040WM073140E

WM-73

Department of Energy
Albuquerque Operations Office
P.O. Box 5400
Albuquerque, New Mexico 87115

DEC 2 8 1987

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DOCKETED USNRC JAN 0 4 1988 MAIL SECTION DOCKET CLERK

Edward F. Hawkins, Chief
Licensing Branch 1
Uranium Recovery Field Office
Nuclear Regulatory Commission, Region IV
Box 25325
Denver, CO 80225

Dear Ed,

By your letter dated November 17, 1987, the Nuclear Regulatory Commission (NRC) submitted comments on the Remedial Action Plan and Final Design for the Tuba City, Arizona, uranium mill tailings site. Enclosed for your use and information are responses to those comments. These responses should adequately address NRC's concerns; we are, therefore, requesting NRC concurrence with the proposed remedial action by January 29, 1987.

As you are aware, a subcontract for remedial action at Tuba City was awarded by MK-Ferguson Company on December 17, 1987. Notice to proceed is scheduled to be given to the subcontractor on January 5, 1988. In order to avoid remedial action delays which might result from delays in receipt of NRC concurrence, we request that, if NRC identifies any concerns with the enclosed responses, NRC notify DOE immediately and, if necessary, a meeting can be scheduled to resolve outstanding concerns.

If you have comments or questions regarding this transmittal, please contact Debbie Mann at FTS 846-1243.

Sincerely,

W. John Arthur, III

W. John Arthur, III
Acting Project Manager
Uranium Mill Tailings Project Office

Enclosure

cc w/enclosure:
T. Olsen, NRC-URFO
R. Gonzales, NRC-URFO

cc w/o enclosure:
G. Gnugnoli, NRC-HQ
J. Oldham, MK-F
M. Nelson, JEG

UMTRA DOCUMENT REVIEW FORM

SECTION 1

Site: Tuba
Document: RAP and Final Design, Date: November 17, 1987
Commentor: NRC

Comment: Page 1

SURFACE HYDROLOGY

Calculation No. 18-890-02, Volume V, Supplement, Final Design
April 1987

Page 2 of 3 shows that dense basalt is to be oversized by 7.7 percent using a factor of 2 for frequently saturated areas. This is not correct. For frequently saturated areas, oversizing factor should be 10. Therefore, oversizing should be 5 times what MKE determined or 5 (7.7) = 38 percent.

SECTION 2

Response: Page ________ By: MKE Date: 12-17-87

Guidelines for the selection of the best available rock and for oversizing of less durable erosion protection have been revised since Calculation No. 18-840-02 was prepared. We have replaced that calculation by Calculation No. 18-890-10, utilizing specification test requirements which were based on data from four types of quality tests. The new calculation is based on the latest NRC guidelines. A copy of the calculations and a draft copy of the new guidelines is attached. Final design of erosion protection will be revised as required to conform.

Plans for Implementation:

As stated above.

SECTION 3

Confirmation Of Implementation:

Checked By: ______________________, Date: ______________

Approved By: ______________________, Date: ______________

5057-TUB-R-01-01369-00
4422U/0131U

Calculation Cover Sheet

Contract No. 4005-18 Discipline EARTH SCIENCES Calc. No. 18-890-10 No. of Sheets 2

Project

UMTRA / TUBA CITY

Feature

EROSION PROTECTION

Item

ROCK QUALITY - RIPRAP OVERSIZING

Sources of Data

Sources of Formulae & References

REF. 1. MKE DOCUMENT No. 4005-TUB-R-01-01166-00, SUBCONTRACT DOCUMENTS, SPECIFICATION No. 02278 - EROSION PROTECTION, ITEM 2.1.C, APRIL 1987.

2. NRC DRAFT DOCUMENT, ROCK DURABILITY - "CRITERIA FOR SELECTION AND OVERSIZING OF ROCK", NOVEMBER 17, 1987

3. WESTERN TECHNOLOGIES INC., "PETROGRAPHIC ANALYSIS OF PROPOSED EROSION PROTECTION MATERIAL FROM TUBA CITY, ARIZONA", NOVEMBER 6, 1986.

Preliminary Calc. ☐ Final Calc. ☒ Supersedes Calc. No. 18-890-02

Rev No	Revision	Calculation By	Date	Checked By	Date	Approved By	Date
		[signature]	12-1-87	[signature]	12-2-87	N. C. [signature]	2 Dec 87

Form 42-110

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project: UMTRA / TUBA CITY
Feature: EROSION PROTECTION
Item: ROCK QUALITY - RIPRAP OVERSIZING
Contract No. 4005.18
Designed: D. Bolton
Checked: J.A.K.
Sheet 1 of 2
File No.
Date 12-1-87
Date

DENSE BASALT ROCK — SHADOW MOUNTAIN QUARRY

TEST	SPECIFIED LIMIT (REF. 1)	* RAW SCORE	* WEIGHT FACTOR (IGNEOUS)	WEIGHTED SCORE	* MAX. RAW SCORE	MAX WEIGHTED SCORE
SPECIFIC GRAVITY	2.65	8	9	72	10	90
ABSORPTION (%)	2.5	2	2	4	10	20
SODIUM SULPHATE (%)	5	8	11	88	10	110
LA ABRASION (%)	10	5	1	5	10	10
			TOTALS	169		230

[* FROM REF 2.]

PERCENT OF MAX. = $\frac{169}{230} \times 100$ = 73%

(Ref. 2) { OCCASIONALLY SATURATED AREAS — OVERSIZING REQUIRED
FREQUENTLY SATURATED AREAS — OVERSIZING REQUIRED

(Ref. 2) { OVERSIZE FOR FREQUENTLY SATURATED AREAS BY A FACTOR OF (100 − 73) = 27%

OVERSIZE FOR OCCASIONALLY SATURATED AREAS BY A FACTOR OF (80 − 73) = 7%

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA / TUBA CITY — Contract No. 4005-18 — Sheet 2 of 2
Feature EROSION PROTECTION — Designed D. BOLTON — File No.
Item ROCK QUALITY - RIPRAP OVERSIZING — Checked J.A.C — Date 12-1-8
Date 12-2-

The petrographic analysis of the Shadow Mountain Quarry (Ref. 3) recommends the use of the dense basalt for use as erosion protection. The analysis describes the dense basalt as "hard" and "very competent".

REF. 1

on other project sites for more than 20 years, rock that has functioned satisfactorily as foundation stone or building facing for 50 years or more, and abandoned quarry faces which have maintained their integrity after not being worked for approximately 50 years or more. Durability shall be indicated by lack of significant weathering or loss of volume and strength over decades of exposure to natural weathering elements.

c. The riprap materials shall meet the requirements of Paragraphs B and C, and bedding materials shall meet the requirements of Paragraphs B and D of this Article.

B. The materials shall be free from radioactive or other contamination.

C. Riprap Materials:

1. Individual pieces shall be dense, sound, resistant to abrasion, and shall be free from cracks, seams, and other defects as shown in the petrographic examination.

2. The shape of at least 75 percent of the material, by weight, shall be such that the minimum dimension is not less than one third of the maximum dimension.

3. Quality:

Tests	Designation	Requirements
Specific Gravity (Saturated Surface Dry Basis)	ASTM C127	Not less than 2.65.
Soundness	ASTM C88	Na_2SO_4 Test: Not more than 5 percent loss of weight after 5 cycles.
Abrasion (Los Angeles Machine)	ASTM C131	Not more than 10 percent loss of weight after 100 revolutions.
Petrographic Examination	ASTM C295	The Subcontractor shall furnish a report for review by the Contractor.
Absorption	ASTM C127	Not more than 2.5 percent.

REF. 2

4. SELECTION OF THE BEST AVAILABLE ROCK

Investigations should be conducted to identify several sources of available rock within a reasonable distance of the site. The suitability of these rocks as protective covers should then be assessed by laboratory tests to determine the physical characteristics of the rocks. Several durability tests, such as those listed in Appendix D, should be performed to classify the rock as being of poor, fair, or good quality and to assess the expected long-term performance of the rock.

Where rock of good quality is reasonably available, the cover design should incorporate this rock. In those cases where only rock of less-than-good quality is reasonably available, increases in the average rock size and riprap layer thickness may be necessary. An acceptable procedure for oversizing of less durable rock or utilizing rock may be found in Appendix D.

In many cases, it may be difficult to demonstrate that less-than-good quality rock will be durable for 1000 years. Therefore, in accordance with the 200-year durability criteria of 40 CFR 192, the applicant should clearly document and justify the use of rock which is not of good quality. This documentation and justification should include analyses and discussions regarding the location, durability, and costs associated with the most practical source of good-quality rock and/or the difficulties and costs associated with its placement.

It should be emphasized that the oversizing procedure is an attempt to quantify additional rock size requirements, based on staff experience with rock durability at several UMTRA sites and limited field data. The procedure should be used with a great deal of engineering judgment and should be used only in those cases where the licensee/applicant has clearly documented that good-quality rock is not reasonably available.

APPENDIX D

OVERSIZING OF LESS DURABLE EROSION PROTECTION

Frequently, situations arise where it may be necessary to utilize rock that is not good quality as erosion protection. These situations arise sometimes in areas of the Western United States where many uranium mill sites are located.

Determining the quality of riprap needed for long-term protection and stability can be a somewhat difficult and subjective task. Very little design guidance is available to quantitatively assess the degree of oversizing needed for a particular rock type to survive for long periods, based on its physical properties.

In assessing the long-term durability of erosion protection, the NRC staff has relied principally on the results of durability tests at several UMTRA sites and on information and analyses presented in NUREG/CR-4620 "Methodologies for Evaluating Long-Term Stabilization Design of Uranium Mill Tailings Impoundments," (Reference 18). This document provides a quantitative method for determining the oversizing requirements for a particular rock type to be placed at specific locations on or near a remediated embankment.

Staff review of actual field data from several tailings sites has indicated that the methodology presented in NUREG/CR-4620 may not be sufficiently flexible to allow the use of "borderline" quality rock, where a particular type of rock fails to meet minimum qualifications for placement in a specific embankment zone, but fails to qualify by only a small amount. In such cases, it may be acceptable to utilize such rock, provided that the rock is of relatively good quality and is the best that is reasonably available.

Based on NRC staff review of the actual field data, the methodology presented in NUREG/CR-4620 has been modified to incorporate additional flexibility; these revisions include modifications to the score required for use in a particular zone, re-classification of the placement zones, reassessment of weighting factors based on the rock type, and more detailed procedures for computing the oversizing required.

A step-by-step procedure for implementing the revised methodology is presented below.

DESIGN PROCEDURE

Step 1 Locate and Test Rock Sources

1. Locate least costly source(s) of "good" (80-100%)(1) rock

2. Locate least costly source(s) of "other quality" (50-80% score) rock

For each rock source the scores should be based on the results of about 3-4 different durability test methods for initial screening and about 6 test methods for final sizing of the rock(s) selected for inclusion in the reclamation plan.

Step 2 Develop Best Designs

1. Using the oversizing criteria given below, if necessary, develop designs for the rock sources identified above.

2. Develop unit cost data for each of the different rock sizes that are needed in each design.

3. Develop a final design utilizing the best rock that is reasonably available.

Step 3 Develop Alternate Designs, As Necessary

If:

a. only poor-quality (less-than-good quality) rock is available and oversizing is not reasonably feasible, or

b. good-quality rock is reasonably available but is not of adequate size.

Then:

a. use Appendix D methodology to justify use of a flood less than the PMF, and

b. develop alternative designs based on floods less than the PMF.

OVERSIZING CRITEIRA

A. Frequently Saturated Areas - Channels, Poorly-Drained Toes and Aprons

Score

65-100	Oversize using factor of (100-Score)
Less than 65	Reject

B. Occasionally Saturated Areas - Top Slopes, Side Slopes, and Well-Drained Toes and Aprons

Score

80-100	No Oversizing Needed
50-80	Oversize using factor of (80-Score)
Less than 50	Reject

---

1. Score developed using scoring criteria, and represents % of maximum score for all tests that were performed. For preliminary screening of rock sources, the score should be based on the results of about four durability tests. For final selection and oversizing, the score should be based on those durability tests indicated in the scoring criteria. Other tests may also be substituted or added, as appropriate.

2. Scoring criteria was developed using NUREG/CR-2642 and from NUREG/CR-4620 - Chapter 6, with several modifications depending on rock type. The percentage increase is applied to the diameter of the rock.

3. [The rock that is to be oversized mus: first be subjected to a petrographic examination and must get at least a 'fair" rating.] Otherwise, the rock will not be acceptable.

Replace w/ [Insert 1] from p. 2

4. An occasionally saturated area is defined as an (slopes steep enough to preclude ponding considering differential settlement) area with underlying filter blankets and slopes that provide good drainage (~~slopes ≥ 2%~~) and are located well above normal groundwater levels; otherwise the area is classified as frequently-saturated. Natural channels and <u>most man-made diversion channels</u> should be classified as frequently-saturated. Generally, any toe or apron located below grade should be classified as frequently saturated; such toes and aprons are considered to be poorly-drained in most cases.

5. If a rock type barely fails to meet minimum criteria for placement in a particular area, with proper justification and documentation it may be feasible to throw out the results of a test that may not be particularly applicable and substitute a ~~more applicable~~ test, with a higher weighting factor, depending on the rock type or site location. If this is done, consideration should be given to performing several additional tests. The additional tests should be those which are the most applicable tests for a specific rock type, as indicated in Reference .

6. The oversizing calculations represent minimum increases. Rock sizes as large as practicable should be provided. (It is assumed, for example, that a 12" layer of 4" rock costs the same as 12" of 6" rock). The rock layer must be at least 12" or 1-1/2 x D_{50} thick, whichever is greater.

7. ~~It may be acceptable to utilize freeze-thaw tests in lieu of the sulfate soundness tests.~~ Additional guidance for ~~utilizing~~ freeze/thaw ~~tests~~ testing may be found in Reference . The number of freeze/thaw cycles to be used in the oversizing equations should be determined on a site-specific basis, utilizing climatological data for that specific site area.

8. In performing any oversizing analyses, two factors are of utmost importance:

   - The best rock that is reasonably available will be used, and

   - The designs, utilizing the rock type selected, will meet applicable standards

These factors should be clearly documented in analyses and calculations.

SCORING CRITERIA

	WEIGHTING FACTOR			SCORE										
						USBR FAIR (8–5)								
TEST	Limestone	Sandstone	Igneous	10	9	8	7	6	5	4	3	2	1	0
Sp. Gravity	12	5	9	2.75	2.70	2.65	2.60	2.55	2.50	2.45	2.40	2.35	2.30	<2.3
Absorption %	13	5	2	.1	.3	.5	.67	.83	1	1.5	2.0	~~3.5~~ 2.5	3.0	>3.0
Sodium Sulfate %	4	3	11	1	3	5	6.7	8.3	10	12.5	15	20	25	>25
L/A Abrasion, (100) %	1	8	1	1	3	5	6.7	8.3	10	12.5	15	20	25	>25
Schmidt Hammer	11	13	3	70	65	60	54	47	40	32	24	16	8	>8
Tensile Strength psi	5	4	10	1400	1200	1000	833	666	500	400	300	200	100	<100

1. Scores derived from Tables 6.2, 6.5, and 6.7 of NUREG/CR-2642 - "Long-Term Survivability of Riprap for Armoring Uranium Mill Tailings and Covers: A Literature Review," 1982.

2. [Any rock to be ~~oversized~~ used must be qualitatively rated at least "fair" in petrographic examination conducted by a geologist experienced in petrographic analysis.] [Insert ① to p. 5]

3. Weighting Factors derived from Table 7 of "Petrographic Investigations of Rock Durability and Comparisons of Various Test Procedures," by G. W. DuPuy, Engineering Geology, July 1965. Weighting factors are based on inverse of ranking of test methods for each rock type. Other tests may be used; weighting factors for these tests may be derived using Table 7.

4. Test methods should be standardized (ASTM, e.g.) and should be ~~equivalent to~~ those used in NUREG/CR-2642.

REF. 3

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Tuba, City, Arizona

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Phoenix, Arizona 85036
(602) 437-3737

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Gateway Plaza
663 West Second Avenue
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Flagstaff
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Flagstaff, Arizona 86001
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Pinetop
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Pinetop, Arizona 85935
(602) 367-3011

Tucson
423 South Olsen Avenue
Tucson, Arizona 85719
(602) 624-8896

Sierra Vista
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Sierra Vista, Arizona 85635
(602) 458-0364

Bullhead City
460 Main Street
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Bullhead City, Arizona 86430
(602) 754-2271

Albuquerque
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Albuquerque, New Mexico 87109
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Las Vegas, Nevada 89102
(702) 382-7483

St. George
Sunshine Plaza
430 West, 145 North
St. George, Utah 84770
(801) 628-2883

Submitted to:

Morrison-Knudsen Engineers
180 Howard Street
San Francisco, California 94105
Attention: Mr. R. W. Heneks

December 4, 1986
Invoice No. 31461155

WESTERN
TECHNOLOGIES
INC.

2400 East Huntington Drive
Flagstaff, Arizona 86001
(602) 774-8708

Morrison-Knudsen Engineers
180 Howard Street
San Francisco, CA 94105

November 6, 1986

Attn: Mr. R.W. Heneks

Re: Petrographic Analysis of
Proposed Erosion Protection Material
from Tuba City, Arizona

Ref. No. 3146W113

Transmitted herewith is our petrographic analysis for the above referenced material.

Rock types identified in the two samples examined are olivine basalt and vesicular olivine basalt breccia. Both rock types appear to be adequately stable for use as an erosion protection material, although the olivine basalt is the more competent of the two rock types.

This report recomends use of the olivine basalt for erosion protection material. Use of the vesicular olivine basalt breccia should be limited where possible.

This report concludes our current petrographic services. Please contact us if any questions arise.

Sincerely,
WESTERN TECHNOLOGIES INC.
Northern Arizona District

John Steven Davis

John Steven Davis
Geologist

INTRODUCTION

The purpose of the petrographic analysis of two samples of erosion protection material, to be used to stabilize processed uranium ore tailings, was to aid in determining the material's long-term stability. No standard for such examination has been set by the American Society for Testing and Materials (ASTM), but the ASTM standard C295-85, "Petrographic Examination of Aggregates for Concrete", was used as a general guide for the petrographic examination.

The material submitted in both samples consisted of hand-sample sized specimens (generally larger than 5" in the longest dimension) which were examined as such.

The petrographic examination included identification and description of the rock types represented in each sample, degree of weathering and general condition of particles. The observations were used to determine the general suitability and long-term stability of the samples when used as an erosion protection material.

ROCK DESCRIPTIONS

General Both samples were monolithologic and appear to be of the same lithology. Both samples appear to have been collected from the same lava flow with the vesicular sample being from the basal strata of the flow and the more massive basalt from the middle strata of the flow.

Sample 1

Olivine Basalt
Color: Fresh - dark gray to black
Weathered - dark rust to tan
Hard, porphyritic - aphanitic with pylotaxitic groundmass, phenocrysts to 1 cm, slightly to moderately vesicular with flattened vesicles up to 5mm long.
Composition: Olivine (bimodal, fayalite and a more magnesium rich variety) 97%, hypersthene pyroxene 3% (phenocryst assemblage), plagioclase microlites in groundmass.

Sample 2

Vesicular Olivine Basalt Breccia
Color: Fresh - black
Weathered - dark brown
Moderately hard to hard, porphyritic-aphanitic with pylotaxitic groundmass, phenocrysts to 8 mm, highly vesicular with flattened to ellipsoidal vesicles up to 1.2 cm in greatest dimension; breccia clasts are subrounded to angular, up to 15 cm in greatest dimension, and surrounded by matrix of same composition.
Composition: Olivine (bimodal, fayalite and a more magnesium rich variety) 97%, hypersthene pyroxene 3% (phenocryst assemblage), plagioclase microlites in groundmass

Weathering: Both rock types have been affected to some extent by weathering. The matrix of the vesicular olivine basalt breccia is weathered completely through while the clasts are relatively free of weathering effects. The olivine basalt exhibits few effects of the weathering process other than a weathering rind less than 0.5 mm thick.

The effects of weathering appear to be primarily a result of chemical action. The most obvious effect of chemical weathering has been the hydration and alteration of the olivines, especially of the magnesium rich variety. Minor oxidation of groundmass iron-bearing minerals also appears to have occurred.

Mechanical weathering seems to have had little affect on either sample submitted, although the vesicular olivine basalt breccia contains some fractures. Both samples appear to have been collected from an outcrop, thereby minimizing possibility of exhibiting mechanical weathering affects other than those due to freezing and thawing action.

General Physical Condition: The olivine basalt appears to be very competent while the vesicular olivine basalt breccia is less competent. The presence of vesicles in both samples does not appear to have introduced any extreme weakness resulting from mechanical weathering such as freezing. However, the highly vesicular basalt has undergone much more extensive chemical weathering which appears to have "softened" the matrix material.

Due to the crystalline nature of both samples, no well defined particle shapes were produced by crushing. In general the particle shapes were spindle shaped or irregularily shaped with no preferred dimensions.

CONCLUSIONS

Both samples appear to be acceptable for use as an erosion protection material. The highly vesicular olivine basalt breccia should be used as sparingly as possible due to its more advanced state of weathering, and the possibility of more rapid mechanical and chemical weathering due to high vesicularity. The less vesicular olivine basalt should be given preference for use as an erosion protection material.

UMTRA DOCUMENT REVIEW FORM

SECTION 1

Site: Tuba
Document: RAP and Final Design, Date: November 17, 1987
Commentor: NRC

Comment: Page ___

urface Hydrology

Calculation No. 18-890-02, Vol. V, Supplement, Final Design - April 1987.

Page 2 of 3 states that absorption should not be included in the specifications because absorption is not used in the oversizing equation. We do not agree, absorption must be included.

Dense Basalt - Absorption varies 1.5 percent to 2.1 percent
Vesicular Basalt - Absorption varies 3.5 percent to 3.8 percent.

On page 2 of calculation No. 18-890-03, Volume V Supplement, April 1987, the proposed rock source is Dense Basalt. Therefore, the absorption specification should be set at not more than about 2.5 percent.

SECTION 2

Response: Page ___ By: MKE Date: 12-17-87

We agree that absorption should be included in the specifications. Specification Section 02278, 2.1.C, Erosion Protection, will be revised to include the requirement that absorption shall not be more than 2.5 percent.

Plans for Implementation:

As stated above.

SECTION 3

Confirmation Of Implementation:

Checked By: ____________________, Date: ____________

Approved By: ____________________, Date: ____________

5057-TUB-R-01-01369-00
4422U/0131U

UMTRA DOCUMENT REVIEW FORM

SECTION 1

Site: Tuba
Document: Calc. No. 18-839-19 (stability), DATE: ____
Commentor: NRC (November 17, 1987)

Stability

Comment: Page 1

1. The design values presented in Appendix D of the RAP are not in agreement with the parameters used in the stability models. Specifically, please clarify why the undrained shear strength cohesion value of the radon barrier material was increased to 520 psf from 260 psf.

2. It is difficult to evaluate the results of the stability model as it appears that only selective results were submitted. Please submit the entire output for each computer run or as a minimum, the input data summary and minimum circle results for each separate run.

SECTION 2

Response: Page ____ By: MKE Date: 12/18/87

See Attachments A and B.

Plans for Implementation:

No further action is required.

SECTION 3

Confirmation of Implementation:

Checked by: ____, Date: ____

Approved by: ____, Date: ____

5057-TUB-R-01-01369-00
4422U/0131U

ATTACHMENT A

Comment No. 1

"Short-term" shear strength parameters for the radon barrier are defined by two UU (or "Q") tests performed on samples compacted to 95% of the Standard Proctor maximum dry density. Data for these tests and interpretation of the results is presented on pp. 92-93 in the MKE Calc. No. 18-839-01-00 (Tuba City Calculation Vol. I). See attached pages. The interpretation of results is presented with the reasonable and standard approach of a best-fit line through the p'_f-q_f data points. We believe that the design parameters are appropriate for the following reasons:

1. The "UU" cohesion of 520 psf is based on a best-fit curve through the data points. The TAC's value for "UU" cohesion of 260 psf is considered very conservative.

2. Based on our recommended values of 520 psf for "undrained cohesion" and 14 degrees for "undrained friction angle", the average shear strength of the radon barrier is about 640 psf (= C+ tan = 520 + (122 x 1.5 + 123 x 2.5) tan 14° = 640 psf). An undrained shear strength of 640 psf is typically a "medium" clay as per Terzaghi and Peck (pg. 30 in Soil Mechanics in Engineering Practice, Wiley & Sons, 1967). Because the radon barrier material at Tuba City will be compacted to 100% of the Standard Proctor maximum dry density, it should have a shear strength higher than that of a "medium" clay. Thus, the recommended UU shear strength parameters are considered appropriate.

3. The laboratory UU tests were performed at 95% of the Standard Proctor density; however, the radon barrier will be compacted in the field to 100% of the Standard Proctor density. This fact identifies the laboratory test results as conservative for the application in Tuba City analyses.

4. Finally, of most importance, the proposed stability of the stabilized embankment will not be controlled by the shear strength of the radon cover. Results of the stability analysis show that the critical slip

surface always passes predominantly through the in-situ tailings. Only a small portion of the slip surface (or less than 10% of the length of the slip arc) passes through the radon cover. See Calc. No. 18-839-19 (Tuba City Calculations Vol. III). The contribution of the radon cover to the overall resistance of the critical slip surface is therefore small, and so the resulting factor of safety is not very sensitive to the shear strength parameters of the radon barrier material. For all practical purposes, determination of the "exact" shear strength parameters of the radon cover may not be the most critical item for concern.

FROM VOL. I, CALCULATIONS, CALC. NO. 18-833-01-

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA - TUA
Feature EMBANKMENT DESIGN
Item MATERIAL PROPERTIES
Contract No. 4205
Designed E.C.TIR
Checked W.C.A.
Sheet 91
File No.
Date 1-7-86
Date 5-21-86

SHEAR STRENGTH OF GREASEWOOD LAKE MATERIAL

4 triaxial compression tests were carried out; 2 unconsolidated undrained tests (UU) and 2 consolidated undrained tests with pore pressure measurements ($\overline{CU}$). The UU tests were run on unsaturated specimens & the strength parameters (in terms of total stress) are appropriate for analyzing end-of-construction stability. The specimens in $\overline{CU}$ tests were saturated with backpressure, and the effective strength parameters obtained by these tests are appropriate for long-term stability analysis.

The UU test results are shown on pp. 92-93. From these tests, c = 0.26 TSF and ϕ = 14.4°.

The $\overline{CU}$ test results are shown on p. 94 and the $p_f' - q_f$ plot on p. 95. From these data, $c' = 0$, $\phi' = 30.6°$, say, 30.5°.

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA - TUB
Feature EMBANKMENT DESIGN
Item MATERIAL PROPERTIES

Contract No. 4005
Designed E.C. TSE
Checked W.C.A.

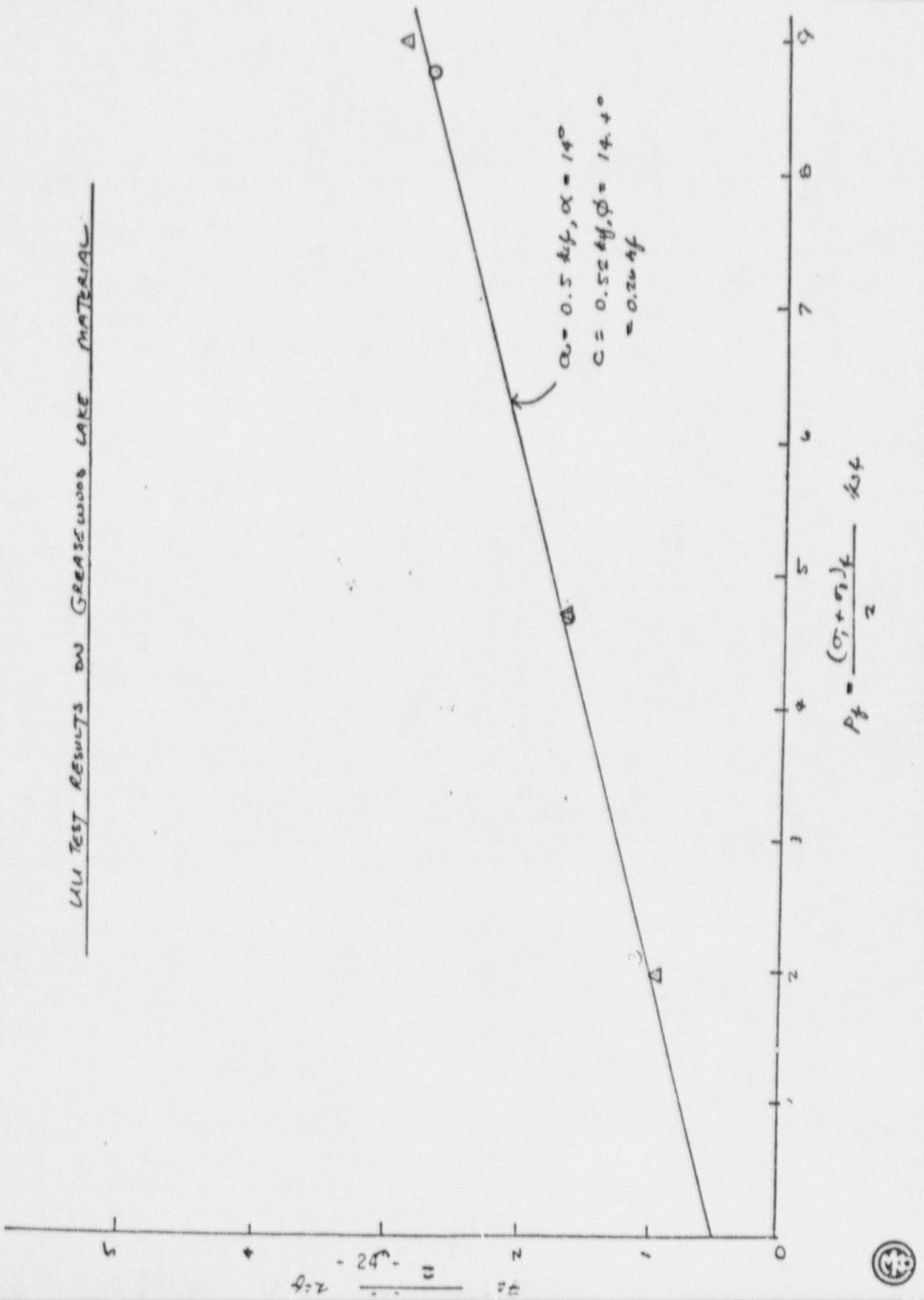
Sheet 92
File No.
Date 1-7-86
Date 5-21-86

SUMMARY OF UU TEST RESULTS - GREASEWOOD LAKE MAT'L

BORING NO.	DEPTH (FT)	σ_3 (ksf)	p_f (ksf)	q_f (ksf)	SYMBOL
TP 874	0-8.5	1.008 3.024 6.048	2.10 4.66 8.73	1.09 1.64 2.69	○
TP 872	1.0-7.0	1.008 3.024 6.048	1.98 4.69 8.96	0.97 1.67 2.91	△

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project: UMTRA - TIB	Contract No. 4005	Sheet 93	File No.
Feature: EMBANKMENT DESIGN	Designed: E.C. TIE	Date: 1-7-86	
Item: MATERIAL PROPERTIES	Checked: W.C.A.	Date: 1-21-86	



ATTACHMENT B

Comment No. 2

The entire computer output for critical sections x-x, y-y and z-z for both short-term and long-term cases, (each with seismic coefficients ranging from 0.0 to 0.3 or 0.35) is included in Calculation Volume III pages 28-71, 86-124, and 133-163. Minimum safety factors are presented for each case. Summaries of results are given on pages 24(a), 82-84 and 129-131.

Original copies of the computer input for the slope stability program cannot be produced due to the fact that we no longer own the computer which produced it. The table below summarizes the slope stability seismic analyses. (The input for the static cases are presented in Calc. No. 18-839-19, Calculation Vol. III for $S_1=S_2=0$.)

Section	Required Safety Factor	Design Safety Factor: Short-Term Case	Design Safety Factor: Long-Term Case
X	1.10	2.45	2.20
Y	1.10	1.74	1.88
[illegible]	1.10	2.35	1.95

The critical section for both short-term and long-term stability analyses is Y-Y. Therefore we have copied the old STABR program and retyped the input into our new computer to produce the input and corresponding output for the critical cases. The required seismic coefficients for the short-term and long-term stability analyses are 0.11 and 0.14, respectively. Therefore we have chosen to reproduce the closest values of 0.10 and 0.15 for short-term and long-term analyses, respectively. See the attached computer printouts.

In conclusion, the results verify those presented in Calculation Vol. III. The computer output for both our newly generated output and that in Calculation Vol. III are identical and complete; therefore we did not present only selective results.

Program STABR -- Version 2.84 (MS-DOS)

BISHOP MODIFIED AND/OR ORDINARY METHOD OF SLICES

UMTRA-TUBA CITY, STABR SHORT-TERM STABILITY CRITICAL CASE SECTION Y-Y

CONTROL DATA

NUMBER OF SPECIFIED CENTERS	0
NUMBER OF DEPTH LIMITING TANGENTS	1
NUMBER OF VERTICAL SECTIONS	12
NUMBER OF SOIL LAYER BOUNDARIES	6
NUMBER OF PORE PRESSURE LINES	0
NUMBER OF POINTS DEFINING COHESION PROFILE	0

SEISMIC COEFFICIENT S1,S2 = .10, .10

UNIT WEIGHT OF WATER = 62.40

SEARCH IS BASED ON BISHOP MODIFIED METHOD

SEARCH STARTS AT CENTER (300.0, 100.0) WITH FINAL GRID OF 20.0

ALL CIRCLES TANGENT TO DEPTH, 205.0,

GEOMETRY

SECTIONS	.0	200.0	212.0	240.0	258.0	286.0	409.0	430.0	434.0	448.0	450.0
T. CRACKS	174.0	174.0	176.4	182.0	185.6	191.2	215.8	220.0	220.0	220.0	220.0
W IN CRACK	174.0	174.0	176.4	182.0	185.6	191.2	215.8	220.0	220.0	220.0	220.0
BOUNDARY 1	174.0	174.0	176.4	182.0	185.6	191.2	215.8	220.0	220.0	220.0	220.0
BOUNDARY 2	175.5	175.5	177.9	183.5	187.1	192.7	217.3	221.5	222.0	222.0	220.0
BOUNDARY 3	180.5	180.5	182.9	188.5	192.1	197.7	222.0	222.0	222.0	222.0	220.0
BOUNDARY 4	222.0	222.0	222.0	214.0	214.0	222.0	222.0	222.0	222.0	222.0	220.0
BOUNDARY 5	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0	220.0
BOUNDARY 6	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0

SOIL PROPERTIES

LAYER	COHESION	FRICTION ANGLE	DENSITY
1	.0	31.0	122.0
2	520.0	14.0	123.0
3	520.0	14.0	121.0
4	.0	35.0	123.0
5	.0	40.0	136.0

BISHOP MODIFIED AND/OR ORDINARY METHOD OF SLICES

UMTRA-TUBA CITY, STABR SHORT-TERM STABILITY CRITICAL CASE SECTION Y-Y

NUMBER	TANGENT	RADIUS	(X) CENTER	(Y) CENTER	FS(BISHOP)	FS(OMS)
1	205.0	105.0	300.0	100.0	2.677	2.649
2	205.0	105.0	260.0	100.0	2.211	2.151
3	205.0	145.0	300.0	60.0	2.520	2.502
4	205.0	105.0	340.0	100.0	4.680	4.677
5	205.0	65.0	300.0	140.0	2.945	2.889

6	205.0	105.0	240.0	100.0	2.325	2.248
7	205.0	125.0	260.0	80.0	2.189	2.141
8	205.0	105.0	280.0	100.0	2.362	2.318
9	205.0	85.0	260.0	120.0	2.281	2.202
10	205.0	125.0	240.0	80.0	2.309	2.248
11	205.0	145.0	260.0	60.0	2.188	2.149
12	205.0	125.0	280.0	80.0	2.284	2.250
13	205.0	145.0	240.0	60.0	2.324	2.274
14	205.0	165.0	260.0	40.0	2.197	2.165
15	205.0	145.0	280.0	60.0	2.228	2.200
16	205.0	165.0	240.0	40.0	2.336	2.294
17	205.0	165.0	280.0	40.0	2.204	2.181
18	205.0	125.0	280.0	80.0	2.284	2.250
19	205.0	125.0	240.0	80.0	2.309	2.248

F.S. MINIMUM= 2.188 FOR THE CIRCLE OF CENTER (260.0, 60.0)

Program STABR -- Version 2.84 (MS-DOS)

BISHOP MODIFIED AND/OR ORDINARY METHOD OF SLICES

UMTRA-TUBA CITY, STABR LONG-TERM STABILITY CRITICAL CASE SECTION Y-Y

CONTROL DATA

NUMBER OF SPECIFIED CENTERS	0
NUMBER OF DEPTH LIMITING TANGENTS	1
NUMBER OF VERTICAL SECTIONS	12
NUMBER OF SOIL LAYER BOUNDARIES	6
NUMBER OF PORE PRESSURE LINES	0
NUMBER OF POINTS DEFINING COHESION PROFILE	0

SEISMIC COEFFICIENT S1,S2 = .10, .10

UNIT WEIGHT OF WATER = 62.40

SEARCH IS BASED ON BISHOP MODIFIED METHOD

SEARCH STARTS AT CENTER (240.0, 80.0) WITH FINAL GRID OF 20.0

ALL CIRCLES TANGENT TO DEPTH, 214.0,

GEOMETRY

SECTIONS	.0	200.0	212.0	240.0	258.0	286.0	409.0	430.0	434.0	448.0	450.0
T. CRACKS	174.0	174.0	176.4	182.0	185.6	191.2	215.8	220.0	220.0	220.0	220.0
W IN CRACK	174.0	174.0	176.4	182.0	185.6	191.2	215.8	220.0	220.0	220.0	220.0
BOUNDARY 1	174.0	174.0	176.4	182.0	185.6	191.2	215.8	220.0	220.0	220.0	220.0
BOUNDARY 2	175.5	175.5	177.9	183.5	187.1	192.7	217.3	221.5	222.0	222.0	220.0
BOUNDARY 3	180.5	180.5	182.9	188.5	192.1	197.7	222.0	222.0	222.0	222.0	220.0
BOUNDARY 4	222.0	222.0	222.0	214.0	214.0	222.0	222.0	222.0	222.0	222.0	220.0
BOUNDARY 5	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0
BOUNDARY 6	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0

SOIL PROPERTIES

LAYER	COHESION	FRICTION ANGLE	DENSITY
1	.0	31.0	122.0
2	520.0	14.0	123.0
3	520.0	14.0	121.0
4	.0	35.0	123.0
5	.0	40.0	136.0

BISHOP MODIFIED AND/OR ORDINARY METHOD OF SLICES

UMTRA-TUBA CITY, STABR LONG-TERM STABILITY CRITICAL CASE SECTION Y-Y

NUMBER	TANGENT	RADIUS	(X) CENTER	(Y) CENTER	FS(BISHOP)	FS(OMS)
1	214.0	134.0	240.0	80.0	2.166	2.078
2	214.0	134.0	200.0	80.0	2.797	2.657
3	214.0	174.0	240.0	40.0	2.154	2.092
4	214.0	134.0	280.0	80.0	1.951	1.892
5	214.0	94.0	240.0	120.0	2.244	2.104

6	214.0	134.0	260.0	80.0	2.023	1.950
7	214.0	154.0	280.0	60.0	1.931	1.882
8	214.0	134.0	300.0	80.0	2.036	1.990
9	214.0	114.0	280.0	100.0	1.999	1.926
10	214.0	154.0	260.0	60.0	2.017	1.956
11	214.0	174.0	280.0	40.0	1.926	1.884
12	214.0	154.0	300.0	60.0	1.983	1.944
13	214.0	174.0	260.0	40.0	2.020	1.968
14	214.0	194.0	280.0	20.0	1.928	1.892
15	214.0	174.0	300.0	40.0	1.945	1.912
16	214.0	194.0	260.0	20.0	2.027	1.983
17	214.0	194.0	300.0	20.0	1.926	1.898
18	214.0	154.0	300.0	60.0	1.983	1.944
19	214.0	154.0	260.0	60.0	2.017	1.956

F.S. MINIMUM= 1.926 FOR THE CIRCLE OF CENTER (280.0, 40.0)

Program STABR -- Version 2.84 (MS-DOS)

BISHOP MODIFIED AND/OR ORDINARY METHOD OF SLICES

UMTRA-TUBA CITY, STABR LONG-TERM STABILITY CRITICAL CASE SECTION Y-Y

CONTROL DATA

NUMBER OF SPECIFIED CENTERS	0
NUMBER OF DEPTH LIMITING TANGENTS	1
NUMBER OF VERTICAL SECTIONS	12
NUMBER OF SOIL LAYER BOUNDARIES	6
NUMBER OF PORE PRESSURE LINES	0
NUMBER OF POINTS DEFINING COHESION PROFILE	0

SEISMIC COEFFICIENT S1,S2 = .10, .10

UNIT WEIGHT OF WATER = 62.40

SEARCH IS BASED ON BISHOP MODIFIED METHOD

SEARCH STARTS AT CENTER (260.0, 60.0) WITH FINAL GRID OF 20.0

ALL CIRCLES TANGENT TO DEPTH, 222.0,

GEOMETRY

SECTIONS	.0	200.0	212.0	240.0	258.0	286.0	409.0	430.0	434.0	448.0	450.0
T. CRACKS	174.0	174.0	176.4	182.0	185.6	191.2	215.8	220.0	220.0	220.0	220.0
W IN CRACK	174.0	174.0	176.4	182.0	185.6	191.2	215.8	220.0	220.0	220.0	220.0
BOUNDARY 1	174.0	174.0	176.4	182.0	185.6	191.2	215.8	220.0	220.0	220.0	220.0
BOUNDARY 2	175.5	175.5	177.9	183.5	187.1	192.7	217.3	221.5	220.0	220.0	220.0
BOUNDARY 3	180.5	180.5	182.9	188.5	192.1	197.7	222.0	222.0	222.0	222.0	220.0
BOUNDARY 4	222.0	222.0	222.0	214.0	214.0	222.0	222.0	222.0	222.0	222.0	220.0
BOUNDARY 5	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0	220.0
BOUNDARY 6	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0

SOIL PROPERTIES

LAYER	COHESION	FRICTION ANGLE	DENSITY
1	.0	31.0	122.0
2	520.0	14.0	123.0
3	520.0	14.0	121.0
4	.0	35.0	123.0
5	.0	40.0	136.0

BISHOP MODIFIED AND/OR ORDINARY METHOD OF SLICES

UMTRA-TUBA CITY, STABR LONG-TERM STABILITY CRITICAL CASE SECTION Y-Y

NUMBER	TANGENT	RADIUS	(X) CENTER	(Y) CENTER	FS(BISHOP)	FS(OMS)
1	222.0	162.0	260.0	60.0	2.523	2.439
2	222.0	162.0	220.0	60.0	2.985	2.824
3	222.0	202.0	260.0	20.0	2.490	2.428
4	222.0	162.0	300.0	60.0	2.078	2.032
5	222.0	122.0	260.0	100.0	2.614	2.490

6	222.0	162.0	280.0	60.0	2.316	2.257
7	222.0	182.0	300.0	40.0	2.078	2.040
8	222.0	162.0	320.0	60.0	1.871	1.824
9	222.0	142.0	300.0	80.0	2.095	2.037
10	222.0	182.0	320.0	40.0	1.831	1.790
11	222.0	162.0	340.0	60.0	1.966	1.930
12	222.0	142.0	320.0	80.0	1.920	1.865
13	222.0	182.0	300.0	40.0	2.078	2.040
14	222.0	202.0	320.0	20.0	1.799	1.764
15	222.0	182.0	340.0	40.0	1.926	1.896
16	222.0	202.0	300.0	20.0	2.087	2.056
17	222.0	222.0	320.0	.0	1.782	1.751
18	222.0	202.0	340.0	20.0	1.892	1.866
19	222.0	222.0	300.0	.0	2.101	2.076
20	222.0	242.0	320.0	-20.0	1.774	1.746
21	222.0	222.0	340.0	.0	1.862	1.840
22	222.0	242.0	300.0	-20.0	2.112	2.092
23	222.0	262.0	320.0	-40.0	1.847	1.828
24	222.0	242.0	340.0	-20.0	1.833	1.813
25	222.0	262.0	300.0	-40.0	2.122	2.105
26	222.0	262.0	340.0	-40.0	1.810	1.792
27	222.0	222.0	340.0	.0	1.862	1.840
28	222.0	222.0	300.0	.0	2.101	2.076

F.S. MINIMUM= 1.774 FOR THE CIRCLE OF CENTER (320.0, -20.0)

Program STABR -- Version 2.84 (MS-DOS)

BISHOP MODIFIED AND/OR ORDINARY METHOD OF SLICES

UMTRA-TUBA CITY, STABR LONG-TERM STABILITY CRITICAL CASE SECTION Y-Y

CONTROL DATA

NUMBER OF SPECIFIED CENTERS	0
NUMBER OF DEPTH LIMITING TANGENTS	1
NUMBER OF VERTICAL SECTIONS	12
NUMBER OF SOIL LAYER BOUNDARIES	6
NUMBER OF PORE PRESSURE LINES	0
NUMBER OF POINTS DEFINING COHESION PROFILE	0

SEISMIC COEFFICIENT S1,S2 = .10, .10

UNIT WEIGHT OF WATER = 62.40

SEARCH IS BASED ON BISHOP MODIFIED METHOD

SEARCH STARTS AT CENTER (300.0, .0) WITH FINAL GRID OF 20.0

ALL CIRCLES TANGENT TO DEPTH, 234.0,

GEOMETRY

SECTIONS	.0	200.0	212.0	240.0	258.0	286.0	409.0	430.0	434.0	448.0	450.0
T. CRACKS	174.0	174.0	176.4	182.0	185.6	191.2	215.8	220.0	220.0	220.0	220.0
W IN CRACK	174.0	174.0	176.4	182.0	185.6	191.2	215.8	220.0	220.0	220.0	220.0
BOUNDARY 1	174.0	174.0	176.4	182.0	185.6	191.2	215.8	220.0	220.0	220.0	220.0
BOUNDARY 2	175.5	175.5	177.9	183.5	187.1	192.7	217.3	221.5	222.0	222.0	220.0
BOUNDARY 3	180.5	180.5	182.9	188.5	192.1	197.7	222.0	222.0	222.0	222.0	220.0
BOUNDARY 4	222.0	222.0	222.0	214.0	214.0	222.0	222.0	222.0	222.0	222.0	220.0
BOUNDARY 5	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0
BOUNDARY 6	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0

SOIL PROPERTIES

LAYER	COHESION	FRICTION ANGLE	DENSITY
1	.0	31.0	122.0
2	520.0	14.0	123.0
3	520.0	14.0	121.0
4	.0	35.0	123.0
5	.0	40.0	136.0

BISHOP MODIFIED AND/OR ORDINARY METHOD OF SLICES

UMTRA-TUBA CITY, STABR LONG-TERM STABILITY CRITICAL CASE SECTION Y-Y

NUMBER	TANGENT	RADIUS	(X) CENTER	(Y) CENTER	FS(BISHOP)	FS(OMS)
1	234.0	234.0	300.0	.0	2.691	2.597
2	234.0	234.0	260.0	.0	3.088	2.969
3	234.0	274.0	300.0	-40.0	2.683	2.608
4	234.0	234.0	340.0	.0	2.526	2.452
5	234.0	194.0	300.0	40.0	2.722	2.600

6	234.0	234.0	320.0	.0	2.594	2.509
7	234.0	254.0	340.0	-20.0	2.510	2.445
8	234.0	234.0	360.0	.0	2.379	2.323
9	234.0	214.0	340.0	20.0	2.556	2.470
10	234.0	254.0	360.0	-20.0	2.425	2.374
11	234.0	234.0	380.0	.0	2.446	2.396
12	234.0	214.0	360.0	20.0	2.421	2.356
13	234.0	254.0	340.0	-20.0	2.510	2.445
14	234.0	254.0	380.0	-20.0	2.417	2.373
15	234.0	214.0	380.0	20.0	2.478	2.421
16	234.0	214.0	340.0	20.0	2.556	2.470

F.S. MINIMUM= 2.379 FOR THE CIRCLE OF CENTER (360.0, .0)

Program STABR -- Version 2.84 (MS-DOS)

BISHOP MODIFIED AND/OR ORDINARY METHOD OF SLICES

UMTRA-TUBA CITY, STABR LONG-TERM STABILITY CRITICAL CASE SECTION Y-Y

CONTROL DATA

NUMBER OF SPECIFIED CENTERS	0
NUMBER OF DEPTH LIMITING TANGENTS	1
NUMBER OF VERTICAL SECTIONS	12
NUMBER OF SOIL LAYER BOUNDARIES	6
NUMBER OF PORE PRESSURE LINES	0
NUMBER OF POINTS DEFINING COHESION PROFILE	0

SEISMIC COEFFICIENT S1,S2 = .15, .15

UNIT WEIGHT OF WATER = 62.40

SEARCH IS BASED ON BISHOP MODIFIED METHOD

SEARCH STARTS AT CENTER (300.0, 100.0) WITH FINAL GRID OF 20.0

ALL CIRCLES TANGENT TO DEPTH, 205.0,

GEOMETRY

SECTIONS	.0	200.0	212.0	240.0	258.0	286.0	409.0	430.0	434.0	448.0	450.0
T. CRACKS	174.0	174.0	176.4	182.0	185.6	191.2	215.8	220.0	220.0	220.0	220.0
W IN CRACK	174.0	174.0	176.4	182.0	185.6	191.2	215.8	220.0	220.0	220.0	220.0
BOUNDARY 1	174.0	174.0	176.4	182.0	185.6	191.2	215.8	220.0	220.0	220.0	220.0
BOUNDARY 2	175.5	175.5	177.9	183.5	187.1	192.7	217.3	221.5	222.0	222.0	220.0
BOUNDARY 3	180.5	180.5	182.9	188.5	192.1	197.7	222.0	222.0	222.0	222.0	220.0
BOUNDARY 4	222.0	222.0	222.0	214.0	214.0	222.0	222.0	222.0	222.0	222.0	220.0
BOUNDARY 5	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0
BOUNDARY 6	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0

SOIL PROPERTIES

LAYER	COHESION	FRICTION ANGLE	DENSITY
1	.0	31.0	122.0
2	.0	32.0	122.0
3	.0	32.0	117.0
4	.0	35.0	123.0
5	.0	40.0	136.0

BISHOP MODIFIED AND/OR ORDINARY METHOD OF SLICES

UMTRA-TUBA CITY, STABR LONG-TERM STABILITY CRITICAL CASE SECTION Y-Y

NUMBER	TANGENT	RADIUS	(X) CENTER	(Y) CENTER	FS(BISHOP)	FS(OMS)
1	205.0	105.0	300.0	100.0	1.933	1.883
2	205.0	105.0	260.0	100.0	2.125	2.007
3	205.0	145.0	300.0	60.0	1.883	1.859
4	205.0	105.0	340.0	100.0	1.804	1.819
5	205.0	65.0	300.0	140.0	2.050	1.941

6	205.0	105.0	320.0	100.0	1.867	1.851
7	205.0	125.0	340.0	80.0	1.797	1.816
8	205.0	105.0	360.0	100.0	1.680	1.724
9	205.0	85.0	340.0	120.0	1.814	1.824
10	205.0	125.0	360.0	80.0	1.682	1.725
11	205.0	105.0	380.0	100.0	CIRCLE	OUTSIDE SLOPE
12	205.0	85.0	360.0	120.0	1.677	1.722
13	205.0	85.0	340.0	120.0	1.814	1.824
14	205.0	85.0	380.0	120.0	CIRCLE	OUTSIDE SLOPE
15	205.0	65.0	360.0	140.0	1.671	1.719
16	205.0	65.0	340.0	140.0	1.830	1.832
17	205.0	65.0	380.0	140.0	CIRCLE	OUTSIDE SLOPE
18	205.0	45.0	360.0	160.0	CIRCLE	OUTSIDE SLOPE
19	205.0	85.0	340.0	120.0	1.814	1.824
20	205.0	85.0	380.0	120.0	CIRCLE	OUTSIDE SLOPE
21	205.0	45.0	380.0	160.0	CIRCLE	OUTSIDE SLOPE
22	205.0	45.0	340.0	160.0	1.863	1.847

F.S. MINIMUM= 1.671 FOR THE CIRCLE OF CENTER (360.0, 140.0)

Program STABR -- Version 2.84 (MS-DOS)

BISHOP MODIFIED AND/OR ORDINARY METHOD OF SLICES

UMTRA-TUBA CITY, STABR LONG-TERM STABILITY CRITICAL CASE SECTION Y-Y

CONTROL DATA

NUMBER OF SPECIFIED CENTERS	0
NUMBER OF DEPTH LIMITING TANGENTS	1
NUMBER OF VERTICAL SECTIONS	12
NUMBER OF SOIL LAYER BOUNDARIES	6
NUMBER OF PORE PRESSURE LINES	0
NUMBER OF POINTS DEFINING COHESION PROFILE	0

SEISMIC COEFFICIENT S1,S2 = .15, .15

UNIT WEIGHT OF WATER = 62.40

SEARCH IS BASED ON BISHOP MODIFIED METHOD

SEARCH STARTS AT CENTER (340.0, 160.0) WITH FINAL GRID OF 20.0

ALL CIRCLES TANGENT TO DEPTH, 214.0,

GEOMETRY

SECTIONS	.0	200.0	212.0	240.0	258.0	286.0	409.0	430.0	434.0	448.0	450.0
T. CRACKS	174.0	174.0	176.4	182.0	185.6	191.2	215.8	220.0	220.0	220.0	220.0
W IN CRACK	174.0	174.0	176.4	182.0	185.6	191.2	215.8	220.0	220.0	220.0	220.0
BOUNDARY 1	174.0	174.0	176.4	182.0	185.6	191.2	215.8	220.0	220.0	220.0	220.0
BOUNDARY 2	175.5	175.5	177.9	183.5	187.1	192.7	217.3	221.5	222.0	222.0	220.0
BOUNDARY 3	180.5	180.5	182.9	188.5	192.1	197.7	222.0	222.0	222.0	222.0	220.0
BOUNDARY 4	222.0	222.0	222.0	214.0	214.0	222.0	222.0	222.0	222.0	222.0	220.0
BOUNDARY 5	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0
BOUNDARY 6	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0

SOIL PROPERTIES

LAYER	COHESION	FRICTION ANGLE	DENSITY
1	.0	31.0	122.0
2	.0	32.0	122.0
3	.0	32.0	117.0
4	.0	35.0	123.0
5	.0	40.0	136.0

BISHOP MODIFIED AND/OR ORDINARY METHOD OF SLICES

UMTRA-TUBA CITY, STABR LONG-TERM STABILITY CRITICAL CASE SECTION Y-Y

NUMBER	TANGENT	RADIUS	(X) CENTER	(Y) CENTER	FS(BISHOP)	FS(OMS)
1	214.0	54.0	340.0	160.0	2.155	1.993
2	214.0	54.0	300.0	160.0	2.492	2.161
3	214.0	94.0	340.0	120.0	1.974	1.903
4	214.0	54.0	380.0	160.0	1.877	1.855
5	214.0	14.0	340.0	200.0	CENTER BELOW INTERPOLATED CR	

6	214.0	54.0	360.0	160.0	2.010	1.921
7	214.0	74.0	380.0	140.0	1.844	1.839
8	214.0	54.0	400.0	160.0	1.694	1.730
9	214.0	34.0	380.0	180.0	1.951	1.892
10	214.0	74.0	400.0	140.0	1.694	1.730
11	214.0	54.0	420.0	160.0	CIRCLE	OUTSIDE SLOPE
12	214.0	34.0	400.0	180.0	1.694	1.730
13	214.0	74.0	380.0	140.0	1.844	1.839
14	214.0	94.0	400.0	120.0	1.736	1.773
15	214.0	74.0	420.0	140.0	CIRCLE	OUTSIDE SLOPE
16	214.0	94.0	380.0	120.0	1.826	1.830
17	214.0	94.0	420.0	120.0	CIRCLE	OUTSIDE SLOPE
18	214.0	54.0	420.0	160.0	CIRCLE	OUTSIDE SLOPE
19	214.0	54.0	380.0	160.0	1.877	1.855

F.S. MINIMUM= 1.694 FOR THE CIRCLE OF CENTER (400.0, 140.0)

Program STABR -- Version 2.84 (MS-DOS)

BISHOP MODIFIED AND/OR ORDINARY METHOD OF SLICES

UMTRA-TUBA CITY, STABR LONG-TERM STABILITY CRITICAL CASE SECTION Y-Y

CONTROL DATA

NUMBER OF SPECIFIED CENTERS	0
NUMBER OF DEPTH LIMITING TANGENTS	1
NUMBER OF VERTICAL SECTIONS	12
NUMBER OF SOIL LAYER BOUNDARIES	6
NUMBER OF PORE PRESSURE LINES	0
NUMBER OF POINTS DEFINING COHESION PROFILE	0

SEISMIC COEFFICIENT S1,S2 = .15, .15

UNIT WEIGHT OF WATER = 62.40

SEARCH IS BASED ON BISHOP MODIFIED METHOD

SEARCH STARTS AT CENTER (400.0,-100.0) WITH FINAL GRID OF 20.0

ALL CIRCLES TANGENT TO DEPTH, 222.0,

GEOMETRY

SECTIONS	.0	200.0	212.0	240.0	258.0	286.0	409.0	430.0	434.0	448.0	450.0
T. CRACKS	174.0	174.0	176.4	182.0	185.6	191.2	215.8	220.0	220.0	220.0	220.0
W IN CRACK	174.0	174.0	176.4	182.0	185.6	191.2	215.8	220.0	220.0	220.0	220.0
BOUNDARY 1	174.0	174.0	176.4	182.0	185.6	191.2	215.8	220.0	220.0	220.0	220.0
BOUNDARY 2	175.5	175.5	177.9	183.5	187.1	192.7	217.3	221.5	222.0	222.0	220.0
BOUNDARY 3	180.5	180.5	182.9	188.5	192.1	197.7	222.0	222.0	222.0	222.0	220.0
BOUNDARY 4	222.0	222.0	222.0	214.0	214.0	222.0	222.0	222.0	222.0	222.0	220.0
BOUNDARY 5	234.0	234.0	234.0	234.0	234.0	234.0	234.0	222.0	222.0	222.0	220.0
BOUNDARY 6	300.0	300.0	300.0	300.0	300.0	300.0	300.0	234.0	234.0	234.0	234.0
								300.0	300.0	300.0	300.0

SOIL PROPERTIES

LAYER	COHESION	FRICTION ANGLE	DENSITY
1	.0	31.0	122.0
2	.0	32.0	122.0
3	.0	32.0	117.0
4	.0	35.0	123.0
5	.0	40.0	136.0

BISHOP MODIFIED AND/OR ORDINARY METHOD OF SLICES

UMTRA-TUBA CITY, STABR LONG-TERM STABILITY CRITICAL CASE SECTION Y-Y

NUMBER	TANGENT	RADIUS	(X) CENTER	(Y) CENTER	FS(BISHOP)	FS(OMS)
1	222.0	322.0	400.0	-100.0	1.801	1.819
2	222.0	322.0	360.0	-100.0	1.847	1.845
3	222.0	362.0	400.0	-140.0	1.797	1.818
4	222.0	322.0	440.0	-100.0	1.913	1.938
5	222.0	282.0	400.0	-60.0	1.806	1.821

6	222.0	362.0	380.0	-140.0	1.813	1.825
7	222.0	382.0	400.0	-160.0	1.796	1.817
8	222.0	362.0	420.0	-140.0	1.806	1.833
9	222.0	342.0	400.0	-120.0	1.799	1.818
10	222.0	382.0	380.0	-160.0	1.813	1.826
11	222.0	402.0	400.0	-180.0	1.795	1.816
12	222.0	382.0	420.0	-160.0	1.805	1.831
13	222.0	402.0	380.0	-180.0	1.817	1.831
14	222.0	422.0	400.0	-200.0	1.793	1.816
15	222.0	402.0	420.0	-180.0	1.803	1.830
16	222.0	422.0	380.0	-200.0	1.824	1.839
17	222.0	442.0	400.0	-220.0	1.792	1.815
18	222.0	422.0	420.0	-200.0	1.801	1.829
19	222.0	442.0	380.0	-220.0	1.832	1.849
20	222.0	462.0	400.0	-240.0	1.794	1.817
21	222.0	442.0	420.0	-220.0	1.800	1.828
22	222.0	462.0	380.0	-240.0	1.842	1.860
23	222.0	462.0	420.0	-240.0	1.799	1.827
24	222.0	422.0	420.0	-200.0	1.801	1.829
25	222.0	422.0	380.0	-200.0	1.824	1.839

F.S. MINIMUM= 1.792 FOR THE CIRCLE OF CENTER (400.0,-220.0)

Program STABR -- Version 2.84 (MS-DOS)

BISHOP MODIFIED AND/OR ORDINARY METHOD OF SLICES

UMTRA-TUBA CITY, STABR LONG-TERM STABILITY CRITICAL CASE SECTION Y-Y

CONTROL DATA

NUMBER OF SPECIFIED CENTERS	0
NUMBER OF DEPTH LIMITING TANGENTS	1
NUMBER OF VERTICAL SECTIONS	12
NUMBER OF SOIL LAYER BOUNDARIES	6
NUMBER OF PORE PRESSURE LINES	0
NUMBER OF POINTS DEFINING COHESION PROFILE	0

SEISMIC COEFFICIENT S1,S2 = .15, .15

UNIT WEIGHT OF WATER = 62.40

SEARCH IS BASED ON BISHOP MODIFIED METHOD

SEARCH STARTS AT CENTER (420.0,-100.0) WITH FINAL GRID OF 20.0

ALL CIRCLES TANGENT TO DEPTH, 234.0,

GEOMETRY

SECTIONS	.0	200.0	212.0	240.0	258.0	286.0	409.0	430.0	434.0	448.0	450.0
T. CRACKS	174.0	174.0	176.4	182.0	185.6	191.2	215.8	220.0	220.0	220.0	220.0
W IN CRACK	174.0	174.0	176.4	182.0	185.6	191.2	215.8	220.0	220.0	220.0	220.0
BOUNDARY 1	174.0	174.0	176.4	182.0	185.6	191.2	215.8	220.0	220.0	220.0	220.0
BOUNDARY 2	175.5	175.5	177.9	183.5	187.1	192.7	217.3	221.5	222.0	222.0	220.0
BOUNDARY 3	180.5	180.5	182.9	188.5	192.1	197.7	222.0	222.0	222.0	222.0	220.0
BOUNDARY 4	222.0	222.0	222.0	214.0	214.0	222.0	222.0	222.0	222.0	222.0	220.0
BOUNDARY 5	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0
BOUNDARY 6	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0

SOIL PROPERTIES

LAYER	COHESION	FRICTION ANGLE	DENSITY
1	.0	31.0	122.0
2	.0	32.0	122.0
3	.0	32.0	117.0
4	.0	35.0	123.0
5	.0	40.0	136.0

BISHOP MODIFIED AND/OR ORDINARY METHOD OF SLICES

UMTRA-TUBA CITY, STABR LONG-TERM STABILITY CRITICAL CASE SECTION Y-Y

NUMBER	TANGENT	RADIUS	(X) CENTER	(Y) CENTER	FS(BISHOP)	FS(OMS)
1	234.0	334.0	420.0	-100.0	2.301	2.261
2	234.0	334.0	380.0	-100.0	2.118	2.082
3	234.0	374.0	420.0	-140.0	2.271	2.238
4	234.0	334.0	460.0	-100.0	2.845	2.786
5	234.0	294.0	420.0	-60.0	2.335	2.286

6	234.0	334.0	360.0	-100.0	2.161	2.124
7	234.0	354.0	380.0	-120.0	2.120	2.089
8	234.0	334.0	400.0	-100.0	2.177	2.141
9	234.0	314.0	380.0	-80.0	2.120	2.080
10	234.0	354.0	360.0	-120.0	2.171	2.139
11	234.0	354.0	400.0	-120.0	2.168	2.135
12	234.0	314.0	400.0	-80.0	2.188	2.148
13	234.0	314.0	360.0	-80.0	2.153	2.112

F.S. MINIMUM= 2.118 FOR THE CIRCLE OF CENTER (380.0,-100.0)

UMTRA DOCUMENT REVIEW FORM

SECTION 1

Site: Tuba , DATE: ______

Document: Calc. No. 18-839-19 (Stability)

Commentor: NRC (November 17, 1987)

Comment: Page 1,2

3. The evaluation of the results did not consider shallow sloughing failures of the cover systems to be of any significance. As the integrity of the cover system will be instrumental in supporting the design life of the facility, you will need to submit an evaluation of modeling of shallow failure circles which would disrupt the cover system.

4. A dynamic analysis was not submitted. Please address why a pseudo-static analysis for the facility was deemed appropriate.

SECTION 2

Response: Page ______ By: MKE Date: 12/17/87

See Attachments C and D.

Plans for Implementation:

No action is required.

SECTION 3

Confirmation of Implementation:

Checked by: ______, Date: ______

Approved by: ______, Date: ______

ATTACHMENT C

Comment No. 3

The results of each case for Sections x, y and z, where the minimum safety factor is characterized by shallow sloughing, are tabulated on the attached Table A. All cases of sloughing occurred in the long-term stability analyses.

The required minimum long-term safety factors for static and dynamic stability cases are 1.50 and 1.10, respectively. The seismic coefficients for static and dynamic analyses are 0.00 and 0.14 respectively. All of the minimum safety factors for cases with seismic coefficients between 0.0U and 0.15 are greater than 1.50 for failure by shallow sloughing. Failure by shallow sloughing need not, therefore be considered a problem.

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA-SPOOK
Feature STABILITY ANALYSIS
Item NRC COMMENTS & RESPONSE
Contract No. 505707
Designed RMB
Checked
Sheet
File No.
Date 12-8-8
Date

TABLE A

SECTION	SEISMIC COEFFICIENT $(K = \varsigma = S_2)$	SAFETY FACTOR	VOLUME III, CALC. NO. 18-839
X	STATIC CASE 0.00	2.905	pg. 52
	Falls within range of required seismic coefficients 0.10	1.928	pg 55
	0.15	1.640	pg 58
	0.20	1.424	pg 61
Y	STATIC CASE 0.00	3.014	pg. 105
	0.00	3.053	pg. 106
	Falls within range of required seismic coefficients 0.10	1.970	pg. 109
	0.10	1.996	pg. 110
	0.15	1.671	pg. 113
	0.15	1.694	pg. 114
	0.20	1.448	pg. 117
	0.20	1.468	pg. 118
	0.30	1.134	pg. 121
	0.30	1.151	pg. 122
Z	STATIC CASE 0.00	2.985	
	0.00	3.136	
	Falls within range of required seismic coefficients 0.10	1.955	
	0.10	2.033	
	0.15	1.660	
	0.15	1.720	
	0.20	1.438	
	0.20	1.486	
	0.30	1.127	
	0.30	1.162	

ATTACHMENT D

Comment No. 4.

Pseudo-static rather than dynamic analysis is deemed appropriate for the slope stability studies at the Tuba City site. The rationalization for using pseudo-static analyses is that the embankment materials will not exhibit significant loss of strength during earthquakes, a criterion which can be rerefenced to H.B. Seed's 1979 Rankine Lecture, "Considerations in the earthquake resistant design of earth and rockfill dams." Seed's discussion suggests that clays and clayey soils , dry or moist cohesionless soils, or extremely dense cohesionless soils do not lose significant strength during earthquakes, and therefore can be analyzed with the pseudo-static analysis. The tailings and contaminated soil will be compacted at or near the optimum water content beneath the radon barrier and more than 20 ft. above the water table. In the embankment these materials will be compacted to 90% of the Standard Proctor Density. Therefore, the tailings and contaminated material both will not be loose and will have no potential to become saturated. Please refer to our response to liquefaction Comment 1. The radon barrier material is cohesive and shall be compacted to 100% of the Standard Proctor Density between 0% and 3% of the optimum moisture content. So the radon barrier material is cohesive or clayey and, in addition, will be very dense in the embankment.

The possibility of development of significant pore water pressures during earthquakes in these materials is therefore very remote, as supported by the liquefaction analysis and by our response to comments on liquefaction. There is no possibility that these materials will "lose significant strength during earthquakes"; and therefore pseudo-static analysis is appropriate in this case.

As can be reviewed in Calculation Volumes I and V (Supplement), conservative values have been selected for soil parameters. In addition, the most critical pseudo-static case for the slope stability evaluation results in short-term and long-term safety factors of 1.74 and 1.88 which are well over the required minimum value of 1.10 (i.e., 1.74 - 1.10 = 158%). This high safety factor implies that soil parameters of less strength than utilized in the analysis would still produce an acceptable safety factor.

UMTRA DOCUMENT REVIEW FORM

SECTION 1

Site: Tuba

Document: RAP and Final Design, Date: Nov. 17, 1987

Commentor: NRC

Comment: Page 2

Liquefaction

1. You submitted four different liquefaction analyses using four different methods. Of the four, three (Koizumis, RD, Seed-Idriss) indicate that material may be liquefiable and only one (Chinese) shows no liquefaction. How does this support the conclusion that there will be no liquefaction concerns?

2. Your analyses utilized average SPT blowcounts, factors of safety, clay contents, inc. Liquefaction studies generally search for any liquefiable zones, rather than overall evaluating stability. Please discuss why the use of average values is appropriate.

SECTION 2

Response: Page ________ By: MKE Date: 12-17-87

See attached Comment Response

Plans for Implementation:

SECTION 3

Confirmation Of Implementation:

Checked By: ____________________, Date: ____________

Approved By: ____________________, Date: ____________

5057-TUB-R-01-01369-00
4422U/0131U

Comment Response

Koizumi's Method and the Relative Density Comparison indicate that under fully saturated conditions, limited zones in the Acid pile and the Carbonate Pile #1 may possess liquefaction potential. The Seed and Idriss Simplified Method, a more precise method than the two mentioned above, was used to further review the liquefaction potential of these zones. This method indicates that only one six inch interval of all the areas investigated had a factor of safety below the 1.5 (but greater than 1.0) considered acceptable for fully saturated conditions.

The liquefaction calculation for the Tuba City site may be moot since, as discussed in the introduction to Calculation No. 18-839-18, the materials at Tuba City site are unsaturated and the groundwater level is well below the tailings pile foundation. Saturation of the materials in the tailings embankment and the embankment foundation could only occur from rainwater percolating downward through the cover system. This possibility will be effectively removed by stringent control exercised over the construction of the radon barrier layer. To effectively eliminate infiltration, measures will be taken to assure and verify that a conductivity of 1×10^{-8} cm./sec. or less will be achieved by the radon barrier layer for a long period of time, i.e., 1000 years. Saturation, and the possibilities for liquefaction potential, are therefore not realistic concerns for this site.

UMTRA DOCUMENT REVIEW FORM

SECTION 1

Site: Tuba
Document: RAP and Final Design, Date: Nov. 17, 1987
Commentor: NRC

Comment: Page 2

Liquefaction

3. An in-house analysis identified two layers of foundation material in TAC boring 820 as possibly being liquefiable. The NRC analysis, as in your analyses, was required to make certain assumptions such as saturation and sand densities. Please re-evaluate the soils in this area.

4. The areas identified as "sand" in figure 3.2 of the RAP would generally be the areas studied for liquefaction. There was, however, only one boring, TAC boring 820, in these areas. Please establish that the "sand" areas cannot, over the design life, become saturated or submit additional borings and the associated analyses.

SECTION 2

Response: Page ______ By: MKE Date: 12-17-87

See response to Comments 1 and 2.

Plans for Implementation:

SECTION 3

Confirmation Of Implementation:

Checked By: ______________________, Date: ______________

Approved By: ______________________, Date: ______________

UMTRA DOCUMENT REVIEW FORM

SECTION 1

Site: Tuba, Date: Nov. 17, 1987
Document: RAP and Final Design
Commentor: NRC

Comment: Page 2

Settlement

1. The in-house review of the settlement calculations was performed by randomly selecting several profiles and verifying your CONSOL modeling. After discussions with the TAC due to the numerical type of errors in the modeling, it is recommended that the calculation be revised by correcting several of the models. The impact of the corrections may demonstrate conservatism or may demonstrate the need for additional study. You will need to determine the impact on primary and differential settlement of correcting the models and, if necessary, submit a corrected calculation that has been independently checked.

SECTION 2

Response: Page ________ By: MKE Date: 12/14/87

See attached Comment Response.

Plans for Implementation:

SECTION 3

Confirmation Of Implementation:

Checked By: ______________________, Date: ______________

Approved By: ______________________, Date: ______________

5057-TUB-R-01-01369-00
4422U/0131U

Comment Response

Discussions with TAC and NRC personnel indicates the "numerical type of errors" in the settlement calculation modeling is a reference to the values of the preconsolidation pressures used in the analysis. The following paragraph discusses the procedure used in determining these values for analysis of a typical profile.

The following preconsolidation pressure values were used for the slime sublayers of Profile 205, as shown in Calculation No. 18-839-17-01, Sheet 87b:

Sublayer	Depth to Center of Sublayer (ft.)	Preconsolidation Pressure (psf)
4	13.00	1600.00
6	19.00	2000.00
7	22.00	2300.00
8	25.00	2600.00
9	26.75	2800.00

Note that sublayers 1, 2, 3 and 5 are not included since they are sands and therefore not relevant to this discussion. The depths and thicknesses of the sublayers were obtained from the profile on Sheet 44 of the calculations. The corresponding preconsolidation pressures were then obtained by reference to the depth versus preconsolidation curve on Sheet 50 of the calculations. The input values for the CONSOL program for the example, Profile 205, are shown on Sheet 51. This approach to determining preconsolidation pressures is a correct and approved procedure.

UMTRA DOCUMENT REVIEW FORM

SECTION 1

Site: Tuba
Document: RAP and Final Design, Date: Nov. 17, 1987
Commentor: NRC

Comment: Page 2

Settlement

2. The cracking potential of the cover was evaluated by assuming a plasticity index (PI) of eleven for the soil. Please indicate how this analysis is representative of actual field conditions, as no requirement for PI is included in cover material selection process.

SECTION 2

Response: Page ________ By: MKE Date: 12/14/87

The method used in the analysis of cracking potential has been used routinely on other UMTRA sites, and is an approved UMTRA design procedure. As indicated in Figure 14-1 of the UMTRA Design Procedures, the lower bound for tensile strains causing failure in soils compacted at moisture contents which are no drier than about 3% below optimum is .05% for soils with essentially zero PI, and increases with an increase in PI. The potential tensile strains of the cover were estimated at between 0.04 and 0.05%, indicating that even material with essentially zero PI would not crack. PI will therefore not be a controlling factor.

Plans for Implementation:

SECTION 3

Confirmation Of Implementation:

Checked By: ____________________, Date: ____________

Approved By: ____________________, Date: ____________

UMTRA DOCUMENT REVIEW FORM

SECTION 1

Site: Tuba , Date: Nov. 17, 1987
Document: RAP and Final Design
Commentor: NRC

Comment: Page 3

Radon Barrier

The final design of the radon barrier will be evaluated when it is submitted. To facilitate the review of the final cover, the dispersive and shrinkage characteristics of the selected soil materials will need to be addressed in the final design package.

SECTION 2

Response: Page ______ By: MKE Date: 12-17-87

Acknowledged.

Plans for Implementation:

SECTION 3

Confirmation Of Implementation:

Checked By: ______________________, Date: ______________

Approved By: ______________________, Date: ______________

UMTRA DOCUMENT REVIEW FORM

SECTION 1

Site: Tuba
Document: RAP and Final Design, Date: November 17, 1987
Commentor: NRC

Comment: Page 3

Construction

1. As mentioned previously, the specifications do not require that the radon barrier materials meet any requirements for PI, as acceptable material will be classified as S. or SM. These two soil types do not limit PIs to any specific range. As discussed extensively for the Lakeview, Oregon, site, limits should be established on the acceptable lower bound of PI. This will be a condition for concurrence in the RAP.

SECTION 2

Response: Page ________ By: MKE Date: 12/17/87

For response, see attached Comment Response.

Plans for Implementation:

SECTION 3

Confirmation Of Implementation:

Checked By: ______________________, Date: ______________

Approved By: ______________________, Date: ______________

5057-TUB-R-01-01369-00
4422U/0131U

Response to Comment 3

Please refer to the response to Settlement, Comment 2, above. As explained in that response, for the minor differential settlement predicted for this site it is not necessary that the radon barrier have a PI greater than zero to protect against cracking. A specific minimum PI corresponding to the design permeability and radon diffusion coefficient has not been established. However, the average PI for the composite samples tested for these characteristics is known (Average PI = 11) and is the same as the average PI for all Greasewood Lake samples. Permeability and diffusion coefficient tests were run on two composite samples from four representative test pits, excavated in Greasewood Lake, classified as SC and SM. Thus, as long as material is an SC or SM from Greasewood Lake, it will be satisfactory for the radon barrier for this site.

For added insurance the materials have been analyzed in detail and will be selected as follows:

1. The deposits in Greasewood Lake are generally characterized by a sandy clay layer over a clayey sand layer, with some small sand layers, the upper clay layer being thickest near the center of Greasewood Lake. Thus, it is prudent to begin excavation near the center of the lake and to excavate from a full vertical face.

2. The specifications have been changed to specify that the radon barrier materials shall be excavated from deposits in the central area of Greasewood Lake (the approximate center of the lake is defined by coordinates) from locations designated by the Contractor (DOE).

3. The specifications further require that the material will be excavated from a 4 feet deep face to produce a composite mixture from all horizontal layers in the face of the deposit, except that the depth of the face may be decreased as directed by the Contractor (DOE) to avoid excavation of underlying sand deposits.

Specification requirements will therefore assure that radon barrier material will be excavated from the central area containing the greatest proportion of higher PI clayey materials, resulting in increased quality of the borrow materials.