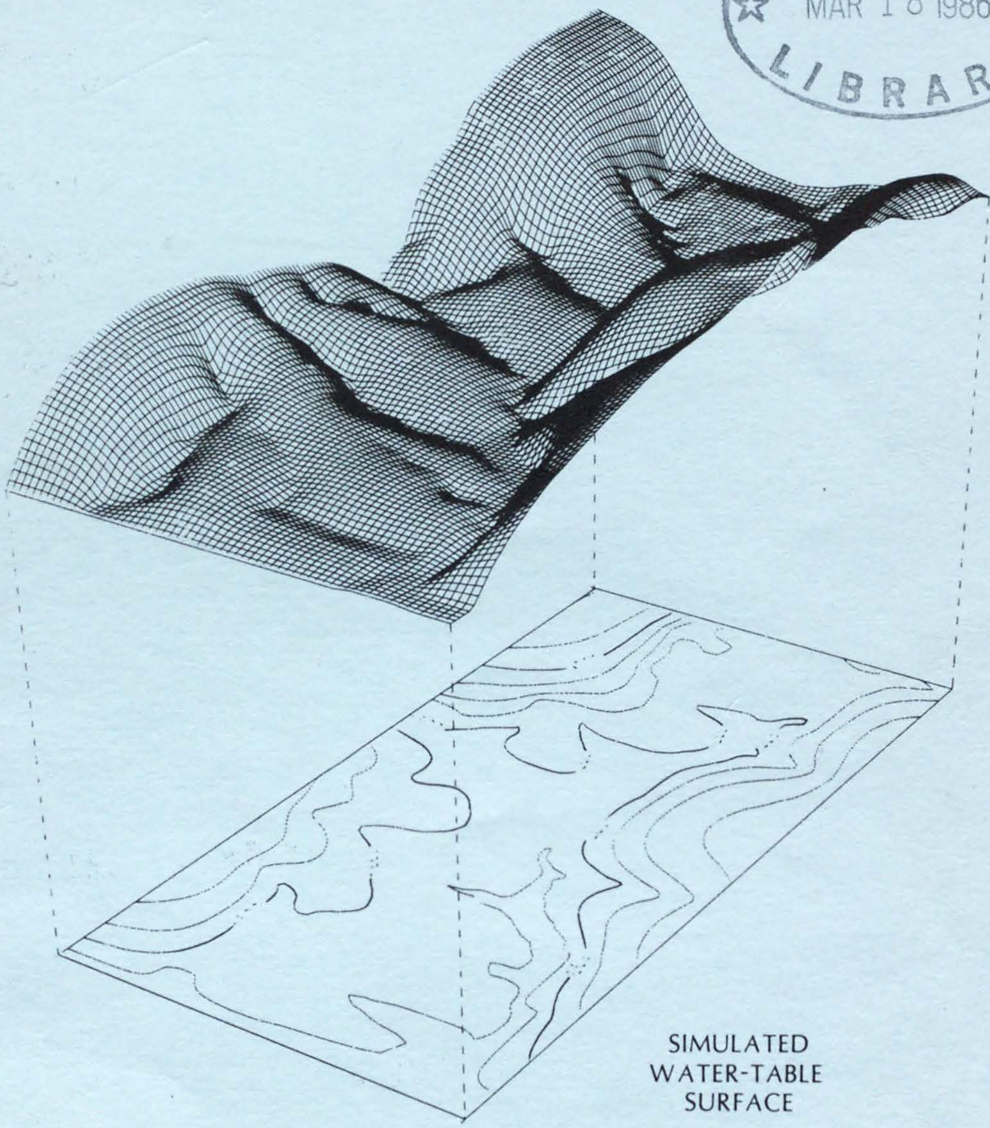
WATER-RESOURCES INVESTIGATIONS REPORT 85-4221

GROUND-WATER FLOW IN MELTON VALLEY, OAK RIDGE RESERVATION, ROANE COUNTY, TENNESSEE-- PRELIMINARY MODEL ANALYSIS

U.S. GEOLOGICAL SURVEY



Prepared in cooperation with the
U.S. DEPARTMENT OF ENERGY

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Patrick Tucci

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Nashville, Tennessee

1986

UNITED STATES DEPARTMENT OF THE INTERIOR

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GEOLOGICAL SURVEY

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CONVERSION FACTORS

For use of readers who prefer to use metric units, conversion factors for terms used in this report are listed below:

Multiply	By	To obtain
inch (in.)	25.4	millimeter (mm)
inch per year (in/yr)	25.4	millimeter per year (mm/yr)
foot (ft)	0.3048	meter (m)
foot per day (ft/d)	30.48	centimeter per day
foot per day per foot [(ft/d)/ft]	30.48	centimeter per day per centimeter [(cm/d)/cm]
square foot (ft^2)	6.452	square centimeter (cm^2)
foot squared per day (ft^2/d)	6.452	centimeter squared per day (cm^2/d)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
mile (mi)	1.609	kilometer (km)

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ABSTRACT

Shallow-land burial of low-level radioactive waste has been practiced since 1951 in Melton Valley. Ground-water flow modeling was used to better understand the geohydrology of the valley, and to provide a foundation for future contaminant-transport modeling. The three-dimensional, finite-difference model simulates the aquifer as a two-layer system that represents the regolith and bedrock. Transmissivities, which were adjusted during model calibration, range from 8 to 16 feet squared per day for the regolith, and from 0.2 to 1.5 feet squared per day for bedrock. An anisotropy ratio of 1:3 for strike-normal to strike-parallel transmissivity values, in conjunction with recharge rate equal to 6 percent of precipitation that is uniformly distributed over the model area, produces the best match between simulated and observed water levels.

Simulated water levels generally compare well to observed or estimated 1978 ground-water conditions. Simulated water levels for the regolith for 39 of 69 comparison points are within ± 10 feet of average 1978 levels. Simulated vertical-flow components are in the observed direction for 9 of 11 comparison points. Preliminary simulations indicate that nearly all ground-water flow is within the regolith and discharges to either the Clinch River or the White Oak Creek-Melton Branch drainage systems. Less than 3 percent of the flow is between the regolith and bedrock, and less than 1 percent of the total ground-water flow discharges to the Clinch River through bedrock.

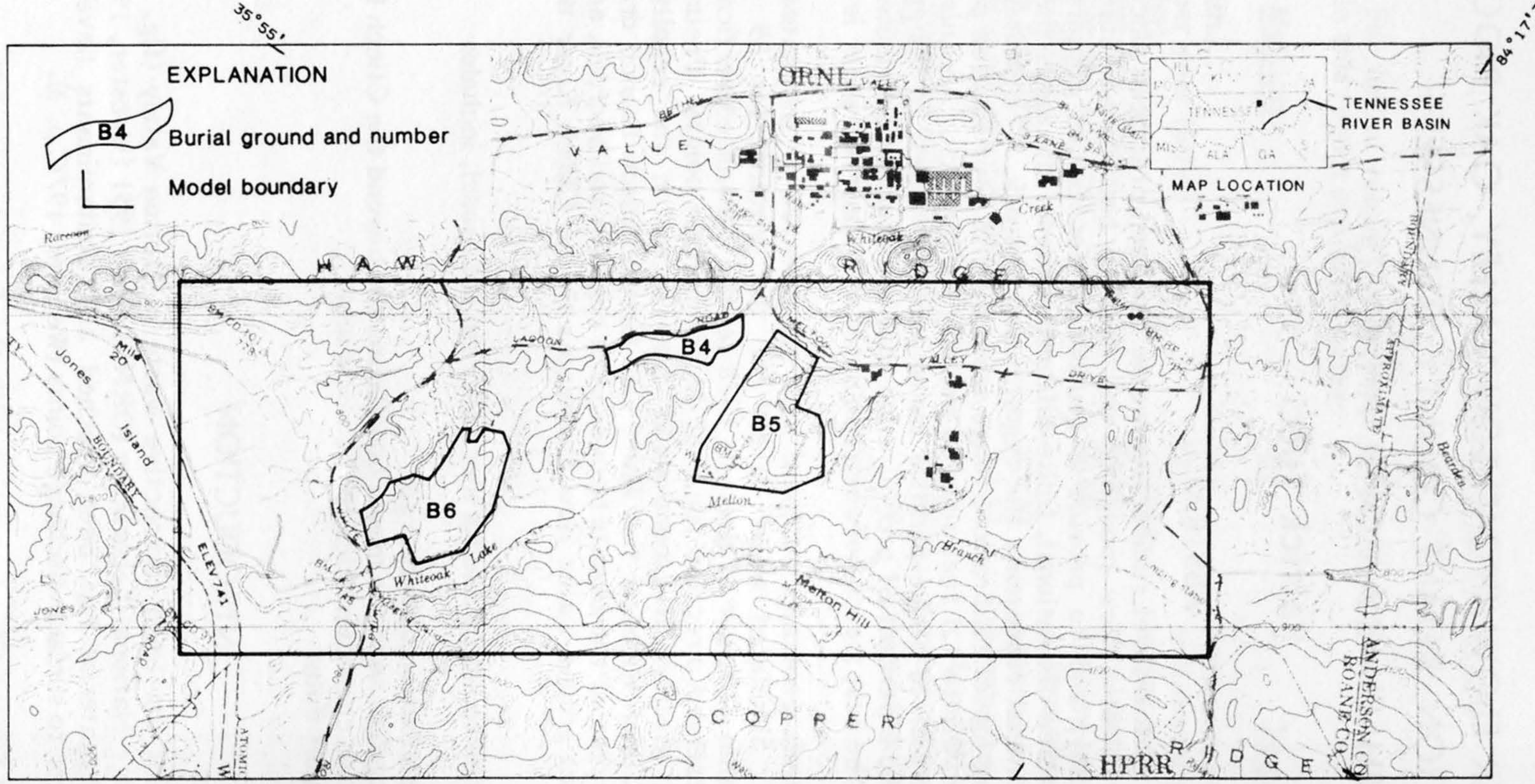
Additional data needed to refine and further calibrate the model, include:

1. Quantity and areal distribution of recharge;
2. Water levels in the regolith near the model boundaries and beyond the Clinch River;
3. Water levels and aquifer characteristics for bedrock; and
4. Additional surface-water data.

INTRODUCTION

Shallow-land burial of low-level radioactive waste in Melton Valley (fig. 1) has been practiced by Oak Ridge National Laboratory (ORNL) since 1951 (Webster, 1976, p. 34). Buried radioactive material has been leached and contaminants have been transported by ground water to surface discharge points (Webster, 1976, p. 3).

The U.S. Geological Survey, in cooperation with the Department of Energy, has conducted an on-going study of the geohydrology of the burial grounds since 1975. The



Base from Tennessee Valley Authority-
U.S. Geological Survey, Bethel Valley.
Tenn., 1:24,000, 1968

0 1000 2000 3000 4000 5000 FEET
0 500 1000 METERS
CONTOUR INTERVAL 20 FEET
DATUM IS SEA LEVEL

N

Figure 1.-- Model area and location of burial grounds.

use of ground-water flow models as an aid in understanding the ground-water system has been included in that study since May 1984. This report describes the first phase of modeling, discusses preliminary modeling results up to October 1, 1984, and discusses additional data needs.

The goals of the modeling effort are:

1. To test the use of a three-dimensional, finite-difference model to simulate the ground-water flow system of Melton Valley;
2. To aid in the definition of general areas of data deficiencies;
3. To provide a foundation for more detailed ground-water flow and contaminant-transport models of individual burial grounds; and
4. To aid in selection of long-term surface-water and ground-water monitoring sites.

GEOHYDROLOGIC SETTING

Geology and Aquifer Characteristics

Melton Valley is underlain by the Conasauga Group of Cambrian age (McMaster, 1963), which consists of six formations (in ascending order): Pumpkin Valley Shale, Rutledge Limestone, Rogersville Shale, Maryville Limestone, Nolichucky Shale, and Maynardville Limestone (Davis and others, 1984, p. 16). The formations strike northeast at about 56 degrees from north and dip southeast at angles generally between 30 and 40 degrees, although local variations are common (Webster, 1976, p. 8). A generalized geologic map of Melton Valley (fig. 2) was constructed on the basis of core-hole data, regional geologic mapping by McMaster (1963), and, where data were lacking, on the observation that topographic highs generally are underlain by limestone formations and lows generally are underlain by shale (C. S. Haase, Martin Marietta Energy Systems, Inc., oral commun., 1984). Alluvial deposits are located near the Clinch River, but are not shown on the geologic map.

The depth of weathering within the Conasuaga is variable and ranges from less than 5 feet in low-lying areas to as much as 40 feet on the ridges (Webster, 1976, p. 9). This variation in weathering is probably related to the different weathering characteristics of the different lithologies that underlie these topographic features. The weathered zone is referred to as "regolith" in this report. The regolith generally consists of silty clay with increasing residual rock fragments with depth.

Hydraulic conductivity values of the regolith, based on slug test results, are variable but generally range between 0.01 and 1.0 ft/d (D. A. Webster, U.S. Geological Survey, written commun., 1984). Slug test results in Burial Ground 4 (fig. 1), indicate hydraulic conductivity values of the regolith developed on the Pumpkin Valley Shale range from 0.01 to 0.5 ft/d. Hydraulic conductivity values of the regolith developed on the Rogersville Shale in a small area in Burial Ground 5 are about the same as those for Burial Ground 4. Hydraulic conductivity values of the regolith developed on the Maryville Limestone range from 0.01 to 6.7 ft/d, and generally are greater in the southwest half of the valley than in the northeast half.

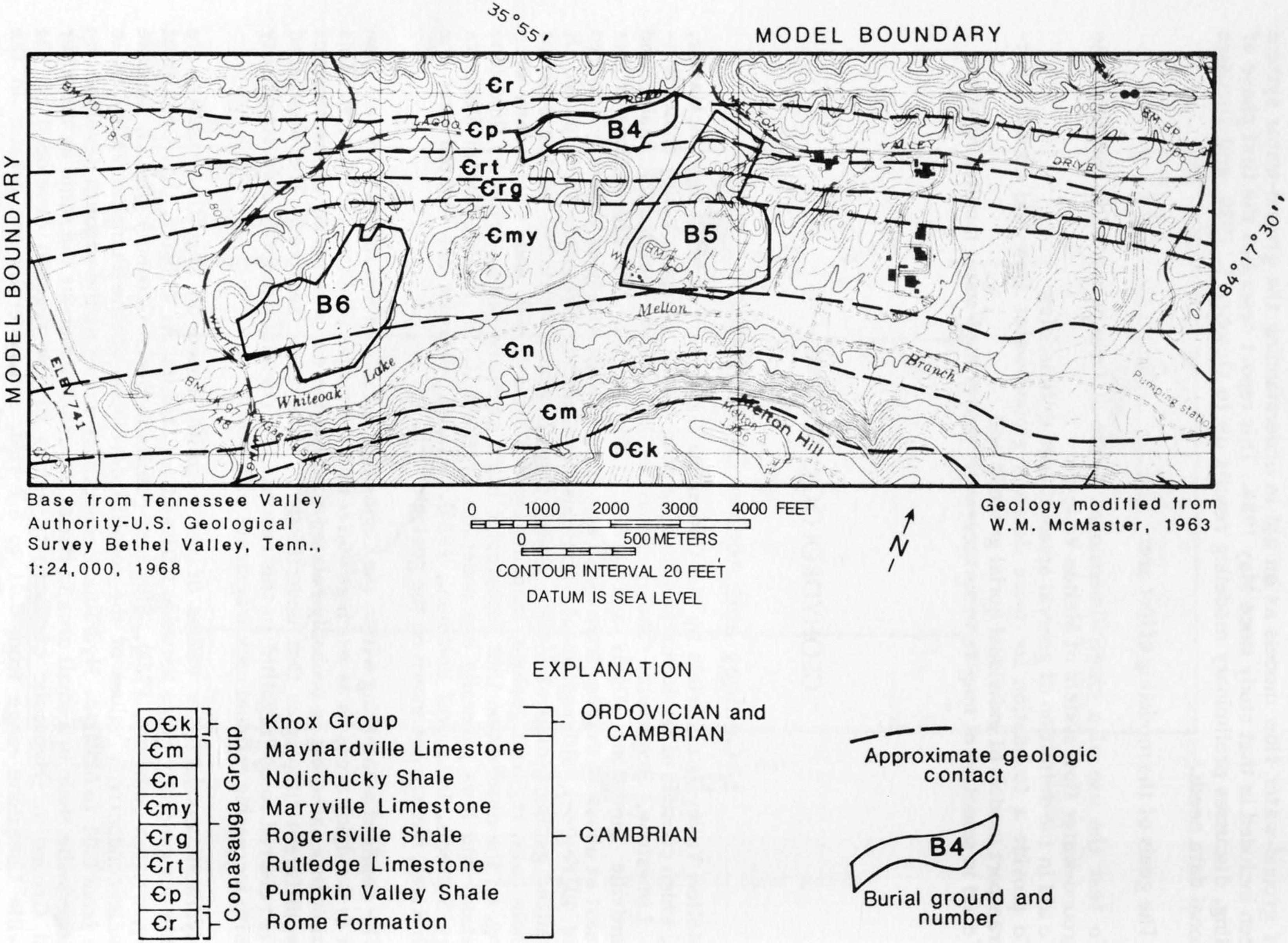


Figure 2.-- Generalized geology of Melton Valley model area.

Transmissivity of the unweathered part of the Maryville Limestone was obtained from two aquifer tests conducted in Burial Ground 5. The transmissivity values calculated from these tests were 1.55 and 1.64 ft^2/d (D.A. Webster, U.S. Geological Survey, written commun., 1984). These values were obtained for depth intervals of 150-200 feet and 44-100 feet, respectively.

Several investigators have studied the geologic controls on hydraulic properties of the Conasauga Group (Webster, 1976; Sledz and Huff, 1981; Davis and others, 1984). The reported ratio of strike-normal (northwest-southeast) to strike-parallel (northeast-southwest) hydraulic conductivity values range from 1:3 to 1:20 (E. R. Rothschild, Martin Marietta Energy Systems, Inc., written commun., 1984).

Recharge and Discharge

Almost all recharge to the ground-water system is derived from precipitation, which averages about 54 inches per year at ORNL (Webster, 1976, p. 10). Infiltration from Whiteoak Creek and man-made discharges to streams may provide minor amounts of recharge. Recharge from precipitation can be estimated on the basis of hydrograph separation techniques described by Rorabaugh (1964) and Daniel (1976). Because of a lack of continuous, long-term streamflow records in Melton Valley, data from Poplar Creek, which is located about 6 miles northwest of the study area, were used for the hydrograph-separation analysis. Geologic settings of both drainage systems are similar, although about half of the drainage to Poplar Creek is from the Cumberland Plateau, which is underlain mainly by Pennsylvanian sandstone and shale. Streamflow per square mile is lower during dry months for streams on the Plateau than for streams in the Ridge and Valley physiographic province in which Melton Valley is located (R.D. Evaldi, U.S. Geological Survey, written commun., 1984). The recharge for the Poplar Creek drainage area is estimated to be about 25 percent of precipitation (R. D. Evaldi, U.S. Geological Survey, written commun., 1984).

Discharge from the ground-water system is by seepage to the Clinch River, Whiteoak Creek, Melton Branch and Whiteoak Lake, and by evapotranspiration. At the present time (1984), underflow beyond Melton Valley and the Clinch River has not been investigated, and is assumed to be negligible. On a yearly average basis, the ground-water system is considered to be in equilibrium; that is, recharge is equal to discharge.

Ground-Water Movement

Average water levels for 1978 in the regolith are shown in figure 3. Water-level data for this time, which were used for model calibration, were available only for the burial ground areas. The configuration of the water table generally follows the topography of Melton Valley. Ground-water flow in the regolith is controlled by both the topography and the geology. Flow generally is from high elevations to low elevations and to surface drains, but is somewhat skewed in the direction of strike because of remnant structure in the regolith. Ground-water flow in the bedrock is thought to be mainly through fractures and joints within the upper 200 feet of the ground-water system (Webster, 1976, p. 17; Davis and others, 1984, p. 75-94). Topography also influences vertical flow in bedrock--the flow component is generally upward at topographically low sites, and generally downward at higher locations. Information concerning the bedrock flow system is sparse, however, and these generalizations may not hold true throughout the valley.

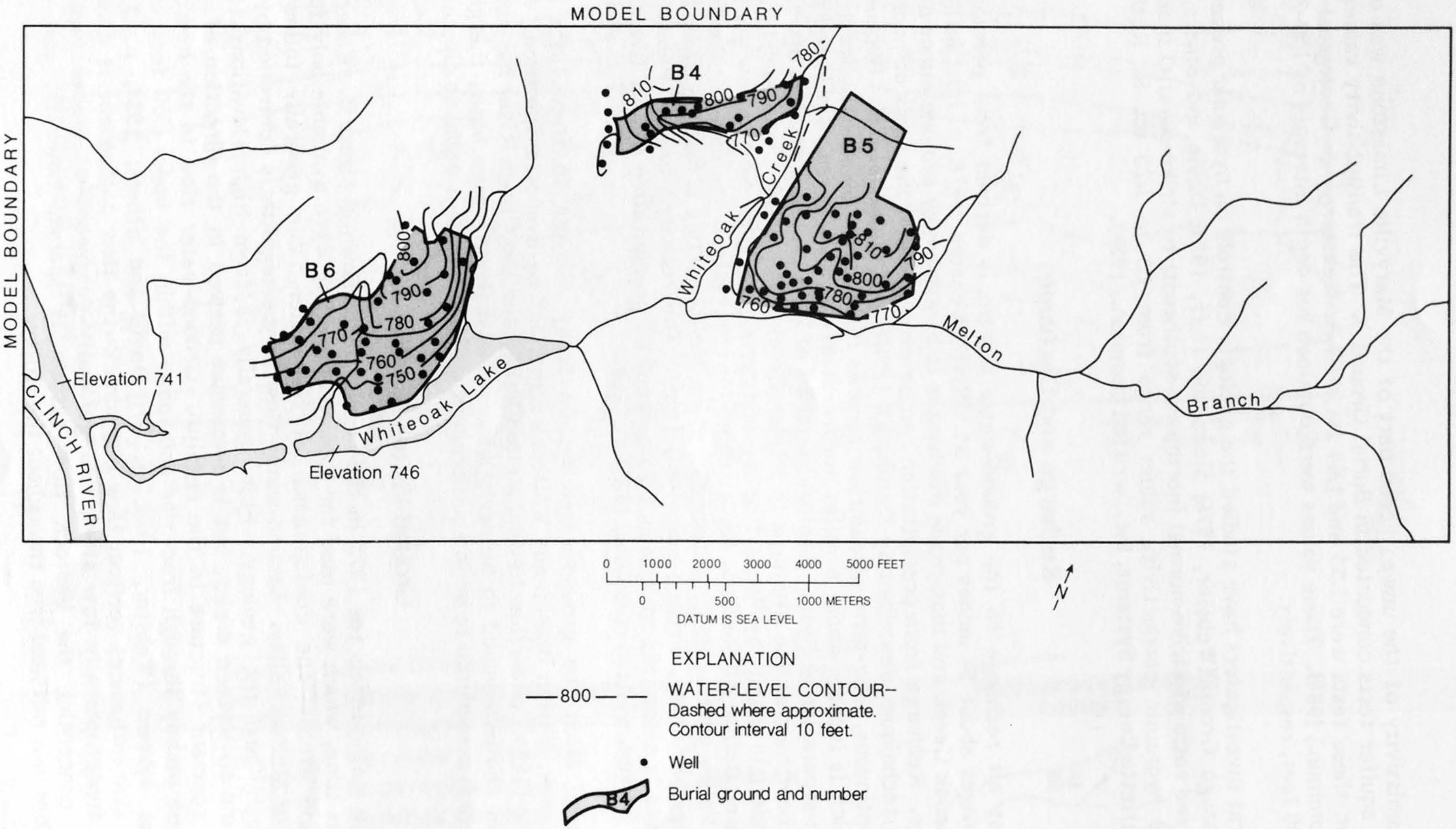


Figure 3.-- Average 1978 water levels in regolith near burial grounds 4, 5, and 6.

GROUND-WATER MODELING

Model Assumptions, Boundary Conditions, and Construction

A computer program to simulate three-dimensional ground-water flow (McDonald and Harbaugh, 1984) was used to model flow in Melton Valley. The program uses finite-difference techniques to solve the ground-water flow equation for three-dimensional, steady or non-steady flow in an anisotropic, heterogeneous medium. The three-dimensional model was used to simulate vertical flow and differences in hydraulic properties of the regolith and bedrock.

The model area (fig. 4) approximately coincides with the Whiteoak Creek-Melton Branch drainage in Melton Valley. The model grid consists of variable grid-block sizes, which range in area from about 22,000 to 245,000 square feet. The smallest blocks were used in the burial ground areas to provide greater detail for analysis.

The aquifer was simulated as a two-layer system. The upper layer represents the regolith, and the lower layer represents bedrock. Transmissivities for the regolith (fig. 5) are variable based on slug-test results for Burial Grounds 4, 5, and 6 (D. A. Webster, U.S. Geological Survey, written commun., 1984), and slug tests for proposed solid-waste storage area 7 (E. R. Rothschild, Martin Marietta Energy Systems, Inc., written commun., 1984). Hydraulic conductivity values of 0.5 and 0.6 ft/d were arbitrarily assigned to the Rome Formation and the Knox Group for which slug tests were not available. The values chosen were similar to those obtained from slug tests on the Rutledge Limestone. Average hydraulic conductivity values were used for individual formations and average thickness of the regolith was assumed to be 20 feet, based on the reported range of regolith thickness of 5 to 40 feet, in order to calculate transmissivity. Transmissivity values were adjusted from original values during model calibration.

Transmissivity values for bedrock were available only for the Maryville Limestone (1.5 ft^2/d). Transmissivities of other formations were estimated on the basis of slug-test results for the regolith. For example, slug-test results indicate that the ratio of the average hydraulic conductivity of the regolith developed on the Pumpkin Valley Shale to that developed on the Maryville Limestone is 0.13. Using this ratio the average transmissivity of the Pumpkin Valley is estimated to be 0.2 ft^2/d in relation to the average transmissivity of 1.5 ft^2/d for the Maryville. Hydraulic conductivity ratios were also calculated for the other formations in relation to the Maryville, and average transmissivities for these formations were estimated from those ratios. Resulting transmissivity values for the lower layer ranged from 0.2 to 1.5 ft^2/d (fig. 6).

Anisotropy ratios for strike-normal to strike-parallel transmissivity values ranging from 1:1 (isotropic) to 1:20 were tested in the model. An anisotropy ratio of 1:3 (0.33) produced the best model results.

A leakance factor, which is vertical hydraulic conductivity divided by thickness, is required between model layers. Although no data are available on vertical hydraulic conductivity for Melton Valley, an assumed uniform leakance value of 1.0×10^{-5} (ft/d)/ft for each model node produced the best model results.

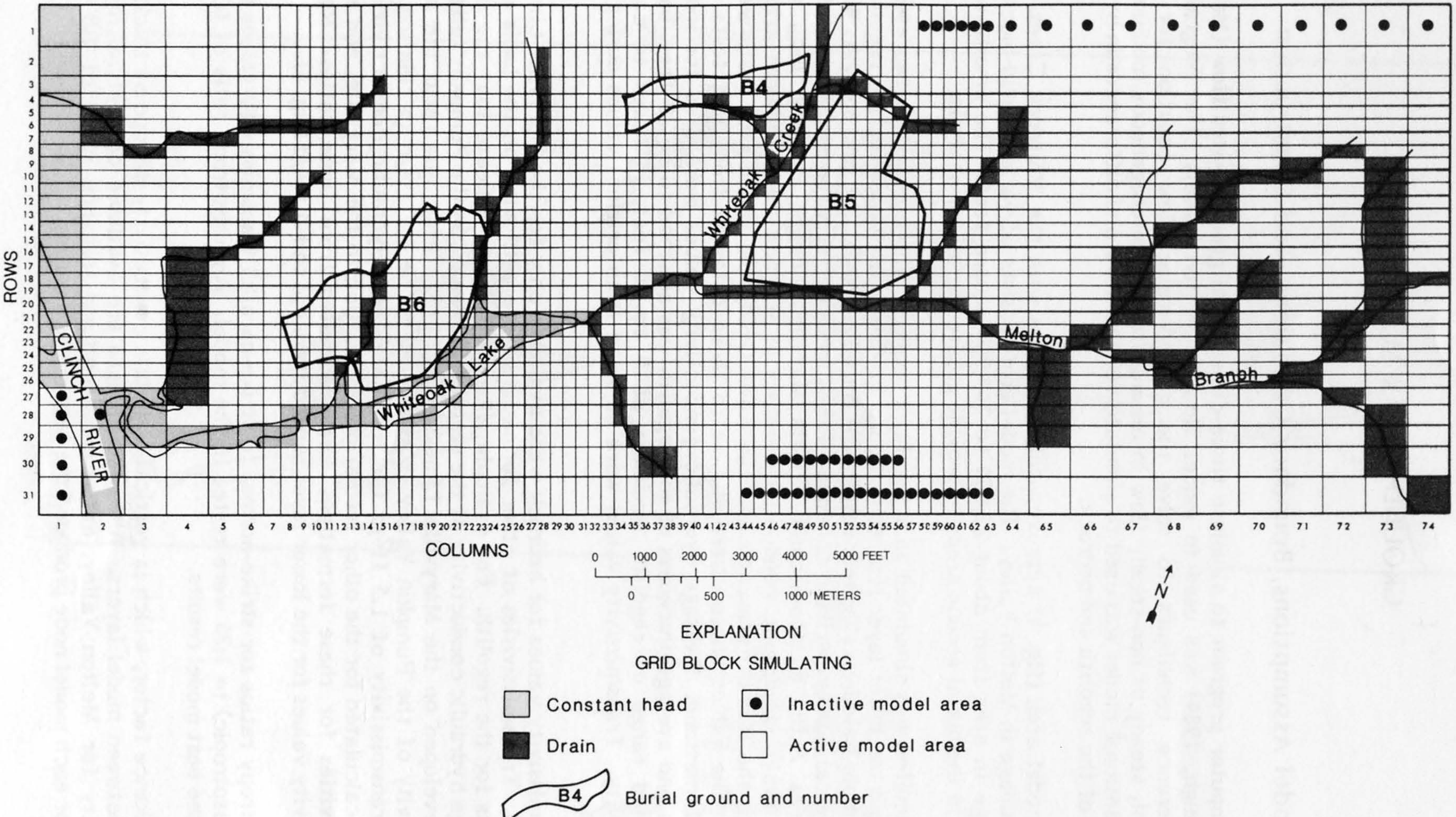
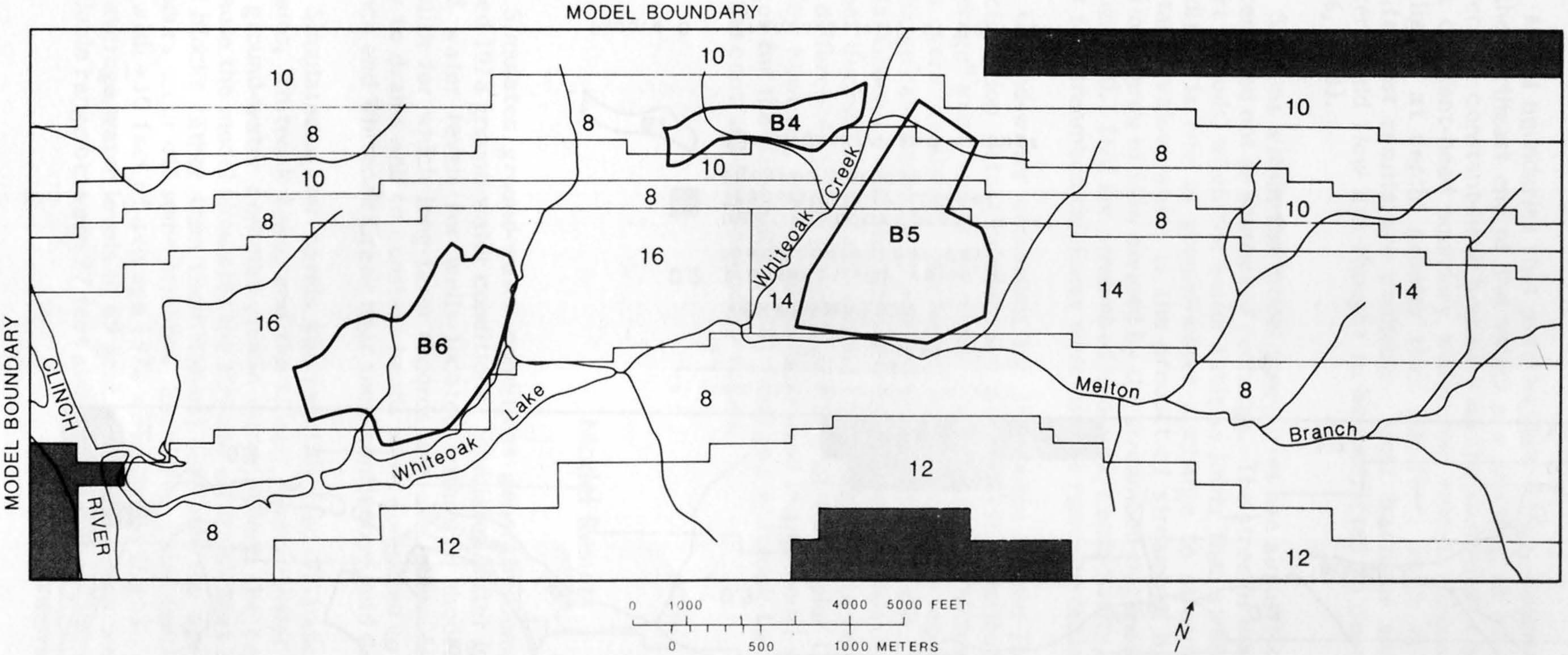


Figure 4.-- Model grid and location of boundary types.



EXPLANATION

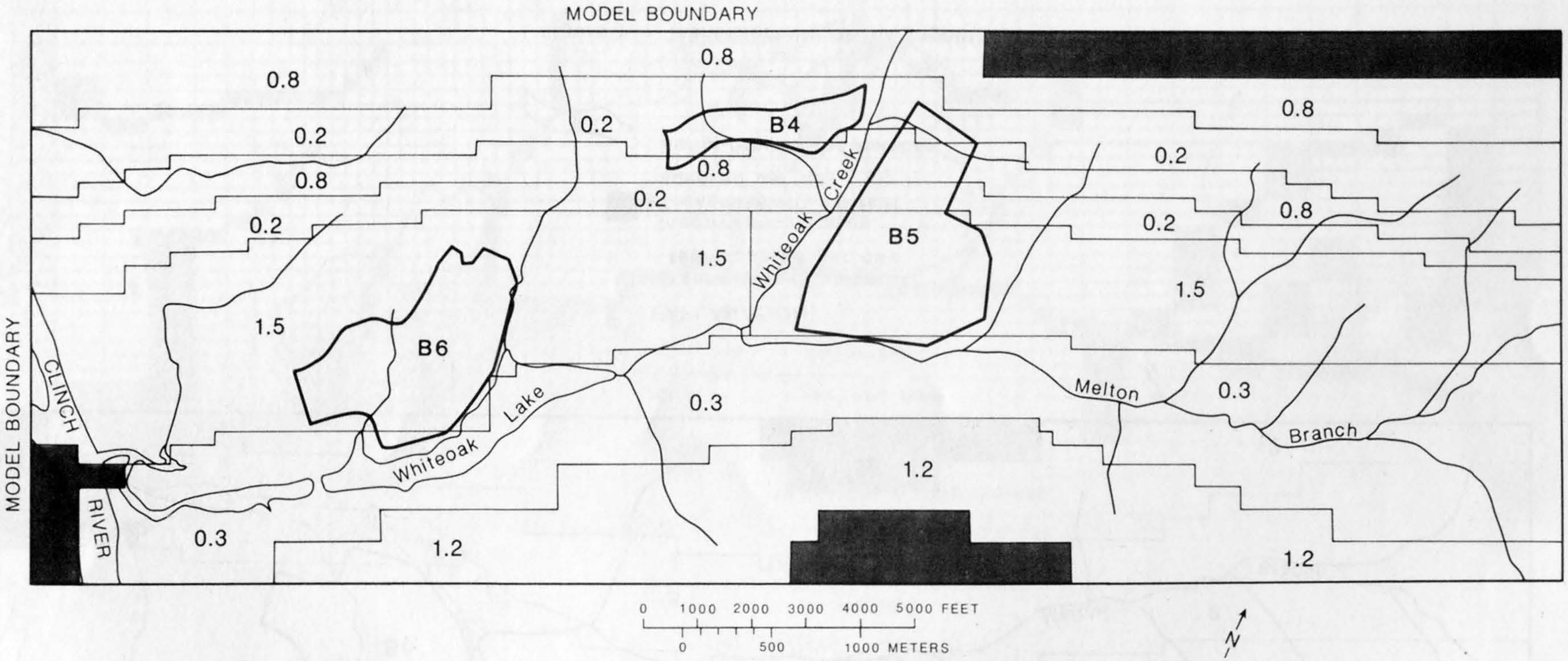
10 Transmissivity value in feet squared per day

Inactive model area. Transmissivity = 0 feet squared per day.

Burial ground and number

B4

Figure 5.-- Transmissivity of the regolith.



EXPLANATION

0.2 Transmissivity value in feet squared per day

Inactive model area. Transmissivity = 0 feet squared per day.

Burial ground and number

Figure 6.-- Transmissivity of bedrock.

Model boundaries that parallel Haw Ridge, Copper Ridge, and the drainage divide at the northeast end of the valley are assumed to be no-flow boundaries. The Clinch River is a constant-head boundary on the southwest edge of the model. Whiteoak Lake is a constant-head boundary within the model. Ground-water flow is assumed to be negligible at depths greater than 200 feet, which is the maximum depth for which aquifer-test results are available. Most fractures and joints through which ground-water could flow are thought to be restricted to depths less than 200 feet (Webster, 1976, p. 11).

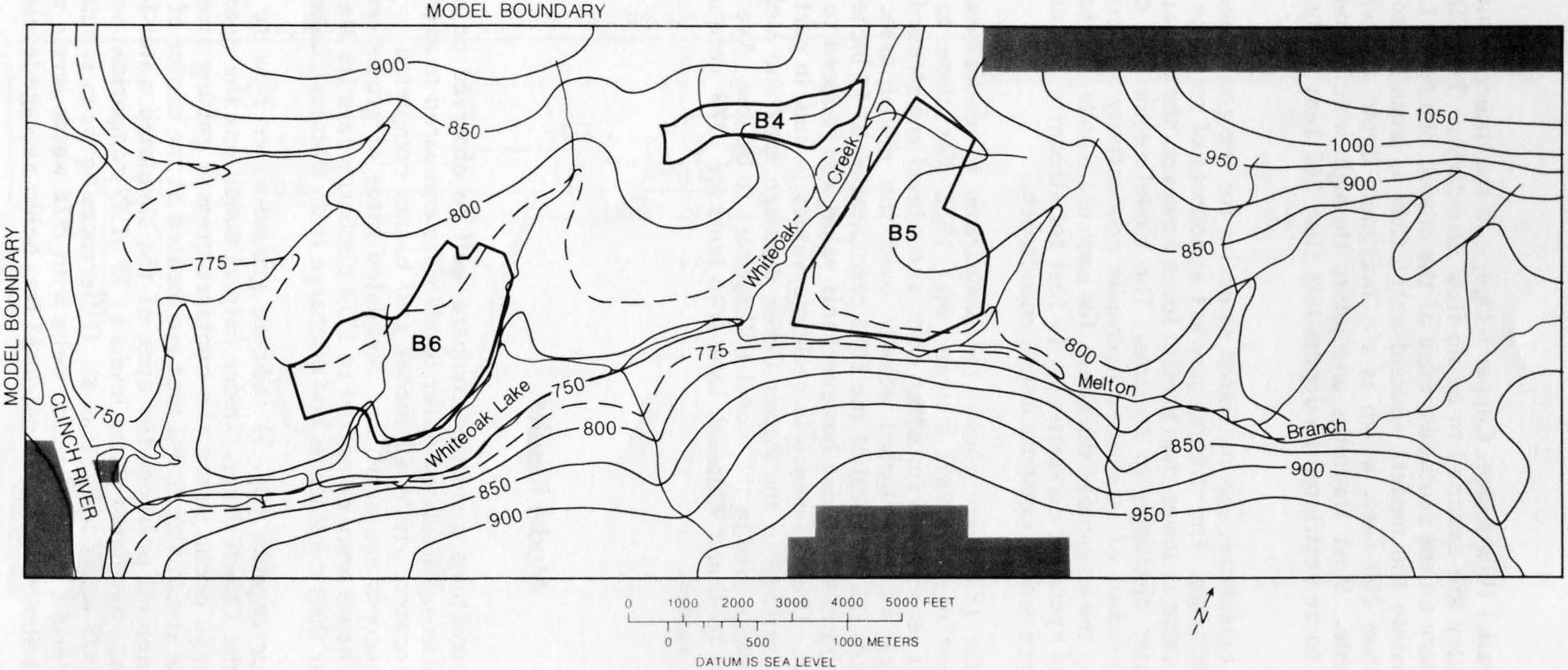
Streams within the model boundaries are simulated as drains for the ground-water system, and not as sources of recharge. The streams may act as sources of recharge for short periods, when the water table is lower than stream level; however, the prevailing condition is one of ground-water discharge to streams. The model requires a conductance value, which is the product of streambed hydraulic conductivity and cross-sectional area of flow divided by the streambed thickness, for each drain node. Uniform values of 0.1 ft/d for streambed hydraulic conductivity, 15 feet for stream width, and 1 foot for streambed thickness were used to compute drain conductance.

Ground-water conditions for 1978 were chosen for comparison to model results. Precipitation data (Webster and others, 1982) indicate that 1978 was close to an "average" year, and is the most recent time for which both water-level and streamflow data were available. Recharge was distributed equally over the model area. A recharge rate equal to 30 percent (15.6 inches) of the 1978 precipitation of 52 inches at Burial Ground 6 was initially used in the model; however, this value was reduced to 3.2 inches during model calibration. The difference in recharge values is due, in part, to the differences in the geologic settings of the Poplar Creek drainage area and Melton Valley; however, the recharge value used in the model still appears to be low. Average stages for the Clinch River (741 feet) and Whiteoak Lake (746 feet) for 1978 were used for the constant-head-boundary values.

Model Results

Simulated ground-water conditions generally compare well to observed or estimated 1978 ground-water conditions. Simulated water levels were compared to average 1978 water levels for wells located within 69 model grid blocks completed in the regolith for which long-term records are available. Simulated rates of ground-water flow to drains and to constant heads were compared to 1978 discharge data for Melton Branch and Whiteoak Creek near their confluence, and discharge from Whiteoak Lake.

Simulated water levels for regolith (fig. 7) indicate ground-water flow to the streams, Whiteoak Lake, and the Clinch River. Under natural conditions the apex of the ground-water contours should occur where the contours cross a gaining stream. Because the model simulates the streams as drains that are located at the center of the grid blocks rather than their natural position, the apex of the simulated water-level contours occur off some streams. Simulated water levels at 39 of 69 comparison points are with ± 10 feet of average 1978 water levels (fig. 8). Differences between simulated and average water levels in 69 grid blocks for which wells with 1978 water levels were available range between 27 feet above average levels to 23 feet below average levels.



EXPLANATION

—775— — WATER-LEVEL CONTOUR--
Dashed where approximate.
Contour interval 25 and 50 feet.

Inactive model area

Burial ground and number

Figure 7.--Simulated water levels for the regolith.

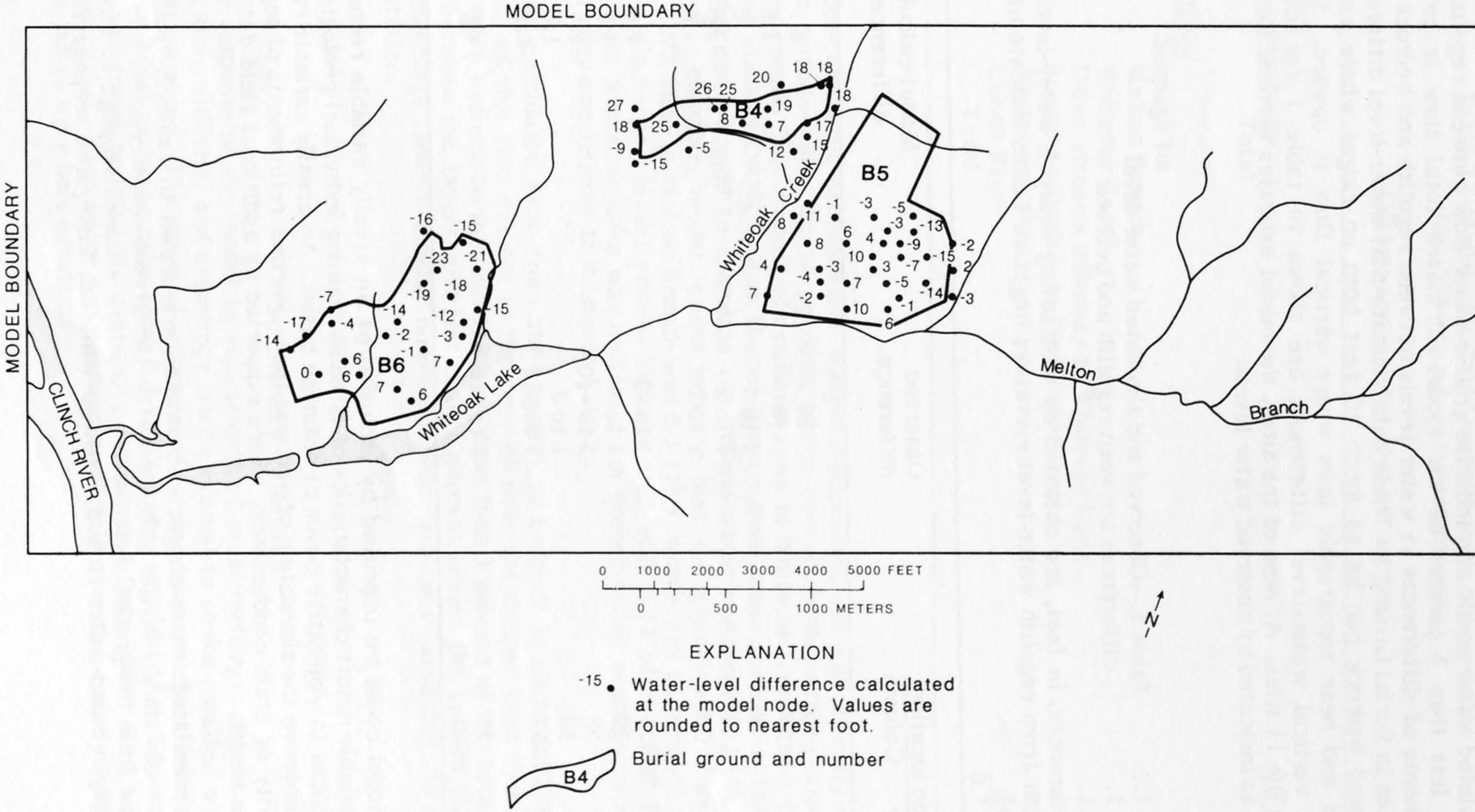


Figure 8.--Difference between simulated and average 1978 water levels for 70 comparsion points in the regolith.

Simulated water levels also indicate ground-water flow between regolith and bedrock; however, less than 3 percent of the model-calculated total flow is between layers. Measurements of differences in water levels between regolith and bedrock are available for 11 sites in Burial Ground 5. These data indicate that water-level differences between regolith and bedrock can be as much 10 feet both on ridges where vertical flow is downward and near topographic lows where vertical flow is upward. Simulated and observed vertical water-level differences are shown in table 1 for the nodes that represent the 11 sites. At nine of the sites, the model indicates vertical flow in the same direction as indicated by observed water levels.

Table 1.--Observed and simulated water-level differences between regolith and bedrock

[Differences, in feet, are obtained by subtracting bedrock water-level elevation from regolith water-level elevation; negative values indicate upward flow]

Node location		Observed difference	Model-calculated difference
Row	Column		
11	53	10	6
13	57	10	1.6
14	46	1 to 5	.2
15	44	1 to 2	-3.6
15	50	1 to 2	4.6
15	56	-1 to -2	1.6
16	50	1 to 2	3.8
16	58	-5 to -10	-6.8
17	50	1 to 2	1.7
17	57	-5 to -10	-6.1
19	51	-5 to -10	-13.8

The model could be improved by inclusion of an areally variable recharge rate to simulate variable runoff characteristics of streams draining individual geologic formations and differences in vegetative cover of drainage basins. An areally variable recharge rate could also improve the simulation of vertical flow. Further refinements of input data for transmissivity or drain conductance, where supported by additional field data, could also improve the model.

Model-calculated water-budget components are shown in table 2. Recharge from precipitation (0.7 ft^3/s) is the only inflow to the ground-water system and is equal to total outflow from the ground-water system. Outflow includes seepage to streams within Melton Valley, ground-water flow directly to Whiteoak Lake, and seepage to the Clinch River.

Table 2.--Model-calculated water-budget components for 1978 ground-water conditions

[Values are in cubic feet per second]

Inflow	
Recharge	0.7
Total	0.7
Outflow	
Seepage to:	
Melton Branch	0.3
Whiteoak Creek	.1
Other streams tributary to Whiteoak Lake	.1
Streams tributary to the Clinch River	.1
Whiteoak Lake	.05
Clinch River	.05
Total	0.7

Model-calculated ground-water budget components are not directly comparable to available surface-water discharge data, which contain both surface- and ground-water flow components. The amount of artificial input to Whiteoak Creek from the wastewater treatment plant at ORNL and to Melton Branch from other sources in 1978 is unknown. The model can be used to calculate the ground-water component of the measured discharge. For example, model results indicate that the ground-water component of the average 1978 flow in Melton Branch was 0.3 ft^3/s, which was 11 percent of the average measured discharge. Model results indicate that only 0.55 of the 13.3 ft^3/s measured outflow from Whiteoak Lake was derived from ground-water seepage to streams within Melton Valley and directly to Whiteoak Lake.

Model-calculated flow from the regolith to bedrock is about 0.02 ft^3/s; however, almost all of this flow returns to the regolith near the drains. Less than 0.01 ft^3/s discharges from bedrock to the Clinch River. Less than 3 percent of the total ground-water flow is between the layers, and less than 1 percent leaves the system through bedrock. This percentage seems small, however, data are not available to evaluate this interpretation.

Sensitivity Analyses

The response of the model to adjustments of areal recharge, regolith transmissivity, bedrock transmissivity, and anisotropy (strike-normal to strike-parallel) was evaluated by sensitivity analysis. The range of adjustments for the four variables were from 0.5 to 2.0 times the areal recharge rate; from 0.5 to 3.0 times regolith transmissivity values; from 0.01 to 100 times bedrock transmissivity values; and from about 0.15 to 3.0 times the anisotropy value. Each value was adjusted uniformly over the entire model area while all other variables were held constant.

Differences between measured and simulated water levels in the regolith were used as an indication of the sensitivity of the model to adjustments of a variable. The root mean square error (RMSE) was calculated for measured and simulated water levels by

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N} (h_i^m - h_i^c)^2}{N}}$$

where N is number of observations (69);

h_i^m is the measured water level, in feet; and

h_i^c is the simulated water level, in feet.

RMSE was plotted for each adjustment in a variable to display the range of sensitivity.

RMSE for all variables used in the original model is 12.5 ft. The model was considered sensitive to changes in variable values when the RMSE exceeded 15.5 ft, which is 3 ft more than the RMSE of the original model. Simulated ground-water flow to streams was not used as an indicator of sensitivity because the amount of ground-water seepage to streams is unknown in Melton Valley.

The model was sensitive to changes in recharge rates of less than 0.5 and more than 1.25 times the value used in the original model (fig. 9a), and was more sensitive to increases than to decreases in the recharge rate.

The model was very sensitive to decreases in regolith transmissivity values (fig. 9b). Decreasing transmissivities less than 0.8 times increased the RMSE to more than 15.5 ft; however, the transmissivities could almost be doubled before increasing the RMSE to more than 15.5 ft.

The model was much less sensitive to adjustments to anisotropy. The ratio of strike-normal to strike-parallel transmissivity could be reduced to 1:10 before increasing the RMSE to greater than 15.5 feet. Increasing the anisotropy ratio to 1:1.5 (0.66) actually reduced the RMSE slightly (12.1 feet); however, simulated vertical water-level gradients did not compare as well to measured gradients. Simulating the ground-water system as isotropic (anisotropy ratio = 1.0) increased the RMSE to only 12.9 feet.

The model was least sensitive to adjustments to bedrock transmissivity values. Decreasing bedrock transmissivities by as much as 0.01 did not change the RMSE; however, the simulated vertical water-level gradients were significantly different from measured gradients. Increasing bedrock transmissivity values by 100 had similar effects on the RMSE and vertical water-level gradients.

ADDITIONAL MODEL ANALYSES AND DATA NEEDS

Model results generally compare well to 1978 ground-water conditions; however, the results of the Melton Valley model should be considered preliminary at its present stage of development. Differences between simulated and average water levels for the calibration

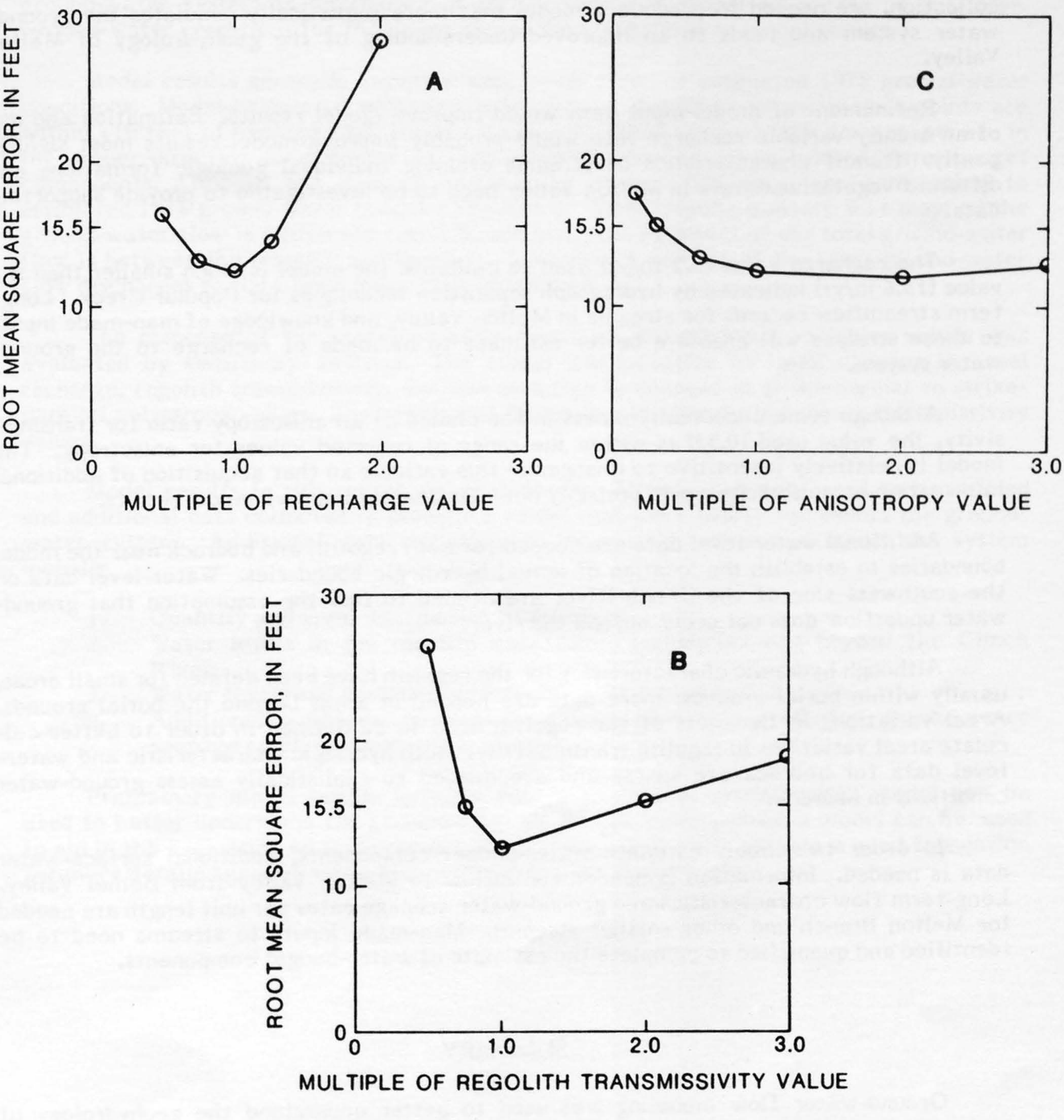


Figure 9.-- Model sensitivity to changes in (A) recharge, (B) regolith transmissivity, and (C) anisotropy.

period, which are acceptable at many nodes, are unacceptably large at some nodes, and "actual" water-budget components used to evaluate the model results were only estimated. Further refinements of model-input data, supported by additional field-data collection, are needed to produce a model that more realistically simulates the ground-water system and leads to an improved understanding of the geohydrology of Melton Valley.

Refinement of model-input data would improve model results. Estimation and use of an areally variable recharge rate would probably improve model results most significantly. Runoff characteristics of streams draining individual geologic formations and different vegetative covers in Melton Valley need to be investigated to provide supporting data.

The recharge value (3.2 in/yr) used to calibrate the model is much smaller than the value (15.6 in/yr) indicated by hydrograph separation techniques for Popular Creek. Long-term streamflow records for streams in Melton Valley, and knowledge of man-made inputs to these streams will enable a better estimate to be made of recharge to the ground-water system.

Although some uncertainty exists in the choice of an anisotropy ratio for transmissivity, the value used (0.33) is within the range of reported values for anisotropy. The model is relatively insensitive to changes in this variable so that acquisition of additional information on anisotropy would probably not significantly improve model results.

Additional water-level data are needed for both regolith and bedrock near the model boundaries to establish the location of actual hydrologic boundaries. Water-level data on the southwest side of the Clinch River are needed to test the assumption that ground-water underflow does not occur beyond the river.

Although hydraulic characteristics for the regolith have been defined for small areas, usually within burial grounds, more data are needed in areas beyond the burial grounds. Areal variations in thickness of the regolith need to be defined in order to better calculate areal variations in regolith transmissivity. Both hydraulic characteristic and water-level data for bedrock are sparse and are needed to realistically assess ground-water conditions in bedrock.

In order to reliably estimate water-budget components, additional surface-water data is needed. Information is needed for inflow to Melton Valley from Bethel Valley. Long-term flow characteristics and ground-water seepage rates per unit length are needed for Melton Branch and other smaller streams. Man-made inputs to streams need to be identified and quantified to complete the estimate of water-budget components.

SUMMARY

Ground-water flow modeling was used to better understand the geohydrology of Melton Valley, where shallow-land burial of low-level radioactive waste has been practiced since 1951. The model simulates the aquifer as a two-layer system that represents the regolith and bedrock in Melton Valley. Transmissivities range from 8 to 16 ft^2/d for the regolith, and from 0.2 to 1.5 ft^2/d for bedrock. An anisotropy ratio of 1:3 for strike-normal to strike-parallel transmissivity values produces the best model results.

The Clinch River and Whiteoak Lake are simulated as constant-head boundaries, and streams within the modeled area are simulated as drains. Simulated recharge to the ground-water system is distributed uniformly over the model at a rate of 3.2 in/yr. Ground-water conditions for 1978 were chosen for comparison to model results.

Model results generally compare well to observed or estimated 1978 ground-water conditions. Model-calculated water levels for regolith for 39 of 69 comparison points are within ±10 feet of average 1978 levels. Model-calculated vertical flow components are in the proper direction for 9 of the 11 comparison points. Model-calculated water-budget components, although not directly comparable to available data, are comparable to estimated 1978 ground-water budget components. Model results indicate that most of the ground-water flow is within the regolith, and less than 3 percent of the total ground-water flow is between the regolith and bedrock. Less than 1 percent of the total ground-water flow discharges to the Clinch River through bedrock.

The response of the model to adjustments of several input variables values was evaluated by sensitivity analysis. The model was sensitive to small changes in areal recharge, regolith transmissivity, and less sensitive to changes in strike-normal to strike-parallel anisotropy values. The model was insensitive to changes in bedrock transmissivity values.

Model results in this report are preliminary. Model-input data need to be refined and additional data collected to produce a model that more nearly represents the ground-water system. Additional data necessary to accurately assess and model the system include:

1. Quantity and areal distribution of recharge;
2. Water levels in the regolith near model boundaries and beyond the Clinch River;
3. Water levels and aquifer characteristics for bedrock; and
4. Additional surface-water data (long-term flow characteristics, ground-water seepage rates, and man-made inputs).

Preliminary model results indicate that a calibrated, ground-water model can be used to better understand the geohydrology of Melton Valley. Such a model can be used to aid in the evaluation of management alternatives, and should provide a good foundation for more detailed ground-water flow and solute transport models.

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