2

COMMENTS FROM PRELIMINARY TECHNICAL REVIEW OF THE NRC TECHNICAL POSITION PAPER ON "TECTONIC MODELS IN THE ASSESSMENT OF PERFORMANCE OF HIGH-LEVEL RADIOACTIVE WASTE REPOSITORIES"

(Draft technical position dated 13 June 1989)

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The following comments have resulted from the preliminary technical review by CNWRA staff and consultants of the draft technical position paper entitled "Tectonic Models in the Assessment of Performance of High-level Radioactive Waste Repositories" (Draft technical position dated 13 June 1989):

COMMENT #1

Statement of Concern (Re - See pages specified below under "Basis" and "Recommendations") --- The terminology used throughout this technical position paper for distinguishing between different types of models is less than concise, and definitions provided in the glossary do not adequately clarify this terminology. Also, it is not clear what is meant by a "full range" of models or "thoroughly supported" models. The treatment of terminology contributes greatly to the lack of verbal clarity in the position paper.

Basis --- The following terms and combinations of terms are used in the position paper in a manner such that the attempted distinction between different types of models is not always clear: (1) tectonic model(s) --- in the title and throughout the text on pages 1 - 9, glossary of page 11; (2) predictive model(s) --- pages 1,2,7, glossary of page 11; (3) alternative tectonic model(s) --- pages 3,4,6,7; (4) alternative conceptual model(s) --- pages 5,7; (5) alternative conceptual tectonic model(s) --- page 7; (6) thoroughly supported tectonic model(s) --- page 3; (7) full range of alternative tectonic models --- page 4; (8) full range of tectonic models --- page 8; (9) realistic conceptual tectonic model(s) --- page 7; conceptual model(s) --- glossary of page 11. Furthermore, the glossary (pg 11) defines "conceptual model" as a "pictorial or narrative used to represent..."; "predictive model" as a "conceptual model used to predict..."; and "tectonic model" as a "predictive model describing tectonics of the geologic setting".

By its very nature, a "model" can only be a representation of reality based on the data available for construction of that model. Consequently, all "models" discussed in the position paper could be considered "conceptual", since, even in their most refined state, all merely represent the relationships between components of the tectonic system. (It appears from the definition in the glossary that a "conceptual model" is at least always descriptive, rather than mathematical.)

Tectonic models are not used only to make predictions about, or assess the possibility of, future changes in the tectonic environment as certain statements in the position paper may sometimes imply (e.g. - pg 2, Sect 2.2, para 1, lines 3-4). They can also be used to assist with analyzing and understanding both present and past changes and conditions, or to illustrate a representation of the tectonic environment at some point in time. Consequently, it could be perceived that a "predictive model" merely indicates one way in which a tectonic model may be used.

Recommendation --- Terminology related to modeling has already evolved to be relatively complex in the high-level radioactive waste program. In order to simplify the terminology presented in this paper, consider eliminating the term,

or combinations of terms built around, "conceptual model" by incorporating the adjective "conceptual" into the definition of "tectonic model". This change would remove "conceptual model" from the rank of a restrictive model type in relationship to tectonic models, and would clarify the concept that most tectonic models are, in fact, at least partially conceptual in nature. (A purely conceptual tectonic model could not be rigorously used in a predictive sense.) This suggested approach addresses the idea of specifying the model based on the "system" to be modeled (e.g. - the "tectonic system" is analyzed through the use of tectonic models; the "hydrologic system" is analyzed through hydrologic models; etc.), rather than on the function or application of the model. System performance assessment models will incorporate elements of several geological "system" models in order to address performance of the repository.

Going futher with ideas about application of tectonic models, in order to simplify the terminology even more, consider treating predictive models and predictive modeling as one application for tectonic models. Tectonic models could then be broken down in relation to functionality --- i.e. - for analyzing and predicting potential future changes and conditions; for analyzing and understanding present conditions, features, and processes; and for analyzing and understanding past changes, conditions, and processes. This breakdown may be a more concise terminology than that currently presented in the technical position paper. (The concept that tectonic models may be used to assist in recognition of existing features or processes that had not been detected previously is already stated [pg 5, para 1, lines 13-16] in the position paper; as is the concept that tectonic models may be used to identify processes not evidenced in the Quaternary record, but likely to have been active during the Quaternary [pg 5, para 2, lines 12-13]. Both of these concepts involve assessment of present and past conditions and features rather than direct prediction of future changes, although the information gained by applying the concepts would be used in prediction of future changes.)

It would be helpful to qualify the concepts of a "full range of tectonic models" (? based on all conceivable combinations of structures which define the tectonic regime, on extreme ranges of input data, or both ?) and "thoroughly supported tectonic models" (? based on a well-defined and refined data base or exactly equivalent to "full range of" ?) by defining these descriptive phrases. A descriptive definition can be provided that does not go beyond the bounds of the position paper, which specifically does not address criteria by which a tectonic model will be reviewed or evaluated. (Should the position paper have addressed such criteria?)

The list of definitions in the glossary should also include "alternative tectonic model(s)", which can perhaps be equated with the well-established concept of multiple working hypotheses and defined in light of the descriptions for "full range of" and "thoroughly supported" models. The definition should at least clarify the relationship between "alternate tectonic models", a "set of models supported by a representative data base", a "full range of tectonic models", and a "thoroughly supported tectonic model". Perhaps an alternative tectonic model could be viewed as a model which presents a different interpretation of the factual data.

<u>References</u> --- None cited by CNWRA reviewers

COMMENT #2

Statement of Concern (Re - pg 1, Sect 1.1, title) --- As currently written, this section addresses both purpose and objectives, whereas the title of the subsection indicates only "Purpose".

Basis --- Section is inaccurately titled.

Recommendation --- Considering re-titling this section as "Purpose and Objectives".

References - None cited by CNWRA reviewers

COMMENT #3

Statement of Concern (Re - pg 1, Sect 1.1, para 1, lines 4-6) --- This sentence repeats essentially the same idea as that stated in the preceding sentence of this paragraph.

Basis --- Sentence repeats same idea as the preceding sentence.

Recommendation --- Consider deleting the sentence, and incorporating the statement about "the need for the technical position" in the first sentence of this paragraph.

References - None cited by CNWRA reviewers

COMMENT #4

Statement of Concern (Re - pg 1, Sect 1.3) --- The points outlining the structure of the technical position indicate three things that are to be addressed in this document, but leave out other things which are addressed that may be deemed just as important. It is also noted that there is not a one-to-one correspondence between these three points and the three objectives stated under Section 1.1.

Basis --- It is not clear why the three points mentioned, which do not correlate directly with the stated objectives of the position paper, are selected for delineation as the "main" specific points to be addressed in the paper. As written, the list appears incomplete.

Recommendation --- If this section is to remain, consider summarizing all included points which are deemed to be pertinent. The list of points could well include those which parallel the three objectives stated in Section 1.1.

References --- None cited by CNWRA reviewers

COMMENT #5

Statement of Concern (Re - pg 2, Sect 1.4, title) --- The title of this section, "Alternatives", seems inappropriate for the content as written. The section actually defines what a technical position is and is not.

Basis --- The title of this section may be confused with the concept of "alternative models" at a quick glance, and seems inappropriate for the section because it actually defines what a technical position paper is and is not.

Recommendation --- Consider re-titling this section to indicate that it provides the general rationale for development of technical position papers.

References --- None cited by CNWRA reviewers

COMMENT #6

Statement of Concern (Re - pg 2, Sect 1.4) --- As written, part of the rationale for development of technical position papers may be considered to be missing. R. Browning has commented that position papers are done to provide a mechanism for resolving specific open technical issues outlined in the SCP and to assist with early identification of potential problems.

Basis --- This section may be viewed as lacking a statement about part of the rationale for development of technical position papers, as explained above.

Recommendation --- Consider adding a statement to capture the rationale mentioned above for development of technical position papers.

References --- R. Browning, 16 August 1990, Personal Communication.

COMMENT #7

Statement of Concern ---(Re - pg 2, Sect 2.2, both para) --- While parts of this may be re-written if the ideas under COMMENT #1 are implemented, the statement about prediction of future conditions and changes in the geologic setting (para 1) may be too strong considering that what is apparently meant is "assessing [potential] future behavior" (as the first sentence of para 2 implies).

Basis --- The concept of prediction of future conditions and changes vs assessment of [potential] future behavior gives the feeling that "assessment" may be a better way to state what will be done with tectonic models. This wording may be better, in light of the uncertainties which will exist no matter how many data are collected. The "assessment" includes iterative evaluation of potential effects of these future changes and conditions on the repository, since the goal is to understand repository performance. Likewise, data gaps and resultant data needs may be specified (Objective 3 on pg 1) during the iterative analysis of tectonic models and alternative tectonic models. (It should also be remembered

that tectonic models can be used in the analyses of future, present, and past changes, conditions, features, and processes as discussed under COMMENT #1.)

Recommendation --- Consider changing the wording to stress the concept of assessment of future changes and conditions in the geologic setting (rather than "prediction"), and to link the assessment with evaluation of these future changes and conditions as they bear on repository performance. It could also be stated that iterative analyses using alternative tectonic models will help specify data gaps and assist with addressing Objective 3 as stated on page 1 of the technical position paper.

References --- None cited by CNWRA reviewers

COMMENT #8

Statement of Concern (Re - pg 3, para 1, lines 3-4) --- The phrase "set of models supported by a representative data base" may need clarification.

Basis --- It is not clear whether a "set of models" actually refers to "alternative models developed and used in an iterative manner". It is also not clear exactly how a data base would be rigorously determined to be "representative", even though the definition provided in the glossary (pg 11) indicates that this means "sufficient to establish the range of conditions". It may be more accurate to state the definition as "sufficient to represent the presumed range of conditions", in order to capture the concept that even the range of conditions being used is partially an interpretation.

Recommendation --- Consider replacing "set of models" with a phrase like "alternative tectonic models". As suggested above under Comment #1, "alternative tectonic model(s)" should be defined in the glossary so that this expression is clearly understood.

Since the concept of "representative data" is a key issue, consider defining the term "representative data base" to mean "sufficient to represent the presumed range of conditions, with relevant parameters commonly comprised by a range of data rather than single values". It could also be pointed out that use of upper and lower values for specific parameters makes it possible to assess effects of ranges in data even during initial evaluations.

References --- None cited by CNWRA reviewers

COMMENT #9

Statement of Concern (Re - pg 3, para 1, 6-10) --- This sentence stresses the thought that, unless real data are integrated into the tectonic model, the model may misrepresent "undetected" features and result in an inaccurate assessment of future behavior of the natural system relative to those features.

8

Basis --- The statement referenced above may be deemed incomplete, because integration of real data into the tectonic model aids assessment of both detected and undetected features, conditions, and processes relative to behavior of the natural system. Tectonic models also assist with analysis of past, present, and future conditions and changes as discussed under COMMENT #1.

Recommendation --- Consider stating that integration of real data into the tectonic model should be done iteratively to analyze both detected and undetected features, conditions, and processes relative to the behavior of the natural system and, later, of the repository.

References --- None cited by CNWRA reviewers

COMMENT #10

Statement of Concern (Re - pg 3, para 2, lines 7-11) --- A concept is implied that alternative tectonic models are used mainly when the data base is "insufficient".

Basis --- The concept that alternative tectonic models are used mainly when the data base is "insufficient" seems inaccurate, since alternative tectonic models can be assembled and analyzed by using different values for data points within the range shown for a specific parameter, or different combinations of structures as well, even when the data base is "more sufficient".

Recommendation --- Consider stating that viable alternative tectonic models can and should be used through an iterative process of model construction and analysis, from early times when data are sparse to later times when more data exist. (This iterative use of tectonic models is already expressed in the position paper [pg 6, para B].)

References --- None cited by CNWRA reviewers

COMMENT #11

Statement of Concern (Re - pg 3, Sect 2.2.1, lines 10-13) --- Reference is made to "bounding conditions of ... tectonic events" and "bounding the tectonic events" without any clear definition of what these "bounds" are. It is stated that bounding conditions should be established to assist repository design development.

Basis --- The meaning of "bounding conditions of ... tectonic events" and "bounding the tectonic events" is fuzzy. Does establishing the bounding conditions refer to determining and refining the potential structures, through the modeling, which may control the tectonic events, and making certain that these structures are properly represented in the tectonic models, so that they can be factored into design considerations?

Recommendation --- Consider qualifying the concept of "bounding conditions" and how they are established, as discussed above.

References --- None cited by CNWRA reviewers

COMMENT #12

Statement of Concern (Re - pg 4, para 2, lines 1-2) --- The statement is made that tectonic models have a key role in "determining the processes and events that are sufficiently likely to occur...".

Basis --- The statement may be viewed as incomplete, since there are other roles in which tectonic models play a key part as well. Possibly as important as the determination of the processes and events themselves is the concept that tectonic models may also help define the structural features which control or "localize" the processes and events. Definition of controlling structural boundaries seems another important aspect of tectonic models.

Recommendation --- Consider adding the concept that tectonic models may also assist in defining the structural features which control the processes and events.

References --- None cited by CNWRA reviewers

COMMENT #13

Statement of Concern (Re - pg 4, para 2, lines 5-6) --- The statement calls for demonstration that "the full range of alternative tectonic models ... has been identified".

Basis --- While the concept of definition of the expression "full range of alternative tectonic models" has already been addressed in Comment #1, the idea of demonstrating that this full range of alternative tectonic models has been identified presents another issue. How the identification of a "full range of alternative tectonic models" (once the expression is adequately defined) would be demonstrated is not clear. Would this involve an assessment of the likelihood that these models could be operative based on the Quaternary record? (The concept of demonstration is an issue separate from determination of criteria by which a tectonic model would be reviewed and evaluated.)

Recommendation --- Consider qualifying how one would demonstrate that a "full range of ... models" had been identified, possibly by relating the models to the concept of whether or not they were operative in the Quaternary.

References --- None cited by CNWRA reviewers

COMMENT #14

Statement of Concern (Re - pg 4, para 5, line 3) --- A reference is made to "ranges of relevant parameters", without specifying how this relates to the concept of a "representative data base", the expression which is coined on page 3, defined in the glossary on page 11 of the technical position paper, and discussed in this review under Comment #8.

Basis --- It is unclear whether the expression "ranges of relevant parameters" is equivalent to "representative data base", or whether these two expressions discriminate between two distinctive types of data. The definition in the glossary suggests that the expressions may be equivalent, if "conditions" are interpreted to include data. Therefore, it may be deemed logical to define the expression "representative data base" in the manner suggested under Comment #8 to illustrate how "ranges of relevant parameters" are considered to be a part of a representative data base.

Recommendation --- Consider re-phrasing this expression by replacing "... parameters at a particular site" with the phrase "... parameters presumed to be representative of the site". "Representative data base" should be defined as discussed under Comment #8.

References --- None cited by CNWRA reviewers

COMMENT #15

Statement of Concern (Re - pg 5, para 1, lines 11-13) --- The statement is made that tectonic models "describe ... relationships among structural features and ... tectonic processes".

Basis --- As stated, the utility of tectonic models seems underrated. Tectonic models certainly "describe" geometric, mechanical, and kinematic relationships among structural features and past, present, and future tectonic processes. The models may be considered to do more than just "describe", however. They also can link the specified relationships and structural features with past, present, or future tectonic processes in a fashion that goes beyond pure description. This point addressing the possibility of linking relationships and features with tectonic processes would seem to be an important one for both the preclosure and postclosure periods.

Recommendation --- Consider adding words to embellish upon the utility of tectonic models to link relationships and features with tectonic processes as described above.

References --- None cited by CNWRA reviewers

COMMENT # 16

Statement of Concern (Re - page 6, para "B", line 2) --- The statement implies that use of tectonic models cannot start before the initiation of formal site characterization.

Basis --- Remembering that "site characterization" has a specific meaning in the high-level waste program, as long as some data exist for the area of investigation, preliminary models addressing structure and tectonics issues can be set up (even if only as 2-D cross section models) well in advance of formal site characterization. Preliminary models exercised in advance of formal site characterization could help in planning certain data-collecting activities for the site characterization program.

Recommendation --- Consider reinforcing the importance of the iterative use of tectonic models by indicating that they may be used in advance of formal site characterization as soon as appropriate data exist, and that early use may specify data gaps which must be filled during site characterization.

References --- None cited by CNWRA reviewers

COMMENT #17

Statement of Concern (Re - pg 6, para "D", lines 1-4) --- From the referenced statement, one may infer that both tectonic modeling and identification of anticipated processes and events "should be based on deterministic considerations, not probabilities". (On page 8, Section 4.3, the concept is stated that the identification of anticipated and unanticipated processes and events will be based on deterministic criteria, and tectonic models will be based on those criteria. That is, the modeling process appears to be somewhat more separated from the identification of processes and events in that section, even though these are certainly linked activities.)

Basis --- The presentation of the concept that tectonic modeling should be "based on deterministic considerations" only may cause some confusion. Does this indicate that no probabilistic considerations will be used for any part of the tectonic modeling process? Since the modeling process is iterative and even probabilistic approaches will improve as more and better data are incorporated, it may not be necessary to impose this constriction for the entire modeling process. Also, is it not possible that both deterministic and probabilistic approaches may be used in the identification of processes and events? It may be logical to distinguish the modeling effort from the identification of processes and events in a clearer fashion, while still specifying that these are linked activities. Certainly some phases of tectonic modeling will not be involved with concerns about deterministic vs probabilistic approaches.

Recommendation --- Consider removing the implied constriction that tectonic modeling will not, at any time from start to finish, use probabilistic considerations in the iterative modeling process, unless this is the rigid approach that is planned. If this is the approach planned for the modeling

effort, then some additional word of explanation may be necessary. However, if phases of the modeling effort can be more clearly distinguished from the identification of processes and events, then this minor point of confusion will probably be clarified.

References --- None cited by CNWRA reviewers

COMMENT #18

Statement of Concern (Re - pg 6, para "E") --- The statement is made that the DOE should demonstrate that the site characterization program will provide data that are "sufficiently representative" of events and processes so that the "full range of conditions" at the site can be identified.

Basis --- The concept of "sufficiently representative data" is a much-debated topic for geological data. Certainly the site characterization effort should be planned to provide all data possible on the events and processes which are deemed important. The interpretation of "sufficiently representative" must still allow for some uncertainty in both the data and the models, however. In this discussion, one could mention the link between tectonic modeling and indication of data gaps. With this link, the initial modeling effort may be viewed as a part of site characterization planning.

Concerning the concept of identifying the "full range of conditions" at the site from these representative data, the meaning of "full range" is somewhat unclear. Does this refer to all anticipated events, or to both anticipated and unanticipated events? How will it be demonstrated that this "full range" has been identified?

Recommendation --- It may be useful to state that sufficiently representative data do not remove all uncertainties, and that it is anticipated that collection of additional data based on indications of data needs from modeling will be undertaken during the site characterization process. This statement would reinforce the role of the modeling effort in detection of data gaps.

Consider qualifying what is meant by "full range of conditions" by indicating whether anticipated, or both anticipated and unanticipated, events are being included. This approach would at least indicate what general types of conditions must be identified based on terms which are already defined. Addressing how demonstration of the identification of the full range of conditions would be done would also be useful.

References --- None cited by CNWRA reviewers

COMMENT #19

Statement of Concern (Re - pg 7, para 2, lines 6-10) --- The statement is made that "tectonic models should ... identify ... processes and events that are

reasonably likely to occur, as well as form a ... basis for assessing likelihood ... of tectonic events over the period of performance."

Basis --- It is somewhat unclear from this statement whether or not both anticipated and unanticipated events would be identified using tectonic models.

Recommendation --- Consider clarifying, with a single sentence, whether it is thought that both anticipated and unanticipated events would be identified using tectonic models.

COMMENT #20

Statement of Concern (Re - pg 8, para 2, lines 5-8) --- The statement is made that "data collected during site characterization ... should be sufficiently representative of tectonic conditions that the range of tectonic conditions can be established."

Basis --- There may be questions about exactly what is meant by data "representative of tectonic conditions" which establish "the range of tectonic conditions" at the site. Are data sufficient to completely specify the complete tectonic history being referred to, or something less than that? Will iterative modeling and data collection not be involved in the determination and collection of "representative data"?

Recommendation --- Consider clarifying what types or levels of data are being referred to, and make the link between iterative modeling and improvement of data.

References --- None cited by CNWRA reviewers