Appendix C

QA Related Records

9002260445 - PART 2

C.1 TAR Team Selection Record (N-QA-008)

TECHNICAL ASSESSMENT REVIEW TEAM SELECTION RECORD

N-QA-008
7/88

Technical Assessment Review Subject Geologic & Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed Exploratory Shaft

FUNCTION	REPRESENTATIVE
Secretary & Geologist	J. Marshall Davenport
Geophysicist	Ernest L. Hardin
Geologist	Terry A. Grant
Geophysicist / QA Specialist	Forrest D. Peters
Geophysicist	David Cummings
Geologist	David F. Fenster
Performance Assessment/Evaluation Spec.	Thomas E. Hinkebein
Geotechnical Engineer	Jonathan D. Istok
Geophysicist	Jeff Rimball
Geophysicist	Mohammad S. Mozumder
Geologist	Gerald L. Shideler
Geophysicist	Douglas P. Klein
Geologist	Richard Snyder
Geologist	David Dobson
Engineer	Maurice Grieve
Secretary & Geologist	Michael Parsons

Based on review of the qualification documentation, these representatives cover the functions for this Review and are acceptable as team members to accomplish the scope and purpose of this review.

Signed Richard C. Lee

Attachment:

Qualification Documentation

C.2 Employer Certification of TAR Team Member Qualifications

Attachment 4

May 19, 1989

Dr. Richard C. Lee, Chairman
Technical Assessment Review Team
Science Applications International Corporation
101 Convention Center Drive, Suite 407
Las Vegas, NV 89109

Dear Dr. Lee:

By this letter, (employer's name) certifies that (team member's name) meets the minimum education and experience criteria, as described in Attachment 4a, for participation as a (technical discipline or disciplines) in the Technical Assessment Review: Geologic and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location, being conducted by the Yucca Mountain Project Office.

(Employer's name) acknowledges its responsibility to: (1) obtain and retain documentation verifying the education, experience, and independence of the review team member; (2) make this documentation available for surveillance and audit by the U.S. Nuclear Regulatory Commission or the U.S. Department of Energy; and (3) notify the Yucca Mountain Project Office prior to destruction of this verification documentation.

_____
Name and title

_____
Date

Science Applications International Corporation

M89-TEI-JMD-64
WBS 1.2.6.1.1
QA

INTEROFFICE MEMO

DATE: May 23, 1989

TO: Review Record Memorandum
Technical Assessment Review: Geologic and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

FROM: William V. Macnabb WVM

SUBJECT: Qualifications of SAIC members of Technical Assessment Review Team

Science Applications International Corporation (SAIC) certifies that the SAIC personnel listed below meet the minimum education and experience criteria for the indicated technical disciplines, as described in Attachment 1, for participation in the Technical Assessment Review: Geologic and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location, being conducted by the Yucca Mountain Project Office.

Team Member	Technical Discipline
Richard C. Lee	Geophysicist
J. Marshall Davenport	Geologist
Ernest L. Hardin	Geophysicist
Terry A. Grant	Geologist
Forrest D. Peters	Geophysicist
David Cummings	Geophysicist

W.V. Macnabb, Deputy Project Mgr.
Name & Title

May 23, 1989
Date

WVM:JMD:bji

101 Convention Center Dr., Ste. 407, Las Vegas, NV 89109 (702) 295-1204

Other SAIC Offices Albuquerque, Ann Arbor, Arlington, Atlanta, Boston, Chicago, Huntsville, La Jolla, Los Angeles, McLean, Orlando, Santa Barbara, Sunnyvale, and Tucson.

Attachment 1

Categories of Technical Assessment Review (TAR) team member technical disciplines, and criteria for qualification in each category:

Category	Minimum Criteria for Qualification
Performance Assessment/ Evaluation Specialist	Advanced degree in a technical field (i.e., mathematics, science, or engineering and 3 years experience applicable to reviewing evaluations of: seismic hazards to the ESF/impact on Title II design).
Geologist, or Geophysicist	Each of these categories requires seven years experience in the particular technical area (i.e., geology or geophysics) applicable to the scope and purpose of this TAR; or an advanced degree in the particular technical area and 2 years applicable experience.

INSTRUCTIONS FOR COMPLETION

SPECIAL TRAINING ASSIGNMENT

1. The manager making the assignment completes the top portion of the Special Training Assignment form.

2. Manager then determines the required level of training, either indoctrination or proficiency, and completes sections I and/or II.

3. When assigning proficiency training, the manager will designate the type of training recommended using the following symbols:

   R - Reading Assignment with evaluation (test)

   W - Workshop with demonstration of proficiency

   C - Classroom training with evaluation (test) or demonstration of proficiency

4. Manager gives the form to the assigned individual for completion of training.

5. Manager also makes a copy of the STA, marks "COPY" at the top of the form, and forwards it to the Training Center for tracking of completion.

6. Individual completes Indoctrination Reading Assignments as required and initials and dates in Section I when complete.

7. Individual attends/completes required Proficiency Training, enters date completed, and has instructor verify with initials in Section II.

8. After all required training is complete, the individual returns the form to the manager. The manager reviews the form for completion, signs and dates the form.

9. The manager forwards the completed STA to the Training Center for updating the individual's training transcript and filing in the individual training file.

Department of Energy
Nevada Operations Office
P. O. Box 98518
Las Vegas, NV 89193-8518

JUN 09 1989

WBS #1.2.5
"QA: N/A"

Dr. Richard C. Lee, Chairman
Technical Assessment Review Team
Science Applications International Corporation
The Valley Bank Center, Suite 407
101 Convention Center Drive
Las Vegas, NV 89109

CERTIFICATION FOR DAVID C. DOBSON TO SUPPORT TECHNICAL ASSESSMENT REVIEW (TAR)

Reference: Letter, Blanchard to Distribution, dtd. 5/25/89

By this letter, the U.S. Department of Energy (DOE) certifies that David Dobson meets the minimum education and experience criteria, as described in Attachment 4a, for participation as a geologist in the Technical Assessment Review: Geologic and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location, being conducted by the Yucca Mountain Project Office (Project Office).

DOE acknowledges its responsibility to: (1) obtain and retain documentation verifying the education, experience, and independence of the review team member; (2) make this documentation available for surveillance and audit by the U.S. Nuclear Regulatory Commission or the DOE; and (3) notify the Project Office prior to destruction of this verification documentation.

Maxwell Blanchard
Maxwell B. Blanchard, Director
Regulatory and Site Evaluation Division
Yucca Mountain Project Office

YMP:MBB-4273

WESTON
MANAGERS DESIGNERS/CONSULTANTS
955 L'ENFANT PLAZA, S.W.
8TH FLOOR
WASHINGTON, D.C. 20024
PHONE: (202) 646-6600

May 24, 1989

Dr. Richard C. Lee, Chairman
Technical Assessment Review Team
Science Applications International
Corporation
101 Convention Center Drive, Suite 407
Las Vegas, NV 89109

Dear Dr. Lee:

By this letter, Roy F. Weston, Inc. certifies that David F. Fenster meets the minimum education and experience criteria, as described in Attachment 4a, for participation as a Geologist in the Technical Assessment Review: Geologic and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location, being conducted by the Yucca Mountain Project Office

Roy F. Weston, Inc. acknowledges its responsibility to: (1) obtain and retain documentation verifying the education, experience, and independence of the review team member; (2) make this documentation available for surveillance and audit by the U.S. Nuclear Regulatory Commission or the U.S. Department of Energy; and (3) notify the Yucca Mountain Project Office prior to destruction of this verification documentation.

K. Michael Cline, Manager

May 24, 1989
Date

Parsons Brinckerhoff 100 YEARS

Parsons Brinckerhoff Quade & Douglas, Inc.

Engineers
Architects
Planners

303 Second Street
Suite 700 North
San Francisco, CA 94107-1317
415-243-4600

Fax: 415-243-9501

July 7, 1989

Dr. Richard C. Lee, Chairman
Technical Assessment Review Team
Science Applications International Corporation
101 Convention Center Drive, Suite 407
Las Vegas, NV 89109

Dear Dr. Lee:

By this letter, Parsons Brinckerhoff Quade & Douglas, Inc. certifies that Mr. Maurice Grieves meets the minimum education and experience criteria, as described in Attachment 4a, for participation as a mining engineer in the Technical Assessment Review: Geologic and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location, being conducted by the Yucca Mountain Project Office.

Parsons Brinckerhoff Quade & Douglas, Inc. acknowledges its responsibility to: (1) obtain and retain documentation verifying the education, experience, and independence of the review team member; (2) make this documentation available for surveillance and audit by the U.S. Nuclear Regulatory Commission or the U.S. Department of Energy; and (3) notify the Yucca Mountain Project office prior to destruction of this verification documentation.

Richard F. Harig
Richard F. Harig
Sr. Vice President

July 7, 1989
Date

Sandia National Laboratories

Albuquerque, New Mexico 87185

May 23, 1989

Dr. Richard C. Lee, Chairman
Technical Assessment Review Team
Science Applications International Corporation
101 Convention Center Drive, Suite 407
Las Vegas, NV 89109

Dear Dr. Lee:

By this letter, the Nuclear Waste Repository Department of Sandia National Laboratories certifies that Thomas E. Hinkebein meets the minimum education and experience criteria, as described in Attachment 4a, for participation as a Performance Assessment/Evaluation Specialist in the Technical Assessment Review: Geologic and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location, being conducted by the Yucca Mountain Project Office.

Sandia National Laboratories acknowledges its responsibility to: (1) obtain and retain documentation verifying the education, experience, and independence of the review team member; (2) make this documentation available for surveillance and audit by the U.S. Nuclear Regulatory Commission or the U.S. Department of Energy; and (3) notify the Yucca Mountain Project Office prior to destruction of this verification documentation.

Sincerely,

AJ Stevens for

Joe R. Tillerson, Supervisor
Geotechnical Design Division 6314

May 24, 1989
Date

Science Applications International Corporation

M89-TEI-JMD-66
WBS 1.2.6.1.1
QA

INTEROFFICE MEMO

DATE: June 1, 1989

TO: Review Record Memorandum
Technical Assessment Review: Geologic and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

FROM: William V. Macnabb

SUBJECT: Qualifications of SAIC members of Technical Assessment Review Team

Science Applications International Corporation (SAIC) certifies that the SAIC personnel listed below meet the minimum education and experience criteria for the indicated technical disciplines, as described in Attachment 1, for participation in the Technical Assessment Review: Geologic and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location, being conducted by the Yucca Mountain Project Office.

Team Member	Technical Discipline
Jonathan D. Istok	Geotechnical Engineer

W. V. Macnabb, Deputy Project Mgr.
Name & Title

June 1, 1989
Date

WVM:JMD:bji

Department of Energy
Washington, DC 20585

Dr. Richard C. Lee, Chairman
Technical Assessment Review Team
Science Applications International Corporation
101 Convention Center Drive, suite 407
Las Vegas, NV 89109

Dear Dr. Lee:

By this letter, U.S. Department of Energy certifies that Jeff Kimball the minimum education and experience criteria, as described in Attachment 4a, for participation as a Geophysicist/Geologist in the Technical Assessment Review: Geologic and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location, being conducted by the Yucca Mountain Project Office.

U.S. Department of Energy acknowledges its responsibility to: (1) obtain and retain documentation verifying the education, experience, and independence of the review team member; (2) make this documentation available for surveillance and audit by the U.S. Nuclear Regulatory Commission or the U.S. Department of Energy; and (3) notify the Yucca Mountain Project Office prior to destruction of this verification documentation.

Stephan J. Brocoum, Chief
Name and title

May 25, 1989
Date

United States Department of the Interior

GEOLOGICAL SURVEY
BOX 25046 M.S. 425
DENVER FEDERAL CENTER
DENVER, COLORADO 80225

TAKE PRIDE IN AMERICA

IN REPLY REFER TO:

WBS#: 1.2.9.3
QA: QA
June 28, 1989

Dr. Richard C. Lee, Chairman
Technical Assessment Review Team
Science Application International Corporation
101 Convention Center Drive, Suite 407
Las Vegas, NV 89109

Dear Dr. Lee:

By this letter, the undersigned state that according to the Office of Personnel Management guidelines and the Yucca Mountain Project - U.S. Geological Survey requirements, Douglas P. Klein meets the minimum education and experience criteria, as described in Attachment 4a, for participation as a Geologist in the Technical Assessment Review: Geologic and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location, being conducted by the Yucca Mountain Project Office.

The YMP-USGS Technical Project Officer and Quality Assurance Manager acknowledge their responsibility to: (1) obtain and retain documented evidence of the education, experience, and independence of the review team member; (2) make this documentation available for surveillance and audit by the U.S. Nuclear Regulatory Commission or the U.S. Department of Energy; and (3) notify the Yucca Mountain Project Office prior to destruction of this verification documentation.

Larry R. Hayes
YMP-USGS Technical Project Officer

June 28, 1989
Date

for A. H. Landy
YMP-USGS Quality Assurance Manager

June 28, 1989
Date

cc: R. B. Raup, USGS, Denver, CO
D. P. Klein, USGS, Denver, CO
QA File 3.3.07
Local Records Center

#210-A

Department of Energy
Washington, DC 20585

Dr. Richard C. Lee, Chairman
Technical Assessment Review Team
Science Applications International Corporation
101 Convention Center Drive, suite 407
Las Vegas, NV 89109

Dear Dr. Lee:

By this letter, U.S. Department of Energy certifies that Mohammad S. Mozumder the minimum education and experience criteria, as described in Attachment 4a, for participation as a Geophysicist/Geologist in the Technical Assessment Review: Geologic and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location, being conducted by the Yucca Mountain Project Office.

U.S. Department of Energy acknowledges its responsibility to: (1) obtain and retain documentation verifying the education, experience, and independence of the review team member; (2) make this documentation available for surveillance and audit by the U.S. Nuclear Regulatory Commission or the U.S. Department of Energy; and (3) notify the Yucca Mountain Project Office prior to destruction of this verification documentation.

Stephan J. Brocoum, Chief
Name and title

May 25, 1989
Date

Science Applications International Corporation

July 24, 1989

Dr. Richard C. Lee, Chairman
Technical Assessment Review Team
Science Applications International Corporation
101 Convention Center Drive, Suite 407
Las Vegas, NV 89109

Dear Dr. Lee:

By this letter, Science Applications International Corporation certifies that Michael W. Parsons meets the minimum education and experience criteria, as described in attachment 4a, for participation as a Geologist in the Technical Assessment Review: Geologic and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location, being conducted by the Yucca Mountain Project Office.

Science Applications International Corporation acknowledges its responsibility to: (1) obtain and retain documentation verifying the education, experience, and independence of the review team member; (2) make this documentation available for surveillance and audit by the U.S. Nuclear Regulatory Commission or the U.S. Department of Energy; and (3) notify the Yucca Mountain Project Office Prior to destruction of this verification documentation.

W V MacNabb 7/24/89
William V. MacNabb
Deputy Project Manager

July 24, 1989

101 Convention Center Dr., Ste. 407, Las Vegas, NV 89109 (702) 295-1204

Other SAIC Offices Albuquerque, Ann Arbor, Arlington, Atlanta, Boston, Chicago, Huntsville, La Jolla, Los Angeles, McLean, Orlando, Santa Barbara, Sunnyvale, and Tucson.

United States Department of the Interior

GEOLOGICAL SURVEY
BOX 25046 M.S. 425
DENVER FEDERAL CENTER
DENVER, COLORADO 80225

TAKE PRIDE IN AMERICA

IN REPLY REFER TO:

WBS#: 1.2.9.3
QA: QA
June 28, 1989

Dr. Richard C. Lee, Chairman
Technical Assessment Review Team
Science Application International Corporation
101 Convention Center Drive, Suite 407
Las Vegas, NV 89109

Dear Dr. Lee:

By this letter, the undersigned state that according to the Office of Personnel Management guidelines and the Yucca Mountain Project - U.S. Geological Survey requirements, Gerald L. Shideler meets the minimum education and experience criteria, as described in Attachment 4a, for participation as a Geologist in the Technical Assessment Review: Geologic and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location, being conducted by the Yucca Mountain Project Office.

The YMP-USGS Technical Project Officer and Quality Assurance Manager acknowledge their responsibility to: (1) obtain and retain documented evidence of the education, experience, and independence of the review team member; (2) make this documentation available for surveillance and audit by the U.S. Nuclear Regulatory Commission or the U.S. Department of Energy; and (3) notify the Yucca Mountain Project Office prior to destruction of this verification documentation.

Larry R. Hayes
YMP-USGS Technical Project Officer

June 28, 1989
Date

for R. H. Sandy
YMP-USGS Quality Assurance Manager

June 28, 1989
Date

cc: R. B. Raup, USGS, Denver, CO
G. L. Shideler, USGS, Denver, CO
QA File 3.3.07
Local Records Center

#210-A

United States Department of the Interior

GEOLOGICAL SURVEY
BOX 25046 M.S. 425
DENVER FEDERAL CENTER
DENVER, COLORADO 80225

TAKE PRIDE IN AMERICA

WBS#: 1.2.9.3
QA: QA
June 28, 1989

IN REPLY REFER TO:

Dr. Richard C. Lee, Chairman
Technical Assessment Review Team
Science Application International Corporation
101 Convention Center Drive, Suite 407
Las Vegas, NV 89109

Dear Dr. Lee:

By this letter, the undersigned state that according to the Office of Personnel Management guidelines and the Yucca Mountain Project - U.S. Geological Survey requirements, Richard P. Snyder meets the minimum education and experience criteria, as described in Attachment 4a, for participation as a Geologist in the Technical Assessment Review: Geologic and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location, being conducted by the Yucca Mountain Project Office.

The YMP-USGS Technical Project Officer and Quality Assurance Manager acknowledge their responsibility to: (1) obtain and retain documented evidence of the education, experience, and independence of the review team member; (2) make this documentation available for surveillance and audit by the U.S. Nuclear Regulatory Commission or the U.S. Department of Energy; and (3) notify the Yucca Mountain Project Office prior to destruction of this verification documentation.

Larry R. Hayes
YMP-USGS Technical Project Officer

June 28, 1989
Date

for Al H. Handy
YMP-USGS Quality Assurance Manager

June 28, 1989
Date

cc: R. B. Raup, USGS, Denver, CO
R. P. Snyder, USGS, Denver, CO
QA File 3.3.07
Local Records Center

#210-A

C.3 QMP-02-08, ICN Number 1, and TAR Plan Training Documentation

CONTROLLED COPY 209

INTERIM CHANGE NOTICE

N-QA-023
10/88

ICN Number: 1	Effective Date: February 7, 1989	Page 1 of 5

Applies to QMP:
Number 12-08 Rev. 0 Title Technical Assessment Review

REQUIRED CHANGES:

QMP SECTION	CHANGE TO

1. Change "Nevada Nuclear Waste Storage Investigations (NNWSI)" to "Yucca Mountain Project (YMP)" and "Waste Management Project Office (WMPO)" to "Yucca Mountain Project Office (Project Office)" throughout the QMP.

2. Change last sentence of Section 2.0 to read: "This procedure can be used in meeting the requirements for technical assessment reviews as defined in Section 4.2.5.2 of the Systems Engineering Management Plan (SEMP), and for those specific technical reviews described in U.S. Department of Energy (DOE) Order 4700.1, Project Management System, Chapter III, Part G, Attachment III-1, 2.a., Technical Reviews, which fall within the scope of a Project Office Technical Assessment Review (see Section 3.1)."

3. Change Section 3.2, second sentence to: "The Technical Assessment Review Notice or attachments thereto (e.g., a plan) shall provide the following:

   1. ...,
   2. ...,
   3. ...."

4. Add: "4.1.3 Based upon the scope, complexity, or special nature of the planned Technical Assessment Review, the responsible Branch Chief or designee shall determine if the Technical Assessment Review Notice with attachments, including changes, is to be reviewed by a qualified individual for technical adequacy prior to issuance and, as appropriate, designate an individual as the reviewer for technical adequacy."

5. Add: "4.5 PROJECT QUALITY MANAGER (PQM)

   The PQM is responsible for the review and approval of the quality related aspects of the information required in Section 3.2, Item 1, as delineated in the Technical Assessment Review Notice or attachments, and changes thereto."

APPROVALS

Project Manager, T&MSS	Project Quality Manager	Project Manager for Carl Gertz
Date 2/7/89	Date 2/7/89	Date

REQUIRED CHANGES:

QMP SECTION	CHANGE TO

6. Add: "4.6 REVIEWER (TECHNICAL ADEQUACY)

   The reviewer (technical adequacy) is the individual designated by the responsible Branch Chief or designee to perform the review of the Technical Assessment Review Notice and attachments, including changes, in order to verify that the areas and items identified to be assessed and the planned depth of the assessment are correct, adequate, applicable, and complete vis-a-vis the technical requirements imposed on the specific Technical Assessment Review."

7. Identify the paragraph under 5.1 as "5.1.1." Delete the second sentence.

8. Add:

   "5.1.2 Prior to issuance, the Technical Assessment Review Notice with attachments shall be provided to the PQM by the responsible Branch Chief or designee for review and approval in accordance with QMP-06-03, Document Review/Acceptance/Approval. The PQM shall review the quality related aspects of the Technical Assessment Review Notice and attachments to ensure the requirements of Section 3.2, Item 1, have been addressed, i.e., the purpose and scope of the planned review are within the definition of a Technical Assessment Review (see Section 3.1); the items and areas identified to be assessed and the planned depth of the assessment satisfy the requirement or request, as appropriate, for conducting the Technical Assessment Review; and the Technical Assessment Review Notice with attachments, as appropriate, includes the correct, adequate, complete, and applicable quality assurance requirements delineated in the Project Office QA Program Plan (WMPO/88-1) and this procedure.

   5.1.3 As determined appropriate by the responsible Branch Chief or designee based upon the scope, complexity, or special nature of the planned Technical Assessment Review, a review of the technical adequacy of the Technical Assessment Review Notice may be warranted. In such cases the Technical Assessment Review Notice with attachments shall be provided by the responsible Branch Chief or designee in accordance with QMP-06-03 to a qualified individual who shall review these documents to verify that the areas and items to be assessed and the planned depth of the assessment are correct, adequate, applicable, and complete vis-a-vis the technical requirements imposed on the specific Technical Assessment Review.

REQUIRED CHANGES:

QMP SECTION	CHANGE TO

5.1.4 The PQM and other reviewers, as appropriate, shall document the results of their reviews on Document Review Sheets (DRSs) and, if needed, DRS Continuation Sheet(s) (see QMP-06-03), Document Review/Acceptance/Approval). Reviewers shall provide their DRSs to the responsible Branch Chief or designee for resolution of comments, if applicable, and for inclusion in the Review Record Memorandum. Upon the documented resolution of comments regarding the technical adequacy, as appropriate, and when satisfied with the quality related aspects of the Technical Assessment Review Notice and attachments, the PQM shall indicate approval by signing/dating page 1 of the Technical Assessment Review Notice.

5.1.5 Following approval of the Technical Assessment Review Notice and attachments by the PQM, the responsible Branch Chief or designee shall transmit a copy of the original issue of the Technical Assessment Review Notice (identified as Revision 0) with attachments to the PQM; Manager, Compliance Department; designated reviewers; and other appropriate personnel in accordance with QMP-06-02, Document Control. Revisions to the Technical Assessment Review Notice or attachments (see Section 5.1.6) shall be distributed to the same individuals and organizations as the original in accordance with QMP-06-02."

5.1.6 Changes to the Technical Assessment Review Notice and/or attachments that revise the information required in Section 3.2, Item 1 shall be subject to the same review and approval controls as the original documents. Minor changes to the Technical Assessment Review Notice or attachments that do not revise the information required in Section 3.2, Item 1 shall be issued directly by the Branch Chief or designee without subjecting the revised Technical Assessment Review Notice to the reviews required in Sections 5.1.2 and 5.1.3. The responsible Branch Chief, or designee, shall indicate "Not Applicable" in the space provided in Figure 1 for the PQM's approval. Page 1 of the Technical Assessment Review Notice shall reflect its current revision indicator, beginning with Revision 0 for the original version issued and 1, 2, etc., for subsequent revisions. A change to a Technical Assessment Review Notice attachment only shall be considered a change to the Technical Assessment Review Notice, and the revision indicator of the Technical Assessment Review Notice shall be revised accordingly and distributed with the revised attachment. All revisions to a Technical Assessment Review Notice shall be distributed to the same individuals and organizations as the original."

9. Change 3.5, No. 2 to "Technical Assessment Review Notice with attachments and associated DRSs (PQM's as a minimum)."

ICN Number:	Applies to QMP:	Effective Date:	Page 4 of 5
1	02-08	February 7, 1989	

REQUIRED CHANGES:

QMP SECTION	CHANGE TO
10. Add: "WMPO/88-1, Project Office QA Program Plan," "QMP-06-02, Document Control," and "QMP-06-03, Document Review/Acceptance/Approval" to Section 6.0. Change title of QMP-17-01 to "Record Source and Record User Responsibilities" in Sections 6.0 and 8.0. Identify all references as "latest revision."	
11. Change Figure 1, "Technical Assessment Review Notice," to provide designated spaces for the recording of the Technical Assessment Review Notice revision indicator and PQM's approval.	

ICN Number:	Applies to QMP:	Effective Date:	Page 5 of 5
1	02-08	February 7, 1989	

REQUIRED CHANGES:

QMP SECTION — CHANGE TO

TECHNICAL ASSESSMENT REVIEW NOTICE N-QA-010 1/89

Revision _____

To _____ Date _____

Technical Area to be Reviewed _____

WBS No.: _____

Review Date _____ Location _____ Time _____

Technical Assessment Review Chairperson _____

Based on a review of the qualification documentation, this Technical Assessment Review Chairperson is qualified to execute the responsibilities of QMP-02-08 with respect to the scope and purpose of this Technical Assessment Review.

Scope of Technical Assessment Review:

Purpose of Technical Assessment Review:

Signed _____

Reviewed and Approved:

_____ Project Quality Manager _____ Date

Attachments:

Figure 1. Technical Assessment Review Notice

CONTROLLED COPY

Title	No. QMP-02-08 Rev. 0
TECHNICAL ASSESSMENT REVIEW	Effective Date 08-Aug-1988
	Page 1 of 12

1.0 PURPOSE AND SCOPE

This procedure defines the method to be used and responsibilities for performing Technical Assessment Reviews for the Nevada Nuclear Waste Storage Investigations (NNWSI) Project. The requirements of this procedure may be supplemented with further documented guidance that defines the logistics and methodologies to be used in a review.

2.0 APPLICABILITY

This procedure applies to Technical Assessment Reviews conducted by the Waste Management Project Office (WMPO) for the NNWSI Project. A Technical Assessment Review is one of a set of review methods defined for the NNWSI Project in section 4.2.5 of the Systems Engineering Management Plan (SEMP). This procedure can be used in meeting the requirements for technical reviews defined in the SEMP and in U.S. Department of Energy (DOE) Order 4700.1, Attachment III-1, Page III-47, Section 2.

3.0 DEFINITIONS

3.1 TECHNICAL ASSESSMENT REVIEW

The Technical Assessment Review is a documented evaluation of technical status, technical progress, or technical merit, in combination or separately. It is performed by qualified individuals other than those who performed the technical work being reviewed, but who may be from the same organization. Technical Assessment Review is a management method that may be used to accomplish such items as the following:

1. Assessing requirements.
2. Determining the degree to which technical work meets requirements.
3. Identifying technical issues in a timely fashion, including interfaces with site and design efforts.
4. Assessing the technical status or technical progress of activities.
5. Providing a basis to accept technical services rendered.

APPROVED BY

Project Manager, T&MSS	WMPO Project Quality Manager	WMPO Project Manager
Date 3 August 1988	for J. Blaylock Date 08/03/88	for Date 8/4/88

6. Defining and directing necessary changes in accordance with WMPO procedures.

3.2 TECHNICAL ASSESSMENT REVIEW NOTICE

The Technical Assessment Review Notice (Figure 1) is issued by the responsible WMPO Branch Chief, or designee, announcing the Technical Assessment Review. The notice provides the following:

1. Technical Assessment Review scope and purpose, identifying areas and items to be assessed, including an indication of the required depth. This may be accomplished in a variety of ways, including the use of questionnaires, checklists, a list of design requirements, or through other suitable means.

2. Date, time, location, and other logistical information for the Technical Assessment Review meeting.

3. Name of the Technical Assessment Review Team Chairperson.

3.3 TECHNICAL ASSESSMENT REVIEW TEAM SELECTION RECORD

3.3.1 The Technical Assessment Review Team Selection Record (Figure 2) is completed, signed, and dated by the Technical Assessment Review Team Chairperson. It identifies the functions involved in the review, and the names of qualified individuals selected to be on the Technical Assessment Review Team. The review team members are assigned the responsibility for reviewing and providing comments, as applicable, for those functions. The review team members must be other than those who performed the technical work, but they may be from the same organization.

3.3.2 The Technical Assessment Review Team Selection Record includes the documentation of the qualifications of the review team members assigned for the various review functions.

3.4 TECHNICAL ASSESSMENT REVIEW PACKAGE

The Technical Assessment Review Package is a collection of documents (e.g., reports, schedules, plans, and drawings) that provides the information to be assessed by the review team members to achieve the established scope and purpose.

3.5 REVIEW RECORD MEMORANDUM

The Review Record Memorandum is a documented summary of the Technical Assessment Review prepared by the Secretary, which includes the following:

1. Scope of the review.
2. Technical Assessment Review Notice.
3. Technical Assessment Review Meeting minutes.
4. Technical Assessment Review Team Selection Record.
5. Technical Assessment Review Comment Records identifying comments and resolutions.
6. List of meeting attendees and, when specified, their Technical Assessment Review responsibilities.
7. Correspondence relating to the Technical Assessment Review.
8. Information presented during the Technical Assessment Review meeting and other information provided to the review team members that was not contained in the original Technical Assessment Review Package or in subsequent additions or modifications to the package.
9. Conclusions and recommendations.

3.6 TECHNICAL ASSESSMENT REVIEW COMMENT RECORD

The Technical Assessment Review Comment Record is a form used to document Technical Assessment Review comments and their resolution (Figures 3 and 4).

3.7 TECHNICAL ASSESSMENT REVIEW DATA PACKAGE

The Technical Assessment Review Package is a set of Quality Assurance (QA) records consisting of the Technical Assessment Review Package and the Review Record Memorandum, including any supplements as described in Section 5.5.6.

4.0 RESPONSIBILITIES

4.1 RESPONSIBLE WMPO BRANCH CHIEF OR DESIGNEE

4.1.1 The responsible WMPO Branch Chief or designee shall plan, schedule, and announce the Technical Assessment Review, designate the Technical Assessment Review Chairperson, and distribute the Review Record Memorandum.

4.1.2 If the responsible WMPO Branch Chief determines that a Project Participant is to be the designee, the responsible WMPO Branch Chief shall document that decision and the designated organization shall prepare and issue the Technical Assessment Review Notice.

4.2 TECHNICAL ASSESSMENT REVIEW CHAIRPERSON

The Technical Assessment Review Chairperson is responsible for the following:

1. Designating the Secretary for the Technical Assessment Review.
2. Determining the technical disciplines to be used to accomplish the scope and purpose of the review.
3. Establishing minimum qualifications (e.g., education, experience, and independence) needed by review team members to fulfill technical disciplines to accomplish the scope and purpose of the review.
4. Obtaining suitable documentation of review team members' qualifications for the various technical disciplines.
5. Ensuring that the documentation of the review team members' qualifications meets the needs of the review.
6. Determining the number of reviewers for the Technical Assessment Review Team.
7. Obtaining information for the review from the appropriate Technical Project Officer (TPO) and others, as appropriate.
8. Coordinating the Technical Assessment Review Team, the meeting, and the review process.
9. Issuing the Review Record Memorandum to the responsible WMPO Branch Chief for distribution.
10. Compiling a data package of the Technical Assessment Review.

4.3 SECRETARY

The Secretary documents the Technical Assessment Review Team activities. Specifically, the Secretary records the meeting minutes, collects comments and resolutions, and prepares the Review Record Memorandum (per Section 3.5).

4.4 TECHNICAL ASSESSMENT REVIEW TEAM MEMBERS

It is the responsibility of the review team members to review and provide comments in their technical area, as designated by the Chairperson, and to participate in the evaluation of proposed resolutions.

5.0 PROCEDURE

5.1 INITIATION OF THE TECHNICAL ASSESSMENT REVIEW

The responsible WMPO Branch Chief or designee plans, scopes, and schedules the Technical Assessment Review and designates the Technical Assessment Review Chairperson. The responsible WMPO Branch Chief or designee also issues the Technical Assessment Review Notice to Quality Assurance, Regulatory Compliance, and others, as appropriate.

5.2 TEAM SELECTION

5.2.1 The Technical Assessment Review Chairperson performs the following:

1. Designating the Secretary for the Technical Assessment Review.

2. Determining the technical disciplines to be used to accomplish the scope and purpose of the review.

3. Establishing minimum qualifications (e.g., education, experience, and independence) needed by review team members to fulfill the technical disciplines to accomplish the scope and purpose of the review.

4. Obtaining suitable documentation of review team members' qualifications for the various technical disciplines, as described in Section 5.2.2

5. Ensuring that the documentation of the review team members' qualifications meets the needs of the review, and signing and dating the Technical Assessment Review Team Selection Record(s).

6. Determining the number of reviewers for the Technical Assessment Review Team.

7. Ensuring that assigned Review Team Members are trained to this procedure and other applicable documents.

5.2.2 The Technical Assessment Review Chairperson requests the following information for each of the review team members: name of the person and a statement that the review team member meets the education, experience, and independence qualifications established for the review. This information is to be provided by the employer of the review team member.

5.2.3 If a review team member's employer is an agency outside of the NNWSI Project, the chairperson is responsible for notifying the agency that the documentation verifying the education, experience, and independence of the review team member must be obtained and retained by that agency. This documentation shall be made available for surveillance and audit by the U.S. Nuclear Regulatory Commission or the DOE. In addition, the agency shall be required to notify the WMPO prior to destruction of this verification documentation.

5.3 TECHNICAL ASSESSMENT REVIEW PACKAGE

The Technical Assessment Review Chairperson obtains the information for the review from the appropriate TPO and others, as appropriate.

5.4 TECHNICAL ASSESSMENT REVIEW

5.4.1 The review team members review the material and document their comments on Technical Assessment Review Comment Records. If a review team member has no comment, this is documented on a Technical Assessment Review Comment Record.

5.4.2 The Secretary records meeting minutes, collects comments and resolutions, and prepares the Review Record Memorandum (per Section 3.5). The Technical Assessment Review Chairperson reviews, signs, and dates the Review Record Memorandum.

5.5 RESOLUTION OF TECHNICAL ASSESSMENT REVIEW COMMENTS

5.5.1 The Technical Assessment Review Chairperson obtains resolutions for the Technical Assessment Review comments from the appropriate TPO.

5.5.2 The Technical Assessment Review Chairperson coordinates the team's evaluation of the resolutions obtained in Section 5.5.1. After deciding the appropriateness of the resolutions, such acknowledgment is documented to the appropriate TPO.

5.5.3 Any unresolved comments are referred by the Chairperson to the appropriate TPO for resolution. (The appropriate TPO is the one who has responsibility for the subject of the unresolved comment.)

5.5.4 The Chairperson, upon submittal of a review comment resolution by the appropriate TPO, shall ensure that the resolution is provided to the review team member and the responsible WMPO Branch Chief.

5.5.5 The review team member who had the unresolved comment shall evaluate the provided comment resolution, and either:

1. Sign and date the review comment resolution (according to the Chairperson's instruction) to indicate agreement, and return it to the Chairperson.

2. If a disagreement exists, attempt to achieve an agreement, (via the Chairperson) with the appropriate TPO. If agreement cannot be reached, provide the documented basis for the disagreement to the Chairperson and request assistance from successively higher levels of management.

5.5.6 The Chairperson may complete the Review Record Memorandum with a documented unresolved comment; however, supplements must be provided to the memorandum as the appeals process is pursued, such that a complete record of the comment is retained as a QA record.

5.6 REVIEW RECORD MEMORANDUM

The Technical Assessment Review Chairperson issues the Review Record Memorandum to the responsible WMPO Branch Chief for distribution to the TPO(s) and others, as appropriate.

5.7 CLOSURE OF RESOLUTION

The responsible WMPO Branch Chief or designee shall ensure that the appropriate TPO satisfies and closes out the commitments made in resolutions to the Technical Assessment Review comments.

5.8 TECHNICAL ASSESSMENT REVIEW DOCUMENTATION

The Technical Assessment Review Chairperson shall (1) compile a data package relative to the Technical Assessment Review that consists of the Technical Assessment Review Package and the Review Record Memorandum (including any supplements as described in Section 5.5.6) and (2) provide for disposition of the data package in accordance with Section 8.0.

6.0 REFERENCES

The latest revisions of the following apply:

NNWSI/88-3, NNWSI Project Systems Engineering Management Plan

DOE Order 4700.1, Project Management System

QMP-17-01, QA Records

7.0 FIGURES

At a minimum, the information needs on the forms shown on the following figures shall be satisfied. This may be accomplished by the use of the form itself or a suitable alternate.

Figure 1, Technical Assessment Review Notice

Figure 2, Technical Assessment Review Team Selection Record

Figure 3, Technical Assessment Review Comment Record

Figure 4, Technical Assessment Review Comment Record Continuation Sheet

8.0 QA RECORDS

The following are QA records and are maintained in accordance with QMP-17-01, QA Records.

1. Technical Assessment Review Package.

2. Review Record Memorandum (including any supplements as described in Section 5.5.6).

TECHNICAL ASSESSMENT REVIEW NOTICE

N-QA-010
7/88

To _____ Date _____

Technical Area to be Reviewed _____

WBS No.: _____

Review Date _____ Location _____ Time _____

Technical Assessment Review Chairperson _____

Based on review of the qualification documentation, this Technical Assessment Review Chairperson is qualified to execute the responsibilities of QMP-02-08 with respect to the scope and purpose of this Review.

Scope of Technical Assessment Review:

Purpose of Technical Assessment Review:

Signed _____

Attachments:

Figure 1. Technical Assessment Review Notice.

TECHNICAL ASSESSMENT REVIEW TEAM SELECTION RECORD

N-QA-008
7/88

Technical Assessment Review Subject ______________________

FUNCTION	REPRESENTATIVE
Secretary	

Based on review of the qualification documentation, these representatives cover the functions for this Review and are acceptable as team members to accomplish the scope and purpose of this review.

Signed ______________________

Attachment:

Qualification Documentation

Figure 2. Technical Assessment Review Team Selection Record.

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD

N-QA-006
7/88

Sheet ____ of ____

Technical Assessment Review Subject _____

Reviewer _____ Organization _____ Date _____

Comments Resolved By _____ Organization _____ Date _____

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Reference Doct. No.	Comments	Accept	Reject	Reason	Accept	Reject

Figure 3. Technical Assessment Review Comment Record.

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD
CONTINUATION SHEET

N-QA-006
7/88

Technical Assessment Review Subject _____ Sheet _____ of _____

REVIEWER'S COMMENTS			RESOLUTION		REVIEWER'S DISPOSITION	
Item Number	Reference Doc. No.	Comments	Accept	Reject	Accept	Reject
			Reason			

Figure 4. Technical Assessment Review Comment Record Continuation Sheet.

N-AD-077
4/13/89

SPECIAL TRAINING ASSIGNMENT

TO: David Cummings
(Print Name)

Date Prepared 5/18/89

JOB TASK/ACTIVITY Technical Assessment Review (T.A.R.): Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

You are assigned to complete the following special training by 5/22/89 (Date).

Completion of the training assignment(s) is a prerequisite to your performance of work as a T.A.R. Team Member in the above activity.

Complete indoctrination/proficiency training as indicated below.

I. INDOCTRINATION READING ASSIGNMENT

Doc. No.	Title	Rev.	Initials	Date
QMP-02-08	Technical Assessment Review	0	DC	5/22
ICN 1	Interim Change Notice Applying to QMP-02-08		DC	5/22
	Technical Assessment Review Plan	0	DC	5/22

II. PROFICIENCY TRAINING

Title	Rev.	Type Tng R/W/C	Comp. Date	Instr. Initial
N/A				

The above individual has satisfactorily completed this assignment.

RCL 6/6/89

Team Leader ~~Manager~~: Richard C. Lee
(Print Name)

T.A.R. Chairperson
(Title)

Richard C. Lee
(Signature)

6/6/89
(Date)

N-AD-077
4/13/89

SPECIAL TRAINING ASSIGNMENT

TO: J. MARSHALL DAVENPORT
(Print Name)

Date Prepared 5/18/89

JOB TASK/ACTIVITY Technical Assessment Review (T.A.R.): Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

You are assigned to complete the following special training by 5/22/89 (Date).

Completion of the training assignment(s) is a prerequisite to your performance of work as a T.A.R. Team Member in the above activity.

Complete indoctrination/proficiency training as indicated below.

I. INDOCTRINATION READING ASSIGNMENT

Doc. No.	Title	Rev.	Initials	Date
QMP-02-08	Technical Assessment Review	0	[illegible]	5/19/89
ICN 1	Interim Change Notice Applying to QMP-02-08		[illegible]	5/19/89
	Technical Assessment Review Plan	0	[illegible]	5/19/89

II. PROFICIENCY TRAINING

Title	Rev.	Type Tng R/W/C	Comp. Date	Instr. Initial
N/A				

The above individual has satisfactorily completed this assignment.

RCL 6/6/89

Team Leader: ~~Manager~~: Richard C. Lee
(Print Name)

T.A.R. Chairperson
(Title)

Richard C. Lee
(Signature)

6/6/89
(Date)

N-AD-077
4/13/89

SPECIAL TRAINING ASSIGNMENT

TO: David C. Dobson (Print Name) Date Prepared 5/18/89

JOB TASK/ACTIVITY Technical Assessment Review (T.A.R.): Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

You are assigned to complete the following special training by 5/22/89 (Date).

Completion of the training assignment(s) is a prerequisite to your performance of work as a T.A.R. Team Member in the above activity.

Complete indoctrination/proficiency training as indicated below.

I. INDOCTRINATION READING ASSIGNMENT

Doc. No.	Title	Rev.	Initials	Date
QMP-02-08	Technical Assessment Review	0	[illegible]	5/26/89
ICN 1	Interim Change Notice Applying to QMP-02-08		[illegible]	5/26/89
	Technical Assessment Review Plan	0	[illegible]	5/26/89

II. PROFICIENCY TRAINING

Title	Rev.	Type Tng R/W/C	Comp. Date	Instr. Initial
N/A				

The above individual has satisfactorily completed this assignment.

Team Leader: RCL 6/6/89

~~Manager:~~ Richard C. Lee (Print Name) — T.A.R. Chairperson (Title)

Richard C. Lee (Signature) — 6/6/89 (Date)

N-AD-077
4/13/89

SPECIAL TRAINING ASSIGNMENT

TO: David F. Fenster (Print Name) Date Prepared 5/18/89

JOB TASK/ACTIVITY Technical Assessment Review (T.A.R.): Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

You are assigned to complete the following special training by 5/22/89 (Date).

Completion of the training assignment(s) is a prerequisite to your performance of work as a T.A.R. Team Member in the above activity.

Complete indoctrination/proficiency training as indicated below.

I. INDOCTRINATION READING ASSIGNMENT

Doc. No.	Title	Rev.	Initials	Date
QMP-02-08	Technical Assessment Review	0	DFF	5/24/89
ICN 1	Interim Change Notice Applying to QMP-02-08			
	Technical Assessment Review Plan	0	DFF	5/24/89

II. PROFICIENCY TRAINING

Title	Rev.	Type Tng R/W/C	Comp. Date	Instr. Initial
N/A				

The above individual has satisfactorily completed this assignment.

RCL 6/6/89

Team Leader: ~~Manager:~~ Richard C. Lee (Print Name) — T.A.R. Chairperson (Title)

Richard C. Lee (Signature) — 6/6/89 (Date)

N-AD-077
4/13/89

SPECIAL TRAINING ASSIGNMENT

TO: TERRY A. GRANT (Print Name) Date Prepared 5/18/89

JOB TASK/ACTIVITY Technical Assessment Review (T.A.R.): Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

You are assigned to complete the following special training by 5/22/89 (Date).

Completion of the training assignment(s) is a prerequisite to your performance of work as a T.A.R. Team Member in the above activity.

Complete indoctrination/proficiency training as indicated below.

I. INDOCTRINATION READING ASSIGNMENT

Doc. No.	Title	Rev.	Initials	Date
QMP-02-08	Technical Assessment Review	0	[illegible]	5/22/89
ICN 1	Interim Change Notice Applying to QMP-02-08		[illegible]	5/22/89
	Technical Assessment Review Plan	0	[illegible]	5/22/89

II. PROFICIENCY TRAINING

Title	Rev.	Type Tng R/W/C	Comp. Date	Instr. Initial
N/A				

The above individual has satisfactorily completed this assignment.

RCL 6/6/89

Team Leader: ~~Manager:~~ Richard C. Lee (Print Name) — T.A.R. Chairperson (Title)

[signature] (Signature) — 6/6/89 (Date)

N-AD-077
4/13/89

SPECIAL TRAINING ASSIGNMENT

TO: MAURICE GRIEVES
(Print Name)

Date Prepared 5/18/89

JOB TASK/ACTIVITY Technical Assessment Review (T.A.R.): Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

You are assigned to complete the following special training by 5/22/89 (Date).

Completion of the training assignment(s) is a prerequisite to your performance of work as a T.A.R. Team Member in the above activity.

Complete indoctrination/proficiency training as indicated below.

I. INDOCTRINATION READING ASSIGNMENT

Doc. No.	Title	Rev.	Initials	Date
QMP-02-08	Technical Assessment Review	0	MG	7/7/89
ICN 1	Interim Change Notice Applying to QMP-02-08			
	Technical Assessment Review Plan	0	MG	7/7/89

II. PROFICIENCY TRAINING

Title	Rev.	Type Tng R/W/C	Comp. Date	Instr. Initial
N/A				

The above individual has satisfactorily completed this assignment.

Team Leader: ~~Manager~~: Richard C. Lee
(Print Name)

T.A.R. Chairperson
(Title)

Richard C. Lee
(Signature)

7/14/89
(Date)

N-AD-077
4/13/89

SPECIAL TRAINING ASSIGNMENT

TO: ERNEST HARDIN (Print Name) Date Prepared 5/18/89

JOB TASK/ACTIVITY Technical Assessment Review (T.A.R.): Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

You are assigned to complete the following special training by 5/22/89 (Date).

Completion of the training assignment(s) is a prerequisite to your performance of work as a T.A.R. Team Member in the above activity.

Complete indoctrination/proficiency training as indicated below.

I. INDOCTRINATION READING ASSIGNMENT

Doc. No.	Title	Rev.	Initials	Date
QMP-02-08	Technical Assessment Review	0	EWA	5/30/89
ICN 1	Interim Change Notice Applying to QMP-02-08		EWA	5/30/89
	Technical Assessment Review Plan	0	EWA	5/30/89

II. PROFICIENCY TRAINING

Title	Rev.	Type Tng R/W/C	Comp. Date	Instr. Initial
N/A				

The above individual has satisfactorily completed this assignment.

RCL 6/6/89

Team Leader ~~Manager~~: Richard C. Lee (Print Name) — T.A.R. Chairperson (Title)

Richard C. Lee (Signature) — 6/6/89 (Date)

N-AD-077
4/13/89

SPECIAL TRAINING ASSIGNMENT

TO: THOMAS E. HINKEBEIN (Print Name) Date Prepared 5/18/89

JOB TASK/ACTIVITY Technical Assessment Review (T.A.R.): Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

You are assigned to complete the following special training by 5/22/89 (Date).

Completion of the training assignment(s) is a prerequisite to your performance of work as a T.A.R. Team Member in the above activity.

Complete indoctrination/proficiency training as indicated below.

I. INDOCTRINATION READING ASSIGNMENT

Doc. No.	Title	Rev.	Initials	Date
QMP-02-08	Technical Assessment Review	0	TEH	5/23/89
ICN 1	Interim Change Notice Applying to QMP-02-08		TEH	5/23/89
	Technical Assessment Review Plan	0	TEH	5/23/89

II. PROFICIENCY TRAINING

Title	Rev.	Type Tng R/W/C	Comp. Date	Instr. Initial
N/A				

The above individual has satisfactorily completed this assignment.

RCL 6/6/89

Team Leader: ~~Manager~~: Richard C. Lee (Print Name) — T.A.R. Chairperson (Title)

Richard C. Lee (Signature) — 6/6/89 (Date)

N-AD-077
4/13/89

SPECIAL TRAINING ASSIGNMENT

TO: Jonathan D. Istok (Print Name) Date Prepared 5/18/89

JOB TASK/ACTIVITY Technical Assessment Review (T.A.R.): Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

You are assigned to complete the following special training by 5/22/89 (Date).

Completion of the training assignment(s) is a prerequisite to your performance of work as a T.A.R. Team Member in the above activity.

Complete indoctrination/proficiency training as indicated below.

I. INDOCTRINATION READING ASSIGNMENT

Doc. No.	Title	Rev.	Initials	Date
QMP-02-08	Technical Assessment Review	0	JDI	5/30/89
ICN 1	Interim Change Notice Applying to QMP-02-08		JDI	5/30/89
	Technical Assessment Review Plan	0	JDI	5/30/89

II. PROFICIENCY TRAINING

Title	Rev.	Type Tng R/W/C	Comp. Date	Instr. Initial
N/A				

The above individual has satisfactorily completed this assignment.

RCL 6/6/89

Team Leader: ~~Manager:~~ Richard C. Lee (Print Name) — T.A.R. Chairperson (Title)

Richard C. Lee (Signature) — 6/6/89 (Date)

N-AD-077
4/13/89

SPECIAL TRAINING ASSIGNMENT

TO: Jeff Kimball (Print Name) Date Prepared 5/18/89

JOB TASK/ACTIVITY Technical Assessment Review (T.A.R.): Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

You are assigned to complete the following special training by 5/22/89 (Date).

Completion of the training assignment(s) is a prerequisite to your performance of work as a T.A.R. Team Member in the above activity.

Complete indoctrination/proficiency training as indicated below.

I. INDOCTRINATION READING ASSIGNMENT

Doc. No.	Title	Rev.	Initials	Date
QMP-02-03	Technical Assessment Review	0	JKK	5/25/89
ICN 1	Interim Change Notice Applying to QMP-02-08		JKK	5/25/89
	Technical Assessment Review Plan	0	JKK	5/25/89

II. PROFICIENCY TRAINING

Title	Rev.	Type Tng R/W/C	Comp. Date	Instr. Initial
N/A				

The above individual has satisfactorily completed this assignment.

RCL 6/6/89

Team Leader: ~~Manager~~: Richard C. Lee (Print Name) — T.A.R. Chairperson (Title)

Richard C. Lee (Signature) — 6/6/89 (Date)

N-AD-077
4/13/89

SPECIAL TRAINING ASSIGNMENT

TO: DOUGLAS P. KLEIN (Print Name) Date Prepared 5/18/89

JOB TASK/ACTIVITY Technical Assessment Review (T.A.R.): Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

You are assigned to complete the following special training by 5/22/89 (Date).

Completion of the training assignment(s) is a prerequisite to your performance of work as a T.A.R. Team Member in the above activity.

Complete indoctrination/proficiency training as indicated below.

I. INDOCTRINATION READING ASSIGNMENT

Doc. No.	Title	Rev.	Initials	Date
QMP-02-08	Technical Assessment Review	0	DPK	5/30/89
ICN 1	Interim Change Notice Applying to QMP-02-08		DPK	5/31/89
	Technical Assessment Review Plan	0	DPK	5/31/89

II. PROFICIENCY TRAINING

Title	Rev.	Type Tng R/W/C	Comp. Date	Instr. Initial
N/A				

The above individual has satisfactorily completed this assignment.

RCL 6/6/89

Team Leader: ~~Manager~~: Richard C. Lee (Print Name) — T.A.R. Chairperson (Title)

Richard C. Lee (Signature) — 6/6/89 (Date)

N-AD-077
4/13/89

SPECIAL TRAINING ASSIGNMENT

TO: Richard C. Lee (Print Name) Date Prepared 5/18/89

JOB TASK/ACTIVITY Technical Assessment Review (T.A.R.): Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

You are assigned to complete the following special training by 5/22/89 (Date).

Completion of the training assignment(s) is a prerequisite to your performance of work as a T.A.R. Team Member in the above activity.

Complete indoctrination/proficiency training as indicated below.

I. INDOCTRINATION READING ASSIGNMENT

Doc. No.	Title	Rev.	Initials	Date
QMP-02-08	Technical Assessment Review	0	RCL	5/22/89
ICN 1	Interim Change Notice Applying to QMP-02-08		RCL	5/22/89
	Technical Assessment Review Plan	0	RCL	5/22/89

II. PROFICIENCY TRAINING

Title	Rev.	Type Tng R/W/C	Comp. Date	Instr. Initial
N/A				

The above individual has satisfactorily completed this assignment.

Manager: Jerry L. King (Print Name) — Department Manager (Title)

(Signature) — 5/22/89 (Date)

N-AD-077
4/13/89

SPECIAL TRAINING ASSIGNMENT

TO: Mohammad S. Mozumder
(Print Name)

Date Prepared 5/18/89

JOB TASK/ACTIVITY Technical Assessment Review (T.A.R.): Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

You are assigned to complete the following special training by 5/22/89 (Date).

Completion of the training assignment(s) is a prerequisite to your performance of work as a T.A.R. Team Member in the above activity.

Complete indoctrination/proficiency training as indicated below.

I. INDOCTRINATION READING ASSIGNMENT

Doc. No.	Title	Rev.	Initials	Date
QMP-02-08	Technical Assessment Review	0	MSM	5/22/89
ICN 1	Interim Change Notice Applying to QMP-02-08		MSM	5/22/89
	Technical Assessment Review Plan	0	MSM	5/22/89

II. PROFICIENCY TRAINING

Title	Rev.	Type Tng R/W/C	Comp. Date	Instr. Initial
N/A				

The above individual has satisfactorily completed this assignment.

Team Leader: RCL 6/6/89
~~Manager:~~ Richard C. Lee
(Print Name)

T.A.R. Chairperson
(Title)

Richard C. Lee
(Signature)

6/6/89
(Date)

N-AD-077
4/13/89

SPECIAL TRAINING ASSIGNMENT

TO: Michael W. Parsons
(Print Name)

Date Prepared 5/18/89

JOB TASK/ACTIVITY Technical Assessment Review (T.A.R.): Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

You are assigned to complete the following special training by 5/22/89 (Date).

Completion of the training assignment(s) is a prerequisite to your performance of work as a T.A.R. Team Member in the above activity.

Complete indoctrination/proficiency training as indicated below.

I. INDOCTRINATION READING ASSIGNMENT

Doc. No.	Title	Rev.	Initials	Date
QMP-02-08	Technical Assessment Review	0	[illegible]	7/14/89
ICN 1	Interim Change Notice Applying to QMP-02-08		[illegible]	7/14/89
	Technical Assessment Review Plan	0	[illegible]	7/14/89

II. PROFICIENCY TRAINING

Title	Rev.	Type Tng R/W/C	Comp. Date	Instr. Initial
N/A				

The above individual has satisfactorily completed this assignment.

Team Leader: ~~Manager:~~ Richard C. Lee
(Print Name)

T.A.R. Chairperson
(Title)

[illegible]
(Signature)

7/18/89
(Date)

N-AD-077
4/13/89

SPECIAL TRAINING ASSIGNMENT

TO: Forrest D. Peters (Print Name) Date Prepared 5/18/89

JOB TASK/ACTIVITY Technical Assessment Review (T.A.R.): Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

You are assigned to complete the following special training by 5/22/89 (Date).

Completion of the training assignment(s) is a prerequisite to your performance of work as a T.A.R. Team Member in the above activity.

Complete indoctrination/proficiency training as indicated below.

I. INDOCTRINATION READING ASSIGNMENT

Doc. No.	Title	Rev.	Initials	Date
OMP-02-08	Technical Assessment Review	0	[illegible]	5/26/89
ICN 1	Interim Change Notice Applying to QMP-02-08		[illegible]	5/26/89
	Technical Assessment Review Plan	0	[illegible]	5/26/89

II. PROFICIENCY TRAINING

Title	Rev.	Type Tng R/W/C	Comp. Date	Instr. Initial
N/A				

The above individual has satisfactorily completed this assignment.

RCL 6/6/89

Team Leader: ~~Manager~~: Richard C. Lee (Print Name) T.A.R. Chairperson (Title)

[signature] (Signature) 6/6/89 (Date)

N-AD-077
4/13/89

SPECIAL TRAINING ASSIGNMENT

TO: Gerald L. Shideler (Print Name) Date Prepared 5/18/89

JOB TASK/ACTIVITY Technical Assessment Review (T.A.R.): Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

You are assigned to complete the following special training by 5/22/89 (Date).

Completion of the training assignment(s) is a prerequisite to your performance of work as a T.A.R. Team Member in the above activity.

Complete indoctrination/proficiency training as indicated below.

I. INDOCTRINATION READING ASSIGNMENT

Doc. No.	Title	Rev.	Initials	Date
QMP-02-08	Technical Assessment Review	0	JLS	5-30-87
ICN 1	Interim Change Notice Applying to QMP-02-08		JLS	5-30-89
	Technical Assessment Review Plan	0	JLS	5-30-89

II. PROFICIENCY TRAINING

Title	Rev.	Type Tng R/W/C	Comp. Date	Instr. Initial
N/A				

The above individual has satisfactorily completed this assignment.

RCL 6/6/89

Team Leader: ~~Manager~~: Richard C. Lee (Print Name) T.A.R. Chairperson (Title)

Richard C. Lee (Signature) 6/6/89 (Date)

N-AD-077
4/13/89

SPECIAL TRAINING ASSIGNMENT

TO: Richard P. Snyder
(Print Name)

Date Prepared 5/18/89

JOB TASK/ACTIVITY Technical Assessment Review (T.A.R.): Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

You are assigned to complete the following special training by 5/22/89 (Date).

Completion of the training assignment(s) is a prerequisite to your performance of work as a T.A.R. Team Member in the above activity.

Complete indoctrination/proficiency training as indicated below.

I. INDOCTRINATION READING ASSIGNMENT

Doc. No.	Title	Rev.	Initials	Date
QMP-02-08	Technical Assessment Review	C	RPS	5/24/89
ICN 1	Interim Change Notice Applying to QMP-02-08		RPS	5/24/89
	Technical Assessment Review Plan	0	RPS	5/24/89

II. PROFICIENCY TRAINING

Title	Rev.	Type Tng R/W/C	Comp. Date	Instr. Initial
N/A				

The above individual has satisfactorily completed this assignment.

RCL 6/6/89

Team Leader: ~~Manager:~~ Richard C. Lee
(Print Name)

T.A.R. Chairperson
(Title)

Richard C. Lee
(Signature)

6/6/89
(Date)

C.4 Questionnaire for Documenting Independence of TAR Team Members

Attachment 5

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

Questionnaire for documenting the independence of Technical Assessment Review (TAR) team members

(Please Print)

Name: David Cummings

Review Function(s): Geology and Geophysics

1. List the titles of any reports you have authored or co-authored that bear on geological and/or geophysical interpretations in the vicinity of the Exploratory Shaft Facility (ESF). Enter "None" if appropriate.

Cummings, David, 1968, Mechanical analysis of the effect of the Timber Mountain Caldera on Basin and Range faults: Jour. Geophys. Res, v. 73, no. 8, p2787-2794

2. List the titles and authors of reports of geological and geophysical nature that are relevant to structure in the vicinity of the ESF that you have provided policy and/or technical reviews. Enter "None" if appropriate.

Spengler and Fox (in press) Structure and Stratigraphy, Yucca Mountain (ANS pub) -tech review-

author (?) - geodetic survey, vicinity of Yucca Mtn - study plan -tech (mgt) reviewer

3. List any committees you previously belonged to that have reviewed geological and/or geophysical data relevant to geologic structure in the vicinity of the ESF and your role on each committee. Enter "None" if appropriate.

none

Signature: [signature]

Date: 5/22/89

Attachment 5

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

Questionnaire for documenting the independence of Technical Assessment Review (TAR) team members

(Please Print)

Name: J. MARSHALL DAVENPORT III

Review Function(s): SECRETARY, MEMBER OF GEOLOGY TEAM

1. List the titles of any reports you have authored or co-authored that bear on geological and/or geophysical interpretations in the vicinity of the Exploratory Shaft Facility (ESF). Enter "None" if appropriate.

NONE

2. List the titles and authors of reports of geological and geophysical nature that are relevant to structure in the vicinity of the ESF that you have provided policy and/or technical reviews. Enter "None" if appropriate.

NONE

3. List any committees you previously belonged to that have reviewed geological and/or geophysical data relevant to geologic structure in the vicinity of the ESF and your role on each committee. Enter "None" if appropriate.

NONE

Signature: J. Marshall Davenport III

Date: 5/19/89

Attachment 5

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

Questionnaire for documenting the independence of Technical Assessment Review (TAR) team members

(Please Print)

Name: David C. Dobson

Review Function(s): Geologist

1. List the titles of any reports you have authored or co-authored that bear on geological and/or geophysical interpretations in the vicinity of the Exploratory Shaft Facility (ESF). Enter "None" if appropriate.

None

2. List the titles and authors of reports of geological and geophysical nature that are relevant to structure in the vicinity of the ESF that you have provided policy and/or technical reviews. Enter "None" if appropriate.

None

3. List any committees you previously belonged to that have reviewed geological and/or geophysical data relevant to geologic structure in the vicinity of the ESF and your role on each committee. Enter "None" if appropriate.

None

Signature: David C. Dobson

Date: 6/6/85

Attachment 5

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

Questionnaire for documenting the independence of Technical Assessment Review (TAR) team members

(Please Print)

Name: David Fenster

Review Function(s):

1. List the titles of any reports you have authored or co-authored that bear on geological and/or geophysical interpretations in the vicinity of the Exploratory Shaft Facility (ESF). Enter "None" if appropriate.

None.

2. List the titles and authors of reports of geological and geophysical nature that are relevant to structure in the vicinity of the ESF that you have provided policy and/or technical reviews. Enter "None" if appropriate.

Smith & Ross, 1982, USGS OFR 82-182

3. List any committees you previously belonged to that have reviewed geological and/or geophysical data relevant to geologic structure in the vicinity of the ESF and your role on each committee. Enter "None" if appropriate.

None

Signature: David F. Fenster

Date: 5/24/89

Attachment 5

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

Questionnaire for documenting the independence of Technical Assessment Review (TAR) team members

(Please Print)

Name: Terry Grant

Review Function(s):

1. List the titles of any reports you have authored or co-authored that bear on geological and/or geophysical interpretations in the vicinity of the Exploratory Shaft Facility (ESF). Enter "None" if appropriate.

NONE

2. List the titles and authors of reports of geological and geophysical nature that are relevant to structure in the vicinity of the ESF that you have provided policy and/or technical reviews. Enter "None" if appropriate.

NONE

3. List any committees you previously belonged to that have reviewed geological and/or geophysical data relevant to geologic structure in the vicinity of the ESF and your role on each committee. Enter "None" if appropriate.

NONE

Signature: Terry A. Grant

Date: 5/22/89

Attachment 5

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

Questionnaire for documenting the independence of Technical Assessment Review (TAR) team members

(Please Print)

Name:

Review Function(s):

1. List the titles of any reports you have authored or co-authored that bear on geological and/or geophysical interpretations in the vicinity of the Exploratory Shaft Facility (ESF). Enter "None" if appropriate.

NONE

2. List the titles and authors of reports of geological and geophysical nature that are relevant to structure in the vicinity of the ESF that you have provided policy and/or technical reviews. Enter "None" if appropriate.

① ESF - REPOSITORY INTERFACE CONTROL DRAWINGS R07061 thru R07070 (Rev 1)
Prepared by Parsons Brinckerhoff for SNL.
This is a QA Level I Document and my role was 'checker' to verify the design.

② Shaft lined analysis for ESF Design (Preliminary Draft - in progress) By Parsons Brinckerhoff
This is a QA Level I Document and my role is coordination review checker.

3. List any committees you previously belonged to that have reviewed geological and/or geophysical data relevant to geologic structure in the vicinity of the ESF and your role on each committee. Enter "None" if appropriate.

NONE

Signature: [illegible]

Date: 7/7/89

Attachment 5

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

Questionnaire for documenting the independence of Technical Assessment Review (TAR) team members

(Please Print)

Name: ERNEST HARDIN

Review Function(s):

1. List the titles of any reports you have authored or co-authored that bear on geological and/or geophysical interpretations in the vicinity of the Exploratory Shaft Facility (ESF). Enter "None" if appropriate.

EXPLORATORY SHAFT LOCATION DOCUMENTATION REPORT (NVO-326)
W/ P. GNIRK and M. D. VOEGELE.

2. List the titles and authors of reports of geological and geophysical nature that are relevant to structure in the vicinity of the ESF that you have provided policy and/or technical reviews. Enter "None" if appropriate.

NONE.

3. List any committees you previously belonged to that have reviewed geological and/or geophysical data relevant to geologic structure in the vicinity of the ESF and your role on each committee. Enter "None" if appropriate.

DESIGN ACCEPTABILITY ANALYSIS - TAR (TECHNICAL SPECIALIST)

Signature: E L Hardin

Date: 5/24/89

Attachment 5

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

Questionnaire for documenting the independence of Technical Assessment Review (TAR) team members

(Please Print)

Name: THOMAS E. HINKEBEIN

Review Function(s): PERFORMANCE ASSESSMENT / EVALUATION SPECIALIST

1. List the titles of any reports you have authored or co-authored that bear on geological and/or geophysical interpretations in the vicinity of the Exploratory Shaft Facility (ESF). Enter "None" if appropriate.

SELECTED ANALYSES TO EVALUATE THE EFFECT OF THE EXPLORATORY SHAFTS ON ~~THE~~ REPOSITORY PERFORMANCE AT YUCCA MOUNTAIN, by JOSEPH A. FERNANDEZ THOMAS E. HINKEBEIN, & JOHN B. CASE, SAND 85-0598, JAN, 1989.

2. List the titles and authors of reports of geological and geophysical nature that are relevant to structure in the vicinity of the ESF that you have provided policy and/or technical reviews. Enter "None" if appropriate.

NONE

3. List any committees you previously belonged to that have reviewed geological and/or geophysical data relevant to geologic structure in the vicinity of the ESF and your role on each committee. Enter "None" if appropriate.

NONE

Signature: Thomas E. Hinkebein

Date: 5/23/89

Attachment 5

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

Questionnaire for documenting the independence of Technical Assessment Review (TAR) team members

(Please Print)

Name: Jonathan D. Istok

Review Function(s):

1. List the titles of any reports you have authored or co-authored that bear on geological and/or geophysical interpretations in the vicinity of the Exploratory Shaft Facility (ESF). Enter "None" if appropriate.

None

2. List the titles and authors of reports of geological and geophysical nature that are relevant to structure in the vicinity of the ESF that you have provided policy and/or technical reviews. Enter "None" if appropriate.

None

3. List any committees you previously belonged to that have reviewed geological and/or geophysical data relevant to geologic structure in the vicinity of the ESF and your role on each committee. Enter "None" if appropriate.

None

Signature: Jonathan Istok

Date: 5/31/89

Attachment 5

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

Questionnaire for documenting the independence of Technical Assessment Review (TAR) team members

(Please Print)

Name: Jeff Kimball

Review Function(s): Review of Geologic + Geophysical Items in The TAR Package

1. List the titles of any reports you have authored or co-authored that bear on geological and/or geophysical interpretations in the vicinity of the Exploratory Shaft Facility (ESF). Enter "None" if appropriate.

None

2. List the titles and authors of reports of geological and geophysical nature that are relevant to structure in the vicinity of the ESF that you have provided policy and/or technical reviews. Enter "None" if appropriate.

Policy + Tech Review of ESF Seismic Design Recommend. For Title 2 - Dated 4/88

3. List any committees you previously belonged to that have reviewed geological and/or geophysical data relevant to geologic structure in the vicinity of the ESF and your role on each committee. Enter "None" if appropriate.

TAR on the DAA / Coauthored Part II on Location Analysis

Signature: Jeffrey K Kimball

Date: 5/25/89

Attachment 5

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

Questionnaire for documenting the independence of Technical Assessment Review (TAR) team members

(Please Print)

Name: Douglas Klein

Review Function(s):

1. List the titles of any reports you have authored or co-authored that bear on geological and/or geophysical interpretations in the vicinity of the Exploratory Shaft Facility (ESF). Enter "None" if appropriate.

Review of Geoelectric Surveys in the region of Yucca Mtn (1966-1985) [to be part of a "Geophysics Whitepaper"], in review to Dec 88.

2. List the titles and authors of reports of geological and geophysical nature that are relevant to structure in the vicinity of the ESF that you have provided policy and/or technical reviews. Enter "None" if appropriate.

None

3. List any committees you previously belonged to that have reviewed geological and/or geophysical data relevant to geologic structure in the vicinity of the ESF and your role on each committee. Enter "None" if appropriate.

None

Signature: Douglas P. Klein

Date: 31 May 89

Attachment 5

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

Questionnaire for documenting the independence of Technical Assessment Review (TAR) team members

(Please Print)

Name: Richard Lee

Review Function(s): TAR Chairman

1. List the titles of any reports you have authored or co-authored that bear on geological and/or geophysical interpretations in the vicinity of the Exploratory Shaft Facility (ESF). Enter "None" if appropriate.

None

2. List the titles and authors of reports of geological and geophysical nature that are relevant to structure in the vicinity of the ESF that you have provided policy and/or technical reviews. Enter "None" if appropriate.

None

3. List any committees you previously belonged to that have reviewed geological and/or geophysical data relevant to geologic structure in the vicinity of the ESF and your role on each committee. Enter "None" if appropriate.

None

Signature: Richard L. Lee

Date: 5/22/89

Attachment 5

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

Questionnaire for documenting the independence of Technical Assessment Review (TAR) team members

(Please Print)

Name: Mohammad S. Mozumder

Review Function(s): Geophysics

1. List the titles of any reports you have authored or co-authored that bear on geological and/or geophysical interpretations in the vicinity of the Exploratory Shaft Facility (ESF). Enter "None" if appropriate.

None

2. List the titles and authors of reports of geological and geophysical nature that are relevant to structure in the vicinity of the ESF that you have provided policy and/or technical reviews. Enter "None" if appropriate.

None

3. List any committees you previously belonged to that have reviewed geological and/or geophysical data relevant to geologic structure in the vicinity of the ESF and your role on each committee. Enter "None" if appropriate.

None

Signature: Mohammad S. Mozumder

Date: 5/23/89

Attachment 5

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

Questionnaire for documenting the independence of Technical Assessment Review (TAR) team members

(Please Print)

Name: Michael W. Parsons

Review Function(s):

1. List the titles of any reports you have authored or co-authored that bear on geological and/or geophysical interpretations in the vicinity of the Exploratory Shaft Facility (ESF). Enter "None" if appropriate.

None

2. List the titles and authors of reports of geological and geophysical nature that are relevant to structure in the vicinity of the ESF that you have provided policy and/or technical reviews. Enter "None" if appropriate.

- "Preliminary Seismic Design Cost-Benefit Assessment of the Tuff Repository Waste Handling Building No. 2", Bechtel, 1988

3. List any committees you previously belonged to that have reviewed geological and/or geophysical data relevant to geologic structure in the vicinity of the ESF and your role on each committee. Enter "None" if appropriate.

None

Signature: Michael W. Parsons

Date: July 17, 1989

Attachment 5

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

Questionnaire for documenting the independence of Technical Assessment Review (TAR) team members

(Please Print)

Name: Forrest D. Peters

Review Function(s):

1. List the titles of any reports you have authored or co-authored that bear on geological and/or geophysical interpretations in the vicinity of the Exploratory Shaft Facility (ESF). Enter "None" if appropriate.

None.

2. List the titles and authors of reports of geological and geophysical nature that are relevant to structure in the vicinity of the ESF that you have provided policy and/or technical reviews. Enter "None" if appropriate.

I have reviewed many different publications (both geological and geophysical) for the Yucca Mountain Project, but none of these are specifically applicable to this problem, as far as I know now.

3. List any committees you previously belonged to that have reviewed geological and/or geophysical data relevant to geologic structure in the vicinity of the ESF and your role on each committee. Enter "None" if appropriate.

None.

Signature: [illegible]

Date: 5/26/89

Attachment 5

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

Questionnaire for documenting the independence of Technical Assessment Review (TAR) team members

(Please Print)

Name: Gerald Shideler

Review Function(s):

1. List the titles of any reports you have authored or co-authored that bear on geological and/or geophysical interpretations in the vicinity of the Exploratory Shaft Facility (ESF). Enter "None" if appropriate.

None

2. List the titles and authors of reports of geological and geophysical nature that are relevant to structure in the vicinity of the ESF that you have provided policy and/or technical reviews. Enter "None" if appropriate.

None

3. List any committees you previously belonged to that have reviewed geological and/or geophysical data relevant to geologic structure in the vicinity of the ESF and your role on each committee. Enter "None" if appropriate.

None

Signature: Gerald L. Shideler

Date: 5-30-89

Attachment 5

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology of the Exploratory Shaft Facility Location

Questionnaire for documenting the independence of Technical Assessment Review (TAR) team members

(Please Print)

Name: Richard Snyder

Review Function(s):

1. List the titles of any reports you have authored or co-authored that bear on geological and/or geophysical interpretations in the vicinity of the Exploratory Shaft Facility (ESF). Enter "None" if appropriate.

None

2. List the titles and authors of reports of geological and geophysical nature that are relevant to structure in the vicinity of the ESF that you have provided policy and/or technical reviews. Enter "None" if appropriate.

Technical Reviewer for:

Spengler, R.W. and Chornak, M.P., 1984, Stratigraphic and structural characteristics of volcanic rocks in core hole USW G-4, Yucca Mountain, Nye County, Nevada: U.S. Geological Survey Open-File Report 84-789, 77 p.

3. List any committees you previously belonged to that have reviewed geological and/or geophysical data relevant to geologic structure in the vicinity of the ESF and your role on each committee. Enter "None" if appropriate.

None

Signature: Richard P. Snyder

Date: 5/25/89

Appendix D

Meeting Minutes

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology at the Exploratory Shaft Facility Location

TECHNICAL ASSESSMENT REVIEW GEOLOGY TEAM TELECONFERENCE
MEETING MINUTES
May 24, 1989
101 Convention Center Drive
Las Vegas, NV 89109
Room 709 10:00am

ATTENDANCE:
(In Person)
D.C. Dobson, Project Office Representative (YMP)
R.C. Lee, TAR Chairperson (SAIC)
J.M. Davenport, TAR Secretary (SAIC)
T.A. Grant, Geology Team Leader (SAIC)
E.L. Hardin, Geophysics Team Leader (SAIC)
D. Cummings (SAIC)
(Via Telephone)
D. Fenster (Weston)
T.E. Hinkebein (SNL)
M. Mozumder (DOE-HQ)

This teleconference served as an introductory meeting for the Technical Assessment Review (TAR) Geology Team. Each participant verified that he had received a copy of the TAR package that was sent on Friday, May 19, 1989. All are in the process of completing the required paperwork and will send it back to the TAR Chairperson upon completion. All questions regarding the required forms and the TAR schedule were answered.

Terry Grant stated that he would start circulation of the set of air photos that he currently has on May 25th. Each Geology Team member should review these and pass them on. He expects to have another set in a week or so and will route them to the team members then. Terry also stated that he will send a map of the Exploratory Shaft Area area to each team member on the 25th. He informed the team that his plans for field work include staying at the site on Wednesday, June 7th. (Marshall Davenport will handle all necessary arrangements.)

Ernie Hardin mentioned that the TAR Geophysics Team will conduct its introductory meeting on Friday, May 26th at 10:00am.

Dave Dobson informed all participant members of the team that a letter to their respective Technical Project Officers approving this task (TAR) will be mailed today.

The meeting was adjourned at 10:20am.

J. M. Davenport — DATE 5/30/89
TAR Secretary

Richard C. Lee — DATE 5/30/89
Concurrence

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology at the Exploratory Shaft Facility Location

TECHNICAL ASSESSMENT REVIEW GEOPHYSICS TEAM TELECONFERENCE
MEETING MINUTES
May 26, 1989
101 Convention Center Drive
Las Vegas, NV 89109
Room 714 10:00am

ATTENDANCE:
(In Person)
J.M. Davenport, TAR Secretary (SAIC)
T.A. Grant, Geology Team Leader (SAIC)
E.L. Hardin, Geophysics Team Leader (SAIC)
D. Cummings (SAIC)
Forrest Peters (SAIC)
(Via Telephone)
M. Mozumder (DOE-HQ)
J. Kimball (DOE-HQ)
D. Dobson, Project Office Representative (YMP)

This teleconference served as an introductory meeting for the Technical Assessment Review (TAR) Geophysics Team. All members stated that they were in the process of completing the required paperwork. The DOE-HQ members stated that their paperwork was express-mailed to the TAR chairman on 5/25/89.

Ernest Hardin stated that the U.S. Geological Survey (USGS) has not yet committed a geophysicist to the TAR Geophysics Team. Dave Dobson took an action item to contact the USGS and try to get someone on the team. Ernest informed the team that the June 7th field trip to the exploratory shaft facility site was optional. The DOE-HQ members said that June 6th would be a better date for them because they would then be able to conclude any business in Las Vegas after the trip. It was agreed that the TAR Team would reconsider the date of the field trip.

Ernest then outlined the work planned for the Geophysics Team during the TAR. The following is a summary of the discussion:

TASK DESCRIPTION:	RESPONSIBLE PARTY(IES):
1a. Review USGS-OFR-82-182 -submit "Informal Concerns" about report to team leader on 6/12/89.	Entire Geophysics Team
1b. Review USGS-OFR-82-182 original records, location data, survey methods, etc. Interview USGS-OFR-82-182 authors -submit report to team leader on 6/19/89	USGS Representative (lead) Mohammad Mozumder
2a. Assess any other available electrical data in the ESF vicinity -submit report to team leader on 6/19/89	Dave Cummings (lead)

TASK DESCRIPTION:	RESPONSIBLE PARTY(IES):
2b. Review USGS-OFR-82-182 with respect to 2a -submit report to team leader on 6/19/89	Dave Cummings
2c. Perform a search to ensure no additional pertinent electrical data are available -if any is found, turn over to TAR team immediately	USGS Representative
3. Reinterpretation of USGS data: --Assessment --Modeling -Ernest will perform initial modeling to assess results and determine an approach; will report findings to Geophysics Team on 6/19/89; estimates 2 weeks of work after determining approach; feels a sensitivity study is needed, but no "full-blown" modeling	Ernest Hardin

Final versions of the results of above activities due on 6/27/89.

Three quality assurance concerns were raised during the meeting:

1. The use of people outside of the TAR to assist in the work-- Forrest Peters stated that they could be used as long as the work they performed was documented and the TAR member they were assisting made the decisions and drew the conclusions.

2. Validation and verification (V and V) of modeling software-- It will be impossible to V and V the modeling software during the TAR. Just because it is published and the TAR confirms the results does not satisfy V and V requirements. The TAR Team has to be very careful how the modeling results are used.

3. Presentation of preliminary results of above task 1a-- Informal methods should be used. Do not submit "comments", submit "Informal Concerns". The preliminary work has to kept informal.

The next Geophysics Team meeting will be a teleconferrence on Thursday, 6/15/89 at 9:00am PDT to discuss progress on the tasks above.

Meeting was ajourned at 11:15am.

J.M. Thompson
TAR Secretary

DATE 6/1/89

Ernest Hardin
Concurrence

DATE 6/1/89

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology at the Exploratory Shaft Facility Location

TECHNICAL ASSESSMENT REVIEW (TAR) TEAM
MEETING MINUTES
June 7, 1989
Coyote Wash, Nevada Test Site
11:30 am

Attendance: See attached page

Richard Lee opened the meeting by asking each member of the TAR Team present to introduce himself. He then asked the team members from the U.S. Geological Survey to get their employer qualification statements to him as soon as possible.

After presenting the agenda for the field investigations (attached) to the team, he explained the purpose and the goals of the investigations. The Geology Team was to search for surface evidence of faulting in the area of the exploratory shafts. The Geophysics Team was to retrace the lines (as accurately as possible) in which the USGS-OFR-82-182 resistivity measurements were taken looking for surface characteristics that could be reflected in the geophysical data.

All questions concerning the field investigations were answered and the meeting was adjourned at 11:45am.

J. M. Shumpert
TAR Secretary

DATE 6/16/89

Richard C. Lee
Concurrence

DATE 6/16/89

June 7, 1989
TAR Meeting Attendance
Coyote Wash NTS

Name	Organization	Phone No.
Dave Fenster	WESTON	(202) 646-6647
Jeff Kimball	DOE/HQ	FTS 896 1063
Ernest Hardin	SAIC	FTS 544 7617
Richard Lee	SAIC	FTS 544-7134
Scott Sinnock (for TAR Team)	SNL/LV	FTS 544-7200
Mohammad S. Mozumder	DOE/HQ	FTS 896-5684
Richard P. Snyder	USGS	FTS 776-1263
Forrest D. Peters	SAIC	FTS 544-7753
David Cummings	SAIC	FTS 544-7835
Gerald Schlueter	USGS	FTS 776-1273
TERRY GRANT	SAIC	FTS 544-7647
MARSHALL DAVENPORT	SAIC	FTS 544-7661
David C Dobson	DOE/YMPO	FTS 544-7440
Paul Prestholt	NRC	FTS 598-6125

June 1, 1989

TO:

YMPO Branch Chief responsible for TAR: David Dobson
TAR Chairperson: Richard Lee — SAIC FTS 544-7134
TAR Secretary: Marshall Davenport — SAIC FTS 544-7661

Team Members:	Team/discipline	
Dave Dobson	Geology	YMPO FTS 544-7940
Mohammad Mozumder	Geophysics	DOEHQ FTS 896-5560
Jeff Kimball	Geophysics & Geology	DOEHQ FTS 896-1063
Ernie Hardin	Geophysics (Team Leader)	SAIC FTS 544-7617
Terry Grant	Geology (Team Leader)	SAIC FTS 544-7647
Forrest Peters	Geophysics (QA Specialist)	SAIC FTS 544-7753
David Cummings	Geophysics & Geology	SAIC FTS 544-7835
Gerald L. Shideler	Geology	USGS FTS 776-1273
Douglas P. Kline	Geophysicist	USGS FTS 776-1313
Richard Snyder	Geology	USGS FTS 776-1263
Dave Fenster	Geology	Weston 202-646-6647
Thomas E. Hinkebein	Engineering	SNL FTS 846-0580

FROM: Terry Grant, Richard Lee

SUBJECT: Proposed Itinerary for TAR Field Visit

Listed below is our proposed itinerary for the field visit on June 7 & 8. Please note that each individual is responsible for his own personal gear (ie. hat, canteen, hammer, compass, etc.). Arrangements have been made for the geology team to stay in Mercury for the night of June 7. The itinerary shows the geology team using two full days at the site. We may or may not finish earlier depending on our progress.

JUNE 7, 1989

8:00 AM Meet in lobby of Valley Bank Building. Drive to Mercury in DOE vehicles.

10:00 AM Arrive Mercury; clear badging office, pick up sack lunches at cafeteria; leave for Coyote Wash.

11:00 AM Arrive Coyote Wash. Introductions, discussion of purpose of field visit, familiarization with local geography (shaft locations, borehole locations, probable geophysical line locations).

12:00 Noon Lunch

1:00 PM Familiarization with local geology. Climb Dead Yucca Ridge, look at examples of "breccia zones" mapped by previous workers, determine criteria for distinguishing mapped units in area (cll, lower

lithophysal; crs, rounded step; cul, upper lithophysal), examine nature of contacts on the ridge, review expression of Ghost Dance fault.

2:30 PM Examine other features that are of interest to the group.

3:00 PM Geology and geophysics teams split to look at areas of special areas of interest to each. (Geophysics team returns to Las Vegas when they are ready) Geology team finalizes selection of criteria for distinguising contact between map units and begins tracing contacts across south face of Dead Yucca Ridge, starting at Ghost Dance fault and working eastward to cover location of shafts. Exposures of contacts marked with stakes and flagging. (Team may split at this point to have one subgroup work cll-crs contact, and another subgroup work crs-cul contact) Team (or each subgroup) begins to plot location of flagged contact on map using compass triangulation.

5:30 PM (or later depending on progress) Return to Mercury. Arrangements have been made to spend night in Mercury housing.

JUNE 8, 1989 (Geology Team only)

7:30 AM Depart Mercury. Pick up lunches at Mercury cafeteria.

8:30 AM Arrive at Coyote Wash.

11:30 AM Complete mapping started on previous day, discussion of results, determine need for mapping of north facing slope of Live Yucca Ridge.

12:00 Noon Lunch

12:30 PM Systematic traverse of area between shafts to look for evidence of faulting.

1:30 PM Review of previously mapped fracture zones, minor faults, and breccia zones in area. Also field check any lineaments noted on air photos.

3:00 PM Mapping of north slope of Live Yucca Ridge (if needed) and/or review or any other areas of interest to group.

5:30 PM(or when complete) Complete field work. Discussion of results, assignments made for items to be completed prior to TAR meeting.

6:00 PM Depart for Las Vegas.

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology at the Exploratory Shaft Facility Location

TECHNICAL ASSESSMENT REVIEW TEAM TELECONFERENCE
MEETING MINUTES
June 14, 1989
101 Convention Center Drive
Las Vegas, NV 89109
Room 744 10:00am

ATTENDANCE:
(In Person)
R.C. Lee, TAR Chairperson (SAIC)
J.M. Davenport, TAR Secretary (SAIC)
T.A. Grant, Geology Team Leader (SAIC)
Forrest Peters (SAIC)
D. Cummings (SAIC)
(Via Telephone)
D. Fenster (Weston)
T.E. Hinkebein (SNL)
Jeff Kimball (DOE-HQ)
E.L. Hardin, Geophysics Team Leader (SAIC)
G.L. Shideler (USGS)
R.P. Snyder (USGS)
D.P. Klein (USGS)
J.D. Istok (Oregon State Univ.)

Richard Lee opened the meeting by reminding the USGS Team Members that he had not received their employee qualification forms. They said the forms should be sent to him in a couple of days. Richard then announced a change in the TAR schedule: the June 26th TAR Team caucus will be moved to July 10th and the completion date for the Review Record Memorandum (RRM) will also be moved forward to a date to be determined. He then scheduled the next TAR Team meeting (teleconference) for Wednesday, June 21st at 10:00am PDT. In preparation for that meeting, the team leaders should give the TAR Chairman an outline of RRM input by Monday, June 19th. Richard Lee then asked the team leaders to give a progress report.

Terry Grant (Geology Team Leader) outlined his team's input into the RRM and assigned responsibility:

1. Previous mapping efforts (history)—Snyder and Shideler of the USGS;
2. Results of air photo interpretation—all team members write summary and submit to T. Grant;
3. Review results of Geology Team field investigations—T. Grant; and
4. Conclusions and recommendations—To be discussed at Geology Team caucus.

A Geology Team caucus was scheduled for Wednesday, June 21st at 8:00am in Las Vegas.

Ernest Hardin (Geophysics Team Leader) led off his discussion by scheduling a Geophysics Team caucus for Tuesday, June 20th at 8:00am in Las Vegas. He then outlined his team's input into the RRM:

1. Analysis of resistivity data;
2. Presentation of other applicable data;

3. Presentation of new data found (if any);
4. Review of USGS-OFR-82-182 based on contributions by team members;
5. Effects/limitations on resistivity data; and
6. Conclusions and recommendations.

He announced that he would like RRM input by team members on June 20th.

Tom Hinkebein then reported on his work on shaft engineering and design. His RRM input was proposed as:

1. Performance of the shaft(s) and repository with respect to faulting and fracturing (i.e., water inflow)—will summarize available reports; and
2. Occupational safety and construction concerns with respect to faulting and fracturing (i.e., fault slippage)—will revisit the 100 foot standoff criteria used in the Bertram report (SAND 84-1003, a TAR reference).

Richard Lee reminded the members of the upcoming caucuses and TAR team meeting and this meeting was adjourned at 11:05am.

J. M. Davenport
TAR Secretary

DATE 6/16/89

Richard C. Lee
Concurrence

DATE 6/16/89

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology at the Exploratory Shaft Facility Location

TECHNICAL ASSESSMENT REVIEW TEAM TELECONFERENCE
MEETING MINUTES
June 21, 1989
101 Convention Center Drive
Las Vegas, NV 89109
Room 745 10:00am

ATTENDANCE:
(In Person)
See Attached List
(Via Telephone)
D. Fenster (Weston)
T.E. Hinkebein (SNL)
Jeff Kimball (DOE-HQ)

Richard Lee opened the meeting with the following announcements:

-Next TAR Team meeting will be a teleconference on Thursday, June 29th at 10:00am PDT. (He assigned Marshall Davenport the responsibility of running the meeting in his absence.)
-The TAR Team caucus will be held on Tuesday, July 11th at 8:00am (Meeting site-TBD).
-Team members' text should be to Team Leaders by July 11th.

He then asked Terry Grant (Geology Team Leader) to give a status report of his team's activities. Terry reported that:

-USGS has completed a draft Section 3.1 of the 6/21/89 Proposed Review Record Memorandum (RRM) Outline (attached). The Proposed RRM Outline had been distributed to the TAR Team prior to the meeting.
-He has completed a draft Section 3.2.
-The Geology Team is presently discussing Section 3.4
-The Geology Team members need to get their air photo interpretations to him as soon as possible.

Ernest Hardin (Geophysics Team Leader) then reported on the activities of the Geophysics Team:

-The Geophysics Team RRM outline was completed at a team meeting yesterday.
-Responsibilities for sections of the outline were also assigned.
-RRM input is due in two weeks.

Ernest also gave the TAR Team an overview of the modeling activities being performed.

Richard asked Terry for the preliminary conclusions of the Geology Team. Terry stated that the team:

-generally agrees with the Scott and Bonk map;
-saw no surface evidence of fault displacement during its field review;
-will probably recommend detailed mapping of the main pad excavation;
-is presently discussing other pre-pad excavation field investigations; and
-will conclude that breccia features, fractures, joints, etc. will be

intersected by the shafts during excavation.

Tom Hinkebein reported on the engineering activities. He stated that he is looking at construction and performance assessment effects of faulting on the shaft and its design.

After the Team Leaders' reports, Jeff Kimball gave an overview of his upcoming presentation to the Advisory Committee on Nuclear Waste. He stated that he will send a copy to the Dave Dobson as soon as possible so that the Project can submit comments before the presentation next week.

The meeting was adjourned at 11:20am.

TAR Secretary DATE 7/7/89

Concurrence DATE 7/6/89

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology at the Exploratory Shaft Facility Location

TECHNICAL ASSESSMENT REVIEW TEAM MEETING
JUNE 21,1989
101 Convention Center Drive
Las Vegas, NV 89109
Room 745 10:00am

ATTENDANCE LIST

NAME	ORGANIZATION	PHONE
J. MARSHALL DAVENPORT	SAIC	544-7661
T. A. GRANT	SAIC	544-7647
David Cummings	SAIC	544-7835
Mohammad Mozundar	DOE/HQ	896-5684
Scott Sinnock	SAIC/LV	544-7200
Richard Lee	SAIC	544-7134
Gerald Stridder	USGS	FTS:776-1273
Richard P. Snyder	USGS	776-1263
Forrest D. Peters	SAIC/LV	FTS 544-7753
Ernest Hardin	SAIC	FTS 544 7617
David C Dobson	DOE	544-7940

PROPOSED RRM OUTLINE

6/21/89

Table of Contents

List of Figures

List of Tables

Executive Summary

1. Introduction
   1.1 Purpose
   1.2 Scope
      1.2.1 Geology subcommittee
      1.2.2 Geophysics subcommittee
      1.2.3 Engineering subcommittee
   1.3 Conduct of TAR
      1.3.1 QA Levels and Controlling Procedure
      1.3.2 TAR Plan
      1.3.3 TAR Participants
      1.3.4 Approach to Developing Comments, Conclusions, and Recommendations
      1.3.5 Reference Validation
   1.4 Records
      1.4.1 QA-Related Records in the RRM
      1.4.2 Other Records in the RRM

2. Historical Perspective

   2.1 Summary of geological and geophysical work undertaken to address Bertrum(1984)
   2.2 Other geologic and geophysical data pertinent to investigations of Coyote Wash
   2.3 Basis of inferred fault shown in Figure 1-40 of the SCP and in USGS OFR84-792, and its relationship to OFR82-182.
   2.4 Geologic basis for decision to locate Exploratory Shaft

3. Geology Subcommittee Chapter

   3.1 Review of Approach and techniques Used For Existing Geologic Mapping

      3.1.1 Techniques used to perform mapping/available documentation
      3.1.2 Evaluations by original authors on the accuracy of their maps, and estimated resolving power for estimating apparent vertical offset.
      3.1.3 Original purpose of data, limitations of data, and implications of faulting

   3.2 Review of Aerial Photography
      3.2.1 Description of photography reviewed by team
      3.2.2 Acceptability of the interpretations shown on the mapping when compared to features visible on the photography.
      3.2.3 Evaluation of geologic evidence for or against faulting in the exploratory shaft area that should have been considered in the mapping of the area

   3.3 Review of Field Relations

3.3.1 Date and location of review; techniques used during review.
3.3.2 Selection and nature of contacts mapped in area.
3.3.3 Criteria for the mapping/review
3.3.4 Nature and expression of known faulting of Ghost Dance fault.
3.3.5 Results of tracing contacts across ES locations.
3.3.6 Evaluation of fractures and breccia zones

3.4 Conclusions and Recommendations

3.4.1 On the acceptability and reasonableness of the existing mapping
3.4.2 Geologic evidence for or against a fault in the vicinity of the exploratory shaft.
3.4.3 Were the geology recommendations of the Bertrum report adequately implemented?
3.4.4 Were the geologic data appropriately used in making the ES location decision?
3.4.3 Recommendations on future geologic investigations

3.5 Concurrence Signatures

4. Summary of Geophysics Subcommittee

4.1 Introduction (structure vs interpretation; emphasis on geoelectric data & models)

4.2 Geophysical Data Applied to ESF location and inferred fault evaluation

4.2.1 Original surveys of S&R
4.2.2 other surveys (pub./unpub.;EM, ER, grav., mag.,seis., VES, slingram)
4.2.3 unique aspects of S&M data set/summary statement
4.2.4 Well logs/petrophysical data (include discussion of res. values, IP)

4.3 Geoelectric model
4.3.1 S&R model
4.3.2 model relationships to observed material resistivity
4.3.3 General discussion of uniqueness, resolution, and sensitivity.
4.3.4 Other models that may satisfy the data

4.4 Technical issues and concerns (distilled from consensus; leads into analysis)

4.5 Additional modeling considerations
4.5.1 2-d effects
4.5.2 3-d effects
4.5.3 Sensitivity to starting model
4.5.4 Applicability of other existing geophysical data
4.5.5 Other published models?
4.5.6 Other aspects of dipole-dipole data?

4.6 Geologic interpretation
4.6.1 S&R interpretation
4.6.2 Relationship of S&R interpretation to known geology
4.6.3 Petrophysical relationships
4.6.3.1 pore vs. surface conduction
2 alteration
3 fracturing vs. fault zone material

4.6.4 Limitations of numerical modeling and geophysical model analogs to geologic structures

4.6.5 Latitude for geophysical interpretation (significance; # of geophysical data jointly considered; purpose of 1979 work; context for SCP Figs. 1-40)

4.7 Conclusions and Recommendations

4.7.1 Applicability of S&R interpretation to ESF location.

4.7.2 Applicability of other existing data, dipole-dipole data, EM & ER methods in general, and other methods (e.g., seismic)

4.8 Concurrence signatures

5. Summary of Engineering Subcommittee

5.1 Impact on the shaft construction. In Bertram (1984) the exploratory shaft was located to avoid potentially adverse structures. The exact definition of a potentially adverse structure is not presented. It is implied however, that a fault is such a structure. It is our belief however that the implications of such faulting likely to be dependent on the fault characteristics.

5.1.1 In order to test this belief, consider what characteristics a fault would have to possess to cause concerns during shaft construction. Answer the following questions by using specific examples and best engineering judgment:

If subsurface faulting were encountered near or in the shaft, what characteristics of the fault would make it difficult to sink, line, and/or to install seals, (construction or permanent)?

Consider fault and rock characteristics such as dip, strike, aperture, slip, rubble, waterproducing zones, etc., and combinations of these.

Consider implications on the area set aside for the shaft pillar. Would this zone have to be altered to accommodate the presence of a fault?

Consider the operational safety of workers since liner may be as much as 30 feet above the working face.

5.1.2 Outline ground support systems for the five ground classes outlined in SCP-CDR. These include ground support required for a fault zone to indicate that DOE has considered the construction implications of encountering an underground fault.

If ground support systems are required windows may be placed in those systems to allow access to and study of water producing zones.

Ground support systems may be removed to allow drainage required of sealing systems.

5.2 Impact on the shaft performance.

5.2.1 What characteristics of a fault would cause potential impacts to the

long-term performance of the Exploratory Shaft or the underground facility.

5.2.1.1 Consider the projected conductivity of a fault to both water and gaseous movement. Are fault conductivities any different from bulk rock conductivities given in the RIB.

5.2.1.2 Consider analysis of Ross (1989) to determine faulting conditions which may lead to perched water. What sequences of welded-nonwelded unit, what conductibities of units and what offsets across the fault are necessary to allow perching?

5.2.1.3 Consider appropriateness of analyses in Fernandez et al. (1987), Fernandez et al. (1989), Peters (1988), Wang and Narasimhan (1980), Rulon et al., (1987), DAA (Appendix J, pp2-5, 2-6, 2-16, 2-26, 2-31).

Are the mechanisms considered appropriate for water flow in a fault?

Are the conductivities appropriate so that results may be allied to a faulted satuation?

Are gasous mechanisms appropriate for describing flow in a fault?

5.2.2 Purpose of a shaft is to characterize the repository and therefore want to be near faults for representativeness purposes. What representativeness concerns are there if (1) there are faults through the ES and (2) if there are no faults in the ES

5.3 Concurrence signatures

6. TAR Summary (if necessary)

Appendix A —QMP-02-08 with ICN Number 1

Appendix B —TAR Notice and Plan
B.1 TAR Notice
B.2 TAR Plan
B.3 Differences Between TAR Plan And Conduct of TAR (if any)
B.4 Project Office QMP 06-03 Review Comments on Draft TAR Plan

Appendix C —QA-Related Records
C.1 TAR Team Selection Record (N-QA-008)
C.2 Employer Certification of TAR Team Member Qualifications
C.3 QMP-02-08, ICN Number 1, and TAR Plan Training Documentation
C.4 Questionnaire for Documenting Independence of TAR Team Members
C.5 Standard Deficiency Reports and Observations (if any)

Appendix D —Meeting Minutes

Appendix E —TAR Reference List (TAR Package List)

Appendix F —Correspondence Related to TAR

Appendix G —TAR Comment Forms

Appendix H —List of Reviewers by Name, Organization, and Discipline

Appendix I —Supporting Documentation for the TAR
I.1 Computer code verification and validation (if necessary)
I.2 Input/output files for all code runs

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology at the Exploratory Shaft Facility Location

TECHNICAL ASSESSMENT REVIEW TEAM TELECONFERENCE
MEETING MINUTES
June 29, 1989
101 Convention Center Drive
Las Vegas, NV 89109
Room 716 10:00am

ATTENDANCE:
(In Person)
J.M. Davenport, Secretary
E.L. Hardin, Geophysics Subcommittee Leader
T.A. Grant, Geology Subcommittee Leader
(Via Telephone)
D. Fenster (Weston)
T.E. Hinkebein (SNL)
Jeff Kimball (DOE-HQ)
Mohammad Mozumder (DOE-HQ)
G.L. Shideler (USGS)

Marshall Davenport (in the absence of TAR Chairman, R.C. Lee) opened the meeting with the following announcements:

-No TAR Team teleconference next week
-The TAR Team caucus will be held on Tuesday, July 11th at 8:00am in SAIC Room 745. Although the caucus is not expected to last all week, the room is available all week. Room 1010 (a small conference room) will be available on the 13th and 14th.
-A meeting will be held with Lynn Hoffman on Monday July 10th to discuss production support for the Review Record Memorandum (RRM). E.L. Hardin and T.A. Grant are requested to attend. Time TBD.
-Subcommittee Leaders are requested to compile a list of all new materials (not in the TAR package that have been collected, reviewed, considered, etc. and give the list to J.M. Davenport for the RRM.

Ernest Hardin (Geophysics Subcommittee Leader) then reported on the activities of the Geophysics Subcommittee:

-D. Cummings has submitted a draft of Chapter 4.2
-D. Klein is working on a draft of 4.3
-DOE-HQ is working on a draft of 4.4 to be sent out on 6/29 or 6/30
-Modeling to complete by 7/11

Terry Grant (Geology Subcommittee Leader) gave a status report of his team's activities. Terry reported that:

-He has sent the subcommittee members a draft Section 3.2 and would like comments as soon as possible.
-Has received comments from D. Cummings.
-The USGS reported that their comments went out on 6/28.
-The subcommittee members need to get their air photo interpretations to him as soon as possible. D. Cummings and M. Davenport have completed this. D. Fenster reported that he will send his out on 6/29 or 6/30.

Tom Hinkebein stated that the Engineering Subcommittee met on 6/22 and 6/23. He has not finalized a schedule as yet, but does not foresee any problems. He then explained some of the history of the 100' fault setback criteria in the Bertram Report. He stated that he had completed his review of the air photos and forwarded them to D. Dobson on 6/28.

The meeting was adjourned at 10:20am.

J. M. Vincent
TAR/Secretary

DATE 7/10/89

Concurrence

DATE 7-10-89

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology at the Exploratory Shaft Facility Location

TECHNICAL ASSESSMENT REVIEW TEAM
MEETING MINUTES
July 11, 1989
101 Convention Center Drive
Las Vegas, NV 89109
Room 745 8:00am

ATTENDANCE:
See attached list

Rich Lee opened the meeting by informing the team of the TAR meeting arrangements for the week (7/11 through 7/14). He then made the following announcements:

-Lynn Hoffman will be assisting the team in the preparation and publication of the Review Record Memorandum (RRM);
-Maurice Grieves, a mining engineer with Parsons, Brinckerhoff, Quade and Douglas, Inc. will be joining the TAR Team and will be working with T.E. Hinkebein on the Engineering Subcommittee; and
-A TAR meeting will be held at 11:00am on Thursday (7/13) in Room 745; one of the discussion points will be TAR Team recommendations

A discussion of the RRM with Forrest Peters followed. Forrest concluded that the decision to "Control" the RRM is a management decision and not a quality assurance (QA) decision and reference verification on the RRM is not needed, from a QA point of view.

Short status reports were then given by the chairmen of the Geology and Geophysics Subcommittees.

Following the status reports, the TAR Team broke into subcommittees to work on input into the subcommittee recommendations and input into the RRM. The TAR Team agreed to reconvene at 4:00p to discuss progress.

At 4:00p. the TAR Team reconvened. The team discussed results of the subcommittee meetings. Because of the Geophysics Subcommittee's need for additional time to prepare conclusions, no recommendations were formed.

The meeting was adjourned at 5:15p.

A. Marshall Stewart
TAR Secretary

DATE 8/21/89

Richard C. Lee
Concurrence

DATE 8/21/89

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology at the Exploratory Shaft Facility Location

TECHNICAL ASSESSMENT REVIEW TEAM MEETING
JULY 11, 1989
101 Convention Center Drive
Las Vegas, NV 89109
Room 745 8:00am

ATTENDANCE LIST

NAME	ORGANIZATION	PHONE
J. MARSHALL DAVENPORT	T&MSS/SAIC	FTS 544-7661
Paul Prestholt	NRC	FTS 598 6125
Forrest D. Peters	SAIC	FTS 544-7753
Gerald L. Shideler	USGS	FTS 776-1273
Richard P. Snyder	USGS	FTS 776-1263
Richard C. Lee	SAIC	FTS 544-7134
TERRY A. GRANT	SAIC	FTS 544-7647
DOUG KLEIN	~~SAIC~~ USGS	FTS 776-1313
Ernest Hardin	SAIC	FTS 544-7617
Dave Fenster	Weston	(202) 646-6647
David Cummings	SAIC	FTS 544-7835
Mohammad S. Mozumder	DOE/HQ	FTS 596-5684

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology at the Exploratory Shaft Facility Location

TECHNICAL ASSESSMENT REVIEW TEAM
MEETING MINUTES
July 13, 1989
101 Convention Center Drive
Las Vegas, NV 89109
Room 745, 11:00 am

ATTENDANCE:
See attached list

The TAR Chairman, R. Lee opened the meeting by announcing that Maurice Grieves had joined the TAR team to serve on the Engineering Subcommittee. Also, Patrick Waters, DOE-HQ, may attend future TAR meetings to surveil TAR team activities. Ivan Cottle, SAIC/T&MSS, will be available to support/advise the team on matters related to ESF construction. Also, M. Davenport (TAR Secretary) has a new Project assignment and will not be able to perform the Secretary role full-time. M. Parsons will be added to the TAR Team to support the Team in the capacity of TAR Secretary.

Subcommittee reports followed. The Geophysics subcommittee reported results from 2-D modeling of resistivity data. It was agreed that the subcommittee should further pursue modeling efforts because the results suggest other, non-fault related explanations for the resistivity anomaly. The subcommittee reported that limited access to proper computer facilities has and may continue to impact the timely completion of their work. To properly address the possibility that alteration of tuffs is related to observed resistivity anomalies, D. Klein and G. Shideler will inquire into using other expert geoscientists familiar with this concept. G. Shideler submitted comments by D. Cummings on a draft of Section 4.6.

T. Hinkebein of the Engineering Subcommittee reported on the performance-related aspects of faulting in or near an ES (primarily water movement). As a result of discussions with the TAR team at this meeting, he will revisit his calculations assuming other performance-related anomalies (i.e. a zone of increased saturation). M. Grieves reported on the impacts of faulting to an ES from the standpoint of "constructability."

The Geology Subcommittee did not make a report.

The TAR Team agreed to meet again on Friday, 7/14/89 at 11:00 am. The meeting was adjourned at 1:30 pm.

Michael W. Parsons
TAR Secretary

DATE 9/6/89

Richard C. Lee
Concurrence

DATE 9/7/89

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology at the Exploratory Shaft Facility Location

TECHNICAL ASSESSMENT REVIEW TEAM MEETING
JULY 13, 1989
101 Convention Center Drive
Las Vegas, NV 89109
Room 745 11:00am

ATTENDANCE LIST

NAME	ORGANIZATION	PHONE
M.W. Parsons	SAIC/T&MSS	FTS-544-7857
J. Marshall Davenport	SAIC/T&MSS	FTS 544-7661
Terry A. Grant	SAIC/T&MSS	544-7647
Richard C. Lee	"	544-7134
Doug Klem	USGS	776-1313
Gerald Shideler	USGS	776-1273
Maurice Grieves	Parsons Brinckerhoff	415-243-4634
Thomas E. Hinkebein	SANDIA	505-846-0580
Ernest Hardin	SAIC	702/794 7617

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology at the Exploratory Shaft Facility Location

TECHNICAL ASSESSMENT REVIEW TEAM
MEETING MINUTES
July 14, 1989
101 Convention Center Drive
Las Vegas, NV 89109
Room 745, 11:00 am

ATTENDANCE:
See attached list

Richard Lee opened the meeting by noting that the meeting was considered optional, due to TAR team members' travel arrangements. R. Lee also announced plans for a telecon for Wednesday, July 19, at 10:00 am, PST. R. Lee also stated a concern expressed to him by QA surveillance staff: that the TAR team should keep records of each draft of their respective subcommittee reports.

The purpose of the meeting was to review and discuss each subcommittees' preliminary recommendations. Preliminary drafts of the Geophysics and Engineering subcommittees recommendations were distributed for discussion. Based upon the discussion, T. Hinkebein (SNL) decided to reorganize the Engineering subcommittee's report/recommendations into two sections: Performance (of an ESF with a nearby fault) and Constructibility (of an ESF with a nearby fault).

The meeting was adjourned at 1:00 pm.

Michael W. Parson
TAR Secretary

DATE 9/6/89

Richard C. Lee
Concurrence

DATE 9/7/89

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology at the Exploratory Shaft Facility Location

TECHNICAL ASSESSMENT REVIEW TEAM MEETING
JULY 14, 1989
101 Convention Center Drive
Las Vegas, NV 89109
Room 745 11:00am

ATTENDANCE LIST

NAME	ORGANIZATION	PHONE
Mike Parsons	SAIC/Tmss	FTS - 544-7857
R. Lee	"	" 7134
Doug Klein	USGS	776-1313
TERRY A. GRANT	SAIC/Tmss	544-7647
Tom HINKEBEIN	SANDIA	846-0580
Ernest Hardin	SAIC	FTS 544-7617

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology at the Exploratory Shaft Facility Location

TECHNICAL ASSESSMENT REVIEW TEAM
MEETING MINUTES
July 19, 1989
101 Convention Center Drive
Las Vegas, NV 89109
Room 745, 10:00 am

ATTENDANCE:
See attached list

The meeting was structured as a telecon with team members from DOE-HQ, SNL, USGS as well as those on the attendance list.

The TAR Chairman (Richard Lee) opened the meeting with two observations: 1) the Project Office has decided to perform reference verification on references used in the RRM of this TAR, thereby adding approximately two weeks onto the TAR schedule; 2) subcommittee report authors must forward copies of references used to the TAR Secretary.

Subcommittee reports followed:

Geology: T. Grant reported that Chapter 3 is nearly complete. Chapter 2 could be done early next week. G. Shideler (USGS) reported on the discovery of documentation on the moving of the ES location. He will forward this material to the TAR Secretary. D. Dobson submitted comments (marked-up text) to T. Grant on Chapter 3.

Geophysics: E. Hardin reported that the first draft of Chapter 4 will be complete late this week; draft 2, with D. Klein's input, will be ready approximately 7/26.

Engineering: T. Hinkebein reported on the status of Chapter 5 (Performance aspects) and Chapter 6 (Constructability).

Rich Lee proposed a meeting among himself, D. Dobson, subcommittee leaders, and any other interested team members to integrate subcommittee recommendations. After discussion, the meeting participants agreed to meet in Las Vegas on Wednesday, 1:00 pm, 7/26/89 and (if necessary) Thursday, 7/27/89.

E. Hardin requested review/editing assistance for his text. He requested R. Lee's assistance on this matter.

The meeting was adjourned at 10:45 am.

Michael W. Parsons
TAR Secretary — DATE 7/21/89

Richard C. Lee
Concurrence — DATE 8/21/89

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology at the Exploratory Shaft Facility Location

TECHNICAL ASSESSMENT REVIEW TEAM MEETING
July 19 ~~JULY 14~~, 1989
101 Convention Center Drive
Las Vegas, NV 89109
Room 745 ~~11:00am~~
10:00 am

ATTENDANCE LIST

NAME	ORGANIZATION	PHONE
Mike Parsons	SAIC/TRMSS	FTS-544-7857
Paul Prestholt	NRC	FTS 598 6125
Forrest D. Peters	SAIC	FTS 544-7753
J. Marshall Davenport	TRMSS/SAIC	FTS 544-7661
David C. Dobson	DOE/YMPO	FTS 544-7940
Ernest Hardin	SAIC	FTS 544 7617
Richard C. Lee	"	544-7134
TERRY GRANT	"	544-7647

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology at the Exploratory Shaft Facility Location

TECHNICAL ASSESSMENT REVIEW TEAM
MEETING MINUTES
August 11, 1989
101 Convention Center Drive
Las Vegas, NV 89109
Room 709, 8:00 am

ATTENDANCE: See attached list.

The TAR team met to discuss comments on the draft of the first seven chapters of the Review Record Memorandum (RRM), which had been mailed to them previously.

Richard Lee showed examples of color photocopies of color prints for use as figures in the RRM. It was agreed that we will use this medium for reproducing the photos in the RRM.

Discussion on the recommendations of Chapter 4, Geophysics, followed. Discussion centered around the need to recommend that the Project attempt to reproduce the resistivity anomaly (i.e. the basic data) or the interpretation of the anomaly. E. Hardin will amend Chapter 4 to address an attempt to reproduce the resistivity anomaly. E. Hardin also requested assistance in writing Section 4.5.3, Sensitivity Studies.

A telecon, starting at 10:00 PST, followed the meeting. During the telecon, the team agreed to send Chapters 2, 3, 5, and 6 to Technical Editing early next week. Chapter 4 (and perhaps the other chapters) will be sent out for team review again on (or about) Wednesday afternoon, 8/16/89. D. Klein inquired if an independent reviewer should read the final RRM, before we finalize it. Team members felt this was not necessary, but if D. Klein wanted to pursue this informally on his own, that was acceptable.

The meeting was concluded at 10:45, PST.

Michael W. Larson — 9/6/89
TAR Secretary — Date

Richard C. Lee — 9/7/89
Concurrence — Date

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology at the Exploratory Shaft Facility Location

TECHNICAL ASSESSMENT REVIEW MEETING
August 11, 1989
101 Convention Center Drive
Las Vegas, NV 89109
Room 709, 8:00 am

ATTENDANCE LIST

NAME	ORGANIZATION	PHONE
Mike Parsons	SAIC/T+MSS	FTS - 544-7857
TERRY GRANT	SAIC/T&MSS	544-7647
Dave Cummings	" "	
Gerry Shideler	USGS	
Reidun Lee	SAIC/T+MSS	
Ernie Hardin	SAIC/T+MSS	

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology at the Exploratory Shaft Facility Location

TECHNICAL ASSESSMENT REVIEW TEAM
MEETING MINUTES
August 22, 1989
101 Convention Center Drive
Las Vegas, NV 89109
Room 706, 10:00 am

ATTENDANCE: See attached list.

The meeting was conducted as a telecon with all interested TAR team members in attendance or having dialed in.

Regarding the schedule for production of the RRM, R. Lee noted that EG&G's plotter was down, potentially delaying production of several figures (maps) for the RRM.

Changes and edits of the text and recommendations of each subcommittee were discussed. Significant discussion centered around two items:

1) D. Klein felt that sections 4.7.1 and 7.1 of the RRM were not consistent in our recommendations regarding effects of alteration of tuff on shaft constructibility. It was agreed that Chapter 7 should contain a summary statement on whether or not there are impacts to shaft constructibility.

2) D. Dobson (with discussion by others) felt that we should reconsider the appropriateness of recommending a centerline borehole to total depth of the shaft, given the MPBHs and pilot boreholes already planned (Section 7.2.3 of RRM). Terry Grant will address this concern.

It was decided to have team members concur only on the RRM chapters for which they were subcommittee members, and on Chapter 7. Also, subcommittee leaders' recommendations on comment forms would represent all subcommittee members' concerns, with members submitting a statement so stating, unless the member explicitly chose to submit a different recommendation. M. Parsons will transmit the recommendations and forms for signature to team members as soon as possible.

The meeting was concluded at 11:50 am PST.

Michael W. Parsons — 9/7/89
TAR Secretary — Date

Richard C. Lee — 9/7/89
Concurrence — Date

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology at the Exploratory Shaft Facility Location

TECHNICAL ASSESSMENT REVIEW MEETING
August 22, 1989
101 Convention Center Drive
Las Vegas, NV 89109
Room 706, 10:00 am

ATTENDANCE LIST

NAME	ORGANIZATION	PHONE
Mike Parsons	SAIC / TRW SS	FTS 544-7857
Marshall Davenport	SAIC / T&MSS	FTS 544-7661
Ernest Hardin	SAIC	FTS 544 7617
Richard Lee	"	FTS 544-7134
[illegible]	"	FTS 544-8935
Jerry A. Grant	"	544-7647
David Dobson	DOE /	

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology at the Exploratory Shaft Facility Location

TECHNICAL ASSESSMENT REVIEW TEAM
MEETING MINUTES
July 26, 1989
101 Convention Center Drive
Las Vegas, NV 89109
Room 450, 1:00 pm

ATTENDANCE: See attached list.

The meeting was opened by the TAR chairman, R. Lee with a request for status of each subcommittee of the TAR team.

E. Hardin reported for the Geophysics subcommittee. After additional modeling work, an anomaly is still present in the data. Team members discussed various methods to further characterize the anomaly, including test borings and mini-sosie. Team members generally agreed that we should attempt to pinpoint the alluvium/bedrock contact depth. R. Lee stated that any proposed geophysical method might be subject to a feasibility study.

T. Grant spoke for the Geology subcommittee. No changes have been made to their recommendations. Discussion centered around where to locate the boreholes mentioned above.

T. Hinkebein reported on the status of the Engineering subcommittee. He would like to have another qualified person review the draft of Chapters 5 and 6.

The meeting was adjourned at 2:30 pm.

Richard W. Parsons
TAR Secretary

9/7/89
Date

Richard C. Lee

9/7/89

Technical Assessment Review: Geological and Geophysical Evidence Pertaining to Structural Geology at the Exploratory Shaft Facility Location

TECHNICAL ASSESSMENT REVIEW MEETING
July 26, 1989
101 Convention Center Drive
Las Vegas, NV 89109
Room ~~245~~, 1:00 pm
450 7/24/89

ATTENDANCE LIST

NAME	ORGANIZATION	PHONE
Mike Parsons	SAIC/T+MSS	FTS-544-7857
Marshall Davenport	SAIC/T&MSS	FTS 544-7661
Richard C. Lee	"	FTS 544-7134
Thomas E. Hinkebein	SANDIA	FTS 846-0580
Terry A. Grant	SAIC/T&MSS	FTS 544-7647
Gerald L. Shideler	USGS/GD	FTS 776-1273
Jeff K. Kimball	DOE/HQ	FTS. 896 1063
Ernest Hardin	SAIC	FTS 544 7617

Appendix E

TAR Reference List (TAR Data Package List)

3. Selected plates from the original manuscript of Smith and Ross (1982, USGS Open File Report 82-182): Plates II, III, IV, V, VI, VII.

4. Unpublished contractor's field map showing location of dipole-dipole line YM-10.

5. Unpublished work map showing location of dipole-dipole line YM-11.

6. Unpublished preliminary map showing faults on Yucca Mountain inferred from Vertical Electrical Sounding data.

7. Unpublished, working map for the resultant map (item 6), showing dipole-dipole line locations and locations of resistivity contrasts.

8. Unpublished contractor's pseudo-section drawings for dipole-dipole line YM-11 and part of YM-10.

9. Unpublished contractor report relating to dipole-dipole lines TR-3, TR-4.

10. Ross and Lunbeck, 1978 (complete bibliographic citation under RRM References).

11. Daniels, 1983 (complete bibliographic citation under RRM References).

12. Daniels et al., 1981 (complete bibliographic citation under RRM References).

REFERENCES USED IN THE REVIEW RECORD MEMORANDUM

Adamson, A. W., 1976. Physical Chemistry of Surfaces, 3rd Edition, John Wiley and Sons, New York.

American Geological Institute, 1962. Dictionary of Geological Terms, prepared under the direction of the American Geological Institute, Doubleday and Company, Inc., Garden City, New York.

Anderson, L. A., 1981. Rock Property Analysis of Core Samples from the Yucca Mountain UE25 a-1 Boreholes, Nevada Test Site, Nevada, Open File Report USGS-OFR-81-1338, U.S. Geological Survey.

Anderson, L. A., 1984. Rock Property Measurements on Large-Volume Core Samples from Yucca Mountain USW GU-3/G-3 and USW G-4 Boreholes, Nevada Test Site, Nevada, Open File Report USGS-OFR-84-552, U.S. Geological Survey.

Anderson, L. A., written communication. Preliminary draft of report on results of rock property measurements made on core samples from Yucca Mountain boreholes UE25 a#4, a#5, a#6, a#7, and p#1, sent to E. Hardin by D. Klein; August 3, 1989.

Barbier, M. G., 1983. The Mini-Sosie Method, International Human Resources Development Corporation, Boston, Massachusetts.

Appendix E

REFERENCES COMPRISING THE TAR PACKAGE

Bertram, S.G., 1984. NNWSI Exploratory Shaft Site and Construction Method Recommendation Report, SAND84-1003, Sandia National Laboratories, Albuquerque, NM.

Chronology of Events, Prepared by T. Grant, 4/89.

Letter from Dixon (USGS) to Vieth discussing detailed geologic mapping of 5 sites recommended by Ad Hoc TOC Committee

Memo from A.E. Stephenson (SNL) to R.C. Lincoln with report "Recommendation of the Site for the NNWSI Exploratory Shaft by the Ad Hoc TOC Committee", dated 6/25/82.

Scott, R.B., and J. Bonk, 1984. Preliminary Geologic Map of Yucca Mountain, Nye County, Nevada, with Geologic Sections, USGS-OFR-84-494, Open-File Report,U.S. Geological Survey. (manila envelope)

Scott, R.B., et al, 1984. Geological and Geophysical Evidence of Structures in North-West Trending Washes, Yucca Mountain, Southern Nevada, and Their Possible Significance to a Nuclear Waste Repository in the Unsaturated Zone, USGS-OFR-84-567, Open-File Report, U.S. Geological Survey.

Smith, C., and H.P. Ross, 1982. Interpretation of Resistivity and Induced Polarization Profiles with Severe Topographic Effects, Yucca Mountain Area, Nevada Test Site, Nevada, USGS-OFR-82-182, Open-File Report, U.S. Geological Survey. (acco binder)

Spengler, R.W., and M.P. Chornack, 1984. Stratigraphic and Structural Characteristics of Volcanic Rocks in Core Hole USW G-4, Yucca Mountain, Nye County, Nevada, with a section on geophysical logs by D.C. Muller and J.E. Kibler, USGS-OFR-84-789, Open-File Report, U.S. Geological Survey. (with Plate 1 in envelope in notebook cover)

Spengler, R.W., and J.G. Rosenbaum, 1980. Preliminary Interpretations of Geologic Results Obtained from Boreholes UE25a-4, -5, -6, -7, Yucca Mountain, Nevada Test Site, USGS-OFR-80-929, Open-File Report, U.S. Geological Survey.

USGS (U.S. Geological Survey) (Comp), 1984. A Summary of Geologic Studies Through January 1, 1983, of a Potential High-Level Radioactive Waste Repository Site at Yucca Mountain, Southern Nye County, Nevada, USGS-OFR-84-792, Open-File Report, U.S. Geological Survey.

Package of materials provided by D. P. Klein, 6/3/89, including:

1. An unpublished sketch summarizing geoelectric-defined faults in the area of Coyote Wash.

2. Figure showing dipole-dipole lines A, B, B', C of Smith and Ross, 1982.

Barton, N., 1988. "Rock Mass Classification and Tunnel Reinforcement Selection Using the Q-System," Rock Classification Systems for Engineering Purposes, ASTM STP 984, Louis Kirkaldie, ed., American Society for Testing and Materials, Philadelphia, pp. 59-88.

Barton, C. C., W. R. Page, and T. L. Morgan, 1989. Fractures in Outcrops in the Vicinity of Drill Hole USW G-4, Yucca Mountain, Nevada, Open File Report USGS-OFR-89-92, U.S. Geological Survey, 13 p.

Bell, Bruce S., 1979. Summary report on the symmetrical Schlumberger vertical electrical soundings and induced polarization and dipole-dipole resistivity traverse work on and outside the Nevada Test Site, Contract no. 14-08-0001-17817, transmitted to D. Hoover, U.S. Geological Survey, from the Vice President of Phoenix Geophysics, March 7, with enclosures.

Bentley, C. B., J. H. Robinson, and R. W. Spengler, 1983. Geohydrologic Data for Test Well USW H-5, Yucca Mountain Area, Nye County, Nevada, Open File Report USGS-OFR-83-853, U.S. Geological Survey.

Bertram, S. G., 1984. NNWSI Exploratory Shaft Site and Construction Method Recommendation Report, SAND84-1003, Sandia National Laboratories Albuquerque, New Mexico.

Beyer, J. H., 1977. Telluric and D.C. Resistivity Techniques Applied to the Geophysical Investigation of Basin and Range Geothermal Systems, Part II: A numerical Model Study of the Dipole-Dipole and Schlumberger Resistivity Methods. University of California at Berkeley, LBL-6325, 2/3, Lawrence Berkeley Laboratory, 211 p.

Bish, D. L., 1987. Evaluation of Past and Future Alterations in Tuff at Yucca Mountain, Nevada, Based on the Clay Mineralogy of Drill Cores USW G-1, G-2, and G-3, LA-10667-MS, Los Alamos National Laboratory, Los Alamos, New Mexico.

Bish, D. L. and S. J. Chipera, 1989. Revised Mineralogic Summary of Yucca Mountain, LA-11497-MS, Los Alamos National Laboratory, Los Alamos, New Mexico.

Chesnut, D., personal communication. Discussion with E. Hardin concerning some of the facts reported in a draft report on rock property measurements made on core samples, by L. A. Anderson; August 3, 1989.

Cross, J. A., 1986. Letter to D. L. Vieth concerning "Location of Shafts for the Exploratory Shaft Facility (ESF)," dated July 29, 1986.

Daniels, Jeffrey J., 1983. "Hole to Surface Resistivity Measurements," Geophysics, Vol. 48, No. 1, p. 87-97.

Daniels, J. J., J. H. Scott, and J. T. Hagstrum, 1981. Interpretation of Geophysical Well-Log Measurements in Drill Holes UE25a-4, -5, -6, -7, Yucca Mountain, Nevada Test Site, Open File Report USGS-OFR-81-389, U.S. Geological Survey, 29 p.

Dey, A., 1976. Resistivity Modeling for Arbitrarily Shaped Two-Dimensional Structures, Part II: User's Guide to the FORTRAN Algorithm RESIS2D, University of California at Berkeley, LBL-5283, Lawrence Berkeley Laboratory.

Dey, A., and H. F. Morrison, 1976. Resistivity Modeling for Arbitrarily Shaped Two-Dimensional Structures, Part I: Theoretical Formulation, University of California at Berkeley, LBL-5223, Lawrence Berkeley Laboratory.

Dey, A., and H. F. Morrison, 1979. "Resistivity Modeling for Arbitrarily Shaped Three-Dimensional Structures," Geophysics, Vol. 44, p. 753-780.

Dixon, G. L., 1982. Letter to D. L. Vieth dated July 16, 1982.

DOE (U.S. Department of Energy), 1986. Environmental Assessment, Yucca Mountain Site, Nevada Research and Development Area, Nevada, DOE/RW-0073, 3 vols., U.S. Department of Energy, Washington, D.C.

DOE (U.S. Department of Energy), 1988. Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada, DOE/RW-0199, 9 vols., U.S. Department of Energy, Washington, D.C.

DOE (U.S. Department of Energy), 1989. Review Record Memorandum: Exploratory Shaft Facility (ESF), Title I Design Acceptability Analysis and Comparative Evaluations of Alternative ESF Locations, YMP/89-3, Nevada Operations Office, Yucca Mountain Project Office, Las Vegas, Nevada.

DOE (U.S. Department of Energy), in review. Report on Geophysical Activities at Yucca Mountain.

Fernandez, J. A., P. C. Kelsall, J. B. Case, and D. Meyer, 1987. Technical Basis for Performance Goals, Design Requirements, and Material Recommendations for the NNWSI Repository Sealing Program, SAND84-1895, Sandia National Laboratories, Albuquerque, New Mexico. [HQS.880517.2673]

Fernandez, J. A., T. E. Hinkebein, and J. B. Case, 1989. Selected Analyses to Evaluate the Effects of the Exploratory Shafts on Repository Performance at Yucca Mountain, SAND85-0598, Sandia National Laboratories, Albuquerque, New Mexico. [NN1.881209.0038]

Fitterman, David V., 1982. Magnetometric Resistivity Survey Near Fortymile Wash Nevada Test Site, Nevada, Open File Report USGS-OFR-82-401, U.S. Geological Survey, 27 p.

Flanigan, V. J., 1981. A Slingram Survey at Yucca Mountain on the Nevada Test Site, Open File Report USGS-OFR-81-980, U.S. Geological Survey, 38 p.

Flathe, H. J., and W. Liebold, 1976. Manual for Field Work in Direct Current Soundings, Federal Institute for Geoscience and Natural Resources, Hanover, Germany.

Fox, R. C., G. W. Hobmann, T. J. Killpack, and L. Rijo, 1980. "Topographic Effects in Resistivity and Induced-Polarization Surveys," Geophysics, Vol. 45, pp. 75-93.

Frischknecht, F. C., and P. V. Raab, 1984. "Time-Domain Electromagnetic Soundings at the Nevada Test Site, Nevada," Geophysics, Vol. 49, No. 7, pp. 981-992.

Furgerson, Robert B., 1982. Remote-Reference Magnetelluric Survey, Nevada Test Site and Vicinity, Nevada and California, Open File Report USGS-OFR-82-465, U.S. Geological Survey, 13 p.

Gnirk, P., E. Hardin, and M. Voegele, 1988. Exploratory Shaft Location Documentation Report, NVO-326, Nevada Operations Office, U.S. Department of Energy, 127 p.

Halliday, M. E., 1985. Dipole-dipole resistivity/IP 2-D modeling workstation (commercial program for the HP-9000 series of computers), Austin, Texas.

Holcombe, H. T., and G. R. Jiracek, 1984. "Three-Dimensional Terrain Corrections in Resistivity Surveys," Geophysics, Vol. 49, pp. 439-452.

Hoover, D. B., M. P. Chornack, and M. M. Broker, 1982. E-Field Ratio Telluric Traverses Near Fortymile Wash, Nevada Test Site, Nevada, Open File Report USGS-OFR-82-1042, U.S. Geological Survey, 13 p.

Istok, J., in press. Groundwater Flow and Solute Transport Modeling by the Finite Element Method.

Kane, M. F., and R. E. Bracken, 1983. Aeromagnetic Map of Yucca Mountain and Surrounding Regions, Southwest Nevada, Open File Report USGS-OFR-83-616, scale 1:48,000, U.S. Geological Survey.

Keller, G. V., and F. C. Frischknecht, 1966. Electrical Methods in Geophysical Prospecting, Pergamon Press, New York, 519 p.

Killpack, T. J., and G. W. Hohmann, 1979. Interactive Dipole-Dipole Resistivity and IP Modeling of Arbitrary Two-Dimensional Structures (IP2S) Users Guide and Documentation), University of Utah Research Institute (UURI), Earth Science Laboratory, ESL/UURI Report 15, Salt Lake City, Utah.

Klein, D. P., written communication. Package received from the U.S. Geological Survey and appended to the Technical Assessment Review package; June 1, 1989. The contents are listed in Appendix E of the Review Record Memorandum.

Lahoud, R. G., D. H. Lobmeyer, and M. S. Whitfield, Jr., 1984. Geohydrology of Volcanic Tuff Penetrated by Test Well UE-25b#1, Yucca Mountain, Nye County, Nevada, Water Resources Investigations Report 84-4253, U.S. Geological Survey.

Linehan, J., 1987. Letter to M. P. Kunich discussing open items raised during meeting with NRC on April 14-15, 1987, dated August 19, 1987.

Lipman, P. W., and E. J. McKay, 1964. Geology of the Topopah Spring SW Quadrangle, Nye County, Nevada, Technical Letter NTS-72 (February 25, 1964), U.S. Geological Survey, 8 p.

Lipman, P. W., and E. J. McKay, 1965. "Geologic Map of the Topopah Spring SW Quadrangle, Nye County, Nevada," Map GQ-439, U.S. Geological Survey.

MacDougall, H. R., L. W. Sculley, and J. R. Tillerson (compilers), 1987. Site Characterization Plan Conceptual Design Report (SCP-CDR), SAND84-2641, Sandia National Laboratories, Albuquerque, New Mexico.

Maldonado, F., 1985. "Geologic Map of the Jackass Flats Area, Nye County, Nevada," Map I-1519, U.S. Geological Survey.

Martinez, M. J., 1988. Capillary-Driven Flow in a Fracture Located in a Porous Medium, SAND84-1697, Sandia National Laboratories, Albuquerque, New Mexico. [NN1.880928.0024]

Montazer, P., and W. E. Wilson, 1984. Conceptual Hydrologic Model of Flow in the Unsaturated Zone, Yucca Mountain, Nevada, Water Resources Investigation Report 84-4345, U.S. Geological Survey. [HQS.880517.1675*, NNA.870407.0009, NNA890327.0051]

Murphy, S. D., 1986. Letter to D. L. Vieth concerning "Revised Minutes to the Exploratory Shaft Facilities Studies Kick-Off Meeting of August 20, 1986," dated September 16, 1989.

Nelson et al., (in review). Summary of Geophysical Logs and Core Measurements from Forty Boreholes at Yucca Mountain, Nevada.

Nettleton, L. L., 1976. Gravity and Magnetics in Oil Prospecting, McGraw-Hill.

Ogard, A. E., and D. T. Vaniman (eds.), 1985. Research and Development Related to the Nevada Nuclear Waste Storage Investigations (July 1 - September 1984), LA-10299-PR, Los Alamos National Laboratory, Los Alamos, Newe Mexico.

Ortiz, T. S., R. L. Williams, F. B. Nimick, B. C. Whittet, and D. L. South, 1985. A Three-Dimensional Model of Reference Thermal/Mechanical and Hydrological Stratigraphy at Yucca Mountain, Southern Nevada, SAND84-1076, Sandia National Laboratories, Albuquerque, New Mexico.

Pelton, W. H., L. Rijo, and C. M. Swift, Jr., 1978. "Inversion of Two-Dimensional Resistivity and Induced-Polarization Data," Geophysics, Vol. 43, pp. 788-803.

Peters, R. R., 1988. Hydrologic Technical Correspondence in Support of the Site Characterization Plan, SAND88-2784, Sandia National Laboratories, Albuquerque, New Mexico.

Peters, R. R., E. A. Klavetter, I. J. Hall, S. C. Blair, P. R. Heller, and G. W. Gee, 1984. Fracture and Matrix Hydrologic Characteristics of Tuffacious Materials from Yucca Mountain, Nye County, Nevada, SAND84-1471,

Sandia National Laboratories, Albuquerque, New Mexico. [NNA 870407.0036, HQS.880517.1692, HQS.880517.1816]

Pridmore, D. F., G. W. Hohmann, S. H. Ward, and W. R. Sill, 1981. "An Investigation of Finite-Element Modeling for Electrical and Electromagnetic Data in Three Dimensions," Geophysics, Vol. 46, pp. 1009-1024.

Prindle, R. W., and P. L. Hopkins, (in prep). On Conditions and Parameters Important to Model Sensitivity for Unsaturated Flow Through Layered, Fractured Tuff: Results of Analyses for HYDROCOIN Level 3 Case 2, SAND89-0652, Sandia National Laboratories, Albuquerque, New Mexico.

Rijo, Luiz, 1977. Modeling of Electric and Electromagnetic Data, University of Utah, Ph.D. thesis, 242 p.

Ross, H. P., and J. Lunbeck, 1978. Interpretation of Resistivity and Induced Polarization Profiles, Calico Hills and Yucca Mountain Areas, Nevada Test Site, ESL-UURI-8, University of Utah Research Institute, Salt Lake City, Utah, 17 p.

Rulon, J., G. S. Bodvarsson, and P. Montazer, 1986. Preliminary Numerical Simulations of Groundwater Flow in the Unsaturated Zone, Yucca Mountain, Nevada, LBL-20553, Lawrence Berkeley Laboratory, University of California at Berkeley, California. [NNA.870908.09027]

Scott, R. B., G. D. Bath, V. J. Flanigan, D. B. Hoover, J. G. Rosenbaum, and R. W. Spengler, 1984. Geological and Geophysical Evidence of Structures in the Northwest-Trending Washes, Yucca Mountain, Southern Nevada, and Their Possible Significance to a Nuclear Waste Repository in the Unsaturated Zone, Open File Report USGS-OFR-84-567, U.S. Geological Survey.

Scott, R. B., and J. Bonk, 1984. Preliminary Geologic Map of Yucca Mountain Nye County, Nevada with Geologic Section, Open File Report USGS-OFR-84-494, U.S. Geological Survey. [HQS.880517.1443]

Scott, R. B., R. W. Spengler, S. Diehl, A. R. Lappin, and M. P. Chornack, 1983. "Geologic Character of Tuffs in the Unsaturated Zone at Yucca Mountain, Southern Nevada," Role of the Unsaturated Zone in Radioactive and Hazardous Waste Disposal, J. Mercer, R. Rao, I. Marine (eds.), Ann Arbor Sciences, Ann Arbor, Michigan. [NNA.870406.0034, HQS.880517.1446]

Senterfit, R. M., D. B. Hoover, and M. Chornack, 1982. Resistivity Sounding Investigation by the Schlumberger Method in the Yucca Mountain and Jackass Flats Area, Nevada Test Site, Nevada, Open File Report USGS-OFR-82-1043, U.S. Geological Survey, 8 p. and appendix.

Serra, O., 1984. "Fundamentals of Well-Log Interpretation," Developments in Petroleum Science Series #15A, Elsevier, New York.

Sinnock, S., Y. T. Lin, and J. P. Brannen, 1984. Preliminary Bounds on the Expected Postclosure Performance of the Yucca Mountain Repository Site, Southern Nevada, SAND84-1492, Sandia National Laboratories, Albuquerque, New Mexico.

Smith, C., and H. P. Ross, 1982. Interpretation of Resistivity and Induced Polarization Profiles with Severe Topographic Effects, Yucca Mountain Area, Nevada Test Site, Nevada, Open File Report USGS-OFR-82-182 with introduction by D. B. Hoover, U.S. Geological Survey.

SNL (Sandia National Laboratories), 1989. ESF - Repository Interface Sealing Details, Drawing Numbers R07072, Rev. 1; R07073, Rev. 1; R07074, Rev. 1, Sandia National Laboratories, Albuquerque, New Mexico.

Spengler, R. W., M. P. Chornack, D. C. Muller, and J. E. Kibler, 1984. Stratigraphic and Structural Characteristics of Volcanic Rocks in Core Hole USW G-4, Yucca Mountain, Nye County, Nevada, Open File Report USGS-OFR-84-789, U.S Geological Survey, 77 p.

Spengler, R. W., D. C. Muller, and R. B. Livermore, 1979. Preliminary Report on the Geology and Geophysics of Drill Hole UE25a-1, Yucca Mountain, Nevada Test Site, Open File Report USGS-OFR-79-1244, U.S. Geological Survey.

Spengler, R. W., and J. G. Rosenbaum, 1980. Preliminary Interpretations of Geologic Results Obtained from Boreholes UE25a-4, -5, -6, -7, Yucca Mountain, Nevada Test Site, Open File Report USGS-OFR-80-929, U.S. Geological Survey, 33 p.

Stephenson, A. E., 1982. Sandia National Laboratories memo to R. C. Lincoln concerning "Ad Hoc Technical Overview Contractor Committee Recommendation of the Site for the NNWSI Exploratory Shaft," dated June 25, 1982.

Sumner, J. S., 1976. Principles of Induced Polarization for Geophysical Exploration, Elsevier Scientific Publishing Co., Amsterdam, Netherlands, 277 p.

Taylor, E. M., and H. E. Huckens, 1986. "Carbonate and Opaline Silica Fault-Filling on the Bow Ridge Fault, Yucca Mountain, Nevada--Deposition from Pedogenic Processes or Upwelling Ground Water?" (abs.), Abstracts with Programs, Vol. 18, No. 5, p. 418, Geological Society of America, Rocky Mountain Section.

Telford, W. M., L. P. Geldart, R. E. Sheriff, and D. A. Keys, 1976. Applied Geophysics, Cambridge University Press, Cambridge, United Kingdom.

Tripp, A. C., G. W. Hohmann, and C. M. Swift, Jr., 1984. "Two-Dimensional Resistivity Inversion," Geophysics, Vol. 49, pp. 1708-1717.

USGS (U.S. Geological Survey), 1984. A Summary of Geological Studies through January 1, 1983, of a Potential High-Level Radioactive Waste Repository Site at Yucca Mountain, Southern Nye County, Nevada, Open File Report USGS-OFR-84-792, U.S. Geological Survey.

USGS (U.S. Geological Survey), 1988. Geologic and Hydrologic Investigations of a Potential Nuclear Waste Disposal Site at Yucca Mountain, Southern Nevada, M. D. Carr and J. C. Yount (eds.), Bulletin 1790, 152 pp.

Vieth, D. L., 1986. U.S. Department of Energy Action Memorandum to S. H. Kale concerning "Reevaluation of Exploratory Shaft (ES) Requirements for

the Nevada Nuclear Waste Storage Investigations (NNWSI) Project (WMPO Action Item No. 87-824)," dated November 29, 1986.

Vieth, D. L., 1986. Letter to J. A. Cross concerning "Location of Shaft for the Exploratory Shaft Facility (ESF)," dated August 21, 1986.

Vieth, D. L., 1987. Letter to J. P. Knight concerning "Transmittal of Summary of the April 14-15, 1987, Meeting on Proposed Changes to the Nevada Nuclear Waste Storage Investigations (NNWSI) Project Exploratory Shaft," dated April 27, 1987.

Wang, J. S. ., and T. N. Narasimhan, 1986. Hydrologic Mechanisms Governing Partially Saturated Fluid Flow in Fractured Welded Units and Porous Non-Welded Units at Yucca Mountain, SAND85-7114, Sandia National Laboratories, Albuquerque, New Mexico. [NNA.870806.0063]

Wang, J. S. Y., and T. N. Narasimhan, 1988. Hydrologic Modeling of Vertical and Lateral Movement of Partially Saturated Fluid Flow Near A Fault Zone at Yucca Mountain, SAND87-7070, Sandia National Laboratories, Albuquerque, New Mexico. [NNA.871109.0057]

Waxman, M. H., and E. C. Thomas, 1974. "Electrical Conductivities in Shaly Sands--I. The Relation Between Hydrocarbon Saturation and Resistivity Index; II. The Temperature Coefficient of Electrical Conductivity," Journal of Petroleum Technology, February 1974, pp. 213-225.

Wu, S. S. C., 1985. Topographic Maps of Yucca Mountain Area, Nye County, Nevada, Open File Report USGS-OFR-85-620, U.S. Geological Survey, 6 sheets.

Yucca Mountain Project, 1989. Reference Information Base, YMP/CC-0002, Revision 4.

Appendix F

Correspondence Related to TAR

CORRESPONDENCE RELATED TO THE TECHNICAL ASSESSMENT REVIEW

This appendix contains correspondence relating to the Technical Assessment Review (TAR) that, for the most part, is not reproduced elsewhere in the Review Record Memorandum. (Correspondence strictly related to administration of the TAR is not included.)

The following documents are included:

1. May 25, 1989, letter from Maxwell B. Blanchard to Distribution, "Announcement of Actions Underway by the Yucca Mountain Project Office (Project Office) in Response to U.S. Nuclear Regulatory Commission (NRC) Concerns Regarding the Geophysically Inferred Fault in the Vicinity of the Proposed Exploratory Shaft Location."

2. June 27, 1989, letter from Ralph Stein to B. J. Youngblood regarding Exploratory Shaft location documentation. (Note that the attachment to this letter, announcement of the Technical Assessment Review, is not included. It is item 1 of this appendix.)

3. July 31, 1989, letter from Carl P. Gertz to Robert R. Loux, Jr., "Transmittal of Technical Assessment Review (TAR) Materials Regarding Exploratory Shaft Facility-Site Resistivity Anomaly." (Note that the attachments to this letter are not included. They can be found in item 1 of this appendix, Appendix A of this RRM, and the TAR Data Package, available through the Yucca Mountain Project Records Center.)

4. July 17, 1989, memorandum from Maxwell B. Blanchard to David C. Dobson, "Keith McConnell's View of July 3, 1989 about Additional Evidence for Possible Faulting in the Vicinity of the Exploratory Shafts."

5. August 7, 1989, letter from Douglas P. Klein to Richard C. Lee, "Judgement as to Validity and Limitations of GW1 Code for 3-D Resistivity Studies."

Department of Energy
Nevada Operations Office
P. O. Box 98518
Las Vegas, NV 89193-8518

WBS #1.2.6
"QA: N/A"

MAY 25 1989

Leslie J. Jardine, LLNL, Livermore, CA
Larry R. Hayes, USGS, Las Vegas, NV
Richard J. Herbst, LANL, Los Alamos, NM
Thomas O. Hunter, SNL, 6310, Albuquerque, NM
John H. Nelson, SAIC, Las Vegas, NV
Joseph C. Calovini, H&N, Las Vegas, NV
Robert F. Pritchett, REECo, Las Vegas, NV
Richard L. Bullock, F&S, Las Vegas, NV
Addanki M. Sastry, MACTEC, Las Vegas, NV

ANNOUNCEMENT OF ACTIONS UNDERWAY BY THE YUCCA MOUNTAIN PROJECT OFFICE (PROJECT OFFICE) IN RESPONSE TO U.S. NUCLEAR REGULATORY COMMISSION (NRC) CONCERNS REGARDING THE GEOPHYSICALLY INFERRED FAULT IN THE VICINITY OF THE PROPOSED EXPLORATORY SHAFT LOCATION

At the direction of the Office of Civilian Radioactive Waste Management in response to NRC concerns regarding an inferred fault near the proposed Exploratory Shaft Facility (ESF), the Project Office will conduct a Technical Assessment Review (TAR) of the relevant geological and geophysical data, and its interpretation. If necessary, the review will also consider the potential impact the inferred fault may have on the exploratory shaft and ESF Title II design. The enclosure describes the purpose and scope of the TAR, which will be conducted in accordance with Quality Management Procedure (QMP)-02-08. This transmittal satisfies the requirements of Section 3.2, QMP-02-08, of the TAR Notice.

The NRC is expected to raise this potential fault as a Site Characterization Plan comment, and it is important to respond adequately and promptly. The TAR will begin immediately, and it is expected to be completed by mid-July. We anticipate that the required level of support of the team members will average half-time for the next 6-8 weeks.

The purpose of the TAR is contained in the enclosed TAR Plan. Also provided in the enclosure is a preliminary schedule for the review, a list of participating organizations, and composition of the TAR Team. You are requested to make arrangements for appropriate staff to participate in the TAR. A list of suggested team members is included in the enclosed plan. If the named individuals are unavailable, please provide alternates with equivalent qualifications. As the Project Office Designee, Science Applications International Corporation (SAIC) is to conduct the TAR in accordance with this announcement. Richard Lee of SAIC has been named Chairman of the TAR team. The TAR will be initiated with the distribution of training materials and the TAR Package. All team members will be contacted by the TAR Chairperson or their group leader regarding individual assignments and schedule. It is expected that all team members will be asked to attend a tour

MAY 25 1989

of the Coyote Wash area on June 7, 1989. Additional time in the field may be required of members on the geology team. It is also expected that all team members would be present at the SAIC offices for the week of June 26 to caucus on the TAR Review Memorandum.

David C. Dobson, Chief of the Regulatory Interactions Branch, will be the DOE lead in the TAR. If you have any questions about the details in this letter, please contact him at (702) 794-7940 or FTS 544-7940 or Richard C. Lee or SAIC at (702) 794-7134, or FTS 544-7134.

Maxwell Blanchard

Maxwell B. Blanchard, Director
Regulatory and Site Evaluation Division
Yucca Mountain Project Office

YMP:DCD-4016

Enclosures:
1. TAR Notice w/Schedule
2. TAR Team

cc w/encls:
S. H. Kale, HQ (RW-20) FORS
Ralph Stein, HQ (RW-30) FORS
Stephan Brocoum, HQ (RW-221) FORS
Jeffrey Kimball, HQ (RW-221) FORS
Mohammed Mozumder, HQ (RW-22) FORS
David Siefken, Weston, Washington, DC
David Fenster, Weston, Washington, DC
M. D. Voegele, SAIC, Las Vegas, NV
S. H. Klein, SAIC, Las Vegas, NV
J. L. King, SAIC, Las Vegas, NV
D. B. Jorgenson, SAIC, Las Vegas, NV
R. C. Lee, SAIC, Las Vegas, NV
J. M. Davenport, SAIC, Las Vegas, NV
E. H. Hardin, SAIC, Las Vegas, NV
T. A. Grant, SAIC, Las Vegas, NV
F. D. Peters, SAIC, Las Vegas, NV
T. E. Hinkebein, SNL, 6314, Albuquerque, NM
R. B. Raup, USGS, Denver, CO
G. L. Shideler, USGS, Denver, CO
D. P. Klein, USGS, Denver, CO
Adel Zhody, USGS, Denver, CO
M. P. Chornack, USGS, Denver, CO

TECHNICAL ASSESSMENT REVIEW NOTICE

N-QA-010
1/89

Revision 0

To Yucca Mountain Project Manager Date May 18, 1989

Technical Area to be Reviewed Technical Assessment Review Notice: Geologic & Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed Exploratory Shaft

WBS No.: 1.2.3.2.1 (see attachment 1)

Review Date June 7 1989 Location Las Vegas Time see attachment 1

Technical Assessment Review Chairperson Richard C. Lee

Based on a review of the qualification documentation, this Technical Assessment Review Chairperson is qualified to execute the responsibilities of QMP-02-08 with respect to the scope and purpose of this Technical Assessment Review.

Scope of Technical Assessment Review: See Attachment 1

Purpose of Technical Assessment Review: See Attachment 1

Signed [signature]

Reviewed and Approved:

[signature] 5/18/89

Project Quality Manager Date

Attachments:

Background, Purpose and Scope of Technical Assessment Review

ENCLOSURE 1

BACKGROUND, PURPOSE AND SCOPE OF TECHNICAL ASSESSMENT REVIEW: GEOLOGIC AND GEOPHYSICAL EVIDENCE PERTAINING TO THE STRUCTURAL GEOLOGY IN THE VICINITY OF THE PROPOSED EXPLORATORY SHAFT LOCATION

Background: U. S. Geological Survey Open File Report 82-182 (OFR 82-182) shows an interpretation of geophysical resistivity data that indicates a fault may be present near the proposed exploratory shaft site. The NRC has reviewed OFR 82-182 and may request a summary of the actions DOE has taken to address the fault shown by that report. In addition, the NRC may request a summary of the DOE actions that were taken to address the recommendations in Bertram (1984) for additional detailed geological and geophysical work in the vicinity of the exploratory shaft site. The work proposed in the Bertram report was completed; there is a letter report from Dixon to Vieth (1982) on geological mapping and open file reports summarize additional drilling and geophysical work completed in response to the recommendations.

The NRC staff have also expressed interest in an inferred fault near the exploratory shafts shown on SCP Figure 1-40. This figure is based on faults interpreted from geophysical data shown on a map in U. S. Geological Survey Open File Report 84-792. The OFR report does not give any detail on the data on which the map is based, although OFR 82-182 is referenced. R. Stein (DOE/HQ) requested in March, 1989, that DOE be prepared to talk to NRC on this topic by the end of April, 1989. Although a date for discussion with the NRC has not been firmly established, it is envisioned that this TAR will serve as the basis for such an interaction.

Purpose: The purpose of the TAR is to: (1) review the data and interpretations on which OFR 82-182 is based; (2) review the results of other geologic and geophysical investigations that relate to the possibility of faulting in the vicinity of the exploratory shafts; and (3) after reviewing the data, the TAR Team will determine the interpretations allowed by the evidence on the presence or absence of faulting in the vicinity of the exploratory shafts.

The TAR team will also review the existing documentation to determine: (1) how the geologic and geophysical data were considered in making the decision on the location of exploratory shafts; and (2) whether the recommendations of the Bertram (1984) report were adequately implemented.

Scope of Technical Assessment Review: The following tasks will be accomplished by the Technical Assessment Review Team. The findings of the team will be documented in narrative form in the Review Record Memorandum.

1. Review the data collection and processing techniques, and subsequent interpretations, which form the basis for the proposed existence of the small fault shown near the location of the exploratory shafts in U. S. Geological Survey Open File Report 82-182. The TAR team will establish and document criteria for the technical reviews. They will then summarize the original objective and purpose of the work, the limitations of the data, and they will evaluate the interpretations (including alternatives) supported by the data. If appropriate, sources for review criteria will be identified.

2. The TAR Team will determine what other geologic and geophysical data are available that may bear on the presence or absence of a fault near the location of the exploratory shafts. The TAR team will review any such data discovered and determine the original purpose of the work, the implications of the data with respect to the presence or absence of faulting in the vicinity of the exploratory shafts, and the limitations of the data.

3. At the discretion of the TAR chairperson, the reviews described in 1 and 2, above, may also include a detailed field review of the geologic mapping in the vicinity of the exploratory shafts, or field reviews of the geophysical work by members of the TAR team, or qualified designees. Prior to conducting any proposed field reviews, the TAR team shall establish and document criteria for the review.

4. After completing Items 1, 2 and 3, the TAR team will determine whether the possible fault shown in U. S. Geological Survey Open File Report 82-182 was adequately considered during the selection of the exploratory shaft location. The team will develop criteria for the determination, and then evaluate the impacts on the exploratory shaft and ESF Title II design process if it was concluded that a fault did exist.

5. The TAR Team should consider, and make recommendations on, future work that should be undertaken as a result of the findings of the technical assessment.

6. Following completion of the tasks described above, the TAR Team will compile a report which summarizes the results of the assessment, and specifically addresses at least the following topics:

   A. Historical perspective: summarize the sequence of events that occurred relevant to this topic, and the documents that exist in YMP files regarding the geological and geophysical work.

   B. Geophysical perspective: summarize the past work, the rationale for conducting the studies, the interpretations (and alternatives) that are consistent with the data, and the limitations of the data.

   C. Geological perspective: summarize the rationale for, and the results of, the past studies, the interpretations (and alternatives) that are consistent with the data, and the limitations of the data.

   D. Results of field checks (optional): summarize any work accomplished, and what results are indicated.

E. Summary and recommendations, to include, at a minimum: (A) assessment of the data relevant to the possible presence of a fault near the proposed ESF, (B) evaluation of whether the available data were adequately considered during the process of selecting the proposed shaft locations; (C) perspective on the possible impact on Title II design if the presence of a fault was demonstrated; and (D) recommendations for further action.

Logistical Information for the Technical Assessment Review

The first meeting of the Technical Assessment Review Team will be convened by the Review Chairman in May, 1989, in Las Vegas. The current schedule is shown below. Members of the team will be named by the Review Chairman, who will establish and document criteria for their selection. Team members will be notified of further details as they become available.

ESF Resistivity Fault TAR Schedule

Week	Goal
May 22, 1989	TAR Chairman makes contact with each team member; Initiate TAR and distribute Plan; Define and qualify team; distribute TAR Package.
May 26	Team members have telephone conferences with team leaders; reading assignments are completed; strategies are defined.
May 30	Preparation for field trip to Coyote Wash area; continuation of work.
June 7	Field trip to Coyote Wash taking one full day in field; one to four days of additional verification work as required by Geology team leader.
June 12	Any re-interpretation of geologic data completed.
June 19	Any re-interpretation of resistivity data completed.
June 26	TAR team caucus; complete preliminary draft of RRM.
July 10	Final RRM completed.
July 17	Transmit TAR Data Package to Document Control.

REFERENCES

Bertram, S.G., 1984, NNWSI Exploratory Shaft Site and Construction Method Recommendation Report, SAND 84-1003, Sandia National Laboratories, Albuquerque, NM.

Letter from G. Dixon to D.L. Vieth, July 16, 1982, discussing detailed geologic mapping of 5 sites recommended by Ad Hoc TOC Committee.

Smith, C. and H.P. Ross, 1982, Interpretation of Resistivity and Induced Polarization Profiles with Severe Topographic Effects, Yucca Mountain Area, Nevada Test Site, Nevada, USGS OFR 82-182, Open File Report, U.S. Geological Survey.

USGS (U.S. Geological Survey), 1984, A Summary of Geologic Studies Through January 1, 1983, of a Potential High-Level Radioactive Waste Repository Site at Yucca Mountain, Southern Nye County, Nevada, USGS OFR 84-792, Open File Report, U.S. Geological Survey.

TAR Team

YMPO Branch Chief responsible for TAR: David Dobson
TAR Chairperson: Richard Lee — SAIC FTS 544-7134
TAR Secretary: Marshall Davenport — SAIC FTS 544-7661

Team Members:	Team/discipline	
Dave Dobson	Geology	YMPO FTS 544-7940
Mohammad Mozumder	Geophysics	DOEHQ FTS 896-5684
Jeff Kimball	Geophysics & Geology	DOEHQ FTS 896-1063
Ernie Hardin	Geophysics (Team Leader)	SAIC FTS 544-7617
Terry Grant	Geology (Team Leader)	SAIC FTS 544-7647
Forrest Peters	Geophysics (QA Specialist)	SAIC FTS 544-7753
David Cummings	Geophysics & Geology	SAIC FTS 544-7835
Gerald L. Shideler	Geology	USGS FTS 776-1273
Adel Zhody	Geophysicist	USGS FTS 776-1222
Richard Snyder	Geology	USGS FTS 776-1263
Dave Fenster	Geology	Weston 202-646-6647
Thomas E. Hinkebein	Engineering	SNL FTS 846-0580

ENCLOSURE 2

Department of Energy
Washington, DC 20585

JUN 27 1989

ACTION
CC:
CC:
CC:
CC:
CC:
CC:
CC:
CC:
CC:
CC:
CC:
CC:

REC'D IN WMPO
7/6/89

Mr. B. J. Youngblood, Deputy Director
Division of High-Level Waste Management
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Youngblood:

In December, 1988, DOE produced the Exploratory Shaft Location Documentation Report, Gnirk et. al., (NVO-326), which presented a historical summary of information relevant to locating, relocating, and designing the exploratory shafts for site characterization at the Yucca Mountain site. NVO-326 specifically described related events prior as well as subsequent to, publication of SAND84-1003, the report by Bertram on the NNWSI Exploratory Shaft Site and Construction Method Recommendation Report, August, 1984 (Bertram, 1984), but did no new analyses and was not intended to be a Subpart G document.

In February, 1989, DOE produced a Technical Assessment Review (TAR) (Yucca Mountain Project Review Record Memorandum: Exploratory Shaft Facility Title I Design Acceptability Analysis and Comparative Evaluation of Alternative ESF Locations, February,1989 (YMP/89-3). A part of that TAR, the Comparative Evaluation, evaluated alternative exploratory shaft locations with respect to differences in waste isolation potential and potential adverse effects of shaft sinking, and assessed what influence, if any, these differences might have had on the selection of the preferred shaft location, had they been an explicit consideration in the location selection process

With respect to both NVO-326 and the Comparative Evaluation of YMP/89-3, DOE assumed that the specific location of Exploratory Shaft-2 (ES-2) was within one of the five preferred areas delineated in Bertram, 1984. In fact NVO-326 states on page 66 that:

> *The new locations [e.g. the new locations for ES-1 and ES-2] are within the Coyote Wash ESF site area identified and recommended on the basis of the results of the ES site screening activity in 1982 (Bertram, 1984).*

As you know (letter from Linehan to Kunich, Aug 19, 1987), a plot of the location of the shafts shows that the actual site of ES-2 is located about 130 feet northeast of the Bertram preferred area that was selected for the location of the exploratory shaft.

The Comparative Evaluation of YMP/89-3 of the ES locations explicitly compiled and presented site characteristics for the five preferred areas in Bertram (1984) relative to waste isolation potential and the potentialy adverse affects of shaft construction. The data base for parameters related to

RECORD COPY

locations outside the preferred areas (such as the actual ES-2 location) contains information at the same level of detail, but was not explicitly tabulated in the report.

The effect on waste isolation that this location difference is thought to have is currently judged to be insignificant. This conclusion is based upon the Comparative Evaluation itself and on the assessments of impacts of the shafts on the ability of the site to isolate wastes contained in Section 8.4 of the SCP. However, we do consider it prudent to reserve our final judgement on the significance of the location difference until we have available the results of an ongoing assessment and review the significance of an anomoly in an earlier electrical resistance survey. This review will consider the results of the Technical Assessment Review which is underway, evaluating the geophysical anomaly (USGS, Open File Report, 82-182, 1982) and geologic mapping results (Dixon, 1982, Scott and Bonk, 1984) completed near the current shaft locations. A copy of the letter announcing this Technical Assessment review is attached for your information.

If you have any question regarding the above actions, please contact me, FTS 896-6046 or Jerome Saltzman, FTS 896-9692.

Ralph Stein

Ralph Stein
Associate Director for Systems
Integration and Regulations
Office of Civilian Radioactive
Waste Management

Attachment

cc: K. Stablein, NRC
R. Loux, State of Nevada
C. Johnson, State of Nevada
D. Bechtel, Clark County, NV
S. Bradhurst, Nye County, NV
M. Baugham, Lincoln County, NV

Department of Energy
Nevada Operations Office
P. O. Box 98518
Las Vegas, NV 89193-8518

WBS #1.2.5.4.1
"QA: N/A"

JUL 31 1989

Robert R. Loux, Jr.
Executive Director
Nuclear Waste Project Office
State of Nevada
Evergreen Center, Suite 252
1802 North Carson Street
Carson City, NV 89710

TRANSMITTAL OF TECHNICAL ASSESSMENT REVIEW (TAR) MATERIALS REGARDING EXPLORATORY SHAFT FACILITY-SITE RESISTIVITY ANOMALY

In response to your letter of June 21, 1989, enclosed please find:

1. A letter announcing actions proposed by the Yucca Mountain Project Office in response to concerns regarding the geophysically inferred fault in the vicinity of the proposed exploratory shaft location (enclosure 1).

2. A copy of the Technical Assessment Review Reference Package (enclosure 2).

3. A package of the instructions and procedures which were provided to each member of the TAR team (enclosure 3).

Should you have any questions regarding this matter, please contact David C. Dobson of my staff at (702) 794-7940.

Carl P. Gertz, Project Manager
Yucca Mountain Project Office

YMP:DCD-4916

Enclosures:
1. Ltr 5/25/89 Blanchard to Distribution
2. Technical Assessment Review Reference Package
3. Technical Assessment Review Instructions/Procedures

cc w/o encls:
Ralph Stein, HQ (RW-30) FORS
S. J. Brocoum, HQ (RW-21) FORS
Allen Benson, HQ (RW-123) FORS
R. C. Lee, SAIC, Las Vegas, NV
S. M. Volek, SAIC, Las Vegas, NV

cc w/encls:
S. H. Kale, HQ (RW-20) FORS
Ralph Stein, HQ (RW-30) FORS
Stephan Brocoum, HQ (RW-221) FORS
Jeffrey Kimball, HQ (RW-221) FORS
Mohammed Mozumder, HQ (RW-22) FORS
David Siefken, Weston, Washington, DC
David Fenster, Weston, Washington, DC
M. D. Voegele, SAIC, Las Vegas, NV
S. H. Klein, SAIC, Las Vegas, NV
J. L. King, SAIC, Las Vegas, NV
D. B. Jorgenson, SAIC, Las Vegas, NV
R. C. Lee, SAIC, Las Vegas, NV
J. M. Davenport, SAIC, Las Vegas, NV
E. H. Hardin, SAIC, Las Vegas, NV
T. A. Grant, SAIC, Las Vegas, NV
F. D. Peters, SAIC, Las Vegas, NV
T. E. Hinkebein, SNL, 6314, Albuquerque, NM
R. B. Raup, USGS, Denver, CO
G. L. Shideler, USGS, Denver, CO
D. P. Klein, USGS, Denver, CO
Adel Zhody, USGS, Denver, CO
M. P. Chornack, USGS, Denver, CO

Department of Energy
Nevada Operations Office
P. O. Box 98518
Las Vegas, NV 89193-8518

WBS 1.2.5
"QA"

JUL 17 1989

David C. Dobson, Chief, Regulatory Interactions Branch, YMP, NV

KEITH MCCONNELL'S VIEW OF JULY 3, 1989, ABOUT ADDITIONAL EVIDENCE FOR POSSIBLE FAULTING IN THE VICINITY OF THE EXPLORATORY SHAFTS (NN1-1989-2923)

Please examine the evidence provided and the hypothesis proposed in the enclosed note by Keith McConnell and determine if it would be appropriate to revise the ongoing Technical Assessment Review (TAR) to include this view. If you do not recommend revising the TAR, please provide a justification of why.

Maxwell B. Blanchard
Maxwell B. Blanchard, Director
Regulatory and Site Evaluation Division
Yucca Mountain Project Office

YMP:MBB-4889

Enclosure:
Memo 7/3/89 McConnell to Justus

cc w/encl:
S. J. Brocoum, HQ (RW-221) FORS
Gordon Appel, HQ (RW-331) FORS
M. D. Voegele, SAIC, Las Vegas, NV
J. L. Younker, SAIC, Las Vegas, NV
T. A. Grant, SAIC, Las Vegas, NV
M. A. Glora, SAIC, Las Vegas, NV

JUL 18 1989
EM, Hardin, King, Lee
Cummings

ENCLOSURE 1

DRAFT

JUL 0 3 1990

NOTE FOR: Phil Justus

NOTE FOR: Phil Justus

FROM: Keith McConnell

SUBJECT: ADDITIONAL EVIDENCE FOR POSSIBLE FAULTING IN THE VICINITY OF THE EXPLORATORY SHAFTS

In reviewing several publications (of early 80's vintage), I have developed what I believe is additional evidence to support possible faulting in the vicinity of the Exploratory Shafts. Generally, my analysis compares and contrasts relationships observed in boreholes G-4 and UE25a-6. These boreholes define an west-east trending section running just south of the sites of the proposed exploratory shafts in Coyote Wash. To the best of my knowledge, the DOE in its investigation of shaft location concerns has not carried out a similar comparison between these two boreholes, a task that would seem to be routine in a thorough examination of available data.

The analysis of the data in the two boreholes suggests that a conceptual model of faulting is possible in which the current locations of the ES are in or adjacent to an extension of the zone of imbricate faulting that has been referred to in the SCP as bordering the repository on the east. The validity of this model is open to debate, however, there is enough data available supporting the model to warrant consideration. In any event, DOE's claim in the Technical Assessment Review documentation that only the resistivity survey of Smith and Ross (1982) supports the presence of fault in the vicinity of the ES is not totally accurate.

Attachment 1 shows the relationship between borehole G-4, the exploratory shaft locations, and borehole UE25a-6. The boreholes are approximately 1400 ft. apart and borehole UE25a-6 is approximately 1000 ft east of the exploratory shaft locations. Both boreholes appear to be within the CPDB. A comparison of some pertinent data derived from the two boreholes is listed below.

	G-4	UE25a-6
Thickness of Alluvium	30'	20'
Avg. Strike	N 15 W	N 23 E
Avg. Dip	10 NE	08 SE
Elevation of base of Tiva Canyon	4028.6'	3907'
Elevation of top of Topopah Spring	3938.6'	3824'

Assuming a uniform dip of 9 degrees (i.e., average of dips in boreholes) to the northeast, the base of the Tiva Canyon at UE25a-6 should be approximately 221 feet below the level indicated in G-4 (i.e., 3806.9')

the Tiva Canyon is at an elevation of 3907' in UE25a-6 (Spengler and Rosenbaum, 1980), a difference of 100'.

Also of interest is that Daniels and others (1981) report that if the degree of welding is approximately the same for UE drillholes, then near-surface fracture zones are likely to occur near UE25a-6. Core recovery was poor in UE25a-6, the worst of all of the UE boreholes described by Spengler and Rosenbaum (1980). The poor core recovery is also suggestive of fracturing.

Several questions are raised by the comparison of boreholes G-4 and UE25a-6.

1) Why is the thickness of the alluvium in UE25a-6 (which is east of and presumably in a deeper part of Coyote Wash than G-4) equal to or less than that in G-4?

2) Why is the orientation of bedding so distinctly different between boreholes G-4 and UE25a-6?

3) Why is the elevation of the base of the Tiva Canyon 100' higher than would be suggested by a uniform dip of 5 degrees to the east?

4) What is the significance of the statement by Daniels and others (1981) that near-surface fracture zones may be present near UE25a-6 when viewed in the context of the poor core recovery and the areas of intense fracturing near the location of the exploratory shafts?

Each of these questions has more than one possible answer, some of which would not involve faulting. However, one possible model that does provide answers to all of these questions and support the "resistivity fault" of the Smith and others (1982) report would consider the possible presence of a major fault or series of minor faults (i.e., imbricates) between boreholes G-4 and UE25a-6 and including the area of the ES. Total vertical offset along this fault or series of faults would be on the order of 100'. This model is given added credence when viewed in the context of the statement made in the Bertram (1984) report that the western boundary of the zone of faults on the east side of the exploration block is not well defined and that a set-back distance of 2000' was used to place the shaft outside of that zone of faulting (Bertram, 1984, p. 54). If the zone of faulting mentioned in Bertram continues to the west through the area containing UE25a-6 and into the area of the shaft locations, then the criteria for set-back distance from the imbricate fault zone used in the Bertram report for shaft locations appears to be unsupported.

Perhaps the most significant question regarding the data available from UE25a-6 is why a simple cross-section between boreholes G-4 and UE25a-6 has not been presented by DOE. These two boreholes are the closest boreholes to the ES locations. No documentation has been presented to suggest that data related UE25a-6 was considered in the present location of the shafts or to indicate that this information is under consideration in the Technical Assessment Review.

References Cited

Bertram, S., 1984, NNWSI Exploratory shaft site and construction method recommendation report: Sandia National Laboratory, SAND 84-1003, 100 p.

Daniels, J.J., Scott, J.H., and Hagstrum, J.T., Interpretation of geophysical well-log measurements in drill holes UE25a-4, -5, -6, and -7, Yucca Mountain, Nevada Test Site: U.S. Geological Survey Open-File Report 81-389.

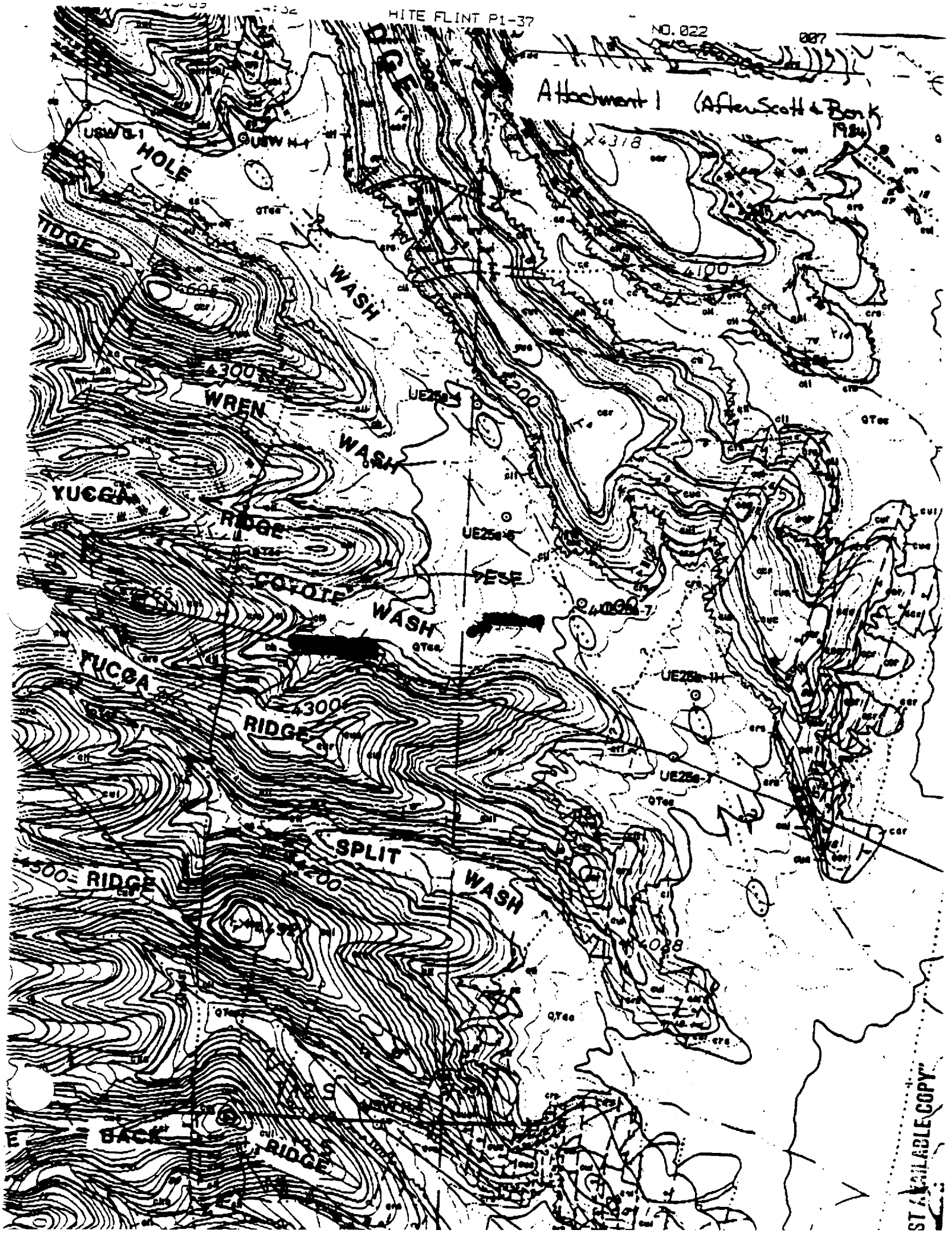
Smith, C. and Ross, H.P., 1982, Interpretation of resistivity and induced polarization profiles with severe topographic effects, Yucca Mountain area, Nevada Test Site, Nevada: U.S. Geological Survey Open-File Report 82-182, 21 p.

Spengler, R.W., and Rosenbaum, J.G., 1980, Preliminary interpretations of geologic results obtained from boreholes UE25a-4, -5, -6, and -7, Yucca Mountain, Nevada Test Site: U.S. Geological Survey Open-File Report 80-929, 33 p.

Spengler, R.W., and Chornack, M.P., 1984, Stratigraphic and structural characteristics of volcanic rocks in core hole USW G-4, Yucca Mountain, Nye County, Nevada: U.S. Geological Survey Open-File Report 84-789, 77 p.

CC: C.Abrams
J.Trapp
A.Ibrahim
K.Stablein
D.Gupta

Attachment 1 (After Scott & Bonk 1984)



BEST AVAILABLE COPY

United States Department of the Interior

GEOLOGICAL SURVEY
BOX 25046 M.S. 964
DENVER FEDERAL CENTER
DENVER, COLORADO 80225

TAKE PRIDE IN AMERICA

IN REPLY REFER TO: Mail Stop 964

WBS: 1.2.3.2.2.6
QA: 1

August 7, 1989

Richard C. Lee
SAIC, Suite 3407
101 Convention Center Dr.
Las Vegas, Nevada 89109

Re: Judgement as to validity and limitations of GW1 Code for 3-D DC Resistivity Studies

Dear Mr. Lee:

In response to your request of 10 July, 1989, I offer the following opinion regarding the use of the GW1 computer code for modeling the effects of off-axis topography and resistivity contrasts on dipole-dipole DC resistivity data in the vicinity of Coyote Wash.

The computer code is generally valid for the purposes stated in your letter based on the following considerations:

Code GW1 was developed for ground-water flow models. The theoretical foundation of this code is also applicable to DC resistivity models because the fundamental equations have the same form (LaPlace or Poisson equation).

The numerical foundation of code GW1, the finite element method, is also applicable and has been well established in the professional literature for DC and AC resistivity problems.

Limitations in application of the code are related to the implimentation of mesh design, use of symmetry conditions, and establishment of boundary conditions. Under proper useage the computer code should not be limited in any fundamental way. However, I point out possible limitations related to symmetry conditions inasmuch as such conditions are often invoked for practical reasons. For first-order evaluation of the significance of off-axis topography and resistivity contrasts, the use of symmetry conditions should provide no major limitation. However, more detailed modeling may require the following considerations:

1. If bilateral symmetry is used to simplify model geometry, then topographic or buried resistivity contrasts will not be fully 3-D. The 3-D representation may be further degraded if symmetry conditions require that current sources be along the plane of bilateral symmetry. The lack of full 3-dimensionality will require careful model planning to minimize over- or under-estimations of off-axis effects.

2. Inasmuch as the observed resistivity lines of Coyote Wash are located on the edges of the Wash, an approximation of bilaterally symmetric models along the lines may serve primarily to set extreme limits on possible off-axis effects of topography on this data.

Sincerely,

Douglas P. Klein
Geophysicist

cc: E. L. Hardin

Appendix G

TAR Comment Forms

8/24/89

Memo to file on QMP 02-08 Reviewer's Comments

Because a portion of the scope outline in the TAR Notice and Plan required recommendations beyond the scope of recommendations of existing documents, there are numerous QMP 02-08 comments that have either no Document Identification number or description, or are identified with N/A (not applicable). These QMP 02-08 comments are therefore recommendations for future Project consideration, and are not comments on specific documents contained in the TAR Data Package.

Michael W. Parsons

Michael W. Parsons

TAR Secretary

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD

N-QA-006
11/88

Sheet 1 of 2

Technical Assessment Review Subject Geologic & Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed ES

Reviewer Richard C. Lee Organization SAIC Date 8/24/89

Comments Resolved By _____ Organization _____ Date _____

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
1.	N/A	Improvements in management and integration of Project technical data appear to be in order at both the Project participant and at the YMP level. It was evident that engineers and managers outside of the USGS did not have ready access to compilations of all relevant technical data and interpretations for the ES area studies: studies that included site characterization planing and ES relocation studies. Relevant technical data in this case would include mapped and interpreted faults and fault segments, mapped fractures and breccia zones, geophysical survey line locations, stratigraphic fence diagrams based on surface and subsurface stratigraphic data. In addition, the future volume of applicable geotechnical data, as a result of future site characterization, suggests that these integration and management problems of geotechnical data will be compounded. Although there are a variety of useful technical data bases available to the Project, none can provide the Project with efficient, reliable, and hands-on data review capability as can a graphical information system. We recommend that the Project develop a data base that is suitable for an industry standard Graphical Information System. It is also recommended that all geotechnical data (this includes rock mechanics, geology, geophysics, hydrology, and geochemistry), related or proposed geotechnical					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD
CONTINUATION SHEET

N-QA-006
11/88

Sheet 2 of 2

Technical Assessment Review Subject Geologic & Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed ES

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
1. cont.		surveys, and geotechnical interpretations, that lend themselves to a graphical presentation, relevant to regional and local studies, be developed prior to site characterization planning. Such a system would enable project managers, site characterization program reviewers, document reviewers, and others to have the capability of interactively viewing arbitrary data "layers" at desired scales and projections. This system would efficiently portray the state of knowledge for any desired area and for a specific subset of geotechnical data or interpretations.					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD

N-QA-006
11/88

Sheet 1 of 7

Technical Assessment Review Subject: Geologic and geophysical evidence pertaining to structual geology of ESF location

Reviewer: T. A. Grant, for Geology Subcommittee — Organization: SAIC T&MSS — Date: 8/16/89

Comments Resolved By: _____ Organization: _____ Date: _____

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
1	Bertram, 1984	In general, the methodology used by the Ad Hoc TOC Committee (Bertram, 1984) to select exploratory shaft sites is reasonable and defensible. Minor shortcomings in the report involve: (1) the lack of a clear distinction in the report between shaft site selection methodology (criteria in the report) and shaft site suitability criteria and; (2) absence of a clear listing of the sources of data that was or was not considered in applying the methodology. Bertram (1984) states the site selection method related to potentially adverse structures as distances from those structures. In actual application, Bertram (1984) used a preliminary version of the faults mapped by Scott and Bonk (1984) as the basis for determining excluded or less preferred areas. It would have been clearer if the report had defined the term "potentially adverse structures" in terms of the physical ground conditions that were the true basis of concern, since it was probably not the intent of the committee to create a situation where any fault or structure of any size would automatically disqualify the site if one were found in the future. The report should then have documented the rationale for selecting the preliminary map of Scott and Bonk (1984) as the source for the location of					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD
CONTINUATION SHEET

N-QA-006
11/88

Sheet 2 of 7

Technical Assessment Review Subject Geologic and geophysical evidence pertaining to structual geology of ESF location

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
1 cont.		potentially adverse structures and discussed why other sources were or were not used.					
2		As part of this review, the TAR team members attempted to identify the location of mapped faults and inferred faults from geophysical sources for a relatively small area in the controlled area. The team found that this type of information is not easily compiled for use by the project office or participants. Currently such data are scattered among a large number of published and unpublished reports that in some instances may be produced by different participants. With the large number of people working on the project and the planned volume of site characterization work, it appears probable that it will become increasingly difficult for individuals or task groups to successfully locate all of the data potentially pertinent to a specific analysis. It is recommended that the project review its system of graphical data management and retrieval (ie. computer graphics system) to evaluate whether it is comprehensive and timely enough for routine use by the project staff. One example of the use of such systems is provided by the fault inferred to exist in Coyote Wash by Smith and Ross (1982). When low resolution techniques are interpreted to indicate the presence of possible structures, the potential existence of such a structure needs to be					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD
CONTINUATION SHEET

N-QA-006
11/88

Sheet 3 of 7

Technical Assessment Review Subject Geologic and geophysical evidence pertaining to structural geology of ESF location

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
2 cont.		highlighted in the system to indicate the need for more detailed follow up studies to determine the nature of such anomalies.					
3		The file record does not appear to be complete with regard to the process of relocating the exploratory shafts. The TAR team could find no record of the review and concurrence on the new site by the national laboratories required by the project office or of the geological investigation planned by F&S. Geological factors were apparently not considered during the relocation because the ES-1 location was kept in the area identified during the previous screening by Bertram (1984). However, the new ES-2 location was placed outside the area identified by Bertram (1984). The U. S. Nuclear Regulatory Commission was aware of this fact, and documented their approval in a letter from J. Linehan to M. Kunich, dated August 19, 1987. While such a move is acceptable given the new factors (flooding & erosion) being considered in 1986, it would seem reasonable to have evaluated the new site with respect to the presence of potentially adverse structures that could affect shaft construction, worker safety, and repository performance. Such concerns would appear to be equally applicable to both shafts. The TAR team recommends that current procedures for the creation of file packages documenting such project decisions be reviewed to					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD
CONTINUATION SHEET

N-QA-006
11/88

Sheet 4 of 7

Technical Assessment Review Subject Geologic and geophysical evidence pertaining to structural geology of ESF location

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
3 cont.		determine if the procedures have adequate requirements for the creation of file packages and that reviews of such packages exist to assure that the packages are complete and the disposition of all required or planned actions has been documented.					
4	Lipman & Mckay, 1965; Scott & Bonk, 1984 and in Dixon, 1982; Barton and others, 1989	The geology subcommittee agreed with the geologic mapping of the Coyote Wash area as presented in Lipman and McKay (1965), Scott and Bonk (1984 and in Dixon, 1982), and Barton and others (1989). The geology subcommittee found the methods used in preparing the maps to be reasonable for the scales used in the compilation of these maps. The geologic interpretation and map accuracy also were found to be reasonable and acceptable for the mapping scale used.					
5	Smith & Ross, 1982	The geology subcommittee found no evidence that would indicate the presence of a fault in the area between the two exploratory shafts, as postulated by Smith and Ross (1982). The review of the aerial photography revealed no lineaments or other evidence of faulting in this area. The lithologic logs from boreholes in the area show no evidence of lithologic contacts occurring at anomalous elevations, or missing or added section that might indicate a concealed fault below the Tiva Canyon Member. The					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD
CONTINUATION SHEET

N-QA-006
11/88

Sheet 5 of 7

Technical Assessment Review Subject Geologic and geophysical evidence pertaining to structrual geology of ESF location

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
5 cont.		field review of the contacts between the lower lithophysal, rounded step, and upper lithophysal zones of the Tiva Canyon Member confirmed that these contacts cross the area immediately upslope from shaft locations without any recognizable offset. No evidence of breccia or gouge zones was detected that might affect shaft construction. The nature of the contacts and the exposures in the area between the exploratory shafts indicates that the methods employed by Scott and Bonk (1984) and the review geology subcommittee would have detected faults with displacements greater than 2 to 3 m. However, minor faults with small displacement are known to exist at other localities where conditions favor their detection (Scott and Bonk, 1984 and in Dixon, 1982). The presence of such minor faults, with offsets less than the detection limits allowed by the nature of contacts and local exposures, should be considered as possible at other localities, such as Coyote Wash. Because faulting in the area is not always accompanied by prominent secondary features, it is possible that a fault with a displacement that is less than 2 to 3 m could exist, undetected, in this area. It is also possible that faulting could exist in this area as a zone of distributed displacement along numerous small faults. However, the total offset across such a zone of distributed displacement would					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD
CONTINUATION SHEET

N-QA-006
11/88

Sheet 6 of 7

Technical Assessment Review Subject Geologic and geophsical evidence pertaining to structural geology of ESF location

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
5 cont.		have to be small because an apparent increase in the dip of the contact is not evident in this area. A third possibility is that a fault is present at depth that predates, and is buried by, the Tiva Canyon Member.					
6	Smith & Ross, 1982	The geology subcommittee recommends that, to increase confidence with respect to conditions that may be encountered during shaft excavation, the contact between the lower lithophysal and rounded step zones be cleared of talus in the area between the shafts and the resulting continuous exposure be mapped in detail. It is recommended that a strip about 4 to 5 m wide and 160 m long be cleared along the cll-crs contact in the area of the exploratory shafts. The clearing could be accomplished by a crew using compressed air or water and pry bars. The cleaned exposure should then be photographed and mapped in detail at a suitable scale (1:20 to 1:50) to show the nature of the contact and any structural features that might offset it.					
7	Smith & Ross, 1982	A second step recommended by the geology subcommittee is to map the extensive exposures that will be created by exploratory-shaft pad excavation. The Title I design indicates that the cuts					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD
CONTINUATION SHEET

N-QA-006
11/88

Sheet 7 of 7

Technical Assessment Review Subject Geologic and geophysical evidence pertaining to structural geology of ESF location

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
7 cont.		for the pad parallel to the wash would create bedrock exposures up to 20 m high across the area where the fault postulated by Smith and Ross (1982) is located. It is recommended that the pad excavation site be cleared of talus prior to blasting operations. The site should then be examined for faults, breccias, and fracture systems prior to the development of blast-induced effects. After excavation, the exposures should be cleaned and inspected before other exploratory shaft work begins. If the results of the inspection are favorable, the results of the inspection should be documented as shaft construction proceeds by photographing and mapping the exposures in detail at a suitable scale (1:20 to 1:50) to describe the nature of any faults, fractures, joints, and breccia zones that might be present. It is also recommended that the northern limit of the pad excavation be moved slightly to the north so that the contact between the lower lithophysal and rounded step zones is exposed in the cut. The pad excavation in the vicinity of the ES-1 shaft should also be designed to expose the fractures and breccia zone shown on the Scott and Bonk (1984 and in Dixon, 1982) maps near this location.					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD

N-QA-006
11/88

Sheet 1 of 1

Technical Assessment Review Subject: Geologic and Geophysical evidence pertaining to structural geology of ESF location

Reviewer: J. Marshall Davenport III, Geologist — Organization: SAIC/T&MSS — Date: 8/29/89

Comments Resolved By: _____ Organization: _____ Date: _____

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
1	Chapter 2 and 3	"My comments are included in subcommittee leader Terry Grant's comments. The subcommittee leader also has resolution acceptance/rejection authority."					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD

N-QA-006
11/88

Sheet 1 of 1

Technical Assessment Review Subject Geologic and geophysical evidence pertaining to structural geology of ESF location

Reviewer G. L. Shideler Organization USGS Date 8/25/89

Comments Resolved By _____ Organization _____ Date _____

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
		My comments are included in subcommittee leader Terry Grant's comments. The subcommittee leader also has resolution acceptance/rejection authority.					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD

N-QA-006
1-/88

Sheet 1 of 1

Technical Assessment Review Subject: Geologic and geophysical evidence pertaining to structural geology of ESF location

Reviewer: David F. Fenster *David F. Fenster* Organization: Roy F. Weston, Inc. Date: 8/28/89

Comments Resolved By: _____ Organization: _____ Date: _____

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
		My comments are included in subcommittee leader Terry Grant's comments. The subcommittee leader also has resolution acceptance/rejection authority.					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD

N-~~[illegible]~~006
11/88

Sheet 1 of 1

Technical Assessment Review Subject: Geologic and geophysical evidence pertaining to structural geology of ESF location

Reviewer: Richard P. Snyder Organization: U.S. Geol. Survey Date: 8/28/89

Comments Resolved By: _____ Organization: _____ Date: _____

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
		My comments are included in subcommittee leader Terry Grant's comments. the subcommittee leader also has resolution acceptance/rejection authority.					

AUG-25-'89 08:27 ID:SAIC LAS VEGAS # 1 TEL NO:702-794-7009 #794 P26

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD

N-QA-006
11/88

Technical Assessment Review Subject: Geologic and Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed ES

Sheet 1 of 1

Reviewer: M.W. Parsons Organization: SAIC / TRMSS Date: 1/8/90

Comments Resolved By: _____ Organization: _____ Date: _____

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
		My comments are included in subcommittee leader Terry Grant's comments. The subcommittee leader also has resolution acceptance/rejection authority. M.W. Parsons 1/8/90					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD

N-QA-006
11/88

Sheet 1 of 10

Technical Assessment Review Subject _____

Reviewer Ernest Hardin Organization _____ Date _____

Comments Resolved By _____ Organization _____ Date _____

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
1	N/A	1. The geoelectric models of Smith et al. (1982) for Lines A and B exhibit several general aspects which are geologically plausible. The models indicate the existence of low-resistivity, somewhat continuous feature or body, the top of which is buried at roughly 100 ft (see Section 4.3). The association by these authors of low resistivity with mineral alteration is plausible as discussed in Section 4.6.3. The statement that lower resistivity in units below the Tiva Canyon Member occurs beneath washes, than beneath ridges, is plausible as discussed in Section 4.6, although better supported for comparison of conditions associated with major topographic features. (Re: Section 4.6.4)					
2	N/A	2. The fault hypothesis (i.e. fault or fracture zone) would be a plausible geologic interpretation for sharp resistivity contrast in the east-west direction near the mouth of Coyote Wash. Vertically offset stratigraphy is probably not required for geophysical detection of faults, for rock types and conditions					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD
CONTINUATION SHEET

N-QA-006
11/88

Sheet 2 of 10

Technical Assessment Review Subject _____

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
		representative of Yucca Mountain. The manner and location of tuff alteration could be controlled by a fault or fracture zone. Also, although not stated by Smith et al., it is conceivable that a buried fault exists that is not evident from surface mapping. (Re: Section 4.6.4)					
3.	N/A	3. The algorithm and approach used by Smith et al. (1982) for geoelectric modeling may be regarded as standard for the industry, particularly in 1979. However, a number of aspects of their implementation of this approach to Coyote Wash give cause for concern: a) 3-D effects (topography, geoelectric structure) are essentially neglected; b) mapped alluvium-bedrock contacts are not incorporated as model constraints; c) criteria for model "fit" were not established; d) the results from sensitivity tests were not convincingly documented; and					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD
CONTINUATION SHEET

N-QA-006
11/88

Sheet 3 of 10

Technical Assessment Review Subject

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
		e) the range of acceptable geoelectric models was not considered. It is probable that these aspects gave rise to overly complex models, and produced significant uncertainty in the model results and interpretation, that could be eliminated through application of a more systematic approach. (Re: Section 4.3.5)					
4.	N/A	4. Apparent lateral resistivity contrasts of the type modeled by Smith et al. (1982) and retained in sensitivity tests performed for this TAR, could be associated with causes other than faulting. The following alternatives are identified: a) The topographic surface and the configuration of alluvium in Coyote Wash are such that runoff from upper portions of the wash probably slows when it reaches the lower part, where infiltration and associated mineral alteration could be concentrated. b) Lateral variation in composition or fabric of the PTn unit, or possibly the Tiva					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD
CONTINUATION SHEET

N-QA-006
11/88

Sheet 4 of 10

Technical Assessment Review Subject

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
		Canyon or upper Topopah Spring Members (unit designations from Ortiz et al., 1985) as a result of syndepositional factors or processes. Such variation might cause an electrical contrast directly, or produce groundwater accumulation and associated effects. c) Locally increased percolation and associated alteration could result from changes in fracture density, or from a fracture zone not directly associated with a fault. Such a zone need not strike N-S at the mouth of Coyote Wash, but could trend E-W beneath the wash. d) Resistivity contrast that is a remnant of previous (perhaps Miocene) hydrothermal alteration. e) The apparent lateral contrast in the buried conductor is not significant, or does not exist. The present uncertainty could be related to the insufficiency					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD
CONTINUATION SHEET

N-QA-006
11/88

Sheet 5 of 10

Technical Assessment Review Subject _____

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
		of the modeling approach to account for surface conductors and terrain effects. The abundance of clay alteration observed in borehole USW G-4 could be associated with lateral facies changes on a scale much larger than Coyote Wash. This is a reasonably complete list of plausible alternatives, reduced by the TAR team from a larger, redundant list. (Re: Section 4.6.4)					
5.	N/A	5. Based on the analysis provided in Chapter 4 of the TAR (particularly Section 4.3) and the availability of new data since the original work of Smith et al. (1982), it is recommended that electrical resistivity data from Coyote Wash by remodeled and reinterpreted. This effort should also consider resistivity data from nearby areas which may be applicable to the evaluation of possible structure in Coyote Wash. The systematic approach to modeling presented in Section 4.3.4 of the RRM is also recommended. (Re: Section 4.3.4)					
6.	N/A	6. Sensitivity tests for the TAR were					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD
CONTINUATION SHEET

N-QA-006
11/88

Sheet 6 of 10

Technical Assessment Review Subject

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
		inconclusive in that no models were found for Line A or B that are unequivocally simpler than those of Smith et al. (1982). Test results indicate that simpler models "fit" the data in a way that is roughly comparable, but because "fit" is difficult to define, it is not possible to assert that these models meet or exceed the "fit" achieved by Smith et al. The simplest models used in these sensitivity tests did not incorporate a resistivity structure that would be interpreted as a fault or fault zone. (Re: Section 4.3.5)					
7.	N/A	7. Sensitivity tests for the TAR show that (combined 2-D and) 3-D topography has an effect of roughly 40% on the observed apparent resistivity. This is a significant effect, comparable to about twice the effect of generalized 2-D topography computed by Smith et al. (1982) for Lines A and B in Coyote Wash. If the effect is not accounted for in 2-D modeling, then "fit" may be achieved via the use of unrealistic model features. (Re: Section 4.5.3)					
8.	N/A	8. Sensitivity tests reported in the literature, and performed for the TAR, show that conductors outcropping beneath the survey line have a					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD
CONTINUATION SHEET

N-QA-006
11/88

Sheet 7 of 10

Technical Assessment Review Subject _____

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
		significant effect on dipole-dipole response. 3-D sensitivity tests show that finite strike-length reduces the magnitude of the response to roughly half that of the computed 2-D effect; nevertheless, shallow outcropping conductors should not be neglected. (Re: Section 4.5.3)					
9.	N/A	9. The geologic interpretation of Smith et al. (1982) has limited applicability to assessing the suitability of the proposed ESF location. The geoelectric models and other available data strongly suggest that the clay-alteration observed in USW G-4 will be observed in the exploratory shafts. The fault hypothesis is geologically plausible and cannot be dismissed altogether without further modeling and interpretation, and possibly collection of additional geophysical data. The Smith et al. published geoelectric models are not constrained by currently available information such as alluvium-bedrock contacts, borehole data, and more direct measurements of electrical properties. This is generally because such information was unavailable at the time. If the geophysical models are constrained by such information, sensitivity studies					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD
CONTINUATION SHEET

N-QA-006
11/88

Sheet 8 of 10

Technical Assessment Review Subject

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
		performed for this TAR show that simpler, more geologically reasonable models can result. Thus it would be inappropriate to ascribe too much importance to the Smith et al. interpretation based on these models, without further analysis and possibly collection of additional geophysical (and geologic) data.					
10.	N/A	10. The smallest level of average misfit (defined in Section 4.3) that can be expected for Lines A and B is estimated to be about 15%. None of the geophysical models considered, including those of Smith et al. (1982), fit the data to this level. Rather, the models tend to cluster around a higher misfit level, so that discriminating between important alternatives is barely feasible. The two principal aspects of alternative models that are affected by this uncertainty are: (a) depth extent of the buried, conductive body in lower Coyote Wash; and (b) existence and sharpness of a lateral contrast in resistivity of the buried, conductive body in lower Coyote Wash. The geophysics subcommittee recommendations provide a reasonable way to reduce the uncertainty associated with these aspects.					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD
CONTINUATION SHEET

N-QA-006
11/88

Sheet 9 of 10

Technical Assessment Review Subject

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
11.	N/A	11. Detection and delineation of a fault that occurs at the surface in the Tiva Canyon bedrock can be readily accomplished using geological mapping methods as recommended elsewhere in this report. Detection of a buried fault in pre-Tiva Canyon strata can be approached using surface geophysics, which is appropriate for improving confidence in the use of borings for this purpose. Additional data collection is recommended for this use of geophysics, because of limitations on levels of modeling and interpretive uncertainty that are attainable using the existing data (Re: Section 4.5.3). It is further recommended that geophysical surveys be designed to further investigate the geoelectric structure, rather than for direct detection of a fault or fracture zone. The objectives for such investigation of a possible buried fault should be to determine: a) the existence, sharpness, and location of a significant lateral contrast in resistivity of a buried conductive body in this area; b) the depth extent of such a body, particularly whether it is limited stratigraphically;					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD
CONTINUATION SHEET

N-QA-006
11/88

Sheet 10 of 10

Technical Assessment Review Subject _____

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
		c) the N-S extent of such a body with respect to the surface or near-surface features of Coyote Wash; and d) information on the variability of depth-to-bedrock and alluvium resistivity, needed to reduce modeling uncertainty so that models expressing the possible range of a) through c) above can be compared. The geophysical program described in Section 4.7.2 includes a dipole-dipole survey, slingram survey, shallow seismic refraction, shallow Schlumberger soundings, and detailed interpretation which make use of the approach described in Section 4.3.4. It is recommended that this program be undertaken immediately. Conditions under which the faulting hypothesis would be supported, or not supported by the results of the activities recommended to address these objectives are given in Section 4.7.2.					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD

N-QA-006
11/88

Sheet 11 of 11

Technical Assessment Review Subject: ESF Geophysical Anomaly —

Reviewer: Jeff Kimball Organization: DOE Date: 12/27/89

Comments Resolved By: _____ Organization: _____ Date: _____

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
		My comments are included in subcommittee ~~the~~ leader Ernie Hardin's comments. The subcommittee leader also has resolution acceptance/rejection authority — Jeff Kimball 12/27/89					

DEC-26-'89 10:40 ID:SAIC LAS VEGAS # 2 TEL NO:702-794-7008 #359 P13

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD

N-QA-006
11/88

Sheet ____ of ____

Technical Assessment Review Subject: RRM for the TAR on the resistivity anomaly near the ESF.

Reviewer: Mohammad S. Mozumder Organization: US DOE/OCRWM HQ Date: 12/27/89

Comments Resolved By: ____ Organization: ____ Date: ____

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
		My comments are included in subcommittee leader Ernie Hardin's comments. The subcommittee leader also has resolution acceptance/rejection authority. Mohammad S. Mozumder 12/27/89					

DEC-26-'89 10:40 ID:SAIC LAS VEGAS # 2 TEL NO:702-794-7008 #359 P13

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD

N-QA-006
11/88

Sheet _____ of _____

Technical Assessment Review Subject _____

Reviewer Jonathan D. Istok Organization _____ Date _____

Comments Resolved By _____ Organization _____ Date _____

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
		My comments are included in subcommittee leader Ernie Hardin's comments. The subcommittee leader also has resolution acceptance/rejection authority Jonathan Istok 1/3/90					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD

N-QA-006
11/88

Sheet 1 of 1

Technical Assessment Review Subject

Reviewer David Cummings Organization SAIC Date 8/31

Comments Resolved By Organization Date

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
		My comments are included in subcommittee leader Ernie Hardin's comments. The subcommittee leader also has resolution acceptance/rejection authority.					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD

N-QA-006
11/88

Technical Assessment Review Subject: Geological and geophysical evidence pertaining to structural geology of the exploratory shaft facility

Sheet 1 of 1

Reviewer: Douglas P. Klein

Organization: U.S. Geological Survey

Date: 24 Aug 1989

Comments Resolved By: _____

Organization: _____

Date: _____

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
		My comments are included in subcommittee Ernie Hardin's comments. The subcommittee leader also has acceptance/rejection authority.					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD

N-QA-006
11/88

Sheet 1 of 2

Technical Assessment Review Subject: Geologic and Geophysical Evidence Pertaining to Geology in the Vicinity of the Proposed ES

Reviewer: Thomas E. Hinkebein — Organization: Sandia National Laboratories Division 6314 — Date: 8/23/89

Comments Resolved By: _____ — Organization: _____ — Date: _____

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
1		While the performance implications of a fault zone or zone of increased saturation located near the exploratory shafts are not explicitly considered by Bertram(1984), these effects have been reviewed in this Review Record Memorandum. Based upon studies performed subsequent to the Bertram analysis, our current understanding of the hydrology of Yucca Mountain indicates that only minor quantities of water would migrate through a hypothetical fault and into the shaft. These quantities of water are projected to be less than the drainage and storage capacity of the Exploratory Shaft Facility so that no repository performance impacts would be expected. Under normal conditions, unsaturated zone hydrology is expected to apply to the subsurface tuffs located above the water table at Yucca Mountain. For the unsaturated conditions expected at Yucca Mountain, faults and fractures are expected to be barriers to fluid flow and not conduits. Two general conditions were considered by which local saturation might allow flow into the shafts: (1) water concentration by infiltration pulses and (2) water concentration by lateral diversion.					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD
CONTINUATION SHEET

N-QA-006
11/88

Sheet 2 of 2

Technical Assessment Review Subject Geologic and Geophysical Evidence Pertaining to Geology in the Vicinity of the Proposed ES

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
1		Significant water inflow into the exploratory shafts would not be expected by either of these local saturation mechanisms as judged from performance calculations done by several authors. Further, enhanced gaseous movement caused by a potential fault intersecting the shaft is not considered to be a concern because the shaft backfill air conductivity is primarily responsible for retarding migration of gasses. In order to cause reduced performance for the repository, this conductivity would have to be increased over a significant portion of the shaft length to increase gaseous releases. This is not expected to occur as a result of possible faulting. Since this understanding is based upon non-validated models and limited data, it is important that site characterization hydrologic studies be conducted as planned.					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD

N-QA-006
11/88

Sheet 1 of 3

Technical Assessment Review Subject: Geologic and Geophysical Evidence Pertaining to Geology in the Vicinity of the Proposed ES

Reviewer: Maurice Grieves Organization: PBQ&D, Mining Department Date: 8/25/89

Comments Resolved By: _____ Organization: _____ Date: _____

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
1		"A potentially adverse structure" (Bertram, 1984) as it applies to shaft sinking is defined as a single, steep, moderate fault (see the RRM for a description of fault classes). If such a fault were revealed before shaft sinking, it would be reason to choose a new site for the ES shafts. However, if such a fault were to remain undetected, only discovered during sinking, then the difficult conditions encountered would need to be weighed against the additional man-hours of exposure, and the delays in siting the shafts in a new location and starting sinking all over again. Minor faults will cause little or no appreciable disruption to sinking activities. Moderate faults require additional temporary support measures, will increase cost and cause some schedule delay.					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD

N-QA-006
11/88

Sheet 2 of 3

Technical Assessment Review Subject Geologic and Geophysical Evidence Pertaining to Geology in the Vicinity of the Proposed ES

Reviewer Maurice Grieves Organization PBQ&D, Mining Department Date 8/25/89

Comments Resolved By _____ Organization _____ Date _____

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
2		Ground conditions should be known reliably before sinking commences, and the shaft center boreholes are recommended to eliminate uncertainty in this respect. These boreholes provide confirmation on the sinking method to be adopted, the equipment to be used, concreting lengths, temporary ground support system, and station elevation. The drilling and logging of the center-line ES boleholes is recommended. The analysis of data obtained is aimed at understanding the material properties for mining purposes, and providing additional stratigraphic control prior to ES pad construction. For the highest confidence that any fault would be discovered, these center-line holes should be drilled to total exploratory shaft depth. We recognize that center-line boreholes may effect other studies planned for the MPBHs and pilot holes and that some of these studies may be alternately performed in the center-line holes.					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD

N-QA-006
11/88

Sheet 3 of 3

Technical Assessment Review Subject Geologic and Geophysical Evidence Pertaining to Geology in the Vicinity of the Proposed ES

Reviewer Maurice Grieves Organization PBQ&D, Mining Department Date 8/25/89

Comments Resolved By _____ Organization _____ Date _____

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
3		A near vertical minor or even moderate fault could perhaps remain undetected until encountered by probe holes also recommended during sinking. These probe holes should be kept at least 20 feet below the shaft floor. Such a fault could cause additional cost to be incurred, and could result in schedule delays, resulting from changes to the excavation method, increasing the amount of temporary support and the need to keep the concrete lining closer to the shaft floor. Worker safety is of paramount importance, and the measures described in the RRM reduce to a minimum worker exposure to potentially hazardous situations and protect against the consequences of uncontrolled incidents.					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD

N-QA-006
11/88

Sheet 1 of 2

Technical Assessment Review Subject: Structural Geology of the ESF Location

Reviewer: Forrest D. Peters 8/31/89 Organization: SAIC Date: 8/31/89

Comments Resolved By: _____ Organization: _____ Date: _____

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
1	RRM	I am in general agreement with the conclusions in the Review Record Memoranda, and the recommendations for additional work to be performed. However, preference should be given to direct or "hard" evidence for or against faulting, such as geologic mapping core holes, and geophysical logging of those holes; as opposed to indirect or "soft" evidence such as extended media, or potential-field/extended-media types of geophysical surveys. The extended media types of geophysical surveys, such as seismic refraction, Schlumberger electrical soundings, dipole-dipole electrical surveys, abd Slingram surveys, will not provide definitive evidence for or against faulting, by themselves alone; and must be backed up by "hard" or direct evidence, in all cases. For these reasons, the proposed additional work should have the following overall priorities or overall order of importance:					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD
CONTINUATION SHEET

N-QA-006
11/88

Sheet 2 of 2

Technical Assessment Review Subject Structural Geology of the ESF Location

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
		1. The immediate clearing and mapping of the Tiva Canyon units exposed along the south slope of Dead Yucca Ridge. This phase should be conducted prior to the ESF pad construction, but could occur prior to or during the exploratory drilling program. 2.The drilling and logging of the centerline ES coreholes. 3. The proposed geophysical work could be done at any time, but precedence should be given to the work identified in 1. and 2. above,if any conflicts in performing the work arise. 4. The detailed geologic mapping of the exposure created by the ES pad construction. This can be conducted during pad excavation, and should not delay pad construction.					

TECHNICAL ASSESSMENT REVIEW COMMENT RECORD

N-QA-006
11/88

Sheet 1 of 1

Technical Assessment Review Subject: Geologic and Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed ES.

Reviewer: David C. Dobson Organization: YMPO Date: 1/4/90

Comments Resolved By: _____ Organization: _____ Date: _____

REVIEWER'S COMMENTS			RESOLUTION			REVIEWER'S DISPOSITION	
Item Number	Document Identification	Comments	Accept	Reject	Reason	Accept	Reject
1		No Comments: The document is well written and appears to be comprehensive David C Dobson					

Appendix H

List of Reviewers by Name, Organization, and Discipline

Membership on the Technical Assessment Review Team Concerning

Geological and Geophysical Evidence Pertaining to

Structural Geology of the Proposed Exploratory Shaft Location

YMPO Branch Chief responsible for TAR: David Dobson
TAR Chairperson: Richard Lee — SAIC FTS 544-7134
TAR Secretary: Michael W. Parsons — SAIC FTS 544-7857

Team Members:	Team/discipline	
Dave Dobson	Geology	YMPO FTS 544-7940
Mohammad Mozumder	Geophysics	DOEHQ FTS 896-5330
Jeff Kimball	Geophysics & Geology	DOEHQ FTS 896-1063
Ernie Hardin	Geophysics (Team Leader)	SAIC FTS 544-7617
Terry Grant	Geology (Team Leader)	SAIC FTS 544-7647
Forrest Peters	Geophysics (QA Specialist)	SAIC FTS 544-7753
David Cummings	Geophysics & Geology	SAIC FTS 544-7835
Marshall Davenport	Geology (also TAR secretary)	SAIC FTS 544-7661
Gerald L. Shideler	Geology	USGS FTS 776-1273
Douglas P. Klein	Geophysics	USGS FTS 776-1313
Richard Snyder	Geology	USGS FTS 776-1263
Dave Fenster	Geology	Weston 202-646-6647
Thomas E. Hinkebein	Engineering	SNL FTS 846-0580
Jonathan D. Istok	Engineering	Consultant 503-737-2041
Maurice Grieves	Engineering	Parsons, Brinckerhoff, Quade and Douglas (415) 243-4634

Appendix I

Supporting Documentation for the TAR

I.1 Computer Code Verification and Validation

SAIC
Science Applications International Corporation

M89-TAD-ELH-25
WBS 1.2.5.2
QA: I

INTEROFFICE MEMO

DATE: July 11, 1989

TO: File

FROM: Ernest L. Hardin and
Harry Leake

SUBJECT: Test plan for code verification and validation activities (per QP 3.2), in support of the Technical Assessment Review: Geologic and Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed Exploratory Shaft.

Introduction

Guidance has been received from the TAR team QA Specialist as to quality assurance for computer codes used in the Technical Assessment Review (TAR). Consistent with this guidance, and with discussions held in meetings of the geophysics team, it is not necessary to perform exhaustive verification and validation. However, this requires that computer codes be used for sensitivity studies only and not for data interpretation. Sensitivity studies will be used to determine whether the resistivity data interpretation published in the Smith and Ross (1982) report is the most supportable in view of all currently available information.

Notwithstanding conditions on the use of modeling results, any codes used must be properly documented and controlled. Moreover, the TAR team QA Specialist has indicated that code users must document the process used to verify that the code is performing its intended function. Also, he has identified specific requirements on input and output files, code version control, and logging of computer runs. We believe that it is possible to conform to this guidance, and still comply with T&MSS procedure QP 3.2 (Use and Control of Computer Programs). In accordance with that procedure, this test plan was prepared jointly by us, and consists of a description of verification and validation activities to be undertaken. An account of the results obtained from those activities will be prepared later, as an addendum to the plan.

Background

The GW1 code was provided by its author, Dr. Jack Istok of Oregon State University, who is a TAR team member. He provided a flexible disk containing the FORTRAN source files, and a draft of a textbook he has written which documents the GW1 code (and other codes also). According to Jack, and in my experience thus far with the code, the files he provided match the source codes printed in the draft textbook.

Several changes to the textbook code were necessary as described below:

1) (5-31-89 by J. Istok & E. Hardin) Changed the use of parameter MAX4 in subroutine MATERL, to MAX2. This was a bug that apparently affected program function only when models were large relative to the arrays declared. Also changed the parameter list and COMMON declarations in module COMALL.; substituting MAX2 for MAX4, and changed one of leading comments in COMALL.; indicating that MAX4 is now not used. Also made minor changes to the formatting of printouts.

2) (6-1-89 by E. Hardin) Changed the way that input data is read into subroutines NODE, ELEMENT, MATERIAL, and BOUND from the "INF" file. A negative value in the first field of the last input line of the block of input file data for each of these subroutines is supposed to terminate input in these operations, but was giving rise to negative array indexing. The fix was to buffer input, and not copy it to the sensitive arrays until a test had been done to determine if each line is a termination sequence (for which -1 values are used). Also changed the test for a termination sequence from .eq.-1 to .le.0 for these operations. The correct procedure for entering a terminating line in the above input operations is to use the same number of fields as the previous input line, and negate at least the first field. The first field must never be zero.

3) (6-19-89 E. Hardin and J. Istok) Added option 8 (icode=8) to subroutine DUMP, allowing potential values for specified nodes to be dumped rather than all such values. Increased MAX1, MAX2, and MAX8 limits in COMALL.; to their present values (20000, 15000, and 2250000 respectively) which required resetting page quotas for the resident VMS account, in order to link program GW1.

4) (6-26-89 by E. Hardin) Added write statements to modules GW1.FOR and DUMP.FOR, printing a code revision number in each output file or dump file.

Both the original and the modified source files for the GW1 code, and the executable file used for all modeling activities, are under control within the T&MSS computer system such that they cannot be changed by TAR team members, or without system privileges.

Test Plan - Validation

In accordance with guidance received from the TAR team QA Specialist, modeling efforts for the TAR team will be limited to sensitivity studies (not data interpretation) which contribute to the TAR recommendations. Validation will be limited to that deemed appropriate by the responsible parties under QP 3.2. Accordingly, an expert opinion will be sought from Mr. Douglas Klein, Geophysicist for the U.S. Geological Survey and a TAR team member who is not directly involved with the modeling activities performed by T&MSS personnel, as to the validity of using the GW1 code for specified 3D sensitivity studies. The letter that will be used for this purpose is presented in Appendix A.

Test Plan - Verification

The following are the major concerns to be addressed by verification activities:

a) correct function of the code for 2-D problems,
b) element size near the current electrodes,
c) correct function of 3-D code features,
d) proximity of zero-potential boundaries located transverse to the dipole-dipole line in the 3-D model,
e) proximity of zero-potential boundaries off each end of the line modeled in 3-D, and
f) simulation of the analytical dipole-dipole response of a half-space to specified accuracy.

The items will be addressed in successive phases dedicated to 2-D and 3-D problems as described below.

2-D Problems

Items a) and b) will be addressed by 2-D cases which compare the numerical solution to an analytical solution. The problem will be that of classical conduction in a rectangular plate with zero-potential boundaries and a point source of flux in the center (Figure 1), for which the Fourier solution is presented in Appendix B. The objective will be to try various 2-D finite meshes until certain nodal potentials agree with the analytical solution to within a tolerance level discussed below.

A simple approach will be used to estimate the size of tolerable errors in the calculated results, compared to analytical solutions. The dipole-dipole conduction problem may be thought of as the superposition of two monopole problems, with potential measurements at two field points for each problem. In this sense there are four quantities which contribute to the calculated dipole-dipole response. Error in each of these quantities contributes to error in the dipole-dipole computations. The next paragraph develops a criterion for determining whether deviations between analytical and calculated potential field values are sufficiently small. Element size will then be adjusted until the error criterion is met.

It will be assumed that the errors for these quantities are uncorrelated, random, and identically distributed according to the behavior of that quantity which deviates most from the corresponding analytical monopole solution. (This is generally the field value closest to the source.) In fact the errors are correlated, and the random component is rather small, such that the resulting error in the dipole-dipole computation is smaller than that assumed. The objective will be to reduce variance in the dipole-dipole result to 0.1 of the analytical values. If there are four independent contributing variables, and if the dipole-dipole response is about 0.05 of the monopole field in a particular vicinity, then the variance for a particular field value should be less than 0.00125 of the analytical monopole (Fourier) solution. For reasonably well-behaved deviatory behavior this means calculated monopole field values should be within about 1% of the analytical (Fourier) solution.

The approach described above is not rigorous, and tends to be sensitive to the largest errors (which occur at small distances from the source). However, the largest errors occur where the curvature of the potential field is greatest and fit most approximately by linear finite elements. Thus the approach is appropriate for determining element size to match the field curvature. Note that the approach does not consider the effects of the proximity of zero-potential boundaries, because this type of boundary is explicitly represented in both the finite element model and the Fourier solution. The effects of zero-potential boundaries will be examined through 3-D modeling.

A number of meshes will be tried using realistic values for material conductivity and flux (conductivity in mhos/m, flux in amps, with the necessary units conversion factors) and a model with dimensions of 2,000 feet or more. Realism is needed because these values scale the curvature of the potential field. The objective will be to devise a mesh using linear quadrilateral elements that agrees to better than 1% with analytical monopole (Fourier) field values at nodes spaced on 200-foot intervals from 200 to at least 1,400 feet along the upper boundary (Figure 1). The best model will be that which produces this result with as few elements and nodes as possible, and the largest sized elements near the source. A systematic relationship between successive successful numerical representations of the problem (meshes) and deviation from the analytical solution, as well as agreement with the analytical solution, will be taken as verification of proper function of the GW1 code for 2-D problems.

3-D Problems

The 3-D model will consist of a number of slices, oriented normal to the direction of the dipole-dipole line on the surface (Figure 2). The size of elements near the line, and the spacing between slices, will be based on the largest element size found to be suitable from 2-D problems. For ease of generating the mesh, all slices will be the same and the spacing between slices situated off each end of the line will be increased gradually. Note that present plans call for introducing a vertical plane of symmetry (no-flux boundary) corresponding to the dipole-dipole line, thus halving the size of the 3-D model although reducing flexibility to model complicated terrain.

The first test will compare the nodal potentials at 200-foot intervals in both directions from a monopole source located on the midpoint of the dipole-dipole line (on the symmetry plane), with the analytical solution for the potential field around a monopole source on the surface of a half-space (Keller and Frischknecht, 1965, Eqn. 71). The length dimension of the mesh will be greater than the width and depth, and and the zero-potential boundaries along the sides and bottom of the mesh may produce a recognizable effect. The length and depth dimensions of the mesh will be extended by increasing the size of elements along the boundary, with the objective of bringing the selected nodal potential values along the upper edge of the symmetry plane (Figure 2) to within 1% of the analytical solution for the selected nodes. The basis for application of the 1% criterion is the same for 3-D problems as for 2-D.

The finite length of the model and the zero-potential ends of the mesh may

also have a recognizable effect. The spacing between slices at the distal ends of the model will be adjusted, with the objective of bringing the nodal potentials along the upper edge of the symmetry plane (Figure 2) to within 1% of the analytical solution. In addition, in another case the monopole source will be moved along the dipole-dipole line to 1,400 feet from either end of the area that is intended for occupation by source/receiver nodes. If end effects are important, the slices at the ends will be relocated or increased in number, with the objective of maintaining 1% agreement with the analytical solution. The model will be run with the source near each end of the model, to test whether identical results are obtained.

Finally, a series of input files will be created whereby the dipole-dipole response of a half-space will be simulated with n=1,2,...,6. It is anticipated that only half of the profile (from the midpoint of the model dipole-dipole line to the end) will need to be calculated. If the approach described above for estimating tolerable error for element size determination and boundary effects is sufficient, then the variance of the errors present in the dipole-dipole calculations should be less than 0.1 of the analytical dipole-dipole values.

References

Keller, G.V. and F.C. Frischknecht, 1966, Electrical Methods in Geophysical Prospecting, Pergamon, Pitman Press, Bath, U.K., 519 pp.

EH:sw

Enclosures

cc w/encl:
F. Peters (T-22)
H. Leake (T-10)
E. L. Hardin (T-24)

Figure 1. Schematic of 2-D Fourier conduction problem, showing the position of the source, zero-potential boundaries, and nodes where calculated potential was analyzed.

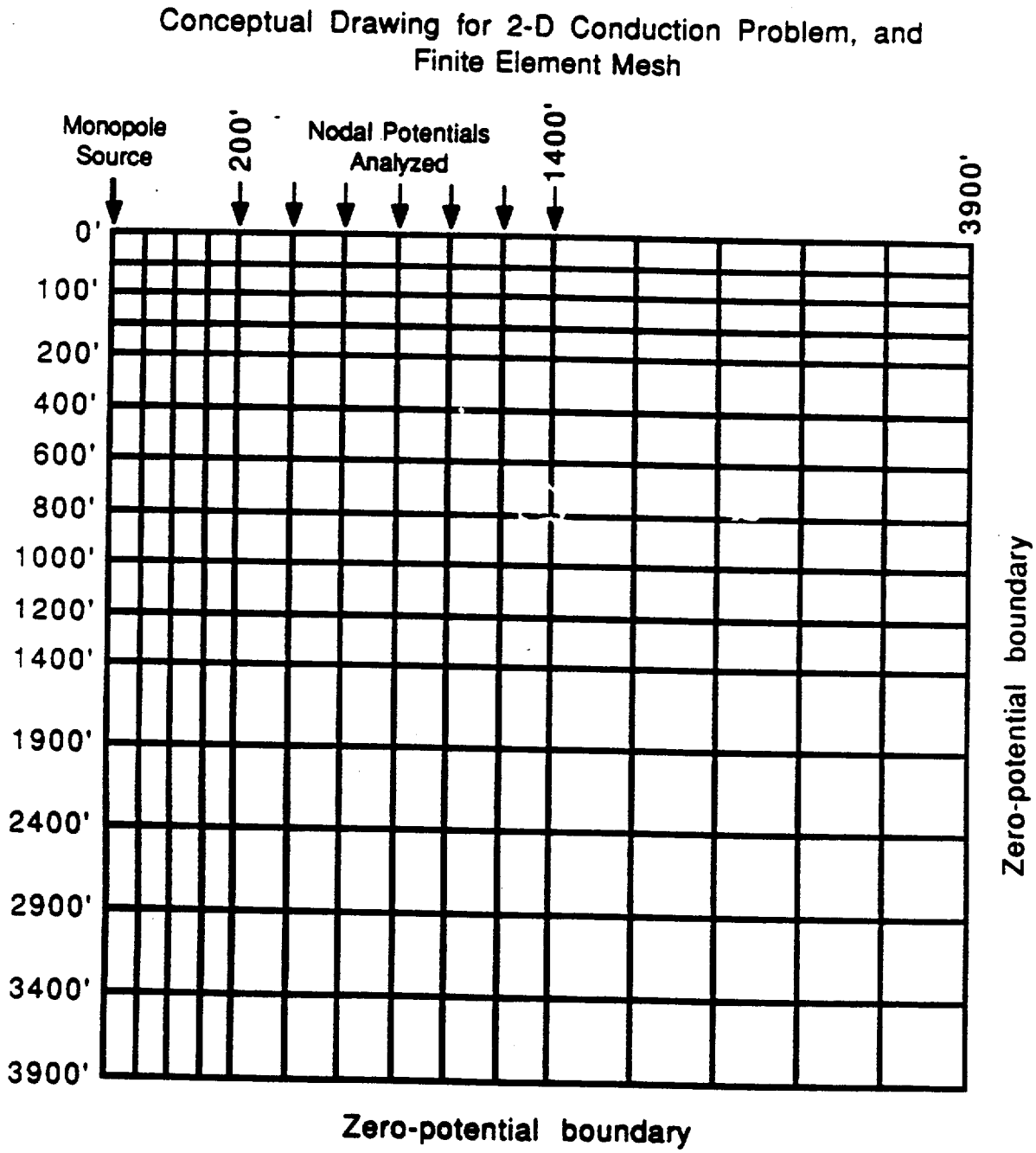
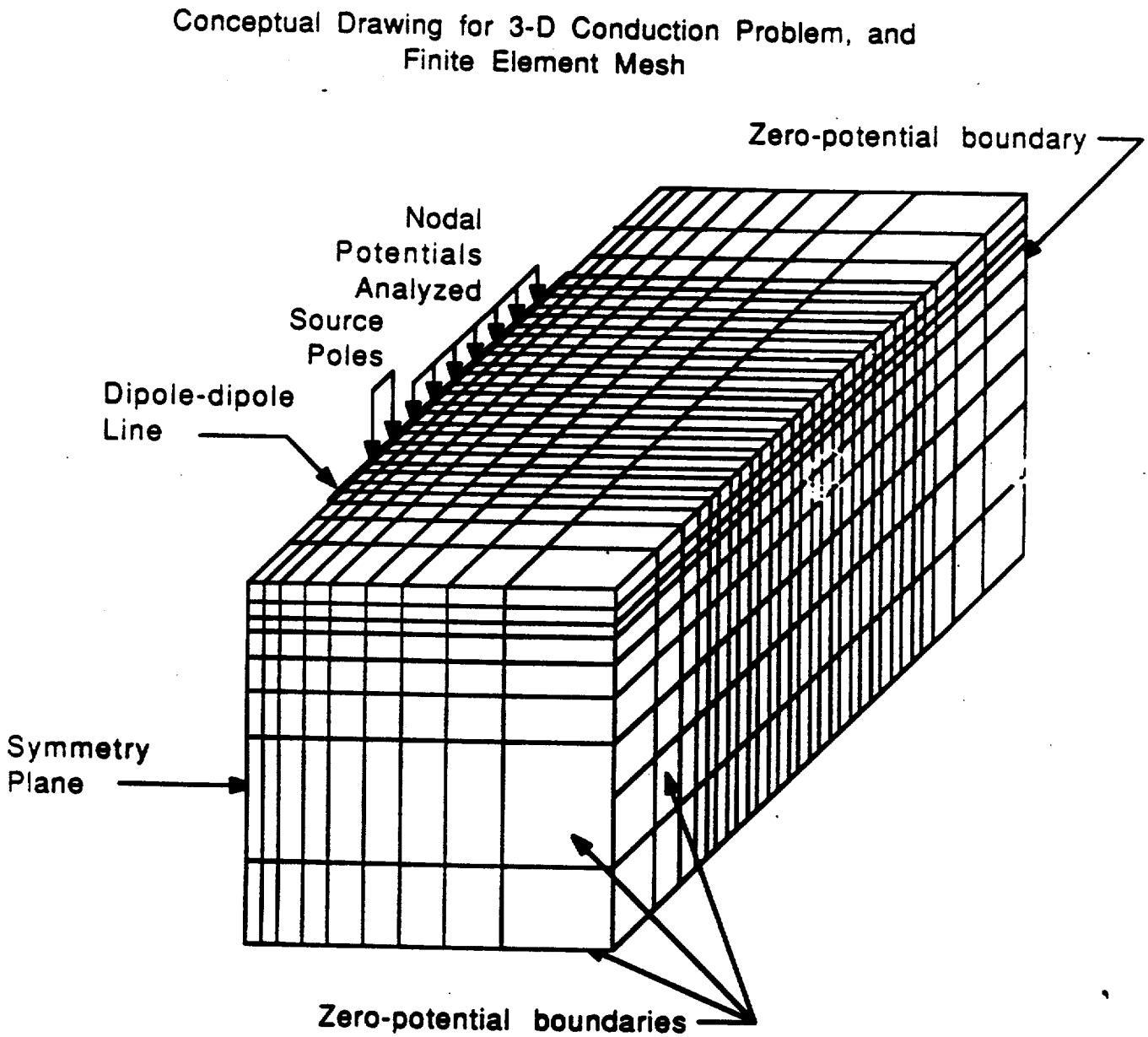


Figure 2. Schematic of 3-D problem, showing symmetry plane, dipole-dipole line, source and receiver electrode locations, and zero potential boundaries.



Appendix A - Letter Requesting Expert Opinion on Model Validity

WBS: 1.2.5.2
QAL 1

Douglas Klein
U.S. Geological Survey
MS 964, Denver Federal Center
Denver, CO 80225

PRELIMINARY DRAFT

Dear Mr. Klein,

This letter is a request for you to provide an expert judgement as to the validity of using a certain computer model for the Technical Assessment Review (TAR) of geophysical data from Yucca Mountain, in which you are involved. The following paragraphs provide background information as to how the model is to be used in the TAR, and why your expert opinion is needed. Also, enclosed you will find a report documenting the theoretical basis for the model and its computer implementation. Based on this information, please provide an opinion to me in writing as to the validity, and any limitations you may feel are important to the stated use of the model.

The TAR geophysics team leader has undertaken a modeling effort that is primarily intended to determine if off-axis terrain effects contribute significantly to the dipole-dipole data set acquired from Coyote Wash. The approach adopted calls for using a 3-D finite element code originally written for saturated, steady-state groundwater flow problems. This is the GM1 code described in the enclosed report. The approach does not address the induced polarization data, which is considered subsidiary to resistivity for interpretion of earth structure. The effect that will be modeled is DC resistivity, which is sufficiently similar to the low frequency (0.1 Hz) apparent resistivity data from Coyote Wash.

In addition to terrain effects the model may be used to evaluate the importance of off-axis resistivity contrasts such as might be associated with alluvium in Coyote Wash, or with moisture influx through the alluvium and into the underlying strata. This application is somewhat uncertain at this time because the need for it depends on results from other studies and technical exchange with other members of the geophysics team, and because it would involve significant effort to set up.

The use of computer codes on the SAIC/T&MSS Project requires compliance with T&MSS procedure QP 3.2 (Use and Control of Computer Programs). The TAR is a QA level 1 activity, so the procedure requires documentation and control of the GM1 code. The procedure requires the user to collaborate with the T&MSS Computer Services Branch (CSB) Manager to produce a plan for verification and validation (V&V) activities. Although the V&V activities will be limited in scope, the CSB Manager has requested expert confirmation of the validity of the model upon which the GM1 code is based, for the purpose described above. Note that you are requested to judge only the model or differential equation, and not the computer implementation. Review or use of the source code is therefore not required.

Your response on or before July 14, 1989 would be greatly appreciated.

Sincerely,

Richard C. Lee
Chairman, Technical Assessment Review

cc w/out encl.:
E. Hardin, SAIC/Las Vegas
H. Leake, SAIC/Las Vegas
F. Peters, SAIC/Las Vegas

Appendix B - Derivation of 2-D Fourier Solution for Steady-State Conduction in a Rectangular Plate

The physical basis for the model consists of a square plate with insulated faces, and edges maintained at zero-potential. The length of each side of the plate is $2a$. At the geometric center of the plate, flux is added at a constant rate, by a source with strength Q. The conductivity of the plate is k. For closest correspondence between the finite element and analytical solutions to this problem, the following discusion pertains to the fourth quadrant portion of the analytical problem in Cartesian coordinates, with the origin at the source position.

The problem is governed by Poisson's equation, with a forcing term proportional to the 2-D delta function:

$$\nabla^2 U = \frac{Q}{k}\delta(x)\delta(z) = u(x,z)$$

The potential field is found by assuming the desired potential function is a Fourier series of the form:

$$U(x,z) = \sum_{m=1}^{\infty}\sum_{n=1}^{\infty} B_{mn} \cos\frac{\pi x(2m-1)}{2a} \cos\frac{\pi z(2n-1)}{2a}$$

By the choice of basis functions this series is maximal at the origin, and zero at the boundary. Substituting this series into the governing equation, and transforming the forcing function, gives:

$$\begin{aligned}\nabla^2 U &= \frac{-\pi^2}{4a^2}\sum_{m=1}^{\infty}\sum_{n=1}^{\infty}\left((2m-1)^2+(2n-1)^2\right)B_{mn}\cos\frac{\pi x(2m-1)}{2a}\cos\frac{\pi z(2n-1)}{2a}\\ &= \frac{16Q}{ka^2}\sum_{m=1}^{\infty}\sum_{n=1}^{\infty}\cos\frac{\pi x(2m-1)}{2a}\cos\frac{\pi z(2n-1)}{2a}\end{aligned}$$

Equating coefficients to obtain the Fourier series for the potential function yields:

$$U(x,z) = \frac{16Q}{k\pi^2}\sum_{m=1}^{\infty}\sum_{n=1}^{\infty}\frac{1}{(2m-1)^2+(2n-1)^2}\cos\frac{\pi x(2m-1)}{2a}\cos\frac{\pi z(2n-1)}{2a}$$

This solution has been coded in the FORTRAN program presented in Figure B-1. A series convergence scheme is used whereby $n = m$, and both are increased together as necessary to achieve relative convergence of the terms in the series. A sample problem with input and output is presented in Figure B-2. Values of n and m as large as 1000 or more have been used to obtain relative convergence of order 10^{-3} (see Figure B-2).

Figure B-1. FORTRAN source code for calculation of analytical solution to Fourier conduction problem.

```
      program monocart
c     evaluates a 2D fourier series soln for steady-state conduction in a
c     rectangular 2a on a side, centered on (x,z) = (0,0), w/ flux supplied
c     at the origin, insulated faces, and edges fixed at zero potential.
c     values of potential are calculated along a ray in the 4th quadrant.
c     the source flux is divided among the quadrants, so the specified
c     value is quadrupled in the calculation
      real*4 pts(100)
      character*20 infile,outfile
      data pi/3.1415926/
      write(*,*)' input file name? '
      read(*,'(a20)')infile
      open(unit=2,status='old',file=infile)
      read(2,*)a
      read(2,*)npts
      do 1 i=1,npts
1     read(2,*)pts(i)
      read(2,*)ang
      read(2,*)q
      read(2,*)relcon
      read(2,'(a20)')outfile
      open(unit=1,status='new',file=outfile)
      const=16.*q/(pi**2.)
      do 100 i=1,npts
      x=pts(i)*sin(pi*ang/180.)
      z=-pts(i)*cos(pi*ang/180.)
c     start with the m=i, n=1 term
      p=const*cos(pi*x/(2.*a))*cos(pi*z/(2.*a))/2.
      in=1
c     increment n,m together until relative convergence
10    psav=p
      in=in+1
c     for fixed n, add terms for m=[1,n]
      rnf=2.*float(in)-1.
      fn=cos(rnf*pi*x/(2.*a))
      do 20 im=1,in
      rmf=2.*float(im)-1.
20    p=p+const*cos(rmf*pi*z/(2.*a))*fn/(rmf**2.+rnf**2.)
c     fix m, add remaining terms for n=[1,m-1]
      im=in
      rmf=2.*float(im)-1.
      fm=cos((2.*float(im)-1.)*pi*z/(2.*a))
      do 30 in=1,im-1
      rnf=2.*float(in)-1.
30    p=p+const*fm*cos(rnf*pi*x/(2.*a))/(rmf**2.+rnf**2.)
      in=im
      delp=p-psav
      if(abs(delp).gt.relcon)goto 10
100   write(1,*)pts(i),in,p
      stop
      end
```

Figure B-2. Example input and output for calculation.

```
3900
14
   0
   10
   25
   50
  -100
   150
   200
   400
   600
   800
   1000
   1200
   1400
   1600
90
100
1e-3
buffer.;

length of one edge of square plate
number of points along a ray, for calculation
   input radial distance for pt. # ...
          .
          .
angle from vertical for ray, in degrees
strength of source (w/ flux into quadrant)
relative convergence criterion
output file name
```

0.0000000E+00	1153	525.1515
10.00000	261	393.5779
25.00000	105	335.2458
50.00000	510	283.7362
100.0000	99	241.8944
150.0000	560	211.7795
200.0000	459	193.5045
400.0000	483	149.5916
600.0000	1122	123.9867
800.0000	661	105.5841
1000.000	646	91.39137
1200.000	1130	79.83626
1400.000	651	69.93484
1600.000	889	61.42817

I.2 Results of Verification and Validation Activities, and Listing of Pertinent Files

Science Applications International Corporation

M89-TAD-ELH-014
WBS: 1.2.5.2
QA: N/A

MEMO

DATE: September 8, 1989

TO: File

FROM: Ernest Hardin
Harry Leake

SUBJECT: Addendum to Test Plan for Validation and Verification (V & V) Activities, per QP 3.2 for the GW1 Finite Element Code Used in the Technical Assessment Review entitled "Geologic and Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed Exploratory Shaft"

This memo contains a description of the V&V activities prescribed by the test plan (M89-TAD-ELH-25). The subject addendum was described by that plan, and is organized into four parts: (1) validation; (2) 2-D problems; (3) 3-D problems; and (4) the disposition of the GW1 source and executable computer code, and the input and output files used in the TAR. The appendices provided with this addendum are assigned letter designations beginning with Appendix C so as to correspond to the original test plan, which included Appendices A and B.

Part 1: Validation

As called out in the test plan, an expert opinion was obtained on the validity of the conduction model upon which the GW1 code is based for application to geoelectric resistivity problems. The opinion is in the form of a letter from Dr. D.P. Klein, of the U.S. Geological Survey, who is also a TAR team member. The letter is presented in Appendix C and states that the conduction model, and the GW1 finite element implementation, are generally valid for the purposes stated in the letter comprising Appendix A to the test plan. The opinion further states that using a symmetry condition should pose no major limitation to using the model for first-order evaluation of the significance of off-axis topography and resistivity contrasts. Specific considerations that would be important for more detailed modeling are identified.

Part 2: 2-D Problems

A number of 2-D meshes were generated for comparison to the 2-D Fourier conduction problem described in Appendix B of the test plan. The specific analytical solution used was the one listed in Figure B-2. A total of six finite element models were run, as described below:

1. 'example3' - This mesh has 169 linear quadrilateral elements in a 13 X 13 array (196 nodes). The spacing of nodes in the x and z directions is the same, starting from the origin in the upper left corner: two 100-ft increments, six 200-ft increments, and five 500-ft increments.

2. 'example4' - This mesh has 225 linear quadrilateral elements in a 15 X 15 array (256 nodes). The spacing of nodes in the x and z directions is the same, starting from the origin in the upper left corner: four 50-ft increments, six 200-ft increments, and five 500-ft increments.

3. 'element5' - This mesh has 361 linear quadrilateral elements in a 19 X 19 array (400 nodes). The spacing of nodes in the x and z directions is the same, starting from the origin in the upper left corner: eight 25-ft increments, six 200-ft increments, and five 500-ft increments.

4. 'triangular3' - This mesh has 165 linear quadrilateral elements, and 8 linear triangular elements. The mesh is the same as for 'example3' except that each of the four square (100 X 100 ft) quadrilateral elements in the upper left corner is split into 2 isosceles triangular elements. The orientation of the major sides of all the triangular elements is the same; successive trials were run with the major sides oriented from lower left to upper right, and from upper left to lower right.

5. 'quadratic4' - This mesh has 209 linear quadrilateral elements and 4 quadratic quadrilateral elements. The mesh is the same as for 'example4' except that 16 square (50 X 50 ft) linear elements in the upper left corner are replaced by four larger (100 X 100 ft) quadratic elements.

A source strength of 100 was used in the series solution of the analytical Fourier problem. This parameter is the product of the resistivity (inverse conductivity) and the equivalent source/unit length of a line source. Original speculation that the source strength would scale the potential distribution was unfounded for this problem, which has a constant flux-forcing condition. The corresponding values in the finite element runs for source strength and conductivity were 100 and 1, respectively.

From 'example3' it was learned that the computed potential field is approximately the correct shape 200 to 1400 ft from the source and that the largest error occurs at 200 ft, nearest the source (Tables 1 and 2). However, the potential curve appeared to be offset over the interval of interest (200 to 1400 ft), possibly from the effect of numerical inconsistency near the source.

The next model, 'example4', addressed this problem by doubling the density of quadrilateral elements within 200 ft of the source node. This reduced the errors somewhat, so they were well under 1 percent from 200 to 1400 ft (Table 1). The next model 'example5' included even more quadrilaterals near the source, resulting in a somewhat smaller reduction in error than that obtained between 'example4' and 'example3'.

Although the 'example4' model satisfied the 1 percent approximate limit of acceptable error derived in the test plan, additional models were run to investigate whether the same result could be obtained using fewer elements or nodes. The 'triangular3' model produced an error of 1.12 percent at 200 ft (Table 2), indicating that linear triangular elements would not substantially improve accuracy for a given number of nodes relative to quadrilateral elements (Table 1). The 'quadratic4' model produced an error of only 0.2 percent at 200 ft, but error elsewhere was comparable to the 'example4' model (Table 1).

The systematic relationship shown in Tables 1 and 2 between the levels of model detail and agreement with the analytical solution is taken as verification of proper 2-D operation for GW1.

Part 3: 3-D Problems

From the results obtained with the 2-D problems discussed above, the 'example4' mesh was judged the most practical basis for 3-D problems. The important applications to the 3-D mesh are linear parallel piped elements, 50-ft node spacing in the direction of survey the line, and 50-ft node spacing for some distance laterally away from the survey lines. The 'quadratic4' model produced accuracy that was better than the 'example4' model for a given number of nodes, but only at the 200-ft distance. Linear elements are preferred for implementing the GW1 code as configured for the TAR, because a 3-D mesh with combined linear and quadratic elements is more difficult and the number of nodes (and thus the memory) for the quadratic model is no less than for the linear model.

Description of Models

All 3-D models have certain aspects in common. The 3-D meshes are composed of a series of vertical slices arranged in parallel and perpendicular to the symmetry plane (see Figure 2 of the test plan). The spacing of nodes within each slice is similar to the 2-D models discussed above, with element size increasing away from the upper left corner, which is the intersection with the survey line (see Figure 1 of the test plan). In the x-direction (horizontally away from the survey line), the node spacing is 50 ft near the line and increases geometrically starting 100 to 200 ft from the line. In the z-direction (positive upward), the topmost nodes are spaced at 25 to 50 ft, with geometrical increase of spacing with depth.

Slices are spaced along the y-axis (parallel to the dipole-dipole line) to create a region from y = 0 to 4,000 ft in the mid-portion of the mesh, where the spacing between slices is 50 ft. This region is designed to be where source and potential poles are "placed" to study earth response, and is designated the "study area" of the mesh. The coordinate system is fixed with the origin on the intersection of the symmetry plane and the slice at the (y = 0) end of the study area. (The z-coordinate of the survey line varies from model to model.) The final common aspect is that the y-spacing of slices located off each end of the study area is the same as the x-spacing of nodes offset from the survey line within each slice.

The studies described below have to do with the dimensions of the mesh, the number of elements per slice, the fixing of the potential of certain nodes on the boundary, and the placement of source poles at nodes on the upper edge of the symmetry plane. In accordance with the test plan, the 3-D cases run may be divided into three categories: (1) boundary standoff distance studies; (2) dipole-dipole line response uniformity studies; and (3) comparison to the dipole-dipole analytical solution for a quarter-space. The models are described in more detail as follows, with summary statistics in Table 3:

Model Group 1: Boundary standoff distance studies (each of these models has a single, monopole current source of 10 A at y=2,000 ft):

a) 'quarter1' model - Each slice consists of 36 elements (49 nodes). Spacing increments in the x- and z-directions are two at 50 ft, one at 100 ft, one at 200 ft, one at 400 ft, and one at 800 ft. Boundary nodes on all mesh faces (except the surface and symmetry plane) are set to zero.

b) 'quarter2' model - Each slice consists of 110 elements (132 nodes). Spacing increments in the x-direction are four at 50 ft, two at 100 ft, two at 200 ft, one at 400 ft, and one at 800 ft. Spacing increments in the z-direction are two at 25 ft, three at 50 ft, two at 100 ft, two at 200 ft, one at 400 ft, and one at 800 ft. Boundary nodes on all mesh faces (except the surface and symmetry plane) are set to zero.

c) 'quarter3' model - Each slice consists of 132 elements (156 nodes). Spacing increments in the x-direction are four at 50 ft, two at 100 ft, two at 200 ft, one at 400 ft, one at 800 ft, and one at 18,000 ft. Spacing increments in the z-direction are two at 25 ft, three at 50 ft, two at 100 ft, two at 200 ft, one at 400 ft, one at 800 ft, and one at 18,000 ft. Boundary nodes on all mesh faces (except at the surface and on the symmetry plane) are set to zero.

d) 'quarter4' model - Same mesh as 'quarter3' model, with different boundary conditions. All boundary nodes at vertices of the outer corners of the mesh, and located at the ends of the mesh, are "released" (i.e., not fixed a any value). All the other boundary nodes (except at the surface and on the symmetry plane) are set to zero.

e) 'quartertest' model - Same mesh and boundary conditions as 'quarter4' model, but with additional boundary nodes released. All boundary nodes at all vertices of the outer surface of the mesh are released. All other boundary nodes (except at the surface and on the symmetry plane) are set to zero.

Model Group 2: Response uniformity studies (each of these studies uses the same mesh as the 'quarter4' model, and the same monopole source strength, but with a different source location):

a) 'quarter5' model - Source located at y = 0.

b) 'quarter5' model - Source located at y = 1,000.

c) 'quarter4' model - Source located at y = 2,000; same model used in Model Group 1.

d) 'quarter7' model - Source located at y = 3,000.

e) 'quarter8' model - Source located at y = 4,000.

Model Group 3: Comparison to dipole-dipole analytical solution:

a) 'dipoletest' model - Same mesh and boundary conditions as 'quartertest' model described above, but with a (+) monopole source at y = 0 and a (-) monopole source at y = 200 ft.

Boundary Standoff Studies (Model Group 1)

For boundary standoff distance studies, models 'quarter1' through 'quarter3' showed progressive improvement as the number of nodes/elements and the boundary standoff distance were increased. Table 4 compares the potentials from a monopole source calculated from the analytical solution (see Appendix D) and from these different models. The monopole source location for each of the five models in Model Group 1 (see Table 3) was at y = 2,000. The potentials calculated on the survey line, at equal distances but different sides of the source (y < 2,000 and y > 2,000) generally agreed to at least 3 significant digits.

The problem with model 'quarter3' is that the computed potentials deviate from the analytical values, although the deviation is a relatively constant function of distance (Table 4). The magnitude of the analytical value of the potential (in an infinite quarter-space) at a source distance equal to the boundary standoff distance is similar to the uniform magnitude of the deviation of the potentials for each model. Moreover, all the computed potentials are less than the analytical values. This suggests that the reason for deviation is the zero potential boundary condition.

Another possible contributing factor to deviation was explored with models 'quarter4' and 'quartertest'. The linear parallel piped elements on the outer corners of the mesh are forced to zero throughout their volume if four or more noncoplanar boundary nodes (needed to define the element) are forced to zero. With this in mind, all the outer corner nodes at the ends of the mesh (y = -20,000 and y = 24,000) were "released" in model 'quarter4'. As unconstrained nodes they are free to adjust to the computed potential field. The effect of this change was slightly better agreement. Model 'quartertest' involved "releasing" all the outer corner nodes, including the ones along sides of the model (x = 20,000, z = 0). This resulted in another slight improvement. This factor was thus substantially eliminated as the major cause of deviation between analytical and computed potentials.

The deviation between analytical and computed monopole potentials, even for the 'quartertest' model, is more than the 1% accuracy criterion stated in the test plan. The effect is probably caused both by the presence of a zero potential boundary and by the rectilinear shape of the boundary. This is a common problem in finite element conduction problems, and has been addressed by setting the potential at each boundary Dirichlet node to the value that would be expected at that location from the analytical solution for a quarter-space (Holcombe and Jiracek, 1984; Pridmore et al., 1981). However, this step was not taken pending the outcome of the dipole-dipole test described below (Model Group 3). The conclusion from this group of models is that accuracy of the computed monopole field is principally limited by the boundary standoff distance for the 3-D mesh concept developed. Error associated with the 'quartertest' model exceeds the 1% criterion locally by a small amount that could probably be eliminated by further extending the boundary standoff distance. However, this would probably require more elements, resulting in more computation than is really necessary for the kind of model needed for 3-D dipole-dipole sensitivity studies.

Dipole-Dipole Response Uniformity Studies (Model Group 2)

Using the 'quarter4' mesh and boundary conditions, the monopole source was moved to five separate locations along the survey line within the study area for investigation of uniformity. The resulting calculated potentials are presented in Table 5. The potentials are tabulated in terms of distance from the source, so uniformity can be compared directly by scanning the lines in the table. Note that for each model except 'quarter4' the potentials could not be computed for

some portion of the distance range, from -1,400 to +1,400 ft. For sources located off-center, a slight amount (<1%) of asymmetry was observed in the potential field on both sides of the source. Because of this effect, uniformity was limited to >99%. Note that the computed gradient (differences between adjacent values) is uniform for all models to >99%, (although the apparent gradient differs from the analytical value to an extent that ranges from about 1% near the source to a little less than 2% at a 1,400 ft distance. The conclusion of this test is that computed response is sufficiently uniform over the length of the survey line in the study area (although absolute accuracy of 1% was not achieved consistently).

Comparison to the Dipole-Dipole Analytical Solution (Model Group 3)

The dipole-dipole test model consists of the 'quartertest' model, with a positive source pole at y = 0, and a negative source pole at y = 200. The source dipole was placed at the limit of the study area to increase the possibility for error. The results are shown in Table 5. Deviation from the analytical solution for dipole-dipole response in an infinite quarter-space (see Appendix D of this addendum) is less than 1% in the range of interest, except at N = 2 and N = 6. If the deviations are treated as independent, which is a crude assumption made in the test plan to try to define acceptable error in terms of the value of a single parameter, then the variance for N = 2 through 6 is on the order of 10^{-4}. This is two orders of magnitude less than the acceptable variance stated in the plan, which is one tenth of the smallest analytical value for dipole-dipole potential. The conclusion of this test is therefore that the GW1 code and the 'quartertest' model configuration produce an acceptable rate of error in computed dipole-dipole potentials.

Clarification of Acceptable Accuracy

The test plan gives two definitions of acceptability for 3-D tests: one based on 1% or better agreement with analytical monopole potential field values, and the other based on a concept of variance in the computed dipole-dipole potentials. These definitions were developed by the reasoning process explained under the heading "2-D Problems" in the test plan. The purpose was to derive a goal for level of acceptable error in 2-D cases that would help ensure that needed accuracy was attained from subsequent 3-D test cases. As acknowledged in the test plan, the following three steps were very conservative: (1) the assumption that errors in the individual monopole field values that are differenced to calculate dipole-dipole response are uncorrelated; (2) taking the dipole-dipole response magnitude to be 0.05 of the response of a constituent monopole, which from Tables 4 and 5 is seen to be applicable at 1,200 to 1,400 ft (i.e., N = 6) but generally is too small; and (3) approximating the average magnitude of the deviation of computed dipole-dipole values from the analytical values for six values in a set (N = 1 through N = 6) with zero mean deviation and variance of 0.00125 as 1% when, based on the assumptions of the variance concept, the average magnitude would be closer to 3.5%. This latter step introduced a factor of about

3, which was intended to prevent outliers from causing the 0.1 variance concept to be exceeded. The 0.1 level was not exceeded, but the 1% level was, as shown in Table 5.

The above discussion indicates that the 1% limit defined in the test plan is appropriate for simulating analytical solutions to problems with explicit boundaries (e.g., the 2-D Fourier conduction problem), but is too optimistic for finite simulations of analytical solutions for potential variation in infinite bodies. The intent of adopting a 1% accuracy criterion was to provide an initial accuracy condition that would ensure that a final accuracy condition was met. The final condition has been met, and the interim condition needs to be redefined so it is not construed as a rigid requirement for acceptable modeling accuracy. Accordingly, this addendum to the test plan stipulates that the interim accuracy criteria in the test plan are subsidiary to the condition that the variance (assuming results for different values of N are uncorrelated) of the computed dipole-dipole potential differences relative to the analytical solution for a quarter-space, for a suite of values for N = 1 through 6, should not exceed 0.1 of the smallest analytical potential value in the suite.

Part 4: Disposition of Computer Files

During the conduct of modeling activities using the GW1 code for the TAR, copies of the FORTRAN source files and the machine-executable version were maintained in an account on the T&MSS VAXcluster computer system in a directory that allowed read-only or execute-only access to TAR team members or to any user without system privileges. This controlled code was identified as Rev. 0, and was used in all runs of the GW1 program for the TAR.

Input and output files for every application of the GW1 program that is reported or used in this memo or the RRM have been archived in a tape storage facility. The pre & post test files were not completed, which was determined by inspection. The GW1 input files for 3-D problems are large, because they contain detailed information on the finite element meshes, boundary conditions, and source conditions. As a result, they are too large to reproduce in the RRM. All the archived files are listed in Appendix E of this addendum.

References for Addendum

Holcombe, H.T., and G.R. Jiracek, 1984 "Three-Dimensional Terrain Corrections in Resistivity Surveys" Geophysics, v. 49, pp. 439-452.

Pridmore, D.F., G.W. Hohmann, S.H. Ward, and W.R. Sill, 1981. An Investigation of Finite-Element Modeling for Electrical and Electromagnetic Data in Three Dimensions," Geophysics, v. 46, pp. 1009-1024.

Table 1. Results obtained for 2-D cases, compared to the computed series solution for the Fourier conduction problem. Distance is given along an edge of the plate from the source. Blank entries indicate where nodes were not located, thus potentials were not computed.

Distance (ft)	Analytical Fourier Soln.	FEM example3 Soln.(a)	FEM example4 Soln.(b)	FEM example5 Soln.(c)	FEM triangular3 Soln.(d)	FEM quadratic4 Soln.(e)
0	525.15	575.01	418.86	462.93	340.90	415.07
25	333.25			327.72		
50	283.74		273.64	279.85		291.91
100	241.89	229.78	235.76	236.42	240.90	231.17
150	211.78		210.32	210.71		208.44
200	193.50	191.69	192.08	192.23	195.67	193.12
400	149.59	148.48	148.51	148.51	148.35	148.42
600	123.99	123.40	123.40	123.41	123.49	123.44
800	105.58	105.29	105.29	105.30	105.30	105.29
1000	91.39	91.17	91.17	91.18	91.18	91.18
1200	79.84	79.59	79.59	79.60	79.59	79.59
1400	69.93	69.75	69.75	69.76	69.75	69.75

(a) 100-ft elements within 200-ft of source; 200- and 500-ft elements elsewhere (see text).
(b) 50-ft elements; (ditto).
(c) 25-ft elements; (ditto).
(d) similar to 'example3' with same nodal array but with triangular elements within 200-ft of source.
(e) similar to 'example4' with same nodal array but with quadratic elements within 200-ft of source.

Table 2. Error for selected values of computed potential from 2-D cases. Error is defined as a percentage of the computed analytical Fourier series solution with a monopole source, as defined in the text.

Distance From Source (ft)	FEM example3 Soln. Error	FEM example4 Soln. Error	FEM example5 Soln. Error	FEM triangular3 Soln. Error	FEM quadratic4 Soln. Error
200	-0.94%	-0.73%	-0.66%	1.12%	-0.20%
400	-0.74	-0.72	-0.72	-0.83	-0.78
600	-0.48	-0.48	-0.47	-0.40	-0.44
800	-0.27	-0.27	-0.27	-0.27	-0.27
1000	-0.24	-0.24	-0.23	-0.23	-0.23
1200	-0.31	-0.31	-0.30	-0.31	-0.31
1400	-0.26	-0.26	-0.24	-0.26	-0.26

Table 3. Summary statistics for 3-D meshes.

Model Name	# Nodes/ Elements Slice	# Slices	x=y=z Boundary Standoff	Uniform Resis- tivity	Source Pole(s) y-coord.	"Released" Boundary Nodes
Model Group 1:						
quarter1	49/36	93	1,600 ft	30 ohm-m	2,000 ft	None
quarter2	132/110	101	2,000	500	2,000	None
quarter3	156/132	103	20,000	500	2,000	None
quarter4	156/132	103	20,000	500	2,000	Boundary corners at end of mesh
quartertest	156/132	103	20,000	500	2,000	All boundary corners
Model Group 2 (response uniformity study):						
quarter5	156/132	103	20,000	500	0	Boundary corners at end of mesh
quarter6	156/132	103	20,000	500	1,000	Boundary corners at end of mesh
quarter4	156/132	103	20,000	500	2,000	Boundary corners at end of mesh
quarter7	156/132	103	20,000	500	3,000	Boundary corners at end of mesh
quarter8	156/132	103	20,000	500	4,000	Boundary corners at end of mesh
Model Group 3 (comparison to analytical quarter-space solution):						
dipoletest	156/132	103	20,000	500	0 (-) & 200 (+)	All boundary corners

Table 4. Comparison of analytical and computed potentials, for study of boundary standoff distance and boundary conditions (Model Group 1). All potential values are in volts.

Source Distance	Analytical Monopole Solution(a)	quarter1 Model(b)	quarter2 Model	quarter3 Model	quarter4 Model	quartertest Model
200	26.10	22.98	23.80	24.73	24.78	25.02
400	13.05	10.38	10.84	11.77	11.82	12.05
600	8.700	6.16	6.58	7.50	7.55	7.78
800	6.525	4.09	4.45	5.37	5.42	5.65
1000	5.220	2.88	3.19	4.10	4.15	4.39
1200	4.350	2.12	2.37	3.26	3.31	3.55
1400	3.729	1.59	1.80	2.68	2.73	2.97

Table 5. Dipole-dipole test case results. The 'dipoletest' model has a uniform resistivity of 500 ohm-m.

N	Analytical Dipole-dipole Solution	dipoletest Model Result	Error(%)	Apparent Resistivity
1	-8.700	-8.700	~0 (a)	500 ohm-m
2	-2.175	-2.141	-1.55	492
3	-0.870	-0.865	-0.57	497
4	-0.435	-0.436	0.12	501
5	-0.249	-0.250	0.72	504
6	-0.155	-0.157	1.16	506
7	-0.104	-0.105	1.43	507
8	-0.0725	-0.0735	1.43	507
9	-0.0527	-0.0533	1.02	505
10	-0.0396	-0.0396	~0 (a)	500

(a) Zero error at three significant digits.

Appendix C. Expert Opinion Validating the Use of the Conduction Model Which is the Basis of the GW1 Code

United States Department of the Interior

GEOLOGICAL SURVEY
BOX 25046 M.S. 964
DENVER FEDERAL CENTER
DENVER, COLORADO 80225

IN REPLY REFER TO: Mail Stop 964

WBS: 1.2.3.2.2.6
QA: 1

August 7, 1989

Richard C. Lee
SAIC, Suite 3407
101 Convention Center Dr.
Las Vegas, Nevada 89109

Re: Judgement as to validity and limitations of GW1 Code for 3-D DC Resistivity Studies

Dear Mr. Lee:

In response to your request of 10 July, 1989, I offer the following opinion regarding the use of the GW1 computer code for modeling the effects of off-axis topography and resistivity contrasts on dipole-dipole DC resistivity data in the vicinity of Coyote Wash.

The computer code is generally valid for the purposes stated in your letter based on the following considerations:

Code GW1 was developed for ground-water flow models. The theoretical foundation of this code is also applicable to DC resistivity models because the fundamental equations have the same form (LaPlace or Poisson equation).

The numerical foundation of code GW1, the finite element method, is also applicable and has been well established in the professional literature for DC and AC resistivity problems.

Limitations in application of the code are related to the implimentation of mesh design, use of symmetry conditions, and establishment of boundary conditions. Under proper useage the computer code should not be limited in any fundamental way. However, I point out possible limitations related to symmetry conditions inasmuch as such conditions are often invoked for practical reasons. For first-order evaluation of the significance of off-axis topography and resistivity contrasts, the use of symmetry conditions should provide no major limitation. However, more detailed modeling may require the following considerations:

1. If bilateral symmetry is used to simplify model geometry, then topographic or buried resistivity contrasts will not be fully 3-D. The 3-D representation may be further degraded if symmetry conditions require that current sources be along the plane of bilateral symmetry. The lack of full 3-dimensionality will require careful model planning to minimize over- or under-estimations of off-axis effects.

2. Inasmuch as the observed resistivity lines of Coyote Wash are located on the edges of the Wash, an approximation of bilaterally symmetric models along the lines may serve primarily to set extreme limits on possible off-axis effects of topography on this data.

Sincerely,

Douglas P. Klein
Geophysicist

cc: E. L. Hardin

Appendix D. Analytical Solutions for Monopole and Dipole-Dipole Potential Field Variation in An Infinite Quarter-Space

The analytical solution for the potential field caused by a steady, monopole current source of strength I applied to the surface of a half-space is

$$U_{1/2} = \frac{\rho I}{2\pi r}$$

where ρ is the resistivity and r is the distance from the source (Keller and Frischknecht, 1966). For 3-D problems with all source and potential poles on an edge of a symmetry plane as described in the text, the nominal current is conducted through half a quarter-space, so the right-hand-side is multiplied by two

$$U_{1/4} = \frac{\rho I}{\pi r}$$

This is the expression used with nominal values for current in the text. The polar dipole-dipole potential response for a half-space may be derived from Keller and Frischknecht (1966, Equation 71), and reduces to

$$\Delta U_{1/2} = \frac{-\rho I l^2}{\pi z(z-l)(z+2l)}$$

where z and l are the dipole separation (between closest poles), and dipole length, respectively. For 3-D problems with all source and potential poles on a symmetry plane as described in the text, the nominal current is conducted through a quarter-space, so the right-hand-side is multiplied by two

$$\Delta U_{1/4} = \frac{-2\rho I l^2}{\pi z(z+l)(z+2l)}$$

This is the expression u- . with nominal values for current in the text. Finally, the apparent resistivity ρ_a may be found algebraically from the quarter-space result

$$\rho_{a,1/4} = \frac{\pi l n(n+1)(n+2)\Delta U_{1/4}}{2I}$$

where $n = 1, 2, 3, \ldots$ is the minimum separation distance, in dipole lengths, between current and potential dipoles.

Appendix E. Lists of Archived Computer Files.

```
Listing of save set(s)

Save set:           WATER.BCK
Written by:         OPERATOR
UIC:                [000010,000001]
  te:               18-AUG-1989 19:45:09.18
ommand:             BACKUP/IGNORE=LABEL USER$15:[GRD_WATER.REVISED] MTA0:WATER.BC
K/SAVE
Operating system:   VAX/VMS version V5.1
BACKUP version:     V5.0
CPU ID register:    018438E8
Node name:          _YMV1::
Written on:         _YMV1$MTA0:
Block size:         8192
Group size:         10
Buffer count:       3

[GRD_WATER.REVISED]ASMBK.FOR;21                    111  19-JUN-1989 11:37
[GRD_WATER.REVISED]BOUND.FOR;5                      11   1-JUN-1989 10:57
[GRD_WATER.REVISED]COMALL.;44                        9  26-JUN-1989 12:56
[GRD_WATER.REVISED]DECOMP.FOR;6                      8  19-JUN-1989 12:41
[GRD_WATER.REVISED]DUMP.FOR;7                       13  26-JUN-1989 12:24
[GRD_WATER.REVISED]ELEMENT.FOR;8                     7   1-JUN-1989 11:06
[GRD_WATER.REVISED]GW1.COMP;2                        1  30-MAY-1989 14:48
[GRD_WATER.REVISED]GW1.EXE;9                        76  26-JUN-1989 12:57
[GRD_WATER.REVISED]GW1.FOR;19                        6  26-JUN-1989 12:24
[GRD_WATER.REVISED]GW1.LINK;2                        1  30-MAY-1989 14:50
[GRD_WATER.REVISED]KSUB.FOR;1                       92  26-MAY-1989 16:52
[GRD_WATER.REVISED]LOC.FOR;1                         5  26-MAY-1989 16:54
[GRD_WATER.REVISED]MATERL.FOR;8                      9   1-JUN-1989 10:53
[GRD_WATER.REVISED]NODES.FOR;5                       9   1-JUN-1989 10:46
[GRD_WATER.REVISED]SOLVE.FOR;2                       8  30-MAY-1989 14:43
  RD_WATER.REVISED]VFLOCITY.FOR;4                   86   1-JUN-1989 11:05
[GRD_WATER.REVISED]VSUB.FOR;1                       76  26-MAY-1989 16:56

Total of 17 files, 528 blocks
End of save set
```

Listing of save set(s)

```
Save set:           GW1.BCK
Written by:         OPERATOR
UIC:                [000010,000001]
  te:               18-AUG-1989 19:48:43.61
.ommand:            BACKUP/IGNORE=LABEL USER$5:[HARDIN.GW1.COMPLEX] MTA0:GW1.BCK/
SAVE
Operating system:   VAX/VMS version V5.1
BACKUP version:     V5.0
CPU ID register:    018438E8
Node name:          _YMV1::
Written on:         _YMV1$MTA0:
Block size:         8192
Group size:         10
Buffer count:       3

[HARDIN.GW1.COMPLEX]AF_2000.0;1                    1193  13-JUL-1989 23:02
[HARDIN.GW1.COMPLEX]AF_2000.0POTS;1                   4  14-JUL-1989 00:26
[HARDIN.GW1.COMPLEX]AF_2000.1;1                    1193  13-JUL-1989 23:07
[HARDIN.GW1.COMPLEX]AF_2000.1POTS;1                   4  14-JUL-1989 02:50
[HARDIN.GW1.COMPLEX]AF_2000.2;1                    1193  13-JUL-1989 23:11
[HARDIN.GW1.COMPLEX]AF_2000.2POTS;1                   4  14-JUL-1989 07:53
[HARDIN.GW1.COMPLEX]AF_2000.3;1                    1193  13-JUL-1989 23:13
[HARDIN.GW1.COMPLEX]AF_2000.3POTS;1                   4  14-JUL-1989 17:13
[HARDIN.GW1.COMPLEX]AF_2000.4;1                    1193  13-JUL-1989 23:15
[HARDIN.GW1.COMPLEX]AF_2000.4POTS;1                   4  14-JUL-1989 18:05
[HARDIN.GW1.COMPLEX]AF_2000.5;1                    1193  13-JUL-1989 23:17
[HARDIN.GW1.COMPLEX]AF_2000.5POTS;1                   4  14-JUL-1989 19:22
[HARDIN.GW1.COMPLEX]AF_2000.COM;1                     2  14-JUL-1989 16:10
[HARDIN.GW1.COMPLEX]AF_2000.DD;1                     18  14-JUL-1989 00:26
[HARDIN.GW1.COMPLEX]BF_2000.0;1                    1196  25-JUL-1989 16:51
  ARDIN.GW1.COMPLEX]BF_2000.0POTS;1                   4  25-JUL-1989 19:42
.HARDIN.GW1.COMPLEX]BF_2000.1;3                    1196  25-JUL-1989 17:10
[HARDIN.GW1.COMPLEX]BF_2000.1POTS;1                   4  25-JUL-1989 21:14
[HARDIN.GW1.COMPLEX]BF_2000.2;3                    1196  25-JUL-1989 17:11
[HARDIN.GW1.COMPLEX]BF_2000.2POTS;1                   4  25-JUL-1989 22:40
[HARDIN.GW1.COMPLEX]BF_2000.3;3                    1196  25-JUL-1989 17:11
[HARDIN.GW1.COMPLEX]BF_2000.3POTS;1                   4  26-JUL-1989 00:10
[HARDIN.GW1.COMPLEX]BF_2000.4;3                    1196  25-JUL-1989 17:12
[HARDIN.GW1.COMPLEX]BF_2000.4POTS;1                   4  26-JUL-1989 01:11
[HARDIN.GW1.COMPLEX]BF_2000.5;2                    1196  25-JUL-1989 17:10
[HARDIN.GW1.COMPLEX]BF_2000.5POTS;1                   4  26-JUL-1989 02:06
[HARDIN.GW1.COMPLEX]BF_2000.COM;1                     2  25-JUL-1989 16:44
[HARDIN.GW1.COMPLEX]BF_2000.DD;1                     18  25-JUL-1989 19:42
[HARDIN.GW1.COMPLEX]CF_2000.0;2                    1195  25-JUL-1989 17:37
[HARDIN.GW1.COMPLEX]CF_2000.0POTS;1                   4  26-JUL-1989 03:01
[HARDIN.GW1.COMPLEX]CF_2000.1;2                    1195  25-JUL-1989 17:38
[HARDIN.GW1.COMPLEX]CF_2000.1POTS;1                   4  26-JUL-1989 03:53
[HARDIN.GW1.COMPLEX]CF_2000.2;2                    1195  25-JUL-1989 17:39
[HARDIN.GW1.COMPLEX]CF_2000.2POTS;1                   4  26-JUL-1989 04:46
[HARDIN.GW1.COMPLEX]CF_2000.3;2                    1195  25-JUL-1989 17:40
[HARDIN.GW1.COMPLEX]CF_2000.3POTS;1                   4  26-JUL-1989 05:38
[HARDIN.GW1.COMPLEX]CF_2000.4;2                    1195  25-JUL-1989 17:41
[HARDIN.GW1.COMPLEX]CF_2000.4POTS;1                   4  26-JUL-1989 06:31
[HARDIN.GW1.COMPLEX]CF_2000.5;2                    1195  25-JUL-1989 17:42
[HARDIN.GW1.COMPLEX]CF_2000.5POTS;1                   4  26-JUL-1989 07:25
[HARDIN.GW1.COMPLEX]CF_2000.COM;2                     2  25-JUL-1989 17:43
 ARDIN.GW1.COMPLEX]CF_2000.DD;1                      18  26-JUL-1989 03:01
 ARDIN.GW1.COMPLEX]DF_2000.0;2                      1192  27-JUL-1989 13:15
[HARDIN.GW1.COMPLEX]DF_2000.0POTS;1                   4  27-JUL-1989 15:03
[HARDIN.GW1.COMPLEX]DF_2000.1;2                    1192  27-JUL-1989 13:16
[HARDIN.GW1.COMPLEX]DF_2000.1POTS;1                   4  27-JUL-1989 16:29
[HARDIN.GW1.COMPLEX]DF_2000.2;2                    1192  27-JUL-1989 13:17
[HARDIN.GW1.COMPLEX]DF_2000.2POTS;1                   4  27-JUL-1989 17:28
[HARDIN.GW1.COMPLEX]DF_2000.3;2                    1192  27-JUL-1989 13:18
```

```
[HARDIN.GW1.COMPLEX]DF_2000.3POTS;1          4  27-JUL-1989 18:42
[HARDIN.GW1.COMPLEX]DF_2000.4;2           1192  27-JUL-1989 13:19
[HARDIN.GW1.COMPLEX]DF_2000.4POTS;1          4  27-JUL-1989 20:14
[HARDIN.GW1.COMPLEX]DF_2000.5;2           1192  27-JUL-1989 13:20
[HARDIN.GW1.COMPLEX]DF_2000.5POTS;1          4  27-JUL-1989 21:40
 'ARDIN.GW1.COMPLEX]DF_2000.COM;2            2  27-JUL-1989 13:21
..ARDIN.GW1.COMPLEX]DF_2000.DD;1            18  27-JUL-1989 15:03
[HARDIN.GW1.COMPLEX]EF_2000.0;2           1193   2-AUG-1989 20:52
[HARDIN.GW1.COMPLEX]EF_2000.0POTS;1          4   2-AUG-1989 22:18
[HARDIN.GW1.COMPLEX]EF_2000.1;2           1193   2-AUG-1989 20:53
[HARDIN.GW1.COMPLEX]EF_2000.1POTS;1          4   2-AUG-1989 23:28
[HARDIN.GW1.COMPLEX]EF_2000.2;2           1193   2-AUG-1989 20:54
[HARDIN.GW1.COMPLEX]EF_2000.2POTS;1          4   3-AUG-1989 00:21
[HARDIN.GW1.COMPLEX]EF_2000.3;2           1193   2-AUG-1989 20:55
[HARDIN.GW1.COMPLEX]EF_2000.3POTS;1          4   3-AUG-1989 01:15
[HARDIN.GW1.COMPLEX]EF_2000.4;2           1193   2-AUG-1989 20:56
[HARDIN.GW1.COMPLEX]EF_2000.4POTS;1          4   3-AUG-1989 02:08
[HARDIN.GW1.COMPLEX]EF_2000.5;2           1193   2-AUG-1989 20:57
[HARDIN.GW1.COMPLEX]EF_2000.5POTS;1          4   3-AUG-1989 03:00
[HARDIN.GW1.COMPLEX]EF_2000.COM;2            2   2-AUG-1989 20:58
[HARDIN.GW1.COMPLEX]EF_2000.DD;1            18   2-AUG-1989 22:18
[HARDIN.GW1.COMPLEX]SUPER.COM;1              4  25-JUL-1989 17:52

Total of 71 files, 36038 blocks
End of save set
```

Listing of save set(s)

```
Save set:            GW1.BCK
Written by:          OPERATOR
UIC:                 [000010,000001]
  te:                18-AUG-1989 19:51:42.63
.ommand:             BACKUP/IGNORE=LABEL USER$5:[HARDIN.GW1.FINITE] MTA0:GW1.BCK/S
AVE
Operating system:    VAX/VMS version V5.1
BACKUP version:      V5.0
CPU ID register:     018438E8
Node name:           _YMV1::
Written on:          _YMV1$MTA0:
Block size:          8192
Group size:          10
Buffer count:        3

[HARDIN.GW1.FINITE]3A_2000.0;2                    1192  25-JUL-1989 13:05
[HARDIN.GW1.FINITE]3A_2000.0POTS;1                   4  25-JUL-1989 19:51
[HARDIN.GW1.FINITE]3A_2000.1;2                    1192  25-JUL-1989 13:07
[HARDIN.GW1.FINITE]3A_2000.1POTS;1                   4  25-JUL-1989 22:03
[HARDIN.GW1.FINITE]3A_2000.2;2                    1192  25-JUL-1989 13:08
[HARDIN.GW1.FINITE]3A_2000.2POTS;1                   4  25-JUL-1989 23:59
[HARDIN.GW1.FINITE]3A_2000.3;2                    1192  25-JUL-1989 13:10
[HARDIN.GW1.FINITE]3A_2000.3POTS;1                   4  26-JUL-1989 01:56
[HARDIN.GW1.FINITE]3A_2000.4;2                    1192  25-JUL-1989 13:11
[HARDIN.GW1.FINITE]3A_2000.4POTS;1                   4  26-JUL-1989 03:53
[HARDIN.GW1.FINITE]3A_2000.5;2                    1192  25-JUL-1989 13:13
[HARDIN.GW1.FINITE]3A_2000.5POTS;1                   4  26-JUL-1989 05:50
[HARDIN.GW1.FINITE]3A_2000.COM;2                     2  25-JUL-1989 13:15
[HARDIN.GW1.FINITE]3A_2000.DD;1                     18  25-JUL-1989 19:52
[HARDIN.GW1.FINITE]A2_2000.0;5                    1192  25-JUL-1989 12:57
[HARDIN.GW1.FINITE]A2_2000.0POTS;1                   4  13-JUL-1989 08:40
[HARDIN.GW1.FINITE]A2_2000.1;3                    1192  25-JUL-1989 12:58
[HARDIN.GW1.FINITE]A2_2000.1POTS;1                   4  13-JUL-1989 10:45
[HARDIN.GW1.FINITE]A2_2000.2;3                    1192  25-JUL-1989 12:59
[HARDIN.GW1.FINITE]A2_2000.2POTS;1                   4  13-JUL-1989 12:03
[HARDIN.GW1.FINITE]A2_2000.3;3                    1192  25-JUL-1989 13:00
[HARDIN.GW1.FINITE]A2_2000.3POTS;1                   4  13-JUL-1989 13:18
[HARDIN.GW1.FINITE]A2_2000.4;3                    1192  25-JUL-1989 13:01
[HARDIN.GW1.FINITE]A2_2000.4POTS;1                   4  13-JUL-1989 14:33
[HARDIN.GW1.FINITE]A2_2000.5;3                    1192  25-JUL-1989 13:02
[HARDIN.GW1.FINITE]A2_2000.5POTS;1                   4  13-JUL-1989 16:00
[HARDIN.GW1.FINITE]A2_2000.COM;2                     2  13-JUL-1989 07:19
[HARDIN.GW1.FINITE]A2_2000.DD;1                     18  13-JUL-1989 08:44

Total of 28 files, 14392 blocks
End of save set
```

```
Listing of save set(s)

Save set:           GW1.BCK
Written by:         OPERATOR
UIC:                [000010,000001]
  te:               18-AUG-1989 19:52:56.49
..mmand:            BACKUP/IGNORE=LABEL USER$5:[HARDIN.GW1.SLOPE] MTA0:GW1.BCK/SA
VE
Operating system:   VAX/VMS version V5.1
BACKUP version:     V5.0
CPU ID register:    018438E8
Node name:          _YMV1::
Written on:         _YMV1$MTA0:
Block size:         8192
Group size:         10
Buffer count:       3

[HARDIN.GW1.SLOPE]SLOPE.DD;1                          15  25-JUL-1989 22:40
[HARDIN.GW1.SLOPE]SLOPETEST.1;7                      873  26-JUL-1989 08:45
[HARDIN.GW1.SLOPE]SLOPETEST.2;4                      873  26-JUL-1989 08:46
[HARDIN.GW1.SLOPE]SLOPETEST.3;4                      873  26-JUL-1989 08:47
[HARDIN.GW1.SLOPE]SLOPETEST.4;4                      873  26-JUL-1989 08:48
[HARDIN.GW1.SLOPE]SLOPETEST.5;2                      873  25-JUL-1989 15:55
[HARDIN.GW1.SLOPE]SLOPETEST.COM;11                     2  26-JUL-1989 08:20

Total of 7 files, 4382 blocks
End of save set
```

```
Listing of save set(s)

Save set:            HARDIN.BCK
Written by:          OPERATOR
UIC:                 [000010,000001]
Date:                25-JUL-1989 18:45:36.58
Command:             BACKUP/IGNORE=LABEL/LIST=HARDIN.LIS;9 USER$5:[HARDIN.GW1.BEYE
 ASE] YMV1$MTA0:HARDIN.BCK/SAVE
 perating system:    VAX/VMS version V5.1
BACKUP version:      V5.0
CPU ID register:     018438E8
Node name:           _YMV1::
Written on:          _YMV1$MTA0:
Block size:          8192
Group size:          10
Buffer count:        3

[HARDIN.GW1.BEYERCASE]AI_2000.0;2                          1192  13-JUL-1989 07:37
[HARDIN.GW1.BEYERCASE]AI_2000.0POTS;1                         4  13-JUL-1989 10:41
[HARDIN.GW1.BEYERCASE]AI_2000.1;2                          1192  13-JUL-1989 07:38
[HARDIN.GW1.BEYERCASE]AI_2000.1POTS;1                         4  13-JUL-1989 12:04
[HARDIN.GW1.BEYERCASE]AI_2000.2;2                          1192  13-JUL-1989 07:39
[HARDIN.GW1.BEYERCASE]AI_2000.2POTS;1                         4  13-JUL-1989 13:11
[HARDIN.GW1.BEYERCASE]AI_2000.3;2                          1192  13-JUL-1989 07:40
[HARDIN.GW1.BEYERCASE]AI_2000.3POTS;1                         4  13-JUL-1989 14:49
[HARDIN.GW1.BEYERCASE]AI_2000.4;2                          1192  13-JUL-1989 07:41
[HARDIN.GW1.BEYERCASE]AI_2000.4POTS;1                         4  13-JUL-1989 16:28
[HARDIN.GW1.BEYERCASE]AI_2000.5;2                          1192  13-JUL-1989 07:42
[HARDIN.GW1.BEYERCASE]AI_2000.5POTS;1                         4  13-JUL-1989 17:32
[HARDIN.GW1.BEYERCASE]AI_2000.COM;2                           2  13-JUL-1989 07:44
[HARDIN.GW1.BEYERCASE]AI_2000.DD;1                           18  13-JUL-1989 10:41

Total of 14 files, 7136 blocks
End of save set

Listing of save set(s)

Save set:            HARDIN.BCK
Written by:          OPERATOR
UIC:                 [000010,000001]
Date:                25-JUL-1989 18:46:41.71
Command:             BACKUP/IGNORE=LABEL/LIST=HARDIN.LIS;7 USER$5:[HARDIN.GW1.DEYC
ASE] YMV1$MTA0:HARDIN.BCK/SAVE
Operating system:    VAX/VMS version V5.1
BACKUP version:      V5.0
CPU ID register:     018438E8
Node name:           _YMV1::
Written on:          _YMV1$MTA0:
Block size:          8192
Group size:          10
Buffer count:        3

[HARDIN.GW1.DEYCASE]DEY2.0;3                               1192  21-JUL-1989 12:07
[HARDIN.GW1.DEYCASE]DEY2.1;3                               1192  21-JUL-1989 12:07
[HARDIN.GW1.DEYCASE]DEY2.2;3                               1192  21-JUL-1989 12:07
[HARDIN.GW1.DEYCASE]DEY2.3;3                               1192  21-JUL-1989 12:08
[HARDIN.GW1.DEYCASE]DEY2.4;3                               1192  21-JUL-1989 12:08
[HARDIN.GW1.DEYCASE]DEY2.5;3                               1192  21-JUL-1989 12:08
[HARDIN.GW1.DEYCASE]DEY2.COM;2                                2  18-JUL-1989 18:37
[HARDIN.GW1.DEYCASE]DEY2.DD;1                                18  18-JUL-1989 19:48
[HARDIN.GW1.DEYCASE]DEY2_0.POTS;1                             4  18-JUL-1989 19:48
[HARDIN.GW1.DEYCASE]DEY2_1.POTS;1                             4  18-JUL-1989 20:40
[HARDIN.GW1.DEYCASE]DEY2_2.POTS;1                             4  18-JUL-1989 21:44
[HARDIN.GW1.DEYCASE]DEY2_3.POTS;1                             4  18-JUL-1989 22:55
[HARDIN.GW1.DEYCASE]DEY2_4.POTS;1                             4  19-JUL-1989 00:27
[HARDIN.GW1.DEYCASE]DEY2_5.POTS;1                             4  19-JUL-1989 01:31
```

```
[HARDIN.GW1.DEYCASE]DEY6.0;1                                  1192  24-JUL-1989 18:04
[HARDIN.GW1.DEYCASE]DEY6.1;2                                  1192  24-JUL-1989 18:05
[HARDIN.GW1.DEYCASE]DEY6.2;2                                  1192  24-JUL-1989 18:06
[HARDIN.GW1.DEYCASE]DEY6.3;2                                  1192  24-JUL-1989 18:07
[HARDIN.GW1.DEYCASE]DEY6.4;2                                  1192  24-JUL-1989 18:08
[HARDIN.GW1.DEYCASE]DEY6.5;2                                  1192  24-JUL-1989 18:09
[HARDIN.GW1.DEYCASE]DEY6.COM;2                                   2  24-JUL-1989 18:11
[HARDIN.GW1.DEYCASE]DEY6.DD;1                                   18  24-JUL-1989 20:10
[HARDIN.GW1.DEYCASE]DEY6_0.POTS;1                                4  24-JUL-1989 20:10
[HARDIN.GW1.DEYCASE]DEY6_1.POTS;1                                4  24-JUL-1989 22:07
[HARDIN.GW1.DEYCASE]DEY6_2.POTS;1                                4  25-JUL-1989 00:04
[HARDIN.GW1.DEYCASE]DEY6_3.POTS;1                                4  25-JUL-1989 02:01
[HARDIN.GW1.DEYCASE]DEY6_4.POTS;1                                4  25-JUL-1989 03:58
[HARDIN.GW1.DEYCASE]DEY6_5.POTS;1                                4  25-JUL-1989 05:55

Total of 28 files, 14392 blocks
End of save set

Listing of save set(s)

Save set:           HARDIN.BCK
Written by:         OPERATOR
UIC:                [000010,000001]
Date:               25-JUL-1989 18:49:18.62
Command:            BACKUP/IGNORE=LABEL/LIST=HARDIN.LIS;5 USER$5:[HARDIN.GW1.TOPO
] YMV1$MTA0:HARDIN.BCK/SAVE
Operating system:   VAX/VMS version V5.1
BACKUP version:     V5.0
CPU ID register:    018438E8
Node name:          _YMV1::
Written on:         _YMV1$MTA0:
Block size:         8192
Group size:         10
Buffer count:       3

[HARDIN.GW1.TOPO]TOPO10E.;2                                   1730   8-JUL-1989 16:16
[HARDIN.GW1.TOPO]TOPO10E.POTS;1                                  4   9-JUL-1989 02:14
[HARDIN.GW1.TOPO]TOPO10W.;2                                   1730   8-JUL-1989 16:01
[HARDIN.GW1.TOPO]TOPO10W.POTS;1                                  4   8-JUL-1989 20:50
[HARDIN.GW1.TOPO]TOPO12E.;2                                   1730   8-JUL-1989 16:17
[HARDIN.GW1.TOPO]TOPO12E.POTS;1                                  4   9-JUL-1989 04:11
[HARDIN.GW1.TOPO]TOPO12W.;2                                   1730   8-JUL-1989 16:02
[HARDIN.GW1.TOPO]TOPO12W.POTS;1                                  4   8-JUL-1989 21:41
[HARDIN.GW1.TOPO]TOPO14W.;2                                   1730   8-JUL-1989 16:04
[HARDIN.GW1.TOPO]TOPO14W.POTS;1                                  4   8-JUL-1989 22:32
[HARDIN.GW1.TOPO]TOPO16W.;2                                   1730   8-JUL-1989 16:05
[HARDIN.GW1.TOPO]TOPO16W.POTS;1                                  4   8-JUL-1989 23:23
[HARDIN.GW1.TOPO]TOPO18W.;2                                   1730   8-JUL-1989 16:06
[HARDIN.GW1.TOPO]TOPO18W.POTS;1                                  4   9-JUL-1989 00:14
[HARDIN.GW1.TOPO]TOPO20W.;2                                   1730   8-JUL-1989 16:08
[HARDIN.GW1.TOPO]TOPO20W.POTS;1                                  4   9-JUL-1989 01:05
[HARDIN.GW1.TOPO]TOPO2E.;2                                    1730   8-JUL-1989 16:10
[HARDIN.GW1.TOPO]TOPO2E.POTS;1                                   4   8-JUL-1989 18:27
[HARDIN.GW1.TOPO]TOPO2W.;2                                    1730   8-JUL-1989 15:53
[HARDIN.GW1.TOPO]TOPO2W.POTS;1                                   4   8-JUL-1989 17:20
[HARDIN.GW1.TOPO]TOPO4E.;2                                    1730   8-JUL-1989 16:12
[HARDIN.GW1.TOPO]TOPO4E.POTS;1                                   4   8-JUL-1989 20:24
[HARDIN.GW1.TOPO]TOPO4W.;2                                    1730   8-JUL-1989 15:55
[HARDIN.GW1.TOPO]TOPO4W.POTS;1                                   4   8-JUL-1989 18:12
[HARDIN.GW1.TOPO]TOPO6E.;2                                    1730   8-JUL-1989 16:13
[HARDIN.GW1.TOPO]TOPO6E.POTS;1                                   4   8-JUL-1989 22:21
[HARDIN.GW1.TOPO]TOPO6W.;2                                    1730   8-JUL-1989 15:56
[HARDIN.GW1.TOPO]TOPO6W.POTS;1                                   4   8-JUL-1989 19:06
[HARDIN.GW1.TOPO]TOPO8E.;2                                    1730   8-JUL-1989 16:14
[HARDIN.GW1.TOPO]TOPO8E.POTS;1                                   4   9-JUL-1989 00:18
[HARDIN.GW1.TOPO]TOPO8W.;3                                    1730   8-JUL-1989 16:00
```

```
[HARDIN.GW1.TOPO]TOPO8W.POTS;1                                  4    8-JUL-1989 19:57
[HARDIN.GW1.TOPO]TOPOE.COM;2                                    1    8-JUL-1989 16:27
[HARDIN.GW1.TOPO]TOPOW.COM;1                                    1    8-JUL-1989 16:23

Total of 34 files, 27746 blocks
End of save set

Listing of save set(s)

Save set:              HARDIN.BCK
Written by:            OPERATOR
UIC:                   [000010,000001]
Date:                  25-JUL-1989 18:51:50.06
[redacted]
TER] YMV1$MTA0:HARDIN.BCK/SAVE
Operating system:      VAX/VMS version V5.1
BACKUP version:        V5.0
CPU ID register:       018438E8
Node name:             YMV1::
Written on:            YMV1$MTA0:
Block size:            8192
Group size:            10
Buffer count:          3

[HARDIN.GW1.QUARTER]BOUNDTEST.COM;2                             1    6-JUL-1989 22:50
[HARDIN.GW1.QUARTER]DIPOLE.POTENTIALS;1                         4    7-JUL-1989 14:45
[HARDIN.GW1.QUARTER]DIPOLETEST.;2                            1196    7-JUL-1989 12:36
[HARDIN.GW1.QUARTER]DIPOLETEST.COM;3                            1    7-JUL-1989 13:24
[HARDIN.GW1.QUARTER]QUARTER.LISTING;1                           3   25-JUL-1989 14:00
[HARDIN.GW1.QUARTER]QUARTER1.POTENTIALS;1                       4   19-JUN-1989 15:33
[HARDIN.GW1.QUARTER]QUARTER2.POTENTIALS;1                       4   19-JUN-1989 18:45
[HARDIN.GW1.QUARTER]QUARTER3.;4                              1197    6-JUL-1989 16:48
[HARDIN.GW1.QUARTER]QUARTER3.POTENTIALS;1                       4    6-JUL-1989 17:44
[HARDIN.GW1.QUARTER]QUARTER4.;3                              1196    6-JUL-1989 21:56
[HARDIN.GW1.QUARTER]QUARTER4.POTENTIALS;1                       4    6-JUL-1989 21:53
[HARDIN.GW1.QUARTER]QUARTER5.;2                              1196    6-JUL-1989 22:13
[HARDIN.GW1.QUARTER]QUARTER5.POTENTIALS;1                       4    7-JUL-1989 00:43
[HARDIN.GW1.QUARTER]QUARTER6.;2                              1196    6-JUL-1989 22:21
[HARDIN.GW1.QUARTER]QUARTER6.POTENTIALS;1                       4    7-JUL-1989 02:37
[HARDIN.GW1.QUARTER]QUARTER7.;2                              1196    6-JUL-1989 22:23
[HARDIN.GW1.QUARTER]QUARTER7.POTENTIALS;1                       4    7-JUL-1989 04:31
[HARDIN.GW1.QUARTER]QUARTER8.;2                              1196    6-JUL-1989 22:26
[HARDIN.GW1.QUARTER]QUARTER8.POTENTIALS;1                       4    7-JUL-1989 06:24
[HARDIN.GW1.QUARTER]QUARTERTEST.;4                           1192    7-JUL-1989 08:18
[HARDIN.GW1.QUARTER]TEST.POTENTIALS;1                           4    7-JUL-1989 10:34

Total of 21 files, 9610 blocks
End of save set
```

Appendix J

TAR Team Member Concurrence Sheets

CONCURRENCE SHEET

I, Richard C. Lee, hereby concur with the contents and recommendations contained in Chapter 7 (General Summary and Recommendations) of the Review Record Memorandum of the Technical Assessment Review of Geologic and Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed Exploratory Shaft.

Subcommittee Member Name	Signature	Date
Richard C. Lee	Richard C. Lee	Jan 08, 1990

CONCURRENCE SHEET

I, Thomas E. Hinkebein, hereby concur with the contents and recommendations contained in Chapter 5 (Summary of Engineering Subcommittee- Performance Evaluation), Chapter 6 (Summary of Engineering Subcommittee-Construction-related Impacts) and Chapter 7 (General Summary and Recommendations) of the Review Record Memorandum of the Technical Assessment Review of Geologic and Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed Exploratory Shaft.

Subcommittee Member Name	Signature	Date
Thomas E. Hinkebein	Thomas E Hinkebein	12/6/89

CONCURRENCE SHEET

I, Richard Snyder, hereby concur with the contents and recommendations contained in Chapter 2 (Historical Perspective), Chapter 3 (Summary of Geology Subcommittee) and Chapter 7 (General Summary and Recommendations) of the Review Record Memorandum of the Technical Assessment Review of Geologic and Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed Exploratory Shaft.

Subcommittee Member Name	Signature	Date
Richard Snyder	Richard P. Snyder	12/7/89

CONCURRENCE SHEET

I, Douglas P. Klein, hereby concur with the contents and recommendations contained in Chapter 4 (Summary of Geophysics Subcommittee) and Chapter 7 (General Summary and Recommendations) of the Review Record Memorandum of the Technical Assessment Review of Geologic and Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed Exploratory Shaft.

Subcommittee Member Name	Signature	Date
Douglas P. Klein	Douglas P. Klein	8 Dec 89

CONCURRENCE SHEET

I, David Cummings, hereby concur with the contents and recommendations contained in Chapter 4 (Summary of Geophysics Subcommittee) and Chapter 7 (General Summary and Recommendations) of the Review Record Memorandum of the Technical Assessment Review of Geologic and Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed Exploratory Shaft.

Subcommittee Member Name	Signature	Date
David Cummings		12/6/89

CONCURRENCE SHEET

I, Gerald L. Shideler, hereby concur with the contents and recommendations contained in Chapter 2 (Historical Perspective), Chapter 3 (Summary of Geology Subcommittee) and Chapter 7 (General Summary and Recommendations) of the Review Record Memorandum of the Technical Assessment Review of Geologic and Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed Exploratory Shaft.

Subcommittee Member Name	Signature	Date
Gerald L. Shideler	Gerald L. Shideler	12-19-89

CONCURRENCE SHEET

I, Terry A. Grant, hereby concur with the contents and recommendations contained in Chapter 2 (Historical Perspective), Chapter 3 (Summary of Geology Subcommittee) and Chapter 7 (General Summary and Recommendations) of the Review Record Memorandum of the Technical Assessment Review of Geologic and Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed Exploratory Shaft.

Subcommittee Member Name	Signature	Date
Terry A. Grant	Terry A. Grant	12/6/89

CONCURRENCE SHEET

I, Forrest Peters, hereby concur with the contents and recommendations contained in Chapter 4 (Summary of Geophysics Subcommittee) and Chapter 7 (General Summary and Recommendations) of the Review Record Memorandum of the Technical Assessment Review of Geologic and Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed Exploratory Shaft.

Subcommittee Member Name	Signature	Date
Forrest Peters	[signature]	12/15/89

CONCURRENCE SHEET

I, David C. Dobson, hereby concur with the contents and recommendations contained in Chapter 2 (Historical Perspective), Chapter 3 (Summary of Geology Subcommittee) and Chapter 7 (General Summary and Recommendations) of the Review Record Memorandum of the Technical Assessment Review of Geologic and Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed Exploratory Shaft.

Subcommittee Member Name	Signature	Date
David C. Dobson	David Dobson	12/9/85

CONCURRENCE SHEET

I, David F. Fenster, hereby concur with the contents and recommendations contained in Chapter 2 (Historical Perspective), Chapter 3 (Summary of Geology Subcommittee) and Chapter 7 (General Summary and Recommendations) of the Review Record Memorandum of the Technical Assessment Review of Geologic and Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed Exploratory Shaft, with the addition of the insert as shown on the attached page

Subcommittee Member Name	Signature	Date
David F. Fenster	David F. Fenster	12/8/89

additional investigations:

1. The conduct and interpretation of the proposed geophysical surveys. These surveys could confirm or refute the Smith and Ross (1982) apparent resistivity data, and possibly delineate the extent of any resistivity contrast that may be present. If a contrast is present, the combination of geoelectric soundings and shallow seismic data will substantially increase confidence in the interpretation of conditions at depth.

2. Clearing and mapping of the Tiva Canyon units exposed along the south slope of Dead Yucca Ridge would be conducted following the geophysics program, and should conclusively demonstrate the presence or absence of a significant fracture zone (greater than several feet in width) at the surface. This phase would be conducted prior to the start of the ESF pad construction, but could occur prior to or during the exploratory drilling program.

3. Drilling and logging of the center-line ES boreholes. These data would provide direct evidence of the material properties for mining purposes, and provide additional stratigraphic control prior to ES pad construction. If the centerline boreholes are drilled, they would probably obviate the need for the currently planned pilot holes. In addition, the existence of these boreholes could necessitate a revisitation of the scientific testing currently planned for the multipurpose boreholes. Although centerline holes would clearly provide better information (for ESF construction) on geomechanical properties, than the MPBH holes, their existence could compromise the quality of the hydrologic information designed to be obtained from the MPBH. Therefore, an evaluation would be required to develop an optimum test strategy for the revised drilling sequence and configuration.

without proper sealing

7.3 RECOMMENDATIONS ON MITIGATING ACTIONS FOR UNCERTAIN OR POOR ROCK PROPERTIES DISCOVERED IN THE COURSE OF EXPLORATORY SHAFT EXCAVATION

Ground conditions should be known reliably before shaft sinking commences, and the shaft center boreholes recommended in Section 7.2 and described in Table 6-1, Sheet 5 (item #4), should eliminate uncertainty in this respect. However, a near vertical minor or even moderate fault could conceivably remain undetected until encountered during sinking. Such a fault could result in schedule delays resulting from changes to the excavation method, or could increase the amount of temporary support and the need to keep the concrete lining closer to the shaft floor, as described in Table 6-1 (or Section 6.1.7). Worker safety is of paramount importance, and the measures described in Table 6-1 reduce to a minimum worker exposure to potentially hazardous situations and protect against the consequences of uncontrolled incidents.

7.4 ADEQUACY OF THE IMPLEMENTATION OF THE BERTRAM (1984) RECOMMENDATIONS ON THE ORIGINAL EXPLORATORY SHAFT LOCATION

CONCURRENCE SHEET

I, Jeffrey Kimball, hereby concur with the contents and recommendations contained in Chapter 4 (Summary of Geophysics Subcommittee) and Chapter 7 (General Summary and Recommendations) of the Review Record Memorandum of the Technical Assessment Review of Geologic and Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed Exploratory Shaft.

Subcommittee Member Name	Signature	Date
Jeffrey Kimball	Jeffrey K Kimball	12/6/89

CONCURRENCE SHEET

I, Mohammed Mozumder, hereby concur with the contents and recommendations contained in Chapter 4 (Summary of Geophysics Subcommittee) and Chapter 7 (General Summary and Recommendations) of the Review Record Memorandum of the Technical Assessment Review of Geologic and Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed Exploratory Shaft.

Subcommittee Member Name	Signature	Date
Mohammed Mozumder	Mohammed Mozumder	12/7/89

CONCURRENCE SHEET

I, Ernest L. Hardin, hereby concur with the contents and recommendations contained in Chapter 4 (Summary of Geophysics Subcommittee) and Chapter 7 (General Summary and Recommendations) of the Review Record Memorandum of the Technical Assessment Review of Geologic and Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed Exploratory Shaft.

Subcommittee Member Name	Signature	Date
Ernest L. Hardin	Ert Hardin	12-8-89

CONCURRENCE SHEET

I, J. Marshall Davenport III, hereby concur with the contents and recommendations contained in Chapter 2 (Historical Perspective), Chapter 3 Summary of Geology Subcommittee) and Chapter 7 (General Summary and Recommendations) of the Review Record Memorandum of the Technical Assessment Review of Geologic and Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed Exploratory Shaft.

Subcommittee Member Name	Signature	Date
J. Marshall Davenport III	J. Marshall Davenport III	12/7/89

CONCURRENCE SHEET

I, Michael W. Parsons, hereby concur with the contents and recommendations contained in Chapter 2 (Historical Perspective), Chapter 3 (Summary of Geology Subcommittee) and Chapter 7 (General Summary and Recommendations) of the Review Record Memorandum of the Technical Assessment Review of Geologic and Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed Exploratory Shaft.

Subcommittee Member Name	Signature	Date
Michael W. Parsons	Michael W. Parsons	1/8/90

CONCURRENCE SHEET

I, Maurice Grieves, hereby concur with the contents and recommendations contained in Chapter 6 (Summary of Engineering Subcommittee-Construction-related Impacts) and Chapter 7 (General Summary and Recommendations) of the Review Record Memorandum of the Technical Assessment Review of Geologic and Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed Exploratory Shaft.

Subcommittee Member Name	Signature	Date
Maurice Grieves	[illegible]	Jan 5 '90

CONCURRENCE SHEET

I, Jonathan D. Istok, hereby concur with the contents and recommendations contained in Chapter 4 (Summary of Geophysics Subcommittee) and Chapter 7 (General Summary and Recommendations) of the Review Record Memorandum of the Technical Assessment Review of Geologic and Geophysical Evidence Pertaining to Structural Geology in the Vicinity of the Proposed Exploratory Shaft.

Subcommittee Member Name	Signature	Date
Jonathan D. Istok	Jonathan Istok	12/20/84