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U.S. Nuclear Regulatory Commission
ATTN: Mrs. Deborah A. DeMarco
Office of Nuclear Material Safety and Safeguards
Program Management, Policy Development, and Staff
Office of the Director
Mail Stop 8D–37
Washington, DC 20555

Subject: Programmatic Review of Abstract

Dear Mrs. DeMarco:

The enclosed abstract is being submitted for programmatic review. This abstract will be submitted for presentation at the 10th International High-Level Radioactive Waste Management Conference to be held March 30–April 3, 2003, in Las Vegas, Nevada. The title of the abstract is:

> "Evaluation of Alternative Conceptual Models for Saturated Zone Flow at Yucca Mountain Using an Independent Site-Scale Flow Model" by J. Winterle and H. Arlt

Please advise me of the results of your programmatic review. Your cooperation in this matter is appreciated.

Sincerely,

Budhi Sagar
Technical Director

/ph
Enclosures: Abstract
NRC Form 390A

cc

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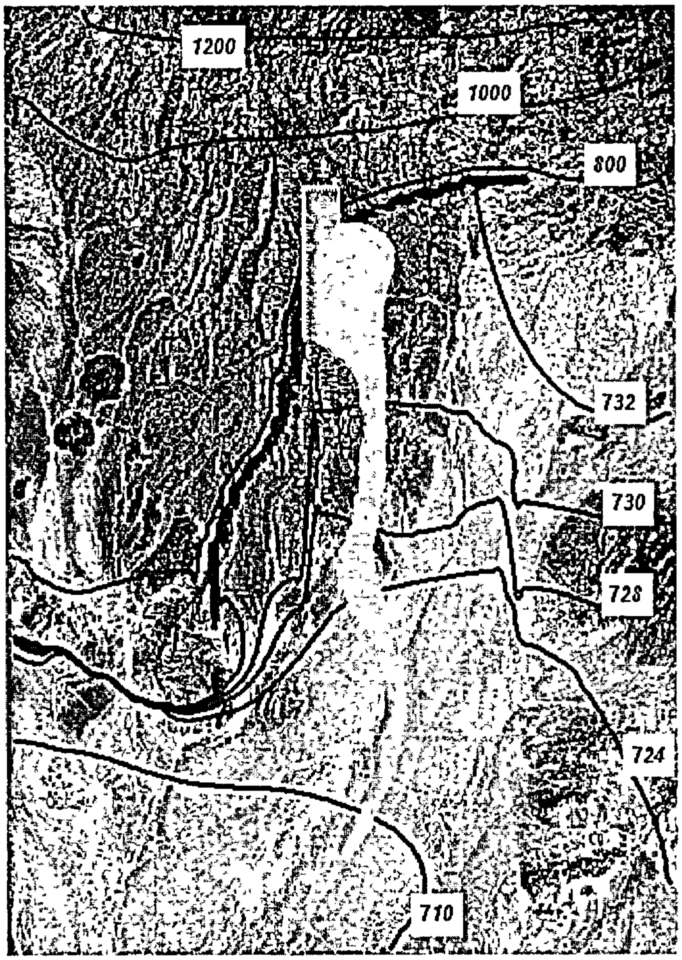
An Independent Groundwater Flow Model for Yucca Mountain as a Regulatory Tool

James R. Winterle
Hans D. Arlt



The Center for Nuclear Waste Regulatory Analyses (CNWRA) has developed a three-dimensional, site-scale saturated zone flow model for the region of Yucca Mountain, Nevada. The purpose of this flow model is to provide the U.S. Nuclear Regulatory Commission (NRC) with a tool to evaluate parameter uncertainties and alternative conceptual models for saturated zone flow and determine their effects on predicted flow paths from the Yucca Mountain site and travel times to the 18-km compliance boundary.

The model was developed using the Groundwater Modeling System (GMS), version 3.1, for model grid development and for execution of the MODFLOW groundwater flow model, and the MODPATH particle tracking algorithm. The computational grid covers a 28.5 x 41.4-km area surrounding Yucca Mountain to a depth of 2,500 m below mean sea level. Six hydrostratigraphic layers and 13 structural features are explicitly considered. Each of 30 model layers is uniformly discretized into 300-m square grid blocks for a total of 393,300 computational cells. The geometries of the structural features and the hydrostratigraphic layers are based on correspondence to aquifers, aquitards, and fault zones represented in a CNWRA independent hydrogeologic framework model and subsequently assigned to grid cells. Isotropic hydraulic conductivity values are assigned to the various material types. Constant head boundary conditions are assigned on the lateral model boundaries based on an interpretation of water table elevations derived from regional well data. The bottom of the model is assigned a no-flow boundary condition. A net recharge rate of 1 mm/yr is imposed on the top model layer in the northern 1/4 of the model domain.

Steady-state solutions were obtained for several alternative model scenarios, including both confined and unconfined conditions in the upper model layers, varied amounts of recharge north of Yucca Mountain and in Fortymile Wash, differing geometries and permeabilities of fault zones, and differing conceptual models for the large hydraulic gradient to north of Yucca Mountain. The model was calibrated by varying hydraulic conductivity and, in some cases, surface recharge rates, to match observed hydraulic potentials in monitored locations at various depths. For most model scenarios, calibration was accomplished using a trial and error approach. The PEST parameter estimation algorithm was used in the calibration of a basecase scenario, but the improvement over the trial and error approach was not significant.

Calculated heads from the steady-state simulation (see figure above) compare favorably to heads recorded in observation wells, especially east of the potential repository area where observed heads are between 700 and 750 m above sea level. Calculated heads also match the upward hydraulic gradient observed between the Paleozoic aquifer and the overlying volcanic tuff aquifers.

Calibration residuals (differences between modeled and observed hydraulic potentials) were greatest for observation points near structural features that result in steep hydraulic gradients. Much of the residual error in such areas is an artifact of the coarse grid discretization and is not considered programmatic. For example, across the Solitario Canyon Fault, the hydraulic potential changes by tens of meters within a lateral distance equivalent to one grid cell. Residual errors in this area could be reduced by grid refinement or by widening the area of the model used to represent the fault zone, but the effect on calculated flow paths would be minimal.

Results of flow-path analyses for the various alternative scenarios indicate that flow paths originating from the water table beneath Yucca Mountain do not change substantially without an accompanying substantial degradation in the model calibration. Flow paths are generally due east from beneath Yucca Mountain until they reach a zone of enhanced permeability used to represent the Bow Ridge and Paintbrush Fault Zones; at that point, flow paths turn sharply to the south. The distance of a particle traveling east before turning south is affected by the geometry of this enhanced permeability zone. At the area of transition between volcanic tuff and alluvial aquifer systems, flow paths narrow to less than one km wide as a result of higher hydraulic conductivity in alluvium. Flow paths generally remain within 100 m from the water table. A scenario of pumping at a rate of 3.7×10^6 cubic meters per year [3,000 acre-feet per year] from a single well at the 18-km regulatory compliance boundary resulted in the capture of all flow paths originating from the water table beneath Yucca Mountain. 3,000 acre-feet is the representative volume of groundwater given in 10 CFR Part 63.

The three-dimensional groundwater flow model will enable the NRC to prepare to conduct a technical review of a potential license application for a proposed high-level radioactive waste repository at Yucca Mountain. The CNWRA model can be used to evaluate the potential effects of various data and model uncertainties on saturated zone flow paths. Those evaluations can then be used for comparison with the level of uncertainty considered in the DOE performance assessments resulting from factors such as groundwater specific discharge and flow path lengths through various material types. The flow model also provides an independent way to evaluate the sensitivity of simulated flow paths, groundwater travel time, and capture zones of pumping wells, to the underlying interpretation of geologic structures.

Acknowledgment: This abstract describes work performed by the CNWRA for the NRC under Contract No. NRC-02-97-009. This report is an independent product of the CNWRA and does not necessarily reflect the views or regulatory position of the NRC.