a landfill or a facility that could accept residual radioactive material. This infrequent hauling is not expected to affect traffic in the Monument Valley area. Workers commuting to and from the site would not affect traffic.

No Action Alternative

Because no transportation would take place, the no action alternative would not affect transportation.

4.14 Environmental Justice Considerations

4.14.1 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 the Monument Valley uranium mill was located on tribal lands, contamination resulting from activities at the site has the potential to affect members of the Navajo Nation almost exclusively.

4.14.2 Environmental Consequences

Proposed Action Alternative

Under the proposed action alternative, DOE would attempt to improve ground water quality to the standards specified in 40 CFR 192, which would beneficially affect ground water and the populations who depend on it. Therefore, disproportionate effects would not occur to tribal members.

No Action Alternative

Under the no action alternative, ground water quality would not be improved, and effects could be disproportionate to tribal members.

4.15 Cumulative Effects Assessment

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 Monument Valley site in the foreseeable future. There would be a

beneficial cumulative effect to ground water quality associated with the proposed action alternative because contamination in the ground water from past activities would be cleaned up to concentrations below EPA standards within approximately 20 years, and the movement of the plume would be contained. The cumulative effect of the no action alternative would be an eventual decrease in contaminant concentrations over the long term (greater than 100 years) and an increase in the areal extent of the contaminant plume.

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

5.0 Persons or Agencies Consulted

George Abe	Tuba City Agency
Nancy Olson	Arizona Game and Fish Department Non-Game Branch Phoenix, Arizona
Michelle James	U.S. Fish and Wildlife Service Ecological Services Division Flagstaff, Arizona
Ray Russel	Navajo Abandoned Mine Lands Reclamation Window Rock, Arizona
Madeline Roanhorse	Navajo UMTRA Project Director Division of Natural Resources Window Rock, Arizona
John Nystedt	Navajo Fish and Wildlife Department Natural Heritage Foundation Window Rock, Arizona

In addition to these contacts, DOE has discussed the aspects of the proposed action with Navajo representatives on a number of occasions. Public scoping meetings were conducted, including a 3-day meeting in Grand Junction, Colorado, June 30–July 2, 1999.

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