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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

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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,

/S/

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

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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.

Enclosure

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.

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.

Enclosure

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.