Department of Energy
Washington, DC 20585

AUG 30 1993

Mr. Joseph J. Holonich, Director
Repository Licensing & Quality Assurance
Project Directorate
Division of High-Level Waste Management
Office of Nuclear Material Safety
and Safeguards
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Holonich:

Enclosed are the U.S. Department of Energy's (DOE) responses to three comments and two questions from the U.S. Nuclear Regulatory Commission's (NRC) Phase II review of study plan 8.3.1.2.1.4, "Regional Hydrologic System Synthesis and Modeling," (enclosure 1). Enclosure 2 contains the responses to these comments and questions.

The NRC has recommended in Comments 1 and 2 that study plans be updated to include additional information. We are concerned that some of the recommendations propose changes for this study plan that diverge from the concept of study plans as planning documents. We do not want study plans to become historical documents that record the evolution of the site characterization program. We believe that revisions to study plans are warranted if the results of site characterization indicate a need to change the scope or direction of the work. We do not believe that revisions to study plans are warranted if the intent is merely to report new data or information derived from the study. This role is fulfilled by the technical and interpretive reports published by participant organizations that document the conditions under which the work proceeded, data and analyses, and conclusions reached.

If you have any questions, please contact Ms. Sheila Long at 202-586-1447.

Sincerely,

Dwight E. Shelor
Associate Director for
Systems and Compliance
Office of Civilian Radioactive
Waste Management

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

APR 6 1993

Mr. Dwight E. Shelor, Associate Director
for Systems and Compliance
Office of Civilian Radioactive Waste Management
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, D.C. 20585

Dear Mr. Shelor:

SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION STAFF REVIEW OF STUDY PLAN FOR REGIONAL HYDROLOGIC SYSTEM SYNTHESIS AND MODELING

In a letter to the U.S. Department of Energy (DOE) dated May 6, 1992, the Nuclear Regulatory Commission informed DOE that the NRC staff's Phase I Review had identified no objections with any of the activities proposed in the "Study Plan for Regional Hydrologic System Synthesis and Modeling" (Study Plan 8.3.1.2.1.4). At that same time, NRC also indicated that it had decided to proceed with a Detailed Technical Review (DTR) of that study plan. The purpose of this letter is to transmit the results of the NRC staff's DTR.

This study plan has four activities: (1) conceptualization of regional flow systems; (2) subregional 2-D areal hydrologic modeling; (3) subregional 2-D cross-sectional modeling; and (4) regional 3-D hydrologic modeling. According to its current schedule, work under this study will be completed in 1999. This study is related to performance issues of groundwater travel time and radionuclide transport in the saturated zone. The regional models developed under this study will be used to evaluate the hydrologic effects of future events such as climatic changes, tectonic events, and large scale groundwater withdrawals. Results of regional modeling will also be used to establish boundary conditions for site-scale models of flow in the saturated zone.

The NRC staff's review resulted in the identification of three comments and two questions. The enclosed comments and questions on this study plan will be tracked by the NRC staff as open items similar to Site Characterization Analysis (SCA) objections, comments, and questions. NRC recommends timely resolution of these open items. The comments and questions raised by this review are of sufficient importance that they should be addressed in the next revision to this study plan.

Comment 1 refers to a scientific procedure that is being developed for the regional reconnaissance of features such as wells and springs. The NRC staff requests that a copy of this procedure be provided when it is available.

On July 23, 1992, DOE requested that the NRC staff provide information on the relationship of this study plan to SCA Comments (6, 9, 10, and 95) identified in its Phase I review. In response to that letter, we have determined that

Enclosure 1
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those SCA Comments identified in the Phase I review deal with broader issues that cannot reasonably be addressed at the study plan level. Therefore, we consider that the attached comments and questions comprise the only open items directly related to this study plan.

If you have any questions concerning this letter or the enclosure, please contact Charlotte Abrams, of my staff, at (301) 504-3403.

Sincerely,

Joseph J. Holonich, Director
Repository Licensing and Quality
Assurance Project Directorate
Division of High-Level Waste
Management
Office of Nuclear Material Safety and
Safeguards

Enclosure: As stated

cc: R. Loux, State of Nevada
T. J. Hickey, Nevada Legislative Committee
C. Gertz, DOE/NV
M. Murphy, Nye County, NV
M. Baughman, Lincoln County, NV
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STUDY PLAN 8.3.1.2.1.4, Rev. 0: REGIONAL HYDROLOGIC SYNTHESIS AND MODELING

Comment 1

The study plan needs to identify what minimum information and documentation about pre-existing wells will be acceptable to support the use of those wells in calibrating regional models.

Basis

Previous reports on regional modeling in the Yucca Mountain region that will be used to support site characterization activities do not provide sufficient information about wells and boreholes used to obtain hydraulic heads (and other data) for model calibration. For example, Czarnecki and Waddell (1984) provide a table of hydraulic heads and a list of data sources. However, of the five sources listed, only two are published reports, and only one of these (Walker and Eakin, 1963) lists tabular information about wells in the region. The Walker and Eakin (1963) reference is almost 30 years old and presents well locations using township and range coordinates rather than the currently-used Nevada State plane coordinate system. The other published data source cited by Czarnecki and Waddell (1984) is Waddell (1982). This reference cites Thordarson and Robinson's (1971) inventory of over 6000 wells and springs within a 100-mile radius of the Nevada Test Site, but that reference is more than 20 years old. Because these references are decades old, the current status of the documented wells is unknown.

It is recognized that regional modeling studies rely heavily on existing data sources such as irrigation wells, farm and ranch wells, and mining exploration boreholes. These wells and boreholes were not designed for the scientific collection of ground water data; therefore, details of their construction are usually not well documented. Nevertheless, such wells and boreholes are indispensable for establishing long-term water-level changes and calibrating regional models, and known details about such data sources should be documented.

Study Plan 8.3.1.2.1.3, "Characterization of the Yucca Mountain Regional Ground-Water Flow System," is a key regional hydrogeologic study that will provide information important for constructing and calibrating the models developed under this synthesis study. Based on page 3.2-20 of Study Plan 8.3.1.2.1.3, it appears that a scientific notebook procedure is being developed for regional reconnaissance of features such as wells and springs. This procedure should clearly specify the types of information needed to adequately document calibration wells.

Recommendations

Future reports related to site characterization that document ground water modeling (whether on regional or site scales) should include adequate summaries of the wells and boreholes selected and used to calibrate models.

The general criteria for selecting (or rejecting) boreholes as calibration wells should also be described in the study plan or relevant procedures. Types of supporting information that should be reported for calibration wells and boreholes include: (1) owner, and location coordinates of borehole; (2) borehole elevations and reference points (top of casing, etc.); (3) measured or reported water level elevation and date of measurement; (4) documented changes in water level over time; (5) borehole construction data; (6) present or past use of borehole; (7) current condition of borehole; (8) aquifer identification; (9) available hydrochemical data, and other available information of hydrologic significance.

Regional well data are being collected and documented under Study Plan 8.3.1.2.1.3 which will provide input to the synthesis study. Based on these well data a subset of wells in the region will be selected for use in calibrating regional flow models. It is recommended that the data for these calibration wells also be documented in the modeling reports that are prepared under Study Plan 8.3.1.2.1.4. Criteria for selecting calibration wells should also be provided in the reports. Any data not collected under a quality assurance program meeting the requirements of 10 CFR Part 60, Subpart G, and intended to support DOE's license application, should be qualified as discussed in NUREG-1298 (NRC, 1988) or, alternatively, DOE should provide rationale for why the data is not qualified.

DOE should also consider the development of an updated map depicting hydrologic features to support regional modeling work. This should include locations of items such as springs and wells or boreholes used to collect hydrologic head data. Wells that penetrate the Paleozoic carbonate aquifer system should also be identified.

References

Czarnecki, J. B. and R. K. Waddell, 1984, Finite-element simulation of ground water flow in the vicinity of Yucca Mountain, Nevada-California: Water-Resources Investigations Report 84-4349, U. S. Geological Survey, 38 p.

NRC, 1988, Qualification of existing data for high-level nuclear waste repositories: NUREG-1298, Division of High-Level Nuclear Waste Management, Office of Nuclear Material Safety and Safeguards, U. S. Nuclear Regulatory Commission, 21 p.

Thordarson, W. and B. P. Robinson, 1971, Wells and springs in California and Nevada within 100 miles of point 37 D 15 M N., 116 D 25 M W. on Nevada Test Site: U.S. Geological Survey Report 474-85, 178 p.

Walker, G. E. and T. E. Eakin, 1963, Geology and ground water of Amargosa Desert, Nevada-California: Ground-Water Resources - Reconnaissance Series, Report 14, U.S. Geological Survey, 57 p.

Enclosure

Waddell, R. K., 1982, Two-dimensional, steady-state model of ground water flow, Nevada Test Site and vicinity, Nevada-California: Water Resources Investigations Report 82-4085, U.S. Geological Survey, 72 p.

Enclosure

STUDY PLAN 8.3.1.2.1.4, Rev. 0: REGIONAL HYDROLOGIC SYNTHESIS AND MODELNG

Comment 2

The study plan needs to be updated with respect to available literature on alternate conceptual models for the regional ground water system. The study plan does not adequately describe the approach for modifying existing conceptual models based on new hydrogeologic data.

Basis

During the 1980's, the USGS performed regional modeling for the area of southern Nevada. This work was documented in published reports, papers, and abstracts, including Waddell (1982), Czarnecki and Waddell (1984), and Czarnecki (1985). These documents are cited in the subject study plan. The study plan does not cite a key reference (Czarnecki, 1989) that presents potentiometric data from the Greenwater Range and a new conceptual model of ground water flow. Study Plan 8.3.1.2.1.3, "Characterization of the Yucca Mountain Regional Ground-Water Flow System," which supports this "synthesis" study, cites Czarnecki (1989) and includes a discussion about the alternate flow model. This alternative flow model is based on the acquisition of potentiometric data in the Greenwater Range that shows possible evidence for significant groundwater recharge and suggests the presence of a ground water flow divide beneath this range. Overall, the potentiometric data suggest the need for revision of previous conceptual models of regional groundwater flow. This also suggests the need for model recalibration and revision of the model boundaries of Czarnecki and Waddell (1984) and Czarnecki (1985).

Recommendations

DOE should include an updated list of references related to regional modeling, including Czarnecki (1989), in Revision 1 of this study plan. Future revisions of this study plan should also include a discussion of the process for determining when and if major revisions are needed for existing models. Finally, the modeling program may benefit from information on existing sources of potentiometric and hydraulic property data from areas such as the Funeral Mountains. Given the significance of data collected in the Greenwater Range, the DOE's characterization of the subregional ground water system could confirm whether there is significant groundwater recharge in these mountain ranges and whether they serve as flow divides.

References

Czarnecki, J. B., 1985, Simulated effects of increased recharge on the ground water flow system of Yucca Mountain and vicinity, Nevada-California: Water-Resources Investigations Report 84-4344, U.S.Geological Survey, 33 p.

Czarnecki, J. B., 1989, Characterization of the subregional ground water flow system at Yucca Mountain and vicinity, Nevada-California: Radioactive Waste Management and the Nuclear Fuel Cycle, Vol. 13 (1-4), p. 51-61.

Czarnecki, J. B. and R. K. Waddell, 1984, Finite-element simulation of ground water flow in the vicinity of Yucca Mountain, Nevada-California: Water-Resources Investigations Report 84-4349, U.S. Geological Survey, 38 p.

Waddell, R. K., 1982, Two-dimensional, steady-state model of ground water flow, Nevada Test Site and vicinity, Nevada-California: Water Resources Investigations Report 82-4085, U.S. Geological Survey, 72 p.

STUDY PLAN 8.3.1.2.1.4, REV. 0: REGIONAL HYDROLOGIC SYNTHESIS AND MODELING

Comment 3

The study plan does not describe how the DOE will ensure that sufficient data will be obtained to adequately construct and calibrate subregional (or regional) groundwater models. It is not clear that data will be adequate to support planned 3-D modeling.

Basis

The study plan does not adequately describe how the DOE will ensure that sufficient data on boundary conditions, hydrogeologic properties, and hydraulic heads will be obtained for the regional and subregional models.

The subregional (or regional) flow system predicted by 2-D or 3-D numerical models will greatly depend on the representativeness of the boundary conditions. In most situations, mathematical boundary conditions can be inferred from the physical or hydraulic boundaries of the subregion. These boundary conditions, however, need to be reasonably confirmed by field data collection.

Three-dimensional (multilayer) numerical models can be useful tools for understanding the interactions between unconfined and confined aquifers. However, there must be sufficient hydrogeologic data to reasonably define and calibrate a model to justify the use of 3-D techniques.

The study plan (DOE, 1992) cites previous regional modeling reports and indicates that a preliminary quasi-3-D model has already been developed, citing Sinton and Downey (written communication). This model consists of two layers, the lower of which represents the Paleozoic carbonate rocks. On page 3.4-1 of the study plan, it is stated that "With the existing data base, use of more than two layers to represent the regional ground-water flow system is not expected to be justified because of a sparsity of data on the three-dimensional hydrogeologic properties of the system."

It is not clear that 3-D modeling of even two layers can be supported given that very little hydrologic information presently exists for the deep Paleozoic aquifer system (upper and lower carbonate aquifers). In the vicinity of the Yucca Mountain Site, only one well (UE-25 p#1) penetrates deep Paleozoic carbonate rocks. At this location the carbonates are 1.2 km deep and have a hydraulic head that is about 19 m higher than in the overlying zone. Even within the tuffs that overlie the deep carbonate rocks, there are zones that are confined or semi-confined, illustrating the complexity of the saturated zone flow system. Without the necessary subsurface data, there may not be enough potentiometric or physical property data from the Paleozoic carbonates to adequately calibrate a 3-D model.

Data limitations are also discussed in the study plan "Characterization of the Yucca Mountain Regional Ground Water Flow System" (DOE, 1991). That is the key study plan under which data will be collected to support the regional groundwater modeling activities. On page 3.1-6 of that plan, it is stated that:

> "Little is known about the distribution of hydraulic head with depth within the flow system. Hydraulic-head data in the vertical dimension are critical for calibrating three-dimensional models of ground-water flow. At present, only a handful of points exist where hydraulic head has been determined at various depths."

DOE has identified additional wells to be drilled in the vicinity of Yucca Mountain that may penetrate the Paleozoic aquifer and would contribute to 3-D site models. They would not, however, significantly add to regional well coverage. Wells proposed to be drilled in Crater Flat, near Lathrop Wells, and near the Funeral Mountains (DOE, 1991) would improve the regional data base, but the data may not be sufficient to help calibrate a 3-D model that includes the Paleozoic carbonates as a separate layer.

Recommendations

Future revisions of this study plan should include a detailed description of DOE's approach to ensure that the mathematical boundary conditions and other characteristics of 2-D and 3-D models are reasonably supported by field data.

In particular, DOE should be able to demonstrate that sufficient data have been obtained to support planned 3-D modeling, particularly for the Paleozoic carbonate aquifer system.

References

DOE, 1991, Characterization of the Yucca Mountain regional ground water flow system: U.S. Geological Survey for U.S. Dept. of Energy, Office of Civilian Radioactive Waste Management, Washington, DC, Study Plan 8.3.1.2.1.3, Rev. 0.

STUDY PLAN 8.3.1.2.1.4, Rev. 0: REGIONAL HYDROLOGIC SYNTHESIS AND MODELING

Question 1

What approaches will be used to evaluate evapotranspiration (ET) and recharge on a regional basis? Under which studies and activities will this work be performed? In previous regional modeling conducted by the USGS, what is the basis for assuming zero recharge over most of the region south of Yucca Mountain?

Basis

It is not clear how estimates of ET and recharge will be obtained for use in regional modeling efforts conducted under the subject study plan. Study 8.3.1.2.1.3, which will provide input to Study Plan 8.3.1.2.1.4, concerns characterization of the regional ground water flow system and includes an activity titled "Evapotranspiration Studies." The objective of the activity is to estimate ET rates in the Amargosa Desert to provide data for regional and subregional models. Although the objective refers to the Amargosa Desert, the activity mainly emphasizes work at Franklin Lake Playa, a key discharge area. Franklin Lake Playa was identified in a previous modeling study (Czarnecki and Waddell, 1984) as having particular significance. In sensitivity studies of a parameter estimation model, specified flux at the Franklin Lake Playa had the largest effect of all the specified fluxes on the estimate of hydraulic properties in the vicinity of Yucca Mountain. As a result of the sensitivity studies, Czarnecki (1990) performed extensive fieldwork at the playa to measure hydraulic gradients and to evaluate various methods to estimate ET.

It is recognized that there is a need to obtain improved estimates of ET and ground water underflow at Franklin Lake Playa, especially in light of the alternate conceptual flow model presented by Czarnecki (1989) in which the playa area may act as the principal discharge area for the subbasin that includes Yucca Mountain. There is also a need for improved estimates of ET for other areas within the region in order to better estimate rates of deep percolation through the unsaturated zone to the water table. Such estimates are dominated by ET rates because the percentage of precipitation that returns to the atmosphere via ET greatly exceeds the percentage of rainfall that ultimately becomes ground water recharge.

Groundwater recharge rates are thought to be small over most of southern Nevada. More ground water recharge is expected to occur in areas of higher elevation, due to lower temperatures and greater annual precipitation. Some areas, such as Forty-Mile Wash, are considered capable of producing high recharge fluxes during infrequent, surface-water runoff events of large magnitude. In his base-case, steady-state, subregional model, Czarnecki (1985) used areally distributed recharge rates ranging from 0.0 mm/yr

(Amargosa Desert, western Rock Valley, Franklin Lake Playa, Funeral Mountains) to 410 mm/yr (Forty-Mile Wash). Intermediate recharge rates of 0.5 and 2.0 mm/yr were assigned to other areas, with Timber Mountain having a designated rate of 2.0 mm/yr. The total amount of areally distributed recharge in the model was significant as it was of the same magnitude as the total recharge across specified flow boundaries; however, it is not clear why zero areally distributed recharge was assumed to occur over most of the modeled region south of Yucca Mountain. Potentiometric data from the Greenwater Range suggest that significant groundwater recharge may be occurring in areas south of Yucca Mountain (Czarnecki, 1989).

Other studies related to evaluation of recharge and ET include 8.3.1.2.1.1 (meteorology for regional hydrology) and 8.3.1.2.2.1 (unsaturated zone infiltration). However, based on descriptions in the Site Characterization Plan, it is not apparent that they are intended to produce regional estimates of ET and discharge.

Recommendation

The DOE should identify and describe those studies and activities that will provide regional estimates of recharge and evapotranspiration for use in regional ground water modeling under the subject study plan. Also, DOE should provide the basis for assuming zero areally distributed recharge over most of the modeled region south of Yucca Mountain, as in the base-case, steady-state model of Czarnecki (1985).

References

Czarnecki, J. B., 1985, Simulated effects of increased recharge on the ground water flow system of Yucca Mountain and vicinity, Nevada-California: Water-Resources Investigations Report 84-4344, U.S. Geological Survey, 33 p.

Czarnecki, J. B., 1989, Characterization of the subregional groundwater flow system at Yucca Mountain and vicinity, Nevada-California: Radioactive Waste Management and the Nuclear Fuel Cycle, Vol. 13 (1-4), p. 51-61.

Czarnecki, J. B., 1990, Geohydrology and evapotranspiration at Franklin Lake Playa, Inyo County, California: Open-File Report 90-356, U.S. Geological Survey, 96 p.

Czarnecki, J. B. and R. K. Waddell, 1984, Finite-element simulation of ground water flow in the vicinity of Yucca Mountain, Nevada-California: Water-Resources Investigations Report 84-4349, U.S. Geological Survey, 38 p.

STUDY PLAN 8.3.1.2.1.4, Rev. 0: REGIONAL HYDROLOGIC SYNTHESIS AND MODELING

Question 2

Will the calibration of the regional and subregional flow models be performed by use of an automated parameter estimation technique (i.e., inverse method)? If so, what techniques and codes will be used for the parameter estimation?

Basis

The study plan states that the regional and subregional models will be calibrated by adjusting hydraulic parameters. It is not clear whether this calibration will be performed manually or by use of an automated inverse modeling technique (Cooley and others, 1986; Yeh, 1986).

Recommendation

The DOE should identify and describe the specific approaches to be used in the model calibration process. Also, areas within the regional model where hydrologic testing data have been collected should be delineated. This should be made a part of the documentation for regional modeling and would clearly show those areas represented by actual data and those over which estimates should be obtained.

References

Cooley, R. L., L. F. Konikow, and R. L. Naff, 1986, Non-linear-regression ground water flow modeling of a deep regional aquifer system: Water Resources Research, 22(13), p. 1759-1778.

Yeh, W. W-G, 1986, Review of parameter identification procedures in ground water hydrology; The Inverse Problem: Water Resources Research, 22(2), p. 95-108.

U.S. DEPARTMENT OF ENERGY (DOE) RESPONSES
TO U.S. NUCLEAR REGULATORY COMMISSION (NRC) COMMENTS
ON STUDY PLAN 8.3.1.2.1.4
(REGIONAL HYDROLOGIC SYSTEM SYNTHESIS AND MODELING)

NRC Comment 1

The study plan needs to identify what minimum information and documentation about pre-existing wells will be acceptable to support the use of those wells in calibrating regional models.

DOE Response to Comment 1

The qualification of data for regional models is an issue that the DOE has been working on for some time. Regional models must rely on data collected by many different investigations over a long period of time. Probably most of this data was not collected under the current Yucca Mountain Site Characterization Project (YMP) quality assurance (QA) program meeting the requirements of 10 CFR 60.152. As a result this data will have to be qualified. To qualify all of the data used in the model may be impossible. The approach being used in this study is to construct models using all available data that either pre- or post-date a qualified QA program and then determine if: (1) there are data points that significantly alter model results; (2) these data points are not corroborated by the bulk of the rest of the available data; and (3) these model results are critical to a license application. If such data points are found, then these data would need to undergo a qualification exercise in accordance with NUREG-1298. The available data that corroborates model results but that were not gathered under a qualified QA program would need to be evaluated to determine if it should undergo qualification or whether an adequate case could be made with fully qualified data solely. The appropriate method or combination of methods of qualification cannot be determined until such data points (if they exist) are identified.

Several programs have been conducted to obtain updated water levels within the ground water flow system since water levels were collected for the Czarnecki and Waddell modeling in 1984. The most notable water level collection program was reported recently in the U.S. Geological Survey (USGS) Water Resources Investigations Report 89-4101 entitled, "Ground Water Conditions in Amargosa Desert, Nevada-California, 1952-87" by Kathryn C. Kilroy. Ongoing monitoring of water levels is also being done by various groups within the Site Characterization Program and the Environmental Monitoring Program of the YMP. Finally, a USGS Open-File Report, "Ground Water Altitudes and Well Data, Nye County, Nevada and Inyo County, California" by M.S. Ciesnik, is in final USGS review and will form the basis for potentiometric data used in future subregional-scale models of the flow system.

Data reports and interpretive reports prepared and published by participant organizations, such as those mentioned above document the data sought by the NRC in Comment 1. Study plans themselves are not meant to be historical documents to record how site characterization work progressed. That is, study plan revision is not warranted if the intent is merely to report new data or information. Our end goal is not to have a "perfect plan" to explain how the site was characterized. Revisions to study plans are warranted if the results of site characterization indicate a need to change the scope and/or direction of the work. The data collected by this study will occur under a fully qualified QA program and will be contained in the DOE's Technical Data Base. Quarterly updates to the Technical Data Catalog are provided to the NRC (the most recent update was sent in a letter, Shelor to Holonich, dated August 4, 1993). Finally, quarterly water level monitoring is being done by LAC Minerals Inc. (formerly Bond Gold Bullfrog) as part of an agreement with the State Engineer and the National Park Service and data from this effort has been obtained by the YMP.

ENCLOSURE 2

The recommendation asks for the criteria used for selecting (or rejecting) calibration points. These criteria have not yet been developed and cannot be developed until modeling begins in ernest. At this time, it is not yet clear whether the model will be calibrated against individual wells and springs, against an interpretative potentiometric surface map, or (most likely) a combination of both approaches. However, whatever the calibration criteria are, they will be clearly documented in the reports about the model.

The DOE is already in the progress of updating or producing a series of maps depicting regional hydrologic features. These maps will be released either as stand-alone products or in combination with modeling reports.

NRC Comment 2

The study plan needs to be updated with respect to available literature on alternate conceptual models for the regional ground water system. The study plan does not adequately describe the approach for modifying existing conceptual models based on new hydrogeologic data.

DOE Response to Comment 2

The pertinent text related to addressing changes in conceptual models of the ground water flow system is presented in Study Plan 8.3.1.2.1.3 (Characterization of Yucca Mountain Ground Water Flow System) on pp. 3.2-5 through 3.2-12 and is also contained in Czarnecki (1989) and Czarnecki and Wilson (1990) which are referenced in Study Plan 8.3.1.2.1.3. Characterization of potential ground water divides beneath the Greenwater Range, the Funeral Mountains, and northern Crater Flat is also discussed in Study Plan 8.3.1.2.1.3. Because of the explicit ties between Study Plans 8.3.1.2.1.3 and 8.3.1.2.1.4, and because the requested changes in this comment are addressed in Study Plan 8.3.1.2.1.3, no revision to Study Plan 8.3.1.2.1.4 is necessary.

The DOE does update the list of references cited in study plan revisions if they are cited in the study plan. However, future revisions will not include exhaustive discussion of the process for determining if conceptual or numerical models themselves need to be revised. A model is considered viable if it is consistent with observations and data available at that time. Data reports and interpretive reports produced by USGS are the appropriate vehicles to discuss the basis for revisions to conceptual or numerical models. Study plans describe plans to characterize the site and are not the vehicle to report the data or conclusions that result from that work. Participant reports that contain information, data, discussion, or analyses that are the basis for altering the scope or direction of a study plan would be cited in revisions to the plan. The fact that a study plan revision took place and a brief explanation why it was done is reported in Site Characterization Progress Reports.

As noted by Czarnecki (1989), there is evidence of a potential ground water divide in the Greenwater Range. As other data becomes available, this divide may or may not be confirmed and other divides could potentially be found. It is not yet clear whether the existence of such divides is critical to the characterization of the flow system at Yucca Mountain, and it is premature to determine if DOE must characterize such divides.

NRC Comment 3

The study plan does not describe how the DOE will ensure that sufficient data will be obtained to adequately construct and calibrate subregional (or regional) ground water models. It is not clear that data will be adequate to support planned 3-D modeling.

DOE Response to Comment 3

The subregional and regional flow systems at Yucca Mountain are extremely complex multi-layered systems that are structurally and stratigraphically controlled. Numerical modeling of the system in just two dimensions limits the investigator's understanding of the inter-relationships of combined vertical and horizontal flow components. DOE's plan of regional three-dimensional (3-D) modeling is directed toward understanding the Death Valley ground water flow system of southern Nevada and California of which Yucca Mountain is a part (Bedinger et al., 1989).

The 3-D modeling study is being conducted by DOE for various reasons. First, the study is directed toward synthesizing all existing data in the area. This includes not only hydrologic data (water levels, pump test transmissivities, water chemistry, lithologic and geophysical logs, etc), but also spatial and non-spatial data in the form of geologic maps and cross sections, soil surveys, vegetation maps, surface water maps, spring localities, meteorologic data and remote sensing imagery. This extensive data collection has been gathered, organized and integrated in a 3-D Geographic Information System (GIS) so that it may be used to help conceptualize the regional flow system and aid in the numerical model and parameter estimation process. This rather exhaustive data gathering exercise was initiated because preliminary attempts at modeling the flow system using quasi-three dimensional methods (Sinton, 1987) demonstrated that a detailed hydrologic and geologic data base would be required. Since no previous attempts have been made to gather all the existing data and integrate these data into a true, 3-D numerical model, it has yet to be determined if adequate data presently exists.

Second, the use of the 3-D GIS enables the investigators to construct a true, 3-D hydrogeologic framework model within the computers that house the integrated hydrologic and geologic data base. This hydrogeologic framework model describes the geometry, composition and physical properties of the material forming the natural, Death Valley regional hydrogeologic system. This working model of the system allows existing hypotheses about geologic structure and the potential behavior of ground water flow to be queried. This preliminary step to numerical flow modeling is an efficient way to assess the controls of regional vertical flow components, sub-basinal ground water flux, high transmissivity zones, and physical boundaries to the basin. With the aid of the 3-D GIS, various configurations of structure and stratigraphy can be developed that may be alternative ways of interpreting the relatively sparse regional data. These multiple hypotheses will help to: (1) determine the most feasible interpretation of the system given the existing data base; (2) determine the location and type of additional data that will be needed to reduce uncertainty; (3) study the potential controls that the Paleozoic carbonate aquifer may exhibit on regional ground water flow at Yucca Mountain; and (4) study the potential effects of tectonic and climate changes in the system during past and future periods.

Finally, DOE has chosen to study the Death Valley regional flow system because it is the single most finite ground water basin of which Yucca Mountain is a part. In other words, the Death Valley basin is defined predominantly by physical boundaries that most often coincide with hydraulic boundaries created by regional recharge mounds. Only comparatively small amounts of ground water can be accounted for by underflow into or out of the basin. Specifying boundary conditions coincident with ground water basin margins serves two purposes: (1) boundary conditions can be specified in three dimensions in a spatially correct manner; and (2) boundaries will have less effect on the

interior parts of the model which ultimately will describe regional flow near Yucca Mountain. By developing framework and numerical models of this basin, a full accounting of the regional water budget (recharge, discharge and flux) and an understanding of the structural and stratigraphic features which control regional flow need to be developed.

The method employed in Activity 8.3.1.2.1.4.4 (Regional 3-D Modeling) was designed to specifically address the same concerns posed in Comment 3. The approach of hydrogeologic framework construction, hypothesis testing and numerical modeling will ensure that mathematical boundaries represented in the numerical model will be sufficiently supported by field data. The method will also efficiently address the need of determining the location and type of data required to reduce uncertainty in the regional modeling process.

In summary, DOE's approach is to synthesize all existing data and all fully qualified data into the best models that can be generated. DOE recognizes that the available data are quite sparse, particularly for the deeper Paleozoic carbonate aquifer system. Uncertainty is likely to remain about the deeper flow system.

References

Bedinger, M. S., K. A. Sargent, W. H. Langer, (eds.) 1989. "Studies of Geology and Hydrology in the Basin and Range Province, Southwestern United States, for Isolation of High-Level Radioactive Waste--Characterization of the Death Valley Region, Nevada and California," U.S. Geological Survey Professional Paper 1370-F, 49 pp, U.S. Government Printing Office, Washington, D.C.

Sinton, P. O., 1987. "3-D Steady-State, Finite Difference Model of the Ground Water Flow System in the Death Valley Ground Water Basin, Nevada-California," Unpublished Master of Engineering Thesis, Department of Geology and Geological Engineering, Colorado School of Mines, Golden, CO, 145 pp.

NRC Question 1

What approaches will be used to evaluate evapotranspiration (ET) and recharge on a regional basis? Under which studies and activities will this work be performed? In previous regional modeling conducted by the USGS, what is the basis for assuming zero recharge over most of the region south of Yucca Mountain.

DOE Response to NRC Question 1

In addition to the Evapotranspiration Studies Activity (8.3.1.2.1.3.3), DOE has several other studies planned which directly address the evaluation of regional discharge and recharge and which will be used as input to regional modeling efforts. The Quaternary Regional Hydrology Study (Study Plan 8.3.1.5.2.1) discusses several activities that address regional discharge. Specifically, the Past Discharge Activity (8.3.1.5.2.1.3) has been designed to locate, map, describe and estimate flux from present and past discharge areas within the Death Valley ground water flow system including discharge from free-water surfaces (lakes, ponds, and wet playas), bare soil surfaces (wet playas and diffuse discharge areas), vegetation evapotranspiration (phreatophytes and wetlands), and regional spring areas. Methods for locating the discharge areas, classifying the type of discharge occurring in the areas and estimating the flux from these areas include: (1) air-photo interpretation analysis; (2) remote sensing image processing; (3) field mapping; (4) GIS synthesis and analysis; (5) geochemical, faunal, and isotope characterization; and (6) evapotranspiration estimation. Specific details can be found in Study Plan 8.3.1.5.2.1. Since plans had already been made to study regional discharge fluxes in this study, the Regional 3-D Modeling Activity (8.3.1.2.1.4.4) does not explicitly discuss these activities.

Regional recharge estimation also is being studied as part of the Future Climate Changes Activity (8.3.1.5.2.2.3), and the Analog Recharge Activity (8.3.1.5.2.1.4). The Future Climate Changes activity is directed toward studying the effects of future climate changes on the regional ground water flow system. As part of this activity, the controls of present-day regional recharge will be studied, and ultimately, the findings will be used to predict potential changes in recharge rates in response to future climatic changes. The Analog Recharge Activity is directed toward testing precipitation-runoff methods for estimating recharge on a basin by basin basis.

Quaternary and Future Regional Hydrology Studies (8.3.1.5.2.1 and 8.3.1.5.2.2) are presently cooperating with Meteorology for Regional Hydrology (8.3.1.2.1.1) and Unsaturated-Zone Infiltration Studies (8.3.1.2.2.1) to develop new methods for estimating regional recharge. Utilizing regional meteorologic data, geomorphological data, and remote sensing imagery (used to map vegetation and surficial deposits on a regional basis), investigators are testing GIS modeling methods for estimating the amount of average annual precipitation that ultimately becomes ground water recharge. These methods are modifications of those developed by Rice (1984). While the estimation method is still a variation on water budget accounting, it does contribute to an increased understanding of the mechanisms that control regional ground water infiltration and recharge. Also, the use of comparative hydrologic data contained in the integrated 3-D hydrologic and geologic GIS data base aid in the understanding of the spatial controls on regional ground water recharge that cannot be observed by the presently used "first approximation method" developed by Eakin et al. (1951).

With regard to the specification of areal recharge used in the model of Czarnecki (1985), that specification was made by applying the method of Eakin et al. (1951). Zero recharge was specified over areas that received less than eight inches of precipitation per year (much of the flow system receives less than four inches of precipitation per year). One possible explanation for the apparent recharge mound beneath the Greenwater Range mentioned in Czarnecki (1989) is that the mound may be an artifact of a

pluvial climate (13,000 years b.p.) in a hydrologic setting with lacustrine hydrogeologic units of low permeability. Hydrochemical sampling might help to confirm this.

References

Czarnecki, J. B., 1989. "Characterization of the Subregional Ground Water Flow System at Yucca Mountain and Vicinity, Nevada-California," Radioactive Waste Management and the Nuclear Fuel Cycle, Vol. 13, pp. 51-61.

Eakin, T. E., G. B. Maxey, T. W. Robinson, J. C. Fredericks, and O. J. Loeltz, 1951. "Contributions to the Hydrology of Eastern Nevada," Water Resources Bulletin No. 12, Office of the State Engineer, State of Nevada, Carson City, 55 pp.

Rice, W. A., 1984. "Preliminary Two-Dimensional Regional Hydrological Model of the Nevada Test Site and Vicinity," SAND83-7466, Sandia National Laboratories, Albuquerque, NM.

NRC Question 2

Will the calibration of the regional and subregional flow models be performed by use of an automated parameter estimation technique (i.e., inverse method)? If so, what techniques and codes will be used for the parameter estimation?

DOE Response to NRC Question 2

No specification was made in Study Plan 8.3.1.2.1.4 as to how model calibration will be done (manual vs. automated procedures) so as not to limit the approach to be used. Initially, manual calibration will be used and if necessary parameter-estimation methods will be invoked.

When model results are documented, the data used by the model will be discussed. These discussions will clearly show where actual data were available and where data were estimated.

Enclosures:
1. Ltr, 4/6/93, Holonich to
   Shelor, w/encl
2. Responses to NRC Comments

cc:
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