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Long-Term Surveillance and Maintenance Program

Long-Term Management Plan for the Former UMTRCA Title I Processing Site at Grand Junction, Colorado

September 2002

U.S. Department of Energy

GRAND JUNCTION OFFICE

Work Performed Under DOE Contract No. DE–AC13–02GJ79491 for the U.S. Department of Energy
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Prepared by
U.S. Department of Energy
Grand Junction Office
Grand Junction, Colorado

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1.0 Introduction

1.1 Purpose

This Long-Term Management Plan documents how the U.S. Department of Energy (DOE) will fulfill requirements of Title 40 *Code of Federal Regulations* Part 192 (40 CFR 192) Subpart B as the long-term custodian for the former Grand Junction, Colorado, uranium-ore processing site (formerly called the Climax millsite).

1.2 Regulatory Requirements

DOE removed residual radioactive materials (RRM) from the Grand Junction Processing Site and stabilized them in an engineered repository off site under Title I of the Uranium Mill Tailings Radiation Control Act. This action brought the former processing site into compliance with U.S. Environmental Protection Agency (EPA) soil standards established in 40 CFR 192, Subparts A and C. Unlike the two-step U.S. Nuclear Regulatory Commission (NRC) licensing process for RRM stabilization in place or stabilization onsite, the NRC does not require a license at these former processing sites and does not require a Long-Term Surveillance Plan (Statements of Consideration for 10 CFR 40, April 30, 1992). Ground water contaminated by milling-related activities remains at the site. As a best management practice, DOE prepared this Long-Term Management Plan to ensure that long-term stewardship of the site effectively protects human health and the environment from potential hazards that remain.

DOE followed the National Environmental Policy Act (NEPA) process to determine the appropriate level of NEPA documentation for ground water issues. A Programmatic Environmental Impact Statement (DOE 1996) discussed general considerations. An Environmental Assessment (DOE 1999a) completed for this site discussed specific considerations. The Ground Water Compliance Action Plan (GCAP) is the concurrence document with NRC for compliance with Subpart B of 40 CFR 192 for the Grand Junction Processing Site and provides details of required ground water monitoring (DOE 1999b). Regulatory concurrence documents from NRC and the state of Colorado the GCAP are provided in Attachments A and B.

1.3 DOE Role

In 1989, DOE established the Long-Term Surveillance and Maintenance (LTSM) Program to manage the long-term surface and ground water stewardship of all DOE Title I and Title II sites for which remedial actions have been completed. The program is responsible for preparation, revision, and implementation of this Long-Term Management Plan.

This plan provides information on ground water monitoring, including annual sampling, inspection and maintenance of monitor wells, and specifies other long-term surveillance activities such as confirming that institutional controls remain effective, maintaining access agreements for sampling, specifying reporting requirements, and records management.

2.0 Final Site Conditions

2.1 Site Description

The former Grand Junction Processing Site, historically know as the Climax millsite, is located in the Grand Valley in Mesa County, Colorado, Sections 23 and 24, Township 1 South, Range 1 West, Ute Principal Meridian (Figure 1). The site encompasses approximately 114 acres in an industrial area of the southern portion of Grand Junction and is bounded on the south by the west-flowing Colorado River.

The former millsite was originally constructed as a sugar beet mill in 1899, processing sugar from sugar beets grown in the Grand Valley. In 1950, the old mill was converted into a uranium/vanadium mill that eventually processed more than 2 million tons of ore, producing about 12 million pounds of uranium oxide (U_3O_8) and 46 million pounds of vanadium oxide (V_2O_5), before it closed in 1971. Ore was crushed, ground, salt roasted, and water leached to remove vanadium; uranium was extracted with sulfuric acid. The Climax Corporation demolished most of the mill buildings and seeded the tailings piles before leaving the site in 1976. From the late 1980s to 1994, the site was used as an interim repository for mill tailings removed from Grand Junction area properties, known as vicinity properties, as part of the Uranium Mill Tailings Remedial Action (UMTRA) Project. DOE conducted surface cleanup from 1989 through 1994. During this time, approximately 4,655,000 cubic yards of tailings and other contaminated materials and all remaining buildings except the old sugar beet warehouse were demolished and hauled to the Grand Junction Disposal Site about 18 miles southeast of Grand Junction. A minimum of 6 inches of clean topsoil was placed over remediated areas that were seeded with grasses to provide a vegetative cover.

In 1995 and 1996, the U.S. Army Corps of Engineers constructed a flood control levee through the southern part of the site. A concrete sidewalk on top of the levee and a footbridge were constructed in 1997 as part of the City's riverfront trail corridor connecting the north side of the Colorado River to the south side at Orchard Mesa Middle School via a footbridge. The City designated the former millsite as a greenway. Future uses for the property may include a city park or the location for storm water retention ponds, but plans have not been formalized at this time. The City is also planning a Highway 6&50 bypass through this part of town, and a portion of the site may be used for this purpose.

2.2 Site Ownership and Access

The former millsite is owned by the City of Grand Junction and administered by the Parks and Recreation Department. DOE will contact the City before collecting samples from on-site monitor wells 1014 and 1001 (Figure 1). Downgradient monitor well 0590 and downgradient surface water location 0427 are on city property, and upgradient well 0745 and surface water location 0423 are on private land. DOE will contact the private landowners before collecting samples. Access agreements are in place with all parties.

2.3 Hydrogeology

The Final Site Observational Work Plan (DOE 1999c) discusses the hydrogeology for the site. The three main hydrogeologic units beneath the Grand Junction site are an unconfined alluvial

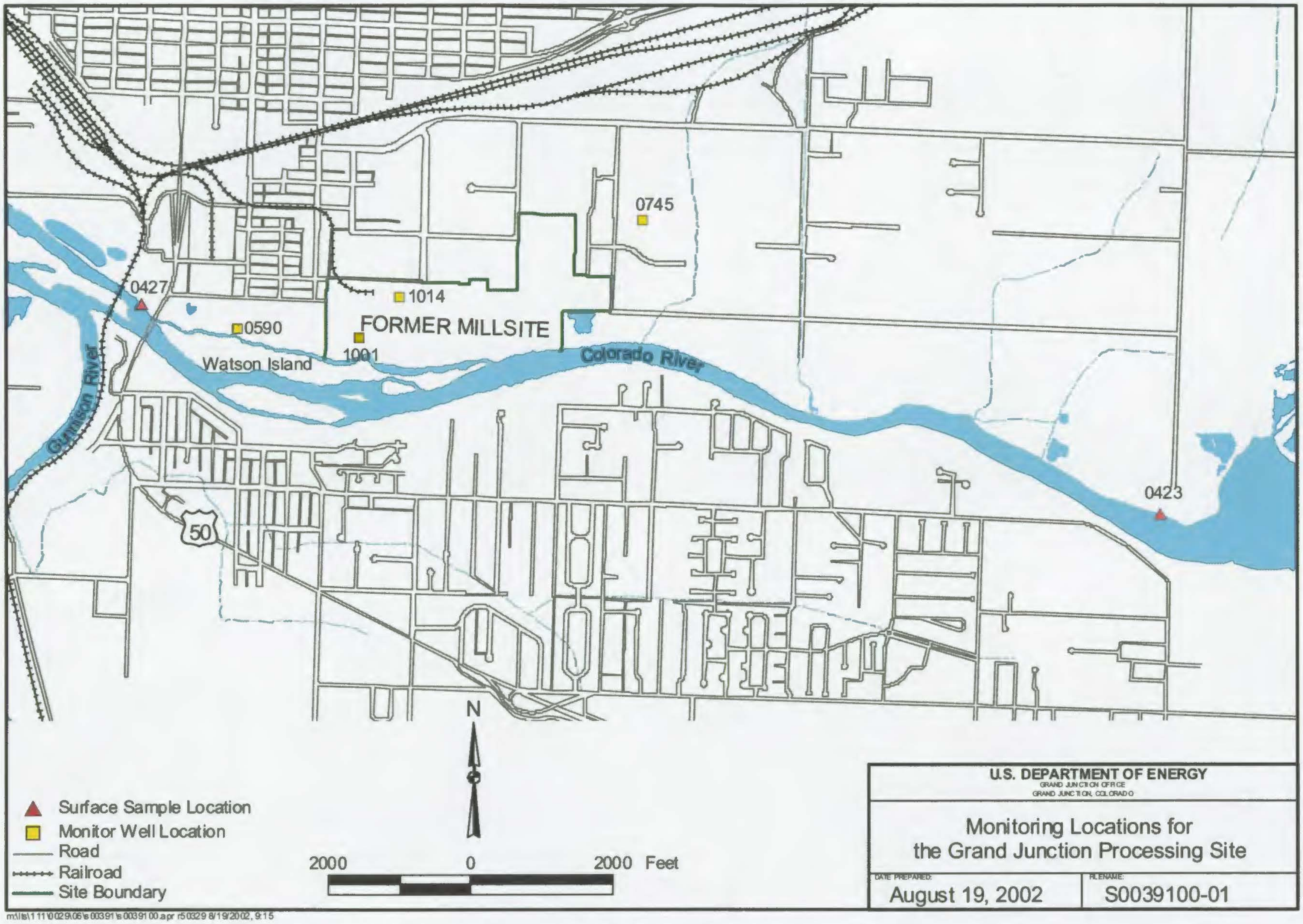

Figure 1. Monitoring Locations for the Grand Junction, Colorado, Processing Site

aquifer, an underlying aquitard composed primarily of shale units in the Cretaceous Dakota Sandstone, and a confined aquifer in sandstone units of the Dakota Sandstone. The alluvial aquifer is considered the uppermost aquifer at the site. Surface components of the hydrologic system in the area include the Colorado River along the south boundary of the site and irrigation canals and drainage ditches north of the site.

The alluvial aquifer is composed of unconsolidated clays, silts, sands, gravels, and cobbles. Ground water is unconfined in the alluvial aquifer; depth to the water table ranges from zero near the river to approximately 20 feet (ft) at the northern end of the site. The saturated thickness of the aquifer ranges from 5 ft to 20 ft. Ground water generally flows southwest toward the Colorado River at a horizontal gradient of about 0.004. The alluvial aquifer is recharged by infiltration of precipitation directly on the site, leakage from upgradient irrigation canals and ditches in the area, and infiltration of Colorado River water during spring runoff. Seasonal fluctuations in water levels beneath the site range from 2 ft to 5 ft in response to changes in river stage. Limited amounts of recharge also occur as upward leakage from the underlying Dakota Sandstone aquifer. Ground water discharge is primarily limited to drainage into the river during low stage. Some discharge also occurs as evapotranspiration from vegetation growing in areas of shallow ground water near the Colorado River. Hydraulic conductivity in the alluvial aquifer ranges from 20 ft/day to more than 200 ft/day, based on aquifer pumping tests in several monitor wells. The variability is a result of lateral and vertical facies changes typical of alluvial deposits and from other boundary conditions in the vicinity. The average linear ground water velocity beneath the site is 2.0 ft/day, based on an estimated average hydraulic conductivity of 100 ft/day, a hydraulic gradient of 0.004, and an effective porosity of 20 percent.

Underlying the alluvial aquifer is a shale aquitard composed of low-permeability shale units in the Dakota Sandstone. Thickness of the shale aquitard in the Dakota may be as much as 50 ft; depths to the top of the aquitard range from less than 10 ft to about 20 ft below the ground surface. Although the shale unit is regarded as an aquitard, wells completed within the unit indicate that it is saturated with ground water. Horizontal hydraulic conductivity for the aquitard is variable depending on the degree of weathering of the unit, but the lower end of the range for unweathered material may be as low as 0.02 ft/day. Previously collected data indicate a vertical hydraulic gradient, with a few exceptions noted during high water levels in the alluvial aquifer.

The confined aquifer in sandstones of the Dakota Sandstone underlies the shale aquitard. This aquifer was not extensively characterized during site investigations because of the presence of the overlying aquitard and a vertical upward hydraulic gradient that minimizes the potential for any infiltration of contamination from the alluvial aquifer. Recharge to the Dakota Sandstone occurs as infiltration of precipitation on outcrops to the south. Ground water flow direction in the Dakota Sandstone beneath the site likely follows regional gradients, which vary between a northwest and a northeast orientation. Sparse information on hydraulic conductivity for this unit indicates a range of 0.02 ft/day to 0.13 ft/day (Lohman 1965).

2.4 Human Health and Ecological Risks

2.4.1 Human Health Risk

The Baseline Risk Assessment (DOE 1995) indicated that residential use of ground water, mainly as drinking water, would present the only unacceptable pathway for exposure to ground water at the site. The constituents of potential concern identified in the 1995 Baseline Risk Assessment were evaluated using 1998 sampling data. Potential risks calculated using the recent data in a residential drinking water exposure scenario indicate that the major risk contributors are ammonia, iron, manganese, molybdenum, vanadium, and uranium. Although there is no consensus as to what concentration of sulfate is acceptable in drinking water, concentrations detected in the site ground water are sufficiently high to be of potential concern (DOE 1999c).

Although risks calculated for the hypothetical use of site ground water in a residential setting are unacceptably high, no actual risks exist at the site because no pathways for human use of ground water are complete. Therefore, the only reasonable human exposure pathway of contaminated ground water from the alluvial aquifer is incidental dermal contact, and this would pose no increased risks to human health (DOE 1999c).

Ingestion of ground water is not probable because deed restrictions on the site prevent the use of ground water. The area downgradient the site is inside Grand Junction city limits, and city code requires residents to be connected to the municipal water system. Because institutional controls on and downgradient of the site will continue to prohibit the use of ground water, current and future human health risks are not unacceptable.

2.4.2 Ecological Risk

DOE collected samples of surface water, sediment, and vegetation to evaluate risks to the environment from site-related contaminants. Plant communities, aquatic organisms including threatened and endangered fish such as humpback chub, bonytail chub, Colorado pikeminnow and razorback sucker, benthic organisms, and terrestrial and wetland wildlife receptors were considered. Samples were collected from the plume area and from a reference area located in an ecologically similar environment about 3 miles east (upgradient) along the Colorado River.

Results of this sampling indicate generally low levels of a few site-related contaminants in sediment, surface water, and plant tissues (DOE 1999c). Some residual levels of millsite-related constituents still remain in vestiges of ponds constructed in 1994 along the Colorado River as wetlands areas. Flooding in the Colorado River has removed these ponds. Periodic flooding of the Colorado River adjacent to the site will continue to disperse any contaminants found in these areas. Because data evaluation did not indicate an unacceptable ecological risk for the Grand Junction site, no further ecological risk assessment was performed. The contaminants discussed in the 1995 Baseline Risk Assessment and a summary of the rationales for retaining or deleting them are provided in the Site Observational Work Plan (DOE 1999c).

Exposure to site ground water discharging to the Colorado River or surfacing in excavations or ponds would not produce significant risk to ecological receptors, including plants with roots in site-affected ground water and animals that might ingest water from the river or ponds. This information is summarized in the Environmental Assessment (DOE 1999a).

2.5 Ground Water Compliance Strategy

The compliance strategy to meet EPA ground water protection standards, which was proposed in the Environmental Assessment (DOE 1999a) and Ground Water Compliance Action Plan (DOE 1999b), is no remediation and application of supplemental standards on the basis of limited use ground water (40 CFR 192.21[g]). In this situation, limited use ground water is defined as ground water in the uppermost aquifer that is not a current or potential source of drinking water because 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 (40 CFR 192.11[e][2]). Ground water in the alluvial aquifer is of limited use because of widespread, elevated concentrations of naturally occurring uranium and selenium.

2.5.1 Background Ground Water Quality

Uranium values for background ground water average 0.047 milligrams per liter (mg/L); the UMTRA Project maximum concentration limit in 40 CFR 192 is 0.044 mg/L. Background selenium values average 0.04 mg/L; the UMTRA Project maximum concentration limit is 0.01 mg/L. Selenium concentrations are high in some wells and not detected in others. The population is bimodal; if the nondetect values are assumed to be the detection limits, the average of 0.04 mg/L is above the maximum concentration limit of 0.01 mg/L. Previous studies by the U.S. Geological Survey (USGS) found concentrations of selenium in valley ground water as high as 0.88 mg/L (Butler et al. 1994).

The source of uranium and selenium in background ground water is thought to be the dark marine shales in the Mancos Shale. Black shales are known to contain unusually high concentrations of uranium (Levinson 1974), and Late Cretaceous marine shales, such as the Mancos, are known to have high concentrations of selenium (USGS 1997). These shales underlie most of the Grand Valley and are leached by ground water moving to the south and southwest.

Other constituents in background ground water that have concentrations above the secondary drinking water standards in the Safe Drinking Water Act (40 CFR 143) include chloride, iron, manganese, sulfate, and total dissolved solids (Table 1). Although the secondary drinking water standards are not enforceable, they do indicate that the background ground water is of poor quality. The mean total dissolved solids concentration for background ground water is 5,238 mg/L, which is below the 10,000 mg/L concentration that can define a limited use aquifer, but still elevated. The data for uranium and selenium concentrations support using the criterion of widespread ambient contamination in alluvial ground water for supplemental standards.

2.5.2 Reasonableness of Ground Water Treatment

Even though ground water has no current or projected use, a study was performed to evaluate the reasonableness of treating contaminated ambient ground water for municipal potable use. The study addressed the criterion in 40 CFR 192.11(e)(2) that the water cannot be treated by

Table 1. Summary of 1998 Ground Water Quality at the Grand Junction, Colorado, Processing Site

Contaminant	Maximum mg/L	Mean mg/L	MCL mg/L	SMCL mg/L	RBC mg/L
Ammonia (as NH_4)					
Plume	233	71.4			0.20 (as NH_3)
Background	0.321	0.093			
Arsenic					
Plume	0.0349	0.005	0.05		0.001N
Background	0.0014	n/a			0.000045C
Chloride					
Plume	1,160	796		250	
Background	991	437			
Fluoride					
Plume	7.57	1.93	4	2	2.2N
Background	1.62	0.895			
Iron					
Plume	21.2	3.88		0.3	11N
Background	3.13	0.552			
Manganese					
Plume	4.54	2.82		0.05	1.7N
Background	2.22	1.4			
Molybdenum					
Plume	0.299	0.101	0.1		0.18
Background	0.124	0.0587			
Selenium					
Plume	0.016	n/a	0.01		0.18
Background	0.137	0.036			
Sulfate					
Plume	3,700	3,154		250	
Background	3,720	2,566			
^{234}U and ^{238}U					
Plume	1,668	215.3	30 pCi/L		
Background	57	42			
Uranium (total)					
Plume	2.5	0.304	0.044		
Background	0.0662	0.0469			
Vanadium					
Plume	0.832	0.0857			0.33
Background	0.0049	0.0019			
Total Dissolved Solids					
Plume	7,840	6,525		500	
Background	7,400	5,238			

Note: MCL = maximum concentration limit (UMTRA Project)
SMCL = secondary maximum contaminant level (Safe Drinking Water Act)
RBC = risk based concentration (human health) (EPA 2002)
N = noncarcinogenic risk
C = carcinogenic risk

"methods reasonably employed in public water systems." The Site Observational Work Plan (DOE 1999c) describes the results of this study, and guidance in *Guidelines for Ground-Water Classification Under the EPA Ground-Water Protection Strategy* (EPA 1988). The study showed that the cost of producing potable water from the alluvial aquifer is conservatively estimated at $680 per household per year. This value exceeds the threshold of $300 per household per year provided by the EPA 1988 guidelines as a reasonable cost. When adjusted for inflation of 3 percent per year, the threshold is $400 per year, and the cost is still well above the threshold. The three sources of municipal water in the Grand Valley are Grand Junction city water, Clifton water, and Ute water. Mr. Terry Franklin, Grand Junction Water Superintendent, provided average private household domestic costs for local water. The average household uses about 8,000 gallons (26,000 liters) per month; the cost for each is

- Grand Junction: $222 per year per household
- Clifton water: $222 per year per household
- Ute water: $216 per year per household

These average amounts are about one-third the estimated cost of treating alluvial ground water.

3.0 Long-Term Management Program

3.1 Ground Water Monitoring

Limited ground water monitoring is proposed as a best management practice to determine when concentrations of site-related constituents are at a level that certain uses of ground water may no longer be restricted. These uses may be somewhat limited by the poor ambient quality of the ground water. Monitoring locations will include on-site monitor wells 1014 (the well with the highest contaminant levels) and 1001 (located directly downgradient of 1014), off-site and downgradient monitor well 0590, background well 0745, and upgradient river location 0423 and downgradient river location 0427 (see Figure 1). Sample results from location 0423 will provide background values, and results from location 0427 will provide continuing verification that mill-related constituents in ground water are not affecting water quality of the river. Analytes will include ammonia (as NH_4), molybdenum, and uranium. Samples will be collected and analyzed annually for the first 5 years and every fifth year thereafter for 30 years. Results of sampling will be evaluated after each sampling event. If, after the first 5-year period, concentrations of target analytes are consistently below maximum concentration limits or baseline values, the analyte list or frequency of sampling may be modified. Sampling at 5-year intervals will continue until all analytes are below their respective maximum concentration limits or background values, or until the monitoring program (Table 2) is modified. Because monitoring is specified in the GCAP, DOE will obtain NRC concurrence for changes to the monitoring program.

Table 2. Ground Water Monitoring at the Grand Junction, Colorado, Processing Site

Sample Location	Location	Interval	Analytes	Frequency
1014	On site Well	Alluvial aquifer	Uranium, molybdenum, ammonia (as NH_4)	Annually for 5 years, then once every 5 years for 30 years until concentrations of all constituents are below their standards or background values, or until the monitoring program is modified
1001	On site Well	Alluvial aquifer		
0590	Downgradient Well	Alluvial aquifer		
0745	Background Well	Alluvial aquifer		
0427	Colorado River Downgradient	Surface water		
0423	Colorado River Upgradient	Surface water		

3.2 Institutional Controls

Future activities for the site will include verification of institutional controls to ensure continued protection of human health and the environment. Verification will be conducted annually for the next 5 years and will consist of consultation and documentation of discussions with the Grand Junction city Engineering Department, the state Engineer's Office, and the local Office of Colorado State Water Quality Division. Annual inspections of the form millsite will also be conducted. If no changes are found or if no issues arise that might compromise established institutional controls, contact will subsequently be made every 5 years for the next 20 years. Documentation of the contacts will consist of telephone logs sent to the LTSM Program file for the Grand Junction Processing Site.

3.2.1 On-Site Controls

The state of Colorado, through the Colorado Department of Public Health and Environment (the Grantor), transferred the Climax millsite property to the city of Grand Junction (the Grantee) via two quitclaim deeds recorded in the Mesa County Courthouse, Book 2320, pages 882 to 886, on March 29, 1997. As part of the agreement, the city agrees "not to use ground water from the site for any purpose, and not to construct wells or any means of exposing ground water on the property unless prior written approval of construction plans, designs and specifications is given by the Grantor and the U.S. Department of Energy."

3.2.2 Downgradient Controls

Controls are in place to ensure that private landowners downgradient of the millsite are not exposed to contaminated ground water. Ground water from the alluvial aquifer is not a current or potential source of drinking water. Potable water is readily available from the municipal water system in the vicinity of the site and is required by city code for domestic use (Attachment C). Ground water from the alluvial aquifer is not currently used, and there is no historical record of wells completed in this unit beneath or downgradient of the site. Future use of ground water from the alluvial aquifer is unlikely based on historical information, city restrictions, and the planned future development in the area. Therefore, the current and reasonably projected uses of site-affected ground water would be preserved with the city code and deed restrictions on the former millsite.

3.3 Site Inspections, Reports, and Records

3.3.1 Inspections

The site will be inspected in conjunction with water sampling in the fall of each year. The integrity of the monitor wells will be noted and maintenance will be performed as necessary. Any exposures of ground water, such as seeps, will also be noted.

3.3.2 Reports

An annual report of inspection and monitoring activities required by this Long-Term Management Plan will be submitted to the site record and a courtesy copy will be sent to the NRC by March 31 for the next year. The report will include the status of the monitor wells, water quality data from the annual sampling round, and water level data (if needed) from the four monitor wells. Other information will include an evaluation of these data and a summary of site conditions and the effectiveness of the compliance strategy.

3.3.3 Records

The LTSM Program records are maintained in full compliance with DOE requirements:

- DOE Order 200.1, "Information Management Program"
- 36 CFR Parts 1220–1236, National Archives and Records Administration

The LTSM Program maintains selected Grand Junction Processing Site records at the Grand Junction Office (GJO) facility. These records were chosen because they contain critical information needed to ensure the continued management and the follow-on actions and controls (including property management) required to protect public health and the environment and to demonstrate compliance with applicable legal requirements. This stewardship record collection does not include information pertaining to employee and public health and safety considerations with respect to former site operations. The DOE Albuquerque Operations Office is responsible for personnel inquiries for staff working on the DOE remediation of the site.

The stewardship collection is indexed and integrated into the LTSM Program files and databases. The records and selected site-specific references at the GJO are managed using the GJO records system, and geographical and environmental data are managed using a separate electronic database. The LTSM Working File Index provides guidance on management of the collection.

3.3.3.1 Access and Retrieval

The records at the GJO are available to the LTSM site steward as well as all stakeholders. Key site documents (e.g., closure reports, environmental assessments, fact sheets, records of decision, inspections, and long-term surveillance plans) and site mapping/environmental data (e.g., boundaries, structures, and wells) are viewable from the LTSM website (**www.gjo.doe.gov/**, select Projects and Programs).

3.3.3.2 Pre-Stewardship Record Collection

The pre-stewardship collection created during remediation of the processing and disposal sites (known as the AL UMTRA Surface Collection) was created and managed by the DOE Albuquerque Operations Office. The ground water cleanup for the Grand Junction Processing Site is documented in the UMTRA Ground Water Collection, which is managed by the GJO. Selected portions of the AL UMTRA Surface Collection were transferred to the GJO for continued use by the LTSM site steward, and the remainder of the collection was transferred to the Rocky Mountain region of the national archives and federal records center in Denver.

The Rocky Mountain region of the national archives and federal records center in Denver is currently the designated archive facility for the Grand Junction Processing Site records created during remediation and long-term stewardship of the site. To facilitate retrieval of records after site operations cease and because the greatest repository of site knowledge rests with the site steward, the LTSM Program will obtain copies of the box and file indexes (as available) and Records Transmittal and Receipt forms (SF 135) for the site. These indexes and the SF 135s will be retained with the site stewardship collection.

Currently, permission to access those site documents that reside in the federal records center must be obtained from the DOE Albuquerque Operations Office. The LTSM Program will work with the DOE Albuquerque Operations Office to ensure that the LTSM site steward is included in the concurrence for the destruction of any temporary records.

3.4 Quality Assurance and Health and Safety

The long-term care of the former Grand Junction Processing Site and all activities related to the annual surveillance and maintenance of the site will comply with DOE Order 414.1A, "Quality Assurance, and Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs" (American Society for Quality Control 1994).

Health and safety procedures for long-term management program activities will be consistent with DOE orders, regulations, codes, standards, and the *Long-Term Surveillance and Maintenance Program Project Safety Plan* (DOE 2001).

4.0 References

40 CFR 143. "National Secondary Drinking Water Regulations."

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36 CFR 1220–1236, "National Archives and Records Administration."

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DOE Orders

Order 414.1A, *Quality Assurance*, Washington, D.C., August 1999.

Order 200.1, *Information Management Program*

Attachment A

Nuclear Regulatory Commission Concurrence Letter and Final Technical Evaluation Report for the Grand Junction, Colorado, Uranium Mill Tailings Site (Part A, surface project)

UMT 57153

GRJ RAP

C.13.1.1

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

July 18, 1994

SURF018531

Mr. Albert R. Chernoff, Project Manager
Uranium Mill Tailings Remedial Action
Project Office
U.S. Department of Energy
Albuquerque Operations Office
P.O. Box 5400
Albuquerque, NM 87115

Dear Mr. Chernoff:

SUBJECT: FINAL TECHNICAL EVALUATION REPORT FOR THE GRAND JUNCTION, COLORADO, URANIUM MILL TAILINGS SITE

The U.S. Nuclear Regulatory Commission staff has completed its review of the final Remedial Action Plan and Site Design (RAP) and the Remedial Action Inspection Plan (RAIP), Revision C, for the inactive uranium mill tailings site at Grand Junction, Colorado. The staff's review is documented in the enclosed final Technical Evaluation Report (TER).

Based on this review, the NRC staff concurs in the Grand Junction RAP and RAIP. The Department of Energy (DOE) has proposed deferral of groundwater cleanup at the Grand Junction processing site until a second phase of the remedial action program. The NRC staff considers this deferral to be acceptable and will review this aspect of remedial action upon DOE's submittal of a groundwater cleanup plan. As a result of the staff's concurrence, NRC is prepared to sign the signature pages for the Grand Junction RAP, following their submittal by DOE.

If you have any questions regarding this action, please contact Ms. Charlotte Abrams of my staff at (301) 415-5808.

Sincerely,

Joseph J. Holonich, Chief
High-Level Waste and Uranium
Recovery Projects Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosure: As stated

cc: C.Smythe, DOE Alb
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Final Technical Evaluation Report
for the Proposed Remedial Action at the Grand Junction Uranium Mill Tailings Site, Grand Junction, Colorado

Uranium Mill Tailings
Remedial Action Project

U.S. Nuclear Regulatory Commission

Office of Nuclear Material Safety and Safeguards
Division of Waste Management

July 1994

FINAL
TECHNICAL EVALUATION REPORT
FOR THE PROPOSED REMEDIAL ACTION AT THE
GRAND JUNCTION URANIUM MILL TAILINGS SITE
GRAND JUNCTION, COLORADO

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1.0 INTRODUCTION

The Grand Junction site was designated as one of 24 abandoned uranium mill tailings piles to receive remedial action by the U.S. Department of Energy (DOE) under the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA). UMTRCA requires, in part, that the U.S. Nuclear Regulatory Commission concur with DOE's selection of remedial action, such that the remedial action meets appropriate standards promulgated by the U.S. Environmental Protection Agency (EPA). This final Technical Evaluation Report (TER) documents the NRC staff's review of the DOE Final Remedial Action Plan and Site Design (RAP; DOE, 1991a; 1991b), and associated documents.

1.1 EPA Standards

As required by UMTRCA, remedial action at the Grand Junction site must comply with regulations established by the EPA in 40 CFR Part 192, Subparts A-C. These regulations may be summarized as follows:

1. The disposal site shall be designed to control the tailings and other residual radioactive material for 1000 years to the extent reasonably achievable and, in any case, for at least 200 years [40 CFR 192.02(a)].

2. The disposal site design shall prevent radon-222 fluxes to the atmosphere from residual radioactive materials from exceeding 20 picocuries/square meter/second or from increasing the annual average concentration of radon-222 in air by more than 0.5 picocuries/liter [40 CFR 192.02(b)].

3. The remedial action shall ensure that radium-226 concentrations, in land that is not part of the disposal site, averaged over any area of 100 square meters, do not exceed the background level by more than 5 picocuries/gram averaged over the first 15 centimeters of soil below the surface and 15 picocuries/gram averaged over any 15-centimeter thick layer of soil more than 15 centimeters below the land surface [40 CFR 192.12(a)].

On September 3, 1985, the U.S. Tenth Circuit Court of Appeals remanded the groundwater standards (40 CFR Part 192.2(a)(2)-(3)) and stipulated that EPA promulgate new groundwater standards. EPA proposed these standards in the form of revisions to Subparts A-C of 40 CFR Part 192 in September, 1987. The proposed standards consist of two parts; a first part, governing the control of any future groundwater contamination that may occur from tailings piles after remedial action, and a second part, governing the clean-up of contamination that occurred before the remedial action of the tailings. In accordance with UMTRCA Section 108(a)(3), the remedial action shall comply with the EPA proposed standards until such time as the final standards are promulgated. At that time, DOE has committed to re-evaluate its groundwater protection plan and undertake such action as necessary to ensure that the final EPA standards are met.

1.2 Site and Proposed Action

The Grand Junction mill site is a 114-acre property adjacent to the south side of the city of Grand Junction, Colorado, and adjacent to the north side of the

Colorado River (See Figure 1.1). The site consists of the tailings pile, mill site, and effluent ponds of the former Climax Uranium Mill site, which was operated by the Climax Uranium Company between 1951 and 1970. The estimate of total contaminated materials to be placed in the disposal cell from all sources is 5.7 million cubic yards. The tailings on the site are covered with approximately six inches of soil, and the site is sparsely vegetated. Concrete and brick from demolished mill buildings were placed as riprap along the northern bank of the Colorado River.

The proposed disposal site is on Bureau of Land Management (BLM) land located off U.S. Highway 50, 18 miles southeast of Grand Junction, near Cheney Reservoir (See Figure 1.2).

The proposed remedial action consists of the following major activities:

- Movement of all contaminated materials, by a combination of rail and truck, to a disposal site located near Cheney Reservoir.

- Stabilization of contaminated materials in an embankment, which will rise approximately 30 feet above the surrounding terrain and which will extend up to 40 feet below existing grade.

- Coverage of the tailings embankment with a multilayered cover system on the top and sideslopes. Starting from the layer directly over the contaminated materials, the topslope cover system will consist of a 2-foot-thick radon/infiltration barrier, covered by a 2-foot-thick frost protection layer, a 6-inch-thick sand bedding/drainage layer, and finally a 1-foot-thick Type A riprap layer. The sideslopes will consist of a 42-inch-thick radon/infiltration barrier, covered by a 6-inch-thick sand bedding/drainage layer, and finally a 1-foot-thick Type B or C riprap layer.

- Restoration of the processing site with uncontaminated fill from the disposal site excavation.

1.3 Review Process

The NRC staff review was performed in accordance with the Standard Review Plan for UMTRCA Title I Mill Tailings Remedial Action Plans (SRP; NRC, 1993) and consisted of comprehensive assessments of DOE's remedial action plan and site design.

The remedial action information assessed by the NRC staff was provided primarily in the following documents (DOE, 1991a-f), (MK-Ferguson, 1991):

1. DOE, "Remedial Action Plan and Site Design for Stabilization of the Inactive Uranium Mill Tailings Site at Grand Junction, Colorado," Final, UMTRA-DOE/AL 050505.0000, September 1991 (Grand Junction RAP), Remedial Action Selection Report (RAS).

2. Grand Junction RAP, Attachment 1: Contract Documents, Design and Engineering Calculations (Calculations Volumes I-V).

3. Grand Junction RAP, Attachment 2: Geology Report

4. Grand Junction RAP, Attachment 3: Groundwater Hydrology Report and Appendix A, Volumes I-IV.

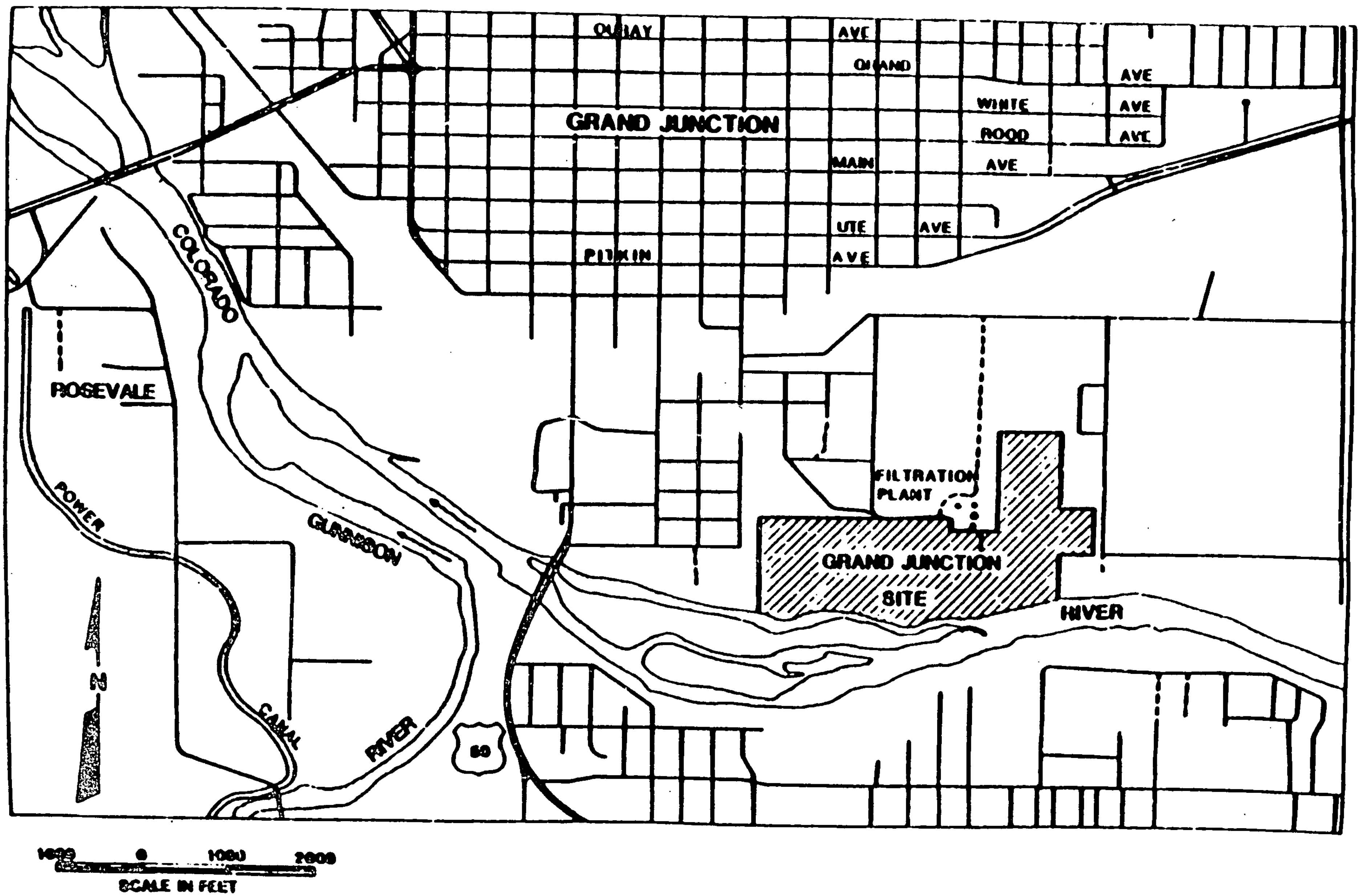

FIGURE 1.1
THE GRAND JUNCTION SITE AND ITS VICINITY

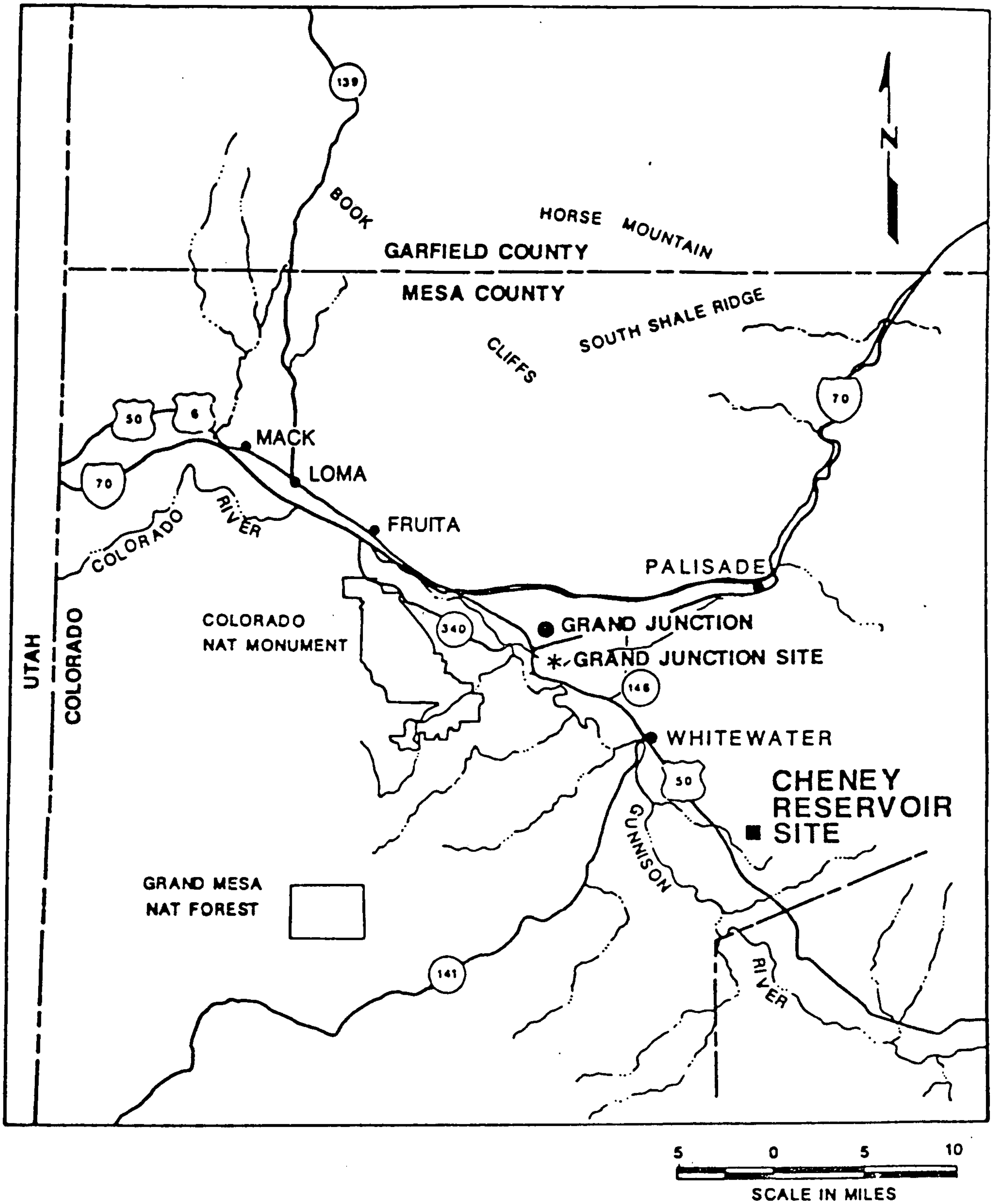

FIGURE 1.2
LOCATION OF CHENEY RESERVOIR DISPOSAL SITE

5. Grand Junction RAP, Attachment 4: Water Resources Protection Strategy

6. Grand Junction RAP, Attachment 5: Summary of Field Investigations, Volumes I and II.

7. MK-Ferguson Company, "UMTRA Project, Grand Junction, Colorado, Remedial Action Inspection Plan," Revision C, April 1991.

Information in the documents listed above was supplemented by DOE responses to NRC staff comments and concerns. Those responses were transmitted to NRC on April 25, 1994 (DOE, 1994).

1.4 TER Organization

The purpose of this final TER is to document the NRC staff review of DOE's Final RAP for the Grand Junction processing site and the designated disposal site, Cheney Reservoir. The following sections of this report have been organized by technical discipline relative to the EPA standards in 40 CFR Part 192, Subparts A-C. Sections 2, 3, and 4 provide the technical basis for the NRC staff's conclusions with respect to the long-term stability standard in 192.02(a). Section 5, Water Resources Protection, summarizes the NRC staff's conclusions and evaluation regarding the adequacy of DOE's compliance demonstration with respect to EPA's groundwater protection requirements in 40 CFR Part 192. Section 6 provides the basis for the staff conclusions with respect to the radon control standards in 192.02(b) and soil cleanup in 192.12.

1.5 Status of Issues

The NRC staff's review of DOE's preliminary final data and designs identified certain issues which have been satisfactorily addressed by DOE in the Final RAP, with the exception of groundwater cleanup which has been deferred until a later phase of the Uranium Mill Tailings Remedial Action (UMTRA) Project.

2.0 GEOLOGIC STABILITY

2.1 Introduction

This section of the TER documents the NRC staff's review of geologic information for the proposed remedial action at the Grand Junction uranium mill tailings disposal site. Background information for this TER is derived from DOE's RAP (DOE, 1991a-f), supplementary information provided during the review process, staff's site visits, and independent sources as cited.

2.2 Location

For this remedial action, site characterization is required for two areas in Colorado: (1) the processing site, consisting of an abandoned mill and tailings pile located in Grand Junction, Colorado, on the Colorado River and along Interstate 70, 250 miles west of Denver, and (2) the proposed disposal site near Cheney Reservoir, located approximately 18 miles southeast of Grand Junction, in the Gunnison River valley.

2.3 Geology

The EPA standards listed in 40 CFR 192 do not include generic or site-specific requirements for the characterization of geologic conditions at UMTRA Project sites. Rather, 40 CFR 192.02(a) requires control shall be designed to be effective for up to 1000 years, to the extent achievable, and in any case for at least 200 years. NRC staff have interpreted this standard to mean that certain geologic conditions must be met in order to have reasonable assurance that this long-term performance objective will be achieved. Guidance with regard to these conditions is specified in NRC's UMTRA Project Standard Review Plan (SRP; NRC, 1993).

2.3.1 Stratigraphic Setting

DOE characterized regional and site stratigraphy by reference to published work and original field investigations as recommended in SRP Section 2.3.1 (NRC, 1993). Bedrock in the region of the processing and disposal sites consists of a thick sequence of marine and continental sedimentary rocks, and is overlain by surficial deposits which include alluvium, terrace gravels, and colluvium. Both the processing and disposal sites occur in broad valleys developed along strike of the Cretaceous Mancos Shale. The Mancos is a thick sequence of fissile shale containing sparse siltstones and sandstones. The Mancos underlies the entire Grand Valley area, and has a thickness in excess of 3800 feet (Lohman, 1965). Each site occurs near the base of the Mancos, which is in turn underlain by Cretaceous Dakota Sandstone and the Burro Canyon Formation. The Mesa Verde Formation occurs up-section and crops out near the tops of Grand Mesa and the Book Cliffs to the east and north. Tertiary volcanic rocks form the caps of Battlement and Grand Mesas to the east. The staff finds that DOE has adequately characterized the regional stratigraphy. At the processing site, the abandoned mill tailings are underlain by up to 20 feet of unconsolidated Colorado River alluvium. In general, the alluvium consists of a thin upper layer of silty deposits and a thicker lower layer of coarser sand and gravel. Only a few wells penetrate the Mancos Shale beneath the tailings, and it appears that the Mancos extends to a depth of 60 feet. Both Mancos and Dakota crop out on the southern bank of the river, and the Mancos pinches out completely within one-half mile southwest of the site. Details of the mill area's stratigraphy, as it affects hydrogeologic and geotechnical conditions of the site and ability of the remedial action to meet

UMTRA Project groundwater standards, are discussed in other sections of this TER.

The Cheney disposal area is located on the Grand Mesa Piedmont in the Gunnison River Valley. Surficial deposits beneath the site consist of unconsolidated alluvial material, approximately 15 to 30 feet thick in the disposal cell area. DOE determined that these deposits consist mainly of mixtures of silty gravel with cobbles and boulders derived from the basalt rocks that cap Grand Mesa. Mancos Shale, approximately 800 feet thick, underlies the deposits and crops out along arroyo exposures. The Mancos is underlain by the Dakota and older strata which are not of significance to the remedial action. The staff finds reasonable assurance that detailed subsurface geological conditions at Cheney will not affect the site's ability to meet remedial action standards.

2.3.2 Structural Setting

DOE characterized the region's structural setting by reference to published regional geological maps, aerial reconnaissance, and field observation and mapping of features critical to assuring long-term stability of the remedial action. These studies are recommended in SRP section 1.3.5 (NRC, 1993). The Grand Junction area is situated on the northeast flank of the Uncompahgre Uplift. The Uncompahgre Uplift is northwest-trending, and asymmetrically tilted with a Precambrian core. It is bounded on the northeastern and southwestern flanks by abrupt, locally faulted monoclines. Movement on the Uncompahgre Uplift began as early as Pennsylvanian time. Repeated uplift occurred as recently as Miocene or Pliocene time, and may continue to the present (Kirkham and Rogers, 1981). Potentially active faults associated with the northeast side of the uplift, mapped by Kirkham and Rogers (1981), lie 6 to 25 miles from the Cheney disposal site.

The Uncompahgre Uplift is bordered to the north by the Piceance Basin. Strata underlying the Grand Junction area dip northward and form a transitional zone between the two structural features. The Piceance Basin formed in Laramide time and has undergone gradual uplift through Pliocene time (DOE, 1991c). The basin is bounded on all sides by uplifts of Laramide age, and developed over 8200 feet of stratigraphic section since the Late Cretaceous.

2.3.3 Geomorphic Setting

DOE characterized the region's physiography by reference to published literature and topographic maps, as recommended in SRP section 1.3.4 (NRC, 1993). Site geomorphic conditions were characterized by aerial photographic interpretation and field observations. The area is located in the Canyonlands section of the northeastern Colorado Plateau physiographic province (Hunt, 1974). The Book Cliffs, a few miles to the north, form the northern boundary of the Canyonlands Section and the southern edge of the Uinta Basin. The Colorado and Gunnison Rivers occur along strike valleys in the Mancos Shale.

The Grand Junction mill site and tailings pile are located on a 114-acre site on the Colorado River's floodplain. The tailings are currently protected from the river by a 30-foot berm of concrete blocks and other debris (DOE, 1991a). In some places, the river approaches directly to the berm. Elsewhere, the river bank shows evidence of recent erosion, such as development of transverse cracks near the water's edge and mass wasting into the river. A constant need for bank maintenance and other measures to isolate the tailings from erosion is a principal reason for proposed removal of all contaminated material from the present disposal site.

The Cheney disposal site occurs on one of a series of nine pediment levels lying below and west of Grand Mesa. The pediments are graded to ancestral levels of the Gunnison River or its tributaries. Each pediment surface is separated from adjacent ones by an erosional scarp. The pediments are eroded on shallowly dipping Mancos Shale and include up to 40 feet of Quaternary deposits in the proposed disposal area. The deposits are poorly-sorted, consist of clay to boulder size material, and appear to be derived from Cretaceous strata and Tertiary volcanic rocks that flank Grand Mesa.

Surface-water drainage from the disposal area is mainly by sheet flow. However, flow becomes channelized in many places, especially where the drainage area or surface gradient is high, and gullies have formed adjacent to or down gradient from the proposed disposal site. Headward erosion and widening of the gullies are the most significant geomorphic process with which the remedial action must be concerned (DOE, 1991c).

2.3.4 Seismicity

DOE characterized regional seismicity by obtaining data bases provided by the National Oceanographic and Atmospheric Administration (NOAA), by applying accepted techniques to determine earthquake magnitudes, and by employing methods suggested in SRP section 1.3.5 (NRC, 1993) for calculating peak horizontal ground accelerations generated by a design-basis event.

Grand Junction and the Cheney site are both located in the northeastern portion of the Colorado Plateau, bordered to the east by the Rocky Mountain physiographic province. Historical and instrumental seismic events have been concentrated along the margins of the Plateau, where it meets the Basin and Range or Rocky Mountain physiographic provinces (DOE, 1991c). The plateau includes a stable interior and several border zones which experience elevated seismicity, thinner crust, higher terrestrial heat flow, normal faults, and high occurrence of Tertiary and Quaternary volcanic rocks. Nearly all large magnitude historic earthquakes of the plateau are associated with the border zones. The disposal site is located in the Colorado Plateau's border zone with the western Rocky Mountains.

NOAA's compilation of historical earthquake epicenters includes only five events within 65 km of the site. Calculated Richter magnitudes of the quakes were as high as 4.4. However, faults responsible for the earthquakes have not been identified with certainty (DOE, 1991c).

DOE's analysis of potential earthquake magnitudes for the interior Colorado Plateau included determination of both the Maximum Earthquake (ME) and Floating Earthquake (FE) for the region. To augment its analysis of Colorado Plateau seismicity, DOE studied four regional structures for the occurrence of capable faults. First, faults in the Piceance Basin were determined through preliminary study to be not capable. Faults in the Paradox Basin, while displaying evidence of Neogene movement, are associated with salt dissolution and collapse, are not associated with lithospheric tectonism, and are not capable of generating earthquakes in excess of Richter magnitude 5. Staff find these two areas do not present a seismic risk to long-term site stability. Based on literature review, DOE assumed several faults on the flanks of the Uncompahgre Uplift were potentially capable. Field examination of these faults within 40 miles (65 km) of Cheney resulted in no observations of evidence that any of these faults have experienced Quaternary movement (DOE, 1991c). Seismic activity in the western Rocky Mountain province is mainly associated with the San Juan Mountains and Grand Hogback, each of which form the border with the Colorado Plateau.

Despite discovery of no capable faults in the Uncompahgre area, it appears that the Uncompahgre Uplift may be experiencing regional tectonic movement at this time. DOE concludes that the association of faults in the study area with an active regional structure requires that the faults be considered capable, regardless of surficial expression of such. NRC staff find this conclusion an acceptable and conservative basis upon which to calculate maximum credible earthquake magnitudes and peak horizontal ground acceleration values. See the Seismotectonic Stability section of this TER (Section 2.4.3) for a discussion of DOE's analysis of the design earthquake and peak horizontal ground acceleration value for the Cheney disposal site.

2.4 Geologic Suitability

Geological conditions and processes at the proposed site are characterized to determine the ability to meet 40 CFR 192.02(a). In general, site lithologic, stratigraphic, and structural conditions are considered for their suitability as a disposal foundation and their potential interaction with tailings leachate and ground water. Geomorphic processes are considered for their potential impact upon long-term tailings stabilization and isolation. Potential geologic hazards, including seismic shaking, liquefaction, on-site fault rupture, ground collapse, and volcanism are identified for the purpose of assuring the long-term stability of the disposal cell and success of the remedial action.

2.4.1 Bedrock Suitability

DOE's proposed remedial actions are influenced mainly by characteristics of unconsolidated floodplain deposits at Grand Junction's mill site and colluvial deposits at Cheney. The staff concludes that bedrock stratigraphic and structural conditions at the sites should have no effect on DOE's ability to meet remedial action standards.

2.4.2 Geomorphic Stability

Stabilization of mill tailings in their present location would likely require constant maintenance and repair of existing erosion control features. Proposed removal of the Grand Junction site's tailings will result in elimination of the processing site's major geomorphic hazard: erosion of tailings during a catastrophic flood event in the Colorado River basin.

Adequate characterization and interpretation of surficial deposits and bedrock conditions at Cheney presented a major concern early in NRC's review process. Geomorphic issues addressed by NRC focused on (1) evidence at the site that the Cheney area has experienced long-term landscape stability in the past, and (2) potential for future channel incision and site instability.

Geomorphic features observed by site investigators, and cited as evidence of past long-term landscape stability, included relic bar-and-swale topography, desert pavement, desert varnish on surficial stones, and well-developed soils with argillic B and calcic C horizons. The staff found that presentation of DOE's observations and interpretations were not clear or complete, and made comments on the draft RAP regarding landscape stability at Cheney. Careful review of the RAP, references to applicable geological literature, discussion between staff and DOE's geomorphic consultant, requests for additional information, and staff site visits resulted in a better understanding of the site's features as described in the RAP. Site visits by NRC staff confirmed the existence of several of the features, and interpretations that the pediment surface is at least late Pleistocene in age (DOE, 1991c) appear to be accurate. The staff, however, suggested the bar-and-swale features could be evidence of recent overland flow concentration and incipient channel formation. Therefore, the NRC staff concludes that potential channel growth and erosion of the site will be accounted for in the site design.

Based on a compilation of erosion rates from an extensive literature study, DOE (1991c) considers that the greatest geomorphic hazard at the Cheney site is headward extension of deep gullies, one of which occurs south of the edge of the proposed disposal area. The NRC staff considered in its early reviews that formation of new gullies was a hazard which DOE also needed to consider.

DOE's analysis of this hazard includes discussion of several conditions which enhance geomorphic stability at the site. These include diversion of overland surface flow by placement of the cell, backfilling of the south-side gully, and naturally-armoring site conditions. DOE also proposes that the disposal cell be surrounded by rock aprons designed to safely convey flood runoff away from the tailings and prevent gully erosion into the stabilized pile. Section 4.3.2 of this report discusses the design of the rock apron and the staff has concluded that the design of the apron is adequate to prevent erosion of the disposal cell.

2.4.3 Seismotectonic Stability

In order to select a design earthquake and estimate on-site horizontal ground acceleration for use in subsequent engineering analyses, DOE employed attenuation relationships of Campbell (1981). The NRC staff considered that use of Campbell (1981) relationships were unacceptably restrictive, and were biased toward geologic and seismic conditions of the California area. The staff's original review finding perceived a failure to employ current and germane methods that are acceptable to the seismologic community in general.

Based on a further analysis that accounted for regional variations of attenuation, the staff determined that calculated peak ground acceleration varied only 0.01g between the two methods. Therefore, the original calculations are considered to be reasonably conservative for design calculations, and further analysis is unnecessary.

Based on fault and seismicity analyses described above, DOE concluded that faults near the Cheney site are associated with modern tectonic activity in the Uncompahgre Uplift. DOE employed published methods to determine an expected magnitude (Bonilla and others, 1984) and on-site peak horizontal ground acceleration (Campbell, 1981) resulting from rupture on any fault associated with the Uncompahgre Uplift or other faults considered capable. As a result, DOE adopted the nearest fault (number 8; DOE, 1991c, page 79 and Plate 2.1) as the design fault for the Cheney site. Fault number 8 is predicted to experience a maximum credible earthquake of magnitude 6.8 and produce an on-site peak horizontal bedrock acceleration of 0.42g. These criteria were derived through reasonable and conservative means, and the staff accepts their adoption as design criteria for the Cheney disposal site.

2.5 Conclusions

Based upon review of the Final RAP and associated documents, and DOE's response to NRC comments on drafts of these documents, the staff has reasonable assurance that regional and site geological conditions have been characterized adequately to meet 40 CFR 192. As discussed in Section 2.4.2, the staff's concern regarding the potential for future gully intrusion into the tailings embankment has been resolved by DOE's proposed revised apron design. Other conditions which would hinder long-term stability have been identified and mitigated by the design features.

3.0 GEOTECHNICAL STABILITY

3.1 Introduction

This section presents the NRC staff review of the geotechnical engineering aspects of the proposed remedial actions at the Grand Junction, Colorado UMTRA Project site, as detailed in DOE's Final RAP (DOE, 1991a-f) and Remedial Action Inspection Plan (MK-Ferguson, 1991). The review results consist primarily of evaluations of the site characterization and geotechnical stability aspects of the stabilized tailings embankment and the cover design. The staff review of related geologic aspects such as stratigraphic, structural, geomorphic, and seismic characterizations of the site is presented in Section 2.0 of this report. The staff review of the groundwater conditions and protection strategy for the site is presented in Section 5.0 of this report.

3.2 Site and Material Characterization

3.2.1 Processing Site Description

The uranium mill tailings at Grand Junction were placed in one pile covering the southwestern and central areas of the site. The pile forms a deposit that is approximately 10 feet thick at the western end of the site and is as much as 52 feet thick in the northeastern part. Shortly after the mill was shut down, efforts were made to stabilize the pile by the placement of concrete and brick from demolished mill buildings as riprap along the river. The settling ponds were also covered with material from demolished buildings and then were contoured with an estimated 174,000 tons of tailings transferred from the main tailings pile. The tailings pile was then covered by a minimum thickness of six inches of soil and revegetated. Contamination of material below the tailings pile has occurred due to the movement of tailings liquids into the subpile materials. As discussed in Section 1.2, contaminated material from cleanup of vicinity properties in the Grand Junction area has been placed in an area adjacent to and east of the tailings pile near the ponds since 1973.

The Grand Junction site is on a young alluvial terrace a few feet above the present level of the Colorado River. Bedrock beneath the site consists of the Cretaceous-age Mancos Shale, Dakota Sandstone, and Burro Canyon Formation, which dip to the northeast under the site. A detailed geologic study at the mill site was not conducted since the tailings and other contaminated materials will be relocated for stabilization.

3.2.2 Processing Site Investigations

Several subsurface investigations have been performed at the Grand Junction processing site in order to characterize the tailings and contaminated materials for geotechnical engineering and radiological aspects of the remedial action (DOE, 1991f). A study by Bendix Field Engineering Corporation in 1985, to determine the extent of contamination, consisted of 358 shallow soil samples, 177 boreholes, and 175 in-situ Ra-226 measurements. Results of this investigation were used in estimating the volume of contaminated material to be relocated to the Cheney Reservoir disposal site. Additional investigations conducted by Colorado State University in 1980; Sergeant, Hauskins, and Beckwith in 1981; Golder Associates in 1982; Jacobs Engineering Group in 1984 and 1989; and Lincoln-DeVore in 1987, resulted in over 240 borings, 5 test pits, 27 lysimeters, and monitoring wells, from which samples for laboratory analysis were obtained. Geotechnical engineering characteristics of the tailings and contaminated materials have been determined through laboratory analysis of the samples from these investigations.

3.2.3 Cheney Reservoir Disposal Site Description

The Cheney Reservoir disposal site lies between Grand Mesa and the Gunnison River, 18 miles southeast of Grand Junction along U.S. Highway 50. The terrain at the site is very flat and the area is sparsely covered with grasses and shrubs. The average elevation of the disposal area is about 5230 feet. The zero- to 3-foot-thick layer of surficial material at the site is an eolian-derived silt with some clay and sand with gravel to boulder size basalt fragments. Underlying the silt is a mixture of alluvium with colluvium deposits and mudflow debris consisting of interlayered clay, silt, sand, and gravel with occasional layers of basalt cobbles and boulders.

3.2.4 Cheney Reservoir Disposal Site Investigations

Investigations conducted by Jacobs Engineering Group in 1984 and 1989, Lincoln-DeVore in 1986, and Western Engineers in 1987 were performed at the Cheney Reservoir Site in order to obtain geotechnical engineering and groundwater characterization data (DOE, 1991f). These investigations included over 130 borings, 158 test pits, and 38 monitoring wells from which samples for laboratory analysis were obtained. Geotechnical engineering characteristics and certain radiological characteristics of the materials were determined through laboratory analysis of samples from these investigations. In addition, 1200 linear feet of continuous trench were excavated and a surface geophysical survey was conducted to learn the nature of the shallow groundwater beneath the disposal site.

3.2.5 Cheney Reservoir Disposal Site Stratigraphy

The site stratigraphy can be divided into four zones as defined by the soil borings described in the previous section. These four zones are: (1) the surficial layer of unconsolidated deposits described in section 3.2.3 above; (2) the upper weathered zone of the Mancos Shale; (3) the lower, less-weathered portion of the Mancos Shale; and (4) the Dakota Sandstone and other formations underlying the Mancos Shale. The unconsolidated deposits of the surficial layer range in thickness from 15 feet to 50 feet based on the borings. Soils of this unit range from clays to large boulders. Finer-grained materials consist of clays (CL), clay and silt mixtures (CL-ML), and sandy silts and clays (SM and SC). These materials are intermixed and interlayered with sand and gravel deposits that are cemented to varying degrees. Larger cobbles and boulders are frequent and randomly mixed throughout the entire thickness of the deposit. Generally, the clays and silts range from low to medium plasticity. The coarse-grained materials are usually rounded to subrounded and contain the full distribution of sizes. Substantial gypsum deposits resulting from evaporation of transient waters in paleochannels are present within this unit. The upper unit is underlain by the Mancos Shale, which extends to depths on the order of 750 feet. The surface of the Mancos Shale was eroded before the surficial materials were deposited, creating gullies in the Mancos.

Groundwater in the Cheney Reservoir disposal site area occurs in isolated, thin paleochannels within the basal portion of the alluvium, in fracture systems in the underlying unweathered Mancos Shale, and in the Dakota Formation. However, detailed field investigations identified a large area suitable for the disposal cell that is devoid of water-filled paleochannels (see Section 5.0).

The staff has reviewed the details of the test pits and borings as well as the scope of the overall geotechnical exploration program discussed in Section 3.2.4 above. The staff concludes that the geotechnical investigations conducted at the Cheney Reservoir disposal site adequately establish the stratigraphy and the soil conditions at the Cheney Reservoir site, that the explorations are in general conformance with applicable provisions of Chapter 2 of the NRC SRP (NRC, 1993), and that they are adequate to support the assessment of the geotechnical stability of the stabilized tailings and contaminated material in the disposal cell.

3.2.6 Testing Program

The staff has reviewed the geotechnical engineering testing program for materials from the Grand Junction processing site and the Cheney Reservoir disposal site. The testing program included specific gravity, Atterberg limits, particle size distribution, moisture/density relationships, shear strength, permeability, and consolidation tests on samples of tailings and contaminated materials and soils from the disposal site. The staff finds that the testing program employed was appropriate for support of necessary engineering analyses and that the scope of the testing program and the utilization of the test results to define the material properties are in general agreement with applicable provisions of the NRC SRP.

3.3 Geotechnical Engineering Evaluation

3.3.1 Stability Evaluation

The staff has reviewed the exploration data, test results, critical slope characteristics, and methods of analyses pertinent to the slope stability aspects of the remedial action plan for the Grand Junction UMTRA Project disposal embankment. The analyzed cross section with the 5 horizontal to 1 vertical slope has been compared with the exploration records and the design details. The staff finds that the most critical slope section has been considered for the stability analysis.

Soil parameters for the various materials in the stabilized embankment slope have been adequately established by appropriate testing of representative material. Values of parameters for other earthen materials have been assigned on the basis of data obtained from geotechnical explorations at the site and data published in the literature. The staff also finds that appropriate methods of stability analysis (the Morgenstern-Price Method and infinite slope) have been employed and have addressed the likely adverse conditions to which the slope may be subjected.

Factors of safety against failure of the slope for seismic loading conditions and static loading conditions have been evaluated for both the short-term (end-of-construction) and long-term state. The values of the seismic coefficients used in the analysis are 0.25g for the long-term condition and 0.19g for the short-term condition. These values were derived from the 0.42g peak horizontal bedrock acceleration (see Section 2.4.3) in accordance with the recommended methods in the NRC SRP and are acceptable to the staff. The staff finds that the use of the pseudo-static method of analysis for seismic stability of the slopes is acceptable considering the flatness of the slopes and the conservatism in the soil parameter values. The minimum factors of safety against failure of the slope were 2.36 and 1.05 for the short-term static and pseudo-static conditions, respectively, compared to required minimums of 1.3 and 1.0, respectively. The minimum factors of safety against failure of the slope were 3.28 and 1.01 for the long-term static and pseudo-static conditions, respectively, compared to accepted minimums of 1.5 and 1.0, respectively. Although groundwater levels may be shallower than those assumed by DOE, the stability of slopes will not be adversely affected.

The supporting calculations reflect the current excavation plan, i.e. an additional 6 feet of excavation into the Mancos shale to accommodate an additional 1.1 million cubic yards of contaminated materials. The effect of this design change on slope stability was addressed adequately by information submitted by DOE prior to the Final RAP (DOE, 1993).

3.3.2 Settlement

The staff has reviewed the analysis of total and differential settlement of the disposal cell and foundation materials and the resulting potential for cracking of the radon barrier. Calculations indicate that all settlement due to placement of the main pile tailings, off-pile tailings, and radon barrier will have taken place by the time the radon barrier construction is completed. Therefore, the primary concern is the settlement due to the placement of the erosion protection materials. Settlements due to the placement of the erosion protection were calculated at three profiles along an east-west partial cross section through the disposal cell. The staff agrees that an appropriate section has been chosen to assess the most critical conditions for differential settlement. Calculated settlements along the profile varied from 0.03 inches to 1.6 inches, with a resulting maximum horizontal strain of 0.005 percent. The calculated tensile failure strain for the proposed radon barrier material (PI=19) was 0.108 percent.

DOE has concluded that total and differential settlement of the materials comprising the proposed disposal cell will not have an adverse effect on the ability of the cell to meet the stability standards. The staff agrees that settlement will generally be small due to the compaction of the materials in the cell and the granular nature of much of the material. Differential settlement should not cause ponding concerns due to the sloping configuration of the cell. Cracking of the cover due to settlement should not occur, since the resulting maximum strain is well below the calculated tensile failure strain.

3.3.3 Liquefaction

The staff has reviewed the information presented on the potential for liquefaction at the site based on the results of geotechnical investigations, including boring and test pit logs, test data, soil profiles, and other information. The consolidated shale bedrock foundation material is not susceptible to liquefaction. The compacted dry density of the stabilized tailings and contaminated materials will be equal to a minimum of 90 percent of maximum dry density as determined by the ASTM D-698 test, and the tailings pile embankment design provides for the tailings materials to be mostly in an unsaturated condition. DOE has indicated that a portion of the tailings may become saturated for a time. A two-dimensional, finite element method flow analysis of transient drainage of tailings pore water shows that the maximum depth of saturation in the tailings (at the base of the disposal cell) will range from zero to 12.3 feet within one to two years after completion of the remedial action. However, given the compacted nature of the tailings, the conservatism applied in the worst-case transient drainage analysis, and the unlikelihood of a heavy earthquake during the period of saturation, the staff concludes that the stability of the disposal cell will not be adversely affected by seismically-induced liquefaction.

3.3.4 Cover Design

The proposed cover design for the Cheney Reservoir disposal cell employs a multi-layered system of earthen materials with differing layers on the top slopes and the side slopes. On the top, in descending order from the surface, are: (1) a one-foot-thick Type A riprap layer; (2) a 6-inch-thick clean sand bedding/drain layer; (3) a 2-foot-thick frost protection layer; and (4) a 2-foot-thick radon/infiltration barrier. On the side slopes, in descending order are: (1) a one-foot-thick Type B or C riprap layer; (2) a 6-inch-thick clean sand bedding/drain layer; and (3) a 3.5-foot-thick radon/infiltration barrier. This cover system provides a total of from 5 to 5.75 feet of cover over the contaminated material, and collectively is designed to limit infiltration of precipitation, protect the pile from erosion, and control the release of radon from the cell. Details of the staff review of the cover's performance related to erosion protection features is presented in Section 4.0 of this TER; the review of the cover's performance related to limiting infiltration are addressed in Section 5.0; and the review of the radon attenuation aspects of the cover is presented in Section 6.0. However, there are certain other aspects of the cover (frost protection, gradation/filter design, etc.) that are addressed in this section of the TER.

The RAS (DOE, 1991a) indicates that the radon/infiltration barrier will consist of compacted clay that will limit infiltration and inhibit radon emanation. The specifications provide for the use of excavated silty clay material from depths of about 10 to 15 feet, or if necessary, screened material from the overlying gravelly layer. These two materials will have satisfactory permeabilities of at least 1×10^{-7} cm/sec, which is consistent with the requirements of the water resources protection strategy.

The RAS indicates that the layer immediately above the radon barrier is to be a 6-inch-thick sand bedding/drain layer, intended to drain water laterally off the cell and protect the radon barrier from the riprap.

The top layer of cover on the side slopes is proposed to consist of 1-foot of Types B and C riprap (D_{50} > 6 in). The proposed erosion protection for the top slope is a 1-foot-thick Type A riprap. Details of the review of the erosion protection design are found in Section 4.0 of this report.

The cover design includes a 2-foot-thick layer constructed solely for the purpose of protecting the radon barrier against frost damage. A computer analysis of the depth of frost penetration indicates that the combined thickness of the various layers of material and the radon barrier itself will provide adequate frost protection. The staff concurs that no additional frost protection is necessary.

Based on the geotechnical review of the disposal cell cover design, the staff has determined that the cover has been adequately designed from a geotechnical engineering perspective to provide the necessary protection for the long term.

3.4 <u>Geotechnical Construction Details</u>

3.4.1 Construction Methods and Features

The staff has reviewed and evaluated the geotechnical construction criteria provided in Attachment 1 to the RAP. Based on this review, the staff concludes that the plans and drawings clearly convey the proposed remedial action design features. In addition, the excavation and placement methods and specifications represent accepted standard practice.

3.4.2 Testing and Inspection

The staff has reviewed and evaluated the testing and inspection quality control requirements provided in the Remedial Action Inspection Plan (RAIP). In general, the RAIP is found to provide a program for testing and inspection that is consistent with the Staff Technical Position on Testing and Inspection (NRC, 1989a).

3.5 Conclusions

Based on the review of the geotechnical engineering aspects of the design of the Grand Junction, Colorado proposed remedial action, the NRC staff has reasonable assurance that the long-term stability aspects of the EPA standards [40 CFR Part 192.02(a)] will be met by the design selected by DOE.

4.0 SURFACE WATER HYDROLOGY AND EROSION PROTECTION

4.1 Hydrologic Description and Site Conceptual Design

DOE proposes to move the existing tailings in the city of Grand Junction, Colorado, from their present location in the floodplain of the Colorado River to the Cheney Reservoir site. The Cheney Reservoir site is located approximately 18 miles southeast of Grand Junction.

The disposal site is in a remote, relatively flat area and is located on a pediment surface that forms a divide between two small ephemeral washes. These washes are located 1400 feet north of the tailings pile and 1000 feet south of the pile and merge with Indian Creek approximately ½ mile below the site. Indian Creek flows into Kannah Creek, which discharges into the Gunnison River.

A local drainage area of about 240 acres drains toward the pile. Slopes in this watershed average about 2 1/2 to 3 percent. Flows from about 140 acres of this drainage area will be intercepted by a diversion channel, located northeast of the remediated pile. Some gullying is occurring in the watershed and in the small ephemeral streams in the site vicinity.

In order to comply with EPA standards, which require stability of the tailings for 1,000 years to the extent reasonably achievable and, in any case, for at least 200 years, DOE proposes to stabilize the contaminated materials in an engineered embankment to protect them from flooding and erosion. The design basis events for design of the erosion protection included the Probable Maximum Precipitation (PMP) and the Probable Maximum Flood (PMF) events, both of which are considered to have low probabilities of occurrence during the 1000-year stabilization period.

As proposed by DOE, the tailings will be consolidated into a single pile, which will be protected by a rock cover. The rock cover will have a maximum slope of 2.3% on the top slopes and 20% on the side slopes. The disposal cell will be surrounded by aprons which will safely convey flood runoff away from the cell and prevent gully intrusion into the contaminated materials. In addition, a drainage swale (diversion ditch) north of the embankment will be constructed to divert flood flows from the upland drainage area away from the disposal cell toward an existing gully on the east side of the site. This diversion ditch will be located about 400 feet away from the contaminated material.

4.2 Flooding Determinations

The computation of peak flood discharges for various design features at the site was performed by DOE in several steps. These steps included: (1) selection of a design rainfall event; (2) determination of infiltration losses; (3) determination of times of concentration; and (4) determination of appropriate rainfall distributions, corresponding to the computed times of concentration. Input parameters were derived from each of these steps and were then used to determine the peak flood discharges to be used in water surface profile modelling and in the final determination of rock sizes for erosion protection.

4.2.1 Selection of Design Rainfall Event

One of the most disruptive phenomena affecting long-term stability is surface water erosion. DOE has recognized that it is very important to select an appropriately conservative rainfall event on which to base the flood protection designs. DOE has concluded and the NRC staff concurs (NRC, 1990) that the selection of a design flood event should not be based on the extrapolation of limited historical flood data, due to the unknown level of accuracy associated with such extrapolations. Rather, DOE utilized the PMP, which is computed by deterministic methods (rather than statistical methods), and is based on site-specific hydrometeorological characteristics. The PMP has been defined as the most severe reasonably possible rainfall event that could occur as a result of a combination of the most severe meteorological conditions occurring over a watershed. No recurrence interval is normally assigned to the PMP; however, DOE and the NRC staff have concluded that the probability of such an event being equalled or exceeded during the 1000-year stability period is small. Therefore, the PMP is considered by the NRC staff to provide an acceptable design basis.

Prior to determining the runoff from the drainage basin, the flooding analysis requires the determination of PMP amounts for the specific site location. Techniques for determining the PMP have been developed for the entire United States primarily by the NOAA in the form of hydrometeorological reports for specific regions. These techniques are widely used and provide straightforward procedures with minimal variability. The staff, therefore, concludes that use of these reports to derive PMP estimates is acceptable.

A PMP rainfall depth of approximately 7.9 inches in one hour was used by DOE to compute the PMF for the small drainage areas at the disposal site. This rainfall estimate was developed by DOE using Hydrometeorological Report (HMR) 49 (NOAA, 1977). The staff performed an independent check of the PMP value, based on the procedures given in HMR 49. Based on this check of the rainfall computations, the staff concludes that the PMP was acceptably derived for this site.

4.2.2 Infiltration Losses

Determination of the peak runoff rate is dependent on the amount of precipitation that infiltrates into the ground during the occurrence of the rainfall. If the ground is saturated from previous rains, very little of the rainfall will infiltrate and most of it will become surface runoff. The loss rate is highly variable, depending on the vegetation and soil characteristics of the watershed. Typically, all runoff models incorporate a variable runoff coefficient or variable runoff rates. Commonly-used models such as the U.S. Bureau of Reclamation Rational Formula (USBR, 1977) incorporate a runoff coefficient (C); a C value of 1 represents 100% runoff and no infiltration. Other models such as the U.S. Army Corps of Engineers (ACE) Flood Hydrograph Package HEC-1 separately compute infiltration losses within a certain period of time to arrive at a runoff amount during that time period.

In computing the peak flow rate for the design of the rock riprap erosion protection at the proposed disposal site, DOE used the Rational Formula (USBR, 1977). In this formula, the runoff coefficient was assumed by DOE to be unity; that is, DOE assumed that no infiltration would occur. Based on a review of the computations, the staff concludes that this is a very conservative assumption and is, therefore, acceptable.

4.2.3 Times of Concentration

The time of concentration (tc) is the amount of time required for runoff to reach the outlet of a drainage basin from the most remote point in that basin. The peak runoff for a given drainage basin is inversely proportional to the time of concentration. If the time of concentration is computed to be small, the peak discharge will be conservatively large. Times of concentration and/or lag times are typically computed using empirical relationships such as those developed by Federal agencies (USBR, 1977). Velocity-based approaches are also used when accurate estimates are needed. Such approaches rely on estimates of actual flow velocities to determine the time of concentration of a drainage basin.

Various times of concentration for the riprap design were estimated by DOE using several methods, such as the Kirpich Method (USBR, 1977) and the Manning's Equation (Chow, 1959). Such velocity-based methods are considered by the staff to be appropriate for estimating times of concentration. Based on the precision and conservatism associated with such methods, the staff concludes that the tc's have been acceptably derived. The staff further concludes that the procedures used for computing tc are representative of the small steep drainage areas present at the site.

4.2.4 Rainfall Distributions

After the PMP is determined, it is necessary to determine the rainfall intensities corresponding to shorter rainfall durations and times of concentration. A typical PMP value is derived for periods of about one hour. If the time of concentration is less than one hour, it is necessary to extrapolate the data presented in the various hydrometeorological reports to shorter time periods. DOE utilized a procedure recommended in HMR 49 and by the NRC staff (NRC, 1990). This procedure involves the determination of rainfall amounts as a percentage of the one-hour PMP, and computes rainfall amounts and intensities for very short periods of time. DOE and the NRC staff have concluded that this procedure is conservative.

In the determination of peak flood flows, approximate PMP rainfall intensities were derived by DOE as follows:

Rainfall Duration (minutes)	Rainfall Intensity (inches/hr)
2.5	52.0
5.0	43.0
15.0	24.0
60.0	7.9

The staff checked the rainfall intensities for the short durations associated with small drainage basins. Based on a review of this aspect of the flooding determination, the staff concludes that the computed peak rainfall intensities are conservative.

4.2.5 Computation of PMF

4.2.5.1 Top and Side Slopes

The PMF was estimated for the top and side slopes using the Rational Formula (USBR, 1977), which provides a standard method for estimating flood discharges for small drainage areas. For a maximum top slope length of 1650 feet, and an additional side slope length of about 180 feet, DOE estimated the peak flow rate to be about 1.0 cubic feet per second per foot of width (cfs/ft) for the top slope and 1.1 cfs/ft for the side slope. These estimates are based on the conservative use of a maximum top slope length of 1650 feet. Based on staff review of the calculations, the estimate is considered to be conservative.

4.2.5.2 Apron/Toe

A PMF flow rate of 1.2 cfs/ft for the downstream apron was computed similarly to the design flow rate for the top and side slopes. As discussed above, the flow rate is considered to be conservative.

4.2.5.3 Diversion Ditch

The diversion ditch is a trapezoidal channel designed to intercept and divert runoff from the upland area into a natural gully (Creek C) on the east side of the site. The channel will run north and south along the east side of the disposal cell and will be aligned perpendicular to the natural grade. The side slope of the channel on the embankment side is 20 percent and on the upland side varies from 20 percent to 4 percent. The bottom width of the channel is 20 feet at the most upstream location and gradually widens to 200 feet at the outlet. The total tributary area is about 140 acres.

In the PMF analysis, the Rational Formula was used to compute peak flow rates at different locations. A maximum flow rate of about 1700 cfs was estimated as the peak PMF discharge. Based on a check of the calculations of drainage area, time of concentration, and rainfall intensity, the staff concludes that the PMF estimate is acceptable.

4.3 <u>Water Surface Profiles and Channel Velocities</u>

Following the determination of the peak flood discharge, it is necessary to determine the resulting water levels, velocities, and shear stresses associated with that discharge. These parameters then provide the basis for the determination of the required riprap size and layer thickness needed to assure stability during the occurrence of the design event.

4.3.1 Top and Side Slopes

In determining riprap requirements for the top and side slopes, DOE utilized the Safety Factors Method (Stevens, and others, 1976) and the Stephenson Method (Stephenson, 1979), respectively. The Safety Factors Method is used for relatively flat slopes of less than 10 percent; the Stephenson Method is used for slopes greater than 10 percent. The validity of these design approaches has been verified by the NRC staff through the use of flume tests at Colorado State University. It was determined that the selection of an appropriate design procedure depends on the magnitude of the slope (Abt and others, 1987). The staff therefore concludes that the procedures and design approaches used by DOE are acceptable and reflect state-of-the-art methods for designing riprap erosion protection.

4.3.2 Apron/Toe

The design of the 20-foot wide apron on a 10% slope at the toe of the disposal cell is based on the following:

1. provide riprap of adequate size to be stable against the design storm (PMP),

2. provide uniform and/or gentle grades along the apron and the adjacent ground surface such that runoff from the cell is distributed uniformly at a relatively low velocity, minimizing the potential for flow concentration and erosion, and

3. provide an adequate apron thickness to prevent undercutting of the disposal cell by (a) local scour that could result from the PMP, or (b) potential gully encroachment that could occur due to gradual headcutting over a long period of time.

The key elements which DOE considered in the design of riprap protection for the apron/toe are:

1. the lower part of the 20% side slope immediately upstream of the grade break,

2. the toe, which is the relatively flat lower slope (10%) immediately downstream of the grade break formed when the side slope meets the apron,

3. the downstream portion of the apron which is assumed to have collapsed due to scour or long-term erosion, and

4. the ground surface adjacent to the apron.

DOE used several analytical methods for designing the riprap for the apron/toe. Additional detailed discussion of the riprap design of various components of the apron/toe can be found in Section 4.4.1.2, below.

4.3.3 Diversion Ditch

The ACE HEC-2 was used to estimate depths and velocities under the estimated discharge conditions in the main section of the channel. The flow depths and velocities in the channel range from 0.7 to 2.2 feet and from 4.5 to 8.5 feet per second, respectively. The invert slope of the channel varies from 1.25 percent at the upstream end to 1.00 percent at the downstream end. The upper portion of the natural gully at the channel outlet will be filled with oversized large riprap; thus, DOE considers that the maximum outlet velocity will not cause headcutting or further erosion of the natural gully. The design of erosion protection for the outlets of the ditch is further discussed in Section 4.4.1.3.3, below.

The Safety Factors Method was used to determine riprap sizes for the ditch. Based on staff review of the calculations, the analysis is acceptable. Additional detailed information related to the design of erosion protection for the ditches may be found in Section 4.4, below.

4.4 <u>Erosion Protection</u>

4.4.1 Sizing of Erosion Protection

Riprap layers of various sizes and thicknesses are proposed for use at the site. The design of each layer is dependent on its location and purpose.

4.4.1.1 Top and Side Slopes

The riprap on the top slope has been sized to withstand the erosive velocities resulting from an on-cell PMP, as discussed above. DOE proposes to use a 1.0-foot-thick layer of Type A rock with a minimum D50 of 1.8 inches. A six-inch layer of riprap will be used where the riprap protects clean fill material. The riprap will be placed on a 0.5-foot-thick bedding layer. The Safety Factor Method was used to determine the rock size.

The rock layer on the side slopes is also designed for an occurrence of the local PMP. DOE proposes to use a 1.0-foot-thick layer of rock with a minimum D50 of approximately 5.5 inches. The rock layer will be placed on a 0.5-foot-thick bedding layer. Stephenson's Method was used to determine the required rock size. Conservative values were used for the specific gravity of the rock, the rock angle of internal friction, and porosity.

The riprap sizes proposed for the top and side slopes include a 15% allowance for oversizing, based on the results of durability tests (See Section 4.4.2, below). For the top slope and side slopes, riprap sizes of only 1.0 and 4.7 inches would be required, respectively; however, DOE will provide larger sizes to accomodate NRC durability criteria (NRC, 1990).

Based on staff review of the DOE analyses and the acceptability of using design methods recommended by the NRC staff, as discussed in Section 4.3 of this report, the staff concludes that the proposed rock sizes are adequate.

4.4.1.2 Apron/Toe

DOE evaluated the design of the apron/toe in four separate segments, as discussed in Section 4.3.2, above. Following is the staff evaluation of each of the segments.

4.4.1.2.1 Lower Side Slope

For the lower portion of the side slopes, DOE proposes to use a 1.0-foot-thick layer of Type C rock, gradually increasing in thickness to a 4.0-foot-thick layer of rock, with a minimum D50 size of 16 inches. Several methods were used to check the rock size required for the toe. DOE determined the shear forces associated with PMP flows down the side slope and assumed that turbulence would be created on the lower portion of the slope where it meets the toe. To account for this turbulence (and energy dissipation), DOE increased the shear stress by 50% in accordance with USACE recommendations (ACE, 1970). The maximum rock size of 13 inches was computed using the Safety Factors Method. Based on staff analysis of DOE's methods and assumptions, the 16-inch Type C rock proposed for this portion of the slope is acceptable.

4.4.1.2.2 Toe

For the actual toe area, which will have a 20-foot length and a 10% slope, DOE used the Stephenson Method to determine the required rock size. The flow rate was increased by a factor of 3 to account for flow concentrations near the downstream of the apron. The rock size calculated using this method was found to be about 13 inches, which is smaller that the proposed D50 size of 16 inches. Based on our review of DOE's calculations, the rock size is acceptable.

4.4.1.2.3 Collapsed Slope

As part of the analysis of the toe area, DOE conservatively assumed that the natural ground downstream of the toe would be eroded due to cumulative local scour and/or erosion at its base, resulting in the collapse of the rock into the eroded area. It was assumed that the collapsed slope of the rock would be 1 vertical (V) on 3 horizontal (H). The required rock size for flow over this slope was calculated using the Stephenson Method, as recommended by the staff. Using this method, the required size is calculated to be about 16 inches. Since this computed size is equivalent to the proposed size of 16 inches, the rock is acceptable.

4.4.1.2.4 Natural Ground

In order to determine the depth to which the toe must be placed, it is necessary to estimate the depth of scour which will occur to the graded natural ground slope just downstream of the toe. DOE assumed that the ground slope would be about 6% and assumed that a flow concentration factor of 3, corresponding to gully flows, would occur. Using the Lacey Regime Equation (Davis and Sorensen, 1969), the scour depth was estimated to be about three feet. However, DOE proposes to place the toe to a depth of four feet to provide added conservatism to account for a possible increased erosion. Staff review of the calculations indicates that the methods are appropriate and conservative.

4.4.1.3 Interceptor Ditch

The riprap design of the interceptor ditch was analyzed by DOE in the following areas:

1. design of the ditch side slopes for runoff directly down the side slopes from the embankment and from the upland drainage area,

2. design for runoff directly through the ditch,

3. design of ditch outlet, and

4. sediment considerations.

4.4.1.3.1 Ditch Side Slopes

A Type B riprap layer with a minimum D50 of 7.2 inches is proposed for a substantial length of the ditch. The design of the ditch side slopes considered the effects of PMF sheet flows directly down the proposed 1V on 5H embankment side slopes and from the upland drainage area. For the embankment side of the ditch, DOE checked the proposed rock size for a flow of 0.60 cfs/ft. Using the Stephenson Method for the 1V on 5H ditch side slope, the required D50 was found to be 3.2 inches, which is less than the size proposed. For the other side of the ditch (which receives flows from the upland drainage area) and a flow rate of 2.64 cfs/ft. (corresponding to a flow concentration factor of 3), the required D50 was found to be about 6 inches, approximately the size proposed.

However, the design condition for the embankment side of the channel is the formation of flow concentrations near the side slope, resulting from sedimentation and gullying near the toe of the slope. Under these conditions, DOE assumed that nearly all of the PMF flow in the ditch was concentrated near the toe. The required rock size was calculated by DOE to be 11 inches. In addition, the scour depth associated with this condition was calculated to be about 5 feet. To accomodate this, DOE proposes that the side slope on the embankment side of the channel will consist of Type C riprap, with a D50 of 13 inches, and will extend 5 feet below the channel bottom.

For the upland side slope of the channel, a severe condition exists where the flows from natural gullies could impinge. The proposed Type B rock size of 7.2 inches is not adequate to prevent erosion of the slopes under PMF conditions in a natural gully. However, the staff considers that this erosion will not affect the stability of the contaminated tailings for the following reasons: (1) the diversion channel is at least 400 feet away from the tailings; (2) the erosion that occurs to the diversion channel will occur in a limited area at the immediate location of the incoming gully flow; (3) the embankment side slope consisting of Type C rock to a depth of 5 feet is adequate to limit the extent of erosion; (4) the Type B rock is capable of resisting erosion from 200-year flood event; (5) the slope of the tailings embankment is towards the channel, preventing flows from reaching anywhere near the contaminated tailings, if damage to the embankment side slope occurs; and (6) DOE has documented that PMF overflows (resulting from blockage, for example - see Section 4.4.1.3.4) will not result in erosion of the Type A riprap on the 2.3 percent embankment slopes.

It should be emphasized that some damage can be expected to occur to the upland side slopes of the diversion channel. The damage is not expected to be extensive or to compromise the stability of the tailings over a 1000-year period. This expected condition should be noted in the Long Term Surveillance Plan (LTSP) for the Grand Junction site.

4.4.1.3.2 Ditch (Main Section)

For flows directly through the ditch, the Safety Factors Method was used to determine the rock size. Based on a review of the calculations, the proposed Type B rock size of 5.5 inches for the channel bottom and upland side slope is considered to be adequate. The Type C riprap proposed for the embankment side slope is more than adequate to resist flow velocities directly along the length of the ditch.

4.4.1.3.3 Ditch Outlets

Maximum potential scour depths due to the PMF flows were computed using the U.S. Department of Transportation (DOT, 1975) formula and Lacey's formula (Davis and Sorensen, 1969). The maximum potential scour depths were calculated by DOE to be about five feet, using both of these formulae. DOE proposes that the riprap at the ditch outlets will, therefore, be extended down to five feet below grade.

The outlet section of the ditch is assumed to collapse due to either 1) gully headward erosion over a long period of time, or 2) the PMF flow in the ditch. In order to reduce the rock size at the outlet, a pre-formed outlet slope of 1V on 5H will be constructed. This slope requires a stable rock size of about 11 inches, calculated using the Stephenson Method. Type C riprap will be used in the immediate area of the outlet and will also be placed for a length of about 280 feet past the outlet to prevent headward gully development. Additionally, oversized boulders, with diameters in excess of 24 inches, will be placed along the bank of Creek C in the swale outlet area to prevent lateral erosion and further ensure geomorphic stability.

Based on a review of the calculations by the staff, the design of the outlet area is considered to be acceptable.

4.4.1.3.4 Sediment Considerations

In general, sediment deposition can be a problem in diversion ditches when the slope of the diversion ditch is less than the slope of the natural ground where flows enter the ditch. It is usually necessary to provide sufficient slope and capacity in the diversion ditch to flush or store any sediments which will enter the ditch. In particular, significant design features may be necessary in areas where natural gullies are intercepted by the diversion ditch. Concentrated flows and high velocities could transport large quantities of sediment, and the size of the particles transported by the natural gully may be larger than the man-made diversion ditch can effectively flush out.

For this site, a considerable amount of sediment from the upland drainage area can be expected to enter the diversion ditch, for the following reasons:

1. The upland drainage area has an average slope of about 2.5 percent in the vicinity of the ditch, whereas the diversion ditch itself has been designed with a relatively flat slope of about one percent in the reaches adjacent to the tailings embankment. Flow velocities in the ditches may not be as high as those occurring on the natural ground. Therefore, sediment, cobbles, and boulders may be transported to the ditch and may not be easily be flushed out by the lower velocities in the ditch.

2. The potential for gully development (and resulting high flow velocities) in the upland drainage area and subsequent transport of bed-load material into the diversion ditch is high. Gullies and areas of flow concentration are evident upstream of the diversion ditch, based on review of topographic maps of the area and a staff site visit to the area. Flows moving towards the diversion ditch will tend to concentrate in these gullies, increasing the potential for gully incision and transport of sediment.

In order to document the acceptability of the ditch design, DOE demonstrated that (1) the ditch will have some sediment-carrying capacity, (2) potential sediment deposition in the ditch will not significantly affect the ditch capacity, (3) any sediment blockage in the ditch will not have an adverse effect on the stability of the contaminated tailings, and (4) the Type C riprap on the embankment side of the ditch is large and extends to a depth of 5 feet, providing protection against direct impingement of natural gully flows. First, DOE provided analyses which indicated that the diversion ditch, with a slope of about one percent, will be able to flush out much of the sediment, other than the larger gravels and cobbles. Using storm events ranging in magnitude from the annual flood to the PMF, DOE calculated the critical shear stresses and velocities needed to transport materials of various sizes. It was determined that the slope of the ditch was sufficient to transport much of the smaller-sized materials during most flood events.

Second, DOE estimated the amount of sediment that will be deposited in the diversion ditch. DOE determined that the diversion ditch, with a width of as much as 200 feet at the downstream end, would have adequate flow capacity, even if a significant amount of blockage occurred.

Third, DOE estimated the amount of sediment which could build up in the ditch over a long period of time. Taking no credit for sediment removal, DOE performed analyses using HEC-2 and determined the effects of sediment buildup flow velocities and water surface profiles. Under conservative assumptions of large flow blockages, DOE determined that PMF flows in the ditch could possibly reach the 2.3% slope of the remediated embankment near the ditch. Using the Safety Factors Method, DOE estimated that a riprap size of 1.5 inches would be needed to resist the PMF forces. Since a riprap size of 1.5 inches is proposed for this portion of the cell, the riprap is considered by the staff to be adequate.

Fourth, the Type C riprap on the embankment side of the ditch will provide protection against direct impingement and concentration of natural gully flows. Since the ditch will be aligned perpendicular to the natural gullies, (and the upland side of the ditch is not designed for these flows), it is necessary to protect the opposite side slope of the ditch, particularly where the ditch is narrow and flows would not be dissipated in the ditch itself. As discussed in Section 4.4.1.3.1. of this report, the Type C riprap on the embankment side slope (extending to a depth of 5 feet) is sufficient to provide protection against substantial flow concentrations in the ditch.

4.4.2 Rock Durability

The EPA standards require that control of residual radioactive materials be effective for up to 1000 years, to the extent reasonably achievable, and, in any case, for at least 200 years. The previous sections of this report examined the ability of the erosion protection to withstand flooding events reasonably expected to occur in 1000 years. In this section, rock durability is considered to determine if there is reasonable assurance that the rock itself will survive and remain effective for 1000 years.

Rock durability is defined as the ability of a material to withstand the forces of weathering. Factors that affect rock durability are 1) chemical reactions with water, 2) saturation time, 3) temperature of the water, 4) scour by sediments, 5) windblown scour, 6) wetting and drying, and 7) freezing and thawing.

DOE identified an acceptable source of rock in the immediate site vicinity. The suitability of the rock as a protective cover was then assessed by laboratory tests to determine its physical characteristics. DOE conducted the tests and used the results of these tests to classify the rock's quality and to assess the expected long-term performance of the rock. In accordance with past DOE rock-testing practice, the tests included:

1. Petrographic Examination (ASTM C295). Petrographic examination of rock is used to determine its physical and chemical properties. The examination establishes if the rock contains chemically unstable minerals or volumetrically unstable materials.

2. Bulk Specific Gravity (ASTM C127). The specific gravity of a rock is an indicator of its strength or durability. In general, the higher the specific gravity is, the better the quality of the rock.

3. Absorption (ASTM C127). A low absorption is a desirable property and indicates slow disintegration of the rock by salt action and mineral hydration.

4. Sulfate Soundness (ASTM C88). In locations subject to freezing or exposure to salt water, a low percentage is desirable.

5. Schmidt Rebound Hammer. This test measures the hardness of a rock and can be used in either the field or the laboratory.

6. Los Angeles Abrasion (ASTM C131 or C535). This test is a measure of rock's resistance to abrasion.

7. Tensile Strength (ASTM D3967 or ISRM Method). This test is an indirect test of a rock's tensile strength.

DOE then used a step-by-step procedure for evaluating durability of the rock, in accordance with procedures recommended by the NRC staff (NRC, 1990), as follows:

Step 1. Test results from representative samples are scored on a scale of 0 to 10. Results of 8 to 10 are considered "good"; results of 5 to 8 are considered "fair"; and results of 0 to 5 are considered "poor."

Step 2. The score is multiplied by a weighting factor. The effect of the weighting factor is to focus the scoring on those tests that are the most applicable for the particular rock type being tested.

Step 3. The weighted scores are totaled, divided by the maximum possible score, and multiplied by 100 to determine the rating.

Step 4. The rock quality scores are then compared to the criteria which determines its acceptability, as defined in the NRC scoring procedures.

In accordance with the procedures suggested by the staff, DOE determined from preliminary testing that the rock proposed for the disposal site scored approximately 65-85. Since rock is needed in frequently-saturated areas, DOE proposes to oversize the rock by about 15%, based on the minimum score of 65. The staff concludes that oversizing based on the minimum score is conservative and that the rock will be of sufficient quality to meet EPA standards.

4.4.3 Testing and Inspection of Erosion Protection

The staff has reviewed and evaluated the testing and inspection quality control requirements for the erosion protection materials. Based on a review of the information provided in the RAIP, the staff concludes that the proposed testing program is acceptable.

4.5 Upstream Dam Failures

There are no impoundments near the site whose failure could potentially affect the site.

4.6 Conclusions

Based on review of the information submitted by DOE, the NRC staff concludes that the site design will meet EPA requirements as stated in 40 CFR 192 with regard to flood design measures and erosion protection. The staff concludes that an adequate hydraulic design has been provided to reasonably assure stability of the contaminated material at the disposal site for a period of 1,000 years, or in any case, at least 200 years.

5.0 WATER RESOURCES PROTECTION

5.1 Introduction

The NRC staff reviewed the Final RAP (DOE,1991a-f) for the Grand Junction, Colorado UMTRA Project site for compliance with EPA's proposed groundwater protection standards in 40 CFR Part 192, Subparts A-C.

DOE proposed to: (1) transfer the tailings from the processing site near Grand Junction for stabilization and isolation at a proposed disposal site near Cheney; and, (2) implement a site (surface) remediation plan in the processing site area, but defer groundwater remediation at that site until sometime in the future.

To achieve compliance with the proposed EPA groundwater protection standards in the disposal site area, DOE proposed application of narrative supplemental standards in lieu of the primary standards. This was based upon classification as Class III of the groundwater in the uppermost aquifer (Dakota Sandstone), which has a total dissolved solids content of 10,000 ppm or more. DOE further asserted that the proposed supplemental standards will assure protection of human health and the environment, and come as close to meeting the otherwise applicable standards, due to the hydrologic isolation of the uppermost aquifer and other site characteristics. The NRC staff concurred with DOE's assessment that application of supplemental standards is justified based on EPA's proposed groundwater protection standards, and considering that groundwater in the uppermost aquifer is Class III. The NRC staff also agreed that the proposed site (surface) remediation in the processing site area would not interfere with groundwater remediation in the future by DOE. Furthermore, DOE is committed to maintain site surveillance and monitoring for protection of groundwater users and potential receptors, during the interim period between surface reclamation and groundwater reclamation in the processing site area.

5.2 Hydrogeologic Characterization and Geochemical Conditions

5.2.1 Identification of Hydrogeologic Units

A. Processing Site

The hydrogeologic units that are most susceptible to impacts from the processing site are described below:

- The uppermost hydrogeologic unit is the unconfined alluvium aquifer, which ranges in thickness from approximately 5 to 15 feet, depending on location with respect to the Colorado River. The alluvium is comprised principally of silts, sands, gravel, and cobbles. The water level ranges from 4 to 20 feet below the ground surface, and seasonal water level fluctuations are about two to five feet. Groundwater in the alluvial aquifer is in hydraulic connection with the Colorado River, which can be expected to receive baseflow from the aquifer during low-stage and contributes to the aquifer recharge when the river stage is high.

- The Mancos Shale Formation underlies the alluvium and varies in thickness from zero to greater than 100 feet. This formation is comprised primarily of shale, but contains some thin sandstone beds. The Mancos Shale behaves as an aquitard because of its low permeability and low yield.

- The Dakota Sandstone/Burro Canyon Formation (D/BC) aquifer consists of sandstone, conglomeratic sandstone, shale, and coal beds. Groundwater occurrence and movement in this formation have not been characterized at the site. DOE considers the confining properties of the overlying Mancos Shale to be adequate to prevent contaminants from reaching this aquifer. Water level data for three wells drilled into the Dakota Sandstone appear to support this position, since the water level data from these wells show the potentiometric head elevation in the D/BC aquifer to be several feet above the potentiometric head elevation in the alluvium. Therefore, inter-aquifer flow is largely upward.

B. Disposal Site

The Cheney disposal site is located on the west flank of the Grand Mesa. From a hydrogeologic standpoint, the stratigraphy at the site is described as follows:

- The site is underlain by alluvial deposits, which consist mostly of mixtures of silty gravel with some cobbles and boulders, with a thickness ranging from 5 to 40 feet. Paleochannels occur locally at the base of the alluvium, which were formed by erosional processes into the upper surface of the weathered Mancos Shale bedrock. Three paleochannel systems were identified in the vicinity of the Cheney disposal site by DOE. Only one has a sustained flow near the disposal cell area, and the nearest flow is within 100 feet from the northwest corner of the disposal cell footprint. Discharge from the paleochannels is believed to occur through evapotranspiration and infiltration into the weathered zone of the Mancos Shale through local fractures. DOE indicated that recharge to the paleochannels is from Indian Creek and surface runoff in Creek C (north of the site).

  DOE proposes to construct a partially below-grade disposal cell by excavating up to 35 feet of surface materials. The base of the cell will be located in unweathered Mancos Shale to eliminate the possibility of any ponded water within the cell seeping into the surrounding alluvial paleochannels. By installing the base of the disposal cell into the bedrock, DOE has identified the Dakota Sandstone aquifer as the uppermost aquifer for the disposal site.

- Underlying the alluvium is 700 to 750 feet of shale which constitutes the Mancos Shale Formation. The upper portion of the Mancos Shale is fractured and weathered; although, the lower portion is generally competent. Thin limestone and sandstone beds are scattered throughout the formation. Although it contains isolated areas of perched water, the Mancos Shale has been characterized by DOE as an aquitard, because it is largely unsaturated and has a low hydraulic conductivity (see following section). The Mancos Shale acts as a confining unit for the underlying Dakota Sandstone, as evidenced by large head differentials in wells completed in these formations and based on age dating of the water.

- Groundwater in the Dakota Sandstone is believed to occur primarily in fractures within the upper part of the formation. The highly dense matrix of the sandstone material limits groundwater from occurring due to low primary porosity. The dense matrix also acts to help confine water occurring within the formation. Recharge to this aquifer may be occurring through an outcrop near the Gunnison River.

5.2.2 Hydraulic and Transport Properties

Based on information from DOE, the hydraulic conductivities at the processing and disposal sites are summarized below:

Table 5.1 - Hydraulic conductivity, Grand Junction Processing Site

Unit	Hydraulic Conductivity ft/day	cm/s	Method
Alluvium	85	3E-2	Pump Test
Mancos Shale	1.1E-2	4E-6	Slug
Dakota Sandstone	7.1E-2	2.5E-5	Slug

Table 5.2 - Hydraulic conductivity, Cheney Reservoir Disposal Site

<table>
<tr><th rowspan="2">Unit</th><th colspan="2">Hydraulic Conductivity</th><th rowspan="2">Method</th><th rowspan="2">Direction</th></tr>
<tr><th>ft/day</th><th>cm/s</th></tr>
<tr><td>Alluvium</td><td>4.8E-1</td><td>1.7E-4</td><td>R</td><td>H & V</td></tr>
<tr><td>Weathered Mancos</td><td>1.4E-1
1.4</td><td>5.06E-5
5.06E-4</td><td>F & C
Packer</td><td>H
H</td></tr>
<tr><td>Unweathered Mancos</td><td>7.74E-3
1.63E-2</td><td>2.73E-6
5.75E-6
2E-7</td><td>R, F, and C
Packer
SDRI</td><td>H
H
V</td></tr>
</table>

note: R = Rising head test; F = Falling head test; C = Constant head test; SDRI = Standard double ring infiltrometer; H = Horizontal direction; V = Vertical direction

DOE calculated the average linear groundwater velocity in the alluvium at the processing site to range from 0.2 to 5.0 feet per day (7.04E-5 to 1.76E-3 cm/s). The average linear groundwater velocity in the paleochannels was estimated at 0.34 feet per day (1.2E-4 cm/s); based on an average hydraulic conductivity of 3.4 ft/day, a hydraulic gradient of 0.025 ft/ft, and an effective porosity of 0.25. No estimates were made of the average linear groundwater velocity within the Dakota Sandstone at either site, because of insufficient information to determine the hydraulic gradients.

Although DOE did not characterize the hydraulic and transport properties of the Dakota Sandstone aquifer, NRC staff considers characterization of this aquifer unnecessary given that DOE has adequately shown that this is a Class III aquifer and that transport to this aquifer will be limited by the confining units.

5.2.3 Geochemical Conditions and Extent of Contamination

A. Processing Site

DOE has concluded that seepage from tailings fluids has contaminated the uppermost, alluvial aquifer at the processing site. The contamination plume was estimated by DOE to extend westward from the tailings area to a distance of 2500 feet, and discharges into the Colorado River. Concentrations of several hazardous constituents are above background concentrations in the alluvium, and the water quality in the alluvial aquifer at the processing site needs to be restored.

Contaminants were initially detected in the Colorado River immediately at the site and down-gradient to a distance of 1640 feet; however, later measurements including measurements in low-flow periods have indicated the contaminant concentrations in the river near the processing site had subsided to acceptable levels within the established standards.

DOE did not submit a plan for groundwater remediation, and proposed to defer groundwater cleanup at the processing site. The geochemistry and extent of contamination in the processing site area will be re-evaluated based on new data that will be collected by DOE as a groundwater remediation plan is formulated. This may involve installation of new wells for monitoring and identifying hazardous constituents and delineating the contaminant plume on and off the processing site.

B. Disposal Site

DOE has presented data to show that the Dakota Sandstone aquifer, at the Cheney Disposal site, is saline, with total dissolved solids concentrations exceeding 10,000 mg/l; therefore, the aquifer is considered a Class III groundwater under the EPA definition [40 CFR Part 192.11(e)]. Background water quality data show that average combined concentrations of radium-226 and radium-228 exceed the EPA proposed MCL. Natural gas and measured redox potential indicate a reducing environment.

DOE has also provided information to show that groundwater in the Mancos Shale (where present) is in a reducing condition. Geochemical models indicate that arsenic, molybdenum, selenium, vanadium, uranium, cadmium, lead, copper, and nickel constituents are likely to be removed from solution by chemical precipitation in such an environment. Laboratory batch tests also show that arsenic and cadmium are almost completely attenuated by the shale matrix, and selenium and molybdenum are partially attenuated.

The NRC staff concludes that DOE has adequately characterized the geochemical properties of the Cheney Disposal site.

5.3 Water Use

A. Processing Site

DOE indicates the primary source of drinking water for Grand Junction is the Grand Mesa surface water, which is located far up-gradient from the processing site. The Gunnison River serves as an additional source during heavy demand. The municipal water intake into the Gunnison River is located immediately up-gradient from the processing site. Although contaminants were initially detected in the Colorado River at and down-gradient from the processing site, later measurements including measurements in low-flow periods have indicated the contaminant concentrations in the river near the processing site had subsided to acceptable levels within the established standards.

DOE indicates there is only one unregistered well, completed in the alluvial aquifer, in the vicinity of the processing site. This well is located up-gradient from the site, and is used for dewatering purposes. In addition, DOE states that the potential for future use of groundwater in the alluvial and Dakota Sandstone aquifers will be minimal because of the availability of city water, and the poor water quality (seasonally for the alluvial aquifer). The impact on existing and potential future users outside the immediate area of the processing site cannot be determined. However, as stated previously, DOE is committed to provide periodic surveillance of the site and survey of wells throughout the interim period between site reclamation and groundwater remedial action.

B. Disposal Site

Based on the information provided by DOE, there are no registered wells within two miles of the Cheney Disposal site. Existing groundwater use in the area is minimal due to the following factors: 1) the current population density is low; 2) the availability of shallow groundwater is limited; and 3) shallow groundwater is too poor in quality for domestic use. It is reported that residents in the area receive their water by hauling it in from nearby communities and collecting rainfall in cisterns.

DOE has not projected what groundwater usage will be in the future; however, based upon the reasons given for existing minimal usage and the fact that groundwater in the Dakota Sandstone is saline and fairly expensive to drill to, it is unlikely that future groundwater usage in the area will change greatly.

The paleochannels discussed in Section 5.2.1 B constitute the only potential source of water in the proposed disposal site area. Although the available yield from these formations is expected to be small, protection was provided by DOE, through proper siting of the disposal cells (i.e., by avoiding the paleochannel areas), disposal cell design and construction, and incorporating in the RAP monitor wells for proper monitoring of water level and quality, in order to identify any seepage from the disposal cell to the paleochannels.

5.4 Conceptual Design Features for Water Resources Protection

DOE proposes to relocate the tailings and vicinity property materials from the Grand Junction processing site to the Cheney disposal site. Construction dewatering will be required at the processing site to excavate the contaminated materials below the water table. A slurry trench will be constructed around the site to facilitate the dewatering. At the completion of the excavation, windows will be installed in the slurry wall to restore natural flushing. The processing site will be restored with uncontaminated fill from the disposal site, and then re-vegetated and mulched. A wetland system will be created at the down-gradient edge of the site, along the river.

Disposal of the tailings and vicinity property materials will occur in a 60-acre cell partially below grade. The disposal cell will be excavated up to 35 feet below the existing grade, through the alluvium, into the Mancos Shale. Clean-fill dikes will be constructed to surround the contaminated materials. These dikes, which will extend above the original grade, are designed to minimize the risk of mounded leachate within the pile reaching one of the paleochannels in the alluvium. The contaminated materials will be placed in the disposal cell in such a way as to minimize infiltration into and through the cell, and to minimize mounding during transient drainage. To accomplish this, DOE proposes to place the lower-permeability vicinity property materials over the higher-permeability tailings. This will create a capillary barrier, i.e., suction within the partially saturated vicinity property materials will have to be overcome before water can penetrate into the coarser-grained tailings.

The cover design for the facility consists of, in ascending order: (a) a 2-foot radon barrier constructed of alluvial clay from the disposal site, with a saturated hydraulic conductivity of 1E-7 cm/s; (b) a 6-inch sand drain layer, with a hydraulic conductivity of 1E-4 cm/s; (c) a 15-inch erosion protection/ bio-barrier layer; and (d) a 2-foot layer of rooting soil. The erosion protection/ bio-barrier and rooting soil medium will also serve to provide frost and freeze protection for the radon barrier. Grasses, cacti, and sage will be planted on the top of the cover to increase evapotranspiration and thus reduce infiltration into the pile.

Because of the great depth to the uppermost aquifer, the geochemical attenuation properties of the Mancos Shale, and the poor quality of the Dakota Sandstone groundwater, the NRC staff is primarily concerned, in terms of the cell design, with the potential for perched contaminated water reaching one of the highly transmissive paleochannels. The closest reported paleochannel to the disposal cell, with sustained groundwater flow, occurs along the northern edge of the pile. Flow in this channel is reported to be within 100 feet of the northwestern edge of the pile. DOE has redesigned the cell to eliminate potential seepage from the northwest corner of the disposal cell. In addition, DOE will install wells for proper monitoring and early detection of any contaminants from the disposal cell to the paleochannels.

DOE has determined that the vertical hydraulic conductivity of the foundation material is 2E-7 cm/s, which is only slightly more permeable than the design saturated hydraulic conductivity of the radon barrier; however, ponding within the disposal cell is not expected to be a problem for the following reasons:

- DOE has calculated the expected maximum ponding depth in the cell to be 12.3 feet, which is below the depth of any nearby paleochannels; and

- The clean-fill dikes surrounding the contaminated materials will minimize lateral migration of leachate.

The NRC staff agrees with DOE's assessment that ponded leachate should not reach any nearby paleochannels for the following reasons:

- Conservative calculations by the NRC staff show that nearly 45 feet of water would be required to obtain a sufficient hydraulic gradient for lateral migration of leachate at a rate equal to the saturated conductivity of the barrier. Given the huge volume of the disposal cell, it is estimated that it would take over 200 years of infiltration at a flux equal to the saturated hydraulic conductivity of the barrier to achieve such a head.

- The expected infiltration through the cover is expected to be less than the saturated hydraulic conductivity because the other components of the cover will reduce the flux received by the barrier. One component of the cover which will help reduce infiltration will be the vegetation at the top of the cover. DOE proposes to design the vegetation layer similar to ambient conditions. The ambient vegetation cover appears to limit infiltration into the ground as evidenced by caliche deposits within the soils and gypsum deposits within the alluvium.

- DOE has indicated its intention to excavate an additional 6 feet below the grade specified in its design. This additional 6 feet will provide additional storage for any ponded leachate.

- Independent calculations by NRC staff confirm that seepage from the base of the cell will exceed influx to the cell. These calculations were based upon an influx equal to the saturated hydraulic conductivity of the radon barrier (i.e., 1E-7 cm/s) and a vertical hydraulic conductivity of the foundation material equal to 2E-7 cm/s.

- Placement of the lower permeability vicinity property material over the coarser-grained tailings will create a capillary barrier, as long as the vicinity property material is partially saturated.

5.5 Compliance with Water Resources Protection Standards

The regulations for protection of water resources for uranium mill tailings are provided in EPA's proposed health and environmental protection standards in 40 CFR Part 192, Subparts A, B, and C. DOE is required to comply with the standards for the control of residual radioactive materials (i.e., disposal standards) at the proposed Cheney disposal site, as required by Subparts A and C of 40 CFR Part 192, and with the standards for cleanup of groundwater (i.e., cleanup standards) at the processing site near Grand Junction, as required by Subparts B and C.

5.5.1 Compliance with Disposal Standards

The proposed EPA standards in 40 CFR Part 192, Subpart A, for control of residual radioactive materials and their listed constituents include the following main provisions for water resources protection at tailings disposal sites:

1. Identifying a list of hazardous constituents and their concentration limits (§192.02 (a) (3) (i), (ii), and (iii));

2. Establishing a monitoring program to determine background water quality (§192.02 (a) (3) (iv));

3. Compliance with the performance standard as indicated in §192.02 (a) (4);

4. Implementing a monitoring plan to demonstrate that initial performance of the disposal cell is in accordance with the design requirements (§192.02 (b)); and,

5. A groundwater restoration/cleanup program if established groundwater standards are projected to be exceeded (§192.02 (c))

However, the proposed EPA standards also include a provision, in Subpart C (§192.22), that permits Federal agencies implementing Subparts A and B to apply supplemental standards, if one or more of the criteria in §192.21 can be met. The supplemental standards permit Federal agencies like DOE to select and perform actions, in lieu of those in Subparts A and B, that come as close as possible to meeting the otherwise applicable standard as is reasonable under the circumstances.

In lieu of the primary standards, DOE proposed to apply the supplemental standards for the Cheney disposal site, on the basis of Criterion (g) in §192.21. DOE identified the Dakota Sandstone as the uppermost aquifer in the Cheney disposal site area, and asserted that the groundwater in this aquifer has a total dissolved solids content of 10,000 mg/l or more, and is therefore considered a Class III. Nearby paleochannel sand deposits are located off the disposal site and are at a higher elevation than the bottom of the disposal cell.

In consideration of the water quality of the uppermost aquifer (Class III), and other available information and data for the proposed disposal site, the NRC staff accepted DOE's proposal to apply supplemental standards at the Cheney disposal site. The NRC staff believes that the characteristics of the proposed disposal site and disposal cell design come as close to meeting the standards in Subpart A as is reasonable under the circumstances. This is because the Dakota Sandstone formation is separated from the disposal cell by several hundred feet of the Mancos Shale, which has a very low hydraulic conductivity (see Table 5.2). Accordingly, the NRC staff concurs with DOE's application of supplemental standards at the Cheney disposal site.

Furthermore, the NRC staff reviewed the proposed design and other activities at the Cheney disposal site, and concluded that the proposed action by DOE for this site is in compliance with the applicable EPA groundwater protection standards, as discussed more specifically in the following paragraphs.

5.5.1.1 Hazardous Constituents and Concentration Limits

By selecting the supplemental standards for the Cheney disposal site, DOE did not identify a list of hazardous constituents or establish their concentration limits as otherwise required. The NRC staff considers this to be justified based on the site characteristics. The available data indicate that the uppermost aquifer (Dakota Sandstone) is separated from the disposal cell by a thick shale formation (Mancos Shale), which has a very low hydraulic conductivity. In addition, according to DOE, there are other indications that the disposal cell is hydraulically isolated from the uppermost aquifer; these include:

- The upward pressure gradient and confinement of the Dakota Sandstone should keep contaminants from migrating to that zone;
- The geochemical attenuation properties of the thick Mancos Shale and any perched water systems within the Mancos Shale should effectively remove contaminants prior to reaching the Dakota Sandstone; and
- Age dating of the groundwater in the Dakota Sandstone indicates that recharge to this aquifer is not from local precipitation through the overlying Mancos Shale aquitard in the general area of the site.

On the basis of the above, the NRC staff agrees with DOE that it is unlikely that constituents from the disposal cell would reach the uppermost aquifer during the life of the disposal facility.

5.5.1.2 Establishing Background Groundwater Quality

DOE characterized groundwater quality in the Cheney disposal site area, and established that the water in the Dakota Sandstone aquifer is Class III, thereby justifying the selection of the supplemental standards. The application of supplemental standards, and the site characteristics, preclude the need for establishing a background groundwater quality in the formal sense as otherwise required by the regulations. The NRC staff agrees with DOE that establishing background water quality for the Cheney disposal site is not required under the supplemental standards.

5.5.1.3 Performance Demonstration

In accordance with the performance standards of 40 CFR Part 192.02(a)(4), DOE is required to demonstrate that the proposed disposal design will (1) minimize and control groundwater contamination, (2) minimize the need for further maintenance, and (3) meet design performance standards.

DOE provided information to show that infiltration through the cover under average climatic conditions will be 5.6E-8 cm/s; under long-term conditions, infiltration is predicted by DOE to be essentially nil. In addition, DOE presented information indicating that the geochemical properties of the Mancos Shale and perched water zones within the Mancos Shale effectively limit migration of contaminants to the uppermost aquifer.

The NRC staff does not agree that infiltration through the disposal cell cover can be ruled out completely, as indicated by DOE's estimates. However, the staff agrees that the infiltration rate and the flux through the cover would be small. Furthermore, the thickness and hydraulic conductivity and the attenuation properties of the Mancos Shale constitute a barrier that would isolate the disposal cell and reduce the possibility that constituents would reach the uppermost aquifer during the life of the disposal cell.

In addition, DOE has provided calculations to show that mounded water within the cell, during transient drainage, will not reach any nearby paleochannels. The maximum predicted mounding is 12.3 feet, which will take place in the toe area of the cell. Transient drainage is predicted to last roughly 12-14 years. Transient drainage calculations were made using a flux equal to the saturated hydraulic conductivity of the radon barrier (i.e., 1E-7 cm/s), and a vertical hydraulic conductivity of 2E-7 cm/s for the foundation material (i.e., competent Mancos Shale).

5.5.1.4 Groundwater Monitoring to Demonstrate Performance

Pursuant to the proposed EPA groundwater protection standards in 40 CFR Part 192.02 (b), DOE is required to implement a groundwater monitoring plan during the post-disposal period, in order to demonstrate that initial performance of the disposal cell is in accordance with the design requirements of §192.02 (a).

As part of licensing the long-term care of the completed disposal site, DOE will provide a LTSP, which will include a groundwater monitoring plan as required by the regulations. The plan will include visual check for seeps or other surface exposures during routine surveillance of the site.

In addition, monitoring wells will be installed in the shallow, paleochannel aquifer and monitored by DOE throughout the disposal operation, including the post-closure period, to verify that the disposal cell performs according to design. The monitoring wells will also be used to verify that the paleochannels will not be adversely impacted by any fluid build-up in the disposal cell.

5.5.1.5 Corrective Action Program for the Disposal Site

DOE will provide information on the corrective action plan in the LTSP, which will be submitted to the NRC subsequently. The NRC staff will review the proposed corrective action plan as part of the review of the LTSP. In the LTSP, DOE will consider corrective action to be taken in the event of failure of the cover in addition to the development of seeps. Possible corrective action includes: 1) constructing a sump or other device to collect the contaminated groundwater and treating or evaporating the collected water and 2) covering the contaminated water to control access.

5.5.2 Compliance with the Cleanup Standard

The proposed EPA standards in 40 CFR Part 192, Subpart B, for cleanup of inactive uranium mill tailings sites that are contaminated with residual radioactive materials include the following main provisions for water resources protection at such sites:

1. The concentration of any listed constituent in groundwater shall not exceed the established site-specific standard as provided in the regulations (§192.12 (c).

2. Implementation of a monitoring program to define the extent of groundwater contamination by listed constituents and to monitor compliance with the regulations (§192.12 (c)(1).

3. DOE may propose alternate concentration limits, in lieu of the otherwise applicable standards, subject to certain regulatory requirements (§192.12 (c)(2).

4. The remedial action period may be extended by a period not to exceed 100 years, if certain requirements outlined in the regulations can be met (§192.12 (c)(4);

To date, DOE has collected data for characterization of contamination in the processing site area. DOE identified the following inorganic constituents in the tailings fluids at the Grand Junction processing site: antimony, arsenic, beryllium, barium, cadmium, chromium, cobalt, copper, net gross alpha activity, lead, mercury, molybdenum, nickel, nitrate, radium -266 and -228, selenium, silver, and uranium. Additionally, the following elements contained in hazardous constituent compounds were identified: aluminum, cyanide, fluoride, strontium, sulfide, tin, vanadium, and zinc. A scan of groundwater samples from three wells revealed no volatile, semi-volatile, or other organic compounds present in the groundwater.

The NRC staff reviewed DOE's assessment of the hazardous constituents using the following three criteria to select hazardous constituents: 1) whether or not the constituents are reasonably expected to be in or derived from the tailings; 2) whether or not constituents are listed in Appendix VIII of 40 CFR Part 261, with the addition of radium -226 and -228, uranium, nitrate, molybdenum, and net gross alpha particle activity as specified in 40 CFR 192.02(a)(3)(i); and 3) whether or not constituents were detected in the tailings or groundwater at the site. Based upon an independent analysis of the information provided by DOE, the NRC staff concludes that the list of identified hazardous constituents is appropriate. It is also noted that the hazardous constituent list could be updated based on new data that may be collected by DOE at the processing site in the future, as the groundwater remedial action plan is prepared and submitted to NRC for review.

DOE proposed to defer cleanup and control of existing groundwater contamination to a later phase of the remedial action project, as permitted by UMTRCA (1982 Amendment). The NRC staff agrees that groundwater cleanup may be deferred, because, consistent with the regulations, DOE has demonstrated that: 1) the proposed site remediation will not interfere with planned groundwater cleanup in the future; and 2) public health and safety will be protected during the interim period between site remediation and groundwater cleanup. Furthermore, DOE is committed to maintain site surveillance and monitoring for protection of groundwater users and potential receptors, during the interim period between surface reclamation and groundwater cleanup in the processing site area. DOE will also continue to monitor water quality of the groundwater in the uppermost alluvial aquifer and the Colorado to update and improve site characterization in the processing site area, and to detect any effects of site remediation activities on water quality.

DOE has not submitted a plan for groundwater remediation in the processing site area to date. When the groundwater remediation plan is completed by DOE, the NRC staff will review and evaluate the plan in consideration of the groundwater standards in the proposed EPA standards for inactive uranium mill sites, which have already been cited.

5.6 Conclusions

Based on staff review of the Final RAP, the NRC staff concludes that DOE's proposed remedial action to date complies with EPA's proposed groundwater protection standards for inactive uranium mill sites.

6.0 RADON ATTENUATION AND SITE CLEANUP

6.1 Introduction

This section of the Technical Evaluation Report (TER) documents the staff review of the radon attenuation design and the radiation cleanup plan for the remedial action at the Grand Junction, Colorado, UMTRA Project site. The review consists primarily of evaluations of the material characterization, radon barrier design, proposed remedial action, and radiological verification plan to assure compliance with the appropriate EPA standards. The adequacy of the quality control program in these areas is also reviewed. The review followed the procedures in Chapter 5 of the NRC SRP (NRC, 1993).

6.2 Radon Attenuation

As described in previous sections of this report, the radon/infiltration barrier will be composed of material excavated from the Cheney Reservoir disposal site and placed over the stabilized tailings embankment. The design thickness of this barrier is 2 feet for the top slopes of the pile and 3.5 feet for the sideslopes. The barrier thickness is designed to satisfy criteria for construction, settlement, cover cracking, infiltration of surface water, and the reduction of radon gas release at the surface of the completed cell.

The review of the cover design for radon attenuation included evaluation of the pertinent design parameters for main pile tailings, off-pile contaminated materials, and the radon/ infiltration barrier material. The design parameters evaluated include: long-term moisture content, material thickness, bulk density, specific gravity, porosity, and radon diffusion coefficient. Radium content and radon emanation coefficient parameters were evaluated for the tailings and other radiologically-contaminated materials.

The parameters of the materials in other layers of the cover were evaluated for their ability to protect the radon barrier layer from drying and disruption. The stability of the cell as a whole was also determined because of the potential of causing cracking in the barrier layer due to settlement or heaving. These aspects of cell design are discussed in detail in chapter 3 of this TER.

DOE used the RAECOM computer code to calculate the radon barrier thickness required to meet the radon flux limit. NRC staff evaluated the code input, and performed an independent analysis of the design using the RADON code (NRC, 1989b), which is a version of RAECOM.

6.2.1 Parameter Evaluation

The required thickness of the radon barrier depends on the properties of the barrier soil(s) and the underlying contaminated materials. NRC staff reviewed the physical and radiological parameter values used to determine the thickness of the radon/infiltration barrier required at the Grand Junction site. The values were evaluated to determine if each is: valid, representative of the material, conservative, and based on long-term conditions.

The material thicknesses used in the analysis are based on the conceptual design of the RAP and the available data. The design assumptions are that these layers are uniform, and that average parameter values are adequate. The tailings from the ponds area and vicinity property cleanup materials, referred to as the off-pile contaminated materials, have a lower average radium content than the main pile tailings. Most of this low-activity material will be placed on top of the main pile tailings and was therefore modeled as a separate layer. It is possible that some of the details of the design will change during construction. Reanalysis of barrier thickness will be necessary if the radium content of the off-pile material placed next to the barrier is significantly higher than values used in the computer model, or if the thickness of this low-activity layer is less than the value used in the model.

The bulk density and specific gravity were determined by field and laboratory tests, and the corresponding porosity was calculated. The average bulk density and porosity values used in the RAECOM analysis are: 1.39 gm/cc and 0.492 for the tailings (seven samples), 1.78 gm/cc and 0.34 for the off-pile contaminated materials (10 samples), and 1.73 gm/cc and 0.375 for the radon/infiltration barrier material (six samples), respectively. These values were apparently determined from representative samples of the materials, and the staff finds them to be acceptable.

The design uses the following long-term moisture contents: 18 percent assumed for the tailings based on 4 percent drying after placement at 22 percent moisture content; 10 percent for the off-pile contaminated materials (three samples); and 14.7 percent for the radon/infiltration barrier material (six samples). In selecting these values, DOE considered primarily the results of capillary moisture laboratory tests, but also the SWRDAT computer code (USSCS, 1985), an empirical relationship developed by Rawls and Brakensiek (1982), and specifications for placement moisture. The laboratory tests support the use of these moisture contents. The use of the SWRDAT code for predicting water retention capacity at different suction pressures does not appear to conflict with the methods in the SRP (NRC, 1993).

Radon diffusion coefficients for the main pile tailings (four samples) and barrier material (six samples) were derived from correlation curves of moisture saturation versus radon diffusion coefficient developed from laboratory measurements of soil samples representative of expected conditions in the stabilized pile. The average diffusion coefficient for the tailings is 0.012 cm^2/s and the barrier material values are 0.0029 and 0.0037 cm^2/s using the capillary moisture and SWRDAT model respectively. DOE states that a conservatively high diffusion coefficient (0.01 cm^2/s) was assumed for the off-pile contaminated materials because of the material property uncertainties. This assumption is based on a calculated value of 0.007 cm^2/s for material sampled in 1987. Since much vicinity property material has been deposited since 1987, the calculated value may not be representative of the total off-pile materials and the assumed value may not be conservative. A value of 0.02 cm^2/s may be more appropriate; however, DOE's assumed value is acceptable to the staff considering that more testing will be done on the vicinity property material and the radon attenuation model re-evaluated before radon barrier placement is completed.

The radon emanation coefficients for the contaminated materials were measured in the laboratory. Average values of 0.36 (29 samples) for main pile tailings, and 0.35 (6 samples) for the off-pile contaminated materials, were determined. These values are acceptable to the staff.

A weighted average value of the radium content for the tailings material was calculated to be 571 pCi/g (423 samples, SEM 30). A value of 64 pCi/g (30 samples, SEM 14.5) was estimated from limited data for the off-pile contaminated materials. DOE's analysis adjusts average parameter values by adding or subtracting the SEM (whichever is more conservative), but these average parameter values are not always representative of the spread of the parameter values. For example, the Ra-226 concentrations in the main pile tailings average 575 pCi/g, but the standard deviation is 632 pCi/g, and the vicinity property materials average 60 pCi/g with a standard deviation of 72 pCi/g (DOE, 1991a, Table 6.1). The values chosen for the tailings and the off-pile materials are optimistically based on a uniform mixing of the materials and do not adequately represent the variability of the data. However, the average Ra-226 concentration values for the design appear acceptable to the NRC staff in this case, since DOE has indicated that 75 percent of the main tailings pile samples were below 800 pCi/g, and 75 percent of the vicinity property materials samples were below 80 pCi/g.

The ambient air radon concentration is a required parameter value for the RAECOM model and has been measured at the Grand Junction site as 0.8 pCi/l. The technique used to measure the radon concentration and the result appear to be acceptable to the staff.

6.2.2 Radon Barrier Evaluation

The radon/infiltration barrier thickness necessary to comply with the radon flux limit was calculated by DOE using the RAECOM computer code. The EPA standard requires that the release of radon-222 from residual radioactive material to the atmosphere does not exceed an average rate of 20 $pCi/m^2/sec$.

DOE analyzed the radon/infiltration barrier in a manner that represents the placement of the contaminated materials in two layers. The important model assumptions are that the upper layer (off-pile contaminated material) will be at least 10 feet (305 cm) thick and will contain a maximum average Ra-226 content of 150 pCi/g.

The model is conservative in that the radon attenuation of the frost protection and drain layers is not considered. The cover on the sideslopes does not include a frost protection layer but the radon barrier is 42 inches thick instead of the 24 inches designated for the top of the cell. This extra 18 inches of barrier material is adequate for frost protection and provides additional radon attenuation not accounted for in the model. NRC staff determined that there was adequate protection so that frost damage to the radon barrier layer did not need to be considered in the model.

Based on RAECOM modeling results, DOE concludes that 2 feet of radon barrier will be more than adequate to reduce the radon flux to below the 20 $pCi/m^2/sec$ standard. Using the average parameter values discussed in the previous sections, modeling demonstrates that 1.3 feet of barrier would be sufficient. Based on the SWRDAT long-term moisture values, 1.6 feet of barrier would be required. Use of average parameter values plus or minus (which ever is conservative) their SEM, combined with the SWRDAT determined moisture values, results in a 2.0-foot-thick barrier needed to achieve the radon flux limit.

NRC staff used the RADON computer code to model the radon flux using various combinations of conservative parameter values. The analyses each resulted in a radon flux of less than 20 $pCi/m^2/s$ at the top of the radon barrier layer.

Although some parameter values are based on limited and possibly unrepresentative samples, the NRC staff accepts the radon barrier as designed because DOE has committed to conduct further testing of materials and evaluation of the radon barrier design. Any necessary changes would be made by RAP modifications to insure that the final design demonstrates compliance with the radon barrier standards.

6.3 Site Cleanup

6.3.1 Radiological Site Characterization

Field sampling and radiological surveys at the Grand Junction site identified approximately 5,260,000 cubic yards of contaminated materials covering over 100 acres at the processing site and adjacent areas. Subpile contamination exceeds 15 pCi/g Ra-226 above background to an average depth of one foot under the main pile. The results of the site characterization survey are being used to plan the control monitoring for the contaminated material excavation, as well as the final radiological verification survey for the land.

Background levels of Ra-226 average 2.0 pCi/g in the Grand Junction area soil. The methods of determination for radioisotope levels and the results are acceptable to NRC staff.

6.3.2 Cleanup Standards

DOE has committed to excavate contaminated areas to meet the 5 pCi/g (surface) and 15 pCi/g (subsurface) plus background, EPA standard for Ra-226 in soil, and to place the contaminated materials in an engineered disposal cell. If Th-230 is encountered in significant concentrations after Ra-226 has been removed to the EPA standards, supplemental standards for Th-230 will be imposed. The standard will be to reduce the Th-230 concentration such that: (1) the Ra-226 concentration in 1000 years will not exceed the 15 pCi/g criterion, or (2) the projected concentration of radon decay products in a house will not exceed 0.02 working levels in 1000 years. Based on the DOE generic thorium policy, the NRC staff understands that the second criterion would only be used for deeply buried deposits that would be difficult to excavate. Excavations will be monitored to ensure that cleanup efforts are complete.

All buildings and equipment on the site have been removed or demolished. The stockpiled debris will be buried in the disposal cell.

DOE states in the RAP that as the remedial action progresses, excavation control monitoring will be performed to insure that the contamination will be removed from the processing site to the levels imposed in the EPA standards. Contaminated asbestos is to be properly packaged, transported, and placed in the disposal cell.

6.3.3 Verification

The final radiological verification survey for land cleanup will be based on 100-square-meter areas. DOE may use a variety of measurement techniques, depending on particular circumstances. The standard method for Ra-226 verification is analysis of composite soil samples, by gamma spectrometry. The procedures identified in the RAP for the final radiological verification survey are consistent with generic procedures (RAC-015) including the bulk averaging of radionuclides in cobbly soils (cobbles-to-fines correction, RAC-OP-003) that have been reviewed and approved by NRC staff.

DOE states that a minimum of four percent of all processing site verification samples (grids) will be analyzed for Th-230. In addition, at least 10 percent of the samples from areas suspected of having Th-230 mobilized below the Ra-226 cleanup boundary will be analyzed. If Th-230 concentrations are found to exceed the guideline, samples from surrounding grids will also be analyzed for

Th-230. NRC staff has agreed that this approach is adequate considering that the UMTRA Project generic policy for Th-230 cleanup and verification was not final at the time this aspect of the Grand Junction RAP was finalized.

6.4 Conclusions

Based on review of the radon attenuation design and analyses presented in the Grand Junction final RAP, NRC staff concludes that the radon attenuation model is adequate to support the Grand Junction radon barrier design, but must be substantiated by further testing and analysis. This is necessary to provide reasonable assurance that the disposal cell will meet the EPA standards for radon flux contained in 40 CFR 192.02. DOE has stated (DOE, 1991a, page 57) that "The final cover design will be based on actual measurements of the as-placed contaminated materials and will incorporate any restrictions on the quantities of the radon barrier materials." The final as-built model presented in the Completion Report will demonstrate compliance with the radon flux standard; therefore, NRC concurs on this aspect of the RAP.

The staff finds the radiological characterization program, the proposed processing site cleanup, and the verification plan are acceptable as they should result in the site meeting the EPA standards for soil cleanup in 40 CFR 192.12 and 192.22.

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Attachment B

Nuclear Regulatory Commission Concurrence Letter and Technical Evaluation Report (Part B, ground water project)

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

January 3, 2002

RECEIVED DOE
JAN - 9 2002
GRAND JCT. OFFICE

Ms. Donna Bergman-Tabbert, Manager
U.S. Department of Energy
Grand Junction Office
2597 B3/4 Road
Grand Junction, CO 81503

SUBJECT: CONCURRENCE WITH THE GROUND WATER COMPLIANCE ACTION PLAN FOR THE URANIUM MILL TAILINGS REMEDIAL ACTION PROJECT SITE AT GRAND JUNCTION, COLORADO

Dear Ms. Bergman-Tabbert:

In separate letters dated April 8, 1999, and June 25, 1999, respectively, the U. S. Department of Energy (DOE) submitted the Ground Water Compliance Action Plan (GCAP) and Final Site Observational Work Plan (SOWP) for the Uranium Mill Tailings Remedial Action Project at Grand Junction, Colorado. In a letter dated February 8, 2001, the U. S. Nuclear Regulatory Commission (NRC) staff provided its acceptance of the Grand Junction SOWP, however, the staff also identified several issues which required resolution to complete the review of the GCAP. These issues were in relation to the use of institutional controls as part of DOE's strategy for ground water protection. To address these issues, DOE submitted a revised GCAP by letter dated May 9, 2001.

The Staff has completed its detailed review of the revised GCAP as documented in the enclosed (Enclosure) Technical Evaluation Report (TER). As discussed in the TER, the staff finds that the Grand Junction site GCAP satisfies the requirements of the Uranium Mill Tailings Radiation Control Act of 1978, as amended, and the groundwater protection standards in 40 CFR Part 192. Accordingly, the staff concurs with the GCAP.

If you have any questions regarding this letter, please contact Rick Weller, the Project Manager for Grand Junction, at (301) 415-7287 or by e-mail to RMW2@nrc.gov.

In accordance with 10 CFR 2.790 of the NRC's "Rules of Practice," a copy of this letter will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's document system (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/NRC/ADAMS/index.html (the Public Electronic Reading Room).

Sincerely,

Melvyn Leach

Melvyn Leach, Chief
Fuel Cycle Licensing Branch
Division of Fuel Cycle Safety and Safeguards
Office of Nuclear Material Safety and Safeguards

Docket No.: WM-54

Enclosure: Technical Evaluation Report for the
Ground Water Compliance Action Plan
For the Grand Junction UMTRA Project Site

cc: D. Metzler, DOE GJO
R. Plieness, DOE GJO
J. Jacobi, CDPHE Den

TECHNICAL EVALUATION REPORT
FINAL GROUND WATER COMPLIANCE ACTION PLAN FOR THE GRAND JUNCTION, COLORADO UMTRA PROJECT SITE

FACILITY: Grand Junction, Colorado

TECHNICAL REVIEWER: William von Till

PROJECT MANAGER: Rick Weller

SUMMARY AND CONCLUSIONS:

The U. S. Department of Energy (DOE) submitted a Final Ground Water Compliance Action Plan (GCAP) for the Grand Junction, Colorado, UMTRA Project Site by cover letter dated May 9, 2001. The compliance strategy proposed in the GCAP is no remediation, based on the application of supplemental standards. This is based on DOE's assertion that the contamination is confined to *limited use groundwater.* The U. S. Nuclear Regulatory Commission (NRC) and Colorado Department of Public Health and Environment (CDPHE) agree with DOE's characterization of the aquifer as a *limited use groundwater.* Therefore, the criteria for supplemental standards, on the basis of *limited use groundwater,* has been met. In addition, DOE is implementing institutional controls to assure that the compliance strategy is protective of human health and the environment. Based on the reviewed information, the staff finds that the Grand Junction site GCAP satisfies the requirements of the Uranium Mill Tailings Radiation Control Act of 1978, as amended, and the groundwater protection standards in 40 CFR Part 192. Accordingly, the staff concurs with the GCAP.

BACKGROUND:

In separate letters dated April 8, 1999, and June 25, 1999, respectively, the U. S. Department of Energy (DOE) submitted the Ground Water Compliance Action Plan (GCAP) and Final Site Observational Work Plan (SOWP) for the Uranium Mill Tailings Remedial Action Project at Grand Junction, Colorado. In a letter dated February 8, 2001, the U. S. Nuclear Regulatory Commission (NRC) staff provided its acceptance of the Grand Junction SOWP, however, the staff also identified several issues which required resolution to complete the review of the GCAP. These issues were in relation to the use of institutional controls as part of DOE's strategy for ground water protection. To address these issues, DOE submitted a revised GCAP by letter dated May 9, 2001.

Regulatory Framework:

The UMTRA Project regulations provide several ways to comply with the groundwater protection standards in 40 CFR Part 192.12(c) of Subpart B. These include meeting the provisions of 40 CFR Part 192.02(c)(3) of Subpart A or supplemental standards established under 40 CFR Parts 192.21 and 192.22 of Subpart C.

Criteria for applying supplemental standards is detailed in 40 CFR Parts 192.21 and 192.22. Supplemental standards can be requested if the groundwater meets the criteria of 40 CFR Part 192.11(e) for *limited use groundwater.* The definition of *limited use groundwater,* per 40 CFR Part 192.11(e), is provided as:

192.11(e) for *limited use groundwater*. The definition of *limited use groundwater*, per 40 CFR Part 192.11(e), is provided as:

> groundwater that is not a current or potential source of drinking water because (1) the concentration of total dissolved solids is in excess of 10,000 mg/l, or (2) widespread, ambient contamination not due to activities involving residual radioactive materials from a designated processing site exists that cannot be cleaned up using treatment methods reasonably employed in public water systems, or (3) the quantity of water reasonably available for sustained continuous use is less than 150 gallons per day. The parameters for determining the quantity of water reasonably available shall be determined by the Secretary with the concurrence of the Commission.

Site Description:

The site is located in Grand Junction, Colorado along the banks of the Colorado River. The site was used as a uranium-ore processing facility from 1950 to 1970 with a total of 2,281,614 tons of ore processed. The mill also had a side-stream vanadium circuit. By 1994, all of the contaminated materials from the old processing site and vicinity property materials were transported to the Cheney Disposal Cell, located about 15 miles southeast of Grand Junction. Groundwater contamination at the site resulted from the leaching of uranium and other milling constituents from mill tailings, settling ponds, and evaporation ponds. The alluvial aquifer is composed of unconsolidated clays, silts, sands, gravels, and cobbles. Groundwater is unconfined in this aquifer and depth to water ranges from 0-20 feet. Groundwater from the aquifer flushes into the Colorado River. Groundwater table fluctuations occur as a result of River level fluctuations. Underlying the alluvial aquifer is a shale "aquitard" composed of low-permeability shale units in the Dakota Sandstone. The confined Dakota Sandstone aquifer underlies the shale unit.

Selenium and uranium background values are high and thought to be from the dark marine shales of the Mancos Shale, which is found throughout the valley. Iron, chloride, manganese, sulfate, and total dissolved solids (TDS) are also high as background concentrations, further indicating the poor water quality of the alluvial aquifer.

TECHNICAL EVALUATION:

Based on the *Final Programmatic Environmental Impact Statement for the Uranium Mill Tailings Remedial Action Groundwater Project* (PEIS, DOE, 1996), DOE has proposed no remediation in conjunction with the application of supplemental standards and the criteria for limited use groundwater. Groundwater in the uppermost aquifer is not a current or potential source of drinking water because widespread, ambient contamination, not due to activities involving radioactive materials from the designated processing site, exists that cannot be cleaned up using treatment methods reasonably employed in public water systems.

DOE evaluated uranium, arsenic, cadmium, fluoride, nickel, radium 226, strontium, sulfate, vanadium, zinc, ammonia, iron, manganese, molybdenum, and vanadium as chemicals of potential concern. The Baseline Risk Assessment of 1995, conducted by DOE, indicated that residential use of groundwater, mainly as drinking water, presents the only unacceptable pathway for exposure to groundwater at the site. Since the aquifer is not used for drinking water purposes and with current and future application of institutional controls (groundwater restrictions), the probability of this pathway occurring is acceptably small.

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The NRC and CDPHE agree with DOE's characterization of the aquifer as *limited use groundwater* (CDPHE, 2000). In making this determination, the staff relied heavily on CDPHE"s extensive knowledge of the character of the aquifer and its classification for limited use. Since the aquifer has been classified as *limited use groundwater*, the criteria for supplemental standards has been satisfied. The background data for uranium and selenium support DOE's case that widespread ambient contamination exists in the alluvial aquifer. Groundwater from the alluvial aquifer is not a current or potential source of drinking water. Potable water is available from a municipal water system in the area. DOE also concluded that treating the water for a drinking water source would be more costly ($680 per household) than the Environmental Protection Agency threshold value of $300 per household (EPA, 1988), further supporting the criteria for *limited use groundwater* under 40 CFR Part 192.11(e)(2).

<u>Institutional Controls:</u>

The State of Colorado, through the CDPHE (the Grantor), transferred the mill-site property to the City of Grand Junction (the Grantee) via two quitclaim deeds recorded in the Mesa County Courthouse, Book 2320, pages 882 to 886, on March 29, 1997. As part of the agreement, the City agrees "not to use ground water from the site for any purpose, and not to construct wells or any means of exposing ground water on the property unless prior written approval is given by the Grantor and the U.S. Department of Energy."

In addition, for the off-site contamination, in July 1989, the Grand Junction City Council passed Ordinance 2432 of the Grand Junction Zoning and Development Code, which applies to all areas within the city limits. Section 5-4-4 of this Ordinance refers to Potable Water Systems. Paragraph B of Section 5-4-4 states that;

> "All developments shall be served by the City water treatment and distribution system, unless such requirement is deemed unreasonable or impracticable, as determined by the Utilities Director. All water lines shall be designed to connect to each parcel, as set forth in the previous sentence, with City mains in accordance with applicable engineering standards, unless exempted by the Utilities Manager."

DOE stated that searches of the City of Grand Junction water service records showed no evidence of domestic water use from wells within the affected area. Contaminated groundwater as a result of processing operations is confined within the City limits, and with the City ordinance in place, domestic water supply wells should not be installed, thereby making the groundwater ingestion risk scenario extremely low.

REFERENCES:

Colorado Department of Public Health and Environment (CDPHE), 2000. Electronic mail (e-mail) from W. Naugle, CDPHE, to W. von Till, NRC, stating that the CDPHE agrees with DOE's characterization of the aquifer as a *limited use groundwater*, January 11, 2000.

U. S. Department of Energy (DOE), 1996. Final Programmatic Environmental Impact Statement for the Uranium Mill Tailings Remedial Action Ground Water Project, DOE/EIS-0198, October, 1996.

U.S. Environmental Protection Agency (EPA), 1988. Guidelines for Ground-Water Classification Under the EPA Ground-Water Protection Strategy, Office of Ground Water Protection, June 1988.

Attachment C

Colorado Department of Health and Environment Concurrence Letter

Interoffice Memo

Date: 5/19/99

To: File

Cc: R. Bowen, S. Marutzky

From: Richard Dayvault

RE: CDPHE Review of GJ GCAP

According to Don Metzler today, Wendy Naugle's review of the Grand Junction Site Observational Work Plan (SOWP) (especially Section 7) will suffice for a State of Colorado review of the Groundwater Compliance Action Plan (GCAP) . We should **not** expect an additional review of the GCAP and should incorporate all appropriate changes indicated in the SOWP review into the GCAP.

STATE OF COLORADO

Bill Owens, Governor
Jane E. Norton, Executive Director

Dedicated to protecting and improving the health and environment of the people of Colorado

HAZARDOUS MATERIALS AND WASTE MANAGEMENT DIVISION
http://www.cdphe.state.co.us/hm/

4300 Cherry Creek Dr. S.
Denver, Colorado 80246-1530
Phone (303) 692-3300
Fax (303) 759-5355

222 S. 6th Street, Room 232
Grand Junction, Colorado 81501-2768
Phone (970) 248-7164
Fax (970) 248-7198

Colorado Department
of Public Health
and Environment

November 17, 1999

Mr. Donald Metzler
Technical Manager
UMTRA Groundwater Project
U.S. Department of Energy
P.O. Box 2567
Grand Junction, CO 81502

RE: CDPHE Review of Groundwater Compliance Action Plan (GCAP) for the Grand Junction, Colorado Site

Dear Don:

The Colorado Department of Public Health and Environment (CDPHE) has completed its review of the above referenced document, the Environmental Assessment and the Final Site Observational Work Plan for the Grand Junction site. All comments that we had related to these documents have been resolved to our satisfaction. Therefore, this letter is intended to provide you with our formal agreement on the proposed Compliance Strategy for the site

I thank you for the opportunity to provide our input to this effort. Please call me at (303)692-3387 or Wendy Naugle at (303) 692-3394 if you have any questions.

Sincerely,

Jeffrey Deckler
Remedial Programs Manager

cc: John Surmeir, NRC
Paul Oliver, CDPHE-GJ
FILE (GRJ-4-G-4)

Attachment D

Institutional Control Documentation

GRAND JUNCTION

ZONING AND DEVELOPMENT

CODE

Recommended to the Grand Junction City Council
By the Grand Junction Planning Commission

Adopted by the Grand Junction City Council on July 5, 1989
Ordinance No. 2432

Text amendments/revisions passed and adopted as of May 21, 1997
have been incorporated into this Code

SUPPLEMENT
Submittal Standards for Improvements and Development (SSID) Manual
Adopted by the Grand Junction City Council June 2, 1993
Ordinance No. 2679
(Revised and Updated May 1995)

Zoning and Development Code Last Print Date: June 1997

5-4-2 LOTS AND BLOCKS

A. All blocks shall have a length of at least four hundred feet (400') but not more than eight hundred feet (800').

B. No parcel created under this Code shall have less area than required under the applicable zoning requirements.

C. Each lot or parcel shall provide vehicular access to a public street. Parcels with a front and rear street frontage shall be permitted only where necessary to provide separation from arterial streets or incompatible land uses. Rear yards fronting on arterial streets shall be fenced with a minimum six foot (6') high solid fence.

D. Side parcel lines shall be substantially at right angles or radial to street right-of-way lines.

5-4-3 IRRIGATION SYSTEMS AND DESIGN - The applicant shall submit to the Administrator those materials as listed in the SSID Manual.

5-4-4 POTABLE WATER SYSTEM

A. All water treatment and distribution systems, whether individual or public, shall comply with all regulations and specifications of the State and County Health Departments as well as all City or other applicable regulations.

B. All developments shall be served by the City water treatment and distribution system, unless such requirement is deemed unreasonable or impracticable, as determined by the Utilities Director. All water lines shall be designed to connect each parcel, as set forth in the previous sentence, with City mains in accordance with applicable engineering standards, unless exempted by the Utilities Manager.

C. Fire hydrants shall be placed and have fire flow capabilities in accordance with the requirements of the Fire Marshal and the City.

5-4-5 SANITARY SEWER SYSTEM

A. All sewage disposal and treatment systems shall comply with all laws, regulations and specifications of the State and local Health Departments, as well as any City regulations, and shall be located and constructed in a manner that will not pollute or endanger wells or other water sources.

B. A public sanitary sewer collection system and treatment facility shall be required for all developments.