March 19, 2013

MEMORANDUM TO: Stephen J. Cohen, Team Leader
Uranium Recovery Licensing Branch
Division of Waste Management and
Environmental Protection
Office of Federal and State Materials and
Environmental Management Programs

FROM: John L. Saxton, Hydrogeologist **/RA/**
Uranium Recovery Licensing Branch
Division of Waste Management and
Environmental Protection
Office of Federal and State Materials and
Environmental Management Programs

SUBJECT: EVALUATION OF THE NUMERIC GROUNDWATER FLOW MODEL, POWERTECH (USA), INC., DEWEY-BURDOCK PROJECT, FALL RIVER AND CUSTER COUNTIES, SOUTH DAKOTA

Introduction

Nuclear Regulatory Commission (NRC) staff evaluated the numeric groundwater flow model submitted by Powertech (USA), Inc. (Powertech) in support of its license application for the Dewey-Burdock Project. Documentation on the numeric model was submitted in a report entitled *Numerical Modeling of Hydrogeologic Conditions: Dewey-Burdock Project, South Dakota,* which is dated February 2012 (ML120062A096). In addition to the report, the applicant submitted electronic files associated with the model. The electronic files consist of native Groundwater Vistas files (the commercially available pre- and post-processing available software used by the applicant to prepare the model, and native input and output MODFLOW files.

Staff's evaluation consists of the following:

(1) Verify the data presented in the applicant's modeling report by independently running the model and comparing the results of this analysis with those documented in the report.
(2) Analyze the conceptual model for, and design of the numeric model, including geometry, hydraulic parameters and boundary conditions, with respect to appropriateness for the hydraulic setting or possible bias in the applicant's evaluation.
(3) If warranted, revise the model to confirm or test the validity of the applicant's assumptions.

CONTACT: John Saxton, FSME/DWMEP
(301) 415-0697

Background

The applicant's numeric groundwater flow model is a finite difference (MODFLOW) complex, regional-scale groundwater flow model. The model consists of 4 layers, 525 rows and 523 columns. The overall dimensions are 100,000 feet in the east-west direction, 100,000 feet in the north-south direction, and from 4303.13 to -71.4 feet in elevation, represented in the model vertical direction. The regional scale to this model was necessary because the Dewey-Burdock Project is located in close proximity of the eastern limits of the aquifer (Inyan Kara Group) to be subjected to the ISR operations. Consequently, the cells dimensions were either 100 feet by 100 feet, 100 feet by 400 feet or 400 feet by 400 feet.

The layering was assigned to various hydrogeologic units as follows:

Layer 1 Graneros Group (overlying aquifer)
Layer 2 Fall River Formation (upper production zone)
Layer 3 Fuson Shale of the Lakota Formation (intermediate zone)
Layer 4 Chilson Member of the Lakota Formation (lower production zone)

The Fall River and Lakota formations are collectively referred to as the Inyan Kara Group.

The underlying confining layer is the Morrison Formation. The Morrison Formation is a regionally extensive, thick (100 feet) sequence of relatively impermeable shales. The applicant states that the Morrison Formation effectively inhibits the downward migration of fluids from the production aquifer. The base of the numeric model, which is a no-flow boundary, is the top of the Morrison Formation.

The hydraulic properties for layers 2 and 4 are based on the geology, historic pumping tests and model calibration. The hydraulic properties for layers 1 and 3 are assumed values based on estimates for the geology.

Model boundaries consist of constant flux (well) boundaries, general head boundaries (GHBs), and recharge. Simulated wells consist of two groups. The first group consists of private water supply wells within the modeled area; this group includes 57 wells distributed through the model. The flux (i.e., pumping rate) and screened depth were assigned to layer 2 or 4 based on the available data. The pumping rates for this group varied from 0.056 to 16.2 gpm, for a cumulative flux of 132.8 gpm. This group of wells was held constant for all simulations. The second group of wells consists of simulated production wells used in predictive simulations. The pumping rates and locations varied based on the operating status for a stress period in the predictive simulations. The GHBs were place in cells along the perimeter of active cells in layers 2 and 4. The model contains a total of 2,382 GHB cells.

The model was calibrated to a static steady-state simulation and was verified through transient simulations based on drawdown from historic pumping tests. The model is subjected to a sensitivity analysis using parameters for recharge and GHB conditions. Several predictive simulations were then performed using net withdrawal rates for various simulated production scenarios. In addition, predictive simulations were performed to evaluate the hydraulic influence of a hypothetical breccia, if one were located within the license area.

Staff's Verification

Staff reviewed the model geometry, hydraulic properties and parameters and locations of the boundaries. Several minor discrepancies were noted between the electronic files and the report (Table 1). In general, the discrepancies represent minor errors and are common for complex models. Most of the discrepancies would not appreciably impact the model predictions; however, staff was concerned about the abnormal drawdown adjacent to the GHB conditions (Figure 1). The abnormal drawdown may be attributed to discrepancies noted in the recharge, storativity or GHBs (see Table 1), or, conflicts with the starting head file.[1]

Staff corrected the model for discrepancies in recharge, storativity and GHBs, and established starting heads for the predictive simulation using the output from the steady-state calibration simulation. Correcting the model affected the predicted drawdowns in the Fall River Formation and Chilson Member, as shown in Figure 2 and Figure 3, respectively. The effect of the corrected model on the Fall River Formation model-predicted drawdown is to increase the drawdown by approximately 1 foot. The effect on the Chilson Member model-predicted drawdown is less than that for the Fall River Formation.

Staff's evaluation

Based on the applicant's report, the objectives for the numeric modeling include the following:

- Enhance understanding of the Fall River and Chilson aquifer systems with respect to:
  - regional and local flow patterns
  - recharge and discharge boundaries
  - overall water budget (available and sustainable resources)
- Evaluate potential hydraulic impacts (e.g. drawdown and potential dewatering) from production and restoration operations on both the local and regional scale;
- Compare hydraulic impacts of variable bleed rates and production rates on the Fall River and Chilson aquifers;
- Assess potential communication (if any) between the Fall River and Chilson aquifers during production and restoration activities;
- Determine the level of interference between wellfields that could occur with simultaneous production and restoration operations;
- Evaluate the potential impacts of ISR operations to an open pit mine located within the Project Area that intercepts Fall River groundwater;
- Assess the potential hydraulic impacts that would result from a breccia pipe recharge to the Fall River and Chilson aquifers (as hypothesized by Gott et al [1974]) within the Project Area.

Staff finds that the modeling effort is sufficient for the first three objectives but is not sufficient for the latter four objectives. Staff agrees that the maximum model predicted drawdown at the specified bleed is a reasonable estimate.

---

[1] The output files had listed several dry cells, but the starting head file may not have included those dry cells. The starting head file is important for the predictive simulations because the initial stress period was not steady state.

For the potential communication between Fall River and Chilson aquifers, the model assumes hydraulic properties for the Fuson Shale and it cannot simulate drawdown reported for an older pumping test. An assumption is that the observed drawdown is attributed to boreholes and thus cannot be simulated by the numeric model.

For the level of interference between wellfields, the model demonstrates that the drawdown is isolated but to establish the level of interference, the potentiometric heads need to be determined and particle tracking is a useful tool for this evaluation. The applicant did not report model predicted heads or performed particle tracking. (It is my understanding that this analysis is reported elsewhere.)

For the open pit mine, the model includes GHB conditions to simulate the pit. The GHB conditions resulted in minimal (essentially zero) drawdown at the pit. Staff finds that the pit should have been modeled without boundary conditions and/or boundary-condition parameters that would not influence the results to better estimate the impacts.

Finally, the staff does not agree with the breccia pipe modeling presented by the applicant. Although the staff agrees that a breccia pipe will create a water level anomaly in the Fall River and Chilson potentiometric surfaces, the staff does not agree that it will be a mound. The applicant modeled a breccia pipe by assuming that a 200 gpm flow from a breccia pipe would enter the Fall River or Chilson aquifers. However, In general, the potentiometric surface of the Inyan Kara aquifer (Fall River or Chilson aquifers) (Strobel, et.al., 2000) is higher than that of the Minnelusa aquifer (Driscoll, et.al., 2002), from where a breccia pipe would originate. Consequently, a potentiometric surface depression, not a mound, would be realized if a breccia pipe connected the Minnelusa and Inyan Kara aquifers. Regardless of whether the anomaly is a mound or depression, such an anomaly, and therefore a breccia pipe, would be detected during the Criterion 5B(5) Commission-approved background sampling phase of the proposed Dewey-Burdock operations because of the increased sampling density. However, the staff has not found any information indicating that breccia pipes occurred at the Dewey-Burdock Project.

References

Daniel G. Driscoll, Janet M. Carter, Joyce E. Williamson, and Larry D. Putnam. 2002. Hydrology of the Black Hills Area, South Dakota. Water-Resources Investigations Report 02-4094. U.S. Geological Survey and South Dakota Department of Environment and Natural Resources and the West Dakota Water Development District.

Strobel, M.L., Galloway, J.M., Hamade, G.R., and Jarrell, G.J. 2000. Potentiometric Surface of the Inyan Kara Aquifer in the Black Hills Area, South Dakota. Hydrologic Investigations Atlas HA-745-A. U.S. Geological Survey and South Dakota Department of Environment and Natural Resources and the West Dakota Water Development District.

For the potential communication between Fall River and Chilson aquifers, the model assumes hydraulic properties for the Fuson Shale and it cannot simulate drawdown reported for an older pumping test. An assumption is that the observed drawdown is attributed to boreholes and thus cannot be simulated by the numeric model.

For the level of interference between wellfields, the model demonstrates that the drawdown is isolated but to establish the level of interference, the potentiometric heads need to be determined and particle tracking is a useful tool for this evaluation. The applicant did not report model predicted heads or performed particle tracking. (It is my understanding that this analysis is reported elsewhere.)

For the open pit mine, the model includes GHB conditions to simulate the pit. The GHB conditions resulted in minimal (essentially zero) drawdown at the pit. Staff finds that the pit should have been modeled without boundary conditions and/or boundary-condition parameters that would not influence the results to better estimate the impacts.

Finally, the staff does not agree with the breccia pipe modeling presented by the applicant. Although the staff agrees that a breccia pipe will create a water level anomaly in the Fall River and Chilson potentiometric surfaces, the staff does not agree that it will be a mound. The applicant modeled a breccia pipe by assuming that a 200 gpm flow from a breccia pipe would enter the Fall River or Chilson aquifers. However, In general, the potentiometric surface of the Inyan Kara aquifer (Fall River or Chilson aquifers) (Strobel, et.al., 2000) is higher than that of the Minnelusa aquifer (Driscoll, et.al., 2002), from where a breccia pipe would originate. Consequently, a potentiometric surface depression, not a mound, would be realized if a breccia pipe connected the Minnelusa and Inyan Kara aquifers. Regardless of whether the anomaly is a mound or depression, such an anomaly, and therefore a breccia pipe, would be detected during the Criterion 5B(5) Commission-approved background sampling phase of the proposed Dewey-Burdock operations because of the increased sampling density. However, the staff has not found any information indicating that breccia pipes occurred at the Dewey-Burdock Project.

<u>References</u>

Daniel G. Driscoll, Janet M. Carter, Joyce E. Williamson, and Larry D. Putnam. 2002. Hydrology of the Black Hills Area, South Dakota. Water-Resources Investigations Report 02-4094. U.S. Geological Survey and South Dakota Department of Environment and Natural Resources and the West Dakota Water Development District.

Strobel, M.L., Galloway, J.M., Hamade, G.R., and Jarrell, G.J. 2000. Potentiometric Surface of the Inyan Kara Aquifer in the Black Hills Area, South Dakota. Hydrologic Investigations Atlas HA-745-A. U.S. Geological Survey and South Dakota Department of Environment and Natural Resources and the West Dakota Water Development District.

ML13046A280

OFC	DWMEP	DWMEP	DWMEP
NAME	JSaxton	BGarrett	JSaxton
DATE	2/15/13	2/19/13	3/19/13

OFFICIAL RECORD COPY