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Characterization of Regional Hydrologic Synthesis and Modeling

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MARKED-UP COPY OF COLEMAN'S REVIEW

Neil: Here is a marked up copy and two additional pages for your consideration. 3

NRC PHASE II REVIEW OF DOE STUDY PLAN FOR
REGIONAL HYDROLOGIC SYNTHESIS AND MODELING
(STUDY PLAN NUMBER 8.3.1.2.1.4, REV. 0)

by

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INTRODUCTION

Background

During the Phase I review (memo from Federline to Holonich, March 16, 1992) of the study plan, it was concluded that the plan qualified for a Phase II (detailed technical) review. The study plan meets three of NRC's criteria (1, 2, 3) for detailed review of study plans. Criterion 1 relates to key site-related issues and Criterion 2 pertains to NRC open items. Criterion 3 relates to unique analysis methods that do not have a supportive history in licensing. Accordingly, a Phase II review has been performed.

Review Objectives

The Phase II review was based on the Review Plan for NRC Staff Review of DOE Study Plans and Procedures (NRC, 1990). One of the purposes of a detailed technical review is to evaluate the degree to which the proposed study will enable the DOE to collect the information needed for licensing. A detailed review should also evaluate whether there is apparent progress toward resolution of any NRC open items.

DETAILED TECHNICAL REVIEW

The principal objectives of the study plan "Regional Hydrologic Synthesis and Modeling" are the following: (1) to synthesize all existing and new ~~characterization~~ data into conceptual models of regional and subregional flow systems, and (2) to develop numerical models of the ground-water flow systems based on the conceptual models.

The study plan has four activities: (1) conceptualization of regional flow ~~models~~ system; (2) subregional 2-D areal hydrologic models; (3) subregional 2-D cross-sectional modeling; and (4) regional 3-D hydrologic modeling. DOE has already achieved significant progress in activities 1, 2, and 4. Since the early 1980's, USGS staff have performed regional and subregional 2-D modeling of hydrogeology in southern Nevada. As described in the study plan, a preliminary 3-D model has also been produced.

Model Calibration

Previous reports on regional modeling in the Yucca Mountain region do not provide sufficient information about wells and boreholes used to obtain hydraulic heads for model calibration. For example, Czarnecki and Waddell (1984) provide (in their Table 5) Nevada state coordinates (northing and easting) for nodes in their model grid that are nearest to well locations. But it would be better to give coordinates for the wells instead of the model nodes. Hydraulic heads are provided, along with data source codes. However, of the five data sources listed, only two are published reports, and only one of these (Walker and Eakin, 1963) lists tabular information about wells in the region. Walker and Eakin (1963) is an acceptable reference, but it is almost 30 years old and the well locations are given in Township and Range coordinates that are difficult to translate to the currently-used Nevada State plane coordinate system or latitude and longitude. Walker and Eakin (1963) includes data from springs and more than 140 wells in the Amargosa Desert. It includes two wells in the vicinity of Yucca Mountain (Crater Flat), but does not include data from the Nevada Test Site.

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 groundwater data, and thus details of their construction were usually not well documented in the past. Nevertheless, such wells and boreholes are indispensible for calibrating regional models, and known details about such data sources should be documented. Such wells and boreholes are generally privately owned and may become inaccessible to future investigators; therefore, they should be documented to the extent practicable. It is important to document such information in order to better support any current and future groundwater modeling work.

Types of supporting information that should be reported for calibration wells and boreholes include: (1) owner, and Nevada state coordinates of borehole, (2) measured or estimated elevation datum, (3) measured or reported water level elevation and date of measurement, (4) borehole construction data, (5) present or past use of borehole, (6) current condition of borehole, (7) aquifer identification, (8) available hydrochemical data, and other available information of hydrologic significance (see attached comment 1).

Modification of Existing Models

The study plan does not adequately describe the approach for modifying existing conceptual and numerical models based on new hydrogeologic data. The study plan does not cite a key reference (Czarnecki, 1989) that describes a new conceptual model of groundwater flow within the subregion (see attached comment 2).

During the 1980's, the USGS performed a considerable amount of 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.

Czarnecki (1989) presented a new conceptual model of subregional groundwater flow. This new model is based on the acquisition of potentiometric data in the Greenwater Range showing the probable presence of a groundwater flow divide beneath this range. Overall, the potentiometric data suggest the possible need for model recalibration and revision of the model boundaries of Czarnecki and Waddell (1984) and Czarnecki (1985). Figure 1.2-6 (DOE, 1991) gives a new interpretation of the potentiometric surface based on the presence of a hypothesized flow divide beneath the Greenwater Range and the Funeral Mountains.

In Czarnecki's 1985 model, Franklin Lake Playa and Furnace Creek act as discharge areas for the water table aquifer. Based on the data from the Greenwater Range, Franklin Lake Playa may serve as the principal discharge area for the subregional water table aquifer that includes Yucca Mountain. Figure 1.2-2 shows the locations of cross-sections in the newly defined subregional flow system. Figure 1.2-4 shows a hypothesized east-west cross-section that extends from Ash Meadows to Furnace Creek Ranch in Death Valley. Under the new conceptual model, the Greenwater and Funeral mountain ranges serve as flow divides for the upper, water table system. Some groundwater is hypothesized to flow from the Amargosa Desert under the Funeral Mountains via the Paleozoic carbonate aquifer, finally contributing to spring discharge at Furnace Creek Ranch.

Given the importance of Czarnecki (1989) in presenting an alternate conceptual flow model, it is surprising that the subject study plan does not cite it. ~~In fact,~~ DOE (1991) does cite Czarnecki (1989) and includes a discussion about the alternate flow model. The next revision of the "synthesis" study plan should include an updated list of references related to regional modeling, including Czarnecki (1989). The study plan should also include a discussion of the process for determining when and if major revisions are needed for existing models. Finally, the DOE should aggressively continue the search for existing sources of potentiometric data in key areas such as the Funeral Mountains. Given the data collected in the Greenwater Range, the DOE should confirm whether these mountain ranges do

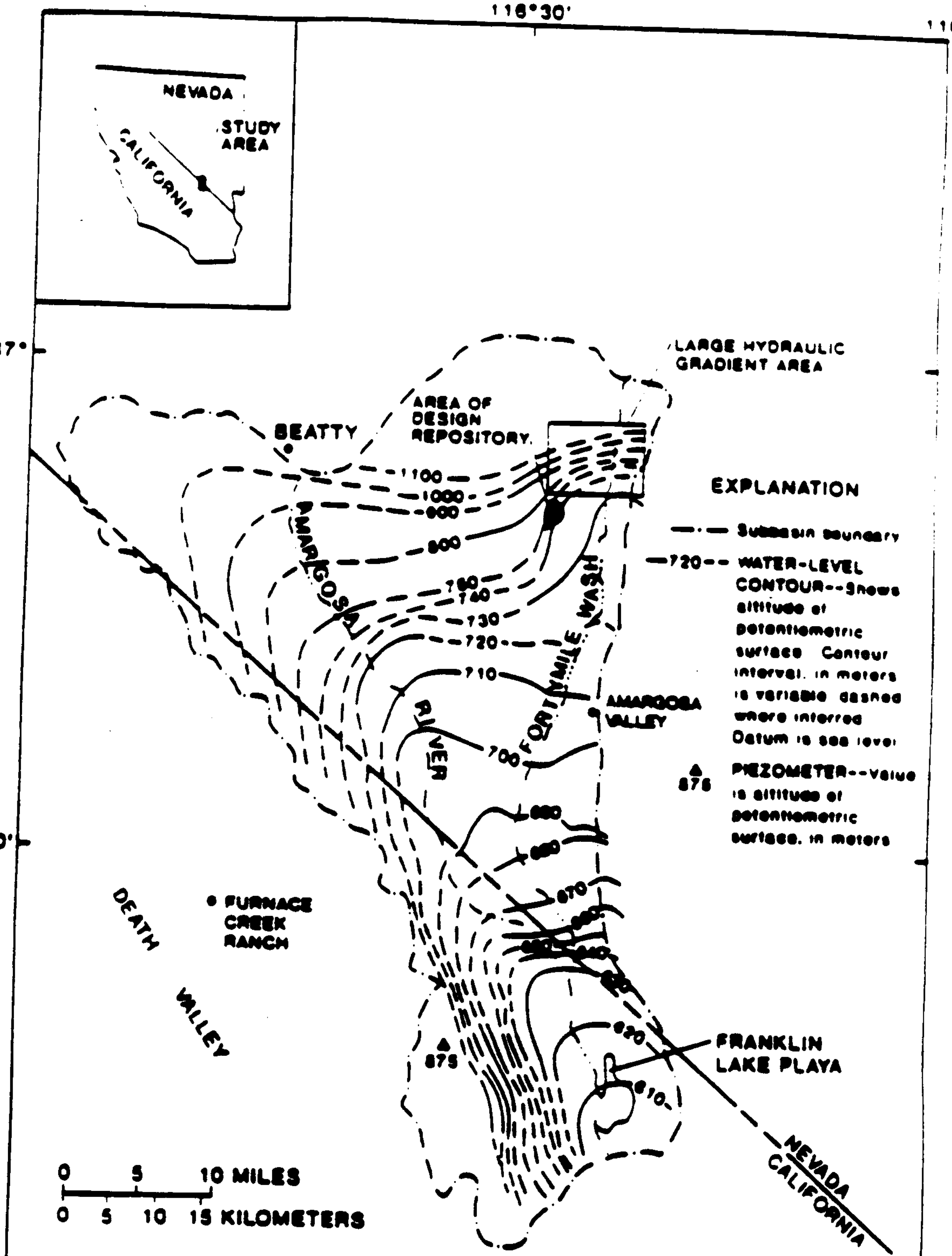

Figure 1.2-6. Subregional potentiometric surface (Czarnecki, 1989).

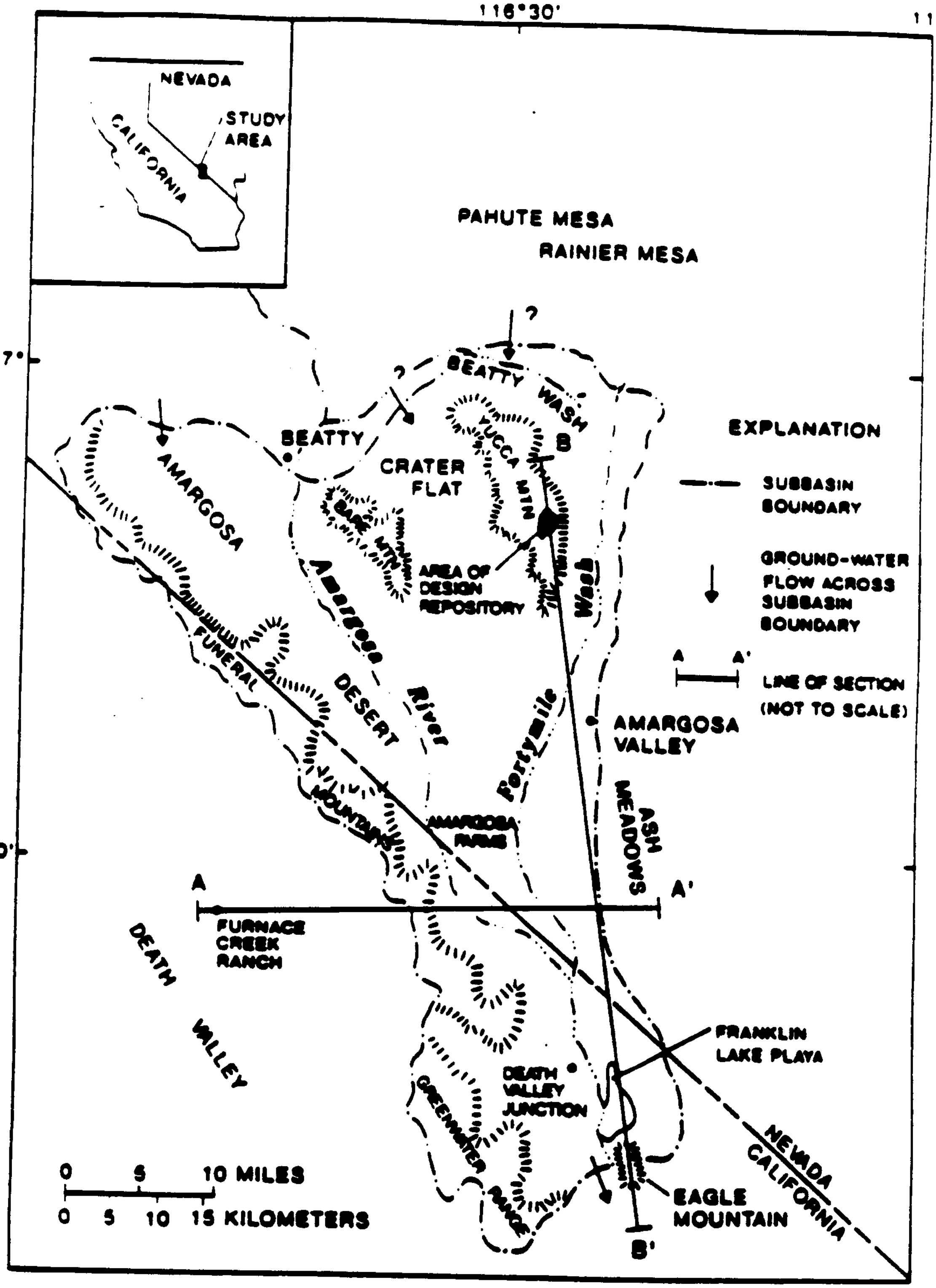

Figure 1.2-2. Location map of ground-water subbasin.

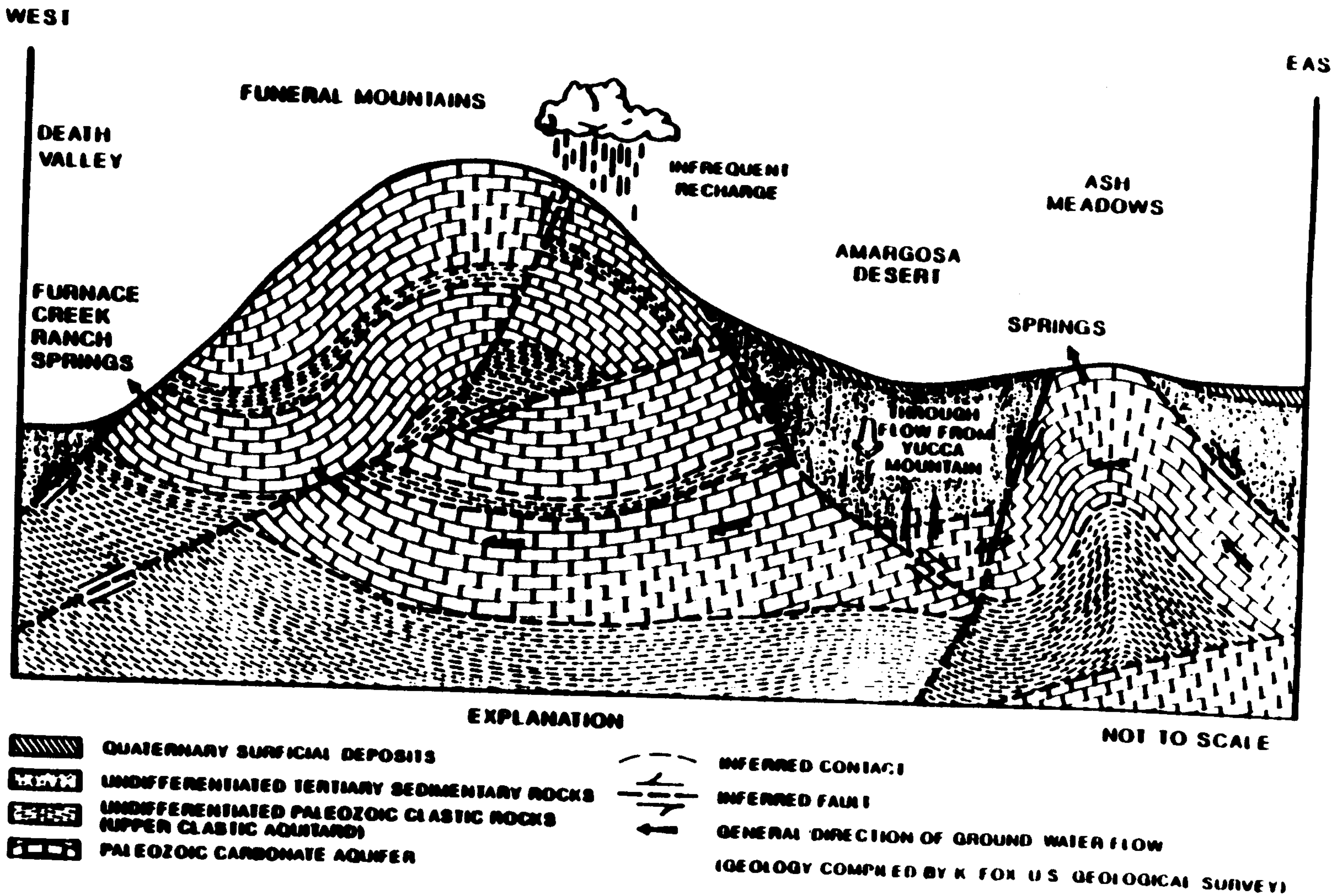

Figure 1.2-4. West-east diagrammatic cross section through subregional flow system

indeed contain groundwater divides. If existing sources of data cannot be located, it would be necessary to drill new boreholes to confirm whether major modifications to existing models are needed.

Calibration of Three-Dimensional Models

The study plan describes plans to perform ~~areal~~ 3-D modeling of the regional flow system that includes Yucca Mountain. It is not clear that 3-D ~~areal~~ modeling can be justified given that very little hydrologic data exist for the deep carbonate aquifer system. – we need not only potentiometric data but also hydrologic properties and boundary conditions. In fact the last two are more important

suggest that this be rewritten

Three dimensional (multilayer) numerical models can be useful tools for understanding the interactions between unconfined and confined aquifers. However, there must be sufficient potentiometric data to reasonably define and calibrate a model to justify the use of 3-D techniques. In other words, to reasonably model in three spatial dimensions, the potentiometric data must be distributed in three dimensions (see attached comment 3).

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 (DOE, 1988, p. 3-201). 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. Unless a commitment is made to acquire the necessary data, there will not likely be enough potentiometric data from the Paleozoic carbonates to adequately calibrate a 3-D model.

Regional Evaluation of Evapotranspiration and Recharge

It is not clear how estimates of ET and recharge will be obtained for use in regional models. Study 8.3.1.2.1.3 concerns characterization of the regional groundwater flow system (DOE, 1991), and includes an activity titled "Evapotranspiration Studies." The objective of the activity is to estimate evapotranspiration rates in the Amargosa Desert to provide data for regional and sub-regional models. In particular, the area of Franklin Lake Playa was identified in a previous modeling study as having particular significance. 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 (Czarnecki and Waddell, 1984). you mean during model calibration?

It is recognized that there is a need to obtain improved estimates of ET at Franklin Lake Playa, especially in light of the alternate conceptual flow model presented in Czarnecki (1989) in which the playa area may act as the principal water table 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 vadose 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 groundwater recharge.

Groundwater recharge rates are thought to be small over most of southern Nevada. More groundwater 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 steady-state, sub-regional model, Czarnecki (1985) used 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. Given the large areas to which zero recharge was assigned, it would be prudent to try to obtain an improved understanding of recharge and ET in these areas (see attached question 1).

<u>SUMMARY</u>

Except for open items related to this study plan, the subject study plan should provide the appropriate information needed for licensing. During the Phase I review, the study plan was perceived to be related to SCA comments 6, 9, 10, and 95. In consideration of the letter received on July 23, 1992 (from Roberts to Holonich), we shall continue tracking SCA comment 95 with respect to this study plan and have determined that SCA comments 6, 9, and 10 comprise broader issues than can reasonably be addressed at the study plan level. The DOE has determined that SCA comment 95 could not be resolved in the near-term, and that a letter will be sent to NRC whenever an adequate basis has been developed to resolve the open item. In addition to SCA comment 95, the three attached comments and one question are considered as new open items related to this study plan.

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

The next revision of the "synthesis" study plan should include an updated list of references related to regional modeling, including Czarnecki (1989). The study plan should also include a discussion of the process for determining when and if major revisions are needed for existing models. Finally, the DOE should aggressively continue the search for existing sources of potentiometric data in key areas such as the Funeral Mountains. Given the importance of data collected in the Greenwater Range, the DOE should confirm whether these mountain ranges do indeed serve as water table flow divides. If existing sources of data cannot be located, it would be necessary to drill new boreholes to confirm whether major modifications to existing models are needed.

The DOE should assess the amount of data that will be needed to calibrate a 3-D model of regional groundwater flow. A determination should be made as to whether sufficient data will exist to justify 3-D modeling. A commitment to perform ~~areal~~ 3-D modeling will have to be accompanied by a commitment to obtain enough data to justify the 3-D approach.

The DOE should identify those studies and activities that will provide regional estimates of recharge and evapotranspiration for use in regional groundwater modeling.

<u>REFERENCES</u>

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, Denver, Colorado, 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), pp. 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, Denver, Colorado, 38 p.

DOE (U.S. Dept. of Energy), 1988. Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada: 7 Volumes, DOE/RW-0160, Office of Civilian Radioactive Waste Management, Washington, DC.

DOE, 1991. Characterization of the Yucca Mountain Regional Ground Water Flow System: Study Plan 8.3.1.2.1.3, Rev. 0, by U.S. Geological Survey for U.S. Dept. of Energy, Washington, DC.

DOE, 1992. Study Plan for Regional Hydrologic Synthesis and Modeling, Revision 0: U.S. Dept. of Energy, Office of Civilian Radioactive Waste Management, Washington, DC.

NRC, 1990. Review Plan for NRC Staff Review of DOE Study Plans, Revision 1: Div. of High-Level Waste Management, Office of Nuclear Material Safety and Safeguards, U.S.

Nuclear Regulatory Commission, Washington, D.C., 20 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, Denver, Colorado, 72 pp.

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.

CORRESPONDENCE

Memorandum from M. Federline (NRC/NMSS) to J. Holonich (NRC/NMSS) re: Phase I review of study "Hydrologic System Synthesis and Modeling, March 16, 1992.

Letter from J. P. Roberts (DOE, OCRWM) to J. J. Holonich (NRC, NMSS) re: open items related to study "Hydrologic System Synthesis and Modeling," July 23, 1992.

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

Comment 1

The study plan does not address the documentation of wells used to calibrate regional models.

Basis

Previous reports on regional modeling in the Yucca Mountain region do not provide sufficient information about wells and boreholes used to obtain hydraulic heads for model calibration. For example, Czarnecki and Waddell (1984) provide (in their Table 5) Nevada state coordinates (northing and easting) for nodes in their model grid that are nearest to well locations. But it would be better to give coordinates for the wells instead of the model nodes. Hydraulic heads are provided, along with data source codes. However, of the five data sources listed, only two are published reports, and only one of these (Walker and Eakin, 1963) lists tabular information about wells in the region. Walker and Eakin (1963) is an acceptable reference, but it is almost 30 years old and the well locations are given in Township and Range coordinates that are difficult to translate to the currently-used Nevada State plane coordinate system. This reference includes data from springs and more than 140 wells in the Amargosa Desert. It includes two wells in the vicinity of Yucca Mountain (Crater Flat) but does not include data from the Nevada Test Site.

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 groundwater data, and thus details of their construction were usually not well documented in the past. Nevertheless, such wells and boreholes are indispensible for calibrating regional models, and known details about such data sources should be documented. Such wells and boreholes are generally privately owned and may become inaccessible to future investigators; therefore, they should be documented to the extent practicable. It is important to document such information in order to better support any current and future groundwater modeling work.

Types of supporting information that should be reported for calibration wells and boreholes include: (1) owner, and location coordinates of borehole, (2) measured or estimated elevation datum, (3) measured or reported water level elevation and date of measurement, (4) borehole construction data, (5) present or past use of borehole, (6) current condition of borehole, (7) aquifer identification, (8) available hydrochemical data, and other available information of hydrologic significance. ~~Based on page 3.2-20 of DOE (1991), it appears that a scientific notebook~~

Something is missing here!

Recommendation

Future reports that document groundwater modeling (whether on regional or site scales) should include adequate summaries of the wells and boreholes selected and used to calibrate models. Based on page 3.2-20 of DOE (1991), it appears that a scientific notebook procedure is being developed for regional reconnaissance of wells. This procedure should clearly specify the types of information needed to adequately document calibration wells.

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, Denver, Colorado, 38 p.

DOE, 1991. Characterization of the Yucca Mountain Regional Ground Water Flow System: Study Plan 8.3.1.2.1.3, Rev. 0, by U.S. Geological Survey for U.S. Dept. of Energy, Office of Civilian Radioactive Waste Management, Washington, DC.

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.

The study plan needs to be updated with respect to available literature on alternate conceptual models (in addition)

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

Comment 2

The study plan does not adequately describe the approach for modifying existing conceptual ~~and numerical~~ models based on new hydrogeologic data.

Basis

During the 1980's, the USGS performed a considerable amount of 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. However, 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 groundwater flow. Czarnecki (1989) presents a new (or alternate) conceptual model of subregional groundwater flow. This new conceptualization is based on the acquisition of potentiometric data in the Greenwater Range, showing the probable presence of a groundwater flow divide beneath this range. Overall, the potentiometric data suggest the possible need for model recalibration and revision of the model boundaries of Czarnecki and Waddell (1984) and Czarnecki (1985). In Czarnecki's 1985 model, Franklin Lake Playa and Furnace Creek Ranch serve as discharge areas for the water table aquifer. Based on the data from the Greenwater Range, Franklin Lake Playa may serve as the principal discharge area for the subregional, water table flow system that includes Yucca Mountain. Under the new conceptual model, the mountain ranges serve as flow divides for the upper, water table system. Some groundwater flows from the Amargosa Desert under the Funeral Mountains via the Paleozoic carbonate aquifer, finally contributing to spring discharge at Furnace Creek Ranch.

Given the importance of Czarnecki (1989) in presenting an alternate conceptual flow model, it is surprising that the subject study plan does not cite it. ~~In fact,~~ DOE (1991) does cite Czarnecki (1989) and includes a discussion about the alternate flow model.

Recommendations

The next revision of this study plan should include an updated list of references related to regional modeling, including Czarnecki (1989). The study plan should also include a discussion of the process for determining when and if major revisions are needed for existing models. Finally, the DOE should aggressively continue the search for existing sources of potentiometric data in key areas such as the Funeral Mountains. Given the data collected in the Greenwater Range, the ~~DOE~~ should

data on hydrologic properties and boundary conditions is more important. May be, we should modify this.

DOE's characterization of the subregional groundwater system confirm whether these mountain ranges do indeed contain groundwater divides. If existing sources of data cannot be located, it would be necessary to drill new boreholes to confirm whether major modifications to existing models are needed.

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, Denver, Colorado, 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), pp. 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, Denver, Colorado, 38 p.

DOE, 1991. Characterization of the Yucca Mountain Regional Ground Water Flow System: Study Plan 8.3.1.2.1.3, Rev. 0, by U.S. Geological Survey for U.S. Dept. of Energy, Office of Civilian Radioactive Waste Management, Washington, DC.

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, Denver, Colorado, 72 pp.

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

ACTIVITY 8.3.1.2.1.4.4: REGIONAL THREE-DIMENSIONAL MODELING

Comment 3

This activity describes plans to perform ~~areal~~ 3-D modeling of the regional flow system that includes Yucca Mountain. A commitment to perform ~~areal~~ 3-D modeling will have to be accompanied by a commitment to obtain enough data to justify the 3-D approach.

Basis

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

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 areal modeling of even two layers can be justified given that very little hydrologic data exists for the deep carbonate aquifer system. 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. Unless a commitment is made to acquire the necessary data, there will not likely be enough potentiometric 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."

Additional wells to be drilled in the vicinity of Yucca Mountain 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 it is questionable whether the data would be sufficient to calibrate a 3-D model that includes the Paleozoic carbonates as a separate layer.

Recommendations

The DOE should assess the amount of data that will be needed to calibrate a 3-D model of regional groundwater flow. A determination should be made as to whether sufficient data exist or will become available to justify 3-D modeling, particularly for the Paleozoic carbonate aquifer. A commitment to perform areal 3-D modeling will have to be accompanied by a commitment to obtain enough data to justify the 3-D approach.

References

DOE, 1991. Characterization of the Yucca Mountain Regional Ground Water Flow System: Study Plan 8.3.1.2.1.3, Rev. 0, by U.S. Geological Survey for U.S. Dept. of Energy, Office of Civilian Radioactive Waste Management, Washington, DC.

DOE, 1992. Regional Hydrologic Synthesis and Modeling: Study Plan 8.3.1.2.1.4, Rev. 0, by U.S. Geological Survey for U.S. Dept. of Energy, Office of Civilian Radioactive Waste Management, Washington, DC.

STUDY PLAN 8.3.1.2.1.4, 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?

Basis

It is not clear how estimates of ET and recharge will be obtained for use in regional models. Study 8.3.1.2.1.3 concerns characterization of the regional groundwater flow system (DOE, 1991), and includes an activity titled "Evapotranspiration Studies." The objective of the activity is to estimate evapotranspiration rates in the Amargosa Desert to provide data for regional and sub-regional models. In particular, the area of Franklin Lake Playa was identified in a previous modeling study as having particular significance. 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 (Czarnecki and Waddell, 1984).

It is recognized that there is a need to obtain improved estimates of ET at Franklin Lake Playa, especially in light of the alternate conceptual flow model presented in 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 vadose 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 groundwater recharge.

Groundwater recharge rates are thought to be small over most of southern Nevada. More groundwater 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 steady-state, sub-regional model, Czarnecki (1985) used 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 other areas, with Timber Mountain having a designated rate of 2.0 mm/yr. Given the large areas to which zero recharge was assigned, it would be prudent to try to obtain an improved understanding of recharge and ET in these areas.

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 SCP, it is not apparent that they are intended to produce regional estimates of ET and discharge.

Recommendation

The DOE should identify those studies and activities that will provide regional estimates of recharge and evapotranspiration for use in regional groundwater modeling.

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, Denver, Colorado, 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. 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, Denver, Colorado, 38 p.

DOE (U.S. Dept. of Energy), 1988. Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada: 7 Volumes, DOE/RW-0160, Office of Civilian Radioactive Waste Management, Washington, DC.

ADDITIONAL COMMENTS GENERATED BY CNWRA

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

Comment 4

The study plan does not adequately describe how the DOE will assure that sufficient boundary condition data will be obtained for the regional and subregional models.

Basis

The subregional (or regional) flow system predicted by the numerical model will greatly depend on the completeness and representativeness of the boundary conditions. In most situations, mathematical boundary conditions can be inferred from the physical or hydraulic boundaries of the subregion. These mathematical boundary conditions, however, need to be confirmed by field data collection. In addition, sufficient data density along specified head boundaries is generally needed to properly reflect head gradients.

Recommendation

The next revision of this study plan should include a detailed description of the approach to be used by DOE to assure that the mathematical boundary conditions are supported by field data.

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 using 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 using an automated inverse modeling technique (e.g., Cooley, et al., 1986; Yeh, 1986).

Recommendation

The DOE should identify and describe the specific approach(es) to be used in the model calibration process.

References

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

Yeh, G. T., 1987, "Review of parameter identification procedures in groundwater hydrology: the inverse problem," Water Resources Research, 22(2), pp. 95-108.