WM DOCKET CONTROL
CENTER

'86 APR 23 A11:05

ITASCA
Consulting Group, Inc.

22 April 1986

David Tiktinsky - SS623
U.S. Nuclear Regulatory Commission
Division of Waste Management
Washington, D.C. 20555

"NRC Technical Assistance
for Design Reviews"
Contract No. NRC-02-85-002
FIN D1016

Dear David:

Enclosed is the review of "Critical Parameters for a High-Level Waste Repository, Volume 2: Tuff (DRAFT)," prepared by E. P. Binnel, H. A. Wollenberg, S. M. Benson, and L. Tsao (Lawrence-Berkeley Laboratory for Office of Nuclear Regulatory Research, Division of Radiation Programs and Earth Sciences, U.S. Nuclear Regulatory Commission, Washington, D.C., February 1986). Please call me if you have any questions.

Sincerely,

Roger Hart

Roger D. Hart
Program Manager

cc: J. Greeves, Engineering Branch
Office of the Director, NMSS
E. Wiggins, Division of Contracts
DWM Document Control Room

Encl.
rdn/ks

WM-RES
~~WM Record File~~
D1016
Itasca

WM Project 10,11,16
Docket No.
PDR ✓
LPDR ✓ (B,N,S)

Distribution:
Tiktinsky

(Return to WM, 623-SS)

8605080265 860422
PDR WMRES EECITAS
D-1016 PDR

2987

ITASCA DOCUMENT REVIEW

File No.: 001-02-13

Document: "Critical Parameters for a High-Level Waste Repository, Volume 2: Tuff (DRAFT)," prepared by E. P. Binnel, H. A. Wollenberg, S. M. Benson, and L. Tsao, Lawrence-Berkeley Laboratory for Office of Nuclear Regulatory Research, Division of Radiation Programs and Earth Sciences, U.S. Nuclear Regulatory Commission, Washington, D.C., February 1986.

Reviewer: Itasca Consulting Group, Inc.
(J. Daemen, L. Lorig)

Date Approved:

Date Review Completed: 21 April 1986

Significance to NRC Waste Management Program

The document identifies critical geomechanical, geological, hydrological, and geochemical parameters for a proposed repository in the Topopah Spring tuff at Yucca Mountain. Critical parameters are defined as physical properties whose values are "essential to evaluate and or monitor leakage of radionuclides from the repository and to evaluate the need for retrieval" (Abstract).

The document, appropriately, repeatedly stresses the likelihood that fracture characteristics might dominate the mechanical behavior and that "Virtually no data are available on properties of individual fractures or the effect of fractures on rock matrix properties" (Section 3.1.2.1). The selection and prioritization of the critical parameters is based on judgement, presumably by the authors, and is influenced by referenced experience at Stripa. No formal selection procedure or prioritization analysis is included. Although disagreements on details are probable, the parameter selection and ranking is reasonable.

Section 3.1.9, on Convective Heat Transfer, deserves explicit attention because it identifies the possibility that convective heat transfer might be significant and might significantly affect temperature distributions and, hence, the numerous behavioral aspects thereby influenced. Convective Heat Transfer has rarely been included in earlier analyses.

The few numerical values given in the document are taken directly from DOE-SAND documents, and the document contains virtually no post-1984 references—i.e., design concepts and analyses tend to be dated.

We are in general agreement with the geomechanical parameters identified as critical. We judge that critical retrievability parameters (e.g., rock strength, stress, decrepitation, canister and support corrosion) are assigned too low a priority, particularly during site characterization. We judge that critical parameters (particularly, faulting) determining repository design flexibility (available usable area) are given too low a priority during site characterization. We judge that far too many measurements related to closure and decommissioning issues are postponed so far into the future that they will be of little, if any, benefit in NRC decisionmaking. We recognize that our judgements, as well as the (very limited) rationale presented in the document reviewed are subjective—i.e., they are based on professional knowledge and experience, familiarity with NNWSI literature and NRC information needs but not guided by the benefit of a formal performance assessment.

Summary of the Document

According to the abstract,

> This report addresses critical parameters specific to a repository in tuff, using the Topopah Springs (sic) Member of the Yucca Mountain tuffs as the principal example.... Parameters which are defined as critical are those essential to evaluate and or monitor leakage of radionuclides from the repository and to evaluate the need for retrieval.* The parameters are considered with respect to the disciplines of geomechanics, geology, hydrology, and geochemistry and are rank ordered in terms of importance. The specific role of each

*The geomechanical section of the document occasionally touches on the feasibility of retrieval—i.e., the NRC 10CFR60 requirement to demonstrate retrievability.

parameter, specific factors affecting the measurement of each parameter, and the inter-relations between the parameters are considered.

The executive summary states that "Of strongest considerations were measurements that focused ultimately on the contamination by radionuclides of water that could become accessible to the biosphere." Also,

> A parameter is considered to be 'critical' if a mistake in its measurement, or the inability to measure it, could lead to the wrong conclusion of the adequacy of the repository ...." A parameter is critical only during the phase or phases when it must be measured or monitored.... The relative importance of critical parameters for tuff was determined for each phase of repository activity: site characterization, construction, operation (including retrievability), and close and decommissioning.

Critical parameters, grouped by discipline, are listed and rank ordered in Chapter 2. Detailed critical parameter considerations are given in Chapter 3; geomechanical parameters are given in Section 3.1. For each parameter, an introductory statement is given and followed by a discussion of:

1. normal parameter range
2. Is this parameter site sensitive?
3. expected parameter variations during normal site operation
4. parameter values that may signal trouble (where sufficient information is available)
5. what may happen if this parameter is not measured
6. measurement conditions and potential instrumentation problems

The following geomechanical parameters are considered:

3.1.1 Displacement and Deformation
3.1.2 Fracture Properties and Induced Fractures
3.1.3 Initial In-Situ Stress and Stress Changes
3.1.4 Rock Strength
3.1.5 Rock Modulus and Poisson's Ratio
3.1.6 Temperature
3.1.7 Expansivity
3.1.8 Thermal Conductivity, Heat Capacity, and Diffusivity
3.1.9 Convective Heat Transfer
3.1.10 Decrepitation and Spalling
3.1.11 Canister Movement

It is clear that many of the geomechanical parameters are complex results or combinations of various parameters and effects.

Geological features with important geomechanical implications are discussed in Section 3.2

Chapter 4, Conclusion, briefly summarizes and identifies the top priorities during the various repository phases.

Problems, Limitations, and Deficiencies

A main problem with the document under review is an apparent ambiguity between the definition of criticality of a parameter and the prioritization of critical parameters. The former, it is clearly and repeatedly stated (e.g., Executive Summary (4th paragraph), Introduction) is guided primarily by the time when the parameter is to be measured. Yet the critical parameter time line (Fig. 1) strongly suggests that the measurements of many parameters are delayed until they become critical for repository performance (i.e., until after NRC will have to have made a decision as to whether or not repository performance is likely to be satisfactory). Such things as measurements critical for predicting retrievability, canister and support corrosion, canister movement, and (thermally) induced fractures are given priority during emplacement operations (i.e., after NRC has made its finding on retrievability—similar situations occur for decommissioning and closure).

In sum, it appears that insufficient attention might have been paid to the time frame of NRC information needs. (This criticism might be invalid if the primary objective of the document is to identify repository performance monitoring rather than providing guidance for the measurement of input data on critical parameters. However, these objectives are not clearly identified, and Fig. 1, in particular, suggests a mix of both, because virtually all top priority parameters during site characterization relate exclusively, or nearly so, to post-closure (isolation) performance.

Most of the geomechanical section, with the noticeable exceptions of the important Sections 3.1.9 (Convective Heat Transfer), 3.1.10 (Decrepitation and Spalling), and 3.1.11 (Canister Movement) closely follow DOE-NNWSI documents and will be familiar to the NRC/NNWSI rock mechanics/design review group. The document does not reference very recent NNWSI documents and, hence, is somewhat dated, particularly with regard to current repository design concepts. The sections on Normal Parameter Range, Expected Parameter Variations During Normal Site Operations, Parameter Values That May Signal Trouble, Measurement Conditions and Potential Problems typically follow DOE-NNWSI documents—i.e., they do not include an independent assessment and, typically, do not go into detail.

Specific comments

It would be desirable to replace "Topopah Springs Member" with "Topopah Spring Member" throughout the text.

Executive Summary

It would be desirable if the Executive Summary could give a clear statement of the objectives of the document. Based on the title, one assumes that "Critical Parameters" refers to criticality for repository performance. In the Executive Summary (4th paragraph) criticality of the parameters is restricted to the time period when they are to be measured (i.e., not necessarily the time period when they are critical for performance). A major ambiguity remains as to what the purpose of the proposed measurements is—i.e., whether predictive, as appears to be the case for most isolation performance-related parameters (e.g., high priority during site characterization) or monitoring (e.g., thermomechanical response, retrievability, permanent closure).

1.0 Introduction

First paragraph — If the primary objective is prediction, as appears to be implied by the last sentence, then, clearly, many of the parameters in Fig. 1 are given the highest priority at a point in time which is too late to be of any use for predictive purposes. The paragraph does indicate that performance monitoring is also an objective, and this would appear to be the primary objective for retrievability, thermomechanical response, and sealing and decommissioning proposed measurements.

Does the first sentence imply that this report identifies parameter to be measured (identification phase) and will be followed by a report(s) discussing the adequacy and reliability of the measurement techniques? (This report includes very little of the latter.)

Second paragraph — It would be helpful to provide references to the numerous analyses that have been performed of the measurement needs. The statement that these numerous analyses have not resulted in a consensus nor an estimate of the relative importance of the different parameters contradicts, at least somewhat, the expectation expressed in the Executive Summary (second column, top paragraph) that only minor ranking changes would be expected in the future.

First column, last line — Does "storage" imply prior to repository emplacement?

Last sentence — Is expert opinion that of the authors, of quoted literature, or of (in)formal surveys?

2.0 Critical Parameters for Tuff

Third paragraph — Although technically it is correct that site characterization, construction, operation, and closure and decommissioning are not necessarily distinct time periods, within a licensing framework (and, hence, with regard to NRC information needs) they are distinct in time. It therefore would be very helpful to superimpose or add an NRC time-information needs schedule to this context (e.g., Wright et al, 1985).

<u>Second column, second paragraph</u> — This appears to at least somewhat contradict the statement in the executive summary that significant changes in ranking are unlikely. More serious, probably, is the fact that a real ranking would seem highly uncertain unless it is based on a specific performance allocation scheme.

<u>Figure 1</u> — Unless a prioritization is based on explicit performance assessment and allocation, it is highly judgmental and individual and, certainly, the following comments are such.

Grouping canister and support system corrosion into one parameter is questionable. The first aspect, canister corrosion, under some performance allocation schemes, could readily be considered as the most critical parameter. Under any scheme, it has to meet specific 10CFR60 requirements. Relegating its priority to a (3) and (4) prior to closure seems to underestimate significantly its likely importance. Conversely, support corrosion is a subsidiary consideration in retrievability. Although an important one is this regard, it obviously cannot compare in significance with the primary radionuclide source term. Knowledge of support system corrosion is particularly important for NRC decisions prior to emplacement, and it would seem largely irrelevant subsequent to closure. This would suggest a higher priority during construction for support corrosion studies and elimination of such studies during closure and decommissioning. Canister corrosion deserves a priority (1) during the entire time line or until proven superfluous.

It is doubtful that fracture aperture and connectivity deserve the high <u>mechanical</u> ranking they are given here, especially if their fracture strength and stiffness are given a much lower ranking.

Tectonics, especially faulting, is ranked far too low during site characterization, given the major concern at this site about limitations of about available area, faults as preferential flow paths, impact of faults on repository stability, constructibility, retrievability, etc.

All mechanical parameters have been assigned a surprisingly low priority, especially strength and stress, given the expectation of significant variability and of potential stability (hence, retrieval) problems.

The highest priority for seal and backfill testing is assigned to closure. This is beyond the time frame within which NRC decisions need to be made.

Tables 1-8 — It would be extremely helpful if the rationale for prioritization would be stated. For example, in Table 1, why do the authors consider thermal parameters significantly more important than mechanical parameters, variations in lithology significantly more important than faulting, water inflow significantly less important than groundwater recharge, etc.?

3.0 Detailed Critical Parameter Considerations

All parameters are site sensitive. Question 2 seems superfluous.

The statement that an extensive data base has been acquired at the Nevada Test Site (NTS) probably is correct, but very few data are given for geomechanical parameters. For example, in Section 3.1.2.1, virtually no data are available on properties of individual fractures or the effect of fractures on rock matrix properties; in Section 3.1.4.3, the dependence of rock strength properties on water content, confining stress, temperature, and time have not yet been determined. For most parameters, the data base is limited, given the expected large variations in rock properties through the repository horizon.

3.1.1.3 — The statement that expected displacements and deformations are difficult to predict precisely with the limited information presently available probably is correct, more so than the one in the Chapter 3 introduction that extensive data from NTS can be applied.

Recommended Action

Section 3.1.9 (Convective Heat Transfer) discusses a topic with potentially major impact on thermomechanical repository performance, with significant rock mechanics and design implications (e.g., retrievability, ventilation, excavation stability) as well as obvious implications for isolation and containment. It is recommended that this topic be studied in more detail—e.g., as a minimum, by a review of the cited references. Considerations might be given to have the authors, who are NRC contractors, develop an expanded discussion and analysis of the subject.

Time limitations have restricted this review to a fairly superficial one, and consideration might be given to provide somewhat more review time if an in-depth review is deemed desirable. It would be expected that most additional geomechanical parameter comments would be minor. No review at all has been made with regard to design and rock mechanics implications of the geological, hydrological, and geochemical sections.

It is recommended that the following references be acquired, provided to Itasca and, preferably, reviewed:

High Priority

Klasi et al, 1982 (SAND 81-7209)
Klasi et al, 1982(a) (SAND 81-7210)
Lappin, 1980 (SAND 78-1147)
Montazer et al, 1985
Nelson et al, 1981
Price et al, 1982
Price et at , 1984
St. John, 1985 (SAND 84-7207)
Tillerson and Nimick, 1984 (SAND 84-0221)

Priority

Binnall and McEvoy, 1985
Carr 1974
Chan et al, 1980
Cook and Hood, 1978
Constanz, 1983
Montazer and Wilson, 1984
Preuss et al, 1984
Rogue and Binnall, 1983
Rulon and Bodvarsson, 1985
Sass and Lauchenbruch, 1982
Scott et al, 1983

Sinnock et al, 1984
Smith et al, 1981
Wang and Narasimhan, 1984

REFERENCES

Wright, R. J., J. T. Greeves, and M. J. Logsdon. "Licensing Information Needs for a High-Level Waste Repository," Geotechnical Assessment and Instrumentation Needs for Isolation of Nuclear Waste in Crystalline Rock: Symposium Proceedings (1984 GAIN Symposium, October 15-19, 1984, Berkeley, California), pp. 19-39. BMI/OCRD-24. September 1985.