NRC FORM 464 Part I (6-1998)

U.S. NUCLEAR REGULATORY COMMISSION

RESPONSE TO FREEDOM OF INFORMATION ACT (FOIA) / PRIVACY ACT (PA) REQUEST

FOIA/PA: 99-377,00-219,00-257

RESPONSE NUMBER: 7

RESPONSE TYPE: FINAL ☐ PARTIAL ☑

REQUESTER: Ms. Kimberly Boggiatto

DATE: JUL 21 2000

PART I. -- INFORMATION RELEASED

☐ No additional agency records subject to the request have been located.

☐ Requested records are available through another public distribution program. See Comments section.

☐ APPENDICES: — Agency records subject to the request that are identified in the listed appendices are already available for public inspection and copying at the NRC Public Document Room.

☑ APPENDICES: M — Agency records subject to the request that are identified in the listed appendices are being made available for public inspection and copying at the NRC Public Document Room.

☑ Enclosed is information on how you may obtain access to and the charges for copying records located at the NRC Public Document Room, 2120 L Street, NW, Washington, DC.

☑ APPENDICES: M — Agency records subject to the request are enclosed.

☐ Records subject to the request that contain information originated by or of interest to another Federal agency have been referred to that agency (see comments section) for a disclosure determination and direct response to you.

☑ We are continuing to process your request.

☐ See Comments.

PART I.A -- FEES

AMOUNT * $

* See comments for details

☐ You will be billed by NRC for the amount listed.

☐ You will receive a refund for the amount listed.

☐ None. Minimum fee threshold not met.

☐ Fees waived.

PART I.B -- INFORMATION NOT LOCATED OR WITHHELD FROM DISCLOSURE

☐ No agency records subject to the request have been located.

☑ Certain information in the requested records is being withheld from disclosure pursuant to the exemptions described in and for the reasons stated in Part II.

☑ This determination may be appealed within 30 days by writing to the FOIA/PA Officer, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001. Clearly state on the envelope and in the letter that it is a "FOIA/PA Appeal."

PART I.C COMMENTS (Use attached Comments continuation page if required)

For your information, the releasable portions of the records identified on Appendix N are maintained at NRC's Public Document Room (PDR). You may contact the PDR directly for copies of these records.

SIGNATURE - FREEDOM OF INFORMATION ACT AND PRIVACY ACT OFFICER

Carol Ann Reed *Carol Ann Reed*

NRC FORM 464 Part II (6-1998) U.S. NUCLEAR REGULATORY COMMISSION

RESPONSE TO FREEDOM OF INFORMATION ACT (FOIA) / PRIVACY ACT (PA) REQUEST

FOIA/PA: 99-377,00-219,00-257

DATE: JUL 21 2000

PART II.A -- APPLICABLE EXEMPTIONS

APPENDICES N

Records subject to the request that are described in the enclosed Appendices are being withheld in their entirety or in part under the Exemption No.(s) of the PA and/or the FOIA as indicated below (5 U.S.C. 552a and/or 5 U.S.C. 552(b)).

☐ Exemption 1: The withheld information is properly classified pursuant to Executive Order 12958.

☐ Exemption 2: The withheld information relates solely to the internal personnel rules and procedures of NRC.

☐ Exemption 3: The withheld information is specifically exempted from public disclosure by statute indicated.

- ☐ Sections 141-145 of the Atomic Energy Act, which prohibits the disclosure of Restricted Data or Formerly Restricted Data (42 U.S.C. 2161-2165).
- ☐ Section 147 of the Atomic Energy Act, which prohibits the disclosure of Unclassified Safeguards Information (42 U.S.C. 2167).
- ☐ 41 U.S.C., Section 253(b), subsection (m)(1), prohibits the disclosure of contractor proposals in the possession and control of an executive agency to any person under section 552 of Title 5, U.S.C. (the FOIA), except when incorporated into the contract between the agency and the submitter of the proposal.

☑ Exemption 4: The withheld information is a trade secret or commercial or financial information that is being withheld for the reason(s) indicated.

- ☑ The information is considered to be confidential business (proprietary) information.
- ☐ The information is considered to be proprietary because it concerns a licensee's or applicant's physical protection or material control and accounting program for special nuclear material pursuant to 10 CFR 2.790(d)(1).
- ☐ The information was submitted by a foreign source and received in confidence pursuant to 10 CFR 2.790(d)(2).

☐ Exemption 5: The withheld information consists of interagency or intraagency records that are not available through discovery during litigation. Applicable privileges:

- ☐ Deliberative process: Disclosure of predecisional information would tend to inhibit the open and frank exchange of ideas essential to the deliberative process. Where records are withheld in their entirety, the facts are inextricably intertwined with the predecisional information. There also are no reasonably segregable factual portions because the release of the facts would permit an indirect inquiry into the predecisional process of the agency.
- ☐ Attorney work-product privilege. (Documents prepared by an attorney in contemplation of litigation)
- ☐ Attorney-client privilege. (Confidential communications between an attorney and his/her client)

☐ Exemption 6: The withheld information is exempted from public disclosure because its disclosure would result in a clearly unwarranted invasion of personal privacy.

☐ Exemption 7: The withheld information consists of records compiled for law enforcement purposes and is being withheld for the reason(s) indicated.

- ☐ (A) Disclosure could reasonably be expected to interfere with an enforcement proceeding (e.g., it would reveal the scope, direction, and focus of enforcement efforts, and thus could possibly allow recipients to take action to shield potential wrongdoing or a violation of NRC requirements from investigators).
- ☐ (C) Disclosure would constitute an unwarranted invasion of personal privacy.
- ☐ (D) The information consists of names of individuals and other information the disclosure of which could reasonably be expected to reveal identities of confidential sources.
- ☐ (E) Disclosure would reveal techniques and procedures for law enforcement investigations or prosecutions, or guidelines that could reasonably be expected to risk circumvention of the law.
- ☐ (F) Disclosure could reasonably be expected to endanger the life or physical safety of an individual.

☐ OTHER (Specify)

PART II.B -- DENYING OFFICIALS

Pursuant to 10 CFR 9.25(g), 9.25(h), and/or 9.65(b) of the U.S. Nuclear Regulatory Commission regulations, it has been determined that the information withheld is exempt from production or disclosure, and that its production or disclosure is contrary to the public interest. The person responsible for the denial are those officials identified below as denying officials and the FOIA/PA Officer for any denials that may be appealed to the Executive Director for Operations (EDO).

DENYING OFFICIAL	TITLE/OFFICE	RECORDS DENIED	APPELLATE OFFICIAL EDO	SECY	IG
William Kane	Director, NMSS	App. N	√		

Appeal must be made in writing within 30 days of receipt of this response. Appeals should be mailed to the FOIA/Privacy Act Officer, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, for action by the appropriate appellate official(s). You should clearly state on the envelope and letter that it is a "FOIA/PA Appeal."

Re: FOIAs 1999-377; 2000-257, 2000-219

APPENDIX M
RECORDS BEING RELEASED IN THEIR ENTIRETY
(If copyrighted identify with *)

NO.	DATE	DESCRIPTION/(PAGE COUNT)
1.	07/26/93	Ltr. to J. Darke from M. Fliegel re: Response to telecon of 7/22/93 (3 pages)
2.	02/02/94	Ltr. to C. Castro from R. Hall re: Confirmation of telecon with E. Hawkins on NRC's willingness to participate in the planned video taped town meeting in Moab, Utah on 2/8/94 (3 pages)
3.	04/20/94	Ltr. to R. Blubaugh from J. Holonich re: Comments to proposed Standby Trust (3 pages)
4.	04/25/94	Ltr. to W. McDougald from A. Mullins re: Transmittal of a copy of the transcript of the Scoping Meeting held in Moab, Utah on 4/14/94 (42 pages)
5.	04/25/94	Ltr. to R. Kroodsma from A. Mullins re: Transmittal of a copy of the transcript of the Scoping Meeting held in Moab, Utah on 4/14/94 (1 page)
6.	04/25/94	Ltr. to S. Mernitz from A. Mullins re: Transmittal of a copy of the transcript of the Scoping Meeting held in Moab, Utah on 4/14/94 (1 page)
7.	04/25/94	Ltr. to R. Robertson from A. Mullins re: Transmittal of a copy of the transcript of the Scoping Meeting held in Moab, Utah on 4/14/94 (1 page)
8.	04/25/94	Ltr. to G. Hazen from A. Mullins re: Transmittal of a copy of the transcript of the Scoping Meeting held in Moab, Utah on 4/14/94 (1 page)
9.	04/25/94	Ltr. to J. Campbell from A. Mullins re: Transmittal of a copy of the transcript of the Scoping Meeting held in Moab, Utah on 4/14/94 (1 page)
10.	04/25/94	Ltr. to K. Davey from A. Mullins re: Transmittal of a copy of the transcript of the Scoping Meeting held in Moab, Utah on 4/14/94 (1 page)
11.	04/25/94	Ltr. to A. Thompson from A. Mullins re: Transmittal of a copy of the transcript of the Scoping Meeting held in Moab, Utah on 4/14/94 (1 page)

NO.	DATE	DESCRIPTION/(PAGE COUNT)
12.	04/25/94	Ltr. to D. Atkins from A. Mullins re: Transmittal of a copy of the transcript of the Scoping Meeting held in Moab, Utah on 4/14/94 (1 page)
13.	05/04/94	Memo to Docket File from A. Mullins re: Review of Land Use Survey Report for Atlas' Moab Mill, 1993 (1 page)
14.	05/11/94	Ltr. to P. Haney, B. Hedden, M. Lammering, N. Poe from A. Mullins re: Transmittal of a copy of the transcript of the Scoping Meeting held in Moab, Utah on 4/14/94 (2 pages)
15.	05/18/94	Ltr. to J. Deason from J. Holonich re: Ltr. confirming discussions during the meeting between NRC staff and representation from DOE (2 pages)
16.	05/23/94	Ltr. to L. Stone from A. Mullins re: Discussion of previously provided information and a copy of the transcript of the Scoping Meeting held in Moab, Utah on 4/14/94 (5 pages)
17.	05/26/94	Ltr. to W. Lamb from J. Holonich re: Invitation to Bureau of Land Management to be Cooperating Agency in Atlas EIS (3 pages)
18.	05/31/94	Ltr. to R. Baker from J. Holonich re: Designation of National Park Service as Cooperating Agency in Atlas EIS (1 page)
19.	06/06/94	Ltr. to G. Wingard from R. Bernero re: Response to 5/13/94 letter on Atlas Uranium Mill (5 pages)
20.	06/10/94	Ltr. to L. Stone from A. Mullins re: Meeting Summary - DOI/NRC Meeting on Atlas EIS (6 pages)
21.	08/10/94	Memo to J. Holonich from M. Bell re: Atlas Corporation's Request for Radon Monitoring Variance (1 page)
22.	09/30/94	Memo to J. Holonich from M. Bell re: Atlas Uranium Mill - Geomorphic Questions and Comments (5 pages)
23.	10/17/94	Memo to J. Holonich from M. Bell re: Atlas Uranium Mill - Additional Questions and Comments (3 pages)
24.	10/18/94	Memo to J. Holonich from M. Bell re: Evaluation of the Atlas Corporation's Response to Comments (11 pages)
25.	10/19/94	Memo to J. Holonich from M. Bell re: Staff Review of "NRC Request for Information - Atlas Corporation Reclamation Plan, Uranium Mill and Tailings Disposal Area, Moab, utah, June 1994." (20 pages)

NO.	DATE	DESCRIPTION/(PAGE COUNT)
26.	11/07/94	Ltr. to R. Kroodsma from A. Mullins re: Transmittal of the pDEIS (1 page)
27.	11/08/94	Ltr. to K. Robinson from A. Mullins re: Request for Copies of Scoping Comments and DEIS for Atlas Moab Uranium Mill (1 page)
28.	11/25/94	Memo to J. Holonich from J. Austin re: Review of surety update and proposed change in surety form and provider for the Atlas Moab Uranium Mill (2 pages)
29.	01/10/95	Memo to D. Gillen, thru M. Nataraja, from P. Justus re: Review of pDEIS, Atlas site, Moab, Utah: Geology and Mineral Resources Sections (12 pages)
30.	01/13/95	Memo to D. Gillen, thru M. Nataraja, from A. Ibrahim re: Review of pDEIS, Atlas site, Moab, Utah, Section 3.2.3 (1 page)
31.	01/17/95	Ltr. to W. Sinclair from J. Holonich re: State of Utah's comments on Atlas study of river water and sediments at the Moab, Utah uranium mill (5 pages)
32.	01/30/95	Memo to J. Holonich from J. Austin re: Review of sediment and matri water sampling data for the Atlas Moab uranium mill (4 pages)
33.	02/07/95	Nondisclosure Agreement by Loren Morton (2 pages)
34.	04/19/95	Memo to J. Holonich from J. Austin re: Review of Atlas Moab calculation of dose commitment to nearest resident (3 pages)
35.	07/12/95	Ltr. to R. Blubaugh from D. Gillen re: LLNL Report (156 pages)
36.	09/08/95	Memo to J. Holonich from M. Bell re: Atlas TER Input - Sections 2, 3, 4, and 6 (100 pages)
37.	11/30/95	Memo to R. Rabideau from D. Gillen re: Atlas Corporation License Fee Letter (1 page)
38.	04/08/96	Ltr. to R. Lugar from J. Taylor re: Responding to constituents inquiry of 3/7/96 (19 pages)
39.	11/20/96	Memo to J. Holonich from J. Hickey re: Review of annual surety update submitted by Atlas Corporation for the Moab Mill, source material license SUA-917 (4 pages)
40.	03/07/97	Note to File from M. Fliegel re: Comments received on Atlas draft TER (194 pages)

NO.	DATE	DESCRIPTION/(PAGE COUNT)
41.	03/25/97	Ltr. to R. Rodgers from M. Fliegel re: Preliminary final EIS for the Atlas Mill Site in Moab, Utah (1 page)
42.	06/04/97	Ltr. to J. McCain from S. Jackson re: Response to letter of concern on the uranium mill tailings pile (4 pages)
43.	06/10/97	Ltr. to P. Bailey from L. Bykoski re: Review of Atlas Corporation financial documents - task order two (2 pages)
44.	07/28/97	Ltr. to D. Feinstein from L. Callan re: Requesting NRC respond to several constituents' letters concerning the uranium mill tailings pile (5 copies)
45.	03/13/98	Memo to C. Paperiello from M. Federline re: Summary of telephone conference call (3 pages)
46.	08/31/98	Ltr. to W. Woessner from M. Fliegel re: NRC-Furnished Materials (1 page)
47.	11/30/98	Memo to J. Craig from J. Greeves re: Appreciation of support from Ralph Cady for this work on the Atlas final EIS (2 pages)
48.	11/30/98	Memo to L. Chandler from J. Greeves re: Appreciation of support from Susan Utall for her work on the Atlas Final EIS (2 pages)
49.	03/11/99	Ltr. to D. Mathes from J. Holonich re: Request for information with respect to claims and payments to Atlas Corporation by DOE under Title X (2 pages)
50.	04/01/99	Memo to K. Stablein from B. Reamer re: Analysis of release and transport of ammonia form the Atlas tailings pile and its fate in the Colorado river (47 pages)
51.	11/30/98	Memo to E. Ten Eyck from J. Greeves, subject: Appreciation of Support from S. Chotoo for Her Work on Atlas EIS, (2 pgs.).
52.	04/28/99	Ltr. to S. Mayberry from C. Paperiello re: Response to 3/17/99 ltr. to the White House, expressing concern about Atlas Corporation's uranium mill tailings near Moab, Utah ,3 pages)
53.	08/12/99	Memo to J. Surmeier from M. Fliegel, P. Kinney, M. Schwartz re: Panel recommendation for Trustee for the Atlas reclamation (2 pages)

Re: FOIA-99-377
00-219
00-257

APPENDIX N

DOCUMENTS BEING RELEASED IN PART

NUMBER	DATE	DESCRIPTION/EXEMPTION
1.	4/2/93	Letter to R. Hall from K. Nielson, re: Copy of QAP-5.8, (3 pgs.) AVAILABLE IN PDR, ACC. NO. 9407060204, QAP-5.8 - Radon Diffusion Coefficient Measurements - Time Dependent Technique/Earthen Materials, (4 pgs.) - WITHHELD, EX. 4.
2.	7/10/96	Letter to R. Blubaugh from J. Holonich, re: Request for Withholding Information from Public Disclosure, Atlas Corp., Source Material License SUA-917, (4 pgs.) - AVAILABLE IN PDR, ACC. NO. 9607230240, Letter to J. Holonich fromR. Blubaugh, re: Atlas Corp., Moab Rock Source, (2 pgs.) - WITHHELD, EX. 4.

40-3453

JUL 2 6 1993

Mr. John Darke
Box 703
Copper Queen Station
Bisbee, Arizona 85603

Dear Mr. Darke:

I am responding to your telephone call to our office on July 22, 1993, and your request for information on the Nuclear Regulatory Commission's proposed action to amend License Number SUA-917 held by Atlas Minerals Corporation. I am enclosing a copy of the Federal Register notice of July 20, 1993, which is the notice of intent to amend the license. This notice identifies points of contact for submittal of comments, or requests for additional information on the proposed action.

I trust that this infomation is responsive to your request.

Sincerely,

Original Signed by
Myron H. Fliegel

Myron H. Fliegel, Acting Chief
Uranium Recovery Branch
Division of Low-Level Waste Management
and Decommissioning
Office of Nuclear Material Safety
and Safeguards

Enclosure: As stated

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trustees as well as disqualified persons with respect to the Plan.[1]

This proposed exemption is conditioned on the following requirements: (1) The sale represents a one-time transaction for cash; (2) the sales price is based upon the appraised value of the Property as determined by a qualified, independent appraiser; and (3) the Plan does not pay any real estate fees or commissions in connection therewith.

For a more complete statement of the facts and representations supporting the Department's decision to grant this exemption, refer to the notice of proposed exemption published on June 2, 1993 at 58 FR 31429.

For Further Information Contact: Ms. Jan D. Broady of the Department, telephone (202) 219-8881. (This is not a toll-free number.)

General Information

The attention of interested persons is directed to the following:

(1) The fact that a transaction is the subject of an exemption under section 408(a) of the Act and/or section 4975(c)(2) of the Code does not relieve a fiduciary or other party in interest or disqualified person from certain other provisions to which the exemptions does not apply and the general fiduciary responsibility provisions of section 404 of the Act, which among other things require a fiduciary to discharge his duties respecting the plan solely in the interest of the participants and beneficiaries of the plan and in a prudent fashion in accordance with section 404(a)(1)(B) of the Act; nor does it affect the requirement of section 401(a) of the Code that the plan must operate for the exclusive benefit of the employees of the employer maintaining the plan and their beneficiaries;

(2) These exemptions are supplemental to and not in derogation of, any other provisions of the Act and/or the Code, including statutory or administrative exemptions and transactional rules. Furthermore, the fact that a transaction is subject to an administrative or statutory exemption is not dispositive of whether the transaction is in fact a prohibited transaction; and

(3) The availability of these exemptions is subject to the express condition that the material facts and representations contained in each application accurately describes all material terms of the transaction which is the subject of the exemption.

Signed at Washington, DC, this 14th day of July 1993.

Ivan Strasfeld,

Director of Exemption Determinations, Pension and Welfare Benefits Administration, U.S. Department of Labor.

[FR Doc. 93-17044 Filed 7-8-93; 8:45 am]

BILLING CODE 4510-29-P

[1] Because Dr. Brice and his wife are the sole participants in the Plan, there is no jurisdiction under title I of the Employee Retirement Income Security Act of 1974 (the Act). However, there is jurisdiction under title II of the Act pursuant to section 4975 of the Code.

NATIONAL COMMISSION ON FINANCIAL INSTITUTION REFORM, RECOVERY, AND ENFORCEMENT

Meeting

AGENCY: National Commission on Financial Institution Reform, Recovery and Enforcement.

Time and Date: 9:30 a.m. to 12:00 p.m., Tuesday, July 27, 1993.

Place: Main Lounge, National Press Club, 13th Floor, 529 14th Street NW., Washington, DC 20045.

Status: The meeting will be open to the public.

Matters to be Considered: At the meeting, the Commission shall release its final report to the President and Congress on the origins and causes of the savings and loan crisis and the Commission's recommendations for reform.

Contact Persons for Additional Information: Larry G. Hicks or Linda Johnson on (202) 632-1556.

Larry G. Hicks,

Director of Administration.

[FR Doc. 93-17152 Filed 7-19-93; 8:45 am]

BILLING CODE 6820-FD-M

NUCLEAR REGULATORY COMMISSION

[Docket No. 40-3453]

Atlas Minerals Corp.; Intent to Amend Source License

AGENCY: U.S. Nuclear Regulatory Commission.

ACTION: Notice of intent to amend Source Material License SUA-917 for the Moab Mill to approve a plan for reclamation of the mill's tailings disposal area as supported by a finding of no significant impact regarding the proposed action for Atlas Corporation, Utah.

SUMMARY: The Nuclear Regulatory Commission is proposing to amend Source Material License SUA-917 to incorporate a revised tailings disposal area reclamation plan for Atlas Corporation's Moab Mill located near Moab, Utah. The accepted plan reclaims the disposal area in place. The proposed action is supported by a Finding of No Significant Impact as concluded in the Environmental Assessment prepared by the Commission.

DATES: The comment period expires August 19, 1993.

ADDRESSES: Copies of the license amendment request and the staff evaluations which are the bases for revision of the license are available for inspection at the Uranium Recovery Field Office, 730 Simms Street, suite 100, Lakewood, Colorado, and the NRC Public Document Room, 2120 L Street, NW. (Lower Level), Washington, DC.

Comments should be mailed to David L. Meyer, Chief, Rules Review and Directives Branch, Office of Administration, P-223, U.S. Nuclear Regulatory Commission, Washington, DC 20555, with a copy to the Director, Uranium Recovery Field Office, U.S. Nuclear Regulatory Commission, P.O. Box 25325, Denver, Colorado 80225.

Comments may be hand-delivered to room P-223, 7920 Norfolk Avenue, Bethesda, Maryland, between 7:30 a.m. and 4:15 p.m., Federal workdays.

FOR FURTHER INFORMATION CONTACT: Ramon E. Hall, Director, Uranium Recovery Field Office, Region IV, U.S. Nuclear Regulatory Commission, P.O. Box 25325, Denver, Colorado 80225. Telephone: (303) 231-5800.

SUPPLEMENTARY INFORMATION: The U.S. Nuclear Regulatory Commission (NRC) and the Environmental Protection Agency (EPA) entered into a Memorandum of Understanding (MOU) which was published in the Federal Register on October 25, 1991 (56 FR 55434). The MOU requires that the NRC complete review and approval of detailed reclamation (i.e., final closure) plans for nonoperational tailings impoundments as soon as practicable, but in any event not later than September of 1993.

The tailings disposal area for the Moab Mill contains approximately 10.5 million tons of material. Tailings were disposed into an approximately 130-acre diked impoundment constructed to a maximum height of about 110 feet. Moab Wash, an ephemeral channel, is located along the north and east sides of the impoundment and discharges into the Colorado River east of the site. The Colorado River flows along the eastern side of the facility.

The reclamation 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 mean sea level (msl). The maximum crest elevation constructed during mill operations was 4058 feet msl, resulting in the necessity to

redesign the reclamation plan. In accordance with 10 CFR part 40, appendix A, the licensee, Atlas Corporation, submitted a revised reclamation plan by letter dated August 2, 1988. Review of the proposed plan resulted in requests for additional information, reevaluation, and redesign. As a result, Atlas submitted a revised reclamation plan by letter dated June 4, 1992. Review of this document resulted in a request for additional information dated March 5, 1993. Revisions to the June 4, 1992, reclamation plan were submitted by letters dated April 14, and April 23, 1993.

On April 6, 1993, the license submitted an Environmental Report Supplement in support of the proposed revised reclamation plan for the disposal area. This document was submitted as a supplement to the Environmental Report submitted in 1973 by the licensee, NRC's "Final Environmental Statement, Moab Uranium Mill," (NUREG-0453, January 1979), NRC's "Final Generic Environmental Impact Statement on Uranium Milling," (NUREG-0706, September 1980), and Atlas' license renewal application dated 1984. The supplement specifically addresses the expected impacts associated with mill tailings reclamation and evaluates alternatives for mitigating the impacts.

The Environmental Assessment was prepared by the Commission to evaluate the proposed licensing action. It was concluded that the reclamation of the tailings in accordance with the proposed plan would not have a significant impact on the environment. Short-term impacts to the environment will be minimal, while long-term impacts will be reduced to levels determined to be acceptable by promulgation of appendix A to 10 CFR part 40. The bases for the finding of no significant impact (FONSI) are provided in an Environmental Assessment.

Review and independent analyses of the revised reclamation plan for the Moab Mill disposal area have resolved all engineering issues and open items regarding reclamation of the disposal area except as noted, and it is concluded that the proposed design is consistent with current design guidance and applicable portions of 10 CFR part 40, appendix A. The bases for this determination are provided in the Memorandum for Docket File No. 40-3453 dated July 7, 1993. It is proposed to amend Source Material License SUA-917 by deleting License Condition No. 37 (regarding the configuration of the Moab Wash) and by modifying License Condition No. 41 to read as follows:

41. The licensee shall reclaim the tailings disposal area in accordance with Sections 1, 4, 5, 6, and 9 of the June 4, 1992, submittal entitled "Atlas Corporation, Technical Specifications, Uranium Mill and Tailings Disposal Area Reclamation" as revised by the April 14, 1993, submittal, and with the drawings submitted by letter dated April 23, 1993, with the following exceptions:

A. The sandy soil layer of the radon barrier shall be 1 foot over the coarse tailings and 2 feet over the fine tailings. The drawings and specifications must be revised and submitted to reflect this change in the design by October 31, 1993.

B. The fenced restricted area shall include the reconfigured Moab Wash. Drawing 88-067-E66 (April 23, 1993) shall be revised and submitted to reflect this change in the design by October 31, 1993.

C. The licensee shall submit a revised outslope design by October 31, 1993, for review and approval that assumes Moab Wash encroaches upon the embankment.

D. The licensee shall submit an erosion protection design for the Northeast Debris Pit located adjacent to the toe of the reclaimed disposal area by October 31, 1993. That protection shall consider flows from Moab Wash and runoff from the reclaimed outslope during a design basis event.

E. The bulk specific gravity of the rock shall be determined by ASTM C 127.

F. Durability testing of the rock portion of the soil/rock matrix shall be performed at the same frequency as that specified for riprap in Section 9.3.4.1 of the specifications dated April 14, 1993.

A completion report including as-built drawings, verifying that reclamation of the site has been performed according to the approved plan shall be provided within 6 months of the completion of construction. The report shall also include summaries of results of the quality assurance and control testing to demonstrate that approved specifications were met.

Ramon E. Hall,

Director, Uranium Recovery Field Office, Region IV.

[FR Doc. 93-17182 Filed 7-19-93; 8:45 am]

BILLING CODE 7590-01-M

Advisory Committee on Reactor Safeguards Subcommittee on Improved Light Water Reactors; Meeting

The ACRS Subcommittee on Improved Light Water Reactors will hold a meeting on August 4, 1993, in room P-110, 7920 Norfolk Avenue, Bethesda, MD.

The entire meeting will be open to public attendance.

The agenda for the subject meeting shall be as follows:

Wednesday, August 4, 1993—8:30 a.m. until the conclusion of business.

The Subcommittee will discuss NRC staff's response to ACRS comments and recommendations related to certain policy, technical, and licensing issues pertaining to evolutionary and advanced light-water reactor designs. Also, the Subcommittee will discuss the staff positions on certain remaining policy issues for passive plant designs. The purpose of this meeting is to gather information, analyze relevant issues and facts, and to formulate proposed positions and actions, as appropriate, for deliberation by the full Committee.

Oral statements may be presented by members of the public with the concurrence of the Subcommittee Chairman; written statements will be accepted and made available to the Committee. Recordings will be permitted only during those portions of the meeting when a transcript is being kept, and questions may be asked only by members of the Subcommittee, its consultants, and staff. Persons desiring to make oral statements should notify the ACRS staff member named below as far in advance as is practicable so that appropriate arrangements can be made.

During the initial portion of the meeting, the Subcommittee, along with any of its consultants who may be present, may exchange preliminary views regarding matters to be considered during the balance of the meeting.

The Subcommittee will then hear presentations by and hold discussions with representatives of the NRC staff, its consultants, and other interested persons regarding this review.

Further information regarding topics to be discussed, the scheduling of sessions open to the public, whether the meeting has been cancelled or rescheduled, the Chairman's ruling on requests for the opportunity to present oral statements and the time allotted therefor can be obtained by a prepaid telephone call to the cognizant ACRS staff engineer, Dr. Medhat El-Zeftawy (telephone 301/492-9901) between 7:30 a.m. and 4:45 p.m. (EDT). Persons planning to attend this meeting are urged to contact the above named individual one or two days before the scheduled meeting to be advised of any changes in schedule, etc., that may have occurred.

40-3453

UNITED STATES

NUCLEAR REGULATORY COMMISSION

REGION IV

URANIUM RECOVERY FIELD OFFICE
BOX 25325
DENVER, COLORADO 80225

SIS 44

FEB 02 1994

KUED Public Television
ATTN: Colleen Castro, Producer
101 Wasatch Drive
Salt Lake City, UT 84112

Dear Ms. Castro:

This confirms your discussion with Mr. Ed Hawkins of my staff confirming our willingness to participate in your planned video taped town meeting in Moab, UT, on February 8, 1994. As previously discussed with Mr. Scott Thompson of your staff, we feel it important that the NRC be represented by two, rather than just one, representative to assure that the issue of continuity is emphasized during the period of closure of the Uranium Recovery Field Office in Denver and the transition of responsibility for the Atlas project to our Low-Level Waste Management and Decommissioning office in NRC headquarters in Rockville, MD.

Attached is a summary statement of the relative responsibilities of myself and Mr. Joseph Holonich, with emphasis on the relative involvement in the Atlas project as the transition occurs. We have not provided biographical information, since it probably is not germane to the town meeting format; however should you desire it, we would be happy to provide it.

Mr. Joe Gilliland, our regional Public Affairs Officer, tentatively plans to attend the public meeting; however, he has schedule conflicts which may preclude his attendance. Should he attend, I will assure that you have the opportunity to interface with him.

Should you have any questions during your preparation for this forum, please feel free to call me (303) 231-5800.

Sincerely,

Ramon E. Hall
Director

Attachment:
As stated

M/2
DFX7

FEB 02 1994

bcc:
Docket No. 40-3453
J. J. Holonich, LLUR (5 E2)
D. D. Chamberlain, RIV
S. J. Collins, RIV
L. Camper, RIV
R. A. Scarano, RV
J. T. Gilliland, RIV
J. T. Greeves, LLWMD, (5 E2)
M. Bell, LLWMD, (5 E2)

FAX to (801) 581-5620

DD:URFO	D:URFO:RIV			
EFHawkins	REHall/db			
02/ 1 /94	02/ 1 /94			

Attachment

NRC PARTICIPATION IN TOWN MEETING
MOAB, UTAH
February 8, 1994--7:00 pm

Mr. Ramon E. Hall is Director of the Uranium Recovery Field Office (URFO). Since 1983, URFO has been delegated the licensing responsibility for the Atlas facility. In this capacity, all requests for amendment or renewal of the NRC license for the Atlas facility have been reviewed and issued by URFO, under the program guidance provided by the NRC headquarters Division of Low-Level Waste Management and Decommissioning. Historically, the approval of the initial reclamation plan in the mid-1980s, the license renewal in 1986, approval of the mill decommissioning plan, inspection and surveillance of activities at Atlas following mill shutdown, and review of the revision to the previously approved reclamation plan for the facility have all fallen within the responsibility of URFO. The decision to publish the Notice of Intent to Amend the License to approve the revision to the previously approved reclamation plan, and the supporting Finding of No Significant Impact was the decision of the Director, URFO, in consultation with all other appropriate portions of the NRC.

The pending closure of URFO in July, 1994, has necessitated a shift in licensing responsibility for all uranium recovery facilities. As part of a phased transition, Atlas will be transferred to NRC headquarters responsibility in February, 1994.

Mr. Joseph J. Holonich is the Chief of the Uranium Recovery Branch, Division of Low-Level Waste Management and Decommissioning, at NRC Headquarters. This branch has been responsible for development of programmatic guidance in the area of uranium recovery facility licensing as implemented by URFO. As a result of the above noted transition, the Uranium Recovery Branch will soon become responsible for all aspects of the Atlas licensing. The Uranium Recovery Branch has been assigned the lead responsibility for the reevaluation of the reclamation plan for the Atlas site, currently being conducted by NRC. In addition, it has been given the lead in readdressing the Environmental Assessment of the proposed plan. The Uranium Recovery Branch staff works regularly with the Uranium Recovery Field Office in coordinating these activities and is preparing to assume the full licensing lead in February.

Docket No. 40-3453 APR 20 1994
License Number SUA-917

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

Dear Mr. Blubaugh:

On March 7, 1994, you sent by facsimile, a proposed Standby Trust document for U.S. Nuclear Regulatory Commission review. NRC staff's comments are listed in the enclosure and were provided to you in a telephone conversation by Allan Mullins, the NRC Project Manager. The Standby Trust arrangement will be satisfactory to NRC when the comments have been addressed. A copy of the completed Standby Trust document should be sent to NRC so that it can be incorporated into the current revision of License Condition No. 42 which you requested by letter of February 23, 1994.

Any questions should be addressed to NRC's Project Manager, Allan Mullins, at (301) 504-2578.

Sincerely,

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

Enclosure:
As stated

cc: William Sinclair, Director
Division of Radiation Control
State of Utah
168 North 1950, West
Salt Lake City, UT 84115-4850

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

APR 20 1994

Docket No. 40-3453
License Number SUA-917

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Atlas Corporation
370 Seventeenth Street, Suite 3150
Denver, Colorado 80202

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

Enclosure:
As stated

cc: William Sinclair, Director
Division of Radiation Control
State of Utah
168 North 1950, West
Salt Lake City, UT 84115-4850

COMMENTS ON ATLAS CORPORATION'S
PROPOSED STANDBY TRUST FOR
LICENSE NUMBER SUA-917

1. At the bottom of the first page, keep the word <u>Definitions</u>.

2. At the bottom of page 5, under designated Section 10, delete the suggested new language at the end of the paragraph, so the paragraph ends with "... matters disclosed in the statement."

3. At the middle of page 10, the name and address listed for the facility should be that for the Atlas Corporation's uranium mill at Moab, Utah.

APR 25 1994

Mr. William McDougald
422 Topaz Circle
Moab, Utah 84532

Dear Mr. McDougald:

As you requested, enclosed is a copy of the transcript of the Scoping Meeting held in Moab, Utah, on April 14, 1994, for the Atlas uranium mill Environmental Impact Statement (EIS).

We appreciate you taking your time to participate in the scoping process for the EIS. Public participation will help produce a more complete environmental assessment for the project.

Sincerely,

/s/

Allan T. Mullins, Project Manager
High Level Waste and
Uranium Recovery Projects Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosure:
As stated

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40-3453

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

***

MEETING WITH STAFF MEMBERS FROM THE NUCLEAR REGULATORY COMMISSION (NRC) AND CITIZENS AND LOCAL AREA POLITICIANS

***

Star Hall
155 E. Center
Moab, Utah

Thursday, April 14, 1994

The above-entitled matter came on for public meeting, pursuant to notice, at 7:00 p.m.

BEFORE:

JOSEPH HOLONICH

APPEARANCES:

JOE HOLONICH, NRC

DAN GILLEN, NRC

ALLAN MULLINS, NRC

MILT LAMERING, EPA - Denver

WALTER DABNEY, National Park Service, Canyonlands

BILL SINCLAIR, State of Utah - Division of Radiation Control

GARY HAZEN, Utah

JACK CAMPBELL, Utah

BARBARA ZINN, Utah

JOSEPH McCAROT, Utah

RICHARD CHRISTIE, Utah

BILL HEDDEN, Utah

CURTIS FREEMAN, Utah

CONTENTS

P R O C E E D I N G S

[7:00 p.m.]

MR. HOLONICH: I'm going to go ahead and get started this evening. My name is Joe Holonich. I'm the chief of the high-level waste and uranium recovery projects branch in the NRC's division of waste management back in Rockville, Maryland.

We're here this evening to have a scoping meeting on the environmental impact statement that we've proposed for the Atlas uranium mill site, which is out here outside of town here at Moab.

What I'd like to do this morning -- or this evening is give a few introductions, and then turn the meeting over to the project manager for the Atlas site, and he's going to give a little bit of a background. And then basically the meeting is your meeting. We are looking for comments and input from members of the public here in Moab. So if folks have comments and inputs they would like to give, we've got eight people signed up to speak, and we would just take you in the order of that list. Given the time we've had planned, which is three hours and the number of folks, we're not going to look for a real strong time limit.

We're not here this evening to answer questions and address issues. This is in fact an

information-gathering process for us this evening.

And when you do come forward, we'd like you to speak into the mike here. There are two mikes. One mike is for the amplification system. One mike is for the court reporter. We do have a court reporter taking a transcript this evening to make sure we get an accurate record of the comments that are given.

When you do come up, please give your name so that she can identify you in the transcript, and then make your comments.

I would like to note that we have decided to go over to an environmental impact statement. We issued a federal registered notice on March 30th identifying that. I think it's important to recognize that the environmental impact statement does not mean that we have made a decision that the tailings should be moved. In fact, the environmental impact statement is an evaluation of Atlas' proposed action, which is reclamation of the tailings in place and considering reasonable alternatives, one of which is moving the tailings' pile.

But the focus of the EIS is on reclamation in place, the licensees' proposed actions, and I want folks to recognize that, because that's a very important point to recognize. Going to an EIS did not mean we necessarily decided that the tailings need to be moved.

What I'd like to do now is take a moment to introduce folks, and I'd like to start with Dan Gillen. Dan is a section leader in my branch, and Dan is responsible for the uranium recovery portion of the program. Allan Mullins -- Allan is the project manager for the Atlas site back at NRC headquarters.

There are a couple of other federal officials and state officials here I'd like to recognize. Milt Lamering from EPA's Denver office; Walter Dabney, who's the chief of the Canyonlands' National Park for the National Park Service; and Bill Sinclair, who's the director of the State of Utah's division of radiation control, are also present this evening.

So what I'd like to do is to turn the presentation portion over to Allan. He's going to give a short background, and then we'd like to start through the comment list and recognize people who signed up to be -- signed up to give comments. At the end of that, if somebody didn't sign up and would like to make comments, we're certainly willing to listen to the additional comments if you didn't sign up, but we're going to start with walking through the sheets.

So what I'm going to do is turn it over to Allan Mullins, the project manager for the Atlas site.

MR. MULLINS: Thank you. We bring you welcome

from your capital city. We're here to get your thoughts and comments. And there are other organizations back in Washington that expect to get your thoughts and comments perfectly by tomorrow. We will be more gentle to you, I hope, than the IRS is.

I'd like to thank Peter Haney, who has worked very closely with us over this in making some services available from the county council in putting some material in this, to helping us coordinate meetings; Patsy Nielsen, with the school district who arranged for the star hall for us; Penny Shield, the librarian who arranged for the PA system. And without those folks help we would have not been able to put this program on tonight.

We're not going to have a long presentation from our standpoint, because the purpose of this meeting is to hear from you all. We have already had, as you are well aware, extensive comments from you all in the past. Those type comments will be automatically considered and incorporated into the scoping process. You certainly are free to reiterate any of the thoughts that you've already shared with us. But if you don't, rest assured that those will still be incorporated.

If you did not sign up to talk, you're not too late. You can let us know when we run through the people who have signed up. We only have about eight people who

have indicated they'd like to talk. So I think we can be fairly loose on how much time each person takes, assuming that somewhere between five, six, seven, eight minutes would be an average. We're prepared to stay till 10:00. We thought the meeting would run from 7:00 to 10:00. We're at your disposal while we're here.

If you would like to provide written comments, either in addition to or supplemental or instead of oral comments, if you'll pick up a copy out at the desk of the federal register notice that we put in saying we were going to do an EIS and having a scoping meeting, there is an address in there that written comments can be provided to us.

We do ask that the comments tonight be limited to those related to the environmental aspects of the Atlas project, because that's what we're doing.

To remind you of some of the general background on this, NRC filed a federal register notice of an intent to do an EIS not too long ago. That was the culmination of a reassessment process that started back last fall when NRC rescinded a notice of a finding of no significant impact on the project, determined that both a technical and an environmental reassessment would be made based on the comments received from the public.

I think it's worth noting that the previous

environmental assessment that was published last summer addressed the differences in a reclamation plan resubmittal that was altering a previously approved reclamation plan. So from the standpoint of picking it up and saying this did not cover all of the environmental aspects of the reclamation plan, that is correct. It covered the environmental aspects of the changes.

Under the current procedures we're going through, we will back up, pick up the environmental aspects of the entire project using the EIS process as opposed to the EA process. The EIS process is a much more structured look-see, involves a lot more coordination and input from both federal agencies and the public.

As I mentioned, we have a technical evaluation underway on the aspects of the reclamation plan itself. That will determine whether the plan is submitted or may be modified, complies with the regulations that NRC has for implementation of reclamation.

We've already asked the licensee to provide additional information related to many of the,thoughts that you all have shared with us in the past, such as the seismic considerations and the faultings that are present on the site, the potential for erosion of the Colorado River. Much of that sort of assessment -- excuse me -- will be done in the technical evaluation. We're expecting that technical

evaluation to be completed probably by late summer. It depends on how fast we get the information that's needed.

In the general overview of the scoping process is what I'll give you in a second. In the federal register notice there's a more detailed description of it. In the federal register notice, there's a general outline that will be utilized in preparing the EIS. That conceptual outline will probably be changed and altered as we go work through the scoping process and as we get deeper into the evaluation.

As I mentioned, we received more than 20 comments last fall from the general public from political leaders at both the state and national level, local county level, governmental agencies. All were interested in this project and shared their thoughts with us, and we heard those and are responding to them. This meeting is an example of the process that is underway now.

The current schedule for the EIS calls for a draft statement in October '94, a final statement in April 1995. Oak Ridge National Laboratory has been contracted to do the EIS for us. Their representatives are here. They're on a site visit this week.

So with that general background, unless any of you have any questions, we'll proceed and call on people who have signed up and would like to speak. Are there any

questions before we start getting your input?

Bill, you are the first person on my list. If you would like to make your comment first.

MR. SINCLAIR: I'll only take an hour or two. I'll be submitting the statement for the record, and we will be providing more detailed written comments before the required deadline.

State of Utah applauds the decision of the Nuclear Regulatory Commission to reexamine the reclamation process for the Atlas mill tailings through the process of performing an EIS. We appreciate the opportunity tonight to submit comments on the scope of the EIS, and we look forward to working with NRC and other agencies involved on a continuing basis to facilitate this process as much as possible.

We have some major points that we'd like to provide at this particular time. Some of these points we have made in previous written comments to the agency, but we'd like to reiterate some of those comments again.

First, we would like to make sure that the EIS contains a rigorous comparison of the viable alternative actions, with the primary alternatives being the relocation of the tailings to the airport site, which would be close to an ideal site, or the capping of the tailings in place. Serious consideration of the Box Canyon site or the no

action alternative, as in the proposed EIS outline, would not be productive. And it's suggested that your available resources be focused on the more detailed examination of the two main alternatives.

Each of these primary alternatives should receive a comprehensive and thorough engineering cost analysis, and a sound technical analysis consistent with the 10 -- and specifications of the 10 CFR 40, Appendix A. Any groundwater remediation or other groundwater monitoring costs should be included in the total cost for each alternative.

Past -- excuse me. Past cost estimates of the proposed reclamation are now outdated and should be rigorously redone. This would require the new detailed engineering designs and new detailed transportation assumptions be performed. To simply use previous cost estimates originally derived in 1977 and inflate them to current dollars is not acceptable. Since 1977, the relative costs of reclamation in place have risen due to the new technical information and regulatory requirements. And let me give you some examples.

For instance, to meet current design requirements, the amount of riprap, or protective rock armor, would be required for in-place stabilization of the pile is much greater now than was originally anticipated. It does show

riprap is required due to potential meandering of the Colorado River which was not originally in the scope, and also the potential for erosion by the Moab Wash. The amount of riprap required for tailings relocation would be much less than needed for capping in place at the other site.

Groundwater remediation costs have not been included in any of the past cost estimates for capping in place, and there's been no effort yet to quantify treatment costs of contaminated water from underneath the pile or contaminated water escaping the site.

Modeling accomplished by Atlas, has shown that Atlas cannot meet EPA's maximum concentration limit, MCL, for uranium beneath the tailings pile. The entire groundwater remediation scenario is based on NRS granting an alternate concentration limit or ACL. And it'll be interesting how NRC does this, since there are no standards in place yet for Title 2 sites, even though there are just recent proposals in the federal register for these standards.

Even if there is an ACL alternative, you will have costs in submitting an ACL petition, subsequent reviews and responses, potential administrative challenges that have not been factored into any groundwater remediation costs. And I can tell you with my experience in the hazardous waste program and dealing with ACL's is the most difficult

process.

Also, along with this -- along the lines of cost estimates, there is also the potential for increased costs due to thickening of the in-place cover design due to some of the seismic concerns that have been raised as of late.

I think one issue that has been raised with me, residents here in Moab, is the availability of suitable riprap. Certainly that is going to be a cost factor, because for instance, at the Green River site we had to import riprap from up near Salina, which is a considerable distance.

In any case, the riprap costs will be very expensive, and the capping in-place option will require more riprap, thus raising the relative costs of the capping in place.

Also for the capping in place, the clay canton of the cover may have to be increased by at least 6 to 12 inches to meet rayon emanation requirements. And this will mean that the clay will have to be imported and then engineered in place. In contrast, there is abundant clay available on site at the proposed airport relocation.

Finally, the entire existing groundwater monitoring system may need to be upgraded or even replaced to ensure that the site is being properly monitored, which may require new well placements. And none of this was

cost-included in the Atlas 1993 environmental assessment.

We would highly recommend that the cost-estimating work be reviewed or separately calculated by a third-party consultant hired by the Nuclear Regulatory Commission, so we can either confirm or deny or dispute the numbers provided by the Atlas consultant.

The philosophy -- excuse me. The philosophy of the thousand-year design is a discriminatory factor in relation to off site removal. An off site tailings repository would be more maintenance-free and would likely last much longer than an in-place option that is continually exposed to erosion by the Colorado River and Moab Wash.

For comparative purposes, it's noted that high level radioactive waste disposal facilities have a 10,000 year standard. The Atlas uranium mill tailings will pose a hazard almost indefinitely due to uranium's long half-life and subsequent radon emanation by uranium decay radionuclides. The potential threat to human health and the environment will certainly last much longer than a thousand years. It just makes common sense to consider longer term consequences of where the tailings are placed.

Also, based on various data obtained, the EIS should contain a thorough and partial analysis and evaluation of the relative risk and relative benefits, including long-term and short-term benefits and risks to

public health, safety and the environment associated with each alternative. The public needs to know and understand what the risks are. Long-term risk assessments should be performed that will compare the actual risk to the public from the various exposure pathways of each alternative. The EIS should address both the risk to human health as well as any ecological risks. And this is not new science. This can be accomplished.

The EIS should also include impacts of the alternatives on the people of Moab and Grand County and on tourism and the local economy. The original 1979 EIS was based on very conservative growth estimates for the Moab and Grand County that have obviously been exceeded. And the original EIS did not consider the substantial transient population of Moab due to tourism.

As the title "Environmental Impact Statement," obviously implies, the EIS should examine the general environmental impacts of each proposed alternative, including impacts to wildlife, the Colorado River ecosystem and endangered species, and should include the impacts of each proposed alternatives on the state of Utah's water resources, especially including the Colorado River and surrounding groundwater resources.

We're disappointed to note that in the proposed scope of the EIS there was a statement which says:

"Extensive water monitoring has identified no contamination in the Colorado River. Therefore, there are no effects on river biota and they will not be assessed." Such a statement is simplistic and misleading.

If the tailings tile is stabilized in place, there will be a continuing flux of contaminants into the Colorado River. Due to the large volume of the Colorado River, once the contaminants have been thoroughly mixed with the river, they are not easily measured. Nevertheless, some contamination will occur, and the Colorado River will experience incremental degradation. The overall flux of contaminants to the river should be quantified. Concentrations of contaminants could be locally higher in the sediments and in the sediment-poor waters on the Atlas side of the river.

To simply assert that at some point downstream contaminants are not measurable is oversimplifying the situation. We urge the NRC, in consultation with the U.S. Fish & Wildlife Service and other interested agencies, to conduct localized sediment and biota sampling,and sediment-poor water sampling adjacent to the Atlas side of the Colorado River to assess the potential for localized negative impacts to river biota and endangered fish species.

The impact of incremental degradation in the water in the Colorado River should also be assessed. If there are

truly no detrimental impacts to water quality and river biota, the new EIS should contain valid data to support that claim.

Additionally, the EIS should include the impacts of each proposed alternative on the surrounding national parks and archeological and historical resources.

And finally to conclude my statement, we'd like the urge to -- we'd like to urge the NRC to conduct public meetings throughout the EIS process, and we urge the NRC to come to Moab on a quarterly basis and hold such meetings.

The NRC may also wish to consider the formation of a citizen's advisory group such that we have known and expected in the superfund process, and as such has been established in Monticello to deal with that particular cleanup.

If the new NRC is really committed to enhance public participation, and that's why you're here tonight, we would appreciate your commitment to ensure that a steady dialogue continues between NRC and the citizens of the state of Utah.

Thank you for your attention. I'll submit these comments to you.

[Microphone malfunctions.]

MR. MULLINS: Bill, that was not in case you put anybody to sleep.

The next person on the list that asked to speak is Curtis Freeman.

MR. FREEMAN: Excuse me at this time, please.

MR. MULLINS: I'm sorry?

MR. HOLONICH: He wants to be excused.

MR. MULLINS: Gary Hazen. I think we've heard from you before, Mr. Hazen by letter.

MR. HAZEN: Only by letter. I'm Gary Hazen, and I have my comments but they're short.

In 1976, a study for the Energy Research & Development Administration revealed that radium had leached from each tailing pile study anywhere from two to nine feet into the subsoil.

In 1954, before Atlas began milling uranium ore, a 40-foot subsurface pit was graded out beneath a 96-acre base of the tailing pile. That graded subsurface pit beneath the tailings pile is in direct contact with the surface groundwater of the Colorado River.

The water in the Colorado River below the Atlas mill site is the primary natural resource for,40 million Americans and infrastructure of the southwest. Contamination of the Colorado River groundwater by the Atlas tailing site is unacceptable. Any contamination of the groundwater and health risk to the American public is a primary consideration of the NRC's EIS for off site

remediation.

Back in '86 I had canvased this information. I found this information out across the street at our library. It was 16 months -- it was about ten months into studying this that I -- it was actually 15,000 cubic yards that was graded out, and it's just in direct contact with the Colorado River, and it should be a consideration.

Thank you.

MR. MULLINS: Thank you, Mr. Hazen.

Jack Campbell.

MR. CAMPBELL: My name is Jack Campbell. I'm an elected official from the town of Castle Valley. I have two --

MR. MULLINS: Excuse me. Do we need to turn that PA system up again? If we can do it without screeching, go ahead.

MR. CAMPBELL: My name is Jack Campbell. I'm an elected official from the town of Castle Valley. I have two very quick comments.

I'd heard that the material that you were considering using to cap the Atlas tailings pile, if you capped it in place, would either be quarried up in Miner's Basin or from Round Mountain in the center of Castle Valley. I would ask you, and the town council would ask you to evaluate the impacts on the town of Castle Valley if you

used either of those two sites as the source of the igneous capping rock to cap that in place.

If you used either Miner's Basin or Round Mountain, you would have, number one, a very large impact on the residents of the town of Castle Valley in the first phase of the transportation.

And the second large impact would be not only on the residents of Castle Valley, but on many of the tourists in Grand County, and that would involve the creation of a very hazardous road situation on the Highway 128 between the town of Castle Valley and where 128 joins 191. It's a very narrow low-speed twisty road. There are lots of tourists on that driving trailers, RV rigs pulling other trailers. They drive very slow because they're gawking at the scenery. They frequently just plain stop in the middle of the road to take pictures. Large ore trucks transporting large amounts of rock from that area to 191 would constitute a really large hazard on that road.

And I would like you to consider both of those two possible impacts in your evaluation.

MR. MULLINS: Thank you, Mr. Campbell.

When you speak, the PA system seems to be on a jump by itself. So you may have to try and raise your voice so that people in the back can hear.

Barbara Zinn.

MS. ZINN: My name is Barbara Zinn. How does that sound? Okay.

I have some property out in Castle Valley. And one of the points I was going to make was essentially what Jack just said. I am concerned about the impacts that these capping materials might have on residents and also on tourists. And basically what Jack says was my concern there.

Also, I'm very concerned about this irreplaceable resource of the Colorado that we have here, and also of the wetlands locally right around the Atlas site. And I'd like to make sure that the corp of engineers is contacted if a 404 permit is required through the Clean Water Act, that that is addressed in your EIS.

Thank you.

MR. MULLINS: Thank you, Ms. Zinn.

Joseph McCarot, you said maybe.

MR. McCAROT: No, no.

MR. MULLINS: Richard Christie.

MR. CHRISTIE: My name is Richard Christie. I'm currently on the Grand County Planning & Zoning Commission, and I've been following this Atlas issue since 1990 in a position as chair of the Atlas Mill Reclamation Task Force, which is appointed by the Grand County government here.

The points that Mr. Sinclair made in many respects

parallel my own. I have prepared a written comment which I've already given a copy of to Tom, and I'll give another copy to your gentlemen here. I won't attempt to read it into the record, because I think it would all cross our eyes, and Mr. Sinclair has also covered many of the points very well.

Basically I would like to make these points, which I don't think have been touched upon at this point.

First, in looking at the overall NRC regulations for tailings reclamation under the radium mine tailings Radiation Control Act, it appears that an ideal reclamation is below grade, away from population on a seismically inactive site, isolated by its natural conditions from exposure to groundwater by leaching or erosion, and also prove against broaching into the air by the same forces.

The Atlas pile, on the other hand, in place represents a 110-foot-high stack of radioactive material with sides proposed for 3 to 10 or 1 to 10 grade, sitting on 70 feet of wet alluvium on the flood plain of the Colorado River, dead on top of the Moab fault, next to, the population center of Grand County with about two million visitors a year currently going by.

And I think you can probably kill that thing. I don't think that there's any problem hearing me.

In particular, the first point I want to make is

that in past rationales that have been coming forth, for example, in the documentation that went into the original EIS, and the supplemental work that appeared in the finding of no significant impact on the capping-in-place plan, there's something that looks very much to me like a neepa segmentation process taking place. That is, each one of these criteria was considered separately and a rationale as to whether or not the reclamation could be said to meet it or not, or some reason why it was not really relevant to the situation at hand was given.

There was no cumulative impact analysis done. Taking a look at, "Okay, how many breaks do we have to have go our way for this sucker to stay put?" You know, we have to have no earthquake. We have to have no major flood. We have to have a whole series. We have to continue to not find any accumulation of toxic materials from the leachate on the Colorado River and so on and so on.

I suggest that looking at all of these problems in a cumulative way is an important part of doing an adequate environmental impact statement process.

In a number of other areas we've had to deal with this issue of about segmentation under the National Environmental Policy Act. In the past there appears to have been a similar process taking place in consideration of the capping-in-place plan. Of course I invite the same

cumulative impact analysis to be applied to any alternative to the capping-in-place plan.

An issue that really hasn't been raised here so far is that in the text which I have here, I have about two pages of citations to the effect that the Moab Fault under the Atlas pile is seismically active, although it's not seismically active in the sense that San Andreas Fault or some other fault block fault is active. That is, there's slippage of rock; rock is moving along; is hanging up; and then it lets go in an earthquake.

Instead what we have is settling quake activity here, because the paradox formation salts are still moving around. And there was a study that was done for the repository at Davis Canyon possibility.

There's a six-year study done on seismic activity in the Paradox Basin, and it shows that the basin is in fact quite active seismically, but in the range of three to four-and-a-half Richter. That is not a major quake. However, a four-Richter earthquake can cause fissuring on the ground for four square miles around the epicenter. That's from the University of Utah.

And so one of the seismic geologists that wrote to us said it was his opinion that an earthquake event of that magnitude on the Moab Fault perhaps directly under the file -- pile -- was not that improbable.

So when looking at the issue of capping in place, the assumption that appeared in the Faunzie, to wit, that we are in a seismically inactive area, should be discarded, and the possibility -- the probability that the pile is located on a seismic structure which is competent to crack open a pile cap should be fully considered.

Now, it may be possible to engineer around this. Mr. Sinclair mentioned that possibility. But that should be competently done, and of course that would have an impact on the cost of capping the pile in place in a fashion that would resist a microquake of the sort that is probable at that site.

The other issue about groundwater discharges Mr. Sinclair covered very well. There's one set of questions, however, that he didn't mention that are on my list. So I'd like to bring them up, which is that I would like to have an examination done of what effect the remediation program that has taken place out there actually has had on the concentration of leachates from the test well. I haven't gotten reliable figures on this.

Talking to the NRC hydrologist that's been doing most of the work, he said that the levels were down somewhat. I don't know what "somewhat" means, and he didn't have the figures at hand at the time.

The question here is: What might we reasonably

project these groundwater remediation efforts to have as an effect? I mean historically in 1988 the test wells were showing levels between 2,000 and 5600 pica curies per liter, where the MCL, maximum concentration limit, is 33 pica curies per liter. That's a ratio somewhere between 800 to 1300 to 1 in respect to how much it was over the limit of the MCL.

And it disturbs me that the approach that had been put forward so far seems to be one of, "Well, gee, we'll do what we can, and then we'll accept whatever we end up with, no matter how much it is." This may not be quite the right procedure for going after an alternative concentration limit.

And so the whole question about bio-accumulation also should be very carefully looked at. The river may dilute the concentrates, but when I was looking at hazardous waste issues a few years earlier here, I ran across studies in respect to heavy metals at least, which showed that there was accumulation up to 10,000 times at the top of aquatic food chains of certain contaminants.

In other words, you found in the fish, the predator fish at the top of the food chain, a concentration 10,000 times that that you found in the water in which these fish were swimming because of the concentration through successive stages of plants, and then plant-eating animals,

and then animal-eating animals to the top of the food chain. And the top of the food chain happens to be what I sport-fish here. So it is relevant, and it does represent the point of exposure other than simply bathing in the Colorado River, which has been heretofore used as the point of exposure.

A couple of the other comments have dealt with the issue of the cost estimating that has been used. I'd like to just reemphasize two things, one of which is that when cost-estimating on the capping-in-place plan, in addition to coming up with cap adequate for the seismic circumstances, if that is possible, and I'm not qualified to say whether it is or not, take a hard look at the cost of getting that rock and placing it, particularly on the steep outer slopes.

Also, please consider the effect of sitting on 70 feet of wet alluvium on the integrity of a rock armor coating in the event of one of these microquakes on the Moab Fault. Because when you have 110 feet of average 28 percent water tailings sitting on top of 70 feet of wet alluvium, you have a gelid situation, which I'm told by, seismologists, acts as a amplifier to both S-waves and horizontal surface waves generated by an earthquake event. So that we are dealing here with a giant Jell-O amplifier for any kind of seismic event which increases the engineering problem of stabilizing it against such an event.

The -- on the other side of it, I think it is a good idea to look at the cost of the plan that Mel Swanson and Larry Anderson worked out for moving the Atlas pile to the Klondike Flat site, which I'm told is geophysically almost the ideal site. It's like God made it to put a tailings pile in. With the rate of percolation by measurement out there and the depth to groundwater, we're actually looking not at a thousand-year or a 10,000-year, but probably about a million-year containment there with no engineering intervention.

Also, the plan that they worked out, basically the primary details are, first, move the pile by rail, which gets traffic off the highway and provides superior safety and spillage possibilities. It does have a front-end cost of course, and moving it by truck doesn't. You have to build a 3.3 mile rail spur. You have to build a transfer station at the pile end and so on. However, once you have that investment made, then the cost per ton moved is very low by rail versus by truck, in addition to being considerably safer.

Also, the infrastructure improvements on the rail line that we put in would be for temporary purposes, and therefore, would not have to be engineered to a grade of durability that you would have to expect for something put in for a more permanent purpose.

The idea that these gentlemen had for the Klondike Flat site was to dig out a giant pit, probably around 300 acres in size, and then get the -- we were offered the ore car dumper that they got out -- they used for the vetro tailings movement. It's sitting out in Tuala County. Apparently we can haul it down here and have it.

That just takes the whole rail car and dumps it in the pit. And after the tailings are put into the pit, which is not filled even to grade, then the manko shale material that was removed, which meets lining standards I'm told by itself, be put back over in a very, very broad shallow-graded cap. The object is to get the grade down below .005, at which point you no longer have gully erosion potential. You only have sheet erosion, and you have a very thick cap. So apparently it would probably be sufficient in and of itself to be good, again, probably for more than a 10,000-year horizon, possibly for a million-year horizon, again without anything -- anyone having to muck about with it.

Last, we have heard, of course, and,are aware of the problems to be had with opening up a tailings pile. Because once you've exposed the tailings, then you have the possibility of escape of radiological material from the site. However, we are not dealing in a theoretical world. We have moved some I believe 23 tailings piles now in the

United States. Isn't that the box score about now?

And here in Utah the vetro tailings pile was moved from Salt Lake City to Tuala County by rail. And so an examination of the methods that were used and the success to suppress fugitive dust and escape of radiologic material from the site to provide for safety of workers and so on, should be carefully examined and carefully spelled out so that we know exactly what we're dealing with and how much hazard there really is in such an operation which is not new, has been done many times, and, I am told, has been done successfully without any undue exposure of risk to public health or to the workers involved in the tailings process.

So those are the things that I would like for you to look at in detail in the scoping process. And here's a copy of it.

MR. MULLINS: Thank you, Mr. Christie.

Bill Hedden. Shall we try this again?

MR. HEDDEN: Well, I'm not sure. I don't have the voice that Lance does, but I'd probably rather just talk than have that thing squealing at me, if people can hear me.

MR. MULLINS: I don't know how to make it quit squealing.

MR. HEDDEN: All right. My name is Bill Hedden. I'm a member of the Grand County Council. And the county council is preparing a detailed submittal to you, and I'm

not really going to try to give you any comprehensive overview of what we're saying in there. There's been quite a bit of that discussed already tonight.

I would like to try to give you a little bit of the flavor of how we think about this issue, though. And to start out doing that, I'd like to play what is for me an extremely unaccustomed role, and that is to act as though I were a real estate agent.

Imagine the following listing for a piece of property: "The only one of its kind. Four hundred choice acres of river front property in the west's hottest new recreation and lifestyle mecca. Adjacent to southern Utah's richest nature preserve, scant yards from Arches National Park. The only industrial property on the Colorado River in the state of Utah. Highway frontage on two state highways, convenient rail access, 11 million tons of radioactive tailings."

What's wrong with this picture? I think that in order to imagine leaving those tailings on the site, you have to imagine that that site somehow has superb characteristics for containing the waste, but in fact that's not the case at all.

I believe, and I've already seen the documents to convince me that you -- the NRC is convinced that something can be engineered there that will protect the pile from a

magnitude four earthquake that shall a depth right under the pile.

And having accomplished that, we will somehow work around the fact that the wash and the river so constrain the site that you can't flatten the out-slopes to the standards that are apparently required for the piles. So we'll allow steeper sides on the pile. We can probably hope to reroute the Moab Wash around it, even though it's a major wash aimed directly at the heart of the pile, and that it sometimes runs a major river during a flood.

We probably can even riprap the pile so that the flood waters of the Colorado washing against the base of it will not cause it all to collapse. We can't do anything about the fact that it's poisoning the groundwater. So we'll issue alternate concentration limits.

This is getting to be, in my estimation, a pretty tall pile of shaky assumptions. And it's precisely to protect us from letting short-term considerations trap us into leaving the waste at a site like that that Appendix A to 10 CFR 40 said that the right way to dispose of tailings is below-ground entombment at a suitable site with the characteristics to protect it from the human and natural environment for the long term without the need for ongoing maintenance.

We have a site like that. It's very nearby. And

what we would like to see in this EIS is that you craft the alternative superbly, the best possible way you can frame it. What is the best, safest, most efficient site out there by the airport? Don't just say the airport site, but find the best site. Analyze very carefully whether the best way to get it there is by train and building spur to get there, or whether a slurry pipeline which would keep exposures much lower and totally eliminate the possibility for highway accidents and impacts of the transportation infrastructure. Look at which alternative for getting it there is the very best way to get it there.

Fully account for the costs of leaving it in place. And I'm worried. I'm worried when you tell me that this thing is going to be done by October. October is very soon. That doesn't really give a chance to get any new information. And if you tell me that all we're going to do is torture the same old numbers again until they tell us what we want to hear, then I will lose faith in a process that I'm excited about at this point.

I think that I want to commend you on being willing to withdraw the Faunzie and open up this EIS process, but let's make it a real one. Let's compare the best possible alternative. And the county council would love to be involved in a process with you in designing those alternatives.

I think that by not doing the kind of work you need to get the information you need, you open yourselves wide up to things like in Atlas' monitoring program it was found that the worst contamination of the groundwater is that at the downstream end of the gradient near the boundary of Atlas' property. What if someone walked right across that property boundary onto the off site area, and drilled a little well and found that the groundwater was just as badly contaminated there? You're going to allow the whole thing to be sideswiped by a completely low-rent test by amateurs like that?

I think that it behooves everyone that these things be done right no matter whether that takes some time and takes some going after new information or not. So I look forward to working with you in what I hope is a really fair search for the best possible way of dealing with this.

Thank you.

MR. MULLINS: Thank you, Bill.

Walter Dabney, canyon -- Mr. Dabney, Canyonlands.

MR. DABNEY: Thank you very much, and it's great to see you here again, and thanks for the opportunity to have a chance to talk to you tonight. I want to thank you for reopening the EIS process. And the National Park Service in conjunction I'm sure with the Department of the Interior will in fact have formal comments to you by the May

13th, I think it is, deadline. And I'm here tonight just representing the parks here.

With Arches, Canyonlands, Glen Canyon, the Grand Canyon and Lake Mead, with in excess of 10 million annual park visitors to these units, either adjacent to or below the Atlas tailings pile on the Colorado River, we have a definite concern about Atlas. Those figures in visitation are going up 15 percent a year. And the life of this pile over a thousand years, there's no telling what the visitation here will be in the future. I don't know where we'd all fit.

This represents a significant benefit in the economies of not only Utah but Arizona and Nevada, bringing in millions of dollars in tourism each year. At certain times of the year in Arches National Park almost 40 percent of that visitation is European or at least foreign. Now and for the next thousand years plus, I guess, we'll have to be concerned with what is happening from the pile subtly, or what would be the actual or perceived danger if the pile was compromised by a catastrophic flood event or earthquake.

And when I say "real or perceived," the impact, even if it's perceived of something like that happening to a tourism economy, the travel agents that are selling tours come in here from Europe and that kind of thing, is just as real whether it's actual or not.

From -- we have a definite concern for the long-term concerns related not only to water quality, as you've talked about and some of the folks before me talked about, not only to the water quality in the flowing river, but to the potential of accumulation of toxics and radionuclides in river sediments and in living organisms. And we're not sure that that's been adequately addressed to this point in time.

From our understanding, most or all of piles up river on the river bank have been moved. We're very interested in the information that would be forthcoming in this EIS process that would show us why this pile would be different, and why we should leave it where it is when these others have in fact been moved.

We've submitted comments during the EA process, as you well know, and look forward to the opportunity to participate with you in examining this, I think, extremely important issue to this part of the country in a more detailed manner. I thank you for being here. And certainly as a representative of the Department of Interior National Park Service, I thank you for responding to ours and others' requests that we reopen the IS process.

Thank you.

MR. MULLINS: Thank you, Walter.

The information of the audience -- the National

Park Service has asked to work with us as a participating agency on this EIS, and we'll be meeting with them towards the end of the month to see exactly what kind of structure that participation might take.

That would be in addition to the type of normal coordination and review that the draft statement would get from our EPA friends or the Department of Interior or any of the other agencies that traditionally review those kinds of things.

Those are the ones that I have listed that indicated they would like to speak. We have time if anyone would like to --

MR. HOLONICH: The gentlemen who passed.

MR. GILLEN: The guy who passed.

MR. MULLINS: Yeah.

MR. HOLONICH: The gentleman who passed, would he like to speak?

MR. FREEMAN: My name is Curtis Freeman, and I would just like to comment that I worked at Atlas for 15-and-a-half years out here, and I have -- I was there when it began, and I was there 15-and-a-half years. And I've been in the uranium game for about 35 years. And I don't understand what the big issue is on this tailings pond at this time, because it has been there. If there's any waste going down the river, it's already gone, as far as I'm

concerned.

The next question I want to ask: If we move it to Timbuktu, what is the possibility of a subdivision being built over the top of it? As they say, they wanted it on the level and so forth. And the way our population is increasing, within the next hundred years supposedly, I look for this flat to be covered with dwellings. So what is the advantage of moving it out there and having those people exposed?

And then talking about the groundwater, there's groundwater out in that vicinity that would be contaminated just as much as what we're contaminating in the river. That is my feelings. And I'd like to see it kept in place. Thank you.

MR. MULLINS: Thank you, sir. Is there anyone else that would like to speak or address the issues that we have tonight?

I will put a sheet outside there on the table where the handouts were, and I guess they're still out there. If you would like a copy of the transcript of the meeting tonight, if you'll make sure that your name and address is put on there very legibly so that I can read them when I get back home, we'll be glad to send you a copy of the transcript.

That's it. Thank you.

With that, the meeting is over, and we appreciate you all letting us come into town and listen to you.

[Whereupon, at 8:30 p.m., the meeting was concluded.]

REPORTER'S CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission
in the matter of:

NAME OF PROCEEDING: Meeting with NRC and Citizens and Local Area Politicians

DOCKET NUMBER:

PLACE OF PROCEEDING: Moab, UT

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Karen Samuel

Official Reporter
Ann Riley & Associates, Ltd.

40-3453

APR 25 1994

Mr. Roger L. Kroodsma
Environmental Assessment Group
Oak Ridge National Laboratory
Bldg. 1505, MS-6038, Rm 388
P.O. Box 2008
Oak Ridge, Tennessee 37831-6038

Dear Roger:

Enclosed is a copy of the transcript of the Scoping Meeting held in Moab, Utah, on April 14, 1994, for the Atlas uranium mill Environmental Impact Statement. Copies of the presentations made by Mr. Sinclair and Mr. Christie at the Scoping Meeting are included.

Also enclosed is a copy of the reference list you requested some time ago, which is a compilation of reference material used by the U.S. Nuclear Regulatory Commission. The fourth enclosure is a write-up on the groundwater situation at the Atlas facility which can be used for general background orientation for your reviewer.

Please call me at 301-504-2578 if you have questions or comments.

Sincerely,

/s/

Allan T. Mullins
Project Manager/Technical Monitor
High Level Waste and
Uranium Recovery Projects Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosures: As stated

cc: (w/o encls.)
D. Gillen
D. DeMarco

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APR 25 1994

Mr. Scott Mernitz
11920 W. 68th Avenue
Arvada, Colorado 80004

Dear Mr. Mernitz:

As you requested, enclosed is a copy of the transcript of the Scoping Meeting held in Moab, Utah, on April 14, 1994, for the Atlas uranium mill Environmental Impact Statement (EIS).

We appreciate you taking your time to participate in the scoping process for the EIS. Public participation will help produce a more complete environmental assessment for the project.

Sincerely,

/s/

Allan T. Mullins, Project Manager
High Level Waste and
Uranium Recovery Projects Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

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APR 25 1994

Mr. Richard B. Robertson
431 E. Minor Ct.
Moab, Utah 84532

Dear Mr. Robertson:

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Sincerely,

/s/

Allan T. Mullins, Project Manager
High Level Waste and
Uranium Recovery Projects Branch
Division of Waste Management
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APR 25 1994

Mr. Gary Hazen
P.O. Box 422
Moab, Utah 84532

Dear Mr. Hazen:

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Sincerely,

/s/

Allan T. Mullins, Project Manager
High Level Waste and
Uranium Recovery Projects Branch
Division of Waste Management
Office of Nuclear Material Safety
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APR 25 1994

Mr. Jack Campbell
CUSR Box 1903
Moab, Utah 84532

Dear Mr. Campbell:

As you requested, enclosed is a copy of the transcript of the Scoping Meeting held in Moab, Utah, on April 14, 1994, for the Atlas uranium mill Environmental Impact Statement (EIS).

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Sincerely,

/S/

Allan T. Mullins, Project Manager
High Level Waste and
Uranium Recovery Projects Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

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APR 25 1994

Mr. Ken Davey
840 Mill Creek
Moab, Utah 84532

Dear Mr. Davey:

As you requested, enclosed is a copy of the transcript of the Scoping Meeting held in Moab, Utah, on April 14, 1994, for the Atlas uranium mill Environmental Impact Statement (EIS).

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Sincerely,

/S/

Allan T. Mullins, Project Manager
High Level Waste and
Uranium Recovery Projects Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

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APR 25 1994

Mr. Anthony J. Thompson
Shaw, Pittman, Potts, and Trowbridge
2300 N Street, N.W.
Washington, DC 20037-1128

Dear Mr. Thompson:

As you requested, enclosed is a copy of the transcript of the Scoping Meeting held in Moab, Utah, on April 14, 1994, for the Atlas uranium mill Environmental Impact Statement (EIS).

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Sincerely,

/S/

Allan T. Mullins, Project Manager
High Level Waste and
Uranium Recovery Projects Branch
Division of Waste Management
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APR 25 1994

Mr. Duran Atkins
532 Cliffview Drive
Moab, Utah 84532

Dear Mr. Atkins:

As you requested, enclosed is a copy of the transcript of the Scoping Meeting held in Moab, Utah, on April 14, 1994, for the Atlas uranium mill Environmental Impact Statement (EIS).

We appreciate you taking your time to participate in the scoping process for the EIS. Public participation will help produce a more complete environmental assessment for the project.

Sincerely,

/s/

Allan T. Mullins, Project Manager
High Level Waste and
Uranium Recovery Projects Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosure:
As stated

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M/12 NLX(?)

May 4, 1994

HLUR:ATM
Docket No. 40-3453

MEMORANDUM FOR: Docket File No. 40-3453

FROM: Allan T. Mullins, Project Manager

SUBJECT: REVIEW OF LAND USE SURVEY REPORT FOR ATLAS' MOAB MILL, 1993

By letter dated March 28, 1994, Atlas Corporation (Atlas) submitted the results of the annual land use survey for 1993 for the area within two miles of the Moab Mill. The staff review of the licensee's submittal indicated the following major points:

1. One new residence is under construction (SE 1-2 mile quadrant).

2. No new wells have been constructed.

3. Grazing continues within the ESE half mile quadrant. Approximately 30 head of cattle grazed in this quadrant during the winter months.

4. There was one family garden in the ESE 1-2 mile quadrant.

5. Construction is underway in the ESE 1-2 mile quadrant for a Recreation Vehicle Park.

6. Population within the two mile area has remained constant at approximately 237, with 220 in the SE 1-2 mile quadrant.

The staff concludes that Atlas has performed an acceptable land use survey as required by License Condition No. 47 of Source Material License SUA-917. No further action is necessary at this time.

Allan T. Mullins
Project Manager

40-3453

MAY 11 1994

Duplicate letter sent
see attached addressee list

Dear :

Enclosed is a copy of the transcript for the Scoping Meeting on the Atlas uranium mill Environmental Impact Statement (EIS) which was held in Moab, Utah on April 14, 1994. Information provided during the meeting and any submittals of written comments received by May 13, 1994, will be considered in defining the scope of the EIS. Oak Ridge National Laboratory is contracted to produce the Atlas EIS and will compile and assess the comments received during the scoping process. We will keep you informed of activities and progress as the EIS process continues and appreciate your interest and assistance.

Feel free to call me at (301) 415-6693 if you have any questions or comments.

Sincerely,

Allan T. Mullins, Project Manager
High-Level Waste and Uranium
Recovery Projects Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosure:
As stated

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Addressee List for Duplicate Letter dated: MAY 1 1 1994

Peter Haney
Grand County Council
125 East Center
Moab, Utah 84533

Bill Hedden
Grand County Council
125 East Center
Moab, Utah 84533

Milton Lammering
U.S. Environmental Protection Agency
Region VIII
999 18th Street, Suite 500
Denver, Colorado 80202-2405

Noel Poe, Superintendent
Arches National Park
National Park Service
P.O. Box 907
Moab, Utah 84532

40-3453

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

MAY 18 1994

Dr. Jonathan P. Deason
Energy Facilities Division
Office of Environmental Policy and Compliance
U.S. Department of Interior
1849 C Street, N.W.
Mail Stop 2340
Washington, D.C. 20240
Attn: Ms. Lillian K. Stone

Dear Dr. Deason:

Confirming discussions during the meeting between U.S. Nuclear Regulatory Commission staff and representation from the U.S. Department of the Interior (DOI), held on May 16, 1994, please arrange a meeting between representatives from DOI and NRC to further discuss participation by DOI in the Environmental Impact Statement (EIS) which is in preparation by NRC on the reclamation of the Atlas Corporation's Uranium Mill Facility at Moab, Utah. Letters are in preparation to the U.S. Bureau of Land Management and the U.S. National Park Service confirming their status as cooperating agencies in the EIS process.

We suggest a date of June 1 or 2, 1994, in DOI's office in Washington for the meeting. Comments or questions should be addressed to Allan T. Mullins, Atlas Project Manager, of my staff at 301-415-6693.

Sincerely,

Joseph J. Holonich

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

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

MAY 23 1994

Ms. Lillian K. Stone, Chief
Energy Facilities Division
Office of Environmental Policy and Compliance
U.S. Department of the Interior
1849 C Street, NW
Mail Stop 2340
Washington, DC 20240

Dear Ms. Stone:

I have sent you under separate cover copies of the information discussed and requested by you in our meeting on May 16, 1994. This included the letters received on the Environmental Assessment (EA) for the reclamation plan for the Atlas Moab uranium mill. As agreed in our meeting on May 16, 1994, those letters received from individuals, which did not offer technical information, were not included.

The EA was prepared by the Nuclear Regulatory Commission and noticed in the Federal Register (FR) on July 20, 1993, with a Finding of No Significant Impact (FONSI). This FONSI was rescinded by notice in the FR on October 8, 1993. An intent to prepare an EIS was noticed in the FR on March 30, 1994. Copies of these FR notices were also included in the package sent to you.

Finally, I included 1) a copy of the transcript of the scoping meeting for the Environmental Impact Statement (EIS) on the Atlas uranium mill which was held in Moab, Utah, on April 14, 1994, and 2) copies of the letters sent to the Atlas Corporation by NRC requesting additional information related to the technical assessment of the reclamation plan.

We are preparing letters to the National Park Service and the Bureau of Land Management confirming their cooperating agency status in the preparation of the EIS. We are also planning to draft a Memorandum of Understanding among the parties and will provide that for your coordination and review when it is completed. A copy of the May 16, 1994, Meeting Summary is enclosed.

In response to your inquiry as to whether NRC would provide travel funds for the participants, we have determined that under the guidelines in 40 CFR 1501.6(b)(5), that a cooperating agency normally uses its own funds. We believe it appropriate in the present situation that each agency provide its own resources.

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Please arrange a meeting among the interested parties in your offices to further discuss our mutual concerns and plans.

We appreciate your efforts and look forward to working with the U.S. Department of the Interior in the preparation of the EIS on the Atlas Moab uranium mill.

Sincerely,

/s/

Allan T. Mullins, Project Manager
High-Level Waste and Uranium
Recovery Projects Branch
Division of Waste Management
Office of Nuclear Material
Safety and Safeguard

Enclosure: As stated

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May 16, 1994 MEETING SUMMARY

ATTENDEES;

U.S. NUCLEAR REGULATORY COMMISSION

Joseph Holonich
Dan Gillen
Allan Mullins
Tom Combs

U.S. DEPARTMENT OF INTERIOR

Kerry Moss, NPS, Denver
Kenneth Havran, DOI, Washington
Marcia Moore, BLM, Washington
Noel Poe, NPS, Moab
Dan Kimball, NPS, Fort Collins
Lillian Stone, DOI, Washington
Chris Turk, NPS, Denver
Brette Bates, NPS, Washington

PURPOSE:

The U.S. Department of Interior (DOI) requested the meeting to discuss:

1) the requests by the National Park Service (NPS) and the Bureau of Land Management (BLM) to be cooperating agencies in the Environmental Impact Statement (EIS) being prepared by the Nuclear Regulatory Commission for the tailings reclamation plan for the Atlas Corporation's uranium mill at Moab, Utah.

2) the role of NPS and BLM in the EIS process as cooperating agencies.

DISCUSSION;

The U.S. Nuclear Regulatory Commission staff opened the meeting by having the individual attendees introduce themselves. The status of the EIS preparation activities was described by NRC (Oak Ridge National Laboratory is contracted for the work). NRC described the process used in evaluating and considering alternatives to proposed actions. In a licensing action, NRC is not necessarily selecting the best alternative from among the ones evaluated. As long as the licensee-proposed site complies with NRC's regulations and is found satisfactory in the environmental evaluation, another site, although environmentally better, would not necessarily be selected.

Lillian Stone (DOI) indicated that she would be the point of contact and would undertake to distribute material for their involvement. Information was identified that will be provided to DOI for their use. Ms. Stone will arrange a meeting in the near future in DOI's offices in Washington at which the roles for the cooperating agencies will be better defined.

The potential degradation of the Colorado River from leaching of contaminated groundwater from the alluvium was discussed. NRC indicated that river water analyses to date had not identified a measurable level of contamination entering the river and that further sampling and analysis did not appear to be warranted. This appeared to be an open issue which will have further discussion and evaluation.

Enclosure

DOI asked whether NRC could provide travel money for the cooperating agencies. NRC agreed to take the request under advisement (DOI has since been informed that the cooperating agencies should use their own funds).

DOI indicated that a Memorandum of Understanding among the parties was very desirable and was their normal procedure. NRC committed to providing a draft for review and comment. NRC agreed to prepare letters to NPS and BLM to confirm their status as cooperating agencies in the EIS.

We appreciate your efforts and look forward to working with the U.S. Department of the Interior in the preparation of the EIS on the Atlas Moab uranium mill.

Sincerely,

Allan T. Mullins, Project Manager
High-Level Waste and Uranium
Recovery Projects Branch
Division of Waste Management
Office of Nuclear Material
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40-3453

MAY 26 1994

William Lamb
Associate State Director
Bureau of Land Management
324 South State Street
Salt Lake City, Utah 84111-2303
Attn: Gregg Thayne

Dear Mr. Lamb:

SUBJECT: INVITATION TO BUREAU OF LAND MANAGEMENT TO BE COOPERATING AGENCY IN ATLAS ENVIRONMENTAL IMPACT STATEMENT

Confirming discussions between Nuclear Regulatory Commission staff and representatives of the Department of Interior (DOI) at a meeting on May 16, 1994, the Bureau of Land Management (BLM) is invited to be a cooperating agency in the preparation of the Environmental Impact Statement (EIS) on the tailings reclamation plan for the Atlas uranium mill at Moab, Utah. The National Park Service will also be a cooperating agency in this endeavor.

Lillian Stone, DOI, Washington, DC, will be the coordinator and principal point-of-contact for DOI. Allan Mullins of my staff, will be the Project Manager and principal point-of-contact for NRC on the EIS and may be reached at (301) 415-6693.

We look forward to working with BLM on this project.

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

cc: See next page

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William Lamb
Associate State Director
324 South State Street
Salt Lake City, Utah 84111-2303
Attn: Gregg Thayne

Dear Mr. Lamb:

SUBJECT: INVITATION TO BLM TO BE COOPERATING AGENCY IN ATLAS EIS

Confirming discussions between Nuclear Regulatory Commission staff and representatives of the Department of Interior (DOI) at a meeting on May 16, 1994, the Bureau of Land Management (BLM) is invited to be a cooperating agency in the preparation of the Environmental Impact Statement (EIS) on the tailings reclamation plan for the Atlas uranium mill at Moab, Utah. The National Park Service will also be a cooperating agency in this endeavor.

Lillian Stone, DOI, Washington, DC, will be the coordinator and principal point-of-contact for DOI. Allan Mullins of my staff, will be the Project Manager and principal point-of-contact for NRC on the EIS and may be reached at (301) 415-6693.

We look forward to working with BLM on this project.

Sincerely,

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

cc: Lillian Stone, DOI
Marcia Moore, BLM

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125 East Center
Moab, Utah 84533

William Sinclair, Director
Division of Radiation Control
State of Utah
168 North 1950 West
Salt Lake City, Utah 84115-4850

Noel Poe, Superintendent
Arches National Park
National Park Service
P.O. Box 907
Moab, Utah 84532

Ms. Lillian K. Stone, Chief
Energy Facilities Division
Office of Environmental Policy and Compliance
U.S. Department of the Interior
1849 C Street, NW
Mail Stop 2340
Washington, DC 20240

Marcia Moore
W0760
Bureau of Land Management
1849 C Street, NW
Washington, DC 20240

Milton K. Lammering
U.S. Environmental Protection Agency
Region VIII
999 18th Street, Suite 500
Denver, Colorado 80202-2405

Mr. Robert M. Baker, Regional Director
Rocky Mountain Region
National Park Service
U.S. Department of the Interior
12795 Alameda Parkway
P.O. Box 25287
Denver, Colorado 80225-0287

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

40-3453

Mr. Robert M. Baker, Regional Director
Rocky Mountain Region
National Park Service
U.S. Department of the Interior
12795 Alameda Parkway
P.O. Box 25287
Denver, Colorado 80225-0287

Dear Mr. Baker:

SUBJECT: DESIGNATION OF NATIONAL PARK SERVICE AS COOPERATING AGENCY IN ATLAS ENVIRONMENTAL IMPACT STATEMENT

The Nuclear Regulatory Commission is preparing an Environmental Impact Statement (EIS) for the tailings reclamation plan for the Atlas Corporation's uranium mill at Moab, Utah. Your letter of March 24, 1994, stated that the National Park Service (NPS) is an agency with jurisdiction by expertise and would like to be a cooperating agency in this action. Confirming discussions held at the recent meeting between the U.S. Department of Interior (DOI) and NRC on May 16, 1994, the NPS as well as the Bureau of Land Management, will be cooperating agencies in the preparation of the EIS.

Lillian Stone was designated as the principal point of contact for DOI and is arranging for a follow-up meeting in DOI's Washington offices to discuss plans for the future work.

We appreciate the assistance which the NPS has provided in the past to NRC staff in our work at the Atlas site and look forward to working with NPS in the future on the EIS. If you have any questions or comments, please call Allan Mullins, the NRC Project Manager, 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

cc: See next page

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Central File

40-3453

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

JUN 0 6 1994

Mr. Greg Wingard
Dawn Watch
P.O. Box 17366
Seattle, WA 98107-1066

Dear Mr. Wingard:

SUBJECT: RESPONSE TO MAY 13, 1994, LETTER ON ATLAS URANIUM MILL

I am responding to your letter to Mr. James M. Taylor, Executive Director for Operations, dated May 13, 1994, regarding the Atlas Corporation (Atlas) Uranium Mill located near Moab, Utah. In that letter, you raised several questions regarding the release of materials from the mill site. You specifically asked about the actions the U.S. Nuclear Regulatory Commission staff had taken in response to the allegations of contaminated salvage and scrap materials being shipped from the Atlas site. Of particular concern to you, was the fact that you did not receive notification of actions taken by the NRC staff in response to the release of material. You also requested information on the actions the staff were taking to remove the material that was shipped to the State of Washington from there, and to address the actions taken by Atlas. In addition, you raised a concern about the need to require an independent verification of materials leaving decommissioned uranium mill sites.

I would like to respond to your concerns by first noting that although some of the material removed from the Atlas site was slightly contaminated above release limits, all items that have been surveyed indicate that they do not present a threat to public health and safety. Please be aware that the discovery of material that did not meet release criteria was made before the alleger, who is the admitted perpetrator, gave an interview to a Salt Lake City television station. Contaminated material had been detected at several locations, and the origin of that material was being researched at the time of the allegation. The staff did not, however, understand the full scope of the issue until the alleger was interviewed.

Once the NRC had sufficient information on the scope of the issue, an initial inspection of this allegation was conducted by staff from NRC's Uranium Recovery Field Office. That inspection revealed that although the radiation control program was in compliance with regulatory requirements, there were deficiencies in the procedures used to implement the program. Therefore, the first action taken by the staff was to obtain a commitment from Atlas to stop shipment of salvage and scrap from the site pending development and implementation of upgraded and revised procedures that had been approved by the NRC. Following the staff's review and approval of the revised procedures, the licensee was allowed to resume release of decontaminated metal. Subsequent inspections have confirmed the adequacy of the new radiation control procedures, as well as their effective implementation. The NRC's Office of Investigation is still evaluating the circumstances surrounding the

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license violation and, therefore, has not determined if any fine or criminal penalties are appropriate.

As to your concern about the staff not providing you with notification of the shipment of material from the Atlas mill to the State of Washington, the NRC does not notify individuals of these types of matters unless there is reason to believe that they might have been directly exposed to material that is radioactive above regulatory limits, or otherwise harmful to them. Because the contamination present on the Atlas material did not result in any health and safety concern, the staff did not believe that it was necessary to inform any single individual. However, the public was amply informed through press releases from NRC and States, and the story received significant attention in the news media throughout the United States.

You are correct that the staff is not sure that it has identified all material released from the site during the time that the perpetrator worked at the mill. All of the States, where shipping records indicate material may have gone, have been notified and they are responsible for any efforts in their States. The staff has been informed by all affected States that they are taking measures to assure that contaminated material is either being decontaminated or returned to Atlas. Shipping records also indicate that some of the scrap steel went to Japan for steel processing, and there is a possibility that some of this material was slightly contaminated above release limits. As I stated earlier, based on the surveys that were conducted and the ultimate use of the material, the staff does not believe that the exposed material constitutes a threat to public health and safety.

Relative to your concern about the actions that remain in Spokane, the State of Washington's Radiation Protection Division (RPD) was notified and kept fully abreast of the situation. RPD and NRC inspectors surveyed the ball mills shipped to Washington, and detected some small areas of contamination slightly above release limits. The RPD is the proper contact for what further actions are being taken.

Finally, you state that there is little assurance "that the NRC is in control of the activities they are charged with regulating." Although the NRC and its licensees share a common responsibility to protect the public health and safety, the safe operation of any nuclear facility is the responsibility of the licensee. Licenses are issued based on independent reviews by the NRC of the ability of the licensees to discharge these responsibilities. The NRC's role is to maintain oversight of the licensee and its facility through periodic inspections and licensing reviews. Through this process, the NRC maintains its ability to ensure that the licensees for all sites are in compliance with their licenses for the release of material. If licensees were found to be in violation of their licenses, they would be subject to possible NRC enforcement action.

Your letter has been placed in the Public Document Room as will be a copy of this response. However, your comments are not germane to the scoping process and the preparation of the Environmental Impact Statement (EIS) for the Atlas mill currently underway. The issue of release of material from a site above release limits is not related to assessing alternatives for reclamation, which is the purpose of the EIS.

I trust this letter responds to your concerns.

Sincerely,

Robert J Burnett
for
Robert M. Bernero, Director
Office of Nuclear Material Safety
and Safeguards

cc: T. R. Strong, DOH, WA
William J. Sinclair, Utah DEQ
Richard Blubaugh, Atlas

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I trust this letter responds to your concerns.

Sincerely,

Robert M. Bernero, Director
Office of Nuclear Material Safety
and Safeguards

cc: T. R. Strong, DOH, WA
William J. Sinclair, Utah DEQ
Richard Blubaugh, Atlas

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I trust this letter responds to your concerns.

Sincerely,

Robert M. Bernero, Director
Office of Nuclear Material Safety
and Safeguards

cc: T. R. Strong, DOH, WA
William J. Sinclair, Utah DEQ
Richard Blubaugh, Atlas

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JUN 1 0 1994

Ms. Lillian K. Stone, Chief
Energy Facilities Division
Office of Environmental Policy and Compliance
U.S. Department of the Interior
1849 C Street, NW
Mail Stop 2340
Washington, DC 20240

Dear Ms. Stone:

SUBJECT: MEETING SUMMARY - DOI/NRC MEETING ON ATLAS EIS

Enclosed is a copy of the Agenda and Meeting Summary for the meeting held between U.S. Nuclear Regulatory Commission staff and representatives of the Department of Interior. The purpose of the meeting was to discuss participation of the National Park Service and the Bureau of Land Management as cooperating agencies in the Environmental Impact Statement which is being prepared by NRC on the reclamation plan for the Atlas Corporation's uranium mill at Moab, Utah.

Any questions or comments should be addressed to me at (301) 415-6693.

Sincerely,

Allan T. Mullins, Project Manager
High-Level Waste and
Uranium Recovery Projects Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosures: As stated

cc: See attached list

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JUN 1 0 1994

Ms. Lillian K. Stone, Chief
Energy Facilities Division
Office of Environmental Policy and Compliance
U.S. Department of the Interior
1849 C Street, NW
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Dear Ms. Stone:

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Any questions or comments should be addressed to me at (301) 415-6693.

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Division of Waste Management
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Enclosures: As stated

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JUNE 1, 1994 MEETING SUMMARY

ATTENDEES;

U.S. NUCLEAR REGULATORY COMMISSION

Allan Mullins
Roger Kroodsma, ORNL

U.S. DEPARTMENT OF INTERIOR

Marcia Moore, BLM, Washington
Noel Poe, NPS, Moab
Lillian Stone, DOI, Washington
Bob Sulenski, BLM, Washington
Ken Mittelholtz, EPA, Washington

PURPOSE:

This was a planning meeting (agenda enclosed) with representatives of the U.S. Department of Interior (DOI) regarding the Environmental Impact Statement (EIS) for the reclamation plan for the Atlas Corporation's (Atlas's) uranium mill tailings at Moab Utah. This EIS is in preparation by Oak Ridge National Laboratory for the U.S. Nuclear Regulatory Commission. The National Park Service (NPS) and the Bureau of Land Management (BLM) are cooperating agencies in the (EIS) and their roles needed to be defined.

DISCUSSION;

The U.S. Nuclear Regulatory Commission staff opened the meeting by providing a discussion of the background and history of the Atlas project. The status of the EIS preparation activities was described by NRC. NRC described the process used in evaluating and considering alternatives to proposed actions. In a licensing action, NRC is not necessarily selecting the best alternative from among the ones environmentally evaluated. As long as the licensee-proposed site complies with NRC's regulations, and is found satisfactory in the environmental evaluation, another site, although environmentally superior, would not necessarily be selected.

NRC committed to providing milestone dates for the EIS within the next 10 days. The schedule for completion of the draft EIS is September 1, 1994. DOI representatives agreed to a two week time for review of sections of the draft which will be provided to all reviewers as they are completed.

The potential degradation of the Colorado River from leaching of contaminated groundwater from the alluvium was discussed. NRC indicated that river water analyses to date had not identified a measurable level of contamination entering the river and that further sampling and analysis did not appear to be warranted.

A copy of the June 1, 1994, response from Atlas to NRC's requests for information was provided to DOE. DOI requested an additional copy.

The representative from the Environmental Protection Agency (EPA) offered to provide a review of the draft EIS sections on the same basis as DOI if NRC believed it desirable. NRC stated that EPA would receive an answer but that the early review would probably not be needed.

BLM stated that additional information for the alternative site would probably be needed to support their assessment and that they would provide a list. They advised that Atlas should file an application to BLM for the alternative site land.

NPS requested that NRC provide a response to their letter of May 10, 1994, which provided NPS' concerns with respect to the NRC's Atlas licensing activity. NRC stated that the issues raised in the letter would be addressed in detail in the EIS but agreed to provide a general response.

NRC indicated that a formal technical advisory committee on groundwater would not be needed. Informal periodic meetings of the EIS participants could serve the same purpose.

MEETING WITH NRC MOAB URANIUM MILL
AGENDA
June 1, 1994

Room 2278 DOI Building

1. Brief general overview.

2. Description of the Scope of Work for EIS preparation.

3. Review of EIS preparation schedule and milestones.

4. Cooperating agency role definition and due dates to receive input.

5. Description of any new studies under preparation.

6. EIS information discussion:

   a. Effects on groundwater-groundwater standards.

   b. Data needs for impacts to aquatic and terrestrial biota.

   c. NPS concerns as outlined in Scoping Memo dated May 10, 1994, and proposed response.

   d. Alternative sites.
      level of assessments.
      transportation routes.

   e. Identification of borrow sites (source).
      amounts of borrow materials used.
      probable haul routes.
      description of activities on BLM lands.

   f. Authorizations/permits for project.

      BLM-alternate sites: borrow materials.
      NPS-none.
      Corp of Eng.- Section 404 permits.
      EPA-none.

   g. Any applicable information available from DOE experiences.

   h. Feedback on use a technical advisory committee on groundwater?

1 1 0 1994

cc's for Letter Dated: ______________________________

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410-3153

MEMORANDUM FOR: Joseph J. Holonich, Chief
High-Level Waste and Uranium
Recovery Projects Branch
Division of Waste Management/NMSS

FROM: Michael J. Bell, Chief
Engineering and Geosciences Branch
Division of Waste Management/NMSS

SUBJECT: ATLAS CORPORATION'S REQUEST FOR RADON MONITORING VARIANCE

Atlas Corporation (Atlas) requested by letter dated May 17,1994, that the Nuclear Regulatory Commission continue to allow for a variance at monitoring station S2. Atlas also requested approval of a maximum concentration above background of 3 pCi/l radon (Rn-222) at monitoring stations S1 and S3. These stations are at the mill site boundary and indicate effluent releases to the unrestricted area.

The variance was granted January 6, 1993, to allow a maximum annual limit of 6 pCi/l Rn-222 at monitoring station S2. Biannual submittal of justification for maintaining this variance was required in license condition No. 49(F); the next submittal due before September 10, 1994.

At the time the variance was granted, 10 CFR Part 20 Appendix B, Table II limited Rn-222 for unrestricted areas to 3 pCi/l, but Section 20.106(b) allowed the Commission to approve proposed higher limits under certain conditions. The 1992 Atlas submittal provided justification that these condtions were met. However, under the new Part 20 that was effective January 1, 1994, Section 20.1302(c) allows approval of effluent values adjustments only to take into account the actual physical and chemical characteristics of the effluents. Also, the new Appendix B has a lower limit (0.1 pCi/l) for Rn-222 effluent concentration.

NRC staff have determined that license condition 49(F) should be deleted the next time the license is revised. Also, Atlas should be advised to demonstrate compliance with 20.1302(b)(1) (annual dose limit to the individual likely to receive the highest dose from the operation), if they can't comply with 20.1302(b)(2) (effluent limits in Table 2 of Appendix B).

Michael J. Bell, Chief
Engineering and Geosciences Branch
Division of Waste Management/NMSS

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September 30, 1994

MEMORANDUM TO: Joseph J. Holonich, Chief
High-Level Waste and Uranium
Recovery Projects Branch
Division of Waste Management/NMSS

FROM: Michael J. Bell, Chief
Engineering and Geosciences Branch
Division of Waste Management/NMSS

SUBJECT: ATLAS URANIUM MILL - GEOMORPHIC QUESTIONS AND COMMENTS

In accordance with your recent request, we have completed our 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.

Our review indicates that erosion and depositional processes in the site area have not been adequately explained or quantified. The report provides some geomorphic observations, but does not provide a definitive technical basis for concluding that the design meets the requirements of 10 CFR 40 Appendix A. The staff concludes that a significant amount of additional information and analyses will be needed to complete our review. Questions and comments documenting our review and the need for additional information are enclosed.

This review was performed by Ted Johnson and Phil Justus. If you have any questions, they may be reached at 415-6658 and 415-6745, respectively.

Attachment: As stated

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NAME	TJohnson/wd		KMcConnell		MBell					
DATE	09/28/94		09/29/94		09/30/94				/ /94	

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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 in a 1000-year period. 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 over the next 1000 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.

October 17, 1994

MEMORANDUM TO: Joseph J. Holonich, Chief
High-Level Waste and Uranium
Recovery Projects Branch
Division of Waste Management/NMSS

FROM: Michael J. Bell, Chief
Engineering and Geosciences Branch
Division of Waste Management/NMSS

SUBJECT: ATLAS URANIUM MILL - ADDITIONAL QUESTIONS AND COMMENTS

In accordance with your recent request, we have reviewed surface water hydrology and erosion protection aspects of information submitted by Atlas, dated January 1992; January 1994; May 1994; and June 1994. Much of this information was submitted in response to recent NRC questions and comments. Based on our review of these documents, we conclude that the proposed reclamation plan should be revised and that additional information and analyses are needed from the licensee. Questions and comments documenting our review are attached.

This review was performed by Ted Johnson. If you have any questions, he may be reached at 415-6658.

Attachments: As stated

cc: A. Mullins, HLUR, w/attach.
D. Gillen, HLUR, w/attach.

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DATE	10/17/94		10/17/94		10/17/94		/ /94	

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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.

Attachment

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. <u>Design of Riprap for Southwest Drainage Channel</u>

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 along 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.

October 18, 1994

MEMORANDUM TO: Joseph J. Holonich, Chief
High Level Waste and Uranium
Recovery Branch
Division of Waste Management/NMSS

FROM: Michael J. Bell, Chief
Engineering and Geoscience Branch
Division of Waste Management/NMSS

SUBJECT: EVALUATION OF THE ATLAS CORPORATION'S RESPONSE TO COMMENTS

The Atlas Corporation submitted responses, dated May 31, 1994, to the U. S. Nuclear Regulatory Commission staff comments on the 1992 Reclamation Plan dated November 29, 1993. Many of the responses by the licensee were not complete, or were not specific enough to address our concerns.

Our evaluation of the responses related to the radon attenuation model is attached. The evaluation includes a summary list of information that is required from the licensee to completely address our earlier comments. If you have any questions on the evaluation, call Elaine Brummett at 415-6606.

Attachments: As stated

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*** See Previous Concurrence**

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NAME	EBrummett		KMcConnell			MBell			
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MEMORANDUM TO: Joseph J. Holonich, Chief
High Level Waste and Uranium Recovery Branch
Division of Waste Management/NMSS

FROM: Michael J. Bell, Chief
Engineering and Geoscience Branch
Division of Waste Management/NMSS

SUBJECT: EVALUATION OF THE ATLAS CORPORATION'S RESPONSE TO COMMENTS

The Atlas Corporation submitted responses, dated May 31, 1994, to the U. S. Nuclear Regulatory Commission staff comments on the 1992 Reclamation Plan dated November 29, 1993. Many of the responses by the licensee were not complete, or were not specific enough to address our concerns.

Our evaluations of the responses related to the radon attenuation model and to cell stability are enclosed. Each evaluation includes a list of information that is required from the licensee to completely address our earlier comments. If you have any questions on the evaluation, call Elaine Brummett at 415-6606 or Daniel Rom at 415-6704.

Attachments: As stated

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NUCLEAR REGULATORY COMMISSION STAFF TECHNICAL EVALUATION OF
THE ATLAS CORPORATION MAY 31, 1994, RESPONSE
TO THE NOVEMBER 29, 1993, REQUEST FOR INFORMATION
ON RECLAMATION PLAN RADON ATTENUATION DESIGN

NRC Comment No.1 "Substantiate that ... representative parameters were used to model the radon attenuation. In particular, parameters associated with the ore and the radiological parameters ..."

The Atlas Corporation (Atlas) indicates that test samples were obtained on the pile by digging six test pits to depths of 7 to 10 feet and collecting a composite sample over the entire depth of the pit. Atlas states that three composite samples each for the fine tailings, coarse tailings, and ore is justified because each type of material is relatively homogenous. Test results demonstrate this homogeneity, as there is only a small variability (low standard deviation) for each parameter tested. As additional evidence of homogeneity, Atlas provides the annual average ore grade data on the blended ore processed at the mill from 1978 to 1984, and indicates that this processed ore represents the top 10 feet of tailings in the pile. Atlas also points out that the low-grade ore layer in the pile originated from a blended-ore stockpile and was further mixed during loading and placement on top of the tailings pile.

Atlas concludes that the tailings radium (Ra-226) concentrations reported by the laboratory are validated by calculating the concentration using the average ore grade processed through the mill. The Atlas calculation based on the ore grade, results in a 12 percent higher Ra-226 value than that calculated from the analytical results. The higher value would only increase the required (code-calculated) sandy soil radon barrier layer of the cover by 2.5 inches.

Atlas indicates that they tested three composite samples from "affected" soil (radioactive due to wind or water borne or spilled tailings, ore, and yellowcake) with the coarsest grain size because that fraction would have a conservative diffusion coefficient. Also, the coarser grain size should yield conservative results for the other physical parameters in the model.

To support the layer thickness parameter, Atlas confirms that the 200,000 cubic yards (cy) of "affected" soil in the mill area were delineated by borehole gamma logging and the 200,000 cy would be equivalent to the 16-inch thickness used in the radon attenuation model for this material. In the unlikely event that the "affected" soil layer is less than the 16 inches stipulated in the design, Altas would augment that layer with clean soil.

NRC staff determined:

a. Sampling Program

At the meeting of Atlas and NRC personnel in Denver, Colorado, on January 13, 1994, NRC staff indicated that the small number of samples tested could yield results that were not representative of the material in the cell. Concern was also expressed about testing aliquots of composited samples as there would be no indication of the variation for each parameter tested. In addition, it was

indicated that the Atlas sampling program may not be appropriate for some parameters of the radon attenuation model, such as Ra-226 concentration.

The sampling program is important because test results derived from these samples provide most of the values for the radon attenuation model. Atlas implies in the May 31, 1994, response, that each tested sample was from one test pit with the material composited over depth. This is in contrast to pages B-7, B-8, and B-101 of the June 1992 reclamation plan that describe the January 1992 sampling program. The program is described as including 36 samples from the tailings impoundment that were collected from 6 test pits. Of these samples, 3 samples were ore; 16 samples were coarse tailings; and 12 samples were of fine tailings. The samples for each type of material were composited then split into 3 samples. Nine other samples from these areas were collected for in-situ density measurements. The clean Moab Wash composite soil sample was also split into 3 samples to allow for repetitive testing; each of these was split in two. One half was used for geotechnical and the other half for radiological testing. The affected Moab Wash composite sample was treated similarly. If the sampling was done in this manner, comparing the three test results for each parameter only indicates how well the samples were mixed and how reproducible the testing was. It would not indicate the homogeneity of each type of material.

To support that the radon attenuation model parameter values based on test results are representative because each type of contaminated material is homogeneous, Atlas should document that three independent samples for each material were tested. This documentation could include sample collection and compositing procedures given to the staff that collected the samples in January 1992, and a copy of the field notes from that sampling program. If Atlas is not able to document that the sampling program was adequate, additional testing, or use of conservative values for some radon model parameters may be required (see discussion on the Ra-226 parameter below).

b. Ra-226 Concentrations

At the January 1994 meeting, NRC staff pointed out that the RADON code used to estimate the radon flux from the pile, is sensitive to the vertical distribution of Ra-226 concentration in the upper 10-16 feet (300-500 cm). The code reflects the fact that radon gas coming from Ra-226 deeper in the pile is less likely to reach the surface of the pile than radon from near-surface Ra-226, because much of the deeper radon decays to a solid daughter product before reaching the surface. If the contaminated materials in the upper 16 feet of the pile are suspected of containing widely varying Ra-226 concentrations (surface to depth), staff recommended that layers of 2-4 feet in thickness be tested for Ra-226 and modeled. Atlas has supplied average tailings Ra-226 values without regard to the vertical distribution. This is not acceptable unless the tailings Ra-226 concentration is fairly homogeneous, or a conservative value is used. Based on the ore grade data presented, and in contrast to the conclusion reached by Atlas, staff believes that Ra-226 values can vary significantly within the upper 10 feet of the tailings.

The tailings (fines and coarse combined) Ra-226 concentration estimated by Atlas from the annual average ore grade processed in the mill during the last

seven years of operation was 641 pCi/g. Atlas indicated that value is representative of the 2 million tons of tailings that comprise the top 10 feet of the cell. NRC staff used the same data and calculated that the volume-weighted value for tailings in approximately the top 2 feet (last 3 years of operation) is 976 pCi/g Ra-226, and at approximately 6-10 feet deep (ore processed 1978-1979) is 447 pCi/g Ra-226. This supports the NRC staff position that Ra-226 values can vary significantly within the upper 10 feet of tailings, and should be measured and modeled by layers instead of obtaining and using a composite (over the entire depth) value.

Windblown and mill site contaminated material (affected soil) are important, as discussed above, because they will be the top layer of contaminated material in the pile. At the January 1994, meeting, NRC staff questioned that 3 samples could represent the 200,000 cy of windblown and mill site contaminated material, especially the Ra-226 concentration. First, the mill site remediation plan indicates excavation up to 8 feet deep so the Ra-226 content could be high in these areas and where tailings slurry spillage occurred (at least three spills are documented, but these areas were not sampled). Second, page B-102 of the 1992 reclamation plan indicates that the affected soil composite sample includes material from depths below the level of planned excavation (not contaminated). If a significant volume of uncontaminated soil was included in the samples that were analyzed for Ra-226, those test values are not representative of the affected soil Ra-226 concentration.

NRC staff concludes that Atlas has not substantiated that the affected soil samples that were tested for Ra-226, are representative of the material that will be placed on the pile. For the radon model, representative sampling is best accomplished after the material has been mixed during excavation and placement on the cell. **To substantiate the radon attenuation model, Atlas should commit to provide adequate analysis of the Ra-226 concentration in the full depth of affected soil after it is placed on the pile.**

NRC Comment No.2 "... Provide the background Ra-226 concentration for soil at your site that was used for design purposes and your basis for that value ..."

Atlas states that the methods used in the reclamation plan to estimate the amount of affected soil do not rely on the existing background value for Ra-226, but on a qualitative comparison between background and contaminated levels. The 45 borehole gamma logs obtained on the mill site in 1987, are part of the May 31, 1994, submittal. Atlas states that excavation of affected soils will be based on threshold gamma radiation levels, and proposes to conduct a background radiological survey prior to implementation of the reclamation plan.

NRC staff determined:

As mentioned by NRC staff at the meeting with Atlas in January 1994, the background Ra-226 should be an average value, not the average value plus two standard deviations as stated in the reclamation plan (Specification Sections 1.14 and 5.3.3). The background value should be representative, not

maximized. The Ra-226 values used in the radon model for the contaminated materials did not include the addition of two standard deviations and neither should the soil background value. **Atlas should revise the pages in the reclamation plan that indicate the background Ra-226 level is defined as the average value plus two standard deviations, to indicate that the background level is the average measured value approved by the NRC.**

The gamma radiation method that Atlas proposes to use to estimate soil Ra-226 levels has limitations. Excavation of contamination and delineation of areas to sample for background soil can be guided by conservative gamma levels that are determined by appropriate correlations with Ra-226 analyses. But, there usually is not a good correlation between gamma meter readings and soil Ra-226 concentration in a 6-inch (15 cm) layer, at the level of concern for determining background (1 to 5 pCi/g). The background value is important since the Ra-226 soil cleanup standard is based on values above background. A soil background value of 5.5 pCi/g Ra-226 was approved for a small area of cleanup at the Atlas site in 1987. This is in contrast to recent soil analysis data from several other sites in the vicinity of the Atlas site that indicate background soil Ra-226 concentrations are between 1 and 2 pCi/g. **Atlas should submit data and obtain approval of the background Ra-226 value to be used for soil cleanup.**

The 1992 reclamation plan (Specification Section 5.3.3) indicates that gamma radiation values will also be used to determine if windblown tailings are present in the sandy soil (Moab Wash) cover borrow area. If the soil does not exceed a certain gamma level, it will be used in the sandy layer of the cover radon barrier. As indicated above, use of gamma meter readings may not be accurate enough to distinguish background levels from low-level Ra-226 contamination. This distinction is important because Criterion 6(5) of 10 CFR Part 40, Appendix A, requires that cover soils have essentially the same radioactivity as surrounding (background) surface soils. **Atlas should commit to provide Ra-226 analysis of the sandy soil after placement in the pile cover to confirm that the Ra-226 level approximates background, or demonstrate that the gamma - Ra-226 concentration correlation that will be used is adequate to distinguish background levels of Ra-226.**

NRC Comment No. 3 "The estimated long-term moisture contents of the proposed clay material and of the fine tailings are not considered acceptable. ... It is our position, based on the information that you have currently submitted, that acceptable estimates of the long-term moisture content for the fine tailings and the clay material are 20 percent and 10 percent by weight, respectively. Therefore, modify the long-term moisture contents and associated parameters in the model for the clay and fine tailings, or substantiate that your proposed values will provide reasonable assurance that the radon flux criterion will not be exceeded during the project design life."

Atlas supports the design values by stating that water is added to the clay during placement and that compaction causes a higher degree of saturation due to reduced porosity. Water is then held in the clay by capillary tension

which is high in the fine-grained Mancos Shale clay. The clay layer is protected from evapotranspiration by the overlying sandy soil and erosion protection layers of the cover. Both of these have low potential for capillary action that would draw water away from the clay layer. Atlas also states that the coarse nature of the soil-rock matrix erosion protection layer will channel runoff downward to the clay layer. Atlas concludes that their 15-bar capillary moisture test results should be acceptable based on a statement in NRC Regulatory Guide 3.64.

The 1992 reclamation plan cover design for the pile top has a radon barrier composed of 6 inches of clay which is covered by 6 inches of sandy soil in the coarse tailings area and 12 inches of sandy soil in the fine tailings area. Atlas recommends that the increased sandy soil layer thickness required by condition 41.A in the 1993 draft license (1 foot in coarse tailings area, and 2 feet in fine tailings area) be implemented. Atlas indicates, as an alternative, a reduction in the moisture contents for the fine tailings and clay in the radon attenuation model by approximately 10 percent, to provide additional confidence in the design. This would result in input values of 27.8 and 14.6 percent for the fine tailings and clay barrier soil, respectively.

NRC staff determined:

a. Capillary Moisture Test

The 15-bar capillary moisture test is one of the methods suggested in NRC Regulatory Guide 3.64, for estimating the long-term moisture content value to be used in the RADON code. There is no assurance that this method is accurate for all soil types, or that it is always performed correctly. As discussed in the July 7, 1993, NRC evaluation of the test data, this method may not provide accurate results for soils with a large fraction fine-grained material. Therefore, when capillary moisture test results are questionable, staff requires supporting evidence that can be provided by the calculation or the in situ measurement procedure that are recommended in the regulatory guide.

b. Long-Term Moisture of the Fine Tailings

NRC staff concludes that the 30 percent value proposed by Atlas for the fine tailings long-term moisture in the radon attenuation model has not been adequately justified. A moisture value of 24 percent is the maximum that can be considered based on the average in-situ measurement of 27.7 percent moisture by weight for this material, the expected long-term conditions, and measurements of similar material at other sites. **Atlas should not use a long-term moisture value for the fine tailings higher than 24 percent.**

c. Long-Term Moisture Value of the Clay

NRC staff pointed out during the January 1994 meeting, that a moisture value as high as 14.7 percent could be justified for the clay layer, if the borrow source were better characterized, and an acceptable quality control program for construction specifications were provided. This value is derived from the

SWRDAT computer code estimate and the 15-bar moisture capillary test results on the Grand Junction, Colorado Mancos shale. Atlas has indicated that their clay source is from the same shale formation.

The clay borrow source characterization is a concern to staff because Atlas indicated (response No. 11, April 1993) that the final borrow site has not been identified. Staff needs assurance, in addition to the specifications, that the test values used in the model are representative of the material that will be used in the final cover.

The specifications for placing the clay are a concern to staff because of the lack of moisture control for the clay layer during placement. The clay layer surface could dry significantly, if it is not covered by the next lift of material within a reasonable time frame, or not moisture-conditioned before the next lift of material is placed. Also, there is no assurance that the optimum moisture of the tested clay samples is representative of the value for the clay that will be placed in the cell cover.

A long-term moisture value for the clay layer of 14.7 percent by weight is acceptable only if Atlas indicates that acceptable quality control measures will be imposed to insure that the clay layer, as placed, has an average moisture content greater than 17 percent by weight. Also, Atlas should demonstrate that adequate measures will be taken during construction to prevent excessive drying of the clay layer surface.

To confirm the moisture content of the clay layer, Atlas should plan to prepare a summary sheet to document the construction of the clay in the radon barrier. The summary should list the location of the moisture and density tests, the actual water content of the clay sample, its optimum moisture content, and the volume of clay represented by the test sample.

d. Diffusion Coefficient

NRC staff mentioned at the January 1994 meeting, that the diffusion coefficient values would also need to be adjusted for the lower long-term moisture values of the fine tailings and clay. Staff determined that the code-calculated diffusion coefficient values are much more conservative (larger) in comparison to the test results provided by Atlas. Site-specific sample testing for the diffusion coefficient is acceptable, but the Atlas test values are questionable because the test samples may not be representative of the material in the pile. In any case, the measured diffusion coefficients for the fine tailings and clay (tested at a moisture of 30 and 15.5 percent, respectively) must be normalized (see NRC Regulatory Guide 3.64) to correspond to the lower moisture values required above. **Atlas should utilize fine tailings and clay diffusion coefficient values in the radon model that correspond to the approved long-term moisture values.**

NRC Comment No. 4 "Because of the previous requests for information, it will be necessary to revise the design of radon barrier thickness and submit it for review and approval. The expected performance of the revised barrier over the design life should be included in the evaluation. For example, this

should include such things as the potential for cracking and freeze-thaw effects."

Atlas agrees to increase the sandy soil layer thickness consistent with the 1993 draft license condition mentioned above. This will provide for additional moisture retention in the radon barrier portion of the cover.

Altas addresses freeze-thaw effects on the cover (also discussed in the 1992 reclamation plan) by indicating that the potential for frost heaving is low because the material below the cover is relatively free draining and will not support capillary action required for frost heaving. Atlas also indicates that the additional thickness of sandy soil over the clay will enhance the stability of the long-term moisture of the clay layer and reduce the possibility for shrinkage in the cover.

NRC staff determined:

a. Revised Radon Barrier Design

A revised radon barrier design is required as the barrier proposed for the top of the pile in the 1992 reclamation plan has been shown to be inadequate by the July 7, 1993, proposed amendment evaluation. The barrier thickness proposed in the 1993 draft license condition may not be adequate, based on the current NRC staff evaluation. Based on the current evaluation, NRC staff modeled the cover radon flux with a decrease in long-term moisture value and corresponding increase in diffusion coefficient for the fine tailings and the clay portion of the radon barrier, plus elevated Ra-226 values for the coarse tailings and affected soil. The resulting estimated radon flux exceeds the regulatory limit, even using the increased thickness of the sandy layer of the cover proposed in the 1993 draft license condition. Because of the uncertainty in some of the input parameters for the long-term radon flux estimate, and the unacceptable diffusion coefficient values for the fine tailings and clay, the design proposed by Atlas does not provide assurance that the long-term flux limit can be met.

Atlas should submit a revised radon barrier design, and obtain approval before placement of the clay layer of the radon barrier. The design should incorporate: (1) acceptable Ra-226 values for the upper coarse tailings and the affected soil, (2) approved moisture values for the fine tailings and the clay, and (3) diffusion coefficient values for the fine tailings and the clay that correspond to the approved moisture values.

b. Freeze-Thaw Effects on the Radon Barrier

Although the free-draining material within the cover system will not support capillary action, freeze-thaw events could affect the finer-grained soils in the radon barrier. Analyses can be performed using the Modified Berggren Equation, as indicated in the U.S. Army Corps of Engineers Special Report 122, titled <u>Digital Solution of Modified Berggren Equation to Calculate Depths of Freeze or Thaw in Multilayered Systems</u> (October, 1968). The procedures discussed in the reference, or other appropriate methods, should be performed to estimate the amount of freeze-thaw damage to the clay layer. **Atlas must**

confirm that the effects of freezing temperatures will not adversely affect the finer-grained soils in the radon barrier.

c. Clay Layer Stability

Based on public comment on the reclamation plan and past experience, NRC staff is concerned about the stability of the proposed 6-inch-thick clay layer of the cover. First, placement of this thin layer with large equipment would disrupt portions of the layer. Second, the integrity of the material could be compromised by areas of decreased attenuation caused by natural defects in the clay. Third, there is not adequate assurance that a continuous 6 inches would exist throughout the cover. Even minor cracking due to settlement, drying, or freeze-thaw effects, would weaken such a thin layer of clay. **Atlas should consider increasing the minimum clay thickness from 6 inches to two layers of 6 inches each, or otherwise address concerns for constructability and stability of the clay layer in the radon barrier.**

d. Model Conservatism

Although not a requirement, Atlas could make the NRC staff aware of any other conservatism in the radon attenuation model, or in the planned reclamation. For example, at the January 1994 meeting, an Atlas representative mentioned that the modeling did not include the clean dike fill, and the May 31, 1994, submittal mentions that additional "affected" soil (up to 3 feet thick) has been placed over the fine tailings. Atlas could indicate the volume and placement of the clean dike fill, and the average thickness or area of affected soil placed on the fine tailings area. This would allow NRC staff to consider the effect of these materials on the estimate radon flux from the pile. Such information could supply additional assurance that the revised design will meet the radon flux criterion.

REQUEST FOR CLARIFICATION AND INFORMATION ON
THE ATLAS RESPONSE TO RADON ATTENUATION DESIGN ISSUES

1. To support that the radon attenuation model parameter values based on test results are representative, because each type of contaminated material is homogeneous, Atlas should document that three independent samples for each material were tested.

2. To substantiate the radon attenuation model, Atlas should commit to provide adequate analysis of the Ra-226 concentration in the full depth of affected soil after it is placed on the pile.

3. Atlas should revise the pages in the reclamation plan that indicate the background Ra-226 level is defined as the average value plus two standard deviations, to indicate that the background level is the average measured value approved by NRC.

4. Atlas should submit data and obtain approval of the background Ra-226 value to be used for soil cleanup.

5. Atlas should commit to provide (or NRC staff will propose a license condition that requires) Ra-226 analysis of the sandy soil after placement in the pile cover to confirm that the Ra-226 level approximates background, or demonstrate that the gamma-Ra-226 correlation that will be used is adequate to distinguish background levels of Ra-226.

6. Atlas should not use a long-term moisture value for the fine tailings higher than 24 percent.

7. A long-term moisture value for the clay layer of 14.7 percent by weight is acceptable only if Atlas indicates that acceptable quality control measures will be imposed to insure that the clay layer, as placed, has an average moisture content greater than 17 percent by weight. Also, Atlas should demonstrate that adequate measures will be taken during construction to prevent excessive drying of the clay layer surface.

8. Atlas should utilize fine tailings and clay diffusion coefficient values in the radon model that correspond to the approved long-term moisture values.

9. Atlas should submit a revised radon barrier design, and obtain approval before placement of the clay layer of the radon barrier. The design should incorporate: (1) acceptable Ra-226 values for the upper coarse tailings and the affected soil, (2) approved moisture values for the fine tailings and the clay, and (3) diffusion coefficient values for the fine tailings and the clay that correspond to the approved moisture values.

10. Atlas must confirm that the effects of freezing temperatures will not adversely affect the finer-grained soils in the radon barrier.

11. Atlas should consider increasing the minimum clay thickness from 6 inches to two layers of 6 inches each, or otherwise address concerns for constructability and stability of the clay layer in the radon barrier.

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

October 19, 1994

MEMORANDUM TO: Joseph J. Holonich, Chief
High-Level Waste and
Uranium Recovery Projects Branch
Division of Waste Management, NMSS

FROM: Michael J. Bell, Chief
Engineering and Geosciences Branch
Division of Waste Management, NMSS

SUBJECT: STAFF REVIEW OF "NRC REQUEST FOR INFORMATION - ATLAS CORPORATION RECLAMATION PLAN, URANIUM MILL AND TAILINGS DISPOSAL AREA, MOAB, UTAH JUNE 1994:" COMMENTS AND RECOMMENDATIONS CONCERNING POTENTIAL FOR CAPABLE FAULT; POTENTIAL FOR SEISMIC AND FAULTING HAZARD; EFFECTS OF OIL/MINERAL EXTRACTION

BACKGROUND

NRC staff, Uranium Recovery Field Office, Denver, CO, requested information from the Atlas Corporation on November 29, 1993, on faulting, seismic, and geomorphic hazards issues relevant to the Atlas Corporation's reclamation plan for its mill tailings pile in Moab, Utah. Information on capable faults, seismic, and faulting hazards and effects of oil extraction was requested as follows:

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 solution and changes due to the development of oil resources."

"Please analyze the structural stability and liquefaction potential of the disposal area using current state-of-the-practice methodology...If these analyses require revisions to [Atlas's] currently proposed design, please submit the revisions for [staff] review and approval."

Atlas Corporation's responses to the request for information were sent to NRC in June 1994. Since then, various NRC staff, have observed the Atlas site and vicinity from the air, by boat, by car, and on foot, interviewed

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Utah Geological Survey geologists in the field and offices and reviewed some pertinent literature. The staff has various technical leads to follow up on, and more observations and analyses to make, so the staff's understanding of the site geology is preliminary. However, the staff considers its current level of understanding of the geology to be sufficient to credibly and constructively review the licensee's responses.

SCOPE OF THIS REVIEW

The focus of this review is on the following components of Appendix A Criteria specific to the site: a) evidence for a fault under the site; b) extent of faulting under the site; c) evidence for Moab fault being a capable fault; d) evidence for surface fault rupture, and the possibility of surface rupture at the site; e) seismic potential for faults adjacent to the site; f) potential for fault movement and subsidence due to salt dissolution at the site; g) potential for changes (e.g., surface subsidence) due to development of oil resources near the site; and h) potential effects of solution mining on the site, the Moab fault and alternative sites.

Fault tectonics, seismicity, salt tectonics-dissolution and oil/mineral drilling and extraction are processes and events that can cause potential geologic hazards. Ten potential geologic hazards have been identified for consideration (Table 2) in the reclamation plan design to effect control of radiological hazards over the next 1000 years. This review focuses on seven hazards reflected in the June 1994 Atlas response (Table 2, nos. 1 thru 6, 9).

In addition to consideration of hazards previously discussed by Atlas, this review will expand into three hazards relevant to the mill site and to alternative disposal sites: ground subsidence-small basin; effects of solution mining; and volcanic ash fall, although the latter is not considered to be of regulatory concern for this project (Table 2, nos. 6, 8, 10).

TECHNICAL APPROACH OF THIS REVIEW

The justification for requesting the information was to enable the staff to determine whether Atlas's plan is in compliance with 10 CFR Part 40, Appendix A, especially Criteria 1(A), 4(D), 5(A)(5) and 6 (see Table 1).

The loads that may be imparted by geological hazards (e.g., differential stress from fault displacement; differential subsidence; vibratory ground motion; sediment loading by slope wasting and ash fall; Table 2), among other sources, will be input to the final design of the tailings pile

and its cover and must be fully evaluated by the licensee and reviewed by the staff (SRP, 1993). Additional hazards associated with certain geomorphic and groundwater requirements are raised in separate memos.

Each of the staff's concerns on the June responses uses the following format: what are the staff's concerns (GENERAL COMMENT or REQUEST FOR INFORMATION); why is it a concern (BASIS); what are selected sources of information (REFERENCES); and what should the licensee consider doing to resolve the concern (RECOMMENDATIONS).

PURPOSE OF THIS REVIEW
The attached GENERAL COMMENTS and REQUEST FOR INFORMATION are intended to elicit clarification of licensee responses, and as needed, additional data and analyses that support demonstrations of compliance with 10 CFR Part 40, Appendix A criteria (requirements) for investigations and analyses of geological, seismological and salt tectonic-dissolution processes and events sufficient for the staff to support a licensing decision.

CLARIFICATIONS AND ADDITIONAL INFORMATION ARE NEEDED
Prior to addressing the GENERAL COMMENTS and REQUEST FOR INFORMATION, the licensee should carefully consider what importance the staff attaches to them, what level of detail the staff indicated it would find adequate, and what degree of uncertainty might be acceptable and what additional data and/or analyses might be necessary. The staff is prepared to meet, discuss and clarify these points.

The tables and attachments were prepared by Philip S. Justus, who may be contacted at 415-6745, if you should have any questions.

Table 1 and Table 2: As stated

Attachments:
1. General Comments on Potential for Capable Fault
2. General Comments on Seismic Potential, Faulting Potential, Effects of Oil Exploration
3. Request For Information On Potential Effects of Future Solution Mining

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TABLE 1

CROSSWALK OF APPENDIX A CRITERIA FOR MILL TAILINGS SITING AND DESIGN DECISIONS AND POTENTIAL GEOLOGIC HAZARDS

Criteria are Cited by Number from 10 CFR Part 40, Appendix A; Geologic Hazards are Identified by Numbers From Table 2

CRITERIA (10 CFR 40, APP. A)	[GEOLOGIC HAZARDS (Table 2)]
1(A). POTENTIAL FOR EROSION, DISTURBANCE, AND DISPERSION BY NATURAL FORCES IS MINIMAL	[1,2,3,5,6,9]
4(A). UPSTREAM RAINFALL CATCHMENT AREAS ARE MINIMAL	[none]
4(B). TOPOGRAPHIC FEATURES PROVIDE GOOD WIND PROTECTION	
4(D). OVERALL STABILITY, EROSION POTENTIAL, AND GEOMORPHOLOGY OF SURROUNDING TERRAIN MUST BE EVALUATED TO ASSURE THAT THERE ARE NOT ON-GOING OR POTENTIAL PROCESSES, SUCH AS GULLY EROSION, WHICH WOULD LEAD TO IMPOUNDMENT INSTABILITY	[5,6,9]
4(E). IMPOUNDMENT MAY NOT BE LOCATED BY A CAPABLE FAULT THAT COULD CAUSE A MAXIMUM CREDIBLE EARTHQUAKE LARGER THAN THAT WHICH THE IMPOUNDMENT COULD REASONABLY WITHSTAND	[1,2,3]
4(F). THE IMPOUNDMENT, WHERE FEASIBLE, SHOULD BE DESIGNED TO INCORPORATE FEATURES WHICH WILL PROMOTE DEPOSITION	[none]
5(A)(5). IMPOUNDMENT DIKES MUST BE DESIGNED TO PREVENT MASSIVE FAILURE	[1,2,3,5,6]
5(G)(2). SUPPLY INFORMATION ON UNDERLYING STRATA; DRILL BOREHOLES AND CONDUCT FIELD SURVEYS TO INCLUDE BOTH GEOLOGIC AND GEOPHYSICAL LOGS SUFFICIENT TO DETERMINE SIGNIFICANT DISCONTINUITIES, FRACTURES AND CHANNELED DEPOSITS OF HIGH HYDRAULIC CONDUCTIVITY; CONDUCT TEST TO DETERMINE SORPTION PROPERTIES OF UNDERLYING SOIL AND ROCK	[not a hazard, per se, but might detect hazard]
6(x). CLOSE WASTE DISPOSAL AREA WITH A DESIGN WHICH PROVIDES REASONABLE ASSURANCE OF CONTROL OF RADIOLOGICAL HAZARDS TO BE EFFECTIVE FOR 1000 YEARS, TO THE EXTENT REASONABLY ACHIEVABLE, AND IN ANY CASE, FOR AT LEAST 200 YEARS, AND LIMIT RADON RELEASES TO AN AVERAGE RELEASE RATE OF 20 PICOCURIES PER SQUARE METER PER SECOND TO THE EXTENT PRACTICABLE	[1,2,3,4,5,6,7,8,9]
6(xx). ENSURE THAT DISPOSAL AREAS ARE CLOSED IN A MANNER THAT MINIMIZES NEED FOR MAINTENANCE	[1,2,3,4,5,6,7,8,9]

TABLE 2

POTENTIAL GEOLOGIC HAZARDS IN VICINITY OF ATLAS SITE, MOAB, UTAH

1) MOAB FAULT-SLIP: fault displacement at the bedrock surface of Moab fault, whether or not it is capable, or is a salt dissolution pathway.

2) MOAB FAULT-EARTHQUAKE: vibratory ground motion from the Moab fault, whether or not it is capable, or might be subject to induced seismicity, such as from future solution mining.

3) COLORADO PLATEAU EARTHQUAKE SOURCE: vibratory ground motion from "floating" earthquake, probably on a NE- or NW-striking basement fault.

4) INDUCED (MAN-MADE) EARTHQUAKES: vibratory ground motion induced by potash solution mining, for example, swarm earthquakes attendant upon mining operations at Potash.

5) GROUND SUBSIDENCE-BROAD BASIN: broad-basin and linear-basin subsidence from salt migration or dissolution (Moab Marsh might be an example of the magnitude of such processes and events; migration of Mill and Pack Creek alluvial terraces and the Colorado River might be examples of potential consequences; Quaternary sediment-filled basins mapped in Salt Valley may be an analog). A variation of this hazard might be linear zones of salt dissolution that resulted in V-synclines, such as those exposed in Cache Valley and adjacent to the Moab fault near Little Valley.

6) GROUND SUBSIDENCE-SMALL BASIN: local sinkhole-like subsidence (collapse basins reported in Moab-Spanish Valley Might be examples; a sinkhole-like depression in Cache Valley might be an analog).

7) MASS WASTING OF CLIFF FACE: landslides, or other rock-mass movements of Triassic rocks derived from the 1000 ft escarpment next to the site, might encroach directly upon the tailings pile or disrupt the drainage near its western borders.

8) EFFECTS OF SOLUTION MINING: subsidence or induced earthquakes from potential future solution mining of soluble deposits, such as in vicinity of Bartlett Wash alternative site; along Moab fault, or near the Moab site.

9) EFFECTS OF OIL/GAS DRILLING/EXTRACTION: surface subsidence around individual boreholes or due to potential future extraction of oil or gas (deep fields in the Paradox Basin apparently do not have attendant surface subsidence).

10) VOLCANIC ASH FALL: not of regulatory concern due to great distance to sources, infrequent events, inability to assess height of eruption cloud, amount of transportable material erupted and wind direction at time of future eruptions.

GENERAL COMMENTS ON ATLAS'S RESPONSES TO STAFF'S REQUEST FOR INFORMATION (RFI) ON POTENTIAL FOR CAPABLE FAULT

RFI 1. 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:

"there is evidence that a fault runs under the disposal site. [Part 1] Evaluate the extent of faulting under the disposal site and [Part 2] determine if there is capability for surface rupture" (Hall, 1993).

GENERAL COMMENTS ON RESPONSE TO RFI 1

Staff's review of licensee's response (Woodward-Clyde, 1994) indicates that it is incomplete with regard to both parts of RFI 1, and additional analyses are required.

RFI 1, Part 1. The response to the part concerning the extent of faulting under the site, requires standard-practice field and lab investigation of faulting under the Atlas site, whether or not there is a capable fault present. Data on the extent of faulting under a specific site rarely can be derived from a literature search alone. However, when relevant published analyses of faults cropping out across the road, and railroad, from the site apparently were not considered, the evaluation was considered incomplete.

Data on faults at a site are generally expected to be obtained from detailed geologic mapping on and around the site, from borehole samples and logs, observations of surface excavations (such as from site grading, borrow pit operations, digging diversion channels), interpretation of aerial photos (comparing pre-site-development features with subsequent overflight photos) and from geophysical surveys, when practicable. When information available from some of these sources was not used to support the licensee's conclusions, the evaluation was considered incomplete.

Therefore, for these and other reasons, this request for an evaluation of the extent of faulting under the site sufficient to permit adequate engineering analysis of structural stability and liquefaction of the tailings pile is considered not to be met.

RFI 1, Part 2. The requested determination of whether there is capability for surface rupture is inadequate for at least two reasons. The licensee's conclusion that the Moab fault is not a capable fault is based upon inconclusive evidence and incomplete discussion of existing evidence. The regulatory criteria for the determination of whether or not a fault is a capable fault requires specific knowledge of a fault (for example, whether or not it moved in the last 3.5x10E4 years) and specific knowledge

of seismotectonics (for example, relationship, or lack of same, of seismic activity and stress distribution to the Moab fault or to faults that might be structurally connected to it). Uncertainties of the data and the limited data base allow alternative conclusions to be drawn. Also, no hard evidence was presented to support the licensee's conclusion that the Moab fault, whether or not it actually underlies the site, is not a capable fault.

BASIS, PART 1

There is evidence that a fault (the Moab fault) or several parallel faults (the Moab fault zone) of several thousand feet of cumulative vertical displacement exist either beneath the site, or adjacent to it on the west (Doelling, 1985; Baars and Doelling, 1987).

Numerous faults occur within one mile of the site to the north of it (Doelling, 1985). These are considered to represent tensional faults on the crest of the Moab salt-cored anticline, which underlies the Moab Valley. It is reasonable to assume that such faults, possibly continuations of those that are exposed near Arche's National Park Headquarters, might occur beneath the alluvium in the vicinity of the Colorado River, and possibly beneath the Atlas site.

The tailings pile, alluvium beneath it, Moab Marsh sediments and alluvium from Mill and Pack Creeks, apparently cover the trace of the Moab fault (exposed about 1 mi north of the site and about 4 mi south of it). The Moab fault apparently has not been observed on the Atlas site.

Aerial photographs of the Atlas site taken prior to site development, and taken at various stages of site development, from about 1950 to date, have not been scrutinized for evidence of surface faults.

A stratigraphic framework of the alluvium beneath the tailings pile has not been developed from logs of borehole data from various locations on the site. Thus, faults that may offset stratigraphic units in the alluvium may be present, but cannot be detected by borehole data analysis.

The bedrock topography beneath the tailings pile is not known because only one borehole penetrated bedrock (Embar oil test hole) and no geophysical surveys have been reported that might provide depth to bedrock information. Thus, faults that may offset the bedrock beneath the site may be present, but are undetected.

Observations of stratigraphic offsets, or the lack of them, from excavations made on site, such as soil stripping for the original

impoundment, operation of borrow pit along route 279, digging the Moab Wash diversion channel, have not been reported. Thus, faults may be present, but are undetected, or are absent.

Published results of fault investigations which include illustrations and discussions of the likelihood of significant faults (although some of the slip surfaces might be soles of landslides) occurring beneath or adjacent to the site have not been considered by the licensee in its evaluations (Doelling, 1987, 1988).

Unpublished results of fault investigations have been cited as personal communications in the licensee's responses to RFI, but such citations are not acceptable for staff consideration, because the bases cannot be reviewed by the staff or various interested parties.

BASIS, PART 2

Basis for Moab fault not being a capable fault is asserted, "...alluvial deposits of Bull Lake age ([approximately] 130,000-200,000 years) do not appear to be offset by the fault" (Woodward-Clyde, 1994). However, no basis for the assertion was provided (e.g., no location map, trench log, age determination data). Therefore, staff have no way to review the assertion and cannot accept it.

Basis for Moab fault not being a capable fault is asserted, "...Bartlett Wash area...clear exposure of Moab fault offsetting Entrada sandstone but not Quaternary deposits and evidence that pileing (sic) of late-Quaternary fine-grained sediments on the upthrown side of the fault is probably controlled by conditions unrelated to faulting" (Woodward-Clyde, 1994). However, this was cited as a personal communication and cannot be fully accepted. Also, the methods of analysis were not explained, so the staff were unable to assess the limitations of the conclusion, e.g., could an offset of as little as a few centimeters have been detected. Further, no basis for understanding the non-faulting alternative conceptual model of piling up was provided. Such a response that does not clearly show how a conclusion was reached, is inadequate.

The Lisbon fault, with a segment that might have moved in the last 1x10E4 years, has been considered to be structurally connected to the Moab fault (Woodward-Clyde, 1982). This is evidence for the Moab fault being a capable fault, or faulting in response to salt dissolution or migration. Such evidence has not been fully evaluated by the licensee.

Quaternary faulting in and near the Salt Valley and Cache Valley fault zones, which are parallel to and possibly structurally related to the Moab fault zone, might be evidence for the Moab

fault being a capable fault, or evidence for faulting in response to salt dissolution or migration. Such evidence has not been fully evaluated by the licensee.

The lowering of base level of Pack Creek in Moab Valley during the Quaternary is evidence for surface deformation by faulting along the Moab fault, or salt dissolution or migration, or some combination of processes (Oviatt, 1988). Such evidence has not been fully evaluated by the licensee.

REFERENCES

Atlas Corporation, 1994, NRC request for information - Atlas Corporation reclamation Plan, uranium mill and tailings disposal area, Moab, Utah: by Canonie Corp., June 1994.

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GENERAL RECOMMENDATIONS

Part 1. To fully evaluate the extent of faulting beneath the site for the purposes of demonstrating compliance with relevant Appendix A criteria, Atlas should consider conducting a comprehensive site investigation of scope and level of detail commensurate with the significance of the information needed.

The staff considers the elements of an adequate investigation of faulting beneath the site to include no less than the following, as practicable, to be conducted by standard practices:

* Compilation and analysis of (from field observations, when practicable, and from the work of others) a detailed geologic map, or maps, and cross sections of the site and vicinity that show the stratigraphy and the location, orientation and width of faults that have been mapped and are inferred to occur under the site or in the site vicinity. Alternative conceptualizations of such faults can be shown on supplementary maps and cross sections. The source of map and section data must be available to the staff.

* Compilation and analysis of data on site stratigraphy and stratigraphic continuity of units transected by boreholes. Use of borehole cuttings and logs would be necessary and should be available to the staff.

* Compilation and analysis of data from observations of surface excavations made on site such as from grading the impoundment, operating the borrow pit at north fence line, digging the Moab Wash diversion channel, as available. These data can be incorporated into maps and cross sections, as appropriate.

* Identification and analyses of lineaments on aerial photos of the site taken prior to grading, and, if remote sense imagery such as Landsat, Earthsat, Spot seems potentially insightful, do the same with those sources of information. The sources must be available to the staff.

* Conduct, or otherwise obtain, and analyse results of geophysical surveys in the site vicinity. The sources, such as seismic profiles and related data processing information, must be available to the staff.

* Conduct a literature search and analyse results of geological mapping that has been done in the area, and apply any relevant information to your evaluation of faulting at the site. Unpublished material must be available to the staff; personal communications are not acceptable support for license submittals.

Part 2. In order to evaluate whether or not the Moab fault is a capable fault for the purpose of demonstrating compliance with Appendix A criteria, Atlas should consider conducting a comprehensive investigation of sufficient scope and level of detail to address each criterion on which a determination of fault capability is based.

The staff considers the elements of an adequate investigation to include no less than the following, as practicable, to be conducted using standard practices:

* Documentation and analyses of maps of surficial deposits along the fault that purport to show no evidence of a fault (of any amount of displacement) having occurred once in the last 3.5x10E4 years or more than once in the last 5x10E5 years.

* Trenching, borehole drilling, and fault-age determinations, with corresponding logs and interpretations, appropriate to gather hard evidence of the age of last movement, ages of multiple movements, and of rates and magnitudes of movement. The staff considers that the surficial deposits across the Moab fault exposed at Bartlett Wash and across the projection of the fault at a borrow pit on Atlas property, are examples of appropriate targets for application of these methods of investigation.

* Consideration of the results of comprehensive investigations, including geologic, geophysical and photogrammetric, designed to identify faults and evaluate their extent at the site.

* Investigations and analyses of regional structures that might be structurally related to the Moab fault, such as the Lisbon fault, parallel or en echelon faults (Lisbon fault?; Salt Valley and Cache Valley fault zones?), northeast-trending (conjugate?) basement faults, or salt-cored anticlines that could initiate faulting of overlying rocks. Such activities are necessary in order to show whether the Moab fault has a structural association with a capable fault or other such structure; if it does, the Moab fault must be considered a capable fault.

GENERAL COMMENTS ON ATLAS'S RESPONSES TO STAFF'S REQUEST FOR INFORMATION (RFI) ON SEISMIC POTENTIAL, FAULTING POTENTIAL, EFFECTS OF OIL EXTRACTION

RFI 2. 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:

"[Part 1] evaluate the seismic potential for faults adjacent to the site, [Part 2] including the potential for fault movement due to salt dissolution and [Part 3] changes due to the development of oil resources" (Hall, 1993).

GENERAL COMMENT ON RFI 2

Staff's review of licensee's response (Woodward-Clyde, 1994; Atlas Corp., 1994) indicates that it is incomplete with regard to each of three parts of RFI 2, and additional analyses are required.

RFI 2, Part 1. The first part requires an evaluation of the seismic potential for faults adjacent to the site, the Moab fault, in particular. The licensee appropriately mentioned the controversy surrounding the depth of penetration of the Moab fault: is it shallow, rooting in salt only a few kilometers below surface (with deformation likely to be aseismic), or it is deep-seated, connected to the basement faults, some of which are seismogenic (deformation likely to be accompanied by earthquakes). The licensee concluded that the Moab fault is shallow and of 'negligible' or 'insignificant' seismicity (Woodward-Clyde, 1994).

However, supporting bases for these conclusions and an analysis of the seismic potential for faults adjacent to the site over the next 1000 years and consideration that the Moab fault is favorably oriented for movement in the existing stress field, was not provided. Therefore, without presentation of data and analyses that provide insight (transparency) into the level of seismicity that the licensee concludes is small, the staff has no basis for agreeing or disagreeing with the licensee's conclusion. Thus, the staff considers the evaluation to be incomplete, and additional analyses to support the conclusions are warranted.

RFI 2, Part 2. The second part requires an evaluation of the potential, over the next 1000 years, for fault movement (or surface subsidence) due to salt dissolution. The licensee appropriately interpreted the RFI broadly, and evaluated

potential for any surface subsidence by salt dissolution, not just fault movement. The licensee considers that "the potential for subsidence related to salt dissolution at the tailings pile appears lower than in latest Pleistocene time" (Woodward-Clyde, 1994). Apparently, the licensee considers that subsidence is continuing at some rate, even if it is a rate lower than that of 1x10E4, or so, years ago. The RFI calls for an analysis of structural stability in light of such (negative) loading. An estimate of the rate (or range of rates) of subsidence, projected over the next 1000 years, and the basis of the inherent uncertainties of such an estimate, is necessary. In the absence of such an estimate and bases, the staff considers this subsidence evaluation to be incomplete, and additional engineering analyses of structural stability of the tailings pile is warranted.

RFI 2, Part 3. The third part requires an evaluation of the changes due to the development of oil resources. The licensee concluded that current production from the closest oil field is too deep and too far to affect the Atlas site (e.g., won't cause surface subsidence; Atlas Corp., 1994). However, in the absence of supporting data on effects of oil extraction, on the effectiveness of borehole casing and plugs, consideration of actual subsidence in Paradox Basin oil/gas fields that could be analogs of a future 'Moab' field, and an evaluation of the potential for subsidence due to oil extraction near the site over the next 1000 years, additional analyses of the potential man-induced hazard are warranted.

BASIS, PART 1

* The licensee interprets the Moab fault "as a structure which developed primarily from salt dissolution and migration although movement along the fault has also probably been in partial response to broad regional tectonic stresses" (Woodward-Clyde, 1994, p.6). Also, the northwest-trending Moab fault is considered to be favorably oriented for normal fault movement in the current stress field (Woodward-Clyde, 1994, p.9). The predominant mode of tectonic deformation within the Colorado Plateau appears to be normal faulting on northwest to north-northwest-trending faults, and most earthquakes occur within 20 km of the surface (Wong and Humphrey, 1989, p.1145). These points suggest that the Moab fault may have some seismic potential.

* Nevertheless, the licensee has concluded, "If the Moab fault is indeed a shallow fault, <u>its seismogenic potential will be negligible</u> (emphasis added) as it will not be subjected to significant tectonic stresses which are largely occurring at depth beneath the top few kilometers of the upper crust" (Woodward-Clyde, 1994, p.6). There appears to be no supporting analyses for this conclusion.

* The licensee also has concluded, "Although strata along the fault zone overlying the salt are likely to deform in a brittle manner in response to movement of the underlying salt, the strata are thin and deformation will be seismogenically insignificant" (emphasis added; Woodward-Clyde, 1994, p.6). The licensee has not yet presented analyses to support the idea that an earthquake on the Moab fault, or several earthquakes, in the next 1000 years, beneath or near the site would be seismogenically insignificant.

* The licensee briefly discussed the controversial nature of the geometry of the Moab fault at depth (Woodward-Clyde, 1994, p.5-9), i.e., whether it is rooted in the salt-cored anticline at shallow depth, whether it becomes listric, whether it is steep and deep, possibly connected to pre-salt-intrusion basement faults. Some evidence in support of the licensee's apparently preferred concept of the Moab fault being listric and rooted in the salt-cored anticline a few kilometers below surface consisted of personal communications that the staff cannot review (ibid., p. 5,6). Therefore, the staff does not know what the bases for the licensee's fault model are, and how the fault model relates to the salt dissolution and subsidence process.

* The licensee further has concluded that while there is seismic potential of a buried fault zone along the Colorado River trending toward the tailings pile (Woodward-Clyde, 1994, p.9), "it is highly unlikely that a large earthquake could be generated within this zone" (ibid., p.9). The licensee has apparently considered the following four points, but has not presented analyses to show how they support the conclusion regarding the future likelihood of a large earthquake along the river: (1) "It is possible that only this linear stretch of the river [northeast-trending Colorado River from confluence with the Green to Moab] has underlying basement faults that are favorably oriented to the contemporary tectonic stress field" (Wong and Humphrey, 1989, p.1134); (2) "Seismicity in the plateau appears to be the result of the reactivation of pre-existing faults not expressed at the surface but favorably oriented to the tectonic stress field..." (ibid., p.1145); (3) "some localized occurrences of strike-slip deformation [occur] on...northeast-striking planes at shallow depths" (ibid., p.1145); and (4) "An issue that remains unresolved is whether there exists a cause-and-effect relationship between the seismicity and the river..." (ibid., p.1134-1135).

BASIS, PART 2

* The licensee considers that "the potential for subsidence related to salt dissolution at the tailings pile appears lower than in latest Pleistocene time" (Woodward-Clyde, 1994, p.10). The only basis provided in support of this statement that is subject to review, "...[subsidence or dissolution] rates have

probably slowed down since the time of Pinedale glaciation (roughly 15,000 to 25,000 years ago) due to a drier climate" (ibid., p.10), needs clarification and elaboration. It appears that the licensee has postulated that lower rates of subsidence than have operated in the past are operating now. It remains for the licensee to fully evaluate, and perhaps, estimate, this hazard.

* The licensee provided geomorphic information to support its contention that subsidence associated with salt dissolution beneath Spanish and Moab Valleys south of the Colorado River has occurred in the Quaternary and probably continued into the Holocene (Woodward-Clyde, 1994, p.9,10; unfortunately, because the information is cited by personal communication, the staff cannot review it; see BASIS, below, for further discussion of geomorphic evidence). The licensee asserts that, "...there is no evidence for late Quaternary subsidence north of the Colorado River in the vicinity of the tailings pile" (ibid., p.10). The licensee considers that "this apparent lack of subsidence could be related to the lack of any perennial streams flowing into the river in this area" (ibid., p.10). However, the licensee has observed more than 400 ft of alluvium, some of it probably late Quaternary, beneath the tailings, in boreholes, and didn't hit bedrock bottom. This observation may or may not be compatible with a no-subsidence concept for the tailings area. The thick alluvium beneath the pile, the suggestion by Harden and others (1986) that the Moab Marsh might represent a broad subsidence basin, the beheading of Little Valley, the salt tectonic model proposed by Baars and Doelling (1987) and Doelling (1988) that includes salt dissolution and landsliding beneath the tailings site, and other information, apparently have not been considered by the licensee in its evaluation of the subsidence potential for the site.

* Numerous collapse features, sinkhole-like, have been identified in the Spanish Valley (Suguira and Kitcho, 1984). The occurrence, or potential future occurrence of such features beneath or near the site do not appear to have been investigated or analysed. Collapse features, sinkhole-like, have been identified by Doelling (1988) in Salt Valley-Cache Valley area and may be analogues for Moab Valley.

BASIS, PART 3

* The licensee concluded that current production from the closest oil field is too deep (more than 7000 ft) and too far (12 miles) to affect the Atlas site, i.e., cause subsidence (Atlas Corp., 1994, p.3).

* The licensee mentioned that one oil test well indicated oil was present about five miles from the site. The geology of the Moab salt-cored anticline is conducive to oil accumulation. One oil

test well was drilled on the Atlas site (Embar well), but little is known of the results.

* The licensee concluded that "it is unlikely that the process of drilling an exploration hole and development of a production well could enhance dissolution of the salt" (Atlas Corp., 1994, p.4). The licensee considered that casing a well and fluid overpressure at depth support its contention. However, no actual evidence was provided for staff review.

* The licensee has identified the possibility that exploration wells that might not be properly cased or sealed, may allow pressurized fluids, e.g., brines, to escape to the surface; aside from contaminating the soil around the wellhead, subsidence might occur in the vicinity of the well. Observations of the Embar well for evidence of surface effects and effectiveness of its plug on the Atlas site might be useful supporting information.

* The prospects of oil/gas exploration and extraction near the site and sufficiently close to the surface to cause subsidence during the next 1000 years apparently was not considered. Analogs of such prospects in the Paradox Basin might be available for comparison, albeit, speculatively.

REFERENCES

Atlas Corporation, 1994, NRC request for information - Atlas Corp. reclamation plan, uranium mill and tailings disposal area, Moab, Utah: by Canonie Corp., June 1994.

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Sugiura and Kitcho, 1981, Collapse structures in the Paradox Basin: Rocky Mountain Association of Geologists - 1981 Field Conference, 33-45.

Wong and Humphrey, 1989, Contemporary seismicity, faulting, and the state of stress in the Colorado Plateau: Geological Society of America Bull., v.101, 1127-1146.

Woodward-Clyde, 1994, Responses to NRC comments on the Moab fault, Utah: Woodward-Clyde Federal Services for Canonie Environmental Services and Atlas Corp., 26 May 1994, 11p.

RECOMMENDATIONS

Part 1. To fully evaluate the seismic potential for faults adjacent to the site for the purpose of demonstrating compliance with Appendix A criteria, Atlas should consider conducting a seismic hazard investigation of the Moab fault zone and other relevant potentially seismogenic structures and present its analysis in quantitative terms, including a discussion of uncertainties commensurate with the significance of seismic loading for input to designs for stabilization. The analysis must consider the next 1000 years.

The staff considers the elements of an adequate investigation of seismic potential to include no less than the following, as practicable, to be conducted by standard practices:

* Consideration of faults that are capable faults that might affect the stability of the tailings pile.

* Characterization of the soil and rock properties under the tailings, such that their behavior during earthquakes (for example, amplification of vibratory ground motion) in the next 1000 years can be evaluated with regard to tailings pile stability. Also, the shape and nature of the bedrock surface under the tailings pile would have to be defined.

* Consideration of the orientation of faults near the tailings in the current and projected stress field.

* Documentation and quantification, with discussion of uncertainties, of conclusions of seismic potential, such as, "[Moab fault] seismic potential will be negligible," and when the Moab fault breaks, the effect on rocks near the surface will be "seismogenically insignificant." The basis for such conclusions must be transparent to the staff reviewers.

Part 2. In order to evaluate the potential for fault movement (or surface subsidence) due to salt dissolution for the purpose of demonstrating compliance with Appendix A criteria, Atlas should consider conducting a comprehensive investigation of sufficient scope and level of detail commensurate with the significance of the information needed.

The staff considers the elements of an adequate investigation of potential for fault displacement due to salt dissolution include no less than the following, as practicable, to be conducted by standard practices:

* Identification and investigation of the presence and extent of strata beneath the site that are subject to dissolution, e.g., evaporites dominated by halite, and their relation to faults beneath or near the site.

* Investigations and analyses of salt dissolution features of broad or basin scale, and those that are local, or sinkhole-like that are beneath the tailings pile, or are in analogous situations.

* Investigations and analyses of the nature and rates of fault displacement or surface subsidence due to salt dissolution that has occurred beneath or near the site, and an assessment of same over the next 1000 years, with a discussion of the uncertainties involved in such an assessment.

* Documentation and quantification, with discussion of uncertainties, of conclusions of potential fault displacement or surface subsidence due to salt dissolution, such as, "...potential for subsidence related to salt dissolution at the tailings pile appears lower than in latest Pleistocene time." The basis for such a conclusion must be transparent to the staff reviewers.

Part 3. To fully evaluate changes due to the development of oil resources for purpose of demonstrating compliance with relevant Appendix A criteria, Atlas should consider conducting a comprehensive investigation of scope and level of detail commensurate with the significance of the information needed.

The staff considers the elements of an adequate investigation of changes due to development of oil resources to include no less than the following, as practicable, to be conducted by standard practices:

* Consider the site's hydrocarbon potential (oil and gas), the presence and depth of reserves or potential target strata, the effectiveness of borehole casing and plugs to prevent dissolution in such strata, the effectiveness of the Embar well plug, and accounts of actual subsidence in Paradox Basin oil/gas fields that could be analogs of a future "Moab" field.

* Documentation and quantification, with discussion of uncertainties, of conclusions of potential surface subsidence due to dissolution along drillholes or from fluid extraction, such as, "It is unlikely that the process of drilling an exploration hole and development of a production well could enhance dissolution of the salt" (Atlas Corp., 1994, p. 4). The basis for such a conclusion must be transparent to the staff reviewers.

REQUEST FOR INFORMATION ON POTENTIAL EFFECTS OF FUTURE SOLUTION MINING

RFI 3. Evaluate the potential effects of future solution mining beneath or near the Moab site for the purpose of demonstrating compliance with relevant 10 CFR Part 40, Appendix A criteria.

BASIS

* Effects of solution mining of potash about 20 km from Moab include earthquakes (up to 1-magnitude 3.3, generally 1-2 km deep, largest having strike-slip motion on northwest or northeast planes, but contrasting principal stress directions; Wong and Humphrey, 1989, p. 1133-1134). Some of the events could be attributed to subsidence of brittle strata overlying the Paradox Formation (ibid.).

* Seismicity apparently induced by potash mining has occurred along a northeast trend from Potash to Moab, more or less parallel to the Colorado River (ibid., and figs. 7, 8). The licensee has apparently not evaluated the potential effects of such events, and projected future events, on the Atlas site.

* "During the winter of 1978-1979, approximately 4 to 5 million gallons of liquified petroleum gas (LPG) were lost at the LPG storage facility in salt caverns just north of Moab. The LPG had been pumped into a cavern created by brine solutioning, and was to be retrieved by pumping brine into the cavern to displace the gas. However, pumping failed to retrieve the LPG, and it was surmised that the gas may have been lost to an unknown solution cavity, either through hydraulic fracturing of the formation, or by passing around an incompletely cemented outer casing" (Woodward-Clyde Consultants, 1982, p. 8-5). The licensee has apparently not considered the potential significance of this event in development of the stabilization plan for its nearby site .

* Potash reserves have apparently been identified beneath or near Bartlett Wash and its junction with the Moab fault. Also, these are apparently in private ownership (personal communication, H. Doelling, Utah Geological Survey, 31 August 1994).

REFERENCES

Wong and Humphrey, 1989, Contemporary seismicity, faulting, and the state of stress in the Colorado Plateau: Geological Society of America Bull., v. 101, 1127-1146.

Woodward-Clyde Consultants, 1982, Geologic characterization report for the Paradox Basin study region, Utah study areas, volume 1 - regional overview: Battelle Memorial Institute, Office of Nuclear Waste Isolation, Columbus, Ohio, ONWI-290, January 1982.

RECOMMENDATIONS

RFI 3. To fully evaluate the potential effects of future solution mining on the Moab site and alternative sites (e.g., Bartlett Wash) for the purpose of demonstrating compliance with relevant Appendix A criteria, Atlas should consider conducting a comprehensive investigation of scope and level of detail commensurate with the significance of the information needed.

The staff considers the elements of an adequate investigation of potential effects due to the exploration and development of soluble mineral resources to include no less than the following, as practicable, to be conducted by standard practices:

* Consider the site's and alternative sites' soluble-mineral resource potential, the presence and depth of reserves or of likely target strata, the effectiveness of borehole casing and plugs to prevent dissolution in such strata, and scenarios which incorporate effects on ground surface of solution mining based upon actual examples from nearby experiences (e.g., see BASIS, above).

* Documentation and quantification, with discussion of uncertainties, of conclusions of potential for surface subsidence and vibratory ground motion due to solution mining. The basis for such conclusions must be transparent to the staff reviewers.

Environmental Assess. .t Group
Oak Ridge National Laboratory
Bldg. 1505, MS-6038, Rm 388
P.O. Box 2008
Oak Ridge, Tennessee 37831-6038

Dear Roger:

Enclosed is a marked up copy of the preliminary draft Environmental Impact Statement (pDEIS) for the Atlas Moab uranium mill reclamation project that you recently provided to the U.S. Nuclear Regulatory Commission for review. After revision, please provide two copies each to me and to:

Ms. Lillian K. Stone, Chief
Energy Facilities Division
Office of Environmental Policy and Compliance
U.S. Department of the Interior
1849 C Street, NW
Mail Stop 2340
Washington, DC 20240

I am notifying Ms. Stone of the pending availability of the pDEIS. She will deliver review copies to the National Park Service and the Bureau of Land Management (cooperating agencies) for their use. You are copied on the letter to Ms. Stone, which also addresses a potential review meeting. ORNL should plan on attendance if such a meeting is held. Any technical staff required will depend on the comments by the reviewing agencies. If needed, I would expect the meeting to be held either in late November or early December in Denver. You might want to make Bob Reed aware of the potential schedule, and determine how you will phase the project manager responsibilities.

If you have any questions, I may be reached at (301) 415-6693.

Sincerely,

Allan T. Mullins
Project Manager
High-Level Waste and Uranium
Recovery Projects Branch
Division of Waste Management
Office of Nuclear Material

Enclosure: As stated

cc: D. DeMarco w/o Encl.

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November 8, 1994

Karen Robinson
2871 East Bench Road
Moab, Utah 84532

SUBJECT: REQUEST FOR COPIES OF SCOPING COMMENTS AND DRAFT ENVIRONMENTAL IMPACT STATEMENT (dEIS) FOR ATLAS MOAB URANIUM MILL

Dear Ms Robinson:

Your letter of October 31, 1994, requested a copy of the Environmental Assessment (EA), the Scoping Comments, and the draft Environmental Impact Statement (EIS) for the Atlas Moab uranium mill. Enclosed are copies of the Scoping Comments and a transcript of the Scoping Meeting held in Moab, Utah, on April 14, 1994.

The EA is being superseded by the EIS and is not included. A copy of the EA is on file at the offices of the Grand County Council in Moab and may be inspected there. The EA is not as complete an environmental assessment as the EIS will be as it only addressed proposed changes in the Atlas reclamation plan which had been approved by the Nuclear Regulatory Commission in 1982. The EIS evaluates the revised reclamation plan which is currently being reviewed by the NRC.

You will receive a copy of the draft EIS when it is published and distributed for public comment. Any additional questions may be addressed to me at (301) 415-6693.

Sincerely,

Allan T. Mullins, Project Manager
High-Level Waste and Uranium
Recovery Projects Branch
Division of Waste Management
Office of Nuclear Material
Safety and Safeguards

Enclosures: As stated

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

November 25, 1994

MEMORANDUM TO: Joseph J. Holonich, Chief
High Level Waste and Uranium
Recovery Projects Branch, DWM/NMSS

FROM: John H. Austin, Chief
Low-Level Waste and Decommissioning
Projects Branch, DWM/NMSS

SUBJECT: REVIEW OF SURETY UPDATE AND PROPOSED CHANGE IN SURETY FORM AND PROVIDER FOR THE ATLAS MOAB URANIUM MILL

In its September 30, 1994, letter to NRC, Atlas Corporation states that it is "evaluating alternative surety instruments and institutions for possible replacement of the existing surety" to ensure availability of funds for decommissioning. Atlas currently has an irrevocable Standby Letter of Credit for this purpose. We have reviewed the two account types submitted by Atlas Corporation: 1) a pledged collateral account agreement, and 2) an escrow letter in which to hold the various securities necessary to fulfill the financial assurance requirements in 10 CFR Part 40. Both are accounts with the brokerage firm of Merrill Lynch, Pierce, Fenner & Smith Incorporated.

We have concluded that, in the event of Atlas' default, bankruptcy, or other similar event, neither the pledged collateral account, nor the escrow letter, as presented, will guarantee unencumbered flow of funds for decommissioning activities at Atlas. Specifically, the pledged collateral account agreement appears to rely on a contractual relationship in which NRC, the assignee, is seen as a lender to, or creditor of, Atlas. This relationship is not acceptable in that NRC is not authorized to enter into such agreements. The escrow letter also is not acceptable since the escrow letter appears to allow an escrow agent to trade in the account. These accounts are basically brokerage accounts with an unstated underlying creditor/debtor relationship.

In addition, the pledged collateral account provides that "Assignee... agrees to indemnify and hold harmless Merrill Lynch... from and against any and all claims, causes of action, liabilities, lawsuits, demands and\or damages, including, without limitation, any and all court costs..." The NRC is not authorized to agree to such terms on behalf of the U.S. Federal government.

Finally, in the event of a licensee's default or bankruptcy, decommissioning funds must be available for decommissioning activities. However, NRC is not authorized to receive decommissioning funds, and at no time can such funds become part of NRC's assets. Funds paid to NRC must be turned over to the U.S. Department of the Treasury. It is therefore contingent upon the licensee to establish a standby trust, or similar vehicle, to allow for the segregation of funds from both the licensee and NRC, thus guaranteeing the availability of funds for decommissioning.

If you require additional information concerning Atlas Corporation's recent inquiry concerning financial assurance instruments for decommissioning, please contact Richard Turtil.

CONTACT: Richard Turtil, DWM/NMSS
415-6721

TICKET: DP-9400138

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

January 10, 1995

MEMORANDUM TO: Daniel Gillen, Section Leader
Uranium Recovery Projects Section
HLUR/DWM/NMSS

THRU: Mysore Nataraja, Acting Section Leader
Geosciences/Geotechnical Engineering Section
ENGB/DWM/NMSS

FROM: Philip S. Justus, Senior Geologist
Geosciences/Geotechnical Engineering Section
ENGB/DWM/NMSS

SUBJECT: REVIEW OF PRELIMINARY DRAFT ENVIRONMENTAL IMPACT STATEMENT, ATLAS SITE, MOAB, UTAH: GEOLOGY AND MINERAL RESOURCES SECTIONS

I have reviewed the Preliminary Draft Environmental Impact Statement (PDEIS) related to reclamation of the uranium mill tailings at the Atlas site, Moab, Utah, and the Source Material License No. SUA 917 received from Allan Mullins on November 22, 1994. For this review, I concentrated on statements concerning geology, stratigraphy, geologic hazards, and mineral resources. Related sections on seismology, soils, groundwater, and surface water hydrology are being reviewed by other staff; and I have discussed such related matters with A. Ibrahim, T. L. Johnson, and A. Mullins. My comments are presented in a general comment section which suggests that addition of two visual aids might assist non-geologists in understanding the text, and a specific comment section which suggests points for consideration by the preparer concerning statements in this draft PDEIS.

GENERAL COMMENTS

1) The discussions in the PDEIS of the geological aspects of the Moab site and the alternate plateau site environments are brief and rudimentary (e.g., pp.3-4 to 3-8). Given that "this DEIS focuses on the potential environmental impacts and environmental suitability of tailings disposal" (p. 1-7, line 32), and few to no impacts of tailings disposal on geology and suitability were found, the level of detail of geological information may be sufficient to understand the discussions. I understand that the audience is to be considered to have prior knowledge of such things as the local geology. However, many readers will need a working knowledge of geology to understand concepts that are not explained in the PDEIS; for example, "Salt-anticlines in the Paradox basin formed by plastic flow of salt down dip (southwest) from near the Uncompahgre Uplift, then by upward flow of salt along northwest trending, basement penetrating, Paleozoic faults, (Baars 1993)" (p. 3-4, line 43).

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If a reader is not familiar with the stratigraphy, geological features, processes, and conditions that are mentioned in the PDEIS, additional information and illustrations should be considered for inclusion to facilitate understanding such things. The quotation from Baars (1993), above, would be understood by many more readers if a cross section, even a schematic one, and a time-stratigraphic chart were provided, which illustrated the relationship of anticlines, basin, Uncompahgre Uplift, basement faults, and Paleozoic age strata (see Enclosures 1a & 1b, for example). I understand that ORNL will include a cross section in the DEIS. Consider including it in the PDEIS.

2) Readers would benefit greatly from a time-stratigraphic chart, which I recommend be included in the PDEIS for the following reason. The significance of stratigraphic terms (for example, Paradox Member of the Hermosa Formation of middle and upper Pennsylvanian age (p. 3-11, line 6) and Wingate and Navajo sandstones of the Glen Canyon Group (p. 3-11, line 27) are too difficult to conjure without a chart that illustrates the stratigraphic succession and range of ages. The staff was informed by the Utah Geological Survey (UGS) that the stratigraphic nomenclature for some units has changed. The PDEIS should conform to the new nomenclature (see Enclosure 2 for nomenclature used by UGS). I understand that ORNL will include a stratigraphic chart in the DEIS. Consider including it in the PDEIS.

SPECIFIC COMMENTS

1) Alternate Sites (p. 2-12, line 16). The plateau site is stated to be about 14 miles from Moab, whereas it is stated to be about 18 miles away in other sections (for example, Summary and Conclusions p. xi, line 34). Consider checking text for consistency on this measurement; also use metric units when mandated by Federal guidelines.

2) Alternate Sites (p. 2-12, line 18). Consider adding the Utah Geological Survey's opinion that potash and the Moab fault are likely present at the plateau site (letter report from M. L. Allison to J. J. Holonich, October 27, 1994, "Atlas Corporation Mill Site, Moab, Utah; Responses to October 7, 1994, NRC Questions," p. 14).

3) Comparison of Impacts of Alternatives (p. 2-21, et. seq.). Consider adding Mineral Resources as a topic for comparison, given that potash, salt, and oil resources are likely to occur at both sites (Allison to Holonich letter, ibid., p. 14). Future exploitation and exploration might need to be prohibited. Such a prohibition might be an economic environmental impact that would need to be discussed.

4) Geology (p. 3-6, lines 31, 32). The conclusionary statements that no displacement on Moab fault near the plateau site is expected, and no evidence of solution activity beneath plateau site is present must either be supported by reference or deleted.

5) Geology (p. 3-6). Several features and processes are omitted from this section that should be considered for inclusion: the swarm of faults across the road (rte 191) from the site mapped by Doelling (1985); the shear zone and landslide across the road (rte 279) at the railroad tunnel mapped by Doelling (1985); the 300 m (1000 ft) scarp a few hundred meters from the site boundary; the rock types and stratigraphy (these are briefly, but incompletely described in the groundwater section (see General Comment 2); and the groundwater section description need not be repeated in the geology section. The Allison to Holonich letter could be cited in support of some of these features and associated geologic processes.

6) Soils (p. 3-8, line 1). The conclusionary statement that there is no potential for ground motion magnification or liquefaction in soils at plateau site needs support by reference or calculations or should be deleted.

7) Mineral Resources (p. 3-8). Consider adding the UGS opinions relevant to a PDEIS, that "Petroleum drilling will likely occur in or adjacent to the Moab Valley within the next 1000 years, the potential for finding oil somewhere near the strike of the Moab fault is good," and "The next area in the Paradox basin that will likely be developed will be the Bartlett Wash-Sevenmile Canyon area" (Allison to Holonich letter, p. 14).

8) Geology, Soils, and Seismicity (p. 4-5, line 21). Delete the conclusion that the magnitudes and frequencies of the geologic hazards phenomena "would have low probabilities of destabilizing the reclaimed...pile...." While this might turn out to be the case, we have not completed our evaluations; thus, it is premature to state such a conclusion.

9) Land Use (p. 4-5). Consider adding discussion on potentially adverse economic impact of the possibility that certain mineral resources (e.g., potash, oil) might have to be removed from the public domain at either the Moab site or the plateau site (see Allison to Holonich letter, p. 14, for basis).

10) Unavoidable Adverse Environmental Impacts. Mineral Resources (p. 4-64, line 19). Consider rephrasing the statement, "No known or commercially valuable mineral resource would be appreciably affected..." in light of the UGS opinions in Allisson to Holonich letter, p. 14 (see specific comment 7, above).

Enclosures (3): 1a. Stratigraphic Column
1b. Cross Section
2. Lexicon of Stratigraphic Nomenclature

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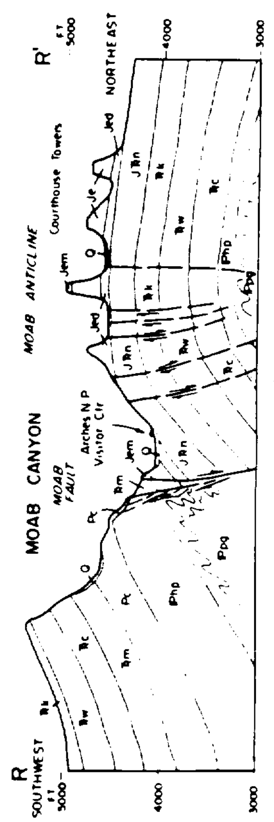
(Doelling

Bull. 122 1985)

Table 1.
Generalized section of bedrock formations in the Arches National Park or Salt Valley-Moab Valley area, Grand County, Utah.

System	Formations and Members	Character	Thickness (feet)
CRETACEOUS	Mancos Shale [Km]		
	Upper Member	Light to dark gray marine shale.	500+
	Ferron Member	Thinbedded sandstone, sandy shale, marine shale, carbonaceous shale, forms a double cuesta.	60-120
	Lower Member	Light to dark gray marine shale, slope-forming.	300-500
	Dakota Ss [Kd]	Sandstone, conglomeratic sandstone, conglomerate, with subordinate gray sandy shale, and marl beds.	0-110
Unconformity			
	Cedar Mountain Fm [Kcm]	Silty variously colored non-resistant mudstones interbedded with ledge-forming quartzite, conglomerate, and gritstone.	100-200
JURASSIC	Morrison Fm [Jm]		
	Brushy Basin Member [Jmbb]	Variously colored slope-forming mudstone with thin ledges of conglomeratic sandstone, conglomerate, nodular limestone, limestone, and gritstone; overall maroon to north, green to south.	300-450
	Salt Wash Member [Jmsw]	Light yellow gray crossbedded lenticular sandstone interbedded with red and gray mudstone and siltstone. Locally contains uranium, vanadium, and copper.	130-300
	Tidwell Member [Jmt]	Red silty shale with large white siliceous concretionary bodies.	40-100
Unconformity			
	Entrada Ss [Je]		
	Moab Tongue [Jem]	Light yellow gray, fine- to medium- grained resistant and massive sandstone, usually jointed.	60-120
	Slickrock Member	Orange-red, fine-grained massive cliff-forming sandstone.	
	Dewey Bridge Member [Jed]	Dark reddish fine-grained silty sandstone, with occasional white beds, contorted bedding, forms weak zone at base of arches.40-235	
Unconformity			
	Navajo Ss [JTRn]	Massive light-hued eolian crossbedded sandstone, forming cliffs, rounded knolls, and domes.	250-550
	Kayenta Fm [TRk]	Lavender gray sandstone with local white and dark brown beds, forming thick step-like ledges.	200-300
	Wingate Ss [TRw]	Massive fine-grained, well-sorted sandstone, forms the most prominent cliff in canyon areas.	250-450
Unconformity			
TRIASSIC	Chinle Fm [TRc]	Reddish-brown silty fine-grained slope-forming sandstone, interbedded with mudstone and gritstone, locally contains uranium and copper in basal part.	200-900
Unconformity			
	Moenkopi Fm [TRm]	Brown, evenly bedded sandy shale and micaceous silty sandstone, often ripple-marked.	0-1300
Unconformity			
PERMIAN	Cutler Fm [Pc]	Red and marroon crossbedded sandstone and conglomerate with subordinate sandy shales.	0-1500
Unconformity			
PENNSYLVANIAN	Honaker Trail Formation [Php]	Limestone, shale, sandstone, arkosic sandstone, locally fossiliferous, forms cliff.	327+
	Non-gypsiferous rocks	Sandstone, limestone, conglomerate, shale, and sandy limestone.	300+
	Gypsiferous rocks (Paradox Fm) [Ppg]	Contorted gypsum with interbeds of black shale; thin chippy limestone and sandstone.	500+

ENCLOSURE 1b



from Doelling (1988)

Figure 50. Cross sections acı
figure 48. Vertical scale is twice

ENCLOSURE 2

LEXICON OF STRATIGRAPHIC NAMES USED IN THE PARADOX BASIN-SAN RAFAEL-HENRY MOUNTAINS AREA, UTAH

Compiled by C. M. MOLENAAR
Shell Oil Co.
Houston, Texas 77001

This compilation is an alphabetical listing of accepted stratigraphic names used in the Paradox Basin, San Rafael Swell and Henry Mountains area. The central Book Cliffs Cretaceous nomenclature is included because of its overlap with the Paradox Basin. In addition, a few informal names that have been widely used and some of those used in areas covered by the field conference are included:

This compilation was derived from available lexicon catalogues, and other available published literature. Below each rock unit and its age are listed:

1) Areal distribution.
2) First reference in literature.
3) Type locality.
4) Generalized lithology and thickness.
5) General information and depositional environment.

Akah Substage (of Four Corners Stage of Paradox Fm)—Pennsylvanian (Desmoinesian)
1) Paradox Basin.
2) D. L. Baars, J. W. Parker, and J. Chronic, 1967, AAPG Bull. v. 51, no. 3, p. 393-403.
3) Shell Hovenweep No. 1, sec. 5, T. 40 S., R. 26 E., San Juan County, Utah.
4) Salt, anhydrite, black sh, ls and dol.
5) Previously referred to as a zone or cycle. Bounded by excellent time-marker beds throughout Paradox Basin. Grades into ls and dol around shelf edge. Oil and gas productive in southernmost Paradox Basin. (evaporite to shelf marine)

Ali Baba Mbr. (of Moenkopi Fm.)—L. Triassic
1) Northeastern Paradox Basin.
2) E. M. Shoemaker and W. L. Newman, 1959, AAPG Bull. v. 43, no. 8, p. 1835-51.
3) Ali Baba Ridge in Sinbad Valley, Colo.
4) Interbedded red-brown cgl ss, silty sh, and ss. (0-290')
5) Conformable to angular contact with underlying Tenderfoot Mbr. (continental)

Alkali Gulch Cycle or Zone (of Paradox Fm.)—Pennsylvanian (Desmoinesian) (Informal name)
1) Paradox Basin.
2) J. A. Peterson and H. R. Olsen, 1963, Four Corners Geol. Soc. Guidebook, p. 69 and 71.
3) Informal designation; therefore no type section. However, name is applied in southern Paradox Basin.
4) Salt, anhydrite, black sh, ls, dol.
5) Conformably underlies Barker Creek Substage and conformably overlies Pinkerton Trail Fm. Consists of several cycles of repeating lithologies. Also referred to as a zone by many workers. (evaporite to shelf marine)

Aneth Fm.—U. Devonian
1) Four Corners region subsurface.
2) R. L. Knight and J. C. Cooper, 1955, Four Corners Geol. Soc. Guidebook, p. 56.
3) Shell Bluff No. 1, sec. 32, T. 39 S., R. 22 E., San Juan Co., Utah, between 8161-8331 feet.
4) Dark resinous ls, dol, and sh; some glauconite. (0-130')
5) Overlies Cambrian and underlies Elbert Fm. (marine)

Barker Creek Substage (of Four Corners Stage of Paradox Fm.)—Pennsylvanian (Desmoinesian)
1) Paradox Basin.
2) D. L. Baars, J. W. Parker, and J. Chronic, 1967, AAPG Bull., v. 51, no. 3, p. 393-403.
3) Shell Hovenweep No. 1, sec. 5, T. 40 S., R. 26 E., San Juan County, Utah.
4) Salt, anhydrite, black sh, ls and dol.
5) Previously referred to as a zone or cycle. Bounded by excellent time marker beds throughout Paradox Basin. Oil and gas productive in southernmost Paradox Basin. (evaporite to shelf marine)

Bilk Creek Sandstone Mbr. (of Wanakah Fm.)—U. Jurassic
1) San Miguel and San Juan Mountains, eastern Paradox Basin, Colo.
2) M. I. Goldman and A. C. Spencer, 1941, AAPG Bull., v. 25, no. 9, p. 1748-1753.
3) Bilk Creek, S.W. Colo.
4) Very fine-grained, light gray ss. (20')
5) Medial member of Wanakah Fm. (lacustrine or embayed-marine)

Black Dragon Mbr. (of Moenkopi Fm.)—L. Triassic
1) NW Paradox Basin, San Rafael Swell and northern part of Circle Cliffs uplift.
2) R. C. Blakey, 1974, Utah Geol. and Min. Survey Bull. 104, p. 13.
3) Black Dragon Canyon, northeastern San Rafael Swell, Utah.
4) Reddish-brown to grayish-red or gray sts, sh, very fine-grained ss, and minor ls and gypsum. (0-235)
5) Recently proposed name for basal slope-forming member of Moenkopi Fm. Unconformably overlies Permian except where Hoskinnini Mbr. is present. Gradational with overlying Sinbad Ls. Mbr. (shallow to marginal marine)

Black Ledge Sandstone Bed (of Chinle Fm.)—U. Triassic (Informal name)
1) Northern Paradox Basin.
2) J. H. Steward, G. A. Williams, H. F. Albee, and O. B. Raup, 1959, USGS Bull. 1046-Q, p. 518.
3) Informal name—no type section.
4) Pale red, very fine-grained, ss. (30-40')
5) A conspicuous, desert-varnished, resistant ss bed in the upper part of the Chinle in the area between the San Rafael Swell and the Moab area. (fluvial)

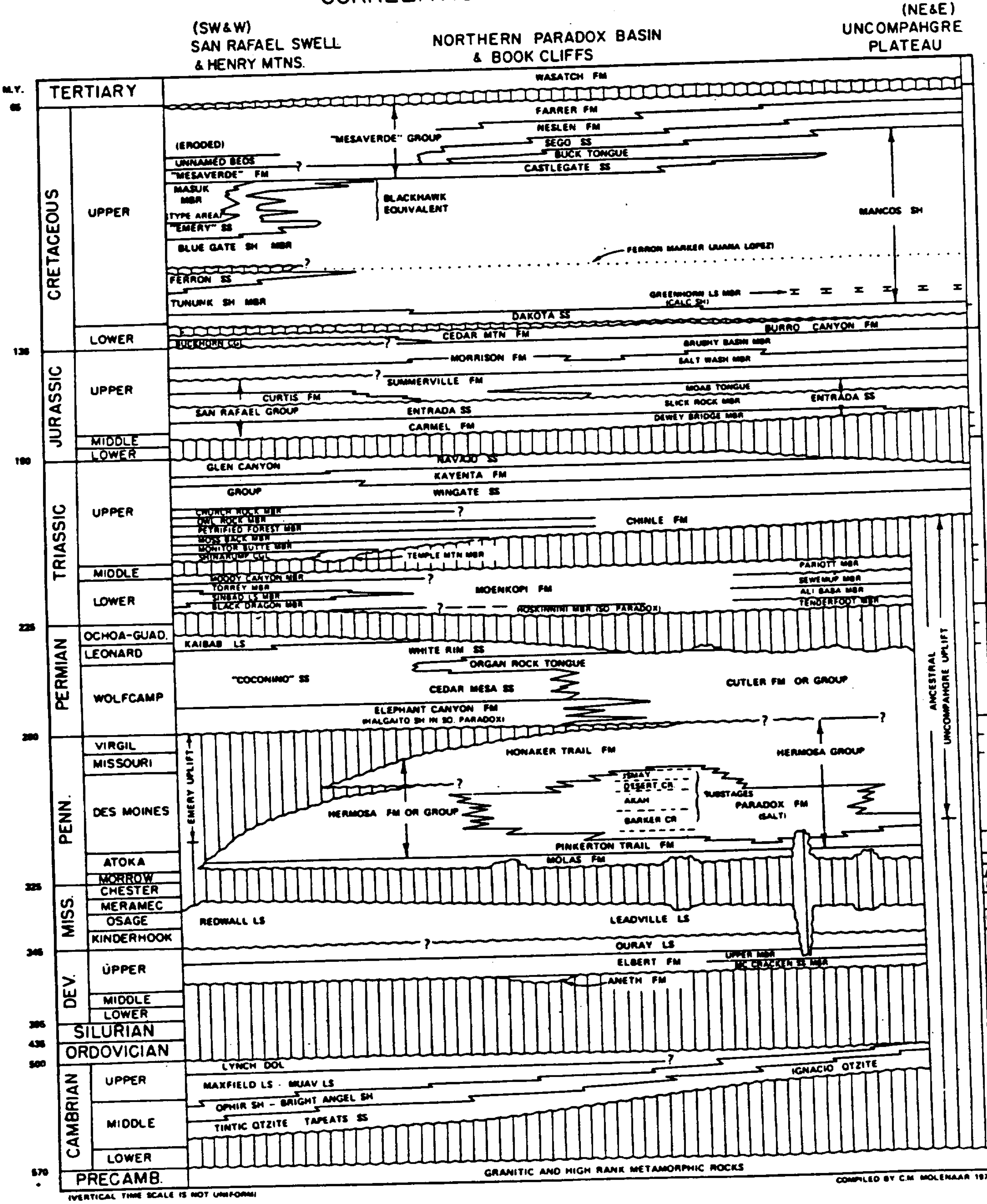
Blackhawk Fm. (of Mesaverde Group)—U. Cretaceous
1) Western Book Cliffs and eastern Wasatch Plateau.
2) D. J. Fisher, 1936, USGS Bull. 852, p. 10-14.
3) Blackhawk, Utah.
4) SS, sh and coal. (0-1200')
5) Major coal producer. Grades from nonmarine coastal plain deposits on west to littoral marine deposits and Mancos Sh. on east.

Blue Gate Shale Mbr. (of Mancos Shale)—U. Cretaceous
1) Henry Mountains and Wasatch Plateau.
2) G. K. Gilbert, 1877, U.S. Geog. and Geol. Survey of the Rocky Mtn. region, p. 4. Amplified by C. B. Hunt, P. Averitt, and R. L. Miller, 1953, in USGS Prof. Paper 228.
3) Blue Gate Plateau in Henry Mountains, Utah.
4) Dark gray marine sh. (1400-1600' in Henry Mtns.)
5) Unconformably overlies Ferron SS. Mbr. in Henry Mtns. Equivalent to the Blue Gate Sh., Emery Ss., and "Masuk" Sh. Mbrs. of the Mancos Sh. in the Wasatch Plateau (Peterson and Ryder, this guidebook). (marine)

Bluff Sandstone—U. Jurassic
1) Four Corners region.
2) A. A. Baker, C. H. Dane, and J. B. Reeside, Jr., 1936, USGS Prof. Paper 183, p. 21.
3) Bluff, Utah.
4) White, gray, buff, and brown, massive ss. (0-250')
5) Uppermost formation of San Rafael Group. Gradational with both underlying Summerville Fm. and overlying Morrison Fm. Equivalent to Junction Creek Ss. and upper part of Cow Springs Ss. Pinches out in northern Paradox Basin. (dominantly eolian)

Bright Angel Shale (of Tonto Group)—M. and U. Cambrian
1) N. Arizona, SE Utah, SW Colo., NW New Mex.
2) L. F. Noble, 1914, USGS Bull. 549.
3) Bright Angel Canyon, Coconino Co., Arizona.
4) Soft greenish micaceous and fossiliferous sh. and ss, with brown crystalline ls (25-375')

CORRELATION CHART



(VERTICAL TIME SCALE IS NOT UNIFORM)

COMPILED BY C.M. MOLENAAR 1975

5) Overlain conformably by Mauv Ls. and underlain conformably by Tapeats (Ignacio) Ss. (marine)

Brushy Basin Mbr. (of Morrison Fm.)—U. Jurassic
1) E. Utah, W Colo., NW New Mexico, NE Ariz.
2) H. E. Gregory, 1938, USGS Prof. Paper 188.
3) Brushy Basin, San Juan Co., Utah.
4) Sh, banded red, green and gray, with thin ss and cgl beds. (0-450')
5) Uppermost Morrison mbr. (fluvial and floodplain)

Buck Tongue (of Mancos Shale)—U. Cretaceous
1) Book Cliffs, northern Paradox Basin.
2) C. E. Erdmann, 1934, USGS Bull. 851, p. 23-32.
3) Buck Canyon, T. 19 S., R. 23 E., Book Cliffs, Utah.
4) Dark gray marine sh. (0-380')
5) A westward-extending tongue of Mancos Sh. Overlies Castlegate Ss; pinches out near Green River. (marine)

Buckhorn Conglomerate Mbr. (of Cedar Mountain Fm.)—L. Cretaceous
1) Northern San Rafael Swell area.
2) W. L. Stokes, 1944, GSA Bull., v. 55, no. 8, p. 958.
3) Buckhorn Flat, SW side of Cedar Mountain, Emery Co., Utah.
4) Cgl. (20-30')
5) A basal cgl of the Cedar Mountain Fm. (fluvial)

Burro Canyon Fm.—L. Cretaceous
1) SE Utah, SW Colorado and NW New Mex.
2) W. L. Stokes and D. A. Phoenix, 1948, USGS Oil and Gas Inv. Prelim. Map 93.
3) Sec. 29, T. 44 N., R. 18 W., Burro Canyon near Dolores River, San Miguel Co., Colo.
4) Ss, cgl, green sh and minor ls. (100-260')
5) Equivalent to Cedar Mountain Fm. of San Rafael Swell. Burro Canyon terminology is generally used east of Colorado River. Conformably (?) overlies Morrison Fm. and is unconformably overlain by Dakota Ss. (fluvial)

Carmel Fm.—M. and U. Jurassic
1) NW New Mexico, N. Ariz., E. Utah and W. Colo.
2) J. Gilluly and J. B. Reeside, Jr., 1926, USGS Press Bull. 6064.
3) Mt. Carmel, western Kane Co., Utah.
4) Red ss, sts, and sh with basal ls. (35-650')
5) Basal formation of San Rafael Group. Regionally unconformable on Glen Canyon Group. (marine and marginal marine)

"Cane Creek" marker (in Paradox Fm.)—Pennsylvanian (Desmoinesian) (Informal name)
1) Paradox Basin.
2) R. J. Hite, 1960, Four Corners Geol. Soc. Guidebook, p. 88.
3) Informal name. Delhi Taylor No. 2, sec. 18, T. 25 S., R. 21 E., Grand Co., Utah. (70-178')
4) Black sh, dol sts, and anhydrite.
5) Thickest penesaline clastic bed within saline facies of Paradox. Has produced oil in a fractured reservoir in Big Flat-Cane Creek areas. (penesaline marine)

Castlegate Sandstone (of Mesaverde Group—U. Cretaceous)
1) Book Cliffs and eastern Wasatch Plateau.
2) J. B. Forrester, 1918, Utah Acad. Sci. Trans. v. 1, p. 24.
3) Near Castlegate, Carbon Co., Utah.
4) Fluvial ss and carb sh on west grading to littoral ss on east. (0-500')
5) One of the main cliff-forming units in Utah part of Book Cliffs. Basal unit of Mesaverde Group from Crescent Junction area to pinch-out edge near Utah-Colo. border. (fluvial to deltaic to littoral marine)

Cedar Mesa Sandstone Mbr. or Fm. (of Cutler Fm. or Group)—L. Permian (Wolfcamp)
1) Southeastern and east-central Utah.
2) A. A. Baker and J. B. Reesioe, Jr., 1929, AAPG Bull., v. 13, no. 11, p. 1420.
3) Cedar Mesa, west of Mexican Hat, San Juan Co., Utah.
4) Predominantly white to buff ss. (0-1200')
5) Correlative with lower Cutler and upper Supai. Raised to formation status by Wengerd and Matheny (1958), but considered a member of the Cutler Fm. by Kirkland (1963). (eolian and shallow marine)

Cedar Mountain Fm.—L. Cretaceous
1) Northwestern Paradox Basin and San Rafael Swell.
2) W. L. Stokes, 1944, GSA Bull., v. 55, p. 951-992.
3) Cedar Mountain, north end of San Rafael Swell, Utah.
4) Ss, mudstone and cgl. (0-550')
5) Equivalent to Burro Canyon Fm. which is terminology used east of Colorado River. Generally thought to be unconformably overlain by Dakota Ss., but Young (1960 AAPG Bull., v. 44, p. 156-194) considers it a basal formation of Dakota Group. (fluvial)

Chinle Fm.—U. Triassic
1) N Arizona, S Utah, SW Colo., N New Mexico, and SE Nevada.
2) H. E. Gregory, 1915, Am. Jour. Sci., 4th Ser., v. 40, p. 102.
3) Chinle Valley, NE Arizona.
4) Variegated sh, silty and sandy in part, with thin ls cgl lenses. (300-1200')
5) Unconformably overlies Moenkopi Fm. Contains the following members in ascending order: Temple Mountain, Shinarump, Monitor Butte, Moss Back, Petrified Forest, Owl Rock and Church Rock. Not all members are present at any given locality. (continental)

Church Rock Mbr. (of Chinle Fm.)—U. Triassic
1) Northeast Arizona.
2) J. H. Stewart, 1957, AAPG Bull., v. 41, no. 3, p. 441-65.
3) Church Rock, near Monument Valley, NE Ariz.
4) Light reddish brn. sdy sltst and very fine-grained ss. (0-300')
5) Uppermost member of Chinle Fm. and equivalent to Rock Point Mbr. of Wingate Ss. in Arizona. Originally considered to extend into northern Paradox Basin, but shown by O'Sullivan (1970, USGS Prof. Paper 644-E) to pinchout near Utah-Arizona border. (lacustrine and marginal fluvial)

Cliff House Sandstone (of Mesaverde Group)—U. Cretaceous
1) SW Colorado and NW New Mexico.
2) A. J. Collier, 1919, USGS Bull. 691-K, p. 297.
3) Cliff-forming unit above cliff houses in Mesa Verde National Park, SW Colo.
4) Massive to bedded buff ss with thin sh partings. (0-800')
5) Intertongues with both underlying nonmarine Menefee Fm. and overlying marine Lewis Sh. (coastal marine)

"Coconino" Sandstone—Permian (U. Wolfcamp-L. Leonard)
1) San Rafael Swell and Circle Cliffs uplift.
2) and 3) Not a recognized formal name and hence, no type section.
4) Cross-bedded white to gray ss. (600-1200')
5) Many early workers of the 20's and early 30's considered the "Coconino" Ss to be equivalent to the Coconino of the Coconino Plateau, Ariz. The name stuck, so quotes are used to differentiate it from the true Coconino Ss. Equivalent to most of Cedar Mesa and White Rim Ss. True Coconino Ss. is equivalent to only a part of the "Coconino." (Eolian and shallow marine)

Curtis Fm. (of San Rafael Group)—U. Jurassic
1) SE and central Utah.
2) J. Gilluly and J. B. Reeside, Jr., 1926, USGS Press Bull., 6064.
3) Curtis Point on NE side of San Rafael Swell, SE Utah.
4) Light gray, glauconitic ss and greenish gray sh. (0-250')
5) Unconformable, locally with angular relationships as at Hanksville, Utah, on Entrada Ss. SSE pinchout edge is in NW Paradox Basin. Partially equivalent to Summerville Fm. (marine)

Cutler Fm.—L. Permian (Wolfcamp, Leonard)
1) Four Corners region.
2) C. W. Cross and E. Howe, 1905, USGS Silverton Folio No. 120.
3) Cutler Creek, 4 mi. N of Ouray, Colo.
4) Red arkosic ss and cgl, sandy sh, and ls. (0-8000')
5) Raised to group status by Wengerd and Matheny (1958), but considered by Kirkland (1963) as a formation containing the following members in the central Paradox Basin: Halgaito Tongue, Cedar Mesa Ss., Organ Rock Tongue, DeChelly-White Rim Ss. (dominantly fluvial with eolian and marine units intertonguing from the west)

Dakota Sandstone or Fm.—U. Cretaceous
1) N Ariz., N New Mexico, Utah, Colo. Great Plains.
2) F. B. Meek and F. V. Hayden, 1862, Proc. Acad. Nat. Sci. Philadelphia, v. 13, p. 419-20.
3) Near Dakota, Nebraska.
4) Brown to buff ss, gray sh, and sub-bituminous coal. (0-350')
5) Considered upper Lower Cretaceous to lower Upper Cretaceous. Given group status (incl. Burro Canyon Fm.) by Young (1960, AAPG Bull., v. 44, p. 156-194), but generally referred to in common usage as a formation. Basal depositional unit associated with the transgression of the Cretaceous sea. (fluvial and coastal marine)

De Chelly Sandstone (member of Cutler Fm.)—M. Permian (Leonard)
1) SE Utah, NE Ariz., NW New Mexico.
2) H. E. Gregory, 1915, Amer. Jour. Sci., 4th Ser., v. 40, p. 102.
3) Canyon de Chelly, Apache Co., Arizona.
4) Massive, cross-bedded, light red ss. (0-1000')

5) Probably equivalent to White Rim Ss. Raised to formation status by Wengerd and Matheny (1958) but considered a member of the Cutler Fm. by Kirkland (1963). Forms monuments of Monument Valley. (dominantly eolian)

Desert Creek Substage (of Four Corners Stage of Paradox Fm.)—Pennsylvanian (Desmoinesian)
1) Paradox Basin.
2) D. L. Baars, J. W. Parker, and J. Chronic, 1967, AAPG Bull., v. 51, no. 3, p. 393-403.
3) Shell Hovenweep No. 1, sec. 5, T. 40 S., R. 26 E., San Juan Co., Utah.
4) Ls, dol, black sh, anhydrite and salt.
5) Previously referred to as a zone or cycle. Bounded by excellent time marker beds throughout Paradox Basin. A major oil-producing zone in the Aneth field. (evaporite to shelf marine)

Dewey Bridge Mbr. (of Entrada Ss.)—U. Jurassic
1) Northern Paradox Basin east of Green River, and Uncompahgre uplift.
2) J. C. Wright, D. R. Shaw, and S. W. Lohman, 1962, AAPG Bull., v. 46, no. 11, p. 2057-2070.
3) North side of Colorado River one mile east of Dewey Bridge NE of Moab, Utah.
4) Reddish brown sandy sts and silty ss. (20-100')
5) Proposed name for Carmel Fm. east of Green River because lithology is more similar to type Entrada of San Rafael Swell. (marginal marine)

Dolores Fm.—U. Triassic
1) SW Colorado.
2) C. W. Cross, 1899, USGS Telluride Folio No. 57.
3) Dolores River valley, SW Colo.
4) Red ss, sts and cgl (800')
5) Unconformably overlies Cutler Fm; overlain unconformably by Entrada Ss. Equivalent to Chinle Fm. Formerly considered also to be equivalent to Glen Canyon Group. Name now largely abandoned. (continental)

Elbert Fm.—U. Devonian
1) Four Corners area.
2) C. W. Cross, 1899, USGS Telluride Folio No. 57.
3) Elbert Creek, a western tributary of Animas River, SW Colo.
4) Interbedded dol, pastel-colored sh, and qtzite. (0-400')
5) Subdivided into Upper Member and McCracken Ss. Member by Knight and Cooper, 1955, Four Corners Geological Society Guidebook, p. 56. (marine)

Elephant Canyon Fm.—L. Permian (Wolfcamp)
1) East-central Utah.
2) D. L. Baars, 1962, AAPG Bull., v. 46, no. 2, p. 149-218.
3) Elephant Canyon, near confluence of Green and Colorado Rivers, San Juan Co., Utah.
4) Sucrosic, cherty, and chalky ls and dol, interbedded with ss, sts, arkose, and thin beds of anhydrite. (1000')
5) Limited to Wolfcampian. Conformable with overlying Cedar Mesa Ss. Unconformably overlies progressively older Penn. to Miss. strata toward San Rafael Swell (Emery uplift). Recognizable from underlying Penn. rocks of similar lithology only on basis of fusulinids. (marine)

Emery Sandstone—U. Cretaceous
1) Wasatch Plateau.
2) E. M. Spieker and J. B. Reeside, Jr., 1925, GSA Bull. v. 36, p. 439.
3) SW of Emery, Utah.
4) Littoral marine ss. (800' in type area)
5) Littoral marine ss which extends east within Mancos Sh as a discontinuous sandy zone. "Emery" Ss. as mapped in Henry Mtns. is not the same unit as at the type area (refer to Peterson and Ryder in this guidebook). (marine)

Entrada Sandstone—U. Jurassic
1) E and S Utah, W and central Colo., N New Mex., and N Ariz.
2) J. Gilluly and J. B. Reeside, Jr., 1926, USGS Press Bull. 6064.
3) Entrada Point in N part of San Rafael Swell, Utah.
4) Light colored to red, usually massive ss. (35-850')
5) Middle formation of San Rafael Group. Divided into three members in NE Paradox Basin by J. C. Wright et al, 1962, which in ascending order are Dewey Bridge, Slick Rock and Moab Mbrs. (dominantly eolian)

Farrer Fm. (of Mesaverde Group)—U. Cretaceous
1) Central Book Cliffs, Utah.
2) D. J. Fisher, 1936, USGS Bull. 852.
3) Coal Canyon, Utah.
4) Buff to white ss and gray sh. (400-1500')
5) Gradationally overlies Neslen Fm. Distinguished fromNeslen by absence of coal and carb sh. (alluvial plain)

Ferron Sandstone Mbr. (of Mancos Sh)—U. Cretaceous
1) Central-eastern Utah.
2) C. T. Lupton, 1914, USGS Bull. 541, p. 128.
3) Castle Valley, Utah.
4) Ss and sandy sh. (0-385')
5) The unit mapped as Ferron Ss. in northern Paradox Basin is a sandy calcarenite, sts & fissile sh more similar to the Juana Lopez of San Juan Basin than to ss of true Ferron which pinches out just east of Farnham dome between Price and Woodside, Utah. Refer to Molenaar in this guidebook. (marine)

Four Corners Stage (of Paradox Fm.)—Pennsylvanian (Desmoinesian)
1) Paradox Basin.
2) D. L. Baars, J. W. Parker, and J. Chronic, 1967 AAPG Bull., v. 51, no. 3, p. 393-403.
3) Shell Hovenweep No. 1, sec. 5, T. 40 S., R. 26 E., San Juan Co., Utah.
4) Rocks represented in Paradox Basin are salt, anhydrite, black sh, ls and dol.
5) Bounded by excellent time-marker beds throughout Paradox Basin. Divided into 4 substages which in ascending order are Barker Creek, Akah, Desert Creek and Ismay substages. (evaporite to shelf marine)

Glen Canyon Group—U. Triassic
1) S and E Utah, N Ariz., SW Colo., and NW New Mexico.
2) J. B. Reeside, Jr., C. E. Dobbin, A. A. Baker, and E. T. McNight, 1927, AAPG Bull., v. 11, no. 5, p. 787.
3) Glen Canyon of Colorado River, Kane County, Utah.
4) Red, red-brown, buff, purple, and white ss, sh, and sts. (0-1000')
5) Includes in ascending order: Wingate Ss., Kayenta Fm., and Navajo Ss. (eolian and fluvial)

Greenhorn Limestone Mbr. (of Mancos Shale)—U. Cretaceous)
1) N New Mexico, E and SW Colorado, Great Plains.
2) G. K. Gilbert, 1896, USGS 17th Ann. Rept. pt. 2, p. 564.
3) Greenhorn Creek near Pueblo, Colorado.
4) Gray shaly ls and calcareous sh. (20-60')
5) Overlies Graneros and underlies the major portion of Mancos Sh. Preserved in some of the synclines in the Paradox anticline area. Limestone grades into shale by facies change in northern Paradox Basin. (marine)

Halgaito Shale Tongue (of Cutler Fm.)—L. Permian (Wolfcamp)
1) SE Utah and NE Arizona.
2) A. A. Baker and J. B. Reeside, Jr., 1929, AAPG Bull., v. 13, no. 11, p. 1420-1446.
3) Halgaito Springs, SW of Mexican Hat, Utah.
4) Red ss and sandy sh. (0-500')
5) Raised to formation status by Wengerd and Matheny (1958) but considered a member of the Cutler Fm. by Kirkland (1963). (marginal marine and floodplain)

Hermosa Group—Pennsylvanian
1) Four Corners area.
2) C. W. Cross and A. C. Spencer, 1899, USGS La Plata Folio No. 60, p. 8.
3) Hermosa Creek, San Juan Mountains, Colorado.
4) Carbonate sequence with interbedded ss, sh, and evaporites. (0-6000'+)
5) Raised from formation to group status by Wengerd and Matheny (1958), who included in ascending order: Pinkerton Trail Fm., Paradox Fm., and Honaker Trail Fm. (marine, restricted marine and fluvial)

Hite Bed (in Chinle Fm.)—U. Triassic
1) Paradox Basin between confluence of Green and Colorado Rivers and the Utah-Arizona line.
2) J. H. Stewart, F. G. Poole, and R. E. Wilson, 1972, USGS Prof. Paper 690, p. 41-43. Informally named by J. H. Stewart, G. A. Williams, H. F. Albee, and O. B. Raup, 1959, USGS Bull. 1046Q, p. 518.
3) Two miles south of Hite, San Juan Co., Utah.
4) Pale red and light greenish gray, very fine-grained ss, cgl and reddish brown sts. (10-60')

5) Underlies Wingate Ss and pinches out to south in NE Arizona within Church Rock Mbr. (fluvial)

Honaker Trail Fm. (of Hermosa Group)—U. Pennsylvanian
1) Four Corners area.
2) S. A. Wengerd and M. L. Matheny, 1958, AAPG Bull., v. 42, no. 9 p. 2048-2106.
3) Honaker Trail in San Juan R. Canyon, W of Mexican Hat, Utah.
4) Interbedded ls, sh, and ss. (0-3000'+)
5) Previously termed U. Member of Hermosa Fm. (marine and fluvial)

Hoskinnini Mbr. (of Moenkopi Fm.)—L. Triassic
1) SE Utah and NE Arizona.
2) A. A. Baker and J. B. Reeside, Jr., 1929, AAPG Bull., v. 13, no. 11, p. 1422-1446.
3) Hoskinnini Mesa, W of Monument Valley, Utah.
4) Red ss and sandy sh. (0-100')
5) Formerly considered member of Cutler Fm. and Permian; given present status by Stewart (1959, AAPG Bull., v. 43, no. 8, p. 1852-1868). (fluvial)

Ignacio Quartzite—U. Cambrian
1) SW Colo., NW New Mexico, SE Utah, extreme NE Ariz.
2) C. W. Cross and A. C. Spencer, 1899, USGS La Plata Folio No. 60 p. 8. 8.
3) Ignacio Reservoir, (Lake Electra), La Plata Co., Colorado.
4) Quartzite and sandy sh. (0-300')
5) Correlative with Tapeats Ss. in Arizona and Tintic Quartzite west of the Kaibab uplift and San Rafael Swell. Represents basal sands deposited by the transgressing Cambrian seas. (marine)

Ismay Substage (of Four Corners Stage of Paradox Fm.)—Pennsylvanian—(Desmoinesian)
1) Paradox Basin.
2) D. L. Baars, J. W. Parker, and J. Chronic, 1967, AAPG Bull., v. 51, no. 3, p. 393-403.
3) Shell Hovenweep No. 1, sec. 5, T. 40 S., R. 26 E., San Juan Co., Utah.
4) Ls, dol, black sh, anhydrite and salt.
5) Previously referred to as a zone or cycle. Bounded by excellent-time-marker beds throughout Paradox Basin. A major oil-producing zone in the Aneth area. (evaporite to shelf marine)

Juana Lopez Mbr. (of Mancos Sh.)—U. Cretaceous
1) NW New Mex., E Utah, SW Colo.
2) C. H. Rankin, 1944 New Mex. Bur. Mines & Min. Resource Bull. 20.
3) Mesita Juana Lopez Grant 6 mi. west of Cerrillos, New Mex.
4) Interbedded sandy, fossiliferous calcarenite, sts, very fine-grained ss and fissile sh. (4-110')
5) A widespread marker bed in the San Juan Basin (also known as Sanostee Mbr.) that extends to the northern Paradox Basin where it has been mapped as Ferron Ss. (Refer to Molenaar in this guidebook). (marine)

Junction Creek Sandstone—U. Jurassic
1) SW Colorado in vicinity of La Plata Mtns.
2) M. I. Goldman and A. C. Spencer, 1941, AAPG Bull., v. 25, no. 9, p. 1745-67.
3) Junction Creek near Durango, Colorado.
4) Cross-bedded and massive white ss. (0-400')
5) Equivalent to Bluff Ss. Gradational with both underlying Summerville Fm. and overlying Morrison Fm. (dominantly eolian)

Kaibab Limestone—M. Permian (Leonard-Guadalupe)
1) N Arizona, S Utah, SE Nevada.
2) N. H. Darton, 1910, USGS Bull. 435
3) Kaibab Gulch, Paria, Utah.
4) Dense, cherty, gray ls. (0-800')
5) Underlies Moenkopi Fm. unconformably. Generally considered Leonardian, but upper part contains Guadalupian fossils near Flagstaff, Arizona. (marine)

Karla Kay Cgl. Mbr. (of Burro Canyon Fm.)—L. Cretaceous
1) SW Colorado and SE Utah.
2) E. B. Ekren and F. N. Houser, 1959, AAPG Bull., v. 43, no. 1, p. 195-199.
3) Karla Kay mine in McElmo Canyon, Montezuma Co., Colo.
4) Chert pebble-rare cobble cgl and conglomeratic ss. (0-65')
5) A lenticular, channeling cgl at base of Burro Canyon Fm. (fluvial)

Kayenta Fm. (of Glen Canyon Group)—U. Triassic
1) S & SE Utah, SW Colo., NE Ariz.
2) A. A. Baker, C. H. Dane, and E. T. McKnight, 1931, USGS Prelim. map of parts of Grand and San Juan Counties, Utah.
3) One mile north of Kayenta, Arizona.
4) Red, gray, and purple ss and sh. (15-320')
5) Middle fm. of Glen Canyon Group. Formerly L. Jurassic. Reassigned to U. Triassic by Lewis et al (1961, GSA Bull., v. 72, no. 9, p. 1437-40). (fluvial)

Leadville Limestone—L. Mississippian)
1) Colorado, NW New Mexico, NE Arizona, SE Utah.
2) G. H. Eldridge, 1894, USGS Anthracite—Crested Butte Folio No. 9.
3) Leadville mining district, Colorado.
4) Massive ls and dol with cherty zones (0-700')
5) Disconformably (?) overlies Ouray Ls. and is disconformably overlain by regolithic Molas Fm. Equivalent to Redwall Ls. Main oil-producing reservoir at Lisbon field. (marine)

Lewis Shale—U. Cretaceous
1) SW Colo. and NW New Mexico.
2) W. Cross and A. C. Spencer, 1899, USGS La Plata Folio No. 60.
3) Fort Lewis, La Plata, Co., Colo.
4) Soft, dark gray sh, sandy sh, and ss. (0-2500')
5) Overlies type Mesaverde Group and underlies Pictured Cliffs Ss. (marine)

Lukachukai Mbr. (of Wingate Sandstone)—U. Triassic
1) NW New Mexico, NE Arizona.
2) J. W. Harshbarger, C. A. Repenning, and J. H. Irvin, 1957, USGS Prof. Paper 291.
3) Escarpment NE of Lukachukai, Apache Co., Ariz.
4) Red-brown ss, fine-grained, cross-bedded. (300')
5) Upper member of Wingate Ss. of NE Arizona and is equivalent to entire Wingate Ss. in Paradox Basin. Overlies Rock Point Mbr. in NE Arizona. (eolian)

Lynch Dolomite—U. Cambrian
1) Central and east-central Utah.
2) J. Gilluly, 1932, USGS Prof. Paper 173.
3) Lynch Ridge, N. of Ophir, Utah.
4) Light to dark gray dol. (0-1400')
5) Uppermost Cambrian Fm. in east-central Utah and Paradox Basin. (marine)

Mancos Shale—U. Cretaceous
1) W Colo., NW New Mex., E Utah, S and central Wyo.
2) C. W. Cross, 1899, USGS Telluride Folio No. 57.
3) Mancos Valley near Mancos, Colo.
4) Dark gray calcareous and fossiliferous sh, with thin ss and ls stringers (2000-3500')
5) Grades southwest, west and northwest into coastal and continental deposits of Mesaverde Group. (marine)

Masuk Mbr. (of Mancos Shale)—U. Cretaceous
1) Henry Mountains, Utah.
2) G. K. Gilbert, 1877, U.S. Geog. and Geol. Survey of the Rocky Mtn. region. Amplified by C. B. Hunt, P. Averitt, and R. L. Miller, 1953, in USGS Prof. Paper 228.
3) Masuk Plateau in Henry Mountains, Utah.
4) Sandy gray sh, carb. sh, and ss. (600-800')
5) The type section of Masuk is nonmarine according to Peterson and Ryder in this guidebook. The "Masuk" Sh. Mbr. of the Mancos Sh. in the Wasatch Plateau, which overlies the Emery Ss., is a marine tongue that was miscorrelated with the type Masuk. (nonmarine)

Maxfield Limestone—M. and U. Cambrian
1) Central and east-central Utah.
2) F. F. Hintz, Jr., 1913, N. Y. Acad. Sci. Annals, v. 23, p. 107.
3) Maxfield mine, Argenta, Utah.
4) Massive ls, with thin green sh. (0-650')
5) Name sometimes applied in E Utah, formerly called Bowman Hartman Ls. by Cooper (1955, Four Cor. Geol. Soc. Guidebook). Use of the equivalent name "Muav" is preferred by Loleit (1963) in all parts of the Four Corners area. (marine)

McCracken Sandstone Mbr. (of Elbert Fm.)—U. Devonian
1) Four Corners area.
2) R. L. Knight and J. C. Cooper, 1955, Four Corners Geol. Soc. Guidebook, p. 56.
3) Shell Bluff No. 1, sec. T. 39 S., R. 23 E. on McCracken Mesa, San Juan Co., Utah.
4) Siliceous ss; in places, glauconitic. (0-150')
5) Basal mbr. of Elbert Fm. Minor oil producer at Lisbon field. (marine)

Menefee Fm. (of Mesaverde Group)—U. Cretaceous
1) SW Colo. and NW New Mex.
2) A. J. Collier, 1919, USGS Bull. 691K.
3) Menefee Mountain, Montezuma County, Colo.
4) Interbedded ss, sh, and coal. (0-2000')
5) Middle fm. of Mesaverde Group. Intertongues with underlying Point Lookout Ss. and overlying Cliff House Ss. (nonmarine coastal plain)

Mesaverde Group—U. Cretaceous
1) E Utah, W Colo., NW New Mex. and Wyo.
2) W. H. Holmes, 1877, U.S. Geol. and Geog. Surv. Terr., 9th Ann. Rept. for 1875, p. 245-248.
3) Mesa Verde, Montezuma County, Colo.
4) Ss, sh, and coal. (900-2500')
5) Includes, in ascending order, Point Lookout Ss, Menefee Fm. and Cliff House Ss, in type area. Name has been used throughout Rocky Mountain area to designate shoreface and coastal plain sandstones, shales and coals overlying main body of Mancos or equivalent shales without regard to type section. Book Cliffs Mesaverde is a good example. (Coastal marine and nonmarine coastal plain)

Moab Tongue or Mbr. (of Entrada Sandstone)—U. Jurassic
1) Northern Paradox Basin.
2) A. A. Baker, C. E. Dobbin, E. T. McKnight, and J. B. Reeside, Jr., 1927, AAPG Bull., v. 11, no. 8, p. 785-808.
3) Moab Valley area, Utah.
4) Massive, white, cross-bedded ss. (0-150')
5) Well developed in Moab-Arches National Monument area. Disconformable on Entrada Ss. and pinches out within Summerville Fm. to the west. Considered a member of Entrada Ss. by J. C. Wright et al, 1962, AAPG Bull., v. 46, no. 11. (dominantly eolian, but probably marginal-marine toward pinchout)

Moenkopi Fm.—L. and M. (?) Triassic
1) Arizona, E and SW Utah, SE Nevada, SW Colorado, NW New Mexico.
2) L. F. Ward, 1901, Am. Jour. of Sci., 4th Ser., v. 12, pp. 401-13.
3) Moenkopi Wash, Coconino County, Arizona.
4) Dominantly redbeds—red to chocolate brown sh, sts, and ss with gray ls intertonguing from the west. (0-800' but locally exceeds 2500' in synclines adjacent to salt anticlines)
5) Basal Triassic unit. The Moenkopi is broken into different members in different areas. In ascending order, includes Tenderfoot, Ali Baba, Sewemup and Pariott Members in northeast Paradox Basin and Black Dragon, Sinbad Limestone, Torrey, and Moody Canyon Members in San Rafael Swell area. Hoskinnini Member is basal unit in southern Paradox. (marginal marine and marine to locally fluvial toward east)

Molas Fm.—L. Pennsylvanian (Atokan)
1) Four Corners area.
2) C. W. Cross and E. Howe, 1905, USGS Silverton Folio No. 120, and GSA Bull., v. 16, p. 470-496.
3) Molas Lake, near Silverton, Colo.
4) Red and variegated sh, thin ls and ss. (0-200')
5) Represents residual and reworked soil mantle on Miss. Leadville Fm. (continental and marine)

Monitor Butte Mbr. (of Chinle Fm.)—Triassic
1) N central Ariz., S. Utah.
2) J. H. Stewart, 1957, AAPG Bull., v. 41, no. 3, p. 452-453.
3) Monitor Butte, Utah: T. 41 S., R. 12 E.
4) Bentonitic mudstone, sts, and ss. (0-250')
5) Not present north of approx. Monticello, Utah. Lies between Shinarump and Moss Back Members. (continental)

Moody Canyon Mbr. (of Moenkopi Fm.)—L. and M.(?) Triassic
1) Western Paradox—San Rafael—Circle Cliffs areas.
2) R. C. Blakey, 1974, Utah Geol. and Min. Survey Bull. 104, p. 46.
3) Moody Canyon, southwestern Circle Cliffs, Garfield Co., Utah.
4) Red mudstone and sts and minor dol, gypsum and ss. (100-400')
5) Upper, slope-forming member of Moenkopi Fm. (marginal marine)

Morrison Fm.—U. Jurassic
1) N New Mex., NE Ariz., E Utah, Colo., Great Plains.
2) G. H. Eldridge, 1896, USGS Mon. 27.
3) Morrison, Colorado, near Denver.
4) Ss, sh, cgl. variecolored. (380-900')
5) Contains four members in ascending order: Salt Wash Ss., Recapture Sh., Westwater Canyon Ss., and Brushy Basin Sh. Only Salt Wash and Brushy Basin Mbrs are differentiated in N Paradox. (continental)

Moss Back Mbr. (of Chinle Fm.)—U. Triassic
1) Monument uplift area, Utah.
2) J. H. Stewart, 1957, AAPG Bull., v. 41, no. 3, p. 441-465.
3) White Canyon area, San Juan County, Utah.
4) Gray ss with cgl lens. (0-150')
5) Overlies Monitor Butte Mbr. in west-central Paradox Basin and becomes basal unit of Chinle by onlap farther north. Basal coarse ss unit of northern Paradox may not be equivalent to Moss Back. (fluvial)

Muav Limestone (of Tonto Group)—M. Cambrian
1) N Arizona and SE Utah.
2) L. F. Noble, 1914, USGS Bull. 549.
3) Muav Canyon, Grand Canyon, Ariz.
4) Blue-gray, thin-bedded, mottled buff sh and ls (450-475')
5) Overlies Bright Angel Sh. Equivalent to Maxfield Limestone of central Utah. (marine)

Naturita Fm.—L. and U. Cretaceous
1) Colorado Plateau (not generally accepted)
2) R. G. Young, 1960, AAPG Bull., v. 44, no. 2, p. 156-194.
3) Near Naturita, Montrose County, Colo.
4) Carbonaceous mudst, coal, cgl, ss, and beach ss. (0-200')
5) Name proposed by Young for basal coastal plain deposits underlying Mancos Sh., generally known as the Dakota Ss. (near-shore marine to continental)

Navajo Sandstone (of Glen Canyon Group)—U. Triassic(?) and L. Jurassic
1) N Ariz., S Utah, and W Colo.
2) H. E. Gregory, 1915, Am. Jour. Sci., 4th Ser., v. 40, p. 102-112.
3) Navajo Country, Arizona.
4) Massive, highly cross-bedded, buff to red ss. (0-600')
5) Upper formation of Glen Canyon Group. Unconformably overlain by San Rafael Group. Formerly considered to be all L. Jurassic. Reassigned to part Jurassic and part U. Triassic(?) by G. E. Lewis et al, 1961, GSA Bull., v. 72, no. 9, p. 1437-40. P. M. Galton, 1971, Journ. of Paleo., v. 45, no. 5, p. 781-795, considers entire Navajo in NE Ariz. to be U. Triassic based on dinosaur fauna. The Thousand Pockets and associated ss tongues at the top of the Navajo farther west intertongue with the Carmel Fm. and are separated from the main body of the Navajo by a regional unconformity (F. Peterson, publication in progress). (eolian)

Neslen Fm. (of Mesaverde Group)—U. Cretaceous
1) Central Book Cliffs, eastern Utah.
2) D. J. Fisher, 1936, USGS Bull. 852.
3) Neslen Canyon north of Thompson, Grand Co., Utah.
4) Carb sh, sltst, gray lenticular ss and coal. (350-1300')
5) Coastal plain deposits overlying and laterally equivalent to regressive shoreface sands of Sego Ss. Contains mineable coal. (nonmarine coastal plain)

Ophir Shale—M. to U. Cambrian
1) N and E central Utah.
2) G. F. Loughlin, 1919, USGS Prof. Paper 107, p. 25-27.
3) Ophir, Utah.
4) Sandy sh, with interbeds of ls, dol, and ss. (0-300')
5) Overlies Tintic Quartzite. Equivalent to Bright Angel Sh. (marine)

Organ Rock Tongue (of Cutler Fm)—L. Permian (Wolfcamp)
1) Western Paradox Basin and Monument Valley, Utah and NE Ariz.
2) A. A. Baker and J. B. Reeside, Jr., 1929, AAPG Bull., v. 13, no. 11, p. 1420-46.
3) Organ Rock, Monument Valley, San Juan County, Utah.
4) Red sh, sts, and ss (0-900')
5) Overlies Cedar Mesa Ss and underlies DeChelly Ss. and White Rim Ss. Probably equivalent to Hermit Sh. of Grand Canyon area. (continental)

Ouray Limestone—U. Devonian & L. Mississippian(?)
1) Four Corners area.
2) C. W. Cross and A. C. Spencer, 1899, USGS La Plata Folio No. 60, p. 8.
3) Ouray, Colo.
4) Massive ls with thin green sh partings. (50-150')
5) Conformably overlies Elbert Fm. and is disconformably (?) overlain by Leadville or Redwall Ls. (marine)

Owl Rock Mbr. (of Chinle Fm.)—U. Triassic
1) Four Corners area south of Moab, Utah.
2) J. H. Stewart, 1957, AAPG Bull., v. 41, no. 3, p. 548.
3) Owl Rock, north of Kayenta, Arizona.
4) Light purple to red and brown sts, with thin beds of ls. (0-450')
5) Between Petrified Forest and Church Rock Members. (continental)

2) J. Gilluly and J. B. Reeside, Jr., 1926, USGS Press Bull. 6064.
3) Summerville Point, north end of San Rafael Swell, Utah.
4) Red, red-brown, and green sts, ss, sh and gypsum. (30-330')
5) Upper fm. of San Rafael Group. (marginal marine)

Tapeats Sandstone (of Tonto Group)—L. and M. Cambrian
1) N Arizona, Grand Canyon, and SE Utah west of Monument Uplift and La Sal Mts.
2) L. F. Noble, 1914, USGS Bull. 549.
3) Tapeats Creek, Grand Canyon.
4) Cross-bedded ss and qtzite with cgl lenses. (0-285'+)
5) Rests unconformably on Precambrian. Lithogenetic equivalent (although older) of Ignacio and Tintic qtzites. (transgressive marine)

Temple Mountain Mbr. (of Chinle Fm.)—U. Triassic
1) Locally in E central Utah.
2) R. C. Robeck, 1956, AAPG Bull., v. 40, no. 10, p. 2499-2506.
3) Temple Mountain, San Rafael Swell, Utah.
4) Interbedded purple and white ss, sh, and cgl. (0-100')
5) Basal mbr. of Chinle Fm. in local areas of San Rafael Swell. Disconformably overlies Moenkopi Fm. and was derived from erosion of Moenkopi beds. (fluvial)

Tenderfoot Mbr. (of Moenkopi Fm.)—L. Triassic
1) Northern Paradox Basin.
2) E. M. Shoemaker and W. L. Newman, 1959, AAPG Bull., v. 43, no. 8, p. 1835-51.
3) Tenderfoot Mesa, Mesa County, Colorado.
4) Arkosic ss, gyp. brown sandy mudstone, and silty ss. (0-290')
5) Basal mbr. of Moenkopi Fm. Probably equivalent to Hoskinnini Member of SE Utah. Unconformable with underlying Cutler. (marginal marine? to continental)

Tintic Quartzite—L. and M. Cambrian
1) Central Utah and extended to Four Corners area by some geologists. Usage probably should be restricted to area west of San Rafael and Kaibab uplifts.
2) G. O. Smith, 1909. USGS Tintic Folio No. 65.
3) Tintic Canyon, Tintic mining district, Utah.
4) Massive siliceous ss and cgl with thin beds of sh. (0-150')
5) Lithogenetic equivalent of Tapeats Ss. of Grand Canyon and Ignacio Qtzite of Four Corners area. (transgressive marine)

Torrey Mbr. (of Moenkopi Fm.)—L. Triassic
1) San Rafael Swell, Circle Cliffs and western Paradox Basin.
2) R. C. Blakey, 1974, Utah Geol. and Min. Survey Bull. 104, p. 35.
3) A few miles south of Torrey, Wayne Co., Utah.
4) Red to nonred silty ss and sandy sts. (150-300')
5) Ledge and cliff-forming member within Moenkopi Fm. (deltaic and marginal-paralic marine)

Tununk Shale Mbr. (of Mancos Sh.)—U. Cretaceous
1) Henry Mtns. and Wasatch Plateau areas, Utah.
2) G. K. Gilbert, 1877, U.S. Geog. and Geol. Survey of the Rocky Mtn. region.
3) Tununk Plateau in Henry Mountains, Utah.
4) Dark gray marine sh. (525'-650')
5) Overlies Dakota Ss. and underlies Ferron Ss. Farthest westerly extending tongue of Mancos Sh. (marine)

Wanakah Fm.—U. Jurassic
1) SW Colo. (restricted, not in common use).
2) W. S. Burbank, 1930, Colo. Sci. Soc. Proc., v. 12, no. 6, p. 172.
3) Wanakah mine, Ouray County, Colorado.
4) Ss, sh, breccia, gypsum, and ls. (25-150')
5) Equivalent to Summerville Fm. Composed of following mbrs. in ascending order: Pony Express Ls, Bilk Creek Ss, and unnamed upper marl member. Present usage restricts the formation to the western and southern margins of the San Juan Mtns., SW Colo. (lacustrine to embayed-marine)

Wasatch Fm. or Group—Tertiary (Eocene)
1) W Colorado, NW New Mexico, Utah, Wyoming, parts of Montana and North Dakota.
2) F. V. Hayden, 1869, USGS Terr. 3rd Ann. Report, p. 191 of 1873 edition.
3) Named for exposures between Carter, Wyoming, and Echo, Utah, after Wasatch (Wahsatch) Station on U. P. Railroad, Summit County, Utah.
4) Brown, buff, and gray ss alternating with buff, gray, brown, red, and variegated sh, locally cgl. (1500-2500' in Book Cliffs N of Paradox Basin)
5) Post-orogenic sediments derived from Laramide uplift. Unconformably overlies U. Cretaceous and intertongues with lower part of Green River Fm. north of Paradox Basin. (continental)

Westwater Canyon Sandstone Mbr. (of Morrison Fm.)—U. Jurassic
1) Four Corners area.
2) H. E. Gregory, 1938, USGS Prof. Paper 188.
3) Westwater Creek, SW of Blanding, San Juan County, Utah.
4) Gray and red ss, sh, and cgl. (0-300')
5) Overlies Recapture Sh. and underlies Brushy Basin Sh. Mbrs. Important uranium producer near Grants, New Mexico. (fluvial)

White Rim Sandstone Mbr. (of Cutler Fm.)—M. Permian (Leonard)
1) SE Utah west of Colorado River.
2) A. A. Baker and J. B. Reeside, Jr., 1929, AAPG Bull. v. 13, no. 11, p. 1444.
3) White Rim escarpment between Green and Colorado Rivers, Utah.
4) White, highly cross-bedded ss. (0-250')
5) Conformably overlies Organ Rock Sh. and unconformably overlain by Moenkopi Fm. Contains large volume of tarry oil in exhumed strat. trap a few miles west of confluence of Green and Colorado Rivers. (eolian and shallow marine)

Wingate Sandstone (of Glen Canyon Group)—U. Triassic
1) SE Utah, SW Colo, NE Arizona and NW New Mexico.
2) C. E. Dutton, 1885, USGS 6th Ann. Rept., p. 136.
3) Cliffs north of Ft. Wingate, McKinley Co., New Mexico (This later proved to be Entrada Ss).
4) Massive, red, cliff-forming ss in Paradox Basin. (0-400')
5) In NE Arizona the massive Lukachukai Mbr. is equivalent to entire Wingate in SE Utah. Wingate Ss is main cliff-forming ss in northern Canyonlands-Moab areas. (dominantly eolian)

FOOD FOR THOUGHT

"Sooner or later a man, if he is wise, discovers that life is a mixture of good days and bad, victory and defeat, give and take. He learns that it does not pay to be too sensitive about his own feelings, and that he should let some things go over his head like water off a duck's back. He learns that all men have burnt toast for breakfast now and then, and that he shouldn't take the other fellow's grouch too seriously. He learns that carrying a chip on his shoulder is the easiest way to get into a fight. He learns that the quickest way to become unpopular is to carry tales and gossip about others. He learns that most people are human and that it doesn't do any harm to smile and say "good morning" even if it is raining. He learns that most of the other fellows are as ambitious as he is, that they have brains that are as good or better, and that hard work and not cleverness is the secret of success. He learns that it doesn't matter so much who gets the credit so long as the job gets done. He comes to the sobering realization that business could run along perfectly without him. He learns not to worry unnecessarily when he does not make a hit every time he comes to bat, because experience has shown if he always gives his best, his average will break well. He learns that no man gets to first base alone and that it is only through the cooperative effort that we move on to better things. He learns that the fellows are not any harder to get along with in one place than another and that "getting along" depends about 98 percent on himself."

Anonymous—*Signposts*—Dec. 28, 1971

( )

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

January 17, 1995

William J. Sinclair, Director
Division of Radiation Control
Department of Environmental Quality
168 North 1950 West
P.O. Box 144850
Salt Lake City, Ut 84114-4850

SUBJECT: STATE OF UTAH'S COMMENTS ON ATLAS STUDY OF RIVER WATER AND SEDIMENTS AT THE MOAB, UTAH URANIUM MILL

Dear Mr. Sinclair:

Your letter dated November 15, 1994, provided comments and suggestions on the Colorado River sediment and water study which by letter dated October 28, 1994, the Nuclear Regulatory Commission had asked the Atlas Corporation (Atlas) to perform. As you have been informed, Atlas moved rapidly and had already completed the sampling program prior to NRC's receiving your comments on the sampling program.

Your letter dated December 21, 1994, expressed your concern that the sampling program had proceeded without allowing a comment period by interested parties. As a matter of public policy, the NRC often solicits comments on significant proposed actions but we did not consider a sampling request to be such an action. We appreciate the thoughtful comments provided by your office and also those provided by Noel Poe with the National Park Service. The requested sampling was designed to provide supplemental specific information where our data were deficient. It was not planned to duplicate information which we already had from Atlas or from the many other sources of water quality data.

Much of the information suggested in your November letter as needed is related to water quality standards which are the responsibility of the State of Utah. The NRC has no regulatory authority to assess or enforce such standards.

An assessment of the baseline conditions and prediction of the potential impact of the tailings on the Colorado River must be provided by Atlas. There is a substantial amount of data available on which to base such an assessment of potential impact. If, after reviewing the data being acquired, it appears that additional information is needed to support such an assessment, Atlas will be required to do additional work.

Atlas has been requested to provide you a copy of the sediment sampling report. To expedite the review of this topic (sampling), I request that you meet with the NRC staff and Atlas to go over this report and data. The meeting will provide a useful forum for Atlas to address your concerns and for all parties to clearly understand the need for any additional sampling. We suggest the week of March 6, 1995, for the meeting in NRC's offices, and will call you for a mutually agreeable time and date.

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Please be assured that the NRC is committed to keeping your office informed and involved in the Atlas reclamation plan review process. If you have any questions or comments please call me at (301) 415-6643.

Sincerely,

[Original signed by Joseph J. Holonich]

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

cc: See attached list

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Addressees - Letter Dated January 17, 1995

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TU-3453

MEMORANDUM TO: Daniel M. Gillen, Section Leader
Uranium Recovery Projects Section
HLW Uranium Recovery Projects Branch/DWM

THRU: Mysore S. Nataraja, Acting Section Leader
Geosciences/Geotechnical Engineering Section /S/
Engineering and Geosciences Branch/DWM

FROM: Abou-Bakr K. Ibrahim
Geosciences/Geotechnical Engineering Section /S/
Engineering and Geosciences Branch/DWM

SUBJECT: REVIEW OF THE PRELIMINARY DRAFT ENVIRONMENTAL IMPACT STATEMENT, ATLAS SITE, MOAB UTAH, SECTION 3.2.3

I have reviewed Section 3.2.3, seismicity, of the "Preliminary Draft Environmental Impact Statement (DEIS)," related to reclamation of the uranium mill tailings at the Atlas site, Moab, Utah.

The seismology section in the DEIS is highly abbreviated. This section should be expanded to give the reader some understanding on the seismic activities in the area. This section should address briefly the impact of the seismic activities on the stability of the mill tailings and how that would affect the environment. Although Oak Ridge National Laboratory (ORNL) states that the Technical Evaluation Report (TER) will address this in detail, the EIS should be a complete report that stands on its own.

Specific Comments:

- The first sentence in Section 3.2.3, p. 3-8, should be taken out, or modified to reflect the band of uncertainty that may be associated with predicting a strong earthquake.
- Algermissen et al. (1991) should be (1990).
- The third sentence in the second paragraph, should be supported by a reference.

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

January 30, 1995

MEMORANDUM TO: Joseph J. Holonich, Chief
High-Level Waste and Uranium Recovery Project Branch

FROM: John H. Austin, Chief
Performance Assessment and Hydrology Branch

SUBJECT: REVIEW OF SEDIMENT AND MATRIX WATER SAMPLING DATA FOR THE ATLAS MOAB URANIUM MILL, (RITS # 233AAD, LICENSE REVIEW # 04003453010E, TAC # L50900).

The chemical analyses of sediment, matrix water, and river water from the Atlas uranium mill site have been reviewed as requested. Samples of river water were taken both upstream and downstream from the site. No contamination is evident in the analyses of the river water. Attached is a table and graph showing our analyses of river sediment which includes both the solids and coexisting matrix water. These samples were collected at or below the water line in three zones on the river - near the tailings, downstream from the tailings, and upstream from the tailings. Samples 943467-3 and 943467-6 are a composite of five locations in the zone nearest the tailings. These samples are matrix water and sediment. Samples 943467-4 and 943467-7 are composites of five matrix water and sediment samples, respectively, taken downstream from the tailings. Samples 943467-5 and 943467-8 are composites of five matrix water and sediment samples, respectively, taken upstream from the tailings.

A general pattern is evident from this set of samples which suggests some constituents being monitored show the highest concentrations in the sediments nearest the tailings. The lowest concentrations of these constituents are generally found in the downstream samples. Significant levels of these constituents occur upstream indicating elevated levels in background are possible. This pattern is seen in the gross alpha, gross beta, and uranium concentrations, for both matrix water and sediment.

From the Atlas Moab Ground Water Detection Monitoring Program (1988), groundwater analyses from three wells, AMM-1, AMM-2, and AMM-3, indicate elevated gross alpha, gross beta, and uranium activity nearest the tailings. Well AMM-2 contains 2400 pCi/L gross alpha and is nearest the sediment samples 943467-3 and 94367-6. The groundwater sample has approximately five times the gross alpha of the matrix water sample from the sediment. This could be due to dilution with river water. The groundwater sample AMM-1 (considered background) has 33 pCi/L gross alpha. This concentration is less than that of the upstream matrix water from the sediment sample, 943467-5, but still above drinking water standards.

CONTACT: J. Bradbury, PAHB/DWM
415-6597

020073

40-3453
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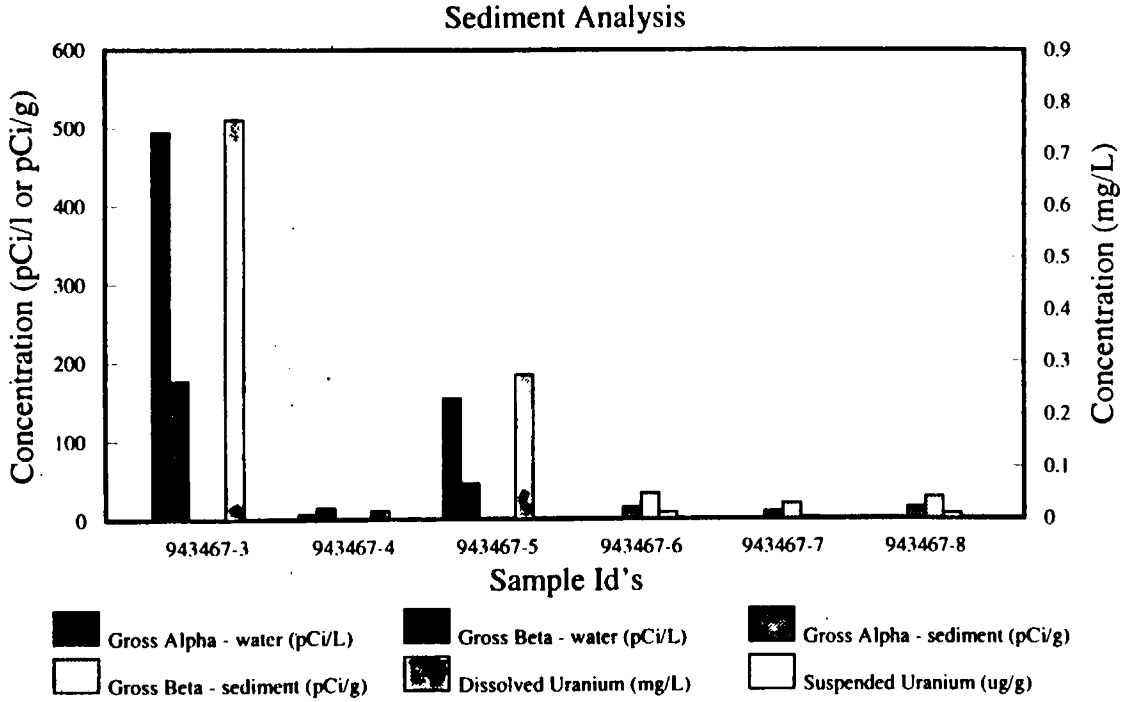
M/32

Sample ID	Dissolved Uranium Matrix Water	Gross Alpha Sediment	Gross Alpha Matrix Water	Suspended Uranium Sediment	Gross Beta Matrix Water	Gross Beta Sediment	Pb-210 Matrix Water	Pb-210 Sediment	Po-210 Matrix Water	Po-210 Sediment
943467-3	0.766		494		176		1.6		0.2	
943467-4	0.0157		6.3		15		0.4		0	
943467-5	0.276		154		46		2.9		0.4	
943467-6		15		8.4		33		2.4		2.[illegible]
943467-7		9.2		2.1		20		1.7		2.[illegible]
943467-8		15		6.8		28		2.5		2.[illegible]

Atlas Moab Uranium Mill



Samples 3 & 6 are closest to tailings; Samples 4 & 7 are downstream; Samples 5 & 8 are upstream

Due to the limited number of samples taken that might represent background and the range in concentrations of those samples, the establishment of background levels is uncertain. Consequently, it can not be ascertained that the elevated levels of measured constituents in the river sediments nearest the tailings are due to contaminant leakage. Discussions with Chris McKenney about the sediments has led to the conclusion that the levels of constituents in the sediments are not high enough to cause health effects from external exposure.

In response to the request to advise you concerning whether fish flesh should be sampled, it should be noted that we have little experience in this area. However, in concert with Chris McKenney, we suggest two possible approaches that can be taken from here:

First Approach More sediment samples could be collected further upstream and downstream to establish the distribution of background concentrations. Since uranium mineralization occurs naturally in the vicinity, it is necessary to better determine the background distribution before one can state the levels in the samples nearest the tailings are due to leakage. If it is shown that the sediments are not contaminated, but just have a high concentration of constituents, consistent with background, fish flesh would not necessarily need to be tested by the licensee. On the other hand, if the sediments are contaminated (above background), fish flesh should be sampled.

Second Approach Instead of testing more sediments, which do not constitute a health risk from exposure, the licensee could assume sediment contamination exists and start sampling fish flesh, for it's the eating of contaminated fish that has been identified as a possible health risk. The specifics of the fish flesh sampling procedure still need to be considered. It should be recognized that fish may naturally contain elevated levels of radioactive constituents, since the rivers and streams cut through mineralized strata. Therefore, interpretation of the results of the fish flesh sampling effort may be difficult.

Attachment: As stated

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NONDISCLOSURE AGREEMENT

I, Loren B. Morton, am employed by the State of Utah, Division of Radiation Control. In that capacity, I am examining information in the possesion of the NRC relating to the Atlas Corporation's uranium mill licensed by the Nuclear Regulatory Commission.

In consideration of the NRC's agreement to allow me to examine documents and information some of which may be considered to be of a proprietary nature or a trade secret by the Atlas Corporation, I agree to abide by the following restrictions:

(1) I will not disclose or allow to be disclosed to any person other than to an NRC employee, the information revealed or learned as a result of the inspection of Atlas' documents that are marked as proprietary;

(2) I agree not to copy or use any information derived from the inspection of Atlas' documents which are marked as proprietary;

(3) I intend to utilize the nonproprietary information only for performing State of Utah Official actions; and

(4) I agree to treat in accordance with the Agreement all information disclosed during this examination, which is identified as proprietary, as proprietary information.

IN WITNESS WHEREOF, Loren B. Morton has caused the Agreement to be executed to be effective as of the date hereinafter mentioned.

BY: Loren B. Morton
(Signature)

Loren B. Morton
(Print Name)

February 7, 1995
(Date)

40-3453
NLXQ

April 19, 1995

MEMORANDUM TO: Joseph J. Holonich, Chief
NMSS\DWM\HLUR

FROM: John H. Austin, Chief
NMSS\DWM\PAHB

SUBJECT: REVIEW OF ATLAS MOAB CALCULATION OF DOSE COMMITMENT TO NEAREST RESIDENT

Your branch requested a review of the Atlas Corporation calculation of dose commitment to the nearest resident for the 1994 year. My staff has reviewed the calculations and find the calculations satisfactory and show compliance with 10 CFR Part 20 requirements. A technical evaluation report is attached detailing the calculation.

Attachment: As stated

cc: D.Gillen
A.Mullins

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40-0345
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M/34

MEMORANDUM TO: Joseph J. Holonich, Chief
NMSS\DWM\HLUR

FROM: John H. Austin, Chief
NMSS\DWM\PAHB

SUBJECT: REVIEW OF ATLAS MOAB CALCULATION OF DOSE COMMITMENT TO NEAREST RESIDENCE

Your branch requested a review of the Atlas Corporation calculation of dose commitment to the nearest residence for the 1994 year. My staff has reviewed the calculations and find the calculations satisfactory and show compliance with 10 CFR Part 20 requirements. A technical evaluation report is attached detailing the calculation.

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A.Mullins

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TECHNICAL EVALUATION REPORT

DOCKET NO. 40-0345 LICENSE NO. SUA-917

LICENSEE: Atlas Corporation

FACILITY: Moab uranium mill facility

PROJECT MANAGER: Alan Mullins

TECHNICAL REVIEWER: Chris McKenney

PUBLIC DOSE CALCULATION AT NEAREST RESIDENT

SUMMARY AND CONCLUSIONS:

The calculations done by Atlas Corporation (Atlas) satisfy the requirements of 10 CFR Part 20, Subpart D. The calculated total effective dose equivalent (TEDE) is 0.96 mSv (96 mrem) to the nearest resident.

DESCRIPTION OF LICENSEE'S AMENDMENT REQUEST:

Atlas used monitoring data at the nearest resident to calculate the TEDE dose for the 1994 year. The radon equilibrium factor (unitless) is based on EPA's NESHAP background information document, Background Information Document, Standard for Radon-222 Emissions From Uranium Mill Tailings, EPA 520/1-86-009, August 15, 1986, and is given a value of 0.094 (based on 3.5 m/s (7.8 mph) average wind speed)).

The TEDE dose is the summation of the external dose and the committed effective dose equivalent (CEDE) from internally deposited radioactive material. Atlas's monitoring program indicates that the nearest resident received 0.2 mSv (20 mrem) from external exposure. The nearest resident's CEDE is mostly from radon-222 daughter products exposure, as the CEDE from the other particulates (uranium, thorium, and radium) are less than 0.01 mSv (1 mrem). The total CEDE is 0.76 mSv (76 mrem), which results in a TEDE of 0.96 mSv (96 mrem).

TECHNICAL EVALUATION:

The regulations in 10 CFR §20.1301 limit the annual TEDE dose to a member of the public to 1 mSv (100 mrem) from any facility. 10 CFR §20.1302 allow a facility to demonstrate compliance by one of two methods: (1) calculation of the TEDE to the maximally exposed individual, based on either measurement or modeling, or (2) demonstrating that effluent releases have been maintained below the concentrations in 10 CFR Part 20, Appendix B, Table 2 and external dose does not result in more than 0.5 mSv (50 mrem). Atlas has calculated the TEDE to the maximally exposed individual based on measurement of the external dose and concentrations at the nearest resident, the member of the public likely to receive the highest dose. Atlas has performed a valid calculation of the public dose and has shown that the nearest resident did not receive a dose in excess of 10 CFR §20.1301 (96 mrem compared to the limit of 100 mrem).

70-3453

July 12, 1995

See Report

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

SUBJECT: LAWRENCE LIVERMORE NATIONAL LABORATORY REPORT

Dear Mr. Blubaugh:

Recently Lawrence Livermore National Laboratory (LLNL) completed a report "Seismic Hazard Analysis of Title II Reclamation Plans" for the Nuclear Regulatory Commission. The report documents LLNL's simplified seismic hazard analysis of Title II sites, including Atlas Corporation's Moab site. Enclosed is a copy of the report. We recognize that the LLNL report is based on limited information and that your evaluation of the seismic hazard at the Atlas site will be based on more detailed geologic and seismic data and information. However, one of your consultants, Bruce Hassinger of Smith Environmental, expressed an interest in receiving the report.

Any questions should be addressed to the project manager, Myron Fliegel at (301) 415-6629.

Sincerely,

Original Signed By

Daniel M. Gillen, Section Leader
Uranium Recovery Projects Section
High-Level Waste and
Uranium Recovery Projects Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosure: As stated

cc: See attached list

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Addressees for Letter to Richard Blubaugh Dated: July 12, 1995

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Seismic Hazard Analysis of Title II Reclamation Plans

Prepared by
D. Bernreuter, E. McDermott, and J. Wagoner

Prepared for
U.S. Nuclear Regulatory Commission

FESSP
Fission Energy and Systems Safety Program

Lawrence Livermore National Laboratory

Disclaimer

This work was supported by the United States Nuclear Regulatory commission under a Memorandum of Understanding with the United States Department of Energy, and performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

Seismic Hazard Analysis of Title II Reclamation Plans

Manuscript date: June 26, 1994

Prepared by
D. Bernreuter, E. McDermott, and J. Wagoner

Lawrence Livermore National Laboratory
7000 East Avenue
Livermore, CA 94550

Prepared for

U.S. Nuclear Regulatory Commission

ABSTRACT

Over the years, mining sites located in New Mexico, Utah, South Dakota and Wyoming have had uranium producing ore extracted and uranium tailings stored on sites. The tailings were usually stored in big piles of material with sometimes no particular considerations for their design with respect to dynamic loading such as seismic events.

In its effort to evaluate the risk associated with those piles, the NRC sponsored the Lawrence Livermore National Laboratory to perform a simplified seismic hazard analysis for all the sites. The emphasis of the study was to review the geology, seismicity and tectonics of the regions, to establish the bases for the selection of the design criteria, when they existed, and to determine whether the perception of the seismic hazard had changed since the last analyses were performed. For example, newly discovered active faults running close to a site could have an important impact on the perception of the hazard at a specific site.

LLNL reviewed all the available literature, interviewed local experts geology, seismicity and ground motion estimation and developed an estimate of the current design criteria for each site. The adequacy of the as built design criteria were then determined on a site by site basis.

For several sites it was found that current practice would call for higher ground motion values than those believed to have been used for the design, or review, of the piles. In addition, it was found that several sites had faults under the piles. None of these faults were considered as active, however, in the event of a nearby earthquake they can be the source of differential compaction across the faults.

EXECUTIVE SUMMARY

The purpose of this study was to evaluate the seismic design assumptions for mining sites in the seismic evaluation of Title II Reclamation Plans where uranium tailings are being stored generally in piles of material. The evaluation consisted in estimating the design ground motion independently, using simplified deterministic and probabilistic techniques and compare them to the actual design assumptions used for a determination of adequacy. The approach used consists of a review of the literature, contacting regional experts to obtain their insights and potential concerns, and also performing both a simplified deterministic and probabilistic hazard analysis for each site. Our primary goal was to provide sufficient information for the NRC staff to make the necessary safety assessments.

In order to arrive at an appropriate estimate for the ground motion it was necessary to have appropriate criteria to use to make the necessary judgments needed to perform the hazard analyses. Our criteria are based on 10 CFR 40 Appendix A. Using a 10^{-4} probability of exceedance (PE) in a year met the criteria of 10 CFR 40 Appendix A. We described how these criteria are used in the deterministic analysis where probability of occurrence of events is not a parameter.

Since the choice of criteria was subjective, we provide the results of a sensitivity analysis for NRC to make decisions. In addition, we included the uncertainty on the estimates to reflect the uncertain nature of the process. This was done by using simplified procedures. Our results for each site are summarized in Table 1.

We found that at most sites the estimates for the peak ground acceleration (PGA) are higher than the PGA values used in design. There are several reasons for this. For example, it is not clear what criteria were used by the licensee to arrive at the design value. Our criteria was to estimate the PGA level that had a 10^{-4} PE level per year. Our criteria may be more conservative than that used for design. In addition, several seismic zones or active faults were found to be much closer to the sites than assumed in the original studies. The historical earthquake catalog we used was significantly better and more complete than the one used in the original design reports. Hence our rates of activity are higher than used in the design reports.

At five sites (see from Table E-1) there is data showing that faults or fracture zones run under tailings piles or dams. Based on our review of the literature and discussions with regional experts, none of these faults were judged to be currently active, meaning that it is the likely source of an earthquake or a capable source by NRC reactor standards described in 10 CFR 100 Appendix A. However, in the event of a nearby earthquake where the site experiences ground motion approaching the 10^{-4} PE level there is considerable concern that this could introduce differential settlement across these faults. This in turn could cause some damage or lead to the rupture of the piles or dams.

This problem should be addressed on a case-by-case basis. Our most serious concerns are: (1) with the Moab fault under the Atlas site because it is a major fault that has shown Quaternary settlement due to salt tectonics and (2) with the potential for large ground motion at the site in the event of a nearby earthquake.

The stability of the tailings piles and the safety of any other critical facilities needs to be evaluated at most sites. The highest priority should be given to the Atlas site in Utah, the Sohio Site in New Mexico and the Western Nuclear site in Wyoming. These sites have the highest hazard.

TABLE E.1
SUMMARY OF RESULTS

Site Name	Location	Values Used In Design	PGA at PE 10^{-4}	PGA at PE $5x10^{-4}$	Deterministic 1-SigmaPGA	Deterministic Median PGA	Fault or Fracture Zon Under Faciliti
Arco	NM	0.21 - 0.1	0.18	0.08	0.15	0.08	Yes fault
Homestake	NM	0.1	0.18	0.08	0.18	0.1	Yes fault
Quivira	NM	0.1	0.18	0.08	0.18	0.1	Yes faults
Sohio	NM	0.1	0.20	0.11	0.42	0.23	No
United Nuclear	NM	N/C	0.16	0.07	0.07(1)	0.07	Yes fracture zones
Edgemont	SD	0.05 - dam ok to 0.2	0.12	0.06	N/A(2)	N/A(2)	No
Atlas	UT	0.1	0.15	0.06	0.4	0.22	Yes
Rio Algom	UT	0.09	0.15	0.06	0.26	0.14 to 0.16(3)	No
Energy Fuels Nuclear	UT	0.1	0.12	0.05	0.12	0.07	No
Plateau Resources	UT	0.1	0.19	0.09	0.3	0.19	No
Western Nuclear	WY	0.08	0.33	0.18	0.55	0.3	No
Kennecott	WY	0.1	0.33	0.18	0.33	0.18	No
Pathfinder SB	WY	0.25	0.33	0.18	(4)	(4)	No
Petrotomics	WY	N/C	0.33	0.18	(4)	(4)	No
Exxon	WY	N/C	0.27	0.13	(4)	(4)	No
Union Pacific	WY	0.05	0.27	0.13	(4)	(4)	No
American Nuclear	WY	N/C	0.33	0.18	0.3	0.17	No
Pathfinder Lucky -Mc	WY	0.15	0.33	0.18	0.3	0.17	No
Umetco	WY	0.05	0.33	0.18	0.3	0.17	Yes

NC: Not considered in design.
PE: Annual Probability of Exceedance
(1) Based on a median estimate - see text 5.9.4.
(2) Deterministic estimate not considered applicable see text 6.5.
(3) Two different eartquakes involved - see text 7.6.2.
(4) Only large distant earthquake considered. Not comparable to probabilistic analysis.

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1.0 INTRODUCTION

1.1 Seismic Evaluation of Title II Reclamation Plans

As part of an ongoing program, Lawrence Livermore National Laboratory (LLNL) is responsible for characterizing seismic hazards at the uranium mine tailings sites using updated seismic information. A major part of this effort is the identification of documented Quaternary faults which have not been previously considered in the seismic evaluation of these sites. Results of this effort with an assessment of revised estimates of the seismic hazard (expressed in terms of Peak Ground Acceleration) using new information are provided to NRC Staff to make necessary judgments about the adequacy of the Title II Reclamation Plans. The ultimate objective of this effort is to develop guidelines which will ensure the long term stability of the uranium mine tailings piles.

For purpose of evaluating seismic hazards at these sites, a two phase process is considered. First, a seismic hazard characterization of the sites is performed. This effort consists of a preliminary seismic hazard assessment that provides bounding estimates of the site design basis as specified in Appendix A of 10 CFR 40. This analysis is conducted using published and unpublished information and interviewing local seismologists. Both a preliminary deterministic and probabilistic seismic hazard assessment is provided in this report.

Based on the results of these preliminary analyses, a decision can be reached whether existing seismic site design criteria are sufficient.

If the findings of this preliminary seismic hazard analysis indicate that seismic hazards are capable of damaging mine tailings on site, LLNL will develop estimates of the design parameters consistent with current seismic hazard characterizations.

This report describes the scope, evaluation procedures, and results of the preliminary site seismic hazard analyses.

1.2 Scope and Goals of this Study

The scope of this analysis is limited to a review of all available published and unpublished information and to provide preliminary deterministic and probabilistic seismic hazards which will be used as bounding values.

The primary goal of this study is to give sufficient information to decide whether a detailed seismic hazard analysis is required for some sites (if any) to develop estimates of ground motion levels which will be used in safety assessments of tailing piles. This report deals specifically with part of the preliminary assessment to be used in the seismic bounding assessment. For example, if assumptions in this report imply that the site-specific design criteria are not satisfied, then more site-specific studies will be needed to address this issue.

1.3 Report Organization

Section 2 of this report provides a glossary of terms.

Section 3 presents an overview of the evaluation procedures and methodologies that are used to perform a preliminary seismic hazard assessment at the sites. Both procedures to estimate preliminary probabilistic and deterministic seismic hazard assessments for each site are described in this section. These assessments are used to assess the ground motion level for use in the determination of the adequacy of existing seismic design parameters. No assessments are made in this report on whether the site-specific seismic criteria are satisfied. For this reason, bounding estimates of the site-specific ground motion levels are provided in this report.

Existing design criteria for each of the sites under study are summarized in Section 4.

Sections 5 to 8 describe the preliminary seismic hazard analyses for each site. For purpose of clarity, sites are first grouped in each section by the state they are within. Within each section, site are grouped by geographic location.

Section 9 presents conclusions and recommendations on the seismic design criteria of each site under study. These conclusions are based on the authors' judgment on the fault characteristics,.tectonic and regional seismicity after a review of the available information. Because all the sites in this study are located in low seismicity regions, there are limited studies which have been performed. Should future studies being carried out, their results might significantly impact the preliminary results presented in this study.

2.0 GLOSSARY OF TERMS

There are a few symbols and acronyms that we use throughout this report which require definitions.

Active or Potential Faults — Faults which are considered capable of having earthquakes with magnitudes greater than 5 and/or potential for surface displacement. No fixed criteria was used in this report to make the assessment. See Section 3.4.2, 8.2 and 9.0 for added discussion.

Capable Tectonic Source — A "capable tectonic source" is a tectonic structure that can generate both vibratory ground motion and tectonic surface deformation such as faulting or folding at or near the earth's surface in the present seismotectonic regime. It is described by at least one of the following characteristics:

(a) Presence of surface or near-surface deformation of landforms or geologic deposits of a recurring nature within the last approximately 500,000 years or at least once in the last approximately 50,000 years.

(b) A reasonable association with one or more large earthquakes or sustained earthquake activity that are usually accompanied by significant surface deformation.

(c) A structural association with a capable tectonic source having characteristics of section a in this paragraph such that movement on one could be reasonably expected to be accompanied by movement on the other.

In some cases, the geological evidence of past activity at or near the ground surface along a particular capable tectonic source may be obscured at a particular site. This might occur, for example, at a site having a deep overburden. For these, cases, evidence may exist elsewhere along the structure form which an evaluation of its characteristics in the vicinity of the site can be reasonably based. Such evidence is to be used in determining whether the structure is a capable tectonic source within this definition.

Notwithstanding the foregoing paragraphs, structural association of a structure with geological structural features that are geologically old (at least pre-Quaternary), such as many of those found in the Central and Eastern region of the United States will, in the absence of conflicting evidence, demonstrate that the structure is not a capable tectonic source within this definition.

M — Magnitude of an earthquake. Generally, the moment magnitude scale is used for the deterministic seismic hazard analysis. No attempt has been made to try to convert the magnitudes recorded in the catalog to the same magnitude scale. Consequently, several magnitude scales have been used in the probabilistic seismic hazard analysis.

M_L — Local (Richter) magnitude

M_u — The largest possible earthquake (regardless of occurrence rate)for a fault or region. Also referred to as the upper magnitude cutoff.

PGA — Peak ground acceleration. Strictly speaking it is not the peak but the average of the two horizontal peaks.

PE — Probability of exceedance - used in conjunction with the criteria to assess the ground motion level from the seismic hazard results.

Tectonic Structure — A tectonic structure is a large-scale dislocation or distortion, usually within the earth's crust. Its extent may be on the order of tens of meters (yards) to kilometers (miles).

3.0 METHODOLOGY

3.1 Overview

The purpose of this analysis is to perform simplified deterministic and probabilistic seismic hazard analyses at uranium mine tailings sites which will be used in an evaluation of the site-specific seismic design criteria.

This analysis is divided into a series of steps designed to proceed through the data collection and review process, seismic hazard assessment, and an updated assessment of the site seismic design basis. The simplified seismic hazard analysis is carried out in three phases. They are:

Phase	Task
1	Identification of seismic sources
2	Risk criteria for performing seismic hazard assessment
3	Simplified deterministic and probabilistic site seismic hazard analysis

An important part of this project is to review all relevant information, either published or not. Because the sites under study are in regions of relatively low seismicity, most recent information may likely not be published and/or readily available. For this reason, geologists and seismologists at each of the state surveys were interviewed for explanations and clarification.

The next sections describe in detail each of these steps.

3.2 Phase 1 - Identification of Seismic Sources

The objective of this phase is to identify site data and to gather appropriate information on regional and site specific information on topography, tectonics, seismic faults, and historical seismicity, results of previous seismic analysis, etc., that are necessary to identify and later analyze possible sources of seismic ground motion that may impact the sites.

The first effort is to obtain environmental impact reports, Reclamation Plans reports, and all other documents available from NRC dockets.

The LLNL library performed a site specific literature search on thirty-eight technical and scientific catalogs, which are listed in Appendix A. The search was not very successful due to the narrow scope of the subject and a general lack of written material on each region of interest. However, the LLNL library was able to obtain various articles and books through interlibrary loan from U.C. Berkeley, the USGS, and the state survey libraries. Various maps and publications used in this study are listed by state in the reference section at the end of this report.

3.3 REGIONAL EXPERTS

Various telephone conversations and meetings with field researchers were conducted to augment information collected from Phase 1. The focus of these interactions is to obtain recent results of current seismic research in the areas of interest. main contacts for the regions under study are:

New Mexico Bureau of Mines and Mineral Resources:

Dave Love

New Mexico Institute of Mining and Technology:
Allan R. Sanford

Los Alamos National Laboratory
Scott Baldrege

South Dakota Geological Survey:
Dick Hammond

Utah Geological Survey (UGS):
Gary Christensen, Michael Ross, and Hellmut Doelling.

University of Utah
Walter Arabasz

Wyoming Geological Survey:
James Case

A number of issues were discussed with other researchers and field workers specialized in the areas under study. One important question that was asked to all researchers was whether they knew of any evidence or had any concerns that active faulting existed near any of the sites under study in this report.

Glen Reagor of the USGS National Earthquake Information Center (NEIC) performed a seismicity search and generated corresponding seismicity maps within a two degree radius of the each site or each cluster of sites. The results of this analysis are used to assess historical seismicity at each of these sites.

3.4 Phase 2 - Risk criteria for performing seismic hazard assessment

No specific risk criteria are currently available to be used in the definition of the site specific seismic design criteria. As a consequence, risk criteria are developed in this study to select ground motion levels and whether a fault is judged active or not.

3.4.1 Determination of Ground Motion Level from Probabilistic Analysis

10 CFR 40 Appendix A provides the criteria to be used in selecting the appropriate level of ground motion to check the safety of the tailings piles. The criteria stipulates that the design be effective for 1000 years to the extent reasonably achievable, and in any case for at least 200 years. The assumption made in this study is that a high degree of confidence is desired that the ground motion level will not be exceeded in the 200 year time frame and that there is a reasonable assurance that it will not be exceeded in the 1000 year time frame. A selection for the probability of exceedance (PE) for PGA in the 10^{-4} range would give a high degree (considering the conservatism's in the design analysis process) of assurance for the 200 year period and in our opinion would meet the 1000 year criteria.

More specifically, a 10^{-4} PE level corresponds to approximately a 2% chance of exceeding the selected ground motion level in 200 years and a 10% chance in 1000 years. Building codes are developed with a 10% chance of exceedance for the lifetime of the structure (usually taken as 50 years) as meeting the reasonable assurance criteria.

Ground motion estimates in terms of PGA are provided at a PE level of 10^{-4} per year for each site. In addition, it could be argued that because of the relatively low risk posed by the tailings piles, the

choice of a PE level of 10^{-4} might be too conservative. For this reason estimates of the ground motion at that $5x10^{-4}$ level are also provided.

3.4.2 Determination of Ground Motion Level from Deterministic Analysis

In performing a deterministic analysis, it is often difficult, (particularly in a limited study in regions of low seismic activity) to be able to determine if a fault is active or not active or what the largest earthquake in the next 1000 years will be. The use of an upper bound is generally too conservative given the above criteria and judgment is required. One approach to address these issues is to reasonably identify which sites require a detailed study and to identify a ground motion level which, if used to assess the stability of the tailings piles, is appropriately conservative. However, because field studies and modification of any tailings piles are very expensive, one of our goals is to be sure that there is indeed a reasonable concern that there is a problem, based on the above criteria.

The assumption made is that 10^{-4} total probability of exceedance means that a relatively high degree of confidence must exist in the judgmental decisions at every step of the analysis. For example, relative to the determination whether a fault is potentially active or not active, a high degree of confidence must exist that the fault is <u>not</u> active to consider it as not active.

However, it is important to note that considering a fault as potentially active does not mean that there is much confidence that it is indeed active. In fact our best judgment might be that it is inactive, however, the uncertainty about what is known about the fault is generally large. These uncertainties can become important at 10^{-4} hazard levels required by the criteria. Hence its activity cannot be excluded. These important judgmental decisions are noted and quantified, when presented.

The above discussion does not really provide a criteria to determine if a fault is active or inactive. For example, in the siting of nuclear power reactors, 10 CFR 100 Appendix A provides more definitive criteria to determine if a fault is capable. In general there simply was not enough data to use to apply any type of definitive criteria. The approach used in this analysis is judgmental and based on assessments from the literature which used varying criteria. Generally speaking, this is not a very satisfactory approach as it could lead to significant variation between sites. This point is discussed in some detail in the Conclusions section, in which the implications of the judgments made relative to calling a fault "active" or "potentially active" are examined.

In section 3.5.1 below, we outline in detail how the PGA estimates are determined for the deterministic analysis. Generally we used the 1-sigma level for our estimates. However, as noted above, it could be argued that, because of the relative low risk posed by the tailings piles, the choice of a PE level of 10^{-4} might be too conservative. For this reason, estimates of the ground motion at $5x10^{-4}$ PE are also provided. If this criteria is used, then the deterministic estimate for the ground motion should be selected at the median estimate.

3.5 Phase 3 - Simplified Deterministic and Probabilistic Site Seismic Hazard Analysis

A typical seismic analysis for the sites follows the following steps:

1) Identification of the faults around each site and determination of which faults should be considered potentially active given that available field data, the large uncertainties introduced due to the very limited field data available, and criteria used for this study.

2) For each fault identified as potentially active, estimation of the largest earthquake that can be reasonably expected to occur based on the criteria used in this study and estimation of the ground motion at t'e site.

3) Identification of which, if any, potentially active faults passes through the site and represents a surface rupture hazard.

4) Identification of any concentration of seismicity that may exist around the site which indicates an active buried fault. Estimation of largest earthquake that could be reasonably expected and the resulting ground motion at the site.

5) Because there appears to be little correlation between the observed seismicity and the known faults around the sites in the study, it is necessary to perform a hazard analysis for a random earthquake. The appropriate ground motion level from the random earthquake is based on the hazard curve and the probability of exceedance criteria discussed below.

3.5.1 Deterministic Analysis

Steps 1 to 4 comprise the deterministic elements of the seismic study. Based on literature reviews, discussions with local experts, and the criteria defined above, faults near the site are first identified as whether, for the purposes of this report, they must be considered active. Once these potentially active faults have been identified, it is possible to estimate the largest earthquake that can be reasonably expected to occur. It should be noted that the assessment of maximum earthquake magnitude is a professional judgment that incorporates an understanding of specific fault characteristics, the regional tectonic environment with comparison with other faults of known seismic potential, and data on regional seismicity.

At present, there are no uniquely accepted methods for assigning a maximum earthquake magnitude to a given fault. Various approaches have been developed based on the geologic characteristics and earthquake history of the fault and were summarized most recently by Wells and Coppersmith (1994). These approaches rely on empirical relationships developed between earthquake magnitude and specific fault parameters, including fault rupture length, fault displacement per event, rupture area and seismic moment. Compilations of these data for worldwide historical earthquakes have been used to develop linear regressions of earthquake magnitude on length, magnitude on displacement, and magnitude on area for faults in different tectonic settings. Each approach has its limitations, such as uniformity in the quality of the empirical data, a limited data set, and possibly an inconsistent grouping of data from different tectonic environments.

Values for magnitudes derived from these relationships represent expected (mean) values. It is a generally accepted practice to use mean values from these relationships to evaluate the maximum earthquake on individual structures because the values for the fault parameters used in these relationships are the maximum values that are geologically reasonable. For the most part in this study, so little is known about the actual fault geometry's that one must rely on a simpler correlation between rupture length and magnitude.

Several methods are commonly used to estimate the maximum length of a fault that can rupture during a single event. Wentworth and others (1969) propose that 50 percent of the total length is a conservative estimate of the maximum rupture length. Slemmons (1982) has proposed empirical relationships that relate rupture lengths to a percentage of the total length. More recently, however, geologists and seismologists have recognized the significance of fault barriers that limit the amount of

pture during individual earthquakes (e.g., Schwartz and Coppersmith, 1984). Where sufficient data exist to define fault barriers and fault segments, the fault segmentation method provides a more reliable estimate of the maximum length of the fault that can be expected to rupture during a single event. Otherwise, we use our judgment to assess the expected rupture length and the relations given in Wells and Coppersmith (1994).

The following judgmental procedure is adopted in this report. If no segmentation data or other compelling data is available the best estimates for M_u are made assuming that 50 percent of the total length of the fault will rupture. An estimate for the possible uncertainty on M_u is made by assuming that the entire fault will rupture in a single event or that two segments will rupture. This term is defined as the upper bound magnitude M_{UB}.

There is not enough reliable information about any of the faults identified as potentially active to estimate the recurrence interval of the largest earthquake. One expects that the largest earthquake possible on any of the faults falls in what might be termed as the characteristic earthquake for the fault (see Schwartz and Coppersmith (1984) and Youngs and Coppersmith (1985)). For the purposes of this analysis the characteristic earthquake implies that two processes are ongoing. First, small to moderate earthquakes in a region follow the usual Gutember Richter Law for the distribution of magnitude

$$\log N = a - bM \qquad (3.1)$$

where N = number of events greater or equal to M

M = magnitude of the earthquake

a,b = constants

The characteristic earthquake does not follow the above relation but has its own characteristic return interval different than implied by the above equation. Generally, the characteristic return period must be determined by geological means - such as observing repeated offsets across a given fault. Often, the characteristic repeat time of large earthquakes is more frequent than would be estimated by use of Eq. (3.1).

Once the magnitude of the earthquake for a given fault has been determined, it is then used to make a ground motion estimate. A number of relations exist to do this. For this report the 1981 Joyner Boore relation is used. Any estimate for the ground motion is highly uncertain given all of the judgmental assessments that must be made. Thus, it is not very useful to use numerous ground motion relations and average the results in this type of analysis.

As outlined above, the deterministic approach often results in two estimates for the maximum earthquake: (1) the best estimate value M_u and (2) the upper bound value M_{UB}. Although the recurrence interval for M_u is generally not known, the upper bound earthquake M_{UB} must have a much lower probability even than M_u. To account for this the ground motion for the best estimate of M_u using the 1 - sigma estimate of the ground motion given the magnitude M_u and distance of the closest approach of the causative fault to site, and for M_{UB} using the median estimate of the ground motion. This is an ad hoc procedure - but in our judgment is a reasonable way to appropriately assess the ground motion.

It should be noted that the use of the 1-sigma level as the appropriate estimate for ground motion has its roots in the safety assessment of nuclear power reactors. Nuclear power reactors pose a much greater risk than posed by the tailings piles. Thus it is not evident that the 1-sigma level is necessarily most appropriate value to use. For that reason we report a range giving both the median and 1-sigma levels where appropriate. However, when we make our estimates, based on M_{UB} we only give the median estimate.

3.5.2 Probabilistic Analysis

The earthquakes in the regions around the sites studied in this report show a relatively poor correlation with known geology. Thus one must expect that a random earthquake could occur almost anywhere. To develop the earthquake recurrence model using Eq. (3.1) in the analysis for each site, both the regional geology and pattern of seismicity must be examined. First, a region from which historical earthquakes occurrences will be used to develop the parameters a and b of Eq. (3.1) must be selected. Since the seismic activity is low, a large region needs to be used to provide reasonable estimates for a and b parameters. Regions which had similar geological and seismological characteristics to the region around the site were selected . For example, for both the sites located in Utah and Wyoming, the earthquakes in the very active Intermountain Seismic Belt were excluded. The USGS catalog obtained from Glen Reagor is used for all of the analyses, except for the South Dakota site.

One of the major problems in developing the recurrence relation in Eq. (3.1), in regions of low seismicity and low population density is the completeness of the catalog. To test for completeness, the procedure developed by Stepp (1972) was used. This procedure, based on Poisson statistics, determines the time period over which the earthquake catalog is assumed complete as a function of magnitude level. This procedure has been applied in numerous previous studies. According to Stepp's method, when the mean rate of earthquake occurrence is constant, the standard deviation of the estimate of that mean rate varies as $1/\sqrt{T}$, where T is the time interval of the sample. Thus, on a plot of standard deviation versus time, stable occurrence rate is indicated by a $1/\sqrt{T}$ slope. Fig. 3.1 is such a plot for the Wyoming region and the time intervals of stable occurrence estimates at different magnitude levels are shown by heavy lines of $1/\sqrt{T}$ slopes. Given these rate estimates, the log N versus M relationship can be determined with more confidence. From Fig. 3.1, earthquakes with magnitudes about 2.25 are fully reported for only about the last 10 years and earthquakes with magnitudes below 4.75 are fully reported for about 30 years.

The record for largest events is incomplete because the time frame for which good coverage exists is too short to have a sufficient number of larger earthquakes for establishing a mean rate.

The a and b values are estimated by judgment using the data for which the record is judged to be sufficiently complete. The fact that the b-value is generally around -1.1 to -0.7 was also used to constrain the b-values.

No attempt is made to remove aftershocks as no large recent events which might have a number of aftershocks were in the catalog. To properly cull the catalog would require considerable effort. Leaving in aftershocks may lead to a somewhat higher seismicity rate (conservative) but also to a steeper slope (not conservative at relatively high ground motion levels).

In addition to the recurrence model, an estimate for the largest random earthquake that can occur is needed. This question was discussed at length with Dr. W.J. Arabasz. He concurred with our assessment of the literature that one could expect earthquakes in the 5.5 to 6.5 range anywhere. Generally, earthquakes larger than 6.5 lead to surface faulting, and smaller earthquakes may or may not lead to surface faulting.

The problem with the recurrence model given by Eq. (3.1) is that there are no limits to the size of the earthquake that can occur. Most regions are characterized by some maximum earthquake, M_u, that can occur. To account for this, a truncated exponential model is used in the hazard analysis. As can be seen from Fig. 3.2, the truncated exponential model starts to depart from the straight line given by Eq. (3.1) approximately 3/4 a magnitude unit from M_u. For Fig. 3.2 $M_u = 5.75$.

Because of the limited nature of this study and the lack of data, no attempt to perform an uncertainty analysis was made. Such uncertainty analyses are very important but very costly to perform properly. A poorly performed uncertainty analysis provides no information. Thus at best, this analysis for the

.ndom earthquake is only a simple estimate for the central value of the hazard. Its main use is to determine if a detailed study is needed, that is if the estimates for the ground motion are used for safety assessments. If the factor of safety is not wel' above 1, then a careful study should be performed.

Some uncertainty parameters were included in the analysis. A factor of ± 2 is used on the seismicity rate. The b value is kept constant and a factor of ± 0.25 units is used on M_u. In addition, to see the sensitivity to M_u, analyses are performed for four values of M_u, 5.5, 5.75, 6.25, and 7. $M_u = 7$ is and upper limit and is used to bound the importance of M_u. As noted above, the most likely values for M_u are in the 5.75 to 6.25 range. For the most part, the results are not too sensitive to the value of M_u.

Finally, since the goal of this report is to assess the appropriate ground motion for tailings piles, liquefaction or other forms of soil or slope stability, only the contributions to the hazard from earthquakes $M \geq 5$ are calculated. Small earthquakes can contribute to the probability of exceeding a given ground motion but these small earthquakes are of short duration and unlikely to induce significant liquefaction or slope movement. Thus they are not included in the analysis.

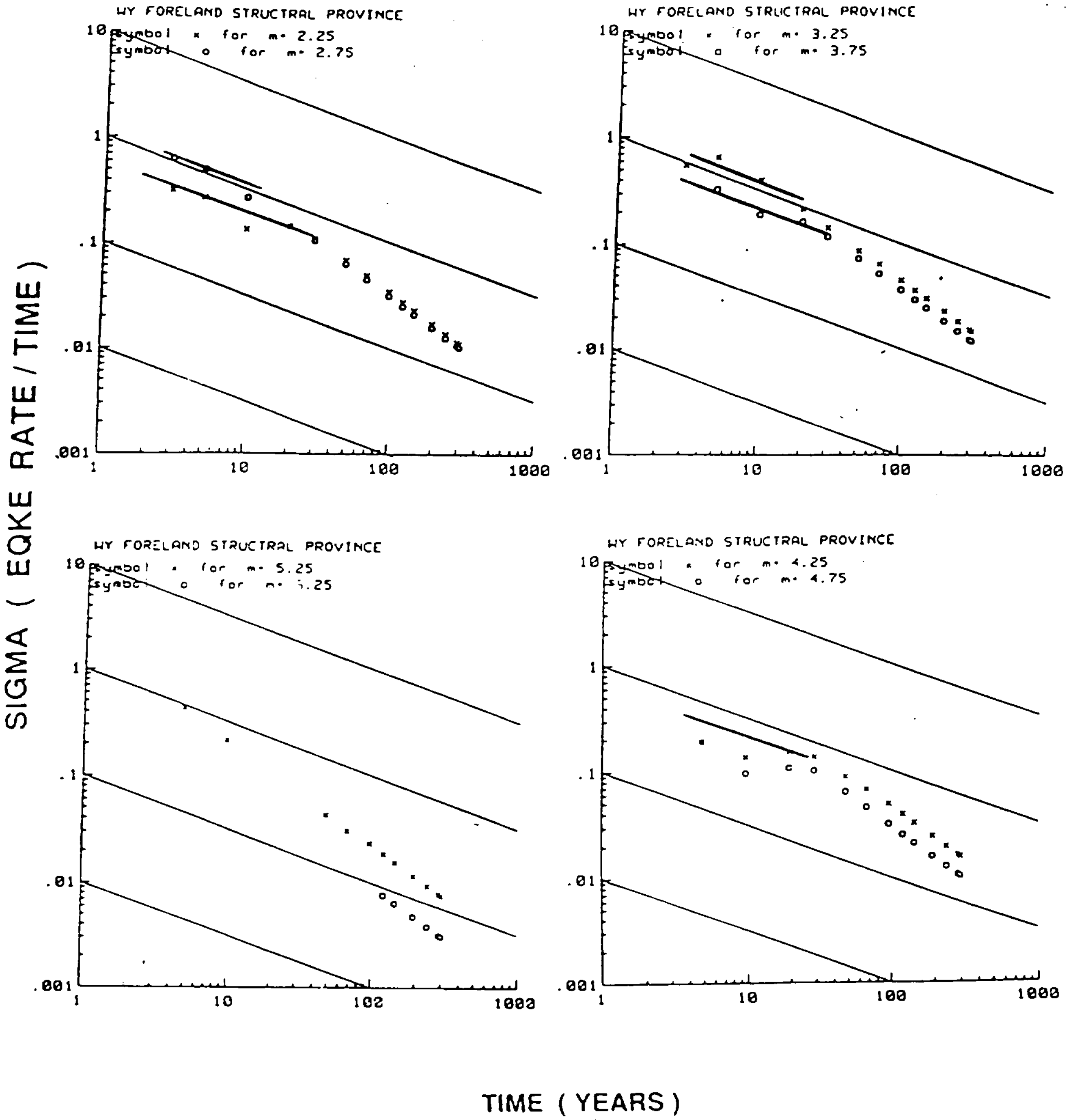
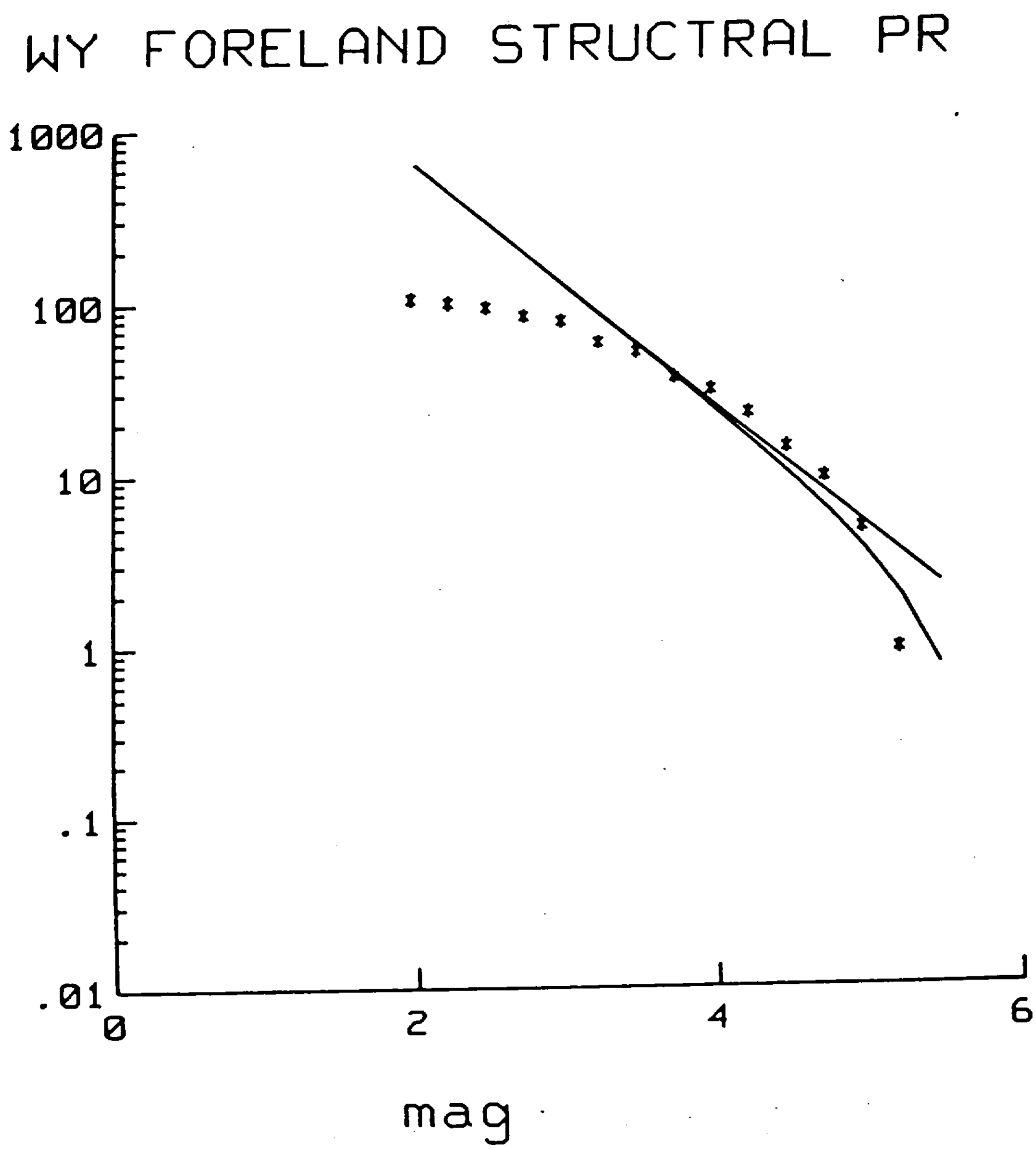


Figure 3.1 **Stepp [1972] plots (sigma is the standard deviation of the estimate of the mean rate of earthquake occurrence ($\sqrt{\lambda}/T$, where λ is mean rate of earthquake occurrence and T is time interval of the sample)**



ıgure 3.2 Comparison of the Richter log N = a-bM model to the truncated exponential model with M_u= 5.75

4.0 SUMMARY OF DESIGN CRITERIA USED AT EACH SITE

Various submittals for each site available in the NRC Docket Room were reviewed and the design criteria used for each site were identified. This task is a difficult one because more than one ground motion level are given for some sites and none for others. For sites with more than one value it was generally difficult to determine how all the values were actually used. The results of the review are summarized below.

4.1 New Mexico

4.1.1 Atlantic Richfield Bluewater Uranium Project

__Sources__: Dames & Moore, 1988, Local Fault Capability Assessment, Arco Coal Company (1990a)

Design Criteria:

- A horizontal acceleration of 0.06g is used in the pseudo-static stability analysis.
- A pseudo-static coefficient of 0.10 is recommended and is used in the slope stability analysis.
- The mean peak horizontal ground acceleration level expected at the site is 0.21g. This value is used in the reclamation design.
- The above criteria determined by Dames and Moore in 1988 are based on three factors:
  - A possible local earthquake
  - Attenuation from an earthquake 60 km to the east
  - "Local" faults within 30 km of the site

4.1.2 Homestake - Grants

Source 1: State of New Mexico Uranium Mill License Renewal Application, 1992

Design Criteria:

- Horizontal Acceleration = .02-.05 g.
- Maximum peak acceleration = 0.04 g (Algermissen and Perkins, 1976).
- Maximum peak acceleration = 0.05 g (Applied Technology Council, 1978).
- Effective peak horizontal acceleration of magnitude 6.0 earthquake originating 45 miles from the site = 0.10 g.

__Source 2__: D'Appolonia Stability Assessment, 1980

Design Criteria:

Maximum horizontal acceleration of 0.1g and a vertical acceleration of 0.067g are used as the seismic coefficients for the dynamic stability.

4.1.3 Quivira - Ambrosia Lake

Source: Kerr McGee Nuclear Company, 1993

Design Criteria:

Effective peak horizontal ground acceleration = 0.10 g. is used in the pseudo-static stability analysis.

4.1.4 Sohio Western, L-Bar

Source: L-Bar Uranium Mine Reclamation and Closure Plan, Intera Technologies (1989)

Design Criteria:

- The tailings impoundment itself is designed (and retrofitted with under drains) to withstand a Peak Ground Acceleration of 0.1 g.
- The Peak Ground Acceleration at the site due to the potential movement on the upper Rio Grande Valley fault is 0.07 g.

4.1.5 United Nuclear - Church Rock

Source: Canonie Environmental (1987)

Design Criteria:

0.05g

4.2 South Dakota

4.2.1 TVA - Edgemont

Source: Edgemont Mill Decontamination and Decommissioning Final Report, TVA (1990)

Design Criteria:

A value of PGA of 0.05 g is used for the design. However, a stability analysis shows that "critical" maximum ground acceleration for the containment dam is about 0.2 g, approximately four times greater than the design acceleration for the Edgemont area which is 0.05 g.

4.3 Utah

4.3.1 Atlas - Moab

Source: Atlas Minerals "Division of Atlas Corporation Source Material License Renewal." (1984)

Design Criteria:

- For a liquefaction potential evaluation, maximum ground acceleration is 0.08 g for the postulated design earthquake.
- Horizontal accelerations is than .05 g.

4.3.2 Plateau Resources - Shootaring Canyon

Source: Plateau Resources Environmental Report, 1979

Design Criteria:

- Specific design number are not given.
- The chance of exceeding 0.04 g horizontal acceleration at the site in the next 50 years is 10 percent or less (Algermissen and Perkins, 1976).
- Reference indicates that the PGA level of 0.04g is too small to be a design consideration.

4.3.3 Rio Algom - Lisbon

Source: Dames & Moore (1980)

Design Criteria:

- In the stability analyses, maximum ground surface acceleration of 0.09 g is used as the estimated design value for the tailings deposit as it is based on data for sites with considerable depths of soil where the local amplification effects have already been included.
- For structures at the site found directly on rock, the value 0.05 g would be compatible with the 0.09 g value used to analyze the stability of the tailings.

3.4 Energy Fuels Nuclear-White Mesa

Source: White Mesa Mill License Application, Umetco (1991)

Design Criteria:

- Specific design number not present in available literature.
- Horizontal ground accelerations would not exceed 0.10 g but would probably range between 0.05 and 0.09 g.
- Estimated peak horizontal acceleration at a distance of 57 km away from the epicenter would be 0.07 g.

4.4 Wyoming

4.4.1 American Nuclear-Gas Hills

Source: N/A

Design Criteria:

Review of Docket suggests that as with many other Wyoming sites the seismic ground motion was considered to be so low that is had no impact on design.

4.4.2 Exxon-Highlands

Source: Exxon Minerals Co. (1978)

Design Criteria:

Put in UBC region 1 - very low seismic hazard. Seismic ground motion not included in design.

4.4.3 Kennecott-Sweetwater

Source: Minerals Exploration Co. (1982)

Design Criteria:

Horizontal acceleration for the site has been estimated to be less than 0.04 g (Algermissen and Perkins, 1976), thus not considered significant in design.

4.4.4 Pathfinder-Shirley Basin-Sweetwater

Source: Shirley Basin Mine Tailings Reclamation Plan, Hydro-Engineering (1993)

Design Criteria:

Horizontal acceleration = 0.025 g. Used in static and earthquake loading condition analysis.

4.4.5 Pathfinder-Lucky Mc

Source: Lucky Mc Mine Tailings Reclamation Plan, Hydro-Engineering (1992)

Design Criteria:

Seismic coefficient of 0.15g was used in pseudo-static stability analysis.

4.4.6 Petrotomics - Shirley Basin

Source: Environmental Report for Source Material Lic. SUA-551 Petrotomics Mill, Getty (1981)

Design Criteria:

Put in UBC zone 1. Not considered significant in the design.

4.4.7 Umetco-Gas Hills

Source: Embankment Stability Report, Water, Waste and Land (1993)

Design Criteria:

- Maximum acceleration on structures has been estimated at less than 0.04 g.
- Earthquake coefficient of 0.05 g was used in an end-of-construction, steady state and earthquake conditions analysis.

4.4.8 Union Pacific-Bear Creek

Source: Environmental Statement: Related to Bear Creek Project. Rocky Mt. Energy Co. (1977).

Design Criteria:

A seismic coefficient of 0.05g was used.

1.4.9 Western Nuclear-Split Rock

<u>Source</u>: Canonie Environmental "Liquefaction and Seismic Analysis Evaluation," 1977

Design Criteria:

- The postulated design seismic event is considered to have peak horizontal accelerations of about 0.08 g.

5.0 NEW MEXICO

5.1 Introduction

The five uranium mills sites evaluated in this section are located within the Grants Mineral Belt in northwestern New Mexico (Fig. 5.1). This belt is the source of more uranium production than any other area in the United States, and extends from several km east of Laguna to the Gallup area, a length of 160 km and width of about ~0 km. Uranium ore deposits in the Grants mineral belt occur principally in certain fluvial sandstones with mudstone interbeds in the Morrison Formation. The mills of interest in this report are located throughout the Ambrosia Lake, Laguna and Churchrock districts and lie within the Colorado Plateau physiographic province (Fitch, 1980). The location of the sites are shown in Fig. 5.2 by site number and Table 5.1.

Regional Geology

The geology of northwestern New Mexico is characterized by several dominant tectonic features including the San Juan Basin, the Zuni Uplift, and a series of northwest-trending high angle reverse faults (See Fig. 5.2). These structures were formed by major deformation of the Precambrian basement and the Late Paleozoic and Mesozoic sediments during the Laramide Orogeny (late Cretaceous and Eocene time).

The Zuni Uplift is a tectonic feature which is characterized by a core of Precambrian crystalline basement rocks composed of granite, schist, and gneiss, and partially mantled by Permian and Triassic sedimentary rocks. The Zuni Uplift is surrounded by several tectonic depressions, including the Gallup Sag to the west-southwest, the Acoma Sag to the southeast and the San Juan Basin to the north. The Precambrian core of the Zuni Uplift crops out in a northwest-trending, elongate mass approximately 72 km long and 9.6 km wide. Sedimentary rocks that flank the uplift gently dip away from the Precambrian core, increasing to a maximum thickness >4.3 km in the center of the San Juan Basin (State of New Mexico Environmental Improvement Division, 1992).

Principal host rocks for the uranium deposits are fluvial sandstones containing mudstone interbeds in the Westwater Canyon Member and Jackpile Sandstone of the Morrison Formation. In addition to the Jackpile Sandstone, other unnamed sandstone beds in the Brushy Basin Member of the Morrison Formation host significant deposits. The Westwater Canyon Member forms a blanket-like deposit that extends over most of the San Juan Basin and ranges from 15 m to >76 m thick. The Westwater Canyon Member hosts ore deposits in the Ambrosia Lake and Church Rock districts. The Jackpile Sandstone hosts large uranium deposits in the Laguna district. It occurs in a northeast trending channel that is about 21 km wide in the Laguna area. The Jackpile is absent in the Ambrosia Lake and Church Rock districts (Fitch, 1980).

Table 5.1 Name of sites in New Mexico shown by site number on Figure 5.2 and 5.3

Site No.	Site Name
1	Sohio Western, L-Bar
2	Homestake - Grants
3	Arco - Blue Water
4	Quivira - Ambrosia Lake
5	United Nuclear - Church Rock

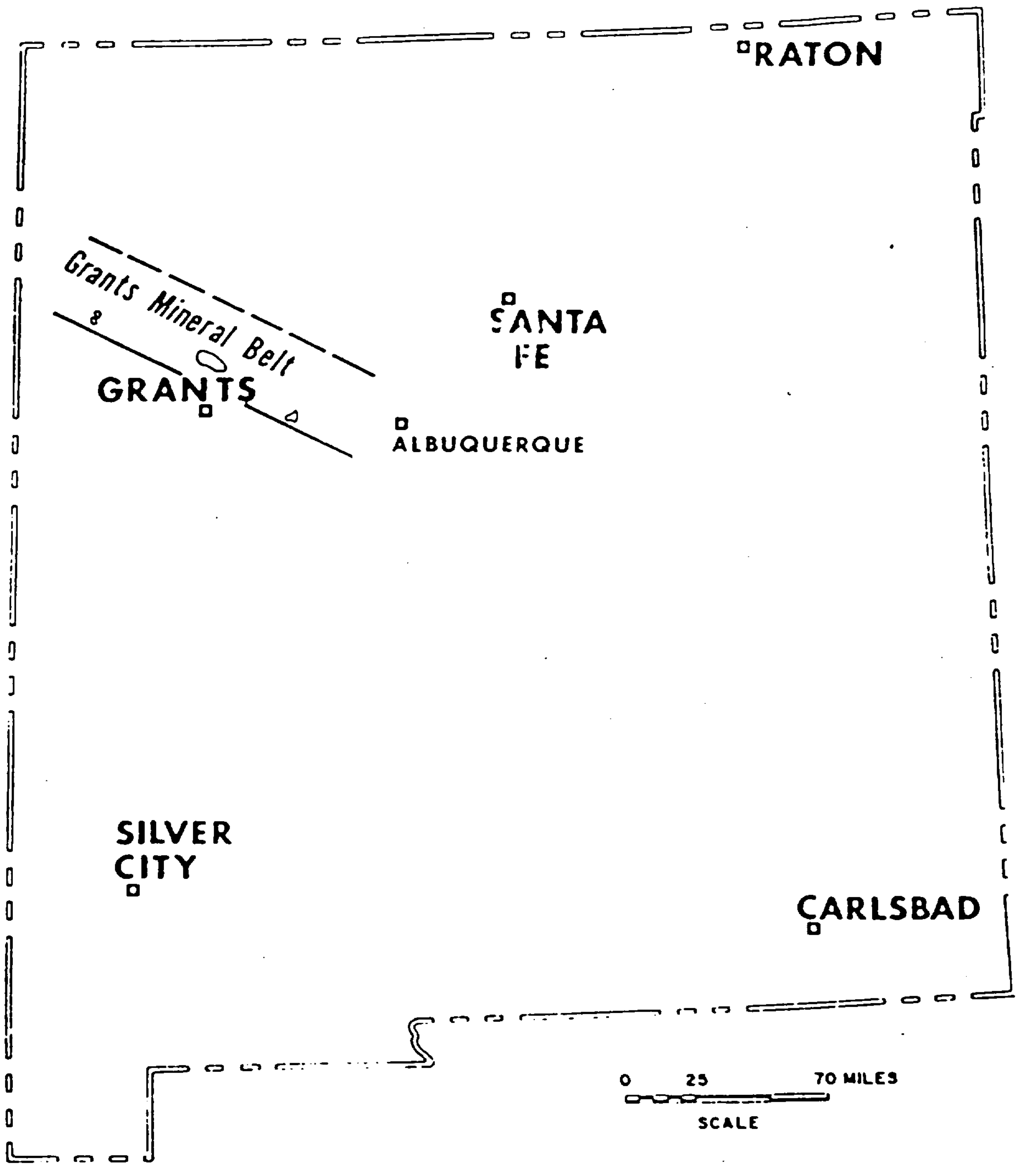


Figure 5.1 Map of New Mexico showing location of Grants Mineral Belt.

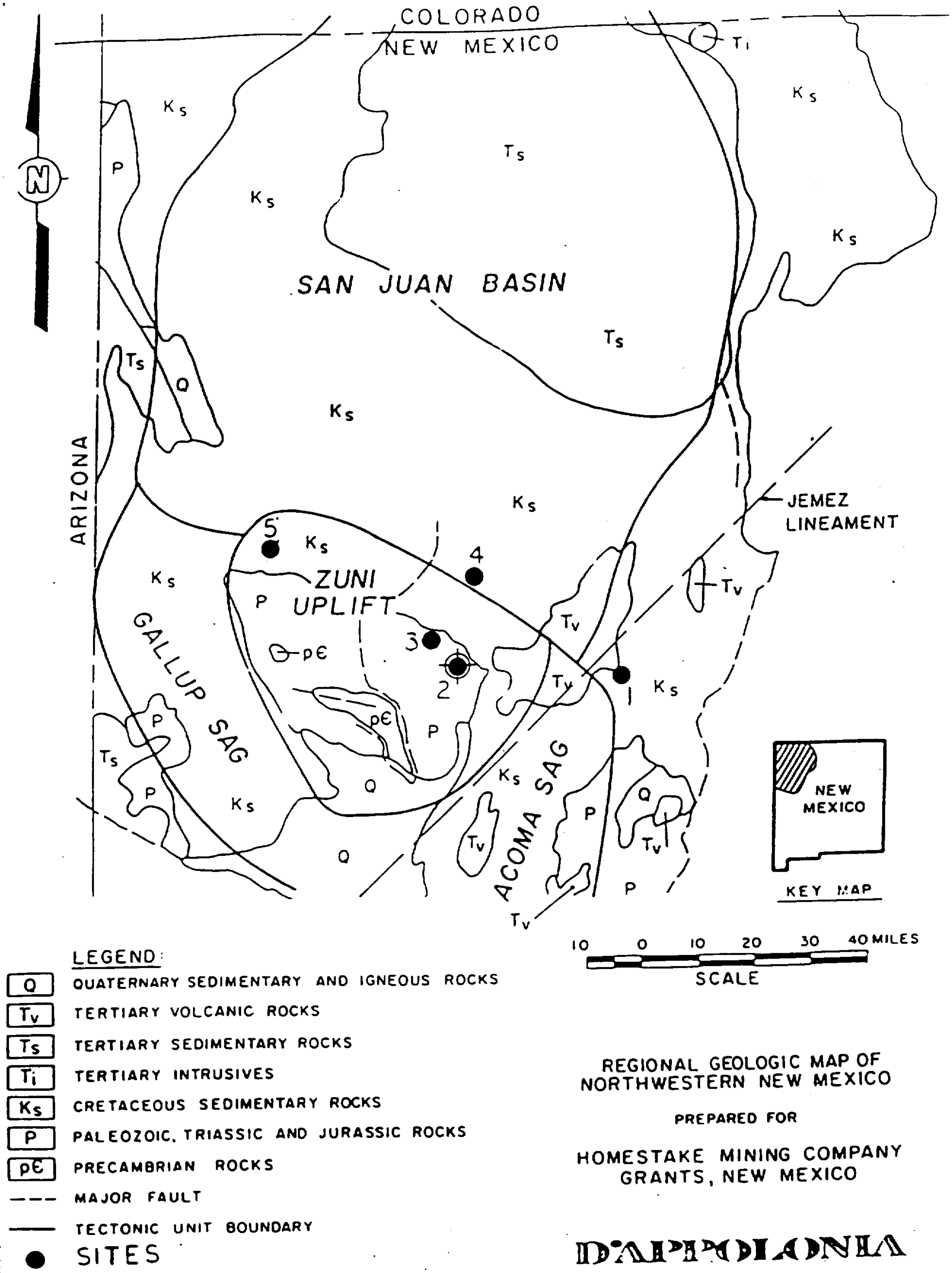


Figure 5.2 Regional Geologic Map of Northwestern New Mexico

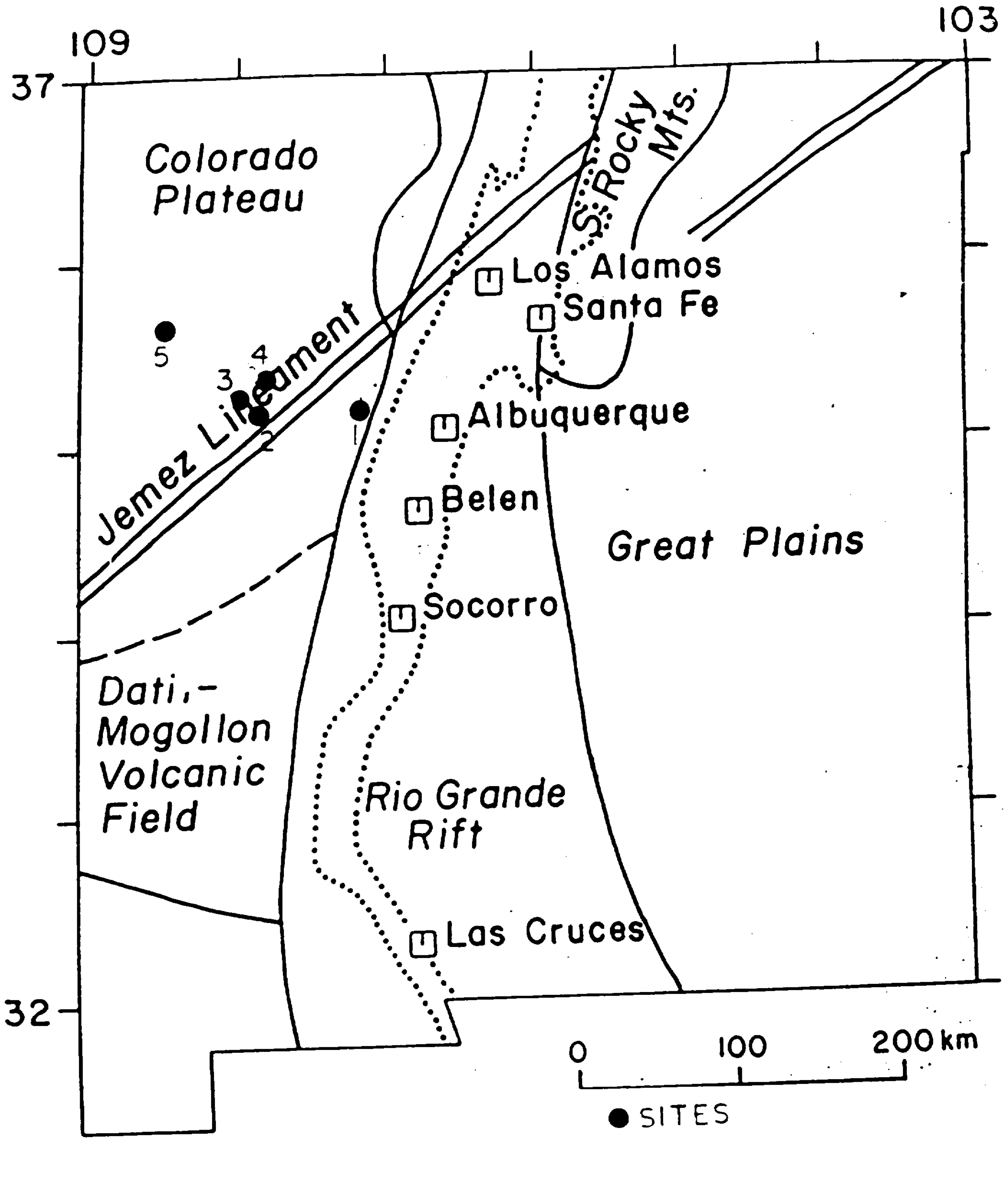


Figure 5.3 Boundaries of the major physiographic provinces in New Mexico. Taken from Sanford and Jaksha (1991). Other proposed boundaries for the Rio Grande rift shown in dotted lines. Approximate location of the site are also shown.

5.2 Regional Discussion of Seismicity and Earthquake Hazards

Fig. 5.3, taken from Sanford and Jaksha (1991), shows the boundaries of the major physiographic provinces in New Mexico and approximate locations of the sites located in New Mexico. The Rio Grande Rift (RGR) is a region with relatively young faulting (faults with surface offsets within the past five million years). The Colorado plateau and the Great Plains provinces are considered to be relatively stable and do not show evidence of young faulting. The Jemez Lineament (JL) is shown in Fig. 5.3. This lineament trends southwestward from northeastern New Mexico across the Rio Grande Rift and through the southern part of the Colorado Plateau. It is defined by an alignment of Pliocene and Pleistocene volcanic, including the Mount Taylor volcanic center. This lineament is not a fault or zone of faults, and does not really correspond with seismicity in the region. The feature may represent a deep seated structure, in the lower crust or upper mantle (Scott Baldrege, personal communication, 1995). The section of the lineament northeastward from Mount Taylor is believed to be locally active (Sanford and Jacksha, 1991).

The most prominent concentration of seismic activity within New Mexico occurs along the Rio Grande Rift, a chain of structural depressions extending roughly north-south through the central part of the state from the Colorado border to Mexico. The majority of the earthquakes within the rift have occurred in the segment between Belen and Socorro.

Sanford and Jaksha (1991) note that the most interesting and puzzling characteristic of the seismicity of New Mexico is the lack of well defined seismic trends that correlate with young tectonics/volcanic features or boundaries between physiographic provinces. They further note that the Colorado and Great Plains provinces have since 1962 a level of seismicity that is almost comparable to the level of seismic activity in the Rio Grande Rift.

5.3 Deterministic Analysis

There is no evidence for active faulting near any of the sites in New Mexico. However, as noted above, the Jemez Lineament (JL) is a lineament of recent volcanism. Although there is no compelling evidence that seismic activity is associated with the JL there is some evidence that there is an alignment of seismicity along the sector of the lineament northeastward from Mount Taylor towards the RGR. As Mount Taylor is near several of the sites it is of concern because no younger surface faulting is observed. It does not appear to be the source of major M > 6.5 earthquakes. In the Methodology section we argue that, based on the literature and discussions with regional experts, we could expect earthquakes of 5.5 to 6.5 to occur anywhere. Thus a value of $M_u = 6.25$ for earthquakes localized on the JL appears reasonable near Mount Taylor.

5.4 Hazard Analysis for Random Earthquakes

5.4.1 Source Zone Selection

As noted above, the seismicity in New Mexico appears to be relatively random without any strong trends such as those observed in Utah and Wyoming where the contrast between the Intermountain Seismic Belt and the more stable region to the east is very evident. However, if geology and recent tectonic activity are used, several source zones can be identified. The potential source zones are the JL, the RGR, the Great Plains, the Colorado Plateau and the Datil-Mogollon Volcanic Field (all shown on Fig. 5.3). In 1966 a series of earthquakes were located on or near the Gallina-Archuleta Arch approximately at the New Mexico-Colorado border. This arch is a little to the west of the RGR.

The three zones shown on Fig. 5.4 are used in the analysis of the random earthquake hazard. There are several points to note about our model for the source configuration: first, we did not model the JL as a source zone because the catalog for this zone is so short and incomplete we could not develop a

meaningful recurrence model for this zone. In addition, the level of activity of even the RGR is not much different from the level, observed in the Colorado Plateau. Secondly, there are a number of possible configurations for the RGR - e.g., see Fig. 5.3 for at least two. We chose a simple configuration (as shown in Fig. 5.4) based on the mapped recent faulting and seismic activity. We explored the use of a much broader definition e.g. as shown on Fig. 5.3. Our choice lead to a slightly higher rate and hazard at the sites involved in the study.

We also included a zone 3 which roughly corresponds to Gallina-Archuleta arch. This region seems to be separate from the RGR and possibly from the Colorado Plateau - zone 1 on Fig. 5.3.

We separated off zone 1 from the rest of the Colorado Plateau based primarily on the observed seismicity. The region in New Mexico (around the sites) has a higher rate of activity than in both Arizona and Colorado near the New Mexico border.

Finally, both the Great Plains and the Datil-Mogollon Volcanic Field were not included because they are so far away and the rate of earthquake recurrence in these two zones is sufficiently low that they make no contribution to the hazard at the New Mexico site.

5.4.2 Recurrence Model Selection

As described in the Section 3.4.2 the Stepp's method is used to determine completeness. For the Colorado Plateau (zone 1) only earthquakes in the 2.5-3 range appeared to be complete in the last 30 years. For the RGR earthquakes in the 3-4 magnitude range appear to be complete for the last 30 years. No completeness was observed in the data in zone 3 for any magnitude range.

Fig. 5.5a shows our selected fit to the data for the last 30 years in the RGR zone. The data is fit reasonably well by (for 30 years):

$$\log N = 3.775 - 0.7M$$

or

by (on a yearly basis):

$$\log N = 2.298 - 0.7M$$

Fig. 5.5b compares our recurrence model to the data for the last 90 years (only 90 years of data is in the catalog.) As expected, for magnitude less than 5 the model is higher than the data, reflecting the incompleteness of the data set (very little coverage before 1964 for smaller events.) The recurrence model is in reasonable agreement with the data for large events - though the catalog is so short that it is not possible to infer very much from this comparison.

Fig. 5.6 shows a comparison of the recurrence model we used to the data for the last 30 years in zone 1. We fit the model to the data at M = 3 because Stepp's method suggested completeness for earthquake in this range over the last 30 years. We choose b = -0.7 in accordance with the value found for the RGR. We note that we used b = -0.8 for the sites in the Paradox Basin and that Arabasz, Peckmann and Brown (1991) found b = -0.71 for their analysis for random earthquakes in Utah.

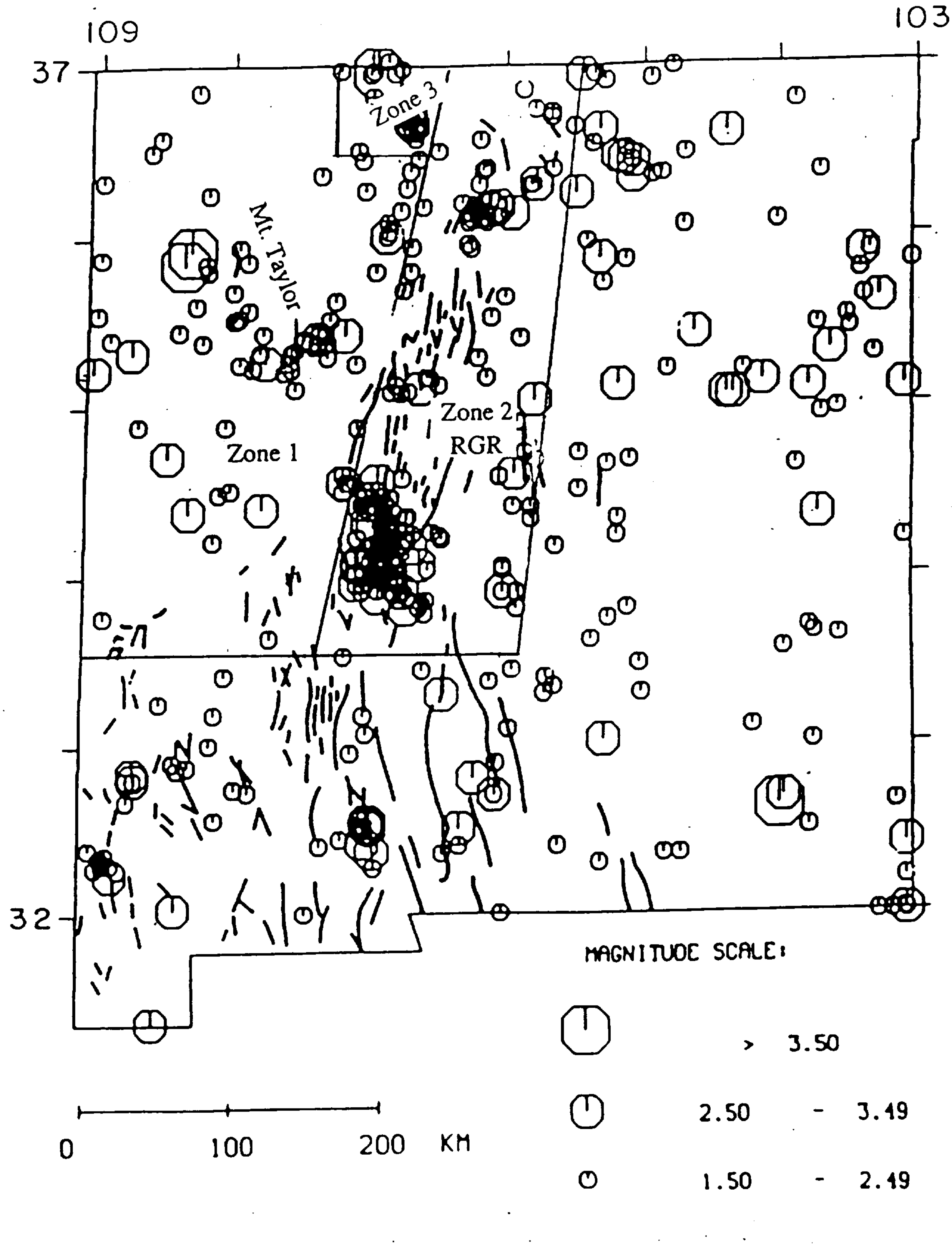


Figure 5.4 Location of faults with surface offsets within past 5 m.y. and New Mexico earthquake activity from 1 January 1962 through 30 September 1986. Taken from Stanford and Jaksha (1991). Also shown are the boundaries of the source zones used in our hazard analysis.

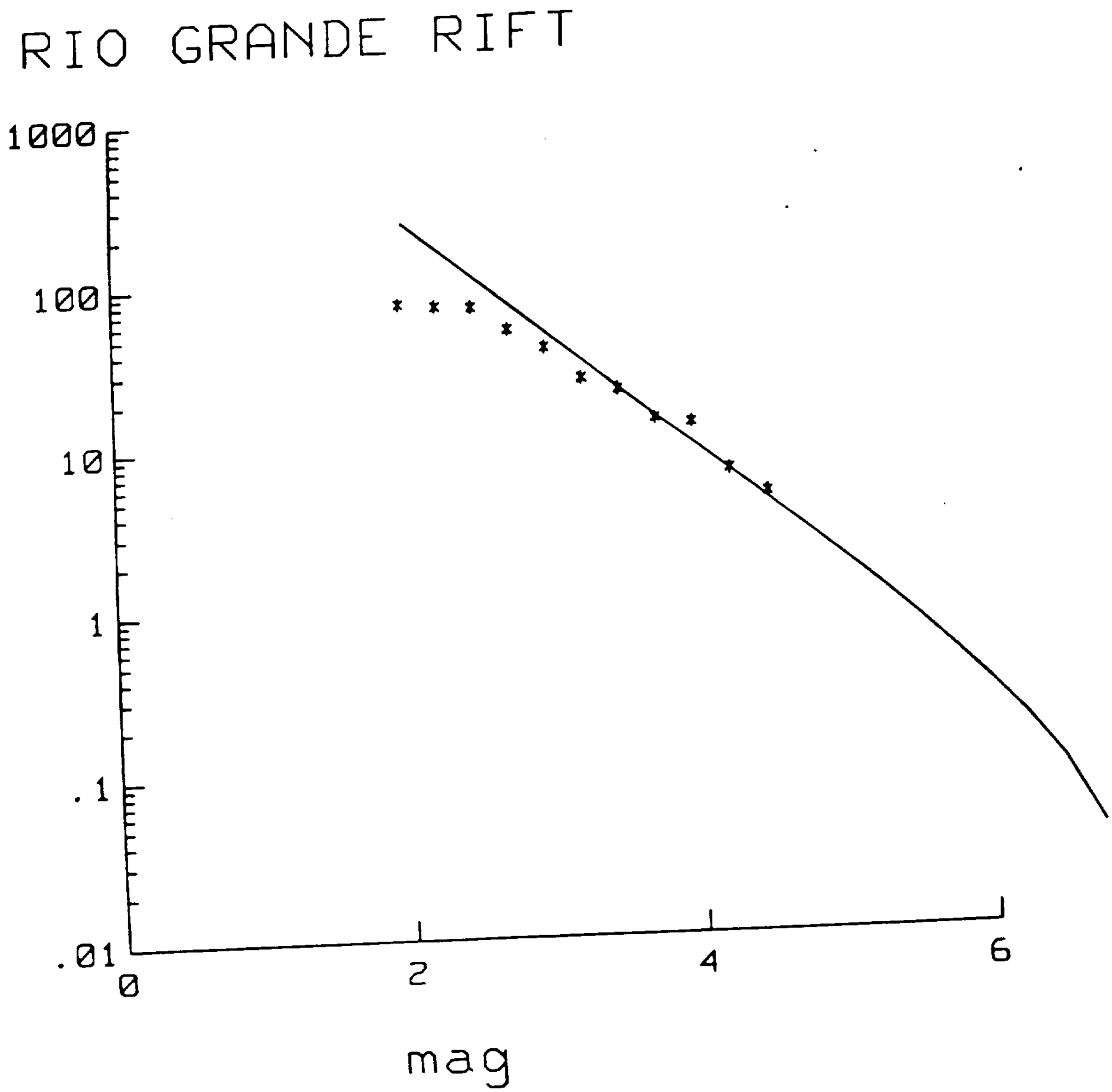


Figure 5.5a Comparison of recurrence model for the RGR Zone (Zone 2) to the data for the last 30 years.

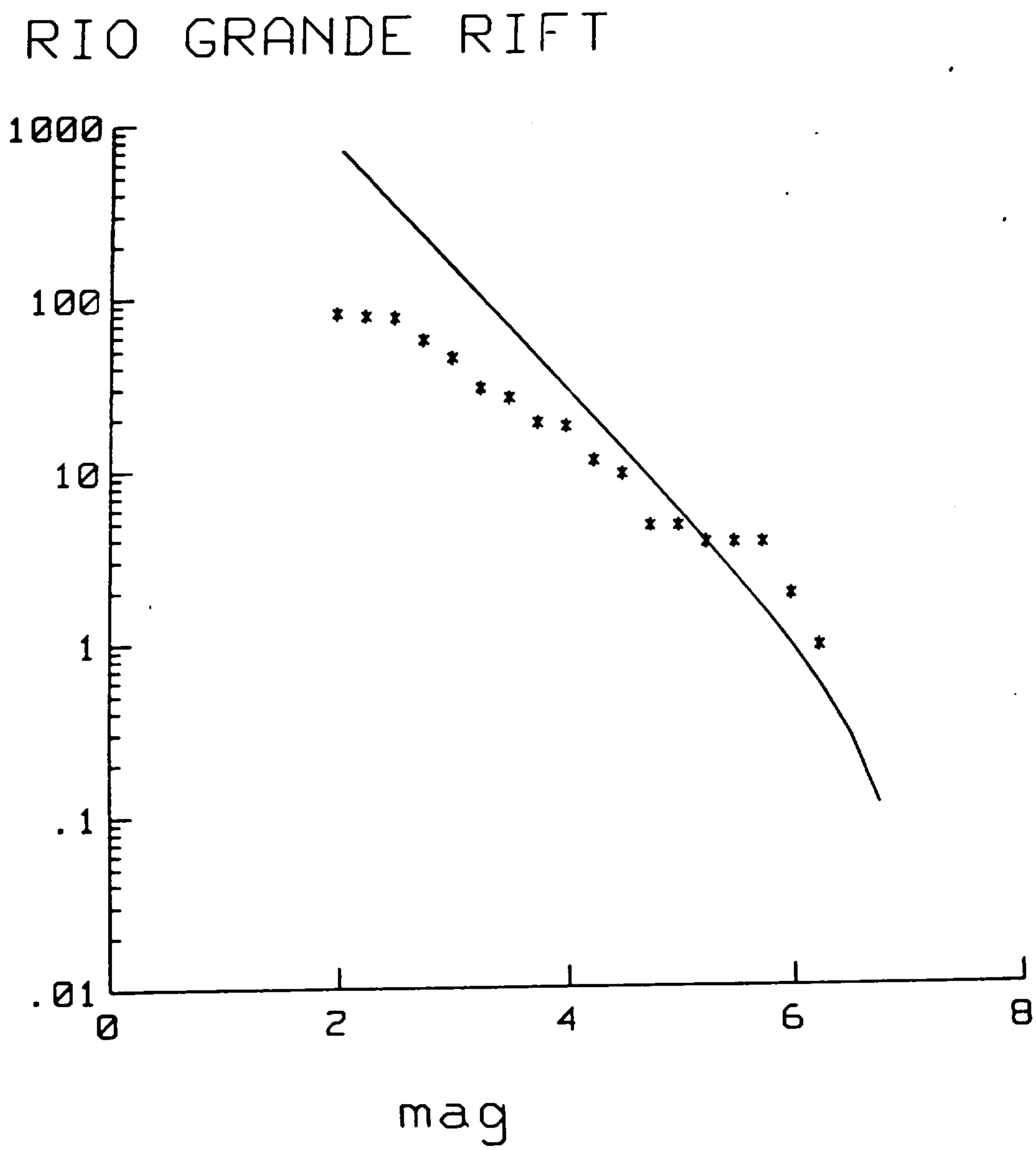


Figure 5.5b Comparison of recurrence model for the RGR Zone to the data for the last 90 years.

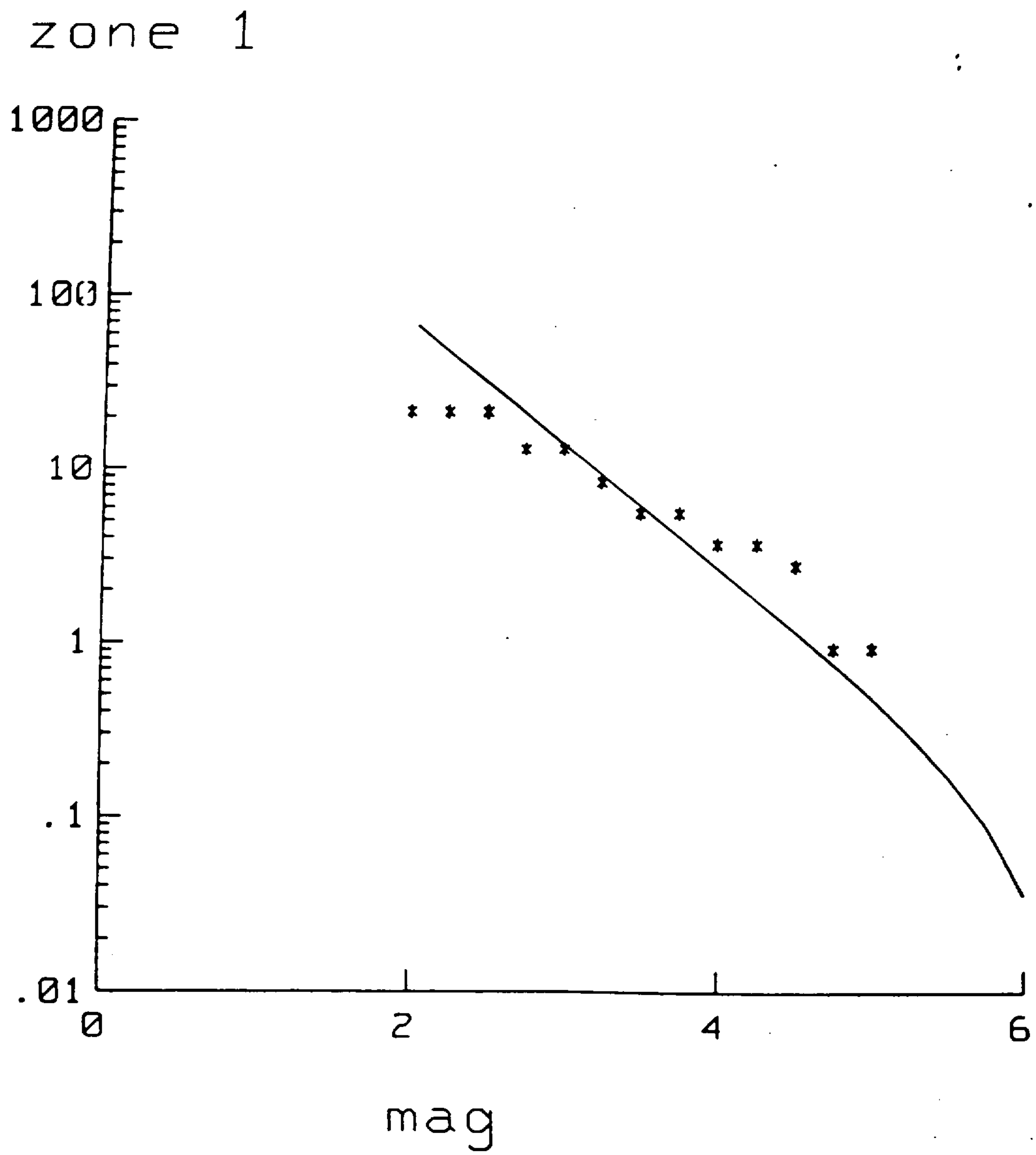


Figure 5.6 Comparison of recurrence model for Zone 1 to the data for the last 30 years in Zone 1.

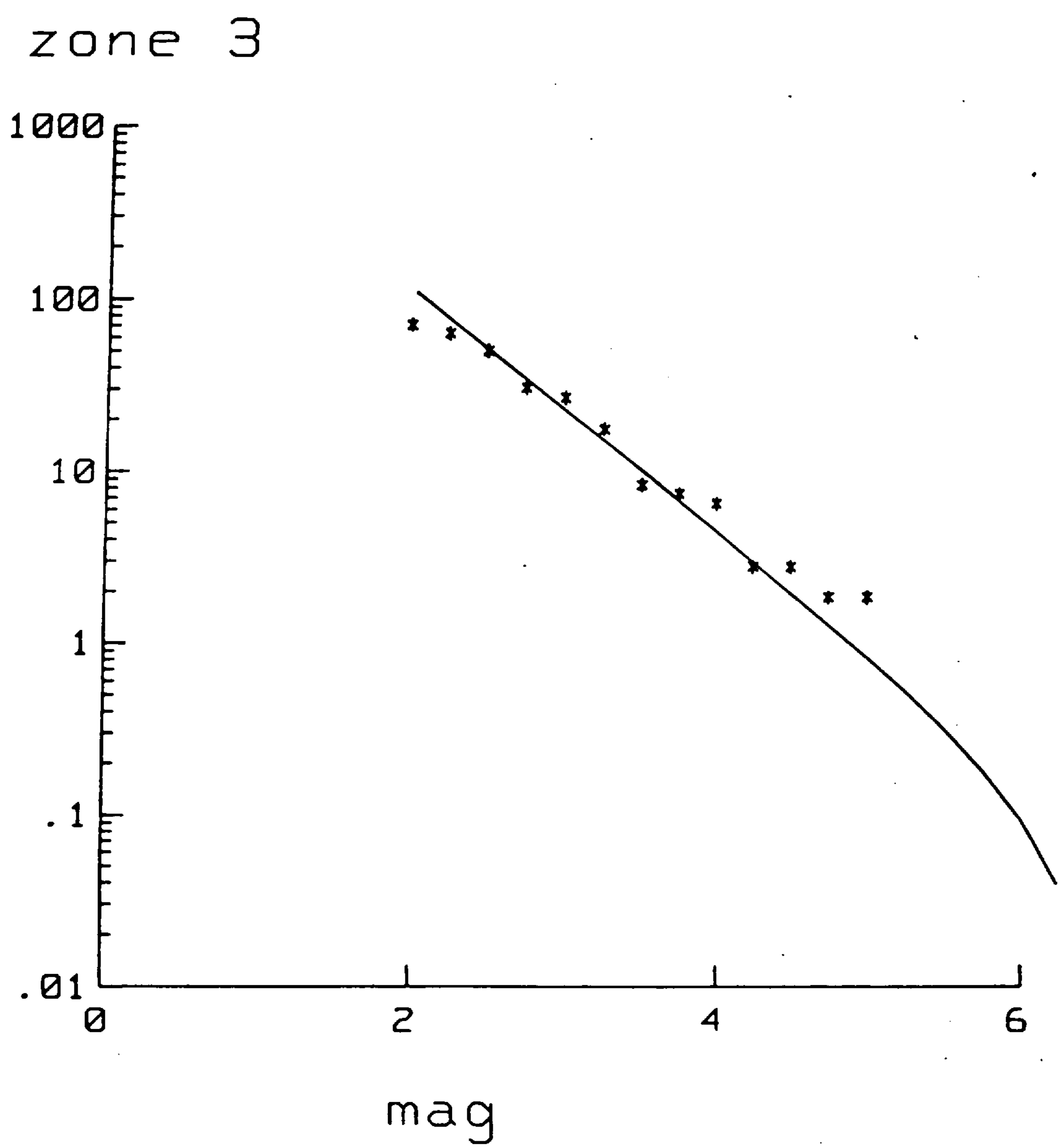


Figure 5.7 Comparison of recurrence model for Zone 3 to the data in Zone 3 for the last 30 years.

The data in zone 3 is primarily from a swarm of earthquakes in 1966. Figure 5.7 compares the recurrence model we used in our analysis to the data since 1963. The data is fit by:

$$\log N = 3.445 - 0.7M$$

Our analysis showed that this zone did not contribute to the hazard at any of the sites. Hence we did not open issues such as culling or other processing.

5.4.3 Selection of M_u

For zone 1 we varied M_u between 5.5 and 7. The most likely value being between 5.75 - 6.25.

In the RGR there are a number of relatively long faults with movement within the last 5 M_a which could potentially support earthquakes in the 6.5 - 7.5 magnitude ranges. We see from Fig. 5.4 that the longest fault in the RGR near the sites is about 60 km long. Even if we assume that the entire fault ruptured in a single event we would estimate $M_u \sim 7.1$ We used $M_u = 7$ with a range of 6.75 to 7.25.

As discussed in the Methodology section, we used a factor of 2 uncertainty on the a-value and performed the analysis for several values for M_u of 5.5, 5.75, 6, 6.25, and 7. For each case we used a $\pm$ 0.25 uncertainty on M_u. However, the uncertainties could be much larger as it is very difficult to estimate them. Hence our analysis is a best estimate type of analysis.

Actually the choice for M_u in the RGR is not too critical. This is shown from Fig. 5.8 where we compare the mean PGA hazard curve at site 1 (Sohio) which is the site closest to the RGR for values of $M_u = 7$ and 6.5 in the SGR. For this comparison we used $M_u = 5.75$ in zone 1. We see from Fig. 5.8 that there is very little difference in the hazard at the Sohio site. Had we taken $M_u = 6.25$ in zone 1 the difference would have been even smaller.

In Fig. 5.9 we compare the mean PGA hazard curves for Sohio and the United Nuclear sites (site 5). We see from Fig. 5.3 that site 5 is the furthest from RGR. For this comparison we used $M_u = 5.75$ in zone 1 to increase the relative importance of the RGR. We see from Fig. 5.9 that the RGR only contributes to the hazard at site 1 for PE levels greater than 10^{-5}.

In Fig. 5.10 we compare the mean PGA hazard curves for sites 2, 4 and 5. We see from Figure 5.10 that there is very little difference in the hazard between sites. Hence we only compute the hazard at one of the sites.

In Fig. 5.11 we give the mean PGA hazard curves for site 1 (Sohio) for M_u of 5.5, 5.75, 6, 6.25 and 7 in zone 1. For all cases $M_u = 7$ in RGR was used. In Fig. 5.12 we give the mean PGA hazard curves for the remaining sites in New Mexico for various values of M_u in zone 1.

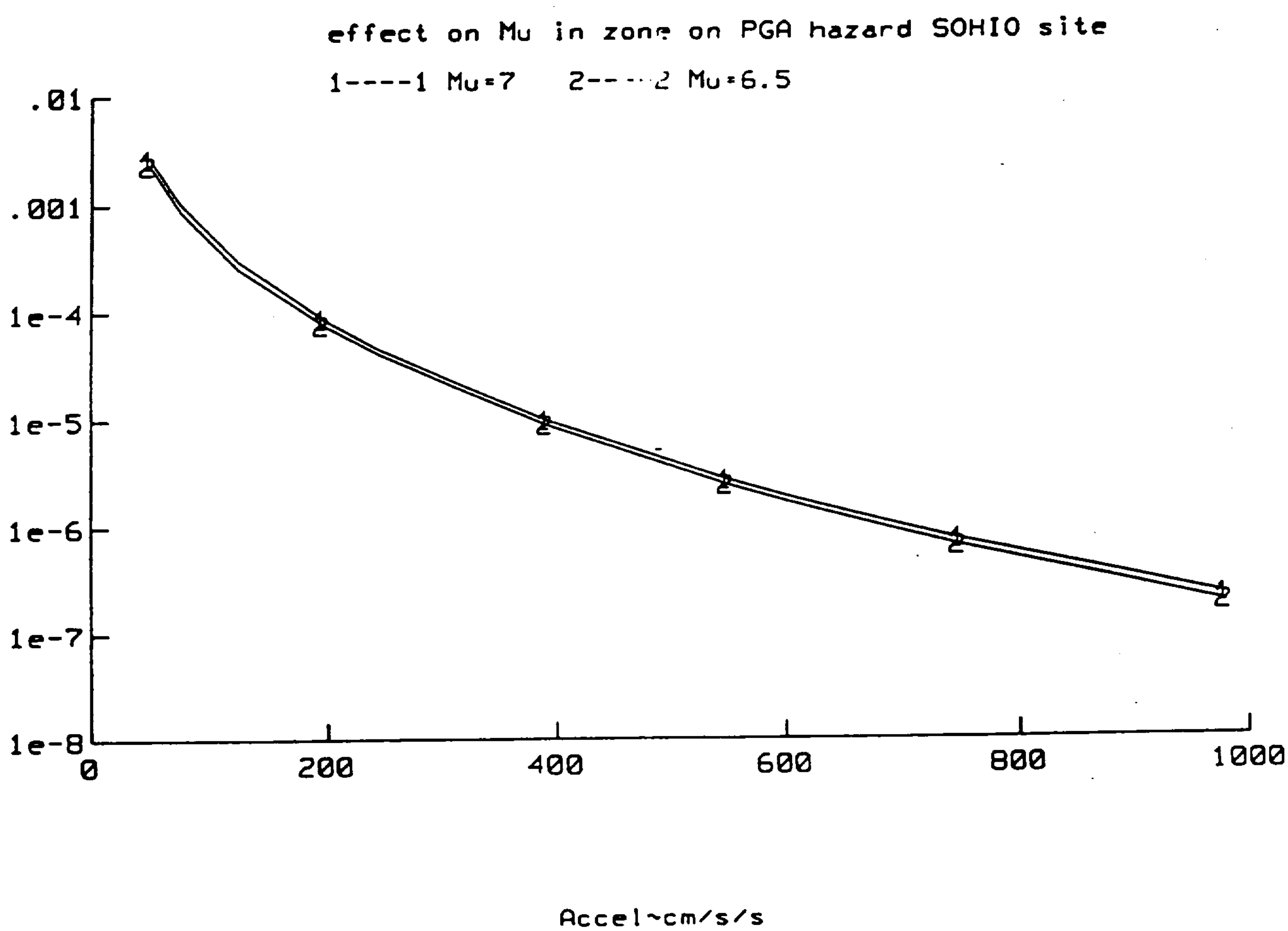


Figure 5.8 Effect on M_u in the RGR zone on PGA hazard Sohio site.

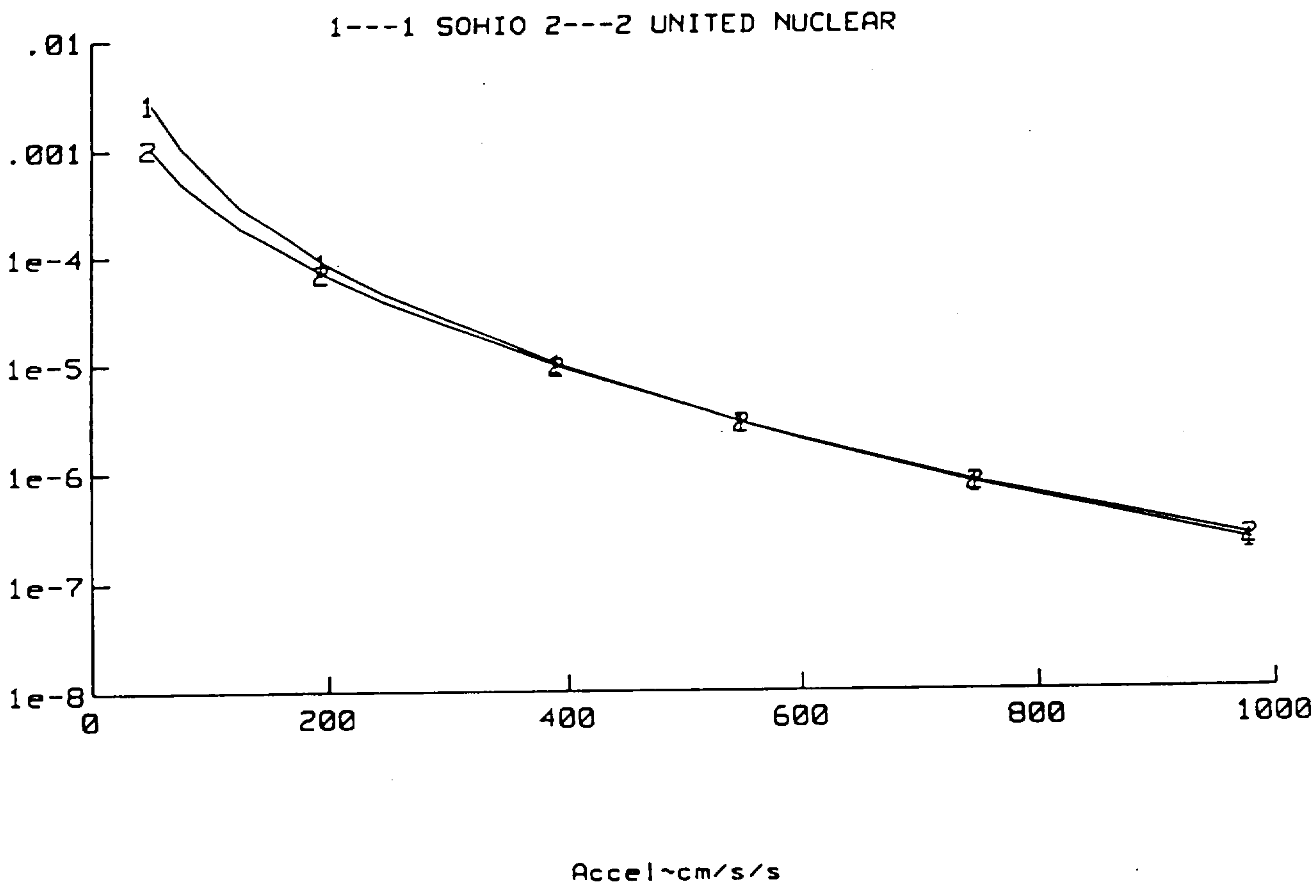


Figure 5.9 Comparison of hazard at Sohio & United Nuclear sites.

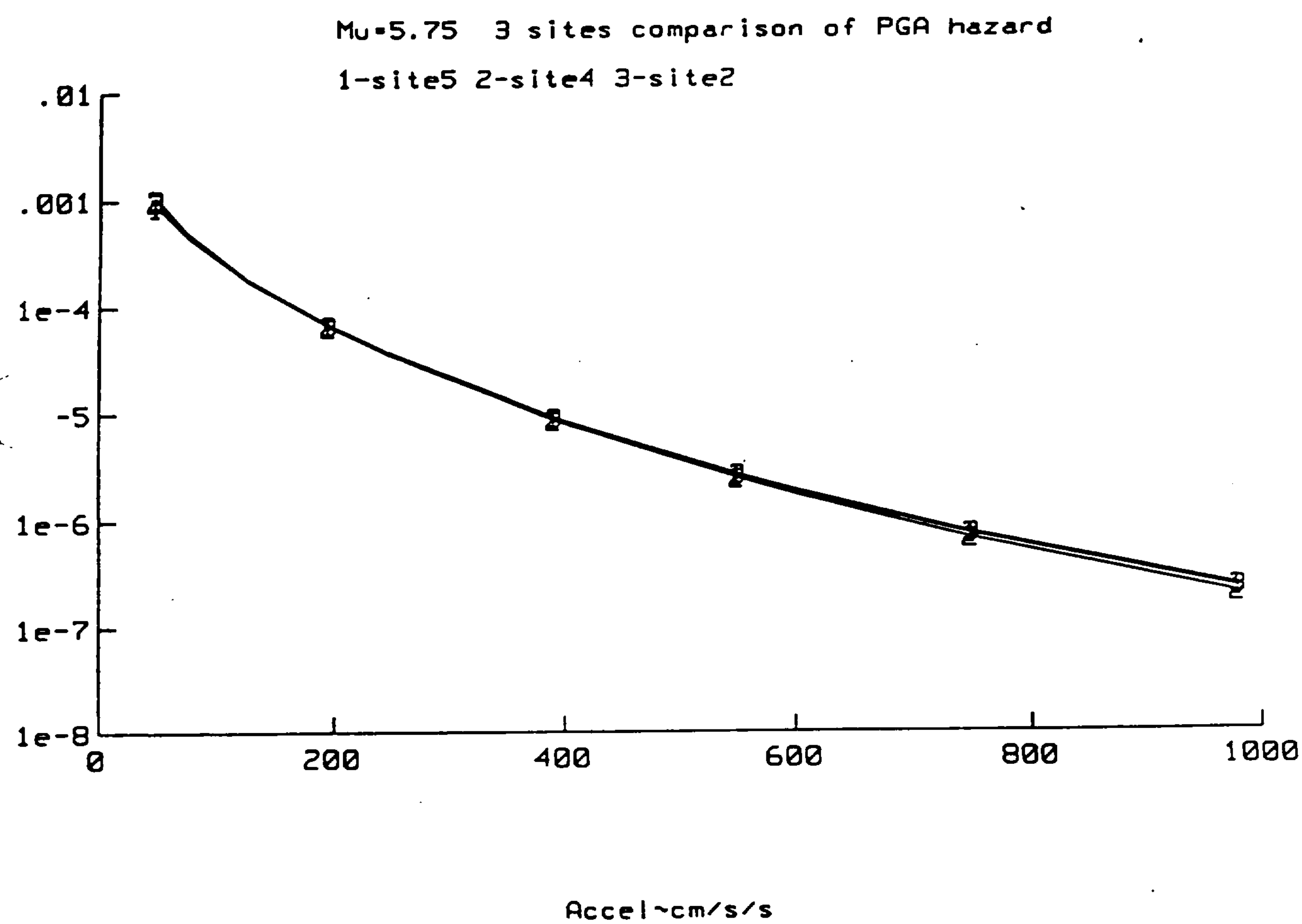


Figure 5.10 Comparison of the PGA hazard for M_u = 5.75 at 3 sites. 1—1 site 5 (United uclear), 2—2 site 4 (Quivira), and 3—3 site 2 (Homestake) see Fig. 5.2 for relative location of sites.

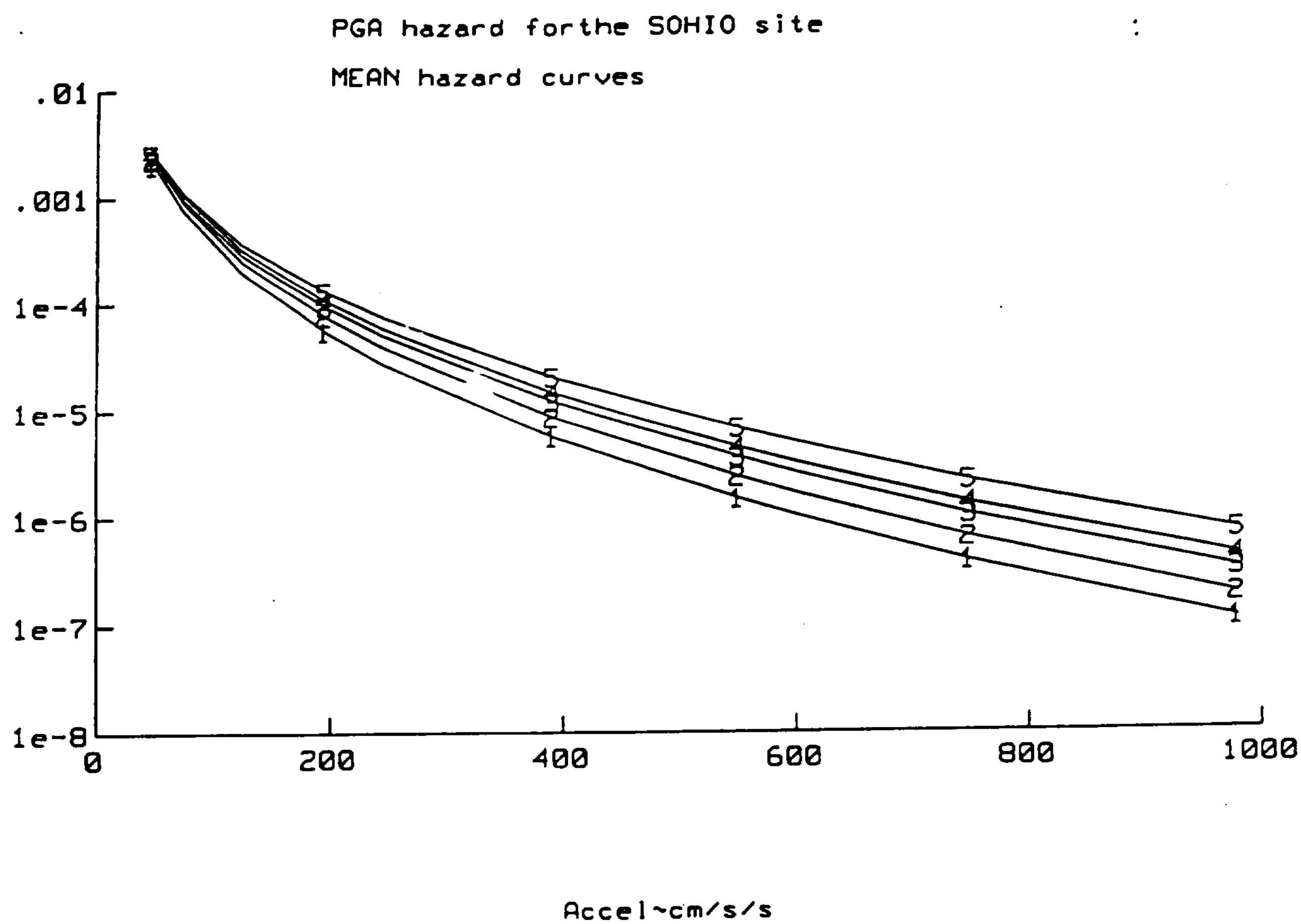


Figure 5.11 Mean PGA hazard curves for the Sohio site (site 1) for various M_u in zone 1. 1—1 , M_u = 5.5, 2—2 M_u = 5.75, 3—3 M_u = 6, 4—4 M_u 6.25, 5—5 M_u = 7.

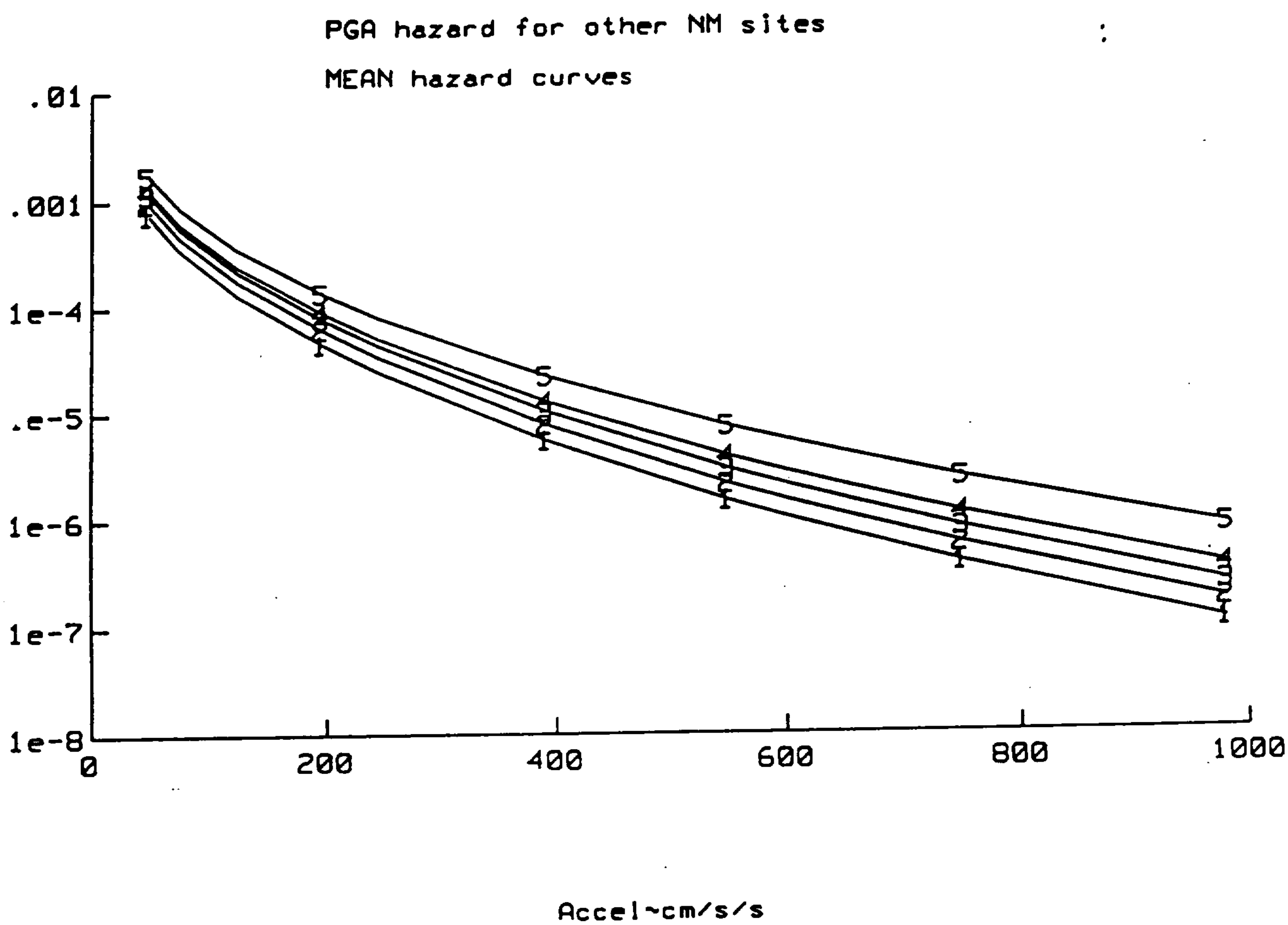


Figure 5.12 Mean PGA hazard curves for the remaining New Mexico sites for various M_u in Zone 1. 1—1 $M_u = 5.7$, 2—2 $M_u = 5.75$, 3—3 $M_u = 6$, 4—4 $M_u = 6.25$ 5—5 $M_u = 7$.

5.5 Atlantic Richfield (ARCO)

Bluewater Mill

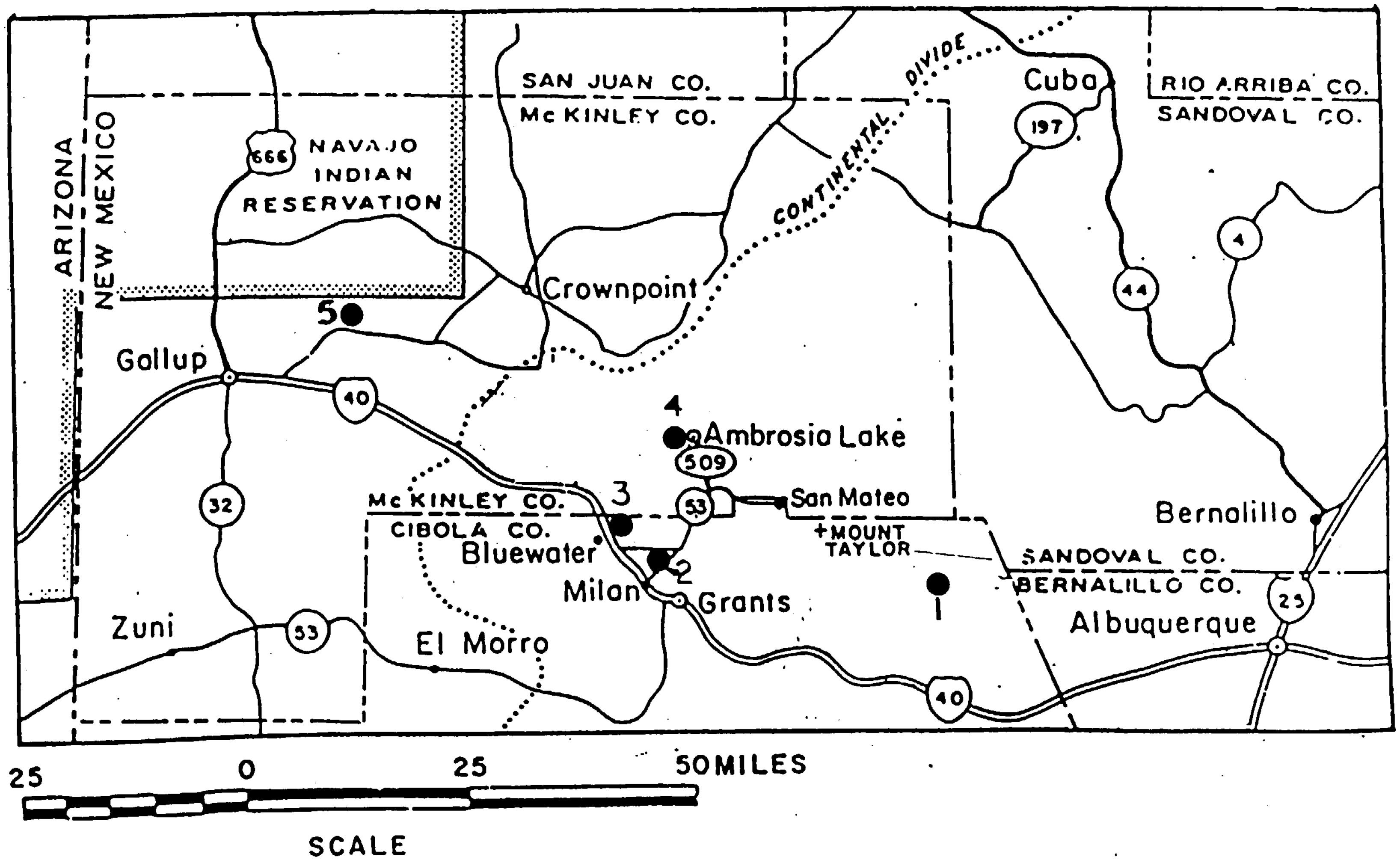
5.5.1 Introduction

The ARCO Bluewater Mill lies within the Ambrosia Lake Uranium district in Cibola County, approximately 16 km northwest of the town of Grants near the village of Bluewater (Figure 5.13). The mill is located in the western portion of the Grants Bluewater Valley within the Colorado Plateau Physiographic Province.

5.5.2 Local Geology

The sedimentary section at the mill is late Paleozoic and Mesozoic age and rests on Precambrian crystalline basement rocks intruded by late Cenozoic age volcanics. The oldest sedimentary formations at the site are sandstone and limestone of the Permian San Andres and Glorieta Formations. These rocks are overlain by sandstone, siltstone, claystone and local conglomerates of the Triassic Chinle Formation. Sedimentary units of Jurassic and Cretaceous age were deposited at the site during uplift of the Colorado Plateau in late Cretaceous and early Tertiary time, but since have been eroded. Rocks at the site dip gently to the north and east, except where local faulting and folding has occurred. The mill area contains regional troughs and uplifts with minor faulting along the margins of the larger uplifts. Within the site, well-developed normal and normal/oblique slip faults of late Tertiary to early Quaternary age are common (Arco Coal Company, 1990).

Formations in the mill area are primarily sedimentary, although basaltic lava flows (Bluewater Basalt) cap the tops of some mesas and fill in pre-existing drainage's. The Bluewater Basalt is a vesicular lava flow filling the ancestral channel of the Rio San Jose to form a rough surface locally referred to as "malpais" topography. Exposed formations in descending order are: alluvium; eolian deposits and volcanics of Quaternary age; the Triassic Chinle Formation; the San Andres Limestone; the Glorieta Sandstone; and the Permian Yeso Formation. Portions of the Chinle Formation have eroded in the vicinity of the mill site, but all other stratigraphic units are present. The middle and uppermost portions of the Chinle Formation form the ridges and bluffs located along and immediately outside the northern and western boundaries of the site. Alluvium and eolian deposits within the site have been controlled by the present and ancestral drainage system of the Rio San Jose (Arco Coal Company, 1990).



igure 5.13 Map showing location of the New Mexico sites. 1—Sohio, 2—Homestake, 3—Arco, 4—Quivira, 5—United Nuclear.

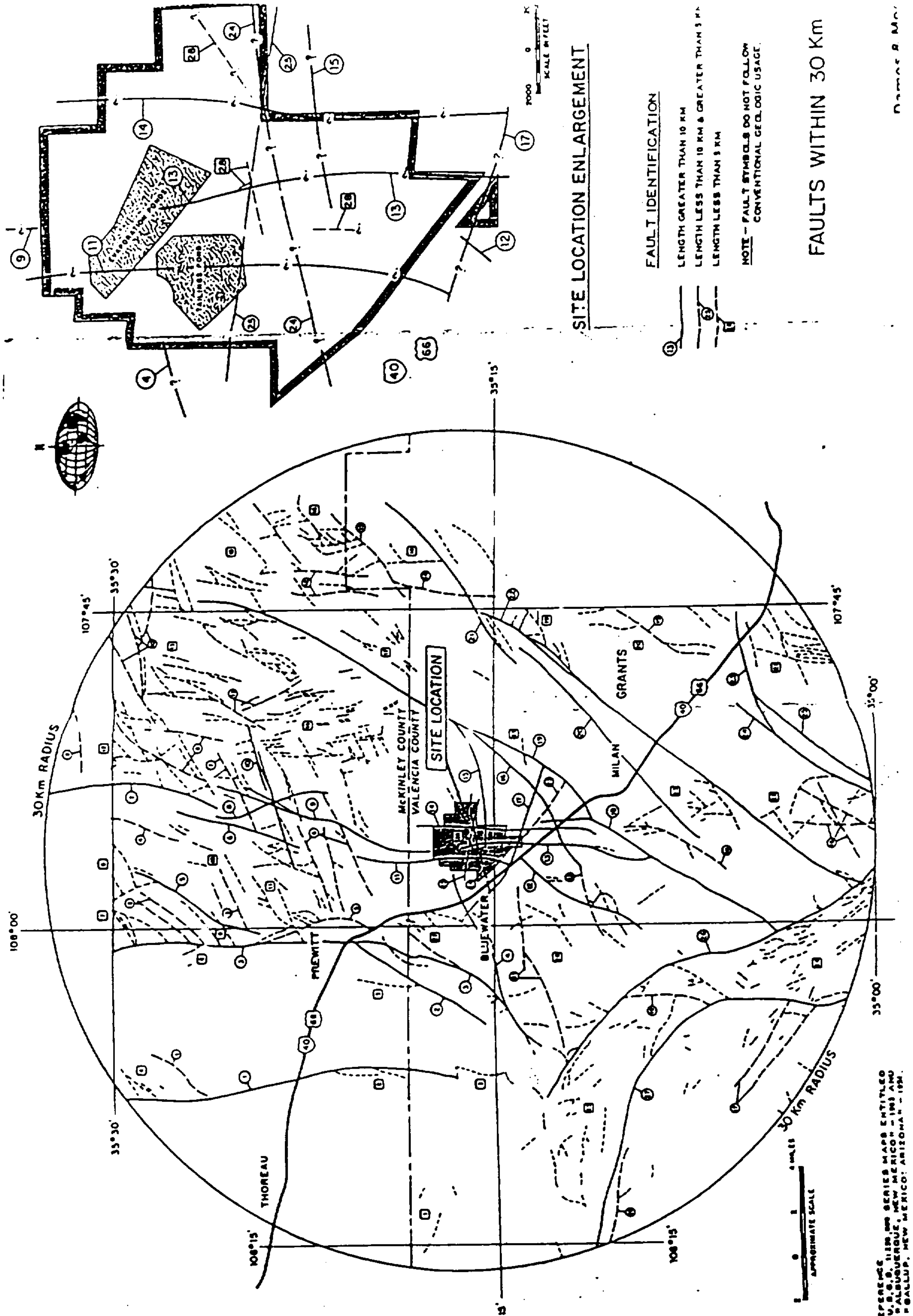


Figure 5.14 Faults within 30 km of the Arco site. Figure taken from Dames and Moore (1988). Numbers on fault are discussed in Dames and Moore (1988). None of the faults are considered active or show quaternary movement.

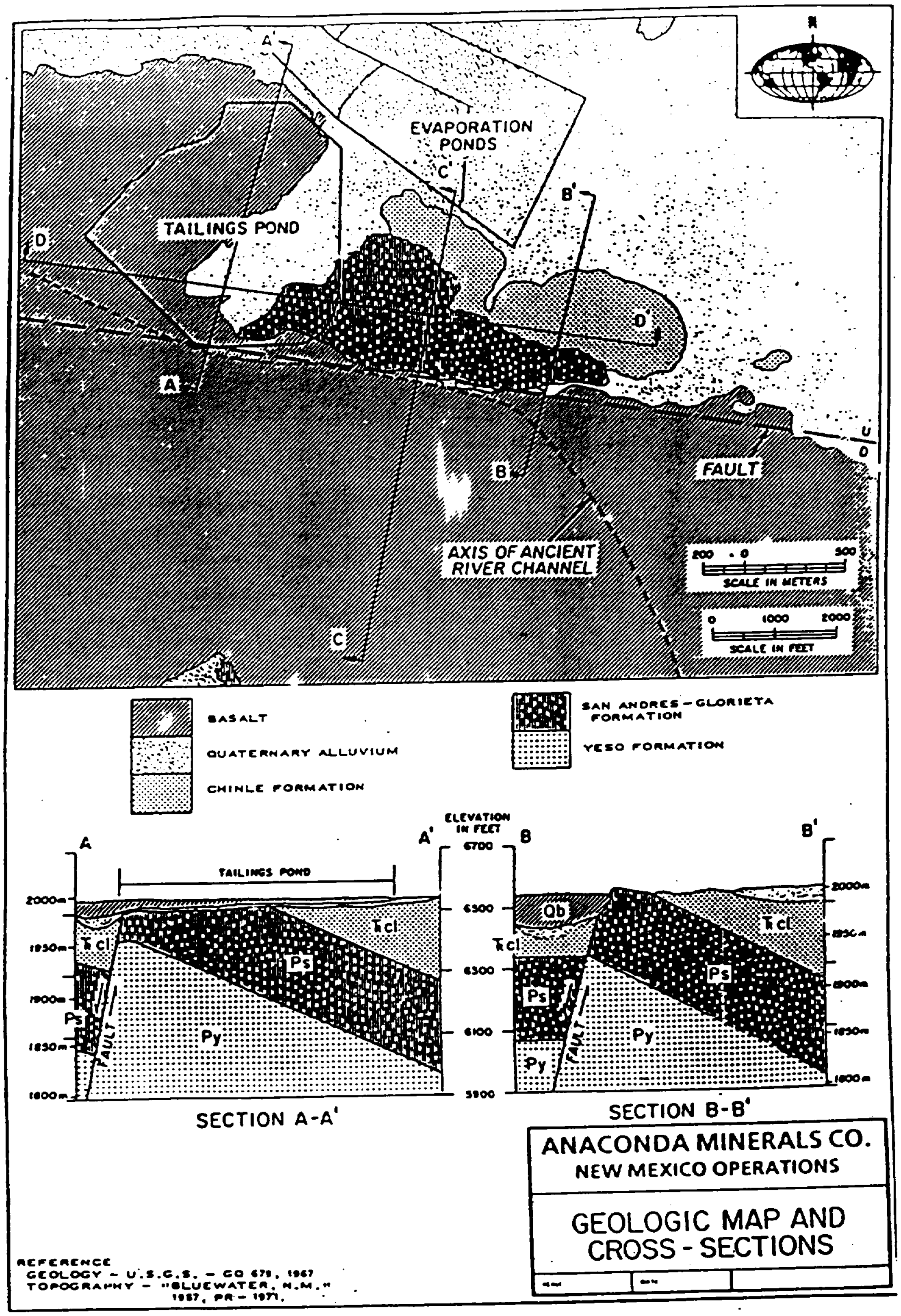


Figure 5.15a Location of fault and cross sections at the tailing pond and evaporation pond.

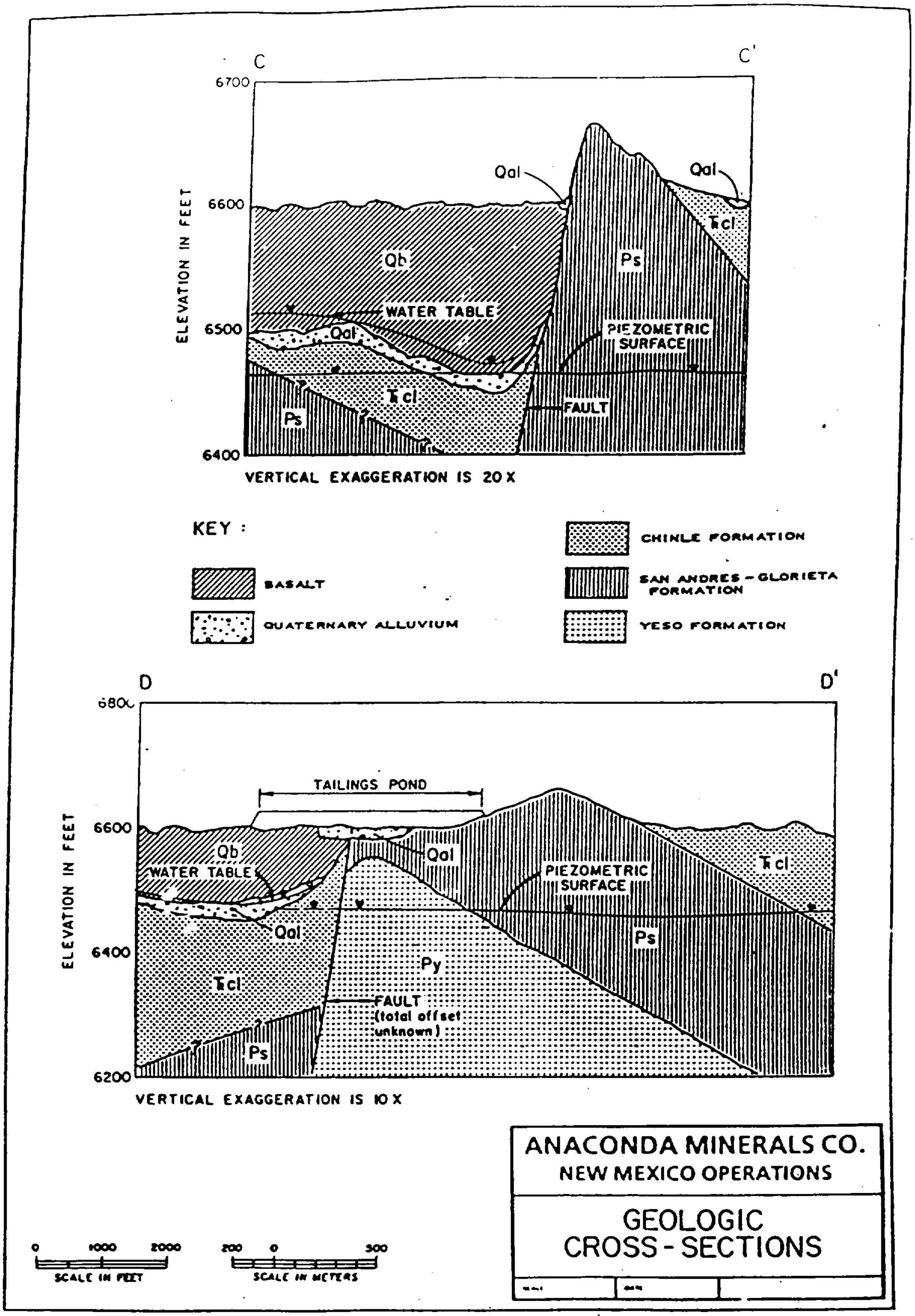


Figure 5.15b Cross sections C-C' and D-D'. Note the north-south trending fault shown in cross section D-D' is not shown on plan view map in Fig. 5.15a.

.5.3 Tectonics and Faulting

The faulting within 30 km of the site was investigated by Dames and Moore (1988.) Figure 5.14 taken from Dames and Moore (1988) shows their compilation of the faulting around the site. They found numerous faults within 30 km of the site — most of them minor. No major through-going fault is observed. None of the faults showed Quaternary movement and none were judged to be capable.

The most southerly portion of the tailings pond overlies the trace of a fault. This fault offsets the San Andres Formation with a displacement of approximately 122 m in the area of the pond. A north-south trending fault is also believed to underlie the tailings area (Figure 5.15 a and b) (Anaconda Minerals Company, 1986). The site lies near the Jemez Lineament described in the regional geology of New Mexico section.

The youthful faults in western New Mexico appear to be restricted to the Basin and Range physiographic province and the Rio Grande Rift. Based on USGS maps, the youngest faulted unit in many cases is Cretaceous age. A few faults cut Tertiary age basalt flows east of Grants on the flanks of Mt. Taylor. Several faults in the vicinity are shown cr. USGS maps as concealed and questionable (Figure 5.14). In addition, the geologic maps show many cross-cutting faults with no apparent displacement relative to each other. Where displacement is shown, the amount of offset along the faults is small (less than 30 m) in most cases. (Arco Coal Company, 1990).

We have relied heavily upon the Dames and Moore (1988) report on faulting at the site. However, we did also review a document submitted on March 30, 1993. Part of this submittal was an undated report prepared by Billings and Associates, Inc. The cover letter of the March 30, 1993 submittal suggests that the report was first submitted to the state of New Mexico in 1984. In the Billings and ssociates report it states that: "The principal faults in the area are inferred to be Pleistocene or unger. Accordingly they are considered to be capable faults. Because the design criteria for the project is established on the basis of the largest credible event that may occur within the present tectonic framework, the probability that this event may occur both within the lifetime of the project and directly below the project site is extremely small."

This is all of the information given. It is impossible to assess this statement. We do know that there are relatively young lava flows in the region, but we have not been able to discover any references to very young, capable faults either in the literature or with our discussions with regional experts.

Our assumption is that the above statement is not based on field work and we have elected to base our analyses on the Dames and Moore (1988) report which we think is later than the Billings report. However, this is an issue that needs to be resolved as it would have a significant impact on the analysis for this site and as can be seen from Figure 5.13 several other nearby sites.

5.5.4 Seismicity and Earthquake Hazard Analysis

Deterministic Analysis

The ARCO site is approximately 30-35 km from seismic activity associated with Mount Taylor. In the section on Regional Seismicity, we argued that the appropriate magnitude for M_u is approximately a 6.25 event. The PGA is estimated using the approach outlined in Section 3.4.1. The 1-sigma estimate for PGA for a M = 6.25 earthquake located 30 km away is 0.15 g and the median estimate is 0.08g.

Hazard Analysis for Random Earthquake

.he sections on Regional Seismicity we found that the ARCO site is sufficiently far enough away from the RGR that the hazard curves for PGA are given by Figure 5.12.

Because the ARCO site is located near Mount Taylor and other tectonic structures it is our judgment that the appropriate value for M_u for the random earthquake hazard is $M_u = 6.25$. We see from the Figure 5.12 that at a PE level of 10^{-4} the PGA is 0.18g and at a PE level of 5×10^{-4} it is 0.08g. The PGA at a PE level of 10^{-4} varies between 0.14g to 0.22g depending upon M_u and between 0.06g to 0.1g at a PE level of 5×10^{-4}.

5.5.5 Conclusions

Our estimate of the PGA to use for the ARCO site ranges between 0.06 to 0.22g based on both the random and deterministic earthquake hazard analysis. We see from the Section 4.1.1 on design criteria that according to ARCO (1990a) a value for PGA of 0.21g was used for the reclamation design. Just how that number was used is not clear since a value of 0.1g was used in the slope stability analysis.

Both the tailings and evaporation ponds have significant faults under them. Although these faults are not judged to be active they are of considerable concern in the event the site experiences a nearby earthquake. Differential settlement or movement could occur across the fault surface. There are a number of other faults in the vicinity which could pose similar hazard to other facilities at the site.

Lastly, as discussed in Section 5.5.3, if the Billings and Associates report is correct and there are indeed capable faults at the site then the above estimates are much too low. As noted, there is not enough information to asses the statements made in the Billings report. However, it appears to be a report issued before the Dames and Moore (1988) report which we used as our primary source of information along with discussions with regional experts.

5.6 Homestake & Quivira Mills

5.6.1 Introduction

The Homestake and Quivira Mining Company Mills are both located in the Ambrosia Lake Uranium district and share many of the same geological and structural characteristics. Thus, the following geological discussions pertain to both mills unless otherwise noted.

As shown in Fig. 5.13 the Homestake Mill is located in northern Cibola County north of Grants. The mill lies within the Colorado Plateau Province at an elevation of about 2010 m. The site is surrounded by mesas ranging in elevation from 2130-2620 m which define a roughly circular valley approximately 16 km in diameter. Mount Taylor, the tallest peak in the region, is 3,444 m elevation and is located 24 km east of the site. The Quivira Mill is located north of the Homestake Mill in the southeastern part of McKinley County. Structural relief in the area is at least 1500 m.

5.6.2 Local Geology

The Ambrosia Lake mining district is named for an almost perpetually dry lake bed which lies approximately 32 km north of the town of Grants, New Mexico. The district is approximately 116 km long and 9.7-16 km wide situated in an elongated strike valley which has been eroded into the lower Mancos Shale Formation. The valley strikes northwest and is bounded on the south by the rim formed by the outcrop of the Dakota Sandstone and on the north by the high sandstone cliffs and steep shale slopes of the Mesaverde outcrop. The surface of the valley is generally flat or gently rolling, broken only by an occasional dry wash or outcrop of thin Tres Hermanos Sandstone of the Mancos Shale (Quivira Mining Company, 1986).

Sedimentary rocks exposed in the area range from Pennsylvanian to Cretaceous and rest on the Precambrian core of the Zuni Uplift. Associated intrusive and extrusive rocks from the Mt. Taylor

and Zuni volcanic fields of Tertiary and Quaternary ages cap mesas and fill valleys. The regional dip is 3° - 5° to the northeast into the San Juan Basin.

Cretaceous units are the only rocks exposed within the immediate area of the millsite. Strata consists of thick sequences of marine and continental deposits of shale and sandstone that intertongue and change lithology abruptly.

Triassic, Jurassic, Permian and Pennsylvanian rocks are exposed south of the mill site area where the more resistant beds form a series of ridges separated by long dip slope valleys (Quivira Mining Company, 1993).

The Homestake Mill is located on the northeast flank of the Zuni Uplift. This Zuni Uplift is surrounded by several tectonic depressions, including the Gallup Sag to the west-southwest, the Acoma Sag to the southeast and the San Juan Basin to the north (See Fig. 5.2).

5.6.3 Tectonics and Faulting

Ambrosia Lake is located in the southern part of the San Juan structural basin. This includes the Zuni Uplift, which is approximately 88 km and 32 km wide. The sedimentary rocks dip northward at angles of 3° - 5° from the central core of the Precambrian rocks of the uplift. Structural relief in the area is at least 1500 m.

The Ambrosia Lake area has been subjected to several minor episodes and one major episode of deformation from Morrison time to the present. The first deformation seems to have been semi-contemporaneous with the Morrison deposition. Faults and associated fractures are common near the Quivira Mill with a predominant northerly trend. Large fault blocks have been mapped in the area, and the mill lies on one of the upthrown blocks. This block is a horst bounded by the Ambrosia Fault which lies approximately 6.4 km west of the mill, and the San Mateo fault which is also located approximately 6.4 km west of the mill.

As mentioned in the regional geology section, major deformation of the Precambrian basement and the Late Paleozoic and Mesozoic sedimentary sequence in the Ambrosia Lake area occurred during the Laramide Orogeny (late Cretaceous-early Tertiary time) and gave rise to the Zuni Uplift, San Juan Basin and the Acoma Embayment. It was also during Laramide time that the principal folds, faults, and the northerly regional dip were established. Subsequent erosion is believed to have reduced the uplifted areas to lowlands in Eocene time and ensuing deposition covered much of the area with clay or fluvial deposits.

Major tectonic activity during the Laramide Orogeny resulted in formation of northwest-trending high angle reverse faults and uplift of the Zuni Mountains. A number of younger faults in the San Mateo and Rio San Jose valleys trend northeast and displace Tertiary volcanics, but not Quaternary volcanics. One of these, the San Mateo fault zone, lies approximately 1.6 km west of the Homestake Mill. Individual vertical displacements on branches of the San Mateo fault zone range from 1.5 to 82 m. Total vertical displacement of the fault zone is approximately 137 m down to the southeast (State of New Mexico Environmental Improvement Division, 1982).

The Mt. Taylor eruptions acquired their present characteristics in late Pliocene time. Continued erosion brought the physiography to its current outlook as late faulting broke the older high level flows in several places.

Also included in the Ambrosia Lake portion of the San Juan Basin is the Ambrosia Lake anticline. This north plunging anticline has formed a series of horsts and grabens along its northeast flank. The west flank dips steeply into the north-south Ambrosia Fault.

This fault, west of Ambrosia Lake is the major fault of the area. It trends north for approximately 16 km with a vertical southeastwardly plunging Dakota Sandstone syncline with an associated fault and fracture system. The syncline and associated fault system are believed to form a closed basin within the Dakota Formation (Quivira Mining Company, 1993).

5.6.4 Seismicity and Earthquake Hazards

All of the mapped and inferred faults near the Homestake and Quivira sites appear to be inactive with no recent movement. All of the structures mapped in the Quaternary basin deposits are inferred, and are projected to the surface from structures in the basement rocks. There is no evidence of recent movement.

Differential compaction is theoretically possible along these buried structures, resulting from strong ground motion from local seismic events. There is no evidence that this has occurred in the recent past, as there would be surficial evidence. Differential compaction and resulting ground rupture is possible in the event of a nearby earthquake located in the Mt. Taylor seismic zone.

Reference should be made to Section 5.5.3. If the assessment of the Billings and Associates report indicates that there are indeed capable faults on the ARCO Bluewater site then the faults at the Homestake and Quivira sites would need very careful field assessments to verify the above statements.

Deterministic Analysis - Homestake Site

The Homestake site is about 25 km from the seismicity zone associated with Mount Taylor. Our estimate for M_u, as discussed earlier, is M_u 6.25. This leads to an estimate for PGA at the 1-sigma level of 0.18 g and 0.1g median estimate.

Quivira Site

The Quivira Site is also about 25km from the seismicity zone associated with Mount Taylor. The estimated for PGA at this site is also 0.18g and 0.1g median estimate.

Hazard Analysis for Random Earthquake - Both Sites

As discussed in Section 5.5 on Regional Seismicity both sites are sufficiently far enough away from the RGR zone so that the appropriate PGA hazard curves are given in Fig. 5.12. As for the ARCO Site we take M_u=6.25 which, (from Fig. 5.12), gives an estimate PGA of 0.18g at a PE level of 10^{-4} and 0.08g at a PE level of $5x10^{-4}$. Depending upon the choice for M_u the PGA varies between 0.14g to 0.22g at a PE level of 10^{-4} and 0.06g to 0.1g at a PE level of $5x1^{-4}$.

5.6.5 Conclusions

Homestake Site

Our estimate for the appropriate value for PGA to assess the facilities at this site ranges between 0.06 to 0.22g, From the section on Design Criteria we see the value used in the design of the facilities appears to be 0.1 g. There is a potential problem depending upon how the various safety assessments were made using the 0.1 g value. This needs to be evaluated to ensure that adequate margins actually exist in light of our estimates of ground motion.

Several faults run under the site. It is difficult to determine if they run under the facilities of interest. If they do then they may pose a different settlement problem in the event of a nearby earthquake.

Quivira Site

Our estimate for the appropriate values for PGA to assess the facilities at the site ranges between 0.06 to 0.22g. The value used for design for this site is 0.1g. There is a potential problem depending, upon how the various safety assessments were made using, the 0.1g value. This should be evaluated to ensure adequate margins exist in light of our estimates for ground motion.

We noted that a north-south inferred structure passes through the site. If the inferred faults are present, as indicated by available mappings and reasonable projections, then in the event of the experiencing its design ground motion, there is potential for differential settlement across there faults. This needs to be evaluated.

5.7 SOHIO

Western L-Bar Uranium Mine

5.7.1 Introduction

The L-Bar Mine is located in the Laguna Uranium District in the southeastern corner of the San Juan Basin on the southern edge of the Mt. Taylor Volcanics (Fig. 5.13). The San Juan Basin and the L-Bar site are located in the eastern part of the Colorado Plateau tectonic province. The site location is approximately 2 km west of the San Ignacio Monocline that forms the boundary between the Colorado Plateau and the Rio Grande Rift tectonic province. It lies within the belt of Cretaceous age rocks exposed around the south and east rim of the basin.

The Colorado Plateau has remained stable throughout geologic time. The San Juan Basin was formed by uplifting in the Tertiary period. Frequent volcanic activity occurred in late Tertiary and early Pleistocene time and is evidenced by the Mt. Taylor Volcanics and the San Juan Volcanics further north.

5.7.2 Local Geology

The basement rocks of the San Juan Basin are Precambrian quartzite, granite and schists. These are overlain by several thousand meters of Mesozoic and Paleozoic sediments.

The ore-bearing Morrison Formation is a series of interbedded fluvial sandstones and shales 152-183 m thick in the project area. At the top of the formation is a local sandstone unit called the Jackpile Sandstone. It is a poorly sorted arkosic sandstone that is 15-30 m thick at the site, but which thins and disappears to the northwest and thickens to the south. The Jackpile Sandstone is the principal ore-bearing unit of the district. The Morrison Formation is divided into three members which are regionally extensive but locally quite variable. In descending order, these are the Brushy Basin, Westwater Canyon, and Recapture members. The Brushy Basin Member consists of gray-green mudstone and discontinuous sandstone layers; the Westwater Canyon Member is characterized by prominent and relatively persistent layers of arkosic sandstone >9 m thick occurring through a 61 m interval; whereas the Recapture Member is typically gray-red and gray-green mottled sandstone.

Because the project site lies at the southeast edge of the Mount Taylor volcanic field, evidence of volcanic activity is conspicuous. Residual fragments of basalt have been noted at the mill site and a small basalt flow remnant caps a high hill approximately 4 km to the northeast. The southern edge of the high and extensive basalt-capped Mesa Chivato is approximately 6.4 km to the northwest (Sohio, 1980).

5.7.3 Tectonics and Faulting

Fractures and jointing are prominent in the region, however aerial photography, surface observation, and drill hole information do not indicate that there is any faulting in the immediate vicinity of the site. A few old faults are shown on the quadrangle map, but there is no evidence that they extend into the site area. The most recent tectonic activity is associated with Mount Taylor. There are relatively young lava flows in the region.

5.7.4 Seismicity and Earthquake Hazards

Deterministic Analysis

The Sohio site is located about 10-15 miles from the Mount Taylor seismic zone. The width of the zone is unknown. We choose a distance of 10 km. The site is the closest site to the RGR zone. This site is approximately 22 km from a 60 km long fault. A smaller potentially active fault is a few kilometers closer, but the M_u for the fault is much less than for the longer fault. The 1-sigma ground motion estimate at the Sohio Site from the M=6.25 earthquake located near Mount Taylor is 0.42 g and the median estimate is .23 g. It is unlikely that all 60 km of the fault east of the site would rupture in a single event. However, since the 1-sigma estimate for PGA from an M=7 event for this fault is 0.34 g it is not necessary to examine that question in detail as the deterministic estimate for PGA at the site is dominated by a M_u 6.25 earthquake located on the Mount Taylor seismic zone.

Hazard Analysis For Random Earthquakes

As discussed in the Section 5.5 on Regional Seismicity the appropriate PGA hazard curves to use for this site are given by Fig. 5.11. We see from Fig. 5.11 that at 10^{-4} PE level the estimate PGA is 0.2g for M_u = 6.25 and 0.11 g at PE level of $5x10^{-4}$. At a PE level of 10^{-4} the PGA varies between 0.17 g to 0.23 g depending upon M_u and 0.09 to 0.12 g at a PE level of $5x10^{-4}$.

5.7.5 Conclusions

Based on the above analysis, our estimate of the appropriate PGA to evaluate the site varies between 0.09 to 0.42 g . We see from the section on Design Criteria that the site was designed at 0.1g. There appears to be potentially a significant problem. Even if it is possible to argue that M_u ~ 6.25 is too large a magnitude to associate with the Mount Taylor seismic zone, the random hazard analysis results in a 0.2 g estimate – which is also significantly larger than the 0.1 g used. Also the estimate of ground motion from a large earthquake located in the RGR is 0.34g.

The critical facilities at this site need to be carefully evaluated to determine if sufficient margins exist or if remedial action is required.

There do not appear to be any faults under the site.

5.8 United Nuclear

Church Rock Mill

5.8.1 Introduction

The Church Rock Uranium Mill is located in the Churchrock Uranium District about 32 km northeast of Gallup in McKinley County (Fig. 5.13). It lies within Pipeline Canyon which is a northeast-southwest trending alluvial valley drained by the Pipeline Arroyo. The tailings disposal area is located primarily on the alluvial valley fill material on the southeast side of the arroyo. The canyon is steep sided with 122 m of relief in the vicinity of the mill site.

5.8.2 Local Geology

The mill is located in the southeastern part of the Colorado Plateau Physiographic Province. The site is located at the juncture of several of the major fold structures within the Plateau: the San Juan Basin, the Zuni Uplift, and the Defiance Uplift. The site lies on the Chaco slope, which forms the northeast edge of the Zuni Uplift, and the southwest rim of the San Juan Basin.

The stratigraphy of the San Juan Basin region is characterized by Mesozoic sediments deposited in and adjacent to the western margin of a transgressing and regressing Late Cretaceous sea. Sedimentary rocks consist primarily of sandstone, shale, siltstone/mudstone and coal. The sandstones were deposited in fluvial, eolian, and nearshore marine environments. During several periods of major transgression, the Mancos Shale (deep marine deposits) extended further westward over the shoreline marked by the sandstones. Shorter cycles of transgression and regression resulted in the layers of siltstone, mudstone, and shale interbedded with the sandstones. The coals (Dilco Coal Member) were deposited in a deltaic environment along the shoreline of the sea.

In the immediate site area, the rocks exposed at the surface include, in ascending order, the Upper D-Cross tongue of the Mancos Shale, the Upper Gallup Sandstone, and the various members of the Crevasse Canyon Formation. Quaternary alluvium covers much of the site area. The dip of bedding is generally to the north so that rocks younger than Crevasse Canyon are exposed to the north of the site and older rocks are exposed to the south of the site.

5.8.3 Tectonics and Faulting

Structural deformation of the plateau consisted of development of a series of uplifts and downwarps and later large-scale, northwest trending folds with associated smaller-scale folding and faulting. The large-scale folds were accentuated by smaller-scale basins and uplifts. In the general vicinity of the site, these basins and uplifts include the San Juan Basin and the Defiance and Zuni Uplifts.

Monoclinal folds are the most distinctive smaller-scale structures, occurring throughout the plateau and commonly forming the boundaries of the larger uplifts and basins. Monoclinal features in the site area include the Nutria and Pinedale Monoclines which occur along the western and northern boundaries of the Zuni Uplift. Other local structural features include the Pipeline Canyon Lineament and the Fort Wingate Lineament.

The Pipeline Canyon Lineament is located along the axis of the Pipeline Canyon trending east-northeast and reportedly passes through the western part of the tailings disposal area. No vertical or horizontal displacement has been measured along the lineament at surface exposures. The Fort Wingate Lineament is located along the eastern edge of the Pipeline Canyon and trends to north-northeast. The trace reportedly passes through the eastern portion of the tailings area to intersect the Pipeline Canyon Lineament in the vicinity of the northern part of the tailings area (Canonie Environmental, 1987).

Large-scale faulting is uncommon in the southeastern portion of the plateau and, therefore, has little control over groundwater flow in the region. However, small-scale joints and fractures, especially those related to the monoclines are prevalent and affect ground water flow. These small scale features have been identified within the site. An orthogonal fracture pattern striking north-northeast and west-northwest is also common in the plateau. This pattern is attributed to very rapid deposition with concurrent dewatering of the sediments during Cretaceous and Tertiary times. The orthogonal fracture pattern is also evident in the sandstone outcrops throughout the site (Canonie Environmental, 1987).

5.8.4 Seismicity and Earthquake Hazards

Deterministic Analysis

Random Earthquake Analysis

The appropriate PGA hazard curves used for this site are given in Fig. 5.12. This site is not near any significant structure hence $M_u = 5.75$ seems appropriate to use for M_u. We see from Figure 5.12 that at the 10^{-4} PE level the mean estimate for the PGA is 0.16 g and at a PE level of $5x10^{-4}$ it is 0.07 g. Depending upon the value M_u at a PE level of 10^{-4} the PGA varies between 0.14 g to 0.22 g and 0.06 g to 0.1 g at a PE level of $5x10^{-4}$.

5.8.5 Conclusions

Our estimate for the appropriate PGA value to evaluate this site is in the range of 0.06 to 0.22 g. We see from Section 4.1.5 that the site was designed to a PGA of 0.05 g This needs to be evaluated to see if adequate margins exist. Two fracture zones pass through the tailings pile. This is a source of possible concern for differential settlement across this zone. This should be evaluated.

6.0 SOUTH DAKOTA

Tennessee Valley Authority
Edgemont Mill

6.1 Introduction

The Edgemont Uranium Mill is the only site of concern in South Dakota. The mill is located in southeastern South Dakota, is operated by the Tennessee Valley Authority, and lies immediately east of the City of Edgemont in Fall River County. See Figure 6.1.

6.2 Regional Geology

Many of the geologic structures in the Edgemont mill area are related to the Black Hills Uplift and reflect regional structures associated with this uplift. See Figure 6.2 taken from Golder Associates (1985).

During the late Paleozoic, vast inland seas inundated the area and deposited marine sediments across a broad dome formed by the underlying Precambrian rocks. Subsequently, during the early Mesozoic Era, the inland seas receded and the area was exposed. During this period, terrestrial deposition of sediments, predominantly sandstone and shale, carried in from the west resulted in the development of a broad penoplane which dipped gently to the east. During the Cretaceous Period, inland seas again invaded the area and resulted in deposition of a thick sequence of marine shale, minor limestone, and sandstone.

Montmorillonite shales were probably derived from tuffaceous and detrital sources and were laid down in fairly uniform, near horizontal beds. This depositional sequence was apparently interrupted by several major volcanic ash-fall events which resulted in the thin but a really extensive bentonite beds. The largely bioclastic limestone layers which occur within the shales also exhibit evidence of imported volcanic debris (Golder Associates, 1985).

During the late Cretaceous, a major uplift of the underlying Precambrian rocks (the Black Hills Uplift) occurred along the alignment of the pre-existing basement dome. This uplift caused folding and spreading of the overlying sediments and resulted in a broad structural dome approximately 193 km long and 97 km wide. The uplift occurred as two blocks. The eastern block underlies nearly all of the Black Hills in South Dakota and is separated from the western block along the Wyoming-South Dakota border by a monocline. The western block moved upward less than the eastern block, causing the Black Hills dome to be somewhat asymmetrical, gently inclined on most of the western margin and steeply inclined on the east. Subsequent to the period of major uplift, minor tectonism continued and several Tertiary igneous bodies were intruded along pre-existing weakness trends. Subsequent erosion of the Cretaceous and Tertiary deposits and deposition of Quaternary and recent sediments resulted in the present topography of the region.

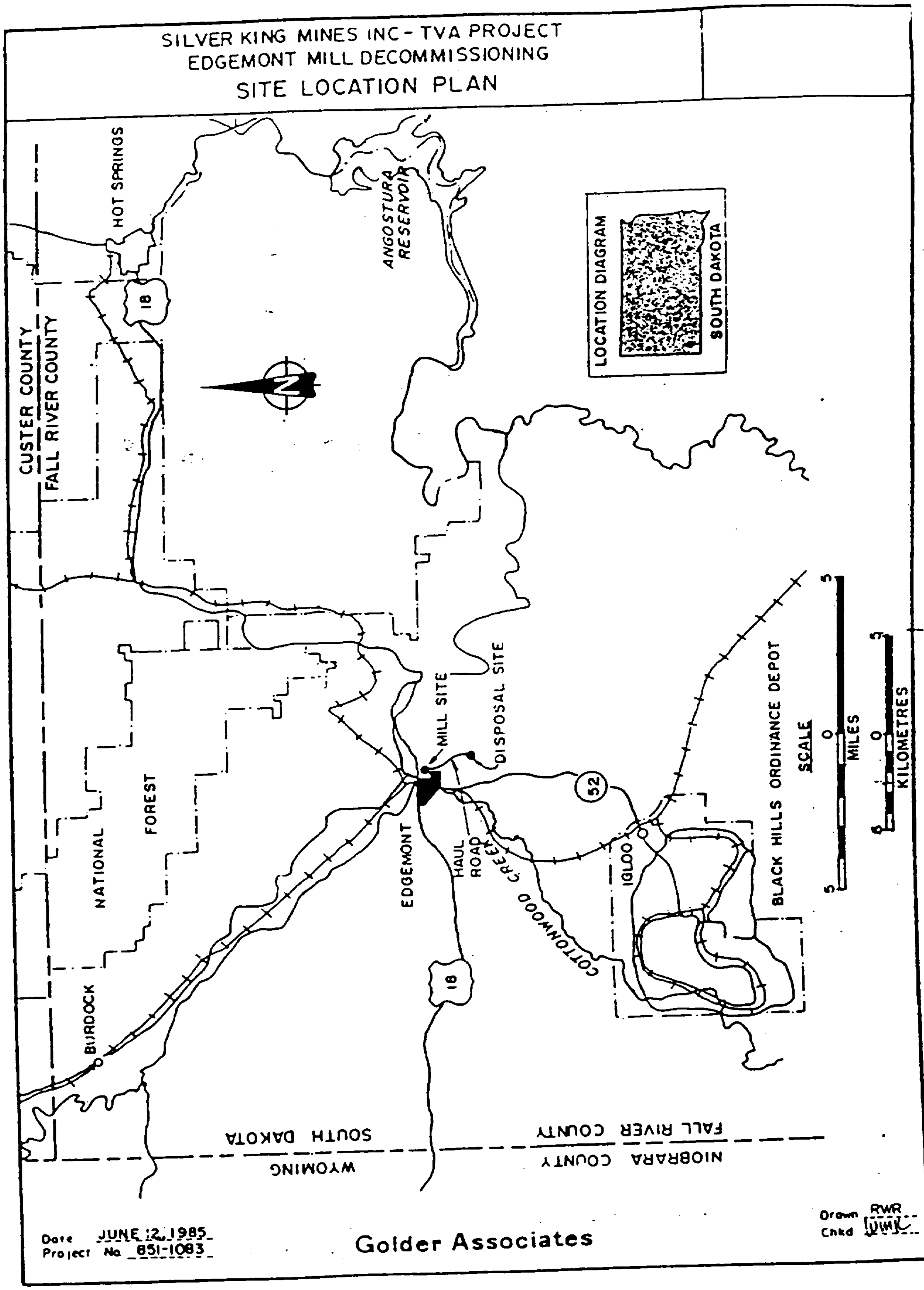


Figure 6.1 Location of the Edgemont Mill in South Dakota.

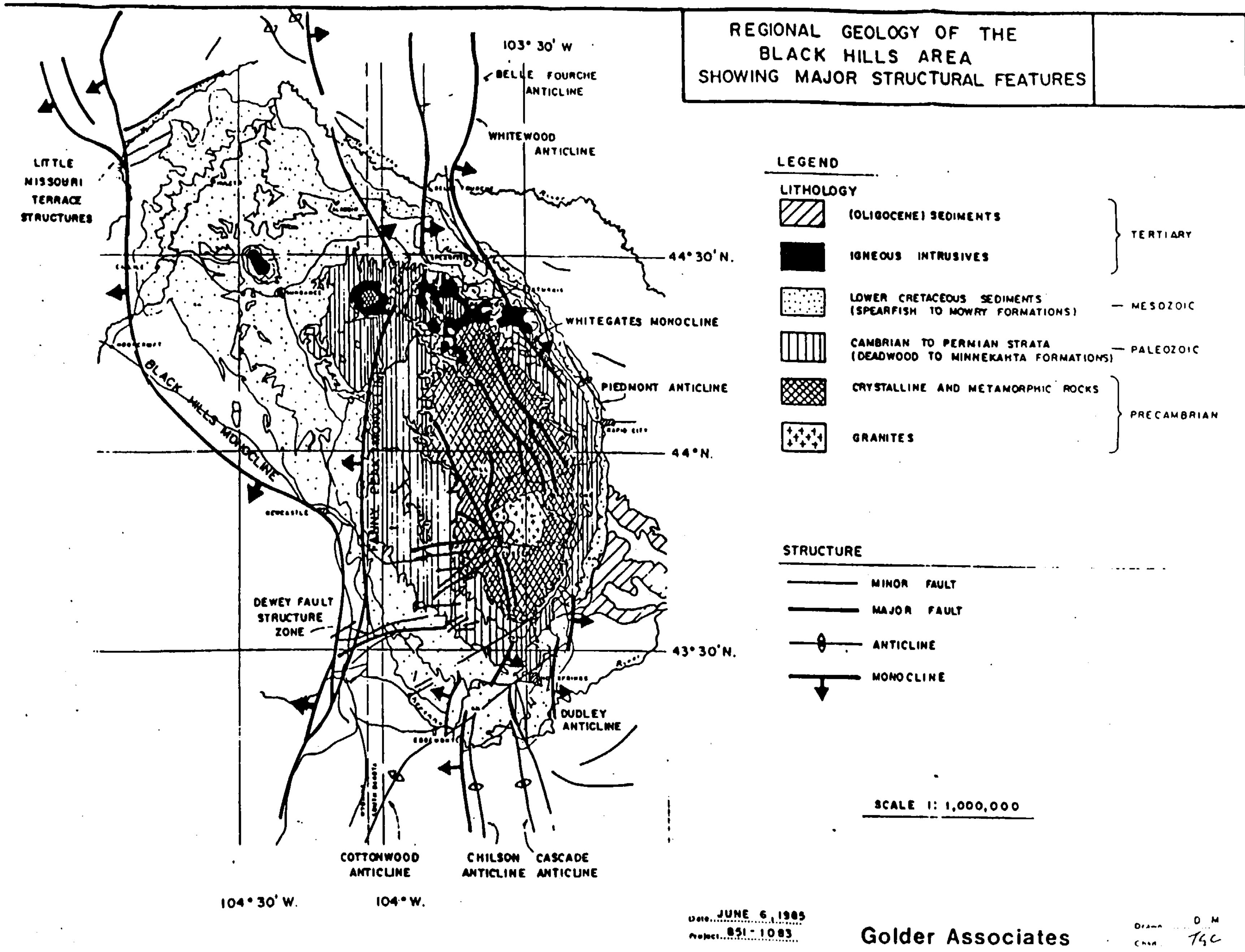


Figure 6.2 Regional Geology of the region around the Edgemont Mill Site.

6.3 Local Geology

The Edgemont Uranium Mill lies immediately south and east of the topographic saddle which forms the head of an ephemeral drainage system within the Cheyenne River Basin. Ground surface across the site varies between about elevations 1100 m - 1120 m.

Unconsolidated overburden deposits at the disposal site generally consist of Quaternary windblown materials and silty clay alluvium overlain by topsoil. The site is underlain at variable depth by shale bedrock of the Lower Greenhorn Formation. The shale outcrops in several local areas within the disposal site area, but is most prominently exposed along the east side of a steep bluff approximately 213-305 m northeast of the impoundment area.

The lower unit of the Greenhorn Formation consists of shales composed of carbonaceous clay and quartz silts, with occasional limestone beds from 15-30 cm thick, and bentonite beds of variable thickness. A 15-30 cm thick limestone bed occurs at the base of the Greenhorn Formation, and is traceable over most of the Edgemont area.

The results of a deep geological drill hole indicates that the bedrock underlying the site consists sequentially of the lower unit of the Greenhorn Formation (extending to elevation 1082 m), Belle Fourche Shale (elevation 1082 to 1026 m), Mowry Shale (elevation 1026 to 982 m), Newcastle Sandstone (elevation 982 to 980 m), and Skull Creek Shale (elevation 980 to 914 m). Below these, the Fall River Formation and the Dakota Formation extend to depths greater than 305 m. Thus, the site is underlain by shales to approximately elevation 981 m or to a depth of about 122 m below the bottom of the present drainage course (MacLaren Engineers, 1983).

6.4 Tectonics and Faulting

The overall bedrock structure in the general area of the disposal site consists of a series of gently warped steps which have been downthrown progressively from northeast to southwest. Several small displacement faults and faults attributable to landslide movements exist near the Edgemont mill. The closest mapped fault lies about .8 km northwest of the disposal site, and consists of an inactive normal fault of small displacement which offsets the basal limestone of the Greenhorn Formation (MacLaren Engineers, 1983).

Drilling and geological mapping performed by Golder Associates in 1985 indicates the existence of a normal fault pattern within the disposal basin which results in a combined total offset of about 23 m from the northeast to the southwest. The majority of these faults are either indistinguishable or are manifested as only a hairline feature on the basin walls, and in these cases the observed offset of certain marker beds within the basin comprise the only visual evidence of faulting. Other fault traces range up to only a width of < 1 cm and are fully healed with a clayey gouge. The observed fault pattern is consistent with similar patterns associated with the Late Cretaceous Black Hills Uplift, and site data does not indicate any offset in the later deposited Quaternary sands above the bedrock (Tennessee Valley Authority, 1985).

During the immediate post-Cretaceous Laramide Orogeny events associated with the Black Hills uplift, some minor, normal faulting of the relatively young, plastic sediments occurred. Four general lineation trends within the disposal basin have been identified through aerial photograph interpretation, and are generally correlatable with regional fault trends:

- A southwest-northeast trending set of lineations which control the topography of the basin area. An essentially southwest-northeast trending set of faults which approximately parallel the regional Precambrian fault trends.
- A northwest-southeast trending set of lineations which parallel several of the drainage courses in the area. A generally northwest-southeast trending set of faults which

parallel some of the minor faulting evident in the Custer area and within the Dewey and Long Mountain structural zones.

- A north-south trending set of lineations which correspond to the overall topographic grain of the fold axes in the southern part of the Black Hills region. A north-south trending set of faults which parallel the major fold axes of the anticlines and monoclines marking the uplifted margins of the easternmost block of Precambrian basement rocks.
- An east-west trending set of lineations which reflect the principal joint direction identified in the hills to the west of the basin. An approximately east-west trending set of faults which are most likely associated with northerly warping of the regional fold axes (1985 Golder Associates).

Based on juxtaposition of faults and offsets of marker horizons, it is considered that the north-south faults which parallel the regional monocline trends of the Black Hills represent features associated with the previously mentioned folding and subsequent slumping of the then relatively young, plastic sedimentary rocks of the basin area. The east-west faults also appear to be associated with the folding and represent normal, southern downthrown features which resulted from tectonic readjustments to the regional warping of the bedding (Golder Associates, 1985).

The southwest-northeast and the northwest-southeast trending faults are probably more-or-less contemporaneous with the previously discussed features although they may slightly post-date the north-south and east-west fault trends. Most of these faults are also "normal" faults and typically are downthrown to the southeast and southwest respectively (Golder Associates, 1985).

5.5 Seismicity and Earthquake Hazards

South Dakota is a region of relatively low seismic activity, and there are no known Quaternary faults. The earthquakes that occur are diffuse and do not correlate with know structures.

Deterministic Analysis

There are only minor faults in the vicinity of the site. These faults are all old and there is no indication that any one of them would be likely to be the causative fault for an earthquake near the site. Thus it is our judgment that the random earthquake hazard analysis is the appropriate way to establish ground motion estimates at this site.

Random Earthquake Analysis

Bernreuter et al. (1989) and its update in 1993, Savy et al. (1993) provide a seismic characterization of the Unites States East of the Rocky Mountains. The purpose of the studies was to provide NRC with estimates of the seismic hazard of all nuclear power plants (NPP) east of the Rocky Mountains. The Edgemont Mill Falls within the far western part of the range of interest of the NRC study. However, the site is located far from any of the NPP considered in the NRC study. The seismicity experts involved in these studies did not carefully examine the seismic zonation in the vicinity of the Edgemont site because the region around the site is a region of low seismic activity. In addition, there is no major tectonic structure to generate large earthquakes that could affect the sites involved in the NRC studies.

For this reason we did not use the NRC study as the basis for developing the hazard for the Edgemont site. Instead we examined the pattern of seismic activity around the site and noted that it was higher than the large zones used in the NRC study.

The source zone we used in the site includes the Black Hills. The Black Hills are different geologically from the rest of the zone. However, there is not enough seismic activity which could be associated with Black Hills to develop recurrence model for such a zone. Given that the tectonics of the Black Hills is very old, it is not known what relation the tectonic structure of the Black Hills has with current tectonic forces and hence it is not clear that it should be considered a separate zone. We note that in a seismic hazard analysis zones are differentiated because one will have compared to the other either a higher rate of activity and/or larger maximum magnitude. There is no reason to assign a higher rate or a larger M_u to a Black Hills zone than the source zone we used.

The source zone we used for the Edgemont site is adjacent to the large source zone referred to on the Wyoming Foreland Structural Province in Section 8 of this report. There is no definitive structural boundary defining the Wyoming Foreland Province and the zone we used for the Edgemont site was based only on seismicity. We examined the pattern of seismicity for both the area around the Wyoming sites and the Edgemont site and in our judgment the Edgemont site should not be considered to be part of the Wyoming Foreland Province.

For this site we used a combination of the database we obtained from Glenn Reagor and the database developed a part of the NRC study which covers the historical record up to 1984. The USGS database covers the time frame between 1984 and 1993. For this site after-shocks have been removed.

We applied Stepp's method described in Section 3.4.2 to determine the completeness intervals. The analysis suggested that in the magnitude 3.5 - 4 range the data was relatively complete over the last 60 years. Figure 6.3 shows our fit to the data to the last 60 years given by:

$$\log N = 4.354 - 0.9M.$$

In the range of completeness there is good agreement between our recurrence model and the data.

Figure 6.4 gives the mean estimate PGA hazard for the Edgemont site for a range of M_u between 5.5 to 7. On the average, the seismicity experts in the NRC study Bernreuter et al. (1989) selected $M_u = 6$ for the large region including the site. Given the historical data, a value of M_u between 5.5 to 6.25 is reasonable. We see from Figure 6.4 that at a PE level of 10^{-4} there is a very little difference between choosing $M_u = 5.75$ or 6.0. Hence a value of PGA of 0.12g. The range of PGA at a PE level of 10^{-4} is 0.095g to 0.14g. At a PE level of 5x10-4 the range of PGA is 0.04g to 0.06g.

6.6 Conclusions

Our estimate for the appropriate PGA level to evaluate this site at a PE level of 10^{-4} is 0.12 g based on the random earthquake analysis. The estimated PGA used in design was 0.05 g. However, as noted in the section on Design Criteria, the containment dam had sufficient margins to withstand a 0.2 g earthquake.

If there are other facilities which pose a risk then they need to be evaluated to determine if they also have sufficient margins.

No faults appear to pose a hazard at this site.

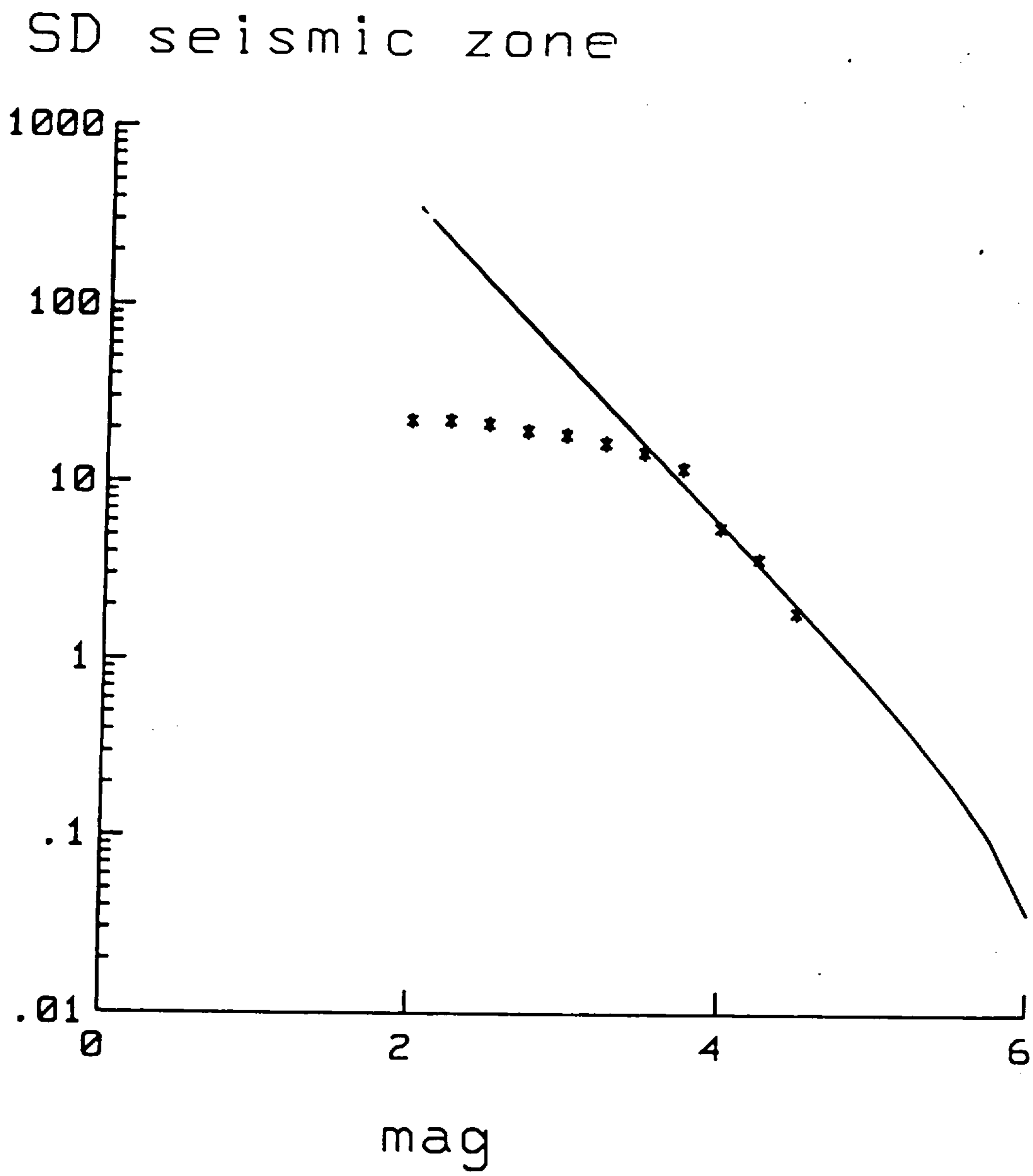


Figure 6.3 Comparison of recurrence model used for the Edgemont site to the data for the last 60 years.

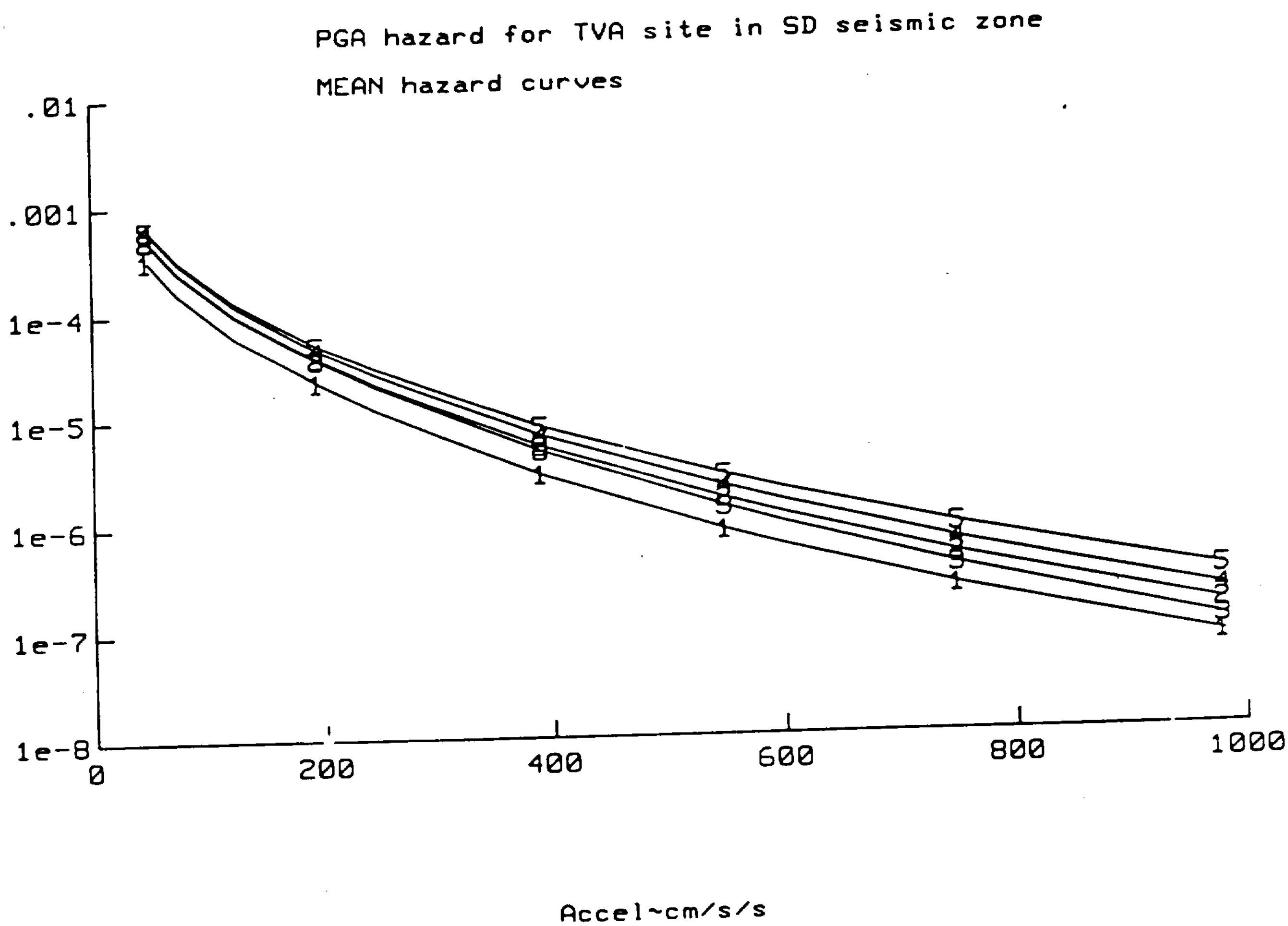


Figure 6.4 Mean PGA hazard curves for the Edgemont site for various M_u. 1—1 $M_u = 5.5$, 2—2, $M_u = 5.75$, 3—3 $M_u = 6$, 4—4 $M_u = 6.25$ 5—5 $M_u = 7$.

7.0 UTAH

7.1 Introduction

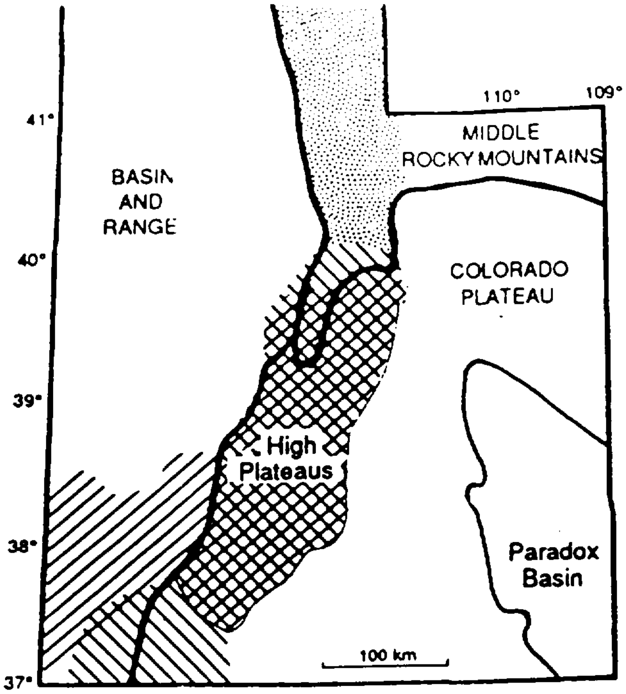
The Atlas Corporation Uranium Mill Tailings site, the Rio Algom Mining Company Lisbon Uranium Mill Tailings site, and the Umetco White Mesa Uranium Mill Tailings site are all located in the Paradox Basin. The Plateau Resources Shootering Canyon Uranium Mill Tailings site is located southwest of the Paradox Basin in the Henry Mountains Basin.

7.2 Regional Geology

Utah is subdivided into three major physiographic and tectonic provinces: the Basin and Range, Middle Rocky Mountains, and Colorado Plateau. The boundary between the Basin and Range and the other two provinces is a zone of transitional physio-tectonic characteristics (Fig. 7.1A).

Western Utah lies within the northern Basin and Range Province. The province is noted for its regularly spaced (20 to 50-kilometers apart), north-trending, elongate mountain ranges and intervening broad, sediment-filled basins. The ranges are bounded on one or, less commonly, both sides by major normal faults that have moderate to steep dips at the surface. Much of the region, known also as the Great Basin, is internally drained. The northeast corner of Utah lies within the Middle Rocky Mountains Province, a region of mountainous terrain, stream valleys, and alleviated structural basins. Principal geographic features of the Middle Rocky Mountains in Utah are the geologically dissimilar north-trending Wasatch Range and east-trending Uinta Mountains. The northern Colorado Plateau of southeastern Utah is distinguished by its relatively high, generally flat topography and deeply incised canyons. Bedrock of the Plateau is spectacularly exposed, whereas surficial deposits characteristically are thin, localized, or absent (Hecker, 1993).

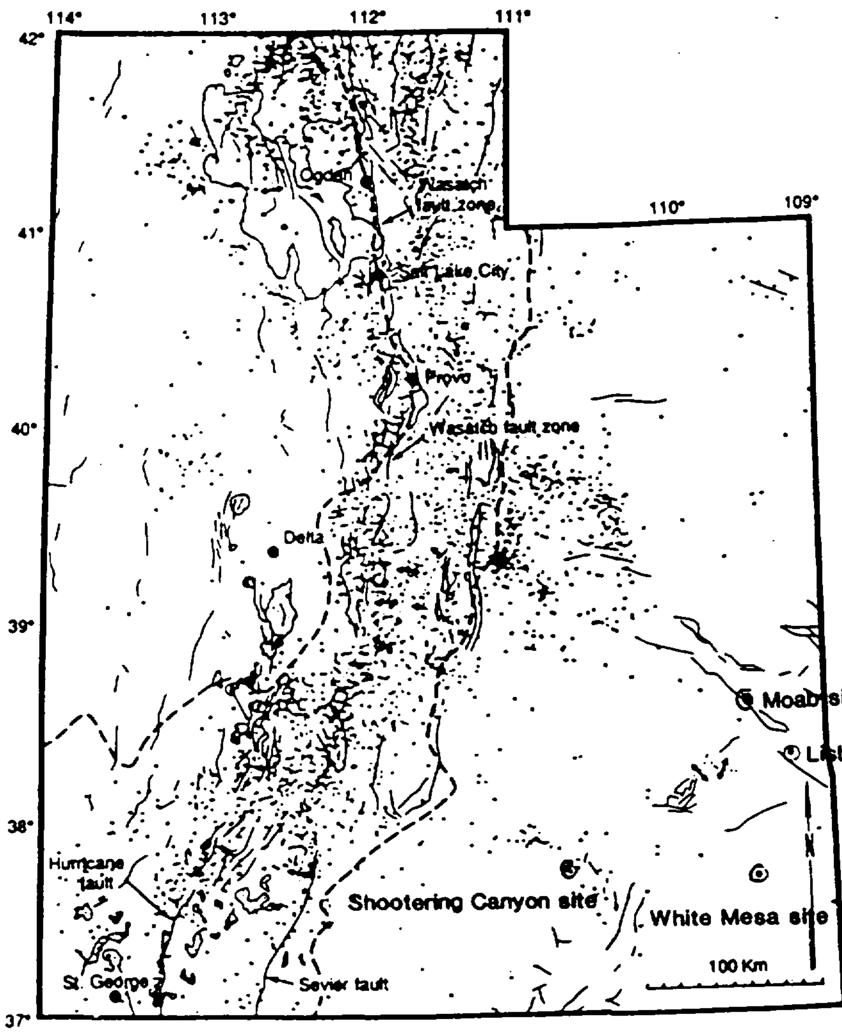
The distinctive physiography of the Basin and Range Province is the product of roughly east-west horizontal extension during the late Cenozoic (Zoback and Zoback, 1989). This latest landscape-shaping period of tectonic deformation is part of an ill-defined, extensively debated history of middle and late Cenozoic crustal rifting. One view maintains that extensional faulting has had a distinct two-part history: block-faulting on widely spaced, mainly high-angle normal faults, which is responsible for the existing topography and continues to the present; and an earlier phase (post -30 million years; pre-10 to -15 million years) of intense deformation associated with closely spaced low-angle faults (Zoback and others, 1981; Eaton, 1982). A quite different perspective is that low- and high-angle faults have formed concurrently as part of the process of extension on large-displacement, low-angle shear zones which penetrate deep into the lithosphere (Wernicke, 1981). With time, both faulting and predominately basaltic volcanism have tended to become concentrated in relatively narrow zones along the margins of the province (Christiansen and McKee, 1978).



A.

Figure U-1 (A) *Major physiographic boundaries in Utah (bold lines) with respect to the transition zone between the Basin and Range Province and (1) the Middle Rocky Mountains Province (stippled area) and (2) Colorado Plateau Province (hachured areas). Alternative interpretations of the Basin and Range - Colorado Plateau transition zone are indicated by hachure patterns (northeast-trending, after Stokes, 1977; northwest-trending, after Anderson and Barnhard, 1992). Area of overlap (cross-hachure pattern pattern) coincides with the High Plateaus region. The Paradox Basin is a major region of the Colorado Plateau. (B) Quaternary tectonic features (simplified from plates 1 and 2) and seismicity (1962-1989; magnitude > 2) of Utah with respect to the Basin and Range - Colorado Plateau - Middle Rocky Mountains transition zone (area between dashed lines). Seismicity from the University of Utah Seismograph Stations catalog (Susan J. Nava, written communication, 1990)*

(from Hecker, 1993)



B.

Figure 7.1a. Major physiographic boundaries in Utah; 7.1b. Major quaternary features in Utah

Block faulting, which is the hallmark of the Basin and Range Province, extends tens of kilometers into the Middle Rocky Mountains and Colorado Plateau Provinces, forming a 100 km-wide zone of transitional tectonics and physiography (Fig. 7.1A). This north-trending boundary zone coincides with the southern portion of the Intermountain seismic belt, a broad zone of diffusely distributed earthquake epicenters (Fig. 7.1B), and it is associated with geophysical characteristics that are consistent with active extension (Smith and others, 1989). Much of the transition zone lies beyond the regime of strongest basin-range deformation and, as a result, extensional structures overprint relatively intact compressional features formed during the Sevier orogeny. The structural fabric of the zone is largely a relict of eastward-directed, thin-skinned thrust sheets, portions of which appear to have accommodated movement in the reverse direction during basin-range extension (Hecker, 1993).

The physiographic boundary between the Basin and Range and Middle Rocky Mountains Provinces in Utah is considered to be the Wasatch Front, the prominent west-facing escarpment that follows the 340 km long Wasatch fault zone (Fig. 7.1B). East of the transition zone, the Colorado Plateau is a relatively coherent and tectonically stable block which has experienced 2 km of epeirogenic uplift during the Cenozoic (Morgan and Swanberg, 1985). The region is underlain by generally horizontal sedimentary strata, disrupted locally by early Tertiary Laramide basement-block uplifts and Oligocene igneous intrusions. The domal, fault-bounded uplifts have variable trends and include the east-trending Uinta Mountains north of the Colorado Plateau. The modern stress field of the Plateau interior was originally thought to be compressive (Thompson and Zoback, 1979; Zoback and Zoback, 1980). However, recent evidence from small-magnitude earthquakes indicates that, although differential stresses are apparently low and variable in magnitude, most of the region may be characterized by horizontal northeast-oriented extension occurring on a combination of normal and strike-slip faults (Wong and Humphrey, 1989; Zoback and Zoback, 1989). Outside of the Paradox Basin, the interior of the Colorado Plateau in Utah appears to be virtually unaffected by recent crustal deformation. Only a few areas have evidence, generally subtle or ambiguous, of minor amounts of possible Quaternary faulting (Hecker, 1993).

A zone of late Paleozoic and younger deformation within the Paradox Basin, a late Paleozoic depositional trough interior to the Colorado Plateau (Fig. 7.1A), is related to the mobility and solubility of evaporites. Major structures of the Paradox Basin include large salt anticlines and faults related both to late Cenozoic dissolutional collapse along the crests of the anticlines and to older, deep-seated tectonics. The structural grain of this subprovince has a northwest orientation, distinct from the western margin of the Colorado Plateau, where most faults trend north to northeast (Hecker, 1993).

7.3 Geology and Structure of the Paradox Basin

The Paradox Basin is characterized by several large anticlinal structures which are the result of regional folding and salt intrusion (Fig. 7.2). The origin of the folds and faults in the Paradox belt is considered to be related to stresses associated with Laramide tectonics and plastic deformation, flowage, and solution of relatively shallow salt deposits of Pennsylvanian age. Tertiary laccolithic intrusions in the La Sal Mountains have caused local radial uplift of pre-Tertiary rocks.

The dominant features are the diapiric salt anticlines. Many closely spaced faults parallel these diapiric structures. The rocks are tilted from gentle to vertical angles and strike mostly parallel to the major structures. Most of these faults have small displacement, but a few, such as the Moab fault, have large displacements (up to 790 m). Between the diapiric salt, the structure is relatively simple; the rocks are gently warped into synclines and are in some places cut by short faults of small displacement (Doelling, Oviatt, and Huntoon, 1988).

The most important faults in the region are the series of northwest-trending faults or flexures (Fig. U-3) that lowered surfaces to form the Paradox Basin (Szabo and Wengerd, 1975). These are presently buried by post-Pennsylvanian sedimentary rocks. They were intermittently active from

Mississippian to Triassic time and were probably reactivated in Tertiary time. In addition, northeast-trending lineaments were simultaneously developed across the region related to basement wrench-faulting (Hite, 1975). Most of the northwest-trending sub-salt faults have their downthrown blocks to the northeast (at least those with the greatest displacements), so that the deeper part of the Paradox Basin is on the northeast side. Seismic data suggest that they die out upward in the Paradox salt beds and most investigators show these faults as high angle normal faults (Doelling, Oviatt, and Huntoon, 1988).

During Tertiary time, lengthy faults with relatively large displacements were formed. McKnight (1940) thought that this faulting was the result of tensional stress that developed after regional compressional stress had gently folded the rocks. The tensional stress was the result of a relaxation at the end of a compressional tectonic phase and was undoubtedly relieved along the old buried "basement" faults. The tectonic fault ruptures were influenced by the salt; some rupturing proceeded directly through the thick salt bodies and other fractures were deflected to the margins. These Tertiary faults can be differentiated from the salt tectonic or dissolution faults by their greater displacement. Faulting induced solely by salt is principally due to collapse of strata above areas where the salt has been dissolved away. Tectonically induced stress that developed in the strata above the salt was relieved by faulting which mostly developed along the flanks of the thick salt accumulations (where the rocks would be weaker). These faults are presently intercalated with others created by salt dissolution.

The most prominent of the Tertiary tectonic faults is the Moab fault. It extends N45W from the Colorado River (southwest side of Moab Valley) for about 67 km, forming several curving branches to the northwest (Fig. 7.4). Dipping from 50 to 75 degrees to the northeast, it reaches a maximum displacement of about 790 m between the Arches National Park Visitor Center and Sevenmile Canyon. Like the Lisbon Valley fault zone to the south, the Moab fault is probably related to salt dissolution, but may have a tectonic component. Studies (Jones, 1959, Shoemaker and others, 1958) indicate that the Moab fault may extend below the salt, offsetting pre-Paradox Formation strata. An unusual saddle and gradient anomalies in Bull Lake age terrace remnants may reflect faulting. Furthermore, several small (10 cm) displacements were observed in the middle to late Pleistocene deposits. Fine-grained late Pleistocene to early Holocene sediments deposited along Bartlett Wash near the northern end of the Moab fault may indicate displacement-related ponding. If so, the sense of movement is opposite to that during the Mesozoic (Hecker, 1993). The age of most recent movement is Late Quaternary.

A series of northwest-trending faults cuts the steep southwest flank of the Moab anticline, north of Moab Valley (Fig. 7.9). These are probably adjustment faults that relieved stresses related to folding of the involved brittle sandstone units. The cross sectional exposure of Glen Canyon Group rocks at the south end of the Moab anticline shows the dips of these faults to range from 35 degrees to vertical, usually to the northeast, and down-dropped on the northeast toward the anticlinal axis. Part of the faulting may be due to local salt dissolution and such faults are mostly found adjacent to the Moab fault (Doelling, Oviatt, and Huntoon, 1988).

A regional compressional tectonic event folded rocks in the region in early to mid-Tertiary time, forming synclines between the salt anticlines and accentuating the diapiric salt anticlines. The Kings Bottom syncline trends N 55-60° W between Moab Valley (Moab anticline) and the Cane Creek anticline. The axis of the Cane Creek anticline is present to the southeast. Most of the faults in the synclines between the salt anticlines are short in length and have small normal displacements. In most cases it is impossible to ascertain if they are adjustments over salt or if they were formed during McKnight's (1940) Tertiary tensional episode.

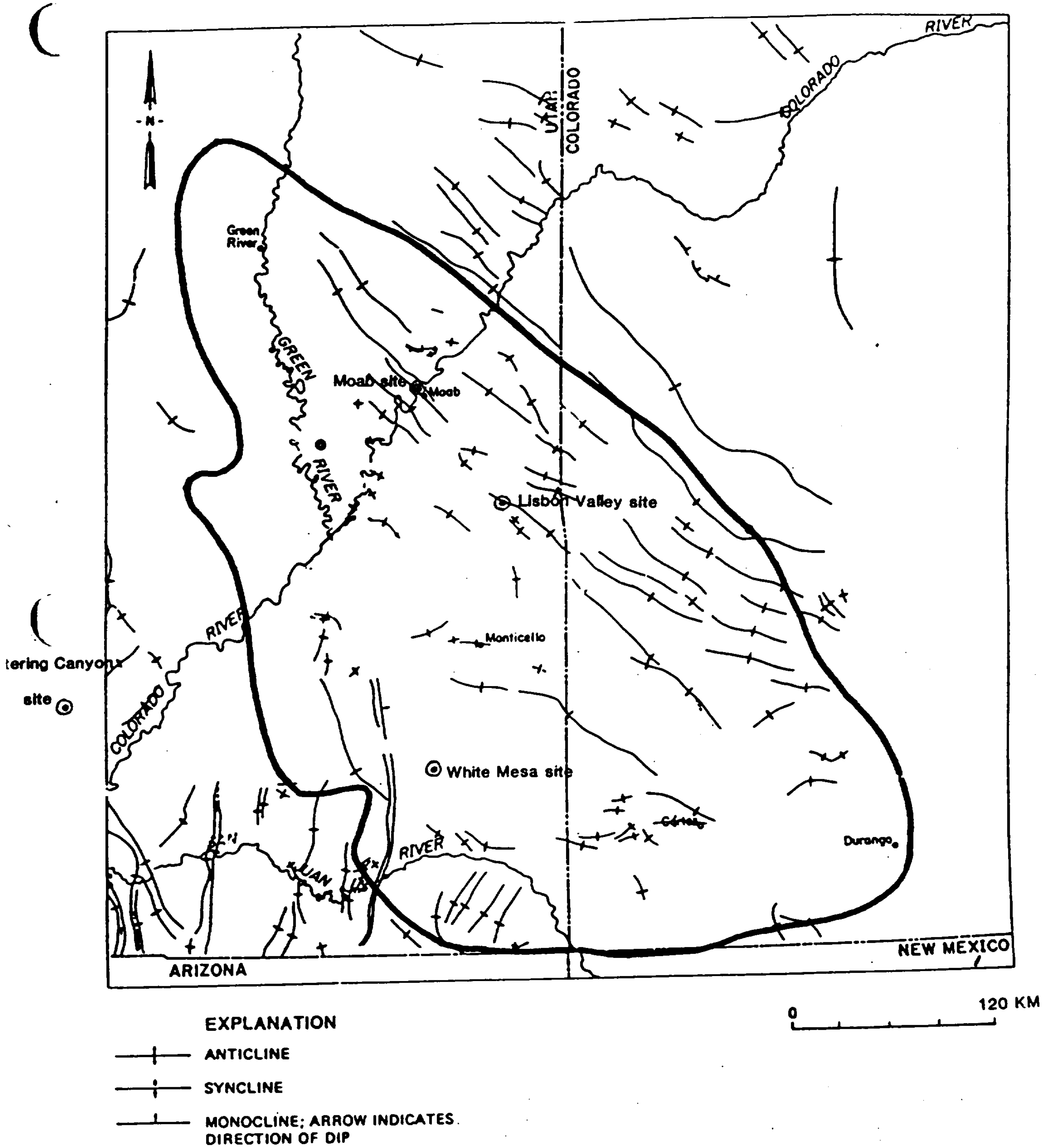


Figure 7.2 Folded structures of the Paradox Basin (from Kitcho, 1981).

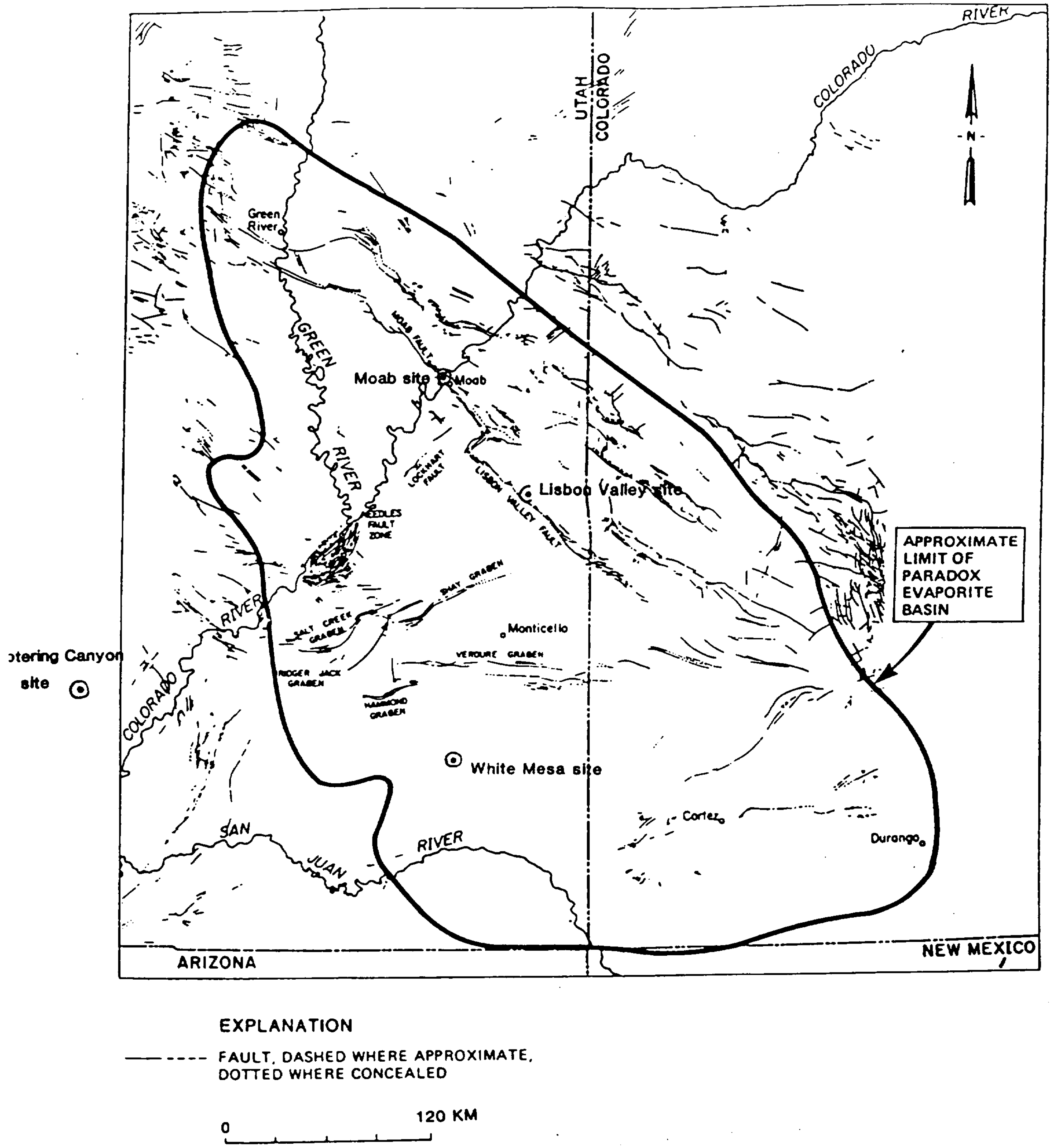


Figure 7.3 Faults of the Paradox Basin (from Kitcho, 1981).

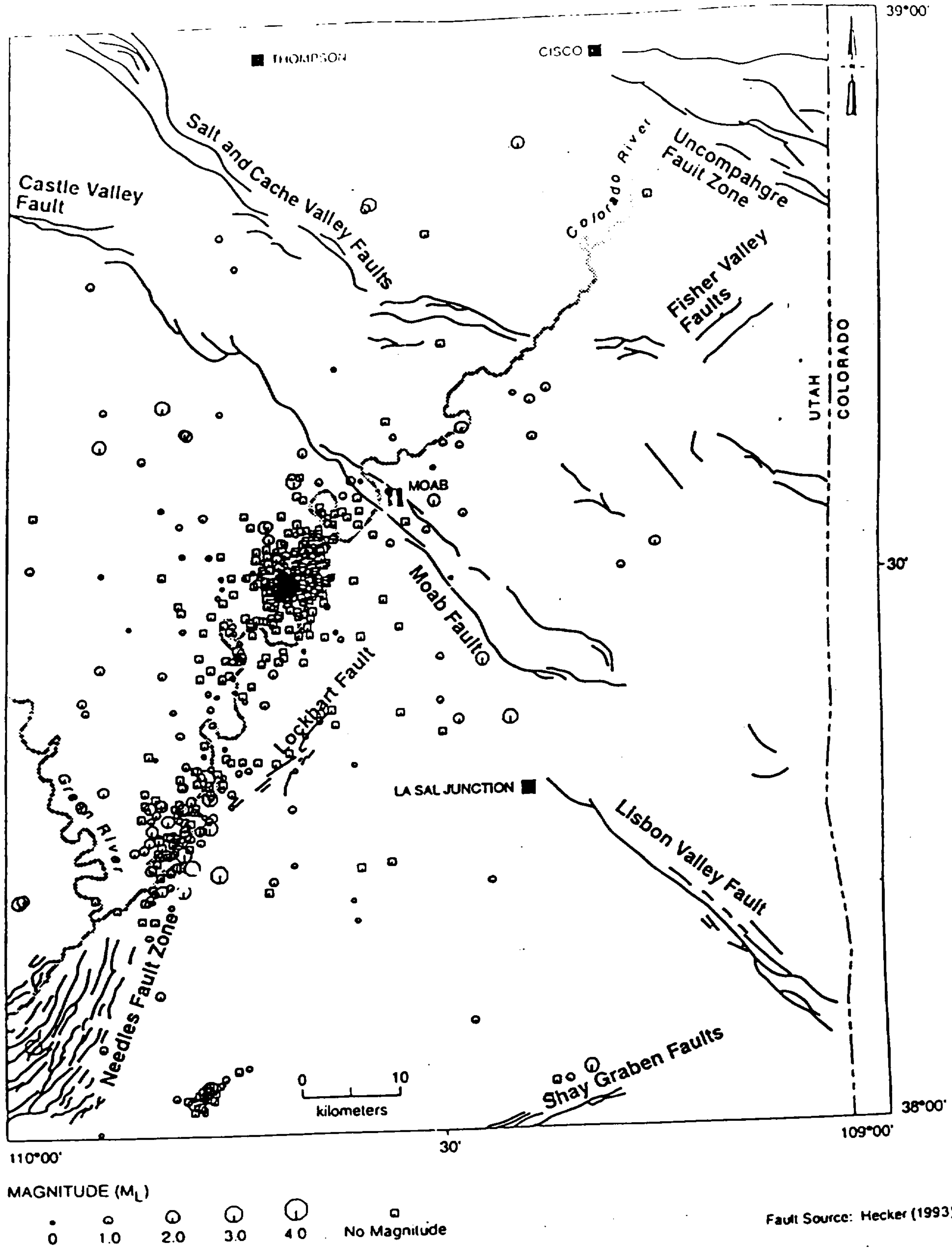


Figure 7.4 Seismicity, 1979-1993, and Late Quaternary faults of the northern Paradox Basin (from Woodward-Clyde Federal Services).

The Moab anticline, as opposed to the larger Moab salt anticline, clearly indicates participation in the compressional event. It trends N 45-50° W and extends from just north of the Colorado River for 9.6 km to about a 800 m north of Sevenmile Wash. Closely spaced paralleling faults have developed, especially along its southwest flank, on which only minor displacements have occurred. They represent minor movement on fractures initially formed as joints.

Prominent joints have formed as a result of the folding and are most pronounced in the brittle sandstone units A little movement has occurred on some, such as over the Moab anticline. These parallel the northwest trends of the folding and do not bend with the salt anticlines where they deviate from this trend(Doelling, Oviatt, and Huntoon, 1988).

7.4 Relationship of Earthquakes to Tectonic Structures

The majority of recorded earthquakes in Utah have occurred along an active belt of seismicity that extends from the Gulf of California, through western Arizona, central Utah, and northward into western British Columbia. The seismic belt is possibly a branch of the active rift system associated with the landward extension of the East Pacific Rise (Cook and Smith, 1967). This belt is the Intermountain seismic belt shown in Fig. 7.5 (Smith, 1978). It is significant to note that the seismic belt forms the boundary zone between the Basin and Range Great Basin Provinces and the Colorado Plateau - Middle Rocky Mountain Provinces. This block-faulted zone is about 75 to 100 km wide and forms a tectonic transition zone between the relatively simple structures of the Colorado Plateau and the complex fault-controlled structures of the Basin and Range Province (Cook and Smith, 1967).

Case and Joesting (1972) have called attention to the fact that regional seismicity of the Colorado Plateau includes a component added by basement faulting. They inferred a basement fault trending northeast along the axis of the Colorado River through Canyonlands. This basement faulting may be part of the much larger structure that Hite (1975) examined and Warner (1978) named the Colorado lineament (Fig. 7.6). This 2100 km long lineament that extends from northern Arizona to Minnesota is suggested to be a Precambrian wrench-Fault System formed some 2.0 to 1.7 billion years before present. While it has been suggested that the Colorado lineament is a source zone for larger earthquakes (m = 4 to 6) in the west-central United States, the observed spatial relationship between epicenters and the trace of the lineament does not prove a causal relation (Brill and Nuttli, 1983). In terms of contemporary seismicity, the lineament does not act as a uniform earthquake generator. Only specific portions of the proposed structure can presently be considered seismic source zones and each segment exhibits seismicity of distinctive activity and character (Wong, 1981). This is a reflection of the different orientations and magnitudes of the stress fields along the lineament. The interior of the Colorado Plateau forms a tectonic stress province, as defined by Zoback and Zoback (1980), that is characterized by generally east-west tectonic compression. Only where extensional stresses from the Basin and Range province of the Rio Grande rift extend into the Colorado Plateau would the Colorado lineament in the local area be suspected of having the capability of generating a large magnitude earthquake (Wong, 1984).

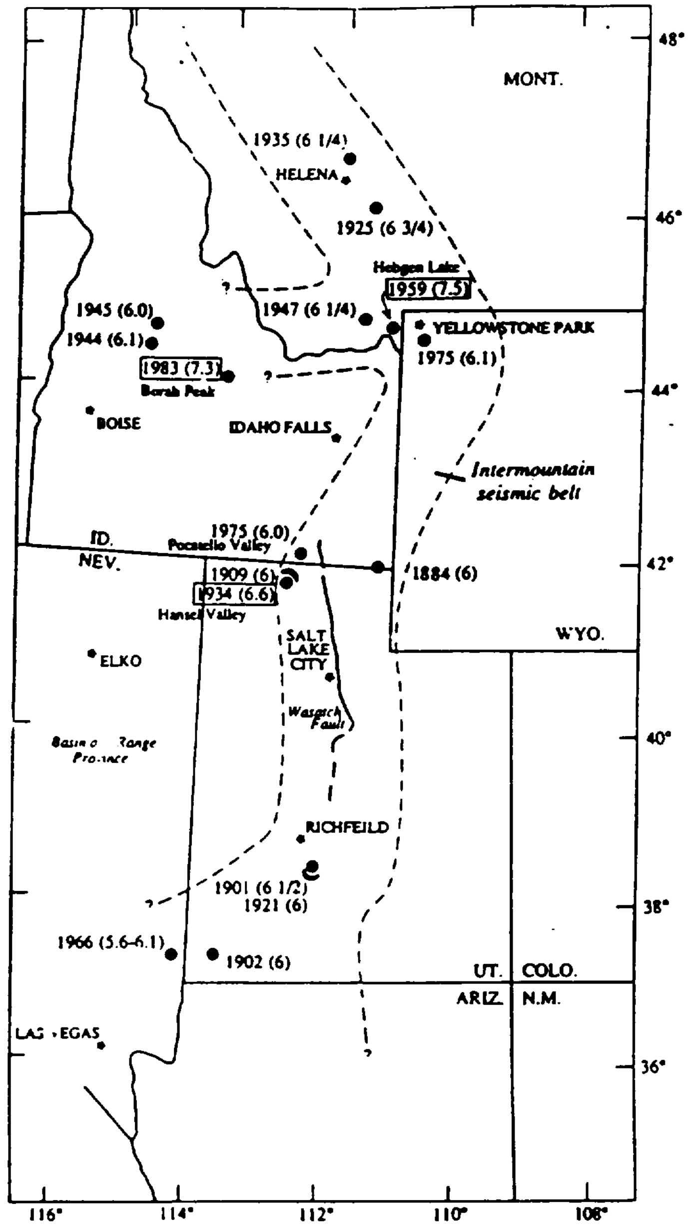


Figure 7.5 Index map of the intermountain seismic belt and historical earthquakes of magnitude 6.0 and greater (solid circles) (from Arabasz and other, 1991).

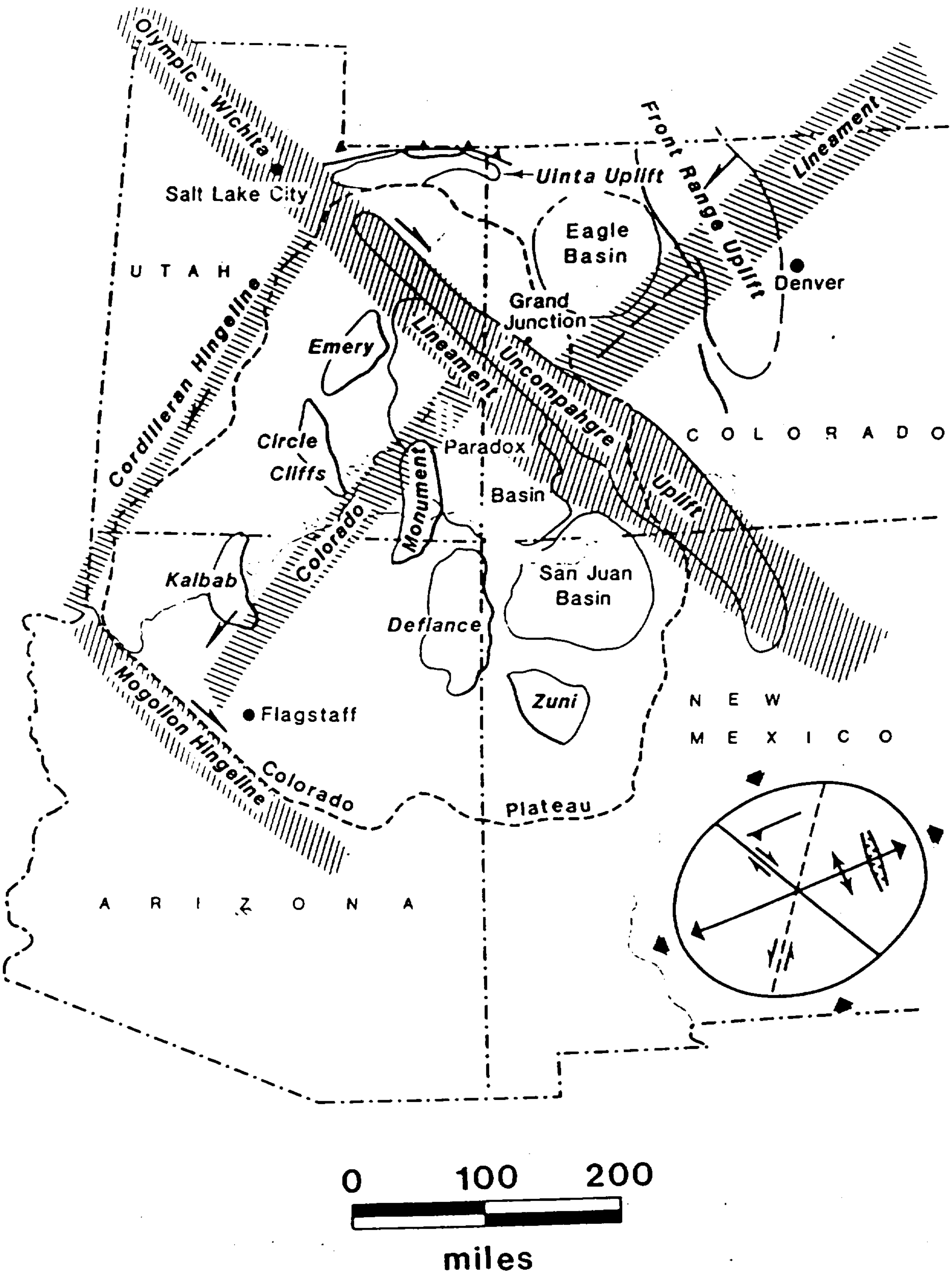


Figure 7.6 Map showing location of Colorado lineament, in relation to the Paradox Basin (from Baars and Stevenson, 1981).

7.5 Atlas Uranium Mill Site

7.5.1 Geology and seismicity

The Atlas uranium mill site is located at the northern end of the Moab Valley in the Canyonlands area of the Paradox Basin (Figs. U-3 and U-7). Moab Valley is the northern portion of the Moab-Spanish Valley, which is surrounded by near vertical sandstone cliffs with relief in excess of 610 m. The Moab-Spanish Valley is the remnant of a breached salt anticline whose downfaulted crest has formed an elongated depression. The Colorado River cuts across the anticlinal structure, dissecting the Moab Valley portion. The collapse of the anticline has been attributed in part to solution and plastic flow of mobilized salt deposits at depth.

The Moab Fault zone strikes ~N45W (Fig. 7.8); the closest exposure of the Moab Fault, 1.6 km northwest of the tailings pile, occurs in the Entrada Sandstone. Considering all of the segments, the zone is 67 km long. In the exposed bedrock located immediately northwest of the site, several geologic structures have been identified. These structures include the Moab anticline and 4 normal faults located in the dipping limb of the anticline. While no evidence of any faults can be observed within the site, one of the faults is inferred to be present in the bedrock beneath the site and has presumably been covered by sediments from the Colorado River (Dames and Moore, 1982).

No direct evidence exists for the southeasterly continuation of the fault, however the Moab Fault is observed along strike in bedrock 6 km southeast of the tailings pile and about 2 km south of Moab (Doelling, 1993). Although there is no definitive evidence for a fault located beneath the tailings pile, a buried fault or deformation zone may exist somewhere in the site (Fig. 7.9).

Recent seismic studies by the Utah Geological Survey (UGS) also suggest that the Moab Fault does not penetrate beneath the salt (Ross, personal communication). According to Ross, a seismic profile shows the Moab Fault becoming listric near the top of the Paradox Formation, at a depth of 914 m, where it soles out in the salt (Woodward-Clyde Consultants, 1982). If the Moab Fault is indeed a shallow fault, it's seismogenic potential will be negligible as it will not be subjected to significant tectonic stresses, which are mainly occurring at much greater depths. deformation along the fault will most likely be aseismic due to the plastic nature of the salt, although strata overlying the salt will likely deform in a brittle manner in response to movement of the underlying salt (Woodward-Clyde Consultants, 1982).

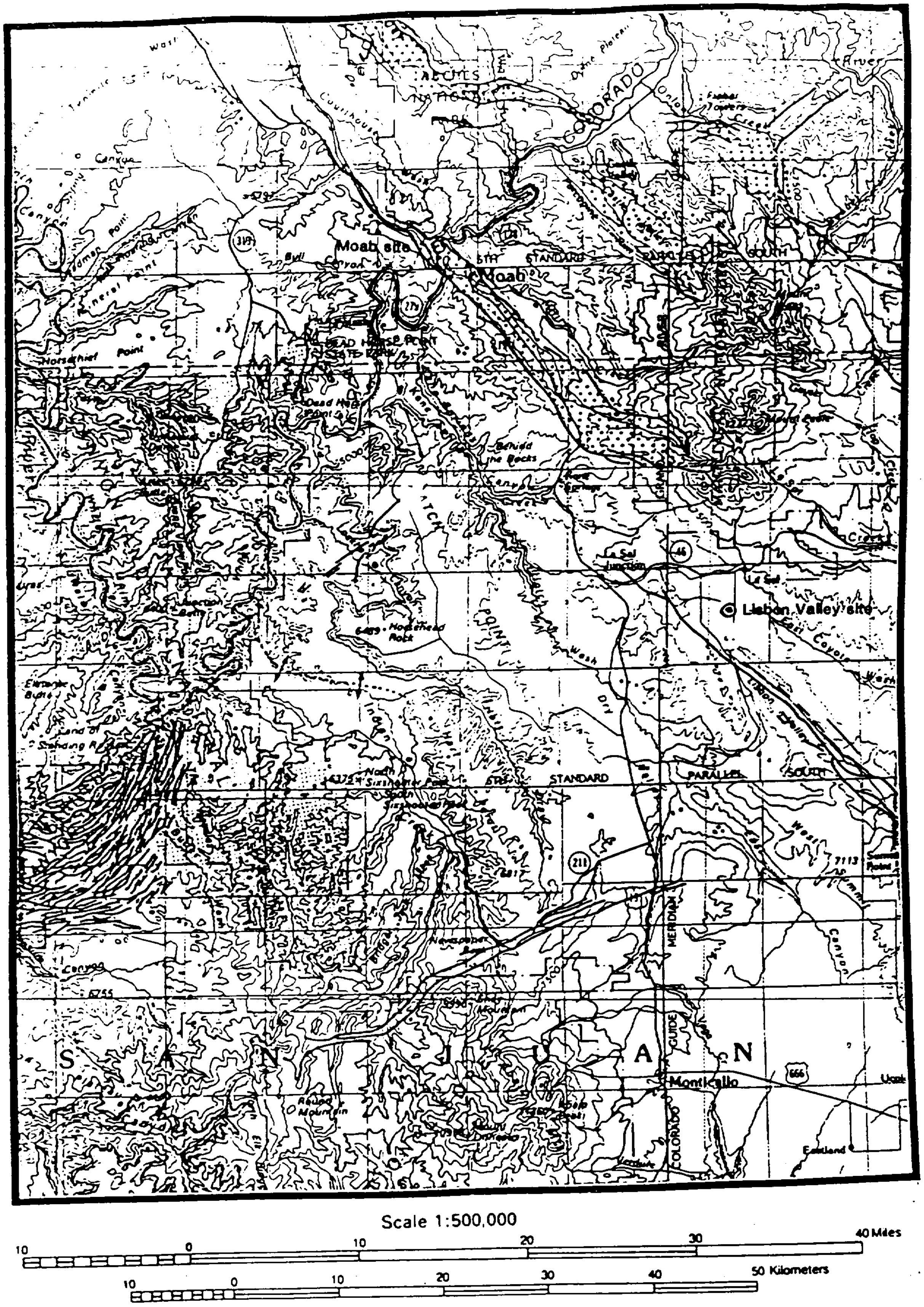


Figure 7.7 Location of the Atlas Moab and Rio Algom sites, with faults having potential Quaternary movement (from Hecker, 1993)

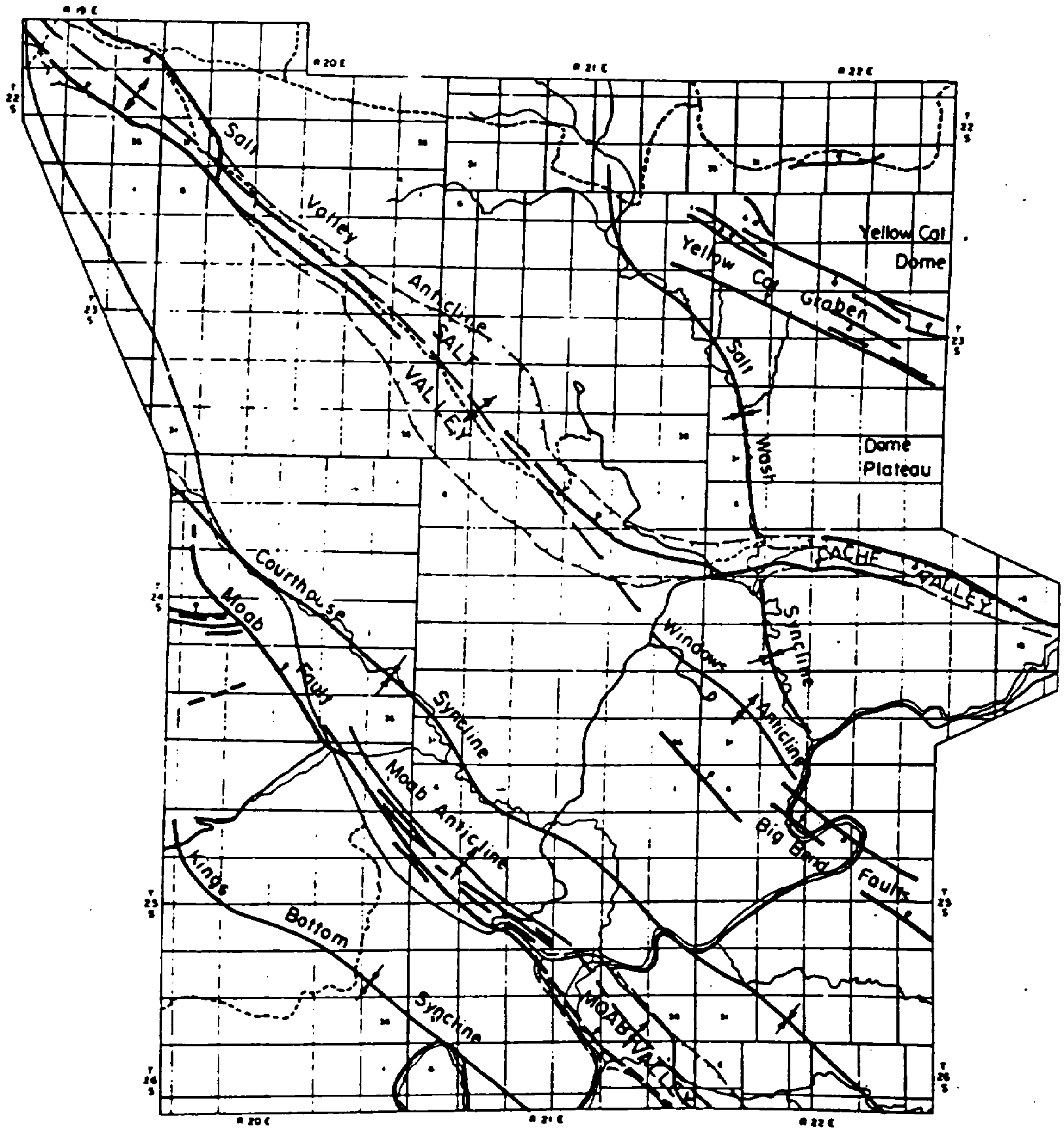


Figure 7.8 Structural geology near the Atlas Moab site.

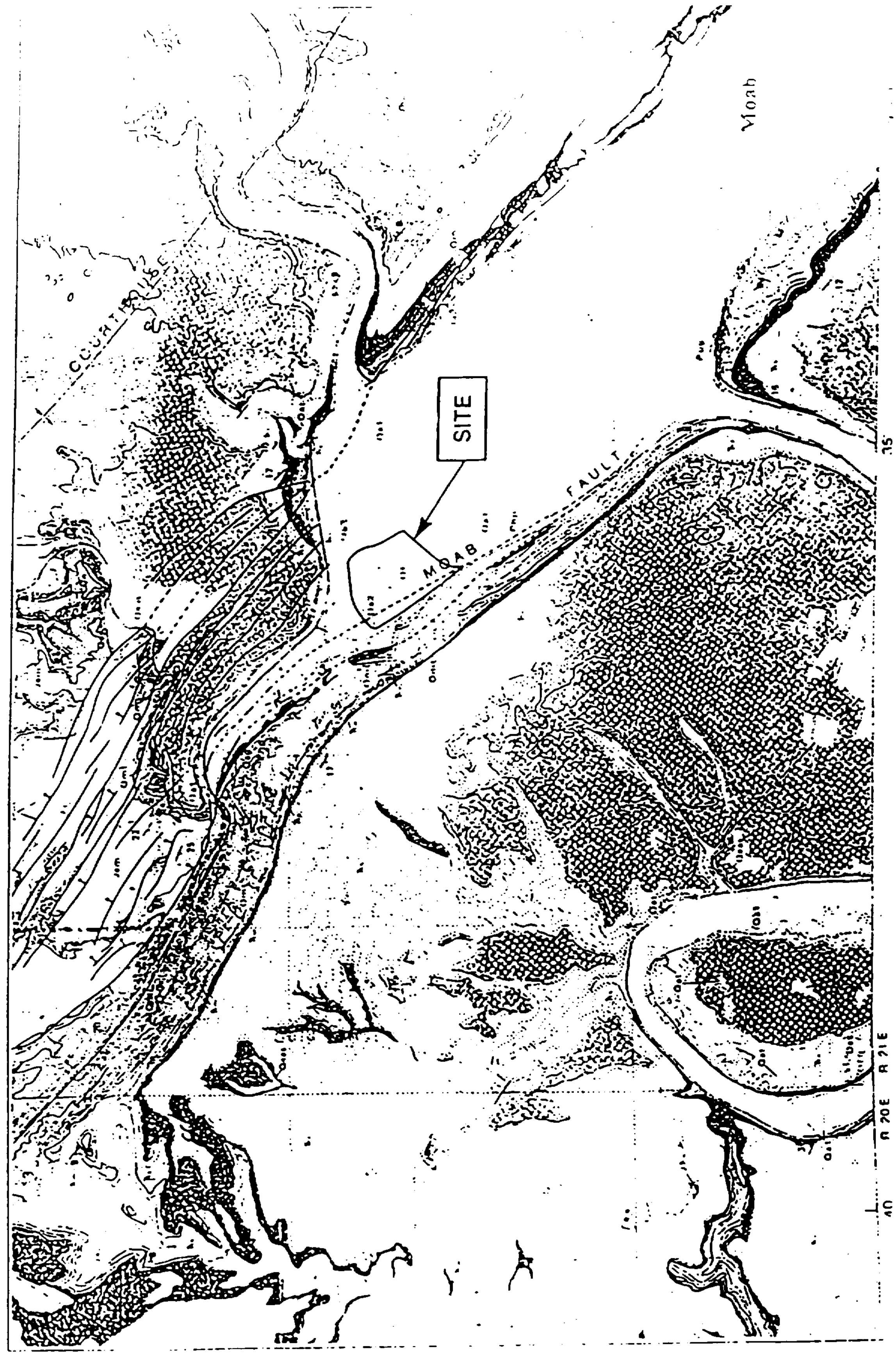


Figure 7.9 Geologic map of the Atlas tailings site (from Woodward-Clyde Federal Services)

G. Christensen of the UGS agrees with the majority of geologists and seismologists who believe that faulting in the Moab region is not a tectonic feature, but rather is due to salt dissolution and subsequent collapse of the overlying earth (Personal Communication, 1994). Christensen also mentioned that areas of intense faulting do not correspond with swarms of activity seen in seismic data, leading him to believe that activity in the area is due to movement along deep-seated basement faults.

There is a series of NE-trending faults located ~48-56 km SW of the site, along the Colorado River, called the Needle Fault zone (Fig. 7.7). This zone contains a large number of short fault segments, which are believed to have Holocene movement (<30,000 yrs.). This zone is related to the Formation of the Meander Anticline, which also has Holocene movement. The axis of the anticline follows the course of the Colorado River, and strikes ~N40E, toward the Atlas site, with the closest approach ~38 km. Both the fault zone and the anticline are thought to be related to salt flowage and gravity tectonics.

One of the major concerns at this site is the Colorado River seismic zone, an area of seismicity along the Colorado River between the site and the confluence with the Green River (Fig. 7.10 and U-4). Wong and Humphrey (1989) document considerable seismic activity in this area along the Colorado River. While much of the seismic activity is shallow and can be attributed to salt mining, etc., there is also deep activity which is difficult to associate with the ongoing mining and subsidence of the salt. There is speculation in the literature that a Precambrian basement fault underlies the Colorado River. On the basis of aeromagnetic data, this part of the Colorado River appears to be underlain by a fault or fault zone in the Precambrian basement, that has experienced previous left-slip displacement (Case and Joesting, 1972). Hite (1975) has proposed that several NE-trending features in the region (including the Colorado River below Moab) may be structurally controlled by basement shear zones or strike-slip faults. If indeed this is the case and for some reason the fault is being reactivated, then a significant earthquake could be generated on this fault.

7.5.2 Seismicity and Earthquake Hazards

As discussion in the Regional Section, most of the earthquakes in Utah occur over 200 km west of the site in Inter-Mountain Seismic Belt (IMSB). Even though the rate of activity and M_u in the IMSB is much higher than is the region around the site the boundary of IMSB is over 200 km away from the site. A simple preliminary bounding analysis shows that the IMSB does not contribute deterministic analysis and contributes less than 1 percent to the probabilistic analysis. Similarly, the other features shown on Fig. 7.6 also are sufficiently far away and have relatively low activity rates so that they do not contribute to either the deterministic or probabilistic hazard estimates for any of the sites located in the Paradox Basin.

Deterministic Analysis

The major concerns to the deterministic analysis at the Atlas site are the seismicity along the Colorado River and the Moab fault zone.

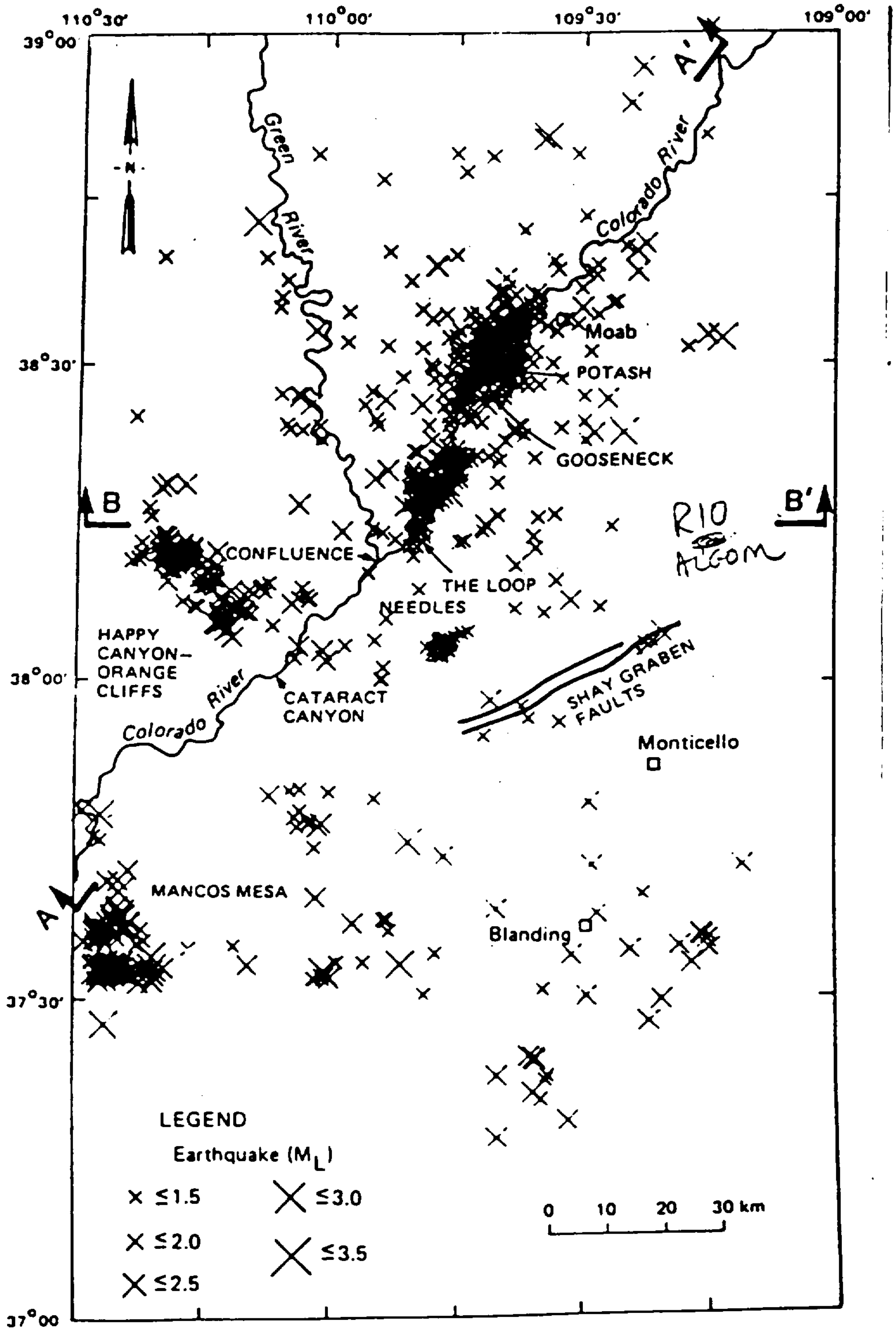


Figure 7.10 Seismicity of the Canyonlands region, July, 1979-July 1987 (from Wong and Humphrey, 1989).

Seismicity Along the Colorado River

As discussed in the geology section, the trend of seismicity along the Colorado River is of considerable concern. We assume for this report that a fault underlies the river along this trend and that it is being reactivated as evidenced by the observed seismicity. Based on this assumption a significant earthquake could be generated on this fault.

As discussed in the Methodology Section, it is possible to estimate how large an earthquake could occur in this zone of activity. The length of the fault which has shown seismic activity is approximately 50 km. A reasonable estimate might be to assume that one-half of the fault might rupture in any one event. This would lead to an estimate for the magnitude of approximately 6.5 based on relations developed by Wells and Coppersmith (1994). If the whole length was to rupture, then the magnitude would be approximately 7.

It is very difficult to associate any type of estimate on the return period of such events. The seismic history is much too short. We also do not know if the Precambrian fault is one large fault or is comprised of several segments. If it is segmented, then we might assume that one or two segments might rupture.

It is clear from the lack of any surface expression that the Precambrian fault, if it exists, has not been reactivated recently, and few very large events (M>6.5), if any, have occurred on it. This would argue that a reasonable value for M_u would be M=6.5. Regionally, about the largest event we see in the historical record is about M~5.8 or less. The most likely "large" earthquake on this trend would be M~5.8-6.5, and very unlikely as large as 7.

. is difficult to estimate an appropriate distance to use to estimate the ground motion at the site because we do not know the exact location of the fault. In addition, it is unlikely that the maximum energy release would be right at the site. An epicentral distance of 5-10 km seems reasonable with a depth of approximately 7 km.

Based on the fact that we are seeking a ground motion level for the assignment of the stability of tailings piles at a PE level of 10^{-4}, our judgment as discussed in Section 3.4.1 is that we should use the 1-sigma estimate for the ground motion from a M=5.8 earthquake, and the median estimate from the larger M=6.5 earthquake. The 1-sigma estimate for the M=5.8 earthquake is 0.4g, the median for the M=6.5 is 0.32g, and for the M=7, the median estimate for PGA is 0.41g. Lastly, the median estimate for M=5.7 earthquake is 0.22g.

Moab Fault

As discussed in the above sections on geology, the Moab fault appears to be due to salt tectonics and not due to major seismic activity. There may be a fault at depth below the salt, however it does not appear to significantly offset the salt and join the Moab fault.

Very little seismicity, if any, is associated with the Moab fault and the postulated basement fault. It therefore seems unlikely that this Fault System would be the cause of a significant earthquake hazard for the site, at least as the source of earthquakes. Because of the nature of the Moab fault, we would only expect small, shallow earthquakes on it. The basement fault could support earthquakes on the same order as the earthquakes postulated to occur on the linear along the Colorado River. However, in our judgment such large earthquakes are much less likely than on the linear along the Colorado River. Thus this fault has no impact on the expected level of ground shaking at the site.

.. is important to note that because branches of the Moab fault appear to run under the tailings piles, it poses a significant hazard for movement or subsidence in the event of a magnitude 6 - 6.5 earthquake at the site, either in the basement fault or the fault postulated to exist under the Colorado River.

Hazard Analysis for a Random Earthquake

The earthquakes in the Paradox Basin do not appear to correlate well with the known surface faulting. This is partly because the observed surface faults are driven by salt tectonics rather than deep-seated movement of the earth's crust. Thus it makes sense to assume that the earthquakes could occur randomly in the Paradox Basin. The activity is low and we have only a short seismic history. Application of Stepp's method as described in the Methodology Section 3.4.2 indicates that the catalog seems reasonably complete since 1965 with very little data before 1965. Thus it is difficult to get a good estimate of the rate of activity and the largest earthquake that could occur in the region and increase the uncertainty in our hazard estimates.

For our simple analysis, the Paradox Basin was treated as a single source zone. We used the USGS catalog from Glen Reagor as our source of seismicity data. Fig. (7.11) shows a plot of the number of events $\geq$ any magnitude M vs. magnitude for events of $M \geq 2$ for the earthquakes in the Paradox Basin since 1965. The data is fit reasonably well by the relation

$$\log N = 3.202 - 0.8M$$

The truncated exponential fit to the data for $M_u = 5.75$ is also shown on Fig. 7.11.

Note that Eq. (1) is for the time frame 1965–1994. Normalized to a per year basis we get $\log N = 1.74 - 0.8M$.

There is of course considerable uncertainty in the above relation and there is no easy way to estimate it. As noted in the Methodology section, we put a factor of 2 uncertainty on the a-value and no uncertainty on the b-value. We expect that the uncertainties are much larger but we have no way to estimate them so our analysis is a simple best estimate case.

The other question is, what is the largest event that could occur in the Paradox Basin? As discussed in the Methodology Section, we examined a range of cases varying from a best estimate of 5.5 to 7.0 with the uncertainty bounds ranging from 5.25 to 7.25. Fig. 7.12 gives a plot of PGA vs. probability of exceedance for several values of best estimate for maximum magnitude, M_u. We see from Fig. 7.12 that increasing M_u above 6.25 has little impact on the seismic hazard. Sensitivity studies indicate that most of the hazard is contributed from the region around the site. Because of the significant structure around the Atlas site we would argue that $M_u = 6.25$ is a reasonable value for M_u. At a probability of exceedance level of 10^{-4}, the PGA is found to be 0.15 g. We note that at 4×10^{-4} (2500 year return period) the PGA is approximately 0.07 g which is in reasonable agreement with Algermissen et al. (1990). Our estimates are somewhat higher and at 5×10^{-4} the estimate is about 0.06g.

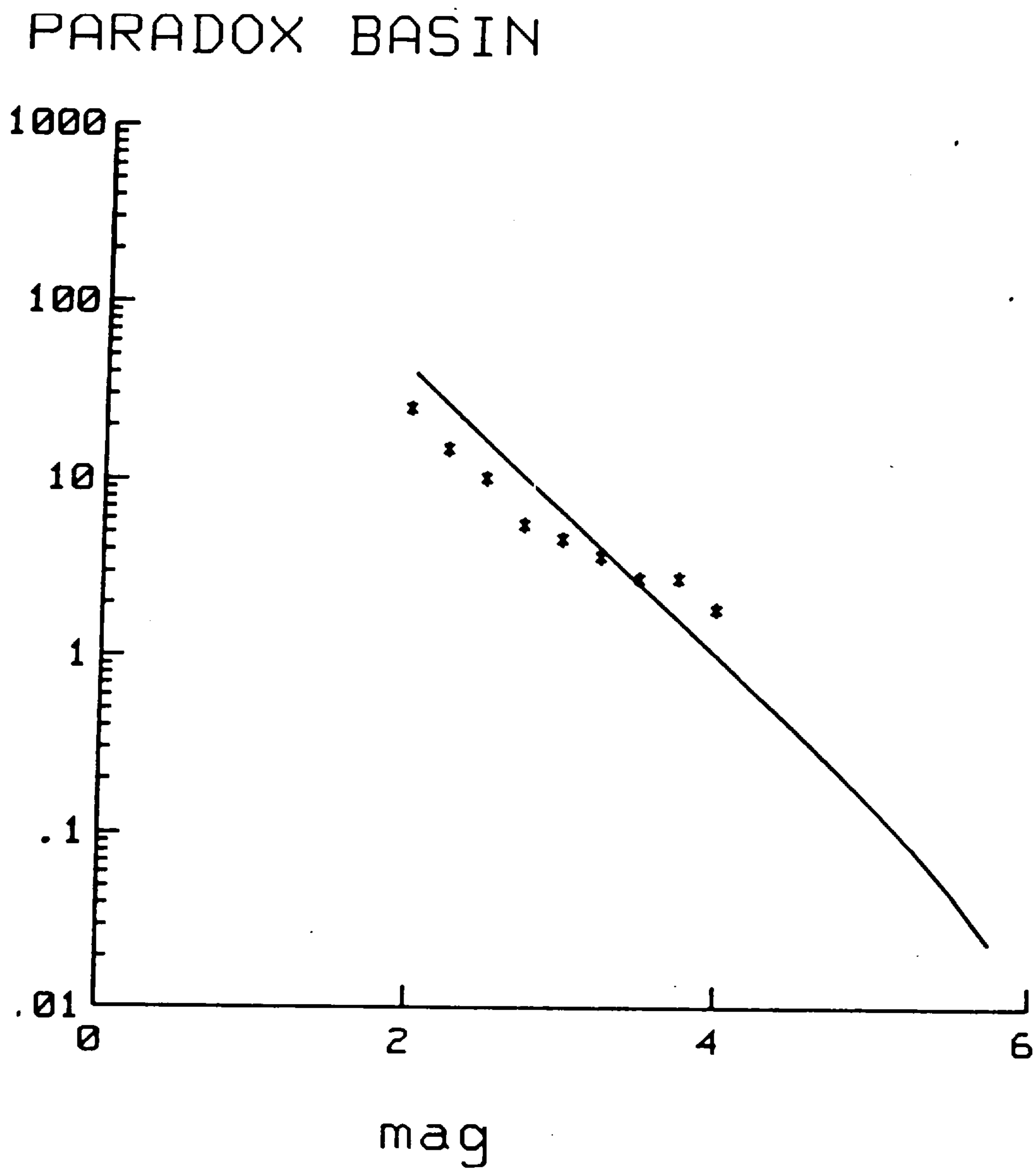


Figure 7.11 Fit of the truncated exponential model with $M_u = 5.75$ used in the hazard analysis for random earthquakes for the sites located in the Paradox Basin to the last 30 years of data.

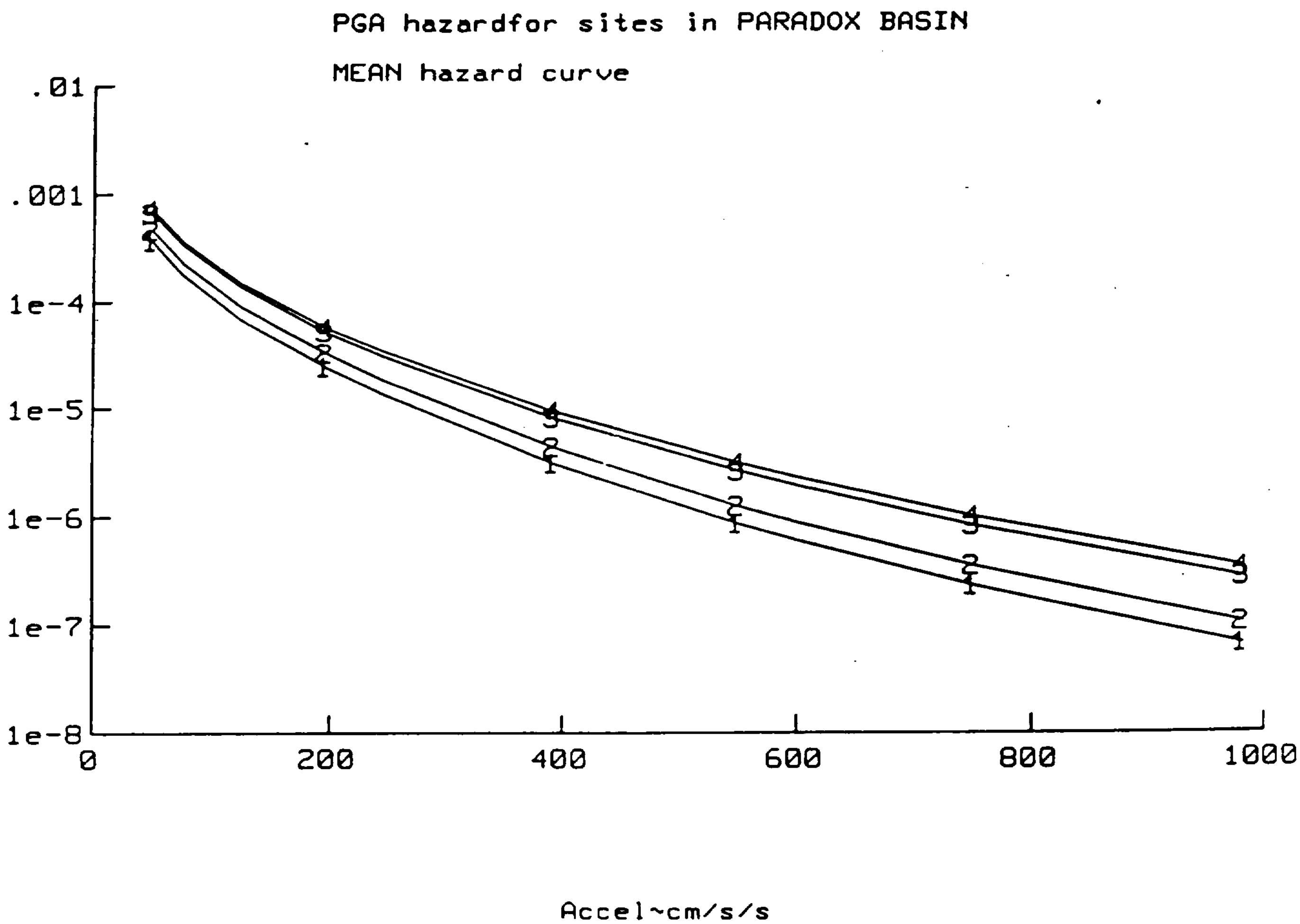


Figure 7.12 Peak ground acceleration (PGA) hazard curves for the random earthquakes for the sites located in the Paradox Basin for various M_u, 1—1 M_u = 5.5, 2—2 M_u = 5.75, 3—3 M_u = 6.25, 4—4 M_u = 7.

7.5.3 Conclusions

Through an extensive literature search, study of geologic and seismicity maps and personal communication with UGS geologists, we have not as yet found evidence of any new Quaternary faults in the Moab area. There seems to be a general consensus throughout the literature that the Moab fault is a surficial expression of underlying salt solution and subsidence rather than a tectonic feature capable of significant seismic activity.

We are concerned about the seismicity along the Colorado River which could indicate that a Precambrian fault thought to exist under the river is being reactivated. This could lead to earthquakes in the range of 5.5 to 7. We concluded that the most likely earthquake would be approximately M~5.8 with a reasonable upper limit of 6.5. It is possible for a 7 earthquake to occur, but because no surface faulting is observed, it is considered highly unlikely that such a large event would occur. We determined estimates for PGA between 0.22g and 0.41g based on a number of different scenarios. The most likely scenario in our view is a M=5.8 event.

The probabilistic estimate for PGA was 0.15g a PE level of 10^{-4} and 0.06g at a PE level of $5x10^{-4}$.

The Moab fault is not considered to be a seismo-tectonic feature, hence we would only expect small (if any) earthquakes on it. There may be a basement fault, however there is little to indicate any activity. It is unlikely that this fault would have an earthquake larger than could occur along the postulated Precambrian basement fault under the Colorado River. In addition, if we use M_u=7 in random earthquake it allows for the likelihood of a large earthquake at the site with a reasonable estimate for the return period. As we noted, the analysis for the random earthquake leads to smaller estimates of the ground motion at a PE level of 10^{-4} than for the earthquakes postulated to occur on the basement fault under the Colorado River.

Although we do not consider the Moab fault as a direct source of significant surficial displacement at the site, we note that a large earthquake on the Precambrian basement fault under the river could introduce differential displacement or consolidation along the Moab fault zone. Because it is likely that this fault zone underlies the tailings piles, this could be a hazard that should be evaluated. Also, failure of the cliffs near the tailings piles could be a problem.

Our estimate for PGA in the 0.2 to 0.4 g as the appropriate value to use to evaluate the facilities at this site is significantly higher than the values that appear to have been used to design the facility in Section 4.3.1. This is a source of significant concern and needs to be carefully evaluated to determine if sufficient margins actually exist to withstand estimated higher ground motion at the site or if remedial action is required.

7.6 Rio Algom-Lisbon Site

7.6.1 Geology

The Rio Algom Corporation Lisbon mine site is located in the Paradox fold and fault belt of the Colorado Plateau (Figs. 7.3 and 7.7). The structure in the site region is dominated by northwest-trending anticlines, synclines, and normal faults.

The Lisbon Valley Fault lies within ~400 m of the site (Fig. 7.13). This northwest-trending fault is similar to others in the region in that it is thought to be related to dissolution and flowage of underlying salt. However, no evidence of Quaternary deformation has been documented along its trace. The fault is ~45 km long and strikes N48W. The fault zone can be divided into 3 distinct segments based on the complexity of surface expression. Geomorphic expression (such as apparent offset drainages) suggests recent faulting, but more work is needed to identify the origin and age of

features. The faults exhibit a normal sense of displacement that is most probably related to evaporite dissolution and collapse along salt anticline crests. Analysis of subsurface data suggests that surface faults do not extend below the Paradox Formation, but the evidence is not conclusive, and a tectonic origin for at least part of the displacement cannot be discounted. Evidence for post-Laramide growth of the Lisbon Valley anticline is inconclusive, but there is evidence for Quaternary growth on the collinear Dolores anticline in Colorado. The Lisbon Valley Fault zone and Moab fault are the longest and most prominent faults in the Paradox Basin (Hecker, 1993).

The Lisbon Valley anticline is an nondiapiric, asymmetrical structure, with the oldest rocks exposed over the structure being limestones and shales of the upper member of the Hermosa Formation. The northeast limb of the anticline is downdropped by a northwestern-trending normal fault of regional extent. This fault brings the upper member of the Hermosa into fault contact with the Dakota Sandstone. Structural closure against the fault is about 762 m. The fault is a collapse structure caused by removal of salt from the adjacent syncline on the northeast, either by flowage or by dissolution. The faulting does not extend into the Paradox Member (Hite and Lohman, 1973). Other nearby structures include the Moab Valley Fault (~12.9 km north) and the Shay Graben (~20 km south).

Shay Graben Fault System

The Shay Graben Fault System is shown on Figs. 7.3, 7.4 and 7.7. Quaternary movement is suspected based on the fault escarpment morphology and the characteristics of associated pediment surfaces. The North Shay fault has a generally poorer surface expression than the South Shay Fault and is less likely to have had Quaternary displacement. The South Shay Fault exhibits dip-slip displacement totaling less than 100 m and is regarded as a possible seismotectonic feature. The graben strikes N65W and is 41 km long. Wong and Humphrey (1989) have documented seismic events between 1979-1987 along the Shay Graben, all with magnitudes <2.5.

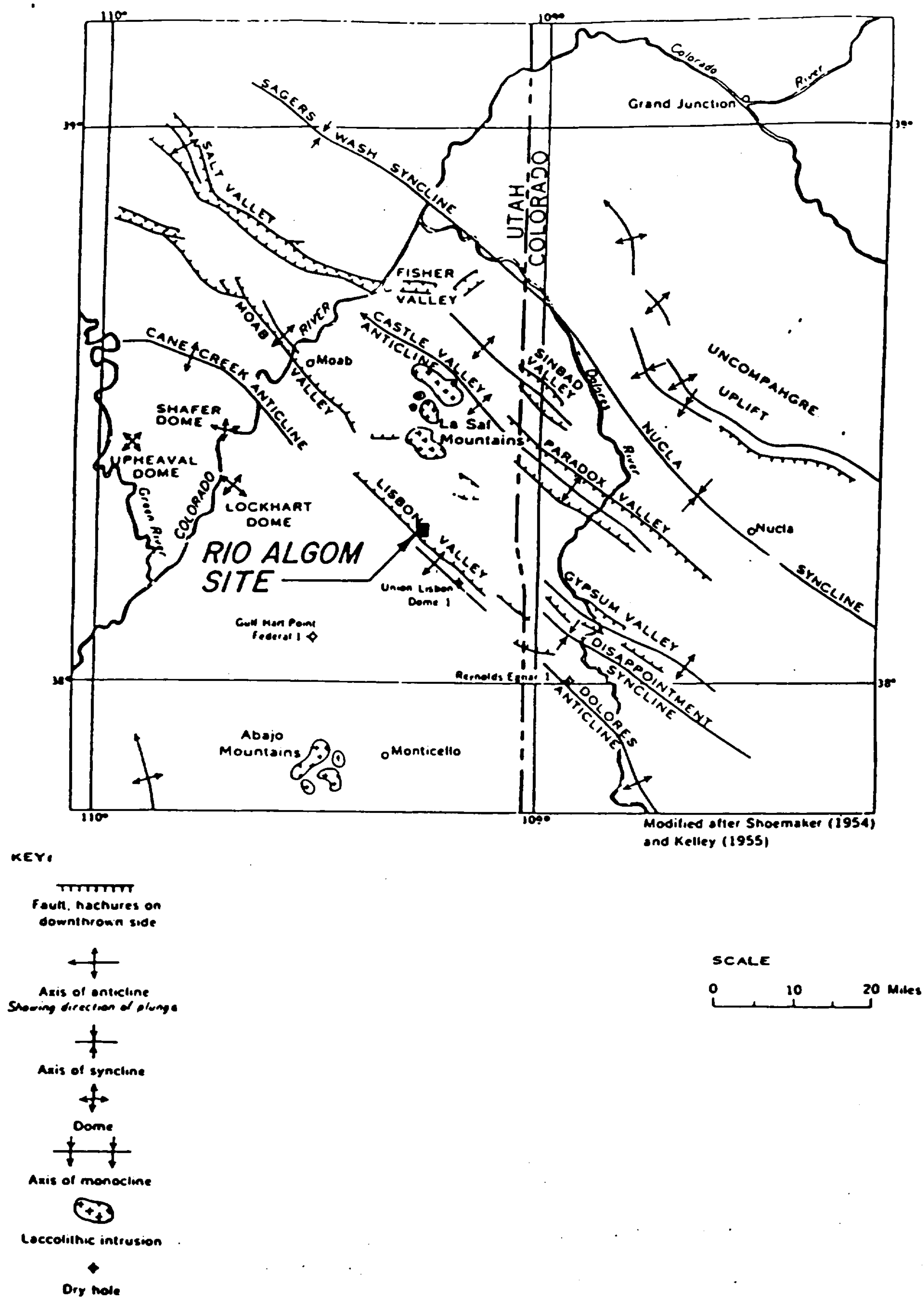


Figure 7.13 Regional geologic structure map of the Rio Algom site (from NRC Docket Report #40-8084).

7.6.2 Seismicity and Earthquake Hazard Analysis

Deterministic Analysis

Although there are a number of faults in the region around the Rio Algom site, the deterministic aspects of the hazard analysis are dominated by the Lisbon Valley fault zone and the Shay Graben fault zone.

Lisbon Valley Fault Zone

As discussed in the section on geology, the Lisbon Valley fault zone appears to be primarily a salt tectonics feature and not due to deep seated activity. There may be a deeper basement fault, however there is no clear evidence that the Lisbon Valley fault is structurally connected to the basement fault. Little or no seismic activity is associated with either fault. There is no evidence of recent Quaternary activity. This, and the lack of any observed seismicity leads us to the conclusion that the fault does not pose a hazard to the site as the source of significant earthquakes ($M > 5$). We consider our hazard analysis for a random earthquake sufficient to account for the hazard posed by the Lisbon fault.

It is not clear if the Lisbon Valley fault and the postulated basement fault are structurally related to the Moab fault and the postulated basement fault under the Moab fault. The reason we note this is because, as discussed in the sections on the Atlas site, we see a potential for a large earthquake ($M \sim 6.5$) in the seismicity along the Colorado River. If such an earthquake should occur, it then could reactivate the Moab fault and possibly the Lisbon Valley fault and the associated basement fault. This is a very low likelihood event and needs only to be considered if a significant earthquake occurs along the Colorado River.

Shay Graben Faults

As discussed above in the geology section, not much is known about the Shay Graben Fault System southwest of the site. These faults are thought to be seismotectonic in origin and have had Quaternary movement, and some seismic activity seems associated with the Fault System. Thus we consider them active for this report. The fault length as shown in Hecker (1993) is approximately 40 km long. The fault appears to have several long (40 km) segments. There appears to be no detailed field investigations to determine if it is segmented. Without the data, we assume that in any single event, up to 40 km of fault could rupture but a rupture of 20 km is more likely. A 40 km rupture could lead to a $M = 6.9$ event and a 20 km rupture could lead to a 6.5 event based on the Wells and Coppersmith (1994) correlations.

The site is located approximately 20 km from the fault zone. The 1-sigma estimate for the PGA for a $M \sim 6.5$ event on the Shay Graben Fault System is 0.26g and a median estimate of 0.14g. To account for the much lower likelihood of a $M \sim 6.9$ event on the Shay Graben Fault System we use the median estimate for PGA which is 0.18g.

Hazard Analysis for a Random Earthquake

The Rio Algom site is located in the Paradox Basin approximately 56 km southeast of the Atlas site. The discussion given in the section for the Atlas site for the random earthquake applies here. The hazard curves are shown on Fig. 7.12. As with the Atlas site, because of the structure in the vicinity of the site, we take $M_u = 6.25$, noting that from Fig. 7.12, large M_u have very little impact on the analysis. The 10^{-4} PGA is found to be 0.15g with an estimate of 0.06g at 5×10^{-4} PE level.

7.6.3 Conclusions

There is no evidence that any faults run through the site. The Lisbon Valley fault is considered to be a salt feature and not seismotectonic. The nearest possible active fault is the Shay Graben Fault System. Our estimates for the PGA ranged between 0.06g and 0.26g.

The facilities at this site seem to have been designed with a PGA of 0.09 g. This is less than the most likely range of our estimates. An evaluation is needed to determine if sufficient margins exist.

7.7 Energy Fuels Nuclear - White Mesa Site

7.7.1 Regional Geology

The White Mesa site is located near the western edge of the Blanding Basin, sometimes referred to as the Great Sage Plain, lying east of the north-south trending Monument Uplift, south of the Abajo Mountains and adjacent to the northwesterly-trending Paradox Fold and Fault Belt (Fig. 7.14). Topographically, the Abajo Mountains are the most prominent feature in the region, rising more than 1219 m above the broad, gently rolling surface of the Great Sage Plain.

According to Shoemaker (1954 and 1956), structural features within the Canyonlands of southeastern Utah may be classified into three main categories on the basis of origin or mechanism of the stress that created the structure. These three categories are: (1) structures related to large-scale regional uplifting or downwarping (epeirogenic deformation) directly related to movements in the basement complex (Monument Uplift and the Blanding Basin); (2) structures resulting from the plastic deformation of thick sequences of evaporite deposits, salt plugs and salt anticlines, where the structural expression at the surface is not reflected in the basement complex (Paradox Fold and Fault Belt); and (3) structures that are formed in direct response to stresses induced by magmatic intrusion including local laccolithic domes, dikes and stocks (Abajo Mountains).

Each of the basins and uplifts within the area is an asymmetric fold usually separated by a steeply dipping sinuous monocline. Dips of the sedimentary beds in the basins and uplifts rarely exceed a few degrees except along the monocline (Shoemaker, 1956) where, in some instances, the beds are nearly vertical. Along the Comb Ridge monocline, the boundary between the Monument Uplift and the Blanding Basin, approximately 12.9 km west of the project area, dips in the Upper Triassic Wingate sandstone and in the Chinle Formation are more than 40 degrees to the east.

Structures in the crystalline basement complex in the central Colorado Plateau are relatively unknown but where monoclines can be followed in Precambrian rocks they pass into steeply dipping faults. It is probable that the large monoclines in the Canyonlands section are related to flexure of the layered sedimentary rocks under tangential compression over nearly vertical normal or high-angle reverse faults in the more rigid Precambrian basement rocks (Kelley, 1955; Shoemaker, 1956).

Situated to the north of the Monument Uplift and Blanding Basin is the most unique structural feature of the Canyonlands section, the Paradox Fold and Fault Belt (Figs. 7.2 and 7.3). This tectonic unit is dominated by northwest trending anticlinal folds and associated normal faults covering an area about 241 km long and 104 km wide. These anticlinal structures are associated with salt flowage from the Pennsylvanian Paradox Member of the Hermosa Formation and some show piercement of the overlying younger sedimentary beds by plug-like salt intrusions. Prominent valleys have been eroded along the crests of the anticlines where salt piercements have occurred or collapses of the central parts have resulted in intricate systems of step-faults and grabens along the anticlinal crests and flanks.

Nearly all known faults in the region of the site are high-angle normal faults with displacements on the order of 91 m or less . The largest known faults near Blanding are associated with the Shay graben on the north side of the Abajo Mountains and the Verdure graben on the south side (Fig. 7.3). Maximum displacements reported by Witkind on any of the faults is 98 m. Because of the extensions

of Shay and Verdure Fault Systems beyond the Abajo Mountains and other geologic evidence, the age of these faults is Late Cretaceous or post-Cretaceous and antedate the laccolithic intrusions (Witkind, 1964).

7.7.2 Blanding Site Geology And Seismicity

The site is located near the center of White Mesa, one of the many finger-like north-south trending mesas that make up the Great Sage Plain. The geologic structure at the site is comparatively simple. Strata of the underlying Mesozoic sedimentary rocks are nearly horizontal; only slight undulations along the caprock rims of the upland are perceptible and faulting is absent. In much of the area surrounding the site the dips are less than one degree. The prevailing regional dip is about one degree to the south. The low dips and simple structure are in sharp contrast to the pronounced structural features of the Comb Ridge Monocline to the west and the Abajo Mountains to the north.

The site is located in a region known for its scarcity of recorded seismic events. Although the seismic history for this region is barely 135 years old, the epicentral pattern, or fabric, is basically set and appreciable changes are not expected to occur. Most of the larger seismic events in the Colorado Plateau have occurred along its margins rather than in the interior central region. Based on the region's seismic history, the probability of a major damaging earthquake occurring at or near the site is very remote.

There are no faults with suspected Quaternary movement within a 32 km radius of the White Mesa site. The closest feature of concern is the Shay Graben, located 43 km to the north (Fig. 7.14). Quaternary movement is suspected based on the fault escarpment morphology and the characteristics of associated pediment surfaces. The north Shay fault has a generally poorer surface expression than the South Shay Fault and is less likely to have had Quaternary displacement. The South Shay Fault exhibits dip-slip displacement totaling less than 100 m and is regarded as a possible seismotectonic feature. The graben strikes N65W and is 41 km long. Wong and Humphrey (1989) have documented seismic events between 1979-1987 along the Shay Graben, all with magnitudes <2.5.

Faults associated with the Verdure Graben are even closer to the site than the Shay Graben, but they show no evidence of recent surface displacement (Fig. 7.3). The Verdure Graben is located ~27 km to the north, strikes east-west, and is a maximum 51 km long. Detailed field studies of the graben show Quaternary pediment gravels and alluvium overlying the graben in several places. Witkind (1964) indicated that the south fault was in igneous contact with the Rocky Trail laccolith with no slickensides present. Stream courses cross the faults with no deflection or gradient change. The implication is that these faults are old and may be of Oligocene age and related to the period of laccolithic intrusion. It is possible that the structures are related to salt dissolution and not related to tectonic stresses (Kirkham and Rogers, 1981). Since the regional stress field in this area is approximately east-west, it is difficult to see how the normal faulting of the Verdure graben or Shay Graben could be produced by tectonic stress. There are other structures located 29 km NE of the site, south of the eastern terminus of the Verdure Graben. These are called the Dodge Point Graben by the Umetco Minerals Corp. Docket Report #40-8681 (August, 1991). These also do not appear on the Hecker (1993) map, and thus are not thought to have had Quaternary movement.

7.7.3 Seismicity and Earthquake Hazard Analysis

Deterministic Analysis

The nearest Quaternary fault to the White Mesa site is the Shay Graben Fault System which is 40 km north of the site. There are other faults 60 km west of the site, the Bright Angel Fault System (Hecker 1993), which may be Quaternary. However, the individual faults in the Bright Angel Fault System are shorter than the Shay Graben Fault System, thus the M_u for the system is smaller than for the Shay Graben. This possible ground motion at the White Mesa site is much lower for earthquakes on the

Bright Angel Fault System from the largest events postulated to occur on the Shay Graben Fault System.

As discussed in the deterministic analysis for the Rio Algom site, the M_u for the Shay Graben Fault System is 6.9 with a more likely value of 6.5. The 1-sigma estimate for PGA for a M~6.5 earthquake located on the Shay Graben Fault System at the site is 0.12g with a median estimate of 0.07g. To account for the less likely 6.9 earthquake we use the median estimate for PGA which is 0.08g.

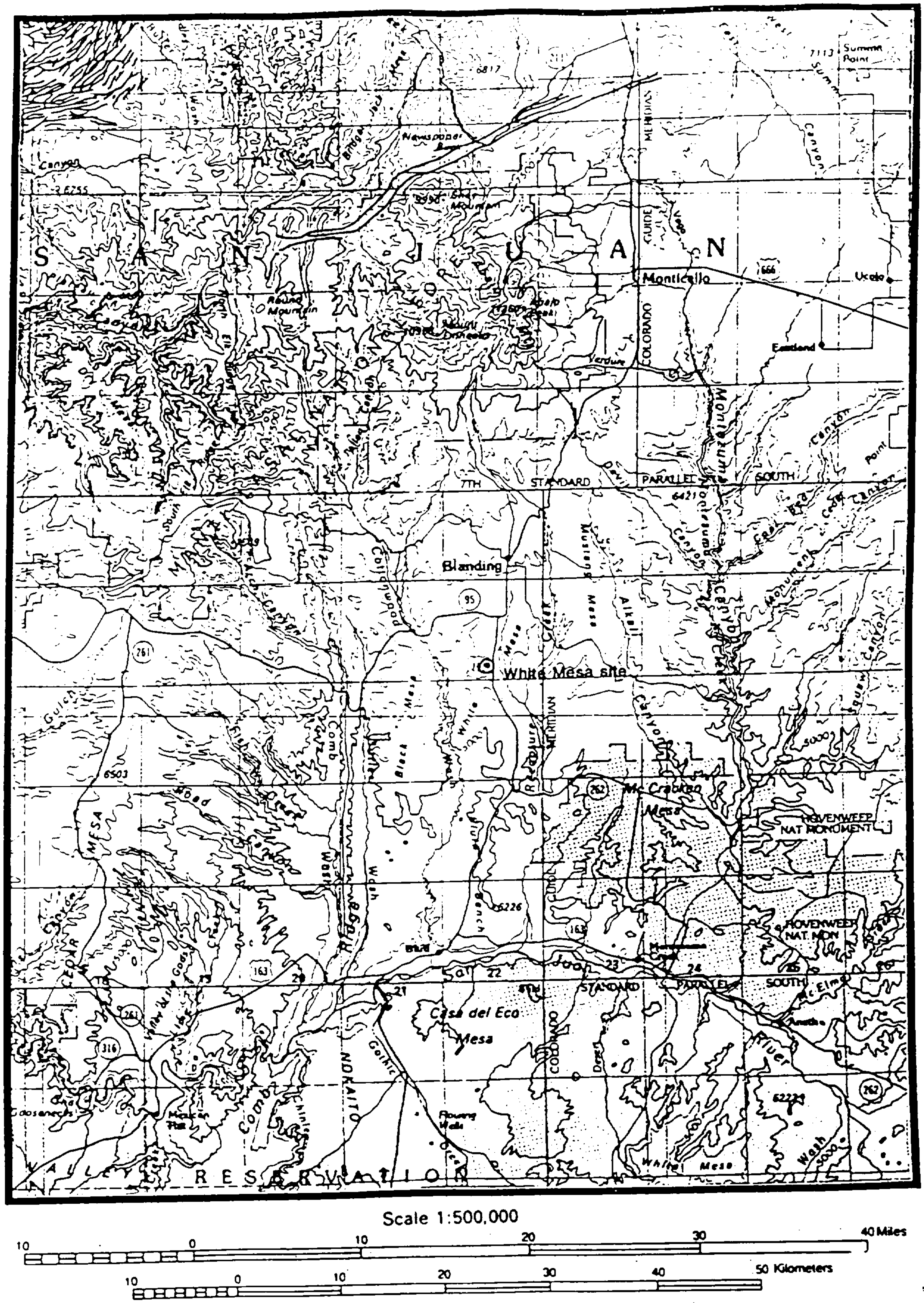


Figure 7.14 Location of the White Mesa site, with faults having potential Quaternary movement (from Hecker, 1993).

Hazard Analysis for Random Earthquakes

The White Mesa site is located in the Paradox Basin approximately 115 km south of the Atlas site. The discussion given in the Section 7.5.2 for the random earthquake hazard analysis for the Atlas site applies for the Umetco site. The hazard curves are given in Fig. 7.12. Because no major basement faults are postulated to exist in the vicinity of the Umetco site, we select $M_u = 5.75$ as the most appropriate hazard curve to use for the WHITE MESA site. This leads to slightly lower ground motion estimates for the Umetco site. We see from Fig. 7.12 that at a PE level of 10^{-4}, the estimate for PGA is about 0.12g and at a PE level of $5x10^{-4}$ the estimated PGA is 0.05g.

7.7.4 Conclusions

There appear to be no faults in the vicinity of the site which could introduce surface rupture through the site and tailings piles. Our estimate for the range of appropriate PGA to use is 0.05 to 0.12g. The (see Section 4.3.4) facilities appear to have been designed to a PGA of 0.1g. However, the actual design calculations need to be reviewed to determine if that is the case, or if that is not possible an assessment of the initial facilities is needed to determine that sufficient margins exist.

7.8 Plateau Resources Limited Shootering Canyon Site

7.8.1 Introduction

Plateau Resource's Shootering Canyon site is located in southeastern Utah near Mount Ellsworth in the Henry Mountains Basin of the Colorado Plateau (Figs. 7.3 and 7.15). Most of the province exceeds 1500 m in elevation and reaches a maximum elevation of more than 3900 m. About 90 percent of the province is drained by the Colorado River and its tributaries. The mill itself is located on a low mesa, and the tailings impoundment rests in a small drainage basin which drains into Shootering Creek.

7.8.2 Local Geology

The site is located in rugged terrain about 8 km southwest of Mount Ellsworth (Fig. 7.15). The bluffs and mesas in the vicinity are typical of the landscape that characterizes much of southeastern Utah. The tailings impoundment site is in a small, isolated catchment that presently drains into Shootering Creek.

The geologic Formations on the site are generally rather simple structurally, with sediments dipping gently westward at about 2 degrees . To the east of the site the sediments tilt up sharply against the diorite porphyry intrusion of Mount Ellsworth, which has forced the sediments up to angles averaging approximately 40 degrees. Some local structural warping has occurred in the area, apparently as an accommodation to the necessary crustal shortening brought on by the intrusion of the laccoliths. Some of this warping may be seen in the minor folding in the lower members of the Summerville and upper Entrada Formations under the butte west of the tailings impoundment site and along the east edge of Shootering Creek, as well as in the upper Summerville immediately underlying the Salt Wash Member of the Morrison in the vicinity of the Plateau Resources Limited mines. The axis of this warp or fold appears to parallel Shootering Creek for some distance and may have oriented the flow of the creek during past geologic time.

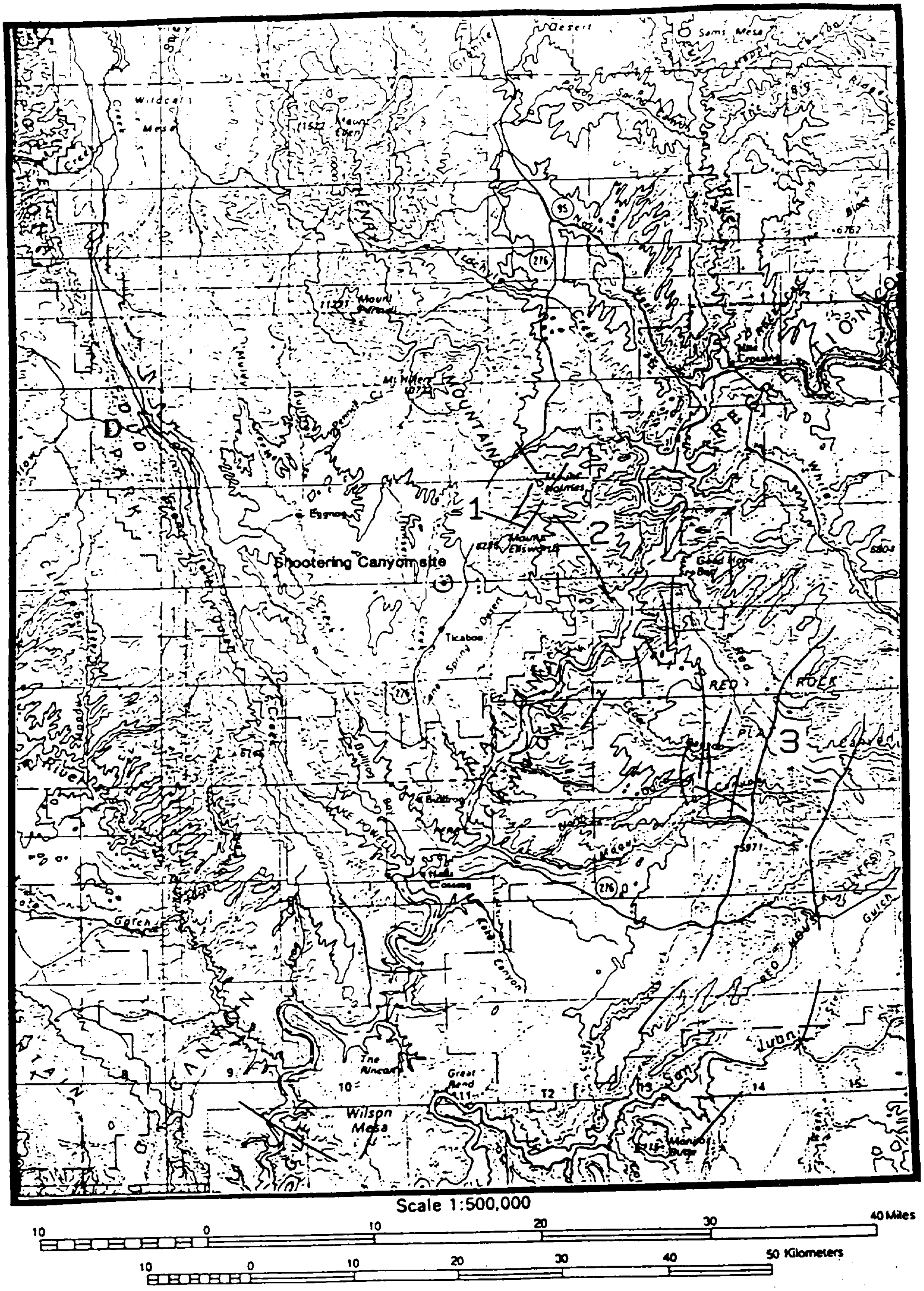


Figure 7.15 Location of the Plateau Resources Shootering Canyon site, with faults having potential Quaternary movement (from Hecker, 1993).

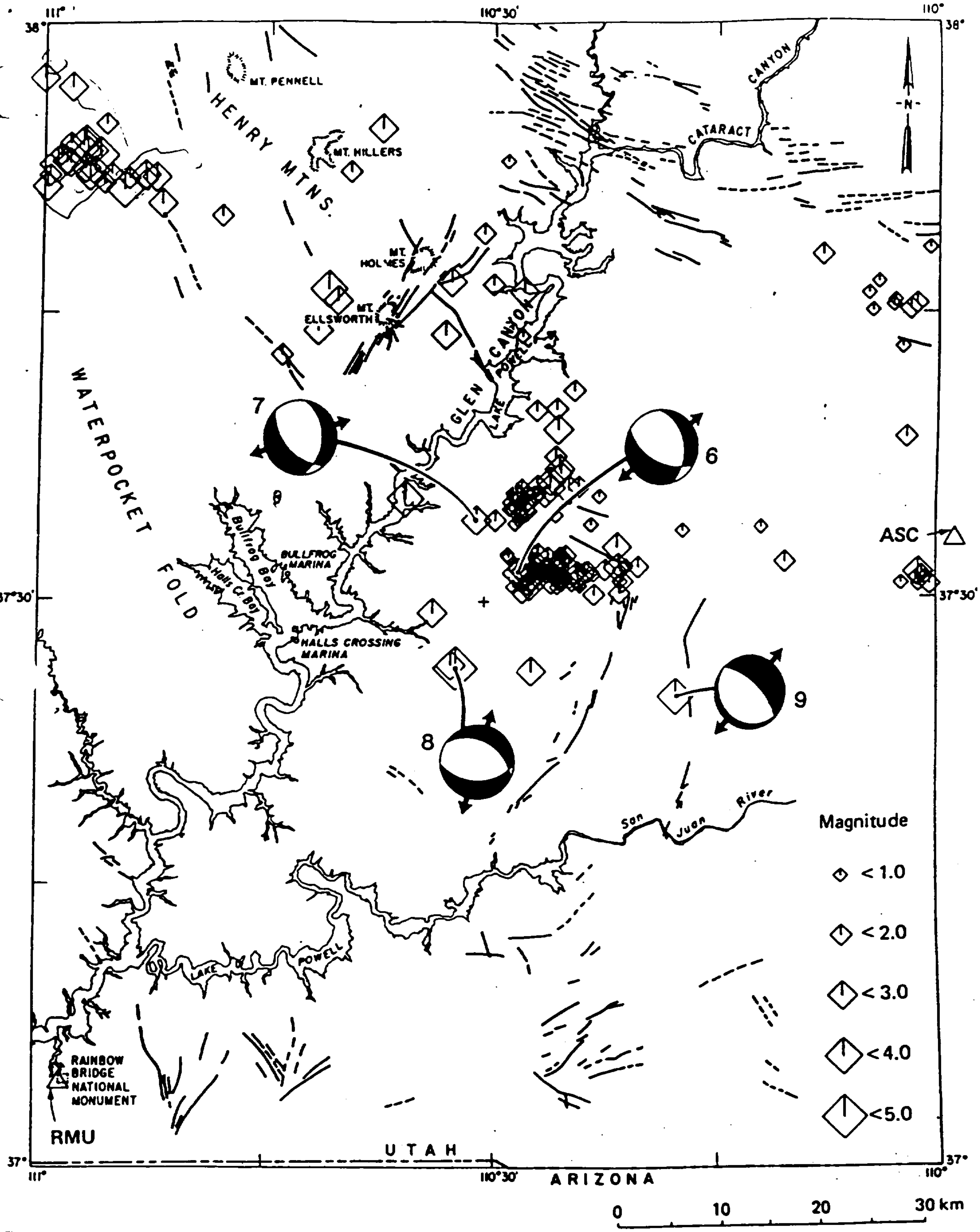


Figure 7.16 Seismicity and focal mechanisms of the Glen Canyon region, July 1979-December, 1986 (from Wong and Humphrey, 1989).

7.8.3 Geology and Fault Characteristics of the Henry Mountains Basin

The Henry Mountains Basin is one of seven major basins that make up approximately one-third of the Colorado Plateau. The basin is bounded on the east by the Monument Uplift, and on the west by the north/south trending Waterpocket Fold. The only faults in the basin are near Mount Holmes, Mount Ellsworth, and the San Rafael Swell. These faults trend west-northwest to east-southeast, and displacements along them range from several meters to several hundred meters.

The closest Quaternary fault to this site is located ~8.8 km N33E (Fig. 7.15). This fault segment is only 4 km total length and strikes N34E. There are only short segments associated with the fault, all near Mount Ellsworth and Mount Holmes. Another longer fault is located east of the site, with a closest approach of 12 km. This fault is ~10.5 km long and strikes N32W. All of these faults are within a 16 km radius of the site, and have been determined to have potential Quaternary movement (<1,650,000) yrs (Hecker, 1993).

Within a 32 km radius of the site are 9 additional short (<11 km long) segments, all of which strike generally N-S, and are located SE of the site. The longest fault with Quaternary(?) movement is located SE of the site, with a closest approach of 34.5 km. The fault is composed of 3 segments, with a cumulative total length of 43 km. The fault strikes N20E.

The regional seismicity map (Fig. 7.16) shows the greatest amount of activity associated with the relatively short faults located 24-40 km SE of the site. The activity is generally < 3.0 magnitude. There are a few "random" events just north of the site (<3 km) with magnitudes of <4.0. These events do not appear to be associated with known surface structures. To the NW, there is a series of 2.0-4.0 events that appear to trend NW/SE. Wong and Humphrey (1989) mapped several short faults near the epicenters (NW strike), but these did not appear on the Hecker (1993) map. The largest nearby event was a magnitude <5.0, and is located ~33.5 km S25E of the site (Wong and Humphrey, 1989).

7.8.4 Seismicity and Earthquake Hazard Analysis

There is a relatively poor correlation between mapped Quaternary faults and mapped faults in general and the regional seismicity. However, there are several centers of relatively high activity (compared to the rest of the Colorado Plateau) around the Plateau Resources site. As discussed in the geology section, there are a number of relatively small Quaternary faults around the site. The fault plane solutions presented by Wong and Humphrey (1989) suggest that northwest trending faults appear to be most favorably oriented with the regional stress field.

Deterministic Analysis

We have singled out three faults for analysis. The first fault which lies approximately 9 km from the site is the nearest to the site. The other two faults are possible Quaternary faults which could have some activity associated with them. They were selected because they were the largest two Quaternary faults around the site. See Fig. 7.15 for the relative location of these faults. They are labeled 1, 2, and 3.

Fault 1

Fault 1, which is approximately 9 km from the site, trends to the northeast and is not favorably oriented with the regional stress field. Hence if it has an earthquake we would expect it to be somewhat smaller than the largest one could expect from a 4 km long fault. The Wells and Coppersmith correlation indicate that a 4 km fault could lead to M~5.8 earthquake. Because of its unfavorable orientation with the stress field, we would expect a smaller earthquake, say M~5.5. The 1-sigma estimate for PGA for a M<5.5 earthquake located on this fault at this site is 0.3g. For the

larger M~5.8 event, we use the median estimate to account for its much lower probability of occurring. This leads to an estimate for PGA of 0.1?g.

Fault 2

Fault 2 trends northwest hence it is favorably oriented with the stress field. The fault is approximately 10 km long. If the entire fault ruptured in a single event this could lead to a M~6.25 earthquake. If we assume only one-half of the fault ruptures, this leads to a M~5.9 earthquake. The fault is approximately 13 km from the site. The 1-sigma estimate for PGA at the site from a M~5.9 earthquake located on what we have labeled fault 2 is 0.28g. Because of its lower probability of occurrence, we use the median estimate for M_u~6.25 which is 0.19g. The median estimate for a M~5.9 event is 0.16g.

Fault 3

This fault is almost due east of the site. The fault is listed as a possible Quaternary fault by Hecker (1993) and could have some seismicity associated with it. The fault trends northeast and hence not in the most likely direction for earthquakes. Thus it is not a likely candidate for earthquakes. However, it is included in the analysis for completeness. The fault has a length of approximately 23 km and lies approximately 35 km from the site. If we assume the entire fault ruptured, this would give rise to a 6.7 earthquake. This is larger than might be expected, at least based on the historical record. However, as we pointed out in the methodology section, it is not clear that the historical record gives a good indication of the largest event that could occur because we expect that the largest possible event would be a characteristic earthquake governed by its own characteristic return interval. If we use a distance of 35 km and M = 6.7 in the Joyner - Boore model, we get 1-sigma estimate of 0.14g.

Random Earthquake Analysis

Based on the geology and pattern of seismicity around the Plateau Resources site, we selected a source zone which seemed reasonable to use to develop our recurrence model. As described in the methodology section we applied Stepp's method to try and determine the completeness of the earthquake catalog. There is no data in the catalog before 1963 for the selected zone. Stepp's method indicated that the catalog was reasonably complete for events of about magnitude 3 for the last 10 to fifteen years. The smaller events did not appear to be complete. Fig. 7.17 shows the data for the last 30 years. Also shown is the truncated exponential model that we use with $M_u = 5.75$. The model appears to fit the data reasonably well. The simple Richter form of the model normalized to a per year basis is

$$\log N = 2.43 - 0.92M$$

We used this recurrence model to develop the seismic hazard for the region around the Plateau Resources site as outlined in our methodology section. Fig. 7.18 gives the hazard curves for values of M_u = 5.5, 5.75, 6.25, and 7. We see from the hazard curves that at a PE level of 10^{-4} the PGA varies between 0.17g to 0.24g. As there are no major faults in the vicinity of the site our preferred choice for M_u is 5.75. This leads to 0.19g estimate for the ground motion at the site from the random earthquake at a PE level of 10^{-4}. At a PE level of 5×10^{-4} the PGA varies between 0.08g to 0.12g depending upon the choice of M_u with a value of 0.09g at $M_u = 5.75$.

7.8.5 Conclusions

There appear to be no faults through the site that could cause problems. Our deterministic analysis ad to an estimate for PGA of 0.16g to 0.3g. The random earthquake analysis gives a lower estimate of 0.17 g to 0.24 g. There is a possibility of a larger earthquake in the vicinity of the site, which is included in the analysis for random earthquakes, however the likelihood is sufficiently low that in our opinion the M~5.5 earthquake meets our criteria.

As indicated in Section 4.3.2, we were unable to determine what the facilities were designed for. It appears that the Licensee considered the postulated ground motion at the site from an earthquake to be so low that it was not a design consideration. In view of our estimates for PGA this is of considerable concern and the critical facilities need to be evaluated to determine if sufficient margins exist or if some remedial action is required.

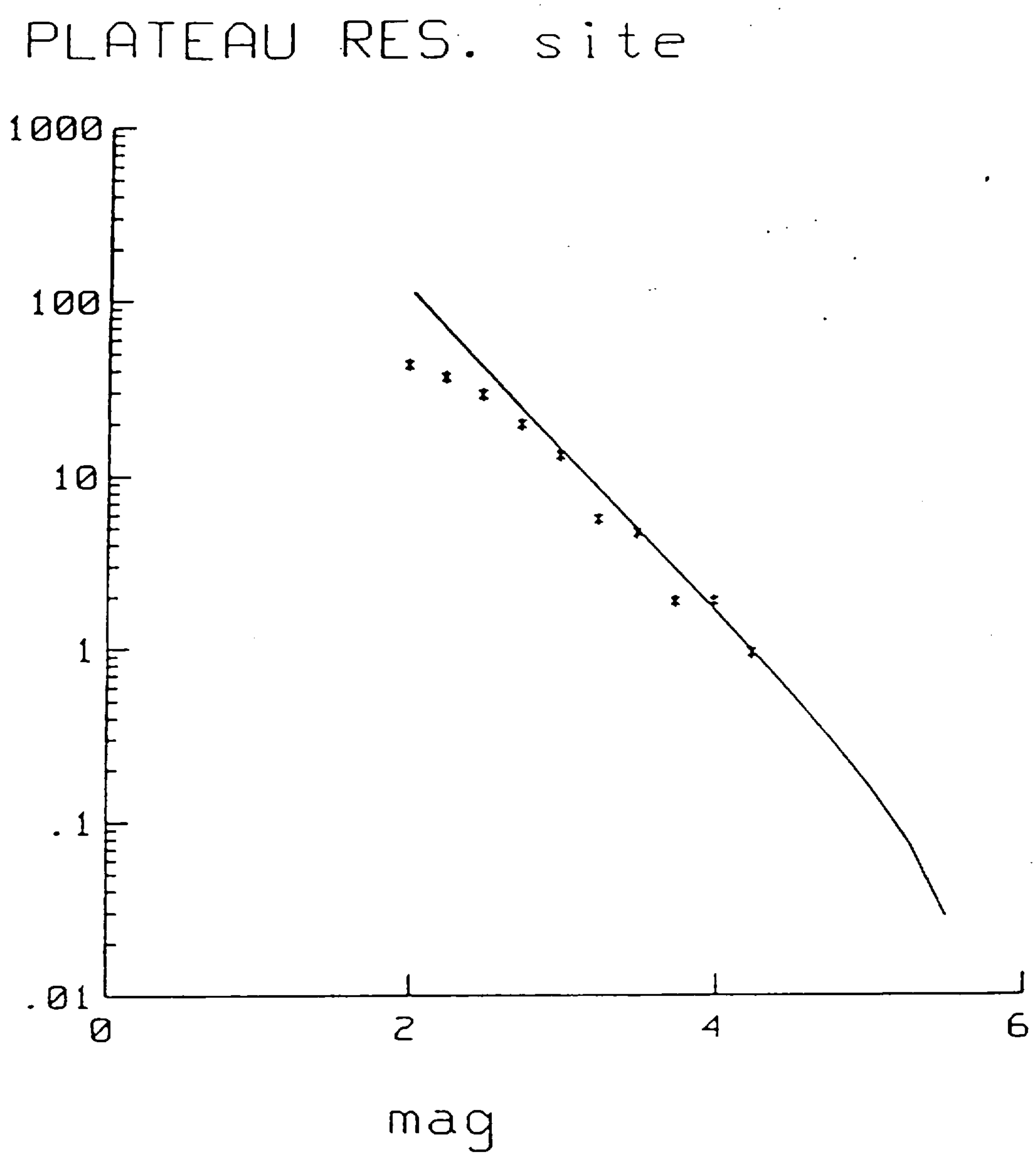


Figure 7.17 Fit of the truncated exponential model with $M_u = 5.75$ used in the hazard analysis or random earthquakes around the Plateau Resources Site. The data shown are for the last 30 years.

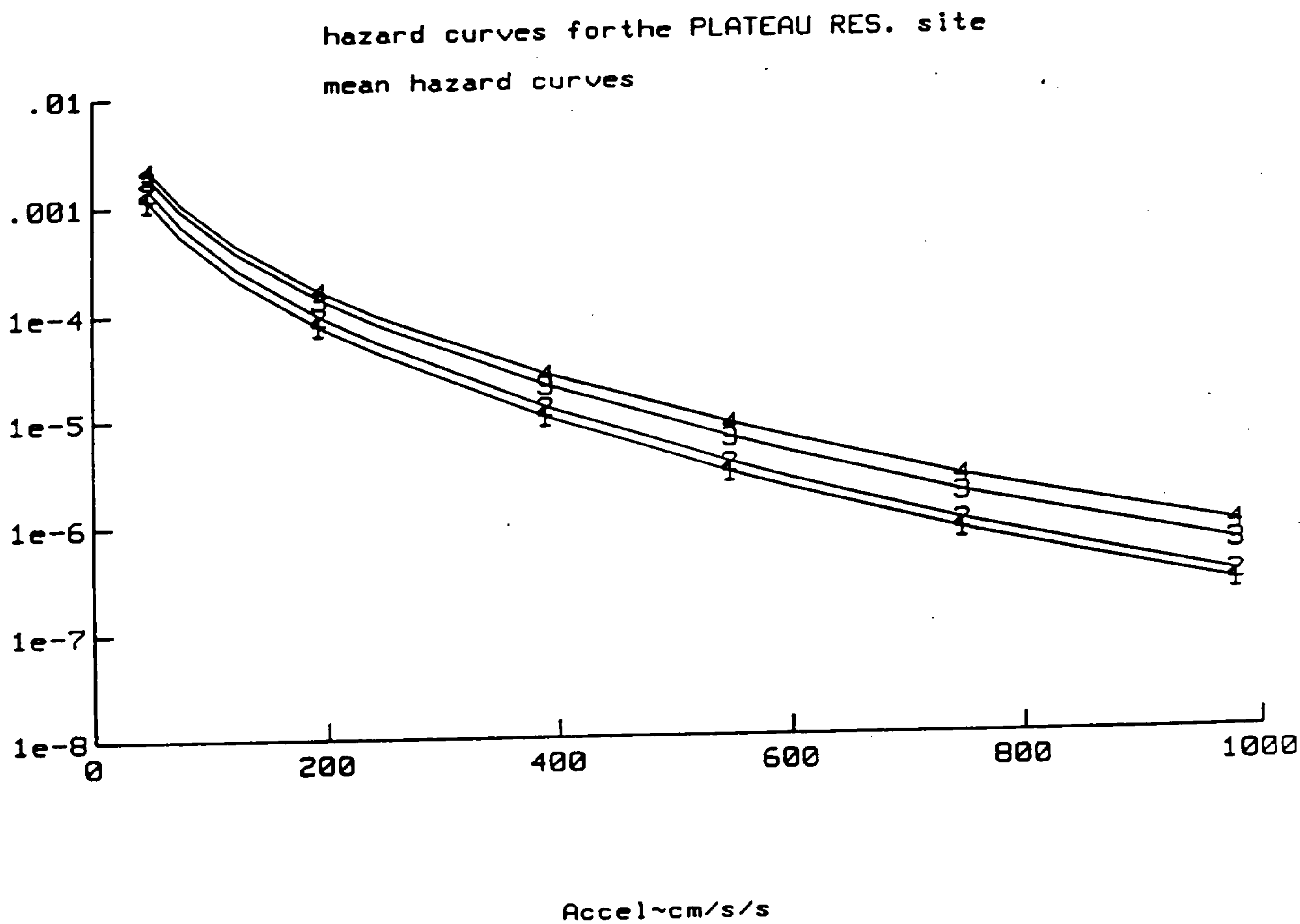


Figure 7.18 Hazard for peak ground acceleration (PGA) for the Plateau Resources Site for various best estimates for M_u . 1—1 $M_u = 5.5$, 2—2 $M_u = 5.75$, 3—3 $M_u = 6.25$, 4—4 $M_u = 7$.

8.0 WYOMING

8.1 Introduction

The nine uranium mill sites focused upon in this report are located in central and east-central Wyoming which is part of the Wyoming Basin physiographic province. This province lies between the Middle Rocky Mountains on the north and west, the Great Plains on the east, and the southern Rocky Mountains and the Colorado Plateau on the south and southeast.

The Wyoming Basin is characterized by deep structural basins and broad, asymmetric anticlinal uplifts that were formed principally during the Late Cretaceous to early Eocene Laramide Orogeny. The uplifts typically have exposed Precambrian rock cores, trend west to northwest, and are bordered on their southern and southwestern margins by Laramide-age thrust faults. Many of the Laramide thrust faults have been reactivated during the late Cenozoic as normal faults, resulting in the gradual collapse of the anticlinal uplifts. The distribution and orientation of late Cenozoic faults, therefore, is influenced strongly by the structural grain established during the Laramide Orogeny (Geomatrix 1988a, b).

8.2 Regional Geology

Fig. 8.1, taken from Case (1991), provides a map of the suspected active faulting in Wyoming. Also shown on Fig. 8.1 are the location of the sites. Case's (1991) report is a literature review and does not contain new field data. We have relied heavily on two reports by Geomatrix (1988a, b) which describes the extensive field work performed to evaluate faults that are significant to the sites included in this section.

Case (1991) does not define a criteria for what he terms active faults. Case writes that Wyoming has a number of know or suspected active faults shown in Fig. 8.1. He compiled the list from a large number of papers. The implication is that the list is comprised of all faults in Wyoming that have been recurrently active during the last 20 million years with an emphasis on faults that have been active during the Quaternary.

Geomatrix (1988a, b) states that a fault is considered active and a potential source of future earthquakes if it has experienced recurrent surface displacement during the late Quaternary (i.e. the Holocene and the latest Pleistocene). The two reports cover much of the same are and supplement the other report.

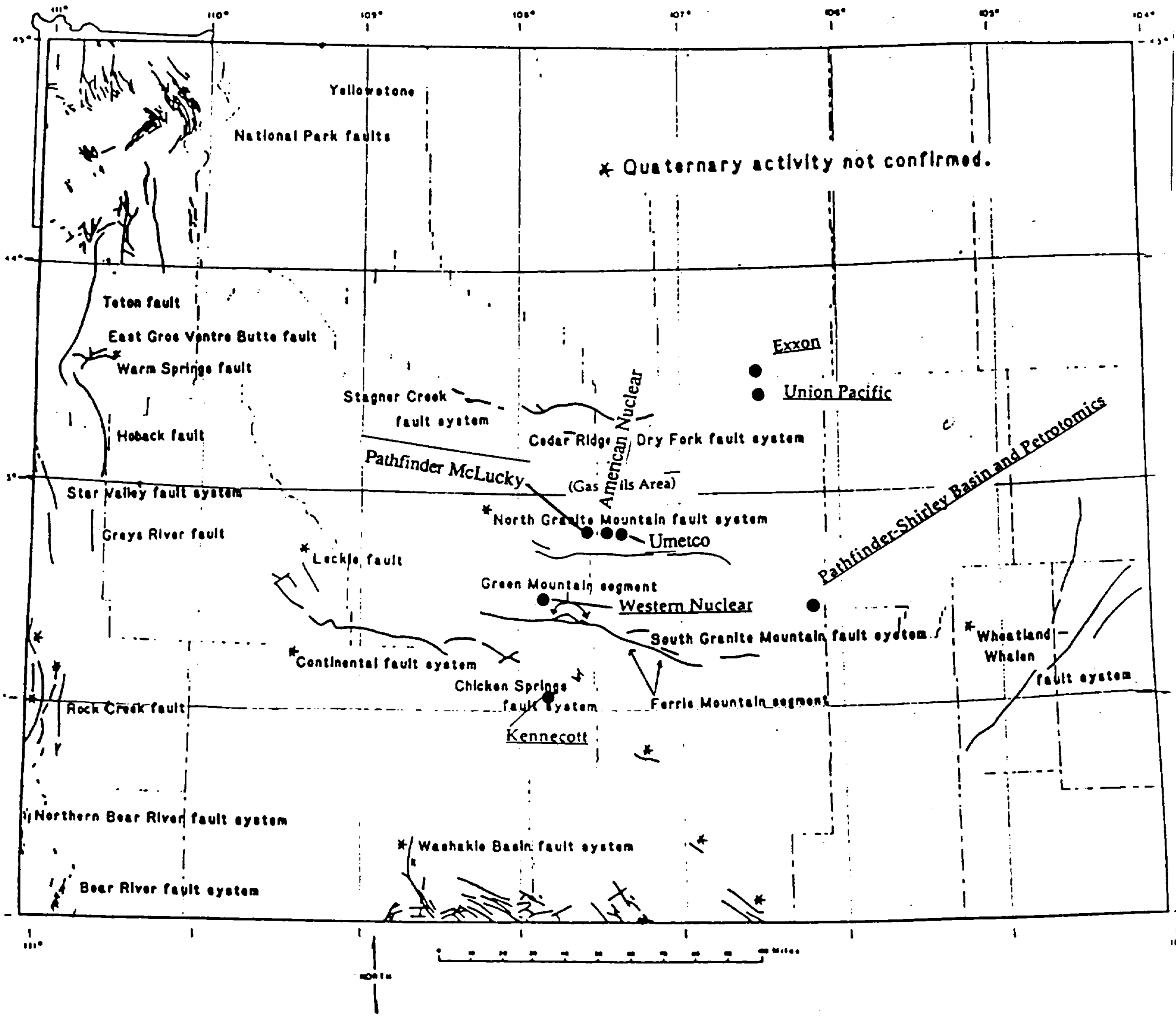


Figure 8.1 Suspected active faults in Wyoming and approximate locations of the sites involved in this study.

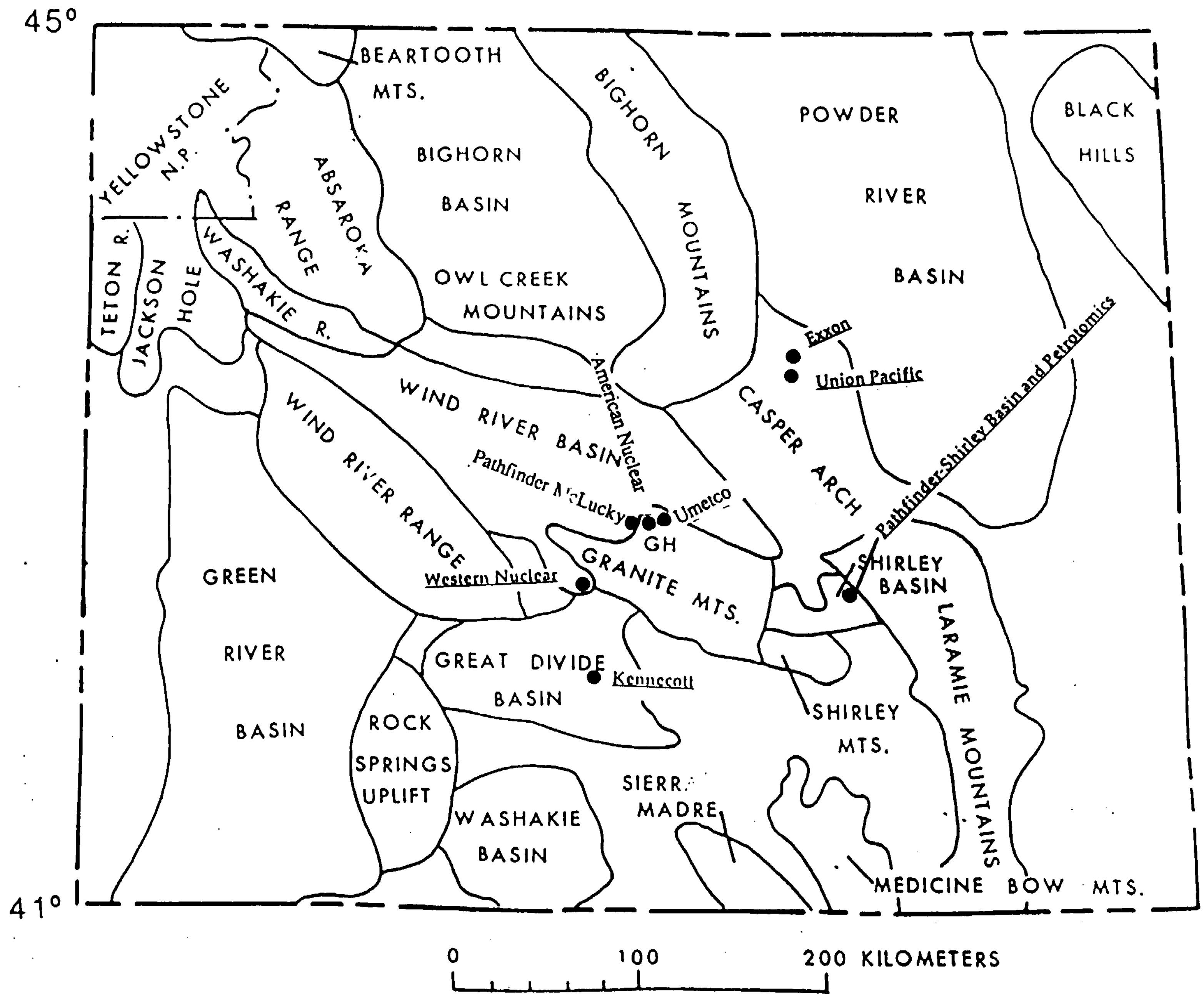


Figure 8.2 Wyoming basins and ranges (modified from Love, 1961). GH, Gas Hill uranium mining district.

There is a considerable difference in criteria between Case (1991) and the Geomatrix studies. The Geomatrix Criteria is approximately the criteria we would like to have used. However at most sites so little is know that it generally is not possible to employ a fixed criteria.

Considering the difference in criteria between Case (1991) and Geomatrix (1988a, b) it is not surprising that there are difference in interpretation between Case and Geomatrix with Case calling a number of faults as potentially active which Geomatrix (and LLNL) will consider inactive.

In Fig. 8.1 the North Granite Mountain Fault System, the Cedar Ridge- Dry Fork Fault System, and the Continental Fault System are included on a map of suspected active faults in Wyoming. These same faults are considered inactive in the Geomatrix report. Because the Geomatrix studies are based on extensive field studies, we are inclined to use their data and interpretations of the status of each of the faults.

The nine uranium mill sites are located in the following physiographic provinces: the Wind River Basin, Granite Mountains Region, Shirley Basin, Powder River Basin, and the Great Divide Basin (see Fig. 8.2). The following fault systems are those located nearest to each of the nine sites throughout central Wyoming:

Casper Frontal Fault

The Casper Frontal Fault is an east-west trending, 40 km long fault located along the northern boundary of the Laramie Uplift. The type of faulting is uncertain, but it has been mapped both as a down-on-the-north normal fault, and a south-dipping thrust fault. Initial deformation probably occurred during the Laramide Orogeny. No evidence of Quaternary activity has been reported and the fault is considered inactive (Geomatrix 1988a).

Cedar Ridge Fault

The Cedar Ridge Fault trends northwest along the southern margin of the Bridger and Bighorn Mountains. The 56 km long fault lies within a 3 km wide zone of folded and faulted Tertiary rocks located up to 6 km south of the Bighorn Mountains. It dips steeply at the surface but may be listric and may merge with the South Owl Creek Mountains fault at depth. The Cedar Ridge Fault has at least 610 m of down-on-the-north displacement. If the eastern end of the fault is continuous with the Dry Fork Fault, the Cedar Ridge/Dry Fork fault is about 80 km long.

Displacement occurred from the latest early Eocene to the late Eocene. Late Cenozoic activity was suspected by Witkind (1975) and Case (1986); Quaternary activity was reported by Thaden (1980b). This fault is considered to be inactive (Geomatrix 1988a).

Chicken Springs Fault System

The Chicken Springs Fault System consists of a west-to-northwest-trending cluster of discontinuous normal faults located 30 km south of the Sweetwater Arch. Mapped faults measure 3 to 30 km in length. Lineaments observed on aerial photographs may be related to bedrock jointing. This fault is considered to be potentially active since there is evidence of Quaternary activity (Geomatrix) (1988a).

Deer Creek Park Fault

The Deer Creek Park Fault trends northeast near the northwest edge of the Laramie Mountains. A fault trace approximately 21 km in length is defined by photogeologic lineaments (Geomatrix 1988). Geomorphic features indicative of Quaternary fault activity were not observed during investigations by Geomatrix for the 1988 evaluation. The fault is considered inactive (Geomatrix 1988a).

Dry Fork Fault

The Dry Fork Fault trends east-west along a linear stream valley at the southern end of the Bighorn Mountains. It measures 24 km long and its down-on-the-north displacement decreases to the northeast. The Dry Fork fault intersects and is most likely an eastern extension of the Cedar Ridge Fault described above.

Initial displacement occurred as southward thrusting of the Bighorn Uplift during the Laramide Orogeny. There is has been no evidence of Quaternary activity observed during recent investigations, and it is considered to be part of the Cedar Ridge Fault which is considered to be inactive (Geomatrix 1988a).

North Granite Mountains Fault System

This east-west trending, 95 km-long high-angle normal fault lies along the southern margin of the Wind River Basin. It is composed of three segments measuring 13, 66, and 38 km in length. It has been recurrently active over the last 20 million years, but there is no evidence for Quaternary activity (Geomatrix 1988b in Case 1991). Displacement of post-Pliocene deposits along the North Granite Mountains Fault has not been documented, although Love (1970) reports that the fault is a potentially active late Cenozoic structure (Geomatrix).

This late Cenozoic activity along the fault is suspected, but no evidence of Quaternary deformation was observed by Geomatrix during photogeologic, aerial reconnaissance and field investigations conducted for the 1988 evaluation. Geomatrix considers this fault inactive, and we concur for the purposes of our report.

Smith Creek Fault

The Smith Creek Fault trends northeast near the northwest edge of the Laramie Mountains. The fault has a discontinuous trace approximately 46 km long and has down-on-the-north stratigraphic displacement. deformation probably occurred during the Laramide orogeny, but late Cenozoic activity has not been reported. No evidence of Quaternary activity has been reported and none was observed during the aerial reconnaissance conducted by Geomatrix for their 1988 evaluation. The Smith Creek Fault is considered to be inactive (Geomatrix 1988a).

South Granite Mountain Fault

The South Granite Mountain Fault is a 135 km-long west-northwest trending normal fault which lies along the southern margin of the Granite Mountains. It dips steeply to the north and has a minimum post-Miocene displacement of about 650 m.

Two periods of movement have occurred along this fault system: during early Eocene when the Granite Mountains were uplifted at least 3 km, and during the Pliocene, when the fault system was reactivated and the Granite Mountains subsided (Love 1970).

The fault is considered to be a potentially active late Cenozoic structure, and evidence of late Quaternary activity was discovered during Geomatrix' investigation (Geomatrix 1988a).

The South Granite Mountain Fault is divided into five segments by Geomatrix (1988b) from east to west:

Seminoe Mountain segment
30 km long, considered inactive by Geomatrix (1988b).

Ferris Mountain segment
This segment is 17 km long. Vertical surface displacements range from 1 to 6 m. Scarp heights range from 2.9 to 12.2 m in trenches that were profiled. Trench analyses indicate vertical offset of .5 m per event in the late Quaternary (Case 1991). This segment is considered active by Geomatrix (1988b).

Muddy Gap segment
The Muddy Gap segment is 23 km long. Minor Quaternary displacement has occurred in the Muddy Gap directly south of the Gas Hills area (Case 1991). This segment is considered inactive by Geomatrix (1988b).

Green Mountain segment
This segment is 25 km long and lies 55 km southeast of the Gas Hills area. Vertical surface displacements of 4 to more than 20 m. Scarp heights range from 6.7 to 26.2 m. Multiple events can be interpreted in late Quaternary deposits (Case 1991). This segment is considered active by Geomatrix (1988b).

Crooks Mountain segment
25 km long, considered inactive by Geomatrix (1988b).

South Owl Creek Mountain Thrust

The South Owl Creek Mountain Thrust borders the southern end of the Owl Creek Uplift, Bighorn Uplift, and Casper Arch. It is a Laramide-age thrust buried by post-middle Eocene sediments. No evidence of Quaternary activity has been reported, and the fault is considered to be inactive (Geomatrix 1988a, b).

Wheatland-Whalen Fault System

This fault system is a zone about 140 km long that contains many discontinuous faults. Displacements are predominantly down-on-the-north along the southern section and down-on-the-south along the northern section.

Faulting may represent a partial reactivation of a northeast-trending Precambrian shear zone. Late Cenozoic activity is suspected, and the fault is considered to be potentially active by Geomatrix (1988b)

8.3 Regional Discussion Of Seismicity And Earthquake Hazards

The major center of earthquake activity in Wyoming occurs along the western part of the state in the Intermountain Seismic Belt which extends into Utah and Arizona. See Fig. 7.5. All of the sites in Wyoming are east of this region of high seismicity and the distance to the sites is sufficiently large that the ground motion at the sites from earthquakes in this zone of high seismicity are not an important contributor to the seismic hazard.

All of the Wyoming sites are located in the Wyoming Foreland Structural Province (Geomatrix 1988b). This is a large province of relatively low seismic activity with a few active faults. For the most part there is a poor correlation between the historical earthquakes and known tectonic structure.

Because there are only a few major active faults in the Wyoming Foreland Structural Province in which the sites are located, and a simple seismotectonic source zonation for the random earthquake hazard is used in this study, it is useful to introduce a general discussion of establishing M_u for the deterministic analysis for each of these faults in this section along with the analysis for the random earthquake. Any site specific issues and estimation of the ground motion is given in the appropriate subsection for each of the sites.

Deterministic Analysis

As discussed in the Regional Geology section, Case's (1991) report identifies the faults in Wyoming that are considered to be active or are suspected active. In our review of the literature we did not find any additional faults which might be considered active.

Of the faults listed by Case (1991) as potentially active, the following are sufficiently close to at least one site to be significant:

1. Stagner Creek Fault
2. Cedar Ridge - Dry Fork Fault system
3. North Granite Mountain Fault system
4. South Granite Mountain Fault system
5. Continental - Flattop Fault systems
6. Chicken Springs Fault System
7. Wheatland - Whalen Fault system

There are several other major faults near the sites that are not considered active or having had Quaternary movement. These include the Owl Creek Mountain Thrust, the Casper Frontal Fault, the Smith Creek and Deer Creek Park Faults, and the Alcova Fault. All of these faults were examined by Geomatrix (1988) and they could find no evidence of Quaternary movement. There is no indication in the literature that any of these faults are considered to be active.

In the geology discussion, each of the six faults that have some indication of activity are discussed. As noted above, the Geomatrix (1988b) report is the most definitive recent study of the faults of interest. They found that only the South Granite Mountain Fault system, the Chicken Springs Fault system, Stagner Creek Fault and the Wheatland - Whalen Fault system were active or at least had Quaternary movement.

Estimation for M_u for Active Faults

Stagner Creek Fault

This is a relatively minor (compared to the South Granite Mountain Fault System) fault that has Quaternary activity. The fault is approximately 120 km from the nearest site. This fault is sufficiently distant and short so that it does not contribute to the deterministic hazard at any of the sites.

South Granite Mountain Fault System

Geomatrix (1988b) carried out extensive field investigations of this fault system. As discussed in the geology section, there are only two segments of this fault that show Quaternary movement, the Ferris Mountain and Green Mountain segments. The Ferris Mountain segment is 18 km and the Green Mountain segment is 24 km long. Geomatrix (1988b) used a number of relations to estimate M_u. Because of their extensive field investigations, they developed additional data that they used to improve upon the estimate for M_u rather than just simple fault length that we have e used elsewhere in this report.

For the Ferris Mountain segment, Geomatrix (1988) estimated a range of M_u between 6.4 to 6.9 with a preferred value of 6.6. For the Green Mountain segment, they obtained a range of M_u between 6.6 to 6.8 with 6.75 as the preferred value.

Because of the activity on the Green Mountain and Ferris Mountain segments, it is hard to totally dismiss the potential for activity in the other segments. The two segments of most interest are the Crooks Mountain segment and the Seminoe Mountains segment. The Crooks Mountain segment is approximately 30 km long and the Seminoe Mountain segment is also approximately 30 km long. Because no Quaternary movement is observable it seems reasonable to assume that, the largest earthquake that could occur would be $M<6.5$. Recall that $M>6.5$ generally lead to surface rupture. We use a value of $M_u = 6.4$ for this segment.

There is some very low probability that a single event could rupture two segments of the fault system. This would give a rupture length of about 50 km. This would give approximately a $M_u=7$ to 7.1. Based on the available data, which seems reasonably good, this should be considered a very unlikely event.

Chicken Springs Fault System

The fault shows surface expression for approximately 15 km. As discussed in the geology section, there is some evidence that the fault is longer, up to 30 km. However, based on the observed surface expression, it seems reasonable to use 15 km as the length to compute M_u. This gives approximately a $M_u=6.4$. A 30 km length would give $M_u \sim 6.8$.

Wheatland - Whalen Fault System

Sufficiently far from all sites so that the level of ground motion expected from earthquakes on this fault system is much less than from the random earthquake hazard at a PE level of 10^{-4}.

Hazard Analysis For Random Earthquakes

As previously noted, all of the Wyoming sites are located in the Wyoming Foreland Structural Province (Geomatrix 1988b). This province is a large region bound approximately on the west by the Idaho-Wyoming Thrust Belt (part of the Intermountain Seismic Belt) to approximately 104W longitude and from 40N to 45N latitude. This is a region of a historically low level of seismic activity as contrasted with the much more active Intermountain Seismic Belt.

The epicenters of the all historical earthquakes $M>1.5$ are shown on Fig. 8.3. Fig. 8.3 includes some events located in the Intermountain Seismic Belt - however none of these events are included in data used to develop the earthquake recurrence models discussed below.

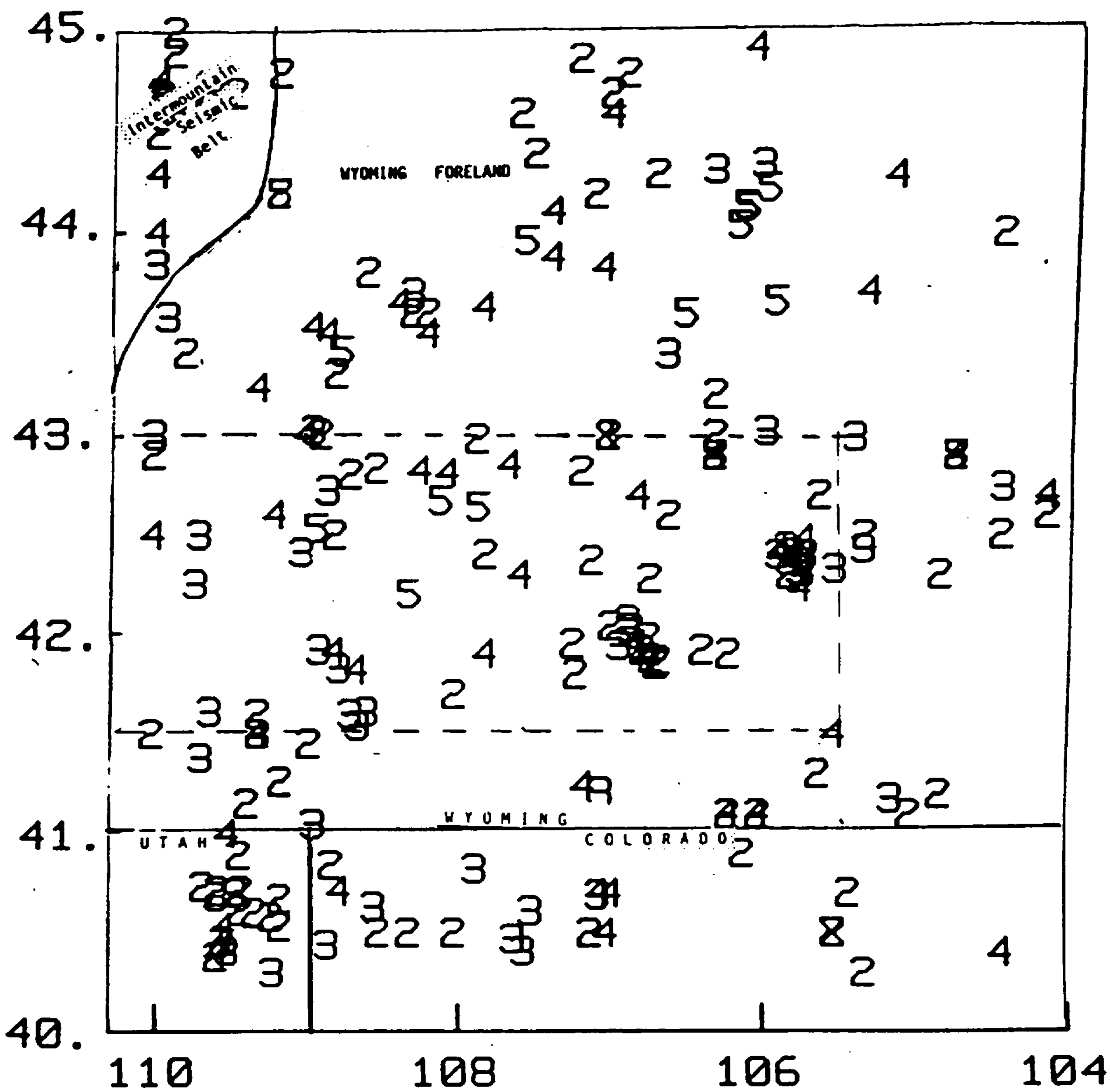


Figure 8.3 Map showing seismicity in the Wyoming foreland structural province. The magnitude of the earthquake is denoted by the number, e.g., 5 is M ~ 5 to 5.5 event. X for M>6. Also shown by dashed lines is the outline of the Central Seismic Zone.

In the Wyoming Foreland Province, there is a relatively poor correlation between the observed seismicity and the known geology east of the Intermountain Seismic Belt. Thus it is reasonable to assume that earthquakes can occur randomly anywhere in the region. A value for M_u in the 6 to 6.5 range seems reasonable for the random earthquake. This selection is based on discussions with Professor W. Arabasz of the University of Utah, and our reading of the literature. The largest earthquake in the region east of the Intermountain Seismic Belt is approximately a magnitude 6.2. This earthquake occurred in 1882, hence its estimate has considerable uncertainty.

The overall approach we used to estimate the seismic hazard from random earthquakes for the Wyoming sites is discussed in the section on methodology. The details of our analysis are described below.

First, we sorted all of the earthquakes in the Wyoming Foreland Province. We examined the data to see if any patterns of seismic activity existed which might suggest more than one zone. We determined that the central region bounded by 109.7W to 105.5W and 41.5N to 43N had a higher seismicity rate than the entire Foreland province. This might in part be due to the fact that this central region contains several faults which are considered active (based on field evidence) as contrasted to the rest of the Wyoming Foreland Structural Province. For simplicity, we will refer to this region as the Central Region Seismic Zone.

It should be noted that there is not enough data to develop recurrence models for any of the faults considered to be active. Thus it is not possible to include specific faults in the probabilistic hazard analysis. The specific faults are included in the deterministic analysis for each site. We performed two probabilistic seismic hazard studies. One, for the sites located in the central region we used the recurrence models based on the earthquakes in just the central region. For the rest of the sites we used a recurrence model based on all of the earthquakes in the Wyoming Foreland Province which is slightly conservative.

Wyoming Foreland Zone

All of the sites could be considered as located in the Wyoming Foreland Structural Province. We applied Stepp's (1972) method to the historical earthquake catalog in this province to look for completeness intervals. We found completeness only for about the last ten years for smaller events (M~3) and completeness for M<5 for about 30 years. Fig. 8.4a shows our fit of the truncated exponential model with M_u=6.25. to the data for the last 10 years, Fig. 8.4b for the last 30 years, and Fig. 8.4c for the last 50 years of data. We see from these Figures that in the ranges where we have completeness, the recurrence model fits the data reasonably well. Our fit is

$$\log N = 2.723 - 0.7M$$

We note that Geomatrix (1988b) developed a recurrence model for the Wyoming Foreland Province. Their model is

$$\log N = 4.29 - 1.11M$$

These two models have the same rate at M = 3.8 however are very different at higher magnitudes. Our fit to the data for very incomplete data for the last 100 years is shown in Fig. 8.5a and the Geomatrix (1988b) fit is shown in Fig. 8.5b. The Geomatrix model fits the data well above M = 4. However, the completeness analysis suggests that above M = 4 there is only completeness for the last 30 years, and above 5 there is no interval of completeness. This is further illustrated by the fact that the catalog has 41 events M>4 of which only 12 before 1963 and 29 since 1963. Thus we would give the Geomatrix (1988b) model a low weight.

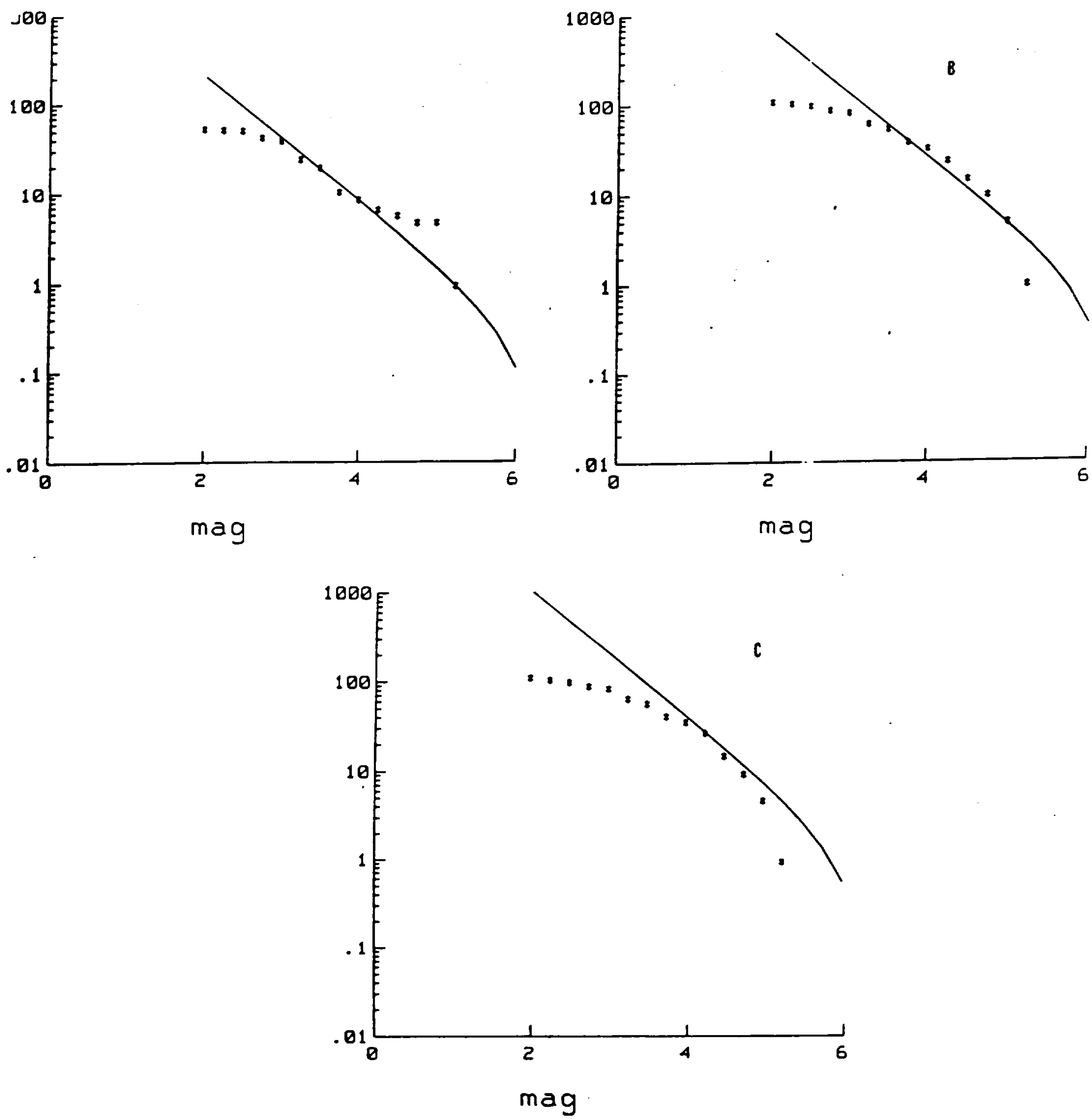
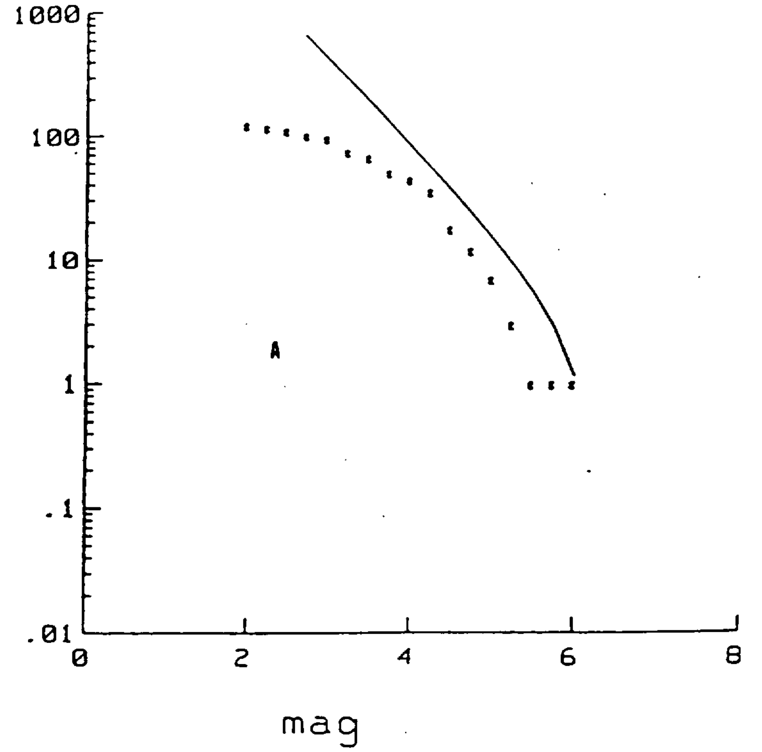


Figure 8.4 Fit of the truncated exponential model with M_u = 6.25 to the data in the Wyoming Foreland structural province: a- for the last 10 years, b- for the last 30 years, c- for the last 50 years.



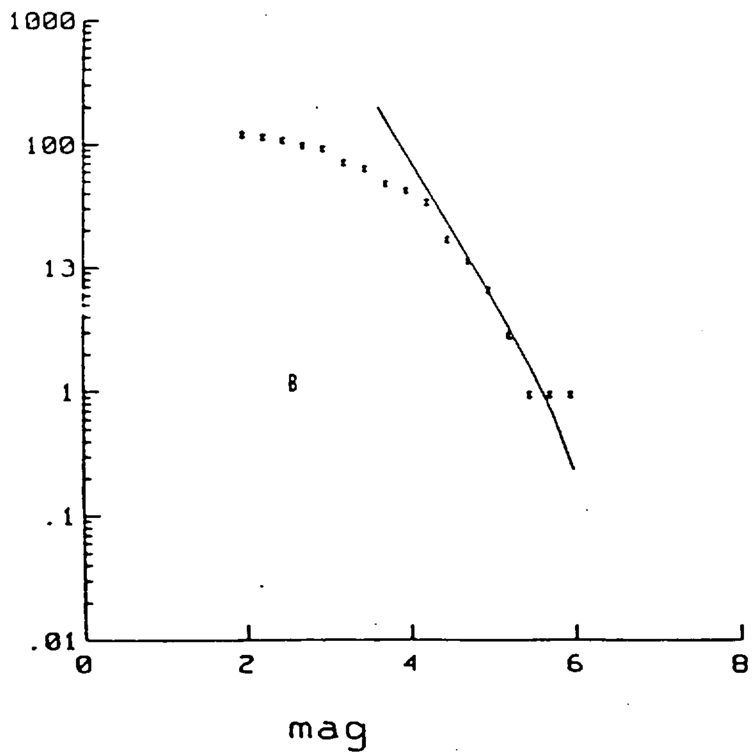


Figure 8.5 a) Fit of LLNL's truncated exponential model to the data for the last 100 years. b) fit of Geomatrix (1988) model for the data for the last 100 years.

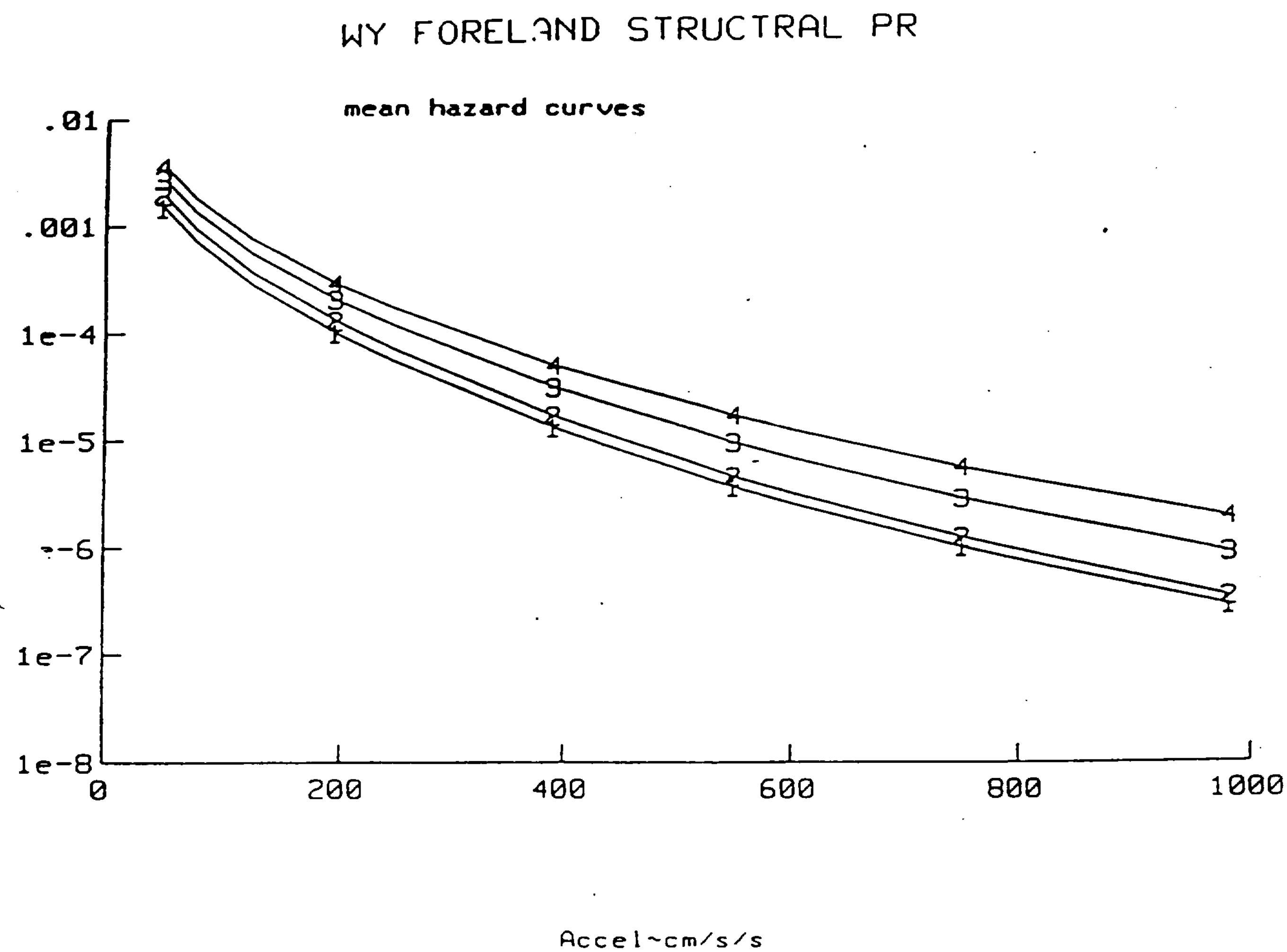


Figure 8.6 Hazard curves for peak ground acceleration (PGA) for the random earthquake in the Wyoming foreland structural province for several values of M_u. 1—1 $M_u = 5.5$, 2—2 $M_u = 5.75$, 3—3 $M_u = 6.25$, 4—4 $M_u = 7$.

As noted in the methodology section, we used a range of values for M_u and a factor of two uncertainty on the rate. The results for the hazard analysis for the random earthquake are shown in Fig. 8.6 for a range of M_u of 5.5, 5.75, 6.25, and 7. A value of $M_u = 6.25$ appears reasonable based on the historical record. The magnitude of the largest event in the province is unknown as it occurred in 1882. The event has been estimated to be as large as $M_L = 6.5$ which is the upper limit for M_u for the hazard curve for a best estimate value for $M_u = 6.25$.

Using the criteria discussed in Section 3.3, we see from Fig. 8.6 that at 10^{-4} PE level for $M_u = 6.25$ the PGA = 0.27g. The range of PGA at 10^{-4} for the range of M_u considered is from 0.2g to 0.3g. We examined the impact of using the Geomatrix (1988b) model in place of our recurrence model. For the Geomatrix model we found that the PGA at a PE level of 10^{-4} was 0.17g for $M_u = 6.25$ as compared to 0.27g for our recurrence model. For the reasons discussed above, we give the results based on the Geomatrix recurrence model a low weight. At a PE level of $5x10^{-4}$ the PGA value ranged from 0.09g to 0.15g.

Central Region Seismic Zone

The American Nuclear Gas Hills site, the Kennecott site, both the Pathfinder Lucky Mc and Shirley Basin sites, Petrotomics site, Umetco site and Western Nuclear site fall within what we have termed the Central Region Seismic Zone.

As discussed in Section 3.4, we applied Stepp's method to look for intervals of completeness. Examination of the results indicate that earthquakes in the 3.5 to 4.5 range were relatively complete over the last 30 years. No completeness was observed for either smaller or larger events. Fig. 8.7 shows the fit of the truncated exponential model for $M_u = 6.25$ to the data since 1963. The simpler Richter model is given by the relation

$$\log N = 4.314 - 0.8M$$

The hazard curves for best estimate values of M_u of 5.5, 5.75, 6.25 and 7 are shown in Fig. 8.8. At a PE level of 10^{-4} the PGA level varies from 0.25g to 0.37g with a value of 0.33g for $M_u = 6.25$. At a PE level of $5x10^{-4}$ on PGA ranged between o.14g a=to 0.2g.

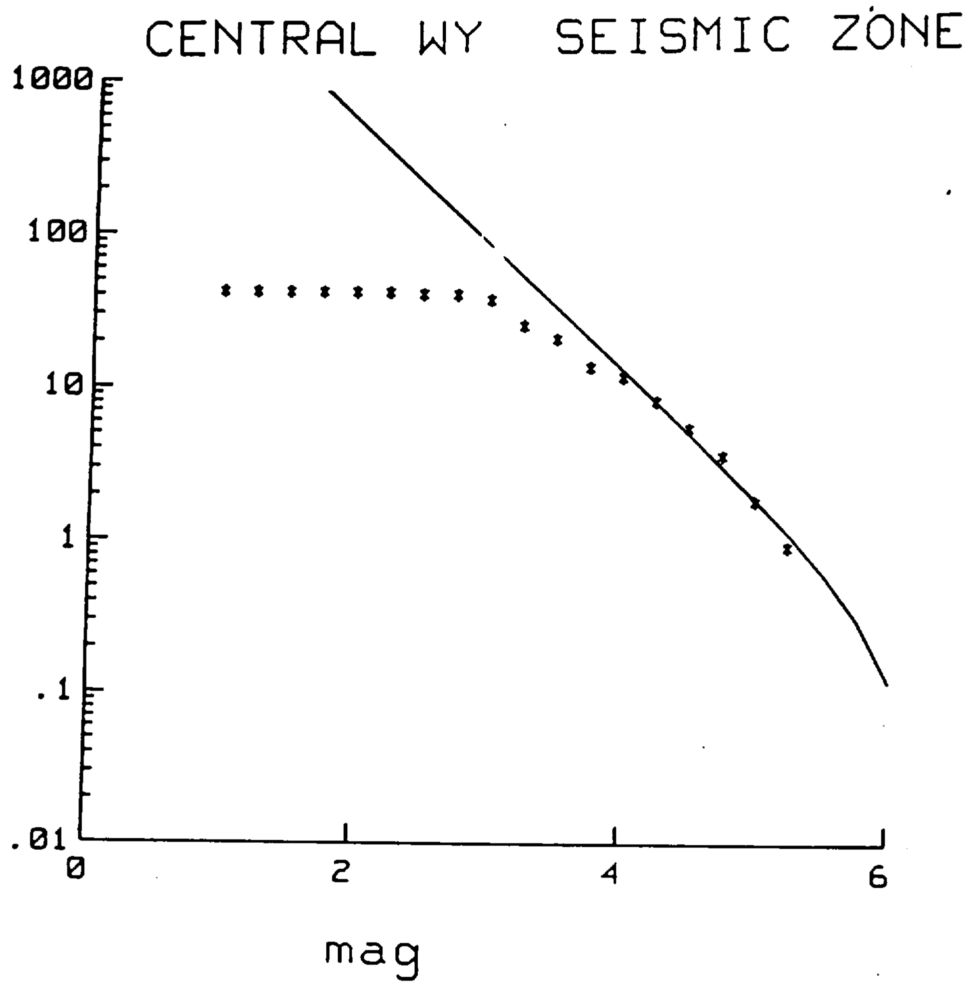


Figure 8.7 Comparison of the truncated exponential model used in the hazard analysis to the data in the central seismic zone for the last 30 years

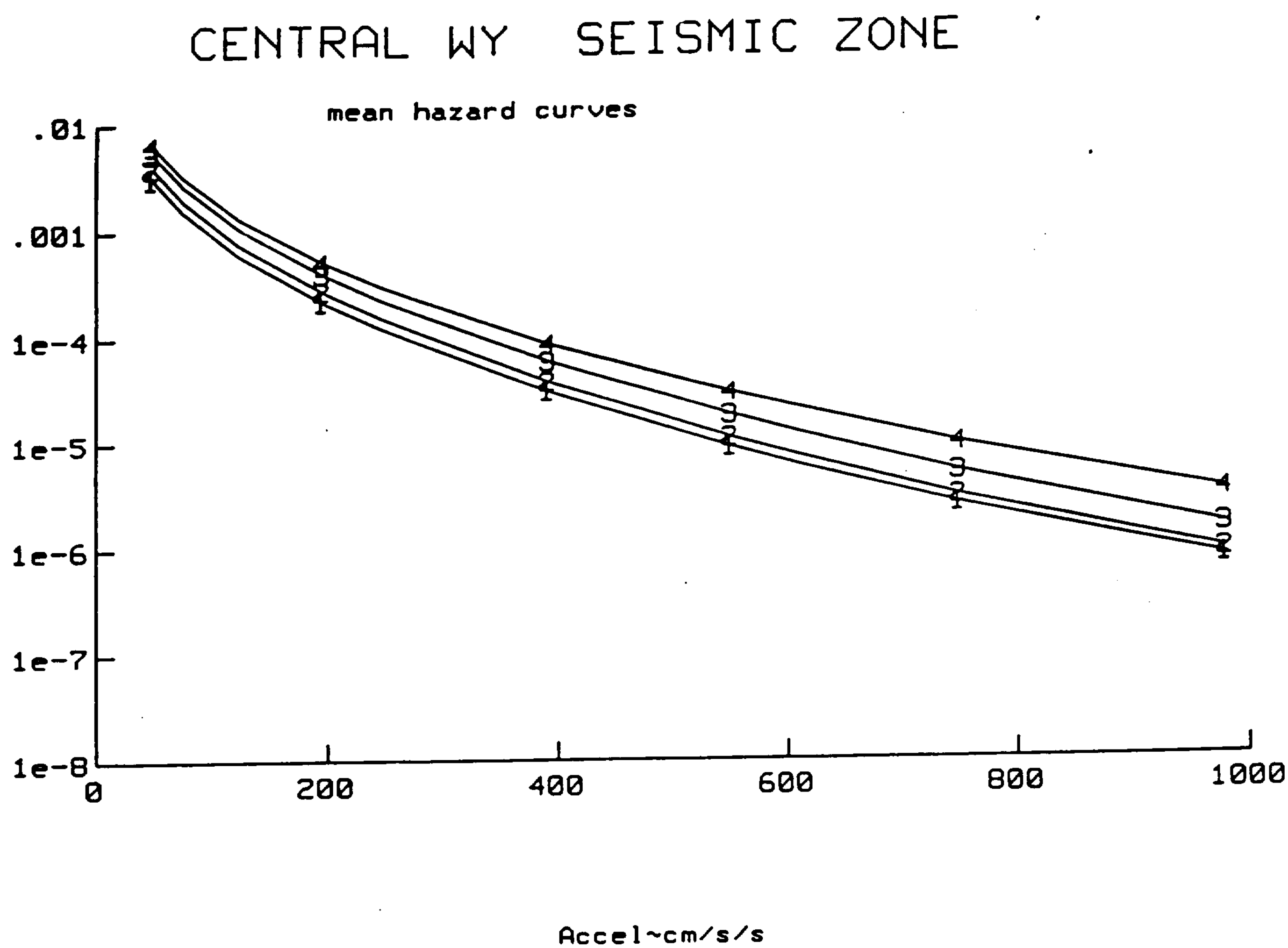


Figure 8.8 Hazard curves for peak ground acceleration for random earthquakes in the central seismic zone for several values of M_u. 1—1 $M_u = 5.5$, 2—2 $M_u = 5.75$, 3—3 $M_u = 6.25$, 4—4 $M_u = 7.0$.

8.4 Granite Mountains Region

Western Nuclear

Split Rock and Day Loma

8.4.1 Introduction

The Split Rock Mill is located 3 km northeast of Jeffrey City in the Wyoming Basin geographic province, in the Granite Mountains in the west-central portion of the Sweetwater Plateau (see Fig. 8-9). The Day Loma heap leach is one of Western Nuclear's ancillary leach facilities located in the Gas Hills northeast of the mill site. Although no site-specific literature on the Day Loma heap leach was found, its location in the Gas Hills sites allows it to be grouped with the mills located in the Gas Hills area for all aspects of the hazard analysis.

8.4.2 Regional Geology

The topography of the area is characterized by broad, flat valleys with granite hills and mountains. The Sweetwater Plateau is a fault block which was uplifted during the Laramide Orogeny, and then subsided in middle Miocene time, resulting in the Formation of east-west trending structures such as the Granite Mountain Graben. The plateau extends from the toe of the Wind River Mountains southeastward to the Hanna Basin.

Site Geology

The Split Rock mill is located at the head of two valleys between granite ridges just south of the Sweetwater River. The base of the valleys is formed by the eroded Precambrian granite surface. These valleys were later filled at varying depths with the Split Rock Formation during Miocene time, and more recently with dune sands and mill tailings.

Bedrock in the site vicinity is composed primarily of Precambrian granitic rocks and the Arikaree Formation. The Split Rock Formation overlies the granite and consists mainly of poorly cemented sandstones with small amounts of conglomerate, limestone, and claystone. This Formation thins near the granite outcrops, yet is more than 457 m deep in other areas near Jeffrey City.

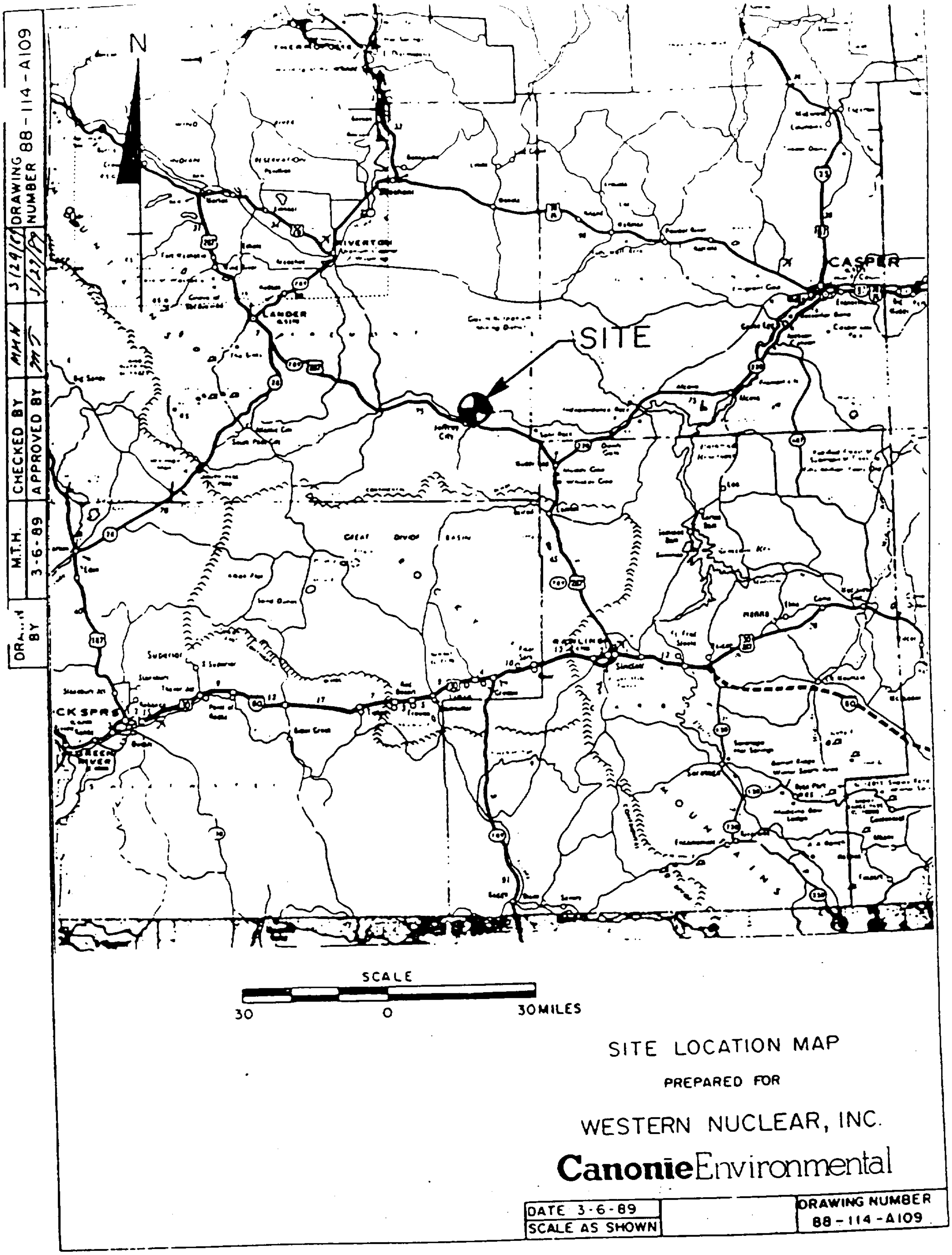


Figure 8.9 Site Location Map

8.4.3 Tectonics and Faulting

The Split Rock Mill is located on the east side of the Central Rocky Mountains in south-central Wyoming. Tectonically, the region can be divided into three seismotectonic provinces; the Yellowstone Province, the Rocky Mountain Province, and the Central High Plains Province. These divisions are based upon the type and age of the rocks and the age and style of deformation, as well as levels of stress release as indicated by size and frequency of earthquakes.

The mill is located in the Central High Plains Province which is characterized by a gently eastward-sloping plain consisting largely of Early to Middle Tertiary terrestrial sediments shed from the uplifted Rockies to the west. Later differential block faulting and subsidence produced a terrain of northwest trending uplifts and intermontane basins. The Central High Plains Province is characterized by low to intermediate level, infrequently occurring earthquakes reflecting different levels and regimes of stress release (D'Appolonia 1977).

The mill lies in a graben bounded by steeply dipping east-west-trending normal faults. The nearest fault systems to the site are the North Granite Mountain Fault System and the South Granite Mountain Fault system. The North Granite Mountain Fault System lies about 20 km north of the mill site. The South Granite Mountain Fault system lies about 10 km south of the site.

It was concluded through extensive field work by Geomatrix (1988b) that the North Granite Mountain Fault system is not active, and for the purpose of this report, we concur. However, Geomatrix (1988b) based on their field investigations believes that the South Granite Mountain Fault system is active.

8.4.4 Seismicity and Earthquake hazard analysis

Deterministic Analysis

This site is only 10 km from the Green Mountain segment of the South Granite Mountain Fault System which totally dominates the hazard at the site. In the discussion of the regional faults Section 8.3 we estimated M_u for the Green Mountain segment as $M_u \sim 6.75$. This leads to an estimate for PGA at the 1-sigma level of 0.55g and 0.3g at the median level.

We also noted in our general discussion that there was some low probability that two segments of the fault could rupture in a single event. The two segment case would lead to an estimate of $M_u \sim 7$ to 7.1. Because of the very low probability of this event, use the median estimate for the motion for PGA which is 0.36g.

Analysis for a Random Earthquake

This site is located in what we termed the Central Region Seismic Zone. The hazard curves are given on Fig. 8.8 discussed earlier in this report. The estimate for PGA at 10^{-4} PE level is 0.25 to 0.37g. This is less than estimated from the deterministic analysis. At a PE level of 10^{-4} and $M_u = 6.25$ the PGA is 0.33g and $5x10^{-4}$ it is 0.18g. At a PE level of $5x10^{-4}$ the PGA varied between 0.14g to 0.2g.

8.4.5 Conclusions

There are no known faults in the vicinity of the site, so surface rupture does not appear to be a problem. Because of the site's close proximity to the active Green Mountain segment of the South Granite Mountain Fault system, the estimated PGA for the site deterministically varies between 0.3g to 0.55g.

As noted in Section 4.4.9 the facilities at this site appear to have been designed to 0.08g. There is a very significant difference between the value for ground motion used for design and our estimate of the appropriate ground motion level to use for evaluation of the safety of the facilities. This is a source of serious concern. The facilities need to be carefully evaluated to determine if safety problems exist or if some remedial action is required.

8.5 Great Divide Basin

Kennecott – Sweetwater

8.5.1 Introduction

The Kennecott - Sweetwater Mill is located in Sweetwater County, Wyoming approximately 70 km northwest of Rawlins (See Fig. 8.10). The facility lies within the Red Desert in the east-central portion of the Great Divide Basin, about 8 km north of the closed lakes that occupy the topographically lowest part of the basin.

8.5.2 Regional Geology

The Great Divide Basin, part of the Wyoming Basin physiographic province, is marked by elongated ridges and isolated buttes. It is a closed basin, and as such, no surface drainage leaves the basin. The Sweetwater Basin is almost completely surrounded by major structural uplifts, including the Sweetwater Uplift to the north and northeast, and the Rawlins Uplift to the east and southeast, the Rock Springs Uplift to the west, and the Wind River Uplift to the northwest. During and subsequent to deposition of the Battle Spring Formation and Wasatch Formation, the region was downwarped creating the Great Divide Basin. The uranium mineralization intruded as roll fronts during this time in the Battle Spring Formation. The downwarping created several secondary synclines and anticlines within the basin. In the Sweetwater Mine area, one of these secondary folds causes the beds to dip to the northwest approximately 15.24 m per km (Minerals Exploration Company 1982).

Site Geology

About 7000 m of sedimentary rocks, ranging in age from Cambrian to Miocene, overlie the crystalline basement rocks at the Kennecott - Sweetwater site. The Battle Springs Formation is the only deposit exposed at the surface within the immediate vicinity of the tailings area. It extends to a depth of approximately 1525 m, and consists of a medium to very coarse-grained arkosic sandstone with interbedded discontinuous fluvial silts. The beds are nearly horizontal and dip northwestward at an angle of less than one degree. Underlying the Battle Spring Formation is the early to early-middle Eocene age Wasatch Formation, which consists of sands, silts, clays, lignites, and coals deposited primarily in a lacustrine environment (Minerals Exploration Company 1982).

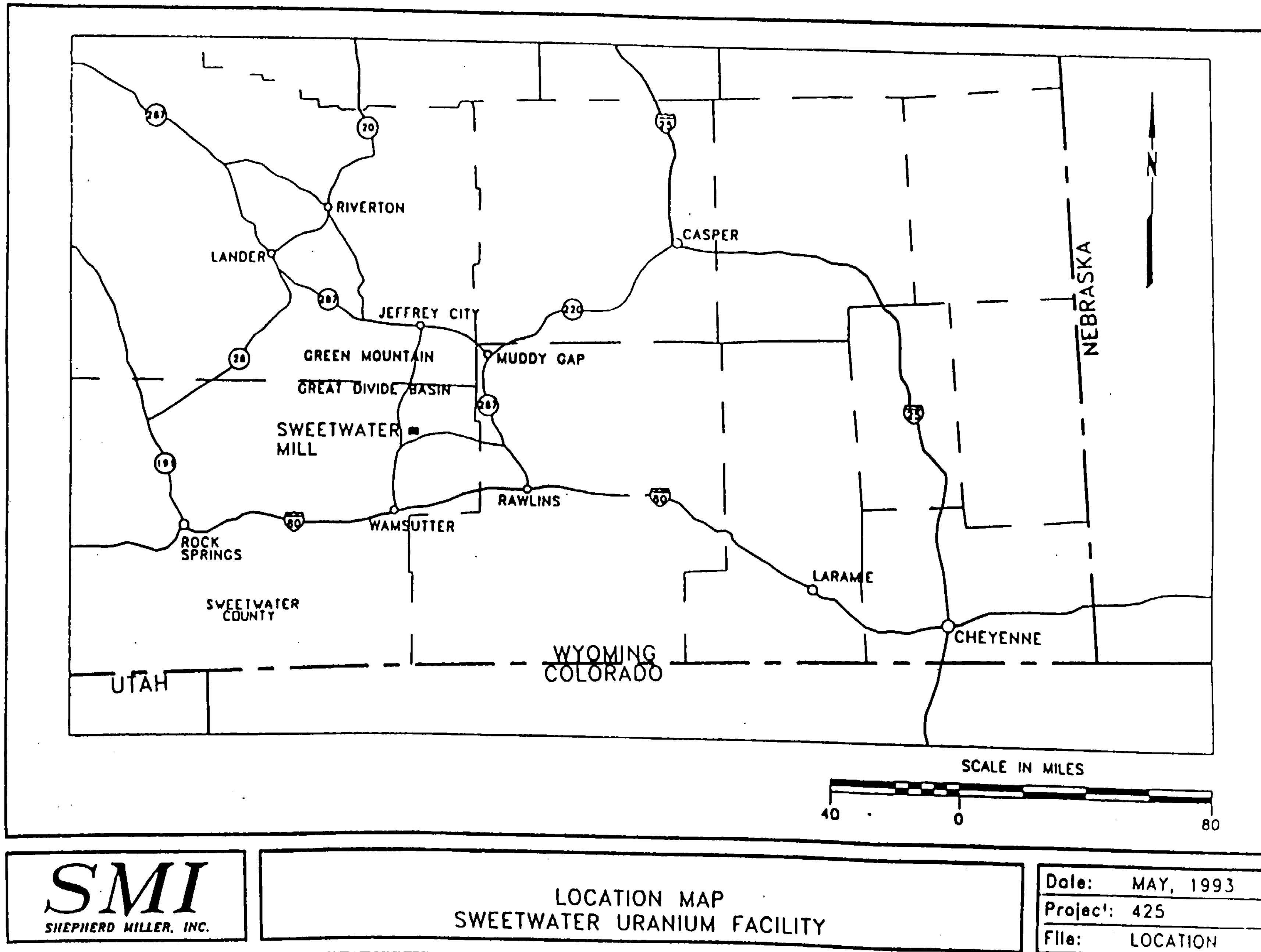


Figure 8.10 Location Map - Sweetwater Uranium Facility

8.5.3 Tectonics and Faulting

The nearest known faults are the Flattop Fault and the Chicken Springs Fault, located approximately 15 km northwest and northeast of the site. Geomatrix conducted field studies on these faults and found that the Flattop contains no evidence of Quaternary movement and they considered it an inactive fault. The Chicken Springs Fault contains some evidence of Quaternary activity and was considered potentially active (Geomatrix 1988b).

A minor fault exists 13 km southwest of the site, but no seismic activity information is available for this fault. According to the extensive field studies by Geomatrix in (1988b), the nearest known active fault is the Green Mountain segment of the South Granite Mountains Fault system located approximately 40 km north of the site. On the Geologic Map of Wyoming, this site is surrounded on the north, east, and south sides by segmented faults as close as 10 km away. The lengths of these faults range from 3 to 12 km. We have no reason to believe that any of these minor faults are active.

A lineament analysis was performed by Sheperd Miller Inc. which revealed no apparent fault traces, major fractures, joint patterns, or scarps within a 8 km radius of the site.

8.5.4 Seismicity and Earthquake Hazards

Deterministic Analysis

The Chicken Springs and South Granite Mountain Fault systems contribute to the seismic hazard at this site.

South Granite Mountain Fault System

The active Green Mountain segment is approximately 40 km from the site. The estimate for M_u, as discussed earlier, is $M_u \sim 6.75$. The 1-sigma estimate for PGA is 0.14g and the median estimate is 0.08g. We noted that there was also some low probability that two segments could rupture in a single event leading to a $M_u \sim 7$. The median estimate for this event for PGA is 0.09g.

Chicken Springs Fault System

The Chicken Springs Fault system is approximately 15 km from the site. We estimated that M_u for the Chicken Springs Fault system is 6.4. The estimate for PGA at the 1-sigma level is 0.33g with a median estimate of 0.18g. We also note that at a very low probability, this Fault System could support $M_u \sim 6.8$. To account for the low likelihood of this event we think it is reasonable to use the median estimate of PGA which is 0.22g.

Analysis for Random Earthquakes

This site falls within what we have termed the Central Region Seismic Zone. The hazard curves are given on Fig. 8.8. The range for PGA from this Fig. at the 10^{-4} PE level is 0.25g to 0.37g. Because the site is near the boundary of the Central Region Zone and there are no large faults in the vicinity of the site, we would select a value of 0.25 to 0.33g for the random earthquake. At a PE level of 5×10^{-4} the PGA varies between 0.14g to 0.2g.

8.5.5 Conclusions

We see no evidence that there are any active faults within the site boundaries. The most likely source of earthquake hazard is from a random earthquake. However, the Chicken Springs Fault system is

also a potential source of an earthquake. Our estimate for PGA at the site varies between 0.18g to 0.33g.

As noted in Section 4.4.3, we were unable to determine what value for PGA was used for design. It appears that seismic ground motion was considered to be too low to be significant in design. The actual design reports would need to be reviewed. This is of considerable concern as the critical facilities need to carefully be evaluated to see if sufficient margins exist or if some remedial action is required in light of our ground motion estimates.

8.6 Shirley Basin

Pathfinder & Petrotomics

8.6.1 Introduction

The Pathfinder - Shirley Basin and Petrotomics mines are located adjacent to one and the other in a remote area of Carbon County, approximately 75 km south of Casper in the Shirley Basin of southeastern Wyoming (See Fig. 8.11). The Basin comprises four geographic units: the Shirley Basin, Bates Hole, Bates Creek Drainage, and the Laramie Mountains. This is an area of low to moderate relief with perennial streams draining all four subareas. Paleozoic sediments are fully represented in the Basin and consist of a thick series of marine, littoral and continental sediments including limestone, sandstone, shale, mud, silt, and claystone.

8.6.2 Regional Geology

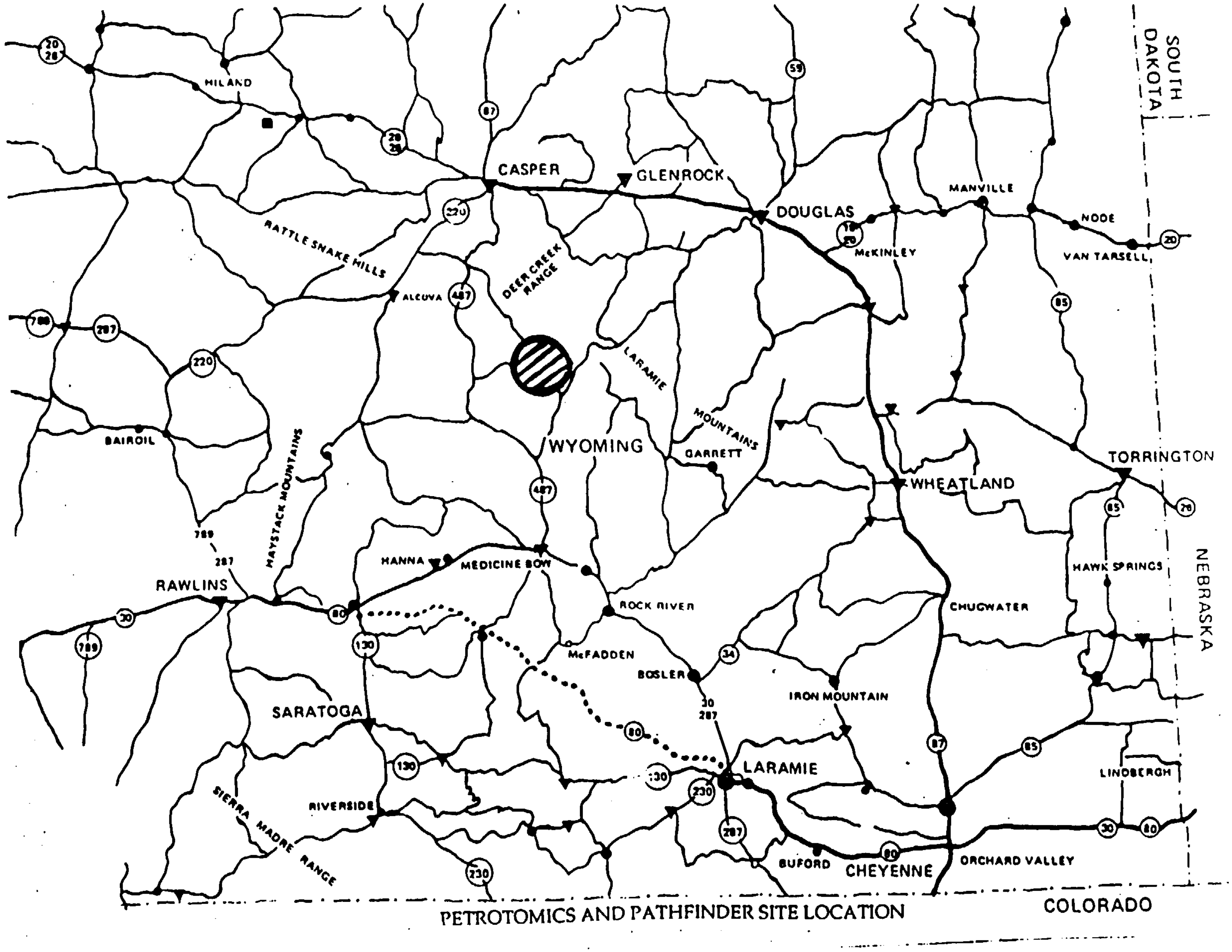
The mills lie within the Shirley Basin which is a Southward extension of the Wind River Basin between the Shirley Mountains on the southwest and the Laramie Mountains on the northeast. The Shirley Basin is structurally simple. It is an erosional feature whose position is governed to some extent by a broad syncline in the pre-Tertiary rocks. The syncline axis trends northwestward, parallel to the erosional axis of the basin, and lies 15-16 km west of the basin axis. Paleozoic, Mesozoic, and to a lesser extent, Tertiary rocks have been broken by faults with small displacements. Two faults with displacements of about 30.5 m are located just west of the project area.

Rocks in the Shirley Basin area are both igneous and sedimentary in origin and range in age from Precambrian to Cenozoic. Quaternary surficial deposits fill the valleys and form terraces related to at least two earlier erosion cycles. The sedimentary rocks, particularly those of Tertiary age, are widespread at the surface and are the host rocks for the uranium deposits. Igneous and metamorphic rocks of Precambrian age and sedimentary rocks of Paleozoic age crop out only in the northeastern part of the area, on the western flank of the Laramie Mountains.

Site Geology

In the immediate vicinity of the mill sites, the topsoil consists of friable brownish-gray loam, about 15 - 20 cm deep, which is underlain by sandstone. The major bedrock units in the mine vicinity are the Wind River and White River Shale Formations. The Wind River Formation is divided onto (1) a lower part composed of fine-grained siltstone and mudstone (2) an upper part composed of coarse grained, poorly sorted arkosic sandstone and granite pebble conglomerate, and numerous bedded lenses of siltstone and mudstone.

Figure 8.11 Petrotomics and Pathfinder Site Location



8.6.3 Faulting and Tectonics

The nearest fault is 30 km north and 25 km south on Geologic Map of Wyoming , however there was no mention of any nearby faults, active or inactive, in the literature for either the Pathfinder or Petrotomics sites. The fault that lies 30 km north of the sites is an unnamed fault which has one 48 km segmented section which continues to the east, completely concealed, for 57 km. The fault that lies 25 km south and 36 km southwest of the sites is an extremely segmented fault zone, segments ranging from 1 to 15 km in length. These faults are considered inactive.

The sites are 50 km from the end of the Seminoe Mountain Segment of the South Granite Mountain Fault system, and about 80 km from the active Ferris Mountain segment. The Wheatland-Whalen Fault system lies approximately 145 km east of the sites. It is considered potentially active by Geomatrix, but the distance from the sites is too great to be considered a potential hazard.

8.6.4 Seismicity and Earthquake Hazards

Deterministic Analysis

The active Ferris Mountain segment is about 80 km from the sites. The estimate for M_u for this segment, as discussed previously, is M~6.6. The estimated PGA from this event at the 1-sigma level is 0.05g. We noted earlier that there is some low probability that two segments could rupture in a single event. The worst case would be for both the Ferris Mountain and Seminoe Mountain segments to rupture. This would put a M~7.1 50 km from the site. For this case we use the median estimate for PGA which is 0.07g. It is of interest to note that the 1-sigma estimate for PGA at the site from the M~7.1 earthquake is 0.125g.

Random Earthquake Analysis

The sites falls within what we have termed the Central Seismic Zone. There are no significant faults in the vicinity of the sites to localize a large magnitude event, however in 1984 a M_L~5.3 occurred approximately 38 km from the sites. This would suggest that a M_u~6.25 is a reasonable upper bound for the truncated exponential model. The hazard curves are given in Fig. 8.8. We see from this Figure that for M_u~6.25 at a PE level of 10^{-4} the estimate for PGA is 0.33g. If we use M_u~5.75, the estimate is 0.29g. If we used the Geomatrix (1988b) recurrence model and the entire Wyoming Foreland Province as the appropriate source zone, the estimate for PGA is 0.18g. At a PE level of 5x10-4 the PGA varies between 0.14g to 0.2g.

8.6.5 Conclusions

There are no known faults going through the sites to suggest any problems. The deterministic element of our hazard analysis leads to an estimate of PGA of 0.07g at the sites. The analysis for the random earthquake leads to an estimate for PGA in the 0.18g to 0.33g range at a PE level of 10^{-4}. Our preferred recurrence model leads to a 0.29 to 0.33g range for PGA. We note that the most likely event is an earthquake M~5.5 near the sites, within 10 km of the sites. This would lend to an estimate of 0.28g to 0.4g.

A value of PGA of 0.025g was used at the Pathfinder site for the analysis of tailings stability. This is much less than the estimates for PGA we arrived at. The stability analysis needs to be carefully reviewed to determine if sufficient margins exist or if some remedial action is required.

We could not determine what PGA was used to evaluate the facilities at the Petrotomics site. It appears that they considered the seismic motion for the site to be so low that it wan not a design

consideration. Thus in light of our estimates a stability analysis needs to be performed at the appropriate ground motion level.

8.7. Powder River Basin

Exxon & Union Pacific

8.7.1 Introduction

The uranium mills operated by Exxon and Union Pacific are located in the southwest portion of the Powder River Basin, a large asymmetric, north-south structural topographic basin. The Exxon Highlands mill lies approximately 58 km north of Douglas, WY, and Union Pacific facility lies about 61 km north-northwest of Douglas, WY (See Fig. 8.12, 8-13, 8-14).

The nearly 20,000 km^2 Shirley Basin is bounded on all sides except the north with structural uplifts: on the west by the Big Horn Mountains and the Casper Arch, on the south by the Laramie Mountains and the Hartville Uplift, and on the east by the Black Hills. To the north, the basin gradually terminates as it enters into Montana (Water, Waste, and Land 1989). All of the major uranium deposits are found in the Tertiary rock Formations. Most of the important uranium deposits are in the Wasatch and Fort Union Formations.

8.7.2 Regional Geology

The Powder River Basin began forming in the late Cretaceous time owing to several uplifts and widespread deposition into the Paleocene. Additional structural deformation and uplift of major mountain blocks seen today occurred during the close of Paleocene time. Large amounts of coarse clastics, forming large fans and braided stream deposits, were formed during the Eocene. Also, several coal beds were formed indicating inactive swamps and low cycles of sediment deposition. Major contributing streams from the southern Laramie Mountains and Hartville Uplift produced deposits of continuous sediments which formed the passageways and allowed deposition of the mineralized uranium solutions being mined today.

Degradation of the area continued throughout the Eocene. During the Oligocene, Miocene and Pliocene, vast thicknesses of sandstone and tuffaceous sediments accumulated. After considerable volcanic activity, uplift and moderate to severe erosion by stream action, the area has been reduced to the low relief and highly eroded surface topography of today.

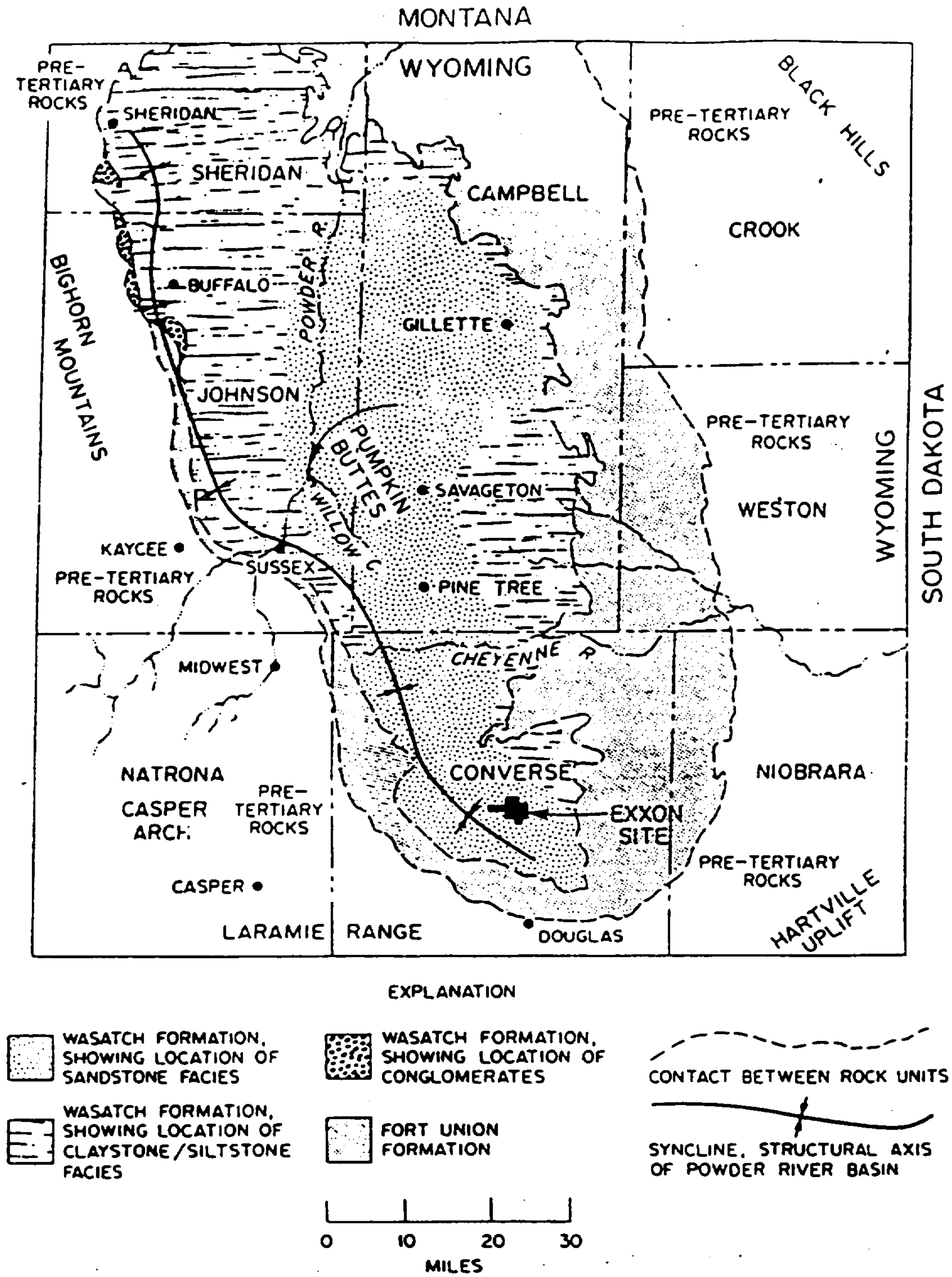


Figure 8.12 Regional geology showing relationship to the Exxon site. Modified from W. M. Sharp and A. B. Gibbon, *Geology and Uranium Deposits of the Southern Part of the Powder River Basin, Wyoming*, U. S. Geological Survey Bulletin No. 1147-D, 1954.

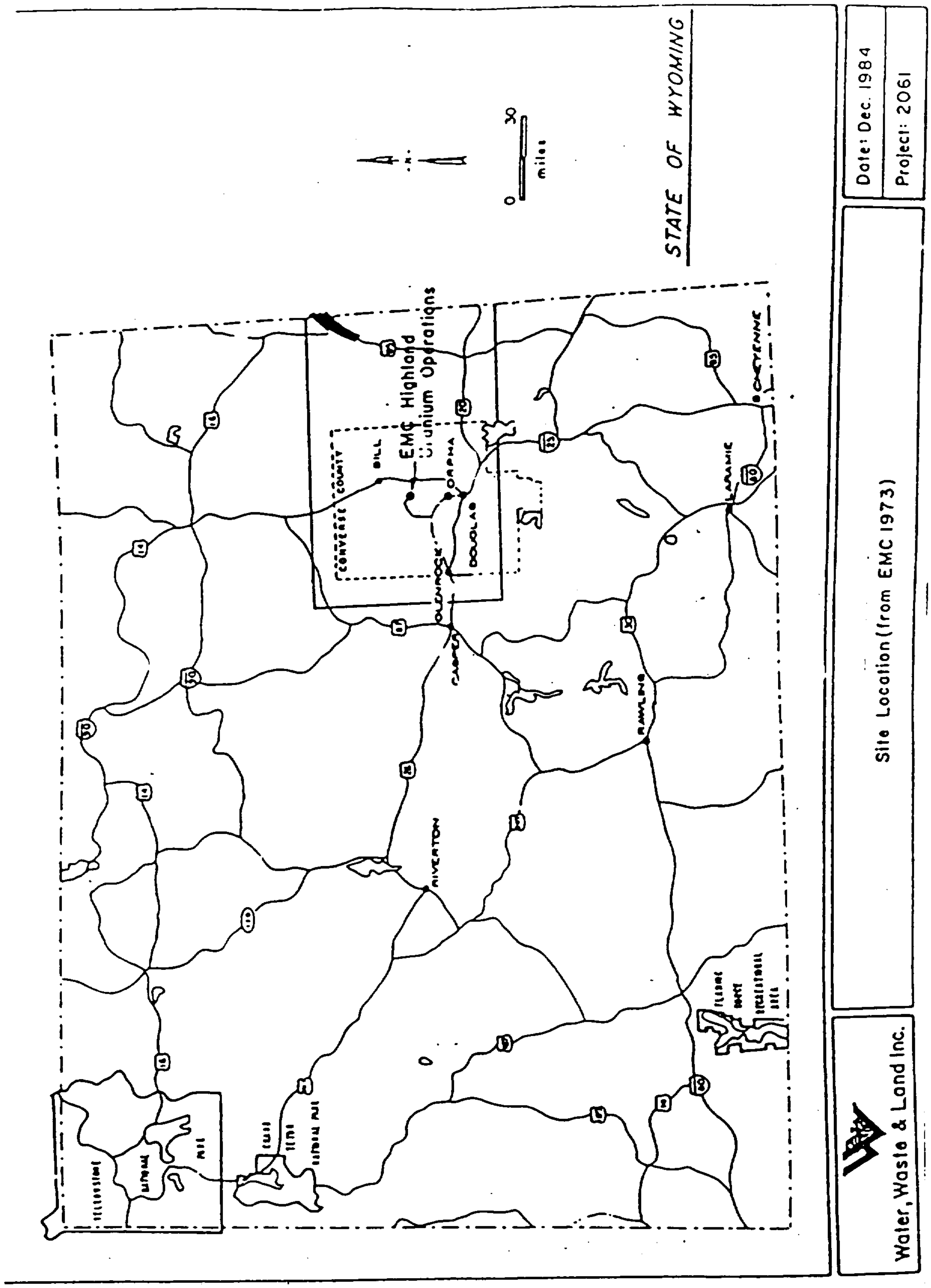


Figure 8.13 Site location of the Exxon (EMC Highland) operation

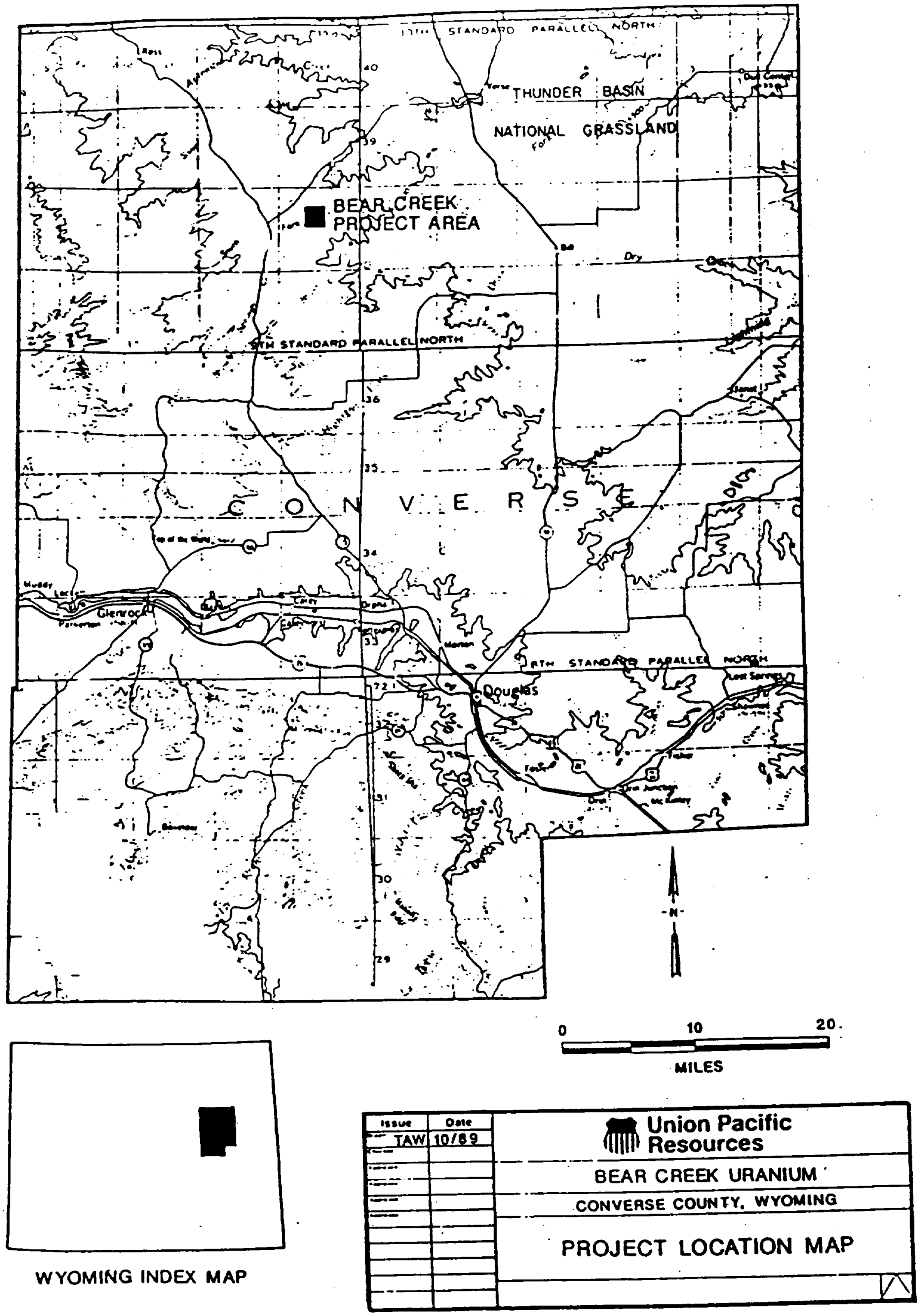


Figure 8.14 Project Location Map - Bear Creek

The Powder River Basin is an asymmetric syncline within the Wyoming Basin Geomorphic Province. It is a westward continuation of the Great Plains Province and they share a common geomorphic history. Both were the site of early Tertiary deposition followed by excavation of the sediments that left behind a stepped topography that is characterized by elevated ancient erosion surfaces often referred to as benches or pediments. The Exxon site is located on one such surface, and its stability during recent geological history is indicated by the relatively well developed thick, residual soils, the lack of incised gullies, and the presence of deflation hollows that have apparently existed since the Altithermal (7-9,000 B.P.) (Water, Waste, and Land 1984).

The structural axis projected to the surface from the Precambrian basement is approximately parallel to the front of the Bighorn Mountains. Pre-Tertiary strata along the east side of the Bighorn Mountains dip from 30° east to locally overturned. Toward the basin, dips of Tertiary strata are generally less than 5° toward the structural axis but locally may be steeper along the limbs of small-scale folds. Structurally, the site consists of a series of northwest plunging anticlines and synclines with amplitudes of 3 to 6 m.

Streams which deposited the sediments flowed northward into the basin and derived sediment from Mesozoic, Paleozoic, and Precambrian rocks of the Laramie and Granite mountains, and from wind-blown volcanic debris of the Absarokas to the west (Exxon Production Research Company, 1982).

Exxon Site Geology

Mining at this site is confined to the Fort Union Formation of Paleocene age. The Fort Union consists of dark gray siltstone and claystone, buff to gray, fine- to coarse-grained channel sandstone, abundant fossils, and coal beds up to 37 m thick. These deposits indicate that the Fort Union Formation was deposited in a swampy, forested lowland threaded by sluggish rivers. The Fort Union Formation and overlying Wasatch Formation dip to the northwest at about .3 m per 30.5 m. The sandstones to be mined are collectively known as the Highland Ore Sandstone, consisting of three distinct sandstones separated by 3 to 6 m of siltstone and shale.

The first major sandstone immediately above the Upper Ore Body Sandstone is referred to the Tailings Dam Sandstone. This sand was probably deposited by the same process that deposited the Ore Body Sandstones. However, it is underlain by a laterally continuous shale, referred to as the Tailings Dam Shale, and is not in vertical contact with the Upper Ore Body Sandstone. Directly above the Tailings Dam Sandstone are several small discontinuous sandstones of the Fort Union Formation, and higher in the section is a major sandstone of the Wasatch Formation locally called the Fowler Sandstone. Below the Lower Ore Body Sandstone are two sandstone units both of which are less continuous than the ore sands.

Union Pacific Site Geology

The site lies within a flat-lying strata of the lower Wasatch Formation of Eocene age. This formation consists of alternating claystone, siltstone, and sandstone. The base of the lowest sandstone which contains uranium mineralization is approximately 61 and 91 m above the base of the Wasatch Formation.

The lithology of the rocks above the uranium-ore-bearing unit varies considerably throughout the project area because of extensive interfingering of claystone, siltstone, and sandstone, therefore no typical sequence of lithic types and thicknesses are uniformly characteristic of the overburden overlying the ore deposits. The overburden ranges from 30 m to 80 m in thickness, due to an increase in elevation of the surface from north to south over the deposits. The overburden is mostly claystone with several discontinuous lenses of sandstone up to 6 m thick. Throughout most of the area, claystone ranges from 60 to 90 percent of the total overburden and sandstone, from 10 to 40 percent (NUREG-0129).

8.7.3 Faulting and Tectonics

The nearest fault to the Union Pacific Bear Creek site is a concealed fault located approximately 30 km to the south of the site on the Wyoming state geologic map. This fault is considered inactive. 160 km west of the site is the easternmost edge of the Cedar Ridge-Dry Fork Fault system which has been considered inactive by Geomatrix (1988b). Approximately 35-60 km south of the site, many minor faults ranging in length from 3-10 km.

A concealed fault approximately 60 km long lies 80 km southeast of the Union Pacific site. This fault is north of the Wheatland Whalen Fault system, but it does not appear to be related to this system. The easternmost extension of the inactive North Granite Mountain Fault system is 59 km southwest of the site, and a cluster of intensely segmented faults lie approximately 55 km west of the site. These faults range in length from 1 to 8 km (NUREG-0489).

A 1981 Amendment Request describes two apparent bedding plane thrust faults on the pit walls at the Union Pacific site. Displacement was about a half meter, but movement was limited to one rock unit. The faults were tight with no observed gouge, and it was concluded that the faults were not significant.

We do not consider the faults to be an issue.

There is no faulting in the vicinity of the Exxon site according to the Geologic Map of Converse County, 1985 Open File Report 85-13. No faulting has been detected on the surface or in the subsurface at the Exxon site.

8.7.4 Seismicity And Earthquake Hazard Analysis

Deterministic Analysis

These sites are far enough away from the active faults so that the ground motion estimates from these faults is much less than from the random earthquake analysis.

Random Earthquake Analysis

These two sites lie in the large Wyoming Foreland Structural Province. The hazard curves are given by Fig. 8.6. We see from this Figure. that for a PE level of 10^{-4} the PGA estimate ranges from 0.2g to 0.3g. We previously noted that there have been several M=5.5 earthquakes in this province and in 1882 some larger earthquakes. The estimate for the 1882 event range as large as M~6.5. We indicated that our preferred value for M_u was 6.25 with uncertainty between 6 and 6.5. This model leads to an estimate for PGA of 0.27g at PE level of 10^{-4} and 0.13g at a PE level of $5x10^{-4}$.

8.7.5 Conclusions

There are no known active faults in the vicinity of the sites. There are no known faults through the Exxon site. There are minor bedding plane faults in the pit walls at the Union Pacific site. While this fault poses no threat of localizing an earthquake on it, a nearby random earthquake could possibly induce differential displacement across these minor faults. This is a relatively low likelihood event but it should be investigated to determine if it is a potential problem. Our preferred estimate for the PGA at these sites to meet our criteria is 0.27g at a PE level of 10-4 and at a PE level of $5x10^{-4}$ it is 0.13g.

We could not determine what value for PGA was used to design the Exxon site. It appears that the seismic motion was considered to be so small that it was not a factor in the design. A value of 0.05g was used for the Union Pacific site. Our estimate for the appropriate ground motion to use is much

higher. This is a source of considerable concern. The critical facilities at both sites need to be carefully evaluated to ensure adequate margins exist or to determine what remedial actions may be required.

8.8 Wind River Basin

American Nuclear, Pathfinder, And Umetco

8.8.1 Introduction

The American Nuclear site, the Lucky-Mc site and the Umetco site are all located within 10 km of each other in the southern portion of the Wind River Basin along the western flank of the Dutton Basin anticline (See Fig. 8.15 and 8.16). This area west of Casper is also known as the Gas Hills area. All of the economically important uranium deposits occur in the Eocene Wind River Formation which lies unconformably over the steeply dipping Cretaceous and Jurassic sediments which outcrop to the east and west of the Basin forming the Gas Hills.

8.8.2 Regional Geology

These three sites are located in the Gas Hills area in the southern portion of the Wind River Basin north of the Sweetwater Arch in central Wyoming. The Wind River Formation of Tertiary age has been divided into two members: an upper, coarse-grained sandstone ranging from 0 to 79.3 m in thickness and a lower, fine-grained member ranging in thickness from 30.5 to 91.5 m. Sediments for the two were derived from two uplifts of the Sweetwater Arch, the first in the Late Cretaceous and the second during the Eocene epoch. The upper coarse-grained sediments were deposited as alluvial fans and became the host rock for the Gas Hills uranium.

The Wind River Formation unconformably overlies progressively older sediments toward the south. In the tailings area, the Wind River Formation consists of interbedded layers of impervious mudstone with medium to very dense, coarse sand with some silt, medium to dense silty and clayey fine sand, clayey silt and silty clay. The older sediments were folded during the Cretaceous or Early Tertiary and deeply eroded prior to deposition of the Wind River Formation. Although this Formation is relatively flat lying, older sediments dip toward the north at 10 to 20 degrees. Folds and faults occur in the older sediments.

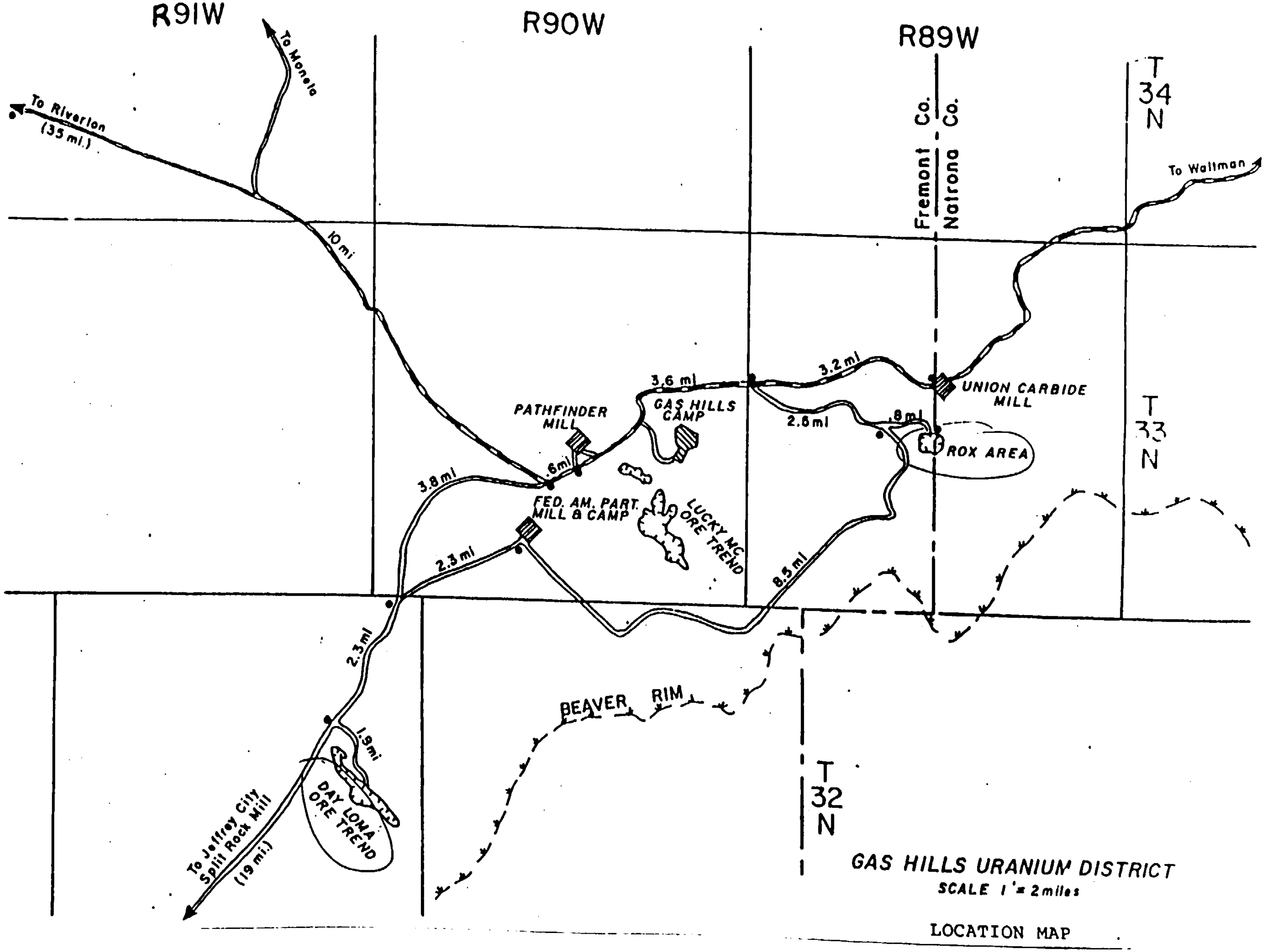


Figure 8.15 Gas Hills Uranium District

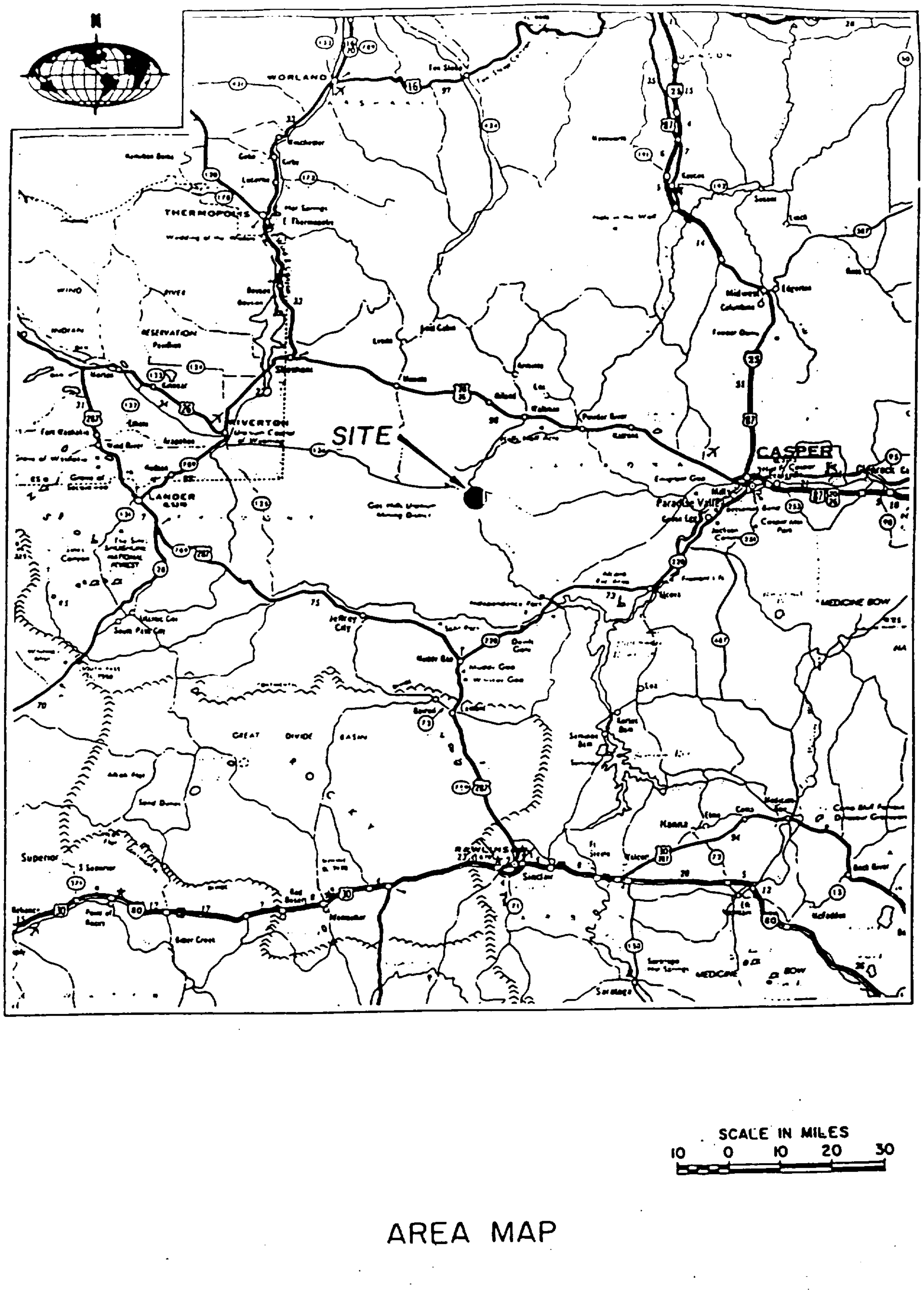


Figure 8.16 Approximate location of the Americal Nuclear, Pathfinder, and Umetco sites. Sites are located within 10km of each other.

The Cody Shale Formation is the other significant bedrock unit in the vicinity of the sites. It is a massively thick formation of shale with some sandstone beds; the upper part is gray to buff, very fine-grained, silty, mostly thin bedded sandstone and siltstone, interbedded with lesser amounts of gray-to-black shale. The lower part is gray-to-black shale, partly bentonitic, partly silty and sandy, and containing a few thin, silty sandstone beds. The Cody shale regionally dips west-northwest at five to 20 degrees.

Northeast of the mill sites are the Gas Hills, a series of hogbacks of steeply dipping Mowry Shale and Cloverly Sandstone located along the north and west flanks of the anticline. Many Tertiary age normal faults exhibit northeast trends across the Dutton Basin Anticline. Most have small displacements, 1.5 m to 15 m, and some exhibit reversal in displacement at opposite ends (NUREG-0702).

American Nuclear Site Geology

Tailings Pond Number 2 of the American Nuclear mill lies upon the upper Wind River Formation and recently deposited alluvial material. These alluvial deposits consist of silty to coarse sand ranging from less than 6.1 to 12.2 m in thickness.

The upper Wind River Formation consists of arkosic sandstone with siltstone and claystone interbeds. It has been largely eroded away in the vicinity of Tailings Pond Number 2, and is completely absent where the ground surface elevation is less than about 1,936 m. It ranges in thickness from 0 to about 79.3 m near the pond (Dames and Moore 1982).

The lower Wind River Formation occurs below elevation 1920 m and consists primarily of claystone, siltstone, and silty sandstone reaching about 91.46 m in thickness. Individual beds dip between 1° and 3° toward the southeast. The unconformable contact between the Wind River Formation and the Cody Shale is very irregular and occurs between elevations 1798 and 1890 m (Dames and Moore 1982).

Pathfinder - Lucky Mc Site Geology

The Lucky Mc Uranium Mill tailings disposal area is located along Reid Draw to the north of the mill. The mill site is situated on a rolling upland east of Serapagus Butte. A 61 m high bluff stands ~1.25 km away from the mill site, between the mill and the tailings disposal area along Reid Draw to the north.

The major bedrock units in the site vicinity are the Wind River and Cody shale Formations. The lower, fine-grained member of the Wind River Formation is the unit forming the bedrock at portions of the mill area, but it is the Cody Shale Formation that underlies the greater part, if not all, of the site (NUREG-0357).

Umetco - Gas Hills Site Geology

Major topography at the site is characterized by rolling terrain broken by dry washes, typical of the Wyoming high plains. The project area is underlain by the Wind River Formation which has been differentiate into upper and lower units. The upper unit consists of sandstone, conglomerate, and mudstone. The lower unit is normally finer grained material that consists of siltstone, mudstone, and fine-grained sandstone or massive conglomerate. In the area of the inactive tailings, the Upper and Lower Wind River Units are separated by about 6.3 m of mudstone. The mudstone is dipping to the southwest at about one degree from horizontal. Traversing from south to north, the Upper Wind River nit becomes thinner from 50 m thick to 3 m thick.

8.8.3 Faulting and Tectonics

American Nuclear

The American Nuclear Site sits between, or very near, two NW/SE trending faults on Wyoming state geologic map. Dames and Moore 1982 mentions the Sagebrush Fault, a normal east-west trending fault. This fault is located about 366 m south of tailings pond no. 2. The north side of the fault is displaced downward about 15 to 30 m.

Length of the continuous Sagebrush Fault appears on the Geologic Map of Wyoming to be about 6 km long.

Pathfinder - Lucky Mc

The primary structural feature in the area is the north-west-trending, north-plunging Dutton Anticline. The axis of this fold lies about 1 km to the east of the tailings disposal area. A high-angle, north-trending reverse fault cuts the west limb of the anticline. Previous investigations have revealed that this fault exists in the Cody Shale east of tailings reservoir No. 1. East of tailings pond number 4, there is a vertical offset along this fault of approximately 305 m. This faulting is considered to be contemporaneous with the folding (Chen 1980).

Umetco

The nearest major fault to the Umetco Gas Hills site is the Thunderbird Graben, located about .8 km south of the A-9 Pit (see Fig. 8.17). There are no indications that this fault is active and it does not appear that any faults exist between the A-9 and C-13 pits.

Fig. 8.17 shows the location of known faults in the immediate site vicinity which were determined from drill hole information and observations in the C-13 pit highwalls in 1984. As shown on Fig. W-17, the nearest known fault in the A-9 pit vicinity lies about 152 m south of the A-9 pit. There is no indication that this, or any of the smaller faults lying to the south of this fault, are active. Probable faults have been projected into the A-9 pit, however there were no visible faults which could be seen in the A-9 pit highwall. Based on this analysis, no faults appear to underlie the A-9 embankment.

The faults that have been projected into the A-9 pit, if they exist, would not be the source of an earthquake, but may induce differential movement. There is a very low likelihood that these faults would pose a hazard to the site, but because of their projected proximity to the pit, further investigations should be conducted.

8.8.4 Seismicity And Earthquake Hazard Analysis

Deterministic Analysis

The two closest active faults to these sites are the South Granite Mountain Fault system (to the south) at a distance of approximately 40 km and the Stagner Creek Fault approximately 60 km to the northwest of the site. Because the M_u for the Stagner Creek Fault is smaller than for the South Granite Mountain Fault system and it is also further away, we only need to consider the South Granite Mountain Fault zone. The active Green Mountain segment is the closest segment of the fault to the sites. As previously discusses, M_u for this segment is M~6.75. The 1-sigma estimate for the PGA is 0.14g with a median estimate of 0.08g. We noted that it is also possible at a very low probability that two segments of the fault could rupture leading to an estimate for M_u~7.1. For this case we use the median estimate for PGA which is approximately 0.09g.

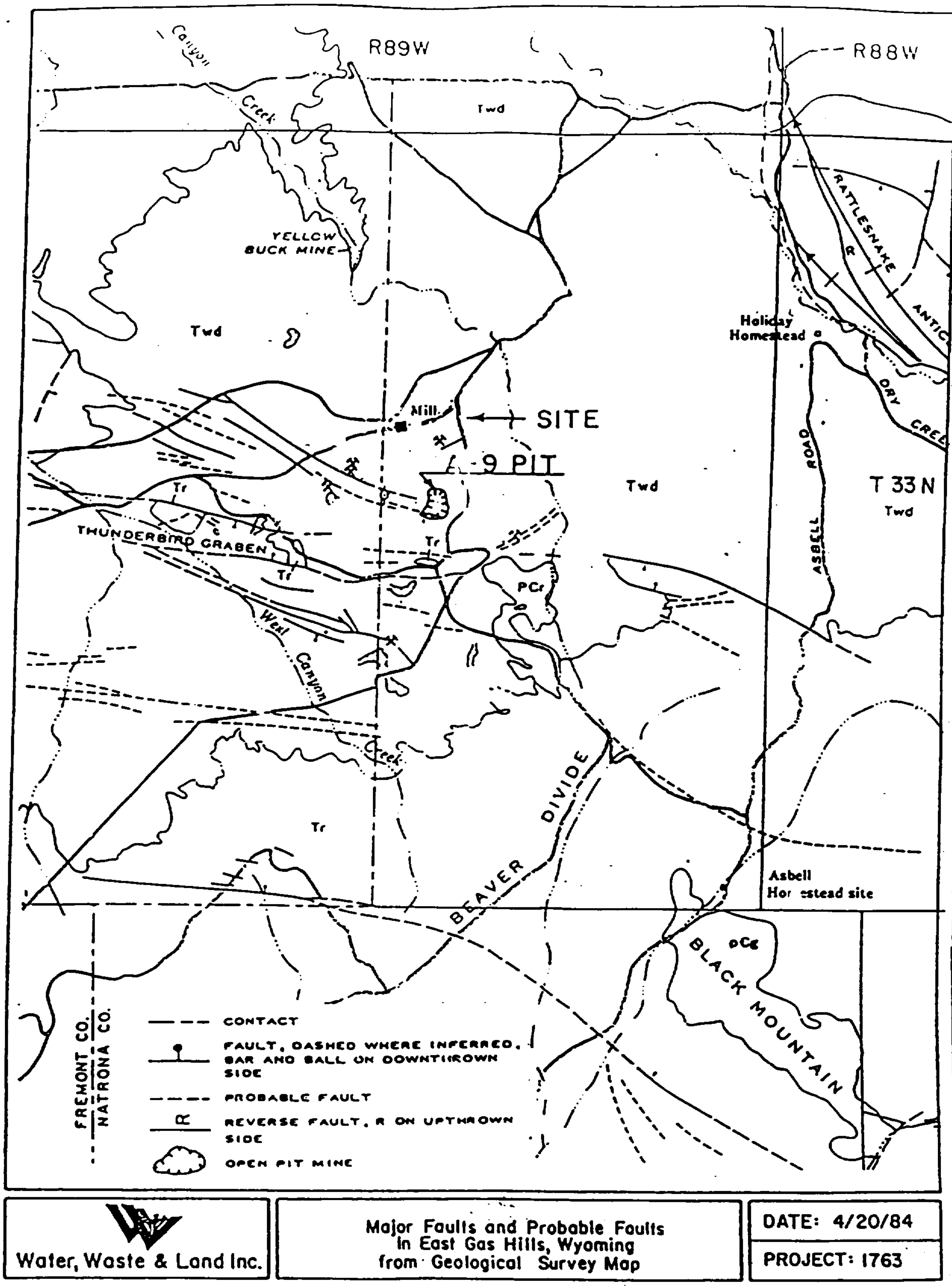


Figure 8.17 Major Fault and Probable Faults in East Gas Hills, Wyoming from Geological Survey Map

The North Granite Mountain Fault system is approximately 15 km from the sites. Based on the field work by Geomatrix (1988b), we do not consider this fault system to be active or at least to expect earthquakes larger than M>6.5. However, it is possible that this fault system could generate a M<6.5 earthquake near the sites because M<6.5 earthquakes often do not lead to surface rupture. Geomatrix (1988b) judged the fault to be inactive based on the lack of observed surface displacement. However, we do see considerable seismicity in the area. The North Granite Mountain Fault system would seem to be the most likely location for an earthquake near these sites. A reasonable value for this event would be M~6.25. The estimate for PGA from a M~6.25 event on the North Granite Mountain Fault system is 0.3g at the 1-sigma level and 0.17g at the median level.

Random Earthquake Analysis

These sites fall in what we have termed the Central Region Seismic Zone. The hazard curves are given on Fig. 8.8. As discussed earlier, our preferred value for M_u for this zone is M_u~6.25. This leads to an estimate for PGA at a PE level of 10^{-4} of 0.33g with a range 0.25g to 0.37g. At PE level of 5×10^{-4} the PGA varies between 0.14g to 0.2g.

8.8.5 Conclusions

There is some possibility that a fault could exist under the A-9 pit at the Umetco site. This fault (if it exists at the pit) is not considered active. However, in the event of a nearby random earthquake of M>5, there could be some potential for differential movement along the fault plane. There is not enough data to evaluate if this is a real concern. It is clearly a low likelihood event.

We recommend a value for PGA of 0.33g for these sites. This value provides protection from random earthquakes, an earthquake between 6.2-6.4 located in the North Granite Mountain Fault system and larger events on the South Granite Mountain Fault system.

We could not determine what value for PGA was used to design the facilities at the American Nuclear Site. As with a number of other sites it appears that the potential seismic motion at the site was considered to be too low to be significant in design. Hence careful evaluation of the critical facilities is needed.

A value for PGA of 0.15g. was used to assess the stability of tailings pile stones at the Lucky Mc mine site. This is less than the 0.33g we recommend. Hence a careful review is needed to determine if sufficient margins exist.

A value of 0.05g was used at Umetco Site. This is significantly less than our recommended value. A careful analysis is required to determine if sufficient margins exist or if remedial action is required.

9.0 DISCUSSION AND SUMMARY OF RESULTS

In this report we have developed estimates of the appropriate levels of PGA to use in the evaluation of seismic design assumption for the Title II reclamation Plans. We also investigated the existence of faults at the sites, determined their likelihood for being active, and evaluated the hazard they present to the sites. The approach for this evaluation is outlined in detail in the Methodology Section 3.0. It consists of (1) a review of the literature and contacting experts to obtain their insights and potential concerns and (2) a deterministic and a probabilistic hazard analysis for each site.

In the Criteria Section 3.3 we describe how we interpreted 10 CFR 40 Appendix A for making the necessary judgments needed to perform both the probabilistic and the deterministic hazard analyses and to make recommendations for the PGA level that should be used for design. Our interpretation was that 10^{-4} PE per year is an appropriate level to use. However, we also provided results at a PE level of $5x10^{-4}$ to allow the decision maker to have flexibility.

The results for each site are summarized in Table 9.1 which gives the site name, location, the value used to design the facility, the estimate of PGA at a PE level of 10^{-4} and $5x10^{-4}$, the estimates of PGA from the deterministic earthquake (when applicable) at the 1-sigma level and the median level, and lastly, notes any potential problem from a fault or fracture zone under the tailings piles.

We noted in Section 1 that our primary goal was to provide NRC with sufficient data for the staff to make the necessary judgments about the adequacy of the Title II Reclamation Plans. In order to be clear and to provide as much information as possible we have also provided our judgments based on the criteria given in Section 3.3. This may not be the most appropriate criteria to use concerning the actual risk these facilities pose and should be treated only as information used by the staff.

Two generic issues need some additional discussion in light of our review/analyses of all the sites:

(1) Should all of the assessments be made based primarily on the probabilistic analyses, primarily on the deterministic analyses or the choice be site dependent?

(2) Has our lack of definitive criteria on what constitutes a potentially active fault had a significant impact on our results?

The first issue is a difficult one. We would like to argue that the assessments should primarily be based on the probabilistic results. However, as often noted in the text, we did not have sufficient data to develop meaningful recurrence models for any of the faults involved in the study. This is most notable at the Western Nuclear site in Wyoming which is near the South Granite Mountain Fault System (SGMFS), the Atlas site in Utah and the Sohio site in New Mexico. There is no doubt that the SGMFS is active and likely to have large earthquakes. It is very difficult to assess the validity of the activity models of the SGMFS for the probabilistic analysis. Without significant fieldwork it is not possible to properly include the SGMFS in the analysis and hence one has to rely on deterministic analysis.

The issue is less clear-cut at the Atlas and Plateau Resources sites and the Sohio site in New Mexico. At the Atlas site we see an enhanced rate of seismic activity of small earthquakes along the lineament under the Colorado River. However, we do not know for sure that it will necessarily lead to an earthquake in the M~6.5 range. This is a case where it would be very useful to perform a full probabilistic analyses. However, in order to make such a study meaningful one would need extensive field work to characterize the nature of the lineament. It is not possible to do this in this report hence we have primarily relied on the deterministic analysis for our conclusions.

At the Sohio site we also see an enhanced rate of activity near Mt. Taylor. We do not have enough data to see if the rate is really significantly higher and if it is more likely that a M~6.25 earthquake will occur near Mt. Taylor as opposed to randomly occurring in the region. Very little is known about

the underlying tectonics of the JL and in particular the Mt. Taylor area. However, it is so close to the site that details are important for developing a probabilistic estimate with meaningfully low uncertainty. The other sites in New Mexico are sufficiently far enough away so that the details are not as important. Thus for the Sohio site we would argue for the deterministic analysis.

At the Plateau Resources site here are several nearby faults which are listed as Quaternary and some seismicity that could be associated with the faults or "random" — i.e. associated with some other buried fault or an unmapped fault. We used the nearest Quaternary fault as the location of a random earthquake to select the distance in the deterministic analysis. It is not known when the fault last moved in the Quaternary — or if the last movement was even in the Quaternary period. Short of extensive field investigations there are no answers to the above questions. However, given the uncertainties, it seems reasonable to use the fault as a location for the local deterministic earthquake. As described in Section 7.8.4, the earthquake magnitude was reduced because the fault was not favorably oriented to the local stress field.

For a number of sites we have not reported a deterministic result — see table 9.1. For these sites there were no nearby faults or lineaments of seismicity which would be likely locations for the occurrence of an earthquake near the site. For these sites it was our view that the best approach would be to only use the probabilistic approach rather than choosing an arbitrary location for a local earthquake to compute a deterministic number.

The above discussion sheds considerable light on the second issue relative to significance of the lack of fixed criteria for determining that a fault is active or potentially active. Table 9.2 summarizes the main role that faults played in the results. There were several other sites that were impacted by our assessment of local faults as potentially active. However, at these sites there was very little difference between the probabilistic and deterministic results. The faults involved are the Chicken Springs Fault System and North Granite Mountain Fault System (NGMFS). The Chicken Springs Fault System was called potentially active by Geomatrix (1988b), but because it was not significant in their study they did not do field work to show that the fault met their criteria (see Section 8) for being active. Geomatrix (1988b) did perform field work to show that by their criteria the NGMFS was not active. We did argue that it was possible for the NGMFS to have up to a M~6.25 earthquake without surface rupture. As this hypotheses leads to the same estimate of ground motion as the probabilistic analysis it appears to be a moot point. It should be noted that if one truly considers the NGMFS as active it could generate a large M~7 earthquake.

Very little is known about the Shay-Graben Fault System in Utah. It is thought to be Quaternary, but no investigations have been performed to know the date of the last movement. Some seismicity appears to be associated with it, but certainly not associated with other than epicenters that are located "near" the fault system. We see from Table 9.2 that the assumption that the fault is potentially active had some impact on the analysis at the Rio Algom site.

Only at the Western Nuclear site in Wyoming is there good evidence that the nearby fault (SGMFS) is indeed active using true criteria. In addition, one can exclude a large M>6.5 earthquake on the NGMFS based on the same criteria. For the rest of the sites, very little is known about the fault systems or lineaments of seismicity which we have considered to be potentially active.

We found that at many sites our estimates for the appropriate value to evaluate the Reclamation Plans are higher than the values used in design. There are several possible reasons for this. For example, it is not clear what criteria were used by the licensee to arrive at the design value. Our criteria was to estimate the PGA level that had a 10^{-4} PE level per year and 5×10^{-4} PE lever per year. This criteria is in some cases more conservative than was used as several of the sites depended on maps in Algermissen and Perkins (1976) which has maps at a 2×10^{-3} PE level.

Our hazard analysis are more site specific than that given in Algermissen and Perkins (1976) and Algermissen et al. (1990). We found a higher level of seismicity around most of these sites than was

used in other regional studies partly because we used smaller source zones and partly because our catalog was longer and more complete. In addition, we identified seismic zones or potentially active faults much closer to some sites than used in the original studies. For example, the Sohio site is very close to the Mount Taylor Seismic Zone which was not identified in the reports that developed the design PGA. For the Atlas site we identified the lineament along the Colorado River. for the Western Nuclear site we found data supporting the Quaternary activity of the South Granite Mountain Fault which was only 10 km from the site.

At four sites there is some indication that an old fault or fracture zone runs under tailings piles or dams. None of these faults were judged to be currently active. However, in the event of a nearby earthquake where the site experiences ground motion approaching the 10-4 PE level there is considerable concerns that this could introduce differential settlement across the fault which could be a problem.

This problem should be addressed on a case-by-case basis. Our most serious concern is with the Moab fault under the Atlas site because it is very major fault that has shown quaternary settlement due to salt tectonics and the potential for large ground motion at the site in the event of a nearby earthquake.

TABLE 9.1
SUMMARY OF RESULTS

Site Name	Location	Values Used In Design	PGA at PE 10^{-4}	PGA at PE $5x10^{-4}$	Deterministic 1-SigmaPGA	Deterministic Median PGA	Fault or Fracture Zone Under Facilities
Arco	NM	0.21 - 0.1	0.18	0.08	0.15	0.08	Yes fault
Homestake	NM	0.1	0.18	0.08	0.18	0.1	Yes fault
Quivira	NM	0.1	0.18	0.08	0.18	0.1	Yes faults
Sohio	NM	0.1	0.20	0.11	0.42	0.23	No
United Nuclear	NM	N/C	0.16	0.07	0.07(1)	0.07	Yes fracture zones
Edgemont	SD	0.05 - dam ok to 0.2	0.12	0.06	N/A(2)	N/A(2)	No
Atlas	UT	0.1	0.15	0.06	0.4	0.22	Yes
Rio Algom	UT	0.09	0.15	0.06	0.26	0.14 to 0.16(3)	No
Energy Fuels Nuclear	UT	0.1	0.12	0.05	0.12	0.07	No
Plateau Resources	UT	0.1	0.19	0.09	0.3	0.19	No
Western Nuclear	WY	0.08	0.33	0.18	0.55	0.3	No
Kennecott	WY	0.1	0.33	0.18	0.33	0.18	No
Pathfinder SB	WY	0.25	0.33	0.18	(4)	(4)	No
Petrotomics	WY	N/C	0.33	0.18	(4)	(4)	No
Exxon	WY	N/C	0.27	0.13	(4)	(4)	No
Union Pacific	WY	0.05	0.27	0.13	(4)	(4)	No
American Nuclear	WY	N/C	0.33	0.18	0.3	0.17	No
Pathfinder Lucky -Mc	WY	0.15	0.33	0.18	0.3	0.17	No
Umetco	WY	0.05	0.33	0.18	0.3	0.17	Yes

NC: Not considered in design.
PE: Annual Probability of Exceedance
(1) Based on a median estimate - see text 5.9.4.
(2) Deterministic estimate not considered applicable see text 6.5.
(3) Two different eartquakes involved - see text 7.6.2.
(4) Only large distant earthquake considered. Not comparable to probabilistic analysis.

Table 9.2 Summary of Most Significant faults labeled as Potentially Active in this Study

Site	Fault System	How Used	Det. PGA	Prob. PGA
Sohio, NM	Mt. Taylor seismic zone linear of activity	Locate regional random EQ	0.42 g	0.23
Atlas, UT	Linear of seismicity under Colorado River	Determine M_u and location	0.4 g	0.15 g
Rio Algom, UT	Shay-Graben correlate with activity	M_u slightly larger than random, location of M_u	0.26 g	0.15 g
Plateau Res, UT	Local fault/local seismicity	Location of random Eq.	0.3 g	0.22 g
Western N. WY	Green Mt. segment/known active	M_u and location	0.55 g	0.33 g

APPENDIX A–LLNL LIBRARY LITERATURE SEARCH CATALOGS

Primary Catalogs:

INSPEC_1969-1994/Oct W1
Meteor. & Geoastro. Abs._1970-1994/Sep
GeoArchive_1974-1994/Jul
SPIN(R)_1975-1994/Aug
GeoRef_1785-1994/Oct B1
Aerospace Database_1962-1994/Jun
Pascal_1973-1994/Sep
GEOBASE (TM)_1980-1994/Sep
NTIS_1964-1994/Sep
Ei Compendex* Plus (TM)_1970-1994/Oct W4
DIALOG SourceOne (SM) Eng_1991-1994/Jun W2

Secondary Catalogs:

BIOSIS PREVIEWS (R)_1969-1994/Oct W4
NTIS_1964-1994/Nov 31
Oceanic Abst._1964-1994/Sep
Enviroline (R)_ 1970-1994/Aug
Pollution Abs_1970-1994/Sep
Aquatic Sci & Fisheries Abs_1979-1994/Aug
Pais Int._1976-1994/Aug
CAB ABSTRACTS_1972-1994/Aug
CRIS/USDA_1994/Aug
Env. Bib._1974-1994/Jun
EMBASE_1974-1994/ISS 39
Academic Index (TM)_1976-1994/Sep W3
CIS_1970-1994/Jun
ASI_1973-1994/Jul
Energy SciTec_1974-1994/Sep B1
TOXLINE (R)_1965-1994/Sep
NEWSEARCH (TM)_1994/Sep 29
CA Search (R)_1967-1994/UD=12112
Public Opinion_1940-1994/Sep
PTS Newsletter DB (TM)_1987-1994/Sep 30
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