UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD PANEL

Before Administrative Judges:
Peter B. Bloch, Presiding Officer
Thomas D. Murphy, Special Assistant

In the Matter of:

ATLAS CORPORATION
(Moab, Utah)

Docket No. 40-3453-MLA-2

Re: Tailings Pile Integrity

ASLBP No. 98-747-02-MLA

ATLAS CORPORATION'S RESPONSE TO THE STATE OF UTAH'S REQUEST FOR HEARING AND PETITION FOR LEAVE TO INTERVENE

I. Introduction

Atlas Corporation ("Atlas") owns a uranium milling facility in Moab, Utah pursuant to Source Material License SUA-917 (the "Facility"). Over the years, Atlas' license has been updated and amended periodically to reflect evolving Nuclear Regulatory Commission ("NRC" or "Commission") regulatory requirements and guidance. In 1984, Atlas ceased active milling operations at the Facility. The mill was permanently shut down, and decommissioning of the mill was begun in 1988. Since 1988, Atlas has been engaged in efforts directed at reclaiming the Facility, including, in particular, the uranium mill tailings pile located on-site at the Facility.

As required under NRC's regulations, Atlas submitted a detailed reclamation plan for the Facility to the Commission in 1981. This plan, which called for disposal of the tailings pile in place, with a clay and earth cap and rock and vegetative cover, was reviewed and accepted by NRC in 1982.[1] Atlas' reclamation plan was revisited by NRC in 1988, in connection with the Commission's renewal of Atlas' operating license, and was again found acceptable as part of a FONSI issued by NRC.

In 1988 and 1989, Atlas submitted revisions to its reclamation plan, as requested by NRC, to address slope design and technical aspects of the rip rap to be placed on the outer slopes of the tailings pile to protect the integrity of the pile in the face of a probable maximum flood.[2] In 1992 and 1993, Atlas submitted further revisions to its reclamation plan in response to a request from NRC to address new erosion protection requirements contained in NRC's guidance entitled Final Staff Technical Position: Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites (1990).[3] In July 1993, NRC issued a finding of no significant impact ("FONSI") and a notice of intent to approve Atlas' revised reclamation plan.[4] However, later in that same year, NRC took the unprecedented step of rescinding the FONSI because of controversy surrounding the in place disposal approach. Among the concerns raised by

[1] U.S. Nuclear Regulatory Commission, Draft Technical Evaluation Report for the Proposed Revised Reclamation Plan for the Atlas Corporation Moab Mill ("DTER")(Attachment A) at 1-1 (Jan. 1996); U.S. Nuclear Regulatory Commission, Final Technical Evaluation Report for the Proposed Revised Reclamation Plan for the Atlas Corporation Moab Mill ("FTER") (Attachment B) at 1-1 (March 1997).

[2] FTER at 1-4, 1-5.

[3] FTER at 1-4, 1-5; Affidavit of Richard E. Blubaugh, Vice President of Environmental and Governmental Affairs, Atlas Corporation (Blubaugh Affidavit)(Attachment C) at ¶ 10.

[4] 58 Fed. Reg. 38,796 (1993).

commenters on the FONSI was the possibility that the Colorado River might migrate over time and eventually encroach upon, and undermine the integrity of, the tailings pile.[5/]

Following its recission of the 1993 FONSI, the Commission initiated an environmental review of Atlas' revised reclamation plan aimed at producing an environmental impact statement ("EIS"). The NRC staff indicated that the EIS would be prepared on a "fast track" basis, and that it was intended that a final EIS would be completed within twelve months.[6/] The State of Utah declined to participate in this EIS process as a cooperating agency, however, at least in part because of its express desire to preserve its option to bring suit against NRC to address any inadequacies in the EIS.

At the same time that NRC was conducting its environmental review to develop an EIS, the Commission staff was also preparing a technical review of Atlas' revised reclamation plan, which ultimately would result in the preparation of a Technical Evaluation Report ("TER"). The purpose of this TER process was to assess whether Atlas' proposed reclamation plan satisfied the technical criteria set out in the Commission's regulations at 10 C.F.R. Part 40, Appendix A.[7/]

In connection with the initiation of the EIS and TER processes, NRC published a notice in the Federal Register on April 7, 1994, announcing Atlas' proposed modifications to its reclamation plan, and inviting any interested party to request a hearing on those proposed

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5/ 58 Fed. Reg. 52,516 (1993) (withdrawal of notice of intent to amend source material license and FONSI); DTER at 1-4; FTER at 1-4.

6/ FTER at 1-5; Blubaugh Affidavit at ¶ 14.

7/ FTER at 1-5.

modifications.[8] The notice specified that any request for hearing would have to be filed within 30 days of the date of publication of the notice in the Federal Register.[9] No hearing was requested within the specified 30-day time period.

In connection with its technical review of Atlas' reclamation plan, and apparently in response to comments received on the 1993 FONSI, NRC requested in late 1993 and 1994 that Atlas provide the Commission with information pertaining to the long-term potential for the Colorado River to migrate toward and encroach upon the tailings pile.[10] In its May 31, 1994 response to these inquiries, Atlas presented the conclusions reached by its consultant, Mussetter Engineering, Inc. ("Mussetter").[11] In its report entitled Geomorphic, Hydraulic and Lateral Migration Characteristics of the Colorado River -- Moab, Utah which was attached to the reply, Mussetter concluded that the lateral migration of the Colorado River toward the Atlas tailings pile was "very unlikely" during the 1,000-year time frame. This conclusion was reached after a careful review of geological characteristics of the area of the tailings pile as well as field and historical evidence.

Nevertheless, in response to the concerns expressed by the NRC staff, Atlas informed the staff of its plans to incorporate a collapsible rock apron into its proposed reclamation plan in its

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[8] 59 Fed. Reg. 16,665 (1994).

[9] Id.

[10] Letter from Ramon E. Hall, Director, Uranium Recovery Field Office, U.S. Nuclear Regulatory Commission, Region IV to Richard Blubaugh, Atlas Corporation at 1 (Nov. 29, 1993)(Attachment D); Letter from Joseph Holonich, Chief, Uranium Recovery Branch, Division of Waste Management, U.S. Nuclear Regulatory Commission to Richard Blubaugh, Atlas Corporation at 1 (Nov. 4, 1994)(Attachment E).

[11] Letter from Richard Blubaugh, Atlas Corporation to Joseph Holonich, Chief, Uranium Recovery Branch, Division of Waste Management, U.S. Nuclear Regulatory Commission (May 31, 1994)(Attachment F).

March 21, 1995 letter.[12] Despite the very low potential for the Colorado River to migrate and impact the tailings pile as indicated by the Mussetter report, Atlas proposed a rock apron that would be 2.5 feet thick and 20 feet wide to provide an extra measure of protection against any potential erosion.

In January 1996, NRC issued its Draft TER for Atlas' proposed reclamation plan. The Draft TER concluded that the potential for the Colorado River to migrate toward and encroach upon the tailings pile was slight, and that, in any event, the design of the collapsible rock apron was adequately protective and would satisfy the requirements of 10 C.F.R. Part 40, Appendix A.[13] These conclusions were confirmed in the Final TER, which was issued by NRC in March 1997.[14]

Subsequently, in the Fall of 1997, the Utah Radiation Control Board (the "Board") received several requests from Peter Haney of Moab, Utah asking the Board to challenge NRC's issuance of the Final TER.[15] In response to this request, the Board invited Haney to present relevant information during its meeting scheduled for November 7, 1997.[16]

At the November 7, 1997 meeting, Peter Haney presented the Board with a report commissioned by the Grand County Council and prepared by the U.S. Army Corps of Engineers

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12/ Letter from Richard Blubaugh, Atlas Corporation to Joseph Holonich, Chief, Uranium Recovery Branch, Division of Waste Management, U.S. Nuclear Regulatory Commission (March 21, 1995)(Attachment G).

13/ DTER at 4-13.

14/ FTER at 4-13, 4-14.

15/ State of Utah's Request for Hearing and Petition for Leave to Intervene (hereinafter "Request for Hearing") at Exhibit 1.

16/ Request for Hearing at Exhibit 2.

("ACE") that questioned the adequacy of the design of the collapsible rock apron at the Atlas tailings pile. Also during this meeting, the staff of the Utah Division of Radiation Control ("UDRC") made its presentation to the Board, reviewing a variety of issues raised by Haney but disagreeing with the NRC staff only over the adequacy of the design of the rock apron.

Following this meeting, the Board forwarded the ACE report to the NRC staff on November 10, 1997.[17/] In a telephone discussion on November 18, 1997, Joseph Holonich, Chief of Uranium Recovery Branch of NRC's Division of Waste Management, informed the UDRC staff that the NRC staff would undertake a detailed evaluation of the ACE report and other issues raised by Peter Haney.

On February 26, 1998, the NRC staff released its report regarding the proposed rock apron, concluding that the migration of the Colorado River to the Atlas tailings pile was unlikely and that the proposed rock apron would adequately protect the pile.[18/] In response to this report, the UDRC staff issued a memorandum on April 2, 1998, continuing to express its disagreement with the NRC staff regarding the protectiveness of the proposed rock apron.[19/] William Sinclair, Director of UDRC, also sent a letter to Joseph Holonich on April 15, 1998, informing the NRC staff of this difference in point of view and expressing the State of Utah's intent to pursue "all available administrative remedies."[20/]

17/ Request for Hearing at Exhibit 4.

18/ Request for Hearing at Exhibit 11.

19/ Request for Hearing at Exhibit 12.

20/ Request for Hearing at Exhibit 14.

Finally, through a letter dated May 27, 1998, Joseph Holonich advised William Sinclair that the NRC staff had determined that all technical issues associated with the proposed rock apron was resolved and that the staff had no plans to revisit this issue. [21]

The State of Utah filed its request for hearing in this matter because it is dissatisfied with the proposed reclamation plan that NRC has found, after several *years* of analysis, to satisfy the requirements of 10 C.F.R. Part 40, Appendix A. Specifically, Utah disagrees with NRC's conclusion regarding the adequacy of the rock apron design included in Atlas' reclamation plan in order to protect the integrity of the reclaimed tailings pile in the event that the Colorado River migrates to and encroaches upon the pile.

II. Procedural Posture

NRC published its Federal Register notice announcing Atlas' proposed changes to its reclamation plan on April 7, 1994. 59 Fed. Reg. 16,665 (1994). The Notice invited parties whose interests might be affected by the proposed changes to request a hearing, and, consistent with the Commission's regulations at 10 C.F.R. § 2.1205, provided that any request for a hearing on the proposed reclamation plan changes would have to be filed with the Commission within 30 days of the date on which the Notice was published. More than four years later, on July 13, 1998, the State of Utah filed its Request for Hearing.

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[21] Request for Hearing at Exhibit 15.

III. Argument

Utah's Request for Hearing was filed more than four years after the regulatory deadline for requesting a hearing on Atlas' proposed reclamation plan modifications had expired. In the intervening years, Utah has participated fully in the decisionmaking process implemented by NRC to address the proposed reclamation plan modifications. Utah has known about the river migration issue from the beginning and about the proposed rock apron design from the time Atlas submitted the proposal. Now, at the eleventh hour, Utah finds that it disagrees with NRC's conclusion that the rock apron design is adequate. Therefore, the State has filed its Request for Hearing. At best, Utah's Request for Hearing represents an attempt on the part of the State to use the hearing process to substitute its judgment for that of NRC's staff; however, a more cynical view would suggest that the State's eleventh hour Request for Hearing is intended to appease political interests that seek to delay final approval of Atlas' reclamation plan.

Regardless of the State's motivation for filing the Request for Hearing, that request must be denied because (i) the request is untimely, (ii) Utah has failed to demonstrate that its four-year delay in requesting a hearing was reasonable, and (iii) a hearing at this point in the decisionmaking process would cause Atlas undue prejudice and unreasonable harm. Moreover, the Request for Hearing should be denied because Utah participated fully in NRC's decisionmaking process to evaluate the revised reclamation plan, and the technical decisions that have been made by the NRC staff in evaluating Atlas' proposed reclamation plan are entitled to deference.

A. Utah's Request for Hearing is Untimely

The right to request a hearing on license amendments proposed by the licensee is established in Section 189(a) of the Atomic Energy Act, 42 U.S.C.§ 2239(a), and is implemented through Subpart L of the Commission's Rules of Practice for Domestic Licensing Proceedings and Issuance of Orders (the "Rules of Practice"), 10 C.F.R. Part 2, Subpart L. Under the applicable regulations, any party whose interests may be affected by a proposed license amendment may request a hearing on that amendment.[22/]

NRC published notice of the proposed modifications to Atlas' reclamation plan in the Federal Register on April 7, 1994. In that notice NRC indicated that any party whose interests might be affected by the proposed changes could request a hearing, and that such a request would have to be made within 30 days of the publication date of the Federal Register notice (i.e., by May 7, 1994). This is consistent with NRC's Rules of Practice, which provide that in informal proceedings:

> A person, other than an applicant, shall file a request for hearing within
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> (1) Thirty days of the agency's publication in the FEDERAL REGISTER of a notice referring or relating to an application or the licensing action requested by an application, which must include a reference to the opportunity for a hearing under the procedures set forth in this subpart.

10 C.F.R. § 2.1205(d)(1).[23/]

22/ 10 C.F.R. § 2.1205.

23/ Although the Federal Register notice announcing Atlas' proposed license modifications informed interested parties of their opportunity to request a hearing, the notice incorrectly referred to the generally applicable procedures set forth in the Rules of Practice (10 C.F.R. §§ 2.105 and 2.714) instead of referring to the rules for informal proceedings (10 C.F.R. § 2.1205). However, Utah cannot have been prejudiced by this error (nor does the
Footnote continued on next page

Utah filed its Request for Hearing on July 13, 1998, more than *four years* after the 30-day deadline set forth in the regulations and repeated in the Federal Register notice announcing Atlas' proposed license amendments. Thus, under the Rules of Practice, Utah's Request for Hearing is clearly untimely. However, the regulations provide that an untimely request for a hearing may nevertheless be granted if the petitioner can establish that:

> (i) The delay in filing the request for a hearing or the petition for leave to intervene was excusable; *and*
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> (ii) The grant of the request for a hearing or the petition for leave to intervene will not result in undue prejudice or injury to any other party.

10 C.F.R. §2.1205(l)(1) (emphasis added). If either of these factors is not established, the request for hearing cannot be granted. Id. The State of Utah in its Request for Hearing has failed to establish either of these necessary conditions. Therefore, the Request for Hearing must be denied.

B. Utah's Delay in Requesting a Hearing was Not Excusable

The State makes two arguments in an effort to convince the Panel that its four-year delay in requesting a hearing is excusable. First, the State argues that at the time Atlas' proposed license amendments were announced in the Federal Register, the State saw no need to pursue adjudication because the State felt it could resolve any differences with NRC Staff on a more informal basis. As stated in its Hearing Request, the "State of Utah, as an NRC Agreement State,

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State claim to have been prejudiced), since the Federal Register notice explicitly stated that hearing requests were required to be filed within 30 days of the date of the notice, which is the deadline set forth in 10 C.F.R. § 2.1205(d)(1), and, in any event, the incorrectly cited rules at 10 C.F.R. § 2.714 require that hearing requests be filed within a time frame similar to that established under 10 C.F.R. § 2.1205.

believed it could work cooperatively with NRC staff to resolve the rock armoring issue without having to resort to the adjudicative process." (Hearing Request at 17) This argument does not excuse Utah's delay.

The State of Utah, when it was put on notice of Atlas' proposed license amendments by publication of the April 7, 1994 Federal Register notice, had to choose whether and how it wanted to participate in NRC's decisionmaking process. In particular, the State had to choose between requesting a hearing to assert its interests in an adjudicative forum, or participating in a more informal process and asserting its interests through a notice and comment process. The State chose to pursue the more informal route of notice and comment decisionmaking. Now, because the State is unhappy with the *outcome* of that process, it is seeking to reverse the decision it made four years ago and now pursue a hearing. However, dissatisfaction with the *outcome* of an informal decisionmaking process does not excuse the failure, at the *beginning* of the process to request a hearing.

In this regard, the Rules of Practice treat the State like any other private party. See, e.g., In the Matter of Nuclear Fuel Services, Inc. and New York State Atomic and Space Development Authority (West Valley Reprocessing Plant), ALAB-263, 1 NRC 208 at 20 (1975). If the State of Utah wanted to assert its interests in Atlas' proposed license amendments in an adjudicative forum, it was required to follow the clear and simple procedure spelled out in the Rules of Practice (and in the 1994 Federal Register notice announcing Atlas' proposed license amendments): it was required to file a hearing request within 30 days of the date on which notice

of the proposed license amendments was published in the Federal Register.[24/] 10 C.F.R. § 2.1205(d)(1).

The second argument advanced by Utah to justify its delay in requesting a hearing is that the State relied on NRC to conduct an "adequate review of the Atlas design basis," and therefore, the State could not have anticipated that the issue of rock apron design would become a point of contention. (Hearing Request at 18) Specifically, the State claims that "the inadequacies in the NRC's analysis of rock armoring did not present itself [sic] until issuance of the final TER, as bolstered by NRC's later supplemental report." (Petition at 17) However, as NRC staff has ably demonstrated in its Nuclear Regulatory Commission Staff's (1) Response to State of Utah's Request for Hearing and Petition for Leave to Intervene and (2) Notice of Staff Participation dated August 3,1998 (hereinafter "NRC Staff's Response"), this argument cannot excuse Utah's four year delay in requesting a hearing.

In the first place, the April 7, 1994 Federal Register notice put the State on notice that Atlas was proposing changes to its reclamation plan that were intended to address the design of the erosion protection cover for the tailings pile, as well as design of drainage channels and other

[24/] Indeed, the State makes a point in its Request for Hearing of highlighting the fact that Utah is an NRC Agreement State (Hearing Request at 17); implying that the State was somehow excused from complying with the procedural requirements spelled out in NRC's Rules of Practice because it expected to work "cooperatively" with NRC Staff (meaning, apparently, that it expected NRC staff to ignore the results of its own independent analysis and simply adopt the position advocated by the State). However, if anything, the fact that Utah is an Agreement State suggests that the State should be held to a *higher standard of compliance* with the procedural requirements in NRC's Rules of Practice, since, presumably, Agreement States are more familiar with those procedural requirements than an ordinary member of the public might be.

Moreover, it should be noted that the State of Utah is *not* an Agreement State for the regulation of 11e.(2) byproduct material. Thus, Utah cannot be presumed to have any particular expertise with respect to the regulation of uranium mill tailings (which are 11e.(2) byproduct material) and the design of uranium mill tailings impoundments.

engineering controls intended to protect against the Probable Maximum Flood. 59 Fed. Reg. 16,665 (1994). Thus, as a result of the 1994 Federal Register notice, the State was aware that NRC was going to evaluate changes to Atlas' reclamation plan pertaining to erosion protection, and that, moreover, the plan did not include any design features specifically addressing the possibility that the Colorado River might encroach upon the tailings pile. Thus, to the extent that the State's interest extended to the adequacy of erosion protection provided under Atlas' reclamation plan, it was incumbent upon the State to choose how it wanted to assert that interest -- in an adjudicatory proceeding or a notice and comment process. It was inappropriate for the State to rely on NRC staff to represent the State of Utah's interests with respect to design of erosion protection measures under Atlas' reclamation plan. As pointed out in the NRC Staff's Response, Utah's reliance on NRC to protect the State's interests cannot excuse the State's delay in requesting a hearing. (NRC Staff's Response at 9, citing Puget Sound Power and Light Co. (Skagit Nuclear Power Project Unit 1 and 2), LBP-79-16, 9 NRC 711, 1979 NRC LEXIS 73, *9-10 (1979), aff'd, ALAB-559, 10 NRC 162, 1979 NRC LEXIS 42 (1979).)

In addition, it is simply untenable for Utah to contend that it could not have known of the "inadequacies in the NRC's analysis of rock armoring" until issuance of the Final TER "as bolstered by NRC's later supplemental report." (Request for Hearing at 17.) In November 1993 and a year later, in November 1994, NRC staff requested that Atlas provide the staff with information relating to river migration and the design of the tailings pile apron.[25] Included with

[25] Letter from Ramon E. Hall, Director, Uranium Recovery Field Office, U.S. Nuclear Regulatory Commission, Region IV to Richard Blubaugh, Atlas Corporation at 1 (Nov. 29, 1993); Letter from Joseph Holonich, Chief, Uranium Recovery Branch, Division of Waste Management, U.S. Nuclear Regulatory Commission to Richard Blubaugh, Atlas Corporation at 1 (Nov. 4, 1994).

the November 1994 request for information was a report from the Utah Geological Survey which addressed, among other things, the possibility of river migration.[26] Atlas responded to these requests for information with submissions dated May 31, 1994 and March 21, 1995, addressing both the possibility of river migration and the design of a rock apron to protect the Atlas tailings pile.[27] The State of Utah was copied on this correspondence. In fact, UDRC has been routinely copied on all correspondences between NRC and Atlas, and any new information about the proposed rock apron presumably would have been reported to the Board by the UDRC staff during bi-monthly meetings.

Thus, at a minimum, the State was aware of the river migration issue as early as 1994 (as evidenced by the Utah Geological Survey report). In addition, the State knew of Atlas' rock apron design by the middle of 1995, when it received copies of the information on rock apron design that Atlas provided to NRC. Then, in 1996, NRC issued its Draft TER, which specifically addressed river migration and Atlas' rock apron design and concluded that the design was adequate to satisfy the requirements of 40 C.F.R. Part 40, Appendix A. Specifically, the Draft TER stated that:

> 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.
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> . . .

26/ Letter from Joseph Holonich, Chief, Uranium Recovery Branch, Division of Waste Management, U.S. Nuclear Regulatory Commission to Richard Blubaugh, Atlas Corporation at Enclosure 6 (Nov. 4, 1994).

27/ Letter from Richard Blubaugh, Atlas Corporation to Joseph Holonich, Chief, Uranium Recovery Branch, Division of Waste Management, U.S. Nuclear Regulatory Commission(May 31, 1994); Letter from Richard Blubaugh, Atlas Corporation to Joseph Holonich, Chief, Uranium Recovery Branch, Division of Waste Management, U.S. Nuclear Regulatory Commission (March 21, 1995). See also Blubaugh Affidavit at ¶ 18.

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

DTER at 4-11, 4-13. With respect to Atlas' rock apron design, the Draft TER noted that although there was a very low probability of the Colorado river encroaching upon the tailings pile, not enough quantitative data had been generated to demonstrate that encroachment would not undermine the pile. In lieu of requiring additional studies to generate this quantitative data, however, NRC staff concluded that it would be sufficient to incorporate into the reclamation plan a design feature intended to protect the stability of the pile in the unlikely event that such encroachment would occur. Specifically, the Draft TER states that:

> 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 description of the apron may be found in Section 4.5.1.2.3.

Id. at 4-14. Thus, the Draft TER in January of 1996 provided Utah with a full understanding of Atlas' and NRC's approaches to the river migration issue. It also supplied the State with detailed information regarding the technical design proposed for the rock apron. Consequently, the State of Utah was aware of the river migration issue and the rock apron design and NRC staff's assessment of the rock apron design at the very latest by January of 1996, when NRC issued its Draft TER. The State has offered no reasonable excuse to explain why it did not request a hearing at that point.

Similarly, on November 7, 1997, Peter Haney -- whom the State in its hearing request identifies as a "nurse"[28] and who, at the time, was an elected member of the Grand County Council -- provided the State with information that purported to call into question the adequacy of Atlas' rock apron design.[29] Thus, by November of 1997, the State not only had knowledge of the river migration issue and of Atlas' rock apron design, and NRC staff's assessment of that design but it also was aware of the specific issue that now forms the basis of its hearing request -- the alleged inadequacy of the rock apron design. Yet, the State offers no reasonable excuse to explain why it did not request a hearing in response to the information it received in November 1997. Indeed, no such excuse is possible. Although the availability of "new" information may in some circumstances excuse late requests for hearing or intervention,[30] as demonstrated above, the State of Utah had information about the river migration issue and about Atlas' rock apron design by January of 1996 at the latest. Moreover, to the extent that allegations regarding deficiencies in particular aspects of the rock apron design may be regarded as "new" information, the State was in possession of that information in November of 1997, at the latest.

Thus, even if one were to excuse the State's failure to request a hearing within 30 days of the April 7, 1994 Federal Register notice, on the grounds that the State received "new" information regarding the purported inadequacy of Atlas' rock apron design in November 1997, the time for the state to have requested a hearing would have been within 30 days of receiving

[28] Request for Hearing at 17.

[29] Request for Hearing at Exhibits 3-5.

[30] Duke Power Company, ALAB-528, 9 NRC 146, 148-149 (1979). See also Cincinnati Gas and Electric Co., LBP-80-14, 11 NRC 570, 572-573 (1980); Consumer Power Co., LBP-82-63, 16 NRC 571, 577 (1982).

that new information -- i.e., in December 1997. It was simply unreasonable for the State to wait an additional eight months before filing its request. See, e.g., Hydro Resources, Inc., LBP 98-9, 1998 NRC LEXIS 21, *39 (1998) (Five-month delay in seeking intervention following receipt of new information held unreasonable.) Moreover, the State's delay cannot be excused by the fact that Utah was engaged in a dialogue with NRC staff over the adequacy of Atlas' design. Nuclear Metals, Inc., LBP-91-27, 33 NRC 548, 1991 NRC LEXIS 25, *6 (1991) (In finding a nine-month delay unreasonable, the presiding officer noted that "the existence of negotiations does not create any excuse for a party to sleep on its obligations to file a petition in a timely fashion, any more than negotiating about a tort (a civil suit) would permit a party to overstay the statute of limitations.")[31]

The petition process available under Subpart L of the Rules of Practice is intended to ensure that all parties whose interests might be affected by a license modification have an opportunity to air their concerns about the proposed action. Utah has participated fully in the decisionmaking process that was used by NRC to evaluate the river migration issue and the technical design for Atlas' tailings impoundment. Now, because the state is unhappy with the results of that decisionmaking process, the state wants to change the rules under which it elected to proceed more than four years ago. However, the state's desire to reach a different result does not provide a reasonable basis for requesting a hearing more than four years after the deadline for

[31] Cf. Umetco Minerals Corporation, LBP-92-20, 36 NRC 112 (1992)(Although the Hearing Officer based his decision to allow an untimely petition to intervene partly on grounds that the petitioner in the case -- State of Utah -- had engaged in negotiations with the NRC Staff, this decision can be distinguished from the facts of the present case on several grounds. To begin with, Umetco involved a different regulatory provision -- 10 C.F.R. § 2.1205(c)(2) -- that is not applicable to the present case. More importantly, in Umetco, the tardiness of the petitioner in filing its request did not result in any undue prejudice to the other participants in the proceeding since the NRC Staff and the licensee had already agreed to delay any action on the proposed license amendment.).

such a request had expired, more than a year after issuance of the Final TER which put the issue of the rock apron design in high relief, and roughly eight months after the specific technical design concerns that form the basis of the State's request for hearing were brought directly to the State's attention. Accordingly, because Utah has failed to demonstrate that its delay in requesting a hearing is excusable, the State's untimely request for hearing must be denied.

C. Granting Utah's Request For Hearing Would Cause Unreasonable Injury to Atlas

NRC has recognized that an applicant has a strong interest in having its license requests acted upon promptly. Thus, the Commission has expressly acknowledged the "right of the applicant to a reasonably prompt administrative assessment of and determination about its application so it can go forth with its planned activities."[32/] Atlas proposed revisions to its reclamation plan in 1988. Since that time, the proposed revisions have undergone extensive environmental and technical review by NRC. This review has included numerous public meetings, the issuance and subsequent withdrawal of a FONSI, the preparation of a draft EIS and a draft TER and the solicitation of comments on both documents, and the issuance of a final TER. During the course of this review process, numerous questions were raised regarding various aspects of its tailings impoundment design, prompting Atlas to conduct additional studies and in some instances to modify its design, in order to address those concerns.

At the conclusion of this exhaustive review process, NRC staff concluded that Atlas' reclamation plan, and in particular its rock apron design, is technically adequate and will satisfy the requirements of 10 C.F.R. Part 40, Appendix A. Specifically, NRC concluded that the

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[32/] 52 Fed. Reg. 20089, 20090 (1987).

probability that the Colorado River will migrate to encroach upon the tailings impoundment is very small, and that, in the unlikely event that such migration were to occur, the rock apron design would provide reasonable assurance of the impoundment's stability, with an adequate margin of safety. The State of Utah disagreed with this conclusion. In particular, the State raised concerns regarding the calculations that were used to derive certain features of the rock apron design.

Despite the efforts of NRC and Atlas over the past seven months to address Utah's specific concerns regarding the adequacy of the rock apron design, the State still disagrees with NRC's conclusion that the rock apron design is adequate. Consequently, the State has requested a hearing, four years after the appropriate deadline, in order to reopen the issue of the rock apron design's adequacy. If this request is granted, Atlas and NRC will have to revisit technical issues that have already been subject to multiple layers of review and re-review. A final disposition regarding the adequacy of Atlas' reclamation plan will be further delayed, as will Atlas' efforts to implement the reclamation plan. In short, Atlas' right to "a reasonably prompt administrative assessment of and determination about its application" will have been grossly violated and Atlas' efforts to go forward with its planned reclamation efforts will have been stymied, a result that flies in the face of the Commission's stated goal of avoiding unnecessary delays in NRC's review and hearing processes.[33/]

33/ In a recent policy statement, the Commission noted:

> *The parties to a proceeding, therefore, are expected to adhere to the time frames specified in the Rules of Practice in 10 C.F.R. Part 2 for filing and the scheduling orders in the proceeding. . . .* [T]he licensing boards are expected to take appropriate actions to enforce compliance with these schedules. . . . *[T]he boards may grant extensions of time under some circumstances, but this should be done only when warranted by unavoidable and extreme circumstances.*

Footnote continued on next page

In addition to trampling on Atlas' right to a speedy disposition of its application, a hearing in this matter would cause Atlas serious financial injury. Every month that site reclamation is delayed costs Atlas nearly $50,000 in administrative costs alone. In addition, the contingent liabilities that will continue to be associated with the Moab Facility until reclamation is complete have the effect of creating a debilitating deterrent to investors. Consequently, every day of delay causes Atlas to lose business opportunities and move one step closer toward financial disaster. When these costs are added to the expenses of participating in the hearing sought by Utah, the overall impact on Atlas is substantial. Given the already weakened financial condition of the company, the imposition of these additional costs for the sake of revisiting technical issues that have already received extensive review and analysis would be unreasonable.[34/]

Utah attempts to argue in its petition that a hearing in this matter will not cause unreasonable harm or prejudice to Atlas because (i) the United States Fish and Wildlife Service ("FWS") objects to the reclamation plan as not being adequately protective of endangered fish in the river; (ii) Atlas has received notice of an intent to file a citizens suit under the Clean Water Act ("CWA"); and (iii) Utah intends to regulate groundwater discharges under state law, and groundwater clean-up will require adequate tailings impoundment design. Each of these factors, the state claims, will delay implementation of Atlas' reclamation plan; therefore, further delay caused by the requested hearing will not cause unreasonable injury.

Footnote continued from previous page

U.S. Nuclear Regulatory Commission, Statement of Policy on Conduct of Adjudicatory Proceedings 6 (July 28, 1998)(Attachment H). The State has failed to allege any "*unavoidable and extreme circumstances*" that would excuse its failure to comply with the established deadlines for filing its Request for Hearing.

[34/] Blubaugh Affidavit at ¶¶ 21-23.

This argument is, in a word, nonsensical. In the first place, the fact that Atlas might have to contend with delays from other proceedings in no way mitigates the harm Atlas would suffer as a result of having further delay and additional expense heaped on the company by having to go forward with the hearing requested by Utah. Moreover, its not at all clear that the factors cited by Utah in its petition are likely to cause delay. First, FWS does not have veto power over NRC's licensing decisions. In fact, FWS has recently issued a final biological opinion explaining the Service's concerns regarding impact on endangered fish.[35/] To the extent it finds necessary, NRC will address those concerns by incorporating appropriate conditions into the reclamation plan. Second, any CWA suit brought against Atlas for discharges from its tailings impoundment is likely to fail, since byproduct material is excluded from regulation under the CWA.[36/] Finally, to the extent that Utah's efforts to regulate groundwater discharges from the tailings impoundment conflict with the NRC-approved reclamation plan for the Facility, those state regulations will be preempted.[37/]

D. Utah Has Participated Fully in the Decisionmaking Process to Evaluate Atlas' Reclamation Plan.

Since 1993 when NRC initiated a detailed environmental review of Atlas' revised reclamation plan aimed at producing an EIS, Utah was afforded and has taken full advantage of

[35/] U.S. Fish and Wildlife Service, Final Biological Opinion for the Proposed Reclamation of the Atlas Mill Tailings in Moab, Utah (July 29, 1998).

[36/] Waste Action Project v. Dawn Mining Corp., 1998 U.S. App. LEXIS 4115.

[37/] See, e.g., English v. General Electric Co., 496 U.S. 72 (1990) (The exercise of state law will be preempted where it conflicts with federal law requirements). See also Brown v. Kerr-McGee Chemical Corp, 767 F.2d 1234 (7th Cir. 1985) (Regulation of non-radiological aspects of 11e.(2) byproduct material under state law is preempted where the radiological aspects are inextricably bound up with the radiological aspects).

numerous opportunities to participate in the subsequent environmental and technical review processes.

In March 1994, NRC issued a notice in the Federal Register indicating that it would prepare a second EIS for the Atlas site.[38] This was followed by a public meeting held in Moab on April 14, 1994 where NRC received written comments from various members of the public as part of the scoping process for EIS. The State participated in this meeting and later submitted its own comments.

Subsequently, when the Commission issued its Draft EIS and Draft TER for the revised reclamation plan in January 1996, the State fully exploited every opportunity to voice its concerns and participate in the review process. Thus, the UDRC staff submitted a lengthy comment on the Draft EIS on April 26, 1996, expressing concerns about various aspects of the proposed reclamation plan such as the need to address existing groundwater contamination in greater depth.

Also on April 26, 1996, the UDRC staff submitted detailed comments on the Draft TER, complaining about alleged inadequacies of various technical aspects of the reclamation plan. For example, the staff contended that NRC had collected insufficient information on geologic stability of the Atlas site and requested additional studies to remedy this perceived shortcoming. Interestingly, the staff did not express any significant concerns about the proposed rock apron

[38] 59 Fed. Reg. 14912 (1994).

other than the general comment that "details of the rock wall transition area at the pile should be included in the engineering plan."[39]

It must be emphasized that by accepting comments on the Draft TER, the Commission went to great lengths to accommodate the public's interest -- including those of Utah -- in the proposed reclamation plan. As NRC noted in the Final TER,

> [i]n 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 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.*[40]

Thus, in many respects, NRC provided the State (and other interested parties) with extraordinary opportunities for review and comment that would not have been available in ordinary licensing proceedings.

More recently, in response to the request made by the State in November 1997, the NRC staff initiated a detailed review of the report issued by ACE regarding the protectiveness of the proposed rock apron at the Atlas site. In addition, in January 1998, NRC reviewed an opinion from Dr. William L. Graf, a geologist, regarding the potential migration of the Colorado River toward the Atlas tailings site, again at State's request. On February 26, 1998, NRC transmitted the results of its detailed reconsideration of the proposed rock apron to the State, concluding that migration of the Colorado River to the Atlas tailings site was unlikely, but that if the river were to migrate to the pile in the future, the proposed rock apron would adequately protect the pile. In

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[39] FTER at A-22.

[40] FTER at 1-1, 1-2 (emphasis added).

undertaking this review, NRC did not rely on technical information submitted by Atlas but instead performed an "*independent analysis*" using ACE design procedures.[41/] Thus, the State's allegation that the February 26, 1998 report constitutes a "post hoc rationalization" intended to bolster FTER is patently absurd.[42/]

As demonstrated above, Utah had a full and robust opportunity to participate in the decisionmaking process regarding the acceptability of the design of the proposed rock apron as well as other aspects of the revised reclamation plan for the Atlas site. Having taken full advantage of that opportunity, the State should not now get yet another "bite at the apple" by requesting a hearing to address the same issues that have already been addressed multiple times and in great detail. Moreover, because the State has participated fully in the decisionmaking process regarding the adequacy of Atlas' reclamation plan, the State cannot complain that it will be prejudiced by not being allowed to air its concerns at a hearing.

E. The NRC Staff's Determination That Atlas' Reclamation Plan is Adequate is Entitled to Deference.

As the regulatory agency authorized by statute to make licensing determinations of the type here at issue, NRC's determination that Atlas' tailings impoundment design is adequate to satisfy the technical requirements of 10 C.F. R. Part 40, Appendix A is entitled to substantial

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[41/] U.S. Nuclear Regulatory Commission, Technical Evaluation of Atlas Erosion Protection Apron 2 (Feb. 26, 1998)(Attachment I).

[42/] Request for Hearing at 18.

deference.[43] Deference is particularly appropriate where, as is the case here, the agency action at issue is technical and complex.[44]

Generally, actions taken by NRC have been accorded greater deference than actions taken by other regulatory agencies. This is because the AEA gives NRC significant regulatory latitude, to a degree that is "virtually unique."[45] Thus, NRC staff's determination regarding technical matters within its area of expertise are routinely given deference.[46]

NRC has exhaustively analyzed, reviewed and re-reviewed the reclamation plan developed by Atlas, including the technical design of the proposed rock apron. This review has been conducted in accordance with protocols developed by the Commission through experience gained from the reclamation of multiple uranium mill tailings disposal sites.[47] Thus, the analysis of Atlas' reclamation plan that has been performed by NRC staff is uniquely within the staff's expertise. Although Utah is dissatisfied with the results of the NRC staff's analysis, the State should not be allowed to substitute its judgment for that of NRC staff.

IV. Conclusion

Utah's Request for Hearing was filed more than four years after the deadline for requesting a hearing under NRC's Rules of Practice had expired, more than two years after the

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[43] See, e.g., Chevron U.S.A. v. Natural Resources Defense Council, 467 U.S. 837 (1984).

[44] See e.g., Aluminum Co. of America v. Central Lincoln People's Util. Dist., 467 U.S. 380, 390 (1984).

[45] Nuclear Info. Resource Serv. v. NRC, 969 F.2d 1169, 1177 (D.C. Cir. 1992) (citing Siegel v. Atomic Energy Comm'n., 400 F.2d 778, 783 (D.C. Cir. 1968).

[46] See e.g., Environmental Defense Fund v. NRC, 902 F.2d 785, 788-89 (10th Cir. 1990).

[47] DTER at 1-5; FTER at 1-5.

NRC staff provided its assessment of the river migration issue and its evaluation of Atlas' rock apron design in the Draft TER, and more than seven months after the specific technical design concerns that form the basis of the State's Request for Hearing were brought directly to the State's attention by Peter Haney. The State's request, therefore, is clearly untimely.

Utah has failed to demonstrate that the State's delay in filing its Request for Hearing was excusable. As the State points out in its request, Utah is an Agreement State. Thus, Utah should have been intimately familiar with the deadline for requesting a hearing set forth in NRC's Rules of Practice. Moreover, it is abundantly clear that Utah was aware of the opportunity to request a hearing, and that the State was even contemplating litigation in this manner, since the State specifically declined to participate in the EIS as a cooperating agency in order to preserve its opportunity to litigate over the sufficiency of the EIS. For this reason, it strains credulity to suggest that Utah's failure to submit its request for a hearing in a timely fashion should be excused.

Because Utah has not offered any legitimate excuse for filing its request late, and because a hearing such as that requested by Utah at this late stage in the process would result in unreasonable injury to Atlas, that State's Request for Hearing must be denied.

Respectfully submitted,

8/11/98
Date

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628615-01 / DOCSDC1

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD PANEL

Before Administrative Judges:
Peter B. Bloch, Presiding Officer
Thomas D. Murphy, Special Assistant

In the Matter of: ATLAS CORPORATION (Moab, Utah)	Docket No. 40-3453 Re: Tailings Pile Integrity ASLBP No. 98-747-02-MLA

STATUS REPORT

Pursuant to the Presiding Officer's Order dated July 24, 1998, Atlas Corporation ("Atlas") respectfully submits this report on the status of settlement discussions in the above-captioned matter. Specifically, the July 24, 1998, Order directs Atlas to provide its assessment of: (i) the likelihood that the issue raised by the State of Utah may be settled by negotiated agreement; and (ii) whether the parties seek the assistance of a mediator.

Atlas received Utah's Request for Hearing and Petition for Leave to Intervene in this matter on July 17, 1998. Since that time, there have been no settlement discussions between Atlas and the State of Utah. Moreover, for the reasons addressed below, Atlas believes that settlement discussions in this matter would be fruitless.

As discussed in greater detail in Atlas' Response to the State of Utah's Request for Hearing and Petition for Leave to Intervene, Utah's request for hearing focuses on a single issue: the adequacy of the rock apron design that Atlas has proposed for the uranium mill tailings pile at its Moab, Utah facility. This precise issue has been the subject of several *years* of analysis on the part of NRC Staff. Atlas has submitted detailed engineering reports and studies in support of the rock apron design. The design was independently evaluated by NRC Staff during the preparation of the Draft Technical Evaluation Report ("Draft TER") and the Final Technical Evaluation Report ("Final TER") for Atlas' reclamation plan. Based upon this independent analysis, NRC Staff concluded in both the Draft and Final TERs that the technical design for the rock apron provides the "reasonable assurance" required by 10 C.F.R. Part 40, Appendix A.

However, in 1997, the State of Utah raised concerns regarding the calculations that were used in designing the rock apron. Atlas sought to address those concerns at a meeting of the Utah Radiation Control Board on November 7, 1997. At the specific request of the State of Utah Division of Radiation Control, NRC staff devoted considerable effort to evaluating the information that had been provided to the State that purported to identify inadequacies in the rock apron design. This was followed up by a detailed report prepared by NRC Staff to explain the results of the Staff's independent evaluation of the rock apron design, in light of the information provided by the State of Utah. This report, which was provided to the State on February 26, 1998, again concluded that the rock apron design is adequate and satisfies the requirements of 10 C.F.R. Part 40, Appendix A.

Now, because it finds that it disagrees with the NRC Staff's conclusion regarding the adequacy of the rock apron design, the State of Utah is requesting a hearing, more than four years after the deadline set out in NRC's Rules of Practice, 10 C.F.R. Part 2. In its argument to excuse the extraordinary tardiness of its hearing request, Utah resorts to disingenuous assertions, suggesting that NRC Staff had engaged in "post hoc rationalization" when, *at the request of the State of Utah*, the Staff evaluated the information provided by the State regarding purported deficiencies in the rock apron design. (Request for Hearing at 18) At another point in its hearing request, the State suggests that NRC Staff's evaluation of the information provided by Utah was undertaken because "the staff felt it necessary to 'bolster' the comments in the FTER regarding the rock apron design" (Request for Hearing at 17), when, in fact, the Staff performed this analysis *at the specific request of the State* in order to address the *State's* concerns about the adequacy of the rock apron design.

The State of Utah has failed utterly to demonstrate why its four year delay in requesting a hearing is excusable. Similarly, the State has been unable to demonstrate why it waited eight months after the issuance of the Final TER to request a hearing. Atlas respectfully submits that in these circumstances it would be wholly inappropriate and unduly prejudicial to Atlas to revisit, at the eleventh hour, an issue that has been evaluated and re-evaluated and re-evaluated again by NRC Staff and by independent experts hired by Atlas. It would denigrate the extensive good faith efforts of the NRC Staff if Utah were allowed, once again, to delay completion of NRC's review of the Atlas reclamation plan in order to revisit, again, an issue that has been resolved through exhaustive analysis and re-analysis.

Accordingly, Atlas respectfully submits that settlement discussions in this matter would serve no purpose. Similarly, Atlas believes that any efforts expended by a mediator in an attempt to resolve this matter through negotiations would also be wasted.

Respectfully submitted,

August 11, 1998
Date

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630072-01 / DOCSDC1

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD PANEL

Before Administrative Judges:
Peter B. Bloch, Presiding Officer
Thomas D. Murphy, Special Assistant

In the Matter of:	Docket No. 40-3453
ATLAS CORPORATION	Re: Tailings Pile Integrity
(Moab, Utah)	ASLBP No. 98-747-02-MLA

CERTIFICATE OF SERVICE

I hereby certify that I caused true and complete copies of the foregoing Atlas Corporation's Response to the State of Utah's Request for Hearing and Petition for Leave to Intervene in the above-captioned matter to be served, by certified mail, return receipt requested, on:

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629860-01 / DOCSDC1

DOCKETED
AUG 12 1998
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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD PANEL

Before Administrative Judges:
Peter B. Bloch, Presiding Officer
Thomas D. Murphy, Special Assistant

In the Matter of:	Docket No. 40-3453
ATLAS CORPORATION	Re: Tailings Pile Integrity
(Moab, Utah)	ASLBP No. 98-747-02-MLA

NOTICE OF APPEARANCE

The undersigned, Anthony J. Thompson, being an attorney at law in good standing admitted to practice before the Supreme Court of Maryland hereby enters his appearance as counsel on behalf of licensee, Atlas Corporation, in any proceeding related to the above-captioned matter.

11 August 1998
Date

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Counsel for Atlas Corporation

CERTIFICATE OF SERVICE

I hereby certify that I caused true and complete copies of the foregoing Notice of Appearance in the above-captioned matter to be served, by hand delivery, on:

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AUG 12 1998
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NUREG-1532

Draft 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

January 1996

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 draft 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.

A draft TER is usually prepared when there is sufficient information to document the staff's review of a proposed reclamation plan and its conclusions with respect to the appropriate regulations. This draft TER contains open issues that must be resolved by Atlas before NRC can approve the proposed reclamation plan. In most licensing reviews, the 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 comment in most licensing cases. However, due to the extensive public interest and comment on the 1993 TER, NRC decided to make this draft TER available for public comment.

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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.

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 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. 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 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

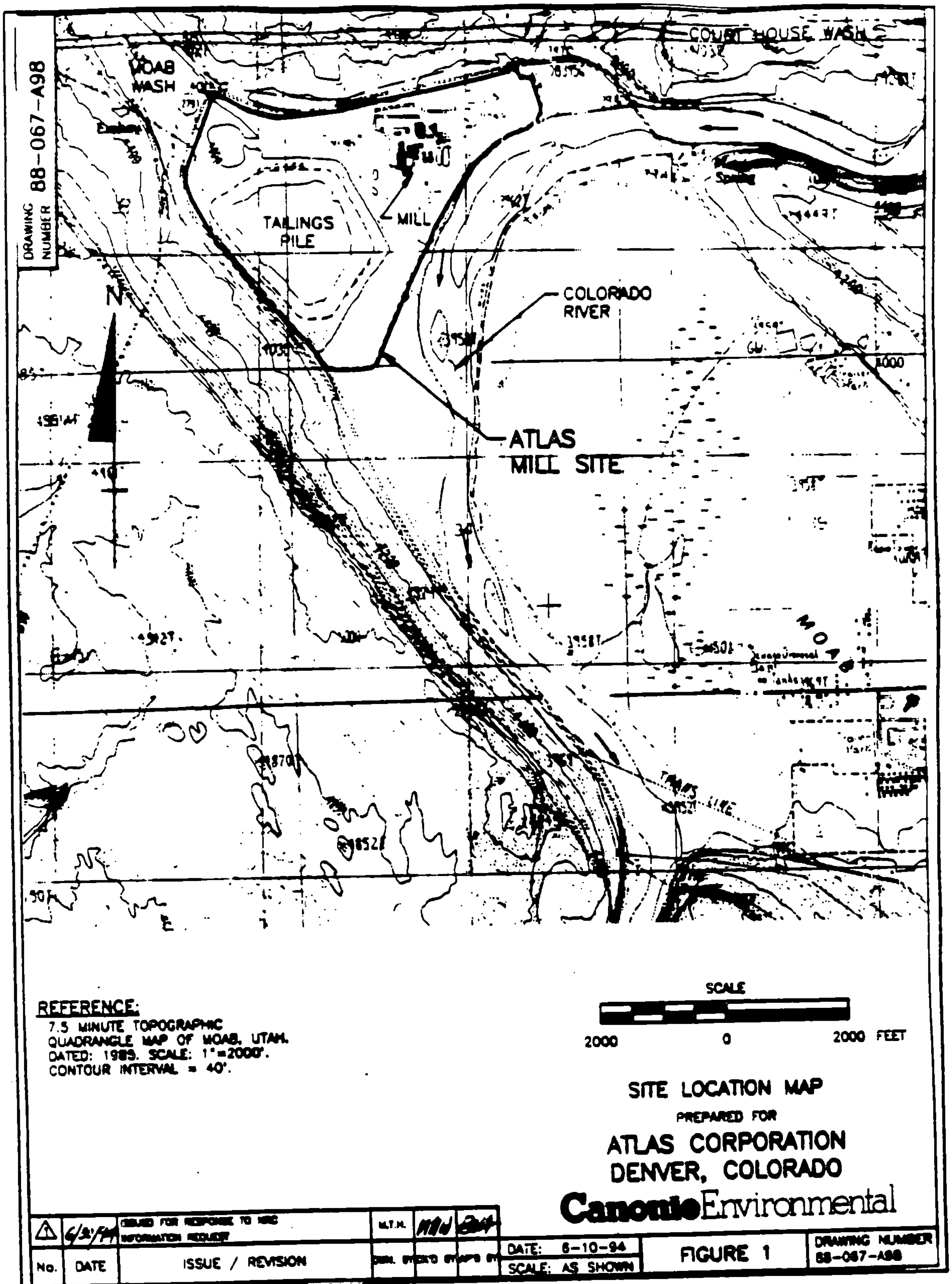

Figure 1-1: Atlas Moab Mill site

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.

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. 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), and
5. March 1995 Response (Canonie, 1995).

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.

1.5 Open Issues

The NRC staff review of the reclamation plan identified a number of issues that have not been adequately resolved through previous rounds of questions and requests for information. These open issues are given in Table 1-1. Until these open issues are adequately resolved, the staff can not support the issuance of a license amendment approving the proposed reclamation plan.

Table 1-1: Open Issues

Open Issue	Section
1. Whether or not the Moab fault and the West Branch fault are capable faults.	2.4.1.1
2. The nature and consequences of the buried fault or scarp beneath the southern edge of the tailings.	2.4.1.2
3. The nature and rate of future subsidence at the site.	2.4.1.3

[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.

4. Whether or not, or in what way, migrating sand dunes might adversely affect the tailings in the future.	2.4.2.1
5. Whether or not a potential landslide hazard exists from Poison Spider Mesa escarpment.	2.4.2.2
6. The licensee has not provided sufficient information to evaluate the seismic design basis for the site.	2.4.3
7. In order to complete the characterization of the tailings and the settlement analysis, the licensee needs to submit additional piezocone information. Prior to approval of the settlement evaluation, the licensee should submit a field exploration plan for the piezocone exploration program.	3.2.2.3
8. The staff cannot conclude 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).	3.3.1
9. The licensee is currently reevaluating the liquefaction potential for the site. The staff's liquefaction analysis review has been suspended until the licensee's reevaluation is complete and the results are made available. Thus, the staff cannot conclude that there is adequate assurance of safety with respect to liquefaction damage.	3.3.3
10. The licensee should provide adequate, detailed construction specifications (or a quality assurance program) for field testing the moisture content of the radon barrier soils when lift placement is interrupted.	3.4.1
11. Portions of the technical specifications have been superseded by later submittals, such as the revised cover design; however, the specifications have not been updated to reflect these revisions. The technical specifications need to be consistent with the reclamation design.	3.4.2
12. The specifications permit the placement of fill in 18-inch-thick lifts; however, such lift thicknesses make uniform compaction difficult to achieve. The licensee should either specify more workable lift thicknesses or describe applicable procedures for verifying that thorough compaction has been achieved.	3.4.2
13. The licensee has not formally submitted revisions to erosion protection features that have been revised; subsequently, inconsistencies with previous submittals exist. Additionally, details of layer thicknesses and gradations have not been provided.	4.5.1

14. Consequences, with respect to erosion protection, of severe landslides have not been adequately addressed.	4.5.1.3.2
15. The licensee must provide additional data to support its interpretation of groundwater flow directions and gradients in the alluvial aquifer near the southern property boundary of the site.	5.2.4
16. The licensee must provide data showing that monitoring well AMM-1 is not influenced by contaminants from the former ore storage pad.	5.2.5
17. The licensee must clarify whether it plans to take engineering credit for any disposal cell component for meeting compliance with the groundwater protection standards for the site. If engineering credit is taken, costs associated with achieving the necessary cover permeability must be incorporated into the reclamation plan.	5.3
18. The licensee must provide a sampling plan for Ra-226 analysis of the upper 3 to 4 feet of coarse tailings and the technical basis for modeling the coarse tailings on the sideslopes as being homogenous (i.e., a single layer) for Ra-226 concentration.	6.2.2
19. The licensee must provide the gamma survey and sampling procedures for verification of tailings cleanup in the Moab Wash sandy soil borrow area for NRC approval. Also provide revised Reclamation Plan Specifications (Section 1.14 and 5.3.3) and page 40 of the text to indicate that the background soil Ra-226 value is the average value approved by NRC to demonstrate that the radon barrier will comply with Criterion 6 (5).	6.2.3
20. The licensee must include in the testing program for the clay borrow material, analysis and/or gamma surveys determine its Ra-226 value, to demonstrate that the radon barrier will comply with Criterion 6 (5).	6.2.3

1.6 Confirmatory Items

The NRC staff review of the Reclamation Plan identified several instances in which the licensee had agreed to revision of the Reclamation Plan but has not formally provided that revision. These items, which the staff considers to be confirmatory items, are given in Table 1-2. Confirmatory items must be resolved before the staff can support the issuance of a license amendment approving the proposed reclamation plan.

Table 1-2: Confirmatory Items

Confirmatory Item	Section
1. Provide revised Reclamation Plan pages pertaining to the method of composite sampling for ore and tailings to accurately describe the sampling program.	6.2.1
2. Incorporate in the Reclamation Plan, the proposed testing program for "affected" soil to substantiate the radon flux model/calculation parameter values.	6.2.2
3. Incorporate in the Reclamation Plan, the final clay borrow area proposed testing program to substantiate the radon flux model parameter values for the clay material.	6.2.3

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 Impoundment Drainage Channel. This channel will convey flood runoff into the Lower Impoundment 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

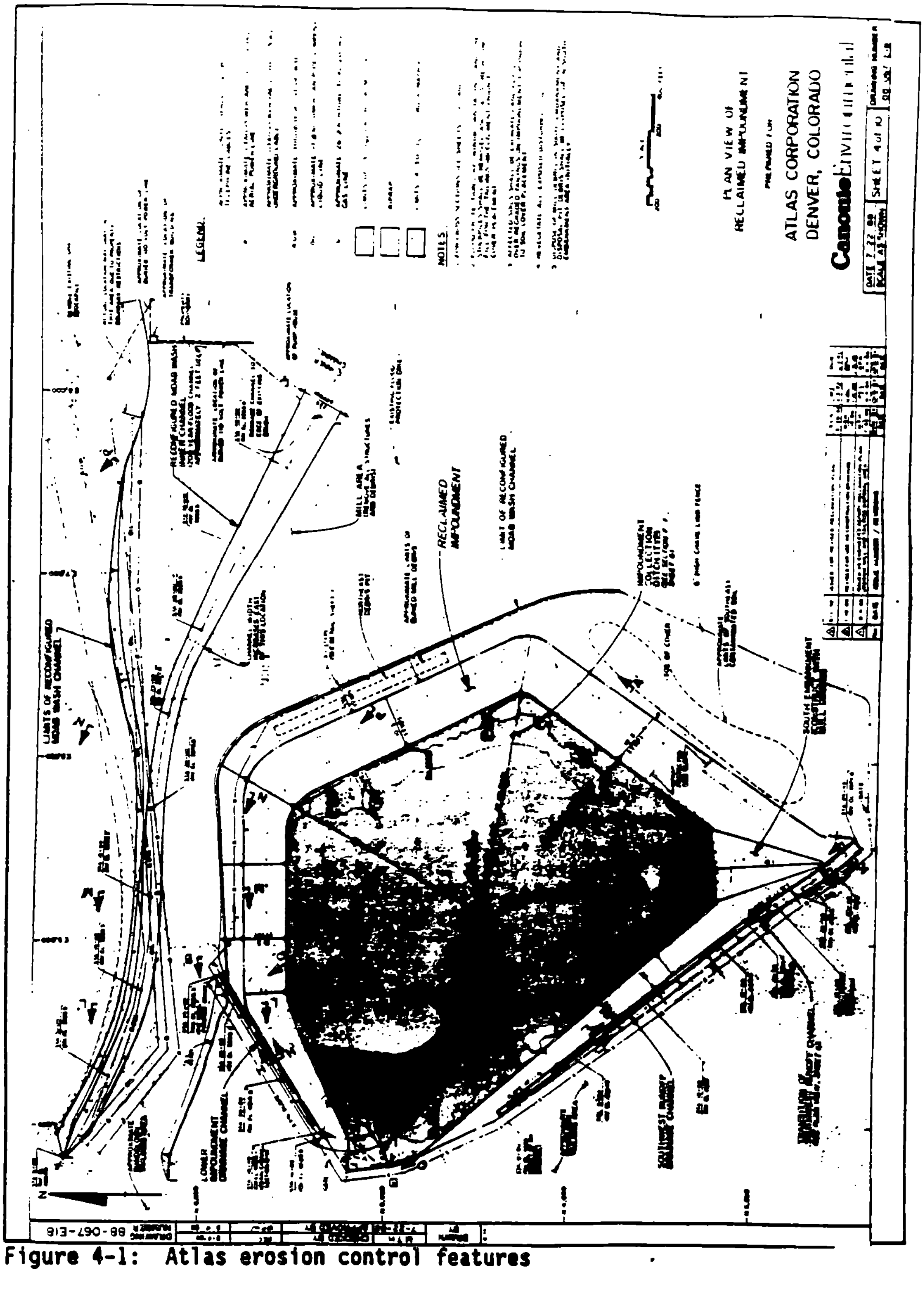

Figure 4-1: Atlas erosion control features

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 Impoundment Drainage Channel (UIDC), the Lower Impoundment Drainage Channel (LIDC), 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
UIDC	.08	1638
LIDC	.09	1640
SWDC	.09	1723

The flow rate for the LIDC, for example, represents a discharge of about 18,000 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 93 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 eroded 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 to this location again. 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. There is some evidence to suggest that 2.5 feet of aggradation have occurred over the last 20 years (Mussetter and Harvey, 1994).

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 below.

For ease of construction, the licensee intends to minimize the number of different rock sizes and gradations to be produced at the quarries that are eventually selected. It should be emphasized that the riprap sizes in the above table and in the following sections are based on recent information that was informally transmitted by the licensee to the NRC staff. At the present time, some of this information conflicts with information presented in tables and calculations previously submitted. The licensee intends to modify the rock sizes, layer thicknesses, and gradations in formal submittals to be provided at a later date. Until those submittals are provided, the staff cannot conclude that the overall riprap design is adequate.

Table 4-4: Riprap sizes and thicknesses

Location/Feature	D50 (inches)	Layer Thickness (inches)
Upper Top Slope	1.3	4
Lower Top Slope	3.0	6
Side Slope (3V:10H)	4.4	9
Moab Wash Buried Rock Wall	4.4	9
Collection Ditches	4.4	9
Upper Impoundment Drainage Channel	4.4	9
Moab Wash Buried Rock Wall	9.0	13.5
Southwest Drainage Channel	9.0	13.5
Apron along Colorado River	11.2	30
Southwest Drainage Channel	11.2	17
Southwest Drainage Channel	17.4	26
Lower Impoundment Drainage Channel	17.4	26
Lower Southwest Drainage Channel	27.6	52

Staff review has focused principally on the D_{50} sizes informally proposed by the licensee, and this review has been done to determine that the D_{50} size is adequate for each of the different locations in the design. However, details of layer thicknesses and gradations have not been provided. Final approval of the layer thicknesses and gradations can be given only after that information is provided for staff review. Therefore, the overall riprap design is considered an OPEN ISSUE, pending formal submittal of the riprap design.

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 the lower portion of the top slope, 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 9-inch layer of rock with a minimum D_{50} of 4.4 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 4.4 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 accepted 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 average scour depth to be about 7-8 feet at most locations 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 averaging about 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 sizes of 9 inches and 4.4 inches are acceptable for the northern and northeastern toe areas, respectively.

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). 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 4.4 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 4.4 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. 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 Impoundment Drainage Channel (LIDC). 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 both the SWDC (for a discharge of 1723 cfs and bottom width of 100 feet) and the LIDC (for a discharge of 1640 cfs and bottom width of 100 feet). This size is larger than the required size of about 16 inches 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.

At the present time, it is not clear if a severe landslide potential exists in the site area. This issue is currently being evaluated by the staff and is further discussed in Section 2.4. If a landslide potential exists, design changes may be needed to the SWDC to accommodate the expected sediment input into the channel. This is an **OPEN ISSUE**.

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.

Initially, the licensee identified seven potential rock sources in the proximity of the Atlas Mill. Four of the sources were rounded igneous alluvial rock, two sources were sedimentary rock, and one source was an igneous outcrop. Petrographic analyses using ASTM C 295 were performed by the licensee on samples from the sedimentary sources and on samples of alluvial rock. These analyses indicated that some of the sources could be considered for further physical testing. Rock samples were then 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). This evaluation indicated to the licensee that the sedimentary rock weathered very rapidly, scoring only 37 and 45 percent. These rock sources are not useable since they scored less than 50 percent. Two samples of the igneous alluvial rock scored 65 and 68 percent. This rock can be used for any application if it is oversized as recommended in the STP on Erosion Protection (NRC, 1990). Use of the alluvial rock source may be limited, because the maximum D_{50} is probably less than 3 inches. The sample from the igneous rock outcrop was the most durable, having scored 78 percent. 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.

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 informal licensee information, the erosion protection design appears to be adequate to provide reasonable assurance of protection for 1000 years, as required in Criterion 6 of 10 CFR Part 40, Appendix A. However, recent information related to rock sizes and layer thicknesses conflicts with information presented in tables and calculations previously submitted. The staff understands that the licensee intends to modify the rock sizes, layer thicknesses, and gradations in formal submittals to be provided at a later date. Until those submittals are provided, the staff cannot conclude that the overall riprap design is adequate. Furthermore, it is not clear if a severe landslide potential exists in the site area. This issue is currently being evaluated in the staff's geology review. If a landslide potential exists, design changes may be needed to the Southwest Runoff Diversion Channel to accommodate the expected sediment input into the channel.

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

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

[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

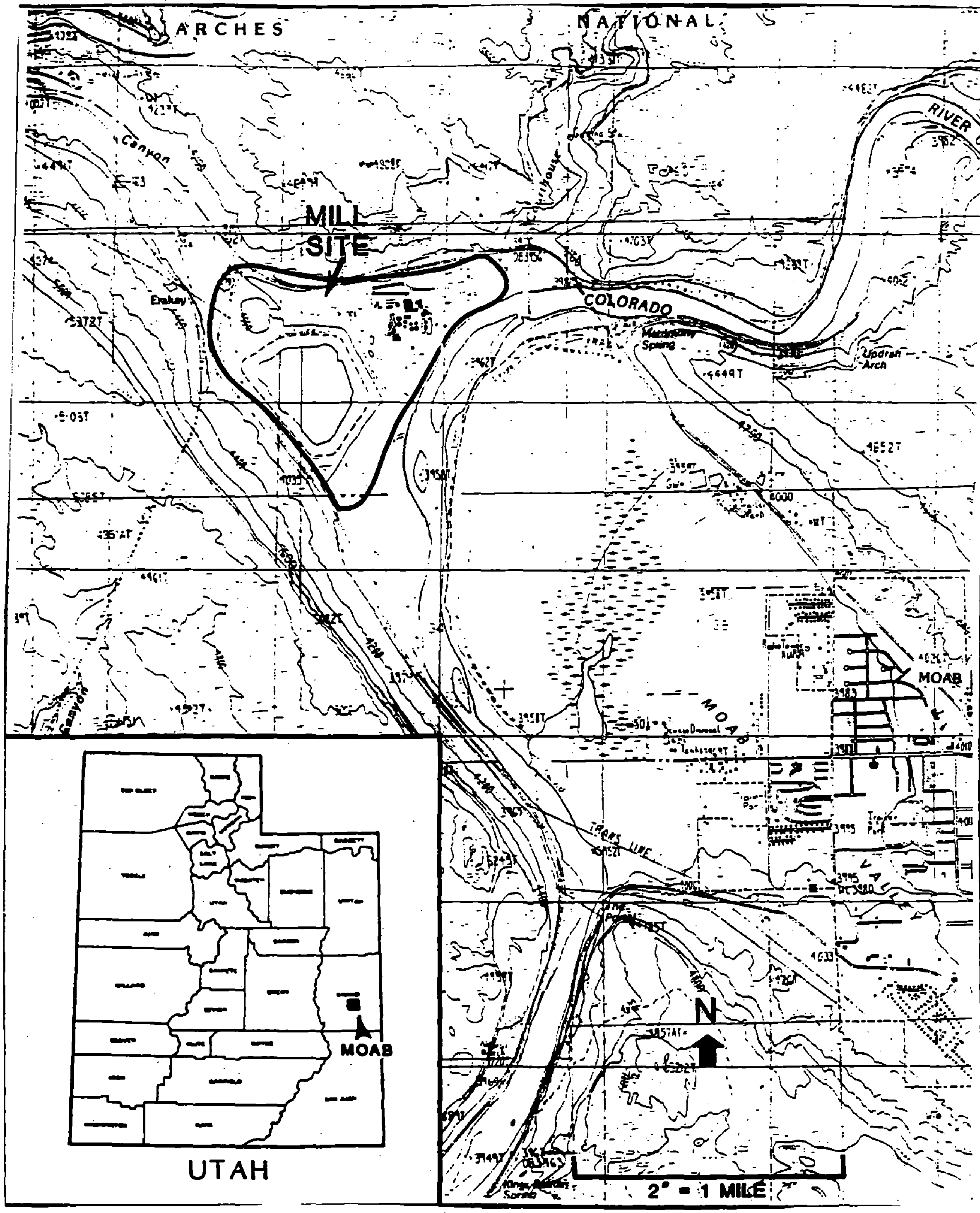

Figure 1-1: Atlas Moab Mill site

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.

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[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

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

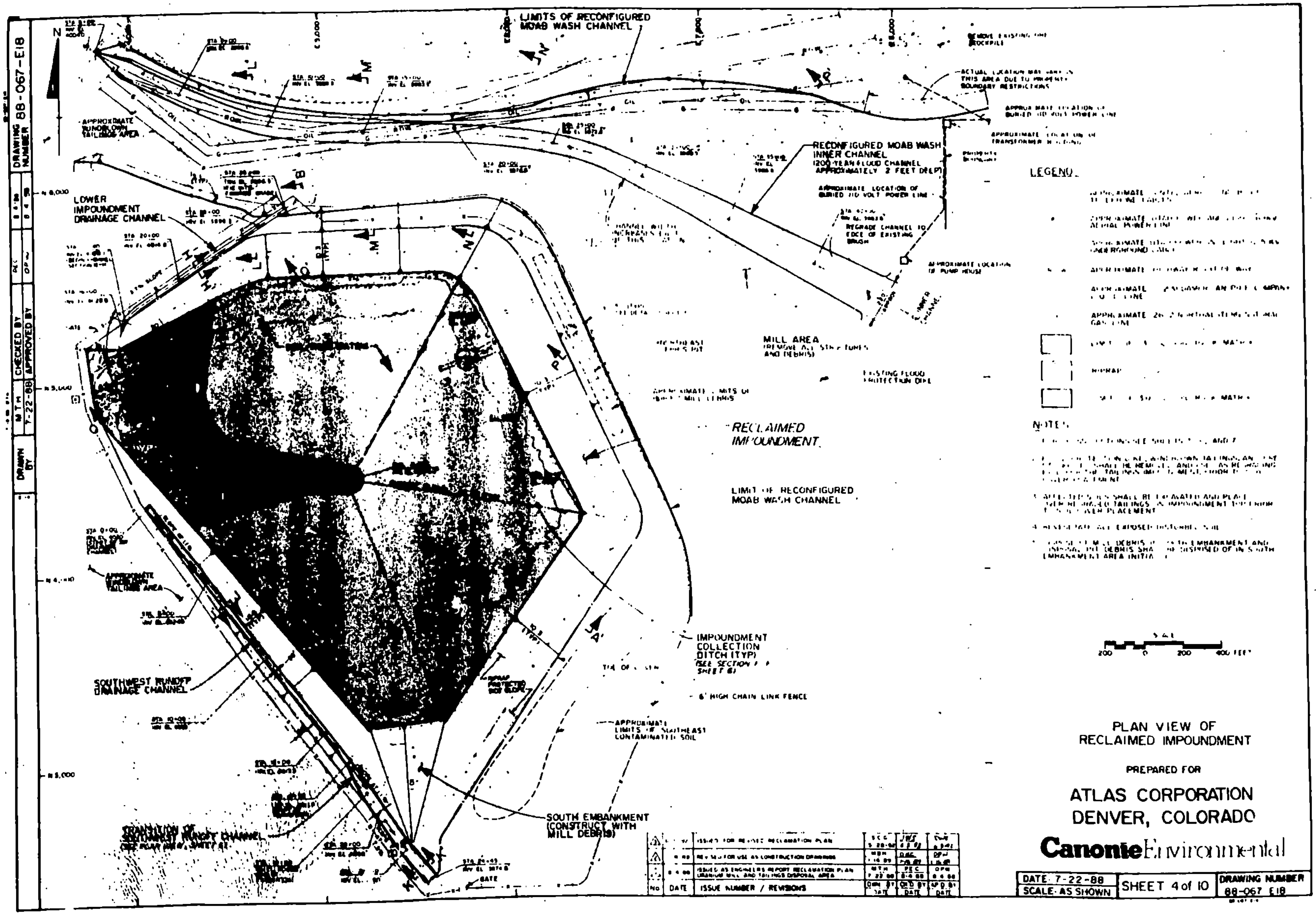

Figure 4-1: Atlas erosion control features

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 18,000 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 93 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.

APPENDIX A

RESPONSES TO COMMENTS RECEIVED ON THE DRAFT TECHNICAL EVALUATION REPORT

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.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD PANEL

Before Administrative Judges:
Peter B. Bloch, Presiding Officer
Thomas D. Murphy, Special Assistant

In the Matter of	)	Docket No. 40-3453-MLA-2
ATLAS CORPORATION (Moab, Utah)	)	Re: Tailings Pile Integrity
	)	ASLBP No. 98-747-02-MLA

AFFIDAVIT OF RICHARD E. BLUBAUGH

Richard E. Blubaugh, being duly sworn, states:

1. My name is Richard E. Blubaugh. I am of sound mind and body and am competent to make this declaration. The factual statements herein are true and correct to the best of my knowledge, and the opinions expressed herein are based on my best professional judgment and experience.

2. The purpose of this declaration is to respond to State of Utah's Request for Hearing and Petition for Leave to Intervene dated July 13, 1998.

STATEMENT OF QUALIFICATIONS

3. I am the Vice President for Environmental and Governmental Affairs at Atlas Corporation ("Atlas" or the "Company"). I have served in that capacity for nine years. Previously, I was

responsible for overseeing licensing and regulatory affairs at Atlas facilities including the mill at Moab, Utah. I have been employed by Atlas for a total of seventeen years.

4. My academic training includes a B.S. from the University of New Mexico; and an M.A. in Public Administration with an emphasis on environmental and public health from the University of New Mexico.

RESPONSE TO ISSUES RAISED IN THE MOTION FOR HEARING

5. In 1962, Atlas purchased the uranium mill located at Moab, Utah from Uranium Reduction Corporation. From 1962 until 1984, Atlas operated the mill to process uranium ore. The mill was put on standby in March 1984 in response to the depressed uranium market. In 1988, due to a severe drop in the price of yellowcake and the bleak forecast for the domestic uranium market, Atlas shut down the mill.

6. Atlas first proposed on-site reclamation of the Moab Facility in connection with the renewal of its operating license in 1979. NRC approved the proposal in its Environmental Impact Statement ("EIS") also issued in 1979.

7. In 1981, Atlas submitted a more detailed reclamation plan that reconfirmed the Company's intent to cap the tailings pile in its existing location. The NRC, through its License Amendment No. 7, dated June 30, 1982, approved the reclamation plan.

8. In May 1984, Atlas submitted an application for renewal of its Source Material License. This application included the previously submitted and approved reclamation plan for on-site capping. NRC renewed the license in 1988.

9. In 1988, NRC requested Atlas to provide certain technical information relating to: (i) rock layers (rip rap) on the pile outslopes assuming flow from a probable maximum flood; (ii) design for rip rap placement based on rock durability; and (iii) an analysis of flatter slopes. Atlas contracted with Canonie Environmental to perform this technical work and submitted a revised reclamation plan in August 1988.

10. After the issuance of a revised technical criteria for designing erosion protection covers in August 1990 -- Staff Technical Position: Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites -- NRC requested Atlas to resubmit its reclamation plan. Atlas revised and resubmitted the reclamation plan in June 1992.

11. In an effort to cooperate with the State of Utah, I met with Dr. Dianne Nielson, Director, Utah Department of Environmental Quality, on March 4, 1993 to explain the proposed reclamation plan. On July 1, 1993, Atlas staff provided Dr. Nielson with a tour of the Moab site and offered additional explanation of the reclamation plan.

12. In July 1993, NRC issued a Finding of No Significant Impact ("FONSI") and a Notice of Intent ("NOI") to amend Atlas' license and approve the proposed reclamation plan.

13. Later in 1993, NRC rescinded its FONSI and NOI in response to several factors including new information about the seismicity of the area near the tailings pile and considerable time that

had elapsed since the issuance of previous Final Environmental Statement ("FES") in 1973. In March 1994, NRC announced its intent to undertake a full blown EIS in reviewing Atlas' proposed reclamation plan.

14. At the time NRC announced its intent to issue an EIS for the proposed reclamation project, Atlas informed the Commission that time was of the essence in completing the EIS process and that Atlas was concerned about a loss of business opportunity due to the continuing uncertainty about the magnitude of liability associated with the Moab site. NRC then indicated its intent to prepare the EIS on a "fast track" basis so that the final EIS would be available in approximately 12 months. Atlas was also advised that existing data would be used to complete the EIS to the maximum extent possible so as to minimize costs to the Company.

15. A public scoping meeting for the EIS was held in Moab in April 1994. Public comments that were submitted at that meeting focused on groundwater and surface water issues. The State of Utah also submitted comments but did *not* raise any specific concern related to the potential migration of the Colorado River or design components that should be included to protect against such a possibility.

16. On December 1, 1994, Atlas hosted a meeting and tour of the Moab site for the members of the Utah Radiation Control Board. The reclamation plan and related issues were discussed at this time in considerable detail.

17. In 1994, Mussetter Engineering, Inc., a consultant hired by Atlas, completed an updated and more detailed geomorphological study dealing with the potential for the Colorado River to

migrate toward the Atlas tailings pile. Mussetter concluded that there was little likelihood of such a migration.

18. In July 1995, Atlas submitted its Draft Reclamation Plan to NRC. The rock apron design was included in the plan. A copy of the plan was provided to William J. Sinclair, Director of Utah Division of Radiation Control and Executive Secretary of Utah Radiation Control Board.

19. In January 1996, NRC issued the Draft Environmental Impact Statement and the Draft Technical Evaluation Report for the proposed reclamation plan. Both documents addressed the proposed rock apron in detail.

20. It has been nearly four and a half years since NRC initiated its "fast track" EIS for the Moab site and almost ten years since Atlas submitted its modified reclamation plan.

21. As early as 1994 when Atlas sought and received NRC's assurance that the EIS process would be completed as soon as practicable, there were serious concerns about the potential impact of any prolonged review of the proposed reclamation plan on the financial condition of the Company. That year, Atlas's attempt to merge with another mining company failed precisely due to the uncertainty surrounding the Company's liability for the Moab site (estimates of which ranged from $15 million to more than $100 million). This uncertainty and the politicization of the reclamation plan review was sufficient to kill the planned merger. Other potential business opportunities have been similarly affected. In addition, the costs of responding to NRC's requests for information have been significant.

22. Atlas has incurred approximately $4 million in costs for the EIS effort alone. However, that is not the total cost involved in this matter. For every year that the process is prolonged, Atlas is required to maintain the license, pay taxes, insurance, surety fees, etc. With overhead included, these costs average approximately $500,000 each year. To date, total costs associated with this licensing action are approximately $6 million. This does not include the cost of lost business opportunities which are practically immeasurable.

23. Due to the potential contingent liabilities associated with the Moab Facility and years of delay in finalizing the EIS, the financial condition of the Company has deteriorated steadily and, as a result, the Company is currently in severe jeopardy. From March 1994 to August 1997 when Atlas lost its listing on the New York Stock Exchange, the value of Atlas' stock had tumbled from a high of ten dollars ($10) per share to less then one dollar ($1). Currently, the stock is trading for less than twenty cents per share.

24. Atlas cannot, and should not have to shoulder the added burden of yet more delay and more unnecessary cost associated with this very lengthy and costly license amendment process. This action by the State of Utah is unduly prejudicial and threatens the very existence of the Company.

25. The State of Utah has had numerous opportunities to intervene in the pending licensing action. As an Agreement state for other radiation licensing functions, Utah is in a position to clearly understand the NRC administrative rules. There should be no excuse for the untimely request filed by the State of Utah.

AFFIDAVIT OF RICHARD E. BLUBAUGH

STATE OF COLORADO)
)ss.
COUNTY OF DENVER)

I, Richard E. Blubaugh, Vice President, Environmental and Governmental Affairs of Atlas Corporation, being first duly sworn upon my oath, deposes and say that the information presented herein regarding the State of Utah Request For Hearing and Petition for Leave to Intervene dated July 13, 1998, is correct and accurate to the best of my knowledge.

Dated this 10th day of August, 1998.

Richard E. Blubaugh
Vice President
Environmental and Governmental Affairs

Subscribed and sworn to before me this 10th day of August, 1998.

Notary Public

My Commission Expires:

Dec. 8, 2001

HOLLY D. NEEL
NOTARY PUBLIC, STATE OF COLORADO

D

UNITED STATES

NUCLEAR REGULATORY COMMISSION

REGION IV

URANIUM RECOVERY FIELD OFFICE
BOX 25325
DENVER, COLORADO 80225

NOV 29 1993

Docket No. 40-3453

Mr. Richard Blubaugh
Vice President of Environmental
and Government Affairs
Atlas Corporation
370 Seventeenth Street, Suite 3150
Denver, Colorado 80202

Dear Mr. Blubaugh:

The Nuclear Regulatory Commission staff, in reviewing your reclamation plan for the Moab, Utah, uranium mill site, has identified several areas in which additional information is required. The information which is required for the review is detailed on Enclosures 1 and 2.

Although all of the requested information is important to our review, Enclosure 1 contains two requests for information which will determine whether the site can meet Appendix A Technical Criteria of 10 CFR Part 40 for stabilization of the mill tailings in place. The first request is in the area of assessment of the capability of the Moab and associated faults which apparently run under the disposal site, the resulting seismic considerations related to that situation, the additional seismic evaluations required because of the site's location within the Paradox Basin, and the potential for movement related to solution of the underlying salt beds. As you are aware, the State of Utah Geologic Survey is currently preparing geologic and geologic hazards maps that include the Moab area, and our concerns are largely based on unpublished information and discussions with them. Mr. M. Lee Allison is the Director of the Utah Geologic Survey, and he may be contacted at (801) 467-7970. His address is 2363 S. Foothills Drive, Salt Lake City, Utah 84109-1491. The second request concerns the potential for Colorado River migration toward and into the pile. Successful resolution of these issues is essential to our determination that the tailings can be reclaimed in place.

Your responses to Enclosures 1 and 2 should be provided for our review within 60 days of your receipt of this letter. The staff expects that additional questions may be forthcoming as our review progresses.

If you have any questions concerning this request for information, please call me at (303) 231-5800.

Sincerely,

Ramon E. Hall
Director

Enclosures:
As stated

cc:
W. Sinclair, RCPD, UT

ENCLOSURE 1

REQUEST FOR INFORMATION - FAULTING, SEISMIC AND GEOMORPHIC CONSIDERATIONS

A. POTENTIAL FAULTING AND SEISMIC CONSIDERATIONS

New geologic information brought to our attention requires a reassessment of the stability of the site. Please analyze the structural stability and liquefaction potential of the disposal area using current state-of-the-practice methodology by providing responses to the following:

1. There is evidence that a fault runs under the disposal site. Evaluate the extent of faulting under the disposal site and determine if there is capability for surface rupture.

2. Evaluate the seismic potential for faults adjacent to the site, including the potential for fault movement due to salt dissolution and changes due to the development of oil resources.

3. Include in your analyses the earthquake loading considering the more recent information on Maximum Credible Earthquakes for the Colorado Plateau, which appears to require a value larger than you have used in the past. Consider in your reevaluation the information on geologic and geologic hazards for the Moab area that the State of Utah is currently preparing.

Please submit for our review and approval the analyses discussed above. If these analyses require revisions to your currently proposed design, please submit the revisions for our review and approval.

B. GEOMORPHIC STABILITY

1. From the available data and our observations, there appears to be no basis to conclude that the Colorado River cannot erode in the direction of the tailings pile. There is also insufficient information currently available to us to determine the rate of erosion. We therefore conclude that this erosion could adversely affect the stability of the tailings pile during the project design life.

Accordingly, provide information to show that the Colorado River will not erode and migrate to the tailings embankment, or substantiate that your proposed design has considered and accounted for the potential for long-term bank erosion and changes in the river's position in the valley. Include consideration of both structural stability and erosion protection.

If you cannot substantiate that the river will not migrate toward the tailings or that your design accommodated this condition, provide a revised design for our review and approval that considers a complete range of river conditions and positions that could be experienced in the project design life.

Include in your substantiation or redesign the estimated location, depth, and dimensions of the channel and any revised designs and analyses of the riprap to be placed along the sides and toe of the pile. Also consider potential future channel locations, estimated depth of the channel, depth of scour, Probable Maximum Flood (PMF) water surface elevation, and other factors which enter into the erosion protection design. Since a new channel could possibly occur in a number of locations along the face of the pile, address in detail the areal extent of the erosion protection for the pile side slopes and toes. Include information to demonstrate that erosion protection is adequate to the scour depth that could be expected for the conditions described above.

November 4, 1994

Mr. Richard Blubaugh, Vice President
Environmental and Government Affairs
Atlas Corporation
370 Seventeenth Street, Suite 3150
Denver, Colorado 80202

SUBJECT: REQUEST-FOR INFORMATION FOR THE REVISED RECLAMATION PLAN REVIEW

Dear Mr. Blubaugh:

On November 29, 1993, the U.S. Nuclear Regulatory Commission wrote you requesting information on radon attenuation, the assessment of the capability of the Moab and associated faults, the resulting seismic considerations related to that situation, the additional seismic considerations based on the site's location within the Paradox Basin, the potential for subsidence related to solution of the underlying salt beds, and the potential for Colorado River migration toward and into the pile.

NRC staff has reviewed the information provided by your letters dated January 28, 1994 and June 1, 1994, and has found the responses insufficient to make the assessment of site stability required by Appendix A to 10 CFR Part 40. In addition, new site-area information which bears on the questions has been acquired from the Utah Geological Survey (copy enclosed).

The enclosed comments address the information which NRC staff has not received from Atlas in the detail needed to support the assessment. Please submit responses to these questions within 60 days, or in the event that is not feasible, tell us within 10 days when such responses can be made.

Any questions should be addressed to NRC's Project Manager, Allan Mullins, at (301) 415-6693.

Sincerely,

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

Enclosures:
1. Geomorphic
2. Surface H_2O Hydrology/
   Erosion Protection
3. Seismic
4. Radon Attenuation
5. Geology
6. Utah Geological Survey

cc: See attached list

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ATLAS URANIUM MILL
MOAB, UTAH
GEOMORPHIC QUESTIONS AND COMMENTS

The following questions and comments are based on staff review of "Geomorphic, Hydraulic, and Lateral Migration Characteristics of the Colorado River Moab, Utah," dated May, 1994. This report was submitted by Atlas in response to NRC staff questions regarding the potential for the Colorado River to migrate toward the tailings pile.

Staff review of the information provided in the report indicates that the important erosion or depositional processes that are ongoing at the site have not been adequately quantified. The report provides some observations that are pertinent to the stability of the Colorado River, but does not provide a definitive technical basis for concluding that the pile will not be affected for 1000 years to the extent reasonably achievable, and, in any case, for at least 200 years. The staff concludes that a significant amount of additional information and analyses will need to be provided in the following areas to substantiate that lateral migration of the river will not affect the stability of the pile:

(1) Previous locations of the river channel across the valley floor and the potential for future movement or meandering;

(2) Resistance to erosion and migration provided by the properties of the channel bank and floodplain;

(3) Rates of lateral erosion, migration, or aggradation;

(4) Effects of other processes, such as sloughing and slumping, which could lead to channel migration;

(5) Dating of alluvial deposits in the area to establish evidence of stability; and

(6) Effects of salt dissolution and/or subsidence on the location of the river channel.

Further discussion of additional information and analyses needed in these areas are provided in Comments 1-6, below.

It is also important to note that other options may be available, if channel stability cannot be demonstrated. For example, the riprap on the side slopes and toe of the pile could be designed to resist the Colorado River channel velocities which would be assumed to occur in the immediate vicinity of the tailings pile. If Atlas chooses this option to design the side slope and toe for river migration, additional information and analyses will need to be provided to substantiate the design of the additional erosion protection.

1. Potential for Channel Migration and Meandering

The report indicates that bedrock inlet and outlet conditions in the Spanish

Valley will restrain the movement of the river channel, such that the ability of the river to develop a sinuous platform is constrained. However, based on observations and map study of the area, it appears that the river channel has moved and has occupied different locations across the valley at various times. Even though there may be constraints for meandering, it appears possible that the river could simply migrate toward the tailings pile on this outside bend in the river.

Additional information and analyses should be provided to substantiate the claim for channel stability. Atlas should provide further detailed discussions of why the river has a low potential for meandering given the bedrock constraints, why the distance between bedrock constraints through this reach of the river is insufficient to develop meanders, why the channel bank will not erode toward the pile, and why previous locations of the river channel are not important with respect to assessing the stability of the river for 1000 years to the extent reasonably achievable, and, in any case, for at least 200 years.

2. Resistance of Channel Banks to Erosion

The report indicates that the sediment transported by Moab Wash and Courthouse Wash includes some very coarse material that is buried beneath the site and is evident in the toe of the river bank adjacent to the tailings pile. At the present time, quantitative evidence of the presence and extent of the material has not been provided. Therefore, it is not clear exactly where this material is located or exactly how coarse the material is. The staff notes that the excavated banks of the current relocated Moab Wash channel (excavated several years ago) contains very little evidence of coarse material. Further, evidence of the size and gradation of the material, such as gradation curves of the riverbank deposits, have not been provided to illustrate the coarseness of the material.

In addition, the staff has recently reviewed a photograph taken in 1985 which shows a dirt road along the bank of the river near the pile. Based on NRC staff site visits to this area in 1994, the bank of the river has apparently been eroded, and this old roadbed is now exposed in the cut bank of the river. The amount of erosion is difficult to determine, but it appears that several feet of the riverbank has been eroded since 1985.

Atlas should provide additional information and maps which characterize the location and areal extent of the coarse material in the riverbank area. Using estimates of the size of the material, Atlas should determine its ability to resist erosion by comparing, for example, the shear stresses produced along the outside bend of the riverbank with the shear stresses that the material is able to resist. (The staff notes that estimates of the maximum bank shear stress were calculated in Section 5.2.2 of the report.) Atlas should also provide estimates of the allowable shear stress for the riverbank material, based on its physical properties of size, cohesion, and density. Such analyses may also be pertinent for other areas along the riverbank, even where there are no deposits of coarse material. In such locations, the allowable shear stress associated with cohesion, type and size of deposits, vegetation, etc. may also be sufficient to withstand expected shear stresses produced by

river flows. In addition, to document the erosion rate along the road near the riverbank, Atlas should make some direct observations in this area and determine (by photographic comparison, for example) the amount of erosion which has taken place since the road was constructed. Atlas should provide additional information and analyses to justify that the erosion will not continue to occur or will not significantly affect the tailings pile. In addition, see Question 3, below.

3. Quantification of Erosion or Aggradation Rates

The report indicates that the net effect of sediment production from Moab Wash and Courthouse Wash is to laterally and vertically aggrade the right bank of the river near the tailings pile. The staff considers that this argument is logical; however, evidence of net aggradation has not been provided to substantiate this claim. In general, the report only discusses the field evidence and historic evidence that was used to substantiate stability of the river channel.

Atlas should provide quantitative information to substantiate that vertical and lateral aggradation has occurred. Such information should include, for example, photographs and maps which are compared over specific time intervals. Any photographs which were studied and provide bases for Atlas' conclusions should be provided for staff review. Any information that forms a basis for Atlas' conclusions of channel stability should also be provided. Further, since it is possible that erosion is occurring at several locations along the stream bank, rates of erosion at various locations should also be quantified.

4. Effects of Processes Other Than Stream Erosion

Based on site visits by the staff, the riverbank area directly fronting the tailings pile (between cross sections 4 and 6) appears to exhibit evidence of erosion and slumping. Based on the configuration of the bank, it appears to be reaching a more stable slope, through a series of erosion/sloughing cycles. It appears that the dominant process affecting the erosion rate of the bank may be sloughing, with subsequent erosion of the material.

Atlas should provide additional information to explain the erosion of the river bank fronting the tailings pile. Atlas should document the rates of erosion and should provide bases for a conclusion that the erosional processes that are active in this location will pose no unacceptable threat to the stability of the pile.

5. Establishing Quantitative Proof of Bank Stability

Based on the presence of several hundred feet of floodplain deposits which separate the tailings pile from the river, it appears that a strong case could be made for river channel stability if the floodplain deposits could be approximately dated. Dating the time of deposit of the alluvial material would indicate with some degree of certainty that no erosion of the floodplain has occurred within that time period. There are numerous methods available to date alluvial deposits; one of the least expensive and most common techniques is radiocarbon dating of deposited organic material. Another simple dating

method could possibly be the dating of Indian artifacts, such as pottery shards, which may have been present for a long period of time in the floodplain alluvium. More complicated methods are also available to date buried sediments.

Atlas should consider the possibility of dating organic material in the alluvial deposits. Such dating may help to establish with some confidence that the river channel is stable or will not unacceptably affect the tailings pile due to erosion.

6. Effects of Salt Dissolution and Subsidence

Based on a review of the geology of the area, it appears that salt dissolution and subsidence are active ongoing processes in the area, particularly in the site area at the northern end of the Moab-Spanish Valley. In "Quaternary Deposits in the Paradox Basin," Biggar, and others, indicate that Holocene subsidence may be indicated by the marshes present along the river and that the subsidence could be caused either by tectonism or by dissolution or migration of salt at depth. In "Quaternary Deposits and Soils in and Around Spanish Valley, Utah," Harden, and others, also indicate that ongoing subsidence at the lower end of Spanish Valley may be indicated by marshes present along the river. At the present time, it is not clear if these processes will have any effects on the location of the river channel. For example, if subsidence similar to that which may have occurred in the Moab Marsh area occurred north of the river, the channel could shift to accommodate the lowering of ground surface.

Atlas should provide additional information and discussion to document that shifting of the river channel, caused by local subsidence, will not occur to the extent that the pile could be unacceptably affected.

ATLAS URANIUM MILL
SURFACE WATER HYDROLOGY/EROSION PROTECTION
QUESTIONS AND COMMENTS

1. Design of Top Slope Riprap and Rock-Soil Matrix

The rock-soil matrix proposed for the top slopes is not considered by the staff to be acceptably designed. The staff notes that two inches of topsoil will be placed above the top surface of the rock. Furthermore, the staff notes that the actual thickness of the rock layer will be only 3 inches. In addition to the difficulties in constructing such a 3-inch rock layer thickness, the staff concludes that a rock-soil matrix presents several design problems that should be considered.

First, if soil is placed above the rock layer, gullying and flow concentrations in this upper layer of soil can be expected to occur, producing shear forces that the underlying rock may not be able to withstand. Because the shear force produced is largely a function of the slope and the depth, the increased depth will increase the shear forces. Even if flow concentrations are not assumed, the proposed rock size is not likely to be adequate to prevent erosion of the underlying radon barrier.

Second, the rock layer thickness should be at least 3 times the D_{50} size of the rock, in accordance with the recommendations of NRC technical assistance contractors. Therefore, the layer thickness should be at least 4 inches, if the D_{50} is 1.3 inches.

Third, because the upper 2-inch layer of soil is placed on a slope designed for rock, it is likely that the soil will be eroded and sedimentation will occur in the drainage channels.

Fourth, the placement of such a rock-soil matrix requires a thorough and complete QA/QC program to assure that the rock placement is adequate and that the soil is properly compacted into the rock layer. A detailed program for such compaction and placement has not been proposed by the licensee.

The staff concludes that the design of the rock-soil matrix should be modified to eliminate the soil portion and to increase the rock layer thickness to at least 4 inches. Alternately, the licensee should provide additional justification that the proposed riprap design is adequate to resolve the staff concerns discussed above.

2. Apron/Toe Design

The design of the rock for the apron/toe area is not considered to be acceptable. The rock size proposed for the toe is similar to the rock size for the side slopes. In general, the toe area will act as an energy dissipation area, producing turbulence and forces that need to be accounted for with an increased rock size. As the soil is eroded, erosion pockets and gullies will form, resulting in turbulence as the flow energy is dissipated.

To resolve staff concerns, Atlas should design the lower portion of the toe to withstand turbulence which would be expected to occur during the design storm. U. S. Army Corps of Engineers design procedures typically include an approximate 50 percent increase in the shear force produced in areas where turbulence is expected (non-uniform flow factor). If such an increase were applied, the resulting D_{50} rock size would increase from approximately 4 inches to approximately 6 inches. Such an increase would produce a design that would be acceptable to the staff. Alternately, Atlas should further justify that the design of the toe is adequate.

It should be noted that there may be a potential for the Colorado River to migrate toward the tailings pile. As discussed in staff geomorphic comments, the design of the toe may need to be revised to accommodate the erosive forces produced if the river channel is assumed to be located directly against the slope of the tailings pile.

If Atlas is not able to demonstrate stability of the river channel, the toe design should be revised. If such a redesign is performed, several factors should be taken into account. The design of the apron/toe should be based on the following general concepts: (1) provide riprap of adequate size to be stable against overland 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 river channel velocities, 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 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 which allows the rock to collapse into a stable configuration in the eroded river channel.

Atlas should revise the toe design, as applicable. Alternately, Atlas should provide additional justification to document the adequacy of the current design.

3. Design of Channel Outlet Protection

The rock riprap for the outlets of the drainage channels appears to be somewhat undersized. Based on review of calculations provided in the January 1994 submittal, the size of the riprap to be placed at the outlets of the Southwest Drainage Channel and the Lower Impoundment Drainage Channel was determined using the bottom slopes of the channels in the vicinity of the outlet. Use of this slope is not appropriate, because scour will occur to the overlying soil during a flood, and flows will discharge down the steeper slope of the buried cutoff wall. Therefore, the slope of the cutoff wall should be used to determine the rock size. The staff notes that the proposed slope of

the cutoff wall is approximately 1.2 vertical (V) to 1 horizontal (H), according to Sheet 6 of the design drawings dated May 18, 1994. (The staff notes that the slope may be incorrectly designated, because the drawing also indicates that the slope will be flatter than the angle of repose of the rock.) The riprap sizes proposed are not likely to be capable of providing adequate erosion protection for flows down very steep apron slopes, since the rock was designed for the flatter channel slopes.

To resolve staff concerns, several design changes could be made. The slope of the cutoff wall could be flattened (for example, to 1-V on 5-H), the channel and apron width could be increased, or a combination of the two could be developed. Using the Stephenson Method, the riprap size can be determined (based on the flow rate per unit width) for slopes steeper than 1-V on 10-H.

Atlas should redesign the riprap for the cutoff walls at the drainage channel outlets. Alternately, additional justification should be provided for the designs proposed.

4. Design of Riprap for Southwest Drainage Channel

The design of the riprap for the side slope of the tailings pile in the Southwest Runoff Drainage Channel (SWRDC) is not considered to be adequate. The design does not appropriately account for localized buildup of rock and sediment which would be expected to occur in the channel. Atlas' assumption that the buildup will occur at a uniform depth of 1.8 feet along the length of the channel is not consistent with actual observations in this area. Based on staff observations, it appears that the rock and sediment buildups could occur in one specific area, rather than being uniformly deposited in the channel.

To resolve staff concerns, Atlas should revise the design of the riprap for the tailings side slopes in the SWRDC area, assuming that the channel is approximately 50 percent blocked by deposited material at various random locations alcng the length of the channel. For example, if the channel has a bottom width of 50 feet, a 25-foot-wide obstruction (of unlimited height for computational purposes) should be assumed in the channel. Flow profiles should then be computed through the constricted channel. Riprap of adequate size should be provided to resist the increased velocities, and this riprap should be extended up the pile side slope to the increased computed elevation of flooding.

Reference:

"Desigr of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Disposal Sites," Final Staff Technical Position, August 1990.

State of Utah
DEPARTMENT OF NATURAL RESOURCES
UTAH GEOLOGICAL SURVEY

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Post-it® Fax Note 7671	Date 10-28-94	# of pages ▶ 18
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October 27, 1994

Joseph J. Holonich, Chief
U.S. Nuclear Regulatory Commission
DWM/NMSS
Washington, D.C. 20555-0001

Dear Mr. Holonich:

We have completed our responses to the questions transmitted in your letter of October 7, 1994, regarding the Atlas Corporation mill site in Moab, Utah. Our responses and a copy of your questions are enclosed. As you know, we have previously discussed our information with various NRC personnel, Atlas Corporation and their consultants, and Grand County officials.

To understand our responses, please refer to the attached geologic maps and the USGS Moab 1:24,000 topographic map. The authors of the responses are Michael L. Ross and Hellmut H. Doelling of the Geologic Mapping Program and Gary E. Christenson of the Applied Geology Program. Mr. Ross and Dr. Doelling are presently working on geologic maps in the area and both have extensive field experience throughout southern Grand County. Mr. Christenson supervised work by William E. Mulvey on the Quaternary geology and geologic hazards in the Moab and Castle Valley area, but has not worked extensively in the field in the area. The responses to question D were reviewed by Craig Morgan of the Economic Geology Program. If you have any questions, please call.

Sincerely,

M. Lee Allison

M. Lee Allison, Director

MLA/sw

Attachment 6

ATLAS CORPORATION MILL SITE, MOAB, UTAH
RESPONSES TO OCTOBER 7, 1994 NRC QUESTIONS

Michael L. Ross, Hellmut H. Doelling, and Gary E. Christenson
Utah Geological Survey

Question A1a. The extent of modern river flooding and channel migration is defined by the geologic flood plain, shown on the attached geologic map (Attachment A) by the unit Qfp (modern flood-plain deposits). Stream terrace deposits representing abandoned flood plains may be used to determine the extent of past channel migration. Colorado River terrace gravels are present on the east side of Courthouse Wash, just north of U.S. Highway 191, approximately 40 feet above the modern river channel. Other possible river gravels are present near the transmission power line (see USGS Moab 1:24,000 topographic map) where it makes a sharp bend immediately southeast of Utah Highway 279 west of the tailings pile. These gravels are approximately 90 feet above the modern river channel. At the present time we have not determined if these gravels were brought in as fill for construction of the highway or if they are in place. If the river gravels are in place, they indicate that the present area of the tailings was at one time (probably in Pleistocene time) part of the Colorado River channel.

Question A1b. One line of evidence would be to investigate the previously mentioned river gravels near the tailings pile (see Question A1a above) to determine if they are in place. Also, a subsurface investigation in the tailings area could be conducted to look for other Colorado River gravel occurrences. The presence of older, higher level terrace gravels does not necessarily indicate a high potential for the river to erode laterally at its present level and reoccupy the area because other constraints may exist now to confine the river.

The river channel may migrate onto any part of its modern flood plain, or erode laterally to expand the flood plain, particularly on the outside of a meander bend such as at the Atlas tailings site. Under natural conditions, it appears possible that the tailings may be affected by such channel migration and erosion within the next 1,000 years.

Question A2. We have no data or maps which characterize the location and areal extent of coarse material along this

portion of the Colorado River. Colorado River flood-plain deposits consist of clay to cobble-size material. Sand and gravel (pebbles to cobbles) are mostly deposited in channels and are typically lenticular in morphology. Sand, silt, and clay characterize the overbank deposits. Deposits from Moab and Courthouse Washes are also variable with respect to clast size and the gravelly deposits are also typically lenticular. Thus, deposits exposed along the Colorado River bank at the Atlas site are expected to be heterogeneous in clast size and lithology, and laterally discontinuous. Because of this, gravels presently exposed in the river bank may not extend laterally and may not be a reliable deterrent to river-bank erosion. The stability of river banks is also controlled by the vegetation.

Question A3. We are aware of no published or available information on rates of vertical and lateral aggradation or erosion of Moab Wash or Courthouse Wash. The Colorado River is the ultimate base level for both washes, so we expect both washes to attempt to grade to the river level.

Question A4. We have not studied the erosion and mass-wasting processes active along the Colorado River bank. However, we can expect the banks to erode and slough to achieve a stable slope angle. Undercutting of the bank by the river will cause renewed erosion and sloughing. We have not evaluated the potential for larger, deep-seated slumps or other slope failures that may affect the tailings pile.

Question A5. To our knowledge there is no information regarding the age of alluvial deposits in the immediate area of the tailings. Because most of the modern flood plain (Moab Slough) was under water during flooding in the early 1980s, it is likely that the upper deposits are all Holocene in age. Alluvium on the northwest side of the Colorado River shows little or no soil development, suggesting it is likely of Holocene age.

Question A6. There is no hard data to indicate that subsidence caused by dissolution of salt has caused the Colorado River at Moab Valley to migrate in the past. However, it seems likely that the Colorado River may change course, at least temporarily, if a new depression were to appear in the flood plain as per your example.

In Cache Valley to the northeast of the Atlas site,

Cache Valley Wash is presently located in the areas of greatest salt-dissolution-induced structural collapse of bedrock units within the Cache Valley graben (Doelling and Ross, 1993). The course of Cache Valley Wash may be the result of two possible processes, or a combination of both. First, Cache Valley Wash may have channeled surface water into pre-existing bedrock fractures, which allowed downward migration of the water to the underlying salt diapir, thereby increasing salt-dissolution along the stream course. Alternatively, Cache Valley Wash may have been superimposed on a structurally and lithologically complex terrain, in which its path is the result of differential erosion and base-level influences of the controlling major drainages.

During periods of alluviation in the evolution of salt-dissolution-induced collapsing valleys, topographic lows are filled with stream alluvium. The stream channels then migrate across the surface of the valley as it fills. Examples of filling and stream migration are present in Castle Valley, Spanish Valley, Fisher Valley, and Salt Valley.

Question B1. The total length of the Moab fault and its interpreted splay faults that are mapped with confidence in Grand County are shown in UGS Open-File Report 287 (Moab 30'x 60' quadrangle, scale 1:100,000). A slightly modified version of this map is included with these responses as Attachment B. The attached map shows our interpretation of the Moab fault system highlighted in red. The exact trend and location of the Moab fault(s?) beneath the floor of Moab and Spanish Valleys is unknown at this time and its estimated position is dotted and queried along the axis of the valleys. A similar queried fault is interpreted by Weir and others (1961) to follow the axis of Spanish Valley south of the southern map boundary of UGS Open-File Report 287. However, structural offset of Mesozoic formations across the valleys can be demonstrated and indicates the formations were offset by a northwest-trending fault (probably the Moab fault) along the crest of the Moab-Spanish Valley salt-cored anticline prior to salt dissolution induced collapse of the crest of the structure. At the present time it is unknown whether the Moab fault is an identifiable feature at shallow depths in and beneath the valley-fill deposits and whether it survived as a coherent and recognizable structural feature during the superimposed salt-dissolution-induced structural collapse.

Moab fault is the name given to the major surface fault that extends from Moab-Spanish Valleys northwestward to the Blue Hills. Detailed paleoseismic studies to attempt to define fault segments have not been performed for the Moab fault.

Question B2. Attachment A is a diagrammatic geologic map of the area in the vicinity of the Atlas site based on H. Doelling's current mapping in the Moab 7.5-minute quadrangle, which will be available as an open-file report after June 30, 1995 for peer review. The report and interpretations regarding the Moab fault will be finalized after review comments are received.

The Moab fault has two branches in the vicinity of the Atlas tailings pile. Discontinuous bedrock exposures along the northeast cliffs of Poison Spider Mesa allow for a good estimate for the location and trend of the west branch of the fault. The trend of the main branch of the Moab fault southeast of its last bedrock exposure in Moab Canyon is interpretive. Attachment A shows the approximate location and trend of the fault as projected by H. Doelling, who considered the edge of the northeasternmost exposure of the Moenkopi Formation found between the two branches. M. Ross estimates the location and trend of the buried main branch of the Moab fault to be slightly more to the northeast (see trend shown on Attachment B), on trend with its last mappable orientation (approximately N45°W).

Question B3. Please refer to Attachment B for locations. In general, the Moab fault trends between N40-50°W and dips between 50-80°NE. Starting near the northwestern end of the Moab fault, the following is a list of fault attitudes and senses of movement.

1. Bartlett Wash area: N45°W, 60-65°NE, down to NE.
2. Courthouse Rock area: N40-50°W, 60-65°NE, down to NE.
3. Old highway site northeast of Little Valley: N50-60°W, 60-80°NE, down to NE.
4. Highway 191 crosses the Moab fault near Arches National Park Visitor Center: E-W, ≈60°N, down to N.

In the vicinity of the Atlas site, poor bedrock exposures and burial by surficial deposits make measurements of the Moab fault difficult. Along the southwest side of Highway 191, just northwest of the Atlas site, limited exposures of the fault indicate a relatively straight fault trace

(≈N45°W) suggesting the fault is relatively high angle. From outcrops where it is possible to make a judgement, the inclination varies from 68°NE to 90°(vertical).

The trend of the west branch of the Moab fault has an erratic trace across topography (Attachment A), suggesting a lower angle of inclination. Where the inclination of the west branch of the fault is measurable, it varies from 35 to 45°NE across the map area. The fault may be slightly steeper to the north. This branch is a normal fault and slickensides indicate dip slip.

Question B4a. Observed slickensides at various locations along the Moab fault and associated splay faults indicate both dip slip and slightly oblique slip movement. Slickensides showing a minor component of oblique slip have rakes varying between 75-85°NW and SE (A. Foxford, Univ.of Liverpool, verbal communication, 1994). No slickensides showing strike-slip movement along the Moab fault have been observed.

The exact amount of vertical displacement along the Moab fault in the vicinity of the Atlas site is difficult to assess because of the potential variations in the thickness of late Pennsylvanian through Jurassic formations resulting from movement of the underlying salt diapir. Estimated displacement on the Moab fault at a point halfway between the Arches National Park Visitor Center and the Atlas tailings pile is approximately 2,500 feet, using data from measured stratigraphic sections and estimated thicknesses of subsurface formations. Field relations show the Moab Member of the Entrada Sandstone is juxtaposed against the Honaker Trail Formation across the two fault branches (Attachment A).

In the vicinity of Sevenmile Canyon, approximately 7 miles northwest of the Atlas site, estimated displacement on the Moab fault is approximately 3,000 feet. Field relations show the Salt Wash Member of the Morrison Formation juxtaposed against the Cutler Formation.

At Bartlett Wash, approximately 13 miles northwest of the Atlas site, estimated displacement on the Moab fault is approximately 600 feet. Field relations show the Cedar Mountain Formation juxtaposed against the Moab Member of the Entrada Sandstone.

Question B4b. Based on the geologic maps of Williams (1964) and Doelling (1993), the youngest stratigraphic unit displaced

by the Moab fault is the Cretaceous Mancos Shale along the southwest limb of the Courthouse Wash syncline. M. Ross interprets the Courthouse Wash syncline as being a Laramide fold whose axial trace is southwest of a pre-existing rim syncline (salt withdrawal basin) in Triassic and older strata along the southwest side of the Salt Valley salt-cored anticline. Laramide orogeny folding and faulting in this part of the Colorado Plateau is believed to range from latest Cretaceous to Eocene. The Moab fault cross-cuts the Courthouse Wash syncline indicating that the fault is younger than the fold and is probably of Tertiary age (Eocene or younger). No Tertiary rocks are present along the trace of the Moab fault to better constrain the period(s) of faulting. There is no evidence that the Moab fault cuts Quaternary deposits

Oviatt (1988) interprets the beheading of the Little Canyon drainage as evidence for deformation due to salt tectonics and/or movement on the Moab fault. He believes this deformation occurred in late Tertiary to early Quaternary time. Little Canyon is a broad, deep canyon on the southwest flank of Moab Canyon, about 5 miles northwest of the Atlas site. At this time M. Ross and G. Christenson believe the structural factors responsible for the geomorphology in the area of Little Canyon are uncertain. H. Doelling believes the hanging valley is caused by headward erosion (stream piracy) of Moab Wash.

Question B5. There is no published seismic reflection data available to constrain the subsurface geometry of the Moab fault in close proximity to the Atlas site. During discussions between various UGS geologists and petroleum company geologists involved in exploration in the Moab area, it was stated that the current interpretation of the Moab fault is that it is a northeast-dipping listric fault that appears to die out in the Moab salt diapir. Several previous investigations reported in the literature have interpreted the Moab fault as terminating in the underlying Moab salt diapir where the fault and salt diapir are superimposed.

The United States Geological Survey (USGS) made available, for examination, several unpublished and poor quality seismic refection geophysical lines to M. Ross and Craig D. Morgan of the UGS. One of these lines extended southwest to northeast across the northern end of the Moab fault in the area of the Blue Hills. Ross and Morgan

interpreted a possible fault (Moab fault) higher in the section, with minimal displacement down to the northeast that appeared to die out listric-northeast in the Paradox Formation. At deeper levels in the seismic section another fault, down-to-the-northeast and high angle, displaced seismic reflectors they interpreted as the Leadville Limestone (pre-salt strata), but died out upward in the Paradox Formation. The deeper fault was offset from the upper level fault (Moab fault). At this location it did not appear that the upper fault was directly connected to the deeper fault.

A steep, northeast-facing gradient in regional gravity and magnetic data is subparallel with the Moab-Spanish Valley salt-cored anticline and Moab fault. Case and Joesting (1972) interpreted the gradient as a discontinuity in the basement rocks (pre-salt rocks). They interpreted the discontinuity as a northwest-striking, high-angle fault with down-to-the-northeast displacement.

Based on the geologic map of Williams (1964), the Lisbon Valley fault is a long, northwest-trending, down-to-the-northeast fault that is very similar in geometry to the Moab fault. Lisbon Valley fault is the name given to the major surface fault at Lisbon Valley. Parker (1981), based on well data, interpreted the Lisbon Valley fault as a high-angle, northeast-dipping listric normal fault that dies out in the Lisbon Valley salt diapir. Well data also indicate a high-angle fault at deeper crustal levels that offsets the pre-salt rocks down to the northeast. The deeper fault is also northwest-striking but is offset to the southwest from the surface trace of the Lisbon Valley fault. The shallow and deep faults are not directly connected, but are separated by the Lisbon Valley salt diapir.

The Lisbon Valley fault trends northwestward and terminates at the Kane Springs graben (see Williams, 1964). Offset of stratigraphic units across Moab-Spanish Valleys (due to the Moab fault) decreases at the southeast end of Spanish Valley where the Kane Springs graben intersects the Spanish Valley collapsed salt cored anticline. Kane Springs graben is northeast-trending and approximately 5 miles long. No detailed structural analysis has been conducted on the graben by the UGS.

The Moab fault is right-stepping from the Lisbon Valley fault at the Kane Springs graben. This suggests that the Kane Springs graben is a cross-structure linking the two faults. M. Ross indicates that the position of the graben

at the termini of the Moab and Lisbon Valley faults suggests a minor right-lateral strike-slip component of offset along the Moab and Lisbon Valley faults. H. Doelling does not interpret the Kane Springs graben as resulting from this type of deformation. He notes that it displays a vertical component of slip.

Question B6. Our response to Question B4b provides information regarding age of movement on the Moab fault. In the vicinity of Moab Valley, it is likely that part of the displacement on the Moab fault evident at the surface was related to dissolution of salt and brittle rock failure in the overlying rock units. However, at the present time we have not made an assessment of the amount of offset along the Moab fault at Moab Valley that is related to tectonic activity vs. superimposed salt-dissolution collapse activity. We interpret that the majority of the offset on the Moab fault, at Moab-Spanish Valleys and northwestward, as being due to Tertiary tectonic activity that predates salt-dissolution deformation.

No Quaternary sediments at the surface of Moab Valley are offset by the Moab fault or any of the additional faults present in the bedrock units that surround the valley. The subsurface geometry of the Quaternary valley-fill deposits in Moab Valley is unknown. Northwest of Moab at Bartlett Wash, reconnaissance investigations indicate that Holocene to latest Pleistocene(?) surficial deposits extend across the trace of the Moab fault with no apparent offset of their upper surface. The absence of a well-developed soil on these deposits suggests a young age. The lack of offset may indicate no surface rupture on the Moab fault at this location during the late Pleistocene or Holocene. More work is needed at this site to document relationships between the fault and the Quaternary deposits and to constrain the age of the deposits.

Question B7. Information regarding seismic potential of the Moab fault and ground-shaking hazards in the Moab Valley area has been published by various workers, particularly Ivan Wong of Woodward-Clyde Consultants, who has conducted the most detailed seismologic work in the area (for example, Wong and Humphrey, 1989). We have no additional information regarding these issues from our work.

Question C1. It is our belief that prior to latest Miocene to

early Pliocene time, a northwest-trending, salt-cored anticline, with its crest faulted down-to-the-northeast, was present in the Moab-Spanish Valley area. Dissolution of the salt diapirs that core numerous anticlines in the northern Paradox basin appears to have begun in the latest Tertiary. The oldest known late Cenozoic deposit preserved in any of the collapsed structural valleys (salt-cored anticlines) is the Geyser Creek Fanglomerate. Geyser Creek Fanglomerate is present in Castle Valley and the Taylor Creek syncline. Probable equivalent age deposits are present in Fisher and Paradox Valleys. At Castle Valley, Geyser Creek Fanglomerate is folded into an asymmetrical syncline that is beveled-off and unconformably overlain by Plio-Pleistocene alluvial-fan gravels. The Plio-Pleistocene gravels are approximately 400 feet thick in the valley and contain a volcanic ash bed near the top of the section that is tentatively correlated with the Guaje Pumice Bed dated at 1.45 million years. At Fisher Valley, paleomagnetic data from alluvium filling the valley indicate probable Geyser Creek-equivalent gravels are older than 2.5 million years (Colman and others, 1988). These data indicate that the Geyser Creek Fanglomerate is Pliocene age. The preservation of the Geyser Creek Fanglomerate in structural valleys indicates salt-dissolution-induced collapse was on-going at the time of deposition (Pliocene) and possibly shortly before. No deposits of Geyser Creek Fanglomerate have been identified in or adjacent to Moab or Spanish Valleys.

Remnants of Plio-Pleistocene gravels are preserved within and around the margins of many of the collapsed structural valleys. Deposits in the valleys are generally thicker than those in other areas. Plio-Pleistocene deposits in Fisher, Cache, and Salt Valleys are deformed by faults and folds, and are characterized by unconformities, tilting of beds, and syndepositional thickening of deposits in response to on-going deformation. These features indicate continued movement/dissolution of salt during the early Pleistocene. Along the northeast side and southern margin of Spanish Valley, Plio-Pleistocene gravels are preserved on topographically high bedrock surfaces at approximately 600 feet above current drainages. This indicates significant post-early Pleistocene stream incision in the Spanish Valley area. The age-assignment and correlation of Plio-Pleistocene deposits is based on the presence of early to middle Pleistocene volcanic ash beds in the deposits or a cap of strongly developed pedogenic

carbonate soils.

Pleistocene alluvial deposits, interpreted to be Bull Lake-age (≈120,000-150,000) and younger, show a complex distribution and morphology at Spanish, Moab, and Castle Valleys. Longitudinal profiles along major creeks show downstream convergence of terraces and burial of older surfaces in the valley bottoms. At Spanish Valley, buried soils at two locations in the middle of the valley have pedogenic carbonate profiles similar to those found on upstream terrace deposits considered to be of Bull Lake-age (Harden and others, 1985). The reappearance of these older terrace deposits and similar-age alluvial-fan deposits at the divide between Spanish and Moab Valleys suggest that the middle of Spanish Valley has subsided in the last 150,000 years relative to the divide. Harden and others (1985) estimate that up to 279 feet of alluvium underlies the late-Pleistocene-Holocene surface of Spanish Valley. Water-well data for Moab Valley suggest that as much as 300 feet of alluvium underlies the present valley surface. Indirect evidence for continued Quaternary subsidence of Moab Valley includes possible continued aggradation of the Colorado River in the Moab Slough area and active alluvial-fan deposition at the base of the cliffs southeast of the Portal in Moab Valley. There is no definitive evidence of late Tertiary or Quaternary salt diapirism within Moab Valley.

At Castle Valley, downstream convergence of Pleistocene alluvial-fan surfaces, the burial of these older surfaces in the lower half of the valley, the presence of late Pleistocene to Holocene alluvium at the surface, and accumulations of as much as 300 feet of valley fill in the lower part of the valley suggest salt-dissolution subsidence has occurred during the last 150,000 years in the lower part of the valley.

Question C2. Rocks west and northwest of the Atlas site between the two branches of the Moab fault are more fractured than similar rocks along the Moab fault north of the splay junction where the two branches merge. Glen Canyon Group sandstones on the north side of Highway 191 across from the Atlas site and in the hanging wall of the main branch of the Moab fault also are highly fractured by numerous closely-spaced faults, joints, and networks of cataclastic slip bands. The concentration of rock fractures and folds at the numerous salt-cored anticlines (for example, Moab Valley) suggest these features are related to salt tectonics. Many

of these structures may have a pre-salt-dissolution origin related to flowage of salt, but may have been reactivated during dissolution of the underlying salt diapir. For example, 1) where these faults trend at an angle to the valley margins, displacement on the faults increases toward the axis of the valley, and 2) fault blocks along the margin of the valley show increased rotation toward the axis of the valley.

Geomorphology of the area around the Atlas site is influenced by geologic structure. The headward erosion of Moab Wash is following the trace of the Moab fault. Numerous small drainages and erosional patterns of the rocks are controlled by the location, trend, and density of fractures. Salt-dissolution-induced collapse of Moab Valley has been greater southeast of the Colorado River than northwest of the river, even though the river has probably been at the northern end of the Moab Valley for a long time. This probably can be attributed to the increase in surface and ground-water flow originating in the LaSal Mountains.

To understand the mechanics, rates, and development of salt-dissolution-induced collapse of the salt diapirs, an understanding of the surface and ground-water hydrogeology, structural geology, and sedimentary petrology of the bedrock units is needed. No studies have been conducted to understand the dynamic relationship between surface water, base level, ground water, structural geology, and salt-dissolution collapse at the large collapse valleys. In general, we believe that salt-dissolution-induced collapse is a near surface (shallow crustal) process that occurs at a relatively slow rate. The salt-dissolution process is controlled by the influx of fresh surface and ground water into the salt diapir. The onset of dissolution of the salt diapirs appears to coincide with the initial contact of fresh water in surface drainages and shallow ground water systems related to the downcutting of the Colorado River system. The Colorado River appears to be a major factor in controlling salt dissolution, but large tributary drainages are also important (for example, Salt Wash, Castle Creek, Pack Creek, and Mill Creek). At shallow crustal levels, the overall rate of collapse-induced deformation was relatively slow to produce the numerous tight folds present at many of the collapse valleys. Brittle rocks in the folds always contain abundant micro- and mesoscopic fractures (for example, cataclastic slip bands, joints, faults). However, the postulated overall slow rate of development does not

preclude the occurrence of localized, rapid collapse of brittle rocks by solutioning of underlying salt and formation of sinkholes and breccia pipes. Faults in the brittle rocks may form in a similar manner. The abundant fractures in the brittle rocks above the diapir provided good fracture permeability for water to reach the salt at depth.

In general, we believe that dissolution of salt is increased during wet climatic conditions and increased stream discharge from melting glaciers. At these times, a greater volume of fresh water is available to enter the hydrologic system to dissolve salt. Recent work (Thompson, 1991, Smith and others, 1993, Fleming, 1994) suggests that the Pliocene climate for southwestern North America was wetter than modern conditions. Fleming (1994) interprets the Pliocene as a period of increased weathering and erosion on the Colorado Plateau. In the Rocky Mountain region, evidence exists for two major glaciations during the late-middle and late Pleistocene. The Bull Lake glaciation is dated at 120,000-150,000 years ago. The Pinedale glaciation is dated at 12,000-30,000 years ago. The LaSal Mountains contain evidence for both of these glaciations. Many of the alluvial-fan and alluvial deposits in Castle, Moab, and Spanish Valleys are suspected to be outwash from these glaciations. The large volume of deposits of these ages in the valleys suggests increased surface water runoff and alluviation of subsiding basins in the valleys.

Question C3. Information relevant to this question is included in Questions C1 and C2 above. No site-specific data are available for northern Moab Valley and along the Moab fault. Geologic features originating from both relatively slow and relatively rapid rates of salt tectonic movement (dissolution or diapirism) are associated with the collapse valleys.

Structural features interpreted as resulting from relatively rapid and episodic types of collapse are sinkholes, breccia pipes, landslides, and faults. Sinkholes are present in Castle Valley along the southwest side of the valley. The sinkholes lie along the trace of a salt-dissolution-induced collapse fault(s), indicating that collapse of solution caverns is a possible mechanism of subsidence accompanying dissolution of salt. Breccia deposits containing a variety of Mesozoic rock fragments are present in Spanish Valley (Weir and others, 1961). Other

breccia pipes are present at Lockhart Basin (Huntoon and Richter, 1979). The breccia bodies have a pipe-like geometry and rock fragments have moved downward in the pipe. Formations prone to landsliding, such as the Chinle and Morrison Formations, may undergo movement along the steep margins of the collapse valleys. The Fisher Ridge landslide on the north side of the LaSal Mountains is a complex landslide feature with reoccurring periods of movement into a salt-dissolution-induced synclinal basin. The rate of movement along the numerous faults associated with the collapse valleys is difficult to determine. It is reasonable to assume that movement on these faults was locally episodic and relatively rapid.

Structural features interpreted to have formed at relatively slow rates are subsidence features (for example, folds, syndepositional thickening of deposits, unconformities, and facies changes in deposits) and faults. At the eastern end of Salt Valley, folds are present in early Pleistocene alluvium. Beds apparently thicken in the axis of a syncline and thin across the axis of an adjacent anticline, indicating syndepositional deformation (Oviatt, 1988). Also at Salt Valley is a possible syndepositional normal fault, and angular unconformities and disconformities indicating deformation related to movement/dissolution of the underlying salt diapir. At Fisher Valley, late Cenozoic valley-fill deposits show evidence for syn- and post-depositional deformation (Colman, 1983). Geyser Creek Fanglomerate-equivalent deposits are faulted and folded into the caprock of the Onion Creek salt diapir. Plio-Pleistocene deposits are slightly infolded into the salt diapir and also dip away from the diapir, up to 15°, toward the center of the subsiding basin (Colman, 1983). These deposits contain several unconformities and syndepositional thickening toward the center of the basin within the valley.

An average rate of subsidence can be estimated for the early to middle Pleistocene deposits in Fisher Valley. During a period of approximately 120,000 years, between eruption of the Bishop volcanic ash (≈740,000 years ago) and eruption of the Lava Creek B volcanic ash (≈620,000 years ago), between 70-90 feet of alluvium was deposited in the valley. During this time, erosion and downcutting were predominant elsewhere throughout the Colorado Plateau, and significant deposition was occurring only in areas of active subsidence. The Fisher Valley data indicate an average of 8 inches per 1,000 years of subsidence and resulting sediment

accumulation in Fisher Valley. At the same time Fisher Valley was subsiding, the Colorado River and its tributaries were downcutting. The estimated long-term erosion rate for the Colorado Plateau is approximately 9.5 inches per 1,000 years (Biggar and others, 1981). Thus, for deposition to be occurring in Fisher Valley at the same time base level was dropping, the estimated subsidence rate for Fisher Valley is probably closer to 17.5 inches/1,000 years (equal to the regional downcutting rate [9.5 inches/1,000 years] plus the sediment accumulation rate [8 inches/1,000 years]. The overall rate of subsidence in Moab Valley, at the Atlas site, may vary from those estimated for Fisher Valley.

Question D1. Petroleum resources are present in the Pennsylvanian Paradox Formation and underlying Mississippian Leadville Formation in nearby areas to the southwest. Bedded evaporites (potash and salt) are present in the Paradox Formation, potash and salt are produced at Potash, located about 14 road miles southwest from the tailings pond.

The most uncertain of these commodities is petroleum. Petroleum drilling will likely occur in or adjacent to the Moab Valley within the next 1,000 years, and the potential for finding oil somewhere near the strike of the Moab fault is good. There is no documented evidence of seismic activity or subsidence related to hydrocarbon withdrawal in Grand County.

It is impossible to predict salt and potash market conditions and the technologies that may develop during the next 1,000 years. Currently, conditions are not favorable for such development The next area in the Paradox basin that will likely be developed will be the Bartlett Wash-Sevenmile Canyon area. Brines were extracted from Moab Valley in the early 1900s. Although seismic activity has been recorded at Potash, there is no documented surface rupture.

Ground water is present both in rock and unconsolidated deposits in the Moab Valley area. Fresh ground water is presently developed for municipal and domestic supplies. Saline ground water is also likely present. Pressure to develop ground-water resources will likely increase in the area.

Question E1. Although we believe subsidence is occurring in the vicinity of the Colorado River in Moab Valley, we have no

data regarding possible rates and no direct observations of displaced Quaternary deposits. Quaternary subsidence is known to have occurred elsewhere in the salt-cored anticline province where Pleistocene sediments have locally been deformed. There are no data concerning rates other than those previously mentioned for Fisher Valley. To our knowledge, no other research has been done to obtain absolute dates in areas of documented subsidence to determine rates. The presence of as much as 300 feet of Quaternary basin fill in Moab Valley in an erosional regime like that of the Colorado Plateau suggests local Quaternary subsidence.

H. Doelling suggests movement will occur along the margins of the salt-cored anticlines. These are natural zones of weakness, already highly fractured and faulted. Tectonic activity would also likely be aligned along these marginal zones. Likewise, these zones provide a direct conduit to the salt, so that fresh water can reach and dissolve it. M. Ross and G. Christenson suggest that deformation, related to dissolution of salt, is possible in the crestal portion of the collapsed salt-cored anticlines anywhere salt is close to the surface in contact with fresh water.

Question E2. We are not performing any studies which bear directly on understanding the effects and control of deep-seated basement shear zones and faults on observed surface faults.

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May 31, 1994

DELIVERED BY FEDERAL EXPRESS

Mr. Joseph J. Holonich
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U. S. Nuclear Regulatory Commission
Division of Low-Level Waste Management
and Decommissioning
NMSS (5 E2)
11555 Rockville Pike
Rockville, MD 20850

Re: License SUA-917
Docket No. 40-3453
November 29, 1993 and
January 3, 1994 Requests
for Information

Dear Mr. Holonich:

Transmitted herewith is Atlas Corporation's (Atlas') response to the Nuclear Regulatory Commission's (NRC's) requests for information dated November 29, 1993, and January 3, 1994. This submittal addresses faulting, seismic, geomorphic, erosion control and radon attenuation issues and completes our responses to the comments provided in these information requests. A previous response to the November 29, 1993, request for information was submitted to NRC on January 28, 1994.

This response includes documents prepared by Woodward-Clyde Federal Services Corp. (faulting issues) and Mussetter Engineering, Inc. (geomorphic issues). The Woodward-Clyde document was submitted to the Utah Geological Survey and they were in general agreement with the response.

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We trust that the responses to the comments adequately address the issues of concern. If you have any questions concerning this submittal, please call me at (303) 825-1200.

Sincerely,

Bruce W. Hassinger for Richard E. Blubaugh

Richard E. Blubaugh
Vice President, Environmental
and Governmental Affairs

REB/ajw

Enclosures

Project 88-067
June 1994

Canonie Environmental

NRC Request for Information

Atlas Corporation Reclamation Plan Uranium Mill and Tailings Disposal Area

Moab, Utah

Submitted by:

Atlas Corporation
Denver, Colorado

Prepared by:

Canonie Environmental Services Corp.
Englewood, Colorado

corresponding to a horizontal earthquake acceleration of 0.21 g (Department of Energy, 1989). This value is used for Scenarios 3, 4, and 5 along with a vertical earthquake acceleration of 0.05 g. The purpose of Scenarios 6 and 7 is to account for a potential earthquake of even greater magnitude during the design life of the reclaimed embankment. Under these scenarios, the maximum horizontal earthquake acceleration under which the reclaimed embankment is stable was determined.

Failure surfaces predicted by PCSTABL5 for the scenarios listed above are shown graphically on Figure 1. Soil properties and strength properties used in the analysis are also presented on Figure 1. Details of the stability evaluation are provided in Appendix A. Appendix A also contains the piezometer coordinates and the most current water level information.

The factor of safety against slope failure is greater than 1 for Scenarios 1, 2, and 3. For worst case Scenarios 6 and 7, the impoundment could withstand an earthquake with a horizontal earthquake acceleration of 0.25 g. This is 400 percent larger than the 250-year earthquake acceleration predicted for Moab, Utah, and 19 percent larger than the MCE loading. Based on the results of the stability analysis and the low probability of the MCE being exceeded, the reclaimed embankment design will provide an adequate factor of safety against shear failure.

B. Geomorphic Stability

Comment

1. From the available data and our observations, there appears to be no basis to conclude that the Colorado River cannot erode in the direction of the tailings pile. There is also insufficient information currently available to us to determine the rate of erosion. We therefore conclude that this erosion could adversely affect the stability of the tailings pile during the project design life.

   Accordingly, provide information to show that the Colorado River will not erode and migrate to the tailings embankment, or substantiate that your proposed design has considered and accounted for the potential for long-term

bank erosion and changes in the river's position in the valley. Include consideration of both structural stability and erosion protection.

If you cannot substantiate that the river will not migrate toward the tailings or that your design accommodated this condition, provide a revised design for our review and approval that considers a complete range of river conditions and positions that could be experienced in the project design life.

Include in your substantiation or redesign the estimated location, depth, and dimensions of the channel and any revised designs and analyses of the riprap to be placed along the sides of the toe of the pile. Also consider potential future channel locations, estimated depth of the channel, depth of scour, Probable Maximum Flood (PMF) water surface elevation, and other factors which enter into the erosion protection design. Since a new channel could possibly occur in a number of locations along the face of the pile, address in detail the areal extent of the erosion protection for the pile side slopes and toes. Include information to demonstrate that erosion protection is adequate to the scour depth that could be expected for the conditions described above.

Note

Additional comments concerning surface water hydrology and erosion protection were submitted to Atlas on January 3, 1994. The comment is repeated below.

Comment

2. It appears that the cross-sections and other estimated hydraulic parameters used in your water surface profile analyses to assess flooding on the Colorado River may not be appropriate. Preliminary review of your data and analyses indicates that the computations presented may not reflect actual conditions, as indicated by direct staff observations of the Colorado River. We have questions and concerns in the following areas:

- Topographic and Colorado River cross-section data
- Underprediction of flow velocities in the river channel
- Changes to river channel cross-sections during flood events
- Use of Manning's 'n' values

It appears that the topographic and cross-section data provided for determining water surface evaluations and velocities are not adequate for assessing flow velocities in the river channel. Based on an examination of the topographic and cross-section information provided, more detailed and correct cross-sections are required to correctly analyze the flows in the Colorado River, particularly with regard to determining flood velocities. For example, the cross-section data provided with the HEC-2 analyses (Appendix F) do not agree with topographic data provided in Drawing 88-067-E64 (Sheet 2 of 10). Specifically, cross-section 800 in the immediate site vicinity, does not reflect the elevations or channel widths indicated on the drawing. Further, direct observations and approximate staff measurements of the river depth indicate that the depths from the top of the bank to the channel bottom are greater than indicated in the HEC-2 data at cross-section 800 and at other cross-sections. These apparent errors could significantly affect the flow profiles computed using HEC-2, particularly if the channel bottom elevations and bottom slope are not well-defined. The calculations take on added significance if the river channel is assumed to migrate toward the pile (see previous questions on geomorphology, dated November 29, 1993). Additional evidence to substantiate that the cross-section data are not correct is provided by direct observations of the flow velocities in the river, which indicate that the maximum predicted PMF channel velocity of about two to three feet per second has apparently been underestimated. The staff observed surface velocities of two to three feet per second in November 1993 during a low-flow period in the river. Channel velocities are likely to increase significantly as the discharge increases during flood events.

In addition, based on map studies, this reach of the river is known to change geometry during and after major flood events, since erosion and deposition occur in various places. Therefore, the flood analyses should assume that

changes will occur to the river geometry during a flood event. These changes would include erosion of channel bars and deepening of the channel during a large flood event. This assumption could be extremely important at cross-sections near the "portal" area, for example, where it appears that significant constriction of flows occur and backwater effects are produced by constricted cross-sections. These sections may not be a significantly constricted during the course of a flood event. In particular, cross-section 200 indicates the presence of a sandbar which constricts flows, but could be eroded by high velocities during a major flood event. In addition, it becomes very important to define stable channel bottom elevations in these constricted sections, since the bottom elevations and bottom slope can have a great effect on velocities and depth of flow.

Also, the Manning 'n' values should be more conservative than those assumed. For example, the channel and overbank 'n' values are assumed to be 0.03. It is likely, particularly during large floods, that channel 'n' values would be less than this. It is also likely, based on the presence of significant amounts of vegetation, that overbank 'n' values would be greater than 0.03. The overall net effect of using lower channel 'n' values would likely be to increase channel velocities and possibly lower water surface elevations. This is significant if the riprap on the pile side slopes needs to be designed for river channel velocities, if the river is assumed to migrate toward the pile (see staff questions on geomorphology). If the river is not assumed to migrate, use of overbank 'n' values of 0.03 is likely to be acceptable, but should be checked and verified using appropriate equations for estimating 'n' values.

During our field visit to the area in November, the National Park Service pointed out high-water marks at the Highway 191 bridge for floods which occurred in the early 1980s. You should attempt to duplicate these historic profiles by adjusting Manning 'n' values, expansion and contraction losses, river geometry, etc. for the flows which occurred. These high-water marks should be surveyed and provided in the analyses as justification for the HEC-2 input parameters selected.

Accordingly, please provide revised and accurate cross-sections to properly model flood flows in the Colorado River. The new data should include surveyed cross-sections which accurately portray river geometry. Also, submit revised HEC-2 analyses using these new data to substantiate the adequacy of the proposed erosion protection on the pile side slopes.

Alternately, it may be possible to conservatively estimate the river depth and velocities to be used for the design of erosion protection using a minimal amount of data. Such estimates could be developed for:

1. Overbank velocities for the case which the river channel is assumed to be stable and does not migrate toward the pile

2. Channel velocities for the case where the channel is assumed to migrate toward the pile

In preparing these "bounding" calculations however, a certain amount of new information will need to be developed. While some river channel widths and bank elevations could possibly be estimated from topographic maps already available, the slope and elevation of the river bottom will need to be accurately determined by surveys. It may be possible to use such measured river slopes and overbank/channel geometry taken from maps in a worst-case analysis to estimate velocities in the vicinity of the pile using simple slope-area methods and conservative estimates of Manning 'n' values for the channel and overbank. This type of worst-case calculation could possible be acceptable, if adequately justified as being appropriate and/or conservative, using sensitivity analyses, for example. This analysis should also attempt to duplicate historic profiles and high water marks.

Response

This response has been prepared by Mussetter Engineering, Inc., Fort Collins, Colorado, under a consulting agreement with Canonie and is provided under separate cover.

FINAL REPORT

GEOMORPHIC, HYDRAULIC AND LATERAL MIGRATION CHARACTERISTICS OF THE COLORADO RIVER MOAB, UTAH

Prepared for

Canonie Environmental and Atlas Corporation

Prepared by

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MEI Ref. No. 94-02

May, 1994

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6. SUMMARY AND CONCLUSIONS

The observations and analyses presented in the preceding chapters indicate that lateral migration of the Colorado River toward the tailings pile is very unlikely during the 1,000 year time frame (per 10CFR40, Appendix A). The reasons for this conclusion are summarized, as follows:

1. In contrast to a river with all of the degrees of freedom for adjustment, the Colorado River, within the project reach, has limited degrees of freedom for adjustment because of constraints imposed by non-fluvial factors. The length of the river and therefore its ability to develop a sinuous planform is constrained by bedrock inlet and outlet conditions to and from Moab-Spanish Valley, respectively.

2. The area on which the tailings pile and old mill site are located is an alluvial fan developed by flows from Moab Wash and Courthouse Wash. Both of the washes have delivered significant quantities of sediment to this area historically, and will continue to do so, unless significant changes occur in the upstream watersheds. This sediment includes some very coarse material that is currently buried beneath the site and is evident in the toe of the river bank adjacent to the tailings pile. Interaction between the river flows and the fan sediments has resulted in the development of a natural toe armor that has maintained the alignment of the river bank between cross sections 4 and 5 through the period of record,

3. Sediment input from Courthouse Wash, which enters the river at cross section 4 contributes a counterbalancing effect to lateral migration similar to Moab Wash. Sediment delivery from Courthouse Wash in about 1956 forced the channel of the Colorado River to the south and necessitated construction of a rock dike across the mouth of the new channel to return the river to its former alignment that would permit water withdrawal for the mill.

4. The combined effects of the backwater caused by the constriction at the Portals and overbank flows into Moab Marsh along the left side of the channel significantly reduce the stress on the right channel bank adjacent to the tailings pile at flows greater than about 30,000 cfs. Historical and field evidence indicates that the dominant process along the right bank of the river has been lateral accretion of sediments and not bank erosion.

5. The average flow velocity in the right overbank near the tailings pile, predicted by the hydraulic model used for this study, was less than 1 fps and the maximum predicted velocity directly adjacent to the toe of the tailings pile was approximately 1.6 fps. These results are not significantly different from the velocities used by Canonie in designing toe protection for the embankment in the reclamation plan.

6. Over 95 percent of the total work on the channel banks, which considers both the magnitude and duration of flows, on an average annual basis occurs at discharges less than the bankfull flow of approximately 40,000 cfs. Because of the hydraulic effects discussed in 4. above, the contribution of flows associated with extreme flood events is expected to be minimal.

7. Historical evidence indicates that the channel is not presently migrating in the direction of the tailings pile. Prior to failure of the left bank levee in the approximate location of cross section 5 in 1984, the shear stress on the right bank would have been higher than it is under current conditions or before the levee was

constructed because flows up to about 70,000 cfs were contained within the channel. Field and historical evidence indicate that even under the pre-levee failure condition, the dominant process was lateral accretion on the right bank.

8. Since the flows that occur in the river on a frequent basis are responsible for virtually all of the work done on the channel banks and the physical factors that cause higher flows to exert very little stress on the right bank are permanent features related to the geology of the site, there is no reason to believe that a tendency for lateral migration of the river toward the tailings pile will occur in the future.

ATLAS CORPORATION
Republic Plaza, 370 Seventeenth Street, Suite 3150
Denver, CO 80202
Telephone: (303) 825-1200 Fax: (303) 892-8808

March 21, 1995

DELIVERED BY FEDERAL EXPRESS

Mr. Joseph J. Holonich
Uranium Recovery Branch
U. S. Nuclear Regulatory Commission
Division of Low-Level Waste Management
and Decommissioning
NMSS (5 E2)
11555 Rockville Pike
Rockville, MD 20850

Re: License SUA-917
Docket No. 40-3453
November 4, 1994
Request for Information

Dear Mr. Holonich:

Transmitted herewith is Atlas Corporation's (Atlas') response to the Nuclear Regulatory Commission's (NRC's) requests for information dated November 4, 1994. This submittal addresses geomorphology of the Colorado River, surface water hydrology/erosion protection and radon protection issues. Preparation of responses to the request for information on the capable fault issue, seismic and faulting potential, effects of oil extraction and effects of future solution mining are on-going and will be submitted at a later date.

We trust that the responses to the comments adequately address the issues of concern. If you have any questions concerning this submittal, please call me at (303) 825-1200.

Sincerely,

Bruce W. Hassinger for Richard Blubaugh

Richard E. Blubaugh
Vice President, Environmental
and Governmental Affairs

REB/rr

Enclosures

cc: Robert M. Baker, National Park Service
Dan Kimball, U.S. Department of Interior
William Lamb, Bureau of Land Management
Milton K. Lammering, U.S. Environmental Protection Agency
Macia Moore, Bureau of Land Management
Noel Poe, National Park Service
Robert M. Reed, Oak Ridge National Laboratory
William J. Sinclair, Department of Environmental Quality
Lillian K. Stone, U.S. Department of the Interior
Christine Turk, National Park Service
Grand County Council

NRC Request for Information - November 4, 1994

Atlas Corporation Reclamation Plan Uranium Mill and Tailings Disposal Area

Canonie Environmental

PARTIAL RESPONSE TO NUCLEAR REGULATORY COMMISSION

REQUEST FOR INFORMATION
REVISED RECLAMATION PLAN REVIEW
NOVEMBER 4, 1994
GEOMORPHIC QUESTIONS AND COMMENTS, SURFACE WATER HYDROLOGY / EROSION PROTECTION QUESTIONS AND COMMENTS, AND CLARIFICATION AND INFORMATION ON RADON ATTENUATION DESIGN ISSUES
RECLAMATION PLAN
URANIUM MILL TAILINGS SITE
MOAB, UTAH

INTRODUCTION

Canonie Environmental Services Corp. (Canonie), as a contractor for Atlas Corporation (Atlas), has prepared a response to the Nuclear Regulatory Commission's (NRC's) November 4, 1994, request for information for the Revised Reclamation Plan at Atlas' Moab, Utah Uranium Mill Tailings site. This response is a partial response addressing the geomorphic, surface water hydrology/erosion protection and radon attenuation issues. The response to seismic and geology issues will be submitted under separate cover at a later, yet to be identified, date. In the following pages each request for information is restated verbatim and a response for each request is provided.

GEOMORPHIC QUESTIONS AND COMMENTS

NRC Comment

The following questions and comments are based on staff review of "Geomorphic, Hydraulic, and Lateral Migration Characteristics of the Colorado River Moab, Utah," dated May, 1994. This report was submitted by Atlas in response to NRC staff questions regarding the potential for the Colorado River to migrate toward the tailings pile.

Staff review of the information provided in the report indicates that the important erosion or depositional processes that are ongoing at the site have not been

adequately quantified. The report provides some observations that are pertinent to the stability of the Colorado River, but does not provide a definitive technical basis for concluding that the pile will not be affected for 1000 years to the extent reasonably achievable, and, in any case, for a least 200 years. The staff concludes that a significant amount of additional information and analyses will need to be provided in the following areas to substantiate that lateral migration of the river will not affect the stability of the pile:

(1) Previous locations of the river channel across the valley floor and the potential for future movement or meandering;

(2) Resistance to erosion and migration provided by the properties of the channel bank and floodplain;

(3) Rates of lateral erosion, migration, or aggradation;

(4) Effects of other processes, such as sloughing and slumping, which could lead to channel migration;

(5) Dating of alluvial deposits in the area to establish evidence of stability; and

(6) Effects of salt dissolution and/or subsidence on the location of the river channel.

Further discussion of additional information and analyses needed in these areas are provided in Comments 1-6, below.

It is also important to note that other options may be available, if channel stability cannot be demonstrated. For example, the riprap on the side slopes and toe of the pile could be designed to resist the Colorado River channel velocities which would be assumed to occur in the immediate vicinity of the tailings pile. If Atlas chooses this option to design the side slope and toe for river migration, additional information and analyses will need to be provided to substantiate the design of the additional erosion protection.

1. <u>Potential for Channel Migration and Meandering</u>

The report indicates that bedrock inlet and outlet conditions in the Spanish Valley will restrain the movement of the river channel, such that the ability of the river to develop a sinuous platform is constrained. However, based on observations and map study of the area, it appears that the river channel has moved and has occupied different locations across the valley at various times. Even though there may be constraints for meandering, it appears possible that the river could simply migrate toward the tailings pile on this outside bend in the river.

Additional information and analyses should be provided to substantiate the claim for channel stability. Atlas should provide further detailed discussions of why the river has a low potential for meandering given the bedrock constraints, why the distance between bedrock constraints through this reach of the river is insufficient to develop meanders, why the channel bank will not erode toward the pile, and why previous locations of the river channel are not important with respect to assessing the stability of the river for 1000 years to the extent reasonably achievable, and, in any case, for at least 200 years.

2. <u>Resistance of Channel Banks to Erosion</u>

The report indicates that the sediment transported by Moab Wash and Courthouse Wash includes some very coarse material that is buried beneath the site and is evident in the toe of the river bank adjacent to the tailings pile. At the present time, quantitative evidence of the presence and extent of the material has not been provided. Therefore, it is not clear exactly where this material is located or exactly how coarse the material is. The staff notes that the excavated banks of the current relocated Moab Wash channel (excavated several years ago) contains very little evidence of coarse material. Further, evidence of the size and gradation of the material, such as gradation curves of the riverbank deposits, have not been provided to illustrate the coarseness of the material.

In addition, the staff has recently reviewed a photograph taken in 1985 which shows a dirt road along the bank of the river near the pile. Based on NRC staff site visits to

floodplain alluvium. More complicated methods are also available to date buried sediments.

Atlas should consider the possibility of dating organic material in the alluvial deposits. Such dating may help to establish with some confidence that the river channel is stable or will not unacceptably affect the tailings pile due to erosion.

6. Effects of Salt Dissolution and Subsidence

Based on a review of the geology of the area, it appears that salt dissolution and subsidence are active ongoing processes in the area, particularly in the site area at the northern end of the Moab-Spanish Valley. In "Quaternary Deposits in the Paradox Basin," Biggar, and others, indicate that Holocene subsidence may be indicated by the marshes present along the river and that the subsidence could be caused either by tectonism or by dissolution or migration of salt at depth. In "Quaternary Deposits and Soils in and Around Spanish Valley, Utah," Harden, and others, also indicate that ongoing subsidence at the lower end of Spanish Valley may be indicated by marshes present along the river. At the present time, it is not clear if these processes will have any effects on the location of the river channel. For example, if subsidence similar to that which may have occurred in the Moab Marsh area occurred north of the river, the channel could shift to accommodate the lowering of ground surface.

Atlas should provide additional information and discussion to document that shifting of the river channel, caused by local subsidence, will not occur to the extent that the pile could be unacceptably affected.

Atlas Response

Atlas and its contractors conclude that for the time frames under consideration (200 to 1,000 years) there is a very low potential for the Colorado River to migrate laterally and impact the tailings pile. A response to NRC's questions and comments has been prepared by Mussetter Engineering, Inc. (MEI) and is included in this document as Appendix A. This response provides specific responses to NRC's concerns and highlights MEI's observations and analyses that back up the

conclusion that there is a very low potential for the Colorado River to migrate and impact the tailings pile. However, to alleviate the concerns of the NRC and the local population with respect to this issue, Atlas has initiated a design change for the tailing pile toe and provisions for a rock apron to protect the pile from the potential for channel erosion. This design is discussed in the response to comments relating to Surface Water Hydrology/Erosion Protection (NRC Comment No. 2) provided later in this document.

The staff concludes that the design of the rock-soil matrix should be modified to eliminate the soil portion and to increase the rock layer thickness to at least 4 inches. Alternately, the licensee should provide additional justification that the proposed riprap design is adequate to resolve the staff concerns discussed above.

Atlas Response

Atlas will modify the reclamation plan to eliminate the soil portion of the proposed rock-soil matrix for the top slopes and increase the layer thickness to 4 inches in the area designated for 1.3 inch D_{50} material (Figure 1). The area designated for 3.0 inch D_{50} material will have a thickness of 6 inches. The riprap design D_{50} (1.3 inches and 3.0 inches) will be placed in the areas as indicated in Sheet 4 of 10 (included in the Figures section of this document). Table 5c of the Reclamation Plan provides the gradations for these rock layers.

Atlas will develop a detailed Construction Quality Control Plan (CQCP) prior to the start of reclamation construction. The CQCP will be prepared in accordance with the specifications.

NRC Comment

2. Apron/Toe Design

The design of the rock for the apron/toe area is not considered to be acceptable. The rock size proposed for the toe is similar to the rock size for the side slopes. In general, the toe area will act as an energy dissipation area, producing turbulence and forces that need to be accounted for with an increased rock size. As the soil is eroded, erosion pockets and gullies will form, resulting in turbulence as the flow energy is dissipated.

To resolve staff concerns, Atlas should design the lower portion of the toe to withstand turbulence which would be expected to occur during the design storm. U.S. Army Corps of Engineers design procedures typically include an approximate 50 percent increase in the shear force produced in areas where turbulence is expected

(non-uniform flow factor). If such an increase were applied, the resulting D_{50} rock size would increase from approximately 4 inches to approximately 6 inches. Such an increase would produce a design that would be acceptable to the staff. Alternately, Atlas should further justify that the design of the toe is adequate.

It should be noted that there may be a potential for the Colorado River to migrate toward the tailings pile. As discussed in staff geomorphic comments, the design of the toe may need to be revised to accommodate the erosive forces produced if the river channel is assumed to be located directly against the slope of the tailings pile.

If Atlas is not able to demonstrate stability of the river channel, the toe design should be revised. If such a redesign is performed, several factors should be taken into account. The design of the apron/toe should be based on the following general concepts: (1) provide riprap of adequate size to be stable against overland 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 river channel velocities, 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 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 which allows the rock to collapse into a stable configuration in the eroded river channel.

Atlas should revise the toe design, as applicable. Alternately, Atlas should provide additional justification to document the adequacy of the current design.

Atlas Response

As indicated in the response to the geomorphic questions and comments Atlas has revised the design of the tailings pile toe to accommodate the erosive forces

produced should the Colorado River migrate toward the pile and the river channel is assumed to be located directly against the slope of the pile. The design consists of a launchable rock apron that, as the erosion occurs, the rock in the apron is undermined and rolls or slides down the slope to protect against additional erosion. The location of the apron is shown in Sheet 4 of 10 in the Figures section of this document. A design detail of the toe of the pile slope and the rock apron is shown on Sheet 5 of 10.

The rock apron consists of an 11.2" D_{50} rock which is sized adequately to be stable against both overland flow and river velocities. The apron is 2.5 feet thick and 20 feet wide which provides an adequate volume of rock to collapse into a stable configuration in the eroded channel. To account for turbulence at the toe, the 11.2" D_{50} rock has been extended approximately 5 feet up the tailings pile side slope. The apron will be constructed at the same slope as the existing ground adjacent to the tailings pile to minimize flow concentration and erosion. The design calculations for the rock apron/toe design are provided in Appendix B.

NRC Comment

3. Design of Channel Outlet Protection

The rock riprap for the outlets of the drainage channels appears to be somewhat undersized. Based on review of calculations provided in the January 1994 submittal, the size of the riprap to be placed at the outlets of the Southwest Drainage Channel and the Lower Impoundment Drainage Channel was determined using the bottom slopes of the channels in the vicinity of the outlet. Use of this slope is not appropriate, because scour will occur to the overlying soil during a flood, and flows will discharge down the steeper slope of the buried cutoff wall. Therefore, the slope of the cutoff wall should be used to determine the rock size. The staff notes that the proposed slope of the cutoff wall is approximately 1.2 vertical (V) to 1 horizontal (H), according to Sheet 6 of the design drawings dated May 18, 1994. (The staff notes that the slope may be incorrectly designated, because the drawing also indicates that the slope will be flatter than the angle of repose of the rock.) The riprap sizes

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

COMMISSIONERS:

Shirley Ann Jackson, Chairman
Nils J. Diaz
Edward McGaffigan, Jr.

**STATEMENT OF POLICY ON
CONDUCT OF ADJUDICATORY PROCEEDINGS**

CLI-98-12

I. INTRODUCTION

As part of broader efforts to improve the effectiveness of the agency's programs and processes, the Commission has critically reassessed its practices and procedures for conducting adjudicatory proceedings, within the framework of its existing Rules of Practice in 10 C.F.R. Part 2, primarily Subpart G. With the potential institution of a number of proceedings in the next few years to consider applications to renew reactor operating licenses, to reflect restructuring in the electric utility industry, and to license waste storage facilities, such assessment is particularly appropriate to ensure that agency proceedings are conducted efficiently and focus on issues germane to the proposed actions under consideration. In its review, the Commission has considered its existing policies and rules governing adjudicatory proceedings, recent experience and criticism of agency proceedings, and innovative techniques used by our own hearing boards and presiding officers and by other tribunals. Although current rules and policies provide means to achieve a prompt and fair resolution of proceedings, the Commission is directing its hearing boards and presiding officers to employ certain measures described in this policy statement to ensure the efficient conduct of proceedings.

The Commission continues to endorse the guidance in its current policy, issued in 1981, on the conduct of adjudicatory proceedings. *Statement of Policy on Conduct of Licensing Proceedings*, CLI-81-8, 13 NRC 452 (May 20, 1981); 46 Fed. Reg. 28,533 (May 27, 1981). The 1981 policy statement provided guidance to the Atomic Safety and Licensing Boards (licensing boards) on the use of tools, such as the establishment and adherence to reasonable schedules and discovery management, intended to reduce the time for completing licensing proceedings while ensuring that hearings were fair and produced adequate records. Now, as then, the Commission's objectives are to provide a fair hearing process, to avoid unnecessary delays in the NRC's review and hearing processes, and to produce an informed adjudicatory record that supports agency decision making on matters related to the NRC's responsibilities for protecting public health and safety, the common defense and security, and the environment. In this context, the opportunity for hearing should be a meaningful one that focuses on genuine issues and real disputes regarding agency actions subject to adjudication. By the same token, however, applicants for a license are also entitled to a prompt resolution of disputes concerning their applications.

The Commission emphasizes its expectation that the boards will enforce adherence to the hearing procedures set forth in the Commission's Rules of Practice in 10 C.F.R. Part 2, as interpreted by the Commission. In addition, the Commission has identified certain specific approaches for its boards to consider implementing in individual proceedings, if appropriate, to reduce the time for completing licensing and other proceedings. The measures suggested in this policy statement can be accomplished within the framework of the Commission's existing Rules of Practice. The Commission may consider further changes to the Rules of Practice as appropriate to enable additional improvements to the adjudicatory process.

II. SPECIFIC GUIDANCE

Current adjudicatory procedures and policies provide a latitude to the Commission, its licensing boards and presiding officers to instill discipline in the hearing process and ensure a prompt yet fair resolution of contested issues in adjudicatory proceedings. In the 1981 policy statement, the Commission encouraged licensing boards to use a number of techniques for effective case management including: setting reasonable schedules for proceedings; consolidating parties; encouraging negotiation and settlement conferences; carefully managing and supervising discovery; issuing timely rulings on prehearing matters; requiring trial briefs, pre-filed testimony, and cross-examination plans; and issuing initial decisions as soon as practicable after the parties file proposed findings of fact and conclusions of law. Licensing boards and presiding officers in current NRC adjudications use many of these techniques, and should continue to do so.

As set forth below, the Commission has identified several of these techniques, as applied in the context of the current Rules of Practice in 10 C.F.R. Part 2, as well as variations in procedure permitted under the current Rules of Practice that licensing boards should apply to proceedings. The Commission also intends to exercise its inherent supervisory authority, including its power to assume part or all of the functions of the presiding officer in a given adjudication, as appropriate in the context of a particular proceeding. *See, e.g., Public Service Co. of New Hampshire* (Seabrook Station, Units 1 and 2), CLI-90-3, 31 NRC 219, 229 (1990). The Commission intends to promptly respond to adjudicatory matters placed before it, and such matters should ordinarily take priority over other actions before the Commissioners.

1. Hearing Schedules

The Commission expects licensing boards to establish schedules for promptly deciding the issues before them, with due regard to the complexity of the contested issues and the interests of the parties. The Commission's regulations in 10 C.F.R. § 2.718 provide licensing boards all powers necessary to regulate the course of proceedings, including the authority to set schedules, resolve discovery disputes, and take other action appropriate to avoid delay. Powers granted under section 2.718 are sufficient for licensing boards to control the supplementation of petitions for leave to intervene or requests for hearing, the filing of contentions, discovery, dispositive motions, hearings, and the submission of findings of fact and conclusions of law.

Many provisions in Part 2 establish schedules for various filings, which can be varied "as otherwise ordered by the presiding officer." Boards should exercise their authority under these options and 10 C.F.R. § 2.718 to shorten the filing and response times set forth in the regulations to the extent practical in a specific proceeding. In addition, where such latitude is not explicitly afforded, as well as in instances in which sequential (rather than simultaneous) filings are provided for, boards should explore with the parties all reasonable approaches to reduce response times and to provide for simultaneous filing of documents.

Although current regulations do not specifically address service by electronic means, licensing boards, as they have in other proceedings, should establish procedures for electronic filing with appropriate filing deadlines, unless doing so would significantly deprive a party of an opportunity to participate meaningfully in the proceeding. Other expedited forms of service of documents in proceedings may also be appropriate. The Commission encourages the licensing boards to consider the use of new technologies to expedite proceedings as those technologies become available.

Boards should forego the use of motions for summary disposition, except upon a written finding that such a motion will likely substantially reduce the number of issues to be decided, or otherwise expedite the proceeding. In addition, any evidentiary hearing should not commence before completion of the staff's Safety Evaluation Report (SER) or Final Environmental Statement (FES) regarding an application, unless the presiding officer finds that beginning earlier, *e.g.*, by starting the hearing with respect to safety issues prior to issuance of the SER, will indeed expedite the proceeding, taking into account the effect of going forward on the staff's ability to complete its evaluations in a timely manner. Boards are strongly encouraged to expedite the issuance of interlocutory rulings. The Commission further strongly encourages presiding officers to issue decisions within 60 days after the parties file the last pleadings permitted by the board's schedule for the proceeding.

Appointment of additional presiding officers or licensing boards to preside over discrete issues simultaneously in a proceeding has the potential to expedite the process, and the Chief Administrative Judge of the Atomic Safety and Licensing Board Panel (ASLBP) should consider this measure under appropriate circumstances. In doing so, however, the Commission expects the Chief Administrative Judge to exercise the authority to establish multiple boards only if: (1) the proceeding involves discrete and severable issues; (2) the issues can be more expeditiously handled by multiple boards than by a single board; and (3) the multiple boards can conduct the proceeding in a manner that will not unduly burden the parties. *Private Fuel Storage, L.L.C.* (Private Fuel Storage Facility), CLI-98-7, 47 NRC ___ (1998).

The Commission itself may set milestones for the completion of proceedings. If the Commission sets milestones in a particular proceeding and the board determines that any single milestone could be missed by more than 30 days, the licensing board must promptly so inform the Commission in writing. The board should explain why the milestone cannot be met

and what measures the board will take insofar as is possible to restore the proceeding to the overall schedule.

2. Parties' Obligations

Although the Commission expects its licensing boards to set and adhere to reasonable schedules for the various steps in the hearing process, the Commission recognizes that the boards will be unable to achieve the objectives of this policy statement unless the parties satisfy their obligations. The parties to a proceeding, therefore, are expected to adhere to the time frames specified in the Rules of Practice in 10 C.F.R. Part 2 for filing and the scheduling orders in the proceeding. As set forth in the 1981 policy statement, the licensing boards are expected to take appropriate actions to enforce compliance with these schedules. The Commission, of course, recognizes that the boards may grant extensions of time under some circumstances, but this should be done only when warranted by unavoidable and extreme circumstances.

Parties are also obligated in their filings before the board and the Commission to ensure that their arguments and assertions are supported by appropriate and accurate references to legal authority and factual basis, including, as appropriate, citation to the record. Failure to do so may result in material being stricken from the record or, in extreme circumstances, in a party being dismissed.

3. Contentions

Currently, in proceedings governed by the provisions of Subpart G, 10 C.F.R. § 2.714(b)(2)(iii) requires that a petitioner for intervention shall provide sufficient information to

show that a genuine dispute exists with the applicant on a material issue of law or fact.[1] The Commission has stated that a board may appropriately view a petitioner's support for its contention in a light that is favorable to the petitioner, but the board cannot do so by ignoring the requirements set forth in section 2.714(b)(2). *Arizona Public Service Co.* (Palo Verde Nuclear Generating Station, Units 1, 2, and 3), CLI-91-12, 34 NRC 149, 155 (1991). The Commission re-emphasizes that licensing boards should continue to require adherence to section 2.714(b)(2), and that the burden of coming forward with admissible contentions is on their proponent. A contention's proponent, not the licensing board, is responsible for formulating the contention and providing the necessary information to satisfy the basis requirement for the admission of contentions in 10 C.F.R. § 2.714(b)(2). The scope of a proceeding, and, as a consequence, the scope of contentions that may be admitted, is limited by the nature of the application and pertinent Commission regulations. For example, with respect to license renewal, under the governing regulations in 10 C.F.R. Part 54, the review of license renewal applications is confined to matters relevant to the extended period of operation requested by the applicant. The safety review is limited to the plant systems, structures, and components (as delineated in 10 C.F.R. § 54.4) that will require an aging management review for the period of extended operation or are subject to an evaluation of time-limited aging analyses. *See* 10 C.F.R. §§ 54.21(a) and (c), 54.29, and 54.30. In addition, the review of environmental issues is limited by rule by the generic findings in NUREG-1427, "Generic

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[1] "[A]t the contention filing stage[,] the factual support necessary to show that a genuine dispute exists need not be in affidavit or formal evidentiary form and need not be of the quality necessary to withstand a summary disposition motion." *Rules of Practice for Domestic Licensing Proceedings--Procedural Changes in the Hearing Process, Final Rule*, 54 Fed. Reg. 33,168, 33,171 (Aug. 11, 1989).

Environmental Impact Statement (GEIS) for License Renewal of Nuclear Plants.[4] *See* 10 C.F.R. §§ 55.71(d) and 51.95(c).

Under the Commission's Rules of Practice, a licensing board may consider matters on its motion only where it finds that a serious safety, environmental, or common defense and security matter exists. 10 C.F.R. § 2.760a. Such authority is to be exercised only in extraordinary circumstances. If a board decides to raise matters on its own initiative, a copy of its ruling, setting forth in general terms its reasons, must be transmitted to the Commission and the General Counsel. *Texas Utilities Generating Co.* (Comanche Peak Steam Electric Station, Units 1 and 2), CLI-81-24, 14 NRC 614 (1981). The board may not proceed further with *sua sponte* issues absent the Commission's approval. The scope of a particular proceeding is limited to the scope of the admitted contentions and any issues the Commission authorizes the board to raise *sua sponte*.

Currently, 10 C.F.R. § 2.714a allows a party to appeal a ruling on contentions only if (a) the order wholly denies a petition for leave to intervene (i.e., the order denies the petitioner's standing or the admission of all of a petitioner's contentions) or (b) a party other than the petitioner alleges that a petition for leave to intervene or a request for a hearing should have been wholly denied. Although the regulation reflects the Commission's general policy to minimize interlocutory review, under this practice, some novel issues that could benefit from early Commission review will not be presented to the Commission. For example, matters of first impression involving interpretation of 10 C.F.R. Part 54 may arise as the staff and licensing board begin considering applications for renewal of power reactor operating licenses. Accordingly, the Commission encourages the licensing boards to refer rulings or certify questions on proposed contentions involving novel issues to the Commission in accordance with 10 C.F.R. § 2.730(f) early in the proceeding. In addition, boards are encouraged to certify

novel legal or policy questions related to admitted issues to the Commission as early as possible in the proceeding. The Commission may also exercise its authority to direct certification of such particular questions under 10 C.F.R. § 2.718(i). The Commission, however, will evaluate any matter put before it to ensure that interlocutory review is warranted.

4. Discovery Management

Efficient management of the pre-trial discovery process is critical to the overall progress of a proceeding. Because a great deal of information on a particular application is routinely placed in the agency's public document rooms, Commission regulations already limit discovery against the staff. *See, e.g.,* 10 C.F.R. §§ 2.720(h), 2.744. Under the existing practice, however, the staff frequently agrees to discovery without waiving its rights to object to discovery under the rules, and refers any discovery requests it finds objectionable to the board for resolution. This practice remains acceptable.

Application in a particular case of procedures similar to provisions in the 1993 amendments to Rule 26 of the Federal Rules of Civil Procedure or informal discovery can improve the efficiency of the discovery process among other parties. The 1993 amendments to Rule 26 provide, in part, that a party shall provide certain information to other parties without waiting for a discovery request. This information includes the names and addresses, if known, of individuals likely to have discoverable information relevant to disputed facts and copies or descriptions, including location, of all documents or tangible things in the possession or control of the party that are relevant to the disputed facts. The Commission expects the licensing

boards to order similar disclosure (and pertinent updates) if appropriate in the circumstances of individual proceedings. With regard to the staff, such orders shall provide only that the staff identify the witnesses whose testimony the staff intends to present at hearing. The licensing boards should also consider requiring the parties to specify the issues for which discovery is necessary, if this may narrow the issues requiring discovery.

Upon the board's completion of rulings on contentions, the staff will establish a case file containing the application and any amendments to it, and, as relevant to the application, any NRC report and any correspondence between the applicant and the NRC. Such a case file should be treated in the same manner as a hearing file established pursuant to 10 C.F.R. § 2.1231. Accordingly, the staff should make the case file available to all parties and should periodically update it.

Except for establishment of the case file, generally the licensing board should suspend discovery against the staff until the staff issues its review documents regarding the application. Unless the presiding officer has found that starting discovery against the staff before the staff's review documents are issued will expedite the hearing, discovery against the staff on safety issues may commence upon issuance of the SER, and discovery on environmental issues upon issuance of the FES. Upon issuance of an SER or FES regarding an application, and consistent with such limitations as may be appropriate to protect proprietary or other properly withheld information, the staff should update the case file to include the SER and FES and any supporting documents relied upon in the SER or FES not already included in the file.

The foregoing procedures should allow the boards to set reasonable bounds and schedules for any remaining discovery, *e.g.*, by limiting the number of rounds of interrogatories or depositions or the time for completion of discovery, and thereby reduce the time spent in the prehearing stage of the hearing process. In particular, the board should allow only a single

round of discovery regarding admitted contentions related to the SER or the FES, and the discovery respective to each document should commence shortly after its issuance.

III. CONCLUSION

The Commission reiterates its long-standing commitment to the expeditious completion of adjudicatory proceedings while still ensuring that hearings are fair and produce an adequate record for decision. The Commission intends to monitor its proceedings to ensure that they are being concluded in a fair and timely fashion. The Commission will take action in individual proceedings, as appropriate, to provide guidance to the boards and parties and to decide issues in the interest of a prompt and effective resolution of the matters set for adjudication.

For the Commission

Annette Vietti-Cook
Assistant Secretary of the Commission

Dated at Rockville, Maryland,
this 28 day of July, 1998.

TECHNICAL EVALUATION OF ATLAS EROSION PROTECTION APRON

1. INTRODUCTION

In 1997, the NRC staff issued a Final Technical Evaluation Report (TER) (NRC, 1997), summarizing its evaluation of technical issues related to Atlas Corporations's proposed reclamation plan for the uranium mill tailings pile near Moab, Utah. Among the issues considered was the ability of the proposed erosion protection design to prevent erosion from various flooding events over long periods of time. One of the features of the erosion protection design evaluated in the TER was the ability of the self-launching rock apron to prevent erosion of the tailings if the Colorado River were to migrate to the pile.

In the TER, the staff concluded that the rock apron provided adequate protection for the reclaimed tailings pile, in the unlikely event that the Colorado River migrated several hundred feet and reached the toe of the pile. Recently, the adequacy of the apron design was questioned by the Utah Division of Radiation Control (DRC) and the Grand County Council (GCC). In addition, the GCC funded a report developed by the United States Army Corps of Engineers (COE) that indicated that the rock apron had not been designed properly. The GCC also solicited the opinions of vegetation and geomorphic experts and provided those opinions to the DRC. These reports, questions, and comments were transmitted to the NRC staff by DRC by letters dated November 10, 1997 and January 9, 1998.

Because the 1997 TER only summarized the NRC staff review of the apron, this supplemental report has been developed to address <u>in detail</u> the questions and concerns raised by public review of the TER and the rock apron. This evaluation will address specific details of the staff review and will provide the technical basis for the staff's conclusions of the adequacy of the apron. This report will also address the issues raised by the GCC, COE, and State of Utah DRC. Specific topics that will be addressed include: (1) evaluation of the potential for erosion and migration of the Colorado River, including evaluations of actual river erosion and need for large riprap; (2) evaluation of riprap needed for the side slopes to protect from overland or overtopping flows; (3) evaluation of riprap size needed to protect the side slope from velocities in the river; (4) evaluation of rock volume needed; (5) re-evaluation of river velocities, indicating that the design velocity is actually less than previously assumed; (6) evaluation of increased vegetation/tamarisk growth and the effects on flow velocities; (7) evaluation of COE design procedures, including specific discussions of scour depth, design velocities, and analytical methods; (8) evaluation of potential for cohesive soils to affect the performance of the rock apron; (9) discussions of reasonable assurance, NRC staff review procedures and regulatory requirements; (10) discussion of post-licensing monitoring and maintenance; and (11) evaluation of other conservatisms in the design. Each of these factors is discussed below in a degree of detail that was not provided in the TER. In addition, specific contentions and questions raised by the GCC, COE, and/or DRC are addressed, as applicable.

2. SUMMARY OF STAFF EVALUATION

Based on the review of information and technical analyses provided by Atlas in the reclamation plan and independent analyses of the erosion protection design, the staff concludes that the design of the rock apron for the Atlas site is acceptable. Staff approval of

the rock apron design is based on independent analyses that indicate that the rock size and rock volume provided for the apron are larger than required to meet the requirements of 10 CFR Part 40 Appendix A. Although the calculations provided in the reclamation plan are somewhat confusing, Atlas proposes to provide a volume of rock for the apron of 50 cubic feet per foot of length (ft^3/ft), based on a rock size on the side slope of 4 inches. Using conservative analyses, Atlas increased the rock size to about 11 inches for the apron. Independent staff analyses indicate that only 34 ft^3/ft of 2.9-inch rock would provide the necessary protection for the side slope. If Atlas had proposed 50 ft^3/ft of 4-inch rock for the apron, the staff would have concluded that the design was acceptable, because Atlas would be providing a rock size and rock volume that are larger than required. Therefore, the staff concludes that the design is not only acceptable, but is also conservative.

Staff review and analyses of the apron design can be summarized as follows:

A. A conservative approach was taken by Atlas in its reclamation plan by assuming that the Colorado River would migrate to the tailings pile and by designing the erosion protection apron to account for that event. This approach eliminated the need to conduct a detailed analysis of river migration and provides a design that is more conservative than the reasonable assurance requirements imposed by 10 CFR Part 40, Appendix A. Further, the staff concludes that river migration is unlikely, based on the opinions and conclusions of expert geomorphologists, independent analyses of aerial photographs depicting channel bank stability, and independent on-site examinations of the river banks. The staff also concludes that the current stability of the river banks is sufficient evidence that extensive riprap protection is not required to prevent erosion, based on the fact that a flood approximating the worst-case design flood recently occurred and did not cause significant erosion or scouring near the banks. This evidence supports the staff's conclusion that large riprap sizes, such as those recommended by COE, are not likely to be necessary. Section 3.1 of this report further discusses the bases supporting this conclusion.

B. The rock size of 11 inches proposed by Atlas for the rock apron is acceptable. Although the calculations presented in Appendix O of the reclamation plan (Atlas, 1996) can be confusing, the design of the rock for the apron was based on the use of 4-inch rock. This rock size was used to compute the volume requirements for the apron. Independent analyses performed by the staff using recently-developed design methods indicate that the required rock size to resist overtopping (overland) flows down the launched rock side slope is approximately 2.9 inches. A rock size of 4.0 inches will resist a flow about 2 1/2 times larger than the total runoff from the probable maximum precipitation (PMP), thus representing consideration of a significant flow concentration factor. The staff recognizes that the calculations and analyses presented in Appendix O may be confusing. However, the staff based its approval of the licensee's design on its independent analyses and did not rely on the calculations in Appendix O. Section 3.2 of this report discusses the methods used by the staff to check the rock sizes and to determine the conservatism of Atlas' proposed design.

C. Independent analyses performed by the staff using COE design procedures indicate

that a rock size of about 2.4 inches is required to resist velocities produced by the Colorado River on the collapsed rock apron. This calculated rock size is based on the most conservative calculated channel velocity of 6.9 feet per second (ft/sec) and considers the effects of channel curvature and increased shear forces on the outside of channel bends. Section 3.3 of this report provides further discussion and details of the staff analyses.

D. The volume of rock provided for the apron is adequate. The calculation of rock volume, as presented in Appendix O of the reclamation plan, was based on the use of 4-inch rock for the side slope. Although these calculations are somewhat confusing, Atlas proposes to provide a volume of rock for the apron of 50 cubic feet per foot of length (ft^3/ft), based on a rock size on the side slope of 4 inches. Using conservative analyses, Atlas increased the rock size to about 11 inches for the apron. Independent staff analyses indicate that only 34 ft^3/ft of 2.9-inch rock would provide the necessary protection for the side slope. If Atlas had proposed 50 ft^3/ft of 4-inch rock for the apron, the staff would have concluded that the design was acceptable. Because Atlas intends to provide rock that is larger than required and to provide a volume larger than required, the staff concludes that the design is not only acceptable, but is conservative. The staff also concludes that an equivalent volume of 11-inch rock will provide acceptable protection to the side slope. The staff agrees with COE that uniform coverage of the slope may be difficult to achieve with this large rock. Smaller, well-graded rock, with approximately the same volume, could be used in the apron to achieve better slope coverage after launching occurs. Section 3.4 provides further clarification of the staff analyses.

E. Based on independent calculations, the staff concludes that the maximum river velocity that should be used for the design of the apron is approximately 5.2 feet per second (ft/sec). Using the HEC-2 model, the staff recalculated the channel velocity using a more appropriate channel width. Based on this reevaluation, the staff concludes that the use of a velocity of 5.2 ft/sec is more appropriate than the use of a velocity of 6.8 or 6.9 ft/sec. If a value of 5.2 ft/sec is used, rather than the value of 6.8 ft/sec used by COE, the resulting rock size for the apron is approximately 4 inches. Based on these independent analyses, the staff concludes that design is acceptable, even if the COE procedure is used. See Section 3.5 for additional details.

F. Based on independent analyses using increased roughness values in the floodplain and overbank areas, the staff concludes that the potentially increased density of vegetation and tamarisks in the floodplains of the river will not significantly affect river velocities. Staff computations indicate that the maximum velocity will be only slightly increased in the river channel near the tailings pile. Based on staff experience with vegetated floodplains and the widespread use of vegetation to stabilize channel banks, it is also likely that increased vegetation density of the river will increase the erosion resistance of the channel banks and floodplain area near the tailings pile. See Section 3.6 of this report for further details.

Based on review of further information provided in the COE report, the staff concludes that

the COE report provides a very conservative interpretation of the design conditions for the rock apron. Staff review of the information can be summarized as follows:

G. The design parameters selected for use in the COE calculations of rock size are very conservative and may not reflect conditions that will exist at the rock apron. Velocities, radii of curvature, and scour depths were based on conditions that exist upstream and do not exist in the vicinity of the apron. Actual velocities that would affect the apron are smaller, and radii of curvature are greater in the vicinity of the apron. In addition, the methods used by COE to determine design velocities, increases in velocities in bends, and scour depths are conservative and incorporate large factors of safety that may not be necessary to provide reasonable assurance that Appendix A requirements are met. However, if less conservative, but likely, values of channel velocity and channel curvature are used in the COE method, the apron design proposed by Atlas is acceptable, even if all of the other COE safety factors are taken into account. Further details of staff analyses of the COE design procedure may be found in Section 3.7.

H. Cohesive soils that could affect the performance of the apron are not significantly present, based on the examination of boring logs provided by Atlas. See Section 3.8 for additional information.

In addition, the staff concludes that various programmatic requirements are met by the proposed design.

I. The requirement of reasonable assurance of site stability for a period of 200-1000 years is met by the proposed apron design. NRC has developed standard review plans and uses design procedures that reflect an approach to tailings management that incorporates an appropriate level of safety. Section 3.9 of this report provides further discussions of the reasonable assurance requirement and the risks posed by uranium mill tailings.

J. A post-licensing monitoring and maintenance program will be implemented for all Title I and Title II sites by the Department of Energy (DOE). As a licensee of the NRC, DOE is required by 10 CFR 40.28 to provide a long-term care program to assure that requirements are met and to assure that any unexpected problems occurring at the site will be promptly detected and mitigated. Although no credit is taken for such programs, the staff concludes that such programs further decrease the likelihood of river migration. See Section 3.10.

K. Other conservatisms that are not immediately obvious are included in the design of the NRC-approved rock apron. See Section 3.11 of this report for additional information.

3. DISCUSSION

As discussed in the TER (NRC, 1997), the staff considers that an adequate design has

been provided for the apron to be placed at the toe of the Atlas tailings pile side slope near the Colorado River. This conclusion is based on many factors, including evaluation of design details that are very site specific. Because the design has been questioned by several parties, it has become necessary for the staff to provide the details of its review, including the site-specific details, that were only summarized in the 1997 TER. This report addresses issues raised by the various parties and provides an explanation of how those issues were considered. The staff recognizes that the information and calculations provided by Atlas in Appendix O of the reclamation plan are somewhat confusing. However, in the TER, the staff based its conclusions on analyses and evaluations of the licensee's proposal, independent of the supporting calculations in Appendix O.

The design of the rock apron at Atlas is affected by three principal factors: (1) the velocity or shear stress that is used in various analytical methods to determine the rock size necessary to resist erosive forces; (2) the analytical methods that are used to determine rock size, layer thickness, and rock volume; and (3) the estimated scour depth that is used to determine volume of rock needed in the apron. For each of these factors there may be several acceptable methods for estimating and calculating the parameters. Also, each parameter requires input data, based to a great extent on the assumed configuration of the river and other assumptions related to expected river velocities.

For many situations where streambank erosion is imminent, a bank configuration can be easily determined, based on observed conditions. However, in this case, the main river channel is hundreds of feet away and not threatening the tailings pile, and the apron must be designed for some future unknown configuration of the river. Therefore, the conservatism and the appropriateness of the assumed river configuration become very important. In making such assumptions, the staff is required by 10 CFR Part 40 Appendix A to have reasonable assurance of tailings stability. The staff is not required to make any determination with absolute certainty. Therefore, given the fact that river migration in itself is unlikely, the staff is required only to assume a reasonable configuration, not necessarily an extreme configuration that maximizes every design parameter or input to a riprap design method.

To assess erosion protection, for example, a designer could assume various combinations of values of velocity, shear stress, radius of curvature, or other inputs to a design method and arrive at different estimates of rock size and rock volume. However, the staff considers it important to use input parameter values that can be reasonably expected to affect the apron (if the river migrated), not values that occur thousands of feet upstream or conditions that occur several miles downstream. For the Colorado River near the pile, the staff assumed that the river would retain its principal characteristics, even though it had migrated. Recognizing that exact characteristics would be difficult to predict, the staff assumed that the river would retain the same width, depth, radius of curvature, and velocity. It is also possible that the river would migrate and develop characteristics such as increased width, decreased depth, decreased velocity, and increased radius of curvature.

All designers realize that a considerable amount of judgment is necessary to predict design conditions, such as river configuration or river velocity. However, to provide reasonable assurance, it is not the position of the NRC staff to assume the most critical value for every input parameter that is used in the calculations. Reasonable assurance only requires that

input parameters be selected within a reasonably conservative range of values of the parameter. See Section 3.9 for further discussion of reasonable assurance and NRC review criteria.

It should also be emphasized that there are many procedures for determining the rock sizes necessary to resist erosion. Over the years, various government agencies and individuals have developed procedures that best suit their needs, given the degree of conservatism necessary, the risk to public health and safety, and other factors, such as cost. Use of any specific one of those procedures, including the COE procedure, for determining rock size is not required. It should be recognized that different methods are used by different organizations and agencies. COE's special need to protect embankments, where erosion or failure could jeopardize many lives behind those structures, are not necessarily the needs of designers to provide reasonable assurance of tailings stability or to meet the requirements of 10 CFR Part 40 Appendix A.

It should be pointed out that the staff does not consider the COE method to be incorrect. Rather, the staff considers that the input parameters selected for use in the method are overly conservative for this specific application and do not represent conditions that can reasonably be expected to occur if the river were to migrate to the rock apron. In this report, discussions of these design conditions will be provided, including the determination of scour depth, velocity to be used for design, and rock sizes and volumes required. For each of these parameters, various analytical methods, assumptions, and input parameters will be examined to show how the staff made its determination of acceptability and how and why the COE report overestimates the riprap sizes and quantity of rock required for the apron to provide reasonable assurance of tailings stability.

To reiterate the basis for staff acceptance of the apron design, the staff concluded that 34 ft^3/ft of 2.9-inch rock would provide acceptable protection for the collapsed (launched) side slope and river bank. Because Atlas proposed to use 50 ft^3/ft of 11-inch rock, the staff concluded that Atlas' use of a larger volume of bigger rock exceeded the design requirements estimated by the staff. Further discussion and details of the complete staff review may be found in Section 3.1 through 3.11 of this report.

3.1 Staff Analysis of Potential Erosion and Migration of the Colorado River

In the TER, the staff concluded that the potential for migration of the Colorado River was very low and provided several bases supporting that conclusion. One of the most important analyses performed by the staff was its examination of aerial photographs taken over a period of about 47 years. In the TER, the staff indicated that aerial photographs had been examined and that the staff agreed with Mussetter and Harvey (Atlas, 1996, Appendix N) that lateral accretion, rather than erosion, has occurred in some areas near the pile.

At the request of Mr. Peter Haney of the GCC (GCC letter to NRC dated July 10, 1996), the staff examined aerial photographs and information provided by Mr. Haney. Mr. Haney indicated that his photographs and analysis clearly documented dramatic changes and movement of the banks of the river. Staff review of the historic photographs indicated, however, that there has been very little change in the banks of the river over the last 47

years. The right bank of the river has maintained its position relative to the tailings pile, and any changes that appear to have occurred are the result of movement of the central channel of the river, shifting around constantly-changing sand bars and alluvial deposits. In addition, the stage of the river (at the time of the photograph) can be misleading and can affect the location of the edge of the water surface that must be distinguished from the channel bank.

Additional aerial photographs that were examined by the staff included photographs dated 1950, 1955, 1975, 1977,and 1995. Each photograph, other than the 1950 photograph (taken before the mill or tailings pile had been constructed), shows the tailings pile located hundreds of feet from an essentially unchanged river bank. For example, the intake structure where Atlas pumped water to the mill is evident in several of the photos, and the river banks around the structure are similar over the time period. If anything, the right bank of the river has aggraded, as suggested by Mussetter and Harvey (Atlas, 1996, Appendix N). Mussetter and Harvey also stated that: "Review of available historical photographs indicates that the right bank segment between cross sections 5 and 6 has remained remarkably fixed spatially." (Emphasis added).

The relative stability of the river banks is an important consideration in the design of the apron. This factor becomes extremely important in any specific case when design procedures of various agencies or individuals produce different answers or conclusions. In the analysis of scour depths, riprap sizes, and riprap volume, for example, it becomes important to realistically assess the ability of the river to significantly erode its banks. To assess erosion, design procedures have been developed to cover a wide range of field conditions, and to assure such coverage, conservatisms are introduced into the procedures. However, if the river bank in its natural state has experienced a design condition (or design flood) several times without significant erosion, it is unlikely that significant rock armoring is needed to protect the bank. Generic design analyses with conservative inputs may show that the bank needs erosion protection when such is not the case. Further, the assumptions used in computational procedures need to be examined in detail to assure that they are applicable to the specific problem. Based on the information provided by Mussetter and Harvey (Atlas, 1996, Appendix N) and its own independent analyses, the staff concluded that very little erosion of the river bank is occurring, despite repeated occurrences of floods that approach the maximum erosive force of the river. This conclusion was verified by the staff during several on-site inspections of the river by boat and by foot. Escorted by National Park Service rangers familiar with the river, the staff personally observed various areas of the river banks, islands, and sand bars. The staff specifically requested to be taken by boat to any areas along this reach of the river that were experiencing erosion problems. No extensive areas were found, and only one area where some minor sloughing had occurred was observed.

Overall, the staff concludes that the likelihood of river migration is very low, based on the absence of lateral erosion of the channel banks over the last 45-50 years. Further, the staff concludes that the current stability of the river banks is sufficient evidence that extensive riprap protection is not required to prevent erosion, based on the fact that a flood approximating the worst-case design flood recently occurred and did not cause significant erosion or scouring near the banks. Along with evidence that repeated occurrences of smaller floods (with nearly the same erosive capability of the design flood) do not cause

erosion, the staff concludes that large riprap sizes, such as those recommended by COE, are not necessary and that erosion and migration of the river are unlikely to occur.

Despite the information available on channel stability, a conservative approach was taken by Atlas in its reclamation plan by assuming that the Colorado River would migrate to the tailings pile and by designing the erosion protection apron to account for that event. This approach eliminated the need to conduct a detailed analysis of river migration and provides a design that exceeds the reasonable assurance requirements specified in 10 CFR Part 40, Appendix A.

3.2 Staff Analysis of Riprap Design for Overland Flow

The licensee's design of the rock apron is presented in Appendix O of the reclamation plan (Atlas, 1996) and was based on a D_{50} size of 4 inches for the side slope to resist overland flows. This D_{50} size was then used in the calculation of apron thickness and rock volume. Atlas modified the design of the side slope rock, but the design of the rock apron was not changed. Atlas' presentation of the apron design and the design calculations in Appendix O are somewhat unclear, and the staff recognizes that these calculations could be misinterpreted.

During review of the design, the staff determined that the 4-inch rock was acceptable to resist erosion from both river flows and overland flows, even though Atlas proposed to provide 11-inch rock for the collapsible apron. This conclusion was based on independent estimates using various procedures.

In considering overland flows down the side slopes, the adequacy of the 4-inch rock for the 1 Vertical (V) on 2 Horizontal (H) collapsed slope was verified by the staff using a procedure developed by Abt and Johnson (1991) specifically for overtopping or overland flows. The procedure was based on flume tests conducted at Colorado State University (CSU) during the late 1980s and early 1990s. The tests were conducted because the staff recognized that use of the Stephenson Method for steep slopes resulted in rock sizes that were very conservative for many overland flow applications. However, the studies were not finalized until after publication of staff guidance in the Final Staff Technical Position (FSTP) (NRC, 1990); therefore, they were not included in the FSTP, and the Stephenson Method was recommended, because it was considered to be adequate and more appropriate than the Safety Factors Method for steep slopes.

The method presented by Abt and Johnson uses the empirical relationship:

$$D_{50} = 5.23\ S^{0.43}\ q^{0.56}$$

where: D_{50} is the required rock size, in inches,
S is the side slope, and
q is the flow rate per unit width, in cfs/ft

Using the licensee's computed flow rate of 0.434 cfs/ft (Atlas, 1996, Appendix O), a slope of 0.5 (1V on 2H, to represent the launched, collapsed slope), and a flow concentration factor of 1.35 (as recommended, to prevent stone movement), the required rock size was computed to 2.9 inches. Insofar as overland flows are concerned, the staff concluded that the 4-inch rock would be more than adequate to provide the necessary protection on the collapsed slope. The 4-inch rock is capable of resisting a flow rate of approximately 1.05 cfs/ft, representing a flow concentration factor of about 2.4.

In the letter report, the COE indicated that the Stephenson Method (Stephenson, 1979) appeared to be somewhat conservative. Using methods developed by other researchers, the COE estimated the required rock sizes for the 1V on 2H slope to be in the range of 2-3 inches. The independent COE calculations are in close agreement with the rock sizes approved by the staff using the Abt/Johnson method.

The COE also indicated in its letter report that a flow concentration factor should be applied to the calculation of rock size. The staff considers that the Abt/Johnson method is conservative and includes an appropriate allowance for flow concentrations. It should be pointed out that the staff is very familiar with the procedure developed by Abt and Johnson, since the research leading to this method was developed under an NRC contract. If the underlying research efforts are examined in detail, it can be seen that the design procedure incorporates a very large flow concentration factor, because the failure flow rates were actually based on the occurrence of concentrated flows. In general, failure occurred after flow had concentrated in a smaller width in the flume. For example, if a 3-inch rock failed with a flow rate of 20 cfs averaged over a flume width of 10 feet (q= 2 cfs/ft), the actual failure of the rock occurred only when a large majority of the flow had channelized and concentrated into a width of less than about 4 feet (actual q = 5 cfs/ft). Therefore, a rock of this specific size can resist a flow rate of nearly 2.5 times the flow rate averaged over the flume width. For additional conservatism, Abt and Johnson recommend that the flow rate be multiplied by 1.35 to prevent any rock movement. Therefore, it can be seen that the design method is conservative and incorporates a significant factor of safety relative to flow concentrations.

Based on the acceptability of the 4-inch rock, the staff did not review in detail the licensee's calculation of rock size using the Stephenson Method. Atlas proposed that the rock that would be used in the apron (to eventually launch onto the 1V on 2H collapsed side slope) would have a D_{50} of about 11 inches. The staff concluded that this rock size was acceptable because it was overdesigned by a factor of about 4, compared to the staff's independent estimate of 2.9 inches.

In a letter dated November 4, 1997, the Utah DRC questioned the calculation of rock size using the Stephenson Method. DRC indicated that their independent use of the Stephenson Method indicated that a rock size of about 12.8 inches was more appropriate. The staff did not perform an independent calculation or check the DRC calculation using this method, because a much smaller rock size was determined to be acceptable. However, it is the staff's experience that the Stephenson Method results in rock sizes that are very large, if the side slope angle approaches the assumed angle of repose of the rock layer. The Stephenson Method uses the difference in these two variables in the denominator of the

design equation. Thus, as the difference in angles approaches zero, the required rock size approaches infinity. Also, it is important to recognize that the Abt/Johnson method has been verified using studies conducted on steep slopes (Robinson, et al, 1995; Rice, et al, 1998). It has been determined that this method is valid for a wide range of rock sizes, slopes, and discharges.

The Abt/Johnson method will be included in a forthcoming revision to the NRC standard review plan and design guidance. The method will be published in NUREG-1623 and will be recommended by the staff for overland flow on steep slopes. The document will also be made available for public comment.

3.3 Independent Staff Calculations of Riprap Size Required for River Velocities

In the TER, the staff indicated that the rock size proposed by Atlas was more than adequate to resist the expected erosive forces of the Colorado River. This conclusion was based on independent analyses performed by the staff to estimate the required rock size using three different methods. The staff concluded that 4-inch rock (actually 2.4-inch rock) was adequate to resist the velocities and shear stresses produced by the river.

3.3.1 COE Shear Stress Method

The first method used by the staff to check the riprap requirements is provided by the COE in the 1970 version of EM 1110-2-1601 (COE, 1970). These design procedures rely on a determination of the shear stress exerted on the riprap, based on the channel velocity. The basic equation for the determination of shear stress is expressed as follows (COE, 1970, Equation 31, page 40, or Plate 32):

$$T = wV^2 / (32.6 \log (12.2\ y/_{D50}))^2$$

where :

- T = shear stress, in lb/ft^2
- w = unit weight of water = 62.4 lb/ft^3
- V = average channel velocity in the cross section, in ft/sec
- y = depth of flow, in feet
- D_{50} = assumed size of riprap on the side slope, in feet

Using the most critical flow parameters existing at cross sections 5 and 6 (Atlas, 1996, Appendix N) where:

- V = 6.9 feet per second, from cross-section 5;
- y = 21 feet, from cross section 6;
- D_{50}= 12 inches (Atlas proposed a size of 11.2 inches),

The shear stress (T) is calculated to be:

T = 0.48 lb / ft3.

Using Equation 33 in the COE manual, with a coefficient (a) of 0.04 and a rock unit weight of 165 lb/ft^3, the required rock size can be determined using the formula:

D_{50} = T / 4.1, where D_{50} is in feet.

Therefore, the D_{50} of the rock required to resist this shear force is calculated to be:

D_{50} = 0.48 / 4.1 = 0.12 feet or 1.4 inches.

Further, the 1970 COE guidance provides methods for estimating the maximum shear stress and/or increases in the shear stress for locations at channel bends. The increase in shear stress is a function of the radius of curvature (R) of the bend and the width (W) of the channel. The value of R was derived from the information presented by Atlas in Appendix N of the reclamation plan (Atlas, 1996). From Figure 5.4 on page 5.8, the value of R between cross section 5 and cross section 6 is 7500 feet. The value of W was derived from page A.5 and A.6, where the average channel width is about 1000 feet. The calculated value of R/W is therefore equal to 7500/1000, or 7.5. However, Plate 34 of the manual only provides shear stress ratios up to a maximum value of R/W equal to 5. (The lower the value of R/W, the greater the correction factor.) Therefore, this value was chosen as a conservative input.

Using Plate 34 and a conservative R/W of 5, the factor for increasing the shear stress for the outside of the bend is about 1.5. This is also the approximate value derived from Figure 5.1 of Appendix N of the reclamation plan, using Soil Conservation Service design methods. If this correction factor is applied to the calculated shear stress, the design shear stress is computed to be:

T = 1.5 x 0.48 = 0.72 lb/ft^2.

Using COE procedures discussed above, the D_{50} size to resist this shear stress is calculated to be:

D_{50} = 0.72 / 4.1 = 0.18 ft or 2.1 inches.

The COE manual also provide methods for determining a side slope correction factor, to apply the procedure to any side slope. Assuming a 1V on 2H collapsed slope, the factor is determined to be 0.72 from Plate 36. However, the COE indicates that this value is too conservative and recommends a value of 0.88 for a 1V on 2H slope. Applying the side slope correction factor of 0.88 for a 1V on 2H side slope, the required D_{50} is computed to be 2.1 / 0.88, or 2.4 inches.

The staff also considered the shear stresses determined by Mussetter and Harvey (Atlas, 1996, Appendix N). In the report, a shear stress value was estimated to determine the work exerted on the banks of the river. Mussetter and Harvey estimated this value to be approximately 0.36 lb/ft^2. Use of this value in the COE shear stress formula results in a calculated D_{50} of about 1.8 inches, applying similar bend stress increases and side slope

corrections.

3.3.2 Basic Shear Stress Equations

The staff also computed the peak shear stress and required D_{50} size using a basic shear stress equation (NRC,1990):

$$T = wyS$$

where:
- T = shear stress in lb/ft^3
- w = unit weight of water = 62.4 lb/ft^3
- y = depth of flow
- S = bottom slope or slope of energy grade line

From HEC-2 calculations performed by Mussetter and Harvey (Atlas, 1996, Appendix N, page B.21), the slope of the energy grade line at cross section 5 for a discharge of 70,300 cfs is approximately 0.000287 ft/ft and the depth of flow is 22.84 feet. Cross section 5 was selected because it provides more conservative values of these parameters than cross section 6. Using these values from section 5 , the peak shear stress is computed to be 0.41 lb/ft^2. Applying factors of safety of 1.5 for bend shear and a side slope correction factor of 0.88, the required D_{50} rock size is about 2.0 inches, using the COE procedures discussed above.

3.3.3 Abt and Johnson Method

The staff also checked the calculations using a variation of the riprap design method developed by Abt and Johnson (1991). Johnson and Abt (1998) have also developed a design method and simple equation for estimating riprap requirements for channel flows. The equation for estimating rock size is given by:

$$D_{50} = 5.23 \; S^{0.43} \; q^{0.56}$$

where:
- D_{50} is the required rock size, in inches, for the channel bottom,
- S is the bottom slope of the channel or slope of energy grade line, and
- q is the flow rate per unit width, in cfs/ft

To illustrate this method, data from cross section 5 were once again used. The slope of the energy grade line for a flow of 70,300 cfs is 0.000287 and the width of the channel is about 1000 feet. The resulting unit discharge of 70 cfs/ft was increased by a factor of 1.5 to account for localized increases in velocity associated with the outside of bends. In addition, the design method recommends that the unit discharge be increased by a factor of 1.35 to prevent stone movement, since the relationship was based on failure of riprap in flume studies. Applying both of these factors results in a flow rate of 1.5 x 1.35 x 70, or about 142 cfs/ft. Using the design equation, the required D_{50} is computed to be 2.5 inches for the channel bottom. When the side slope correction factor of 0.88 is applied, the required D_{50} for the 1V on 2H side slope is computed to be 2.8 inches.

3.3.4 Overall Assessment of Rock Size for Protection Against River Velocities

Using three different methods for determining riprap size, the staff concludes that a rock size of about 2.9 inches is sufficiently large to resist channel velocities of the Colorado River, with sufficient allowances made for the curvature of the channel. Each of the three methods used resulted in an approximate rock size ranging from 2-3 inches. The calculations are considered to be conservative, because: (1) conservative estimates of the maximum channel velocity in the river were used, since the maximum velocity of 6.9 ft/sec occurs upstream of the tailings pile, and the maximum velocity that will be exerted on the apron is probably more on the order of the computed velocity of 3.3 ft/sec at cross section 6 (based on water surface profile calculations by Atlas); (2) the R/W value of 5 used in the calculations is conservative, because the actual R/W value is approximately 7.5 where the apron will be placed; and (3) adequate factors of safety have been applied in these calculations.

3.4 Staff Evaluation of Rock Volume Requirements

The volume of rock to be used in the rock apron (for a 1V on 2H slope) can be determined using COE design procedures, expressed by the formula:

$$V = D \times (5)^{0.5} \times T \times SF$$

where:
- V = Volume of rock required, in ft^3 per ft,
- D = Scour depth, in feet,
- T = Thickness of riprap layer, in feet, and
- SF = Safety Factor to be applied.

The value of $D \times (5)^{0.5}$ represents the length of the launched 1V on 2H slope, based on calculating the hypoteneuse of a right triangle.

To check the rock volume calculations performed by Atlas, the staff used its independently-computed rock size of 2.9 inches and assumed that the required riprap layer thickness is twice this dimension, or 5.8 inches. (In fact, the staff routinely accepts the use of a layer thickness of 1 1/2 times the D_{50}.) The scour depth was determined by Atlas using data from cross section 6 where the maximum depth of flow was computed to be 21 feet. Because this cross section was the only cross section that included the apron, the staff concluded that this maximum depth represented real data and was, therefore, the most appropriate. Additional discussion of scour depth, including the COE recommendation for use of a greater scour depth, may be found in Section 3.7.1 of this report.

Using a scour depth of 21 feet, a layer thickness of 5.8/12 feet, and a safety factor of 1.5, the staff estimated the volume requirement to be 34 ft^3/ft. Because Atlas proposed a volume of 50 ft^3/ft, the staff concluded that the volume proposed was acceptable.

The COE points out that 50 ft^3/ft of 11-inch rock in the apron may not launch properly because some of the rocks in the layer will be larger than 11 inches, and the overall layer is likely to have some gaps or poor slope coverage. Even though the staff expects that the launched 11-inch rock would effectively prevent further erosion, the staff agrees with this

specific point and concludes that the rock would launch better and be more effective if the rock size were smaller and the overall rock layer was well-graded (and the current volume requirement of $50 ft^3/ft$ is used). However, the staff concludes that the current design is acceptable. Further, because the staff does not agree that the rock size needs to be any larger than 2.9 inches, the current volume requirements are acceptable. The staff will discuss this specific issue with Atlas in the near future.

3.5 Staff Re-evaluation of River Velocities

In the COE report, the drop in calculated maximum channel velocity from 6.9 ft/sec (for Q= 70300 cfs) at cross section 5 to 3.3 ft/sec at cross-section 6 was assumed not to persist, and the COE recommended that the velocity immediately upstream of the tailings pile at cross-section 5 be used for design. On that basis, the COE selected a velocity of 6.8 ft/sec for use in computing the required riprap size.

During previous reviews, the staff determined that a velocity of 6.9 ft/sec was conservative. Because the COE questioned the drop in velocity and the velocity is such an important design parameter, the staff also determined that a detailed check of the estimate should be conducted. The purpose of this check was to determine if there were any specific reasons for the large difference in computed velocities between these adjacent cross sections.

One reason for the decrease in channel velocity was the increase in overbank area and increase in overbank discharges (with corresponding reduction of channel discharge) between the sections. However, this alone did not explain the large drop in channel velocity, particularly considering the backwater influence associated with the constricted Portal area downstream. Further analysis of the HEC-2 water surface profiles presented in Appendix N of the reclamation plan revealed a possible extra conservatism in the velocity analysis. Based on examination of cross sections 4,5, and 6, it appeared that the left bank of cross section 5 had been conservatively coded in the HEC-2 program so that the assumed left bank of the river was actually the mid-channel island. In reality, the channel splits around the island, with a significant amount of the channel flow occurring in the portion of the channel south of the island. By assuming the left bank of the channel to be at the island, all of the flow that would occur in the channel south of the island was calculated to flow in the portion to the north. The HEC-2 model calculated a higher velocity to accomodate the flow in this artifically restricted channel.

Using input data to the HEC-2 program presented in Appendix N of the reclamation plan on pages B.4 and B.5, the following determinations were made:

at cross section 4, the channel width used by Atlas in the HEC-2 program was 843 feet;
at cross section 5 the channel width was 413 feet; and
at cross section 6, the channel width was 1074 feet.

The width between channel banks can be easily determined by subtracting the third and fourth fields of the X1 card for each channel section. These fields represent the horizontal station of the left and right banks of the channel.

Based on examination of aerial photos and on-site observations, it is obvious that the river channel does not suddenly narrow to 400 feet at cross section 5, but actually splits the flow around both sides of the island. Therefore, the staff changed the left bank station at cross section 5 to 4000 to better reflect actual conditions of the river. This changed the channel width to 1036 feet, similar to cross section 6. The HEC-2 program was re-run using only this change, and the average channel velocity at section 5 was computed to 5.2 ft/sec.

The staff considers that this analysis better reflects the expected velocity that will occur at section 5 and should be considered as a conservative velocity estimate in the analysis of required rock size. Use of this velocity becomes even more important when using the COE design procedure, where this velocity is multiplied by a safety factor of 1.5 and then raised to the 5/2 power. Assuming that all other variables in the COE method remain unchanged, the rock size would be expected to be cut in half using only this velocity reduction. Further detailed discussion of appropriate velocities can be found in Section 3.7 of this report, along with the use of other variables in the COE rock sizing method.

3.6 Staff Evaluation of River Velocities Assuming Increased Vegetation

The staff received a copy of a letter (Graf, 1997) from Dr. William Graf, Arizona State University, to Peter Haney, indicating eight specific concerns with the expected growth of vegetation, especially tamarisks, in the vicinity of the tailings pile. In those eight concerns, Dr. Graf provided various bases for his conclusion that long-term stability of Colorado River at Moab was unlikely. To evaluate these concerns, a lengthy research study would be required, and such a study is considered to be beyond the scope of this review. For reasons stated above, the staff does not agree with all of the conclusions reached by Dr. Graf. However, even if all of Dr. Graf's conclusions are correct and the river migrates, the rock apron provided by Atlas will prevent erosion of the tailings.

In the staff's opinion, the principal question that needs to be addressed here is whether increased vegetation density will have a significant effect on the rock apron. That is, assuming that the river migrates to the pile, would increased vegetation density identified by Dr. Graf revise the staff conclusions with respect to the adequacy of the rock apron design? To address this question, it is important to determine the effect of vegetation on the velocity that will be experienced by the rock apron.

To determine the sensitivity of the calculations of velocity to changes in vegetation density, the staff independently evaluated water surface profiles and velocities, assuming significant increases in density. Using the HEC-2 program, Manning's n values for the overbank areas at cross section 5 were increased very conservatively from 0.15 to 1.0 (Chow, 1959). Manning's n values are used in river flow analyses to represent frictional effects of stream channels and overbank areas. A value of 0.15 represents reasonably heavy vegetation growth and a value of 1.0 represents extremely heavy growth. Using these two values, the resulting average channel velocity at section 5 was calculated to increase from 5.21 to only 5.37 ft/sec. The increase in n value resulted in a flow rate of only 300 cfs in the overbanks (with 70,000 cfs in the channel). Therefore, under the assumption that the entire overbank area does carry any significant flow because it is choked with vegetation, the resulting

velocity only increases from 5.21 to 5.37 ft/sec. At this, or other cross sections, the effect of the vegetation on channel velocities can be estimated by conservatively ignoring all of the overbank area, conservatively assuming that the water surface elevation remains the same, and determining the velocity by dividing the total flow rate by the computed channel area. For example, at cross section 6 where the overbank area is large, the velocity is increased from 3.3 ft/sec to only 4.4 ft/sec. This velocity is less than the design velocity of 6.9 ft/sec used by the staff to determine rock size requirements on the side slope (See Section 3.3.1). Therefore, the staff concludes any significant increase in vegetation density will have only a minor effect on channel velocities and design of the rock apron.

Based on staff experience with flooding and erosion, the staff also concludes that increased vegetation density in the bank and overbank areas will tend to stabilize the channel banks. Increases in root growth and density of tamarisks and other riparian species will tend to provide erosional stability and will tend to prevent erosion and destabilization of the banks. In fact, riparian species are deliberately planted throughout the United States to prevent erosion of channel banks (IECA, 1998). Numerous examples and case studies can be cited where riprarian species have provided increased erosion resistance along the banks of rivers and streams.

3.7 Evaluation of Apron Design Using COE Design Procedures

The staff reviewed the information and analyses provided by the GCC and COE related to the design of the rock apron. This review included analyses of the COE design procedure that was used to assess the rock requirements for the apron. This procedure considers scour depths, river velocities, increases in river velocities at channel bends, and factors of safety for determining sizes and volumes of launchable rock. The staff also examined the technical basis for the development of the COE procedure, including the supporting laboratory data. In general, the staff concludes that the design procedure was conservatively applied by COE in its evaluation of the rock apron at the Atlas site. Several of the assumptions and input parameters to the procedure do not appear to realistically represent conditions that currently exist near the site or can reasonably be expected to occur if the river were to migrate to the pile. However, the staff considers that the design procedure is robust, and if proper inputs are selected, the adequacy of the design can be verified using this procedure.

The COE procedure consists of several steps that ultimately lead to the calculation of rock size and rock volume needed for a collapsible rock apron. The procedure includes the determination of various design parameters including the depth of scour in the river, average channel velocity, velocity on the outside of the channel bend, and rock layer thickness. Following is additional analysis of each of these parameters and their effect on the calculation of rock size and volume.

3.7.1 Scour Depths

One input parameter to the calculation of rock volume for the apron is the depth of scour produced by the Colorado River. The depth of scour is used in the COE design procedure to determine the depth to which the rock apron must collapse into the eroded section of the

river.

In evaluating Atlas' proposal, the staff concluded that the use of a scour depth of 21 feet, representing the minimum thalweg elevation of the river in the vicinity of cross section 6, could be used. This conclusion was also based on information provided by Mussetter and Harvey (Atlas, 1996) indicating that the potential for river scour was very low, based on the fact that this reach of the river apparently transports large quantities of bed-load material. Such a river regime tends to be relatively stable because material scoured out is rapidly replaced by bed load sediments, resulting in little vertical change to the stream bed.

In calculating the depth of scour, the COE analysis used procedures developed by Maynard (1996). As stated by Maynord, the empirical relationship is very conservative and excludes 95% of the observed data of various researchers. By enveloping the observed data and including only 5% of the data within the curve, Maynard developed a relationship for the maximum depth of scour on the outside of a bend as follows:

$$D_{mxb}/D_{mnc} = 3.37 - 0.66 \ln(R_c/W) \qquad \text{(Eqn. 1)}$$

where D_{mxb} is the maximum depth of scour in the bend,
D_{mnc} is the mean depth of flow in the channel,
R_c is the radius of curvature of the channel, and
W is the width of the channel.

Of considerable importance to the calculation of scour depth is Maynard's conclusion that a best fit of the data is actually defined by the relationship

$$D_{mxb}/D_{mnc} = 2.57 - 0.36 \ln(R_c/W) \qquad \text{(Eqn. 2)}$$

and that Eqn. 1 is conservative for a vast majority of the data.

Notwithstanding the exclusion of a significant amount of research data and the resulting use of a more conservative design equation, there are limiting geomorphic processes affecting channel scour, as discussed above. Therefore, the staff concludes that Eqn 2 better represents the conditions occurring in this reach of the Colorado River.

As seen from Eqn 1 or Eqn 2, the computation of scour depth is also affected by the determination of values of the radius of curvature and the width of the channel. To determine the value of R/W, the COE used the apparent minimum value of R/W = 2.94 that currently exists at cross section 4. An R value of 2500 feet was taken from the Mussetter and Harvey report (Fig 5.4) and a W value of about 850 feet was also taken from that report (p. A.4). It was stated that the value used was consistent with the present configuration of the river.

Using Eqn 1 and R/W of 2.94 at cross section 4, the COE computed a depth ratio of about 2.66 and a resulting scour depth of about 25 feet. This depth was subtracted from the water surface elevation of 3965 ft msl (for a flow of 40,000 cfs) resulting in a channel bottom elevation elevation of 3940. This channel bottom elevation was then assumed to occur

several thousand feet downstream at the pile, and the COE calculated the total scour depth to be 28 feet (3968-3940).

If Eqn 2 and R/W of 7.5 (more representative of conditions near the tailings pile) are used, the depth ratio is computed to be approximately 1.84, and the scour depth is computed to be 18 feet. If a water surface of 3965 is assumed, the total scour depth will be 21 feet. Depending on the equation used, it appears that the scour depth of 21 feet used by Atlas adequately represents reasonably expected scour conditions. It should be noted that use of data from cross section 6 will further decrease the scour depth.

Of particular significance in the COE calculation is the use of data from cross section 4, which is several thousand feet upstream from the beginning of the rock apron. The staff considers it more reasonable to use data from cross sections immediately adjacent to the tailings pile to define the expected river configuration and to determine input parameters to various models. Use of such data will decrease the scour depth. Finally, the staff would like to point out that if 2.9-inch rock were used in a layer thickness of 5.8 inches, the proposed volume of 50 ft^3/ft would acceptably launch to the COE-estimated scour depth of 28 feet.

In the original analyses, the licensee proposed, and the staff concurred, that use of a scour depth of 21 feet, equal to the minimum thalweg elevation near cross section 6, was appropriate. Thus, the licensee's use of this scour depth is considered to be acceptable.

3.7.2 Design Velocities

It appears that the singlemost important parameter to be estimated in the COE design procedure is the design velocity. Because the rock size (and required volume of rock) are proportional to the velocity raised to the 5/2 power, it is extremely important to select appropriate values of this parameter. It should be noted that the COE procedure used to analyze the Atlas rock apron includes a factor of about 1.5 that is multiplied by the average velocity to determine the design velocity in the channel bend. This factor is representative of an R/W of about 3. As discussed above, an R/W value of about 7.5 is a more reasonable value to represent the river configuration if it were to migrate to the pile, because this is the configuration adopted by the river as it exists today.

Using an average channel velocity at cross section 5 of 6.8 ft/sec and R/W value of 3, the COE computed the design velocity to be 10.2 ft/sec. This velocity resulted in a required D_{50} rock size of about 9 inches. Using this rock size, the COE calculated the required layer thickness to be about 18 inches and the required rock volume to be 141 ft3/ft.

Based on the re-evaluation of channel velocities presented in Section 3.5 of this report, the staff concludes that the average channel velocity that should be used in the COE design method is 5.2 ft/sec. Based on examination of information presented in Appendix N of the reclamation plan, a more appropriate value of R/W is 7500/1000 or 7.5, as discusssed in Section 3.7.1 of this report. Using this R/W value in the COE design equation (COE,1994, Plate B-33) for natural channels:

V_{ss} / V_{avg} = 1.74 - 0.52 log (R/W) = 1.74 - 0.52 log(7.5) = 1.29

Computing the design velocity on the side slope,

V_{ss} = 1.29 x 5.2 = 6.7 ft/sec.

Use of this design velocity, instead of the COE value of 10.8 ft/sec results in a computed rock size of 0.34 feet or 4.0 inches, assuming all other parameters in the method remain the same, including factors of safety, etc. Using a rock size of 4 inches and COE's computed scour depth of 28 feet results in a required rock volume of about 45ft^3/ft, which is 10% less than the quantity proposed by Atlas.

Other information and guidance (e.g. Biedenharn, et al., 1997), is available for estimating the design velocity in channel bends. Appendix A of that document generally uses COE methods and discusses various methods for determining rock armor sizes and thicknesses. Figure A.2b provides methods for determining design velocities for various R/W values and channel width to depth ratios. For example, for a width to depth ratio greater than 10 (cross section 4 of the Colorado River has a ratio of approximately 850/10), the recommended design velocity ratio for a 120 degree bend is aproximately 1.12 for a R/W ratio of 7.5. Use of this velocity ratio would result in an even smaller rock size.

To summarize, the rock size and rock volume can be shown to be acceptable using the COE method, if appropriate values of average channel velocity and radius of curvature are used. The staff considers that the average rock size of 4 inches used by Atlas to design the rock apron is acceptable, based on the use of more appropriate parameters in the COE method and independent estimates using other design methods.

3.8 Evaluation of Non-Cohesive Soils

The GCC questioned the performance of the apron if cohesive soils are present to affect the launch slope. Based on an examination of soil boring logs provided in Appendix O of the reclamation plan, the soils near the toe of the slope and in the overbank area are generally classified as sands and silts, of various grain sizes. Most of the material appears to be sandy, and there does not seem to be an overabundance of clayey soils, although some clays are present (Atlas, 1996, Appendix N). Therefore, the staff concludes that the performance of the apron and the launch slope is not likely to be affected by cohesive soils.

3.9 Reasonable Assurance, NRC Review Procedures, and NRC Regulations

Of considerable importance in the NRC staff's assessment of Atlas' proposed design of the rock apron is the concept of "reasonable assurance." NRC regulations require (10 CFR Part 40, Appendix A, Criterion 6) "...a design which provides reasonable assurance of control of radiological hazards to...be effective for 1000 years..." This requirement comes directly from U.S. Environmental Protection Agency requirements in 40 CFR Part 192. These standards do not require absolute nor even near certainty.

Several reasons can be offered to justify the appropriateness of a "reasonable assurance"

requirement, rather than a more conservative requirement. Of primary importance is that exposure to uranium mill tailings do not pose an immediate acute risk to the health and safety of individuals. Rather, the risk posed by tailings is from continual exposure to low levels of radioactivity and is a long-term cumulative risk. If control of tailings were lost (for example, if an earthquake beyond the design basis were to damage the cover and expose tailings), actions could be taken to repair the damage, with little likelihood of endangering individuals.

Additionally, uranium mill tailings disposal sites will be under perpetual government custodial care. If the features providing control of the tailings were damaged or compromised in the future, the government custodian could assess the situation and provide repairs. While NRC standards require that the design for control of radiological hazards not rely on maintenance, the concept of "reasonable assurance" does not preclude contemplation of government custodian actions in unusual or unlikely situations.

Finally, the rock apron does not have to withstand a single, severe event that could occur without warning at any time. This is unlike the situation in designing protection from earthquakes or severe precipitation. For those events, the protective design may not be tested for decades or centuries and then in a very short time have to perform with a design event. If the Colorado River were to migrate towards the tailings pile, it would occur over decades or centuries. There would be ample time to determine whether the assumptions used in the design of the rock apron (e.g., the scour depth, river curvature, river velocity, etc.) were correct.

In summary, NRC regulations and EPA standards do not require the degree of certainty about the potential future threats to the rock apron that would require an extremely conservative design, but rather "reasonable assurance" that the design will protect the tailings pile.

3.10 Post-Licensing Monitoring and Maintenance

The COE and GCC question the ability of the apron design to be effective without maintenance and anticipate that maintenance will be needed to assure proper functioning of the apron. Internal COE requirements are cited, indicating that the design must include provisions for maintenance. It should be emphasized that the staff has never stated that the design will be free of active maintenance. The staff only asserts that no credit was given for maintenance in the design of the apron, even though the maintenance program reduces the probability of river migration.

Monitoring of any engineered structure will always be needed to assure that it is functioning properly and that adequate repairs are undertaken when problems occur. Specifically for reclaimed uranium mill sites, monitoring by the government custodian will be necessary to assure that design assumptions are actually true and that no unexpected problems are occurring at a site. For example, if vandals carry away the riprap on the top of the pile, this problem will be identified in a timely manner through the monitoring program <u>required</u> by NRC regulations. Appropriate actions will then be taken by the government custodian.

Similarly, the monitoring program will be designed to identify potential problems such as unexpected and harmful gully erosion, sedimentation, or vegetation growth.

Unlike an event such as the PMP or maximum earthquake, the erosion of the river banks and migration of the river will not be a sudden event. If it occurs, river migration of several hundred feet will occur over a period of decades or centuries. If the river were to begin migrating toward the site in the future, it is likely that measures will be taken to stabilize the channel banks, possibly for reasons unrelated to the tailings pile. For example, erosion damage could be repaired by the highway department if a bridge or highway were damaged or threatened by channel erosion. Thus, the probability of the river actually eroding to the point where it reaches the tailings pile is less than the probablilty of it doing so naturally. Additionally, license requirements imposed by NRC on the government custodian, currently the Department of Energy (DOE), provide further assurance of the low probabliity that erosion would ever reach the pile. Specific measures to detect and mitigate erosion are a part of DOE's generic Long-Term Surveillance and Maintenance (LTSP) for uranium mills turned over to the United States Government. Also, an LTSP is prepared for each specific site, and there are provisions in each of those LTSPs for the annual inspection and repair of erosion problems. These post-licensing monitoring and maintenance programs will be implemented for all sites by the long-term custodian. As a licensee of the NRC, DOE is required by 10 CFR 40.28 to provide a long-term care program to assure that 10 CFR Part 40 requirements are met and to assure that any unexpected problems occurring at the site will be promptly detected and mitigated.

The staff therefore concludes that the surveillance and maintenance programs required by 10 CFR 40.28 provide further assurance of site stability. While no credit was taken for maintenance in the design of the rock apron and conservative inputs were applied, the low likelihood of unmitigated river migration and bank erosion was considered in the selection of appropriate, rather than very conservative, design parameters for the design of the rock apron.

3.11 Additional Conservatisms

The staff considers that there are many other conservatisms built into the design of the rock apron at the Atlas site. These conservatisms include several that are not immediately obvious, and it is important to recognize that the conservatisms present in the design are considered by the staff to be more than adequate to assure that NRC regulations are met. These factors include: (a) the availability of a substantial extra volume of rock on the 3V on 10H side slope of the pile that could be launched onto the collapsed slope; (b) the rock on the side slope and apron is designed for overland flow from a PMP that has a rainfall intensity approaching the world record rainfall; (c) the thickness of the rock layer is 2 x D_{50}, whereas the staff has accepted 1-1/2 x D_{50} on many occasions at other licensed sites; and (d) the rock size that will actually be provided will certainly be larger than the D_{50} specified, based on staff experience at constructed sites.

A. Additional Rock Volume Available

The staff recognized that the launched 11-inch rock would not necessarily, by itself, achieve an ideal configuration or gradation when launched onto the slope.. However, the current design includes an overdesigned volume of 5.3-inch rock on the side slope of the tailings pile; this extra rock would be available to also launch into any gaps formed in the launched 11-inch rock. As discussed above, the 5.3-inch rock is conservatively oversized (only 2.9-inch rock is needed), and a large volume of this rock could launch and fill in gaps in the rock layer and ultimately protect the pile. The quantity of rock 5.3-inch provided on the 400-foot length of the side slope is approximately 400 x 11/12 x1 = 366 ft^3/ft. Assuming that only 100 ft^3/ft of this rock would launch, this additional volume of rock could move down the slope to fill the voids in the 11-inch rock gradation. Thus, the rock volume provided would be about 150 ft^3/ft. Not only would the suggested COE volume requirement of 141 ft^3/ft tbe met, but the resulting average D_{50} of about 7.5 inches of the total rock layer would nearly meet the COE suggested D_{50} rock size of 9.2 inches. If the re-computed velocity of 5.2 ft/sec is used (as discussed in Section 3.5), the 5.3-inch rock is more than adequate <u>by itself</u> to armor the collapsed slope.

B. Riprap Designed for Intense Rainfall

As noted in Appendix O, the riprap for the side slopes is designed for an overland flow rate of 0.434 cfs/ft. This flow rate is computed by assuming the longest flow path on the side slope and a rainfall intensity of about 50 in/hr, based on a minimum time of concentration of about 1 minute. It should be noted that the world record one-minute rainfall is about one inch in one minute (intensity of about 60 in/hr) and occurred in tropical climate. When one considers that this flow rate can be increased by a flow concentration factor of nearly 3 and that 4-inch rock is sufficient to resist that rate, it is obvious that the rock size is conservative for overland flows.

C. Rock Layer Thickness

It should be noted the COE recommended layer thickness of 2 times the D_{50} is not a requirement, and the NRC staff routinely accepts the use of 1 1/2 times the D_{50} for riprap layers at uranium mill tailings impoundments. In fact, the COE has published standard riprap gradations for layer thicknesses that are 1-1/2 times the D_{50} (COE, 1971). As stated in the FSTP (NRC, 1990), use of these gradations is acceptable to the staff. This fact is very important and further demonstrates the conservatism of the Atlas design, because the volume of rock in the apron is a function of the required layer thickness on the side slope. If a layer thickness of 6 inches (routinely accepted by the staff and accepted by the COE for other applications) is used, rock volume requirements are lessened by approximately 25 percent, compared to the 8-inch layer used by Atlas to design the apron.

D. Actual Rock Size Provided

The rock sizes specified for design of the rock layer are the minimum D_{50} sizes for a specific rock gradation. In the typical construction of a rock layer, the D_{50} that is actually placed is greater than this minimum value. This is because it is difficult to produce rock with an exact

D_{50} of the minimum required. Rather than risk producing riprap that fails to meet specifications, contractors will almost always produce rock with a greater D_{50} than required. Based on staff experience with construction and reclamation activities at many uranium mill sites, the constructed rock size is usually larger than the minimum required by the construction specifications. For example, at the DOE Slick Rock site (DOE, 1997), rock with a D_{50} of 4.0 inches was specified for the side slopes. However, in meeting this minimum requirement, a rock size of 4.5 inches was actually placed. Thus, rock overdesigned by a factor of about 10-15% was used at the Slick Rock site. A similar, or possibly greater overdesign, would likely occur at the Atlas site, due to the general nature of compliance with construction specifications.

4. CONCLUSIONS AND RECOMMENDATIONS

Based on review of the apron design proposed by Atlas and on independent analyses of river flow conditions, the staff concludes that the apron design is acceptable and meets the requirements of 10 CFR Part 40 Appendix A. The staff concludes that rock of adequate size and volume has been proposed for the apron.

The staff concludes that the analyses and recommendations provided by the COE do not realistically portray conditions that can reasonably be expected to be experienced by the rock apron. The staff further concludes that the assumptions and design methods recommended by COE are not required to demonstrate the adequacy of the apron. However, if assumptions of river configuration and channel velocity that can reasonably be expected to occur if the river were to migrate are used in the COE method, the apron design can be shown to adequately meet COE design criteria.

The staff agrees with COE that the oversized rock in the apron may not launch in a manner that achieves good slope coverage. The staff concludes that smaller, well-graded rock of equivalent volume would provide better slope coverage, if launched. However, the current design is acceptable due to the large amount of rock available on the side slope of the pile that could fill in gaps in the rock layer. If the licensee were to propose a design change to smaller rock, the staff would be likely to find it acceptable.

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