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July 14, 1998

Dr. English C. Pearcy, Element Manager
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6220 Culebra Road, Building 189
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SUBJECT: ACCEPTANCE OF INTERMEDIATE MILESTONE 1402-561-850 "ALKALINE WATER-ROCK INTERACTIONS AT THE MAQARIN SITE--JOURNAL PAPER"

Dear Dr. Pearcy:

The journal article "Multicomponent Reactive Transport in Discrete Fractures II: Infiltration of Hyperalkaline Groundwater at Maqarin, Jordan, a Natural Analogue Site," was submitted to me by your letter dated June 25, 1998. This submission was in fulfillment of Intermediate Milestone 1402-561-850, "Alkaline Water-Rock Interaction at the Maqarin Site--Journal Paper." The deliverable was received on June 26, 1998, 91 days before its due date. The U.S. Nuclear Regulatory Commission staff has completed its technical and programmatic review of the subject document. This document is acceptable and fulfills the requirements set forth in the FY 1998 Operations Plan for the Evolution of the Near-Field Environment Key Technical Issue and will be placed in the Public Document Room (PDR).

The journal article is an excellent attempt to apply natural analog information from the Maqarin, Jordan, site to the assessment of coupled hydrologic-chemical processes that may occur in waste repositories where a large quantity of cement is used. In particular, the evaluation of the sensitivity of the system behavior predicted by a process-level model of reactive transport was enlightening. The system sensitivity study demonstrated that relatively small changes in system parameters could lead to completely different alternative conceptual models of flow in the near field of concrete-bearing waste repositories.

Your letter transmitting the deliverable stated that I had commented on an earlier version of this paper. I had previously only seen a one-page abstract of the paper. The following technical comments, including those on the article that is enclosed, should be addressed as part of the journal peer-review process.

Technical comments:

1. One of the predictions of the model is that fracture flow velocities would be on the order of 100's of meters per day. This value is quite high, and no support for these large fracture velocities in this or other natural settings is given in the article. For instance, the relationship between the measured hydraulic conductivity at the site and the predicted fracture velocities is inadequately addressed. In addition, on Page 2, it is stated that flow velocities in fractures are often relatively high, but no values of the flow velocity or references are cited.

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2. The discussion of the projection of the M1 site onto the M2 site fracture is unclear in the text and in Figure 4. According to Figure 5-2 of Milodowski, et al., 1998, if M1 is projected onto the fracture that intersects M2, then the path length along the hydraulic gradient (the orientation of the fracture) is 80 meters, instead of the 100 meters assumed in the paper. The projected M1 site would still be within the Metamorphosed Zone. Does the difference in lithology between the Unaltered Marl and the Metamorphosed Zone impact your calculations or conclusions?

3. The difference in Figure 5-2 of Milodowski, et al., 1998, and your Figure 4 is significant. Further, the characteristics of the fracture system given in Milodowski, et al., 1998, is significantly different than how it is characterized in your article. Milodowski, et al., 1998, states "To this end, a series of actively flowing fractures in Adit A-6 were sampled (Fig. 5-2) to obtain profiles perpendicular to the fracture orientation through the host clay biomicrite. It was intended to collect large profiles of up to a metre in length, but it was not possible to obtain fracture-free host rock over distances greater than 10 cm before another fracture, or water-conducting joint, was encountered." How does this distinction between fracture zones observed at the site and the discrete fractures assumed in your parallel plate model influence your modeling and conclusions? How valid are the conclusions of the modeling if the system behaves more like a multiple interacting continuum or dual permeability system?

4. The reference list and the articles cited in the text should be carefully checked as about 30 percent of the articles listed were either not cited in the text or are missing from the reference list. In addition, the reference to McKinley and Alexander, 1993, is probably wrong and should be their 1992 paper in *Waste Management*. The citation is McKinley, I.G. and Alexander, W.R., 1992, A review of the use of natural analogues to test performance assessment models of a cementitious near field. *Waste Man.* **12**: 253-259. Alternatively, Alexander's 1995 article in *Radwaste* could be cited as it provides some details on the use of the Maqarin site as a natural analog of a cementitious repository. Finally, citations of the chapters in the Maqarin Natural Analogue Study: Phase III Draft report should be consistent with Dr. Smellie's request (January 22, 1998; E-mail from Smellie to Steefel and Lichtner).

5. The importance of potential changes in the hydrologic and chemical properties on the overall repository performance is mis-stated in some places in the article (see pages 3 and 19).

6. The discussion of the initial and boundary conditions, and the thermodynamic and kinetic data base would be clearer if the two sections were rearranged. The discussion of the boundary conditions should be presented first. This would eliminate the inconsistency in the citation order of Tables 2 through 7 in the text.

7. Previous reactive transport modeling efforts of the Maqarin site should be discussed in the context of your results. Chambers (1994) and Chambers, et al., 1998, presented some modeling results that may be relevant to your conclusions. The citation for Chambers 1994 is: Chambers, A.V., 1994, Use of the quasi-stationary state approximation to determine the migration of mineral alteration zones at a natural analogue for the disturbed zone of a cementitious radioactive waste repository. In *Scientific Basis for Nuclear Waste*

Management XVII (eds. A. Barkatt and R.A. Van Konynenburg), *Mat. Res. Soc.* **333**: 639-644.

Once the manuscript has completed the peer-review process, I would urge you to forward a copy of the document to me so that the corrected journal article can be placed in the PDR. If you or the authors of the article have any questions, please contact me at (301) 415-6652.

Sincerely,

Original Signed By

Bret W. Leslie
Program Element Manager
Engineering and Geosciences Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosure: As stated

cc: J. Linehan
B. D. Meehan

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