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April 25, 1997

Shirley Ann Jackson
Chairman
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Ms. Jackson:

I am writing because I am very concerned about a uranium tailings pile near the Colorado River in Moab, Utah. I understand that remediation proposals are currently under consideration by the Nuclear Regulatory Commission (NRC) and a final Environmental Impact Statement (EIS) will be issued soon.

According to media reports, this tailings pile is located in the river's flood plain. I further understand that the spring flows are expected to be the highest in 15 years and that some environmental groups believe the site poses a threat to the Colorado River. I ask that you work with the EPA to ensure the area is secured from the Spring flows.

I am also concerned about how to remediate the tailings pile in the long-term and want to be sure that any action comports with the Clean Water Act. Therefore, I have contacted the Environmental Protection Agency to ask that they evaluate any proposed remediation to ensure that the Colorado River is protected.

I understand that the NRC is poised to issue an EIS which does not require moving the uranium tailings pile but, instead, would cap the materials in place. I am extremely concerned that, given the proximity of these harmful materials to the Colorado River, a flood event could lead to its contamination.

Therefore, in accordance with all appropriate rules, regulations and ethical guidelines, I ask that you take all steps necessary to ensure that any long term plan for remediation of the tailings pile protects the Colorado River and that, in the interim, the Colorado River is protected against any risks that may be posed by an excessive spring flow.

The Colorado River is a vital natural resource. I am sure that you agree that we must do all we can to protect it from pollution.

Sincerely,

John McCain
United States Senator

JM/bsl

NUREG–1532

Final Technical Evaluation Report for the Proposed Revised Reclamation Plan for the Atlas Corporation Moab Mill

Source Material License No. SUA 917
Docket No. 40-3453
Atlas Corporation

U.S. Nuclear Regulatory Commission

Office of Nuclear Material Safety and Safeguards

March 1997

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NUREG-1532

Final
Technical Evaluation Report for the Proposed Revised Reclamation Plan for the Atlas Corporation Moab Mill

Source Material License No. SUA 917
Docket No. 40-3453
Atlas Corporation

U.S. Nuclear Regulatory Commission

Office of Nuclear Material Safety and Safeguards

March 1997

ABSTRACT

This final Technical Evaluation Report (TER) summarizes the U.S. Nuclear Regulatory Commission staff's review of Atlas Corporation's proposed reclamation plan for its uranium mill tailings pile near Moab, Utah. The proposed reclamation would allow Atlas to (1) reclaim the tailings pile for permanent disposal and long-term custodial care by a government agency in its current location on the Moab site, (2) prepare the site for closure, and (3) relinquish responsibility of the site after having its NRC license terminated. The NRC staff concludes that, subject to license conditions identified in the TER, the proposed reclamation plan meets the requirements identified in NRC regulations, which appear primarily in 10 CFR Part 40.

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1.0 INTRODUCTION

1.1 Background

Source Material License SUA-917 for the Moab Mill is held by the Atlas Corporation (Atlas). The mill has not operated since 1984. A decommissioning[1] plan for the mill was approved by Amendment No. 3 dated November 28, 1988. Decommissioning of the mill began in 1988, and interim cover placement over the tailings disposal area began in 1989. The reclamation[2] plan that was prepared in 1981 and approved by NRC in 1982 was based on projected disposal capacity requirements and was designed for an ultimate crest elevation of 4076 feet. The maximum crest elevation constructed before mill operations ceased was 4058 feet, resulting in the necessity to redesign the tailings impoundment and thus revise the reclamation plan. In July 1993, NRC noticed in the Federal Register the intent to approve Atlas' revised reclamation plan and made available for public comment an environmental assessment of the effects of the proposed action. As is usual in cases where a licensee proposes revisions to an approved reclamation plan, both the NRC technical evaluation and environmental assessment only addressed the revised elements of the plan and the environmental effects of changes to the plan approved in 1982. Extensive adverse public comments were received in response to the Federal Register notice. As a result, NRC decided to reevaluate the entire reclamation plan and to prepare an Environmental Impact Statement (EIS) addressing reclamation.

This final Technical Evaluation Report (TER) documents the NRC staff review of Atlas' proposed reclamation plan and staff conclusions with respect to the appropriate regulations. The regulations governing reclamation of uranium mill tailings appear primarily in 10 CFR Part 40. Technical criteria appear in Appendix A to Part 40, which also allows licensees to propose alternatives to the specific requirements in the appendix. NRC can approve an alternative if it finds that it will achieve a level of stabilization and containment of the site, and a level of protection of public health, safety, and the environment, equivalent to, to extent practicable, the level which would be achieved by the requirements in the appendix.

A draft TER was prepared and published in January 1996 documenting the staff's initial review of Atlas' proposed reclamation plan and its conclusions with respect to the appropriate regulations. That draft TER contained 20 open issues that needed to be resolved by Atlas before NRC could conclude that the proposed action of on-site stabilization met the requirements of 10 CFR Part 40, Appendix A. In most licensing reviews, a draft TER is provided to the licensee, in lieu of an additional round of questions and requests for information, as a means to expedite the review process. While the draft TER is a publicly available document, it is not normally available for public

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[1]Decommissioning refers to the dismantling and disposal of the mill buildings and structures.

[2]Reclamation refers to the stabilization and closure of the tailings impoundment.

comment in most licensing cases. However, due to the extensive public interest and comment on the 1993 TER, NRC decided to make the Atlas draft TER available for public comment. The comments received and the staff responses to those comments, are provided in Appendix A of this document.

1.2 Site Description

1.2.1 Location and Description

The Atlas' Moab Mill site is located in Grand County, Utah. The site is located on the northwest shore of the Colorado River, 5 km (3 miles) northwest of the center of Moab (Figure 1-1). The site can be accessed from U.S. Highway 191 north of Moab. The Atlas mill site encompasses 162 hectares (400 acres) on the outside bend of the Colorado River, at the southern terminus of the Moab Canyon. The site is surrounded on the north and west sides by high sandstone cliffs. To the north and east is Moab Wash, to the east and south is the flood plain of the Colorado River, and across the river is Moab Marsh. The city of Moab is southwest of the marsh. The elevation at the mill is approximately 1130 meters (3700 feet) above mean sea level (MSL).

The mill grounds slope generally towards the Colorado River and Moab Wash. The substratum upon which the mill was constructed is composed mainly of alluvial materials brought down the Moab Canyon and Colorado River. Adjacent to the mill site on the north and west are U.S. Highway 191 and Utah Highway 279, respectively. Arches National Park is north of the site across U.S. Highway 191. The Rio Grande Railroad traverses a small section of Atlas property, just west of Highway 279, prior to entering a tunnel that emerges many kilometers down river.

1.2.2 Description of Mill Facility

The processing facility and tailings pond combined, cover approximately 81 hectares (200 acres) of an available 162 hectares (400 acres) owned by Atlas. The mill was authorized to extract uranium oxide (yellowcake) by both the acid and alkaline leach processes and was licensed for production at 850 metric tons (MT, 1,870,000 pounds) of yellowcake annually. During the life of the mill, only one tailings pond was used.

The plant site, before decommissioning, was composed of a main processing plant, a 53-hectare tailings pond, storage yards, ore receiving facilities, various process-related structures, and an office complex. These structures and facilities are enclosed by a four-strand barbed wire fence which prevents random access. All structures, including the office complex, are being razed during decommissioning of the facility.

1.2.3 Description and Characteristics of Tailings

The majority of the ore for the Atlas Mill came from the Big Indian Uranium District approximately 130 km (80 miles) to the southeast. The ore was primarily a sandstone with minor amounts of carbonate. Ore was trucked to the mill, ground to a sufficiently fine consistency to allow maximum efficient chemical reactions to occur. It was then processed through either the acid-leach circuit or the alkaline-leach circuit, both of which were used in this

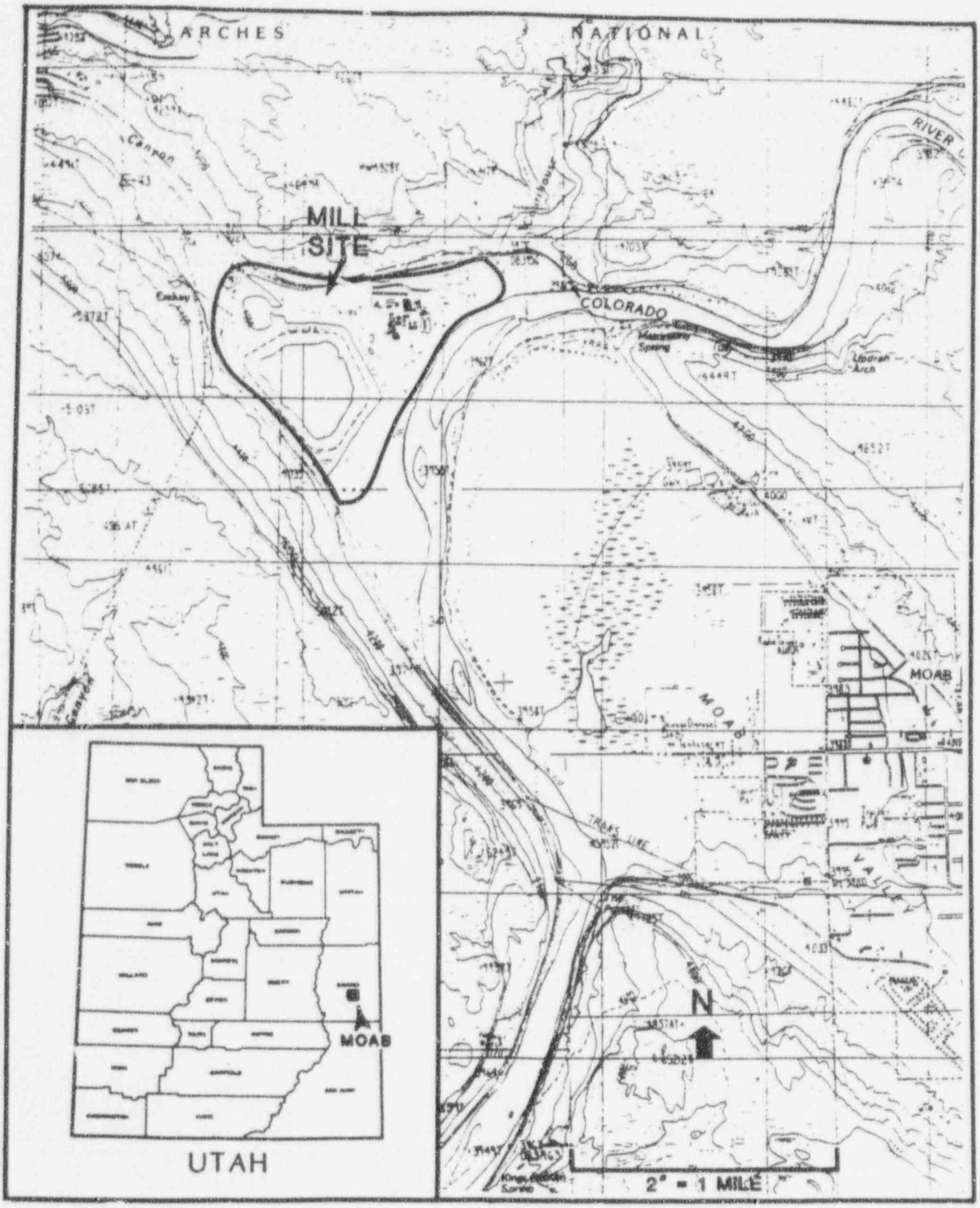

Figure 1-1: Atlas Moab Mill site

mill. Analysis of the mineral content of the ore would determine which circuit the ore would be processed through. After milling, the combined waste slurry from both circuits was pumped to the tailings impoundment.

The approximate wet weight of the tailings contained within the tailings impoundment is determined to be 9.5 million MT (10.5 million tons), with a volume of 5.7 million cubic meters (7.5 million cubic yards). The tailings basin is composed of fine tailings (slimes), coarse tailings (sand), and ore which was placed there at the end of operation of the mill as part of the interim cover. A composite analysis of the tailings by Atlas, determined that the average radium activity of the slimes was 1275 picocuries per gram (pCi/g) and that of the sands was 241 pCi/g. The activity of the ore in the tailings impoundment was determined to be 213 pCi/g radium.

1.3 Site History and Proposed Action

The Uranium Reduction Company (URC) built and began operations at the Moab Mill in October 1956. Atlas acquired URC in 1962 and operated the mill until 1984 when it was placed in stand-by status. Atlas holds NRC Source Material License SUA-917 for the Moab Mill which was changed to a possession only status on December 18, 1992.

A decommissioning plan for the mill was approved on November 28, 1988. Decommissioning of the mill began in 1988, and interim cover placement over the tailings disposal area began in 1989 and was completed in 1995.

The proposed action is approval of a reclamation plan for onsite disposal of the tailings. A reclamation plan was prepared by Atlas in 1981 and approved by NRC in 1982. This plan was based on the projected life of facility disposal capacity requirements; the disposal pile was designed for an ultimate crest elevation of 4076 feet. The maximum crest elevation constructed before the mill ceased operation was 4058 feet, resulting in the necessity to revise the reclamation plan. In accordance with 10 CFR 40, Appendix A, Atlas, by letter dated August 2, 1988, submitted a revised reclamation plan for NRC review and approval. NRC staff review of the proposed plan resulted in requests for additional information, reevaluation, and redesign. As a result, Atlas submitted a revised reclamation plan (Canonie, 1992). NRC staff review of this document resulted in a request for additional information dated March 5, 1993. Revisions to the 1992 reclamation plan were submitted by letters dated April 14, and April 23, 1993. On July 20, 1993, NRC noticed in the Federal Register its intent to approve the reclamation plan and made available for public comment an environmental assessment of the effects of the proposed action which only addressed the environmental effects of changes to the plan approved in 1982. Extensive adverse public comments were received. Major concerns and questions related to seismic and fault evaluations, the potential effects of the Colorado River and local tributaries on the stability of the disposal cell, and the need for an updated, complete environmental assessment of the entire reclamation plan, including alternative disposal locations. The comments received prompted NRC to withdraw, by Federal Register notice dated October 8, 1993, its previously noticed intent to approve the revised reclamation plan. By Federal Register notice dated March 30, 1994, NRC announced its intent to prepare an EIS.

The NRC staff review that resulted in the decision to approve the revised reclamation plan (and noticed on July 20, 1993, in the Federal Register), focused only on revisions to the previously approved reclamation plan. Due to the extensive public comments, NRC decided to reevaluate the revised reclamation plan in its entirety. This lead to additional requests for information by the staff and to submittals by Atlas, in response, in January 1994, June 1994, and March 1995. The draft TER, published in January 1996, contained 20 open issues. In response to these open issues Atlas provided further submittals in February 1996, June 1996, and July 1996, and submitted a revised reclamation plan and technical specifications in October 1996, which were modified by submittals in November 1996 and December 1996. As a result, the reclamation plan reviewed by the NRC staff consists of the following documents:

1. Base Reclamation Plan of June 1992 (Canonie, 1992),
2. April 1993 Response (Canonie, 1993),
3. January 1994 Response (Canonie, 1994a),
4. June 1994 Response (Canonie, 1994b),
5. March 1995 Response (Canonie, 1995),
6. February 1996 Response (Woodward-Clyde, 1996a),
7. February 1996 Response (Smith, 1996a),
8. June 1996 Response (Smith, 1996b),
9. July 1996 Response (Woodward-Clyde, 1996b),
10. Final Reclamation Plan (Smith, 1996c), and
11. Technical Specifications (Smith, 1996d).

1.4 Review Process and TER Organization

The NRC staff review was performed in accordance with the Final Standard Review Plan (SRP)[3] for the Review and Remedial Action of Inactive Mill Tailings Sites under Title I of the Uranium Mill Tailings Radiation Control Act (UMTRCA), Revision 1 (NRC, 1993) and is a comprehensive assessment of Atlas' proposed reclamation plan as documented by this TER. Appendix A to 10 CFR Part 40 contains the technical requirements for disposition of tailings and waste produced from the extraction or concentration of source material from ores. The TER is organized by the technical disciplines involved in the assessment of the reclamation plan to assure compliance with Appendix A. Each section describes the compliance with the applicable Criteria in Appendix A as it pertains to the specific discipline addressed in that section. Sections 2, 3 and 4 provide the technical basis for the NRC staff's conclusions with respect to long-term stability, Section 5 the plan's compliance with groundwater standards, and Section 6 describes radon control assessment. Section 7 provides a criterion by criterion evaluation of the reclamation plan with respect to Appendix A.

[3]Although the SRP is written for the UMTRCA Title I program, the applicable standards for the Title II program are similar. Division of Waste Management guidance directs the staff to use this SRP for Title II reviews to the extent practicable. All NRC licensed mill sites, including the Atlas site, are covered under the Title II program.

1.5 License Conditions

The NRC staff review of the reclamation plan identified a number of issues for which a license condition may be desirable to ensure that staff requirements are met. These items, with appropriate references to related sections of the TER, are identified in Table 1-1.

Table 1-1: License Conditions

License Condition	Section
1. Verification of Ra-226 concentration in coarse tailings	6.2.2
2. Verification of parameter values for "affected" soil	6.2.2
3. Verification of characteristics of clay for cover	6.2.3
4. Justification of radon barrier design if parameter values are not met	6.3

2.0 GEOLOGIC STABILITY

2.1 Introduction

This section of the TER documents the staff's review of geologic and seismologic information and analyses of Atlas Corporation's revised reclamation plan for its mill tailings site at Moab, Utah. 10 CFR Part 40 requires the tailings disposal area to be closed in accordance with a design which provides reasonable assurance of control of radiological hazards to be effective for 1000 years, to the extent reasonably achievable, and, in any case, for at least 200 years [Appendix A, Criterion 6]. Also, the tailings may not be located near a capable fault that could cause a maximum credible earthquake (MCE) larger than that which the tailings could reasonably be expected to withstand [Appendix A, Criterion 4(e)].

NRC staff considers this standard (Appendix A) to mean that certain geologic and seismologic conditions [such as Criteria 4(e) and 6] must be met in order to have reasonable assurance that the long-term performance objectives will be met. Guidance with regard to these conditions is provided in Final Standard Review Plan (SRP) for UMTRCA Title I sites which are applicable to Atlas and other Title II sites (NRC, 1993). Basically, Atlas has to identify geologic processes and events and the seismic hazards that might affect its reclamation designs over the next 1000 years, and provide reasonable assurance that significant hazards will be mitigated.

The staff's review of the geology and seismology is based upon the following sources of information and interpretations: Atlas Corporation's documents; interactions with Atlas Corporation and its consultants, including telephone conference calls, meetings and site visits; interactions (including exchange of documents, phone calls, field trips and office visits) with geologists, seismologists, hydrologists and rangers employed by the Utah Geological Survey (UGS), U.S. Geological Survey (USGS), University of Utah, Utah Division of Radiation Protection, U.S. National Park Service; proprietary reports of the Petroleum Science and Technology Institute, Edinburgh, Scotland; and independent sources, as cited.

2.2 Location

The Atlas site is located at the confluence of Moab Wash and the Colorado River, at the base of an escarpment of about 1100 feet of relief which borders an elongated, northwest-trending, topographic depression called Moab-Spanish Valley. Section 1.2 provides a more detailed description and map location of the site and vicinity in eastern Utah's Paradox Basin.

2.3 Geology

Atlas has presented information about the geology and seismology of its site from such sources as topographic maps and aerial photographs, soil and groundwater samples, geological and seismological maps and observations, geodetic surveys and literature searches. Subsurface geologic data derived from boreholes and logs of cuttings were presented as recommended in Final Standard Review Plan, Section 1.3.2 (NRC, 1993). In addition, Atlas provided

interpreted seismic reflections surveys of its site. Further, Atlas considered and discussed alternative conceptual models of the subsurface at the site. In aggregate, Atlas has provided information on the alluvium and bedrock beneath the tailings and operative geological processes in the site vicinity sufficient to establish specifications of geologic hazards that are reasonably expected to occur in the next 200 to 1000 years. The staff has independently compiled the following descriptions of the site geologic setting emphasizing those features, conditions, processes and events that represent potential geologic hazards or conditions that could adversely affect site stability during the next 200 to 1000 years.

2.3.1 Physiographic Setting

The site is located in the Moab-Spanish Valley, one of about eight prominent topographic depressions in the Paradox Basin. General technical descriptions, which include maps and cross sections of the Colorado Plateau physiographic province and its subprovince, the Paradox Basin in which the Atlas site lies, are found in the following references, among others: Cater (1970); Doelling (1985, 1988) and Hunt (1969, 1974).

2.3.1.1 Colorado Plateau Physiographic Province

The Atlas site lies within a geologically distinct sedimentary rock basin the Paradox Basin - that is part of the Colorado Plateau physiographic province (CPPP). The CPPP is characterized by these features and conditions: extensive plateaus bordered by receding escarpments, canyons, altitudes generally exceeding 5000 feet, semi-arid climate (except for variations caused by local altitude), and angular topography due to the combination of gently dipping strata of contrasting resistance to erosion and penetrative near-vertical fracture sets.

Much of the physiography of the CPPP can be related to subsurface and near-surface geological structures. Examples of physiographic features that are related to subsurface and near-surface structures are salt anticlines and salt depressions like the Moab anticline and Valley, upwarps like the Uncompahgre Plateau, fault valleys like Moab central segment and Lisbon Valleys, igneous domal uplifts like the La Sal Mountains, grabens of Canyonlands National Park (N.P.), and the fins and arches of Arches N.P.

The incised landscape of the CPPP results principally from erosion of upper reaches of drainage basins dominated by stream transport. Streams need not flow year-round to dominate the local sediment transport process. The sediment load of streams may be preserved for awhile as alluvial valley fill or alluvial terraces (both occur at and near the site). Both the erosional and depositional effects of transport by gravity (such as talus and landslides) and by wind (such as sand dunes) are also widespread. However, the spectacular canyons and escarpments (such as the Poison Spider Mesa escarpment adjacent to the site) are evidence of the dominance of erosional processes particularly stream migration and incision in response to on-going plateau uplift often with obvious structural controls.

The Colorado River and its tributaries dominate the drainage history of the plateau and the Paradox Basin. The geomorphic evolution of the Colorado River

is discussed briefly in the Section 2.3.4 on geomorphic setting.

2.3.1.2 Paradox Basin

The Atlas site lies within the thickest stratigraphic section and most structurally deformed zone of a northwest-trending wedge-shaped sequence of sedimentary rocks called the Paradox Basin. Paradox Basin sediments filled an asymmetric structural depression a few miles deep (Cater, 1970). The thickest part of the basin was subjected to a variety of geologic processes, including cyclical evaporite deposition in the Pennsylvanian Period, faulting, salt diapirism, folding, igneous intrusion, jointing, uplift, subsidence, erosion/deposition, and seismicity. The latter four processes are considered to be potential hazards that might adversely affect the tailings pile and are discussed in this section.

2.3.2 Stratigraphic Setting

The thick part of the wedge of the Paradox Basin sedimentary rocks (e.g., the Moab area) has had a long history of deposition and erosion in marine and continental environments periodically punctuated by tectonic, geomorphic and climatic processes and events. The regional stratigraphy is briefly described to provide background to discussions of processes that are deemed likely to continue to operate over the next 1000 years. UGS defers to Molenaar's (1975) lexicon of stratigraphic names for appropriate use in the Paradox Basin. The staff considers the stratigraphic nomenclature, rock descriptions, thickness measurements and correlations in Doelling, et al. (1995) more than adequate for this review. The immediate foundation of the tailings appears to be a wedge of Quaternary alluvium that thickens to the south and west from on the order of 10 m (30 feet) to 120 m (400 feet). The wedge is underlain by probable Paleozoic and Mesozoic rocks that were downfaulted from the cliffs and plateaus around the site. Rocks older than Mississippian occur beneath the site at depths greater than about 3 kms (10,000 feet) (Doelling, et al., 1996, Plate 2). Precambrian basement rocks, still deeper, are the sources of earthquakes that have been adequately characterized by Atlas. Atlas has characterized the Quaternary alluvium and the rocks beneath the site to the extent necessary to support its conclusions of bedrock, geomorphic and seismic stability, as discussed later in this section. Marine conditions existed in the basin throughout the Late Cretaceous Epoch during which clays, silts, and thin layers of sand now referred to as the Mancos Shale were deposited. The Mancos is widely exposed north of Moab Valley (such as by the Moab airport and along Interstate 70 to near Cisco). Alternative disposal sites have been identified in the Mancos and discussed in the FEIS.

2.3.2.1 Stratigraphy of the Moab Area, Utah

The Mesozoic rock sequence exposed around the site from top of Poison Spider Mesa and Arches N.P. down the cliff to Colorado River level includes the Jurassic Entrada and Navajo Sandstones, Kayenta Formation and Wingate Sandstone, and the Triassic Chinle and Moenkopi Formations. The Paleozoic rock sequence exposed near the pile is represented by Permian age rocks of the Cutler Formation, Pennsylvanian rocks of the Honaker Trail Formation and Paradox Formation caprock. Mississippian and older rocks are known to occur in the subsurface (Doelling et al., 1995, Description and Correlation of Map

and Bedrock Units). The basin was nearly filled with cyclical deposits of marine evaporite minerals by the end of the Late Pennsylvanian Epoch. Deposits of potash minerals and other evaporite mineral resources occur in these rocks. Paleozoic rocks also harbor oil and gas in the Grand County, UT area.

There is little rock record for the interval from 67 million to about 5 million years ago in the Paradox Basin. Magma (melted rocks) intruded the area about 25 million years ago that is now exposed in the La Sal Mountains. The Paradox Basin salt-cored valleys, such as Moab-Spanish Valley, which formed by collapse and erosion of cover rocks above salt-cored anticlines, contain conspicuous deposits of sediments that are predominantly Quaternary in age. These deposits suggest that the Moab Valley has been a local depocenter during the Quaternary. Caprock represents the relatively insoluble residue of salt dissolutioning. Caprock is exposed across the Colorado River from the Atlas site (Doelling et al., 1995) and is postulated to occur beneath the site (Woodward-Clyde, 1996, Section 2). Presumably, caprock is continuing to form by salt dissolutioning in the subsurface as evidenced by briney groundwater.

2.3.2.2 Quaternary Stratigraphy

From a regulatory point of view, the record of geologic processes and events which occurred in the last two-million-years, the Quaternary Period, is most indicative of what might occur in the next few thousand years. The site is at the confluence of the Colorado River and Moab Wash and lies a few hundred meters downstream from the Courthouse Wash - Colorado River confluence. Alluvium from the three fluvial systems are expected to occur beneath the site. The Atlas site is underlain by alluvium that apparently is greater than 120 m (400 feet) thick, as suggested from a drillhole on site. The local base level is the Colorado River bed and appears to be controlled by the elevation of the bedrock channel at The Portal. Therefore, the accumulation of alluvium at the site to depths below the elevation of The Portal suggests that the site and Moab Marsh have been subjected to local subsidence of approximately 120 m (four hundred feet) or more. The general maximum thickness of alluvium in Moab Valley is about 150 m (500 feet), shown schematically on some UGS cross sections (Doelling et al., 1995).

The geometry of the alluvial wedge beneath the site has been acceptably defined by Atlas for purposes of assessing site response to future geologic events, such as seismicity and differential subsidence. The Atlas site is underlain by an alluvial wedge that varies from about 10 m (30 feet) on the north boundary to greater than 120 m (400 feet) thick on the south near the Colorado River, as suggested from drillholes (Woodward-Clyde, 1996, Section 3) and seismic reflection surveys (Cooksley, 1995, 1996). The surface on which the alluvium was deposited, dipping southward and westward, has undulations with relief up to about 15 m (50 feet), which is the reported relief across the Moab Fault at the south end of pile (Cooksley, 1995, 1996). This is a substantiated buried scarp. As interpreted by Cooksley, alluvium is thicker everywhere on west side of the Moab fault than on the east side. Cooksley suggests that an eastward dipping reflector in the northeast part of the wedge represents an older stream terrace. The age and fluvial history of the alluvial wedge is insufficiently known to make precise estimates of the

potential future course of the Colorado River or Moab Wash, of subsidence rate, or of deposition rate for the site.

Quaternary to recent eolian sand deposits occur as dunes, sand ramps and discontinuous sheets in the Arches N.P. area near the site (Huntoon et al., 1982). They are derived from the numerous sandstones, especially the Jurassic Entrada Sandstone (Doelling et al., 1995, Description of Map Units). In the Moab area, sand is transported predominantly from the west and accumulates on the northeast-facing slopes and their base (Doelling, 1988). The slopes of Poison Spider Mesa are a prime zone of accumulation. Sand deposits adjacent to the site are largely stabilized (vegetated). However, about 20 cm (8 inches) of sand has blown in and accumulated in and around a borrow-pit on the northeast side of the tailings pile. Atlas has considered the potential hazard caused by windblown sand and the staff has determined that Atlas' proposed design will acceptably mitigate the hazard (see Section 4.5.5).

Quaternary landslide deposits, broken, but coherent rock masses that slip on shears which develop on oversteepened cliffs or on previously developed faults or joints, have been mapped in Moab Valley (Doelling et al., 1995), including the cliff adjacent to the site (Huntoon et al., 1982). They are often associated with the Morrison Formation (Doelling, 1988). However, landslide deposits formerly mapped by Huntoon et al. (1982) are no longer considered by them to be landslides (Smith, 1996, Part 2). Atlas has investigated the potential for future landslides and has adequately demonstrated that it is not a significant hazard (see Section 2.4.2.2).

Quaternary to recent talus deposits are accumulations of rock block, and debris falls on and at the base of steep slopes. Talus has been mapped adjacent to the site and is readily observed. Atlas has considered rock and debris fall and adequately demonstrated that the effects of rock falls and talus encroachment into the drainage system on the western side of the pile will be mitigated by the proposed design (Section 4.5.1.3.2).

Two Quaternary volcanic events that might have affected the site have been preserved in Quaternary basins in Arches N.P: Volcanism near Bishop, CA, about 740,000 years ago and near Yellowstone, WY about 620,000 years ago wafted ash in the area evidenced by scattered deposits in the Park (Oviatt, 1988). Nevertheless, in the staff has concluded that a volcanic ash fall at the site is not sufficiently likely to occur in the next 200 to 1000 years to be considered as a basis for design (see Sections 2.3.3.5 and 2.4.2.3).

2.3.3 Structural Setting

Alternative conceptual tectonic models of the site vicinity generally show agreement on the presence of the following major tectonic elements, including Atlas' concept: (1) the Moab Valley and Moab anticline are underlain by the Moab salt-cored anticline; (2) the Paleozoic and Mesozoic rocks exposed in valley walls and the adjacent plateaus are faulted, mainly by normal slip faults, dominantly subparallel to the salt-anticline axis; (3) most faults in Moab Valley and adjacent rims are rooted in the salt anticline and are not structurally connected to basement faults (for example, the Moab fault system); (4) Moab fault system has been the loci of slip due to differential subsidence caused by dissolution or creep of underlying salt, or by re-

activation episodic diapirism or extensional tectonics (Foxford et al., 1996; Ge et al., 1996); (5) a zone of breccia plugs in the Valley, and one at Arches N.P. entrance were probably caused by subsurface processes not currently operative; (6) the current state of stress in the Colorado Plateau (and Moab area) is generally NE-southwest (SW) extension (Wong and Humphrey, 1989; Wong, et al., 1996); (7) historical seismicity indicates a NE-trending seismic source zone in the basement rocks beneath the Colorado River from confluence with the Green River to Moab, UT is a seismogenic hazard to the site (Woodward-Clyde, 1996, Section 4).

Figure 2-1 shows the general location of the Moab fault system and alignment of seismicity along an alleged basement fault. The Cenozoic faults are after Hecker, 1993. The seismicity includes records from 1953 to 1994 with possible induced seismicity associated with the Cane Creek mine at Potash omitted. Stippled areas represent distributed deformation; ball is on the downthrown side of normal faults (see Olig, et al., 1996; Wong et al., 1996). Figure 2-2 shows a conceptual relationship of the Moab fault, West Branch of Moab fault, Moab salt-cored anticline, Moab anticline and associated faults rooted in the salt-cored anticline, pre-Paradox Formation structure and Poison Spider Mesa escarpment with crest above 1.5 km (5000 feet).

Atlas has performed a literature review of the Moab fault system to develop a basis for seismic and faulting hazard analyses and to assess conceptual tectonic models of the site. It has gathered primary data from field investigations and observations and made interpretations of drill-hole logs, seismic reflection and topographic profiles, such as those described in SRP Sections 1.3.2, 1.3.3 and 1.3.5 (NRC, 1993). Atlas considers that Paleozoic and Triassic rocks may immediately underlie the site west of the Moab fault trace, and Triassic and Jurassic rocks may immediately underlie the site east of Moab fault trace (Woodward-Clyde 1996, Section 2, Figure 2-14; Fig. 2-2). Also, Atlas considers that Paradox Formation (salt beds) is 450 to 610 m (1500 to 2000 feet) below the pile (Woodward-Clyde, 1996, Section 2). Paradox Formation caprock crops out on the south side of the Colorado River, implying that salt is closer to the surface there than at the Atlas site. This is in general agreement with the UGS model (Fig. 2-2). The NRC staff find the general conceptualization to be acceptable and have considered differences among the models in its hazard analyses.

2.3.3.1 Structural Features - Regional

The Paradox Basin structures have been considered to be compatible with a wrench tectonic system, and it has been suggested that part of the Basin is a pull-apart structure (Stevenson and Baars, 1986, 1987). From a regulatory perspective, the evidence for the existence of NW and NE basement faults is sufficient for concluding that an alignment of seismicity at basement depths may be correlated with such an otherwise unseen basement fault. This is the case for the NE-trending Colorado River seismic source which has been delimited in the Moab area (Section 2.4.3; Fig. 2-1).

Tectonism is generally considered to have initiated the salt-wall diapirism of the Late Paleozoic through Cretaceous(?) which led to the formation of salt-cored anticlines with long northwest-trending master faults, such as the Moab fault system. Some of the diapirs breached, or nearly breached, cover rocks,

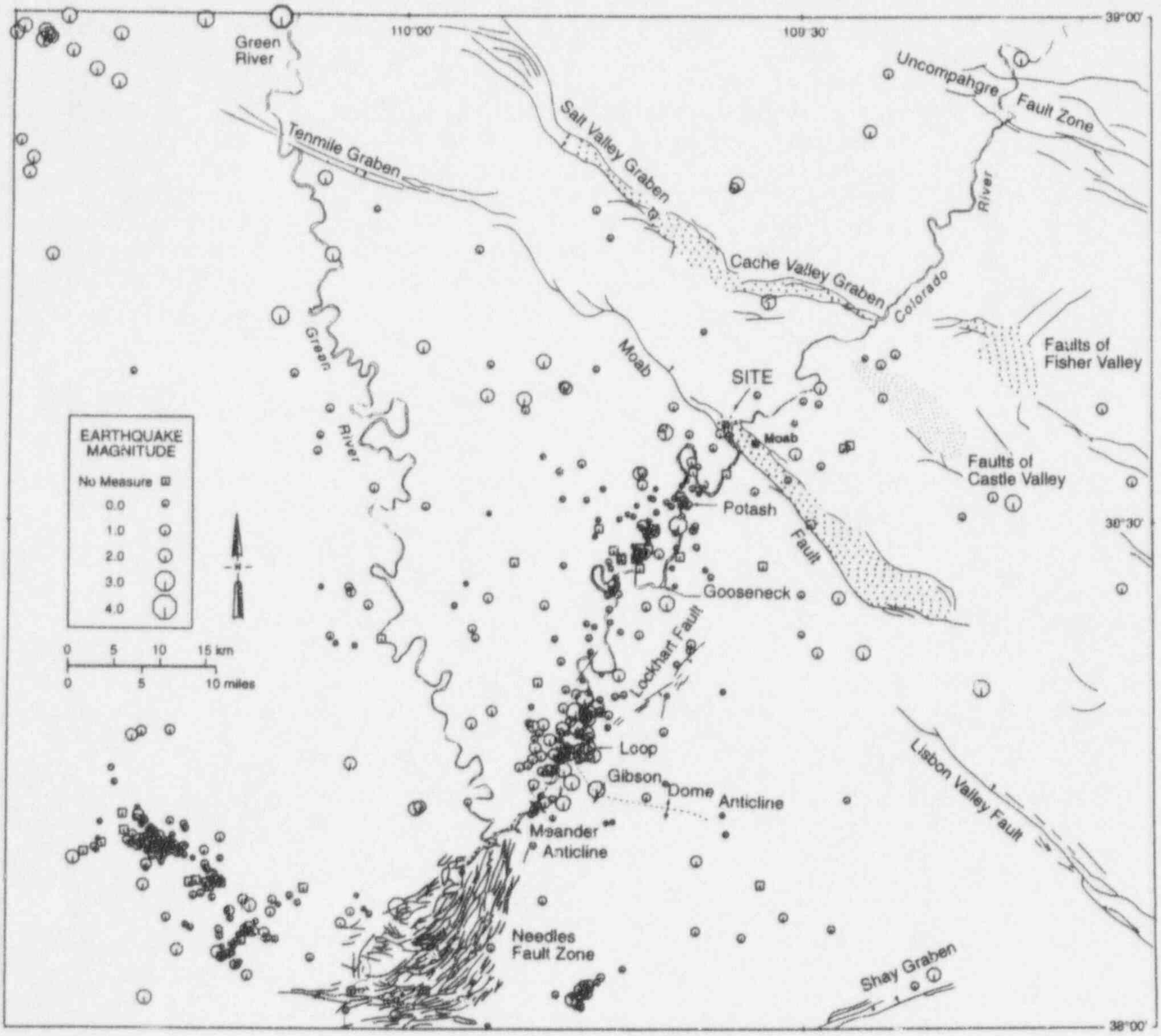

Figure 2-1: Location map of selected Cenozoic faults and seismicity in Moab, Utah area. See text for explanation (from Wong, et al., 1996; by permission).

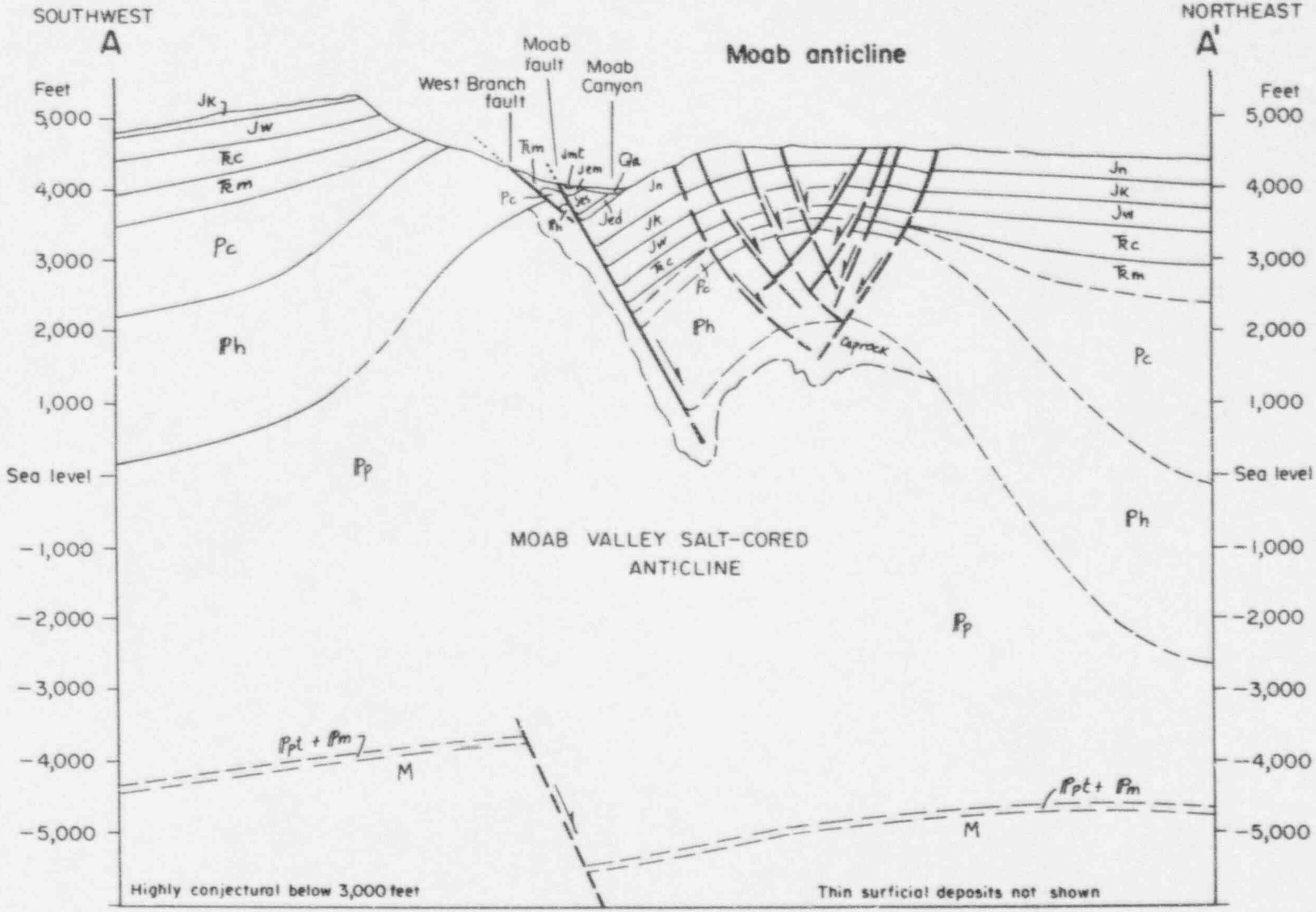

Figure 2-2: Geologic cross section of Moab salt-cored anticline about 1 km north of Atlas site. West Branch and Moab faults are projected to underlie the Atlas site (from Doelling, et al., 1995, Plate 2; by permission).

e.g., Moab (Fig. 2-2), Salt-Cache, Castle and Fisher Valleys. Other diapirs, like the Lisbon Valley salt-cored anticline, have a master fault(s) that penetrated cover rocks, e.g., the Lisbon Valley fault (Fig. 2-1), but have not sufficiently deformed the cover rocks or dissolved or flowed laterally to the extent necessary to initiate collapse of the cover rocks (Cater, 1970).

Mid-Tertiary (about 25 million years old) igneous intrusions which comprise the La Sal Mountains are considered to be structurally controlled by northwest-trending and northeast-trending faults in the Precambrian basement.[4] In particular, the southern intrusive complex intruded the northwest basement fault that is projected to underlie Moab-Spanish Valley. Northeast-trending basement faults are considered to segment the basement into blocks. The Moab-Spanish Valley basement fault (NW) and the Castle Valley-Paradox Valley basement fault (NW) are possibly connected by a northeast-trending basement fault, south of Wilson Mesa[4] (Friedman et al., 1994). The trace of these faults separates deeper basement (2-4 km [7,000-14,000 feet] below sea level) of the northeast portion of the Paradox Basin, from shallower basement, to the south and west. The intrusives occur in and near the fault-controlled, steep, basement gradient.

A recent review of the geophysical and geological evidence for northeast-trending structures in the basement (Friedman et al., 1994), suggested that such features are faults thousands of feet beneath the Colorado River and beneath the middle La Sal Mountains, among other places. In addition, some authors have suggested that basement faults were involved in the alignment of the Colorado River and the La Sal Mountains intrusions[4] (Friedman et al., 1994; Hite, 1975). Further, it has been suggested that the Colorado River seismic zone might be a manifestation of a basement fault segment beneath the river (Wong and Humphrey, 1989). Two northeasterly faults transect the Moab fault, the Roberts Rift (Hite, 1975) and the Kane Springs graben system (Friedman et al., 1994). The Roberts Rift is brecciated and mineralized and considered to be deep-seated, though its displacement is small. The Kane Springs graben is at the southeastern terminus of the Moab fault. The Lisbon Valley fault also terminates at the graben. Several faults parallel to the Lisbon Valley fault, near Lisbon, may have last moved in the Holocene (Woodward-Clyde, 1982b). Evidence suggests that a fault in the Kane Springs graben system moved in the Pleistocene (Friedman et al., 1994). Should the Kane Springs graben or the Lisbon Valley fault system have a structural connection to the Moab fault system, then that would have constituted evidence for presuming that the Moab fault is a capable fault. The staff has concluded that the Moab fault is not a capable fault, for reasons discussed in Section 2.4.1.1.

2.3.3.2 Salt Tectonics - Diapirism and Subsidence

Salt diapirism, differential displacement of up to about 1000 m (3100 feet) on

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[4]Ross, M.L., "Geology of the Tertiary Intrusive Centers of the La Sal Mountains, Utah: Influence of Pre-existing Structural Features on Emplacement and Morphology," U.S. Geol. Surv. Bull., Friedman, J.D. and A.C. Huffman, coord., Laccolith complexes of southeastern Utah: time of emplacement and tectonic setting-- workshop proceedings, in press.

longitudinal master faults in cover rocks (for example, Moab fault), and concomitant stream erosion of cover rocks (for example, Colorado River and tributaries like Moab Wash and Pack Creek) explain the distribution of rocks and sediments, structures and topography in the site vicinity. Active diapirism and longitudinal faulting are no longer controlling-processes in the Moab Valley. However, stream erosion and gradual subsidence are active and are design considerations.

Atlas has postulated that the rates of subsidence related to salt dissolution are lower now than have occurred in the past (Woodward-Clyde, 1994, p. 10). The only basis provided to support this statement is that "...[subsidence or dissolution] rates have probably slowed down since the time of Pinedale glaciation (roughly 15,000 to 25,000 years ago) due to a drier climate" (ibid., p. 10). Also, Atlas has asserted that "...there is no evidence for late Quaternary subsidence north of the Colorado River in the vicinity of the tailings pile" (ibid., p. 10). However, more than 400 feet of alluvium, at least some of it probably late Quaternary, observed by Atlas in borehole ATP-1 beneath the tailings, lies below local baselevel. This suggests that 400 or more feet of subsidence has occurred enabling sediments to accumulate there. There is little or no evidence to suggest that subsidence is not continuing, or will not continue.

Moreover, numerous breccia pipe collapse features attributed to a dissolutioning-stoping mechanism have been identified in the Spanish Valley (Sugiura and Kitcho, 1981; Weir et al., 1961). Such breccia has been mapped about 8 km (5 miles) from the site at Arches N.P. entrance (Doelling et al., 1995). Also, sinkhole-like collapse features have been reported in the Salt Valley-Cache Valley and Castle Valley areas by UGS (Doelling, 1988; Mulvey, 1992). These may be analogs for Moab Valley. However, the UGS has not listed subsidence among the geologic hazards it has identified in the Moab Valley. Although some of these features may be of Tertiary age and of little or no consequence to the site, their occurrence, or potential future occurrence, beneath or near the site, has not been investigated or analyzed by Atlas. One school of thought suggests that regional extension, not diapirism or dissolution, played the main role in the origin of breached salt anticlines and associated longitudinal fault systems (Ge, et al., 1996).

The UGS considers that subsidence in the vicinity of the Atlas site is continuing but has no direct evidence of the rate. Based on observations of relatively rapid and episodic types of collapse features (e.g., sinkholes, breccia pipes, landslides), and of relatively slow types of subsidence features (e.g., folds, syndepositional thickening, unconformities), the UGS considers that a range of rates of future subsidence is possible in the site vicinity (Allison, 1994).

Several estimates of long-term average rates of subsidence, incision of the Colorado River, and denudation for drainage domains in the Colorado Plateau, have been made. They all fall in the range 0.1 m to 1 m (0.3 to 3.1 feet) per 1000 years (Allison, 1994; Friedman et al., 1994; Woodward-Clyde, 1982a, p. 3-20 to 3-21). Such rates, determined from outside the Moab area, have been considered in deliberations of long-term stability of Moab Valley. Similar rates were independently derived in Moab Valley by Atlas (Woodward-Clyde, 1996, Section 3). These average rate estimates say little about the potential

for rapid subsidence-collapse hazards. Atlas has evaluated and estimated the subsidence hazard from all reasonable sources. This is further discussed in Section 2.4.1.3.

2.3.3.3 Moab Fault System

The location of the Moab fault on the site or under the pile, even its existence there, has been particularly controversial because of its potential as a seismic hazard or as the locus of future differential salt-subsidence. Atlas appears to generally agree with the UGS interpretation (Doelling et al., 1995) that two strands of the Moab fault system - the Moab fault and the West Branch of Moab fault - underlie the site (Woodward-Clyde, 1996, Section 2; Fig. 2-2). Atlas has provided evidence from seismic reflection surveys that the Moab fault underlies the pile and the West Branch of Moab fault may underlie the site or pile (Cooksley, 1995, 1996; Woodward-Clyde, 1996, Section 2; additionally, see Baars and Doelling, 1987; Doelling, 1985, 1988; Huntoon et al., 1982; Olig et al., 1996; Foxford et al., 1996).

The location and nature of the Moab fault, especially near the Atlas site, has been subject to several interpretations. For example, McKnight (1940) mapped the fault along the base of the northeastern valley wall, not underlying the present Atlas site. Williams (1964) mapped the fault along the lower slope of the Poison Spider Mesa escarpment, near the current location of the West Branch fault, but not underlying the site. Huntoon et al. (1982) mapped one splay of the Moab fault trending toward but terminating just north of the site boundary and another fault skirting the pile along the base of Poison Spider Mesa escarpment. Doelling (1985, 1993; Allison, 1994) mapped the main Moab fault trace (queried) under the pile and the West Branch of the Moab fault dipping under the pile (indicating the possibility that two faults underlie the site; Fig. 2-2). Seismic reflection survey done for Atlas appears to have imaged the Moab fault under the pile (Cooksley, 1995, 1996). The nearest exposure of the Moab fault to the site is about 0.8 km (0.5 mi) north; the West Branch fault is exposed in the escarpment about 0.3 km (0.2 mi) west. Doelling et al. (1995) mapped three faults within the site boundary: (1) the main Moab fault (queried); (2) the West Branch fault which dips under the site; and (3) an unnamed arcuate fault which intersects the projection of the other two faults (this is the "buried fault" introduced earlier that is not presently considered part of the Moab fault system).

Selected results of detailed mapping and characterization of the Moab fault system relevant to this licensing action are synthesized from Foxford et al. (1996; northern and central segments) and Olig et al. (1996; northern, central, southern segments) are as follows. Total length of Moab fault system, from Tenmile Graben on the north to near Kane Springs structure at southern end of Moab-Spanish Valley is about 54 km (34 mi). The main faults are normal dip slip, down to the east (Fig. 2-1). Three segments are distinguishable from surface characteristics: Northern segment-length is 16 km (10 mi) from Courthouse Rock to Tenmile Wash; vertical component of net slip (throw) varies from about 230 m (750 feet) to zero, diminishing northward; dips are steep at 65-71 NE; the footwall structure is that of subhorizontal strata; the hangingwall structure is that of a normal drag fold; Central segment-length is about 19 km (12 mi) from Courthouse Rock to the Colorado River at The Portal; throw of about 950 m (3100 Feet) a few miles north of the

Atlas site; dips are moderate to steep at 50-75 NE; the footwall structure contains a doubly plunging anticline elongated parallel to the fault; the hangingwall contains the Moab anticline of Arches N.P.; Southern Segment-length is about 19 km (12 mi) from The Portal to southern end of Moab-Spanish Valley; throw is about 300 m (1000 feet); fault dip and structure of rocks adjacent to the fault have not been described.

The UGS geologic map of the Moab area indicates that the Moab fault is rooted in the Moab salt-cored anticline and is not structurally connected to the basement (Fig. 2-2). Such a fault would not meet the definition of a capable fault (10 CFR Part 100, Appendix A), however, it could still represent a hazard that would need to be assessed because it is under the tailings and may be subject to differential subsidence. Atlas has addressed the capable fault and subsidence issues. These are further discussed in Sections 2.4.1.1 and 2.4.1.3.

2.3.3.4 Regional Joint Patterns and Rock Fracturing

Recent studies of regional joint sets that are exposed in the rim synclines and plateaus around Moab Valley and Arches N.P. show that some sets are related to the reactivation of basement structures. However, regional joint sets have produced the dominant fracture fabric of the exposed rocks. These sets more definitively reflect the paleostress fields that produced them (Cruikshank and Aydin, 1995). The regional fracture sets are discreet spatially and temporally and were not produced by propagation upward from the basement[5] (Cruikshank and Aydin, 1995) and they are probably formed after the Moab fault system developed (Foxford et al., 1996). Systems of rock fractures are relevant to analyses of groundwater flow, mass wasting of slopes, and identification of stress fields that may be favorable for rejuvenation of joints or development of faults. The reports mentioned above form a sufficient basis for consideration of the effects of joints on rock mass characteristics and groundwater flow.

2.3.3.5 Volcanism

As much as 4 m (13 feet) compacted volcanic ash from volcanoes in the Western United States fell within 24 km (15 miles) of the site, in Salt Valley (Arches N.P.), from at least two major volcanic eruptions about 740,000 (Bishop Tuff) and 620,000 (Lava Creek B) years ago (Oviatt, 1988). Also, ash beds thought to be correlative to those in Salt Valley have been described from Fisher Valley (Coleman, 1983). The volcanic sources of these Utah ash deposits are active today: Long Valley caldera, CA (Bishop); and Yellowstone N.P., ID/WY (Lava Creek B). However, the infrequent occurrence of future ash falls led the NRC staff to consider the potential volcanic ash hazard a non-issue (Section 2.4.2.3).

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[5]Verbeek, E.R. and M.A. Grout, "Relation Between Basement Structures and Fracture Systems in Cover Rocks, Northeastern and Southwestern Colorado Plateau," U.S. Geol. Surv. Bull., Friedman, J.D. and A.C. Huffman, coord., Laccolith complexes of southeastern Utah: time of emplacement and tectonic setting--workshop proc., in press.

2.3.4 Geomorphic Setting

2.3.4.1 Topography and Geomorphic Features

The Moab, Utah 15' topographic quadrangle is dominated by the Colorado River (flowing NE to SW), Moab-Spanish Valley (axis aligned NW to SE), and plateaus dissected by washes. The Atlas tailings pile lies in the northwest terminus of Moab Valley between the Colorado River and the escarpments that define the valley. It sits at the confluence of Moab Wash and the Colorado River and is on the floodplain of the river. The Colorado River is rock-defended, i.e., its bed is bedrock, just prior to entering (Matrimony Spring) and leaving Moab Valley The Portal). Across the river from the pile lies Moab Marsh or slough, the largest marsh on the river. Courthouse Wash, which drains much of Arches N.P., joins the Colorado near and upstream from the Atlas mill. Terraces occur near the mouth of Courthouse Wash and at various locations along Mill Creek and Pack Creek southeast of town in Spanish Valley. The valley is about 2.4 km (1.5 miles) wide where the Colorado River transects it, and the relief at the pile is about 340 m (1100 feet). The Moab Valley's southeastern end is about 15 miles from the Colorado River at Kane Springs.

The valley walls are fault line scarps. South of the Colorado River linear (actually planar) topographic features in the rim plateaus on both sides of Moab Valley intersect the valley walls. The linears on the plateau south of town trend E-W and represent an eroded joint set. Within a mile north of town, NW-trending linears intersect the valley at the river. These linears are faults. Trending northwest from the site through Moab Canyon is Moab Wash that heads at Little Canyon and appears to have captured Little Canyon Wash. Moab Canyon marks the Moab fault trace. The Moab fault trace runs northwest along the foot of the increasingly subdued scarp to near Courthouse Rock and beyond.

2.3.4.2 Colorado River and Its Tributaries

The potential for migration of the Colorado River toward the tailings has been considered. The potential effects and design to mitigate them are discussed in Sections 4.4.5 and 4.5.1.2.3. The Colorado River channel in its Moab Valley reach is the local base level of Moab-Spanish Valley because the Colorado is rock-defended at The Portal. Therefore, the tributaries to the Colorado (such as Pack and Mill Creeks, flowing northwest, and Courthouse and Moab Washes, flowing southeast) have been, and are likely to remain, in confluence with the Colorado at the elevation of The Portal when at grade. Trending SE to the site through Moab Canyon is Moab Wash that heads at Little Canyon and appears to have captured Little Canyon Wash. Moab Canyon appears to be fault-controlled, delineating the Moab fault trace (Oviatt, 1988).

UGS has provided its perspective on the issue of migration of the Colorado River to the northwest, where the site is located (Allison, 1994). The following is a summary of the UGS discussion.

UGS has mapped the modern flood plain of the Colorado River in the Moab 7.5' quadrangle (Doelling et al., 1995). Stream terraces that mark the former course and elevation of the Colorado River and its tributaries are also mapped. Colorado River terrace gravels are present on the east side of

Courthouse Wash about 40 feet above the modern river channel. Atlas conducted stream profiling and soil studies in this reach to gain an understanding of incision rates or subsidence rates. This is further discussed in Section 2.4.1.3.

Gravels are present west of the tailings about 27 m (90 feet) above the modern river channel. If these are remnants of a former position of the Colorado River, then the Colorado River probably occupied the Atlas site in Pleistocene time.

Vegetation is also a factor when considering the stability of the river bank. Because most of the modern flood plain was inundated in the early 1980s, the UGS considers it likely that upper flood plain deposits are Holocene. There is no conclusive data available which would indicate that subsidence caused by dissolution of salt affected the migration of the Colorado River in Moab Valley.

UGS considers it possible that the tailings may be affected by channel migration of the Colorado River and erosion within the next 1000 years. The UGS also considers the current river bank deposits from Moab and Courthouse Washes to be sufficiently heterogeneous in grain size (even with cobbles present) and laterally discontinuous to not be a reliable deterrent to river-bank erosion. Atlas has considered this possibility and has presented an acceptable mitigative design (Section 4.5.1.2.3).

2.3.4.3 Geomorphic Processes

Running water, gravitational (e.g., mass wasting), and eolian processes are active in the vicinity of the site and have had an effect on impoundment design. With regard to running water, discharge from Moab Wash has been controlled by diversion channels, and a channel of the Colorado River was partially diverted by emplacement of a rock sill. Additional considerations of running water are evaluated in Sections 4.4.4 and 4.4.5.

With regard to gravitational processes, the approximately 330 m (1100 feet) of relief on Poison Spider Mesa escarpment adjacent to the site and near-vertical joint sets and faults, such as the West Branch of the Moab fault system, have promoted mass wasting of the scarp. Rates of scarp retreat estimated for rock types like those holding up Poison Spider Mesa (mainly Triassic and Jurassic sedimentary rocks), based upon long-term erosion of a variety of rock faces, is about 0.24 meters (0.8 feet) to 0.55 meters (1.8 feet) per 1000 years (Woodward-Clyde, 1982a, p. 3-21; Woodward-Clyde, 1996, Section 2). Rock falls have been considered by Atlas and are discussed in Sections 4.5.1.3.2. The landslide potential has been considered by Atlas and is further discussed in Section 2.4.2.2. Salt diapirism is a gravitational process no longer of significance in the site area, and is considered under the heading of structural geology (Section 2.3.3.2).

Wind, aridity, the availability of sand-size particles and nooks, crannies, and rock bastions have combined to promote the deposition of sand dunes, sand ramps and sand sheets in the Moab area (Doelling et al., 1995). Observations indicate that the eolian process continues to be active in the area. Sand that may be deposited in drainage channels has been considered by Atlas and is

discussed in Section 2.4.2.1.

2.3.5 Seismicity

The licensee provided information on the seismicity of the site and environs in the Safety Analysis Report (SAR) in 1975 (Atlas, 1975). The seismic design of the reclamation plan approved by NRC in 1982 relied on information contained in the SAR. However, since issuance of the SAR, considerable geological and seismological data have been obtained in and around the Atlas mill tailings site. In 1995 NRC requested the licensee to address the following specific issues:

1) the adequacy of the current seismic design for the Mill Tailings, and

2) the seismogenic potential of the earthquakes in the Colorado Plateau and along the Colorado river.

In response to this request the licensee performed geological literature and data reviews, geologic field studies, and a seismicity review and evaluation. Based on the new information the licensee identified the design earthquake using deterministic and probabilistic analyses. The licensee submitted a report (Woodward-Clyde, 1996) summarizing their findings.

In its review, the staff has evaluated tectonic provinces and the association between earthquake activity and faulting to determine the vibratory ground motion corresponding to the maximum credible earthquake as required in Criterion 4 of Appendix A to 10 CFR Part 40, and also examined Criterion 6 which requires that the disposal cell be designed to remain stable for 1000 years to the extent reasonably achievable but in any case for at least 200 years. The staff also evaluated geological, seismological, and geophysical information which has been developed since the 1975 SAR. In addition, the NRC staff has engaged in consultations and discussions with University of Utah faculty and the Utah Geological Survey staff.

The Atlas site is located at approximately 38° 36′ 13″ N and 109° 35′ 25″ W in Utah. Utah is subdivided into three major physiographic and tectonic provinces: 1) the Basin and Range; 2) Middle Rocky Mountains; and 3) the Colorado Plateau (Wong and Humphrey, 1989). The Atlas site is located in the Paradox Basin in the interior of the Colorado Plateau. The plateau is generally considered to be relatively stable. The historic record of seismicity in the plateau is very short, and adequate seismic coverage of the area did not occur until 1970. In 1970, the University of Utah, Los Alamos National Laboratory, and the United States Geological Survey installed a regional seismic network which improved the detection of earthquakes to those above magnitude 2.0. The boundaries of the Colorado Plateau are in part adjacent to major zones of recurrent seismic activity. For example, along the western margin of the plateau, there is a significant source of seismicity along the Intermountain Belt (IMB). This belt exhibits a moderate to high level of seismicity of magnitude up to 7.4. This belt is 75-100 km wide and forms a tectonic transition zone between Colorado Plateau and Basin and Range Tectonic Provinces. The IMB boundary is about 200 km (125 mi) from the Atlas site, so the contribution of a large seismic event in the IMB at the site will be negligible.

The Atlas site is located in an area characterized by infrequent, low-level, small magnitude earthquakes. Prior to 1961, the locations of earthquakes were based on the "felt" area. From 1853 to July 1979, 22 seismic events with magnitude greater than 3.0 occurred within the Paradox Basin. From July 29, 1979, to November 1980, a network of stations was installed around the Colorado River south of Moab. Figure 2-1 is a location map showing the seismicity of the Moab area from 1953 to 1994 with possible induced seismicity associated with the Cane Creek mine at Potash omitted (Wong et al., 1996).

The objective of the network is to identify active earthquake sources within the Paradox Basin. During this period, about 500 seismic events with magnitudes greater than 1.0 were recorded in the Paradox Basin. On July 29, 1979, a micro-earthquake swarm was located along the Colorado River about 10 km (6 mi) northeast of its confluence with the Green River. During the 15-month period, about 200 seismic events were recorded along 35 km (22 mi) of the Colorado River between the confluence and Moab. The earthquakes show a north-northeast linear trend along the Colorado River which terminates at Moab. The depth of these earthquakes range from shallow to 50 km. Ninety five percent of the micro-earthquakes occurring in the Paradox Basin are confined to the Colorado River.

From July 1979 to June 1987, about 1100 earthquakes up to magnitude 3.3 were recorded within a 200 km (125 mi) radius of Moab. Examination of temporal behavior of the micro-earthquakes showed an apparent increased level of activity during period of brine extraction.

In the 1975 SAR, the licensee had indicated that there are two potential sources that could generate the maximum credible earthquake at the site. The first is a random earthquake in the northern Colorado Plateau of Intensity V (magnitude 4.0) generating an acceleration of about 0.02g at the site. The other source would be near the Wasatch Front which could generate a maximum magnitude earthquake of 7.4 that would produce an acceleration of 0.02g at the site. The licensee further stated that introducing a margin of conservatism, to account for amplification and a possible locally larger earthquake, the design acceleration will be taken as 0.05g.

In addressing the potential for capable faults to exist in the site area, the licensee indicated that a postulated northeast-trending feature coinciding with the trend of the Colorado River, if it exists, is probably of Precambrian or Paleozoic age. Also, the SAR states on page 2.4-30 that "There has been no seismic activity associated with this trend." This statement is not supported by recent observations (Wong and Humphrey, 1989) which indicates that a swarm of seismic activity north of the confluence of the Colorado River and the Green River is associated with this trend (Fig. 2-1).

In response to requests for additional information regarding several topics, and in particular about the capability of the Moab fault and the maximum credible earthquake for the Colorado Plateau, the licensee provided additional seismic information in its May 31, 1994, submittal (Canonie, 1994a). In that response the licensee indicated that the impoundment was tested and found to be stable using a seismic coefficient of 0.25 (see Section 3.3 for further discussion of the seismic stability of the impoundment). However, the licensee's 1994 response did not adequately address the seismicity in the

vicinity of the site. Therefore, in 1995 the licensee proposed a work plan to obtain additional data to address the staff comments on issues related to geology, seismology, and subsidence. The results from these additional investigations were submitted to NRC in January 1996 (Woodward-Clyde, 1996).

The analyses of the data have resulted in an increased understanding of the surface and subsurface conditions of the site and its vicinity. The new data dictated that the staff reevaluate the maximum credible earthquake that could be generated in the area and the resulting ground acceleration at the site.

Based on aeromagnetic data, the loop part of the Colorado River appears to be underlain by a fault or fault zone within Precambrian basement that has previous left-lateral slip displacement (Case and Joesting, 1972). Hite (1975) proposed that several northeast-trending physiographic features in the region, including the Colorado River below Moab, may be structurally controlled by basement shear zones or strike slip faults. Fault plane solutions from some of these earthquakes north of the confluence of the Colorado and Green Rivers show strike-slip movements. Also, it was suggested that the tectonic stresses in the Colorado Plateau appear to be at critical levels and could provide sufficient strain energy accumulation necessary to generate earthquakes associated with zones of weakness parallel to the Colorado River. Wong et al. (1983) concluded, based on their observations of the seismic activity in the Paradox Basin, that the tectonic state of stress in the area is such that some structural features may be near failure.

The seismic events in the Plateau appear to be the result of activation of pre-existing faults favorably oriented to the stress field. According to McGuire et al, 1982, the largest earthquake recorded in the Colorado Plateau is a magnitude 6.5 event, while Spence et al. (1996) relocated this earthquake in the northern front range.

2.3.6 Natural Resources

There are natural resources on and near the Atlas site. Also, underground storage of liquid natural gas in cavities in salt has occurred in Moab. Groundwater is a resource in the area (see Section 5.0). Copper minerals precipitated in joints near the Moab fault in vicinity of Courthouse Rock (Foxford et al., 1996). There is an oil field about 19 km (12 miles) away, and a solution potash mining operation about 13 km (8 miles) away. Production of those resources is associated with salt strata or salt structures similar to those associated with the salt-cored anticline which underlies Moab Valley and the site. Atlas has addressed the matter of past, present, and potential future potash mining and extraction of oil and gas beneath the site for the purpose of assessing future tailings stability. The following is a summary of the natural resources setting derived from Atlas' reports (Norman, 1995a, 1995b), among others. The potential for disruption of the tailings on site due to future resource exploration or exploitation is not considered a design issue.

2.3.6.1 Potash

Salt layers 5 and 9 in the Paradox Formation are the main targets for potash minerals. These layers have been sought in borehole data (cuttings,

geophysical, and lithologic logs) and in seismic reflection surveys. One of the test holes investigated was the Embar-Big Six, about 400 feet south of the Atlas site. Norman (1995a) reports that the salt layers were very thin, and concluded that "...there is no possibility for potash or other valuable salt minerals to be present under the current Atlas Tailing pile" (ibid., p. 35; it should be noted that the opposite conclusion was reached for the Bartlett Wash alternate site). It is not clear from Norman's report (ibid., p. 40-41) how the 500-feet-thick salt layers with interbedded clastics (his thin potash-poor salt section) under the site relate to the approximately 2100 m (7000 feet) thick Paradox Formation under the site (Doelling et al., 1995, cross section B-B').

No surface subsidence is observed at the nearby Cane Creek potash mine where solution mining is in current use (Morton, 1995; Allison, 1994). However, subsurface collapses in this mine have generated earthquakes of magnitude up to 3.1 (Wong and Humphrey, 1989).

2.3.6.2 Oil and Gas

The Paradox Basin has been producing oil for about 70 years. The main targets have been the Mississippian (Leadville) limestone and the Cane Creek shale. Both occur in the Moab area (Morgan et al., 1991; Morgan, 1992). Norman (1995b) reports thinned upper salt layers, absence of lower salt layers which contains oil shale targets, absence of Mississippian rock targets and only traces of oil, gas or brine in the Embar well near the site and concluded that "There is no possible commercial oil and gas potential at, or in the near vicinity of Atlas Corporation's Moab tailings pile" (ibid., p. 4; note that the opposite conclusion was suggested for the Bartlett Wash alternate site).

Oil and gas prospecting in the Moab area appears likely to continue. New techniques, such as horizontal drilling, have increased success in recovering oil from shale in the area. However, improved casing and plugging technology will lessen solutioning and subsidence around boreholes and better contain the high fluid pressures in the producing units. Surface subsidence over oil wells in Grand County has not been noted (Allison, 1994, p. 14).

2.3.6.3 Underground Storage Space

Underground storage of liquid natural gas was attempted in the salt-cored anticline beneath the town of Moab (Woodward-Clyde, 1982a, p. 8-5). The liquid was not fully recovered, possibly due to migration into nearby cavities. However, mining-for-space could be rejuvenated in the Moab area.

2.4 Geologic and Seismologic Stability

In order for Atlas' reclamation plan to provide reasonable assurance of control of radiological hazards for 200 to 1000 years, the design has to account for all significant geologic and seismologic conditions and processes that might affect the long-term stability of the pile (NRC, 1993).

2.4.1 Bedrock Stability

The following potential sources of bedrock instabilities beneath the site have

been identified: main Moab fault, West Branch of Moab fault, unnamed faults interpreted from seismic reflection surveys, buried scarp interpreted from drillhole data, bedrock surface topography, ground subsidence, and earthquakes. No other sources of bedrock instabilities were investigated in detail because either none were thought likely to exist or the effects of undiscovered instability sources that might occur adjacent to and under the tailings are likely to be bounded by consideration of the existing sources, for purposes of attaining reasonable assurance that the health, safety and environmental protection standards will be met.

2.4.1.1 Moab Fault System

There is evidence that the Moab fault system was active in the Mesozoic Era, probably instigated by salt diapirism, and possibly reactivated in the Tertiary Period by extensional tectonics, an interval of about 200 million years (Foxford et al., 1996; Ge et al., 1995, 1996). However, there is little or no evidence of significant activity in the Quaternary, the last 2 million years (e.g., fault displacement within the limits of geologic observation) (Woodward-Clyde, 1996). In particular, there is no evidence that the Moab fault or West Branch fault slipped at least once in the last 35,000 years* or at least twice in the last 500,000 years*. There is no evidence that the Moab fault or West Branch fault is structurally connected to a significant seismogenic source* that would render them similarly significantly seismogenic. There is little or no paleoseismic (pre-historic) or historical (last 200 years) seismic record* of activity on the Moab fault or West Branch fault (Wong and Humphrey, 1989; Wong et al., 1996; Woodward-Clyde, 1996). Also, the Central segment of the Moab fault system, part of which underlies the pile, is considered by the staff not to be deeply penetrating the crust, as in Foxford et al., (1996). It appears to be rooted in the Moab salt-anticline (upper 2 kms [1.2 miles] of the crust) and is considered unable to generate earthquakes as large as those generated by deep-seated faults (Section 2.3.5). This is the most significant attribute of the Moab fault system that diminishes its potential as a seismotectonic hazard. Further, the segmented nature of the Moab fault system described by Foxford et al. (1996) and Woodward-Clyde (1996, Section 2) suggests that future slip on one stretch need not, a priori, be presumed to propagate along the entire fault length, across segment boundaries. Therefore, the staff concluded that the Moab and West Branch faults, and any other faults in the Central Moab fault system segment associated with them, are not capable faults (capable faults are defined as having at least one of the properties indicated above with asterisks, *; NRC, 1993).

The UGS and other investigators consider that the Moab fault and the West Branch of the Moab fault are rooted in the Moab salt-cored anticline (e.g., Doelling et al., 1995; Fig. 2-2). Also, Atlas' seismic lines suggest that the Moab fault dips steeply into the underlying salt-cored anticline (Cooksley, 1995, 1996). Scale model experiments of salt-cored anticlinal diapirism generally support the concept that longitudinal master faults like the Moab fault are rooted in the salt and are detached from basement faults (for example, Ge et al., 1995, 1996). Such evidence and models are sufficient for the staff to conclude that the Moab fault (and related faults of the Moab fault system, such as the West Branch fault, and several buried, unnamed faults located between the Moab and West Branch faults) is not likely to be

the seismic source that will dominate the seismic hazard calculation (Sections 2.3.5 and 2.4.3). Nevertheless, faults of the Moab fault system are considered potential hazards because they are in positions which may affect the pile if they slip in response to differential subsidence.

Massive blocks of rock involving hundreds or thousands of feet of strata apparently slipped on the West Branch fault. One group of investigators considered those blocks to be passive salt-tectonic landslides responding to dissolution of salt which occurred in the Tertiary or Quaternary (Baars and Doelling, 1987). Another group considers the slide blocks to have been emplaced by active salt-tectonic processes in the pre-Jurassic (Foxford et al., 1996). These investigators consider the period of high-rates of salt-tectonic landsliding to be over, for various reasons. Lacking evidence of late Quaternary or Holocene slip on the West Branch fault, such as a scarp, the staff considers the fault to be relatively inactive but subject to differential subsidence.

Cooksley's (1995, 1996) seismic reflection data did not indicate the presence of the West Branch fault beneath the pile as shown on Doelling's, et al. (1995; Plate 2) cross section. Atlas has assumed that the West Branch fault dips under the site and is subject to slip at the rate of subsidence specified for design. Because it appears that the design will mitigate effects from such slip (even at twice the design basis slip rate) regardless of location of the fault, the staff did not require Atlas to more precisely locate the West Branch fault. Similarly, the exact location of the Moab fault was mooted as a regulatory concern, because Atlas' design would mitigate effects of differential subsidence anywhere under the pile (Sections 3.3.4 and 4.5.1).

Atlas has presented its analyses of borehole data, historical photographs, field observations, seismic reflection surveys, geodetic surveys, terrace gravel analysis, and the UGS's map of the Moab 7.5′ quadrangle, and integrated the results in an adequate analysis of potential fault displacement, seismic and subsidence hazards posed by the Moab fault system. The staff considers that the Moab fault, West Branch fault and unnamed related, buried faults are not capable faults. These faults are potential loci of differential subsidence and are to be considered in designs to mitigate subsidence hazards.

2.4.1.2 Buried Scarp

The potential occurrence of an arcuate buried fault scarp beneath the southern edge of the tailings, parallel to the Colorado River channel, faulted down to the east, was developed by UGS (Doelling et al., 1995) based on information provided by Atlas Corporation (Woodward-Clyde,1996). The evidence for this feature's existence is based on Atlas borehole logs (e.g., Dames and Moore, 1982; Canonie, 1994b). The staff reviewed the evidence and considers the normal fault model to be viable. In addition, the staff considers alternative concepts of a bedrock-surface drop-off viable. Concepts that do not require faulting cannot be ruled out, for example, a buried erosional escarpment, or a buried stream channel or wash. A scarp, whether or not it exists to the extent proposed by the UGS, is a consideration for pile design.

The information provided by UGS and Atlas (Cooksley, 1995, 1996; Woodward-Clyde, 1996, Section 2) on the buried scarp under the site is insufficient for

the staff to reach a conclusion on whether or not the buried scarp is a fault or erosional feature. If this feature were a fault, it would not be considered a capable fault, given that it would likely be rooted in the salt-cored anticline. If the scarp is erosional, it would suggest considerable aggradation of the Colorado River and substantial local subsidence in the same period. Cooksley's seismic line B (Cooksley, 1995, 1996) crossed the trace of the UGS scarp. The seismic data do not indicate the buried scarp occurs at its mapped location. Therefore, the precise location of the scarp is unknown. However, line C does indicate a scarp of about 15 m (50 feet) relief associated with the Moab fault, but tens of meters (several hundred feet) from the UGS buried scarp trace. Nevertheless, the staff considers that the mitigative measures proposed by Atlas to account for potential movement on the Moab or West Branch faults would also mitigate movement on the buried scarp, wherever it is. This is discussed in Section 3.3.

2.4.1.3 Subsidence

The staff considers that future subsidence of the Atlas tailings by salt creep or dissolutioning could be concentrated on any moderately to steeply dipping fault beneath the pile rooted in the Moab salt-cored anticline, or subsidence could occur over a broad area of the pile. Potentially adverse effects, such as disruption of the radon or erosion protection barriers, might occur if differential displacements are propagated to the base of the tailings or through the tailings after penetrating the alluvial wedge. Candidates for such fault subsidence hazards are: Moab fault, West Branch of the Moab fault, unnamed faults interpreted from seismic lines and the buried fault. If such differential subsidence could produce salt-tectonic landslides of the large magnitude described in Baars and Doelling (1987) in the next 200 to 1000 years, radon and erosion protection barriers would likely be breached. However, recent work suggests that large-mass salt-tectonic landsliding ceased in the Cretaceous (Foxford et al., 1996) or Tertiary (Ge et al., 1995, 1996).

In reaching its conclusions about the nature and rate of future subsidence of the pile the staff was cognizant of the uncertainties due to lack of direct observation of subsidence in Moab area, poorly constrained ages of alluvium, and dearth of subsurface data. The principle bases for rate of subsidence were estimates of both the depth of alluvium beneath the Colorado River local baselevel and the age of the oldest alluvium in the wedge. The staff relied on Atlas' seismic reflection interpretation of the alluvial wedge, borehole data, geomorphological age estimates and discussion with the UGS. [Calculation made as follows: take the thickness of alluvial wedge at its thickest place shown on seismic line, between pile and Colorado River, at about 150 m (500 feet); assume the oldest alluvium is nominal age of the Placer Creek sediments ranging from 120K to 150K years (Harden et al., 1985; Woodward-Clyde, 1996, Section 3); consider Placer Creek and Holocene sediments near surface were deposited uniformly in time on a surface that was subsiding and continues to subside; therefore, rate of subsidence equals thickness (150 m) x reciprocal of time since oldest layer was deposited (120 K to 150 K years) = .001-.00125 m/year or 1-1.25 m/ 1000 years (.2-.25 m/200 years). Alternatively, if the age of the oldest sediments beneath the pile is early Quaternary, say, 1-2x10E6 years, rate is much less, about .15-.08 m/1000 years.] The staff concluded that 1 m/1000 years subsidence anywhere under the pile is a reasonable and conservative design basis. Atlas' accepted calculation that

its design could mitigate subsidence of up to 2 m/1000 years (Section 3.3) provided a substantial degree of conservatism in ensuring compliance with Part 40, Appendix A, with respect to the potential subsidence hazard.

UGS and USGS geologists consider that surface subsidence by creep or dissolutioning is continuing, but at a rate reduced since the Pleistocene, when climate conditions were wetter. Doelling (in Allison, 1994) considers that subsidence by salt creep or dissolutioning is concentrated on faults near the margins of the salt anticlines. He cites V-synclines along valley margins as evidence for this. The West Branch fault is favorably situated for this type of movement, as are unnamed faults located beneath the pile (Cooksley, 1995, 1996). Local aseismic subsidence by rapid collapse and site-scale aseismic subsidence by slower downwarping or tilting was considered at the Atlas site (Canonie, 1994; Smith, 1996, Part 2). As discussed below, the staff finds little basis to consider rapid subsidence a likely hazard to the site.

The sinkhole-like features mapped by UGS and related to rapid collapse in Castle Valley are attributed to salt dissolution (Mulvey, 1992). The features are not widespread in Castle Valley and have not been described from Moab-Spanish Valley or any other salt-cored anticlinal valley in Utah. Such a phenomenon, should it occur beneath the pile and propagate through the tailings, would be a potential hazard to radon and erosion barriers. The staff considers that sinkhole-like (rapid) collapse is more likely to propagate through tailings setting directly on salt caprock than one setting on alluvium and rocks which set on caprock. Unfortunately, the seismic survey did not explicitly identify caprock (Cooksley, 1995, 1996), where it was proposed to occur (Woodward-Clyde, 1996; Section 2). This is an uncertainty in Atlas' subsurface model. However, various workers consider that there are Paleozoic and/or Mesozoic strata beneath the pile (Baars and Doelling, 1987 ; Doelling et al., 1995; Cooksley, 1995, 1996; Woodward-Clyde, 1996). Thus, the likelihood of such a phenomenon occurring in Moab Valley, within the footprint of the pile, breaching caprock, causing rapid collapse of the alluvium, disrupting the radon or erosion barriers and causing significant radon release, appears to be low. Therefore, the staff does not consider rapid subsidence, to be a design basis.

Atlas has analyzed borehole data, performed stream profiling, made field observations of soils on ancestral stream terraces and reassessed other critical data and concluded that stream incision rate since Late Pleistocene averaged about 0.4 to 1 mm/year, and this may reflect local subsidence rate. Also, if regional rates of incision, denudation and subsidence described in Section 2.3.3.2 are applicable to Moab Valley, then a rate of about 0.3-1 meters (1-3 feet) per 1000 years would be an appropriate design consideration. The applicability of such an indirectly estimated rate, its significance for pile design, and its attendant uncertainties (e.g., they are long-term averages and may be non-conservative values; rates in Moab Valley could be notably higher for some reason not yet recognized) have been considered by the staff. The staff considers that an average subsidence rate of 1 mm/year at any location beneath the alluvium, or differentially across any fault or fracture beneath the alluvium at the site (e.g., Moab fault, buried scarp), or a maximum of 1 m/1000 years at any point or all points on the bedrock surface beneath the pile, is a reasonable design basis. Additionally, Atlas has

shown, that its pile design is sufficiently robust to mitigate adverse effects of subsidence of up to 2 m/1000 years, twice the design basis. This is discussed in Section 3.3.

2.4.2 Geomorphic Stability

The Atlas site is vulnerable to geomorphic hazards because it is: at the confluence of two active watercourses, Moab Wash and the Colorado River; at the base of an actively retreating escarpment of 1100-feet topographic relief, Poison Spider Mesa escarpment; in a basin of accumulating sediments, including those of eolian, colluvial and fluvial origin and infrequent volcanic ash falls, Moab Valley. Also, in this category of hazards, the staff has considered the potential for subsidence due to future nearby mining, oil and gas extraction. Atlas provided adequate information regarding migrating sand, landslides, rock falls, migration of the Colorado River, diversion of Moab Wash, potash mining, and oil and gas extraction. These have been reviewed, and the attendant issues have been satisfactorily addressed as discussed below and in Sections 4.4.4, 4.4.5, and 4.5.1. A potential volcanic ash hazard has been resolved without need for input from Atlas.

2.4.2.1 Windblown Sand

Sand dunes, sand ramps, and sand sheets exist near the site. They appear generally stable (vegetated). However, observations of several sand ramps, including one near the entrance to Arches N.P. and a few above the pile on Poison Spider Mesa escarpment, indicate localized patches which lack soil and vegetation and with presence of ripples that imply that they are active. About 20 cm (8 inches) of sand, presumably from offsite sources on the Mesa identified by Atlas (Smith, 1996, Part 1), has accumulated in and around a borrow pit on the site. In the next 1000 years it is considered likely by the staff that dunes, ramps, and sheets will be deposited on or near the site, potentially affecting the performance of the erosion barrier and/or drainage systems. Sand infiltration of rip rap and accumulation on the pile may be a generally favorable, stabilizing process. However, sand accumulation in drainage channels may degrade their function. The staff suggested that Atlas consider the rates and amounts of transient and trapped sand that could affect the design of the drainage systems. Atlas' analysis of potential clogging of drainage channels around the pile by windblown sand was reviewed by the staff and the conclusion that sand accumulations in drainage channels will not adversely impact the performance of the pile, was found acceptable (Section 4.5.5).

2.4.2.2 Mass Wasting: Rock Falls and Landslides

The retreat of the Poison Spider Mesa escarpment above the site apparently occurs mainly by rock and debris falls followed by transport by running water of the rocks and debris that fell or slid to the base of the escarpment. It is obvious from field observations that rock and debris fall hazards exist adjacent to the site. Rock-slab fall hazard was observed in the area. Information provided by Atlas on the rock and debris fall hazards (Smith, 1996, Part 2) has been evaluated by the staff. The staff observed the characteristics of subvertical joints and bedding-parallel discontinuities in the Wingate and Kayenta Formations in the cliff above the pile. Rock blocks

capable of falling down the cliff are poised to fall and will fall. However, they will likely disintegrate as they fall and accumulate on or near existing talus. Large slabs of rock like those observed to have slipped and disrupted railroad and road beds (Highway 191, 1 km north of Arches N.P. entrance; Long Canyon Road) are not likely to form on the cliff above the pile because a prominent closely-spaced subvertical joint set orthogonally intersects the cliff face above the pile precluding formation of cliff-parallel slabs there.

The staff reviewed aerial photographs of the site vicinity taken in 1950, prior to site clearance, and did not observe rock-blocks beyond their present positions along the foot of the escarpment. In addition, the site is considered to lie outside of the rock fall hazard zone mapped by UGS (Mulvey, 1992). Nevertheless, the staff considers that a rock and debris fall hazard exists at the site. Prior to staff specifying a design basis rock and debris fall hazard, Atlas performed a robust analysis. An Atlas analysis showed that its proposed southwest drainage system could alleviate the effects of potential rock and debris fall hazards including periodic clogging of the drainage channels to half their height. The staff considers this analysis acceptable and that it provides assurance that the potential hazard will be mitigated (Section 4.5.1.3.2).

Geomorphic landslides need to be distinguished at this site from salt tectonic landslides (Section 2.4.1.1). Landslides above the tailings, in addition to rock falls, might interfere with drainage systems around the pile, or possibly encroach upon the erosion barrier itself (Section 4.5.1.3.2). The specific concern about geomorphic landslides was that several were mapped along the escarpment above the site by Huntoon et al. (1982). Later mapping by Doelling et al. (1995) indicated that the same rock and debris deposits were talus. Huntoon later concurred (Smith, 1995, Part 2).

Recent seismically-induced landslide in Zion, N.P., which involved rocks comprising cliffs similar to those above the Atlas site (i.e., Chinle, Kayenta; Schuster and Wieczorek, 1995; Jibson and Harp, 1996) do not constitute sufficient evidence that similar landslides will occur above the site. Different rock structure, rockmass properties, cliff shape, prior landslide history, and stress state between the sites (at Zion strata dip toward adjacent valley, clayey Triassic rocks were saturated with water and the landslide mass was a relict from an earlier landslide, among others) preclude the analogy. The staff concluded from its review of the literature and field observations of landslides and talus originally mapped by Huntoon, et al. (1982) and Doelling, et al. (1995), and Atlas's analyses (Smith, 1996), that landslides are not a design basis for the Atlas site.

2.4.2.3 Volcanic Ash Fall

The Quaternary sources of volcanic ash that accumulated in Arches N.P., and possibly in Fisher Valley, are still active and could present potential volcanic ash hazards to the site. The potential that simultaneous conditions at a volcanic source (e.g., large volume of ash erupted to great height) and in the troposphere (e.g., sustained winds directed at Moab) would combine to produce significant ash fall onto the pile or into its drainage system nearby, is estimated to be low. Based on the geologic record, ash fall in this area has a low probability of recurrence (approximately twice in more than 740,000

years). The staff considers the likelihood of the volcanic ash hazard to be too low to be a significant concern at the Atlas site. Volcanism is not a design basis for the Atlas site.

2.4.2.4 Potash Mining

The potential for potash exploration and solution mining and potential effects of related technologies on the tailings have been discussed by Atlas (Norman, 1995a). The report provided direct and indirect evidence that the presence of economic deposits of potash and related minerals beneath the site is unlikely. Furthermore, title to the reclaimed site will revert to DOE or the State of Utah (Section 83 of Atomic Energy Act). This title transfer provides NRC with the authority to disallow mineral mining rights or other uses of the subsurface. Therefore, should natural resources be discovered beneath or near the pile site in the future, the integrity of the pile foundation could be protected from any adverse impact of a mining operation by withdrawal or non-issuance of the surface mineral mining rights. The staff considers that potential future mining at or near the site is not a design basis.

2.4.2.5 Oil and Gas

The potential for oil and gas exploration and extraction and potential effects of related technologies on the tailings have been discussed by Atlas (Norman, 1995b). This issue has a similar resolution as the potash mining issue discussed above (Section 2.4.2.4). Basically, there is little reason to consider direct intrusion into the pile, or subsidence at the pile from nearby extraction or dissolution of salt around boreholes, or that the future landowner (DOE or the State of Utah) would permit exploration or extraction. The staff considers that potential oil or gas exploration and extraction at or near the site is not a design basis.

2.4.3 Seismotectonic Stability

As a result of NRC staff review and evaluation of the geologic and seismologic information, and discussions with individuals at the state, Federal, and private levels knowledgeable of the region, the staff has determined that the licensee has acceptably addressed the seismic issue and acceptably determined the seismic design acceleration for the mill tailings facility.

In order to identify the seismic design for the site, Criterion 4 of Appendix A to Part 40 requires consideration of the maximum credible earthquake as defined in Appendix A to Part 100. Criterion 6 of Appendix A to Part 40 requires that the disposal cell be designed to remain stable for 1000 years to the extent reasonably achievable but in any case for at least 200 years.

In order to determine the seismic design for the site, the staff investigated and evaluated the seismicity of the area around the Atlas site. The staff found that according to McGuire et al. (1982), the only significant random earthquake in the Colorado Plateau occurred on November 7, 1882, in the northwest corner of Colorado. The magnitude of the earthquake was estimated by McGuire et al. (1982) as 6.5. Based on McGuire's earthquake location, the epicenter of the earthquake was about 200 km (125 mi) north-northeast of the

site. In a recent study, Spence et al. (1996), based on a comparison with the 1984 Laramie Mountain, WY 5.5 magnitude earthquake, located the 1882 earthquake in the northern Front Range and estimated its magnitude to be 6.6±0.6. Spence et al. (1996) concluded that the 1882 earthquake did not have its source in the Colorado Plateau.

The other potentially significant seismic source of earthquakes is the northeast-trending feature along the Colorado River north of the confluence with the Green River. Wong and Humphrey (1989) located several seismic events in this area along the Colorado River, and concluded that the sources of this seismicity can be attributed to reactivated Precambrian basement faults. The focal depths of these earthquakes range from shallow up to about approximately 50 km.

Another source of seismic activity was observed in the Canyonlands region in the vicinity of the Cane Creek mine (Wong et aa., 1989). The temporal pattern of these earthquakes exhibited a strong correlation with mining activities. The majority of these earthquakes was less than magnitude 1.0. In January 1984 a 3.3 event occurred at a distance of 12 km from the mill tailings and another one of magnitude 3.0 occurred on February 10, 1984 at a distance of 10 km.

To assess the hazard to the site the licensee performed a deterministic and a probabilistic seismic analysis to identify the seismic design for the mill tailings.

Deterministic Analysis:

<u>Capable faults</u> As discussed in Section 2.4.1.1, the Moab fault is identified as a non-capable tectonic fault. The Uncompahgre fault, which showed a Quaternary uplift, is at a distance of about 50 km from the site and would generate an acceleration (0.1g) less than the design acceleration for the mill tailings.

<u>Floating earthquake</u> In Woodward-Clyde (1996), a 6.25 event was considered as the random earthquake. Using the Campbell and Bozorgnia (1994) attenuation model, they estimated peak horizontal accelerations of 0.18g and 0.29g for the median and 84th percentile, respectively. For the Colorado River seismicity, a 6.5 event could be generated, assuming 50 percent of the basement fault would rupture. Based on 6.5 event at 5 km from the site, the expected acceleration would be 0.43g for the median and 0.67g for the 84th percentile, respectively. The return period of the deterministic median value of 0.43g along the Colorado River is about 100,000 years. For the 84th percentile of 0.67g, the return period is about 750,000 years. These values are much greater than the 1000 year stability period required by Criterion 6 of Appendix A to 10 CFR Part 40.

Probabilistic Analysis:

To evaluate the ground acceleration associated with a probability of being exceeded in 1000 years, the licensee performed a probabilistic seismic hazard analysis. This analysis was performed to account for uncertainty in characterizing important faults (especially the lack of historical

earthquakes). 10 CFR Part 100 has recently been revised to allow the use of the probabilistic approach in performing seismic hazard analysis for nuclear power plants. Hence, the use of this type of methodology has been found acceptable in other facilities regulated by NRC.

The approach used by the licensee for the probabilistic seismic analysis is similar to other seismic hazard analyses (Cornell, 1968, McGuire, 1978, Bernreuter, et al., 1989, Electric Power Research Institute, 1988). In this analysis Atlas used logic trees, which are composed of nodes and branches, to identify the likelihood of different earthquake magnitudes associated with different sources. Each branch of the logic tree represents discrete possible values for that state. Probabilities were assigned to each branch using subjective assessments. The logic tree approach assigned weights, using scientific judgement, to the following parameters for each fault: activity, dip, depth, maximum magnitude, recurrence model, and slip rates. Ten of the faults considered in the analysis, including the Moab, Lisbon Valley, Salt Valley, and Paradox Valley faults, are associated with salt structures; the licensee considered them unlikely to be seismogenic and assigned them low weights. In this study, Atlas used three different attenuation models, Boore et al. (1993), Campbell and Bozorgnia (1994), and Sadigh et al. (1987), to examine the effects of different attenuation models on the mean total hazard. Atlas found that the three attenuation models provided similar results. The maximum earthquake magnitudes expected on these faults were estimated using the empirical relationship for fault surface rupture length vs. magnitude of Wells and Coppersmith (1994).

The seismic hazard curves (probability of exceedance vs. peak ground acceleration) were calculated at the mill tailings location for the median, 5th, 16th, 84th, 95th, and the mean percentile. The wide difference between the 5th and 95th percentile hazard curves, especially at the longer return periods, represents the high degree of uncertainty in the model parameters and the attenuation relation used. The licensee performed a sensitivity analysis by varying the weights on the slip rates, seismic sources, and attenuation models. For example, increasing the probability of activity of the Moab fault from 10% to 50% produced some effect on the total hazard at return period greater than 10,000 years. At a 10,000 years return period, the mean acceleration increased from 0.18g to 0.21g.

Based on the probabilistic seismic hazard analysis the licensee proposes a mean peak horizontal ground acceleration of 0.18g for a return period of 10,000 years.

In an independent study sponsored by NRC, Bernreuter et al. (1995) performed a simplified seismic hazard analysis for all Title II reclamation plans. The Atlas site was one of those examined. Bernreuter et al. (1995) reviewed published and unpublished data, and discussed several issues dealing with seismic hazards at Atlas with several organizations. Bernreuter et al. (1995) concluded that: 1) the Moab fault is a surficial expression of underlying salt solution and is a subsidence feature rather than a tectonic feature; and 2) the seismicity along the Colorado River suggests that a basement fault exists under the river and could generate an earthquake of magnitude ranging from 5.5 to 7.0. Bernreuter et al.(1995), estimated the peak ground acceleration at the Atlas site from such fault to range from 0.2g to 0.4g.

Based on his simplified probabilistic seismic hazard analysis he estimated an acceleration of 0.15 g for a return period of 10,000 years. Bernreuter, et al., used the Joyner and Boore (1982) attenuation model to estimate the acceleration at the site.

The staff also asked Dr. Art Frankel of the USGS to provide a probabilistic seismic hazard curve for the Atlas mill tailings site based on the National Seismic Hazard Mapping Project. Based on the information provided, the staff estimated a mean peak ground acceleration of about 0.21g for a 10,000 year return period at the site.

Based on the stability analysis, the licensee indicated that the embankment would have a factor of safety of one with a pseudo-static seismic coefficient of 0.25. This value translates to an acceleration of 0.38g before the slope would be expected to begin yielding. Based on this value, the staff concludes that the mill tailings design acceleration exceeds the design acceleration estimated from the probabilistic seismic hazard analysis.

Geologic and seismologic information and investigations presented by the licensee as required by Part 40, Appendix A, provided sufficient information on the interrelation between seismicity and the basement fault north of the confluence of the Colorado and Green Rivers, and thoroughly addressed the capability of the Moab fault. For example, the licensee identified and presented the maximum credible earthquakes that could be generated from these faults and provided a probabilistic seismic hazard analysis. Also, the licensee discussed in its submittal, the maximum random floating earthquake in the Colorado Plateau.

Therefore, the staff considers the licensee's submittal to be complete and that the seismic design basis for the Atlas site has been addressed. The staff concludes that a 0.25 seismic coefficient for the slope stability, translated to an accèleration of 0.38g, is acceptable for the Atlas site.

2.5 Conclusions

2.5.1 Bedrock Stability Conclusions

The staff concludes that the bedrock features and conditions specified below are potentially significant sources of foundation instability. Atlas has appropriately considered them in pile design. Bedrock stability has been adequately assessed in the proposed design to meet the requirements in Appendix A of Part 40.

1. MOAB FAULT SYSTEM. Faults of the Moab fault system that underlie the site are not capable faults (i.e., are not likely to generate vibratory ground motion which would exceed that from the maximum credible earthquake for the site). Their location beneath the pile, the large vertical displacements on the longer faults, their association with collapsed carapace above the Moab salt-cored anticline, UGS geologists' opinions that they were and may continue to be loci of differential subsidence, make them reasonable and conservative candidates for differential subsidence hazards (see SUBSIDENCE, below). Specifically, the Moab fault, unnamed faults beneath the pile, and the West Branch

fault must be considered in the design, including the possibility that any moderately to steeply dipping fault can intersect the base of the Quaternary alluvial wedge at any location. The potential seismotectonic and differential subsidence hazards have been acceptably addre[illegible] (Section 3.3).

2. BURIED SCARP. The buried scarp, if it is a fault, is not a capable fault. It should be considered a differential subsidence hazard that must be considered in design (see SUBSIDENCE, below). The location of the buried scarp taken from Doelling et al., (1995) and Woodward-Clyde (1996; Section 2) is between boreholes PW-1 and ATP-1, under the southeastern corner of the tailings (Woodward-Clyde, ibid, Fig. 2-18). The buried scarp potential hazard has been acceptably addressed (Section 3.3.5).

3. SUBSIDENCE. The bedrock surface beneath the alluvial wedge at the site should be considered likely to subside in the next 1000 years and such a subsidence hazard must be considered in design. The shape and elevation of the bedrock surface under the pile is reflected in Cooksley (1995, 1996). Relief of the bedrock surface should be taken as 16 m (50 feet) across the Moab fault (Cooksley, 1995, 1996). The minimum acceptable design basis subsidence rate and magnitude are, respectively, average of 1 mm/year anywhere or uniformly distributed under the site, not less than 0.2 m in 200 years or less than 1 m in 1000 years anywhere under the site. Sudden collapse need not be a design basis. Subsidence may be considered to occur by aseismic creep. Subsidence may be uniform over the site with or without tilting, or it may occur differentially across a fault plane or bedrock scarp up to 1 m in 1000 years. The potential subsidence hazard has been acceptably addressed (Section 3.3.5).

2.5.2 Geomorphic Stability Conclusions

The staff concludes that the geomorphic features and conditions specified below are potentially significant sources of surface instability. Atlas has acceptably considered them in pile design. Bedrock stability has been acceptably assessed in the proposed design to meet the requirements in Appendix A of Part 40.

1. WINDBLOWN SAND. Sand has been deposited on the site during its operational phase and is expected to continue to do so. On one hand, sand accumulation on the pile may enhance protective engineered covers, on the other hand, sand accumulation in drainage ditches is a potential hazard that must be considered in design. Uniform sand deposition rate of 0.5 cm (0.2 inches) per year in the drainage ditches is a reasonable and conservative design basis. The migrating sand potential hazard has been acceptably addressed (Section 4.5.5).

2. ROCK AND DEBRIS FALLS. Rock falls and debris falls will continue to occur on the escarpment above the site contributing to scarp retreat of about 0.35 m/year (1.0 foot/year). Some rock and debris may reach the southwest runoff drainage ditch alongside the tailings. Therefore, rock and debris falls are potential hazards that must be considered in

design. Accumulation of rocks and debris resulting in blockage of 50 percent of the channel capacity is a robust design basis. This potential hazard has been acceptably addressed (Section 4.5.1.3.2).

3. MIGRATION OF THE COLORADO RIVER. Gradual migration of the Colorado River channel toward the pile, potentially eroding the erosion protection barrier, is a design consideration. This potential hazard has been acceptably addressed (Section 4.4.5).

4. FLOODING OF MOAB WASH. Moab Wash will continue to be subject to floods, not exceeding the Probable Maximum Flood (PMF). A PMF for Moab Wash is a design basis. This potential hazard has been acceptably addressed (Section 4.5.1.2.2).

The following potential hazards were reviewed by the staff and found too improbable to be considered in design:

1. LANDSLIDES. While landslides might emanate from Poison Spider Mesa escarpment and valley walls north and south of the site, no surficial relict or recent landslide deposit appears to exist adjacent to the site. The staff considers that a landslide hazard has a low likelihood of occurrence at the site and need not be a design basis. Atlas' analysis of clogging of drainage ditches with rocks and debris (from rock and debris falls, Section 4.5.1.3.2) is analogous to an encroachment of a landslide toe and provides a degree of conservatism (additional assurance of compliance) with regard to a low probability landslide hazard.

2. VOLCANIC ASH FALL. Volcanic ash has fallen in the Moab area several times in the last 740,000 years. The staff considers the probability of future ash fall onto the pile to be low, and uncertainties associated with the consequences too high to be a design basis. Atlas' analysis of clogging of drainage ditches with blowing sand (Section 4.5.5) is analogous to clogging by volcanic ash and provides a degree of conservatism with regard to a low probability ash fall hazard.

3. POTASH MINING/OIL AND GAS EXPLORATION AND EXTRACTION/ UNDERGROUND EXCAVATION. Review of Atlas' analysis of natural resource potential of the site suggested a low likelihood: of exploration for natural resources beneath or next to the site; of extraction of resources; and of excavation of potential underground storage volumes (Sections 2.3.6, 2.4.2.4 and 2.4.2.5). Also, future site-owner control of mineral rights provides a way to preclude such human intrusions.

2.5.3 Seismotectonic Stability Conclusions

The staff concludes that the licensee has provided sufficient geologic and seismologic information to evaluate the seismic design basis for the Atlas site. The licensee indicated, and the staff agreed, that Atlas tailings pile slopes are designed to withstand a seismic coefficient of 0.25, which translates into an acceleration of 0.38g. This value is more than twice the estimated acceleration of 0.18g calculated by Atlas, in its probabilistic seismic hazard analysis, as having a return period of 10,000 years.

Therefore, the staff concludes that the design acceleration for the facility, 0.38g, is acceptable for use in the determination of the facility's seismic stability for the 1000 year longevity period.

3.0 GEOTECHNICAL STABILITY

3.1 Introduction

This section presents the results of the NRC staff review of the geotechnical engineering aspects of the closure action proposed at Atlas' Moab, Utah, Title II Project mill site. The closure action consists of the consolidation of all contaminated materials from the processing site to the adjacent tailings pile near Moab, Utah. The final disposal cell will be an above-grade stabilized-in-place embankment extending to a maximum height of 110 feet above the prevailing surface grade. Contaminated material and mill debris will be added to the disposal cell. The cell will be recontoured , and will be covered with a 7-foot-thick minimum sand cover, plus filter layer and rock armor on the embankment; a 39-inch-thick multiple layer cover plus rock armor over coarse tailings; and a 37-inch-thick multiple layer cover plus rock armor over at least seven feet of regraded coarse tailings over the fine tailings portions of the embankment (see licensee Drawing No. 88-067-A112, Canonie, 1995).

The geotechnical engineering aspects reviewed include: (1) information related to the disposal and borrow sites; (2) materials associated with the closure action, including the foundation and excavation materials, tailings, and other contaminated materials; and (3) design and construction details related to the disposal site, disposal cell, and its cover. The staff evaluation of related topics such as geology, geomorphology, and seismic characterization, are presented in Section 2. Surface water and erosion control evaluations are presented in Section 4, and groundwater condition evaluations are presented in Section 5 of this report.

3.2 Site and Material Characterization

3.2.1 Site Description

The 130-acre impoundment (Figure 1-1) is adjacent to the former Atlas mill, about three miles northwest of the town of Moab, Utah. The site is located within the Moab Valley, and is drained by Moab Wash (an ephemeral channel) and the Colorado River. The uranium mill tailings were placed in a single pile consisting of approximately 10.5 million tons. The 130-acre pile forms a deposit with a maximum height of 110 feet. The Atlas Corporation has covered the sides of the pile with an interim soil cover of variable thickness. As the water in the pond atop the tailings has evaporated, additional interim cover has been placed on portions of the top of the pile, working from the edges inward toward the center.

The former mill area is 200 acres in size and contains building foundations and abandoned mill structures which have been partially demolished. Additional contaminated soil lies outside the confines of the tailings pile. The contaminated soil and building rubble generated from the mill demolition will be added to the disposal cell.

3.2.2 Geotechnical Investigations

3.2.2.1 Disposal Cell Area

Several subsurface investigations have been performed at the Atlas processing site in order to characterize the tailings and contaminated materials for geotechnical engineering and radiological aspects of the closure. Drawings in the May 29, 1981 report(Dames & Moore, 1981) illustrate the original test boring and test pit locations. Logs of soil borings and test pits were provided in the licensee's earlier submittals (Dames & Moore, 1977; and Dames & Moore, 1979). In August of 1988, and January of 1992, additional test pits were excavated within the confines of the mill and the tailings embankment. The 1988 and 1992 test pit logs are reported in Appendix A of the June 4, 1992, submittal (Canonie, 1992), as modified by the April 14, 1993, submittal (Canonie, 1993).

Exploration to depth within the tailings embankment was not previously performed since the presence of an active evaporation pond impeded drill rig access. To further characterize the tailings, and to evaluate the embankment with respect to stability and potential settlement, the licensee has committed to perform piezocone or other in-situ tests after the cover has been placed. The piezocone is an instrument which measures the piezometric pressure at a cone tip as the test device penetrates a material. Cone Penetration Test (CPT) pore pressures, thus measured, reflect both the soil type and the stress history of the material. CPT or equivalent test data will be reviewed along with settlement records to better evaluate the time-rate of tailings consolidation.

3.2.2.2 Borrow Areas

Proposed radon barrier clay soils from the Klondike Flats area were evaluated by Canonie Environmental. The Klondike Flats borrow area is located about 13.8 miles north of the tailings pile.

Sandy soil for the radon barrier will be obtained from material excavated during the reconfiguration of Moab Wash (see Section 4). In 1988 and 1992, 15 exploratory test pits were excavated in the Moab Wash area.

Finally, in addition to the sampling associated with the reconfiguration of Moab Wash, three additional samples were taken from the proposed borrow area located west of the tailings disposal area on the Atlas property.

3.2.2.3 Geotechnical Investigation Conclusions

The NRC staff has reviewed the subsurface exploration discussed above. The staff concludes that the geotechnical investigations conducted at the processing, disposal, and borrow sites satisfactorily establish the stratigraphy, that the explorations are in general conformance with applicable provisions of Chapter 2 of the 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. Additional in-situ testing will be performed to confirm the stratification and strength parameters of the tailings and to confirm the settlement analysis. Prior to

approval of the settlement evaluation, the licensee will submit a field exploration plan for the in-situ exploration program.

3.2.3 Testing Program

Geotechnical engineering characteristics and strength parameters for the tailings, contaminated soil, and natural soils have been determined by the licensee, through laboratory analysis of samples from the investigations. Early laboratory testing by Dames & Moore, and later testing by Canonie Environmental, included moisture-density (Proctor) determinations, gradation analyses, specific gravity, saturated hydraulic conductivity determinations, Atterberg Limits, capillary moisture, one-dimensional consolidation, static triaxial, and cyclic triaxial compression. The staff has reviewed the geotechnical engineering testing program for the Atlas site and concludes that the tests identified above were conducted on representative materials.

The licensee's laboratory testing of the Klondike Flats borrow material included gradation, Atterberg Limits, moisture-density determination, specific gravity, saturated hydraulic conductivity, capillary moisture relationships, dispersive tendencies, diffusion coefficient, and triaxial shear strength. The licensee states that additional tests will be made on the borrow soils during construction to confirm conformance with the project specifications.

Within the Moab Wash area, one composite sample was made from the "affected" (contaminated) sandy soils. A second sample was made from "clean" soils (see Section 6.2.1 for additional information). The composite samples were then split into three subsamples, and were redivided for geotechnical and radiological sampling. Laboratory testing by the licensee included gradation, Atterberg Limits, moisture-density relationships, specific gravity, diffusion coefficient, and (for the "affected" soils) radium activity and emanation coefficient determination. Three composite samples from west of the tailings pile area were tested for gradation, Atterberg Limits, moisture-density relationships, specific gravity, diffusion coefficient, and capillary moisture relationship.

Proposed cover materials were evaluated for durability. Testing included Los Angeles Abrasion, sulfate soundness, absorption, specific gravity, Schmidt Hammer, and Brazilian disk tensile tests. Petrographic analyses were also conducted. Further discussion regarding the tests on proposed cover materials is presented in Section 4.

On the basis of the field exploration and laboratory testing programs, the licensee concluded that the proposed borrow sites contain suitable quantities of material acceptable for the proposed radon barrier. Testing indicated the soils are non-dispersive.

Based on the review, NRC staff finds that the number and type of tests conducted in the testing program were appropriate for the support of the engineering analyses performed 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 the applicable provisions of the SRP (NRC, 1993).

3.3 Geotechnical Engineering Evaluation

3.3.1 Slope Stability

The evaluation of the geotechnical stability of the slopes of the disposal cell containing stabilized tailings and other contaminated materials is presented in this section. The staff has reviewed the exploration data, test results, slope characteristics, and methods of analyses pertinent to the slope stability aspects of the reclamation plan. The analyzed cross-sections with 10 horizontal to 3 vertical side slopes have been compared with the exploratory records and design details. The staff finds that the characteristics of the slopes have been satisfactorily represented and that the most critical slope sections have been considered for stability analyses.

Soil parameters for the various materials in the disposal cell slope have been adequately established by appropriate testing of representative materials. Soil parameter values have been assigned to other layers (riprap, gravel bedding, bedrock, etc.) by the licensee, on the basis of data obtained from geotechnical explorations at the site and data published in the literature. The staff finds that the determinations of these parameters for slope stability evaluation follow conventional geotechnical engineering practice, and are also in compliance with the applicable provisions of Chapter 2 of the SRP (NRC, 1993). The staff also finds that an appropriate method of stability analysis (Simplified Bishop method) has been employed by the licensee to address the likely extreme adverse conditions to which the slope might be subjected for the static case.

Factors of safety against failure of the slope for static and seismic loading conditions have been determined by the licensee for both short-term (end of construction) and long-term states. Factors of safety for the static loading conditions were calculated by the licensee to be 1.6 (short- and long-term) which are in excess of minimum required values of 1.3 and 1.5, respectively.

The seismic stability of the proposed slopes was investigated by the licensee using the pseudo-static method of analysis, with horizontal seismic coefficients of 0.21g for both the end-of-construction and the long-term cases. The value of the seismic coefficient was consistent with the design ground acceleration value used for the nearby Green River Title I site. In actuality, a horizontal seismic coefficient equal to 0.67 times the maximum ground acceleration, or 0.14g, would be used in a long-term pseudo-static evaluation, thus the licensee's model is over-conservative. As a further exercise, the licensee arbitrarily increased the horizontal seismic coefficient in order to determine the value which would imply impending failure. The coefficient which resulted in a factor of safety of unity, implying impending failure, was 0.25g.

Subsequently, the licensee performed deterministic and probabilistic ground motion evaluations in January, 1996 (Woodward-Clyde, 1996). The purpose of Woodward-Clyde's re-evaluation was to determine a peak horizontal acceleration value more reasonable than that used by DOE at Green River, yet still conservative. Woodward-Clyde determined that a peak horizontal acceleration of 0.18g, which represents an event with a mean return period of 10,000 years, was an appropriate value for design (see section 2.4.3). Since the licensee's

earlier analysis was based on a peak horizontal acceleration in excess of 0.18g, and stable conditions were confirmed, the conservativeness of the seismic design with respect to slope stability was substantiated.

Based on review of these analyses and the results, NRC staff concludes that the slopes of the disposal cell are designed to endure the effects of the geologic processes and events, including resistance to earthquake and settlement, to which they may reasonably be subjected during the design life and that the analyses have been made in a manner consistent with Chapter 2 of the SRP (NRC, 1993).

3.3.2 Settlement and Cover Cracking

Long-term settlement of materials in the disposal cell, which could result in either local depressions or cracks on top of the cover, was addressed by the licensee in Canonie Environmental's report of June 4, 1992. A proposed settlement monitoring program was provided. Settlement monuments will be installed directly on the tailings prior to the initiation of regrading activities. Construction equipment will be required to maintain a minimum distance of five feet from all monuments.

The monuments will be surveyed for vertical displacement on a daily basis for the first two weeks of initial fill placement, weekly for the following two months, and then monthly for the final two months. When the licensee has concluded that 90 percent of the consolidation settlement is complete, and with NRC's concurrence, final soil cover placement operations can begin.

Settlement monuments will be located in areas where consolidation is expected to be the greatest, including areas believed to have maximum thicknesses of fine tailings. Such an arrangement should assure that differential settlement will not adversely affect the integrity of the cover. Additionally, the final soil cover will be spread and compacted in a uniform manner to minimize the effects of settlement due to the weight of the final soil cover materials. The licensee concluded that 90 percent of the primary consolidation should take 1 to 2 years, based on the fact that there has been no disposal of tailings since 1984 and that the pumping program conducted at the site has accelerated the dewatering process.

In addition, the licensee will conduct an exploration program within the embankment using piezocones or other agreed upon in-situ methods. The in-situ data will be evaluated along with settlement records to confirm the conclusion that 90 percent of the expected settlement has occurred. The in-situ test results can also be used to assess the potential for cover cracking. Subject to confirmatory testing in the in-situ exploration stage, the proposed settlement monitoring program is considered sufficient to satisfy applicable portions of Criteria 1, 6, and 12, of Part 40, Appendix A, regarding reclamation design to control radiological hazards for the design life without active maintenance after reclamation is complete.

3.3.3 Liquefaction Potential

The liquefaction potential for the Atlas site was initially evaluated for the licensee by Dames & Moore (1979). Dames & Moore evaluated the liquefaction

potential based on empirical techniques and on the basis of a laboratory evaluation. Minimum factors of safety of 1.69 (empirical) and 1.90 (laboratory) were derived in the Dames & Moore study. Based on the similarity in results, and considering minimum acceptable safety factors of 1.5, Dames & Moore concluded that no major problem related to liquefaction would occur during the postulated seismic event, which they considered to be a Magnitude 6 event with a hypocentral distance of approximately 50 km and a maximum ground acceleration of 0.08g.

An understanding of seismic hazards and the liquefaction process has improved since 1979. Based on more recent interpretations of potential seismic events, and in accordance with a November 4, 1994, request from the NRC, the licensee re-evaluated the liquefaction potential for the site (Woodward-Clyde, 1996). Liquefaction potential was re-evaluated using standard penetration test values, soil gradation, and sample descriptions from previous analyses with updated empirical relationships. The potential induced stresses were estimated from simplified procedures using field-based methods.

Liquefaction susceptibility can be estimated by either of two approaches. The first method correlates resistance with standard penetration test (SPT) blowcounts, measured in-situ. The second method relies on laboratory measurements of dynamic tests that strain soil samples in repeated cycles of motion until liquefaction is induced. Woodward-Clyde stated that the field-based method is the preferred analytical procedure.

By using methods detailed in Seed and Harder (1990), the in-situ liquefaction resistance was computed. In the Seed and Harder analysis, corrected SPT values are normalized and correlated with the cyclic stress ratio required to trigger liquefaction, in observational data. The field cyclic stress ratio is thus obtained from curves dependent on the normalized blowcounts and soil fines content. For a calculated factor of safety less than 1.1, failure is assumed to occur. For a factor of safety between 1.1 and 1.4, liquefaction is not assumed to occur, but the soils may suffer some strength loss.

Woodward-Clyde showed that very few sample points indicate susceptibility to liquefaction, and that isolated incidences of liquefaction, if it were to occur, would be deep within the embankment. It was inferred that liquefaction of the tailings and underlying soils is unlikely to occur, and that there is no threat to the stability of the embankment.

Based on a review of the analysis presented by the licensee (Woodward-Clyde, 1996), the staff concludes that there is adequate assurance of safety with respect to liquefaction damage.

3.3.4 Cover Design

The licensee has proposed three different embankment cover sections, depending on location:

1) The proposed final cover profile for the embankment will consist of 7 feet (minimum) of sandy soil above the regraded coarse tailings. The sandy soil will be capped by a filter layer and rock armor of variable thickness.

2) The proposed cover profile over coarse tailings will consist of:

6 inches (minimum) of low-grade ore from the mill area,
16 inches (minimum) of affected soil,
8 inches (minimum) of compacted clay,
9 inches of sandy soil

The coarse tailings areas will be covered with rock armor of variable thickness.

3) The proposed cover profile over fine tailings will include:

7 feet (minimum) of regraded coarse tailings,
16 inches (minimum) of affected soil,
12 inches (minimum) of compacted clay,
9 inches (minimum) of sandy soil

A rock armor of variable thickness will cover the sandy soil.

The cover system described above will provide a minimum of 37 inches of cover above tailings on the top and sides of the cell. The system has been designed to limit the infiltration of precipitation, protect the pile from erosion, and to control the release of radon from the tailings below. Details of the staff's review of the cover's performance related to limiting infiltration are addressed in Section 5 of this report; the review of the cover's erosion protection features is presented in Section 4, and the review of the radon attenuation aspects of the cover is presented in Section 6. Certain other design aspects of the proposed cover are discussed herein.

Tests on the compacted clay from Klondike Flats indicate that hydraulic conductivities will be near 10^{-7} cm/sec at placement conditions. In addition, the physical shape and surface grading of the reclaimed tailings embankment will effectively remove surface water resulting from precipitation which falls on the area. The relatively low permeability of the cover materials and the low annual rainfall with high evaporation rate will prevent significant tailings recharge.

The licensee has evaluated the potential for frost penetration using the BERGGREN.BAS computer code developed at the U.S. Army Corps of Engineers (COE, 1968). The code has been used on several other uranium mill tailings remediation projects. In order to evaluate the potential for frost penetration, temperature data including the freezing index, mean annual air temperature, length of freezing season, and geotechnical parameters are considered. The model calculates the heat capacity, thermal conductivity, and latent heat of fusion for the soil layers unless these data are entered manually.

Values used in the computer analysis included the mean and worst-case situations based on the available 31 years of weather records. In the worst-case scenario, the licensee determined that the depth of frost penetration would be 10.2 inches. By thickening the sand layer to 9 inches, and in conjunction with the exterior rock armor, the potential for frost penetration into the clay layer is eliminated, and the cover integrity should not be

significantly affected.

The staff has reviewed the input data used in determining the total frost penetration depth and concludes that these values are a reasonable representation of the extreme site conditions to be expected. Therefore, the licensee's evaluation of the frost penetration depth is acceptable to the staff.

The cover design has been evaluated by the staff for geotechnical long-term stability and the design is acceptable; however, it is required that the licensee perform materials testing during construction and revise the cover design if a need to do so is indicated at that time. The radon attenuation ability of the cover is discussed in Section 6 and the hydraulic conductivity aspects of the cover in Section 5.

3.3.5 Subsidence

Possible mechanisms for ground subsidence due to dissolution or creep of underlying salt are discussed in section 2.4.1.3. The staff concluded that 1 meter of bedrock subsidence at any location below the pile is a reasonable design basis. The licensee presented an analysis (Woodward-Clyde, 1996) to show that a worst-case scenario of subsidence would not adversely affect the stabilized tailings. The Woodward-Clyde approach was based on a simplified procedure by Bray et al (1994a), and considered instantaneous subsidence of 1 meter and, for added conservatism, of 2 meters. The modified Bray procedure was developed from finite element analyses and physical models for propagation of earthquake fault ruptures in the bedrock beneath cohesive soil deposits. The analytical and physical model results were also compared with case histories of earthquake fault rupture propagation through soil, such as those described by Bray et al (1994b). The staff considers the licensee's approach to be conservative for evaluating the surface deformation associated with vertical subsidence caused by salt dissolution because it assumes the deformation to be instantaneous and concentrated within a single narrow zone rather than being incremental and more distributed, as would be expected for salt dissolution subsidence.

The licensee's analysis (Woodward-Clyde, 1996), using the simplified fault rupture propagation model of Bray et al (1994a), indicates that the thickness of alluvium and tailings is greater than the distance of propagation for 1 and 2 meter bedrock offsets. Thus, differential displacements of bedrock, resulting from salt dissolution subsidence under the tailings pile, would not be expected to propagate to the surface and impair the function of the clay cap and radon barrier. The staff concludes that the analysis was conservative for the reasons discussed above. The staff therefore concludes that the licensee provided adequate assurance that the potential for differential offsets reaching the surface of the pile as a result of salt dissolution over the next 1000 years is negligible.

3.4 Geotechnical Construction Details

3.4.1 Construction Methods and Features

The staff has reviewed design text, tables, and drawings in the technical

specifications submitted by the licensee (Smith, 1996). The text discusses the investigations and testing which formed the basis of the design and specifications. Additionally, the text discusses the design concept in detail. The text is supported by tables which summarize design parameters and figures which clearly show plans, profiles, and details of the proposed remedial action.

In summary, the side slopes will be re-contoured to a 10H to 3V proportion. Mill debris is to be buried systematically at the toe of the slope. A permanent layered cover will provide protection from excessive radon emanation, and will permit rainfall to drain away satisfactorily.

The staff has reviewed and evaluated the geotechnical construction criteria provided in the Reclamation Plan. Based on this review, the staff concludes that the plans and drawings clearly convey the proposed closure action design features. In addition, the excavation and placement methods and specifications are consistent with accepted standard practice and the SRP.

3.4.2 Testing and Inspection

The staff has reviewed drawings and technical specifications submitted by the licensee (Smith, 1996). The Technical Specifications discuss testing methods and quality control procedures applicable to the remedial work. Appropriate reference is made to ASTM methods which will govern the placement and testing of soil and rock materials. The specifications are presented in a conventional outline form. Tables and figures are appended to the Technical Specifications.

Based on the NRC staff review, the plan is found to provide a program for testing and inspection that is generally consistent with the Staff Technical Position on Testing and Inspection (NRC, 1989).

3.5 Conclusions

Based on the review of the geotechnical engineering aspects of the design of the Atlas closure action as presented in the Reclamation Plan, the staff concludes that the embankment and proposed borrow soils have been adequately characterized. Furthermore, the cover system appears to be adequately designed to resist the effects of freezing conditions which can reasonably be expected. The staff concludes that the slopes of the disposal cell are designed to endure the effects of the geologic processes and events, including resistance to earthquake and settlement, to which they may reasonably be subjected during the design life and that the analyses have been made in a manner consistent with Chapter 2 of the SRP (NRC, 1993). The staff concludes that there is adequate assurance of safety with respect to liquefaction potential. Therefore, the staff concludes that the geotechnical engineering aspects of the proposed design meet the requirements in Appendix A of Part 40.

4.0 SURFACE WATER HYDROLOGY AND EROSION PROTECTION

4.1 Introduction

This section of the TER describes the staff's review of surface water hydrology and erosion protection issues related to long-term stability. In this section, the staff provides the technical bases for the acceptability of the licensee's reclamation design. Review areas that are covered include: estimates of flood magnitudes; water surface elevations and velocities; sizing of riprap to be used for erosion protection; long-term durability of the erosion protection; and testing and inspection procedures to be implemented during construction.

4.2 Hydrologic Description and Site Conceptual Design

The Atlas tailings disposal area is located on a river terrace approximately 500 to 700 feet from the Colorado River and approximately 3 miles north of the town of Moab, Utah. Moab Wash, an ephemeral stream with a drainage area of about 5 square miles, is located along the north and east sides of the tailings impoundment. The site is surrounded by the near-vertical sandstone cliffs of the Moab Valley.

To comply with Criterion 6 of 10 CFR 40, Appendix A, which requires stability of the tailings for 1000 years to the extent reasonably achievable and in any case for 200 years, the licensee proposes to reclaim the tailings impoundment in place and to protect the tailings from flooding and erosion. The design basis events for design of erosion protection include the Probable Maximum Precipitation (PMP) and the Probable Maximum Flood (PMF) events, both of which are considered to have very low probabilities of occurring during the 1000-year stabilization period.

As shown in Figure 4-1, the top surface of the tailings impoundment will be reconfigured to drain toward three collection ditches, and the embankment side slopes will be flattened to 10H:3V except at the southwest corner where the slopes will be 10H:1V. The three collection ditches on the top surface will merge to form the Upper Tailings Pile Drainage Channel. This channel will convey flood runoff into the Lower Tailings Pile Drainage Channel, which will then discharge into Moab Wash. Moab Wash will be reconfigured to convey flood flows into the Colorado River east of the tailings pile. The Southwest Runoff Drainage Channel will divert runoff from the side slopes on the southwest side of the reclaimed impoundment and from the sandstone bluffs southwest of the channel.

To protect against erosion, the top and side slopes of the tailings impoundment will be covered with layers of rock riprap. At the toes of the side slopes, a riprap apron/toe will be constructed to provide protection against the potential migration of Moab Wash and the Colorado River. The collection ditches and drainage channels will also be protected with riprap.

For Moab Wash, the licensee proposes to excavate a new channel as far away from tailings as possible. The reconfigured channel will flow eastward across

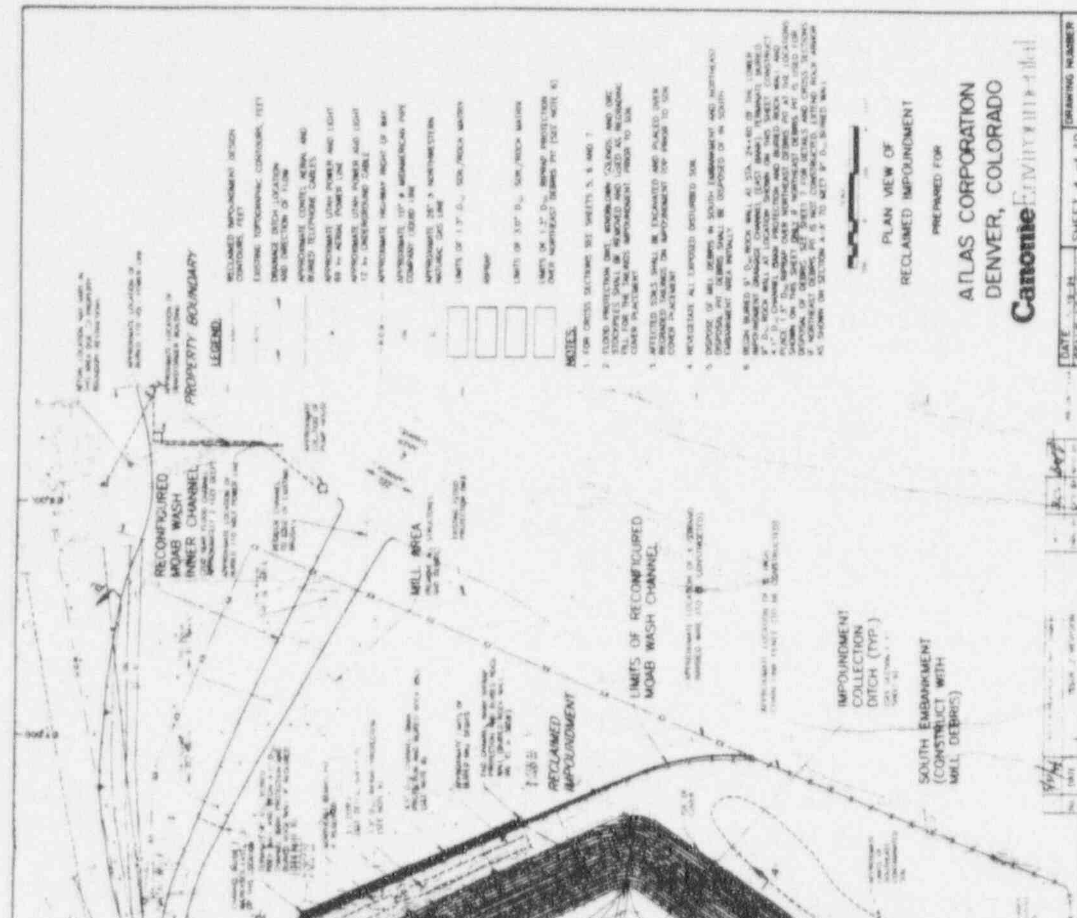

Figure 4-1: Atlas erosion control features

the floodplain and into the Colorado River upstream of the site. The design will provide a shallow trapezoidal channel designed for the PMF. At approximately the center of the main channel, a low-flow channel will be constructed to convey flows up to the 200-year flood.

4.3 Flooding Determinations

The computation of peak flood discharges for various site design features and nearby hydrologic features was performed by the licensee in several steps. These steps included: (1) selection of a design rainfall event; (2) determination of infiltration losses; (3) determination of times of concentration; (4) determination of appropriate rainfall distributions, corresponding to the computed times of concentration; and (5) calculation of flood discharge. 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 (Section 4.4) and in the final determination of rock sizes for erosion protection (Section 4.5).

4.3.1 Selection of Design Rainfall Event

One of the phenomena most likely to affect long-term stability is surface water erosion. To mitigate the potential effects of surface water erosion, the staff considers that it is very important to select an appropriately conservative rainfall event on which to base the flood protection designs. Further, the staff considers 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 an extrapolation. The licensee utilized a PMP computed by deterministic methods (rather than statistical methods) and 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, the staff has concluded that the probability of such an event being equalled or exceeded during the 1000-year stability period is very low. Accordingly, 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 United States by Federal agencies 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.

PMP values were estimated by the licensee using Hydrometeorological Report No. 49 (HMR-49) (NOAA, 1977). The report provides information on distributing the rainfall that falls over a particular drainage area; during a PMP event these rainfall amounts vary inversely with the size of the area (the smaller the area the larger the average rainfall). A 1-hour PMP of 7.4 inches and a 6-hour PMP of 9.36 inches were used by the licensee as a basis for estimating a PMF for Moab Wash which has a drainage area of 5 square miles. For the smaller areas at the site such as the pile top, embankment side slopes, and

the discharge channels, a 1-hour PMP of 8.25 inches was used. For the Colorado River, the licensee did not calculate the PMF using PMP values; rather, the licensee used existing PMF studies to estimate the PMF (See Section 4.3.5.5).

The licensee's procedures for estimating PMP values were reviewed, and it was concluded that a 1-hour PMP of 7.4 inches and a 6-hour PMP of 9.36 inches are acceptable for Moab Wash. For the other small drainage areas at the site, it was concluded that a 1-hour PMP of 8.25 inches was acceptable. Based on staff review of the rainfall computations, the staff concludes that the PMP was acceptably derived for this site.

4.3.2 Infiltration Losses

In addition to the amount of precipitation, the determination of the peak runoff rate is also dependent on the amount of precipitation that infiltrates into the ground during its occurrence and therefore does not contribute to flood flows. 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 (USBR) 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 Flood Hydrograph Package HEC-1 (COE, 1988) 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 small drainage areas at the site, the licensee used the Rational Formula (USBR, 1977). In this formula, the runoff coefficient was assumed to be unity; that is, the licensee assumed that no infiltration would occur. Based on a review of the computations, the staff concludes that this is a conservative assumption and is, therefore, acceptable.

The licensee used HEC-1 to estimate PMF values for larger drainage areas such as the drainage channels and Moab Wash. Basin characteristics used as input parameters to HEC-1 were determined by the licensee using the U.S. Soil Conservation Service Curve Number (CN) Method (USBR, 1977). The CN of an area is an indication of the amount of precipitation that will result in runoff. It is based on the soil and vegetation characteristics of a drainage area and on the soil moisture levels existing prior to the design storm event. In estimating CN values, the licensee assumed that the soil moisture at the beginning of the PMP event would be close to saturation. This resulted in conservative PMFs, because saturated soil conditions limit the amount of infiltration that will occur and maximize the amount of runoff.

4.3.3 Times of Concentration

The time of concentration (t_c) 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.

Times of concentration for the riprap design were estimated by the licensee using several methods, such as the Kirpich Method (USBR, 1977) and the Manning's Equation (Chow, 1959). Such methods are generally accepted in engineering practice and are considered by the staff to be appropriate for estimating times of concentration. Based a review of the calculations provided, the staff concludes that the t_c values used by the licensee were acceptably derived.

4.3.4 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. The licensee utilized a procedure recommended in HMR-49 (NOAA, 1977) 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.

To determine peak flood flows for the pile (for a PMP of 8.25 inches), approximate PMP rainfall intensities were derived by the licensee as shown in Table 4-1.

Table 4-1: PMP Rainfall Intensity

Rainfall Duration (minutes)	Rainfall Intensity (inches/hr)
2.5	54.5
5.0	44.5
15.0	24.4
60.0	8.25

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 acceptable.

The temporal distribution of rainfall is the sequence in which a storm occurs. For example, in some storms, such as the PMP in HMR-49, the largest increments

of rainfall occur at the beginning of the storm and taper off as the rainfall continues. In other storms, rainfall begins slowly, increasing in intensity to a peak near the center of the storm duration before it begins to taper off. It has been shown that a rainfall distribution that peaks near the center of the storm duration results in the most conservative (largest) PMF peak discharge. In order to obtain conservative PMF estimates, the licensee resequenced the incremental rainfall amounts from HMR-49 so that the largest rainfall increments occurred near the center of the storm duration. The resequenced PMP amounts, CN values, t_c estimates and other parameters were then used in the HEC-1 computer program for calculating appropriate PMF peak discharges for the collection ditches, drainage channels, and Moab Wash. Based on its review of these aspects of the flood determinations, the staff concludes that appropriate rainfall distributions were used.

4.3.5 Computation of PMF

Various methods are used to determine peak PMF flows, depending on the location of the feature, the drainage area, and other factors.

4.3.5.1 Top and Side Slopes

To estimate PMF peak discharges for the impoundment top and embankment side slopes, the licensee used the Rational Method (Chow, 1959). This method is a simple procedure for estimating flood discharges that is recommended in the Staff Technical Position (STP) on Erosion Protection (NRC, 1990). In using the Rational Method, the licensee conservatively assumed a runoff coefficient equal to one. This means that the entire PMP would result in runoff, i.e., there would be no losses due to infiltration and evapotranspiration.

For a maximum top slope length of 1440 feet (with a slope of 0.018) and a side slope length of 310 feet (with a slope of 0.3), the licensee estimated the peak flow rates to be about 1.0 cubic feet per second per foot of width (cfs/ft) for the top slope and 0.4 cfs/ft for the side slope. For the 10 percent slope at the extreme southern end of the pile, the peak flow rate was estimated to be 0.7 cfs/ft. Based on a review of the calculations, including the time of concentration, rainfall intensity, and runoff, the staff concludes that the estimates are acceptable.

4.3.5.2 Apron/Toe

PMF flow rates for overland flow for the downstream apron were estimated by the licensee and are similar to the flow rates for the side slopes. As discussed above, the flow rates are considered to be acceptable.

4.3.5.3 Collection Ditches and Drainage Channels

Peak PMF discharges for the collection ditches and drainage channels were estimated by the licensee using the HEC-1 computer program. The program was developed by the U.S. Army Corps of Engineers (COE, 1988), and is a widely used and accepted procedure for estimating flood peak discharges. The method is recommended by the NRC staff (NRC, 1990) and is therefore, acceptable.

Table 4-2 contains a summary of the licensee's calculated PMF peak discharges

for the collection ditches, the Upper Tailings Pile Drainage Channel (TPDC), the Lower Tailings Pile Drainage Channel (TPDC), and the Southwest Diversion Channel (SWDC).

Table 4-2: PMF Peak Discharge

Channel	Drainage Area (square miles)	PMF (cfs)
Collection Ditch 1	.02	376
Collection Ditch 2	.03	482
Collection Ditch 3	.04	614
Upper TPDC	.08	1638
Lower TPDC	.09	1640
SWDC	.09	1723

The flow rate for the Lower TPDC, for example, represents a discharge of about 1[illegible],000 cfs/mi^2. These flow rates were compared with published historic maximum flood rates (Crippen and Bue, 1977). Based on a review of the calculations and comparison with historic floods, the licensee's estimates are acceptable.

4.3.5.4 Moab Wash

To evaluate the adequacy of the licensee's estimated PMF peak discharge for Moab Wash, an independent calculation was performed by the NRC staff. Using the 1:24,000 scale map provided by the licensee, the staff first verified the licensee's estimate of the Moab Wash drainage area (5 square miles). The incremental PMP values were then arranged to provide the largest possible flood peak discharge. A curve number of 9[illegible] was then selected (see discussion of curve numbers above; a CN=100 would mean that 100 percent of the rainfall would result in runoff). Using HEC-1, the staff estimated a PMF peak discharge of 16,069 cfs. This compares favorably with the licensee's estimate of 16,129 cfs. Based on this close comparison, it was concluded that the licensee's PMF estimate for Moab Wash is acceptable.

4.3.5.5 Colorado River

The licensee did not independently estimate a PMF peak discharge for the Colorado River. Instead, existing flood data were reviewed and a search was conducted for additional studies of floods in the area. The review provided a range of Colorado River flood events that included the highest recorded flood, the 100-year, 200-year, and 500-year floods, and two estimates of the PMF. The highest recorded flow, as reported by the U.S. Geological Survey (USGS) for Moab, Utah, was 77,000 cfs in 1917. The USGS estimated 100-year, 200-year, and 500-year flood discharges of 99,500 cfs, 109,500 cfs, and 123,500 cfs, respectively. However, these estimates are for the nearest stream gaging

station which is at Cisco, Utah, located about 35 miles upstream of Moab.

A PMF peak discharge (300,000 cfs) was previously estimated by the NRC staff. This estimate was developed by adjusting the Standard Project Flood estimate of the Corps of Engineers. As a result, it was recognized that the estimate was likely to be conservative. It was significantly higher, however, than the 178,000 cfs estimated by Dames & Moore and reported by Atlas in the May 1984 renewal application.

In reviewing the licensee's reported historic and estimated extreme flood peak discharges for the Colorado River, the NRC staff contacted the USBR. The USBR reported that they have not performed any comprehensive flood studies of the Colorado River at Moab, Utah. However, PMF reports are available for Hoover and Glen Canyon Dams, which are located on the Colorado River downstream of Moab (USBR, 1990). The PMF developed for the Colorado River at Glen Canyon Dam had a peak discharge of 697,000 cfs. This is more than twice as large as the largest recorded flood in the Colorado River which occurred at the site of Hoover Dam in July of 1884. That flood had a peak discharge of about 300,000 cfs. The NRC staff recognizes that these studies are not applicable to the Moab site since the drainage areas at these dam sites are considerably larger; however, they can be used to obtain a rough estimate of a PMF at Moab. Chow states that, "In some homogeneous areas where t_c is a simple function of area, the peak rates will vary directly with some power of the area, usually 0.5 (Chow, 1959)." The Colorado River at Glen Canyon Dam has a drainage area of 108,000 square miles (USBR, 1990). By comparison, the drainage area for the Colorado River at Moab, Utah is about 25,000 square miles, according to the licensee's May 1984 renewal application. Using the Chow relationship, a rough estimate of the PMF for the Colorado River at Moab would be 335,300 cfs. Therefore, assuming a PMF peak discharge of 300,000 at Moab appears to be reasonable and acceptable. This estimate was used by the licensee.

The staff's assessment of flood potential also included a review of paleoflood data for the Colorado River basin. These data were presented in "Paleoflood Evidence for a Natural Upper Bound to Flood Magnitudes in the Colorado River Basin" (Enzel et al., 1993). In this report, the authors indicate that the largest flood on the Colorado River occurred about 4000 years ago. This flood had a magnitude of about 495,000 cfs (14,000 cubic meters per second) at Lee's Ferry (Glen Canyon Dam), where the drainage area is about 108,000 square miles (279,000 square kilometers). This flood magnitude is less than the estimated PMF peak discharge of 697,000 cfs. No data were presented to estimate the magnitude of this historical flood at the site; however, using similar relationships to those discussed by Chow (1959) and discussed above, an approximate estimate of the maximum historical flood at the site (where the drainage area is about 25,000 square miles) would be approximately 238,000 cfs. This discharge is also less than the PMF estimate of 300,000 cfs.

4.4 Water Surface Profiles and Channel Velocities

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 ensure stability during the occurrence of the design event.

4.4.1 Top and Side Slopes

In determining riprap requirements for the top and side slopes, the licensee used the Safety Factors Method (Stevens et al., 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 et al., 1987). The staff, therefore, concludes that the procedures and design approaches used by the licensee are acceptable and reflect state-of-the-art methods for designing riprap erosion protection. Input parameters and design methods for riprap sizing are discussed further in Section 4.5.

4.4.2 Apron/Toe

The design of the apron/toe for this site must be adequate to withstand forces from several different phenomena and is based on the following general concepts: (1) provide riprap of adequate size to be stable against overland (downslope) flows produced by the design storm (PMP), with allowances for turbulence along the downstream portion of the toe; (2) provide uniform and/or gentle grades along the apron and the adjacent ground surface such that runoff is distributed uniformly onto natural ground at a relatively low velocity, minimizing the potential for flow concentration and erosion; (3) provide riprap of adequate size to withstand expected peak flow velocities and scour in Moab Wash, assuming that the channel has eroded and is located in the immediate area of the toe; (4) provide riprap to resist the highest velocities and shear forces expected in the Colorado River channel (such velocities and shear forces may not occur during the PMF, but may occur at lesser river flows where the backwater effects of the Portal area are not present); and (5) provide an adequate apron length and quantity of rock to allow the rock apron to collapse into a stable configuration if the main channel of the Colorado River erodes toward the site.

Several analytical methods were used for designing the riprap for the apron/toe, depending on its location relative to Moab Wash and the Colorado River. Additional detailed discussion of the riprap design of various components of the apron/toe can be found in Section 4.5.1.2, below.

4.4.3 Collection Ditches and Drainage Channels

Using the PMF peak discharges discussed above, flood control features such as collection ditches and drainage channels were designed by the licensee. For the trapezoidal-shaped ditches and channels with little variation in slope or shape, the licensee determined water surface elevations and flow velocities associated with the PMF peak discharges by calculating normal depth (Chow, 1959). Normal depth calculations are generally acceptable for the design of riprap erosion protection. In some cases, flow profiles and velocities were calculated by the licensee using the computer program HEC-2 (COE, 1991). This method is considered to be an acceptable computational method for estimating water surface elevations, flow depths, and flow velocities and is recommended by the staff (NRC, 1990). Based on a review of the licensee's computations,

the staff concludes that the estimates of flow velocity and depth of flow are acceptable.

4.4.4 Moab Wash

There is a potential for the migration of the main channel of Moab Wash toward the tailings pile. The NRC staff reviewed information and analyses provided by the licensee related to channel migration and conducted independent field investigations in the Moab Wash channel and overbank area. Based on available information, the staff is concerned that during the 1000-year design life, Moab Wash may vary its location periodically and unpredictably, and the licensee has provided no basis to conclude that Moab Wash cannot move to a location adjacent to the reclaimed tailings impoundment. To prevent erosion into the tailings embankment, the licensee proposes to provide a large rock toe/apron along the toe of the embankment adjacent to Moab Wash.

Assuming migration of the channel to the toe of the pile, the licensee estimated water surface elevations and flow velocities using HEC-2. The staff reviewed the HEC-2 output files that were provided by the licensee. These files provided information regarding maximum water surface elevations and velocities and included both subcritical and supercritical flow profiles for Moab Wash. Since the supercritical profile resulted in the highest velocities, this profile was used by the licensee to estimate the depth of scour and the configuration of the buried rock wall. Based on staff review of both the supercritical profile and the subcritical profile, the staff concludes that the profiles and velocities were acceptably derived.

In developing the profiles, the licensee used various conservative assumptions regarding the location and configuration of Moab Wash. In addition to the technical bases established by the calculations associated with PMF flows, there are several qualitative reasons for the staff to conclude that the design is acceptable.

First, it is not likely that the channel will migrate all the way to the toe of the pile. A positive slope of about one percent will be maintained from the toe of the embankment toward the main low-flow channel. A large amount of soil will need to be eroded before complete channel migration or avulsion occurs.

Second, the main channel of Moab Wash was assumed to have the same elevation in a migrated condition as its design condition. It is more likely that the channel will have a higher elevation, since it will be eroding into a mass of natural stream deposits in the overbank area that are at a higher elevation. The licensee's estimates of scour depth (See Section 4.5.1.2.2) are therefore conservative, since the migrated channel invert is assumed to be the same as the design condition.

Third, velocities were calculated assuming that the channel retained the same configuration following migration. Such an assumption is conservative, since the eroded channel is likely to be less uniform and have a higher Manning's 'n' value, resulting in a decrease in velocities.

Fourth, the proposed location of Moab Wash is roughly equivalent to the

location of the channel prior to initial construction of the Atlas facility. The existing (relocated) channel of Moab Wash adjacent to the tailings pile was realigned to allow for construction of the mill buildings. Based on review of the information provided by the licensee, the channel is more likely to remain in its undisturbed location, rather than migrate.

Fifth, this area is an aggrading alluvial fan area (Mussetter and Harvey, 1994), and deposition along Moab Wash will continue to occur. Such increases in elevation will increase the conservatisms associated with scour depth and the bottom elevation of the buried riprap wall.

4.4.5 Colorado River

The licensee provided detailed information and analyses (Mussetter and Harvey, 1994) and used the HEC-2 computer program to evaluate the hydraulic characteristics of the Colorado River in the immediate vicinity of the reclaimed pile. The study area extended from the Portal area (downstream of the pile) to a location upstream of the U. S. Highway 191 bridge (upstream of the pile).

For these water surface profile analyses, the licensee surveyed fourteen cross sections of the river. The surveyed sections were tied to the State Plane Coordinate System and were extended into the overbank area using data from available topographic maps. Construction drawings for the Route 191 highway bridge were obtained from the Utah Department of Highways and Transportation.

The licensee first calibrated the HEC-2 model by comparing model results to observed high water marks for known discharges. This calibration was done to verify that input parameters to the model, such as Manning's 'n' value, were appropriate. Comparisons were performed for discharges ranging from 4000 cfs to 48,900 cfs. In addition, the predicted water surface elevation at the toe of the tailings pile for a discharge of 70,300 (peak flow rate of the 1984 flood) was consistent with local observations in 1984 that the flood reached the toe of the tailings pile.

Following calibration of the HEC-2 model, the licensee analyzed water surface profiles and velocities for various discharges up to the magnitude of the PMF. A summary of the analyses is provided in Table 4-3 for cross section 5, which is located near the upstream end of the pile.

For explanation purposes, the event is a brief description of the flow that was analyzed; the flow rate is the flood discharge in cubic feet per second (cfs) for that event; the water surface elevation is the water surface elevation in feet above mean sea level (ft msl) at cross section 5; the channel velocity is the average velocity in feet per second (ft/sec) in the main channel of the Colorado River at cross section 5; and the overbank velocity is the average velocity in ft/sec in the overbank area adjacent to the pile at cross section 5 and is used to conservatively represent the maximum velocity that will occur on the pile side slopes. Cross section 5 was chosen because the computed channel velocities are higher than those at cross section 6.

Table 4-3: Water Surface Profiles and Velocities

	Flow Rate (cfs)	Water Surface Elevation (ft msl)	Channel Velocity (ft/sec)	Overbank Velocity (ft/sec)
Calibration	4000	3952.0	2.51	---
Calibration	20,000	3959.1	4.08	---
1993 Flood	48,900	3964.7	6.03	0.17
1984 Flood	70,300	3967.6	6.91	0.56
500-year Flood	123,500	3975.8	5.75	0.98
PMF (Atlas)	178,000	3983.1	4.61	0.90
PMF (NRC)	300,000	3996.7	3.14	0.71

The HEC-2 analysis performed by the licensee indicated that a peak discharge of 300,000 cfs in the Colorado River would result in an elevation of about 3996.7 ft msl. The maximum flow velocity occurred at a discharge of about 70,000 cfs and was about 7 ft/sec. The toe of the tailings impoundment is at an elevation of about 3968 feet. Therefore, a PMF discharge of 300,000 cfs would result in a depth of water of about 29 feet against the tailings impoundment. The maximum flow velocity (in the overbank against the side slope) of about one foot per second is well below the velocity considered to cause erosion to the rock armored impoundment side slopes. The licensee concluded that the riprap proposed for the impoundment side slopes is adequate for resisting extreme floods in the Colorado River (See Section 4.5, below).

To independently verify the licensee's conclusions, a sensitivity study was performed assuming a larger flood discharge in the Colorado River. This analysis indicated that even a discharge of 600,000 cfs (the approximate PMF at Hoover Dam) would not result in erosive flow velocities against the tailings impoundment. Such a discharge would have a maximum flow velocity against the reclaimed tailings of about 1.6 feet per second (fps), even though the toe of the pile would be inundated by about 50 feet of water.

Such low flow velocities result from a narrow gorge 2 miles downstream of the mill site called the Portal. This channel constriction has limited flood carrying capacity; consequently, during an extreme flood event, floodwaters will pond in the wide river channel and overbank areas upstream of the Portal. This situation is analogous to that of a dam which ponds water in the upper end of its reservoir due to the limited capacity of the outlet. For example, during routine flows, a river channel flowing into the reservoir may have flow velocities in excess of 10 ft/sec; however, if reservoir ponding occurs to inundate the channel, the velocity could be less than one ft/sec in the same channel for a larger flow rate. This is essentially what happens on the Colorado River near the Atlas site during large floods. The river channel at the Portal is capable of discharging only a relatively low (compared to areas upstream) flow, and when that flow rate is exceeded, ponding occurs, reducing

velocities upstream of the Portal.

In spite of the low velocities that are produced during the occurrence of major flood flows, the staff is concerned that there is a potential for the Colorado River to migrate and possibly reach the toe of the reclaimed tailings disposal area. These concerns are based on staff observations and review of licensee analyses which indicate that erosion will occur during lesser flood events and this erosion is currently on-going in the immediate site area. Further, the Colorado River may have once been located north of the pile, and there is no assurance that it could not migrate northward. The licensee has indicated that the potential for migration is very low and that there are several bases supporting this low probability. The staff requested that Atlas provide quantitative evidence to support this conclusion; however, Atlas was not able to do so. Therefore, Atlas intends to provide a large rock apron at the toe of the disposal cell to protect the pile from erosion. The apron will be located on the southeastern side of the pile and will be designed to collapse into the channel, if migration occurs. The staff concludes that providing such a design measure is appropriate, since quantitative proof of channel stability cannot be provided.

However, the staff reviewed the licensee's qualitative information and generally concludes that the potential for migration is very low during a 200-1000 year period. Several site-specific factors need to be considered.

First, channel migration is normally the result of the meandering of a freely-adjustable stream. The ability of the Colorado River to meander across the Moab Valley is restricted by bedrock controls upstream at the valley entrance and downstream at the Portal.

Second, the rate of bank retreat is dependent upon the forces exerted and the resistance of the bank material to erosion. The maximum velocity of the river is about 7 ft/sec, which is generally not extremely erosive. Further, the overbank area between the river and the disposal area is heavily vegetated with grass, weeds, and tamarisks. Such heavy vegetation provides a considerable amount of erosional stability for both erosion and bank sloughing.

Third, the presence of mid-channel bars would tend to indicate that the river is probably aggrading more than it is eroding. This indicates that velocities in the area are low, tending to cause deposition rather than erosion.

Fourth, a considerable amount of aggradation caused by sediments from Moab Wash and Courthouse Wash appears to be occurring. Mussetter and Harvey (1994) discuss evidence suggesting that aggradation has occurred in the vicinity of the site over the last 20 years.

Fifth, aerial photographs indicate that lateral accretion has occurred along the river bank downstream of the site. Photographs taken between 1960 and 1985 indicate that some accretion has occurred in this area.

In summary, the staff concludes that it is unlikely that the river will migrate as far as the tailings pile within the next 200-1000 years. However, because quantitative proof of bank stability was not provided, it is prudent

to design the pile for such an occurrence. The licensee intends to provide an erosion protection apron for the pile and this measure is considered by the staff to be a conservative method for addressing Colorado River erosion concerns. A detailed discussion of the design of the apron may be found in Section 4.5.1.2.3.

4.5 Erosion Protection

The ability of a riprap layer to resist the velocities and shear forces associated with surface flows over the layer is related to the size and weight of the stones which make up the layer. Typically, riprap layers consist of a mass of well-graded rocks which vary in size. Because of the variation in rock sizes, design criteria are generally expressed in terms of the median stone size, D_{50}, where the numerical subscript denotes the percentage of the graded material that contains stones of less weight. For example, a rock layer with a D_{50} of 4 inches could contain rocks ranging in size from 0.75 inches to 6 inches; however, at least 50% of the weight of the layer will be provided by rocks that are 4 inches or larger.

Depending on the rock source, variations occur in the sizes of rock available for production and placement on the reclaimed pile. It is necessary to ensure that the variation in rock sizes is not extreme, and design criteria for developing acceptable gradations are provided by various sources (e.g., COE, 1971, and Simons and Li, 1982).

4.5.1 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. The licensee proposes to use several different sizes and layer thicknesses, depending on the location and erosive forces that could occur. To reduce the number of gradations that need to be produced, the licensee will place larger rock in some areas than is required. For example, rock to be used on the upper portion of the top slope has a average size of 1.3 inches. However, in the extreme upper portion of this upper slope, rock requirements are much less than 1.3 inches. For ease of construction and to minimize the number of gradations, the licensee has purposely overdesigned several areas of the reclaimed surfaces. Table 4-4 summarizes the riprap to be used at the Atlas site.

Discussion of the design of each of these features is provided in the sections that follow.

The staff reviewed the D_{50} sizes proposed by the licensee, and details of layer thicknesses and gradations. Based on this review, the overall riprap design is considered to be acceptable. Additional discussion of the design is provided below.

Table 4-4: Riprap Sizes and Thicknesses

Location/Feature	D50 (inches)	Layer Thickness (inches)
Upper Top Slope	1.3	4
Lower Top Slope (1V:10H)	3.0	6
Side Slope (3V:10H)	5.3	10.5
Collection Ditches	5.3	10.5
Upper Tailings Pile Drainage Channel	5.3	10.5
Moab Wash Channel	9.0	13.5
Southwest Drainage Channel	9.0	13.5
Apron along Colorado River	11.2	30
Southwest Drainage Channel	11.2	17
Lower Tailings Pile Drainage Channel	17.4	26
Lower Southwest Drainage Channel (Outlet)	27.6	42

4.5.1.1 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 in previous sections. The licensee proposes to use a 4-inch rock layer with a minimum D_{50} rock size of 1.3 inches at the upper portion of the cell. For a portion of the top slope with a slope of 1V on 10H, a 6-inch layer with a minimum D_{50} of 3 inches will be used. The Safety Factors Method was used to determine the rock sizes. Based on staff review of the calculations, we conclude that the design is acceptable.

The riprap for the side slopes is also designed for an occurrence of the local PMP. The licensee proposes to use a 10.5-inch layer of rock with a minimum D_{50} of 5.3 inches. The rock layer will be placed on a 6-inch 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. Based on staff review of the

licensee's analyses and the acceptability of using design methods recommended by the NRC staff, as discussed in Section 4.4 of this report, the staff concludes that the proposed rock size for the side slope is adequate.

The riprap proposed for the side slopes of the tailings embankment could be subjected to shear stresses from the PMF in the Colorado River. In addition, the tailings impoundment is located on the outside bend of the Colorado River where the river turns from a westerly to a southerly direction. Because the potential for erosion is greater at the outside bend of a channel, an analysis was performed using the COE procedures (COE, 1970) to determine if the riprap proposed for the embankment side slopes was of sufficient size to resist the erosion potential at the outside river bend. Based on the use of COE procedures, the staff concludes that the estimated flow velocity of about one ft/sec is well below the velocity that the riprap on the embankment side slopes can withstand. On this basis, it was concluded that a PMF in the Colorado River will not adversely affect the stability of the reclaimed tailings pile.

As discussed in Section 4.4.5, there is a potential for the Colorado River to migrate towards the tailings pile. For conservatism, the staff assumed that the river channel will migrate to a location immediately adjacent to the embankment side slope and that the peak channel flow velocity of about 7 ft/sec will occur. The staff considers this scenario to be extremely unlikely, even in a 1000-year design lifetime. However, based on review of the velocity adjacent to the side slope, the proposed riprap size of 5.3 inches is also capable of resisting this peak channel velocity. As discussed in Section 4.5.1.2.3, the controlling hydraulic design force results from overland flows directly down the pile side slope.

4.5.1.2 Apron/Toe

As previously discussed, the design of the apron/toe area must be capable of withstanding various phenomena. The riprap design is dependent on the specific location of the toe, and erosion protection needs to be provided against (1) overland flows down the side slope onto the toe, (2) Moab Wash, and (3) the Colorado River.

4.5.1.2.1 Overland Flows

In those areas where the embankment side slopes or toes are not affected by the Colorado River or by Moab Wash, the licensee has designed the side slopes to simply transition to natural ground. The riprap on the pile side slope will be extended and the toe will consist of rock extended 3 feet below the surface of the ground. This depth is greater than the estimated scour of 0.92 foot, which was estimated using Department of Transportation procedures (DOT, 1975). This method for estimating scour depth is recommended in the STP on Erosion Protection (NRC, 1990). Based on review of the calculations provided by the licensee, the staff concludes that this aspect of the toe design is acceptable.

4.5.1.2.2 Moab Wash

As discussed in Section 4.4.4, above, the licensee provided designs and

analyses of the riprap to be placed along the sides and toe of the pile, assuming that the main channel of Moab Wash had migrated to a new location immediately adjacent to the toe of the side slope embankment. The design included consideration of the: (1) potential future location of the channel; (2) estimated depth of scour; and (3) PMF water surface elevations.

To determine the areal extent of the apron/toe erosion protection, it was necessary for the licensee to analyze the hydraulic characteristics, assuming migration of the main channel of Moab Wash. The licensee developed water surface profiles and velocity estimates for such a channel configuration (See Section 4.4.4). Based on the velocity estimates and an evaluation of the potential for scour, erosion, and deposition, the licensee will construct a buried riprap wall along the toe of the pile, with the rock extending downward to the expected depth of scour. The buried wall will be constructed from the mouth of the lower impoundment drainage channel eastward to the point where the northeast debris pit begins. From there, the buried wall will extend southeastward to a point where the wall joins the rock apron that protects the pile from Colorado River migration (See Section 4.5.1.2.3).

The licensee concluded that the potential for channel migration toward the pile was greatest along the north side of the pile, where Moab Wash could be expected to meander and encroach upon the toe of the slope. In this area, the cross-sectional flow area is smallest, and velocities will be highest. Along the east side of the pile, beginning at the northeast debris pit, the flow area becomes much larger and the flow velocities are much lower. Therefore, the potential for channel migration in this area is lower.

The depth of scour was estimated by the licensee using four different methods, as recommended by Pemberton and Lara (1984). Using the field measurement method, the Regime Equation method, the mean velocity method, and limiting scour control method, the licensee estimated the scour depth to be about 7-8 feet along the northern portion of the disposal cell. Along the northeastern portion of the cell in the area of the debris pit, a scour depth of 3.6 feet was estimated. Based on a review of computations provided by the licensee, the staff concludes that the estimates are acceptable.

The riprap to be provided in the toe area was estimated by the licensee using the Corps of Engineers allowable shear stress method (COE, 1994). This method is appropriate when flow depths are larger than the rock size. The staff reviewed computations provided by the licensee and independently estimated the rock size using methods discussed in NUREG/CR-4651 (Abt et al., 1987). Based on this review, the staff concludes that the proposed D_{50} rock size of 9 inches is acceptable.

4.5.1.2.3 Colorado River

As discussed in Section 4.4.5, above, the licensee provided designs and analyses for the riprap to be placed along the sides and toe of the pile, assuming that the channel of the Colorado River had migrated to a new location immediately adjacent to the toe of the side slope embankment. The revised design included consideration of the: (1) assumed future location of the channel; (2) estimated depth of scour; and (3) required volume and size of the riprap.

To determine the areal extent of the apron/toe erosion protection, the licensee simply assumed that the main channel of the river would erode toward the pile and would ultimately exist immediately adjacent to the toe of the pile at all points along the southeastern side. The staff considers this to be an unlikely situation and a conservative assumption. Based on a geomorphic evaluation (Mussetter and Harvey, 1994) of the potential for scour, erosion, and deposition, the licensee will construct a large rock apron along the toe of the pile. The apron will be provided from the mouth of the southwest drainage channel northeastward to the point where it joins the Moab Wash toe protection in the area of the debris pit.

To estimate the depth of scour associated with migration of the river, the licensee conservatively assumed that the river channel would retain essentially the same elevations and configuration in its migrated state as in its current state. The current minimum river bottom elevation was assumed to be the maximum depth of scour. This assumption resulted in an estimated scour depth of about 21 feet. Based a review of the information provided, the staff concludes that the assumptions are acceptable.

To provide adequate erosion protection and to prevent erosion of the embankment side slope, the licensee will provide a large essentially horizontal, rock apron, designed to collapse onto the side slope of the migrated river channel. The rock volume will be sufficient to cover the channel bank and to prevent further erosion of the river bank and the pile side slope. The riprap to be provided for the rock apron was estimated by the licensee using methods developed by the COE (COE, 1994 and COE, 1995). The staff reviewed computations provided by the licensee. Based on this review, the staff concludes that the proposed apron length and thickness will provide an adequate volume of rock to protect the side slope from further migration of the Colorado River.

The size of the riprap to be placed in the apron is not controlled by flow velocities in the Colorado River. As discussed above, the maximum flow velocity of the river (using the extremely conservative assumption that the main channel, rather than the overbank, is adjacent to the pile side slope) is about 7 ft/sec, produced by a flow of about 70,000 cfs. If this were the controlling case, the side slope rock size of 5.3 inches would be more than adequate to prevent further erosion. Actually, the size of the apron rock is controlled by overland flows directly down the side slope. The licensee assumed that when the rock collapses into the scoured area, it will collapse onto the river bank in a configuration where the side slope is 1V on 2H. Flows directly down a 1V on 2H slope will require a rock size larger than 5.3 inches, which would be adequate for the 3V on 10H side slope. To provide the required protection, the licensee used the Stephenson Method to determine that the riprap apron will need an average rock size of 11.2 inches. Based on review of the computations provided by the licensee, the staff concludes that this rock size is acceptable.

4.5.1.3 Collection Ditches and Drainage Channels

Median rock diameters (D_{50}) for the collection ditches and drainage channels were estimated by the licensee using either the Corps of Engineers' Shear Stress Method (COE, 1994) or the Safety Factors Method (Stevens et al., 1976).

The COE method was used in cases where channel flow depths are large, relative to the median rock diameter. For shallow channels, the Safety Factors Method was used. These rock sizes are summarized in Table 4-4. The methods used by the licensee for designing erosion protection are those recommended in the STP on Erosion Protection (NRC, 1990), and are therefore acceptable.

To verify the licensee's riprap design for the collection ditches and channels, independent analyses were performed using methods developed by NRC contractors (Abt et al., 1987), the Safety Factors Method, and the Corps of Engineers' Shear Stress Method. These independent analyses indicated that the D_{50} values proposed by the licensee are adequate. Therefore, the staff concludes that the riprap sizes proposed by the licensee are acceptable.

4.5.1.3.1 Ditch Outlets

The licensee proposes to construct heavily-armored rock sections at the outlets of both the Southwest Runoff Drainage Channel (SWDC) and the Lower Tailings Pile Drainage Channel (TPDC). Their purpose is to protect the outlets of these channels from headcutting that may result from scour and may propagate upstream, potentially impinging on tailings. The depth of the proposed rock protection is equal to the expected depth of scour, which was estimated by the licensee to be approximately 8 feet. The outlet sections were assumed to collapse due to either: 1) gully headward erosion over a long period of time, or 2) the PMF flows in the ditches. In order to reduce the rock size required at the outlets, the licensee proposes to construct outlet slopes of 1V on 9H. In this design case, the scoured configuration is pre-constructed, rather than assumed to have collapsed randomly into a steeper configuration requiring much larger rock.

The D_{50} sizes of the rock in the outlet sections are proposed by the licensee to be 17.4 inches for the Lower TPDC and 27.6 inches for the SWDC. These sizes are larger than the required sizes computed by the licensee using the Stephenson Method. Based on a review of the calculations by the staff, the designs of the outlet sections are considered to be acceptable.

The licensee does not propose to provide outlet protection at the outlet of Moab Wash because the elevation of the outlet is controlled by the Colorado River. It is highly unlikely that the base level of the Colorado River will change during the performance period (Mussetter and Harvey, 1994). Therefore, the outlet of Moab Wash should remain fairly stable. The NRC staff agrees that outlet protection is not required for Moab Wash.

4.5.1.3.2 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. 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 Southwest Diversion Channel (SWDC), for the following reasons:

1. The upland drainage area has an extremely steep slope in the vicinity of the ditch, whereas the diversion ditch itself has been designed with a relatively flat slope 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 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.

To document the acceptability of the ditch design, the licensee demonstrated that the ditch will be capable of discharging the design flows, even if blockage occurs. The licensee assumed that sediment, debris, and large rocks would be deposited in the SWDC. The licensee determined that this channel would have adequate flow capacity, even if a significant amount of blockage (50%) occurred. The licensee performed analyses using HEC-2 and determined the effects of blockage on flow velocities and water surface profiles. The licensee determined that the blockage would raise PMF water surface elevations in the channel. The licensee proposes to vertically extend the required riprap to the increased elevations. Also, the blockage will increase the velocities, and the licensee will provide riprap of adequate size to resist those increased velocities. The proposed riprap varies in size from 9 inches in the upper reaches of the channel to 17 inches in the lower portions of the channel and was sized using COE design methods (COE, 1994) and the Safety Factors Method (Stevens et al., 1976).

Further, the licensee determined that the increased velocities will increase the depth of scour along the side slope, and therefore proposes to extend the side slope riprap vertically downward to the expected scour depth. The scour depth was determined using procedures discussed by Pemberton and Lara (1984); the acceptability of these scour analyses is discussed in Section 4.5.1.2.2.

Based on a review of the calculations provided, including the water surface profiles and riprap sizing techniques, the staff concludes that the SWDC will effectively accommodate a large amount of rock and debris entering the channel. The staff further concludes that the channel will convey PMF flows in a manner that will not affect the stability of the pile.

A landslide potential exists in the site area. This issue was evaluated by the staff and is further discussed in Section 2.4. Based on this analysis, design changes were not needed to the SWDC to accommodate the expected sediment input into the channel. The assumption of 50 percent blockage, as

discussed above, is considered to be conservative.

4.5.2 Riprap Gradations

The various estimated D_{50} values were used as the basis for the design of well graded mixtures of rock to resist the shear forces of the PMF peak discharge. Riprap gradations and layer thicknesses were developed by the licensee using the criteria outlined in "Surface Mining Water Diversions Design Manual" (Simons and Li, 1982). To verify the adequacy of the licensee's proposed riprap gradations, independent spot checks were made by the staff using design methods presented in NUREG/CR-4620 (Nelson et al., 1986). These checks indicated that the gradations proposed by the licensee are acceptable.

The licensee estimated many riprap sizes for the various applications. However, to reduce the number of different riprap sizes and gradations, the licensee elected to use larger rock than required in many areas. Thus, additional conservatisms are added to the design in those areas where larger rock than required is used.

4.5.3 Rock Durability

NRC regulations 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 TER 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.

To assure that the rock used for erosion protection remains effective for up to 1000 years as required by Criterion 6 of 10 CFR Part 40, Appendix A, potential rock sources must be tested and evaluated to identify acceptable sources of riprap. A procedure for determining the acceptability of a rock source is presented in Appendix D of the STP on Erosion Protection (NRC, 1990). The procedure discussed in the STP includes the following steps:

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.

After these tests are conducted, a rock quality score is determined. Different minimum scores, depending on the location where the rock will be placed, are recommended in the STP. Rock scoring 80 percent or greater indicates high quality rock that can be used for any application. Rock scores between 65 and 80 percent indicate less durable rock that can also be used for most applications, provided that the riprap is appropriately oversized. Rock scoring less than 65 percent cannot be used for critical areas such as diversion ditches or poorly drained toes and aprons. Rock scoring between 50 and 65 percent can be used in non-critical areas such as well drained tailings pile tops and side slopes provided it is oversized as recommended in the STP on Erosion Protection (NRC, 1990). Rock scoring less than 50 percent is not recommended for use in any application.

In general, rock durability testing is performed using standard test procedures, such as those developed by the American Society for Testing and Materials (ASTM). The ASTM publishes and updates an Annual Book of ASTM Standards (ASTM, 1995), and rock durability testing is usually performed using these standardized test methods.

The licensee has identified several acceptable potential rock sources in the proximity of the Atlas Mill. Petrographic analyses using ASTM C 295 were performed by the licensee on samples from a sedimentary source and on samples of alluvial rock. Rock samples were also tested for Bulk Specific Gravity and Absorption (ASTM C 127), Sodium Sulfate Soundness (ASTM C 88), Los Angeles Abrasion (ASTM C 131 or C 535) and Tensile Strength. The results of these tests were then evaluated using procedures recommended in the STP on Erosion Protection (NRC, 1990) and the rocks were found to be acceptable. Atlas reserves the right to either use the tested rock or an alternate source. Regardless of the rock source used, the licensee has committed to meet the durability and oversizing recommendations of the STP on Erosion Protection.

Based on a review of the rock durability analysis provided by Atlas, and considering the commitment to comply with the STP on Erosion Protection (NRC, 1990), it was concluded that acceptable rock will be used for erosion protection.

4.5.4 Testing and Inspection of Erosion Protection

The staff reviewed and evaluated the testing, inspection, and quality control procedures proposed by the licensee for the erosion protection materials and design features. The review included evaluations of programs for durability testing, gradation testing, rock placement, and verification of rock layer thicknesses.

4.5.4.1 Durability Testing

The licensee's proposed rock durability testing will include the following tests, shown with their ASTM designation:

1. Bulk Specific Gravity - ASTM C 127
2. Absorption - ASTM C 127
3. Sodium Sulfate Soundness - ASTM C 88
4. L.A. Abrasion at 100 cycles - ASTM C 131 or ASTM C 535

Durability test results will be used by the licensee to determine a rock durability rating in accordance with Table D-1 of the STP on Erosion Protection (NRC, 1990). The licensee proposes that the following criteria will be used to determine acceptable uses of rock, based on its durability rating:

1. Rock having a durability rating of greater than or equal to 80 may be used as riprap or filter material.

2. Rock having a durability rating of less than 80 and greater than or equal to 65 may be placed in surface water control ditches, and used as riprap or filter material only after being oversized in accordance with the STP.

3. Rock having a durability rating of less than 80 and greater than or equal to 50 may be used on the top or side slopes, only after being oversized in accordance with the STP.

4. Rock having a durability rating of less than 65 may not be used for riprap or filter material in a drainage channel. Rock having a durability rating of less than 50 may not be used for any application.

5. In addition to oversizing the rock according to the durability ratings, an additional oversizing factor of 20 percent will be added if rounded alluvial rock is used.

The licensee proposes that a minimum of one initial test series will be performed prior to using rock for riprap or filter material. Additional test series will be performed when approximately one-third and two-thirds of the total volume of each type of riprap or filter material have been delivered. When the total volume of any type of riprap or filter material exceeds 30,000 cubic yards, the licensee will conduct an additional test series for each additional 10,000 cubic yards delivered. The licensee also committed to performing additional tests when the rock characteristics (i.e., color or texture) in the rock borrow source vary significantly from the rock that was previously tested.

Based on a review of the proposed procedures, the staff concludes that the durability testing program will ensure that rock of acceptable quality is provided. The testing program is equivalent to several which were approved by the staff and have been implemented at other reclaimed sites during construction.

4.5.4.2 Gradation Testing

The licensee proposes that riprap, rock mulch, and the filter material gradations will be verified during reclamation using the following procedures:

1. Filter gradations will be tested using ASTM C 136, Standard Method for Sieve Analysis of Fine and Coarse Aggregates, or ASTM D 422, Standard Test Method for Particle-Size Analysis of Soils, as appropriate.

2. For riprap having a maximum nominal diameter (D_{100}) of less than or equal to 6 inches, ASTM C 136, Standard Method for Sieve Analysis of Fine and Coarse Aggregates, will be used to verify that gradations comply with the specifications.

3. Gradation testing will be performed at the same frequency as rock durability testing.

Based on a review of the proposed procedures, the staff concludes that the gradation testing program will ensure that rock layers with acceptable gradations are provided. The testing program is equivalent to several which were approved by the staff and have been implemented at other reclaimed sites during construction.

4.5.4.3 Riprap Placement

The licensee proposes a placement program where: (1) riprap will be placed to the depths and grades shown on the drawings; (2) riprap will be placed in a manner to ensure that the larger rock fragments are uniformly distributed and the smaller rock fragments serve to fill the void spaces between the larger rock fragments, so that a densely packed, uniform layer of riprap of the specified thickness will result; (3) hand placing will be used, as necessary, to ensure proper results; and (4) material that does not meet these specifications will be either reworked or removed and replaced as necessary.

Based on a review of the licensee's proposal, the staff concludes that the procedures will ensure acceptable placement. The placement procedures are equivalent to several which were approved by the staff and have been implemented at other reclaimed sites during construction.

4.5.4.4 Rock Layer Thickness Testing

The licensee proposes that the thickness of the rock layers will be verified by establishing a 200-foot by 200-foot grid over the tailings impoundment and using specific procedures for measuring and recording depths. Visual examinations will also be conducted to verify the uniformity of depths.

Based on a review of the information provided, the staff concludes that the proposed testing program is acceptable. Combined with the rock placement procedures discussed in Section 4.5.4.3, above, the program conforms to other previously-approved programs that have been implemented at other Title I and Title II sites.

4.5.5 Wind erosion

The tailings impoundment is located in an area that provides some wind protection due to the local topography. Cliffs on the western side of the impoundment rise abruptly for 1000 feet. To the north and east of the site are 500 to 600 ft high barren sandstone formations. The staff considers that

the site will be adequately protected from wind erosion by placement of engineered riprap layers that protect the tailings from surface water erosion. Studies performed for the NRC (Voorhees et al., 1983) have shown that an engineered riprap layer designed to protect against water erosion will be capable of providing adequate protection against wind erosion.

Wind erosion and deposition of wind-blown material could occur and these deposits could accumulate in the various drainage channels. To document that clogging of the channels, particularly the smaller collection ditches on the top slope, the licensee provided analyses of sedimentation and channel flushing. These analyses indicate that the channels will produce sufficient velocities to flush out a considerable amount of material, even during small flood flows. The staff reviewed these computations and concludes that reasonable assumptions and methods were used. Therefore, the staff concludes that the design is acceptable.

4.6 Upstream Dam Failures

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

4.7 Conclusions

Based on review of the information submitted by the licensee and on independent calculations, the NRC staff concludes that the licensee has identified the appropriate floods for the design of erosion protection features at the site. The staff further concludes that water surface profiles and channel velocities were appropriately derived and are acceptable as a basis for the design of erosion protection features. Based on the most recent licensee information, the erosion protection design is adequate to provide reasonable assurance of protection for 1000 years, as required in Criterion 6 of 10 CFR Part 40, Appendix A.

5.0 WATER RESOURCE PROTECTION

5.1 Introduction

The initial monitoring of the water resources at the site, for which there are reliable records, began in 1976 after approximately 20 years of mill operation. This monitoring program was designed to collect surface water samples from the Colorado River and groundwater samples from the alluvial aquifer situated beneath tailings impoundment. These data were used to support the license renewal, which was initiated by an August 31, 1983 licensee application.

New groundwater regulations for uranium mills were codified in 10 CFR 40, Appendix A, shortly after the license renewal. These regulations required detection monitoring, compliance monitoring, and corrective action programs for tailings impoundments at operating mills. Definitions of hazardous constituents in groundwater and associated limits were also established in the regulation. The groundwater protection provisions are contained within Criteria 5, 7, and 13 of 10 CFR 40, Appendix A.

At the time regulations became effective, little or no data on the constituents types and concentrations had been measured in tailings impoundments. Consequently, the NRC initiated a sampling program to collect and analyze tailings solutions from all active uranium milling facilities under NRC license. Analyses were performed on both the dissolved and total constituent load of each sample. Laboratory analyses for this program were conducted by Oak Ridge National Laboratory.

Laboratory results were obtained for the 375 hazardous constituents listed in 40 CFR Part 261, Appendix VIII. The analyses included a gas chromatograph scan for volatile and semi-volatile organics, with specific compound identification of detected peaks; total and dissolved metals; total and dissolved radionuclides; total organic carbon; cyanide; sulfides; various nitrogen containing species; as well as selected anions and cations. The sampling program encompassed the constituents listed in Criterion 13 of 10 CFR Part 40, Appendix A.

Samples were collected from the Atlas tailings impoundment during July, 1987. Analytical results indicated the occurrence of hazardous constituents in the Atlas mill tailings impoundment. As a result, the licensee was required to implement a detection monitoring program to determine if groundwater had been impacted by the impoundment. The monitoring points associated with this program indicated that some of the hazardous constituents had leached from the tailings and moved into the aquifer adjacent to the tailings impoundment. Compliance limits were then determined for released hazardous constituents and a corrective action program was implemented.

The NRC recognizes that remediating contaminated groundwater may require a substantially longer time than that involved in surface reclamation of a tailings impoundment. Consequently, surface reclamation and groundwater reclamation are considered separately by the NRC for demonstrating compliance with the license and appropriate regulations. The information and conclusions

described in this chapter address compliance with the surface reclamation plan. Groundwater clean-up compliance will be addressed by the licensee in future revisions of the Corrective Action Plan (CAP), which is outside the scope of this review. Regardless of the timing, compliance with the groundwater standards must be demonstrated before the license can be terminated. The necessity of cleaning up the contaminated groundwater exists regardless of the surface reclamation plan implemented. Furthermore, the groundwater cleanup strategies are dependent on whether the tailings are stabilized in place or are moved. Therefore, a decision on the licensee's proposed surface reclamation plan is needed before the CAP can be revisited.

5.2 Hydrogeologic Characterization

The hydrogeology of the site has been investigated by the licensee over several years through drilling, well installation, and groundwater sampling and analysis programs for the purposes of expanding the tailings impoundment and complying with regulatory requirements during mill operations. Studies and site investigations had been conducted by Dames & Moore (1975, 1982); EnecoTech (1988); Western Technologies, Inc. (1989); Canonie Environmental Services Corp. (1994); and Harding Lawson Associates (1996). Descriptions of the site hydrogeologic characterization in the following sections are based on the data and information presented in these reports, along with other information contained in the NRC docket file. Specific conclusions made by staff are noted as such.

5.2.1 Hydrogeologic Setting

The Atlas site is adjacent to an outside meander of the Colorado River, located at the northwestern end of Moab Valley. The town of Moab, Utah is located approximately 5 km (3 miles) southeast of the site. The northern end of the valley is flanked to the east and west by high cliffs of the Wingate Sandstone; and a gradually sloping upland area to the north, which contains the ephemeral drainage of Moab Wash. Arches National Park is situated in the upland areas east and northeast of the site. Courthouse Wash drains much of the area of Arches and flows into the Colorado River approximately 1200 m (3900 feet) east of the tailings pile. The upland areas west of the site comprise the Poison Spider Mesa. Figure 1-1 depicts the topographic features associated with the Atlas site.

The mill and tailings impoundment are situated on the relatively level bottom lands along the river. Portions of these bottom lands are within the historical flood plain of the Colorado River. Moab Wash flows through the Atlas property, east of the tailings impoundment. The channel of Moab Wash was rerouted east of the mill during operations at the site to mitigate flooding potential during peak flows.

The area surrounding the Atlas site and Spanish Valley constitutes a complex geological setting. The Spanish Valley outwardly resembles a trough; however, the valley morphology largely resulted from the non-tectonic movement of salt and other evaporites, dissolution of soluble salts and collapse of overlying rock (Blanchard, 1990). Moab and Spanish Valley contain silt, sand, and gravel deposited from streams and rivers, ranging in thickness from about 30 to 122m (100 to 400 feet). These and other geological episodes created the

present geological setting that influences the occurrence, movement, and characteristics of groundwater in the area. Chapter 2, Geologic Stability, provides additional descriptions of the geologic episodes in this area.

5.2.2 Identification of Hydrogeologic Units

Three general hydrogeologic units have been identified for the purpose of describing the groundwater conditions at and surrounding the Atlas site. It is important to note that hydrogeologic units may consist of several distinctive geological, stratigraphical, or lithological rock units, but may be categorized as a single hydrogeologic unit by virtue of common hydraulic or chemical properties that influence groundwater occurrence and characteristics. The three hydrogeological units designated for this evaluation are: (1) Unconsolidated Alluvium, associated largely with the valley floor and river (2) Bedrock Units, situated beneath the alluvium, and (3) Mesa and Upland Units, located east, west, and northwest of the site.

Unconsolidated Alluvium

The shallowest hydrogeologic unit beneath the Atlas site is unconsolidated alluvium of Quaternary age. The alluvium is exposed in the flood plane of the Colorado River, and is described as being a mixture of alluvial fan deposits from the Moab Wash and Courthouse Wash, colluvial deposits from the cliffs located west of the site, and fluvial deposits from the Colorado River. The shallow portions of the alluvium adjacent to the Colorado River, consist of interbedded and intermixed poorly-sorted silt and sand, with some gravel and clay. The deeper alluvium consists of well-sorted, interbedded sand and gravel.

The alluvial depth appears to vary considerably across the site and has been verified by drilling information at several locations and by seismic reflection surveys conducted on site. Bedrock has been encountered at depths ranging from about 8.5 m (28 ft) on the north side of the tailings pile (boring B-4), to about 36.6 m (120 ft) near the northeastern end of the tailings (boring TH-28), and to about 18.3 m (60 ft) near the upgradient well at the northeastern end of the Atlas property (well AMM-1). One drilling location near the eastern corner of the tailings pile (ATP-1) reached a depth of 124 m (406 ft) without encountering bedrock. Bedrock was encountered at a depth of about 30 m (97 ft) in a boring (ATP-2) situated approximately 245 m (800 ft) southwest of ATP-1. Additional descriptions of the unconsolidated alluvium at the site are presented in section 2.3.2.2.

The alluvium in other portions of Moab-Spanish Valley lying southeast of the site is also described as consisting of unconsolidated sediments of diverse origin. The alluvial thickness in the majority of the valley is described as being slightly more than 110 m (360 ft), where penetrated by wells, and rests on an irregular bedrock floor with probable faulting concealed by the alluvium. The average thickness of the saturated alluvium in the valley is estimated at about 21 m (70 ft; Sumsion, 1971).

The alluvium contains the shallowest groundwater at the site and comprises the uppermost aquifer as defined in 10 CFR 40, Appendix A. Alluvial groundwater at the site is generally encountered between about 2.4 and 4.6 m (8 and 15 ft)

of depth.

Bedrock Units

Several stratigraphic units are believed to comprise the bedrock system beneath the alluvium at the site. Much of the information on the bedrock is derived from limited drilling information and the outcrop exposures along the sides of the valley. Displacement of rock units by salt movement, and potential faulting have added complexity to the bedrock configuration beneath the site. Based on best available evidence, the bedrock likely consists of units of the Chinle Formation and the Moenkopi Formation of Triassic age, and the Cutler Group of Permian age west of the Moab fault. Portions of the Glen Canyon Group may occur beneath the alluvium, under the tailings pile. A discussion of these lithologic units is provided in Section 2.3.2.

Mesas and Upland Units

The cliffs to the east of the site and the mesa areas to the west are largely composed of the Wingate Sandstone and Kayenta Formation of the Triassic/Jurassic Glen Canyon Group. The mesa area east of the site, within Arches National Park, also contains large areas of the Triassic Navajo Sandstone, which is also within the Glen Canyon Group, and the Jurassic Entrada Sandstone. Descriptions of these units are derived from published technical reports from the Utah Department of Natural Resources (Blanchard, 1990; Doelling et al., 1995, and Sumsion, 1971).

The Wingate Sandstone is described as a massive, fine-grained, thickly cross-bedded eolian sandstone with a thickness ranging from 91 to 122 m (300 to 400 ft). The Kayenta Formation is described as irregularly interbedded fluvial fine-to coarse-grained sandstone, siltstone an shale. The thickness of the Kayenta Formation varies from about 73 m (240 ft) in western Grand County to nearly zero in the eastern part of the county. The Navajo Sandstone is described as a massive, fine-grained, thickly cross-bedded, eolian sandstone with a thickness of about 122 m (400 ft) in western Grand County. The Entrada Sandstone has been classified as three distinctive members in this area, the Dewey Bridge Member, the Slick Rock Member, and the Moab Sandstone Member. The Entrada Sandstone achieves thickness of about 168 m (550 ft) in the western portion of the county. Descriptions of the lithologic units in the mesas and uplands are provided in Section 2.3.2.1.

5.2.3 Hydraulic and Transport Properties

Unconsolidated Alluvium

The hydraulic conductivity of the shallow alluvium at the site has been investigated by the licensee by performing laboratory and field permeability tests in various boreholes at depths above 21.3 m (70 ft) below land surface (bls). Slug tests in three piezometers in the Moab Wash alluvium north of the alluvium have also been conducted. Table 5-1 provides a tabulation of these hydraulic conductivity measurements, as reported by Atlas.

The available hydraulic data shown in Table 5-1 include 20 independent measurements from ten site locations for a depth ranging from 2.4 to 21.3 m

(8 to 70 ft). An evaluation by staff shows that the measurements range from 1.26×10^{-6} to 7.73×10^{-3} cm/sec (0.0036 to 21.9 ft/day), with a mean of 8.64×10^{-4} cm/sec (2.4 ft/day) and a median of 2.47×10^{-4} cm/sec (0.7 ft/day). No information on the alluvial hydraulic properties below a depth of 21.3 m (70 ft) is available, other than grain size descriptions from drilling logs.

Table 5-1 Summary of Available Hydraulic Conductivity Data

SUMMARY OF AVAILABLE HYDRAULIC CONDUCTIVITY DATA
FOR THE ALLUVIAL AQUIFER
ATLAS MILL SITE

Borehole/ well	Depth in m bls (ft)	Description of Material	Type of Testing*	Hydraulic Conductivity in cm/sec
8	1.7 (5.5)	Fine sand w/ silt	L	1.26×10^{-5}
15	2.4 (8)	Fine sand w/ silt	F	2.47×10^{-4}
15	2.6 (8.5)	Fine sand w/ silt	L	3.58×10^{-4}
8	4 (13)	Fine to coarse sand and gravel	F	8.21×10^{-4}
15	4 (13)	Fine to coarse sand w/ silt	F	4.16×10^{-4}
15	4.1 (13.5)	Fine to coarse sand w/ silt	L	1.06×10^{-6}
8	5.5 (18)	Fine to coarse sand and gravel	F	1.35×10^{-3}
15	5.5 (18)	Fine to coarse sand and gravel	F	2.13×10^{-4}
8	5.6 (18.5)	Fine to coarse sand and gravel	L	9.57×10^{-5}
15	5.6 (18.5)	Fine to coarse sand w/ silt	L	2.22×10^{-4}
8	8.5 (28)	Fine to coarse sand and gravel	F	7.73×10^{-3}
15	12 (39.5)	Fine to coarse sand w/ silt	L	1.74×10^{-4}
A-3	13.1 (43)	Fine to coarse sand w/ gravel	L	8.50×10^{-5}
13	15.1 (49.5)	Fine sand w/ silt	L	4.73×10^{-4}
TH-21	7.3 to 18.3 (24 to 60)	Sand	S	2.06×10^{-3}**

SUMMARY OF AVAILABLE HYDRAULIC CONDUCTIVITY DATA FOR THE ALLUVIAL AQUIFER ATLAS MILL SITE

Borehole/ well	Depth in m bls (ft)	Description of Material	Type of Testing*	Hydraulic Conductivity in cm/sec
TH-24	11.6 to 18.3 (38 to 60)	Sand	S	5.61×10^{-4}**
TH-26	7 to 18.3 (23 to 60)	Sand	S	1.24×10^{-4}**
A-1	18.4 (60.5)	Medium Sand	L	1.26×10^{-6}
A-6	18.9 (62)	Fine to coarse sand w/ gravel	L	1.93×10^{-3}
11	21.2 (69.5)	Fine sand w/ silt	L	3.00×10^{-4}

* L = Laboratory measurements of collected soil samples
F = Field testing of boreholes
S = Slug testing of piezometers
** Represents the average of repeated tests in same piezometer

Sumsion (1971) reported hydraulic conductivities of domestic wells in the Spanish Valley alluvium ranging from about 1.02×10^{-2} to 4.66×10^{-2} cm/sec (29 to 132 ft/day), with an average of about 2.82×10^{-2} cm/sec (80 ft/day). It is assumed that the hydraulic conductivity values reported by Sumsion (1971) are for wells completed over substantially larger aquifer thickness and likely in deeper horizons than the Atlas monitoring wells.

Bedrock Units

No information is available on the hydraulic properties of the bedrock units beneath the alluvium at the site. Blanchard (1990) describes the groundwater conditions in the Paradox Member in portions of Grand County, which may correspond to some of the bedrock units beneath the alluvium. Groundwater in this units is referred to as the lower groundwater system. Although no hydraulic information is available for this lower groundwater system, uranium and petroleum exploratory holes have reportedly been drilled to the top of the Paradox Member and encountered groundwater with total dissolved solids (TDS) concentrations ranging from 160,000 to 300,000 milligrams per liter (mg/L) (Blanchard, 1990). Other portions of the bedrock beneath the alluvium at the site may include lithologies of the Glen Canyon Group. The hydraulic relationship between the bedrock units at the site to the brine in the lower alluvium and the adjacent Glen Canyon aquifer located north and east of the site have not been determined.

Mesas and Upland Units

No specific site information was developed by the licensee for the hydraulic properties of rock units in the adjacent mesas and uplands. Staff recognizes

that these areas are outside the site limits, and the licensee is not required to characterize adjoining properties. However, an evaluation of available published information is warranted to determine if these areas have the potential to influence groundwater conditions at the Atlas site.

Blanchard (1990) and Sumsion (1971) describe the Entrada Sandstone, the Wingate Sandstone, and the Navajo Sandstone as the principal aquifers in the mesas and upland areas. In the area of Mill Creek and Spanish Valley, east of Moab, Blanchard (1990) designates the Wingate Sandstone, Kayenta Formation, and Navajo Sandstone as the Glen Canyon aquifer, because the Kayenta Formation is largely sandstone in this area and the three formations are jointed and fractured, providing hydraulic connection.

The rock strata of the Glen Canyon aquifer generally dips from east to west, making the eastern side of Spanish Valley the discharge point of the aquifer. An aquifer test conducted in the Glen Canyon aquifer (City of Moab wellfield) indicated the presence of impermeable boundaries within the aquifer, with hydraulic properties varying considerably over a short distance. No specific estimates of total aquifer hydraulic properties could be determined from the test; however, specific capacity values for 14 wells completed in the Glen Canyon aquifer ranged from 250 to 167,135 m^2/day (0.25 to 167 gallons per minute-per foot [gpm/ft]) of drawdown. The largest specific capacity value (167,135 m^2/day) was measured in a well where the Glen Canyon aquifer is overlain by about 11 m (36 ft) of alluvial material, which may indicate significant hydraulic connection between the alluvium and the Glen Canyon aquifer.

The Wingate Sandstone, the Navajo Sandstone, and the Entrada Sandstone are separate aquifers over other portions of the area. Sumsion (1971) reports that the intrinsic permeability of the Wingate aquifer is not great because of the fine-grained nature of the sand. The Wingate sandstone generally outcrops in canyon walls and floors, where discharge can occur as springs. The Wingate is overlain by the less permeable Kayenta Formation, which restricts recharge. Where highly fractured, the Wingate yields moderate quantities of water to wells and springs. One well completed in Wingate aquifer is used for water supply in Arches National Park (Blanchard, 1990).

The Navajo aquifer is described by Sumsion (1971) as being of similar grain-size and intrinsic permeability as the Wingate aquifer. The Navajo Sandstone outcrops extensively throughout the Arches National Park. Two water supply wells in the park are completed in the Navajo aquifer (Blanchard, 1990).

The Entrada Sandstone also outcrops in Arches National Park, and provides groundwater to several springs. One of the principal areas of spring discharge from the Entrada aquifer is in Courthouse Wash. Hydraulic conductivity ranging between 0.1 ft/day to more than 1.1 ft/day have been estimated for portions of the Entrada aquifer (Blanchard, 1990).

5.2.4 Groundwater Flow

Unconsolidated Alluvium

Groundwater flow within the alluvial aquifer at the site has been evaluated by

the licensee through the installation of piezometers, monitoring wells, and water level measurements collected over various time periods. Information and data for the site groundwater conditions are summarized in Canonie (1994). Staff has reviewed these data and developed the following conclusions.

Generally, the shallow alluvial groundwater flows from the northwest to the southeast, toward the Colorado River, mimicking the surface topography. The exception to this generality occurs near the tailings pile. The measured water level within the tailings pile is approximately 12 to 18 m (40 to 60 ft) above the alluvial groundwater level, which greatly influences the direction and gradient of flow near the tailings pile. The horizontal hydraulic gradient near the former mill area is estimated to average 0.0039. The estimated gradient near the tailings pile ranges from 0.02 east of the pile to 0.0071 southeast of the pile.

Groundwater flow directions and gradients are likely variable throughout the year, because of Colorado River stage influences. Hydrographs of shallow and deep monitoring wells in the alluvium show a distinct hydraulic connection between the river stage and groundwater levels. During much of the year, the well hydrographs show that groundwater elevations are above the river stage, demonstrating that the river is gaining flow from groundwater influence. However, during periods of spring run-off, the river stage exceeds the groundwater elevation in the alluvial wells. Consequently, the river contributes flow to the alluvial groundwater during high stage episodes. The hydrograph and river stage information provided by the licensee is not adequate for calculating the hydraulic diffusivity for the alluvium.

Based on the available information, staff concludes that the licensee's interpretation of groundwater flow direction and gradient is acceptable. The licensee's interpretation considers the inferred effect of low hydraulic conductivity from the upland area southwest of the tailings pile. Information from Blanchard (1990) and Western Technologies (1989) documents that the rock units outcropping at the base of the uplands near the tailings pile are the Hermosa Formation, the Moenkopi Formation and the Chinle Formation. These units are characterized by extensive shale and clay beds, which are not conducive to transmitting significant quantities of water.

The licensee also excluded water-level data from well ATP-1-S from the interpretation of shallow alluvial flow direction. Well ATP-1-S is screened at the depth interval of the fresh-water/brine interface identified at other locations on the site and, presumably would not provide representative data for the shallower portions of the alluvial aquifer. Therefore, exclusion of this well is acceptable.

The licensee's interpretation of flow direction indicates a potential impact to groundwater quality at adjacent property south of the site. Section 5.2.5 provides a detailed discussion of the contamination extent and distribution associated with seepage from the tailings pile.

Groundwater within the deeper alluvium exhibits a TDS concentration in excess of 100,000 mg/L below a depth of about 24 m (80 ft). The occurrence of the deeper alluvial brine has been confirmed by four deeper monitoring wells situated at two locations on site. No information is available on groundwater

flow directions or gradients within the deeper brine. The brine is characterized as predominately sodium chloride in nature and could be the result of groundwater contacting the evaporites of the Paradox Formation beneath the alluvium (Dames & Moore, 1982), or the result of deeper brine from Blanchard's (1990) lower groundwater system locally migrating upward along an existing fault plane.

Groundwater within the Spanish Valley alluvium is described by Sumsion (1971) as generally flowing down-valley from southeast to north west, toward the Colorado River. Sumsion (1971) also states that although Spanish Valley is underlain by evaporites of the Paradox Member, no saline water or brine has been observed in the alluvium of Spanish Valley. A driller's log from one well indicates a thick, black shale separating the alluvium from the deeper evaporites.

Bedrock Units

No information is available on the groundwater flow of the bedrock units beneath the alluvium at the site; however, given the occurrence of the higher specific-gravity brine within the lower portions of the alluvial aquifer at the site, staff considers that any groundwater flow within the bedrock units are likely hydraulically separate from the groundwater flow in the shallower alluvium. The partitioning of flow between relatively fresh water and salt water is well documented in groundwater literature. Davis and DeWiest (1966), Freeze and Cherry (1979) and other textbooks describe the mechanism of flow separation due to density differences.

Blanchard (1990) identifies some locations within Grand County where the lower groundwater system may be influencing shallower groundwater through upward migration through poorly abandoned exploratory boreholes. Blanchard (1990) further indicates that potentiometric surface from the lower groundwater system may be as much as 61 m (200 ft) in some areas. Additionally, groundwater in the deeper bedrock units is shown (Blanchard, 1990) to flow southwesterly throughout the southern and southwestern portions of Grand County.

Mesas and Upland Units

Blanchard (1990) describes groundwater movement in the Glen Canyon aquifer as generally westward and southwestward toward Spanish Valley, with the principal area of discharge occurring in Moab-Spanish Valley, near the City of Moab. Groundwater movement in the Navajo Sandstone and Wingate Sandstone situated north and west of Spanish Valley is shown by Blanchard (1990, Figure 16) to flow southeasterly. Regionally, groundwater in these aquifers appears discharge in the canyon cut by the Colorado River.

5.2.5 Geochemical Conditions and Contamination Extent

Background Conditions

Pre-operational groundwater quality data are not available at the Atlas site, because site operations began long before many environmental monitoring requirements were initiated. Consequently, groundwater quality in the

uppermost aquifer, which represent pre-milling conditions, has been characterized by sampling wells hydraulically upgradient of the facility.

Originally, background conditions were established in monitoring well ATP-3, which is completed within the Moab Wash alluvium, up slope of the tailings pile and mill area. Water quality measurements from the well showed TDS concentrations of about 1300 to 1400 mg/L, but ranging as high as about 7000 mg/L. However, water quality in this well did not appear representative of site conditions within the alluvium near the river, where the tailings pile is located. Additionally, this well periodically remained dry during a portion of the year. Dames & Moore (1982) concluded that water from well ATP-3 appeared unaffected by tailings seepage despite its proximity to the tailings. A new background well (well AMM-1) was established for the site in 1988 as part of the licensee demonstrating compliance with the new detection monitoring provisions the 10 CFR 40, Appendix A.

Well AMM-1 was established as the NRC-approved background well for the facility. The well is situated approximately at the far northeastern corner of the property, about 244 m (800 ft) northeast of the former mill area. Groundwater samples have been collected from AMM-1 since 1988 and show concentrations of selenium, combined radium-226 and -228 above the NRC maximum concentration limits (MCLs) and elevated concentrations of uranium. TDS concentrations in this well range from about 6500 to 7500 mg/L. Information submitted by Atlas (Harding Lawson Associates, 1996) depicts the cation and anion signatures of surface water and groundwater in the vicinity of the tailings pile. The information shows the TDS and major ion concentrations of various sampling locations at the Atlas site, the Colorado River, and the Matheson Preserve southeast of the site. The groundwater at AMM-1 is generally a sodium/chloride type water, while the tailings fluid is a sodium-magnesium/sulfate type water. Sulfate is the dominant anion of the tailings fluid and can be seen to influence the water quality in well AMM-2 southeast of the pile. Conversely, chloride is the dominant anion in the groundwater at AMM-1. This information strongly indicates that AMM-1 is likely unaffected by tailings seepage.

However, a review of site maps and historical aerial photographs of the site show a former ore storage pad situated about 61 m (200 ft) west of the background monitoring well location. Staff recognizes that placement of an upgradient, background monitoring well had previously presented technical challenges to the licensee, due to size of the milling area and the lack of sufficient groundwater in the previous upgradient well completed in the Moab Wash alluvium. Although the location for this well had previously been approved by the NRC, the licensee was requested to provide data showing that monitoring well AMM-1 is not influenced by contaminants from the former ore storage pad.

Atlas responded by providing a tabulation and graph of water quality measurements in well AMM-1 for selenium, radium-226, radium-228, and uranium for the period from March 1988 to November 1993. The licensee indicated that concentrations of these parameters, over the period of record, is generally stable - neither increasing or decreasing - which is an indication that the AMM-1 is unaffected by the ore storage pad. The licensee further stated that concentrations for these parameters in other wells were increasing until about

1984, when the mill was shut down, and have since shown a declining trend. The licensee also stated that the groundwater flow direction in the vicinity of the pad is southeasterly toward the Colorado River, and not in the direction of AMM-1. The licensee concludes that given the flow direction and stable constituent concentrations in AMM-1 over time confirm the appropriateness of AMM-1 as a background well.

The staff reviewed the information provided by the licensee and does not agree that the provided information shows that well AMM-1 is not influenced by potential contaminants form the former ore storage pad. The licensee's explanation failed to consider two important influences. The characteristics of the tailings as a contaminant source are dramatically different than the characteristics of the ore as a potential contaminant source. The contaminant mobilities and concentrations within the tailings are greatly enhanced by the grinding and chemical processing of the ore. The milling and extraction process is designed to mobilize all metallic-ionic species, including uranium, and allow selective concentration of uranium. Once the tailings are placed in the impoundment, most of the remaining metal species appear to remain mobilized, as evidenced by contaminant concentrations in wells near the tailings.

While the tailings provides a ready supply of mobilized constituents, the ore would likely release constituents at a slower and more steady rate, influencing trace constituent concentrations but not overall major ion chemistries. Contaminants from the ore would be expected to enter the underlying soil and groundwater at a slower rate and less concentrated than those of the tailings pile. The licensee's conclusion that AMM-1 is unaffected by the ore pad, because the groundwater response near the ore pad is not like the response at the tailings pile is not valid, given the difference in the characteristics of contaminant sources.

Additionally, the licensee's conclusion concerning the groundwater flow direction fails to consider that there are few control points associated with the interpreted flow lines near the ore pad. Figure 1 provided in the licensee's response further confirms this observation by presenting the equipotential lines in this area as dashed. Much of the potentiometric information presented in the licensee's maps are interpolated from control points near the tailings pile and AMM-1. The groundwater flow in the vicinity of AMM-1 may be significantly affected by Courthouse Wash, causing localized groundwater flow in an easterly direction rather than a southerly direct as interpreted. The licensee shows a similar influence from Moab Wash in the provided potentiometric map as Figure 1.

The staff concludes that the information and interpretations provided by the licensee do not provide reasonable assurance that well AMM-1 is not influenced by potential contamination from the ore storage pad. Additional information and measurements at locations other than AMM-1 will be needed to corroborate the appropriateness of AMM-1 as a background well.

The staff also concludes that the verification of background at the site has minimal relevance to the review of the proposed plan for onsite surface reclamation of the tailings. The background groundwater conditions do have a large bearing on groundwater compliance for license termination and revisions

to the Corrective Action Plan (CAP) for groundwater cleanup, regardless of the decision with respect to surface reclamation. The background groundwater conditions at the site must be adequately determined and evaluated as a part of a credible CAP.

Contaminant Characterization

The NRC initiated a sampling and laboratory analysis program in 1987 to evaluate hazardous constituents at uranium mills under NRC license, because little or no comprehensive information was previously available on the types of potential hazardous constituents associated with uranium mill tailings impoundments. Both dissolved and total analysis were conducted for the collected tailings solutions, along with a gas chromatograph screening for volatile and semi-volatile organic compounds. Analytical services were contracted with Oak Ridge National Laboratory, an EPA certified laboratory.

Tailings fluids from the Atlas facility were sampled in July 1987. The information developed from this sampling program was used to define the contaminant source and constituents of concern for later groundwater detection and compliance monitoring programs at the site. The results of this testing indicated that several metallic and radiological compounds designated as hazardous constituents were present in the tailings solution. Table 5-2 summarizes the results of this sampling.

Contaminant Extent

The licensee has collected and analyzed groundwater samples from the alluvial aquifer downgradient of the tailings pile on a sporadic basis from 1976 to 1977. The monitoring program has changed several times over the years, and the collected data lack consistency in the sampling points, constituents analyzed, and laboratory methods used. These monitoring program changes make a complete evaluation of the contaminant impact history at the site difficult. Detailed descriptions of the current groundwater monitoring program are provided in section 5.4.3. The surface water monitoring program has remained essentially unchanged over the period of record.

The monitoring program largely consisted of three wells completed in the alluvium between the tailings impoundment and the Colorado River. Water-quality monitoring were originally conducted on a regular basis from 1982 to 1987, in monitoring wells ATP-1-S, ATP-2, ATP-3, MW-1-R, MW-2-R, and MW-3. These wells along with an upgradient monitoring well have been used to evaluate the impacts of the tailings impoundment on the shallow alluvial groundwater and determine the extent of contamination.

Three new wells were installed in 1990 for evaluating groundwater conditions at the site. These wells: AMM-1, AMM-2, and AMM-3 were all located in the river alluvium adjacent to the Colorado River. Monitoring well AMM-1 was designated as the background well, while wells AMM-2 and AMM-3 were designated as point of compliance wells. In addition, the upper completion of well ATP-2 was retained in the new groundwater monitoring program. Figure 5-1 shows the locations of the previous and current site monitoring wells.

Results of the monitoring program indicated that constituents from the

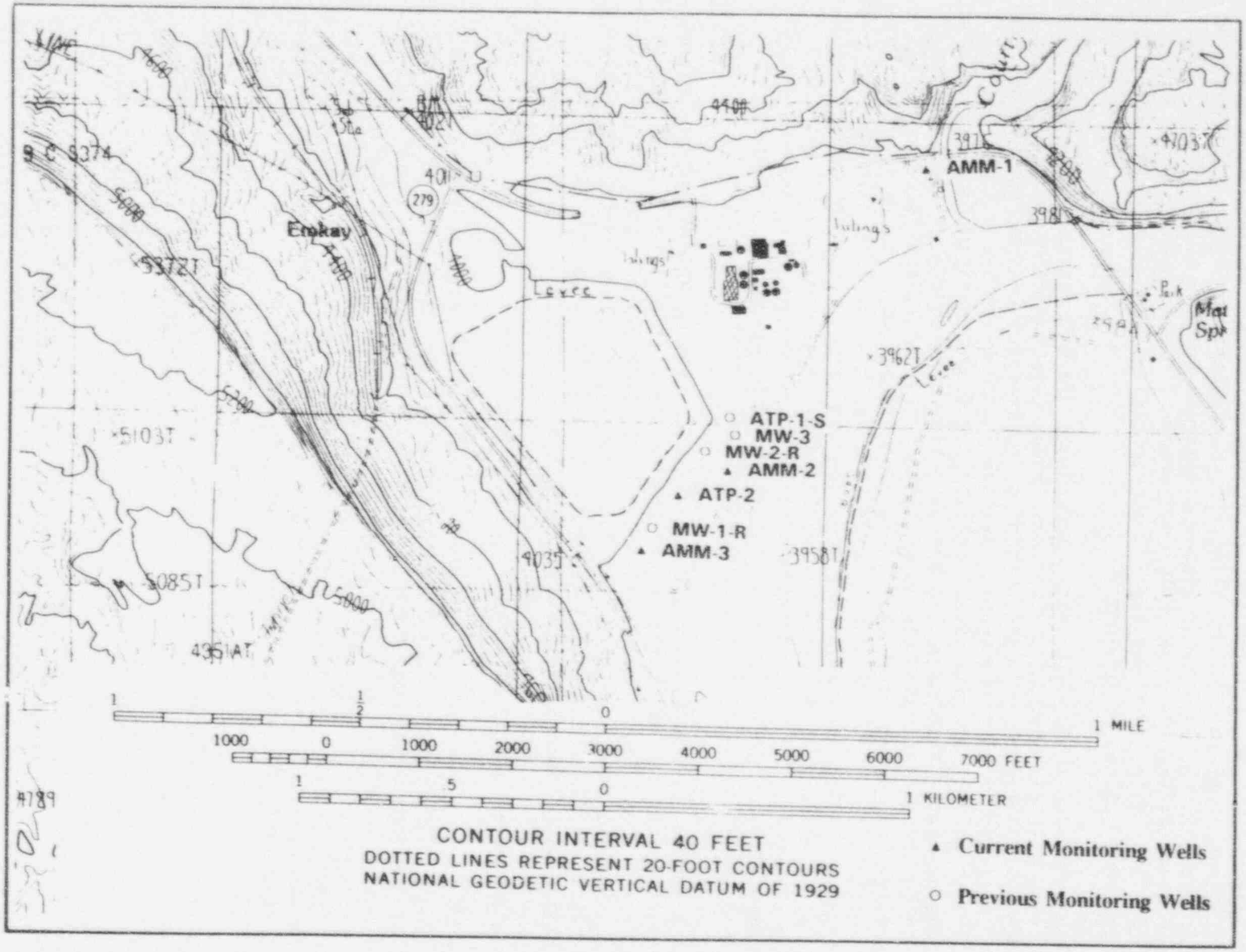

Figure 5-1: Monitoring Well Locations, Atlas Uranium Mill

impoundment had been seeping into the alluvium soils beneath the tailings pile and impacted the shallow groundwater in the alluvium. Consequently, the constituents that entered the alluvial groundwater will either be attenuated or retarded in the soil materials or discharged to the Colorado River. TDS concentrations for the previously monitored wells are shown below in Table 5-3. Table 5-4 shows the TDS concentrations from monitoring wells from the current monitoring program.

Atlas concluded that contaminated groundwater largely extends from the tailings pile eastward to the Colorado River (Western Technologies, 1989; Canonie, 1994); however, contour maps of contaminant concentrations indicate the likelihood that contaminants may have impacted the areas south and southeast of the tailings pile. Section 5.2.4 discusses the potential impact to the adjacent property due to the direction of groundwater flow and the distribution of geologic materials at the site. Additionally, contaminant concentrations measured at the site are consistent with solute transport by advective flow. Other transport mechanisms such as density gradients are not indicated by the site data. The location and measured concentrations within the alluvial monitoring wells appears to provide adequate data control to support the direction of contaminant flow provided by the licensee's documentation. Staff concludes that the lateral extent of contamination within the alluvial aquifer is not adequately determined.

Staff further concludes that the concern of contamination extent on adjacent properties has minimal relevance to the review of the proposed plan for onsite surface reclamation of the tailings. The contamination extent does have a large bearing on groundwater compliance for license termination and revisions to the Corrective Action Plan (CAP) for groundwater cleanup, regardless of the decision with respect to surface reclamation. The contamination extent, constituent concentrations, and potential impacts to adjacent properties must be adequately determined and evaluated as a part of a credible CAP.

The vertical extent of contaminated groundwater was evaluated in a series of nested wells completed to various depth intervals. From the collected data, Atlas concludes that contamination from tailings seepage is restricted to the shallow portions of the alluvial aquifer. This conclusion is based on comparisons of water quality within the aquifer at various depths and the occurrence of brine at depths below about 24 m (80 ft) bls. The staff agrees with the conclusion that the vertical extent of contamination is restricted to the relatively fresh groundwater within the upper portion of the alluvial aquifer.

Additionally, surface water samples have been collected from the Colorado River to evaluate the impact of the tailings seepage since about 1976.

The surface water samples consisted of one sampling location upstream of the mill and five sampling locations below the mill site. Surface water data at similar locations have been periodically collected to the present. Tables 5-5 and 5-6 show the summaries of average concentrations for uranium, radium-226, and thorium-230 in the Colorado River and in the groundwater associated with the various sampling episodes.

Table 5-2: Analytical Results

Analytical Results
Dissolved Constituents*
Atlas Minerals Site

Compound	Concentration**	Compound	Concentration**
Aluminum	450	Silicon	24
Antimony	<2.0	Sodium	1800
Arsenic	1.8	Strontium	3.6
Boron	<0.8	Tin	<2.0
Barium	0.25	Titanium	0.58
Beryllium	0.14	Uranium	8.9
Bromine	<500	Vanadium	53
Calcium	310	Zinc	5.9
Cadmium	0.49	Zirconium	<0.2
Cobalt	1.3	Ammonium	2400
Chromium	1.3	Bicarbonate	<5
Copper	11	Carbonate	<5
Iron	650	Chloride	410
Gallium	<3.0	Cyanide	0.006
Mercury	<0.005	Fluoride	<100
Lead	<2.0	Nitrite	<100
Lithium	3.7	Nitrate	<500
Magnesium	500	pH	2.19 SU
Manganese	28	Phosphate	<500
Molybdenum	0.52	Sulfate	30,000
Nickel	1.1	Sulfide	<5
Phosphorous	5.1	Total Dissolved Solids	23,900
Selenium	0.45	Total Suspended Solids	10
Silver	<0.5		

* Maximum concentration from two samples
** Concentrations expressed in mg/L, unless otherwise indicated

Table 5-3: Total Dissolved Solids; Previous Monitoring Program

Total Dissolved Solids (mg/L)*
Atlas Groundwater
Previous Monitoring Program

Well	Month and Year 5/82	8/83	8/84	8/85	8/86	10/87
ATP-1-S	106409	111860	92200	110000	109000	112000
ATP-2	12359	49053	58500	59300	43600	44300
ATP-3	1386	7440	1300	1420	1350	1360
MW-1-R	19966	19522	[illegible]900	23000	22500	35400
MW-2-R	24604	16788	[illegible]500	20300	23200	22500
MW-3	17482	21465	26300	31000	27600	30300

*all data from Atlas environmental monitoring reports

Table 5-4: Total Dissolved Solids; Current Monitoring Program

Total Dissolved Solids (mg/L)*
Atlas Groundwater
Current Monitoring Program

Well	Sampling Quarter and Year 2-90	4-90	2-91	4-91	2-92	4-92
AMM-1	6720	6710	6950	6980	6810	6570
AMM-2	22800	23200	22500	19400	19594	19300
AMM-3	12100	12100	13300	12300	12712	13400
ATP-2	32100	32200	17500	28200	15552	26000

Well	Sampling Quarter and Year 2-93	4-93	2-94	4-94	2-95	
AMM-1	6830	6660	6940	6450	7500	
AMM-2	17100	18600	18700	18150	19400	
AMM-3	12400	13200	16800	13730	18400	
ATP-2	20100	23100	13800	20930	17000	

*all data from Atlas environmental monitoring reports

Table 5-5: Average Concentrations; 1976 to 1977

Average Concentrations (pCi/l)* 1976 to 1977			
Samples	U-nat	Ra-226	Th-230
Colorado River upstream	20	0.72	2.8
Colorado River downstream	24	0.8	5.1
Atlas Groundwater	3200	2.4	18
*all data from Atlas environmental monitoring reports			

Table 5-6: Average Concentrations; 1979 to 1987

Average Concentrations (pCi/l)* 1979 to 1987			
Samples	U-nat	Ra-226	Th-230
Colorado River upstream	14	0.14	17
Colorado River downstream	9	0.15	5.0
Atlas Groundwater	1171	0.95	3.1
*all data from Atlas environmental monitoring reports			

Additional water quality data for TDS concentrations in the Colorado River have been collected for several years. Grab samples were taken on quarterly frequencies at both upstream and downstream stations. These sample results, for the period of 1989 to 1993 are shown in Table 5-7. These data show essentially no change between upstream and downstream TDS concentrations over the period of record.

A comparison between data collected from 1976 and 1977 to those from 1979 to 1987 indicates that the alluvial groundwater continued to receive seepage from the tailings impoundment, but the measured concentrations of uranium, radium-226, and thorium-230 in the alluvial materials had significantly decreased over that period. Concentrations of these same radionuclides in the Colorado River do not indicate any sort of trend. It should be noted that upstream concentrations of uranium and thorium are larger than those that are measured downstream from the mill. The concentration of radium is essentially the same above and below the mill site.

Table 5-7: Total Dissolved Solids; Colorado River

Total Dissolved Solids (mg/L)*
Colorado River Samples

Location	Sampling Quarter and Year				
	1-86**	3-87	2-88	3-89	1-90
Upstream	695	577	987	800	823
Downstream	734	611	841	850	850

Location	Sampling Quarter and Year				
	1-91	1-92	1-93	1-94	2-95
Upstream	880	910	756	700	750
Downstream	880	970	742	720	790

* all data from Atlas environmental monitoring reports
** Measurements reported for this sampling did not distinguish between upstream and downstream locations. Measurements are reported in the order presented in the licensee's report.

The initial findings from this sampling indicated that constituents entering the river from the site were not detectable in the water column, because of the mixing and dilution with the river water. Consequently, impacts to the downstream uses of river water was concluded to be insignificant.

Additional sampling in the Colorado River has recently been performed to support review efforts for the Environmental Impact Statement (EIS). The recent sampling efforts have focused on sediments and biota, in addition to surface-water samples. Recent sampling episodes, as described in the EIS, show a measurable influence from non-radiological constituents, such as ammonia, in a limited reach of the river. Details and discussions this recent surface water and sediment sampling are presented in the EIS.

5.2.6 Water Use

Water use in the vicinity of the site is described in a report by Western Technologies (1989). The report states that there are no existing groundwater supply wells on the property or hydraulically downgradient of the property. Atlas reported that a water well located approximately 300 meters (900 feet) east of monitoring well AMM-1, which is upgradient of the mill site, as "not fit for human use."

The Utah Division of Radiation Control (DRC), Department of Environmental Quality conducted a recent computer search of Water Rights records for northern Moab Valley, in the vicinity of the Atlas site. This search provided a listing of water rights diversions; which includes both surface water and groundwater uses. These records were provided to staff for the purpose of making an independent and updated verification of the water use inventory conducted by Atlas in 1989. Table 5-8 provides a summary of registered water

rights, provided by Utah DRC, in the vicinity of the Atlas site. The state's records show three registered water right within an approximate 0.8 km (0.5 mile) radius of the tailings pile and 14 water rights within an approximate 1.6 km (1 mile) radius of the tailings pile.

Table 5-8 lists one registered groundwater user (#168/Trapax) near the location mentioned in the Western Technologies report. Additionally, water users of Colorado River water and other surface water are identified from the state's water rights records. Most water registered water users are situated upgradient or upstream of the tailings pile; however, three water rights (#629,#1458, and #16590) are situated on the east bank of the Colorado River across from the site and one water right (#1046) is located approximately 1.1 km downstream of the site. The only other groundwater user within a 1.6 km (1 mi) radius is the National Parks Service at Arches National Park. This well is upgradient of the tailings pile.

5.3 Conceptual Design Features to Protect Water Resources

Staff considers that groundwater cleanup and compliance at the Atlas site are contingent on the disposal cell cover design and long-term performance. The Atlas reclamation plan describes the regraded tailings and engineered soil cover as the primary design components that will minimized water infiltration in the tailings pile (Canonie, 1992). The plan states that regrading the tailings and placement of a contoured soil cover will convey precipitation runoff away from the reclaimed tailings area, thus minimizing infiltration and provide groundwater protection. Atlas also states that infiltration will be reduced 2 to 3 orders of magnitude over the present uncovered condition of the pile, because a layer of Mancos Shale clay (radon barrier borrow material) will be included in the final cover design. The current design specifies 20.3 to 30.5 cm (8 to 12 in) of compacted clay for the radon barrier. Atlas states that assumed permeabilities of 1×10^{-4} to 1×10^{-5} cm/s and 1×10^{-7} cm/s were considered in the cover design (Canonie, 1992 pg. 22); however, no calculation or analysis is provided to support this statement. Furthermore, the reclamation plan does not indicate that a specified permeability was used to determine evaluate compliance with the groundwater protection standards for the site.

The licensee plans to take engineering credit for the disposal cell components for complying with the ground-water protection standards. Specifically, the licensee identified the following cover components: (1) regrading the top of the tailings to enhance runoff and reduce infiltration, (2) reducing infiltration by using native clay borrow material in constructing the radon barrier. The licensee stated that the costs have been included in the reclamation plan. Additionally, the staff notified the licensee by letter dated July 11, 1996 of the future need to revise the current CAP for the site. The notification also advises that the cover components may be subject to redesign and potential retro-fit if the CAP revisions require an additional reduction in the disposal cell infiltration flux.

Table 5-8: Water Rights Inventory

Water Rights Inventory in Vicinity of Atlas Site					
Location Twn Rng Sec	Water Right # / Owner	Water Right Description	Approx. Distance	Water Use*	Hydraulic Relation
25S 21E 27	629/Utah Div. of Wildlife Res.	Colorado River	0.64 km (0.4 mi)	I,S	cross-stream
25S 21E 27	1458/Grand County Con. Dist.	Colorado River	0.64 km (0.4 mi)	I	cross-stream
25S 21E 27	16590/Utah Div. of Wildlife Res.	Colorado River	0.64 km (0.4 mi)	I,O	cross-stream
25S 21E 27	56/McClatchy, Warren & Millie	Colorado River	0.92 km (0.57 mi)	O	upstream
25S 21E 34	1046/U.S. Bureau of Land Mgmt.	Colorado River	1.1 km (0.69 mi)	S,O	down-stream
25S 21E 27	168/Trapax	groundwater	1.2 km (0.7 mi)	D,S	up-gradient
25S 21E 26	629/Utah Div. of Wildlife Res.	Colorado River	1.2 km (0.75 mi)	I,S	upstream
25S 21E 26	1458/Grand County Con. Dist.	Colorado River	1.2 km (0.75 mi)	I	upstream
25S 21E 26	16590/Utah Div. of Wildlife Res.	Colorado River	1.2 km (0.75 mi)	I,O	upstream
25S 21E 26	1612/Utah Div. of Wildlife Res.	groundwater	1.4 km (0.85 mi)	I,O	upstream
25S 21E 26	16591/Utah Div. of Wildlife Res.	groundwater	1.4 km (0.85 mi)	I,O	upstream
25S 21E 26	1055/Canyonland Cattle Co. Ltd.	Colorado River	1.5 km (0.95 mi)	S	upstream
25S 21E 26	17961/Oliver, Delbert O.	groundwater	1.5 km (0.95 mi)	I	upstream
25S 21E 26	1089/Columbia Gas Dev. Corp.	Colorado River	1.6 km (1 mi)	O	upstream
25S 21E 26	18444/Canyonland Cattle Co. Ltd.	Colorado R Pack Creek	1.6 km (1 mi)	S	upstream
25S 21E 21	166/U.S. Nat. Parks Ser.	groundwater	1.6 km (1 mi)	D,O	up-gradient

* D= Domestic, I=Irrigation, S=Stock Watering, O=Other(not specified),

The licensee agreed, in a letter dated August 7, 1996, to thoroughly evaluate infiltration barrier alternatives as part of revising the CAP. Atlas further indicated that once on-site stabilization was found acceptable, adequate time would be available to incorporate any design changes resulting from the CAP review, without delaying the construction schedule. Atlas also committed to delaying the installation of the radon/infiltration barrier, if necessary, to assure that any potential design changes could be included in the disposal cell. Staff considers that appropriate construction control and field testing would be required to verify that the constructed cover met the design specifications.

5.4 Groundwater Protection Standards and Regulatory Requirements

5.4.1 Water Resource Protection Standards

Criterion 5 and Criterion 13 of 10 CFR 40, Appendix A encompass the basic groundwater protection standards for uranium mill tailings impoundments. Paragraph 5B(5) requires that compliance limits for hazardous constituents are set at the background concentration, the Maximum Values listed in Paragraph 5C if the background limit is below the listed value for a particular constituent, or an alternate concentration limit (ACL) based on chemical-specific and site-specific considerations.

5.4.2 Performance Assessment

A performance assessment of the disposal cell for meeting the groundwater protection standards is not required by 10 CFR 40. However, a performance evaluation for meeting proposed ACLs is an integral part of the regulatory review for approving ACLs. If the licensee plans to apply for ACLs, as part of its CAP revisions, then a performance evaluation must be included in the ACL application.

5.4.3 Groundwater Monitoring and Corrective Action

Groundwater Monitoring Program

The requirement to implement a detection monitoring program was incorporated into the Atlas license by Amendment No. 1, dated June 15, 1988. This amendment required the licensee to monitor appropriate hazardous constituents, establish compliance points and a background well, as well as determine the extent and concentration of hazardous constituents in the alluvial aquifer. The groundwater compliance program did not include an examination of deeper aquifers, since existing data indicated that a brine layer exists in the lower portion of the alluvium.

In response to Amendment No. 1, the licensee prepared a March 1989 submittal that compiled groundwater monitoring data, proposed a modified groundwater monitoring program, discussed the extent and concentrations of hazardous constituents in the aquifer, assessed risk and hazards, and evaluated alternative corrective actions. An NRC review of this submittal determined that it was responsive to regulatory requirements relative to groundwater compliance. The major consideration in this report was to determine if there were any impacts at the point of exposure, which is the Colorado River.

License condition 17 established the compliance monitoring program and the compliance limits for certain constituents detected in the groundwater at the site. Table 5-9 lists the compliance points, constituents, compliance limits, and sampling frequencies for the Atlas monitoring program. Monitoring well locations are shown in Figure 5-1.

Table 5-9: Groundwater Protection Standards

Groundwater Protection Standards Atlas Uranium Mill Tailings Pile			
Sampling Frequency and Wells	Parameter or Constituent	Compliance Limit	Compliance Standard Applied
Quarterly sampling of wells AMM-1, AMM-2, AMM-3, and ATP-2-S	chloride	None	N/A
	nitrate		
	sodium		
	sulfate		
	pH		
	TDS		
	water level		
Semi-annual sampling of wells AMM-1, AMM-2, AMM-3, and ATP-2-S	chromium	0.08 mg/L	background
	gross alpha	33 pCi/L	background
	molybdenum	0.05 mg/L	background
	nickel	0.06 mg/L	background
	radium-226 & -228	5 pCi/L	paragraph 5C
	selenium	0.01 mg/L	paragraph 5C
	vanadium	0.04 mg/L	background
	uranium	4.0 mg/L	background

Corrective Action Program

The licensee was required to develop a corrective action program for mitigating contaminated groundwater at the site, in response to the detection of hazardous constituents in excess of the compliance standards. Atlas prepared two submittals that characterized the geology, evaluated the data, and discussed alternative corrective actions. The geology characterization, as well as the collected groundwater data, confirmed that leakage from the tailings impoundment had impacted the alluvial groundwater, and that hazardous constituents eventually traveled to the Colorado River.

The initial conclusion of the water quality data review was that any impacts

to the Colorado River were insignificant, because no measurable concentration differences in the Colorado River could be detected over the period of record. Although the site information indicates that tailings seepage was discharging to the River, the contaminant dilution by relatively large volume of the Colorado River appeared to mitigate any potential health impacts.

The study also estimated a leakage rate of approximately 95 L/min (25 gpm), based on a water balance study. This leakage rate correlated well with the surface area of the tailings impoundment and the estimated hydraulic conductivity of the alluvium, based on soil materials encountered during well drilling. The estimated rate was predicted to diminish to about 30 L/min (8 gpm) over the next 20 years and then maintain that rate for an undetermined period. Additional estimates of the previous seepage rate from 1989 to 1994 have also been performed as part of the Biological Assessment in the EIS. Atlas (Harding Lawson Associates, 1996; and Canonie, 1994) refined the previous estimates using Darcian flow and water budget projections and estimated a seepage rate of about 125 L/min (33 gpm); however, this estimate did not consider contribution from precipitation. Staff formulated a seepage estimate based on TDS concentrations observed in the tailings, groundwater, and seepage entering the river near the mouth of Moab Wash. Staff estimated a seepage rate of about 189 L/min (50 gpm), including precipitation input. Forecasted seepage rates for the long-term, after the existing head in the tailings pile has reached a steady-state condition, are about 60 L/min (16 gpm) without a cover on the pile, and about 30 L/min (8 gpm) with an engineered cover of $1x10^{-7}$ cm/sec permeability. Further discussion of the seepage rate estimates and projected impacts after the proposed reclamation are presented in Appendix E of the EIS.

The licensee submitted a license amendment request which evaluated several corrective action alternatives for mitigating contaminated groundwater. The evaluated corrective actions were divided into two groups. One group of alternatives, which largely focused on altering the tailings pile included:

- moving the tailings to an alternate site,
- mechanically dewatering the tailings,
- constructing a hydraulic barrier wall into the alluvium, and
- constructing a bottom seal for the tailings.

All of these alternatives were considered unreasonably costly, when comparing the risks to benefits. Staff concurred with the licensee's conclusion that these alternatives were unreasonable when considering the risks as well as the costs and associated benefits.

The licensee also evaluated five other corrective action alternatives, which primarily focused on groundwater remediation. These alternatives included:

- pumping and treating groundwater using in situ precipitation of metals,
- pumping and treating of groundwater using biomass removal of metals,

- a gravity feed groundwater treatment system with in situ precipitation of metals,

- pressure feed of groundwater and tailings treatment with in situ precipitation of metals, and

- minimizing recharge to the tailings.

The licensee ultimately recommended the minimizing recharge alternative as the preferred alternative. An NRC assessment of all nine alternative corrective actions indicated that the later five potential corrective actions showed that cost effective alternatives existed.

The licensee proposed to minimize the tailings recharge by constructing an enhanced evaporation system on top of the tailings pile. This system would pump solution from the tailings surface pool, spray it into the atmosphere and onto dry tailings beaches, and thereby rapidly reduce the solution level in the tailings impoundment. Additionally, the licensee agreed to construct and operate a tailings dewatering system that consisted of wells completed into the saturated portion of the tailings.

NRC approved construction and operation of the enhanced evaporation system, which operated for roughly three years at an annual pumping rate of about 7600 kL (20 Mgal). This system eliminated most of the ponded surface water on the tailings by the later part of 1992, although a small pond existed until 1995. A decline in the water level within the tailings also accompanied the removal of the ponded water. Any water that intermittently is found on the tailings impoundment is from precipitation and either recharges the tailings or evaporates to the atmosphere.

The tailings dewatering system was constructed on a test scale in 1990. It consisted of a series of wells in the tailings installed at locations accessible to drilling equipment. Each well was equipped with a pump, which would route tailings solution to the surface of the impoundment for spraying to the atmosphere.

The dewatering system operated for a short period of time, when it became apparent that a combination of poor yields, corrosive solutions, and small particle sizes would be stressful on the equipment and make the feasibility of continuous pumping questionable. However, the NRC considered intermittent pumping feasible, which had been utilized in these wells since their installation. The amounts of solution that were recovered from these wells and the rate of recovery are shown in Table 5-10.

Table 5-10 shows that approximately 16,653 kL (4.4 Mgal) of solution were removed from the tailings pile. It should also be noted that the rate at which the dewatering is taking place has shown a slight decline over the period of record. Additionally, the TDS concentration of the recovered solution has continued to rise, likely in response to the reduced recharge in the tailings areas being dewatered.

Table 5-10: Operation Data: Tailings Dewatering System

Operational Data Tailings Dewatering System Atlas Tailings Pile			
Operational Year	Volume Recovered in kL (gal)	Total System Yield in L/min (gpm)	Total Dissolved Solids (mg/L)
1990	3173 (838,276)	14.5 (3.83)	24,700
1991	7442 (1,966,000)	14.2 (3.74)	25,065
1992	6038 (1,595,000)	12.5 (3.03)	30,250

5.5 Cleanup and Control of Existing Contamination

The approved CAP has eliminated the residual ponded water on the tailings pile and reduced the level of saturation within the tailings. In addition, contaminant concentrations within the alluvial aquifer have been reduced over the same time period. However, contaminant concentrations within the aquifer still remain well above the groundwater compliance limits established in the license. Currently, the licensee has not implemented any corrective action to directly reduce the contaminant levels in the uppermost aquifer. The licensee must address compliance with the groundwater standards in 10 CFR 40, Appendix A through revisions of the CAP.

NRC considers revisiting and revising the CAP as a separate licensing action, because the groundwater cleanup strategies and methodologies will be contingent on the decision for surface reclamation of the tailings. For estimating purposes, the costs and benefits of groundwater cleanup for the proposed on-site closure and the tailings relocation alternatives were factored into the overall cost/benefit analysis conducted for both alternatives. Relocating the tailings to another site for disposal does not remove the need for groundwater cleanup at the current Atlas property. Additionally, relocating the tailings would likely invoke higher groundwater cleanup costs for the relocation alternative over the on-site closure alternative, since the relocation alternative would mandate a cleanup approach to return contaminants over the entire site to levels suitable for releasing the site for unrestricted use. Discussions and evaluations of cost/benefit considerations associated with both disposal alternatives are presented in Chapter 5 of the EIS.

5.6 Conclusions

Water resource information for the Atlas Uranium Mill Tailings Reclamation Plan have been evaluated by staff to determine compliance with the appropriate regulations in 10 CFR 40, Appendix A. Data and technical information that is directly applicable to surface reclamation were examined. Other information and data pertaining to groundwater corrective action were not evaluated for compliance, since NRC determines groundwater cleanup compliance under a separate Corrective Action Plan.

It is apparent that seepage from the tailings impoundment is impacting groundwater quality in the shallow alluvial aquifer, based on the collected water quality data. The seepage is traveling as a dissolved contaminant plume which discharges to the Colorado River. The seepage rate from the tailings pile appears to have declined over the past several years. Currently the leakage rate is estimated to be about 189 L/min (50 gpm) and is further expected to decrease to 30 L/min (8 gpm).

Impacts to the property immediately south of the Atlas property have not been adequately determined by the licensee. Geological information, interpretation of groundwater flow direction, and contaminant concentration contours indicate a potential impact to the adjacent property. The staff concludes that the concern of contamination extent on adjacent properties has minimal relevance to the review of the proposed plan for onsite surface reclamation of the tailings. The contamination extent does have a large bearing on groundwater compliance for license termination and revisions to the Corrective Action Plan (CAP) for groundwater cleanup, regardless of the decision with respect to surface reclamation. The contamination extent, constituent concentrations, and potential impacts to adjacent properties must be adequately determined and evaluated as a part of a credible CAP.

NRC considers revisiting the CAP as a separate licensing action, because the groundwater cleanup strategies and methodologies will be contingent on the decision for surface reclamation of the tailings. The CAP currently being implemented by Atlas was based on the conclusion that existing groundwater contamination was not amenable to active remediation. If groundwater remediation is determined practicable, as a result of NRC's revisiting the CAP, then resulting environmental impact to the Colorado River will be less than that already identified in the EIS. Regardless of the decision on surface reclamation, contaminated groundwater exists on the site and must be cleaned up. Compliance with the groundwater standards must be demonstrated by Atlas before the license can be terminated.

Surface water monitoring for the last 20 years indicates there is no measurable increase of the contaminants in the waters of the Colorado River, due in large part to dilution. This finding was originally predicted to occur in the EIS for license renewal and has been confirmed by upstream and downstream monitoring in the Colorado River. However, monitoring of the Colorado River near the site indicates the presence of a mixing zone with higher concentrations of some contaminants. Additional evaluations of seepage impacts to sediment and biota in the river are assessed in the EIS for reclamation.

Ambient groundwater quality in the alluvial (uppermost) aquifer appears poor, given the moderately elevated TDS concentrations and elevated concentrations of selenium, combined radium-226 & -228, and uranium; however, the proximity of the upgradient background well AMM-1 to a former ore storage pad raises a question to the representativeness of this water quality information. The staff concludes that the information and interpretations provided by the licensee do not provide reasonable assurance that well AMM-1 is not influenced by potential contamination from the ore storage pad. Additional information and measurements at locations other than AMM-1 will be needed to corroborate the appropriateness of AMM-1 as a background well.

The staff also concludes that the verification of background at the site has minimal relevance to the review of the proposed plan for onsite surface reclamation of the tailings. The background groundwater conditions do have a large bearing on groundwater compliance for license termination and revisions to the Corrective Action Plan (CAP) for groundwater cleanup, regardless of the decision with respect to surface reclamation. The background groundwater conditions at the site must be adequately determined and evaluated for a credible CAP.

Sixteen registered water rights are located within a 1.6 km radius of the tailings pile. Fifteen of these water rights are allocated for the Colorado River or other surface water points. Only two water rights are designated for groundwater use. Four of the surface water users are situated either cross-stream or downstream of the tailings pile. Water samples collected in the Colorado River do not indicate that the tailings seepage is impacting the river water quality, other than in a small mixing zone. Both groundwater users are situated upgradient of the tailings pile.

The licensee indicates that construction of an engineered clay cover and contoured top slope will reduce precipitation infiltration into the tailings by 2 to 3 orders of magnitude. The licensee plans to take engineering credit for the disposal cell components for complying with the ground-water protection standards. Specifically, the licensee identified the following cover components: (1) Regrading the top of the tailings to enhance runoff and reduce infiltration, (2) Reducing infiltration by using native clay borrow material in constructing the radon barrier. The licensee stated that the costs have been included in the reclamation plan.

The licensee must revise the current Corrective Action Plan to demonstrate compliance with the groundwater cleanup standards in the license. Additional characterization of hydrogeological conditions around the tailings pile and evaluation of existing contaminant extents will also be needed to address revisions in the CAP. This will be evaluated by staff as part of the groundwater corrective action program.

6.0 RADON ATTENUATION

6.1 Introduction

This section presents the staff evaluation of the radon barrier design aspects of the Reclamation Plan and Technical Specifications for the Moab, Utah, Title II Project site. The staff review was conducted in accordance with guidance in the SRP (NRC 1993). The staff review of the radon attenuation design of the disposal cell cover is to ensure compliance with the radon flux design standard of 20 picocuries per square meter per second (pCi/m^2s) averaged over the impoundment, required by Criterion 6 (1) of Appendix A to 10 CFR Part 40. In addition, the other radiological requirements of Criterion 6 (e.g., gamma levels, cover radionuclide concentration) are considered in this review.

EPA has identified radon-222 (Rn-222) as the main health hazard from uranium mill tailings. Rn-222 is an inert gas resulting from the radioactive decay of radium-226 (Ra-226). Because Rn-222 has a short half-life (3.8 days), the amount of radon from uranium mill tailings reaching the atmosphere is reduced by restricting the gas movement long enough so that radon decays to a solid daughter which remains within the disposal cell. The staff, in its review, evaluates the estimation of the long-term (at least 200 years from now) radon emanation rate (flux) from the disposal cell cover averaged over at least a one-year period by utilizing a computer code (RAECOM or RADON). Fundamental to the use of the code is development of a radon flux model which is based on parameter values derived during characterization of the various materials that will make up the pile and/or the use of conservative estimates. Therefore, the staff's review addressed the adequacy of the parameter values (i.e., code inputs) and the overall radon flux model by evaluating the justification and assumptions made for each value to confirm that each was representative of the material or conservative, consistent with site construction specifications, and based on long-term (at least 200 years) conditions.

Also included in the NRC staff review was an evaluation of related aspects of the cover design. For example, layers of the cover (6-inch filter/bedding on side slopes and 4 to 9-inch rock erosion protection) were evaluated for their ability to protect the radon barrier layer from drying and disruption by considering the long-term effects of freeze-thaw damage and biointrusion. In addition, the review included consideration of the fact that the radon barrier layer thickness is also designed to satisfy criteria for construction, settlement, cracking, and infiltration of surface water. These aspects of cell design are discussed in Section 3 of this report. Erosion protection aspects of the cover design are discussed in Section 4.

The staff's evaluation of the information provided in the Reclamation Plan on the parameter values and the resulting radon flux model are discussed below.

6.2 Evaluation of Model Parameters

This section provides the results of the staff review of the radon flux model parameter values derived by Atlas. The following sections provide staff comments on the approaches to parameter characterization (sampling and testing of materials) followed by Atlas, Atlas' parameter values derived for

contaminated materials at the site, and Atlas' parameter values for radon barrier soils.

In order to assess the appropriate thickness of the earthen cover required to limit radon emission to meet the 20 pCi/m^2s standard, the characteristics (physical and radiological) of the radon barrier soils and approximately the upper 15 feet of contaminated materials must be established. Material parameters that affect radon diffusion and that are used in the computer code include: material thickness, density, porosity, long-term moisture content, and radon diffusion coefficient. In addition, Ra-226 activity concentration and radon emanation fraction of the various types of contaminated materials are parameters of the radon model. The parameter values utilized by Atlas are identified in Table 6-1.

6.2.1 Characterization of Materials

Radiological characterization programs for the site were conducted in 1988 and 1992. Laboratory testing included specific gravity, diffusion coefficient, in-place density and moisture, gradation, and capillary moisture relationships. The porosity value for materials was calculated from the dry density and the measured specific gravity. In addition, analysis for radium activity and emanation coefficient was performed for the contaminated material. Staff considers that all testing methods appear to be appropriate but concerns regarding the limited number and composition of some samples are discussed below.

Tailings and Ore Material

The characterization program for the tailings pile (1992) consisted of six test borings on the top slope to depths up to 8 feet. The samples collected were grouped into three material types; ore (3 samples), coarse sand tailings (16 samples), and fine tailings (12 samples). The Reclamation Plan indicates that samples for each material type were composited and three samples for each type were tested. The number of samples and the method of compositing has the most impact on the Ra-226 value of the tailings and is discussed in Section 6.2.2.

"Affected" and Radon Barrier Sandy Soils

In the characterization of soils, samples from Moab Wash were obtained from 15 pits and grouped, based on the radium concentration, into "affected" and "clean" soils. The licensee defines "affected" soil as any soil in the mill area, boneyard, or outlying area that exceeds the radium concentration of 5 picoCuries per gram (pCi/g) above background in soil that will remain in the upper 15 cm of soil, or exceeds 15 pCi/g above background in soil (averaged for 15 cm layers) that will be below 15 cm from the surface after reclamation. The clean (i.e., uncontaminated) sandy soil obtained from the reconfiguration of Moab Wash will be used for the upper layer of the radon barrier.

Table 6-1: Atlas Radon Input Summary

spec. gravity: 2.7-2.9 measured

AREA/ MATERIAL	THICK-NESS (cm.)	POROS-ITY	DRY DENSITY (g/cm^2)	Ra-226 (pCi/g)	EMANAT. FRACT.	MOISTURE Percent (by wt.)	DIFF. COEFF. (cm^2/s)
FINE T.							
fines	123	.5057	1.44	893	.35	24	.00185
fines	129	.5057	1.44	1339	.35	24	.00185
fines	56	.5057	1.44	1938	.35	24	.00185
coarse	213.4	.435	1.53	241	.23	4.4	.0247
affected	40.6	.295	1.91	19.5	.28	2.8	.0197
clay	30.5	.3897	1.71	0	0	14.7	.00168
sandy	22.9	.3368	1.79	0	0	2.8	.021
FLUX 19.8							
COARSE T.							
coarse	500	.435	1.53	241	.23	4.4	.0247
ore	15.2	.3637	1.72	212.7	.28	9.0	.0083
affected	40.6	.2954	1.91	19.5	.28	2.8	.0197
clay	20.3	.3897	1.71	0	0	14.7	.00168
sandy	22.9	.3368	1.79	0	0	2.8	.021
FLUX 18.5							
SIDE SLOPE							
coarse	500	.435	1.53	241	.23	4.4	.0247
sandy	213.4	.3368	1.79	0	0	2.8	.021
FLUX 19.15							

A composite sample was constructed from three samples of "affected" (contaminated) soils, and another composite sample was constructed from eight samples of clean soils. Atlas indicated that the samples selected were coarser than the average Moab Wash soils to provide conservative test results. The composite samples were divided into three splits, and each of these was then divided in half for geotechnical and radiological testing. In addition, the licensee collected and tested three composite samples of soil from a proposed borrow area (assumed to be uncontaminated) located on Atlas property west of the tailings disposal area. This material represents an alternative source of sandy soil for the radon barrier.

Staff considers that the characterization efforts for the sandy soil of the radon barrier is limited, but adequate for homogeneous material. However, the "affected" soil probably is not homogenous in either physical or radiological characteristics. Therefore, some of the parameter values of "affected" soil from the mill site (to 6 feet deep) could vary significantly from the "affected" windblown surface material in Moab Wash. Specific staff concerns regarding the characterization program for "affected" soils are identified in Section 6.2.2.

Radon Barrier Clay Material

The design of the Atlas radon barrier utilizes a clay layer for the lower portion of the barrier. Three clay samples were collected at the Klondike Flat area, a potential source of this clay material, located approximately 13.8 miles north of the facility. However, the exact location of the clay borrow site has not been chosen. As discussed in detail in Section 6.2.3 of this report, staff determined that additional testing of the final clay borrow material is required.

6.2.2 Parameters for Contaminated Materials

Tailings and Ore Material

The dry density parameter value derived by the licensee for fine tailings is the average in-place dry density adjusted to account for the overburden stress from the relocated coarse sands and the cover system. The measured dry density of the coarse tailings was not adjusted as the effect of overburden stress would be insignificant for this material. Staff considers the values acceptable and notes that the density value is somewhat conservative for the 7 feet of coarse tailings that will be compacted to 90 percent of maximum dry density on top of the fine tailings.

The original Ra-226 values for top slope fine and coarse tailings were derived by the licensee from samples composited over various depth intervals, an appropriate method only if there is evidence that the Ra-226 concentration is fairly homogeneous. Because the computer code used to calculate the estimated long-term radon flux is sensitive to the vertical distribution of Ra-226, if homogeneity cannot be shown, the vertical distribution of Ra-226 must be determined. Therefore, based on the annual processed ore grade data, Atlas subsequently provided a vertical distribution model of Ra-226 concentration in the fine tailings. NRC staff concludes that the vertical distribution of Ra-226 in the fine tailings used by Atlas is acceptable.

Atlas did not revise the Ra-226 value for coarse tailings because it was assumed that sufficient mixing of these tailings should occur during recontouring of the cell. The results of the staff analysis suggests that the Ra-226 input value for the coarse tailings should be 291 pCi/g instead of the 241 pCi/g value used by Atlas. The staff's value was derived by assuming that the only upper 6 feet of coarse tailings on the top slope will be mixed during reconfiguration of the cell. To address this concern, Atlas proposed a sampling plan for Ra-226 analysis in the upper 4 feet of coarse tailings (Sections 4.4.2 of the Reclamation Plan and 11.3.4 of the Technical Specifications). The commitment to perform Ra-226 analysis for the coarse tailings to substantiate the model values is acceptable. A condition will be added to the license requiring Atlas to verify that the Ra-226 concentration in the coarse tailings is 241 pCi/g or less.

The licensee's long-term moisture content value for the coarse tailings was based on the results from capillary moisture testing. The average value of 4.4 percent is conservative and, therefore, acceptable. The in-place moisture content reported for the fine tailings was 27.7 percent and the resulting average moisture of 30.9 percent under 15 bar pressure indicates that the test procedure and/or test results may not be appropriate to estimate the long-term moisture content for fine-grained materials. Based on a review of available data from similar sites, NRC staff recommended that 24 percent moisture be used for fine tailings in the model. The licensee agreed (March 1995) and provided a normalized diffusion coefficient value corresponding to this moisture level for the fine tailings.

The measured diffusion coefficient values for the tailings used in the model are not as conservative as the long-term moisture values and are not conservative (low) when compared to the code-calculated diffusion coefficient. This lack of conservatism is not an open issue because of other conservative aspects of the Atlas radon flux model and the small impact of this parameter (for material in deep layers) on the flux calculation result.

The ore layer in the disposal cell (periphery of top slope) consists of pieces of ore up to 6 inches in diameter, however, most pieces are gravel-sized. Staff determined that this thin layer of ore is of limited importance for the radon model and the parameter values chosen by Atlas are reasonable.

"Affected" Soils

The licensee's parameter input values for the "affected" soil are based on average test values from composited samples. The staff had previously questioned this approach because the sampling procedure may not have provided representative material. In particular, staff was concerned that a Ra-226 value based on a composite of three samples might not adequately characterize the large amount of "affected" soil which includes tailings slurry spillage and deep deposits on the mill site. Atlas responded that the particle size and saturation of the "affected" soil are more critical parameters in the radon model than the Ra-226 concentration and that the volume of soil with high levels of Ra-226 will be small when compared to the large volume of windblown soil with near background levels of Ra-226. Atlas also indicated that the three samples tested were the coarsest samples taken so that the values would be conservative. Staff agrees with Atlas that soil saturation

and the large volume of windblown material are important, but considers that coarse samples do not yield conservative values for the Ra-226 and diffusion coefficient parameters. However, further justification of the parameters values is not warranted because Atlas has proposed a sampling procedure to test for Ra-226 in the "affected" soil after it is placed in the cell.

In the proposed testing program (Sections 4.4.2 of the Reclamation Plan and 11.3.4 of the Technical Specifications), Atlas committed to take samples at 15 locations from the upper and lower half of the "affected" soil layer in the disposal cell. Each sample will be analyzed for grain-size distribution, in-place density and moisture content, specific gravity, Ra-226 concentration, and emanation fraction. In addition, three composite samples will be tested for diffusion coefficient. Atlas stated that the test results will be reported to NRC prior to starting construction of the clay layer of the radon barrier. The staff agrees with the general approach identified by the licensee in its proposed testing program for "affected" soil. A condition will be added to the license requiring Atlas to verify the parameter values for the "affected" soil.

6.2.3 Parameters for Radon Barrier Soils

Moab Wash Sandy Soil

Most of Atlas' parameter values for geotechnical properties for the uncontaminated Moab Wash sandy soils are the average test results of three splits of a composite sample. Staff agrees that the samples taken should be representative of the available borrow material and considers that the limited testing is acceptable for the geotechnical parameters.

The density and porosity values used in the model are within the expected range for sandy soil and are acceptable to staff. The long-term moisture content of 2.8 percent was calculated using the Rawls and Brakensiek equation (NRC 1989) and is conservative considering the nature of the material. The diffusion coefficient value was determined from tests on samples with moisture contents (percent dry weight) that were less than the long-term moisture value which is conservative and, therefore, acceptable to staff.

The Ra-226 parameter value for the sandy soil layer of the radon barrier is assumed to be zero (i.e., background) in the Atlas model. Staff had previously expressed concern that significant concentrations of windblown contamination might remain in Moab Wash soil excavated for the sandy soil layer of the radon barrier. The Technical Specifications indicate that the soil background Ra-226 value is the average value approved by NRC. Also, Appendix D of the Reclamation Plan contains a testing plan for establishing a soil background Ra-226 value. Test results will be provided to NRC for approval, prior to using the Ra-226 value for cleanup verification. Staff considers this approach acceptable to address the Ra-226 background value.

Klondike Flats Clay

Atlas' radiological and geotechnical parameter values for the clay (obtained in the Klondike Flats area) are the average results of testing performed on three samples. Atlas stated that the characteristics of the clay (Mancos

Shale) were uniform throughout the formation and that DOE had used material from the same formation to construct the radon barrier at the Grand Junction Title I site. Atlas has not completed arrangements for a particular borrow source and relies on the construction specifications to support the radon barrier design in lieu of extensive borrow source characterization. The specifications describe prequalification procedures, as well as requirements for testing the borrow source throughout construction.

Based on a review of the physical properties, NRC staff determined that the parameter values for the clay were acceptable. The tested material met the proposed construction specifications for the clay layer of the radon barrier.

Staff notes that the diffusion coefficient value (0.00168 cm^2/s) Atlas used is less conservative than the value (0.0025 cm^2/s) derived by the Department of Energy after extensive testing of the Grand Junction clay at the same moisture content approved for the Atlas clay. The low diffusion coefficient of the radon barrier clay is critical to Atlas' demonstration, through its radon barrier modeling, that the long-term radon flux standard can be met. However, the staff's concern related to the diffusion coefficient has been addressed by Atlas' commitment to do further testing (including at least 3 diffusion coefficient tests) of the clay borrow area prior to construction of the clay layer.

Because Atlas has not chosen a final borrow source for the clay material, staff considers that the test values used for parameter values must be confirmed. Therefore, Atlas incorporated the proposed testing program for the final clay borrow area into Reclamation Plan Section 4.2.1. The clay borrow proposed testing program also includes analysis to demonstrate that the clay layer of the radon barrier will contain background levels of Ra-226, in order to comply with Appendix A, Criterion 6 (5). A condition will be added to the license requiring Atlas to verify that the characteristics of the clay used in the cover meets the parameter values used in the radon flux analysis.

6.3 Calculational Methodology and Results

Atlas modeled the radon flux for the covered disposal cell utilizing the RADON computer code (NRC, 1989). For modeling and design purposes, Atlas divided the disposal cell into three areas: 1) the embankment (side slopes), which consists of coarse tailings; 2) coarse tailings in the peripheral portion of the impoundment (top slope); and 3) fine tailings within the central portion of the impoundment.

Area 1, the side slopes (approximately 45 acres), consists of coarse tailings designed with a 7-foot-thick sandy layer for the radon barrier. Areas 2 and 3 (approximately 62 and 29 acres, respectively) will consist of coarse tailings over ore and fine tailings, respectively, because the licensee proposes to decrease the slope of the existing embankment by moving coarse tailings to the top. This will result in a 7-foot-thick layer over the fine tailings. The fine tailings have a high Ra-226 concentration so the overlying thick layer of coarse tailings will reduce radon emanation from this source. The less contaminated "affected" soil, at least 16 inches thick, will then be placed on top of coarse tailings in areas 2 and 3.

In the proposed design, the radon barrier minimum thickness (clay plus sandy layers) is 17 inches over the coarse tailings area, and 21 inches over the fine tailings area. The clay layer will be a minimum of 8 inches thick over the coarse tailings area and 12 inches thick over the fine tailings area. The clean soil layer minimum thickness is 9 inches over the entire top slope. The side slopes do not contain fine tailings or the clay layer, but will be covered by 7 feet of sandy soil.

The radon flux model for each area, considering parameter values and proposed construction, is somewhat conservative in that the radon attenuation resulting from the 6-inch filter layer on the sideslopes was not included. Also, Atlas noted that portions of the clean dike fill material (originally placed to retain the tailings) and the interim cover will remain in place, but other portions will be mixed with the "affected" soil layer and upper layer of tailings during excavation and regrading. The ultimate disposition of these clean materials cannot be easily quantified at this point but will provide additional radon attenuation capacity not accounted for in the model.

The Atlas radon flux models/calculations assume that the Ra-226 content of the clay and sandy layers of the radon barrier is background. This is appropriate because the footnote to Criterion 6 (1) indicates that the flux standard applies only to emissions from byproduct materials. As discussed in Section 6.2.3, the licensee will be required to verify that cover materials will not contain Ra-226 above background levels.

Atlas' modeling results indicate that the long-term radon flux should be 19.1, 19.8, and 18.5 pCi/m^2s for the side slopes, fine tailings, and coarse tailings areas, respectively. NRC staff used the RADON computer code, with the parameters identified in Table 6-1 to verify the values reported by Atlas. Therefore, the staff concludes that the average radon flux will meet the standard of 20 pCi/m^2s if the parameter values identified in Table 6-1 are met.

Atlas has indicated that it will perform additional flux modeling if the test values for the "affected" soil, coarse tailings, or clay are significantly different than values used in the current radon flux model. A condition will be added to the license requiring Atlas to submit, for NRC approval, a justification of the radon barrier design, if the parameter values shown in Table 6-1 are not met.

6.4 Durability of the Radon Barrier

As discussed in previous sections, disruption of the radon barrier by wind or rain will be prevented by the erosion protection layer, and there is a low likelihood of major cracking of the cover due to differential settlement of the tailings because final cover placement will not begin until 90 percent of primary consolidation (settlement) of the tailings has occurred (Atlas Technical Specifications Section 11.3.1). In addition, the clay layer of the barrier will be protected from significant cracking due to desiccation by the material placed above it and by the moisture-retaining properties of the clay.

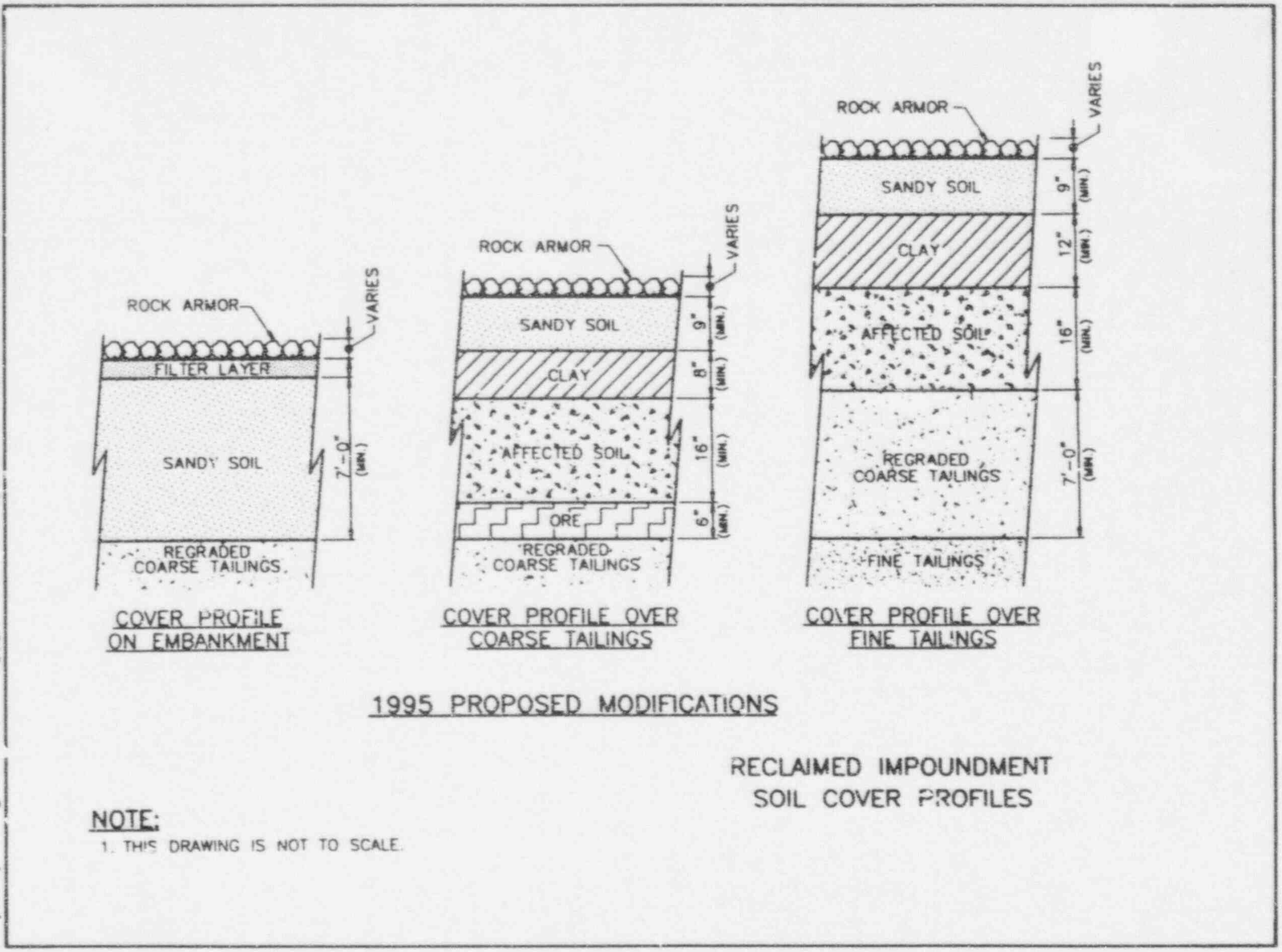

Figure 6-1: Reclaimed impoundment soil cover profiles, taken from drawing No. 88-067-A112, March 21, 1995 Atlas submittal

Staff considers that the proposed clay layer thickness of at least 8 inches can be achieved in construction and that adequate limits on drying and cracking of the layer will be maintained by the design and Technical Specifications Section 7.3.4.

Another aspect of the evaluation of the long-term integrity of the radon barrier is estimating the likelihood of intrusion by burrowing animals or deep-rooted plants. Atlas indicated that biointrusion of the radon barrier will be restricted by the unfavorable environment of the rock layer in the final cover. Although it is recognized that some volunteer plant growth will occur, the licensee concluded that it will most likely be shallow-rooted grasses whose roots should not penetrate the 12 inches of cover materials above the clay layer. Animals indigenous to the area are not expected to select the reclaimed disposal area over native terrain for habitation. The rock cover will not be conducive to digging or to establishing vegetation to create an acceptable habitat. In addition, the tall slopes (about 100 vertical feet) surrounding the disposal area will be armored with rock which should discourage passage onto the upper portion of the disposal area. Based on the staff's experience with other sites, the reclaimed facility does not appear to provide a desirable habitat. Therefore, the staff agrees that the cover is unlikely to be significantly disrupted by burrowing animals or deep-rooted plants.

Frost penetration of the barrier and the potential for resulting disruption within the barrier layer was also examined. Atlas addressed the effect of freeze/thaw cycles on the radon barrier, and concluded that the clay will not be susceptible to frost heave, as the coarse tailings below it will not support capillary action. Therefore, the ability to transport excess water to the frost line does not exist, and the susceptibility of the cover system to frost heave can be considered low. Also, Atlas performed an analysis of potential frost penetration using the Modified Berggren equation method, as proposed by the U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory (COE 1968). Using historical weather data in the equation, it was shown that potential damaging frost penetration of the radon barrier was unlikely, thus the proposed design need not be modified for additional protection. Staff agrees that the data supports the licensee's conclusion that significant freeze-thaw damage is unlikely to occur to the clay layer of the radon barrier as described in the proposed design (see Section 3.3.4 for further discussion).

The licensee's conclusions as to the ability of the proposed borrow materials to perform adequately in the cover system are acceptable to staff, subject to review of the results of the proposed material testing program. Adequate design conservatism should ensure long-term radon barrier integrity, assuming that long-term stability of the disposal cell is achieved (see Sections 2, 3, and 4).

6.5 Measured Radon Flux

Criterion 6 (2) of Appendix A requires licensees to measure the average radon flux as soon as reasonably achievable after placement of the radon barrier to demonstrate that the radon flux criterion has been achieved. The flux limit is the same as that for the modeled (design) long-term radon flux. The

measured flux on newly constructed radon barrier should easily meet the flux criterion because the materials contain, relative to later years, more moisture and fewer cracks. If the radon flux model or the barrier construction were seriously flawed, this would be reflected in the average measured radon flux value submitted to NRC. If the measured flux does not meet the criterion, staff could require corrective action such as placement of additional radon barrier material.

6.6 Conclusions

Based on independent analysis and modeling, and the characteristics and parameters of the various materials, as shown in Table 6-1, staff concludes that the proposed barrier design is acceptable. The staff will require, through a license condition, that parameters and material characteristics used in the analysis be confirmed. Based on the review conducted and the requirements that will be included as license conditions, the staff concludes that the long-term radon flux standard and other cover requirements of Criterion 6 will be achieved.

7.0 APPENDIX A ASSESSMENT

Appendix A to 10 CFR 40 establishes technical, financial, ownership, and long-term site surveillance criteria relating to the siting, operation, decontamination, decommissioning, and reclamation of uranium milling facilities. Each site-specific licensing decision is to be based on the criteria in the appendix, taking into account the public health and safety and the environment. Decisions based on the criteria in the appendix must take into account the risk to the public health and safety and the environment with due consideration to the economic costs involved. Decisions as to the ability of the design to meet "reasonably achievable" criteria must take into consideration the state of technology as well as the economics of improvements in relation to the resulting benefits.

Appendix A provides flexibility in the NRC regulatory program in several ways. It allows licensees to propose alternatives to the specific requirements contained in the appendix. It also requires that licensing decisions take into consideration the economic costs involved (this requirement originates in the Atomic Energy Act of 1954, as amended). One of the reasons for this flexibility was the recognition that some of the regulations in Appendix A could not be applied to existing sites with the same level of conservatism as they could be applied for proposed new sites. The Generic Environmental Impact Statement on Uranium Milling, NUREG-0706 (1980) explicitly discussed this. As a result, the criteria in Appendix A that identify goals, as opposed to specific numerical requirements, are applied to existing sites with the recognition that the goal may not be met to the extent that it would for a new proposed site.

The following Appendix A criteria were considered for the proposed licensing decision to amend Source Material License SUA-917 in accordance with the reclamation plan submittals. Criterion 2, 8, and 11 are not applicable for review and approval of a reclamation plan and were therefore not considered.

<u>Criterion 1</u>

Criterion 1 addresses the general goal of siting and designing facilities to provide for the permanent isolation of tailings and associated contaminates by minimizing disturbance and dispersion by natural forces without the need for ongoing maintenance. As discussed above, it is recognized that the general goal in Criterion 1 may not be met at the existing Atlas site to the extent that it would for a new site. The following site features must be considered when judging the adequacy of an existing site:

1. Remoteness from populated areas:

   The Moab Mill is located on the west bank of the Colorado River, 3 miles northwest of the center of the City of Moab, in Grand County, Utah. There is a private residence adjacent to the restricted area to the northeast. The 1990 census reports a population of 4050 for the city of Moab. This shows a decrease in population from the 1980 census which reported a population of 5333 for Moab. The population of Grand County has also decreased from a population of 8200 in 1980 to 6800 according

to the Utah Department of Employment Security. Review of data from the licensee indicates that the population within a 10 km radius of the mill has been declining since 1970. (See Draft Environmental Impact Statement, October 1995.)

Adjacent lands and waters are used for a variety of activities. State Highway 279 and U.S. Highway 191, both adjacent to the site, are major transportation routes for industry and tourism. Outdoor recreational use of the area is heavy; Arches National Park is across U.S. 191, with the visitor center less than 2 miles northwest of the site.

Population projections for these areas are difficult to make. There may be significant population increases in the immediate future due to the development of outdoor recreational facilities and the proximity of National and State parks. It is doubtful, however, that there will be any increase in the immediate proximity of the disposal area. The Nature Conservatory has purchased the wet-lands between the City of Moab and the Colorado River, prohibiting development in this area. Any development to the east of the disposal area, on the west bank of the Colorado River, would be in the flood plain for Moab Wash and the Colorado River. The licensee will be required to include the entire reconfigured Moab Wash in the final fenced restricted area which will help ensure that there are no future developments in the immediate vicinity of the disposal area.

While the proposed location of the Atlas tailings is not as remote from populated areas as most tailings piles, there are at least two tailings piles that were reclaimed in more densely populated areas. Tailings from the former Vitro rare metals plant site were reclaimed on site within the city of Canonsburg, Pennsylvania. The 1980 census figures (the most recent when the decision was made) showed a population of 7938 within 1 mile of the site. The population within 1 mile from the reclaimed tailings at Shiprock, New Mexico was 2197.

2. Hydrologic and other natural conditions as they contribute to continued immobilization and isolation of contaminants from ground-water sources:

The reclaimed disposal area will be capped with a cover system which will minimize infiltration. The review of ground-water conditions at the site to assure compliance with 10 CFR 40, Appendix A, is currently being done under other licensing actions. The licensee is currently implementing a CAP to return ground-water quality to established standards. The CAP was submitted on March 31, 1989, and was fully operational prior to July 1, 1990. The CAP is being revised as a result of information collected since it was initiated.

3. Potential for minimizing erosion, disturbance, and dispersion by natural forces over the long-term:

The potential for wind and water erosion will be minimized by several design features. The tailings will be re-contoured and covered by an erosion protection cover. A drainage system will be constructed to divert precipitation away from the tailings. The tailings cover and

diversion channels will be protected from flooding and erosion by engineered rock riprap. The cover and channels have been designed in accordance with the guidance suggested by the staff (NRC, 1990). The staff considers that erosion protection which meets that guidance will provide adequate protection against erosion and dispersion by natural forces over the long term.

4. The tailings will be disposed of in a manner that will not require active maintenance to preserve conditions at the site:

The staff considers that the erosion protection will not require active maintenance over the 1000-year design life, for the following reasons: 1) the riprap has been designed to protect the tailings from rainfall and flooding events which have very low probabilities of occurrence over a 1000-year period, resulting in no damage to the layers from those rare events; 2) the rock proposed for the riprap layers will be durable and is not expected to deteriorate significantly over the 1000-year design life; and 3) during construction the rock layers will be placed in accordance with appropriate engineering and testing practices, minimizing the potential for damage, dispersion, and segregation of the rock.

As discussed in Sections 2 and 3, the staff also considers that the site should not require active maintenance to mitigate the effects of geologic, including seismic, disturbances.

Criterion 3

Criterion 3 sets below-grade disposal as the prime option for tailings disposal.

Relocation of the tailings to another site so that all the contaminated material could be placed below grade is technically feasible; however, if the other criteria are met, the benefits of below grade disposal at another location, over stabilizing the tailings in place would be small with respect to this criterion. Since the existing site is adequate and the design of the disposal cell meets the closure criteria, the cost of disposing the contaminated materials below grade by relocating the disposal area would be much greater than the benefit realized, making relocation economically impracticable.

If below-grade disposal is not practicable, the disposal plan must provide reasonably equivalent isolation of the tailings from natural erosional forces. This is addressed in Criteria 4, 6, and 12.

Criterion 4

Criterion 4 sets specific technical criteria for disposal of tailings.

Criterion 4(a) requires that upstream rainfall catchment areas be minimized to decrease erosion potential and the size of the floods which could erode or wash out sections of the tailings disposal area.

The site is located in an area which is flooded by offsite floods from Moab Wash and the Colorado River. However, as discussed in the Section 4, the site is protected from direct onsite precipitation and flooding by engineered riprap layers for the top and side slopes; the tailings disposal cell will need this protection regardless of where it is located. The riprap for the side slopes and drainage ditches is large enough to resist flooding from the minimal flow velocities of floods occurring from a PMF on the Colorado River. A large rock apron has been designed to provide protection against the potential migration of Moab Wash and the Colorado River. The staff therefore concludes that the erosion potential at the site has been acceptably minimized, since any flooding at the site will be mitigated by the erosion protection, and the forces associated with offsite floods are minimal.

Criterion 4(b) states that topographic features should provide good wind protection.

The staff considers that the site will be adequately protected from wind erosion by placement of an engineered riprap layer that protects the tailings from surface water erosion. Studies performed for the NRC have shown that an engineered riprap layer designed to protect against water erosion will be capable of providing adequate protection against wind erosion.

Criterion 4(c) states that cover slopes must be relatively flat after stabilization to minimize erosion potential and to provide conservative factors of safety assuring long-term stability. In general, slopes should not be steeper that 5H:1V.

The side and relatively flat top slopes of the covers will be protected from erosion by engineered riprap layers designed to provide long-term stability (see Section 4.3). In order to reduce the length of the slopes and, therefore, to minimize intrusion onto the Colorado River floodplain, the side slopes will be 10H:3V. The erosion potential of the covers will be minimized by the design of the rock to be sufficiently large to resist flooding and erosion, based on the slope selected. The staff concludes that the slopes, with their corresponding rock designs, will be sufficiently stable to meet the erosion aspects of this criterion.

Criterion 4(d) requires a full self-sustaining vegetative cover be established or a rock cover employed to reduce erosion to negligible levels. The rock cover design must include consideration of such factors as the shape, size, composition, and gradation of the rock particles; rock cover thickness and zoning of particle size; and steepness of underlying slopes. The rock must be good quality.

Due to the arid nature of the site, the licensee made no attempt to substantiate self-sustaining vegetation over a 1000-year period. The contaminated tailings will be protected from flooding and erosion by an engineered rock riprap layer. The riprap has been designed in accordance with the guidance suggested by the NRC staff (NRC, 1990). As discussed in Section 4, the staff considers that erosion protection

which meets that guidance will provide adequate protection against erosion and dispersion by natural forces over the long term. Adequate protection is provided by: (1) selection of proper rainfall and flooding events; (2) selection of appropriate parameters for determining flood discharges; (3) computation of flood discharges using appropriate and/or conservative methods; (4) computation of appropriate flood levels and flood forces associated with the design discharge; (5) use of appropriate methods for determining erosion protection needed to resist the forces produced by the design discharge; (6) selection of a rock type for the riprap layer that will be durable and capable of providing the necessary erosion protection for a long period of time; and (7) placement of a riprap layer in accordance with accepted engineering practice and in accordance with appropriate testing and quality assurance controls.

Criterion 4(e) requires that the impoundment not be located near a capable fault that could cause a maximum credible earthquake larger than that which the impoundment could reasonably be expected to withstand.

There are no capable faults near the site that could generate earthquakes larger than the design basis earthquake. Faults of the Moab fault system, which occur under and adjacent to the site, are not capable faults.

Criteria 5, 7, and 13

Criteria 5, 7, and 13 concern groundwater protection. As previously discussed, groundwater is being addressed under separate licensing actions. However, groundwater protection standards at the site will be in accordance with these criteria.

Criterion 6

Criterion 6 sets forth performance criteria for the disposal of tailings.

Criterion 6(1) requires that waste disposal areas be closed in accordance with a design which provides reasonable assurance that average releases of radon-222 and radon-220 to the atmosphere will be limited to 20 picocuries per square meter per second (pCi/m^2s). The design is to be effective for 1000 years to the extent reasonably achievable and, in any case, for at least 200 years.

The evaluation of the radon barrier utilized the RADON computer code (NRC, 1989b) and acceptable parameters to estimate radon emanation from the pile. The design is supported by adequate construction specifications, settlement monitoring, and quality control programs. Therefore, the staff concludes that the cover design will limit radon releases to atmosphere to 20 pCi/m^2s.

The design basis events for erosion protection features protecting the radon barrier are the PMP and the PMF events. Both of these events are considered to be the most severe that are reasonably possible and thus provide reasonable assurance of not being exceeded during the 1000-year

design life. The erosion protection features should assure that excessive erosion does not occur during the design life.

The design basis for seismic stability is an acceleration of 0.18g, calculated by the licensee, in its probabilistic seismic hazard analysis, as having a return period of 10,000 years. The pile slopes are designed to withstand a seismic coefficient of 0.25, which translates into an acceleration of 0.38g. Therefore, there is reasonable assurance of pile stability under reasonably expected seismic loading for 1000 years. The design basis for subsidence is uniform or differential subsidence of the bedrock surface beneath the site, of 1 meter in 1000 years. The pile is capable of accommodating 2 meters of bedrock subsidence without damage to the cover system. The design will also accommodate other geologic hazards, such as migrating sand, and rock and debris falls, that can be reasonably expected to threaten pile stability over the next 1000 years.

Criteria 6(2) and 6(3) require the licensee to verify by testing, as soon as reasonably achievable after placement of the final radon barrier, or portions of the final radon barrier, the effectiveness of the radon barrier in limiting radon releases. Criterion 6(4) requires the licensee to report the results of the verification within 90 days of completion and to maintain the pertinent data and calculations.

The licensee will be required to verify the effectiveness of the radon barrier by using the procedures described in 40 CFR part 61, appendix B, Method 115, or another method, if approved by NRC, and to report the results to NRC.

Criterion 6(5) precludes the use of materials containing elevated levels of radium in near surface cover materials.

With the exception of sandy soil from Moab Wash, all cover materials will be obtained from uncontaminated borrow areas well away from the site, and should not contain elevated levels of uranium. The licensee will be required to confirm, by testing, that cover material obtained from Moab Wash does not contain elevated levels of radium.

Criterion 6(6) imposes the long-term design requirements of Criterion 6 to all portions of the disposal site that contain a concentration of radium in land, averaged over areas of 100 square meters, which exceed the background level by 5 picocuries per gram (pCi/g) averaged over the first 15 centimeters below the surface and 15 pCi/g averaged over each 15 centimeter layer more than 15 centimeters below the surface.

The cleanup of contaminated areas is required by License Conditions Nos. 21 and 39 of Source Material License SUA-917. The cleanup will result in no areas outside the disposal cell exceeding the limit.

Criterion 6(7) requires that the licensee control, minimize, or eliminate post-closure escape of nonradiological hazardous constituents.

The radon barrier design includes a low permeability clay layer which

will also serve to limit infiltration into the disposal cell. As a result, seepage of nonradiological hazardous constituents from the disposal cell will be minimized to the extent necessary to prevent threats to human health and the environment.

Criterion 6A

Criterion 6A requires the final radon barrier to be completed as expeditiously as practicable considering technological feasibility and that completion dates for the radon barrier and interim milestones be established in the license.

Milestones for the completion of the radon barrier are identified in License Condition No. 55 of Source Material License SUA-917.

Criteria 9 and 10

Criteria 9 and 10 require that a financial surety arrangement be established to assure that sufficient funds are available to carry out the decontamination and decommissioning of the facility and the reclamation of the disposal area, and to cover the payment of the charge for long-term surveillance and control by the long-term custodian of the site.

The licensee's currently approved surety instrument, a performance bond issued by the Acstar Insurance Company of New Britain, Connecticut in favor of the NRC, is in the amount of $6,500,000 for the purpose of complying with Criteria 9 and 10. The licensee also maintains a Standby Trust arrangement for the benefit of NRC, with Norwest Bank of Colorado N.A.

Within 3 months of approval of the reclamation plan for the disposal area, Atlas is required to submit a revised cost estimate. If estimated costs in the newly approved plan exceed the amount covered in the existing financial surety, the licensee is required to have a new surety instrument in place within 3 months of NRC approval of the new cost estimate. (License Condition No. 42 of Source Material License SUA-917.)

Criterion 12

Criterion 12 requires that the final disposition of tailings or wastes at milling sites should be such that ongoing active maintenance is not necessary to preserve isolation.

As discussed in Section 4, the staff considers that the erosion protection should not require active maintenance over the 1000-year design life, for the following reasons: (1) the riprap has been designed to protect the tailings from rainfall and flooding events which have low probabilities of occurrence over a 1000-year period, resulting in no damage to the layers from those rare events; (2) the rock proposed for the riprap layers is designed to be durable and is not expected to deteriorate significantly over the 1000-year design life; and (3) during construction, the rock layers will be placed in accordance with appropriate engineering and testing practices, minimizing the potential

for damage, dispersion, and segregation of the rock.

As discussed in Sections 2 and 3, the staff also considers that the site should not require active maintenance to mitigate the effects of geologic, including seismic, disturbances.

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APPENDIX A

RESPONSES TO COMMENTS RECEIVED ON THE DRAFT TECHNICAL EVALUATION REPORT

The draft TER was published in January 1996 concurrently with the Draft Environmental Impact Statement (DEIS). Due to the extensive public interest, NRC decided to make the draft TER available for public comment concurrent with the comment period for the DEIS. The comment period expired on April 29, 1996. Two hundred forty-five comment letters on these documents were received. Most of the letters and individual comments were directed to the DEIS and are addressed in the Final Environmental Impact Statement. Two comment letters were specifically identified, by the author, as directed at the draft TER. Three other comment letters contained sections of comments that were identified, by the author, as being directed at the draft TER. One comment letter contained several comments related to the draft TER.

All the comments were reviewed and grouped by draft TER section and subject area. Some comment letters contained extensive background information and opinions in addition to comments on the draft TER. Comment letters will be published with the Final Environmental Impact Statement. The comment letters are also available in the public document room. Staff have identified and numbered comments in the margin of the letter. This appendix is organized by draft TER section and subject area of the comments. The name of the commenters and the comment numbers are listed for each issue. Each issue is summarized and a response given to address the major points raised in the comments.

1.0 GENERAL COMMENTS and INTRODUCTION

1.1 General

1.1.1 Commenters

Saxon Sharpe (53-9)
Grand County Council by Jenner & Block (59-80)

1.1.2 Summary of Issues

Sharpe questioned the adequacy of the design for control of radiological wastes for 1000 years, considering that the half-life of Ra-226 is 1622 years. Grand County Council stated that the NRC must decide whether Atlas' plan is the best plan for permanent disposal of the tailings. It also stated that NRC is not objectively evaluating Atlas' plan but is impermissibly favoring Atlas' plan.

1.1.3 Staff Analysis of Comments

The longevity requirement for control of radiological hazards is contained in Criterion 6 of Appendix A to 10 CFR Part 40 and derives from an identical requirement in EPA's standards at 40 CFR Part 192.32(b). The adequacy of these standards, which were upheld as protective of public health and safety in Federal Court, is not the subject of this review. In its review, NRC determines if the licensee has acceptably demonstrated compliance with the applicable requirements. Although NRC encourages its licensees to do the best jobs possible, the NRC must limit its reviews to only determining if a proposal is acceptable not necessarily the best. All NRC reviews are conducted in an objective manner and documented in TERs. The Atlas review is no exception.

1.1.4 Revisions to the TER

No revisions were made to the TER as a result of these comments.

1.2 Open issues in Draft TER

1.2.1 Commenters

Grand County Council by Jenner & Block (59-1)

1.2.2 Summary of Issues

Grand County Council states that the draft TER is a partial and preliminary draft TER because it contains 20 open issues and additional confirmatory items. It further states that a regulatorily sufficient draft TER should be prepared for public review after further NRC review of more information from Atlas.

1.2.3 Staff Analysis of Comments

NRC draft TERs always contain open issues. As explained in Section 1, draft

TERs are prepared by NRC as a means to expedite the process of obtaining additional information from its licensees. If, in a licensing case, there were no open issues after the initial round of NRC requests for information and licensee responses, NRC would proceed directly to the final TER. All draft TERs prepared by NRC are publicly available and the public can comment on them as it can on any publicly available document prepared by NRC. For the Atlas review, NRC took the extraordinary step of publishing the draft TER and formally requesting public comment. Members of the public can provide comments on the final TER, but the staff does not believe that a second draft would identify any new issues that have not already been raised.

1.2.4 Revisions to the TER

No revisions were made to the TER as a result of this comment.

1.3 Site Description

1.3.1 Commenters

Grand County Council by Jenner & Block (59-2)

1.3.2 Summary of Issues

Grand County Council states that there are errors and omissions in the site description: that the tailings pile is 1.5 miles from the city limits of Moab and that Arches National Park and activities that occur in the vicinity of the site are not discussed.

1.3.3 Staff Analysis of Comments

The tailings pile is 3 miles from the center of Moab. Activities that occur in the vicinity of the site are identified and discussed in the FEIS.

1.3.4 Revisions to the TER

Section 1.2 has been revised to clarify that the 3 mile distance is to the center of Moab and to note that Arches National Park is nearby.

2.0 GEOLOGIC STABILITY

2.1 Moab Fault

2.1.1 Commenters

U.S. Department of the Interior (56-1, 56-4)
Atlas Corporation (57-5)
Grand County Council by Jenner & Block (59-12, 59-13, 59-14, 59-15)

2.1.2 Summary of Issues

Two commenters expressed concern that the Moab fault may be inappropriately identified as not being a capable fault, or not being tectonically active, because of inattention to or lack of clarity about certain stratigraphic or

structural relationships. Atlas, however, supported the conclusion that the Moab fault is not a capable fault.

The Department of the Interior, expressed concern that the Moab fault evidenced recent tectonic activity and burial, because Quaternary graben fill (DOI's interpretation) lay adjacent to a fairly uneroded fault scarp (DOI's interpretation). The implication is that the Moab fault may, therefore, be a capable fault.

The licensee, enumerated lines of evidence that support its conclusion that the Moab fault and West Branch fault are not capable faults, that movement in the Quaternary has not been detected, that there is no evidence of any historical earthquake activity along the fault, and that most of the displacement on the fault preceded salt-dissolution subsidence.

Grand County, requested an explanation of why the Moab fault would not meet the definition of a capable fault if it is rooted in a salt-cored anticline and not structurally connected to the basement. According to the commenter, it must be considered a tectonic feature whether it was formed by salt diapirism or plate tectonic forces.

Grand County also requested an explanation of the concept that the near-vertical Moab fault (commenter's interpretation) may have overlain the site and has been removed by erosion.

Further, Grand County requested a better description of certain attributes of the Moab fault than was presented in the draft TER. Particular attributes requested were age and history of faulting, attitude, closest exposure to site, and magnitude of displacement.

In addition, Grand County requested a comprehensive and technically accurate description of geologic and seismic issues pertaining to the fault.

2.1.3 Discussion and Response to Comments

The staff agrees that additional facts and descriptions of the Moab fault and related faults and accompanying explanations of significance were needed than were available at the time the draft TER was published. Additional information has been provided by the licensee and is summarized in the TER. Adequate information on the issue has enabled the staff to conclude that the Moab fault is not a capable fault and thus not a seismogenic hazard to the tailings.

A comprehensive technical description of the fault and a full explanation of the bases for the staff's conclusions are presented in revised Sections 2.3.3.3 and 2.4.1.1. Another intent of those sections is to distinguish between two potential hazards the Moab faults could produce: seismicity and displacement. It should be clear that the staff considers that the faults are not seismogenic hazards (i.e., not capable faults). They are a displacement hazard, and the potential displacements will be aseismic (i.e., ancillary to salt subsidence). Sections on the Moab fault and related faults are thoroughly revised because of new data submitted by the licensee derived from seismic surveys and field mapping by licensee's consultants and published

studies by academic and petroleum industry groups.

2.1.4 Revisions to the TER

As discussed above, revisions were made to the TER discussion of the Moab fault.

2.2 Subsidence/Rate of Dissolution

2.2.1 Commenters

U.S. Department of the Interior (56-1)
Atlas Corporation (57-9)
Utah Division of Radiation Control (58-10, 58-11, 58-12, 58-13)
Grand County Council by Jenner & Block (59-10, 59-11)

2.2.2 Summary of Issues

Three commenters considered that subsidence under the pile occurred in the Quaternary and is probably continuing, but uncertainties about the rate, magnitude, and style of future subsidence are large. The licensee considered that differential subsidence propagated through the alluvium from displacement on buried faults would generate strains too low to adversely affect pile stability.

The Department of the Interior, expressed the opinion that, given the complex geological processes that might be active at the site, the final analysis concerning whether subsidence will be active in the next 200 to 1000 years will be arguable. The Department of the Interior anticipated that by virtue of impending, inconclusive discussions, the site probably violates Appendix A, Criteria 1(c) and 4(e).

The State of Utah, expressed concern that imprecise knowledge of Quaternary alluvium thickness beneath the pile, age of oldest Quaternary sediments and rate of deposition of alluvium would make it difficult to quantify the maximum rates of subsidence. Utah requested that conservative estimates be made if it is impracticable to gather actual data.

Also, the State of Utah asserted that preferential subsidence is possible across the buried scarp and expressed concern that Atlas gave no consideration to rates of land subsidence as they relate to the buried scarp.

Grand County expressed concerns about unsupported conclusions and inconsistent data in Atlas' submittals regarding subsidence, and concluded that the staff's analyses of salt tectonics are rife with inconsistencies and opined that all geologic stability issues analyzed by the staff are flawed and inadequate. Specifically, Grand County cited a statement by Atlas of slower subsidence rate in the last 15,000 - 25,000 years as lacking evidence, and stated that Atlas overlooked borehole data that provided evidence of subsidence between the Colorado River and the pile. The commenter requested that NRC neither accept inconsistent data nor accept conclusions from Atlas that are contradicted by the results of others.

The licensee, calculated that subsidence will occur at a rate of 0.4-1 mm/year or a maximum of 1 m in 1000 years. The licensee concluded that the pile will be deformed in zones above buried faults at a rate of 3.8×10^{-6} per year, or about 0.00038 (0.038%) in 1000 years; and the shear strain would be too small to adversely affect pile stability.

2.2.3 Staff Analysis of Comments

The staff considers the subsidence hazard to be adequately defined for purpose of design to achieve compliance with performance requirements. The staff's analyses and bases are explained in revised Sections 2.3.3.2 and 2.4.1.3. The licensee performed calculations to support its conclusion that the pile design could withstand subsidence twice as great as its proposed maximum. An explanation of the staff's conclusions concerning the conservatism of the licensee's design to mitigate subsidence is in Section 3.3.5.

2.2.4 Revisions to the TER

As discussed above, revisions were made to the TER discussion of subsidence.

2.3 Buried Scarp

2.3.1 Commenters

Atlas Corporation (57-10)
Utah Division of Radiation Control (58-3, 58-6, 58-13)

2.3.2 Summary of Issues

The commenters emphasized the coupling of the potential effects of a buried scarp on the tailings pile with the process of subsidence.

The State of Utah, considers the recurrence of brine in a well in the vicinity of the scarp to be evidence of salt dissolution of Paradox Formation beneath the pile occurring at shallower depth than reported by Cooksley (1996). Utah apparently considers that such dissolution could lead to preferential subsidence across scarp. Also, the commenter considers that the scarp (a vertical plane) may underlie or be sufficiently close to the pile boundary that should subsidence occur across it, future pile stability might be affected. (Other commenters mentioned the buried scarp in the context of potential faulting and subsidence hazards; see TER sections on Moab Fault System and Subsidence for additional discussion of the significance of the buried scarp.)

2.3.3 Staff Analysis of Comments

The hazard imposed on the pile by a buried scarp that may be a fault subject to slip is considered by the staff to be one of differential subsidence similar to that posed by the Moab fault system. The staff considers that the future rate and magnitude of slip on the buried scarp, if it were to occur, would be no more severe than slip on any fault in the Moab fault system. The subsidence rate and magnitude has been adequately bounded. The licensee has demonstrated that its design is sufficient to mitigate differential subsidence

across a fault anywhere under the pile which might slip at a reasonable and conservative rate and magnitude. Therefore, the staff did not require the licensee to precisely locate the alleged buried scarp or determine the nature of rocks and sediments adjacent to it. Section 2.4.1.2 on the buried scarp has been rewritten to reflect the licensee's description of the hazard submitted since the draft TER and the bases for the staff's analyses.

2.3.4 Revisions to the TER

As discussed above, revisions were made to the TER discussions related to the buried scarp.

2.4 Windblown Sand

2.4.1 Commenters

Saxon Sharpe (53-5)
Atlas Corporation (57-10)

2.4.2 Summary of Issues

Saxon Sharpe wanted to know what the presence of sand dunes in the site vicinity means in terms of climate change, source material, and wind direction.

The licensee considered that sand accumulation on the pile and in drainage ditches is insufficient to cause adverse conditions on the pile or in the ditches. The licensee considers deposition on the pile to be in compliance with Criterion 4(f). The licensee considers sand accumulation in drainage ditches will be mitigated by flushing of the ditches by expected future runoff.

2.4.3 Staff Analysis of Comments

The significance of sand dunes generally suggests a climate of aridity and availability of sand source material. The source of sand and migration direction was discussed in Sections 2.3.2.2 and 2.3.4.3. The effects of climate change and sand as a source material is not considered relevant to this application and is not discussed in the TER.

The staff is concerned about designs of erosion protection barriers, including drainage diversion ditches that might lose their function for failure to accommodate expected conditions or processes in the next 200 to 1000 years, in this case, the continued migration of sand across the site. Sand accumulation in drainage ditches might compromise the ditches' function, while sand accumulation on the pile or sideslopes might enhance erosion or radon protection. Atlas has adequately addressed this concern.

2.4.4 Revisions to the TER

Sections 2.4.2.1 and 2.5.2 have been revised to provide a full explanation and the bases for staff's evaluations of Atlas' analyses.

2.5 Landslide

2.5.1 Commenters

Atlas Corporation (57-11)
Utah Division of Radiation Control (58-16)

2.5.2 Summary of Issues

Atlas Corporation investigated the potential landslide hazard by preparing cross sections, reviewing the literature, consulting geologists who mapped the Moab area and made its own field observations. It concluded that the potential for landsliding in the form of block slides from Poison Spider Mesa is currently low to non-existent and that subsidence of 1 m over 1000 years will not increase the potential by concomitant steepening of the escarpment.

The State of Utah, suggested that Atlas' landslide investigation was incomplete because it did not evaluate the potential for large-scale landslides from undercutting or toppling of a large rock slab from the cliff of Poison Spider Mesa.

2.5.3 Staff Analysis of Comments

The staff has evaluated Atlas' submittals and conducted its own field investigations and concludes that the potential for landsliding at or near the site, including the potential for rock-slab sliding, is too low to be considered a design basis.

2.5.4 Revisions to the TER

A full explanation and the bases for the staff's conclusions are provided in revised Sections 2.4.2.2 and 2.5.2 of the TER.

2.6 Rock and Debris Fall

2.6.1 Commenters

Utah Division of Radiation Control (58-16)
Grand County Council by Jenner & Block (59-5)

2.6.2 Summary of Issues

Both commenters consider Atlas' analyses of rock falls and rock-slab slides inadequate and NRC staff's evaluation insufficient to assure compliance with Criteria 4(e) and 6 with regard to this admitted hazard.

2.6.3 Staff Analysis of Comments

In the staff's view, Atlas has performed an engineering analysis that adequately considers the hazard and provides reasonable assurance that its principal potentially adverse effect, clogging the southwest divergence channel, will be mitigated.

2.6.4 Revisions to the TER

Sections 2.4.2.2 and 2.5.2 of the TER have been revised to fully explain the staff's bases for its evaluation.

2.7 Geologic Model of Subsurface

2.7.1 Commenters

Utah Division of Radiation Control (58-1, 58-2, 58-4, 58-5, 58-7, 58-8, 58-9, 58-15)
Grand County Council by Jenner & Block (59-3, 59-4, 59-6)

2.7.2 Summary of Issues

The State of Utah, was concerned that discrepancies between interpretations of geologic mapping and seismic surveys have resulted in ambiguous thicknesses of Quaternary alluvium, vague location of Moab fault and West Branch fault and large uncertainty in depth to salt caprock beneath the pile (Grand County also was concerned about depth to top of the Paradox Formation). The commenter believes that such imprecision might lead to misinterpretation of areas important to subsidence calculations. The commenter requested that the subsurface be further characterized, and seismic survey-mapping inconsistencies be reconciled to resolve these discrepancies.

Grand County considered it a grave deficiency, and an impending violation of NRC staff's obligations to assure compliance with Appendix A criteria, should staff make determinations of geologic or seismic consequences without knowing with scientific certainty whether the foundation of the waste pile is bedrock or sand or if the Moab fault exists under the pile or just what are the engineering properties of the Quaternary strata in the subsurface.

2.7.3 Staff Analysis of Comments

The staff considers there is sufficient information available about the subsurface geology for it to determine sources of geologic hazard and their rates and magnitudes. Sections 2.3.2.2 and 2.4.1.2 have been revised to include full explanation of the bases for staff evaluations using data that became available after draft TER was issued. Scientific certainty about future site conditions is not a requirement for this facility's licensing recommendation. The requirement is that there be reasonable assurance that the pile will perform as needed to meet the radon release standard for 1000 years, but not less than 200 years. Atlas's design adequately mitigates the potential hazards associated with potential instabilities of the subsurface. The design appears sufficiently robust to encompass uncertainties in the geologic model.

2.7.4 Revisions to the TER

As discussed above, revisions were made to the TER discussions related to the geologic model of the subsurface.

2.8 Structural Geology and Diapirism Description

2.8.1 Commenters

U.S. Department of the Interior (56-1)
Grand County Council by Jenner & Block (59-7, 59-8, 59-9)

2.8.2 Summary of Issues

The commenters suggested that the discussion, in the draft TER, of the seismotectonic and salt tectonic history of the Moab salt-cored anticline and site structural geology was confusing. The Department of the Interior opined that at the time of final license application, (geologists) will be arguing whether the Moab fault is capable, and if not, whether diapirism or subsidence will be active in the next 200 to 1000 years.

Grand County was concerned that the staff might not be properly differentiating paleotectonic features from neotectonic features, such as capable faults. Also, the commenter believed the staff stated that diapirism may have occurred during the Quaternary and may still be occurring today. Further, the commenter requested that the staff provide a clearer understanding of diapirism, particularly in regard to its timing and possible ability to influence the vicinity of the Atlas site today.

2.8.3 Staff Analysis of Comments

There is no disagreement with the need to clarify the sections which describe the structural and salt tectonic setting and history of the site. The staff does not consider diapirism to be a design factor in future site stability.

2.8.4 Revisions to the TER

Section 2.3.3.2 has been revised to fully explain the staff's understanding of relevant structural and diapiric processes.

2.9 Topography and Geomorphology

2.9.1 Commenters

Grand County Council by Jenner & Block (59-17)

2.9.2 Summary of Issues

Grand County pointed out that staff's statement that Moab Wash captured Little Canyon Wash is incorrect, and stated that the significance of the matter was not clear. Also, the commenter implied that topographic linears described by the staff as faults should have been more appropriately described in the section on structural setting and their significance or insignificance should have been discussed.

2.9.3 Staff Analysis of Comments

The staff agrees with the comments. The suggestion that headward erosion of

Moab Wash caused the ancestral Little Canyon drainage system to have been beheaded (not captured) constitutes evidence of Tertiary to early Quaternary movement on the Moab fault (Oviatt, 1988, p. 68) was incompletely introduced in the draft TER for the then open issue of whether or not the Moab fault is a capable fault. Stream erosion history and implications for structural control by faults will not be pursued in the TER, considering that the capable fault issue is resolved. The topographic expression of faults and joints in the cliffs and rims bordering Moab Valley south of the Colorado River was incompletely developed in the draft TER for the issue of potential landslides and rock and debris falls on the north side of the river. Considering that the mass wasting issues are resolved, comparisons of geomorphic processes along the valley walls are superfluous and also need not be pursued in the TER.

2.9.4 Revisions to the TER

Sections 2.3.3.2 and 2.3.4.1 of the TER have been revised, as discussed above.

2.10 Migration of the Colorado River

2.10.1 Commenters

Grand County Council by Jenner & Block (59-18)

2.10.2 Summary of Issues

Grand County considered that the staff relied on inconclusive data to state that there is no conclusive data available which would indicate that subsidence caused by dissolution of salt affected the migration of the Colorado River in Moab Valley. The commenter implies that the conclusion is unsupported and cannot be a basis for determining compliance with applicable Appendix A standards.

2.10.3 Staff Analysis of Comments

The staff continues to stand by its statement. Nevertheless, the staff has factored into its evaluation of Atlas' design the possibility that the Colorado River will migrate toward the pile for any reason. The staff considers the pile will be adequately protected from the potential hazard.

2.10.4 Revisions to the TER

Sections 4.4.5 and 4.5.1.2.3 have been revised to more fully explain the bases of the staff's evaluation.

2.11 Specific Clarifications

2.11.1 Commenters

U.S. Department of the Interior (56-2)
Grand County Council by Jenner & Block (59-16)

2.11.2 Summary of Issues

The two commenters requested that a specific term be defined, figures and maps be used to supplement text, and specific data be provided, as follows: the Department of the Interior - define "basement-elevation-gradient;" Grand County - illustrate Moab fault description with figures and maps, provide elevations of the Colorado River and floodplain, and the toe and top of tailings pile.

2.11.3 Staff Analysis of Comments

The staff agrees with the comments and the TER will be revised accordingly. Some of the descriptive information is also in the EIS.

2.11.4 Revisions to the TER

Section 2.3.3.1 has been revised and figures 2-1 and 2-2 have been added to the TER.

2.12 Process of Resolving Issues

2.12.1 Commenters

Grand County Council by Jenner & Block (59-20)

2.12.2 Summary of Issues

Grand County cautioned NRC staff to not unjustifiably rely on unspecified and unquantified terms in making technical determinations, and not to assume that the Atlas plan will comply with Appendix A standards. For example, the commenter cited staff assumption that certain faults are likely to be bounding and assumption that the Moab fault is not a capable fault, made for the purpose of preliminarily calculating seismic hazard. Also, the commenter requested that NRC staff first remedy the deficiencies in the draft TER and only then, after performing an adequate and comprehensive analysis that shows compliance with requirements, close a geologic stability issue.

2.12.3 Staff Analysis of Comments

The staff agree with the comment. The staff has selectively revised Chapter 2 to make transparent the bases for its determinations of geologic and seismologic design inputs. However, NRC staff does not have the burden of making the licensee's case for issue resolution; therefore, the staff does not remedy deficiencies in license applications. The draft TER indicated deficiencies in the licensee's documents which precluded the staff from resolving certain geologic stability issues. Based on its review of the licensee's subsequent submittals, the staff considered all such issues resolved.

2.12.4 Revisions to the TER

All sections in the TER that dealt with draft TER open issues have been revised and the bases for staff's evaluations are provided.

2.13 Seismicity

2.13.1 Commenters

Richard L. Christie (23-1)
U.S. Department of the Interior (56-3)
Atlas Corporation (57-6)
Grand County Council by Jenner & Block (59-19, 59-20)

2.13.2 Summary of Issues

Christie questioned whether the subsurface material characteristics were considered in estimating seismic acceleration at the tailings pile.

The Department of the Interior and Grand County requested that a discussion be provided to identify where brine extraction is taking place and to discuss its implications for the Atlas site.

Grand County Council also requested that the focal depth of the earthquakes in the Colorado Plateau be clarified.

Atlas stated that enough information was submitted to NRC staff to close Open Issue 6.

2.13.3 Staff Analysis of Comments

In estimating ground acceleration the type of rock formation under the site is usually considered. For example, Boore et al (1993) divided the site geology in four classes depending on the average shear-velocity of the formations in the upper 30 m. The licensee considered Boore et al (1993), and other attenuation equations that also factored in subsurface conditions, in estimating the acceleration at the Atlas site. The staff interpreted Christie's reference to wet alluvium under the pile to be a liquefaction concern. Liquefaction is addressed in Section 3.3.3.

Regarding the issue of whether the part of the tailing pile underlain by wet alluvium would react differently due to a seismic event from that part of the tailings pile underlain by drier thinner alluvium? The staff interpreted this comment as a liquefaction comment and this was addressed under Section 3.3.3.

The staff agrees that a discussion of nearby brine extraction and its implications to the Atlas site would be useful. The staff also agrees that the discussion in the draft TER, of focal depth of earthquakes in the Colorado Plateau, could be clarified.

At the time the draft TER was prepared sufficient information was not available for the staff to make a decision on the adequacy of the Atlas tailings impoundment seismic design. Subsequently, Atlas submitted additional information on the geology and seismology of the area. The staff evaluated this information and the adequacy of the seismic design and now concludes that Open Issue 6 is resolved.

2.13.4 Revisions to the TER

Section 2.3.5 has been revised to include discussion of brine extraction and clarification of focal depth. Section 2.4.3 has been revised to explain the basis for the staff's conclusion that the seismic design is adequate.

3.0 GEOTECHNICAL STABILITY

3.1 Capability of Embankment Slopes to Endure Effects of Seismic Events

3.1.1 Commenters

Atlas Corporation (57-7)

3.1.2 Summary of Issues

Atlas commented on the capability of the embankment slopes to endure the effect of seismic forces to which they may be subjected (Open Issue 8). Atlas stated that this issue is tied to resolution of Open Issue 6, seismic design peak acceleration. Atlas stated that it has shown that the disposal cell slopes will maintain their integrity at accelerations of 0.25g or less.

3.1.3 Staff Analysis of Comments

Staff agrees that Atlas has demonstrated that the embankment will meet the seismic stability requirements using approved methodology. Open Issue 8 is resolved.

3.1.4 Revisions to the TER

Section 3.3.1 of the TER has been revised to show that slopes will be stable under the design acceleration.

3.2 Liquefaction Potential of Embankment

3.2.1 Commenters

Atlas Corporation (57-8)
Utah Division of Radiation Control (58-18)

3.2.2 Summary of Issues

Both Atlas and the State of Utah commented on the potential for liquefaction of the embankment. Atlas was of the opinion that the potential for liquefaction damage was "vanishingly small" based on work performed by its consultant, Woodward-Clyde. The State of Utah noted that, if liquefiable soils were clustered in a general location, they could pose a local hazard to the final design.

3.2.3 Staff Analysis of Comments

The staff agrees with Utah on the potential for local clusters of liquefiable soils to present a settlement problem which could, in turn, affect the

integrity of the radon barrier. The licensee has addressed that potential in its more recent submittals. Based on its review of the licensee's analysis, the staff concluded that there is adequate assurance of safety with respect to liquefaction damage.

3.2.4 Revisions to the TER

Section 3.3.3 of the TER has been revised and expanded to explain how this issue was resolved.

3.3 Construction Specifications/Field Testing Requirements

3.3.1 Commenters

Atlas Corporation (57-14 and 57-16)
Utah Division of Radiation Control (58-21)

3.3.2 Summary of Issues

Atlas stated that the lack of construction specifications was a procedural implementation issue. Atlas further noted that submittals which had been superseded by later submittals was also a matter of procedural implementation. Atlas commented that a field testing program would be provided and that construction specifications would be provided upon resolution of open issues. Atlas further committed to providing a consistent set of construction documents.

The State was concerned that compaction specifications had not been provided for the sandy soil or the radon barrier material, and that field density values were uncertain.

3.3.3 Staff Analysis of Comments

As documented in the TER, the licensee has provided an acceptable set of technical specifications and testing programs addressing the issues in later submittals.

3.3.4 Revisions to the TER

Section 3.4 of the TER has been revised to discuss the licensee's technical specifications and testing program.

3.4 Lift Thickness, Long-term Moisture Content, and Desiccation of Clay Layer

3.4.1 Commenters

Atlas Corporation (57-15)
Utah Division of Radiation Control (58-22 and 58-23)
Grand County Council by Jenner & Block (59-30)

3.4.2 Summary of Issues

Atlas commented on the proposed 18-inch-thick lifts, stating that it is a construction issue that will be addressed in the technical specifications. The State of Utah expressed a concern that moisture retention testing had not been conducted, and that the radon barrier would be subject to excessive desiccation due to its composition and thickness. Grand County Council stated that an 8- to 12-inch-thick clay soil cover above the tailings was inconsistent with requirements for Title I sites.

3.4.3 Staff Analysis of Comments

In the technical specification, the licensee has committed to place the clay layer in acceptably thin lifts. One lift of soil will be placed where an eight-inch final layer is required. Two uniform lifts will be placed when a 12-inch final layer thickness is required. The staff concludes that this is acceptable based on standard practice and experience. Since desiccation would not be unexpected within 48 hours, steps will be required to prevent soil desiccation, and/or to recondition areas which become overly dry. Staff does not agree that DOE was "required" to construct soil covers greater than 8 to 12 inches at Title I sites. In some cases, DOE may have elected to construct thicker fill layers. Atlas is responsible for providing an acceptable design independent of design details from Title I projects.

3.4.4 Revisions to the TER

Section 3.4 of the TER has been revised. The TER references technical specifications proposed by Atlas which address issues of lift thickness and desiccation.

3.5 Radon Barrier Permeability

3.5.1 Commenters

Utah Division of Radiation Control (58-19)
Grand County Council by Jenner & Block (59-29)

3.5.2 Summary of Issues

The State of Utah expressed concern regarding the lack of a specified permeability for the radon barrier. Utah requested that field testing to confirm a design value should also be conducted. Grand County Council stated that NRC should require the saturated hydraulic conductivity of the radon/infiltration barrier to be no greater than 10^{-7} cm/sec, which Grand County Council believes to have been a requirement at Title I sites. Grand County Council believes that NRC has not imposed strict hydraulic testing requirements on Atlas.

3.5.3 Staff Analysis of Comments

Field testing may not be required if Atlas can adequately demonstrate that the design permeability is attainable in the field. The use of a design permeability value of 10^{-7} cm/sec is not a requirement at Title I sites;

however, the 10^{-7} cm/sec value has been used at a number of sites. Subsequently, Atlas committed to use a design permeability value of 10^{-7} cm/sec. Atlas will be required to perform field verification tests of the barrier permeability if it cannot adequately confirm that the design permeability is readily attainable.

3.5.4 Revisions to the TER

No revisions were made to the TER.

3.6 Frost Penetration of Radon Barrier

3.6.1 Commenters

Utah Division of Radiation Control (58-20 and 58-21)
Grand County Council by Jenner & Block (59-31)

3.6.2 Summary of Issues

The State of Utah commented that the Berggren frost depth prediction model is sensitive to moisture content and other factors. The State expressed concern that input parameters came from uncompacted native soils and not final engineered materials. The State of Utah expressed concern that Atlas failed to utilize 106 years worth of climatic data for the Town of Moab in its analysis. Further, the State of Utah was concerned that soil moisture content values used by Atlas may not be representative of the soils to be used in the engineered cover. Utah noted that compaction specifications were not required. Finally, the State of Utah noted that Atlas has not conducted moisture retention testing of soil proposed for the clay radon barrier.

Grand County Council stated that NRC's requirements for frost protection at the Atlas site differ significantly from those specified at Title I sites. Grand County Council believes that NRC is not requiring Atlas to provide sufficient and conservative frost protection.

3.6.3 Staff Analysis of Comments

Atlas submitted frost protection calculations prepared in a similar manner to those at Title I sites. Based on its experience in previous reviews, and considering the conservatism and redundancy in design, the staff concluded that the additional historical data will not significantly affect the design, nor will the predicted frost penetration depth vary substantially. The compaction specifications proposed by Atlas are consistent with the design and sufficient to assure adequate resistance to detrimental freeze-thaw of the radon barrier. The staff also concludes that the Atlas frost protection design is comparable to NRC-approved Title I designs.

3.6.4 Revisions to the TER

No revisions were made to the TER.

3.7 Groundwater Fluctuations

3.7.1 Commenters

Grand County Council by Jenner & Block (59-22, 59-27)

3.7.2 Summary of Issues

Grand County Council stated that NRC staff has failed to require Atlas to conduct any groundwater fluctuation studies as part of its geotechnical investigation. For this reason, Grand County Council believes that NRC's analysis is incomplete. Grand County Council also believes that NRC has failed to consider groundwater fluctuations with respect to embankment slope stability.

3.7.3 Staff Analysis of Comments

NRC considered extensive groundwater fluctuations with respect to slope stability of the embankment. The slopes were found to be stable with groundwater elevated to full flood level.

3.7.4 Revisions to the TER

No revisions were made to the TER.

3.8 Steepness of Side Slopes

3.8.1 Commenters

Grand County Council by Jenner & Block (59-24, 59-25)

3.8.2 Summary of Issues

Grand County Council stated that Atlas' embankment slopes are planned to be steeper than regulatorily-permitted. Grand County Council believes that the slopes may not be constructible and/or that active maintenance would be required.

3.8.3 Staff Analysis of Comments

The planned slopes meet the requirements of 10 CFR Part 40, Appendix A. Criterion 4 of the Code section states that, when slopes are steeper than 5h:1v, "...reasons why a slope less steep than 5h:1v would be impracticable should be provided, and compensating factors and conditions which make such slopes acceptable should be identified." Atlas' design includes slopes as steep as 10h:3v because of limitations of available land. The staff concludes that it would be impracticable to flatten those slopes. Extensive experience with earth construction, and review of analyses performed by Atlas' consultants confirms that the design is acceptable and constructible. The staff also concludes that the proposed slopes will not require active maintenance. Design side slopes were determined to be stable and in compliance with the requirements of 10 CFR Part 40.

3.8.4 Revisions to the TER

No revisions were made to the TER.

3.9 Stability of the Embankment

3.9.1 Commenters

Grand County Council by Jenner & Block (59-23)

3.9.2 Summary of Issues

Grand County Council believes that NRC is not demanding strict compliance with regulations requiring the licensee to demonstrate the waste pile's ability to withstand construction activity. Grand County Council believes that Atlas has failed to assess completely the geotechnical stability of the tailings pile in its present configuration.

3.9.3 Staff Analysis of Comments

Based on work performed to date at the Atlas site, and experience with numerous other sites, the staff concludes that the embankment will be able to withstand the proposed construction activity. The licensee has shown, using reasonable engineering judgement and numerical analyses, that the embankment is stable in its present configuration, and that the proposed embankment will be further stabilized. Atlas' methodology is consistent with that applied by other Title II licensees. Despite the foregoing, Atlas has committed to perform additional testing to further confirm embankment stability assumptions.

3.9.4 Revisions to the TER

The TER has been modified (sections 3.2.2.1 and 3.2.2.3) to indicate that the licensee will perform confirmatory tests prior to approval of the settlement evaluation.

3.10 Clay Cover on Side Slopes

3.10.1 Commenters

Grand County Council by Jenner & Block (59-26)

3.10.2 Summary of Issues

Grand County Council notes that Atlas has no plans to place a clay cover on the sideslopes.

3.10.3 Staff Analysis of Comments

There is no design or regulatory requirement to place clay on sideslopes.

3.10.4 Revisions to the TER

No revisions were made to the TER.

3.11 Settlement and Cover Cracking

3.11.1 Commenters

Utah Division of Radiation Control (58-14)
Grand County Council by Jenner & Block (59-28)

3.11.2 Summary of Issues

The State of Utah believes that Atlas' January 1996 report prepared by its consultant, Woodward-Clyde did not adequately evaluate the modes of surface disturbance that could impact the embankment. Utah stated that additional settlement analyses should be performed. Grand County Council expressed concern that Atlas has failed to consider the potential of the embankment to settle excessively.

3.11.3 Staff Analysis of Comments

Atlas' consultants performed additional reviews to examine potential settlement and modes of failure related to subsurface disturbance. Atlas has committed to perform settlement monitoring in a manner consistent with that approved by NRC for other Title II sites. Atlas has further stated that it will perform characterization of the embankment soils with respect to settlement.

3.11.4 Revisions to the TER

Section 3.3.5 of the TER has been revised accordingly. Sections 3.2.2.1 and 3.2.2.3 of the TER have been modified to indicate that the licensee will submit a characterization/testing plan for approval, and that an approved settlement monitoring plan will be carried out.

3.12 Riprap Borrow Materials

3.12.1 Commenters

Grand County Council by Jenner & Block (59-21)

3.12.2 Summary of Issues

Grand County Council stated that NRC staff's discussion of the investigation of borrow areas does not include any reference to the riprap borrow materials.

3.12.3 Staff Analysis of Comments

Sources of riprap borrow are discussed in TER section 4.5 and in the EIS. The licensee must provide materials meeting the design requirements.

3.12.4 Revisions to the TER

No revisions were made to the TER.

3.13 Incomplete Settlement Analysis

3.13.1 Commenters

Atlas (57-13)
State of Utah (58-14)

3.13.2 Summary of Issues

Atlas discussed open issue no. 7 (additional tailings characterization). Atlas stated that the lack of a field testing plan at that time did not implicate the underlying technical suitability of the reclamation plan design. The State of Utah questioned the January 29, 1996, Woodward-Clyde shear strain analysis. It was the State's contention that such an approach cannot adequately evaluate the type of surface disturbance that could impact the pile.

3.13.3 Staff Analysis of Comments

Atlas has completed additional studies which address the various modes of settlement to which the embankment may be subject. The Woodward-Clyde analyses indicate that a buried scarp would not adversely affect settlement of the embankment. Based on its review of the analyses performed by Woodward-Clyde, which examined various potential failure modes, the staff concludes that the embankment will be capable of resisting such extreme conditions.

3.13.4 Revisions to the TER

A new section, 3.3.5, addressing the stability of the pile with respect to subsidence, was added to the TER.

4.0 SURFACE WATER HYDROLOGY AND EROSION PROTECTION

4.1 Design of Rock Apron

4.1.1 Commenters

Richard L. Christie (23-2)
Utah Division of Radiation Control (58-24)
Grand County Council by Jenner & Block (59-39)

4.1.2 Summary of Issues

Christie and the Grand County Council questioned the ability of rock apron to be effective if the Colorado River migrates toward the pile.

The State of Utah indicated that details of the rock wall transition area at the pile should be included in the engineering plan.

4.1.3 Staff Analysis of Comments

The staff has carefully evaluated the design of the rock apron that will provide the ultimate protection against erosion if the Colorado River channel erodes and migrates to the tailings pile. The staff recognizes the importance of this structure and has conservatively evaluated its design in several areas.

First, the design is based on procedures developed by the U. S. Army Corps of Engineers (COE). The COE relies on fundamentally sound, published, and peer-reviewed techniques. In addition, COE designs are field tested and model tested in their extensive research facility at the Waterways Experiment Station in Vicksburg, Mississippi. The COE's detailed design procedures are published in "Toe Scour and Bank Protection Using Launchable Stone," dated September, 1995. The design of the Atlas rock apron conforms to the suggested methods in this report. Second, the size of the rock to be provided in the apron area is larger than needed to resist flow velocities in the Colorado River. Since the design is based on flows down the slope, the overdesign of the rock for flows along the slope provides an added measure of conservatism. Third, the staff has conducted flume studies at Colorado State University for design of erosion protection to prevent gully intrusion by providing rock aprons for collapse into eroded areas. The results of these tests indicate that collapsible rock is an effective method for providing adequate erosion protection. Staff contractors have personally visited several locations where such designs have been implemented. The designs appear to be functioning appropriately.

Atlas provided details of the design of the transition area discussed in the comment. Revised detailed drawings were submitted by Atlas.

4.1.4 Revisions to the TER

Revisions have been made to the TER to reflect that the design of the apron meets criteria developed by the U. S. Army Corps of Engineers (COE); the COE reference was added.

4.2 Moab Wash Erosion Protection Design

4.2.1 Commenters

Richard L. Christie (23-3)
U.S. Department of the Interior (56-5, 56-6, 56-7, 56-9, 56-14)

4.2.2 Summary of Issues

The commenters questioned the design of the erosion protection to be provided for Moab Wash, immediately adjacent to the reclaimed embankment.

Christie requested clarification of the use of average scour depths for determining the depth of placement of the rock toe.

The Department of the Interior questioned if sediment loads and sedimentation

had been considered in the design of the Moab Wash erosion protection. The commenter was very concerned about debris flows and debris flow hazards in those areas where likely deposits would occur in the Moab Wash Channel. The commenter also suggested that floods smaller than the PMF should be addressed in the design. The commenter also requested that water surface profile data for Moab Wash should be included in the TER. The commenter suggested than both subcritical and supercritical profiles be modelled and the data included in the TER. The commenter also indicated that complete avulsion of the Moab Wash channel was a possibility because of the potential of 100-200% blockage of the channel.

4.2.3 Staff Analysis of Comments

The staff agrees that the use of "average" depths of scour is confusing. The intent of the statement was to indicate that Atlas had used several methods to predict the depth of scour and that the depth of scour used in the design was based on the use of several methods.

As discussed in the TER, the design of the erosion protection for Moab Wash is based on several factors. All of these design considerations were carefully evaluated, and a conservative overall design was found acceptable by the staff for the final configuration of the erosion protection.

The area of Moab Wash adjacent to the tailings pile consists of alluvial material deposited over many years. This area is subject to changes during the occurrence of a flood. The staff recognized the problems associated with this area and requested Atlas to provide a design to accommodate potential channel avulsion, erosion, debris flows, deposition, and/or other phenomena.

The staff and Atlas recognized the difficulties associated with quantifying the amount of sedimentation or predicting the exact position of the Moab Wash channel during a major flood. To assure that the reclaimed pile would not be affected, the licensee assumed that debris/sediment deposition would occur near the pile and that erosion/avulsion of the channel would occur during the PMF. Atlas further assumed that the worst erosion conditions would exist immediately adjacent to the toe of the pile.

The design for protection of the pile includes a large riprap toe constructed to a depth of 7-8 feet. The toe will not be undermined by erosion during an occurrence of the PMF and is designed for both supercritical (worst case) and subcritical flows. Smaller floods would have lesser flow velocities and were not considered in the design. Flow profiles and velocity data may be found in the reclamation plan submitted by Atlas.

4.2.4 Revisions to the TER

Reference to average scour depths was removed from the TER.

No other significant revisions were made to the TER regarding the design of the Moab Wash erosion protection.

4.3. Colorado River Flooding

4.3.1 Commenters

U.S. Department of the Interior (56-8)

4.3.2 Summary of Issues

The Department of the Interior suggested that water surface profile data for the 100-year flood on the Colorado River be provided in the TER.

4.3.3 Staff Analysis of Comments

Water surface profile data was provided in the TER. The TER indicates the water surface elevation of the 100-year flood in the vicinity of the tailings pile. Additional information can be found in the Atlas reclamation plan regarding this flood profile and other profiles at various locations in the site area.

4.3.4 Revisions to the TER

No revisions were made to the TER as a result of this comment.

4.4 Colorado River Migration

4.4.1 Commenters

U.S. Department of the Interior (56-10, 56-11, 56-12, 56-13)
Grand County Council by Jenner & Block (59-37, 59-38)

4.4.2 Summary of Issues

Commenters were concerned about the potential migration of the Colorado River toward the pile over a period of 200-1000 years.

The Department of the Interior was concerned about recirculation eddies that could cause redistribution of bank material, such that the river would migrate toward the pile. The commenter also disagreed with the statement that velocities of 7 feet per second are not extremely erosive. The commenter indicated that the mid-channel bar is an indication of deposition in a river reach, but does not indicate that the entire river reach is depositional. The commenter noted that because of the uncertainties associated with river migration, erosion protection to cope with such an occurrence is important.

Grand County Council indicated that evidence exists that the Colorado River has migrated over the last 20 years and that such evidence contradicts NRC conclusions regarding the migration of the river. The commenter suggested that the NRC staff should require Atlas to move the pile, because the staff required all Title I sites in floodplains to be moved.

4.4.3 Staff Analysis of Comments

As discussed in the TER, the staff concludes that there is a potential for the

Colorado River to migrate towards the pile in a period of 200-1000 years, even though this migration is unlikely. To prevent erosion of the tailings, a large rock apron will be provided along the toe of the pile. Due to the effectiveness of rock aprons (as documented by the Corps of Engineers) and the conservatisms associated with the overall erosion protection design, the staff did not consider it necessary to evaluate all erosion mechanisms. Rather, staff relied on geomorphic information which indicated the low probability of erosion and on documented design methods by other Federal agencies.

Staff evaluation of river velocities in the site area indicates that the maximum average channel velocity will be about 7 feet per second (fps). This velocity is not considered to be extremely erosive on the banks of the Colorado River, principally because peak velocities usually occur in the center of channels of large rivers where the depth is greatest and do not occur along the channel bottom or channel banks. Thus, the velocity will be much less along the river's edge. Further, because the depth of flow in the channel is so large, the actual velocity immediately at the water/soil interface along the banks will be lower than 7 fps. Additional information on velocity profiles, velocity distributions, and velocity/depth relationships may be found in Chow's Open Channel Hydraulics, referenced in the TER.

NRC staff did not require DOE to move Title I sites from floodplains. It is the opinion of the staff that several of these piles could have been stabilized in place, if DOE had chosen to do so. The decision to move the piles was made by DOE, and a number of factors were considered, some of which were not related to flooding and erosion.

4.4.4 Revisions to the TER

The reference used to design the rock apron was added to the TER.

4.5 Landslides

4.5.1 Commenters

Atlas Corporation (57-12)

4.5.2 Summary of Issues

Atlas addressed the current open issue related to landslides by indicating that the diversion channel has been overdesigned to accommodate such an event.

4.5.3 Staff Analysis of Comments

Based on staff review of the licensee analyses, the staff agrees that an acceptable design has been provided.

4.5.4 Revisions to the TER

Changes were made to the TER to reflect staff review of the revised analyses and the staff's agreement with the acceptability of the design.

4.6 Submittal of Updated Design and Technical Specifications

4.6.1 Commenters

Atlas Corporation (57-17)

4.6.2 Summary of Issues

Atlas indicated that submittal of an updated design and technical specifications to address NRC staff concerns is a procedural issue and does not compromise the technical suitability of the design.

4.6.3 Staff Analysis of Comments

The licensee provided the design details, as requested.

4.6.4 Revisions to the TER

Changes were made to the TER to indicate that the information was reviewed and approved by the staff.

4.7. Riprap Sources

4.7.1 Commenters

Utah Division of Radiation Control (58-25)
Grand County Council by Jenner & Block (59-40)

4.7.2 Summary of Issues

Commenters indicated that locations of the sources of rock riprap for the erosion protection design should be provided in the EIS and TER.

4.7.3 Staff Analysis of Comments

As discussed in section 4.5.3, Atlas identified the locations of several sources of riprap in a submittal to NRC dated November 19, 1996. Discussion related to the environmental aspects of the riprap sources will be in the FEIS.

4.7.4 Revisions to the TER

Several changes were made to the TER regarding riprap to be used by the licensee for erosion protection.

4.8 Basis for Flood Protection Design

4.8.1 Commenters

Grand County Council by Jenner & Block (59-32, 59-33, 59-34, 59-35, 59-36)

4.8.2 Summary of Issues

Grand County Council indicated that the PMP and PMF were not adequately analyzed in the staff's review of the flood protection design for the site. The commenter was concerned that the mere use of low probability events does not necessarily establish adequate design bases, because numerous events have occurred which approach the magnitude of the PMP or PMF. The commenter asserted that the flood protection design must be sufficient to withstand the PMP and PMF, because of the catastrophic nature of these events. The commenter further indicated that the staff had not adequately analyzed the water surface profiles and channel velocities. The commenter also indicated that evaluation of erosional stability should have included analysis of floods ranging in magnitude between 70,000 cfs and 178,000 cfs, because a flood in this range could be the critical design event. The commenter argued that overbank velocities were underestimated and that roughness coefficients were not properly selected. The commenter suggested that the proper flow regime had not been modelled and that the HEC-2 model was not properly used.

4.8.3 Staff Analysis of Comments

The erosional stability of the pile was analyzed by Atlas and the staff, using the most critical flood events. Staff review of design-basis flood events is carefully detailed in the TER, and the staff concludes that the flood design bases are conservative.

4.8.4 Revisions to the TER

No revisions were made to the TER as a result of these comments.

4.9 Constructability and Durability of Riprap

4.9.1 Commenters

Grand County Council by Jenner & Block (59-41, 59-42)

4.9.2 Summary of Issues

Grand County Council indicated that a 4-inch layer of rock with an average diameter of 1.3 inches could actually be very difficult to construct, and that 6 inches was the minimum thickness provided at Title I sites. The commenter was also concerned that rock with a durability score of 50-65 could be used at the Atlas site, when rock of this quality had not been used at Title I sites.

4.9.3 Staff Analysis of Comments

Relatively thin (4 to 6 inches) layers of rock riprap have been successfully constructed at other Title II sites. The staff reviewed the licensee's construction specifications and testing plans to ensure that they were adequate to achieve similar (and proper) results. Based on that review, the staff concludes that the testing program is equivalent to other programs that have been successfully implemented and is acceptable for providing adequate rock layers.

Atlas may use rock that scores 50-65, even though rock of such quality has not been used at any Title I sites. Atlas has committed that the rock selected will meet applicable NRC criteria, regardless of the source chosen.

4.9.4 Revisions to the TER

No revisions were made to the TER as a result of these comments.

4.10 Biointrusion

4.10.1 Commenters

Grand County Council by Jenner & Block (59-64)

4.10.2 Summary of Issues

Grand County Council indicated that vegetation, particularly tamarisks, could invade the pile and disrupt the riprap cover.

4.10.3 Staff Analysis of Comments

The staff does not believe that the erosion protection design will be significantly altered by tamarisk or other vegetative growth. Tamarisks generally prefer wetter areas; the pile top and side slopes will be well-drained and relatively dry. Even if some vegetative growth occurred through the rock, the function of the riprap layer would not be significantly impaired.

4.10.4 Revisions to the TER

No revisions were made to the TER as a result of this comment.

5.0 WATER RESOURCE PROTECTION

5.1 Groundwater Protection Standards and Regulatory Requirements

5.1.1 Commenters

Atlas Corporation (57-18, 57-19)
Utah Division of Radiation Control (58-36, 58-42, 58-49, 58-50, 58-51, 58-52, 58-53, 58-54, 58-55, 58-56, 58-57, 58-58, 58-59, 58-60, 58-61, 58-62)
Grand County Council by Jenner & Block (59-45, 59-50, 59-52, 59-53, 59-54)

5.1.2 Summary of Issues

The commenters addressed issues pertaining to four areas in the regulatory requirements: Water resources protection standards; performance assessment; and groundwater monitoring requirements; and groundwater corrective action and cleanup requirements. The specific issues raised are discussed separately for each of these aspects in the following paragraphs.

Groundwater Protection Standards. The State of Utah commented that water resource protection standards need to be established for the site, considering both groundwater and surface water uses. It was indicated that analysis of surface seeps along the Colorado River have identified non-radioactive constituents that are not subject to monitoring pursuant to the current license and that the concentrations of such constituents are above State standards. The commenter stated further that the tailings should be analyzed for all constituents, and that the TER should provide a comparison of average constituent concentrations in the tailings to the corresponding MCL or health based standards. It was indicated that the groundwater protection standards in the DTER should be revised based on resolution of the background groundwater quality issue, and re-established in coordination with the State of Utah before approving the site reclamation plan. Utah requested that standards for non-radioactive constituents as well any ACL standards be established in consultation and/or coordination with the State of Utah so that dual regulations can be avoided. It was further stated that language in the current license does not require Atlas to return the concentrations of constituents to specified standards, nor does it specify a time limit on when the standards will have to be complied with.

Performance Assessment. The State of Utah indicated that a performance assessment needs to be performed because the licensee is taking credit for the cover design. The commenter stated that Atlas should be required to provide a quantitative evaluation of the final cover performance, before approving the site reclamation plan. The evaluation should use representative or conservative infiltration and contaminant transport models.

Groundwater Monitoring Requirements. The State of Utah cited what it believed to be inadequacies in the groundwater monitoring program that need to be corrected, including: (1) constituents found in the tailings solution that were not included in the detection monitoring program as required by the regulations; (2) suspect tailings contaminants that may have been mistakenly disregarded and excluded from monitoring as a result of using inadequate analysis methods including the use of high detection limits; (3) constituents not specified in Criterion 13, but that have health impacts and must be regulated; (4) the number of constituents monitored and the constituents for which compliance standards needed to be established were reduced without justification; (5) corrective action monitoring required by the regulations is not documented in the project file; and (6) Atlas's monitoring to date cannot ascertain with assurance the effectiveness of corrective action.

Utah requested that NRC require Atlas to re-evaluate and revise the current groundwater monitoring program to remedy the above inadequacies. It was indicated that the licensee should be required to periodically monitor groundwater for all contaminants originally tested in the tailings effluent, so that retarded contaminants latently released from the tailings are not missed by detection monitoring. The commenter stated that constituents not specified in Criterion 13 must be included in the monitoring program to ensure that they are not a threat to the water quality in the Colorado River.

Both Utah and Grand County Council remarked that the monitoring wells may not have been properly constructed. Utah indicated that the monitoring wells should be designed and installed in conformance with the EPA's RCRA

Groundwater Technical Enforcement Guidance, and that existing wells should be evaluated to determine if they meet such standards, and should be replaced if they do not.

Atlas noted that the tailings solution was tested for all constituents in Criterion 13 of Appendix A, and that groundwater contamination at the site has been characterized and hazardous constituents have been identified through onsite monitoring as required by the license and NRC guidance.

Groundwater Corrective Action and Cleanup Requirements. Utah indicated that the groundwater CAP needs serious revisions, and that the current license does not require Atlas to return the concentrations of constituents to specified standards, nor does the license specify a time limit on when the standards will have to be complied with. The commenter noted also that corrective action to comply with the groundwater protection standards are no longer enforced by NRC, that groundwater quality has been deteriorating and the standards have been exceeded by several orders of magnitude in some compliance wells. Commenters stated that tailings reclamation will not restore groundwater quality in the site area for centuries.

Utah requested that NRC require Atlas to re-evaluate and revise the current groundwater CAP, revise the license to reinstate the compliance requirement consistent with the provisions of Criterion 5D of Appendix A, and to enforce corrective action measures to restore groundwater quality in the site area without delay. It was stated further that the hazardous constituents and groundwater protection standards for the facility should be re-established, in cooperation with the State of Utah, before approving the site reclamation plan.

In addition, Utah noted that Atlas did not adequately monitor contaminant transport in the groundwater offsite, particularly to the north and south of the tailings including the shallow bedrock aquifer in the Arches National Park, and that such contamination should be investigated by installation of additional monitoring wells including offsite monitoring wells, and that groundwater monitoring and corrective action plan should be modified if groundwater contamination in these areas is confirmed.

Grand County Council commented that the NRC staff is obligated to study the full hydrology of the Atlas site and to evaluate the impact of Atlas's reclamation plan on water resources, before approving the site reclamation plan. The commenter indicated that the NRC staff review of the groundwater CAP is inadequate, and the staff improperly separated an analysis of groundwater impacts and surface remedial action. The commenter indicated that NRC policies allow Atlas to defer implementation of the groundwater cleanup, but there is no statutory, regulatory or other authority permitting the NRC to defer data collection and analysis to evaluate the impact of the tailings pile on water resources; and that such impacts should be analyzed before the surface reclamation plan is approved. It was stated that analyzing the impacts may result in improving the surface reclamation plan; and severing the water quality issues violates NRC's regulations and policies and makes it virtually impossible to thoroughly evaluate the remaining site reclamation criteria.

Grand County Council noted further that the DTER is not consistent with the SRP guidelines in that it does not show that deferring the groundwater cleanup to a later project phase will not impact human health or the environment; in addition, deferring the groundwater cleanup will interfere with characterization of background groundwater quality, the leachate, and the extent and transport of contamination from the tailings to the groundwater or surface water.

Grand County Council also remarked that the staff has accepted Atlas's conclusion that the only acceptable corrective action is to construct a tailings cover and let the pile leak indefinitely. The commenter pointed out that the DTER did not explain how the cost-benefit analysis to evaluate corrective action alternatives was conducted, that the staff did not have the information needed to conduct the analysis, and that such analysis may not have been conducted.

Grand County Council asserted that a full public evaluation of the corrective action plan is necessary, and that compliance with the groundwater protection standards should be made a part of the public review of the TER.

Atlas noted that the tailings solution was tested for all constituents in Criterion 13 of Appendix A, and, as of 1993, only 5 constituents exceed the site-specific standards established for the site by NRC.

Atlas added that the site reclamation plan and groundwater CAP must be performed sequentially, that a groundwater protection and treatment plan is addressed in a previous CAP submittal by Atlas, and that additional corrective action requirements will be a function of whether or not the tailings are reclaimed in place. Atlas asserted that the final CAP cannot be selected or implemented until the decision is made on the site reclamation plan.

5.1.3 Staff Analysis of Comments

<u>Groundwater Protection Standards</u>. The groundwater protection standards in the Atlas License were established according to the applicable regulations in 10 CFR Part 40, Appendix A. The standards contained in the NRC regulations conform to standards promulgated by the U.S. Environmental Protection Agency (EPA). Judicial review by Federal Court found that the EPA standard met the Federal legislative mandate for protection of groundwater. Because NRC's requirements conform to the EPA standards, the NRC requirements also meet the Federal legislative mandate, and, therefore, provide adequate health and safety within the meaning of the Atomic Energy Act of 1954, as amended.

The NRC recognizes that there are significant differences between the regulatory programs implemented by the State of Utah and the NRC. There are many aspects of the State of Utah requirements, such as surface-water standards, where the NRC does not have statutory responsibility. In addition, there are many other areas of groundwater protection where the NRC may not need to implement requirements as restrictive as those implemented by the State of Utah to provide adequate protection of public health and safety. In implementing its regulatory program, NRC takes into account the ultimate use of contaminated groundwater. In some cases, groundwater may not be drinking-water quality, and as such, NRC may exercise regulatory discretion regarding

what actions licensees need to take to meet the regulations. The State of Utah, on the other hand, views all groundwater as potential drinking water, and occasionally may require regulatory actions that go beyond NRC regulations.

The NRC notified Atlas Corporation by letter dated July 11, 1996 that a revision to the current groundwater Corrective Action Plan (CAP) is needed to make the CAP more effective. NRC also recognizes that a revision to the CAP would incorporate alternative concentration limits (ACLs) for some constituents, in accordance with NRC regulations. Under the guidance provided in the "Staff Technical Position on Alternate Concentration Limits for Title II Uranium Mills," an ACL must be shown to be as low as reasonably achievable (ALARA) and the constituent's concentration is not likely to increase in the future. These two considerations will lead the staff to look very carefully at the infiltration barrier alternatives and require performance assessments of the alternatives. Any necessary revisions to the groundwater monitoring program at the site would be best addressed in conjunction with revisions to the CAP.

Both NRC and Atlas recognize that the current CAP must be revisited and potentially revised. NRC considers revisiting the CAP as a separate licensing action, because the groundwater cleanup strategies and methodologies will be contingent on the decision for surface reclamation of the tailings. The CAP currently being implemented by Atlas was based on the conclusion that existing groundwater contamination was not amenable to active remediation. If groundwater remediation is determined practicable, as a result of NRC's revisiting the CAP, then resulting environmental impact to the Colorado River will be less than that already identified in the EIS. NRC considers that deferring potential revisions of the CAP is appropriate, given the limited environmental impact identified and that a definitive risk to public health and safety from contamination of groundwater has not been demonstrated.

Performance Assessment. In the July 11, 1996 letter, staff notified Atlas Corporation that additional design considerations for the tailings impoundment could be required for implementing an acceptable groundwater cleanup program if on-site stabilization of the tailings pile is found acceptable. In particular, an evaluation of the disposal cell's cover performance for limiting infiltration would be an integral part of the staff's review of a proposed ACL and revised Corrective Action Plan. The staff views the cover performance as a key factor for demonstrating that a proposed ACL would be as low as reasonably achievable and groundwater concentrations would be unlikely to increase in the future.

The licensee agreed, in a letter dated August 7, 1996, to thoroughly evaluate infiltration barrier alternatives as part of revising the CAP. Atlas further indicated that once on-site stabilization was found acceptable, adequate time would be available to incorporate any design changes resulting from the CAP review, without delaying the construction schedule. Atlas also committed to delaying the installation of the radon/infiltration barrier, if necessary, to assure that any potential design changes could be included in the disposal cell. Staff considers that appropriate construction control and field testing would be required to verify that the constructed cover met the design specifications.

An assessment of various design alternatives and their performance for limiting infiltration will be considered as part of the revised CAP review.

Groundwater Monitoring Requirements. Groundwater monitoring requirements, potential impacts to adjacent properties, and compliance with NRC groundwater protection standards will be closely evaluated as a part of the revised CAP review. As discussed in the previous comment response, the NRC recognizes that there are significant differences between the regulatory programs implemented by the State of Utah and the NRC. Routine monitoring of all constituents of concern may not be necessary at the Atlas site, because: (1) corrective actions generally in practice at mill sites are designed to restore groundwater quality for all constituents; and (2) the licensee will be required to demonstrate compliance with all applicable NRC regulations, including compliance with the standards of all constituents of regulatory concern that are currently in the regulations or license and in the tailings liquor, before the license is terminated and the site transferred to the State or DOE for perpetual care.

Monitoring well construction: The background and point-of-compliance wells currently monitored at the site were installed in 1988 under NRC approval (by letter dated June 15, 1988). The wells are constructed of PVC casing and slotted screen, with filter sand surrounding the screen and a bentonite seal placed above the filter sand. The remaining annular space above the bentonite seal to the surface is filled with a cement-bentonite grout. The wells are installed to depths ranging from 50 to 57 feet within the freshwater portion of the alluvial aquifer and screened from a depth starting at about 10 to 30 feet to the 50- to 57-foot depth. The screen lengths were designed to intercept the vertical extent of the potential contaminant pathway. The materials and construction practices used on the background and point-of-compliance wells are generally consistent with the guidance provided in EPA's RCRA Ground-Water Monitoring Technical Enforcement Guidance Document (TEGD).

Staff has previously considered EPA's TEGD generally acceptable for use at NRC-licensed facilities, even though the document is specific to EPA's RCRA program. However, staff recognizes that some site-specific circumstances at NRC-licensed facilities may require alternative procedures to those specified in EPA's TEGD in order to meet NRC license requirements.

Staff considers that monitoring at additional locations may be necessary to support a revised CAP or verify that adjacent properties have not been impacted by contamination groundwater from the site.

Groundwater Corrective Action and Cleanup Requirements. Comments noted. NRC notified Atlas by letter dated July 11, 1996 that a revision to the existing CAP would be needed. Staff also identified the need for additional evaluation of potential groundwater impact in section 5.2.5 the TER. Historical and current groundwater monitoring data at the site show that groundwater quality has been improving over time by virtue of Atlas ceasing operations and efforts to remove tailings water from the pile under the current CAP; however, the level of contamination in the uppermost aquifer remains well above established compliance limits in the license. The elevated contaminant levels currently exhibited in the groundwater are the basis for NRC initiating revisions to the existing CAP. The evaluation of present and potential future water resource

impacts associated with on-site closure of the tailings are addressed the in EIS.

The separation of groundwater restoration activities from surface reclamation actions is consistent with the approach taken at UMTRCA Title I sites and other uranium mills licensed by the NRC. Additional hydrogeological characterization of hydraulic and contaminant properties needed to address potential CAP revisions would not be adversely affected by on-site closure of the tailings pile, since most of these activities would occur outside of the potential construction area. Ultimately, the license remains in effect for the duration of the groundwater restoration activities, until compliance with established standards are demonstrated and the site is ready for transfer to DOE or for perpetual care.

NRC considers revisiting the CAP as a separate licensing action, because the groundwater cleanup strategies and methodologies will be contingent on the decision for surface reclamation of the tailings. The CAP currently being implemented by Atlas was based on the conclusion that existing groundwater contamination was not amenable to active remediation. If groundwater remediation is determined practicable, as a result of NRC's revisiting the CAP, then resulting environmental impact to the Colorado River will be less than that already identified in the EIS.

The costs and benefits of groundwater cleanup for the on-site closure and the tailings relocation alternatives were factored into the overall cost/benefit analysis conducted for both alternatives. Regardless of the surface reclamation implemented, contaminated groundwater exists at the Atlas site. Relocating the tailings to another site for disposal does not remove the need for groundwater cleanup at the current Atlas property. Additionally, relocating the tailings would likely invoke higher groundwater cleanup costs for the relocation alternative over the on-site closure alternative, since the relocation alternative would mandate a cleanup approach to return contaminants over the entire site to levels suitable for releasing the site for unrestricted use. Discussions and evaluations of cost/benefit considerations associated with both disposal alternatives are presented in Chapter 5 of the EIS.

5.1.4 Revisions to the TER

The TER was revised to include the results of staff's determination that additional characterization and evaluation of the existing contaminant extent will be needed for revising the current groundwater CAP. The TER was also revised to include the licensee's statement that engineering credit has been taken for the reduced infiltration in the cover design and the licensee's commitment to redesign those components if future revisions to the CAP indicate that further reductions in infiltration flux are needed to meet groundwater compliance standards. Additionally, a brief discussion of the cost/benefit evaluation associated with groundwater cleanup was added and reference made to the analysis presented in Chapter 5 of the EIS.

5.2 Hydrogeologic Characterization

5.2.1 Commenters

Richard L. Christie (23-4, 23-5, 23-6, 23-7, 23-8, 23-9)
U.S. Department of the Interior (56-15, 56-16)
Atlas Corporation (57-19, 57-20, 57-22, 57-23)
Utah Division of Radiation Control (58-17, 58-26, 58-27, 58-28, 58-29, 58-30, 58-31, 58-32, 58-33, 58-34, 58-35, 58-38, 58-39, 58-40, 58-41, 58-42, 58-43, 58-44, 58-45, 58-46, 58-47, 58-48, 58-49, 58-64, 58-65, 58-66, 58-67, 58-68, 58-69, 58-70, 58-71)
Grand County Council by Jenner & Block (59-43, 59-44, 59-45, 59-46, 59-47, 59-48, 59-49, 59-50, 59-51)

5.2.2 Summary of Issues

The commenters addressed the following aspects of the hydrogeologic characterization: hydrogeologic setting, hydraulic properties, groundwater flow, contamination impacts, and water use. The specific issues addressed by the commenters are discussed separately for each of these aspects.

Hydrogeologic Setting. One commenter (Utah) raised questions about the geologic and hydrogeologic setting in the site area. Utah noted that there is a need to verify the geologic model proposed by Atlas Corporation for the site. It was indicated that in addition to the Chinle and Moenkopi formations (Triassic age) that underlie the tailings, available outcrop and geophysical data indicate that Jurassic age formations of the Glen Canyon Group (Navajo sandstone, Kayenta formation, and Wingate sandstone) may also underlie the eastern portion of the tailings embankment and the mill site.

The commenter noted further that the hydrogeologic model presented in the DTER is inaccurate in that it incorrectly equates the bedrock units underneath the facility to Blanchard's "lower groundwater system", but the bedrock formations appear to correspond to Blanchard's "upper groundwater system", which includes the Glen Canyon Group that includes important aquifers across the Colorado Plateau.

The commenter indicated also that the freshwater/brine interface has not been adequately characterized, and that the licensee should be required to determine the extent of the interface across the facility by onsite drilling and geophysical logging, so as to develop a justifiable and sound hydrogeologic model.

Hydraulic and Transport Properties. Comments on this aspect of the TER were received from the State Utah. The commenter noted that the hydraulic properties for the bedrock units under the facility should be either measured or conservatively estimated. The commenter stated that regional hydraulic conductivity for the Glen Canyon Group can be rather high, particularly in fractured terrain, and pumping tests in the Navajo sandstone and other Glen Canyon Group formations indicate the bedrock formations are more permeable than assumed by Atlas. In addition, the commenter stated that the bedrock formations may be hydraulically connected to the alluvium, which should be investigated.

The commenter noted further that the alluvium is not hydraulically isolated from all bedrock formations; there is evidence that the alluvium is hydraulically connected to the Glen Canyon Group aquifers; and the hydraulic head in the bedrock is higher than that in the alluvium.

Groundwater Flow Characterization. This aspect of the TER was addressed by the State of Utah and the Atlas Corporation. Utah indicated that additional data are needed to delineate groundwater flow direction in the site area, and that the licensee should be requested to install additional monitoring wells to obtain more data. The commenter underscored the need to delineate groundwater (and contaminant) movement to private land offsite. The commenter noted also that the river stage measurement should be undertaken along with water level measurements in the monitoring wells.

Atlas responded to open issue #15 that had been raised by the NRC staff. In this open issue, the staff had required that the licensee provide additional data to support its interpretation of groundwater flow directions and gradients in the alluvial aquifer near the southern property boundary. Atlas indicated that additional documentation was provided to the staff and that the local groundwater flow direction in the site area was revised based on the staff comment and the new data used in the analysis.

Geochemical and Contaminant Characterization. Five commenters raised concerns pertaining to geochemical and contaminant characterization in the site area. The issues were grouped in the following five categories by the staff: (1) leachate analysis; (2) background groundwater quality characterization; (3) groundwater quality impacts; (4) surface water quality impacts; and (5) contaminant characterization procedures;

Leachate Analysis. Five commenters (Christie, the Department of the Interior, Utah, Grand County Council, and Atlas) addressed the leachate analysis. Christie indicated that the leachate analysis did not include gross alpha, even though gross alpha levels are two orders of magnitude higher than the MCL value, and that Atlas did not demonstrate that there is a statistically significant change in the concentration levels of gross alpha and uranium concentrations in the leachate between 1988 and 1995.

The Department of the Interior indicated that the leachate analysis provided in Table 5-2 is not clear.

Utah indicated that the DTER needed to provide additional information to characterize the leachate, including number of samples collected, sampling locations, type of analysis, and statistical evaluations; and suggested that leachate samples be collected during the penetrometer tests, so that the leachate could be analyzed for constituents of concern at different depths in the tailings.

Grand County Council indicated that the tailings leachate was not adequately analyzed for all possible contaminants, that the collected samples were not representative, and that the data in the DTER are inconsistent with the corresponding data in the DEIS.

Both Utah and Grand County Council also pointed out what they believed to be

inadequacies in the groundwater monitoring program (See section 5.1).

Atlas stated that the hazardous constituents were identified through onsite monitoring as required by the license and NRC guidance, and that the tailings solution was tested for all constituents in Criterion 13 of Appendix A.

Background Groundwater Quality. Four commenters (Christie, Utah, Grand County Council, and Atlas) addressed the background groundwater quality. Christie, Utah and Grand County Council commented that monitoring well AMM-1 may not be representative of background groundwater quality, because this well may have been contaminated by a nearby ore storage pad, water clarification lagoon, and/or and the leachate mound under the tailings during mill operation.

Atlas responded to open issue 16, which had required that the licensee provide data showing that well AMM-1 is not contaminated by the mill operations. Atlas indicated that analysis of groundwater flow directions in the vicinity of this well and consistent concentrations over time reaffirm the previous determination that this well is an appropriate background groundwater monitoring point.

Groundwater Quality Impacts. Three commenters (Utah, Grand County Council and Atlas) addressed groundwater quality impacts. Utah indicated that analysis of surface seeps along the Colorado River have identified non-radioactive constituents that are not subject to monitoring pursuant to the current license and that the concentrations of such constituents are above State standards. In addition, Utah noted that Atlas did not adequately monitor contaminant transport in the groundwater offsite, particularly to the north and south of the tailings including the shallow bedrock aquifer in the Arches National Park, and that such contamination should be investigated by installation of additional monitoring wells including offsite monitoring wells.

Grand County Council indicated that the assertion by Atlas that the contamination is restricted vertically to the fresh groundwater in the upper portion of the alluvium is not adequately supported or verified.

Atlas stated that groundwater contamination was characterized and hazardous constituents were identified through onsite monitoring as required by the license and NRC guidance, and that groundwater contamination is restricted to licensee's property.

Surface Water Quality Impacts. Four commenters (Christie, Utah, Grand County Council, and the Department of the Interior) raised questions concerning characterization of the impacts on surface water quality in the Colorado River. Christie indicated that Atlas's characterization of contamination impacts on the Colorado River does not make sense, that Atlas mistakenly analyzed the water but not the organic material in sediments and in the river food chain to evaluate impacts, and that Atlas's study was inconclusive because it did not collect the right number of samples or sample the proper locations. In addition, Christie pointed out that Atlas did not implement a West Water Engineering study designed by the National Park Service to investigate bioaccumulation in the Colorado River and to achieve

statistically and scientifically reliable results.

Utah indicated that river stage measurement should be continued and that the licensee should establish stations for this purpose; that the hydraulic heads need to be monitored in wells in close proximity to the Colorado River, possibly including new nested wells that are completed at different depths; and that the wells should be completed in conformance to EPA's Technical Enforcement Guidance. Utah stated further that samples collected and analyzed by the State of Utah found radioactive and non-radioactive contaminants in surface seeps on the northern bank of the Colorado River in the vicinity of the Atlas site, and concluded that the seeps contain groundwater that was contaminated by tailings effluent. Utah indicated that non-radioactive constituents that are not subject to monitoring pursuant to the current license have been found in concentrations that are above State standards, and that Atlas should be required to monitor for these contaminants. Specifically, Utah identified specific contaminants that should be analyzed to assess their impacts on the Colorado River water; these include: ammonia, manganese, molybdenum, nitrite and nitrate, and vanadium.

Utah also stated that current and future impacts on water quality in the Colorado River must be considered in the TER.

Grand County Council indicated that the staff did not adequately examine the quality of surface water near the tailings pile, and there are constituents identified in the tailings that were not tested in the surface water samples.

Utah, Grand County Council and the Department of the Interior remarked that locations of sampling points in the Colorado River were not provided in DTER.

<u>Contaminant Characterization Procedures</u>. Three commenters (Christie, Utah, and Grand County Council) raised questions about the procedures followed in characterizing the contaminant transport from the site. Christie indicated that water resources protection is based on estimates and averages, not measurements (e.g., estimates of hydraulic gradient and hydraulic diffusivity for the alluvium and estimates of current and future leachate volumes in the DTER); in addition, the commenter indicated that the reported decline in radionuclide concentrations in the Colorado River does not make sense, and that the data are bad due to errors in sampling locations or laboratory testing, or both.

Utah discussed several quality assurance issues concerning the water quality data from well ATP-3, including errors/flaws in the analytical methods and procedures (lack of error terms and lower detection limits, excessive error terms, excessively high lower levels of detection, and failure to investigate erratic results); inadequacy of the monitoring wells; lack of groundwater sampling quality assurance/quality control plan; and analysis by Atlas's own, uncertified laboratory. It was indicated that suspect tailings contaminants may have been mistakenly disregarded and excluded from monitoring because of using inadequate analysis methods including the use of high detection limits. In addition, Utah indicated that the number of constituents monitored and number of constituents for which compliance standards needed to be established were reduced without justification, which left some hazardous constituents unregulated.

Utah further indicated that it is not clear how the average concentrations provided in the DTER for contaminants in the Colorado River and the groundwater were determined, and that the DTER should also provide number of available samples and the range of the standard deviation. The commenter remarked that NRC should conduct a thorough quality assurance evaluation of all of Atlas data, and require Atlas to submit a quality assurance plan that conforms to the EPA's RCRA Technical Enforcement Guidance.

Grand County Council indicated that the DTER did not provide data showing which constituents have migrated from the tailings pile, and that the staff must verify that the analysis data in the DTER are valid and the sample sizes are statistically representative.

Water Use Characterization. Three commenters (Utah, Grand County Council, and Atlas) commented on the water use characterization in the site area.

Utah indicated that the DTER assertion that the Trapax well is not fit for human use is not substantiated by the available water quality data, and an application for this well was filed with the Division of Water Rights in 1992, long after Atlas began its operation and the well may have been contaminated by the Atlas facility. Utah stated that the TER should be revised to reflect the record for this well. Utah further indicated that the groundwater CAP should be designed to protect current and future uses of groundwater at adjoining properties.

Grand County Council indicated that the analysis of water use is outdated, because the DTER relies on a 1989 study; influx of tourists and new residents since 1989 necessitate a new water use inventory.

Atlas indicated that there are 16 registered water users within one mile of the site, and the only two groundwater rights are located upstream of the site. The remaining water users have surface water rights to the Colorado River and monitoring of the river indicates no measurable increase in river contamination. Atlas indicated further that groundwater in the site area has a high TDS content, it is not suitable for human consumption and must be treated before use. Atlas maintained further that the groundwater contamination is restricted to licensee's property and has effectively no adverse impacts because groundwater is not used on the property, and it flows into and is diluted by the Colorado River.

5.2.3 Staff Analysis of Comments

Hydrogeologic Setting. Comments noted. Staff also considers that some additional characterization is necessary at the site. Staff recognizes that some lithologies of the Glen Canyon Group may be in contact beneath the alluvium in the vicinity of the Atlas site; however, the nature of the hydraulic connection between the alluvium and the surrounding portions of the Glen Canyon aquifer warrants further investigation, rather than confirmation that specific lithologies are present or absent.

The brief description of the hydraulic properties of the bedrock units in the draft TER did not clearly identify which portions of the bedrock beneath the site were hypothesized to correlate with Blanchard's (1990) "lower groundwater

system". Staff agrees with the commenter that portions of the Glen Canyon Group that may potentially occur beneath the alluvium would correlate with Blanchard's "upper groundwater system". However, displacement of lithologies by faulting and the occurrence of brine within the lower portions of the alluvium may be indicative of either localized groundwater contact with salt and potentially correlating with the upper reaches of Blanchard's lower groundwater system or brine from the much deeper portions of the Paradox section potentially migrating to shallower groundwater systems through existing fault planes under the higher head in the lower groundwater system. The specific mechanism of brine placement in the alluvial system at the site is not currently known. However, because the brine effectively forms a no-flow boundary beneath the site, the transition from the upper to the lower flow system may be of only academic interest with regard to contaminant influences from the tailings pile.

The freshwater/brine interface has been identified and confirmed by onsite drilling at two locations at the Atlas property. Additional drilling to specifically delineate the interface would be costly and add little value to the hydrogeologic model for the site. However, if additional information on the freshwater/brine interface can be developed in conjunction with other hydrogeologic characterization activities, without undue cost, then the information should be developed. Extending an investigation of the freshwater/brine interface to locations beyond the Atlas property is not warranted, unless tailings contamination is shown to impact adjacent properties. Staff considers that additional characterization activities are best addressed as part of future revisions to the CAP.

Hydraulic and Transport Properties. Comments noted. Staff considers that additional information on aquifer characteristics and further evaluation of potential hydraulic interconnection with adjacent groundwater systems is needed at the Atlas site. Staff also recognizes that a potential interconnection between the alluvial system and the Glen Canyon Group at the northern extent of the Atlas property could exist, given the highly fractured and faulted nature of this area. As previously stated, staff considers that additional characterization activities are best addressed as part of future revisions to the CAP.

Groundwater Flow Characterization. Comments noted. The need for additional data to delineate groundwater flow direction and gradients is largely consistent with the staff position as provided in open issue #15 in the draft TER. As previously stated, staff considers that additional characterization activities are best addressed as part of future revisions to the CAP.

Leachate Analysis. The results of tailings liquor analysis previously done at the Atlas site are consistent with the results from other mill sites. The tailings leachate was analyzed for all possible contaminants to staff's satisfaction, in accordance with 10 CFR 40, Appendix A. Additional analysis of the leachate at this time does not enhance protection of human health and safety, because human exposure through the groundwater pathway at the site and adjacent properties is essentially non-existent. In addition, future revisions to the CAP and the associated groundwater characterization, must address the adequacy of future monitoring for confirming exposure reductions to aquatic species in the Colorado River. NRC policy also requires that each

licensee demonstrate, through sampling and analysis, that all constituents of regulatory concern in the groundwater are within regulatory compliance before the license is terminated and the site is transferred to DOE or the State for perpetual care.

Background Groundwater Quality. Comments concerning the use of well AMM-1 are consistent with the staff comments in open issue #16 in the draft TER. The staff required the licensee to provide data showing that this well is not contaminated by the mill operations. The licensee has since responded by providing additional data about groundwater flow directions in the vicinity of this well and consistent constituent concentrations over time that reaffirm its previous determination that this well is an appropriate background well. Staff does not consider the responses from the licensee adequately demonstrates the appropriateness of well AMM-1 as an unaffected background well. Staff further considers that additional sampling in the alluvial aquifer, as a part of the further groundwater characterizations for revisions to the CAP will resolve this issue with well AMM-1. The data collected from background wells at sites with existing groundwater contamination, such as Atlas, are primarily used to determine groundwater cleanup standards for the CAP. Consequently, staff considers it appropriate to resolve the issue of well AMM-1's suitability as a background well as a part of the revised CAP.

Groundwater Quality Impacts. Comments noted. Staff recognizes that some constituents, such as ammonia, have been detected in samples of groundwater seepage entering the Colorado River. Discussions of these samples, along with subsequent analyses of river water and the potential impacts of these constituents are presented in the EIS. The limited human exposure potential from the contaminated groundwater, indicates a minimal human impact from the groundwater pathway. Consequently, receptors of potential impacts from contaminated groundwater are limited to aquatic species in the Colorado River, and the EIS contains the descriptions and evaluations of these potential exposures. Duplication of these impact discussions in the TER is unnecessary, since both the EIS and TER are considered in the pending licensing action.

Monitoring additional constituents in the groundwater may be appropriate, however, a complete evaluation additional monitoring needs is best addressed as part of future revisions to the CAP.

Surface Water Quality Impacts. Current and future impacts to the Colorado River from the proposed reclamation of the Atlas tailings pile have been evaluated and described in detail in the EIS. Previous monitoring conducted during mill operations, along with the limited human exposure potential, indicated minimal human impacts from the surface water pathway. Consequently, receptors of potential impacts from the proposed tailings reclamation are limited to aquatic species in the Colorado River, and the EIS contains the descriptions and evaluations of these potential exposures. Duplication of these surface water impact discussions in the TER is unnecessary, since both the EIS and TER are considered in the pending licensing action.

The TER describes general surface water quality characteristics, historical sampling episodes, and influences from the Atlas milling operation. The TER also references the reader to the more detailed discussions in the EIS.

Contaminant Characterization Procedures. The word "estimate" was used to refer to the measured hydrogeological parameters that are used to describe hydrogeologic properties at similar locations at the site. Measurements of these parameters are taken at discrete locations and at discrete intervals, but are qualified as "estimates" for locations at distance from the actual measurement, because of the inherent uncertainty that exists with the hydrogeologic properties such as permeability, hydraulic conductivity, hydraulic gradient or hydraulic diffusivity. These measurements are then extrapolated to other locations and interval of similar characteristics to form the basis of the conceptual hydrogeologic model. Extrapolating measured data to other site locations of similar characteristics is a practice normally applied in earth science investigation, since total quantification of material properties is neither feasible nor practicable. The term "estimate" should not be interpreted as describing a lack of information, but a qualifying term denoting the expected variance of a measured property from location to location. Likewise, as these estimated parameters are used in computer simulations or calculations, a sensitivity analysis and reasonable conservatism should accompany the calculations to address the uncertainty associated with parameter used.

Routine sampling of radionuclide concentrations in the Colorado River support the interpretation that the seepage influences from the Atlas tailings pile are generally overshadowed by natural variations of constituent concentrations in the river from other sources upstream and downstream of the Atlas site. These routine sampling episodes were designed to detect broad and significant changes in the river water quality as a result of tailings influences from seepage and other pathways. Recent sampling episodes, as described in the EIS, show a measurable influence from non-radiological constituents, such as ammonia, in a limited reach of the river. The details of recent river sampling results and assessments of potential environmental impacts are provided in the EIS.

Contaminant concentrations measured in the groundwater were analyzed to staff's satisfaction to support groundwater monitoring license amendments, in accordance with 10 CFR 40, Appendix A. Staff recognizes that additional analysis of groundwater contaminant levels will likely be a part of the licensee's revisions to the CAP and the associated groundwater characterization activities. NRC does not have the authority to require any licensee to conform to EPA guidance documents; however, staff may find the use of EPA's RCRA Technical Enforcement Guidance Document is acceptable if a licensee chooses to model its program after the EPA guidance. Additionally, NRC policy requires that each licensee demonstrate, through sampling and analysis, that all constituents of regulatory concern (contaminants currently in the regulations or in the license and found in the tailings liquor) in the groundwater are within regulatory compliance before the license is terminated and the site is transferred to DOE or the State for perpetual care.

Water Use Characterization. The statement in the TER that the Trapax well, situated on the adjacent property upstream of the tailings pile, is anecdotal evidence reported by Atlas. The commenter's contention that the Trapex well is likely contaminated by tailings seepage is not substantiated by the monitoring data from well AMM-1, which is situated between the pile and the Trapex well. Although staff expressed concern with the appropriateness of

AMM-1 as a background well, staff's concern is centered on trace constituent levels of uranium and other metals that could be attributed to a nearby ore storage pad. The overall water chemistry of major ionic constituents would likely not be affected by trace contamination from ore storage. Any influence from tailings seepage, which has been shown to change the overall water quality character of the groundwater, would be easily detected in well AMM-1.

Information submitted be Atlas by letter dated October 11, 1996 shows that the overall water quality in well AMM-1 is predominantly a sodium/chloride-type water with minor sulfate, which is consistent with the overall water quality at other alluvial sampling locations on the east side of the Colorado River. The tailings water and groundwater impacted by tailings seepage is dominantly a sodium-magnesium/sulfate-type water, with minor chloride. The overall water chemistry of well AMM-1 is not similar to the overall chemistry of groundwater impacted by tailings seepage. Consequently, it is reasonable to conclude that the Trapex well is not impacted by tailings seepage.

The water use survey presented in the TER is not solely based on 1989 information. Atlas performed a water use survey in 1989 and submitted the results to NRC. As a part of the TER review, the Utah Division of Radiation Control provided staff with an up-to-date search of water rights in the vicinity of the Atlas site. The 1989 data supplied by Atlas and the current water right inventory supplied by Utah were used to develop the water use information in the TER.

Finally, the opinion expressed by Atlas that contaminated groundwater is restricted to its property is not fully substantiated by the additional information supplied by Atlas to address open issue #15. Staff concluded that the flow directions and monitoring data along the southern property boundary indicate a likelihood that contaminated groundwater may have impacted the adjacent property. As previously stated, staff considers that additional characterization activities, including further assessment of the groundwater flow directions, are best addressed as part of future revisions to the CAP.

5.2.4 Revisions to the TER

The TER was revised to clarify the vintage of information used to develop the water use characterization. Table 5.2 has been revised to clarify the analytical information presented. The TER was also revised to recognize the potential occurrence of lithologies from the Glen Canyon Group beneath the site and the influence of either salt contact or brine seepage along existing faults as potential mechanisms for brine in the deeper alluvial aquifer.

5.3 Conceptual Design Features to Protect Water Resources

5.3.1 Commenters

Atlas Corporation (57-21, 57-24)
Utah Division of Radiation Control (58-49, 58-64)
Grand County Council by Jenner & Block (59-43)

5.3.2 Summary of Issues

Utah indicated that current and future impacts on water quality in the Colorado River must be considered in the pile cover design. The commenter added that since the cover design constitutes a part of the groundwater protection strategy, Atlas should be required to provide a quantitative evaluation of the final cover performance, before approving the site reclamation plan. The evaluation should use representative or conservative infiltration and contaminant transport models, and cost of the cover should be included in the onsite stabilization cost.

Grand County Council stated that understanding groundwater contamination in the area of the tailings pile and the continuing impact on groundwater is crucial to the cover design, as well as the short-term and long-term effects of onsite tailings stabilization.

Atlas responded to staff's open issue #17, which required that the licensee clarify if it plans to take credit for the engineering components of the disposal cell (i.e. disposal cell cover) toward groundwater cleanup, and to include the cost of achieving the necessary cover permeability in the site reclamation cost. Atlas responded that the radon barrier will play a key role in the site reclamation plan (i.e., to control radon release), and the groundwater CAP (i.e., to control the contaminant source term by isolating the tailings and eliminating or greatly reducing rainfall/runoff seepage into the tailings). The commenter also indicated that the costs associated with the achieving the cover permeability will be included in the updated site reclamation plan.

5.3.3 Staff Analysis of Comments

Comments Noted. The staff agrees that groundwater cleanup and compliance at the Atlas site is ultimately coupled to the disposal cell cover design and long-term performance. The staff considers that unreclaimed and uncontrolled tailings present a greater potential risk to public health and safety than seepage impacts to ambient groundwater of marginal quality which is not currently and not likely to be used by humans in the foreseeable future. Potential post-reclamation impacts to the Colorado River have been evaluated and are presented in the EIS.

Separating the surface reclamation and the groundwater cleanup of mill tailings sites is consistent with NRC's past policies at both the UMTRCA Title I sites and the commercial mill tailings sites (Title II) under NRC license. Additionally, separation of surface reclamation and groundwater cleanup is included in NRC's two step licensing approach for Title I sites. Other Title II sites which have groundwater contamination are reclaimed in the similar two-step approach. Tailings at these sites can be reclaimed and the groundwater cleanup will progress after the surface work has been completed. Since Title II sites are transferred to perpetual care only after license termination, all aspects of the tailings disposal and groundwater cleanup must be in compliance before license termination and property transfer.

NRC considers revisiting the Atlas CAP as a separate licensing action, because the groundwater cleanup strategies and methodologies will be contingent on the

decision for surface reclamation of the tailings. The CAP currently being implemented by Atlas was based on the conclusion that existing groundwater contamination was not amenable to active remediation. If groundwater remediation is determined practicable, as a result of NRC's revisiting the CAP, then resulting environmental impact to the Colorado River will be less than that already identified in the EIS.

5.3.4 Revision to the TER

The TER was revised to clarify NRC's view that groundwater cleanup and compliance at the site are coupled with the tailings disposal cell cover design.

5.4 Coordination with The State of Utah and Public Reviews of Project Documents

5.4.1 Commenters

Utah Division of Radiation Control (58-51, 58-63)
Grand County Council by Jenner & Block (59-50, 59-51, 59-53)

5.4.2 Summary of Issues

The commenters addressed issues pertaining to coordination and consultation with the State of Utah and public reviews of project documents.

Coordination with the State of Utah. The State of Utah indicated that the groundwater CAP needs serious revision, and revision of the CAP should be closely coordinated with the State of Utah. This is to ensure that the State concerns are satisfactorily resolved and to avoid dual regulation of the site by the State and NRC. Coordination and/or consultation with the State should include hydrogeologic and contaminant characterization, water uses and water rights, human and environmental risk, and available technology to control tailings contamination, and approval of revised groundwater protection standards including any ACL standards.

Public Reviews. Grand County Council noted that NRC staff review of the groundwater CAP is inadequate, that the staff improperly separated an analysis of groundwater impacts and surface remedial action, that the DTER did not explain how the cost-benefit analysis to evaluate corrective action alternatives was conducted, and that a public analysis of the CAP is necessary to ensure compliance with the groundwater protection standards.

5.4.3 NRC Staff Analysis of Comments

Coordination with the State of Utah

As discussed in the responses to comments pertaining to Groundwater Protection Standards (section 5.1), the NRC recognizes that there are significant differences between the regulatory programs implemented by the State of Utah and the NRC. Any future revisions to the Atlas CAP will be forwarded to the State of Utah, in accordance with NRC's established policy to conduct consultations with Non-Agreement states potentially impacted by NRC licensing

actions. The complete elimination of dual regulation does not appear feasible at this time, because of the different regulatory approaches used by Utah and the NRC. The NRC considers that opportunities to reduce duplicative efforts do exist and can be developed through open communication and consultation. However, the NRC must ultimately complete the Federal action, if the proposed alternative is found acceptable and complies with NRC regulations.

Public Reviews

NRC's draft Environmental Impact Statements are provided to the public for review and comment in accordance with NRC regulations in 10 CFR Part 51, and as required by the National Environmental Policy Act of 1969, as amended. Proposed licensing actions are reviewed by staff for compliance with NRC's regulations, which administers the protection of public health and safety from radiological hazards. These reviews are documented by the staff in a Technical (or Safety) Evaluation Report (TER). Public availability of TERs are noticed in the Federal Register for significant licensing actions at NRC licensed facilities. In addition, a Notice of Opportunity for Hearing is usually published when a significant application is received or the availability of a TER for a significant action is announced to allow members of the public, or licensees, the opportunity for due process through NRC's administrative procedures. Anyone can obtain and review the staff's TER, and, regardless of notification requirement, can request an opportunity for hearing on the pending licensing action in accordance with 10 CFR Part 2, Subpart L.

The NRC considered that the prominence of the Atlas Reclamation Plan licensing action dictated a public comment on the draft TER, beyond the established administrative procedures for public involvement in other NRC licensing actions. Additional public comment periods for future licensing actions, beyond NRC's normal administrative procedures, are not considered necessary at this time.

5.4.4 Revisions to the TER

No revisions have been made to the TER in response to the above comments.

6.0 RADON ATTENUATION and SITE CLEANUP

6.1 Material Characterization for the Radon Flux Model

6.1.1 Commenters

Saxon Sharpe (23-10, 23-11, 23-12, 23-13)
Atlas Corporation (57-25, 57-26, 57-27, 57-28, 57-29, 57-30)
Utah Division of Radiation Control (58-72, 58-73, 58-74, 58-75, 58-76, 58-77)
Grand County Council by Jenner & Block (59-55, 59-56, 59-57, 59-58, 59-59, 59-60, 59-61, 59-62, 59-63)

6.1.2 Summary of Issues

Characterization of the tailings, "affected" soil (primarily windblown tailings), and the radon barrier materials was discussed by four commenters.

The main concern was that the limited sampling and testing resulted in non-representative parameter values for these materials in the radon flux model, which could result in an under-estimation of long-term radon flux from the disposal cover.

Sharpe stated his belief that 8-foot deep borings on the tailings pile are not adequate, especially to define the fine tailings moisture, which could have a bearing on the liquefaction calculations. He also pointed out that the fine tailings moisture value in Table 6.1 of the draft TER was far below the measured value. Grand County Council stated that 6 borings on the pile topslope resulting in 31 samples for testing was inadequate to characterize the tailings pile.

Sharpe stated that obtaining tailings samples composited over various depths was not appropriate for determining Ra-226 content as it is not known that the coarse tailings are homogeneous. The State of Utah expressed concern with the statement in the draft TER indicating that Atlas should determine the tailings Ra-226 concentrations to a depth of three to four feet because this requirement would not ensure characterization to the depth for which the radon flux model is sensitive.

Grand County Council stated that Th-230 should have been measured in the tailings pile, similar to the Department of Energy (DOE)'s procedure in the Title I program. Grand County stated that not considering thorium could result in serious underestimation of radon flux. Also, Grand County stated that Atlas failed to address sub-pile and sub-raffinate pond Th-230. Grand County's concern was that, if the tailings were moved to a new location, that material would be on top of the pile and could be a potentially significant source of Ra-226 due to decay of Th-230 over the next 1000 years.

The State of Utah expressed concern about the Ra-226 content of the "affected" soils and wanted NRC to approve of the new value (to be measured after placement) before clay radon barrier construction. Utah also stated that because Ra-226 is preferentially partitioned by fine-grained soils, the NRC should require Atlas to include sieve (gradation) analysis with all Ra-226 testing.

The State of Utah questioned the 15 samples Atlas proposed to take of "affected soil" after placement on the pile. Utah stated that this represents less that one sample per 13,000 cubic yards of material, and proposed instead that at least one sample per 10,000 cubic yards of "affected" soil should be tested.

Grand County Council stated that Atlas has failed to properly characterize the tailings pile, provided an unproven commitment to sample for the parameters in the future, and failed to provide assurance that the proper parameters will be evaluated during construction. Grand County was also concerned that sampling of the tailings pile will occur after the Reclamation Plan is approved.

Grand County Council also suggested use of DOE's Title I sensitivity analysis for the radon barrier model. Grand County stated that statistical analyses on cover designs (which staff interpreted to mean radon flux models) ensures that incomplete data are identified and addressed, and without the sensitivity

analysis, Atlas' cover diffusion coefficient is likely to be underestimated.

Grand County Council stated that the confirmatory item on testing the clay borrow should be an open item. Sharpe and the State of Utah pointed out that if, as a result of the tests, Atlas later has to revise the clay layer thickness, this will impact cost and the method of clay application (thickness and number of layers) for appropriate compaction.

The State of Utah expressed concern that NRC staff assumed, in modeling radon flux for the Atlas tailings pile, that clay parameter values would be similar to those used by DOE in modeling radon flux model for the Title I Grand Junction disposal cell cover. Utah stated that NRC had not justified that the DOE analysis was adequate and that the Grand Junction Mancos shale represents local shale or the reconstituted clay at placement conditions and may thus not be appropriate for use in modeling the Atlas cover.

Utah also considered the radon flux model inadequate until several other design parameters are known. Utah identified the following parameters as being of concern: average Ra-226 concentration of the upper 15 feet of tailings pile, including radon barrier soils; unsaturated radon barrier soils characteristics; and the long-term (1000 years) moisture content of radon barrier soils and overlying filter material.

Grand County Council indicated that the sandy radon barrier layer could contain contamination from Moab Wash as Atlas plans to test background Ra-226 in the wash. Grand County suggested that the Atlas soil background Ra-226 sampling program should be similar to the DOE procedure for Title I sites.

Atlas reiterated the DTER issues and confirmatory items related to material characterization for the radon flux model and stated that issues 18, 19, and 20 are procedural implementation issues that will be addressed in the updated Reclamation Plan. Atlas also indicated that Confirmatory Items 1, 2, and 3 were administrative implementation issues that will be addressed in the updated Reclamation Plan.

6.1.3 Staff Analysis of Comments

<u>Characterization of tailings pile</u>: NRC staff considers that sampling the tailings to a depth of 8 feet is adequate for modeling radon flux, because of code sensitivity, the limited range of values for each coarse tailings parameter, and the amount of "affected" soil to be placed over the tailings. The staff recognizes that the value of moisture content in Table 6.1 is far below the measured value. In calculating radon flux, lower moisture values lead to higher flux values, and thus are conservative. The value used in the model (and given in Table 6.1) represents the long-term moisture content and should be lower than the measured moisture content.

The staff agrees that the sample number (16) for coarse tailings discussed in the draft TER, is too limited to adequately characterize the contaminated material. Atlas has agreed to further characterize the coarse tailings to verify the values used in the model. Section 6 of the TER has been revised to reflect this.

The staff concluded that Atlas need sample only the upper 3 or 4 feet of tailings because approximately 4 feet of "affected" soil is expected to be placed on top of the coarse tailings, and under usual circumstances, approximately 90 percent of the radon released at the surface (flux) will come from the upper 8 feet of contaminated material. Also, based on the ore grades processed, the upper few feet of tailings is expected to have a higher concentration of radium than deeper tailings. The upper material provides most of the radon because movement of radon produced by deeper material is retarded such that most of it decays to solid particles before the gas can reach the pile surface. However, in modeling radon flux, the licensee and the staff modeled the upper 16 feet (5 meters) of tailings, which is considered to be an infinite thickness.

Measurement of Th-230: Analysis of tailings for Th-230 was not required because the Th-230 is not expected to be significantly out of equilibrium with Ra-226 and therefore will have no impact on radon concentration over 1000 years. The sub-raffinate pond material, which is at the top o the tailings slimes, could have excessive levels of Th-230. However, testing for Th-230 was not required because this material will be covered by at least 10 feet of other contaminated material, and therefore, the radon produced at this depth will have little influence on the radon flux at the surface of the completed pile. Transfer of the tailings to another location has not been proposed by the licensee and is not the subject of this TER.

Ra-226 content of "affected" and fine soils: The Ra-226 concentration, as well as other characteristics, of the "affected" soils will be verified by the licensee prior to placement of the radon barrier. NRC staff has reviewed the proposed testing program and found it acceptable. In addition, a condition will be added to the license requiring Atlas to verify the parameter values for the "affected" soil.

NRC staff does not see the value of requiring Atlas to provide gradation results with all Ra-226 analyses. The samples should be representative of the material the values are to represent and will be dried and then ground to an even consistency before Ra-226 analysis. Also, samples will be tested for radon emanation coefficient, so the effect of particle size will be reflected in these results.

Proposed sample number for "affected" soil: Atlas did not propose to take 15 samples, but indicated 30 samples (from 15 locations) of "affected" soil would be obtained after soil placement on the pile. The staff has determined that this number is acceptable.

Unproven Atlas commitments to sample and evaluate: Atlas will be required, by license condition, to verify the radon flux model parameters for the "affected" soil, coarse tailings, and clay radon barrier.

Lack of sensitivity analysis: The staff disagrees that a sensitivity analysis, such as is performed by DOE in the Title I program, is necessary. DOE estimates the uncertainty in the radon flux model by combining the standard error of the mean with the average parameter value, for a few parameters. The limit on uncertainty is specified for the combined effect, i.e., radon flux. NRC has not approved the DOE procedure, or the way it is

applied. NRC staff requires adequate test data for the cover diffusion coefficient, or a conservative estimate, to support the radon flux model parameter value.

<u>Lack of characterization of clay radon barrier material</u>: Atlas will be required, by license condition, to verify that the characteristics of the clay used in the cover meets the parameters values used in the radon flux analysis.

<u>Material parameter values used in modeling radon flux</u>: The State of Utah misunderstands how material properties are used in modeling radon flux. Some properties, such as long-term moisture content, are not directly measurable and thus must be estimated. Those values are conservatively estimated, i.e., the values used in the model result in higher radon flux than a best estimate of the parameter. As discussed in the TER, the staff used conservative values for the long-term moisture content.

Other parameters, such as density, can be measured during construction. The staff reviews those parameter values proposed by the licensee to assure that they are reasonable. In the case of the clay parameters proposed by Atlas, the staff concluded that it was reasonable to use values similar to that used by DOE at Grand Junction, since the clay would be obtained from the same formation, the Mancos Shale. Additional support was provided by test data for clay from the local Mancos Shale formation. However, construction specifications require the licensee to test and verify that certain material properties used in the model are actually achieved in construction.

<u>Soil background Ra-226 from possibly contaminated wash</u>: Background concentration of Ra-226 in soil will be determined from samples of soil taken approximately one mile from the site. As required by criterion 6(5) of 10 CFR Part 40, Appendix A, any material from Moab Wash that will be used for the sandy layer of the radon barrier must not be above the background level of radioactivity.

<u>Material characterization issues and confirmatory items</u>: Comment acknowledged.

6.1.4 Revisions to the TER

As discussed above, the TER has been revised to indicate that Atlas will further characterize materials to verify the values used in the radon flux modelling.

6.2 Durability of the Cover

6.2.1 Commenters

Saxon Sharpe (23-14)
Utah Division of Radiation Control (58-77, 58-78)
Grand County Council by Jenner & Block (59-64, 59-65, 59-67)

6.2.2 Summary of Issues

Two commenters were concerned that the potential for biointrusion of the cover

to increase the radon flux from the tailings pile, by disrupting and/or drying the radon barrier, had not been adequately evaluated. Another commenter indicated that various other factors could cause disruption of the cover and must be adequately addressed.

Sharpe stated that the rock cover would trap blowing soil that would promote plant growth and that local deep-rooted plants grow in improbable places. Sharpe also mentioned that burrowing rodents pursue plants roots that grow to 30 feet deep in areas near the Atlas site.

Grand County Council stated that the proposed 4-inch-thick rock cover is inadequate, because at the Shiprock Title I tailings disposal cell, salt cedar (tamarisk) grew in the 6 to 8-inch-thick rock cover, and that a stand of salt cedar is adjacent to the Atlas tailings pile. Grand County stated that vegetation also grew in the rock cover of the Tuba City disposal cell where blowing sand was deposited in the rock on the shady side of the cell.

The State of Utah was concerned that disruption of the radon barrier could occur due to frost penetration (freeze-thaw damage), settlement, or drying. Utah stated that it was unclear if the frost penetration calculations are representative or conservative with respect to possible future on-site conditions. Utah stated that: there is a need to evaluate the magnitude of possible future land subsidence and the ability of the radon barrier to resist it; the conclusions concerning radon barrier design were premature and unjustified because of the settlement issue in DTER page 3-2; and the DTER needs to address changes in radon emanation in the event differential subsidence thins or breaches the radon barrier. Utah also was concerned about the possibility of desiccation cracking during construction of the clay layer.

6.2.3 Staff Analysis of Comments

Biointrusion of the cover: The staff concluded that biointrusion of the radon barrier will be restricted by the unfavorable environment of the rock layer in the final cover. Although it is recognized that some volunteer plant growth will occur, the staff agrees with the licensee's conclusion that it will most likely be shallow-rooted grasses whose roots should not penetrate the 12 inches of cover materials above the clay layer. Based on the staff's experience with other sites, the reclaimed facility does not appear to pr[illegible] a desirable habitat, and therefore, significant damage to the cover due to biointrusion is unlikely.

Disruption of the radon barrier by physical forces: The staff concluded that disruption of the radon barrier by physical forces, i.e. differential settlement, desiccation, or freeze-thaw damage, was unlikely to occur. Although some differential settlement should be expected, the staff concluded that the magnitude would be insufficient to disrupt the cover. Adequate protection from freeze-thaw damage or excessive desiccation will be provided by the external zones of the cover system.

6.2.4 Revisions to the TER

Section 3.3.5, discussing subsidence and its effect on the pile, has been added to the TER.

6.3 Approval of Radon Attenuation Design

6.3.1 Commenters

Utah Division of Radiation Control (58-77)
Grand County Council by Jenner & Block (59-67)

6.3.2 Summary of Issues

The State of Utah commented that NRC should require Atlas to resolve all issues and demonstrate adequate cover design for radon control before NRC approves the Reclamation Plan and allows construction of the pile cover.

Grand County Council stated that the draft TER indicated that if the measured average radon flux exceeded the limit, then Atlas could be required to add more radon barrier. Grand County was concerned that this assumes the problem can be fixed by adding more soil and that Atlas will be around to perform the corrective action. Grand County further stated this approach violates the prohibition against long-term maintenance.

6.3.3 Staff Analysis of Comments

Resolve all issues related to radon control before cover construction: All issues related to radon control have been resolved, as discussed in the TER.

If measured radon flux exceeds the standard: The staff disagrees with the assertion that adding more material to the radon barrier might not solve the problem if the measured radon flux were to exceed the standard. Adding more clean material to the radon barrier would most certainly lower the radon flux, because it would provide a longer pathway for radon to escape from the pile.

The staff considers it unlikely that Atlas would be not around to enhance the radon barrier if radon tests were to show it to be necessary. The radon flux measurements, required by criterion 6(6) of Appendix A to 10 CFR Part 40, must be performed as soon as the radon barrier is completed and before the rock is placed. That is, the work, if necessary, would have to be done during the construction of the cover. If Atlas were unable to perform the necessary construction, it would be dealt with through the financial surety, as would Atlas' failure during any stage of construction.

Additionally, Grand County is incorrect in its assumption that a revision or enhancement to the radon barrier because of radon tests required by criterion 6(6) constitutes long-term maintenance. Cover construction has nothing to do with long-term maintenance because the latter does not begin until the disposal site remediation (cover and surroundings) is complete and the site is transferred to the long-term custodian. NRC must determine that all regulations and license conditions have been met before it terminates Atlas' license. Until it terminates the license, Atlas is responsible for the site.

Finally, NRC staff consider it highly unlikely that the measured radon flux would exceed the standard because of the conservative manner in which the radon barrier is designed.

6.3.4 Revisions to the TER

The TER was revised to identify license conditions related to verifying parameters used in radon barrier modeling.

6.4 Maintenance costs

6.4.1 Commenters

Grand County Council by Jenner & Block (59-66)

6.4.2 Summary of Issues

Grand County Council states that the Atlas proposal will require ongoing maintenance and that Atlas' refusal to fund this maintenance should be considered an open issue.

6.4.3 Staff Analysis of Comments

Atlas' reclamation plan does not take credit for ongoing maintenance in order to meet the standards in 10 CFR Part 40, Appendix A. Therefore, the staff's review did not consider ongoing maintenance in evaluating Atlas' reclamation plan. The amount of money that Atlas will be required to pay, at license termination, for long-term surveillance and control will be determined at that time in conformance with Criterion 10.

6.4.4 Revisions to the TER

No revisions were made to the TER as a result of this comment.

7.0 APPENDIX A ASSESSMENT

7.1 Criterion 1

7.1.1 Commenters

Richard L. Christie (23-15, 23-16, 23-17, 23-18)
U.S. Department of the Interior (56-17, 56-18, 56-19)
Atlas Corporation (57-1)
Utah Division of Radiation Control (58-37)
Grand County Council by Jenner & Block (59-68, 59-69, 59-70, 59-71, 59-72, 59-73)

7.1.2 Summary of Issues

General: Grand County Council states that several Atlas site features do not comply with Criterion 1. Grand County Council further states that the Atlas plan does not meet Criterion 1 for many of the reasons that the Atomic Safety and Licensing Appeal Board concluded, in a different case in 1991, that the Kerr-McGee Chemical Corporation's plan to cap in place an existing radioactive waste pile, did not meet Criterion 1. Atlas Corp. states that several of the site features identified in Criterion 1 relate to selecting a new site from alternatives and are not regulatory criteria against which an existing site

can be evaluated for full compliance.

<u>1. Remoteness from populated areas</u>: Christie and Grand County Council state that the population of Moab and of Grand County are growing. Both commenters take issue with the statements that the City of Moab is 3 road miles and Arches National Park 2 miles, from the site. Grand County Council states that the (direct) distance to the Moab city limits is 1.5 miles and that Arches NationaL Park is located "across the street." Christie states that within 30 years the pile will be 1.1 miles from a densely inhabited area and that the tailings pile and Arches National Park are 1200 feet apart at their closest points.

<u>2. Isolation of contaminants from groundwater sources</u>: Christie states that it is very unlikely that the licensee can return groundwater quality to established standards and that hydrological and other natural conditions at the site work against continued immobilization and isolation of contaminants from groundwater sources. The Department of the Interior states that monitoring wells between the pile and the Colorado River reveal contaminants far exceeding standards, that there is probably no way to reduce those levels, and that ACLs will need to be established. The State of Utah states that Atlas should be required to demonstrate isolation of contaminants from future potential sources of groundwater. Grand County states that until NRC completes its analysis groundwater protection, it cannot show that Atlas' plan meets this component of Criterion 1.

<u>3. Minimizing erosion, disturbance, and dispersion by natural forces</u>: Christie states that the site characteristics favor erosion, disturbance, and dispersion by natural forces over the long-term. The Department of the Interior and Grand County state that the discussion does not recognize open issues, such as the lack of an approved cover design.

<u>4. No active maintenance required to preserve site conditions</u>: Christie states that there is a large margin of uncertainty in estimating the probability of site disturbances which would require active maintenance to repair. The Department of the Interior states that the conclusion that the erosion protection will not require active maintenance is inconsistent with the fact that the cover design has not been approved. Grand County states that NRC has failed to account for bio-intrusion, has underestimated the probability and impact of a PMF and that Atlas' steep slopes have no prior history of constructability or durability.

7.1.3 Staff Analysis of Comments

<u>General</u>: Criterion 1 presents general goals, and site features that must be considered. In promulgating Appendix A, it was recognized that existing sites may not meet these goals to the same level of conservatism as new sites. The Generic Environmental Impact Statement on Uranium Milling, NUREG-0706 explicitly discussed this. In addition, some the features identified are not applicable to an existing site. The Appeal Board decision referred to in the comment was appealed to the Commission. On February 21, 1996, the Commission granted Kerr-McGee's request to terminate the proceeding and vacated the Appeal Board decision.

1. Remoteness from populated areas: The distances in the draft TER were to the center of Moab and to the visitor center at Arches National Park. Additionally, while the nearby population at the Moab site is higher than that for many other tailings piles, at least two tailings piles were reclaimed in more densely populated areas. The TER discussion has been expanded to include this information.

2. Isolation of contaminants from groundwater sources: Clean up of existing groundwater contamination will be addressed under a separate licensing action. We agree with the Department of Interior that ACLs will probably need to be established for some of the constituents, but point out that ACLs are allowable under the standards developed by EPA and adopted by NRC. We agree with the State of Utah that future potential uses of groundwater will need to be considered.

3. Minimizing erosion, disturbance, and dispersion by natural forces: As discussed in section 4, the tailings are located in a reach of the Colorado River, where even during floods, flows are non-erosive. The cover design has been approved and will provide protection against erosion.

4. No active maintenance required to preserve site conditions: The staff agrees that there is a large margin of uncertainty in estimating the probability of the unlikely events that could result in disturbances requiring repair by the site custodian. It is for that reason that the staff uses conservative estimates of design events. For example, although the design life is 1000 years, the seismic event considered has a return period of 10,000 years and the magnitude of this event was estimated in a manner that results in it likely having been over, rather than under estimated. In addition, the longevity standard (1000 years to the extent reasonably achievable, but at least 200 years) is stated in terms of "reasonable assurance," not absolute or even near certainty. The staff acknowledges that there is a small but finite chance that the site custodian will have to repair damage to the pile sometime in the future. The cover design that has been approved does not rely on active maintenance to meet the longevity standard.

7.1.4 Revisions to the TER

Text has been added to state that NRC recognizes that the general goal in Criterion 1 may not be met at the existing Atlas site to the extent that it would for a new site and that this was recognized when the standards were promulgated. The text in item 1 has been revised to more accurately portray the distances to Moab and Arches National Park and a discussion of other tailings piles reclaimed in more densely populated areas has been added.

7.2 Criterion 2

7.2.1 Commenters

Atlas Corporation (57-2)

7.2.2 Summary of Issues

Atlas states that although NRC did not include discussion of Criterion 2 in

the draft TER, reclamation onsite would not result in the creation of new waste disposal sites and would therefore comply with this criterion.

7.2.3 Staff Analysis of Comments

Comment noted.

7.2.4 Revisions to the TER

No revisions were made to the TER as a result of this comment.

7.3 Criterion 3

7.3.1 Commenters

Richard L. Christie (23-19)
U.S. Department of the Interior (56-20)
Atlas Corporation (57-3)
Grand County Council by Jenner & Block (59-74)

7.3.2 Summary of Issues

Christie states that the draft TER discussion brings into clear focus the basic issues of whether the other criteria can be met given mitigation of site problems by design features and whether relocation of the tailings would cost much more than stabilization on-site. The Department of the Interior and Grand County state that the draft TER conclusion that the benefits of below grade disposal over stabilization in place are negligible, is inconsistent with a statement in the DEIS that moving the tailings would be environmentally preferable. Grand County states that NRC's conclusion in the draft TER, that Atlas' proposal complies with Criterion 3, violates the law. Grand County also states that NRC's conclusion, that the cost of relocating the tailings offsite and below grade would be much greater than the benefit, is not supported in the draft TER. Atlas states that Criterion 3 is not applicable to an existing tailings facility but is intended for new sites. Atlas further states that the only part of the criterion applicable to existing sites is the demonstration that above grade disposal will provide reasonably equivalent isolation of tailings and that Atlas' reclamation plan meets that requirement.

7.3.3 Staff Analysis of Comments

The conclusion that the cost of moving the pile is not warranted, is made with respect to this criterion, and not necessarily with respect to other benefits of moving the tailings. That is, the conclusion is that the benefit of achieving below grade disposal does not support the additional cost of moving the tailings. Below grade disposal represents a goal more applicable to proposed new sites than to existing ones.

7.3.4 Revisions to the TER

The Criterion 3 assessment has been revised to clarify that only the benefit with respect to below grade disposal has been considered in determining that relocation is not required.

7.4 Criterion 4

7.4.1 Commenters

Richard L. Christie (23-20, 23-21, 23-22, 23-23, 23-24)
U.S. Department of the Interior (56-21, 56-22)
Atlas Corporation (57-4)
Grand County Council by Jenner & Block (59-75, 59-76)

7.4.2 Summary of Issues

Criterion 4(a) - erosion potential: Christie states that the TER should acknowledge that the site, on the Moab Wash and Colorado River, does not minimize upstream catchment areas and possesses significant erosion potential. Grand County states that NRC's conclusion that the site will be protected from erosion is contradicted by the open issue on erosion protection.

Criterion 4(b) - wind protection: Christie disagrees with the statement in the draft TER that local topography provides good wind protection for the site, stating that the site is effectively located at the bottom of a wind tunnel. However, the commenter agrees with the conclusion in the draft TER that rock riprap will provide adequate protect against wind erosion of the tailings. Grand County states that since Atlas' erosion protection has not been approved by NRC, this criterion is not met. Atlas Corp. agrees that the site and design complies with the criterion.

Criterion 4(c) - flatness of slopes: Christie states that the TER should acknowledge that the slopes are not relatively flat. The Department of the Interior does not believe that it will be possible to get a uniform compaction of clay on the 10H:3V slopes and that NRC should review slope dynamics to ensure stability against gravity, seismic activity, or flood forces.

Criterion 4(d) - self-sustaining vegetative cover or rock cover: Christie states that draft TER is candid about the fact that a self-sustaining vegetative cover is not applicable to this arid site and that the rock armor design is substituted.

Criterion 4(e) - seismic design: Christie states that there is a large margin of uncertainty involved in information used to close this open issue. The Department of the Interior states that, in addition to the northeast trending fault, structural stability is impacted by the arcuate buried fault scarp, random floating earthquakes, and salt tectonics forces.

7.4.3 Staff Analysis of Comments

Criterion 4(a) - erosion potential: The staff considers this criterion a goal more applicable to new sites and that Atlas' approved design will protect the tailings from erosion.

Criterion 4(b) - wind protection: The statement on local topography has been deleted; however, staff still concludes that the approved erosion protect design will provide adequate wind protection.

Criterion 4(c) - flatness of slopes: The top slopes are relatively flat. Testing by Atlas, in accordance with approved construction specifications, will assure that appropriate compaction of the cover is achieved. The NRC staff has reviewed slope dynamics to assure stability.

Criterion 4(d) - self-sustaining vegetative cover or rock cover: Comment noted.

Criterion 4(e) - seismic design: Staff agrees that there is uncertainty in seismic analysis, however, because of the conservative manner in which it performed its evaluation, the staff is confident that the design meets the stability criteria. As discussed in sections 2 and 3, the staff's evaluation of the structural stability of the pile considered all potential earthquake sources.

7.4.4 Revisions to the TER

Criterion 4(b) has been revised to remove reference to local topography.

7.5 Groundwater Criteria

7.5.1 Commenters

U.S. Department of the Interior (56-23)
Grand County Council by Jenner & Block (59-77)

7.5.2 Summary of Issues

The Department of the Interior expressed concern about groundwater quality and contaminants leaching into the Colorado River. Grand County states that, as in the Title I program, Atlas should be required to prove now how it will address groundwater contamination.

7.5.3 Staff Analysis of Comments

As stated in the TER, groundwater protection will be addressed in a separate licensing action. Contrary to Grand County's assertion, in the Title I program, the Department of Energy separated and postponed consideration of groundwater contamination from surface remediation of tailings.

7.5.4 Revisions to the TER

No revisions were made to the TER as a result of these comments.

7.6 Criterion 6

7.6.1 Commenters

Richard L. Christie (23-25)
Grand County Council by Jenner & Block (59-78)

7.6.2 Summary of Issues

Christie takes exception to the statement, under Criterion 6(7), regarding postclosure escape of nonradiological hazardous constituents. Grand County states that the Atlas plan does not provide reasonable assurance of effectiveness for 200 years, because of insufficient data, open issues, and bio-intrusion.

7.6.3 Staff Analysis of Comments

Staff disagrees with Christie in that the radon barrier will limit infiltration into the remediated pile. Staff disagrees with Grand County; based on the analysis described in sections 2, 3, and 4, the staff concludes that there is reasonable assurance that the control of radiological hazard will be effective for at least 1000 years, with even higher confidence in effectiveness for 200 years.

7.6.4 Revisions to the TER

No revisions were made to the TER as a result of these comments.

7.7 Criteria 9 and 10

7.7.1 Commenters

Richard L. Christie (23-26)

7.7.2 Summary of Issues

Christie questions whether the cost estimate, used in the DEIS to justify capping in place, is adequate for reclamation.

7.7.3 Staff Analysis of Comments

The staff acknowledges that the cost estimates discussed in the EIS are approximate and subject to revision. However, the staff has high confidence in its conclusion that the cost different between stabilization in place and off-site at Plateau site are significant. If Atlas' proposed reclamation plan is approved, Atlas will have to provide a detailed cost estimate for NRC review and approval.

7.7.4 Revisions to the TER

No revisions were made to the TER as a result of these comments.

7.8 Criterion 12

7.8.1 Commenters

Grand County Council by Jenner & Block (59-79)

7.8.2 Summary of Issues

Grand County Council disagrees with the staff conclusion that no ongoing maintenance would be required to preserve isolation of the wastes.

7.8.3 Staff Analysis of Comments

The reclamation design proposed by Atlas does not rely on active maintenance to preserve isolation. Sections 2, 3, and 4 discuss the staff analysis and evaluations that lead it to conclude that there is reasonable assurance that the design will be effective for the required duration without active maintenance.

7.8.4 Revisions to the TER

No revisions were made to the TER as a result of this comment.

7.9 General

7.9.1 Commenters

Utah Division of Radiation Control (58-79)

7.9.2 Summary of Issues

The State of Utah felt that many of the conclusions in this section were premature, incomplete and/or unfounded and suggested that the section be rewritten after resolution of the State's concerns on the draft TER.

7.9.3 Staff Analysis of Comments

The staff disagrees with the State of Utah; the conclusions in section 7 of the TER are supported by staff analysis and evaluations discussed in the TER.

7.9.4 Revisions to the TER

No revisions were made to the TER as a result of this comment.

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11. ABSTRACT *(200 words or less)*

This final Technical Evaluation Report (TER) summarizes the U.S. Nuclear Regulatory Commission staff's review of Atlas Corporation's proposed reclamation plan for its uranium mill tailings pile near Moab, Utah. The proposed reclamation would allow Atlas to (1) reclaim the tailings pile for permanent disposal and long-term custodial care by a government agency in its current location on the Moab site, (2) prepare the site for closure, and (3) relinquish responsibility of the site after having its NRC license terminated. The NRC staff concludes that, subject to license conditions identified in the TER, the proposed reclamation plan meets the requirements identified in NRC regulations, which appear primarily in 10 CFR Part 40.

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