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HYDROGEOLOGIC STUDY OF THE FMPC DISCHARGE TO THE GREAT MIAMI RIVER

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LETTER

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Department of Energy
Oak Ridge Operations
P. O. Box E
Oak Ridge, Tennessee 37831

August 1, 1988
DOE-1245-88

Mr. Graham Mitchell
Ohio Environmental Protection Agency
40 S. Main Street
Dayton, Ohio 45402

Dear Mr. Mitchell:

HYDROGEOLOGIC STUDY OF THE FMPC DISCHARGE TO THE GREAT MIAMI RIVER

This letter transmits by attachment, the final version (Attachment I) of the Hydrogeologic Study of the FMPC Discharge to the Great Miami River (Zone of Influence Study). This report was prepared to fulfill the requirements of Order 14B of the Ohio Director's Finding and Orders. The report incorporates the latest responses to comments received from OEPA on the interim study report which was transmitted to OEPA on October 1, 1987 (Attachment II).

Sincerely,

James A. Reafsnyder
Site Manager

DP-84:Stone

Attachments: As stated

cc w/att.:
Rich Bendula, OEPA-Dayton
Catherine McCord, USEPA-5
Robert Cohen, GeoTrans
Jonathan Forstrom, SE-31, ORO

COMMENT RESOLUTION

HYDROGEOLOGIC STUDY OF FMPC DISCHARGE TO THE GREAT MIAMI RIVER

Ohio EPA Comment Number 1

"The zone-of-influence (capture zone) of the SOWC production wells in the Big Bend well field along the Great Miami River is well-defined by water-level measurement surveys made on a monthly basis between April 1986 and August 1987. Groundwater flow directions determined from these surveys consistently demonstrate that most of the FMPC facility is within the capture zone of the SOWC wells (Figure 2)."

Reply

This conclusion is for precipitation and river recharge conditions which existed during the time period April 1986 to August 1987.

Ohio EPA Comment Number 2

"Groundwater modeling by DOE also indicates that groundwater beneath most of the FMPC facility is captured by SOWC's Big Bend well field (Figure 3)."

Reply

A portion of the groundwater flowing beneath the Feed Materials Production Center (FMPC) is captured by the Southwestern Ohio Water Company (SOWC) well field based on the 2-D modeling conducted in August through September 1987 and presented in the October 1987 Zone of Influence Study for normal precipitation, recharge, and river recharge conditions. Final conclusions about water movement from the FMPC to the SOWC well field will be based on the 3-D groundwater modeling performed for the RI/FS.

Ohio EPA Comment Number 3

"Water-level measurements and groundwater modeling (Figures 2 and 3) show that the FMPC main effluent line to the Great Miami River which discharges within the 180-degree "Big Bend" is within the SOWC well field capture

zone. DOE's conclusion (pp. 4-1) that "the FMPC (sewer) discharge could actually be outside the capture zone of the SOWC wells if the river infiltration is greater than assumed" is contradicted by the water-level data."

Reply

In reference to the water table maps (Figures 2.1-13 through 2.1-25) the FMPC discharge is within the cone of depression of the SOWC well field. Flow vectors generated from groundwater modeling were used to determine the zone of influence of the pumping wells. The 2-D modeling was conducted for known pumping rates and with specified hydraulic parameters and river leakage. The model indicates how variable the zone of influence may be depending on the river leakage value given. If the river leakage is increased toward the high value used in the modeling sensitivity analysis, then the edge of the zone of influence (reference to Figure 3.2-4) would shift to the east (using grid north as north) and take the FMPC effluent line out of the zone of influence of the SOWC wells.

Ohio EPA Comment Number 4(a), Paragraph 3

"The range of uranium concentration in the FMPC sewer effluent is not documented by DOE in the subject report or their 'Environmental Monitoring Annual Report for 1986'. Therefore, it is only possible to evaluate C_r based on an average C_{eff}. This is significant because temporal increases in uranium concentration in the SOWC wells will result from temporal increases in C_{eff} and C_r. In 1985, the value of C_{eff} ranged from 352 pCi/L to 1334 pCi/L around a mean of 663 pCi/L (ORAU, 1985). A proportional C_{eff} for 1986 would be 239 pCi/L to 905 pCi/L."

Reply

The calculation of C_r is being reevaluated based on actual recorded values of C_{eff} from the field program discussed in Chapter 5. Further evaluation is being made for C_r using a normal range of C_{eff} values and the results will be reported in the final Zone of Influence Study report.

Ohio EPA Comment Number 4(a), Paragraph 4

"Using equation (1), the average value of C_r is 1.3 pCi/L. In evaluating the range of impacts on C_r, DOE assumes that low flows in the sewer pipe do not occur during high flows in the river and vice versa, based on the storm water runoff contribution to sewer effluent. While apparently logical, this assumption should be checked by comparing available sewer flow, river flow, and uranium concentration data."

Reply

An analysis of existing data is being performed to check the relationship of sewer flow, river flow, and uranium concentrations. The results will be reported in the final Zone of Influence Study report.

Ohio EPA Comment Number 4(a), Paragraph 5

"River water sampling stations upgradient and downgradient of the FMPC effluent discharge outfall are shown in Figure 4. The range and mean dissolved uranium concentrations in river water based on weekly analyses in 1986 are provided in Table 3. These data show that the U concentration in river water sampled at Station W3, is approximately 5 km downstream from the sewer outfall, ranged from 0.81 to 2.4 pCi/L, with a mean value, 1.4 pCi/L, that exceeds the value of C_r calculated by DOE."

Reply

The value of uranium in the river, C_r, is being reevaluated based on actual field data. A sensitivity analysis is being performed using STRIP1B and the results will be reported in the final Zone of Influence Study report. The value used in the draft report was an average value based on historical field records. It should be noted that uranium concentrations at Station W1, upstream of the FMPC discharge, ranged from 0.81 to 3.0 pCi/L with a mean value of 1.2 pCi/L during the same time period. The variation between 1.3 pCi/L and 1.4 pCi/L may be accounted for in analytical variability.

Ohio EPA Comment Number 4(a), Paragraph 7

"The most accurate way to determine the uranium source term for the ground water model is to measure uranium in that portion of the river in the SOWC

zone-of-influence. Samples of river water downgradient of the discharge pipe were taken for analysis as part of this study. Unfortunately, chemical analyses were not complete when the report was prepared. The final assessment of FMPC effluent discharge impacts on the Big Bend well field should rely on actual field data rather than model estimates."

Reply

The value of C_r is being reevaluated based on actual field data collected for the Zone of Influence Study during 1987. Sensitivity analyses will be performed for the surface water model input parameters and this will be presented in the Zone of Influence Study report. Additional river water samples upstream and downstream of the effluent discharge point are being collected and evaluated as part of the RI/FS.

Ohio EPA Comment Number 4(b), Paragraph 1

"DOE applied a hydrodynamic dispersion model, STRIP1B, to evaluate the appropriateness of using a complete-mix model to determine C_r. Deficiencies of the dispersion model application include: (1) failure to conduct a sensitivity analysis; (2) failure to perform a history match; and (3) incorrect calculation of the transverse hydrodynamic dispersion coefficient by using river depth instead of width (the appropriate value of D_z should have been 31 ft^2/s instead of 0.5 ft^2/s. Although STRIP1B is said to have been verified against another porous media model (pp. 3-9), what verification has been performed against other surface water models?"

Reply

Additional modeling using STRIP1B is being performed to address the deficiencies noted by Ohio EPA. This will be reported as part of the Zone of Influence Study. The modeling includes:

- A sensitivity analysis of model input parameters will be performed with the parameter range determined later.
- Model output values will be compared with actual field data collected during September 1987.
- The calculation of transverse hydrodynamic dispersion coefficient will be reevaluated.

- A discussion will be provided in the final Zone of Influence Study report showing the derivation and the equations used in the STRIP1B model and the acceptability of this model for surface water solute transport evaluations.

Ohio EPA Comment Number 4(b), Paragraph 2

"Modeling results suggest that complete mixing of FMPC effluent and river water will occur one mile downstream from the discharge pipe, a distance beyond the calculated capture zone of the Big Bend well field. Field observations document conditions which will inhibit complete mixing within the well field capture zone. DOE (pp. 5-10) reports that 'the FMPC outfall may not mix extensively with river water immediately in the vicinity of the source' due to 'the presence of an eddy pool immediately downstream from the outfall' on the western side of the river and a gravel bar that 'splits the channel into two distinct channels during periods of low flow'. The concentration of uranium, therefore, is probably higher in the portion of the river that is on the outside of the Big Bend than that on the inside. Given data constraints and ground water modeling considerations. DOE decided, nevertheless, to assume complete mixing and a C_r or 1.3 pCi/L for its well field impact assessment.

While we consider this assumption to be justified in lieu of field data at the time of study, its effect may be to underestimate the increase in uranium due to induced river leakage at the western SOWC collector well and to overestimate the increase at the eastern SOWC collector well."

Reply

A comparison will be made of the surface water model results versus field data collected as part of Zone of Influence field study. The object is to further investigate the validity of the complete mix assumption. The results of this analysis will be reported in the final Zone of Influence Study report.

Ohio EPA Comment Number 4(b), Paragraph 4

"It is not clear why DOE did not conduct tracer (dye) experiments, rather than modeling, to evaluate dispersion of the FMPC sewer effluent. Tracer experiments conducted under a variety of river stage conditions will better define dispersion at this site than modeling. Additionally, it may be possible to use tracer experiments to measure the rates of induced river leakage and flow to the SOWC collector wells"

Reply

For this investigation, uranium is being used as a tracer to study dispersion effects in the river. These effects will be more clearly understood once analyses of the Zone of Influence field study results have been completed. The induced river leakage issue is addressed in the reply to Ohio EPA Comment Number 4 (c), Paragraph 5.

Ohio EPA Comment Number 4(c), Paragraph 1

"Steady-state areal (2-D) ground water flow modeling was conducted to quantify the sources of water pumped by the SOWC collector wells in the Big Bend well field. Solute transport was not modeled. Rather, results of the ground water model, the complete-mix river model, and ground water uranium data were input to simple mixing calculations."

Reply

Solute transport modeling will be performed during the sitewide RI/FS.

Ohio EPA Comment Number 4(c), Paragraphs 2 and 3

"The areal flow model was calibrated by matching simulated and observed hydraulic heads in the study area. Based on the ground water modeling, DOE estimates that induced river leakage accounts for 76% of the 18.44 MGD ground water withdrawn at the Big Bend well field. Similarly, based on a limited sensitivity analysis, DOE estimates that the portion of ground water pumped from the well field that is derived from induced river leakage must range between 72% and 82%.

It may be possible to expand this range if a more extensive sensitivity analysis is performed with the ground water model. For example, by increasing aquifer transmissivity and recharge rate values, it may be possible to reasonably simulate the observed hydraulic head distribution with a reduced river leakage rate. Conversely, by lowering the aquifer transmissivity and recharge rate, it may be necessary to increase the river leakage rate to adequately match observed hydraulic heads. DOE did not vary aquifer transmissivity and recharge values input in the seven simulations in their sensitivity analysis. This may result in underestimation of the range of uncertainty associated with mixing calculations used to evaluate impacts of uranium in ground water and sewer discharge from FMPC on SOWC water quality."

Reply

Aquifer transmissivity and precipitation recharge values were varied during model calibration then held constant when a best fit to April 1986 potentiometric head values was achieved. This analysis of transmissivity and precipitation recharge for model calibration was considered adequate for the Zone of Influence Study. Additional sensitivity analyses will be performed as part of the sitewide RI modeling study.

Ohio EPA Comment Number 4(c), Paragraph 5

Calculated uranium concentrations in ground water pumped from the SOWC wells (C_w) using a greater range of input values for C_r, Q_d, and Q_u are given in Table 5. As shown, using Q_d and C_r values that are five times greater than the best estimates of DOE increases the value of C_w from 0.97 to 2.18. The National Academy of Science has proposed a drinking water standard of 35 ppb (23.5 pCi/L) for uranium and U.S. EPA is considering an even higher standard. This sensitivity analysis indicates that it is highly improbable that uranium discharged through the FMPC effluent sewer into the Great Miami River could increase ground water concentrations at the SOWC collector wells to the proposed standard."

Reply

This information will be included in the final Zone of Influence Study report. It helps to confirm the conclusion that there is no significant adverse environmental impact on the SOWC well water from the FMPC discharges.

Ohio EPA Comment Numbers 4(c), Paragraph 5

"Determination of the effect of FMPC effluent discharge into the river on uranium concentrations in ground water at the Big Bend well field is best made by: (1) sampling and analysis of uranium concentrations in C_r, C_{back}, C_{gw}, and C_w; and (2) better determination of the rate of induced river leakage in the vicinity of the SOWC wells by field measurements (i.e., slug tests as recommended, possibly tracer tests, etc.)."

Reply

(1) The surface water dispersion model will be rerun for the Zone of Influence Study based on field data collected during September 1987. The results will be reported in the final Zone of Influence Study report.

(2) Induced river leakage is a function of river stage, water table elevation, river bed hydraulic conductivity, and river water viscosity. Due to the changing river/aquifer conditions, i.e., river stage due to changing runoff conditions; aquifer water table elevation due to changing recharge and withdrawals, stream bed permeability due to changing siltation patterns, and changing river water temperature which changes viscosity; an extensive well installation and sampling program would have to be performed to accurately characterize river leakage rates in the vicinity of the SOWC collector wells. Infiltration rates determined by the U.S. Geological Survey (Dove, 1961) were used in the modeling studies along with a sensitivity analysis to evaluate changes in results due to variations in input values. This was considered adequate for the Zone of Influence Study.

Ohio EPA Comment Number 5

"Table 3.2.5 gives the appearance that DOE used a transient, three-dimensional model to evaluate the sources of ground water flowing to the SOWC wells. Why are values for porosity and storage coefficient (used in transient simulations) and K_v (used in layered simulations) included in the table?"

Reply

The approach to ground water modeling was to progress from 2-D to 3-D. The initial site conceptualization was 3-D so that the 2-D simplification of the hydrogeologic system could be made.

Ohio EPA Comment Number 6

"The main significance of conducting sensitivity analyses with the ground water model for this application is to determine how the volume of water derived from the difference sources (upgradient ground water, upgradient and downgradient river water) will change with changing parameter estimates. This result is not given in Table 3.2.6."

Reply

Water balance calculations are provided in Table 3.2.7. The calculated percentage of flow from the river (Q_R) will be divided into upgradient and downgradient components and the results of the water balance for the collector wells for model cases 1, 2, and 3 will be presented in the final Zone of Influence report.

Ohio EPA Comment Number 7

"It is unclear why Figure 3.2-2 titled 'Conceptual Design for 'Zone of Influence' Ground Water Model' depicts a layered flow domain when only a depth-averaged flow model was used?"

Reply

The approach to ground water modeling was to progress from 2-D to 3-D. The initial site conceptualization was in 3-D so that the 2-D simplification of the hydrogeologic system could be made.

Ohio EPA Comment Number 8

"DOE (pp. 3-26) reports that the calibrated model indicates that 76% of the water pumped at the Big Bend well field is derived from induced river leakage and that only 6% of the river leakage occurs downgradient of the FMPC effluent sewer discharge. How was this quantitation made?"

Reply

The quantification of river leakage from the model output was determined as follows:

> Induced infiltration amounts for each river element was taken from the ground water model output. The values of all elements were totaled and the percentage determined for both upstream and downstream river elements relative to the point of effluent discharge.

Ohio EPA Comment Number 9

"DOE (pp. 4-4) proposes "that a direct field determination of the leakage factor be completed as part of the sitewide RI/FS." What is the status of this proposal?"

Reply

Currently no field work has been performed to determine a river leakage factor. We believe that a very large effort would be required to significantly improve on the USGS work (Dove, 1961). However, additional field studies required to address this issue are currently proposed to be completed during the RI.

Ohio EPA Comment Number 10

"Although Order 14b mandates determination of the impacts of the FMPC effluent discharge on the SOWC Big Bend well field and other major production well fields, no zone-of-influence assessment was made for the Albright and Wilson withdrawal."

Reply

The Albright and Wilson wells were included within the model as a pumping center as indicated in table 3.2.5. The flow vector plot for the model calibration run shown in Figure 3.2-3 includes pumping at these wells (located at Node 162 with a combined pumping rate of 19,000 ft^3/day). The flow vectors show no deflection towards this pumping center from the direction of the SOWC wells.

Based on existing data and the ground water modeling results, the following factors indicate that the FMPC discharge to the Great Miami River does not affect water pumped from the Albright and Wilson wells:

- The Albright and Wilson wells are located far from the Great Miami River south of the FMPC
- The radius of influence for the Albright and Wilson pumping center is small due to relatively low pumping rates

Ohio EPA Comment Number 11

"Assessment of this and other FMPC issues will be facilitated if we can assess (or, preferably, obtain diskette copies of) DOE's environmental data bases (including chemistry, geology, water-levels, well construction, etc.) and ground water modeling input data set. What arrangements can be made to obtain this information?"

Reply

This will be a topic for discussion for the June Technical Information Exchange.

References:

Dove, G.D., 1961, "A Hydrologic Study of the Valley-Fill Deposits in the Venice Area, Ohio," Technical Report No. 4, Ohio Department of Natural Resources, Division of Water.