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ANALYSIS OF HYDROLOGICAL FACTORS
INFLUENCING THE GABLE MOUNTAIN
IRRIGATION PROJECT

September 1970

AEC RESEARCH &
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BNWL-1502

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Water and Land Resources Department
Environmental and Life Sciences Division

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CONTENTS

	<u>Page</u>
INTRODUCTION.....	1
SUMMARY AND CONCLUSIONS.....	1
MATHEMATICAL SIMULATION MODEL.....	2
ANALYSIS OF EFFECTS OF IRRIGATION.....	2
ACKNOWLEDGMENTS.....	10
REFERENCES.....	11

FIGURES

	<u>Page</u>
1 Calculated Transmissivity Distribution Used in the Mathematical Simulation Model	3
2 Contours of the Bottom of the Unconfined Aquifer	4
3 Portion of the Hanford Project to be Irrigated	6
4 Contours of the Predicted Groundwater Flow System Resulting from Continuous Irrigation	7
5 Contours of the Predicted Changes in the Groundwater Flow System Resulting from Irrigation	8
6 Contours of the Present Groundwater Flow System	9

ANALYSIS OF HYDROLOGICAL FACTORS INFLUENCING
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INTRODUCTION

In the present waste management planning for the 200-East and 200-West chemical processing areas, travel times from the processing areas to the Columbia River and the distance from the groundwater table to the waste storage tanks are of considerable importance. This report presents an analysis of the hydrological effects of continued long-range irrigation north of Gable Mountain on the chemical processing area waste management practices.

Previous studies⁽¹⁾ have shown the unconditional release of lands on the Hanford Reservation for use by the general public would generally not be compatible with good waste management practices. However, for certain portions of the Reservation a review of hydrological conditions that exist and that may prevail with various projected operational methods may permit a re-evaluation of the potential risks and benefits of multiple use of Hanford Reservation lands.

SUMMARY AND CONCLUSIONS

Hydrological factors of the Hanford Reservation were evaluated as influenced by the operation of the Gable Mountain Irrigation Project. The study results indicate that there would be no significant hydrologic effect on the current chemical processing waste management practices. Changes in the groundwater piezometric surface were extremely small and generally confined to the irrigated area.

The maximum area that could be irrigated safely was not determined nor was the maximum permissible application rate. Although an irrigated area of about 11,000 acres was studied the results indicate a much larger area could be safely considered.

MATHEMATICAL SIMULATION MODEL

Analysis of the hydrological factors influencing operation of the Gable Mountain Irrigation Project was carried out utilizing the recently developed Variable Thickness Transient (VTT) model reduced to solve steady-state flow problems.⁽³⁾ The Variable Thickness Steady (VTS) Model incorporates the variation of aquifer thickness in the transmissivity term. This approximates a three dimensional analysis. The non-linear partial differential equation used in the VTS model is

(1)

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

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

To use the predictive model described by Equation (1) the permeability distribution of the region considered is a required input. The transmissivity distribution (Figure 1) calculated in FY70 and the recently completed contour map for the lower boundary of the aquifer (Figure 2) were used with the present potential distribution to calculate the permeability from the following equation:

(2)

$$K = T / (\phi - \phi_o)$$

ANALYSIS OF EFFECTS OF IRRIGATION

The analysis was limited to a single set of flow conditions: Low flow of the Columbia River (77,000 cfs) and steady-state conditions. A steady-state analysis represents the worst condition with respect to movement of radio-contaminants in the subsurface environment. When the Columbia River is at low flow, the groundwater gradients are greatest since minimum aquifer thickness

is available at lower river stages for transporting the groundwater (assuming constant irrigation.) Piezometric surface predictions were obtained by setting up the appropriate boundary value problem to describe the present flow system plus additional recharge expected from irrigation. The resulting piezometric surface predictions represent the steady-state height to which the water surface will rise.

Groundwater recharge from irrigation on Hanford soils would be about 15 percent⁽²⁾ (or 0.75 foot per year for an application rate of 5 feet per year). This recharge was assumed to be evenly distributed over the 11,000 acre area proposed for irrigation (Figure 3). The VTT model was used to predict changes in the piezometric surface. Figure 4 shows predicted contours of the piezometric surface for the Hanford Reservation resulting from an application rate of 5.0 feet per year on the irrigated region. The piezometric surface resulting from the irrigation are shown in Figure 5. The influence of the irrigated area would be felt as far north as the 100-N area and as far south as the 200-East and 200-West chemical processing areas. The piezometric surface shows little change from irrigation as compared to the present system (Figure 6) except directly beneath the irrigated area where rises as great as 2.5 feet can be expected. A piezometric surface rise beneath the 200-East and 200-West Areas for steady-state conditions would be less than 1.0 feet.

Flow paths and travel times to the Columbia River were not calculated for the new system since the changes from the present values would be insignificant.

FIGURE 4. Contours of the Predicted Groundwater Flow System Resulting from Continuous Irrigation

HANFORD PROJECT

FIGURE 6. Contours of the Present Groundwater Flow System

ACKNOWLEDGMENTS

The authors are extremely grateful for the help of J. L. Rising in the graphics presentation.

REFERENCES

1. Foster, R. F. Radiological Aspects of Hanford Land Utilization, HW-76772. February 1963.
2. Letter, P. G. Holsted from S. L. Fawcett, D. B. Cearlock, et al. Rattlesnake Mountain Slope Irrigation Study, January 6, 1966.
3. Quarterly Report. Radionuclides in Soils, February 1970. Prepared by the Water and Land Resources Department of Battelle-Northwest.

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