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THE MEMPHIS DEPOT
TENNESSEE

ADMINISTRATIVE RECORD COVER SHEET

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Base Realignment And Closure Team
Federal Facilities Branch

United States Environmental Protection Agency, Region 4
61 Forsyth Street SW
Atlanta, Georgia 30303

DATE: April 8, 1997 # of PAGES (w/ cover sheet) 8

TO:	FAX NUMBER:
Glenn Kaden, DDMT	901.775.4372
Jordan English, TDEC	901.368.7979
Julian Savage, USACE Huntsville	205.895.1469

FROM: Dann Spariosu (404) 562-8552 FAX: (404) 562-8518

re: USGS (EPA reviewer) comments on the WES Dunn Field Groundwater Modeling Report

EPA's conclusion is that the groundwater model report does not contain sufficient information to permit a critical evaluation of the mode: and cannot be approved without the details indicated by our reviewers.

A USGS memo on minimal contents of groundwater modeling reports will be included with these comments via FED EX after I receive the regular mail from USGS. WES principals may contact the primary commentor directly: Mr. James Robinson, USGS Montgomery, AL, at (334) 213-2332, or the USGS project manager, Mr. Jim Kingsbury, USGS Nashville, at (615) 736-5424 for further elucidation on necessary additions to the report.

Dann Spariosu

United States Department of the Interior

U.S. GEOLOGICAL SURVEY

Water Resources Division
810 Broadway, Suite 500
Nashville, TN 37203

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April 7, 1997

Dr. Dann Spariosu
U.S. Environmental Protection Agency, Region IV
Waste Management Division
61 Forsyth Street SW
Atlanta, Georgia 30303

Dear Dann:

As per our converstaion on Friday, April 4, I am returning to you the draft document "Groundwater Modeling Approach for Remediation Design at the Defense Depot, Memphis" prepared by the U.S. Army Corps of Engineers, Waterways Experiment Station. The document was read by myself and Jim Kingsbury in the Nashville office because of our familiarity with the hydrogeology of the Memphis area, and by James Robinson of the U.S. Geological Survey (USGS) Alabama District because of his knowledge of ground-water flow modeling. I have attached a copy of the document with specific and general comments written in the margins for your information.

It is our opinion that the report provides insufficient documentation of model construction and calibration to determine the appropriateness of the model for its intended use. In other words, the report is not ready for review. A list of specific problems and resultant implications, as well as required components of USGS reports describing modeling studies, was prepared by James Robinson from his review and is presented below.

Specific Problems

1. There is no discussion of model assumptions.

2. The model boundaries are inadequately described.

3. The calibration approach, steady-state or transient, is not specified.

4. There is no discussion of model input parameters except for the hydraulic conductivity of the "Fluvial Aquifer".

5. There is no list or discussion of all the model stresses.

6. There is no discussion of the model water budget.

7. There is no discussion of model sensitivity analyses.

Implications

1. There is no way to determine if the model boundaries are valid, and no way to determine how model calibration was influenced by model boundaries.

2. There is no way to compare model input values with previous literature values available for the same area.

3. Without sensitivity analyses, there is no way to determine if model boundaries influence simulation results.

4. Without 1 and 3 above, it is risky to use this model for predictive analyses.

Based on internal USGS guidelines, the report fails to present and therefore satisfy the following specific requirements for modeling reports:

-A description of the hydrologic system under investigation;

-A description of the mathematical methods used and their appropriateness to the problem being solved;

-A description of the hydrogeologic character of the boundary conditions used in the simulation of the system;

-A description of the aquifer system properties that are modeled;

-A description of all the stresses modeled such as pumpage, evapotranspiration from ground water, recharge from infiltration, river stage changes, leakage from other aquifers, etc.;

-If a model is calibrated, a presentation of the calibration criteria, procedure, and results; and

-A discussion of the limitations of the model's representation of the actual system and the impact those limitations have on the results and conclusions presented in the report.

Please feel free to call me at (615) 736-5424, ext. 3137 if you have any questions or comments when you receive this package.

Sincerely,

John K. Carmichael
Hydrologist

copies: J. Kingsbury
J. Robinson

Groundwater Modeling Approach for Remediation Design at the Defense Depot, Memphis

Introduction

The Defense Depot, Memphis (DDMT), like many Department of Defense (DoD) installations, has been exposed to groundwater pollution through the course of defense related activities. The primary contaminant at many of these installations are solvents that were often used in degreasing operations. The primary solvents used, such as trichloroethylene (TCE), and their daughter products are typically found in concentrations below the solubility limit. At DDMT, the primary contaminants for the purposes of this groundwater modeling study include TCE and its daughter products under Dunn Field (Figures 1-2).

Purpose for Modeling

It has become commonplace to use numerical models in planning and conducting remediation operations at DoD installations. Indeed, a substantial investment has been made by DoD in the development of a state-of-the-art modeling system to assist in these cleanup efforts. The reasons for this are clear since contamination at DoD installations is significant as are the costs of cleanup. Modeling systems are essential for DoD to optimize remediation and provide cost efficient cleanup.

Even with the stated goal of optimizing cleanup, it is important to narrowly focus the purpose of the modeling exercise. Modeling does not solve all problems at a cleanup site but does indeed improve the chance for remediation success. Additionally, one modeling approach is not appropriate for all sites just as different contaminants and treatment technologies are site specific.

evaluate

System will not do this

The purpose of this modeling exercise is to design a pump and treat remediation system that will confine the contamination plume and allow it to be treated. To the greatest extent possible, groundwater gradients will be maintained in such a way as to pull contamination back onto DDMT where it can be treated without inconveniencing the public. The models will be used to design the pump and treat remediation system and to predict and monitor cleanup progress over the life of the cleanup activities. Ultimately, performance of the remediation action and the models ability to predict this behavior will be reviewed at the end of five-years to determine the course of treatment action over the remaining life of the remediation project.

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Groundwater Modeling System

The modeling system chosen for the DDMT application is the Department of Defense Groundwater Modeling System (GMS). GMS was designed and constructed precisely for the type of application presented by DDMT. GMS contains a wide variety of database, conceptualization, simulation, and optimization tools to perform remediation designs and manage the remediation effort from beginning to end.

The numerical model selected for application at DDMT is FEMWATER. FEMWATER was originally put into the GMS with support provided by the EPA Athens Laboratory. Their purpose for including FEMWATER in GMS was to provide a rigorous tool for wellhead protection studies. WES continues to provide EPA with support for GMS to accomplish this goal.

Conceptual Model

The conceptual model developed for Dunn Field at DDMT, was based on the best hydrogeologic data as provided by the Law Engineering work in 1990 ~~and~~ later work by CH2MHill in 1996. A total of 64 wells were used to develop the stratigraphy from which the numerical model was based (Figure 3). The USGS, the University of Memphis Groundwater Institute, and other agencies were solicited for conceptual model data that formed the final conceptual model.

The DDMT site overlies a depositional region that provides numerous conceptualization difficulties. The ancestral Mississippi River laid down numerous depositional features that are difficult to determine from a discrete sampling of boreholes. The depth and thickness of the surficial aquifer are highly variable throughout the site. Clay lenses are likely to be present in the surficial aquifer giving the appearance of a shallowing of the aquifer when 100 feet away an entirely different depth to the confining layer is observed. Given an understandable reluctance to punch holes through the lower confining unit and into the Memphis Sands aquifer, it takes some skill and interpretation to determine which observation of the water table is likely to be perched and which clay lens is likely to be part of a larger continuous confining unit.

Given these constraints, a conceptual model of the stratigraphy was developed. Figure 4 is an oblique view of the solid model developed from the boreholes. Its outward appearance does not illuminate the variability that exists inside. Figures 5-8 show cross sections cut through the solid along with the nearest borehole data to the individual sections. The dips in the clean sand aquifer in the middle of Figures 5 and 6 are thought to be a paleochannel that runs along the southern edge of Dunn Field in a northwesterly direction. This appears to be the most

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reliable interpretation of the data. However, it is possible that the paleochannel that is inferred from a few borings could actually be locally anomalies in clay lenses that are not truly the top of the Jackson Clay. The surface relief at DDMT provides no indication of the irregularities that are apparent from the borings. From the fairly low relief of the surface topography, there is on the order of 50 to 100 feet of unsaturated zone.

The potentiometric surface below gives confirmatory evidence of a paleochannel (Figure 9). The southwestern edge of the model, shaded in blue, lies along a constant contour line in Figure 9. This placement of the model boundary was chosen for numerical reasons. Farther down slope and outside the model domain, the thalweg of the paleochannel appears to flow to the northwest. When coupled with a view of a surface connecting the contacts of the bottom confining unit (Figure 10), the possibility of a paleochannel cannot be dismissed. The paleochannel may become, if not currently, a pathway for contaminants to travel off base and potentially into other aquifers.

Numerical Model

The numerical model chosen for this application is the FEMWATER code found in the DoD Groundwater Modeling System (GMS). FEMWATER is an unstructured, variably-saturated groundwater model. It was chosen for this application because its unstructured nature is ideal for describing irregular stratigraphy in a short period of time and it permits quick turnaround in testing multiple pumping configurations with minimal model setup.

The boundaries for the FEMWATER mesh were chosen where they could be easily defined but sufficiently distant from the problem area not to constrain solutions. Toward that end, the bottom of the mesh was defined as the top of the thick Jackson Clay confining unit under the surficial aquifer. The top of the mesh was defined by a surface describing the potentiometric surface. Therefore, the intention of the exercise was to simulate saturated flow conditions in the aquifer without the numerical overhead of 50 to 100 feet of unsaturated zone. Resolution could then be placed near the wells in the saturated zone where they are more useful. However, the model is capable of accurately simulating unsaturated conditions when pumping exceeds inputs to the aquifer.

The final finite element mesh used to design a 17 well pumping plan had a total of 23,018 elements, 13,734 nodes, and 6 layers (Figure 11). This number will vary slightly as different configurations are tested in future simulations.

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Model Calibration

A preliminary calibration has been completed based on the best estimates of the stratigraphy as defined by the boring information collected to date. This model calibration will continuously improve as each additional drilled well provides additional stratigraphic data for the model conceptualization. In the interest of proceeding quickly with the cleanup, seven of the 17 planned wells are scheduled soon and will provide this additional stratigraphic data. After the model is updated, the remaining wells will be added and a new calibration performed.

The initial 17 well calibration consisted of matching pump test performance at the pumping well and observation wells PZ-61 and PZ-62 (Figure 12). These wells are located in the extreme northwestern corner of Dunn Field. The model matched the observed monitoring data fairly well. The best calibration simulations to date used hydraulic conductivities of 2.8 ft/hr in the horizontal and vertical. These values are consistent with data supplied by other modelers for similar applications in the area. The average difference between observed heads and computed in the Dunn Field area is less than 0.6 feet. Considering the degree of uncertainty in the stratigraphy, this is considered acceptable for the purposes of the model study. However, additional improvements in the calibration will be possible as more stratigraphic data is supplied as new wells are drilled.

by whom?

Preliminary Model Results

Several well configurations have been tested to date. Indeed, this highlights the main reason for selecting GMS to accomplish the modeling. Variations of well locations and pumping schedules can be tested without difficulty. Initial testing centered on a four well configuration believed adequate to capture flows toward the southwest and ultimately into the paleochannel, but these were found to be insufficient in accomplishing that purpose. The four well scheme did not capture plume migration to the northwest into what could be another paleochannel.

The second configuration tested a line of interceptor wells that lined the west and north boundaries of Dunn Field. This was a particularly attractive configuration since wells could be placed on DDMT property without access problems from local land owners. This second configuration was effective in eliminating contaminant from leaving DDMT but was not totally effective in capturing the entire plume. Additional wells would be needed to capture off base portions of the plume.

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A third configuration was tested that included a combination of perimeter wells and off base wells to capture most of the plume. Initially 14 wells were used but later 3 additional wells were added off base to capture additional portions of the plume. To date, the 17 well configuration (Figure 13) provides the best capture plan considering the property access constraints. Figure 14 shows the flow field just before pumping begins and Figure 15 shows the capture zone after pumping has reached equilibrium. Heads are displayed as color shaded contours and velocity directions (not magnitude) are shown as arrows. Figure 16 shows a cross sectional view of the drawdown for the wells in the northwestern corner of Dunn Field.

It is clear that the plan effectively captures the on base portion of the plume. To the north of Dunn Field, the scenario actually reverses gradients and pulls the plume back from off base. The area directly west of Dunn Field needs more attention and efforts are underway to locate wells optimally in this area. Figure 17 gives the pumping statistics for each well in this plan and the projected drawdown. It anticipated that the pumping rates along the northern boundary of Dunn Field can be reduced and still be effective. The pumps along the western boundary will likely be optimized individually but the magnitude of the pumping will not change much.

Future Studies

Studies to date have concentrated on quickly finding a configuration of wells that can, through hydraulic control, minimize the migration of groundwater flows (and hence contamination) off base. It is possible that additional wells and alternative pumping rates will be more effective in accomplishing that task. Optimization of pumping locations and rates will reduce overall costs of the cleanup action and improve cleanup. Flow simulations are currently being optimized.

Once the flow processes are thoroughly modeled, transport simulations are planned to track the plume as it is impacted by the flows and transport processes. These simulations will ultimately provide projections of the effectiveness of the remediation design. Calibration of the transport model will be an ongoing process, with improving accuracy as monitoring data becomes available.

Optimization of the flow and transport models will be useful to meet projected goals of the remediation action, to minimize costs, and to provide estimates as to how long the cleanup action will take. With the five year review period in mind, the numerical model and new monitoring data will be essential in planning the remainder of the cleanup action, including the impacts of natural attenuation on the fate of the contaminants.

Also this system may disrupt whatever natural attenuation is occurring

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