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ANALYSIS OF THE EFFECT OF POTENTIAL
REACTOR COOLING PONDS
ON THE HANFORD GROUNDWATER SYSTEM

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ERRATA

The equation on page 3 under MATHEMATICAL SIMULATION MODEL
should be

$$\partial \frac{K (\phi - \phi_0) \frac{\partial \phi}{\partial x}}{\partial x} + \partial \frac{K (\phi - \phi_0) \frac{\partial \phi}{\partial y}}{\partial y} + Q = 0$$

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September 1970

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ANALYSIS OF THE EFFECT OF POTENTIAL REACTOR
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INTRODUCTION

The distances separating the groundwater table (piezometric surface) from overlying waste storage tanks, cribs, trenches and swamps are an important factor in the Hanford chemical processing waste management program relative to radiological considerations. Any project that affects the Hanford groundwater system requires an evaluation to determine its effect on present and future waste management practices. Likewise, hydrological considerations are important in relation to nuclear plant siting studies at Hanford. Although a number of alternatives are available for cooling such plants, the use of cooling ponds will receive serious review due to economic and environmental factors. The potential for large seepage losses from the ponds to the groundwater system exists. These seepage losses could have a significant influence on the groundwater system and hence affect current chemical processing waste management programs. The effect on pond seepage on the groundwater system should be evaluated in conjunction with other hydrologic and geologic criteria prior to detailed siting studies.

A test case involving three hypothetical unlined cooling ponds was proposed for study. Figure 1 shows the location of these ponds on the Hanford Reservation. This report presents an analysis of the hydrological effects of the hypothetical ponds on the Hanford groundwater system and specifically the effects of the hypothetical ponds on the Hanford groundwater system and specifically the effects in the region of the chemical processing plants in the 200 East and 200 West areas.

SUMMARY AND CONCLUSIONS

Hydrological effects of the three reactor cooling ponds on the Hanford Reservation were evaluated in four separate cases. Each pond was analyzed for separate operation and one case was analyzed with all three ponds operating simultaneously. The study results indicate that the piezometric surface beneath the 200-East Area would rise less than 5 feet with all ponds operating simultaneously and less than 3 feet with any one of the ponds operating independently.

FIGURE 1. Locations of the Proposed Reactor Cooling Ponds

The 200-West Area would experience a rise in the piezometric surface of less than 1 foot with either the 420 foot Pond or the 440 foot Pond operating independently. With the 460 foot Pond operating independently or all three ponds operating simultaneously, the piezometric surface in the 200-West Area may rise as much as 25 feet.

In analyzing the effects of the 420 foot Pond it appears that the piezometric surface will rise to the ground surface in some small areas. Surface seeps may also result due to operation in the other ponds. The time limitation imposed on this study precluded definition of those areas which might be inundated. In addition, the combined effect of the proposed Ben Franklin Dam and cooling ponds on the groundwater system was not investigated in this study.

The results presented in this report are preliminary and should not be used to judge the feasibility of the reactor cooling pond concept. The mathematical model used in this study is being verified but this work has not been completed. Subsequent to this work and future model error and sensitivity analysis, the accuracy of the results can be confidently established. In addition, permeability data used in this study were from a limited number of wells and reflect only the permeability of the existing aquifer which may differ significantly from that at or near the ground surface.

MATHEMATICAL SIMULATION MODEL

The Variable Thickness Transient (VTT) model was reduced to steady-state conditions (VTS) to quickly investigate the hydrological influence of the three reactor cooling ponds on the Hanford groundwater system. The VTS model approximates a three-dimensional flow system since changes in transmissivity resulting from changes in aquifer thickness are considered.

The VTS computer routine, solves the following partial differential equation:

$$\partial \frac{K (\phi - \phi_0) \frac{\partial \phi}{\partial x}}{\partial x} + \partial \frac{K (\phi - \phi_0) \frac{\partial \phi}{\partial y}}{\partial y} + Q = Q$$

where K = permeability,
 ϕ = hydraulic potential
 ϕ_0 = lower boundary of the aquifer,
 Q = flux withdrawn from or discharged to the system.

This analysis assumes that: 1) the vertical component of flow is negligible, 2) the inflow and outflow surfaces penetrate the entire system, and 3) the permeability distribution is constant with respect to depth.

To use the predictive model described in equation (1), the permeability and base of the aquifer over the study area must be known. In addition, the Columbia and Yakima River elevations and inflows to the groundwater system must be known. The transmissivity distribution was calculated for the Hanford Reservation, using pump test data and the continuity of flow computer routine (Figure 2). The lower aquifer boundary map was taken from well logs and other geological and hydrological data, (Figure 3). Columbia and Yakima River elevations were based on backwater curves for the low flow period of 1968 when the discharge averaged 77,000 cfs. Recharge from the Rattlesnake Hills and Cold Creek Valley was based on the calculated transmissivity and measured groundwater gradients.

ANALYSIS OF POND OPERATION

Using the previously discussed mathematical model, the hydrological effects of the ponds were evaluated in four cases: 1-3) each pond operated independently, and 4) all ponds operated simultaneously.

The analysis was limited to a single set of flow conditions: low flow of the Columbia River and steady-state analysis. A steady-state analysis represents the worst conditions with respect to movement of radiocontaminants in the subsurface environment. Piezometric surface predictions were obtained by setting up the appropriate boundary value problem describing the present flow system plus holding the water at specified elevations in the ponds. The resulting piezometric surface predictions represent the ultimate height to which the groundwater will rise. Seepage losses to the groundwater system that result from holding the ponds at specified elevations were calculated from the predicted piezometric surface. Table 1 shows the size elevation and calculated seepage losses of the ponds.

FIGURE 3. Contours of the Bottom of the Unconfined Aquifer

TABLE 1

<u>POND DESIGNATION</u>	<u>SIZE, FT.²</u>	<u>SEEPAGE LOSS, FT.³/day</u>	<u>SURFACE ELEVATION</u>
460'	8.4×10^7	8.9×10^7	460'
440'	2.28×10^8	7.7×10^6	440'
420'	4.48×10^8	1.2×10^8	420'

The seepage loss rates were calculated using the following equation:

$$Q = \frac{\partial \Phi}{\partial X} * W * T \quad (3)$$

where Φ = hydraulic potential,
 X = distance between potentials,
 W = width between streamlines,
 T = transmissivity

Figures 4 and 5 show the simulated piezometric surface of the groundwater system resulting from the operation of the 440' and 420' ponds respectively. The piezometric surface shows little change from its present state (Figure 1) under the chemical processing area. However, adjacent to the cooling ponds the piezometric surface will rise approximately 45' above its present level and as discussed earlier localized surface ponding may develop. Figures 6 and 7 show the changes in altitude of the piezometric surfaces resulting from the operation of the 440' and 420' ponds respectively.

Figure 8 shows the simulated piezometric surface of the groundwater system resulting from the operation of the 460' pond. Little change from the present piezometric surface is evident in the 200 East Area. However, a rise of 20-25 feet in the piezometric surface may be expected in the 200 West Area and a rise of 60 feet may occur adjacent to the pond. The change in the piezometric surface resulting from operation of the 460' pond is shown in Figure 9.

Figure 10 shows the predicted piezometric surface of the groundwater system resulting from the simultaneous operation of the three proposed ponds. The piezometric surface will rise less than 5' in the 200 East Area in less than 20 to 25 feet in the 200 West Area. Figure 11 shows predicted changes in the piezometric surface resulting from the simultaneous operation of the three ponds.

FIGURE 4. Contours of the Predicted Groundwater Flow System Resulting from Continuous Operation of the 440' Cooling Pond

FIGURE 5. Contours of the Predicted Groundwater Flow System Resulting from Continuous Operation of the 420' Cooling Pond

FIGURE 7. Contours of the Predicted Change in Water Table Elevation Resulting from Continuous Operation of the 420' Cooling Pond

FIGURE 8. Contours of the Predicted Groundwater Flow System Resulting from Continuous Operation of the 460' Cooling Pond

FIGURE 10. Contours of the Predicted Piezometric Surface Resulting from Simultaneous Continual Operation of the 460' and 420' Ponds

FIGURE 11. Contours of the Predicted Change in the Piezometric Surface Resulting from Simultaneous Continual Operation of the 460', 440' and 420' Ponds

Travel times from the chemical processing areas to the Columbia River resulting from the pond operations were not calculated due to the preliminary nature of this study.

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