THREE-DIMENSIONAL STEADY-STATE SIMULATION OF FLOW IN THE SAND-AND-GRAVEL AQUIFER, SOUTHERN ESCAMBIA COUNTY, FLORIDA

By Henry Trapp, Jr., and Linda H. Geiger

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ABSTRACT

The sand-and-gravel aquifer is the only freshwater aquifer in southern Escambia County and is the source of public water supply for the area, including the City of Pensacola. The aquifer was simulated by a two-layer, digital model to provide hydrologic information for water-resource planning. The lower layer represents the main-producing zone; the upper layer represents all of the aquifer above the main-producing zone including an unconfined zone and discontinuous perched, confined, and confining zones.

The model is designed for steady-state simulation and predicts the response of the aquifer (changes in water levels) to ground-water pumping where steady-state conditions have been reached. Input to the model includes matrices representing constant-head nodes, starting head, transmissivity of layer 1, leakance between layers 1 and 2, lateral hydraulic conductivity of layer 2, and altitude of the base of layer 2. The sources of water to the model are from recharge by infiltrated precipitation (estimated from base runoff), inflow across boundaries, and induced recharge from river leakance in periods of prolonged ground-water pumping. Model output includes final head and drawdown for each layer and total values for discharge and recharge in the model area.

The model was calibrated for 1972 pumping and tested by simulating pumpages during 1939-40, 1958, and 1977. Sensitivity analyses showed water levels in both layers were most sensitive to changes in the recharge matrix and least sensitive to river leakage.

Suggestions for further development of the model include subdivision and expansion of the grid, assignment of storage coefficients for transient simulations, more intensive study of the stream-aquifer relations, and consideration of the effects of infiltration basins on recharge.

INTRODUCTION

Ample quantities of soft water with low concentrations of dissolved solids are obtainable from the sand-and-gravel aquifer in southern Escambia County. However, some public-supply wells have yielded water with high concentrations of iron and carbon dioxide, and some wells have been abandoned because of low yields. Hydrologic information is needed by water-resource planners and others to plan for future expansion of the water-supply systems. To properly plan for expansion, a basis for predicting the effects of various concentrations of pumping on water levels and for defining ground-water flow (and thus the possible movement of contaminants or occurrence of saltwater intrusion) is necessary.

A comprehensive cooperative investigation by the U.S. Geological Survey and the City of Pensacola began in 1970 to provide information on the quality and quantity of water available from the sand-and-gravel aquifer. The investigation was carried out in four 3-year phases, the final one, ending in 1982, was done by the Survey in cooperation with the Escambia County Utilities Authority, which includes the former City of Pensacola Water Department.

The area of investigation extends from the western end of Santa Rosa Island, west to Perdido River, and north through Pensacola to State Road 196 (S-196) north of Quintette (fig. 1). The first phase (1970-73) concentrated on well inventory, water sampling, test drilling, and preliminary interpretation (Trapp, 1972; 1973; 1975). The second phase (1973-76) concentrated on construction and calibration of a preliminary two-dimensional digital model of the aquifer, test drilling, and monitoring effects of spray disposal of treated sewage (Trapp, 1978). The third phase (1976-79) included attempts to refine the two-dimensional model, continuation of test drilling and monitoring activities, and the construction of a three-dimensional digital model. The fourth phase (1979-82) included continued monitoring of the spray disposal of treated sewage and further testing of the three-dimensional model.

This report provides information to water managers, ground-water modelers, and others regarding the use of the three-dimensional digital model as an aid in resolving water-management and development problems in the central and southern part of Escambia County. Also, it provides information for refining or enhancing the model. With proper interpretation and a thorough understanding of its limitations, the model can be used to provide water-management officials with guidance in controlling drawdown, limiting the possibilities of saltwater intrusion into public-supply wells, determining the movement of ground water, and establishing future well locations and withdrawal rates.

Purpose and Scope

This report covers parts of the third and fourth phases of the investigation. It describes the construction and testing of the three-dimensional model, which encompasses refinements of the two-dimensional model. The model provides a better understanding of the hydrology of the area and can be used to furnish information pertinent to water-resources management. It may be used to help predict areas of excessive drawdown and determine ground-water flow.

The report briefly describes the hydrogeologic framework of the model area and defines aquifer hydraulic characteristics. The construction and testing of the three-dimensional model are documented and the assumptions and limitations that govern it are defined. Possibilities for enhancement of the model are briefly discussed in the section called "Further Development of the Model."

A glossary of selected terms used in this report begins on page 83.

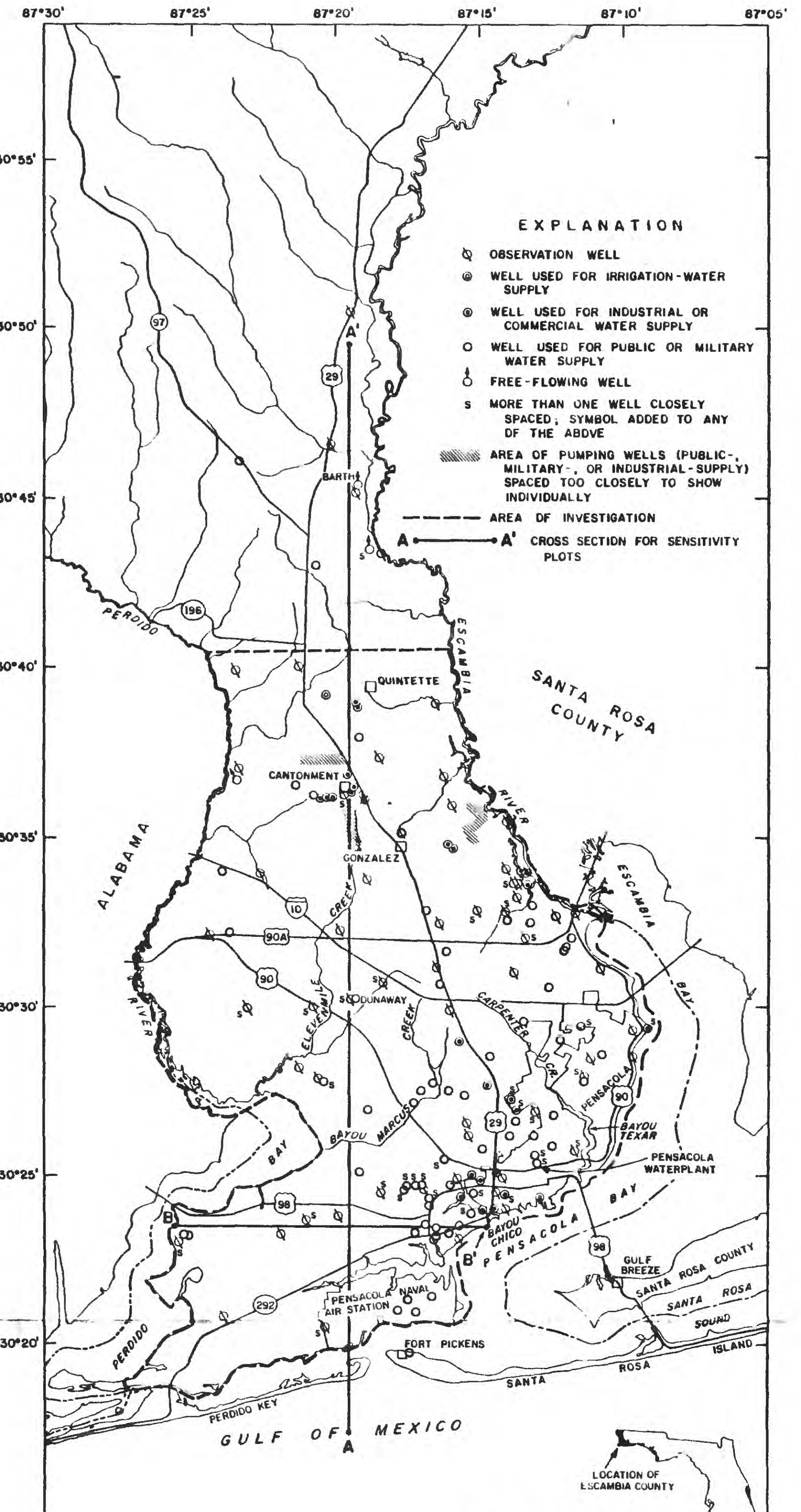

Figure 1.—Area of investigation and locations of observation wells used as control points for the aquifer model and of wells used as the basis for simulated pumping stress.

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Acknowledgments

The application of a digital model to the sand-and-gravel aquifer as a tool for future water management was made possible through the interest of William B. Spriggs and Kenneth Evans, executives of the Escambia County Utilities Authority; and Charles C. Crowder, and William A. Duynslager, former employees of the City of Pensacola Water Department (now a part of the Escambia County Utilities Authority).

HYDROGEOLOGY OF THE AQUIFER SYSTEM

The sand-and-gravel aquifer is the only freshwater aquifer in central and southern Escambia County and is the source of public water supply for the area, including the City of Pensacola. The aquifer is exposed at the surface throughout Escambia County and extends as much as 1,100 feet thick. It extends north and west from Pensacola into Alabama and is recognized as far eastward as the Choctawhatchee River (about 78 miles).

Lithology of the Sand-and-Gravel Aquifer

The sand-and-gravel aquifer consists primarily of quartz sand, ranging in size from very fine (1/16-1/8 mm) to very coarse (1-2 mm) and commonly containing disseminated small quartz pebbles. The sand is locally cemented by iron minerals into thin layers of hardpan. Layers and lenses of gravel, silt, and clay also occur within the aquifer. Most of these layers probably extend laterally for only short distances. The variations in porosity and hydraulic conductivity resulting from variations in sediment texture incompletely isolate parts of the aquifer from each other and contribute to variations in hydraulic head with depth (fig. 2).

Most wells and test holes in southern Escambia County penetrate less than 400 feet of the aquifer, and, consequently, most of the data available apply to this upper section. The upper part of the aquifer generally is noncalcareous and contains few fossils, except for fresh-appearing woody and carbonized plant remains; fossil shells are abundant in the lower part of the aquifer. Fossiliferous sand occurs near the surface locally in southwestern Escambia County.

Hydraulic Properties of the Sand-and-Gravel Aquifer

The sand-and-gravel aquifer comprises a complex system consisting of an upper unconfined zone and many discontinuous partly confined zones, all hydraulically connected in varying degrees. In addition, perched saturated zones overlie the true water table in various parts of Escambia County, particularly in the uplands.

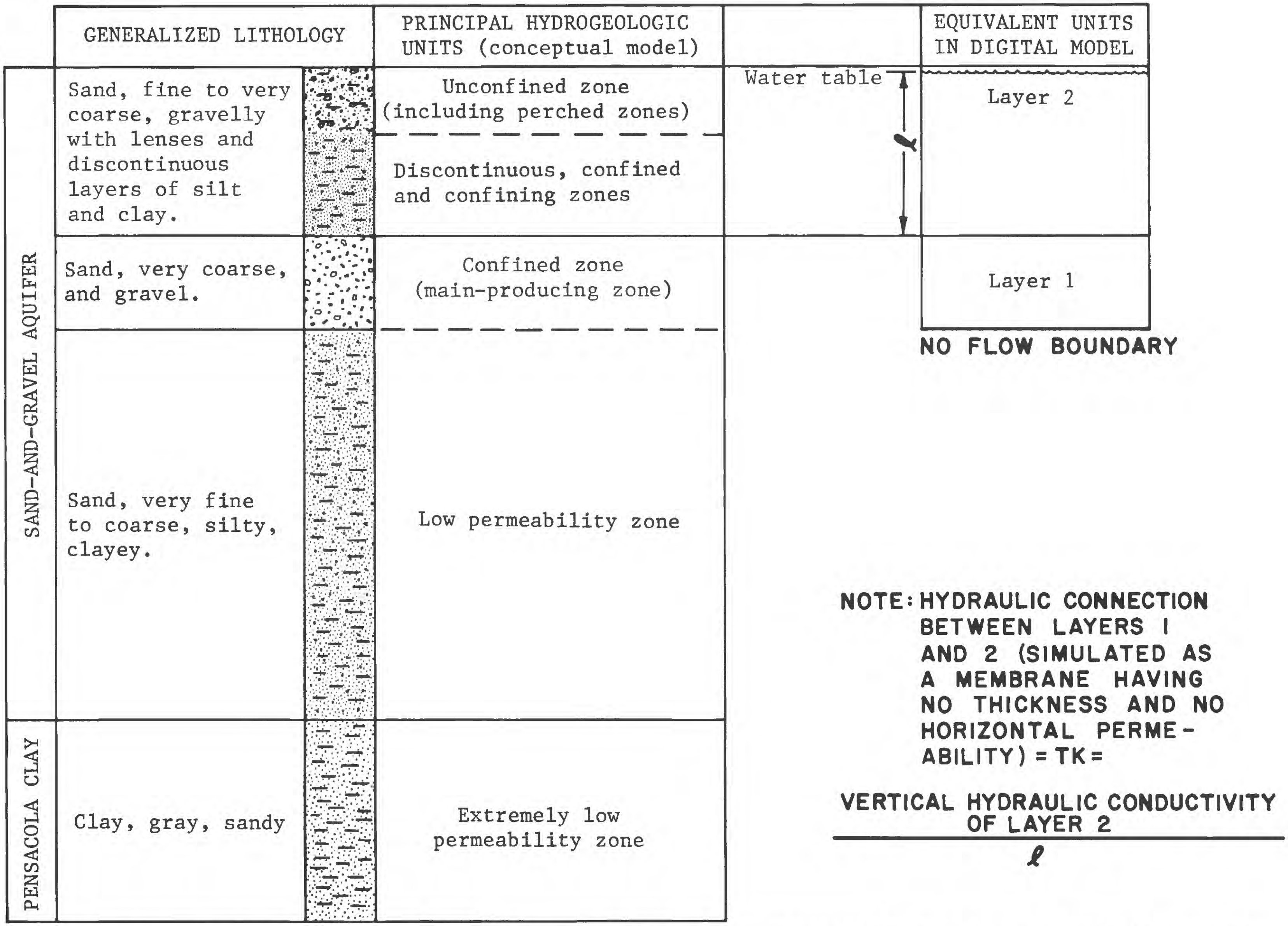

Figure 2.--Generalized geologic units, hydrogeologic units, and equivalent units used in the computer model.

Confinement

Evidence for confinement of deeper zones consists of: differing heads and hydrographs for neighboring wells of differing depths; beds of relatively low hydraulic conductivity separating beds of permeable sand and gravel, as disclosed by well logs; and low storage coefficients, as calculated from the few available records of aquifer tests with observation wells. Evidence for perched zones is provided by neutron logs.

Analysis of aquifer tests by Jacob and Cooper (1940, p. 33-49, table 4) on nine large-capacity wells in Pensacola obtained average values of transmissivity and storage coefficient (current U.S. Geological Survey units) of 10,000 ft^2/d and $6x10^{-4}$. They attributed the low storage coefficients to confined conditions. They also noted that the observed historic reduction of head at the Pensacola Water Plant (fig. 1) from pumping at industrial wells 2 miles southwest was less than one-fourth the theoretical drawdown for a confined infinite aquifer with no recharge. Alternative hypotheses were offered in explanation: (1) vertical recharge beyond the limits of a local confining bed or (2) leaky confined conditions.

Similar low storage coefficients, representative of confined aquifers, have been reported in unpublished results of aquifer tests at industrial sites near Cantonment and Gonzalez, north of Pensacola.

A 3-month aquifer test was run at Pensacola's Dunaway well, screened at 173 feet, to determine the effects of prolonged pumping on the sand-and-gravel aquifer. Of particular interest was: would it act as a single unconfined aquifer or as a confined zone overlain by an unconfined zone? The test site is about 10 miles northwest of the Pensacola Water Plant, between Highways 90 and I-10 and east of Elevenmile Creek (fig. 1). An observation well 260 feet from the pumped well (pumping 1,900 gal/min) and screened at the same depth as the pumped well had 15 feet of drawdown at the end of the period, whereas a shallow observation well at the same location, screened at 57 feet, had less than 1 foot of drawdown. Calculated storage coefficient values ranged from $5x10^{-5}$ to $3x10^{-4}$, depending on the method of analysis. The differences in drawdown between the pumped zone and the shallow zone, together with the low storage coefficient, indicate confinement.

Evidence for confined conditions was also found at two sand-and-gravel aquifer test sites about 38 miles east of Pensacola in the Fort Walton Beach area (Hayes and Barr, 1983). Storage coefficients ranged from $1.4x10^{-4}$ to $4.5x10^{-4}$ and leakance from $9.6x10^{-3}$ to $2.3x10^{-2}$ per day. One of the test sites included an observation well screened in the uppermost part of the saturated aquifer. Drawdown during the pumping period was negligible at this well.

Main-Producing Zone

For purposes of this study, transmissivity values apply to that part of the aquifer most likely to be tapped by large-capacity wells. This part of the aquifer is a poorly defined main-producing zone. On well logs, its top is generally picked at the top of the first massive clean sand below the surficial sands that constitute the unconfined part of the aquifer system. The main-producing zone is generally separated from the unconfined zone by material of low permeability compared to that of the unconfined zone. The base of the main-producing zone is picked at the base of the deepest massive clean sand that is not isolated from the overlying sand layers by substantial thicknesses of clay.

Transmissivity

Transmissivity values were derived from: (1) aquifer tests (Jacob and Cooper, 1940); (2) specific capacities of the wells, using a method by Brown (1963, p. 336-338); (3) sand-size analysis, based on methods described by Johnson (1963); and (4) estimation from geophysical and lithologic logs (Trapp, 1972). Transmissivities based on aquifer tests and specific capacities were adjusted to estimated total productive sand thickness. Preliminary estimates of the transmissivity of the main-producing zone at control points ranged from 5,500 to 38,000 ft^2/d. In a previous two-dimensional aquifer model, transmissivity values were adjusted during calibration to a range of 3,000 to 33,000 ft^2/d (Trapp, 1978, p. 7, fig. 3).

Hydraulic Conductivity of the Unconfined Zone

The flow of water through the unconfined zone of the sand-and-gravel aquifer can be evaluated more appropriately by using hydraulic conductivity rather than transmissivity. In an unconfined zone, transmissivity, a function of both hydraulic conductivity and thickness, varies not only laterally but with time because the saturated thickness varies with fluctuations of the water table. The unconfined zone includes sand bodies that are similar to those in the main-producing zone. However, it also includes material of lower permeability, particularly the beds that confine the main-producing zone. Locally, it also includes unsaturated material underlying perched saturated zones.

Boundaries

Lateral Boundaries

The area of investigation is bounded by the Perdido River and Perdido Bay on the west, the Escambia River and Escambia Bay on the east, and Pensacola Bay and the Gulf of Mexico on the south. The rivers and estuaries act as partially penetrating drains and largely isolate the flow system in the sand-and-gravel aquifer from the areas to the east and west. To the south, the aquifer terminates somewhere in the Gulf of Mexico or its bays, but its precise limit and the position of the freshwater-saltwater interface have not been determined. At Gulf Breeze, in Santa Rosa County south of Pensacola (fig. 1), the base of freshwater is within 160 feet of land surface (Heath and Clark, 1951, p. 16). On Santa Rosa Island, only small supplies of unconfined freshwater have been found, but at Fort Pickens confined freshwater from as deep as 300 feet is used. Carbon-14 analysis of that water indicated an age of 8,200 to 9,600 years, suggesting that its source may be an isolated lens of fossil freshwater (U.S. Geological Survey, 1975, p. 91).

Vertical Boundaries

The upper limit of the aquifer is defined for this report at every point as the true water table or, if present, the shallowest perched water table that is drained by a permanent stream. Because of the addition of stream simulation, this definition differs from that used in Trapp's two-dimensional model in which perched zones were excluded (Trapp, 1978, p. 6, 16).

The base of the sand-and-gravel aquifer was defined by Musgrove and others (1965, p. 12-13, 20-21, figs. 6, 7, 10) as the top of the Pensacola Clay in southern Escambia County and the top of the Floridan aquifer in the northern part of the county. The top of the Pensacola Clay ranges from 400 to 1,100 feet below land surface (Trapp, 1975, fig. 4; Musgrove and others, 1965, fig. 10). The lowermost part of the aquifer tends to be fine grained, and few wells are drilled and screened much below 300 feet in Escambia County. Thus, the base of the main-producing zone is, in places, several hundred feet above the base of the sand-and-gravel aquifer as originally defined.

Recharge and Discharge

The Pensacola area receives freshwater from three sources: rain falling directly on the area, streams flowing in from adjacent areas, and subsurface flow. The average precipitation is 62 inches per year, or about 50,000 million ft^3/yr for that part of Escambia County south of latitude 30°47' N.

The Escambia and Perdido Rivers are sources of water from adjacent areas. Together with their associated estuarine bays they bound Escambia County on the east and west, respectively. Headwaters of these rivers are in Alabama. Because they are gaining streams, stream discharge in the Pensacola area does not enter into the ground-water system significantly except where pumping induces recharge from the rivers. This occurs locally along the Escambia River east of Gonzalez.

Streams not tributary to the Escambia and Perdido Rivers include Elevenmile Creek and Bayou Marcus Creek, both of which flow into Perdido Bay, and Carpenter Creek, which flows into Escambia Bay through Bayou Texar. The lower reaches of these streams and of the rivers are tidal.

Total runoff is 25 in./yr, of which 55 to 75 percent is base runoff. Assuming 65 percent, base runoff is about 16.25 in./yr or 12,600 million ft^3/yr for the area south of latitude 30°47' N. The average unit runoff of gaged tributaries of the Escambia River is 2.1 $(ft^3/s)/mi^2$ (Musgrove and others, 1965, p. 25, 38-45), of which about 1.4 $(ft^3/s)/mi^2$ is base runoff.

A preliminary estimate of ground-water flow through the sand-and-gravel aquifer into the Pensacola area was made by applying Darcy's Law to data available for Trapp's (1978) two-dimensional model. Estimated flow, calculated from values for transmissivity, head, and grid spacing presented by Trapp (1978, figs. 3, 7, and p. 6), is 906,000 ft^3/d or about 331 million ft^3/yr. Flow across that part of the north boundary of the two-dimensional model determined to contribute to the Pensacola area was calculated, node by node, using Darcy's Law in the form:

$$Q = \frac{T_h \, \Delta y}{\frac{\Delta X_1 + \Delta X_2}{2}} \Delta h \qquad (1)$$

where

- Q = flow, in cubic feet per day;
- T_h = harmonic mean of transmissivities of boundary node and adjoining node, in feet squared per day;
- Δy = width of node rectangle (right angles to direction of flow), in feet;
- $\frac{\Delta X_1 + \Delta X_2}{2}$ = distance between boundary node and adjoining node (direction of flow), in feet; and
- Δh = difference in head between nodes, in feet.

This procedure ignores flow in the part of the aquifer above the main-producing zone.

DESCRIPTION OF THE MODEL

The digital model or computer program simulates the sand-and-gravel aquifer using data representing characteristics of the aquifer and the stresses applied to it during a given time period. The output is the simulated response of the aquifer (changes in water levels) to pumping. The model (three-dimensional version) was documented by Trescott (1975) and modified by Larson (Trescott and Larson, 1976). The version used for aquifer simulation as described here incorporates further modifications by S. D. Larson of the U.S. Geological Survey (written commun., 1978) in which the interaction of rivers and the aquifer is simulated (Supplementary Data I).

Assumptions and Simplifications Used in Simulation

The following simplifying assumptions made the present application of the model feasible:

1. All large-capacity wells in central and southern Escambia County tap a single, continuous zone within the sand-and-gravel aquifer that is traceable throughout the project area. This zone, called the main-producing zone, is both overlain and underlain by parts of the sand-and-gravel aquifer having lower permeabilities.

2. The main-producing zone can be treated as a discrete, leaky, confined aquifer, and is represented by layer 1 in the model.

3. That part of the aquifer between the main-producing zone and the water table is represented by layer 2 in the model. Also, the bays are treated as extensions of layer 2.

4. Storage and horizontal flow are assumed to be negligible in the discontinuous, leaky beds of low permeability separating the main-producing zone from the unconfined zone; therefore, vertical flow through these

beds of low permeability can be represented by a matrix of values representing the vertical hydraulic conductivity divided by the thickness of layer 2. A range of vertical hydraulic conductivity values of from 0.0001 to 0.4 ft/d for the section between the water table and the main-producing zone was used in the calibration of the two-dimensional model of Trapp (1978, p. 10, 17-18), and is used as a guide in this model.

5. Layer 2 is assumed to be saturated; however, in reality it, in places, includes zones of unsaturated flow underlying perched saturated zones. The top of layer 2 is, in some places, the true water table and, in other places, it is the top of the shallowest perched body of ground water that supports perennial streams. Unsaturated material makes up only a small part of layer 2.

6. Both model layers are laterally isotropic, with only horizontal flow within each layer.

7. Both layers are laterally bounded partly by constant-head nodes and partly by no-flow boundaries. For both layers, constant-head nodes simulate the continuation of the upland area to the north and northwest of the model area. Constant-head nodes also represent head at sea level in layer 2 in the bays. Layer 1 terminates in no-flow boundaries offshore. The areas east of the Escambia River and west of the Perdido River are represented by no-flow boundaries.

8. The difference between the saltwater head in layer 2 in the bays and the equivalent freshwater head is negligible because of the shallow depth of water, dilution, and scale. Sea level is zero head.

9. Recharge to layer 2 does not include water that is later lost to evapotranspiration. No further provision is made for the process of evapotranspiration in this model.

10. Layer 2 is recharged by: (a) water entering from constant-head nodes, (b) a matrix representing net recharge from precipitation, (c) upward leakage from layer 1, and (d) induced infiltration from rivers resulting from stresses originating in layer 1. It discharges into: (a) constant-head nodes, (b) layer 1, and (c) rivers.

11. Layer 1 is recharged by water entering from constant-head nodes and by downward leakage from layer 2. It discharges into constant-head nodes and into layer 2.

12. Layer 1 has an impermeable base.

13. A steady-state model (no storage) can provide a reasonable simulation of head changes in response to long-term pumping (periods of 1 year or longer). This assumption is justified because steady-state conditions have been approached within a few days in aquifer tests on layer 1 (between 8 to 12 days during the Dunaway aquifer test, U.S. Geological Survey, 1979, p. 114).

Application

Selection of Grid

The Trescott three-dimensional model (Trescott, 1975) uses a block-centered finite difference grid. The map of the study area is divided into a grid of rectangles. A value is assigned to each parameter for each rectangle in the input, and a value is computed for the average head in each rectangle in the output.

The model grid contains 21 rows numbered from west to east and 28 columns numbered from south to north. Thus, node (5,16) is in the 5th row from the west boundary of the grid and the 16th column from the south boundary. On the model grid, the north boundary of column 23 (fig. 3) represents the north boundary of the area of investigation (fig. 1).

The node-rectangle size selected for the sand-and-gravel aquifer model is 1 minute of longitude by 1 minute of latitude over most of the project area, or an average of 6,041 feet for each minute of latitude and 5,254 feet for each minute of longitude. The north-south dimensions of the rectangles in the northern and southern parts of the grid are expanded in stages by a multiplier of 1.5 to a maximum of 30,606 feet at the north end and 13,603 feet at the south end to move the constant-head boundaries away from the area of principal interest without adding unnecessary nodes.

Input

Five groups of data are required for the model. An explanation of each of the five groups and instructions for formatting the data are provided in Supplementary Data II.

The upper layer (layer 2) was simulated as unconfined. The error criterion for closure was set at 0.01 foot. Five iteration parameters were used, and the dampening factor BETA was set at 0.5.

Starting-head matrices.--Separate matrices represent the initial heads in layers 1 and 2 (Supplementary Data III). After calibrating the model, a period of no pumping was simulated and the final-head matrices for both layers were inserted as new starting-head matrices so that drawdown values for succeeding runs represent change from conditions of no pumping.

Storage-coefficient matrices and constant-head nodes.--Separate matrices represent the storage coefficients in layers 1 and 2. At the present stage of model development, storage is assumed to be zero in both layers, and the matrices serve only to establish the constant-head nodes by means of negative values at these node locations, a convention of the model program. The constant-head nodes for layer 1 of this model have been indicated by circles in figure 3.

Layer 1 has a constant-head boundary at the north end of the model. This boundary is about 6 miles north of the northernmost discharging wells simulated in the model (Barth flowing wells) and about 13 miles north of the northernmost area of major well discharge (St. Regis Paper Co. at Cantonment).

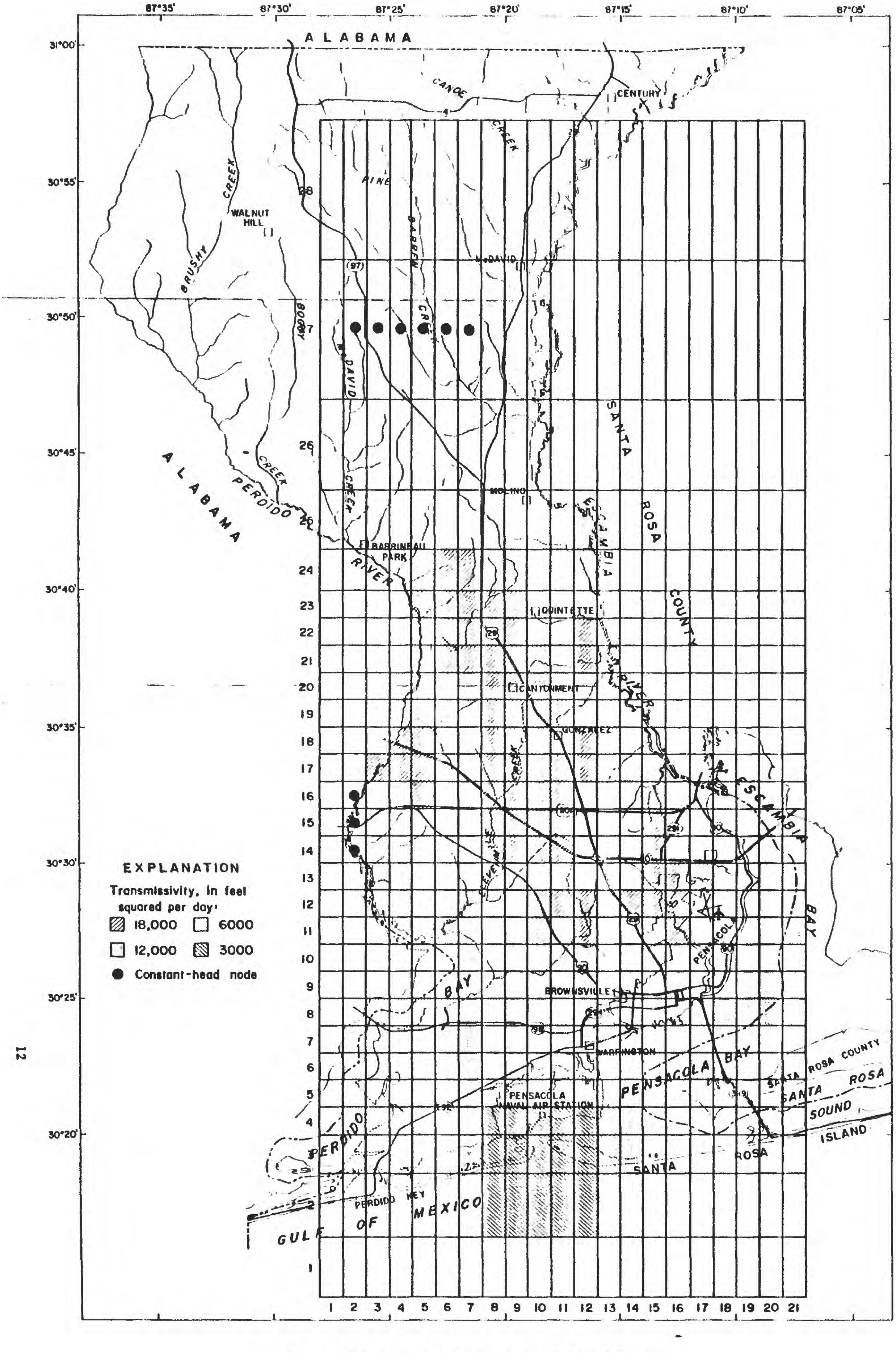

Figure 3--Input values for transmissivity of layer 1.

Layer 2 has constant-head nodes at the north end of the model, but also has them representing sea level in the bays at the south, southwest, and east edges of the model (fig. 5). Layer 1 extends under the sea-level constant-head nodes of layer 2 and terminates in no-flow boundaries.

Transmissivity of layer 1.--Transmissivity values were generalized into blocks having values of 3,000, 6,000, 12,000, and 18,000 ft^2/d (fig. 3), based on transmissivity values at control points within each block. The block pattern was adjusted somewhat during calibration.

Leakance matrix (TK): the hydraulic connection between layers 1 and 2.--The leakance matrix, TK, is defined as $\frac{K_v}{b}$, the vertical hydraulic conductivity of the confining zone divided by its thickness. Where two layers are in direct contact (sand on sand), TK can be represented by the harmonic means of the vertical hydraulic conductivities of layers 1 and 2 (Trescott, 1975, p. II-6, Eq. 26c, corrected by Trescott and Larson, 1976, p. XVII). In constructing the sand-and-gravel-aquifer model, neither method was used to derive the leakance matrix from actual data. No distinct single confining bed could be mapped, and it was not possible to assign an effective vertical hydraulic conductivity to layer 2 because of its heterogeneous lithology. Perched saturated zones in the layer indicate a low leakance value because of the low conductivity of the zone underlying a perched water body, the effect of the underlying unsaturated zone, and often the large effective thickness of the discontinuous confining beds. Therefore, the leakance matrix was derived from the calibration process. So far as possible, the values were assigned to large blocks, which tend to follow topographic and known hydrogeologic features (fig. 4). Perched water tables are most likely to be found in topographically high areas.

Lateral hydraulic conductivity of layer 2 (PERM).--This matrix represents the lateral hydraulic conductivity of layer 2 (fig. 5). Assigning values to it would be fairly straightforward except for two complicating factors: the presence of unsaturated material in parts of layer 2, and the inclusion of bays in some nodes. Unsaturated material could be treated as reducing the effective thickness of the water-bearing layer but, for the purposes of modeling, the hydraulic conductivity was adjusted downward instead.

Hydraulic conductivity values for layer 2 in the land areas were generalized into blocks having values of 2.3, 4.6, 14, 28, 37, and 46 ft/d. The values were adjusted during calibration, along with TK, so as to position the water table appropriately below land surface.

The bays were treated as extensions of layer 2. That is, the water surface of the bays is the equivalent of the water table, and layer 2 in the bays is defined as the interval between the water surface and the top of layer 1. The part of this interval comprising the surface-water body would have a lateral hydraulic conductivity approaching infinity because there is no aquifer material to impede lateral flow. The hydraulic conductivity for these nodes was set at 4.6×10^6, but they are all constant head at sea level. The nodes representing part bay, part land are not constant head. Their hydraulic conductivities were set between the realistic values of the land nodes and 4.6×10^6, depending on the approximate proportions of land and bay.

This modeling procedure can be justified theoretically by comparing the flow path and cross-sectional area of discharge for a partly submerged node rectangle to its simulated equivalent. Disregarding subaerial seepage along the shore, the submerged aquifer discharges upward into the bay, with a flow path and head difference on the order of 10 feet, and a cross-sectional area equal to the area submerged. The model simulates the same discharge under the same gradient with an assumed lateral flow between nodes 5,254 or 6,041 feet apart, depending on direction, and a cross-sectional area equal to the thickness of layer 2 (on the order of 100 feet) multiplied by the length of the side of the node rectangle (either 6,041 or 5,254 feet, depending on direction). In order for the model discharge to approximate the real discharge, the model values for lateral hydraulic conductivity in these nodes must be many times a realistic value for the aquifer (P. P. Leahy, U.S. Geological Survey, oral commun., May 31, 1984).

Altitude of the bottom of layer 2.--The altitude of the bottom of the unconfined zone is required in the computation of its transmissivity. The bottom of layer 2 was picked on logs of wells and test holes, and the altitudes were calculated, plotted on a matrix, and contoured. Node values were assigned according to the contours (Supplementary Data III).

Recharge rate (QRE).--Recharge to layer 2 was distributed to nodes in approximate relation to their infiltration characteristics, with the total recharge adjusted to fit average base runoff in the following manner:

1. Relative values of 0 to 10 were assigned to nodes based on soil permeability characteristics and topography (Supplementary Data III) as shown on a soils map indicating limitations for sewage lagoons and septic tanks (Post, Buckley, Schuh, and Jernigan, Inc., 1977, fig. 15). The map classified areas according to their suitability for septic tanks (high potential for infiltration desirable) and sewage lagoons (high potential for infiltration undesirable). Areas of ground-water discharge and rejected recharge were classified unfavorable for both.

2. The parameter multiplier was then adjusted so that the unit base runoff of the model area is 16.28 in./yr. This value was derived by taking the recharge rate calculated by the model for no pumping (period 1), dividing by the land area of the model excluding constant-head nodes in layer 2 ($4x10^2$ ft^3/s ÷ $9.289x10^9$ ft^2), and converting to in./yr. The process resulted in a maximum nodal recharge rate of 28.31 in./yr. (In this report, some numbers have been extended beyond significant digits for documentation and possible duplication of the model.)

A unit base runoff of 14.1 in./yr was derived in the calibration of Trapp's two-dimensional model of the aquifer, but this did not include discharge from perched water tables (Trapp, 1978, p. 15, 18).

In setting recharge equal to unit base runoff under unstressed steady-state conditions, recharge is defined so as to exclude water lost to evapotranspiration. Layers 1 and 2 are assumed to constitute a single layer in aquifer-stream relations for the determination of unit base runoff.

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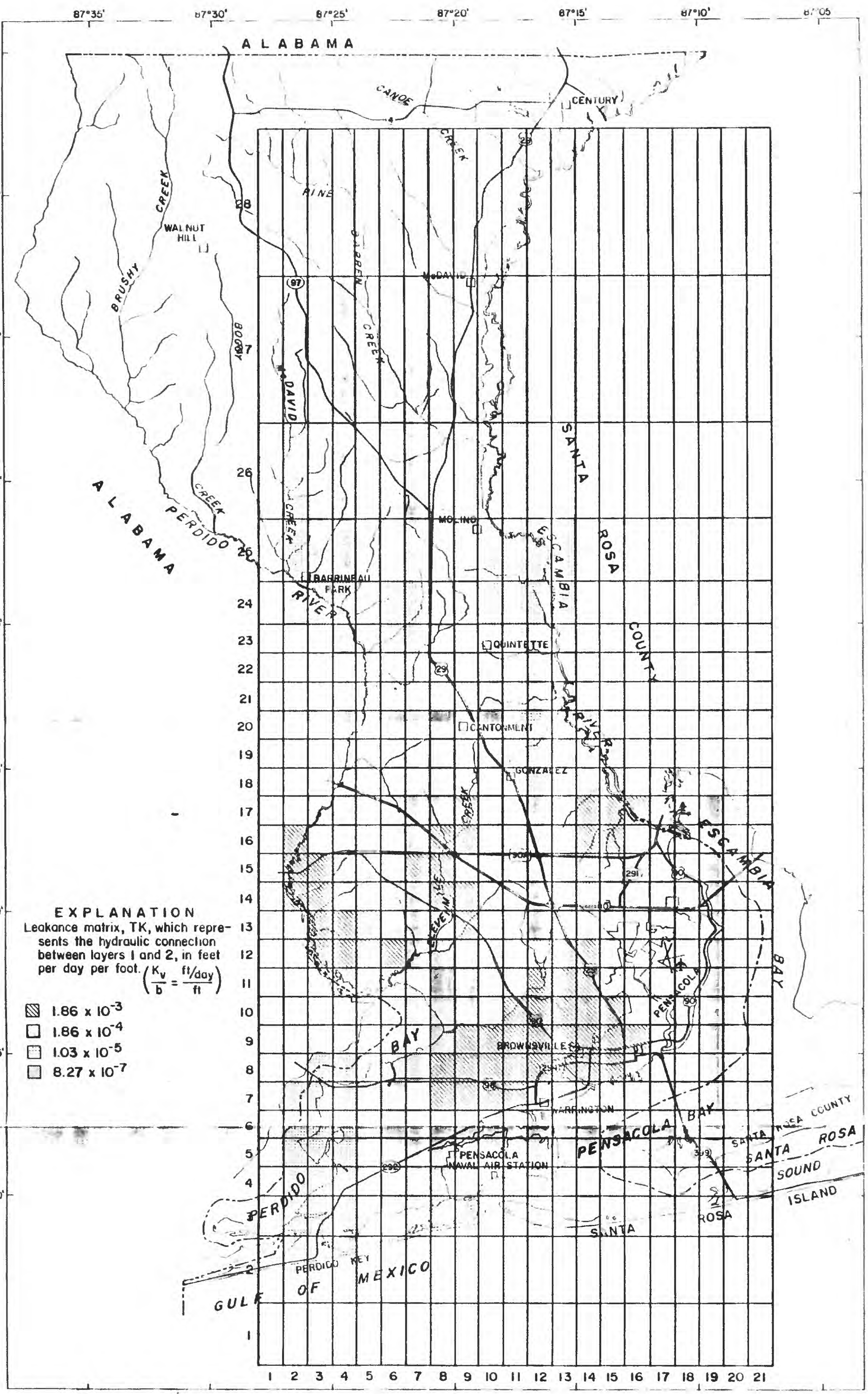

Figure 4.--Input values for TK, which represents the hydraulic connection between layers 1 and 2.

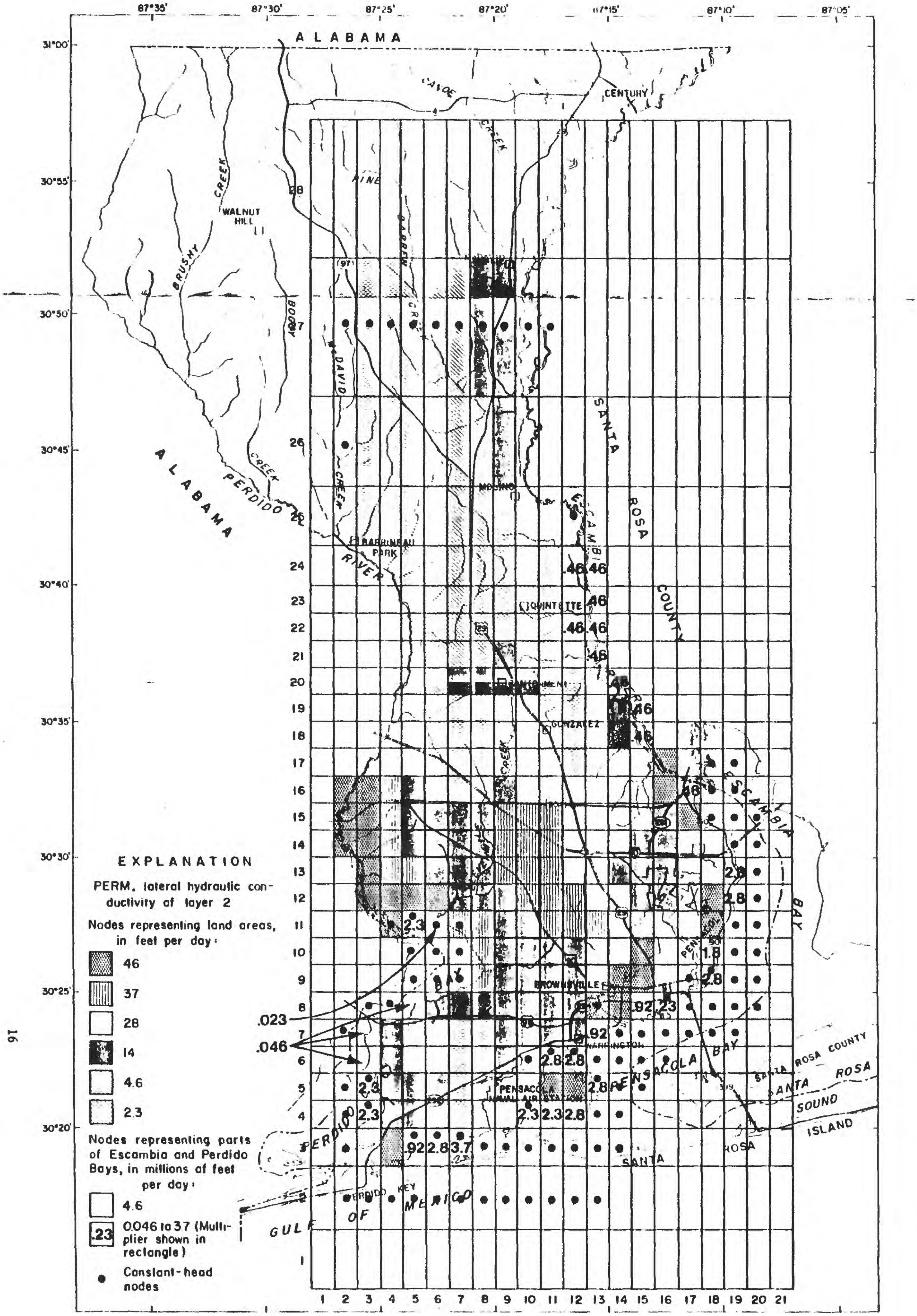

Figure 5.--Input values for PERM, or lateral hydraulic conductivity of layer 2.

The value for unit base runoff, used to determine the recharge rate, may require revision. Most of the stream gaging was done in northern Escambia County where the recharge-runoff relations may not be typical of the southern part of the county. In the southern part of the county the topographic relief is less and the population is more dense. The net recharge in the southern part of the county may tend to be less because of the greater prevalence of areas of natural discharge and the greater density of paving, sewers, and drains.

The recharge applied to the model is based on an average year. For simulation of an unusually wet or dry period, the recharge parameter can be changed. The recharge rate can also be varied to simulate the effects of changes in plant cover, paving, drains, catch basins, and lowering of the water table.

Simulation of rivers.--The streams, other than the Escambia and Perdido Rivers, generally act as drains. Most of them head within the study area, and therefore transfer no water from outside the study area. Streams were modeled by setting the array values of river water level, RH(NRIV), equal to the array values of river-bed bottom, RB(NRIV), so that if the head in the aquifer drops below the stream, the model will compute no aquifer discharge to the stream. The Escambia and Perdido Rivers and the tidal reaches of smaller streams are simulated with the head set a few feet above the bottom, using realistic depth values. Under these conditions, the direction as well as the rate of flow between layer 2 and the stream depends on the relative positions of their heads and river-bed leakance.

The justification for using two different ways of representing streams is that shallow gaining streams are fed by the aquifer and cannot recharge it (except locally or as a result of storms). The two rivers and the tidal reaches are assumed to have a fixed depth of water ("infinite" source in Alabama for the rivers and saltwater from the bays for the tidal reaches) and can recharge the aquifer, depending on the position of river head relative to the head in the aquifer.

The model also has an index array IDR that specifies the nodes containing streams, and a river-bed leakance coefficient matrix RC(NRIV) that includes the ratio of stream bottom to node-rectangle area (Supplementary Data III).

The model was found to have a low sensitivity to changes in the river-bed leakance coefficient; large increases in the coefficient beyond the value used produce only a small increase in the river leakage rate, which is more sensitive to changes in the head of layer 2.

The model-computed leakage rate to streams of 333 ft^3/s (no pumping) can be compared to estimates of 422 ft^3/s for base runoff and 400 ft^3/s for the model's recharge rate. According to Musgrove and others (1965, table 1, p. 97) the average total discharge of the Perdido and Escambia Rivers and of Bayou Marcus and Carpenter Creeks from the Escambia-Santa Rosa Counties part of the drainage basin was 1,420 ft^3/s for 1958-62. The sum of the drainage areas is 690 mi^2. The areas of the Perdido and Escambia River drainage basins within the model area are 141 and 84 mi^2, respectively. (These areas do not include constant-head nodes in layer 2 (shown in fig. 5) because constant-head nodes were not designated as RIVER nodes even if they include streams, and therefore their discharge is not included as RIVER LEAKAGE in the mass balance.) The average discharges of the Perdido and Escambia Rivers from drainage of the model area are estimated at 260 and 180 ft^3/s, respectively, using the proportions of the model drainage basin area to the drainage areas in the two counties. Adding in Bayou Marcus (93 ft^3/s) and Carpenter Creeks (31 ft^3/s) plus an estimated 87 ft^3/s for Elevenmile Creek's natural discharge gives a total river discharge of 650 ft^3/s for the model area. Multiplying by 0.65 (see Recharge and Discharge) gives an estimated base runoff of 422 ft^3/s.

River discharge is affected by pumping and rainfall; therefore, the above estimate applies primarily to the period in which the river discharge estimates were made. Several small streams and bayous were simulated in the model but not included in table 1 of Musgrove and others (1965), and therefore the model's RIVER LEAKAGE should be somewhat more than the base runoff estimate of 422 ft^3/s. This estimate, however, is higher than the model recharge rate of approximately 400 ft^3/s, or 16.28 in./yr, when it should be somewhat lower, to allow for discharge from the aquifer directly into the bays and for pumped ground water that is not returned to the rivers. The estimates for aquifer recharge and river leakage are not based on data sufficiently accurate to support close comparisons of this type, and can only serve as guides to the reasonableness of the mass balance.

Pumping periods.--Five pumping periods were simulated. Pumping period 1 represents conditions before development (no pumping). Tables 1 through 4 show the estimated distributions of simulated pumping for periods 2 (January 1939-March 1940), 3 (1958), 4 (1972), and 5 (1977). Pumping was estimated from published reports (Jacob and Cooper, 1940; Musgrove and others, 1965), water-use data, well-construction and well-abandonment dates, and reported well yields.

CALIBRATION AND MODEL RESULTS

The preliminary calibration of the model was for unstressed conditions. For each node in layer 2 a range of head values was estimated. Its upper limit was set so that the corresponding rectangle, as located on the topographic map, would not be flooded by an excessively high water table beyond mapped surface-water bodies, and its lower limit was equal to RB(NRIV), or average altitude of streams, if the node was a river node. It was assumed that all the streams were gaining under conditions of no pumping, and thus the altitude of the water table must be no lower than the altitude of the average stream surface.

Control for layer 1 for unstressed conditions consisted of historical data and water levels measured in wells remote from areas of heavy pumping. Water levels of wells were sometimes adjusted to derive the estimated node head because the wells are usually not located at the node. The adjustments were based on estimated potentiometric gradient and distance from the node. In the expanded grid rectangles at the north end of the model, such adjustment involves considerable uncertainty. Other possible sources of inaccuracy in the control values are inaccuracies of measurement and in measuring-point altitudes estimated from topographic maps, and measurements at times unrepresentative of average conditions.

Table 1.--Wells and discharge rates per node for pumping period 2: January 1939-March 1940

[Number of well nodes: 14]

Node	Lat.-long. quad[2]	Names of wells and water users	Withdrawal[1] Mgal/d	Withdrawal[1] Ft^3/s
5,20	032-723	Muscogee flowing well	0.01	0.015
8,11	027-720	U.S. Navy Saufley Field wells 3, 4	.1	.155
9,26	045-719	Barth flowing wells	.13	.2
10,25	043-718	Molino flowing wells	.087	.134
11,5	021-717	U.S. Navy NAS 1	.007	.01
11,8	024-717	U.S. Navy Corry Field wells 1, 2, 4, 9, 10, 14	.8	1.24
12,7	023-716	Peoples Water Co., old no. 1	.1	.15
12,8	024-716	U.S. Navy Corry Field wells 7, 8, 11, 12	.007	.01
13,7	023-715	U.S. Navy Bayou Chico Well Field	.1	.155
14,8	024-714	Weis-Fricker Lumber	.1	16.4
		Spearman Brewery	1.5	
		Newport Industries	9.	
15,11	027-713	Peninsular-Lurton	.03	.046
16,8	024-712	Peoples Ice	.5	.77
16,9	025-712	Pensacola Water Works (wells 1-6)	2.351	3.64
19,13	029-709	Pensacola Turpentine Southern Pine Chemical	.7	1.08

[1] Where two or more wells are in one node rectangle, the Mgal/d column shows the withdrawal of each well or group of wells; the Ft^3/s column shows the combined withdrawal for the node.

[2] Abbreviated designation of 1-minute latitude and longitude quadrangles as described by Musgrove and others, 1965, p. 8-9.

Input values were varied within reasonable limits established by control until a satisfactory comparison of computed to observed head was obtained from both layers 1 and 2.

Although the fit between observed and computed head values for unstressed conditions appeared good, the control for layer 1 was sparse and unevenly distributed. Also, the model may not have been sensitive to some of the input parameters under unstressed conditions, but large discrepancies could appear under stress. Therefore, the model was recalibrated for 1972, a year for which there was a much wider distribution of observation wells and widely distributed pumping.

Table 2.--Wells and discharge rates per node for pumping period 3: January-December 1958

[Number of well nodes: 37]

Node	Lat.-long. quad[2]	Names of wells and water users	Withdrawal[1] Mgal/d	Withdrawal[1] Ft³/s
3,7	023-725	U.S. Navy Bronson Field wells 1, 2	0.065	0.1
8,11	027-720	U.S. Navy Saufley Field wells 3, 4	.55	.85
8,20	036-720	St. Regis wells 30-32	7.	10.84
8,21	037-720	St. Regis wells 8-13	8.4	13.01
9,19	035-719	St. Regis wells 20-27	8.4	13.01
9,20	036-719	St. Regis wells 2-5, 15-19	7.	10.84
9,21	037-719	St. Regis wells 6, 7	2.8	4.34
9,26	045-719	Barth flowing wells	.13	.2
10,10	026-718	W. Pensacola Utility Avondale	.2	.31
10,20	036-718	St. Regis well 1	1.4	2.17
10,25	043-718	Molino flowing wells	.087	.134
11,5	021-717	U.S. NAS wells 1, D	.065	.1
11,8	024-717	U.S. Navy Corry Field wells 1, 2, 4, 9, 10, 14	2.6	4.11
12,5	021-716	U.S. NAS well 2	.032	.05
12,7	023-716	Peoples Water Co., wells 1-3	1.14	2.01
12,8	024-716	U.S. Navy Corry Field wells 7, 8, 11, 12	2.2	3.48
12,9	025-716	Pensacola W. Pensacola Plant	.8	1.2
13,7	023-715	Peoples Water well 4	0.38	0.77
		Pensacola Country Club	.1	
13,8	024-715	Newport wells 10, 12, 13	2.6	4.14
13,9	025-715	Newport well 11	.7	1.11
13,11	027-715	Montclair Util. well 1	.2	.31
13,19	035-715	Chemstrand wells 1, 2, 4-7, 9	7.04	11.54
14,8	024-714	Newport Industries	.2	2.64
		Spearman Brewery-Crystal Ice	1.5	
14,9	025-714	Pensacola W & Avery Plant	.8	2.395
		Pensacola I & Cervantes Plant	.8	
14,16	032-714	Pensacola Scenic Hills C. C.	.1	.15
14,19	035-714	Chemstrand well 3	1.	1.64
15,10	026-713	Pensacola No. 9 Plant	.8	2.49
		Pensacola F & Scott Plant	.8	
		Small-capacity Pensacola wells - Kuhn Grocery	.1	

See footnotes at end of table.

Table 2.--Wells and discharge rates per node for pumping period 3: January-December 1958--Continued

Node	Lat.-long quad[2]	Names of wells and water users	Withdrawal[1] Mgal/d	Withdrawal[1] Ft^3/s
15,11	027-713	Agrico, Concrete Supply, Escambia Treating	.065	.1
15,13	029-713	Pensacola Davis Plant	.8	1.2
15,17	033-713	Gulf Power Christ Plant wells 1-3	.2	.3
16,8	024-712	Peoples Ice	.3	.5
16,9	025-712	Pensacola No. 6 Plant	.8	3.6
		Pensacola No. 8 Plant	.8	
		Pensacola East Plant	.8	
16,10	026-712	Pensacola 12th Ave. Plant	0.3	0.45
16,13	029-712	Pensacola 9th Ave. Plant	.8	1.2
16,15	031-712	U.S. Navy Ellyson Field wells 1, 2	.14	.21
17,11	027-711	Pensacola Hagler Plant	.3	.45
17,13	029-711	Pensacola McAllister Plant	.3	.45

Totals for major users

	Mgal/d	Ft^3/s	Mgal/yr
Pensacola	8.9	13.77	3,249.5
Peoples Water Co.	1.73	2.68	632
W. Pensacola Utilities	.13	.2	47
U. S. Navy:			
Bronson, Saufley, Ellyson Fields	.75	1.16	274
NAS	.1	.15	35
Corry Field	4.903	7.59	1,790
St. Regis Co.	35.	54.72	12,775
Chemstrand (Monsanto)	8.51	13.17	3,108
Newport Industries	3.6	5.57	826
Gulf Power	.19	.3	69

[1]Where two or more wells are in one node rectangle, the Mgal/d column shows the withdrawal of each well or group of wells; the Ft^3/s column shows the combined withdrawal for the node.

[2]Abbreviated designation of 1-minute latitude and longitude quadrangles as described by Musgrove and others, 1965, p. 8-9.

Table 3.--Wells and discharge rates per node for pumping period 4: January-December 1972

[Number of well nodes: 51]

Node	Lat.-long. quad[2]	Names of wells and water users	Withdrawal[1] Mgal/d	Withdrawal[1] Ft^3/s
8,11	027-720	U.S. Navy Saufley Field wells 3, 4	0.32	0.5
8,20	036-720	St. Regis wells 30-32,	4.56	7.18
		Farm Hill Util. No. 1	.08	
8,21	037-720	St. Regis wells 8-13	5.47	8.46
8,23	039-720	Mazurek Farm	.12	.19
9,9	025-719	Pensacola Lillian Plant	.44	.68
9,19	035-719	St. Regis wells 20-27	5.47	8.46
9,20	036-719	St. Regis wells 2-5, 15-19	4.56	7.06
9,21	037-719	St. Regis wells 6-7	1.82	2.99
		Cottage Hill Util. well 1	.11	
9,22	038-719	Boise-Cascade well 1	.004	.006
9,23	039-719	Boise-Cascade well 2	.009	.014
9,26	045-719	Barth flowing wells	.15	.2
10,10	026-718	W. Florida Util. Avondale	2.7	4.18
10,20	036-718	St. Regis well 1	.92	1.41
10,25	043-718	Molino flowing wells	.09	.134
11,5	021-717	U.S. NAS Hovey Rd. well	.2	.31
11,7	023-717	Peoples Water well 7	.45	.7
11,8	024-717	U.S. Navy Corry Field wells 1, 2, 4, 9, 10, 14	4.	6.19
11,11	027-717	W. Florida Util. Charbar	0.15	0.23
11,19	035-717	Gonzalez Util. well 1	.11	.17
12,5	021-716	U.S. NAS well 2	.05	.08
12,7	023-716	Peoples Water wells 1-3, 6	1.35	2.09
12,8	024-716	U.S. Navy Corry Field wells 7, 8, 11, 12	3.74	6.48
		Peoples Water well 8	.46	
12,9	025-716	Pensacola W. Pensacola Plant	1.5	2.33
12,11	027-716	Pensacola Montclair 2, 3	1.	1.55
12,14	030-716	Pensacola Broad Plant	1.5	2.33
12,15	031-716	Pensacola Ensley Plant	.9	1.39
12,16	032-716	Pensacola Sweeney Plant	1.5	2.33

See footnotes at end of table.

Table 3.--Wells and discharge rates per node for pumping period 4: January-December 1972--Continued

Node	Lat.-long. quad[2]	Names of wells and water users	Withdrawal[1] Mgal/d	Withdrawal[1] Ft^3/s
12,18	034-716	Monsanto well 11	.97	1.5
13,7	023-715	Peoples Water well 4	.45	.85
		Pensacola Country Club	.1	
13,8	024-715	Newport well 13	1.61	2.49
13,9	025-715	Newport well 11	.46	.71
13,11	027-715	Pensacola Montclair 1	.5	.77
13,18	034-715	Monsanto well 13	1.94	3.
13,19	035-715	Monsanto wells 1-2, 4-9	7.52	11.64
14,8	024-714	Newport well 9	.09	1.84
		Crystal Ice	1.1	
14,9	025-714	Pensacola W & Avery Plant	1.5	4.65
		Pensacola I & Cervantes Plant	1.5	
14,16	032-714	Pensacola Scenic Hills C. C.	.05	.077
14,19	035-714	Monsanto well 3	.11	.17
15,10	026-713	Pensacola F & Scott Plant	1.5	4.65
		Pensacola No. 9 Plant	1.5	
15,11	027-713	Concrete Supply & Escambia Treating	.02	.077
		Agrico	.03	
15,13	029-713	Pensacola Davis Plant	1.5	2.33
15,16	032-713	University of West Florida well 2	.2	.31
15,17	033-713	University of West Florida well 1	.08	2.41
		Gulf Power Christ Plant wells 1-3	1.48	
16,8	024-712	Peoples Ice	.5	.77
16,9	025-712	Pensacola No. 8 Plant[3]	1.5	2.33
16,13	029-712	Pensacola 9th Ave. Plant	1.5	2.33
16,14	030-712	Pensacola Olive Plant	.9	1.39
16,15	031-712	U. S. Navy Ellyson Field wells 1, 2	.2	.31
17,11	027-711	Pensacola Hagler Plant	1.48	2.29
17,13	029-711	Pensacola McAllister Plant	1.5	2.3
17,16	032-711	Pensacola River Gardens well	.1	.16

See footnotes at end of table.

Table 3.--Wells and discharge rates per node for pumping period 4: January-December 1972--Continued

Node	Lat.-long. quad[2]	Names of wells and water users	Withdrawal[1] Mgal/d	Ft^3/s

Totals for major users--Continued

	Mgal/d	Ft^3/s	Mgal/yr
Pensacola	21.9	33.9	7,994.5
Peoples Water Co.	2.7	4.2	987
W. Pensacola Utilities	2.8	4.4	1,040
U. S. Navy:			
Saufley, Ellyson Fields	.5	.8	191
NAS	.25	.39	91
Corry Field	7.7	12.0	2,824
St. Regis Co.	22.8	35.3	8,319
Monsanto Co.	10.5	16.3	3,847
Newport Industries	2.2	3.3	788
Gulf Power	1.5	2.3	540

[1]Where two or more wells are in one node rectangle, the Mgal/d column shows the withdrawal of each well or group of wells; the Ft^3/s column shows the combined withdrawal of the node.

[2]Abbreviated designation of 1-minute latitude and longitude quadrangles as described by Musgrove and others, 1965, p. 8-9.

[3]Well plants No. 6, Pensacola East Plant not in operation in 1972.

The data were analyzed statistically after calibration. Table 5 lists the sites used as control for the head of layer 1 under unstressed conditions (pumping period 1) and compares the altitudes of measured water levels, node heads estimated from those observations, and node heads from the model. Figure 6 shows the same data graphically, with the y-axis representing measured values and the x-axis computed values. The equation of the regression line is $y = -0.2556 + 0.97414x$. The correlation coefficient r is 0.954. If the calibration fit the observed points exactly, the equation would be $y = x$ and the correlation coefficient would be 1. The 95-percent confidence band shows the joint confidence interval for the regression line at any value of x (computed head) from 0 to 70 feet by the Scheffé method (Brown and Hollander, 1977, p. 271-274). The widening of the confidence band for the higher head values may be explained by (1) less refinement in the calibration in the upland (northern) areas where these originated, owing to less control for the input matrices and large grid blocks and (2) more scatter in the measured water-level data, owing to a greater reliance on single measurements at sites, some of which had imprecise land-surface datum control.

Table 4.--Wells and discharge rates per node for pumping period 5: January-December 1977

[Number of well nodes: 58]

Node	Lat.-long. quad[2]	Names of wells and water users	Withdrawal[1] Mgal/d	Withdrawal[1] Ft^3/s
3,7	023-725	Pensacola Bronson wells 1, 2	0.69	1.07
5,16	032-723	Beulah Water System	.2	.31
5,18	034-724	Florida Welcome Station	.007	.01
5,26	046-723	Molino Utility well 2	.11	.17
7,20	036-721	Farm Hill Utility 2	.06	.09
8,11	027-720	U.S. Navy Saufley Field wells 3, 4	.18	.28
8,20	036-720	St. Regis wells 30-32	2.865	4.44
		Farm Hill Util. No. 1	.05	
8,21	037-720	St. Regis wells 8-13	5.73	8.87
8,23	039-720	Mazurek farm	.03	.046
8,25	043-720	Molino Utility well 1	.11	.17
9,9	025-719	Pensacola Lillian Plant	1.04	1.607
9,14	030-719	Pensacola Dunaway Plant	.69	1.07
9,19	035-719	St. Regis wells 20-27	7.64	11.82
9,20	036-719	St. Regis wells 2-5, 15-19	5.73	8.87
9,21	037-719	St. Regis wells 6-7	1.91	3.19
		Cottage Hill Util. well 1	.15	
9,26	045-719	Barth flowing wells	.15	.2
10,10	026-718	W. Florida Util. Avondale	.6	.93
10,20	036-718	St. Regis well 1	.955	1.48
10,25	043-718	Molino flowing wells	.09	.134
11,3	019-717	Gulf Island Natl. Seashore	.075	.116
11,5	021-717	U.S. NAS Hovey Rd. well	.2	.31
11,7	023-717	Peoples Water well 7	.397	.61
11,8	024-717	U.S. Navy Corry Field wells 1, 2, 4, 9, 10, 14	3.83	5.93
11,11	027-717	W. Florida Util. Charbar	.11	.17
11,19	035-717	Gonzalez Util. well 1	.19	.29
12,5	021-716	U.S. NAS well 2	.401	.62
12,7	023-716	Peoples Water wells 1-3, 6	1.59	2.46
12,8	024-716	U.S. Navy Corry Field wells 7, 8, 11, 12	2.74	4.85

See footnotes at end of table.

Table 4.--Wells and discharge rates per node for pumping period 5: January-December 1977--Continued

Node	Lat.-long. quad[2]	Names of wells and water users	Withdrawal[1] Mgal/d	Withdrawal[1] Ft^3/s
		Peoples Water well 8	.397	
12,9	025-716	Pensacola W. Pensacola Plant	1.38	2.14
12,11	027-716	Pensacola Montclair 2, 3	1.73	3.6
		W. Florida Util. Carriage Hills well	.6	
12,14	030-716	Pensacola Broad Plant	1.38	2.14
12,15	031-716	Pensacola Ensley Plant	1.04	1.607
12,16	032-716	Pensacola Sweeney Plant	1.38	2.14
12,18	034-716	Monsanto well 11	1.244	1.925
13,7	023-715	Peoples Water well 4	.397	.769
		Pensacola Country Club	.1	
13,8	024-715	Newport well 13	.42	.65
13,9	025-715	Newport well 11	.42	.65
13,11	027-715	Pensacola Montclair 1	.69	1.07
13,13	029-715	Holiday Inn	.03	.046
13,18	034-715	Monsanto well 13	1.244	1.72
13,19	035-715	Monsanto wells 1, 2, 4-9	9.066	14.03
14,8	024-714	Newport well 9	.42	3.78
		Crystal Ice	2.019	
14,9	025-714	Pensacola W & Avery Plant	1.38	4.28
		Pensacola I & Cervantes Plant	1.38	
14,11	027-714	Hollingsworth Dairy	.002	.003
14,12	028-714	Southern Prestressed Concrete	0.001	0.0015
14,19	035-714	Monsanto well 3	1.244	1.92
15,10	026-713	Pensacola F & Scott Plant	1.38	3.75
		Pensacola No. 9 Plant	1.03	
15,11	027-713	Concrete Supply	.007	.02
		Escambia Treating	.006	
15,13	029-713	Pensacola Davis Plant	1.38	2.14
15,16	032-713	University of West Florida well 2	.224	.35
15,17	033-713	University of West Florida well 1	.08	3.99
		Gulf Power Christ Plant wells 1-3	2.5	
16,9	025-712	Pensacola No. 8 Plant	.69	4.82
		Pensacola No. 6	1.03	
		Pensacola East Plant	1.38	
16,13	029-712	Pensacola 9th Ave. Plant	1.38	2.14

See footnotes at end of table.

Table 4.--Wells and discharge rates per node for pumping period 5: January-December 1977--Continued

Node	Lat.-long. quad[2]	Names of wells and water users	Withdrawal[1]	
			Mgal/d	Ft^3/s
16,14	030-712	Pensacola Olive Plant	.69	1.07
16,15	031-712	U.S. Navy Ellyson Field wells 1, 2	.198	.31
17,11	027-711	Pensacola Hagler Plant	1.03	1.607
17,13	027-713	Pensacola McAllister Plant	1.38	2.14
18,12	028-710	Pensacola Airport N.	.69	1.07

Totals for major users

	Mgal/d	Ft^3/s	Mgal/yr
Pensacola	24.92	38.56	9,095.8
Peoples Water Co.	2.78	4.30	1,015
W. Pensacola Utilities	1.31	2.03	478
U. S. Navy:			
Corry Field	6.57	10.2	2,398
Ellyson Field	.198	.306	14.3
NAS	.601	.930	219
Saufley Field	.18	.28	65.7
St. Regis Co.	24.83	38.42	9,063
Monsanto Co.	12.8	19.8	4,672
Newport Division, Reichhold Chemical	1.265	1.96	462
Gulf Power	2.5	3.87	912
Peoples Ice	2.019	3.124	736.9

[1]Where two or more wells are in one node rectangle, the Mgal/d column shows the withdrawal of each well or group of wells; the Ft^3/s column shows the combined withdrawal of the node.

[2]Abbreviated designation of 1-minute latitude and longitude quadrangles as described by Musgrove and others, 1965, p. 8-9.

Table 5.--Control-node observed and computed head values for layer 1, pumping period 1 (no pumping)

Node	Lat.-Long. quad[1]	Site I.D. No.[2]	Name	Reported or mean observed head (feet)	Period of obervation	Node head: Estimated from observed values (feet)	Node head: From model (feet)	Node head: From model minus estimated from observation (feet)
4,16	032-724	3032080872411.01	USGS 032-724-1	31.7		32	32	0
5,4	020-723	3020520872341.01	USGS TH 25	11	12/72-10/79	10	9	-1
5,13	029-723	3029580872300.01	USGS TH 8	24	03/71-10/79	19	18	-1
7,7	023-721	3023540872105.01	USGS TH 9	10	03/71-10/79	12	13	1
7,12	028-721	3028200872114.01	USGS TH 22	14	03/72-10/79	14	15	1
8,14	030-720	3030060872052.01	USGS TH 7	23	02/71-12/74	24	25	1
9,14	030-719	3030180871922.01	USGS TH 5	32	02/71-12/74	34	38	4
9,16	032-719	3032160871941.01	USGS TH 29	41	04/73-12/74	42	47	5
9,20	036-719	3036140871909.01	USGS Escambia 45	64.5	01/40-04/40	66	65	-1
10,14	030-718	3030430871822.01	USGS TH 4	46	02/71-12/74	45	48	3
12,15	031-716	3031080871623.01	USGS Escambia 46	61.22	01/40-04/40	62	63	1
16,9	025-712	3025230871257.01	Pensacola Water Works	28	1886	19	19	0
		3025550871227.02	Pensacola East Plant	11	04/14/71			

[1]Abbreviated designation of 1-minute latitude and longitude quadrangles as described by Musgrove and others, 1965, p. 8-9.

[2]Unique USGS ground-water site identification number based on approximate latitude and longitude; well data in computer storage.

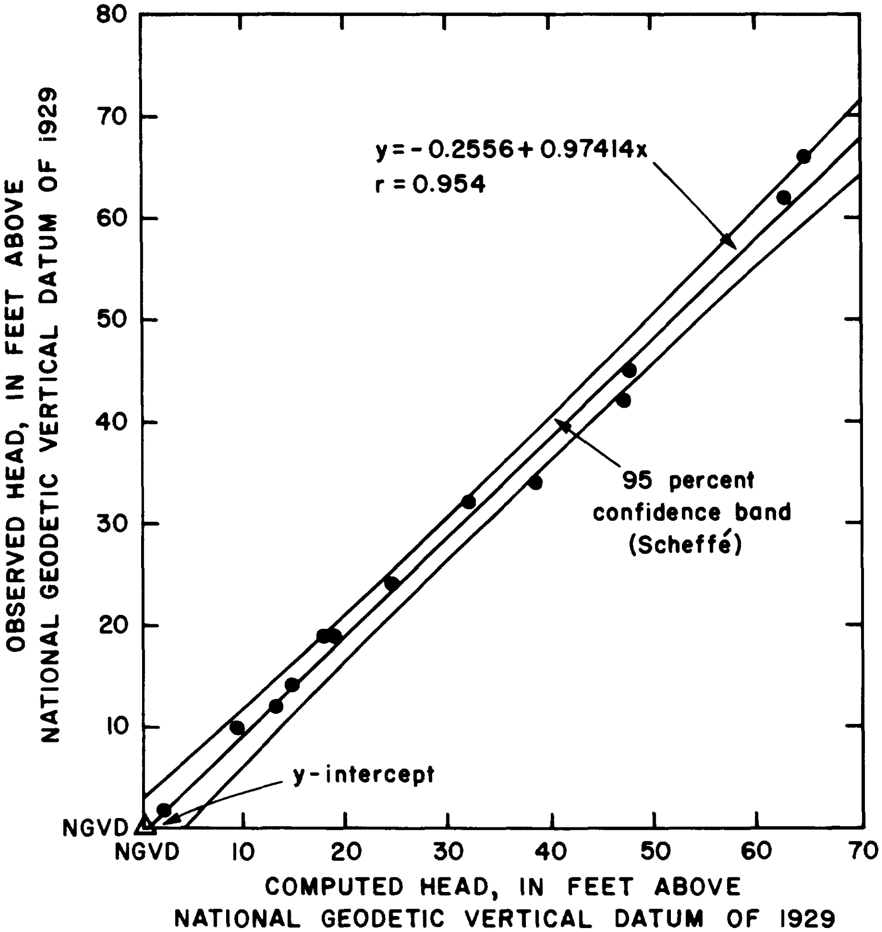

Figure 6.--Observed versus calculated head values, regression line, and confidence band for layer 1 for pumping period 1 (no pumping).

Table 6 lists the sites used as control for the calibration of layer 1 for 1972 (pumping period 4), adjusted observed heads, and heads computed by the model. The interpretation of measured water levels to represent pumping nodes involves more problems than those for other nodes. The model treats pumping in any node rectangle as if it is concentrated in a single well at the node, which is rarely the case. If an observation well is close to a pumping well and both are distant from the node, or if the two are at opposite ends of the node rectangle, measurements in the observation well would not indicate the node value with the pumping well extrapolated to the node. Adjustments were made to some observation-well head values by means of the Theis equation (Lohman, 1979, p. 15): first solve for the drawdown in the observation well produced by the pumping well(s) at the actual radius (or radii) and add it to the mean observed head. Then solve for the drawdown produced in the observation well by a hypothetical well at the node with discharge equal to the sum of all the discharge within the rectangle. This, subtracted from the previously adjusted head, should approximate the head at the well site if pumping were concentrated at the node, except that leakage is ignored. The adjustment appeared to give reasonable results in the simpler situations, but produced a greater discrepancy than the unadjusted value in areas of closely spaced pumping wells. In these areas the unadjusted value was used.

Table 6.--Control-node observed and computed head values for layer 1, pumping period 4 (January-December 1972)

Node	Lat.-Long. quad[1]	Site I.D. No.[2]	Name	Reported or mean observed head (feet)	Period of obervation	Node head: Estimated from observed values (feet)	Node head: From model (feet)	Node head: From model minus estimated from observation (feet)
4,16	032-724	3032080872411.01	USGS 032-724-1	29.98	01-12/72	31	30.25	-0.75
5,4	020-723	3020520872341.01	USGS TH 25	9	12/21/1972	9	9.11	.11
5,13	029-723	3029580872300.01	USGS TH 8	25	02-12/72	18	17.62	-.38
5,20	036-723	3036420872323.01	USGS TH 12	33	02-12/72	32	32.35	.35
5,23	039-723	3039580872332.01	USGS TH 13	46	02-12/72	42	44.81	2.81
7,7	023-721	3023540872105.01	USGS TH 9	9	01-12/72	10	12.15	2.15
7,12	028-721	3028200872114.01	USGS TH 22	12	03-12/72	13	13.89	.89
8,4	020-720	3020330872028.01	USGS TH 23	1	03-12/72	2	6.79	4.79
8,14	030-720	3030060872052.01	USGS TH 7	28	02-12/72	30	24.13	-5.87
9,14	030-719	3030180871922.01	USGS TH 5	35	01-12/72	36	36.29	.29
[3]9,20	036-719	3036140871909.01	USGS Escambia 45	32	01-12/72	9	10.51	1.51
10,8	024-718	3024320871826.01	USGS TH 3	16	01-12/72	18	7.59	10.41
10,14	030-718	3030430871822.01	USGS TH 4	45	01-12/72	44	43.50	-.50
10,17	033-718	3033460871854.01	USGS TH 18	46	05-12/72	46	44.84	-1.16
[3]12,7	023-716	3023080871635.01	USGS Escambia 39	-0.4	01-12/72	-13	-6.69	6.31
12,15	031-716	3031080871623.01	USGS Escambia 46	50.6	01-12/72	51	48.58	-2.42
12,20	036-716	3036100871650.01	Monsanto 74	4	01-12/72	7	9.30	2.30
		3036450871609.01	USGS TH 17	10.2	04-11/72			
12,22	038-716	3038570871635.01	USGS TH 15	7	04-11/72	7	14.50	7.50
[3]13,8	024-715	3024320871517.01	USGS Escambia 62	14.8	01-12/72	0	-1.48	-1.48

See footnotes at end of table.

Table 6.--Control-node observed and computed head values for layer 1, pumping period 4 (January-December 1972)--Continued

Node	Lat.-Long quad[1]	Site I.D. No.[2]	Name	Reported or mean observed head (feet)	Period of obervation	Node head: Estimated from observed values (feet)	Node head: From model (feet)	Node head: From model minus estimated from observation (feet)
13,10	026-715	3026430871536.01	USGS TH 2	36	02-12/72	34	27.39	-6.61
13,16	032-715	3032510871502.01	USGS TH 20	34.3	05-11/72	43	40.35	-2.65
13,19	035-715	3035580871555.01	Monsanto, Escambia 73	-9.6	01-12/72	-15	-12.19	2.81
14,16	032-714	3032490871408.01	USGS TH 21	22.0	03-11/72	32	33.68	1.68
[3]14,19	035-714	3035270871400.01	Monsanto, Escambia 83	-8.9	01-11/72	2.73	-3.31	-6.04
15,10	026-713	3026580871303.01	USGS 026-713-5	21.8	01-12/72	17	14.33	-2.67
15,16	032-713	3032080871327.01	USGS TH 6	21.4	01-11/72	20	21.15	1.15
17,9	025-711	3025410871145.01	USGS TH 1	2	02-12/72	1	3.98	2.98

[1]Abbreviated designation of 1-minute latitude and longitude quadrangles as described by Musgrove and others, 1965, p. 8-9.

[2]Unique USGS ground-water site identification number based on approximate latitude and longitude; well data in computer storage.

[3]Pumping node.

Figure 7 shows observed heads plotted against computed heads for 1972, with the equation of the regression line: y = -0.7121 + 1.059x and correlation coefficient r = 0.974. The 95 percent confidence band is broader than for the no-pumping period, perhaps in part because of the difficulty in adjusting observed water levels at pumping nodes, but the high correlation coefficient indicates that the calibration should be satisfactory for most purposes.

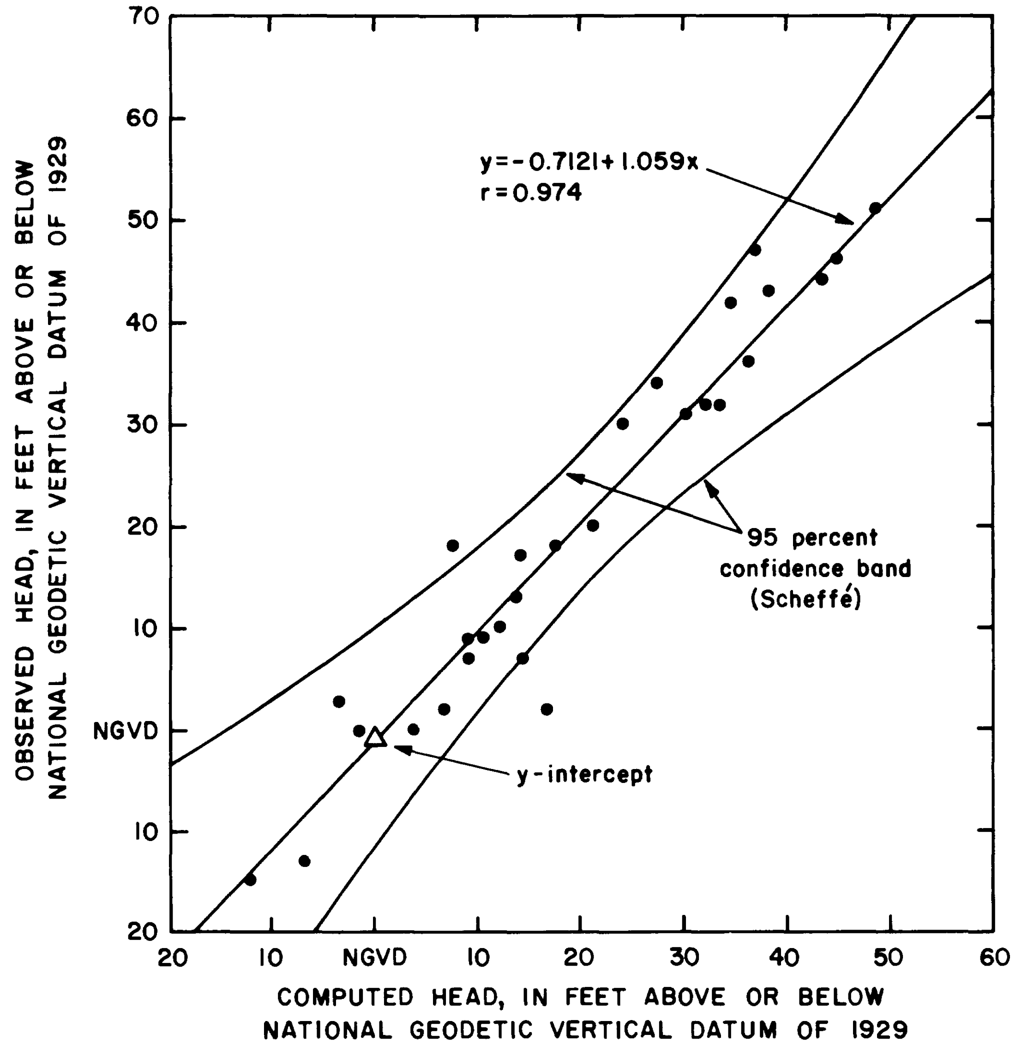

Figure 7.--Observed versus calculated head values, regression line, and confidence band for layer 1 for pumping period 4 (January-December 1972).

Mass Balance

Lohman (1979, p. 63) defined the hydrologic budget of an aquifer with the following equation:

$$R + \Delta R = D + \Delta D + q + S \frac{\Delta h}{\Delta t} \qquad (2)$$

where

R = recharge rate per unit area,
ΔR = change in recharge rate per unit area,
D = natural discharge per unit area,
ΔD = change in discharge rate per unit area,
q = rate of withdrawal from wells per unit area, and
$S \frac{\Delta h}{\Delta t}$ = rate of change in storage per unit area.

In the present model, S is assumed to be zero, and so the equation would read:

$$R + \Delta R = D + \Delta D + q \qquad (3)$$

where

R = a constant recharge rate plus recharge through constant-head nodes,
ΔR = change in recharge through constant-head nodes only,
D = natural discharge rate including discharge through rivers and constant-head nodes,
ΔD = net changes in discharge rate per unit area through rivers and constant-head nodes, and
q = rate of withdrawal from wells per unit area.

The simplifications depart from reality because water produced by wells is always, to some extent, derived from storage in the aquifer, and recharge is likely to increase in response to enlarging cones of depression because of infiltration of water that would otherwise have been rejected.

The mass balance output identifies the contribution from each source, and should show, for each pumping period, that flow into the model area is roughly equal to flow out of the model area.

Mass balances for the five pumping periods are shown in tables 7 through 11. In each case, the error is less than 1 percent. Note that the constant-head input rate is only a small part of the total input and increases only moderately from pumping period 1 (no pumping) to succeeding periods of pumping. This is one indication that the model results are not influenced excessively by the constant-head nodes.

The constant-head input rate actually decreased from pumping period 2 (28.6 ft^3/s) to pumping period 3 (28.1 ft^3/s) although the pumping rate increased more than four times. This can be explained by a change in the distribution of pumping. For pumping period 2 (table 8), pumping was concentrated around Pensacola Bay and, particularly, around Bayou Chico (fig. 1) in node 14,8. Constant-head nodes at sea level in layer 2 under Pensacola Bay (nodes 14,5-6; 15,5-7 and 16,6-7), which had been receiving flow from adjoining nodes in layer 1, became sources of water as a result of pumping. For pumping period 3 (table 9), pumping in node 14,8 continued at only one-fourth the former rate, and all the offshore nodes except 14,6 again acted as sinks rather than sources. This reversal is sufficient to explain the small changes in constant-head input rate between pumping periods 1 and 3.

Table 7.--Mass balance for pumping period 1 (no pumping), with flow rates to constant-head nodes

```
        ----------------------------------------------------------
        |              TIME STEP NUMBER =        12              |
        ----------------------------------------------------------

             SIZE OF TIME STEP IN SECONDS=   10593634.00

                  TOTAL SIMULATION TIME IN SECONDS=   31535952.00
                                           MINUTES=     525599.06
                                             HOURS=       8759.98
                                              DAYS=        365.00
                                             YEARS=          1.00

        DURATION OF CURRENT PUMPING PERIOD IN DAYS=        365.00
                                             YEARS=          1.00


CUMULATIVE MASS BALANCE:            L**3                RATES FOR THIS TIME STEP:            L**3/T
------------------------                                -------------------------

      SOURCES:                                                        STORAGE =          0.0
      --------                                                       RECHARGE =        399.5969
             STORAGE =              0.0                         CONSTANT FLUX =          0.0
            RECHARGE =      12601667584.00                            PUMPING =          0.0
       CONSTANT FLUX =              0.0                    EVAPOTRANSPIRATION =          0.0
       CONSTANT HEAD =        834089728.00                     CONSTANT HEAD:
             LEAKAGE =              0.0                                    IN =         26.4489
       TOTAL SOURCES =      13435756544.00                                OUT =        -92.9309
                                                                     LEAKAGE:
      DISCHARGES:                                FROM PREVIOUS PUMPING PERIOD =          0.0
      -----------                                               RIVER LEAKAGE =       -332.6895
  EVAPOTRANSPIRATION =              0.0
       CONSTANT HEAD =       2930664192.00                       SUM OF RATES =          0.4250
    QUANTITY PUMPED =              0.0
       RIVER LEAKAGE =      10491674624.00
     TOTAL DISCHARGE =      13422338048.00

   DISCHARGE-SOURCES =        -13418496.00
  PER CENT DIFFERENCE =             -0.10
```

Table 7.--Mass balance for pumping period 1 (no pumping), with flow rates to constant-head nodes--Continued

FLOW RATES TO CONSTANT HEAD NODES:

K	I	J	RATE (L**3/T)	K	I	J	RATE (L**3/T)	K	I	J	RATE (L**3/T)
1	2	14	-0.6286759	1	2	15	-2.248747	1	2	16	-2.620985
1	2	27	0.9353443	1	3	27	2.321786	1	4	27	1.204068
1	5	27	-0.2311178	1	6	27	0.1383249E-01	1	7	27	2.757833
2	2	2	-0.3576449E-01	2	2	3	-0.9379415	2	2	4	-0.2511039E-01
2	2	5	-0.4935129	2	2	7	-1.546877	2	2	26	-1.702860
2	2	27	0.0	2	3	2	-0.2786024	2	3	4	-0.3768023
2	3	5	-0.7485507	2	3	8	-0.8674028	2	3	27	0.1797630
2	4	2	-0.2589657	2	4	8	-0.8344899	2	4	11	-0.1794279
2	4	27	0.6868440E-01	2	5	2	-0.3486909E-01	2	5	3	-1.206593
2	5	9	-0.1202393	2	5	10	-0.3944409E-01	2	5	11	-0.7389030
2	5	27	-0.1922248E-01	2	6	2	-0.3482424E-01	2	6	3	-0.3718605
2	6	9	-0.6485665E-01	2	6	10	-0.4321648E-01	2	6	11	-0.8813736
2	6	27	-0.5433216E-01	2	7	2	-0.3367284E-01	2	7	3	-0.1925377
2	7	9	-0.2367910	2	7	10	-0.4832376	2	7	11	-0.9711658
2	7	27	0.2777805E-01	2	8	2	-0.2944864E-01	2	8	3	-1.047325
2	8	27	18.31662	2	9	2	-0.2389192E-01	2	9	3	-0.9233623
2	9	27	-17.76775	2	10	2	-0.1855938E-01	2	10	3	-0.1824912E-01
2	10	4	-1.835188	2	10	6	-0.6415259	2	10	27	-0.7407970
2	11	2	-0.1341477E-01	2	11	3	-0.4524588	2	11	6	-1.408778
2	11	27	-0.8460290	2	12	2	-0.8325920E-02	2	12	3	-0.3691265
2	12	6	-0.6613163	2	12	25	-0.4787253	2	13	2	-0.5739624E-01
2	13	3	-0.5897652E-01	2	13	4	-0.5148983	2	13	5	-0.6886726
2	13	6	-1.016431	2	13	8	-4.455692	2	13	25	-0.2843985
2	14	3	-0.3662811E-01	2	14	4	-0.5160731E-01	2	14	5	-0.8580238E-01
2	14	6	-0.1530992	2	14	7	-1.933840	2	15	5	-0.6661999E-01
2	15	6	-0.1166957	2	15	7	-5.172767	2	16	6	-0.1005096
2	16	7	-0.2108674	2	16	8	-2.710274	2	17	7	-0.1679229
2	17	8	-0.3757278	2	17	9	-1.068161	2	18	7	-0.1206385
2	18	8	-0.2355505	2	18	9	-1.401617	2	18	15	-2.616632
2	18	16	-6.185163	2	18	17	-0.3464202	2	19	7	-0.8984643E-01
2	19	8	-0.1508430	2	19	9	-0.2676231	2	19	10	-1.759278
2	19	11	-2.765608	2	19	14	-2.012836	2	19	15	-0.5636109
2	19	16	-0.4015274	2	19	17	-0.2976057	2	20	8	-0.1236269
2	20	9	-0.2016701	2	20	10	-0.2804552	2	20	11	-0.3833126
2	20	12	-2.377234	2	20	13	-2.677915	2	20	14	-0.4936212
2	20	15	-0.4018235								

Table 8.--Mass balance for pumping period 2 (January 1939-March 1940), with flow rates to constant-head nodes

```
-----------------------------------------------------------------
|                 TIME STEP NUMBER =       13                   |
-----------------------------------------------------------------

      SIZE OF TIME STEP IN SECONDS=   13200612.00

            TOTAL SIMULATION TIME IN SECONDS=    70934208.00
                                     MINUTES=    1182236.00
                                       HOURS=      19703.95
                                        DAYS=        821.00
                                       YEARS=          2.25


DURATION OF CURRENT PUMPING PERIOD IN DAYS=          456.00
                                     YEARS=            1.25
```

```
CUMULATIVE MASS BALANCE:               L**3              RATES FOR THIS TIME STEP:                          L**3/T
------------------------                                 -------------------------

       SOURCES:                                                              STORAGE =                 0.0
       --------                                                             RECHARGE =               399.5969
             STORAGE =              0.0                                CONSTANT FLUX =                 0.0
            RECHARGE =      23345094144.00                                   PUMPING =               -24.0049
       CONSTANT FLUX =              0.0                           EVAPOTRANSPIRATION =                 0.0
       CONSTANT HEAD =       1959302656.00                          CONSTANT HEAD:
             LEAKAGE =              0.0                                           IN =                28.5600
       TOTAL SOURCES =      30304395264.00                                       OUT =               -76.5202
                                                                            LEAKAGE:
       DISCHARGES:                                       FROM PREVIOUS PUMPING PERIOD =                 0.0
       -----------                                                     RIVER LEAKAGE =              -327.3125
  EVAPOTRANSPIRATION =              0.0
       CONSTANT HEAD =       5945442304.00                                  SUM OF RATES =                 0.3188
     QUANTITY PUMPED =        945753600.00
       RIVER LEAKAGE =      23387238400.00
     TOTAL DISCHARGE =      30278430720.00

   DISCHARGE-SOURCES =        -25964544.00
  PER CENT DIFFERENCE =             -0.09
```

Table 8.--Mass balance for pumping period 2 (January 1939-March 1940), with flow rates to constant-head nodes--Continued

FLOW RATES TO CONSTANT HEAD NODES:

K	I	J	RATE (L**3/T)	K	I	J	RATE (L**3/T)	K	I	J	RATE (L**3/T)
1	2	14	-0.6285701	1	2	15	-2.247855	1	2	16	-2.619681
1	2	27	0.9360428	1	3	27	2.322544	1	4	27	1.205248
1	5	27	-0.2289369	1	6	27	0.1804753E-01	1	7	27	2.780319
2	2	2	-0.3554338E-01	2	2	3	-0.9376314	2	2	4	-0.2497742E-01
2	2	5	-0.4931539	2	2	7	-1.546315	2	2	26	-1.702477
2	2	27	0.0	2	3	2	-0.2783367	2	3	4	-0.3766256
2	3	5	-0.7482364	2	3	8	-0.8670115	2	3	27	0.1797647
2	4	2	-0.2587037	2	4	8	-0.8339022	2	4	11	-0.1783601
2	4	27	0.6868523E-01	2	5	2	-0.3460354E-01	2	5	3	-1.203339
2	5	9	-0.1196110	2	5	10	-0.3892963E-01	2	5	11	-0.7352877
2	5	27	-0.1921799E-01	2	6	2	-0.3451202E-01	2	6	3	-0.3706331
2	6	9	-0.6431413E-01	2	6	10	-0.4255798E-01	2	6	11	-0.8759935
2	6	27	-0.5433151E-01	2	7	2	-0.3330293E-01	2	7	3	-0.1917561
2	7	9	-0.2358075	2	7	10	-0.4766617	2	7	11	-0.9555072
2	7	27	0.2778362E-01	2	8	2	-0.2898838E-01	2	8	3	-1.046295
2	8	27	18.32336	2	9	2	-0.2330622E-01	2	9	3	-0.9223428
2	9	27	-17.75414	2	10	2	-0.1787457E-01	2	10	3	-0.1726322E-01
2	10	4	-1.831538	2	10	6	-0.6185333	2	10	27	-0.7394085
2	11	2	-0.1270742E-01	2	11	3	-0.4498727	2	11	6	-1.367820
2	11	27	-0.8443576	2	12	2	-0.7735625E-02	2	12	3	-0.3664257
2	12	6	-0.5744373	2	12	25	-0.4750227	2	13	2	-0.5225262E-01
2	13	3	-0.4320771E-01	2	13	4	-0.5103694	2	13	5	-0.6821963
2	13	6	-0.7015641	2	13	8	-0.4652280E-01	2	13	25	-0.2811447
2	14	3	-0.1998394E-01	2	14	4	-0.1594608E-01	2	14	5	0.8053482E-03
2	14	6	0.8357257E-01	2	14	7	-0.9982020E-01	2	15	5	0.1575590E-01
2	15	6	0.5348389E-01	2	15	7	0.3915464	2	16	6	0.1893463E-01
2	16	7	0.2301145E-01	2	16	8	-0.3880510	2	17	7	-0.3386049E-01
2	17	8	-0.1302996	2	17	9	-0.5435876	2	18	7	-0.4643301E-01
2	18	8	-0.1177080	2	18	9	-1.202133	2	18	15	-2.572173
2	18	16	-6.163735	2	18	17	-0.3361530	2	19	7	-0.4499010E-01
2	19	8	-0.9409666E-01	2	19	9	-0.1945436	2	19	10	-1.611765
2	19	11	-2.589183	2	19	14	-1.887369	2	19	15	-0.5306554
2	19	16	-0.3844688	2	19	17	-0.2870040	2	20	8	-0.8696753E-01
2	20	9	-0.1538383	2	20	10	-0.2315860	2	20	11	-0.3299460
2	20	12	-2.188534	2	20	13	-2.412537	2	20	14	-0.4339812
2	20	15	-0.3704883								

Table 9.--Mass balance for pumping period 3 (January-December 1958), with flow rates to constant-head nodes

```
 --------------------------------------------------------------
|                 TIME STEP NUMBER =        12                 |
 --------------------------------------------------------------

          SIZE OF TIME STEP IN SECONDS=   10593634.00

               TOTAL SIMULATION TIME IN SECONDS=  102470064.00
                                        MINUTES=    1707834.00
                                          HOURS=      28463.91
                                           DAYS=       1186.00
                                          YEARS=          3.25


 DURATION OF CURRENT PUMPING PERIOD IN DAYS=           365.00
                                          YEARS=          1.00


CUMULATIVE MASS BALANCE:            L**3               RATES FOR THIS TIME STEP:              L**3/T
------------------------                               -------------------------

      SOURCES:                                                        STORAGE =             0.0
      --------                                                       RECHARGE =           399.5969
             STORAGE =                 0.0                      CONSTANT FLUX =             0.0
            RECHARGE =      40946737152.00                            PUMPING =          -102.3987
       CONSTANT FLUX =                 0.0                 EVAPOTRANSPIRATION =             0.0
       CONSTANT HEAD =       2844887040.00                     CONSTANT HEAD:
             LEAKAGE =                 0.0                                 IN =            28.0818
       TOTAL SOURCES =      43791622144.00                                OUT =           -77.0772
                                                                     LEAKAGE:
      DISCHARGES:                                FROM PREVIOUS PUMPING PERIOD =             0.0
      -----------                                               RIVER LEAKAGE =          -247.8788
  EVAPOTRANSPIRATION =                 0.0
       CONSTANT HEAD =       8376119296.00                       SUM OF RATES =             0.3238
     QUANTITY PUMPED =       4174993920.00
       RIVER LEAKAGE =      31204315136.00
     TOTAL DISCHARGE =      43755425792.00

   DISCHARGE-SOURCES =         -36196352.00
  PER CENT DIFFERENCE =               -0.08
```

Table 9.--Mass balance for pumping period 3 (January-December 1958), with flow rates to constant-head nodes--Continued

FLOW RATES TO CONSTANT HEAD NODES:

K	I	J	RATE (L**3/T)	K	I	J	RATE (L**3/T)	K	I	J	RATE (L**3/T)
1	2	14	-0.6180032	1	2	15	-2.127840	1	2	16	-2.382780
1	2	27	0.9529506	1	3	27	2.337819	1	4	27	1.222856
1	5	27	-0.2048007	1	6	27	0.5354390E-01	1	7	27	2.878205
2	2	2	-0.3412468E-01	2	2	3	-0.9351748	2	2	4	-0.2364333E-01
2	2	5	-0.4886335	2	2	7	-1.537642	2	2	26	-1.693514
2	2	27	0.0	2	3	2	-0.2766654	2	3	4	-0.3750427
2	3	5	-0.7445371	2	3	8	-0.8614907	2	3	27	0.1798008
2	4	2	-0.2572504	2	4	8	-0.8286950	2	4	11	-0.1713153
2	4	27	0.6869793E-01	2	5	2	-0.3336558E-01	2	5	3	-1.185124
2	5	9	-0.1160410	2	5	10	-0.3630605E-01	2	5	11	-0.7095773
2	5	27	-0.1916831E-01	2	6	2	-0.3327297E-01	2	6	3	-0.3646039
2	6	9	-0.6164511E-01	2	6	10	-0.3935597E-01	2	6	11	-0.8425777
2	6	27	-0.5432604E-01	2	7	2	-0.3203845E-01	2	7	3	-0.1887351
2	7	9	-0.2317168	2	7	10	-0.4467037	2	7	11	-0.8840750
2	7	27	0.2781709E-01	2	8	2	-0.2768869E-01	2	8	3	-1.042980
2	8	27	18.34807	2	9	2	-0.2194509E-01	2	9	3	-0.9198107
2	9	27	-17.70847	2	10	2	-0.1650707E-01	2	10	3	-0.1534369E-01
2	10	4	-1.823801	2	10	6	-0.5230367	2	10	27	-0.7344730
2	11	2	-0.1147370E-01	2	11	3	-0.4454708	2	11	6	-1.233955
2	11	27	-0.8382194	2	12	2	-0.6841768E-02	2	12	3	-0.3627762
2	12	6	-0.4423663	2	12	25	-0.4071658	2	13	2	-0.4565629E-01
2	13	3	-0.3219770E-01	2	13	4	-0.5061311	2	13	5	-0.6778117
2	13	6	-0.6053321	2	13	8	0.8914254	2	13	25	-0.2121775
2	14	3	-0.1481942E-01	2	14	4	-0.1165271E-01	2	14	5	-0.7253606E-02
2	14	6	0.8632764E-02	2	14	7	-1.045144	2	15	5	-0.5224004E-02
2	15	6	-0.8452814E-02	2	15	7	-2.031263	2	16	6	-0.1752451E-01
2	16	7	-0.4310089E-01	2	16	8	-1.014140	2	17	7	-0.5394655E-01
2	17	8	-0.1380969	2	17	9	-0.4476788	2	18	7	-0.5020462E-01
2	18	8	-0.1105619	2	18	9	-1.119269	2	18	15	-2.454134
2	18	16	-6.096914	2	18	17	-0.3165047	2	19	7	-0.4388825E-01
2	19	8	-0.8527285E-01	2	19	9	-0.1707971	2	19	10	-1.515227
2	19	11	-2.482197	2	19	14	-1.888851	2	19	15	-0.5112356
2	19	16	-0.3656895	2	19	17	-0.2715037	2	20	8	-0.7809889E-01
2	20	9	-0.1373822	2	20	10	-0.2104247	2	20	11	-0.3115283
2	20	12	-2.146109	2	20	13	-2.456504	2	20	14	-0.4411887
2	20	15	-0.3628252								

Table 10.--Mass balance for pumping period 4 (January-December 1972), with flow rates to constant-head nodes

```
                    --------------------------------------------------------
                    |              TIME STEP NUMBER =       12              |
                    --------------------------------------------------------

                         SIZE OF TIME STEP IN SECONDS=   10593634.00

                              TOTAL SIMULATION TIME IN SECONDS=  134005920.00
                                                       MINUTES=    2233431.00
                                                         HOURS=      37223.86
                                                          DAYS=       1550.99
                                                         YEARS=          4.25


                    DURATION OF CURRENT PUMPING PERIOD IN DAYS=        365.00
                                                         YEARS=          1.00


CUMULATIVE MASS BALANCE:               L**3                RATES FOR THIS TIME STEP:                L**3/T
------------------------                                   -------------------------

         SOURCES:                                                          STORAGE =            0.0
         --------                                                         RECHARGE =          399.5969
                STORAGE =                0.0                          CONSTANT FLUX =            0.0
               RECHARGE =      535483801 60.00                              PUMPING =         -116.8436
          CONSTANT FLUX =                0.0                      EVAPOTRANSPIRATION =            0.0
          CONSTANT HEAD =       3749702144.00                         CONSTANT HEAD:
                LEAKAGE =                0.0                                     IN =           28.6916
          TOTAL SOURCES =      57298079744.00                                   OUT =          -72.3633
                                                                            LEAKAGE:
         DISCHARGES:                                    FROM PREVIOUS PUMPING PERIOD =            0.0
         -----------                                                  RIVER LEAKAGE =         -238.8204
     EVAPOTRANSPIRATION =                0.0
          CONSTANT HEAD =      10658140160.00                          SUM OF RATES =            0.2611
        QUANTITY PUMPED =       7859748864.00
          RIVER LEAKAGE =      38735712256.00
        TOTAL DISCHARGE =      57253601280.00

      DISCHARGE-SOURCES =         -44478464.00
     PER CENT DIFFERENCE =               -0.08
```

Table 10.--Mass balance for pumping period 4 (January-December 1972), with flow rates to constant-head nodes--Continued

FLOW RATES TO CONSTANT HEAD NODES:

K	I	J	RATE (L**3/T)	K	I	J	RATE (L**3/T)	K	I	J	RATE (L**3/T)
1	2	14	-0.6218303	1	2	15	-2.172899	1	2	16	-2.472457
1	2	27	0.9468842	1	3	27	2.332342	1	4	27	1.216550
1	5	27	-0.2134299	1	6	27	0.4087718E-01	1	7	27	2.843625
2	2	2	-0.3384518E-01	2	2	3	-0.9350005	2	2	4	-0.2377119E-01
2	2	5	-0.4897374	2	2	7	-1.540900	2	2	26	-1.696729
2	2	27	0.0	2	3	2	-0.2763016	2	3	4	-0.3750505
2	3	5	-0.7452425	2	3	8	-0.8632277	2	3	27	0.1797878
2	4	2	-0.2567952	2	4	8	-0.8282269	2	4	11	-0.1689582
2	4	27	0.6869340E-01	2	5	2	-0.3280558E-01	2	5	3	-1.177654
2	5	9	-0.1137239	2	5	10	-0.3446205E-01	2	5	11	-0.7023831
2	5	27	-0.1918608E-01	2	6	2	-0.3253936E-01	2	6	3	-0.3604801
2	6	9	-0.5914081E-01	2	6	10	-0.3685652E-01	2	6	11	-0.8306614
2	6	27	-0.5432801E-01	2	7	2	-0.3113506E-01	2	7	3	-0.1859877
2	7	9	-0.2259806	2	7	10	-0.4337298	2	7	11	-0.8599871
2	7	27	0.2780518E-01	2	8	2	-0.2659074E-01	2	8	3	-1.039533
2	8	27	18.33939	2	9	2	-0.2063478E-01	2	9	3	-0.9169247
2	9	27	-17.72443	2	10	2	-0.1510436E-01	2	10	3	-0.1317975E-01
2	10	4	-1.814915	2	10	6	-0.3271096	2	10	27	-0.7361915
2	11	2	-0.1017445E-01	2	11	3	-0.4407640	2	11	6	-0.8961135
2	11	27	-0.8403531	2	12	2	-0.5885381E-02	2	12	3	-0.3589208
2	12	6	-0.3306782	2	12	25	-0.4294424	2	13	2	-0.3841290E-01
2	13	3	-0.1841126E-01	2	13	4	-0.5014020	2	13	5	-0.6727796
2	13	6	-0.5021709	2	13	8	1.535827	2	13	25	-0.2344906
2	14	3	-0.5362790E-02	2	14	4	0.3265299E-02	2	14	5	0.1636510E-01
2	14	6	0.4177645E-01	2	14	7	-0.9331954	2	15	5	0.9618357E-02
2	15	6	0.1156534E-01	2	15	7	-1.404108	2	16	6	-0.3198000E-02
2	16	7	-0.1593884E-01	2	16	8	-0.7790567	2	17	7	-0.3418356E-01
2	17	8	-0.9783107E-01	2	17	9	-0.3789206	2	18	7	-0.3510365E-01
2	18	8	-0.8091992E-01	2	18	9	-0.9775158	2	18	15	-2.173015
2	18	16	-5.942685	2	18	17	-0.2624688	2	19	7	-0.3150300E-01
2	19	8	-0.6244851E-01	2	19	9	-0.1256670	2	19	10	-1.319514
2	19	11	-2.103735	2	19	14	-1.675495	2	19	15	-0.4182727
2	19	16	-0.3014750	2	19	17	-0.2245355	2	20	8	-0.5713570E-01
2	20	9	-0.1004420	2	20	10	-0.1527642	2	20	11	-0.2285151
2	20	12	-1.801922	2	20	13	-2.094491	2	20	14	-0.3509455
2	20	15	-0.2943223								

Table 11.--Mass balance for pumping period 5 (January-December 1977), with flow rates to constant-head nodes

```
 ---------------------------------------------------------
|              TIME STEP NUMBER =        12               |
 ---------------------------------------------------------

     SIZE OF TIME STEP IN SECONDS=   10593634.00

          TOTAL SIMULATION TIME IN SECONDS=  165541776.00
                                   MINUTES=    2759029.00
                                     HOURS=      45983.82
                                      DAYS=       1915.99
                                     YEARS=          5.25

 DURATION OF CURRENT PUMPING PERIOD IN DAYS=       365.00
                                     YEARS=          1.00
```

CUMULATIVE MASS BALANCE:	L**3
SOURCES:	
STORAGE =	0.0
RECHARGE =	66150023168.00
CONSTANT FLUX =	0.0
CONSTANT HEAD =	4621373440.00
LEAKAGE =	0.0
TOTAL SOURCES =	70771343360.00
DISCHARGES:	
EVAPOTRANSPIRATION =	0.0
CONSTANT HEAD =	12875481088.00
QUANTITY PUMPED =	11832975360.00
RIVER LEAKAGE =	46010372096.00
TOTAL DISCHARGE =	70718783488.00
DISCHARGE-SOURCES =	-52559872.00
PER CENT DIFFERENCE =	-0.07

RATES FOR THIS TIME STEP:	L**3/T
STORAGE =	0.0
RECHARGE =	399.5969
CONSTANT FLUX =	0.0
PUMPING =	-125.9911
EVAPOTRANSPIRATION =	0.0
CONSTANT HEAD:	
IN =	27.6407
OUT =	-70.3121
LEAKAGE:	
FROM PREVIOUS PUMPING PERIOD =	0.0
RIVER LEAKAGE =	-230.6786
SUM OF RATES =	0.2556

Table 11.--Mass balance for pumping period 5 (January-December 1977), with flow rates to constant-head nodes--Continued

FLOW RATES TO CONSTANT HEAD NODES:

K	I	J	RATE (L**3/T)	K	I	J	RATE (L**3/T)	K	I	J	RATE (L**3/T)
1	2	14	-0.6194716	1	2	15	-2.147075	1	2	16	-2.428583
1	2	27	0.9499882	1	3	27	2.335608	1	4	27	1.221417
1	5	27	-0.2046976	1	6	27	0.4845817E-01	1	7	27	2.857878
2	2	2	-0.2530854E-01	2	2	3	-0.9192274	2	2	4	-0.1441772E-01
2	2	5	-0.4555871	2	2	7	-1.470950	2	2	26	-1.695042
2	2	27	0.0	2	3	2	-0.2663670	2	3	4	-0.3644861
2	3	5	-0.7180879	2	3	8	-0.8205265	2	3	27	0.1797956
2	4	2	-0.2486075	2	4	8	-0.7977832	2	4	11	-0.1681295
2	4	27	0.6869692E-01	2	5	2	-0.2636757E-01	2	5	3	-1.082911
2	5	9	-0.1048397	2	5	10	-0.3262978E-01	2	5	11	-0.7006308
2	5	27	-0.1916812E-01	2	6	2	-0.2661610E-01	2	6	3	-0.3354976
2	6	9	-0.5600070E-01	2	6	10	-0.3597777E-01	2	6	11	-0.8336200
2	6	27	-0.5432678E-01	2	7	2	-0.2550685E-01	2	7	3	-0.1756147
2	7	9	-0.2236344	2	7	10	-0.4483680	2	7	11	-0.8971825
2	7	27	0.2781063E-01	2	8	2	-0.2113656E-01	2	8	3	-1.029418
2	8	27	18.34268	2	9	2	-0.1507040E-01	2	9	3	-0.9094177
2	9	27	-17.71869	2	10	2	-0.9322800E-02	2	10	3	-0.5799755E-02
2	10	4	-1.798615	2	10	6	-0.3154951	2	10	27	-0.7355919
2	11	2	-0.4570801E-02	2	11	3	-0.4242138	2	11	6	-0.8815517
2	11	27	-0.8396162	2	12	2	-0.1902157E-02	2	12	3	-0.3467824
2	12	6	-0.2678167	2	12	25	-0.4226190	2	13	2	-0.9446315E-02
2	13	3	0.2605983E-01	2	13	4	-0.4896815	2	13	5	-0.6608217
2	13	6	-0.4838845	2	13	8	0.1637196	2	13	25	-0.2274594
2	14	3	0.2001496E-01	2	14	4	0.3502676E-01	2	14	5	0.5566532E-01
2	14	6	0.6599671E-01	2	14	7	-0.8128561	2	15	5	0.2882824E-01
2	15	6	0.2587660E-01	2	15	7	-0.9825524	2	16	6	0.3449525E-02
2	16	7	-0.9901527E-02	2	16	8	-0.5301549	2	17	7	-0.2528860E-01
2	17	8	-0.7456696E-01	2	17	9	-0.1999629	2	18	7	-0.2733760E-01
2	18	8	-0.6354219E-01	2	18	9	-0.9257270	2	18	15	-2.191554
2	18	16	-5.960639	2	18	17	-0.2683443	2	19	7	-0.2547118E-01
2	19	8	-0.5187935E-01	2	19	9	-0.1069589	2	19	10	-1.283484
2	19	11	-2.025236	2	19	14	-1.661680	2	19	15	-0.4207736
2	19	16	-0.3062133	2	19	17	-0.2288674	2	20	8	-0.4910481E-01
2	20	9	-0.8810866E-01	2	20	10	-0.1390364	2	20	11	-0.2101469
2	20	12	-1.710839	2	20	13	-2.046131	2	20	14	-0.3460529
2	20	15	-0.2944920								

The change in the direction of flow in the constant-head nodes underlying the bay suggests induced infiltration of saltwater during pumping period 2, (January 1939-March 1940, table 8). Although model parameters for the submerged areas are based on projection from the land and conjecture, the simulation is confirmed, in approximate fashion, by the appearance of saltwater in wells in the Bayou Chico area before 1940 (Jacob and Cooper, 1940; Musgrove and others, 1965).

The mass balances (tables 7 through 11) show a decrease in the discharge rate to constant-head nodes of 22.6 ft^3/s (24 percent) and a decrease of 102 ft^3/s (31 percent) in river leakage as pumpage increased from 0 to 125.6 ft^3/s. Therefore, according to the simulation, these are the principal sources of the water pumped.

Flow Between Layers for Each Node

Tables 12 through 16 show the flow between the layers of the model. Positive values indicate upward flow (from layer 1 to layer 2), whereas negative values represent downward flow. The model omits values for all nodes in which transmissivity and conductivity are zero. Thus, nodes in only the active model area have vertical flow rates computed (rates are in ft^3/s).

The highest rates of flow between layers with no pumping (table 12) are approximately 18 ft^3/s for nodes 8,27 (downward) and 9,27 (upward). These are adjoining nodes representing rectangles of the largest size in the model (5,246 ft by 30,606 ft) and with constant-head values in layer 2 of 160 feet and 20 feet, respectively. The steep gradient in layer 2, established by the constant heads, simulates the gradient in the water table associated with the boundary between the uplands to the west and the Escambia River flood plain to the east. The head in layer 1 is not held constant at these nodes. The actual transfer of water from uplands to the flood plain in the area represented by these rectangles is partly through streams draining the upland, but in the model it is treated as if it were all ground-water flow. The downward rate in 8,27 approximately equals the upward rate in 9,27. The unit rate is about 3 $(ft^3/s)/mi^2$. Most of this flow represents increment to the Escambia River in node 9,27. It does not appear as RIVER LEAKAGE in the mass balance because constant-head nodes were not identified as RIVER nodes in the model.

Under conditions of no pumping, the highest rates of interlayer flow per unit area are in nodes 14 and 15,17 and 8,14 and 15, which have flow rates, respectively, of 4.3 and 5.6 ft^3/s, or 3.8 and 4.9 $(ft^3/s)/mi^2$ (51.4 to 66.7 in./yr). Nodes 14 and 15,17 represent areas containing short, steep-gradient streams. Nodes 8,14 and 15 represent part of the deeply incised Elevenmile Creek. Except for extreme values related to discharge to streams, computed rates of interlayer flow generally range from 0.03 to 2 ft^3/s (about 0.4 to 24 in./yr).

The net flow between layers changed from 4.96 ft^3/s upward to layer 2 for no pumping (table 12) to 19.0 ft^3/s downward to layer 1 during pumping period 2 (table 13) and to 120.5 ft^3/s to layer 1 during pumping period 5 (table 16).

Table 12.--Flow to top layer by node in cubic feet per second, pumping period 1 (no pumping)
[See end of table for key to column-numbering system]

FLOW TO TOP LAYER BY NODE

Row:										
2	0.0357645	0.0304862	0.0251104	0.0285656	0.0310275	0.0316104	0.0	0.0	0.0	0.0
	0.0	0.0	-0.0001797	-0.0038965	-0.0040991	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	2.4262695	0.3423986	0.3491943	0.0				
3	0.0356829	0.0308271	0.0265831	0.0306684	0.0331689	0.0335076	0.0339848	0.0	0.0	0.0
	0.3745151	0.5134361	0.4221542	-0.9643918	-0.0781386	1.2168303	0.0	0.0	0.0	0.0
	0.0	0.0	0.1799403	1.3059053	-0.3549452	0.0				
4	0.0354100	0.0058604	0.0184535	0.0271116	-0.0016880	-0.0330740	0.0359253	0.0	0.0	0.0254553
	0.1972234	1.5513792	-0.1877514	-0.6887654	-1.1104784	-0.3675267	1.7871075	0.0987824	0.1044543	0.0
	0.0	1.9244738	0.2175895	-0.0679438	-2.1446266	0.0				
5	0.0348691	0.3938201	-0.2252437	-0.1085326	-0.0007897	0.0000934	0.0386776	0.0390910	0.0394441	0.0372718
	0.4287734	-0.5794907	-0.1319392	-0.1751487	-0.1633678	-0.0213649	0.0935015	1.3369799	0.1121396	0.1354474
	0.1445793	2.3314943	-0.0179397	-1.4182510	-3.2413492	0.0				
6	0.0343242	0.0335220	-0.0919498	-0.5168726	-0.0017773	0.0001740	0.0030161	0.0409877	0.0432165	0.0459207
	0.4990339	-0.8191120	-0.0637743	-1.1747265	-2.0717802	-1.2554035	0.2210206	0.7004868	0.1460702	0.0165015
	0.0865355	0.0306741	-0.1810617	-0.2144573	-0.6727042	3.4591160				
7	0.0336728	0.0317884	-0.3727627	0.4412466	-0.7404379	-0.5354457	0.0019964	0.0427366	0.0486809	0.0489080
	0.8916322	0.6190571	-0.1977060	-1.7250872	-0.9473693	-1.7203836	-1.8099928	-0.0965618	-0.1989979	0.0152473
	0.0315806	0.0254866	-0.1500146	-0.6166818	2.2371960	0.0				
8	0.0294486	0.0297886	-0.0092424	0.4315515	-0.4526845	-0.2777117	1.0265579	0.0031220	0.0028960	-0.1403149
	1.0852261	0.7399877	5.1028795	4.3108406	2.9788284	-0.8769590	-1.3316059	-1.3672056	-2.0503321	-0.0470938
	-0.0035997	0.1513671	-1.7275991	-0.5393050	0.6483151	-18.1786041				
9	0.0238919	0.0235593	-0.0084984	0.3435127	0.5279178	-0.0955907	-0.5799177	0.8126000	0.7883729	-0.7011977
	-0.9022912	1.0458355	-0.7390519	-0.8802874	0.8201793	2.4704475	0.3999042	-1.7315826	-1.6611910	-0.1239570
	-1.4515152	-1.8043890	-2.8843696	0.6367376	0.7071882	17.7723389				
10	0.0185594	0.0182491	0.0167382	0.0102289	0.3902281	0.3235813	-1.7401876	3.3010731	0.0445559	-0.0423156
	-0.0575115	-0.0764309	-0.5168336	-1.1382322	-1.0492067	-1.1596069	-1.3017302	-1.7126417	-0.2002505	-0.1496655
	0.1098776	-0.2951400	0.0851684	0.4475619	0.7127674	0.8087919				
11	0.0134148	0.0134896	0.0132169	-0.0102242	0.3110983	-0.4496008	-1.9321041	-1.9349337	3.2036610	-0.0038869
	-0.0320073	-0.0633188	-1.2995453	-1.0853577	-1.9439440	-2.1577444	-0.1931944	0.0065262	-0.0055216	0.0478162
	0.0702606	0.0208690	0.2321662	0.4017007	0.7319447	0.8995102				
12	0.0083259	0.0086824	0.0095417	-0.0053254	0.1937000	0.2439606	2.7916479	-2.0224047	-0.1722276	2.5761185
	0.0051069	-0.9287617	-1.6053982	-1.7766438	-2.0328646	-1.3094826	-0.0695729	0.0221942	0.0506583	1.4348240
	1.8176212	1.6543579	0.2063938	0.3666521	0.0	0.0				

Table 12.--Flow to top layer by node in cubic feet per second, pumping period 1 (no pumping)--Continued

13	0.0573962	0.0589765	0.0057534	0.0085181	0.1833121	0.3133602	3.4272413	-1.3573132	-0.4428189	-1.9606981
	-2.5837173	-0.1356816	-1.8627844	-1.9245949	-1.7705545	0.1778378	0.0648364	-0.0471638	0.1261439	1.7774115
	1.5014868	1.2972393	0.1800148	0.3149706	0.0	0.0				
14	0.0	0.0366281	0.0516073	0.0858024	0.1530993	0.0188868	0.2542581	-1.5405645	-1.9273787	-2.2869301
	-1.0105619	-0.0380580	-0.1129681	-0.1122569	-3.3372355	4.3742704	0.0851481	0.1216034	0.1252064	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				
15	0.0	0.0	0.0	0.0666200	0.1166957	0.2333719	3.2149277	-0.7984863	-1.9885540	-1.0961456
	0.9565367	-0.2032765	-1.7404518	-1.2833004	3.4309589	5.5976248	0.0865349	0.1050673	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				
16	0.0	0.0	0.0	0.0	0.1005096	0.2108675	0.4858860	-1.5308447	-0.9159420	1.5852289
	1.5992889	-0.7736462	-1.6307764	-1.4264812	-0.0467120	2.5455542	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				
17	0.0	0.0	0.0	0.0	0.0870575	0.1679229	0.3757279	0.6368012	0.9035364	1.1849174
	-1.3079014	-1.2790823	-1.5480967	-0.3257607	1.0090599	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				
18	0.0	0.0	0.0	0.0	0.0	0.1206385	0.2355505	0.4202845	0.6061143	-0.1170905
	-0.4521498	-0.8114843	-0.1730055	0.9502135	0.6076983	0.3464202	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				
19	0.0	0.0	0.0	0.0	0.0	0.0898464	0.1508430	0.2676231	0.3820640	0.5504268
	0.7252091	0.8177230	0.7466837	0.5636110	0.4015275	0.2976058	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				
20	0.0	0.0	0.0	0.0	0.0	0.0	0.1236269	0.2016701	0.2804552	0.3833128
	0.4815618	0.5292006	0.4936212	0.4018236	0.3229890	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				

Key:
Column numbers

Sample row									
2	3	4	5	6	7	8	9	10	11
12	13	14	15	16	17	18	19	10	21
22	23	24	25	26	27				

Table 13.--Flow to top layer by node in cubic feet per second, pumping period 2 (January 1939-March 1940)

[See end of table for key to column-numbering system]

FLOW TO TOP LAYER BY NODE

Row:										
2	0.0355434	0.0303212	0.0249774	0.0284078	0.0308440	0.0314122	0.0	0.0	0.0	0.0
	0.0	0.0	-0.0001797	-0.0038962	-0.0040990	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	2.4245462	0.3422149	0.3488810	0.0				
3	0.0354560	0.0306631	0.0264484	0.0305034	0.0329725	0.0332885	0.0337339	0.0	0.0	0.0
	0.3729661	0.5130085	0.4214302	-0.9647428	-0.0786773	1.2161369	0.0	0.0	0.0	0.0
	0.0	0.0	0.1798103	1.3024264	-0.3608298	0.0				
4	0.0351697	0.0057032	0.0183176	0.0269397	-0.0018934	-0.0333155	0.0356384	0.0	0.0	0.0251976
	0.1957359	1.5487356	-0.1832772	-0.6891474	-1.1112137	-0.3680764	1.7853493	0.0987406	0.1044068	0.0
	0.0	1.9228411	0.2174227	-0.0729086	-2.1540461	0.0				
5	0.0346035	0.3912112	-0.2262768	-0.1115949	-0.0008090	0.0000694	0.0383130	0.0386194	0.0389296	0.0368732
	0.4254615	-0.5799345	-0.1319866	-0.1752123	-0.1634987	-0.0219389	0.0929590	1.3363380	0.1120868	0.1353654
	0.1444721	2.3294668	-0.0217522	-1.4267159	-3.2578163	0.0				
6	0.0345120	0.0332990	-0.0929268	-0.5183420	-0.0018003	0.0001463	0.0029819	0.0404454	0.0425580	0.0452700
	0.4920987	-0.3197499	-0.0638548	-1.1757030	-2.0722084	-1.2561741	0.2203636	0.6998937	0.1451647	0.0164098
	0.0864166	0.0305239	-0.1813867	-0.2153354	-0.6745860	3.4591160				
7	0.0333029	0.0314849	-0.3740285	0.4368551	-0.7416292	-0.5421194	0.0019625	0.0420991	0.0477537	0.0476884
	0.8828470	0.6156476	-0.1989731	-1.7283974	-0.9479415	-1.7209234	-1.8101692	-0.0972262	-0.1990354	0.0151553
	0.0314570	0.0253135	-0.1504215	-0.6180246	2.1851072	0.0				
8	0.0289884	0.0293356	-0.0095871	0.4252112	-0.4545214	-0.2789384	0.9760119	0.0030652	0.0028156	-0.1678991
	1.0712538	0.7355643	5.0937004	4.3067055	2.9762001	-0.8773557	-1.3321476	-1.3673315	-2.0505733	-0.0471810
	-0.0056260	0.1482177	-1.7357903	-0.5412148	0.6427510	-18.1853485				
9	0.0233062	0.0228618	-0.0091275	0.3323552	0.5152835	-0.1004325	-0.5836915	0.7255546	0.7720550	-0.7099071
	-0.9150872	1.0160570	-0.7518076	-0.8815362	0.8150599	2.4667864	0.3992788	-1.7323923	-1.6615562	-0.1240425
	-1.4536343	-1.8051023	-2.8954863	0.5876993	0.6968251	17.7587230				
10	0.0178746	0.0172632	0.0156400	0.0089547	0.3709902	0.2015393	-1.7509079	3.0685329	0.0433727	-0.0435208
	-0.0585888	-0.0770143	-0.5215147	-1.1407213	-1.0509138	-1.1606560	-1.3026381	-1.7129211	-0.2013048	-0.1510638
	0.1077922	-0.2987961	0.0841011	0.4412256	0.7039896	0.8074034				
11	0.0127074	0.0122453	0.0115171	-0.0125828	0.2731166	-0.7934173	-2.1026659	-1.9455833	3.0036459	-0.0051930
	-0.0334550	-0.0642612	-1.3035879	-1.0899601	-1.9444418	-2.1593657	-0.1932586	0.0064597	-0.0055923	0.0477276
	0.0701259	0.0205712	0.2309847	0.3970155	0.7239811	0.8978388				
12	0.0077356	0.0073789	0.0072544	-0.0089606	0.1082869	0.0819383	1.8017206	-2.0471134	-0.5002040	2.3334932
	0.0030161	-0.9508131	-1.6102219	-1.7789173	-2.0332670	-1.3113508	-0.0696564	0.0221204	0.0505839	1.4333735
	1.8155794	1.6500530	0.2052682	0.3629500	0.0	0.0				

Table 13.--Flow to top layer by node in cubic feet per second, pumping period 2 (January 1939-March 1940)--Continued

13	0.0522526	0.0432077	0.0032031	0.0035088	0.0213323	-0.0421179	0.1988568	-1.9361744	-0.8958806	-1.9778194
	-2.6022921	-0.1374078	-1.8725195	-1.9290600	-1.7748737	0.1759703	0.0647539	-0.0472384	0.1260697	1.7760162
	1.4995880	1.2932796	0.1789437	0.3117168	0.0	0.0				
14	0.0	0.0199839	0.0159461	-0.0008053	-0.0835726	-0.0195119	-4.6789408	-1.7179604	-1.9388494	-2.2859507
	-1.0218048	-0.0412002	-0.1146663	-0.1131141	-3.3662434	4.8668575	0.0850795	0.1215335	0.1251347	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				
15	0.0	0.0	0.0	-0.0157559	-0.0534839	-0.1317168	-0.6325815	-1.2700701	-2.0111637	-1.1049147
	0.8642743	-0.2622012	-1.7510061	-1.3018379	3.4392862	5.5884275	0.0864730	0.1050022	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				
16	0.0	0.0	0.0	0.0	-0.0189346	-0.0230115	0.0420896	-2.3557262	-0.9600182	1.4287930
	1.5064144	-0.7824456	-1.6367378	-1.4317150	-0.0510924	2.5314131	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				
17	0.0	0.0	0.0	0.0	0.0025160	0.0338605	0.1302996	0.3284588	0.7103669	1.0666656
	-1.3303699	-1.2940140	-1.5612869	-0.3401605	0.9944199	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				
18	0.0	0.0	0.0	0.0	0.0	0.0464330	0.1177080	0.2780783	0.4958815	-0.1755093
	-0.4994778	-0.8656424	-0.2300029	0.9208592	0.5920520	0.3361530	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				
19	0.0	0.0	0.0	0.0	0.0	0.0449901	0.0940967	0.1945436	0.3149354	0.4841868
	0.6339194	0.6168032	0.6722062	0.5306555	0.3844689	0.2870041	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0869675	0.1538383	0.2315860	0.3299460
	0.4105324	0.4271431	0.4339813	0.3704883	0.3043407	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				

Key:
Column numbers

Sample row									
2	3	4	5	6	7	8	9	10	11
12	13	14	15	16	17	18	19	10	21
22	23	24	25	26	27				

Table 14.--Flow to top layer by node in cubic feet per second, pumping period 3 (January-December 1958)

[See end of table for key to column-numbering system]

FLOW TO TOP LAYER BY NODE

Row										
2	0.0341247	0.0289661	0.0236433	0.0265526	0.0282961	0.0280104	0.0	0.0	0.0	0.0
	0.0	0.0	-0.0001791	-0.0038497	-0.0040921	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	2.1304026	0.3261242	0.3412979	0.0				
3	0.0340796	0.0293937	0.0251841	0.0286896	0.0304251	0.0290828	0.0304201	0.0	0.0	0.0
	0.3616034	0.5006181	0.3500096	-1.0144949	-0.1768839	1.0163326	0.0	0.0	0.0	0.0
	0.0	0.0	0.1549682	1.0127707	-0.4792954	0.0				
4	0.0338645	0.0046329	0.0172255	0.0254047	-0.0039465	-0.0360253	0.0328390	0.0	0.0	0.0237740
	0.1863021	1.4925776	-0.2293437	-0.7281579	-1.2082386	-0.5642114	1.2788877	0.0522576	0.0371868	0.0
	0.0	1.2654953	0.1797628	-0.4488434	-2.2946596	0.0				
5	0.0333656	0.3770080	-0.2331831	-0.1325041	-0.0009500	-0.0001056	0.0358971	0.0360883	0.0363060	0.0347603
	0.4052749	-0.5974374	-0.1352067	-0.1812373	-0.1742330	-0.0449883	-0.3016437	0.4650598	0.0276603	0.0198441
	0.0480568	1.3355227	-0.9212119	-1.9629927	-3.4400625	0.0				
6	0.0332730	0.0323446	-0.0976627	-0.5263228	-0.0019287	-0.0000077	0.0028034	0.0377771	0.0393560	0.0420314
	0.4528467	-0.8301992	-0.0675317	-1.2950811	-2.1562634	-1.6986465	-0.6522365	-0.6766735	-1.8426447	-0.1331490
	-0.0343708	-0.0498208	-0.2550747	-0.2616815	-0.6904328	3.4591160				
7	0.0320385	0.0304108	-0.3788829	0.4176283	-0.7472366	-0.5720724	0.0018100	0.0392404	0.0434472	0.0419540
	0.8358097	0.5839153	-0.2352725	-2.2103519	-1.2125168	-2.0978041	-2.0859356	-1.5726643	-0.3337747	-0.1878226
	-0.1122652	-0.0696042	-0.2342921	-0.6729795	1.8724890	0.0				
8	0.0276887	0.0280632	-0.0106487	0.4027570	-0.4613554	-0.2837681	0.7978819	0.0028355	0.0024498	-0.2932380
	1.0021238	0.7029747	4.8537951	3.7323580	1.0641441	-1.4959803	-1.8758802	-1.4945812	-2.6873064	-0.3452275
	-1.5785093	-1.5915012	-3.1574793	-0.5964521	0.6195119	-18.2100525				
9	0.0219451	0.0212664	-0.0107165	0.2995832	0.4699072	-0.1101288	-0.5964841	0.4327879	0.6949323	-0.7497984
	-0.9773281	0.7692000	-1.1854172	-1.0158596	-1.4172297	-1.2512989	-1.4695082	-2.1946497	-2.2491150	-0.3864309
	-1.8294916	-2.0379238	-3.2373428	-0.2271802	0.6701614	17.7130585				
10	0.0165071	0.0153437	0.0132541	0.0057317	0.3089513	0.0459603	-1.7803574	2.3675957	0.0368466	-0.0488966
	-0.0636111	-0.0823290	-0.6651599	-1.3579578	-1.5515747	-1.6038361	-2.0996237	-2.1404324	-1.4887581	-1.2193737
	-0.8543583	-1.4759722	-0.0023664	0.3829646	0.6736572	0.8024680				
11	0.0114737	0.0102161	0.0084353	-0.0179322	0.1848133	-1.5491428	-2.5103989	-1.9816132	2.4127750	-0.0097143
	-0.0392886	-0.0720466	-1.4105339	-1.4045582	-2.0339766	-2.3848314	-0.2719975	-0.1576559	-0.1815732	-0.1018546
	-0.0426915	-0.0578061	0.1524298	0.3331743	0.6916454	0.8917009				
12	0.0068418	0.0057660	0.0045019	-0.0139802	-0.0209835	-0.3965666	-1.8690567	-2.2217035	-1.1374540	1.7450943
	-0.0036839	-1.0889997	-1.6775541	-1.8863029	-2.1889887	-2.1442413	-0.1809340	-0.1382264	-0.0978319	-0.4260823
	0.3432853	0.6996734	0.1372268	0.2951093	0.0	0.0				

Table 14.--Flow to top layer by node in cubic feet per second, pumping period 3 (January-December 1958)--Continued

13	0.0456563	0.0321977	0.0018415	0.0013403	-0.0228682	-0.1617270	-1.3347139	-2.1097374	-1.4116755	-2.0392008
	-2.6576786	-0.1455181	-1.9659119	-2.0533648	-2.0587788	-0.7939184	-0.0503377	-0.2438724	-0.0237266	0.0071373
	0.2137700	0.4972231	0.1166225	0.2427674	0.0	0.0				
14	0.0	0.0148194	0.0116527	0.0072536	-0.0086328	-0.0017072	-1.2482243	-2.0185966	-1.9492474	-2.2997122
	-1.0726414	-0.0566736	-0.1291827	-0.1277593	-3.6268892	1.7443867	-0.0094737	-0.0369446	-0.0261698	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				
15	0.0	0.0	0.0	0.0052240	0.0084528	0.0260476	1.1272106	-1.2875957	-2.4607582	-1.1408834
	0.6067021	-0.6432037	-1.8305941	-1.4907560	2.3720236	3.3795757	0.0091229	-0.0169802	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				
16	0.0	0.0	0.0	0.0	0.0175245	0.0431009	0.1107908	-2.3716316	-1.0204563	1.1898775
	1.2590675	-0.8480301	-1.6727276	-1.4807129	-0.0975153	2.0427074	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				
17	0.0	0.0	0.0	0.0	0.0223037	0.0539466	0.1380969	0.2648250	0.5629453	0.8644220
	-1.3768549	-1.3561535	-1.5960417	-0.3950159	0.9259807	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				
18	0.0	0.0	0.0	0.0	0.0	0.0502046	0.1105619	0.2384917	0.4231266	-0.2385815
	-0.5405196	-0.8919053	-0.3011947	0.8667725	0.5557536	0.3165047	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				
19	0.0	0.0	0.0	0.0	0.0	0.0438883	0.0852728	0.1707971	0.2791333	0.4456696
	0.6219437	0.7182460	0.6715664	0.5112357	0.3656896	0.2715037	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0780989	0.1373822	0.2104248	0.3115283
	0.4111130	0.4637328	0.4411888	0.3628252	0.2930785	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				

Key:
Column numbers

Sample	2	3	4	5	6	7	8	9	10	11
row	12	13	14	15	16	17	18	19	10	21
	22	23	24	25	26	27				

Table 15.--Flow to top layer by node in cubic feet per second, pumping period 4 (January-December 1972)

[See end of table for key to column-numbering system]

FLOW TO TOP LAYER BY NODE

Row:										
2	0.0338452	0.0289186	0.0237712	0.0269262	0.0290894	0.0295033	0.0	0.0	0.0	0.0
	0.0	0.0	-0.0001793	-0.0038671	-0.0040947	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	2.2362623	0.3319105	0.3440187	0.0				
3	0.0337497	0.0292850	0.0252291	0.0289499	0.0310887	0.0311732	0.0313105	0.0	0.0	0.0
	0.3586341	0.5035498	0.3758343	-0.9958212	-0.1397069	1.0918751	0.0	0.0	0.0	0.0
	0.0	0.0	0.1639097	1.1169405	-0.4368169	0.0				
4	0.0334387	0.0044200	0.0170986	0.0253212	-0.0038721	-0.0356575	0.0328683	0.0	0.0	0.0230941
	0.1828604	1.5020533	-0.2150561	-0.7136725	-1.1713963	-0.4902112	1.4683056	0.0693524	0.0616592	0.0
	0.0	1.5022697	0.1933191	-0.3137192	-2.2443037	0.0				
5	0.0328056	0.3711494	-0.2354092	-0.1403601	-0.0009958	-0.0001656	0.0348032	0.0342415	0.0344621	0.0336734
	0.3973517	-0.5929396	-0.1341395	-0.1789997	-0.1701122	-0.0361890	-0.1535434	0.7867164	0.0582676	0.0614471
	0.0828292	1.6935911	-0.5974693	-1.7703524	-3.3749056	0.0				
6	0.0325394	0.0317111	-0.1009823	-0.5321681	-0.0020264	-0.0001308	0.0026465	0.0352740	0.0368565	0.0404750
	0.4361557	-0.8301750	-0.0665770	-1.2520056	-2.1242647	-1.5283165	-0.3219096	-0.1622985	-1.1235437	-0.0794484
	0.0092386	-0.0208845	-0.2285603	-0.2450458	-0.6847780	3.4591160				
7	0.0311351	0.0294988	-0.3838415	0.3968669	-0.7532756	-0.6115702	0.0016234	0.0355511	0.0394665	0.0398370
	0.6120983	0.5744533	-0.2325906	-2.0601454	-1.1111250	-2.0630016	-2.0203800	-1.4369307	-0.2695674	-0.1152484
	-0.0600896	-0.0354956	-0.2041285	-0.6532791	1.9837160	0.0				
8	0.0265907	0.0267664	-0.0119346	0.3713089	-0.4726277	-0.2907680	0.4939160	0.0023640	0.0018977	-0.2987568
	0.9510679	0.6813771	4.7877340	3.7900219	1.7295923	-1.4158697	-1.8161631	-1.5035114	-2.6318293	-0.2396719
	-1.4745779	-0.9750597	-2.6459627	-0.5766982	0.6277459	-18.2013702				
9	0.0206348	0.0194803	-0.0127450	0.2513136	0.3883840	-0.1202103	-0.6266896	-0.4433773	0.4151842	-0.8474368
	-1.0757532	0.4532632	-1.4725046	-1.0398378	-0.9648741	-1.2219486	-1.1151218	-2.1548605	-2.3568048	-0.2911151
	-1.7588654	-1.9672642	-3.1691933	0.0618749	0.6795366	17.7290192				
10	0.0151044	0.0131797	0.0103918	0.0015255	0.1952696	0.0064064	-1.8271074	0.7566601	-0.0038318	-0.0671601
	-0.0758274	-0.0910368	-0.8096120	-1.4492521	-1.5668926	-1.5974092	-2.0533113	-2.0640049	-1.4382620	-1.1665287
	-0.7926600	-1.1483269	0.0283207	0.4031366	0.6842210	0.8041865				
11	0.0101745	0.0079951	0.0051514	-0.0233662	0.0424896	-1.8521433	-2.7352829	-2.0564976	0.7058334	-0.0247431
	-0.0532361	-0.0867165	-1.5545378	-1.6481562	-2.0460176	-2.3789940	-0.2647416	-0.1236143	-0.1348836	-0.0572959
	-0.0072286	-0.0321183	0.1788171	0.3546664	0.7028319	0.8938345				
12	0.0058854	0.0040007	0.0016434	-0.0187170	-0.1299429	-0.6691349	-2.8021326	-2.3452263	-2.1094875	-0.2454647
	-0.0184518	-1.3961649	-1.9556217	-2.0920697	-2.2968435	-2.1562891	-0.1885646	-0.1227935	-0.0713415	-0.0388800
	0.7348086	0.9763421	0.1587968	0.3173813	0.0	0.0				

Table 15.--Flow to top layer by node in cubic feet per second, pumping period 4 (January-December 1972)--Continued

13	0.0384129	0.0184113	0.0000648	-0.0015453	-0.0834354	-0.2593905	-1.6636448	-2.1219301	-2.0567932	-2.1564312
	-2.7586536	-0.1603705	-2.1398468	-2.1807270	-2.0862598	-0.9931505	-0.0686895	-0.2373477	-0.0063808	0.3354346
	0.5109836	0.7063293	0.1355829	0.2650757	0.0	0.0				
14	0.0	0.0053628	-0.0032653	-0.0163651	-0.0417765	-0.0047203	-1.2199335	-2.3286905	-1.9782505	-2.3242207
	-1.1424818	-0.0808402	-0.1526432	-0.1452453	-3.6936026	1.0938301	-0.0133368	-0.0201521	-0.0092432	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				
15	0.0	0.0	0.0	-0.0096184	-0.0115653	-0.0074741	0.7311167	-1.4131918	-2.8063459	-1.2041759
	0.2198139	-1.1936541	-1.9510002	-1.7658882	1.2517815	1.9199705	0.0078258	-0.0080778	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				
16	0.0	0.0	0.0	0.0	0.0031980	0.0159388	0.0519748	-2.2391434	-1.0444059	0.8422559
	0.8466424	-0.9113562	-1.7837639	-1.5522518	-0.1624250	1.6189280	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				
17	0.0	0.0	0.0	0.0	0.0110997	0.0341836	0.0978311	0.2032897	0.3730434	0.4043481
	-1.4650469	-1.5122604	-1.6913977	-0.5130316	0.7727930	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				
18	0.0	0.0	0.0	0.0	0.0	0.0351036	0.0809199	0.1800505	0.2987818	-0.3880270
	-0.6702420	-1.0356054	-0.5371199	0.7182602	0.4616882	0.2624688	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				
19	0.0	0.0	0.0	0.0	0.0	0.0315030	0.0624485	0.1256670	0.2003436	0.3209942
	0.4708316	0.5501404	0.5384337	0.4182728	0.3014750	0.2245355	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0571357	0.1004420	0.1527642	0.2285151
	0.3110120	0.3575437	0.3509455	0.2943224	0.2399596	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0				

Key:
Column numbers

Sample	2	3	4	5	6	7	8	9	10	11
row	12	13	14	15	16	17	18	19	10	21
	22	23	24	25	26	27				

Table 16.--Flow to top layer by node in cubic feet per second, pumping period 5 (January-December 1977)

[See end of table for key to column-numbering system]

FLOW TO TOP LAYER BY NODE

Row										
Row: 2	0.0253085	0.0200410	0.0144177	0.0131975	0.0091602	0.0011776	0.0	0.0	0.0	0.0
	0.0	0.0	-0.0001792	-0.0038571	-0.0040934	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	2.2187176	0.3306921	0.3426266	0.0				
3	0.0256610	0.0212018	0.0166562	0.0159431	0.0116900	-0.0048185	0.0064466	0.0	0.0	0.0
	0.3572944	0.5010663	0.3598639	-1.0061960	-0.1578611	1.0631237	0.0	0.0	0.0	0.0
	0.0	0.0	0.1624740	1.0949059	-0.4621367	0.0				
4	0.0261340	-0.0019623	0.0103201	0.0154971	-0.0176477	-0.0546638	0.0152022	0.0	0.0	0.0228535
	0.1812292	1.4915371	-0.2246754	-0.7235858	-1.1937227	-0.5157214	1.4195070	0.0661744	0.0579386	0.0
	0.0	1.4691830	0.1912262	-0.3432434	-2.2831755	0.0				
5	0.0263676	0.2969938	-0.2728632	-0.2487267	-0.0017438	-0.0010436	0.0249885	0.0295777	0.0326298	0.0332900
	0.3949987	-0.5966911	-0.1349311	-0.1806501	-0.1736628	-0.0395337	-0.1926484	0.7285337	0.0540502	0.0562080
	0.0783517	1.6447496	-0.6469991	-1.8150978	-3.4408436	0.0				
6	0.0266161	0.0275322	-0.1203210	-0.5631448	-0.0025031	-0.0006423	0.0022120	0.0321345	0.0359778	0.0407881
	0.4426880	-0.8313140	-0.0673637	-1.2777195	-2.1404390	-1.5843201	-0.4054671	-0.2564752	-1.2096462	-0.0859187
	0.0036785	-0.0248025	-0.2326643	-0.2491617	-0.6881620	3.4591160				
7	0.0255069	0.0254169	-0.3982782	0.3446547	-0.7660987	-0.6622803	0.0014118	0.0338098	0.0403039	0.0418711
	0.8273205	0.5747774	-0.2413638	-2.1516314	-1.1512442	-2.0780020	-2.0378571	-1.4588709	-0.2741709	-0.1236564
	-0.0668303	-0.0401462	-0.2089489	-0.6589206	1.9328575	0.0				
8	0.0211366	0.0224740	-0.0143876	0.3351949	-0.4786184	-0.2968820	0.4259499	0.0022541	0.0021427	-0.2451757
	0.9843159	0.6837856	4.6482601	3.6541700	1.4276676	-1.4872522	-1.8449173	-1.5081635	-2.5894690	-0.2519025
	-1.4882851	-1.0595112	-2.7337189	-0.5840977	0.6243823	-18.2046661				
9	0.0150704	0.0141977	-0.0158910	0.2121810	0.3676023	-0.1266440	-0.6293265	-0.5170676	0.5710101	-0.7960653
	-1.0441933	0.4270315	-2.0542612	-1.0787449	-1.4032373	-1.2484732	-1.4318647	-2.2010822	-2.3913784	-0.3040406
	-1.7683249	-1.9804783	-3.1823759	-0.0273570	0.6760538	17.7232819				
10	0.0093228	0.0057998	0.0054543	-0.0029875	0.1751690	0.0057982	-1.8122768	1.3616152	0.0257502	-0.0579441
	-0.0724236	-0.0908900	-0.8509605	-1.4951973	-1.6574678	-1.6057119	-2.0896606	-2.1074343	-1.4620762	-1.1780157
	-0.8122029	-1.2506495	0.0215819	0.3973470	0.6805775	0.8035869				
11	0.0045708	-0.0031157	-0.0022272	-0.0332249	0.0044232	-1.8208017	-2.7014704	-2.0264006	1.5661983	-0.0222798
	-0.0521853	-0.0871125	-1.5732279	-1.7080717	-2.0587234	-2.3953886	-0.2766411	-0.1487519	-0.1575167	-0.0740789
	-0.0190595	-0.0396726	0.1717105	0.3483500	0.6990842	0.8930976				
12	0.0019022	-0.0028817	-0.0062123	-0.0331467	-0.1886348	-0.6565637	-2.5932198	-2.3235807	-2.0250053	-1.2737112
	-0.0201054	-1.4110336	-1.9523001	-2.1206608	-2.3038797	-2.1915522	-0.2087888	-0.1514724	-0.0953212	-0.3077310
	0.5488268	0.8680668	0.1519286	0.3105597	0.0	0.0				

Table 16.--Flow to top layer by node in cubic feet per second, pumping period 5 (January-December 1977)--Continued

13	0.0094463	-0.C260598	-0.0042317	-0.0C76551	-0.1134756	-0.2322875	-0.3334404	-2.C865822	-2.0099163	-2.2102327
	-2.7657156	-C.1612766	-2.1434469	-2.1969423	-2.0986824	-1.155654C	-0.C854604	-0.2739258	-0.C354987	0.0478868
	0.3284581	0.6C50826	0.1288776	0.2580469	0.0	0.C				
14	0.0	-0.C200150	-0.0350268	-0.0556653	-0.C659967	-0.0C68C84	-1.6633015	-2.2788706	-1.9766550	-2.3249359
	-1.1376724	-0.C803113	-C.1526309	-0.1465507	-3.7078934	0.391134C	-0.0345383	-0.0653735	-C.C441450	0.0
	0.0	0.C	0.0	0.0	0.C	0.C				
15	0.0	0.0	0.0	-0.0288282	-0.C258766	-0.0280477	0.4644862	-1.4839144	-2.6683912	-1.1988297
	0.2394150	-1.1477671	-1.9456720	-1.7666073	1.02113C6	0.5355302	-0.0130617	-0.0423833	0.C	0.0
	0.0	C.C	0.0	0.0	0.C	0.0				
16	0.0	0.C	0.0	0.C	-0.CC34495	0.CC99C15	C.0634145	-2.6112070	-1.C549841	0.8632210
	0.8663192	-0.9C47668	-1.7675228	-1.5496483	-0.1644130	1.3872366	0.0	0.0	0.C	0.0
	0.C	0.C	0.0	0.0	0.C	0.C				
17	0.0	0.C	0.0	0.0	0.C059805	0.C252886	0.C745670	0.1059464	0.3509194	0.4689313
	-1.4638815	-1.5C05264	-1.6846647	-0.5031715	0.8014C55	0.0	0.C	0.0	0.C	0.0
	0.0	0.C	0.0	0.0	0.C	0.C				
18	0.0	C.C	0.0	0.C	0.C	0.C273376	0.C635422	0.1417184	0.2770610	-0.3988758
	-0.7702102	-1.C470467	-0.5324230	0.7268909	0.4729466	0.2683443	0.C	0.C	0.C	0.0
	0.0	C.C	0.0	0.0	0.C	0.0				
19	0.0	0.C	0.C	0.0	0.C	0.C254712	0.0518794	0.1069589	C.1831989	0.2972320
	0.4187647	C.5303C75	C.5350711	0.4207737	0.3062133	0.2288674	0.C	0.C	0.C	0.C
	0.0	0.C	0.0	C.C	0.0	0.C				
20	0.0	0.C	C.0	0.0	0.0	0.C	0.0491048	0.C881087	0.1390364	0.2101469
	0.2847524	0.3427832	0.3460530	0.2944920	0.2421917	0.C	C.C	0.C	0.0	0.0
	0.0	0.C	0.C	0.0	0.C	0.C				

Key:
Column numbers

Sample row									
2	3	4	5	6	7	8	9	10	11
12	13	14	15	16	17	18	19	10	21
22	23	24	25	26	27				

Heads and Drawdowns

Computed heads and drawdowns are shown in Supplementary Data III. Drawdown equals the starting head for a given layer in a given pumping period minus the final head for the model run. Because the source data are shown in the head matrices, only contours are shown in the drawdown maps (figs. 8 through 15).

Figure 8 shows a shallow cone of depression in layer 1 for pumping period 2 (1939-40) with two centers adjoining Pensacola Bay. Figure 10, representing drawdown in layer 1 for pumping period 3 (1958), shows that the two centers of drawdown in the previous period have shrunk, have shifted slightly northward, and have been overshadowed by a much deeper cone of depression near the center of the grid. This new cone is the result of the near-maximum pumping rate (later reduced) for industrial purposes near Cantonment and the early stage of industrial pumping near Gonzalez (fig. 1). Figure 12, representing drawdown in layer 1 for pumping period 4 (1972), shows a shallowing of the cone of depression in the center of the grid and the development of two separate centers. This is the result of the reduction in the pumping rate around Cantonment and continued pumping near Gonzalez. Centers of the two cones in the southern part of the area have shifted slightly northward, but have deepened. These changes reflect increased but more dispersed pumping for public supply in and around Pensacola. Figure 14, representing the effects of pumping on layer 1 in pumping period 5 (1977), shows a similar pattern to that in figure 12, but the cones have spread and deepened. This reflects the continuation of the trend of increased but more dispersed pumping.

Figures 9, 11, 13, and 15 show drawdown in layer 2 for the pumping periods 2 through 5. The patterns of their cones of depression are similar to the corresponding ones for layer 1 in figures 8, 10, 12, and 14, but the cones are somewhat shallower and less widespread. According to the model, under steady-state conditions the water table is drawn down one-half to two-thirds as much in the centers of cones of depression as the head in layer 1. Drawdown of the water table is difficult to compare with long-term water-level records because data are scarce and difficult to use in calibration because of variations in the water table with topography, precipitation, and evapotranspiration.

TESTING

The model calibrated for 1972 pumping, was tested by comparing its fit to observed data under other conditions of stress. The pumping periods selected for this purpose were period 2 (January 1939-March 1940), period 3 (1958), and period 5 (1977). The 1939-40 period differed from 1972 in that industrial pumping had not yet begun in the Cantonment and Gonzalez areas (fig. 1), but pumping rates were higher northeast of the Pensacola Naval Air Station than in 1972. The City of Pensacola public-supply wells, although they pumped much less than in 1972, were concentrated around the original water plant (node [1]6,9). Data for the 1939-40 period are mostly from Jacob and Cooper (1940).

During the 1958 period, pumping at Cantonment was near its peak and was substantial near Gonzalez. Total pumpage and distribution of the Pensacola public-supply wells were intermediate between the conditions of 1940 and 1972. The principal sources of data for this period are Musgrove and others (1965, 1966) and long-term records of observation wells established in 1939-40.

By period 5 (1977), pumping centers not active in 1972 had developed and pumping generally increased, with local variations. The sources of data are the current investigation of the sand-and-gravel aquifer, long-term observation-well data, and the statewide water-use program.

Tables 17 through 19 list the sites used as control for the head of layer 1 in pumping periods 2, 3, and 5, respectively, nodal heads estimated from observations, and nodal heads computed by the model. Figures 16 through 18 show the same data graphically.

The equations of the regression lines and the correlation coefficients are:

Pumping Period 2, January 1939-March 1940
$y = 0.8462x + 0.1597$
$r = 0.916$
N = number of data pairs (14)

Pumping Period 3, January-December 1958
$y = 1.87 + 0.8011x$
$r = 0.974$
N = number of data paris (24)

Pumping Period 5, January-December 1977
$y = 5.26 + 0.84x$
$r = 0.958$
N = number of data pairs (34)

These compare fairly well with the calibration regression lines and correlation coefficients, and therefore, the testing of the model shows that it produces usable values within an acceptable range of accuracy for the magnitude and distribution of pumpage to date.

Model Sensitivity to Changes in Input

A sensitivity analysis was included as part of the calibration of the model in order to determine the importance of each parameter in affecting the head. This procedure tests the effects of varying each input parameter while keeping other parameters constant. A multiplier is used to either increase or decrease the calibration value. Five parameters were varied in this manner: TK matrix, horizontal hydraulic conductivity of layer 2, transmissivity of layer 1, recharge, and river leakage. The results indicate deviations from known head caused by varying each parameter. Of the five parameters studied, the model was most sensitive to recharge. After recharge, layer 1 is most sensitive to changes in TK, its own transmissivity, and horizontal hydraulic conductivity of layer 2, in that order. After recharge, layer 2 is most sensitive to its own horizontal conductivity, followed by changes in TK. Both layers were least sensitive to variations in river leakage.

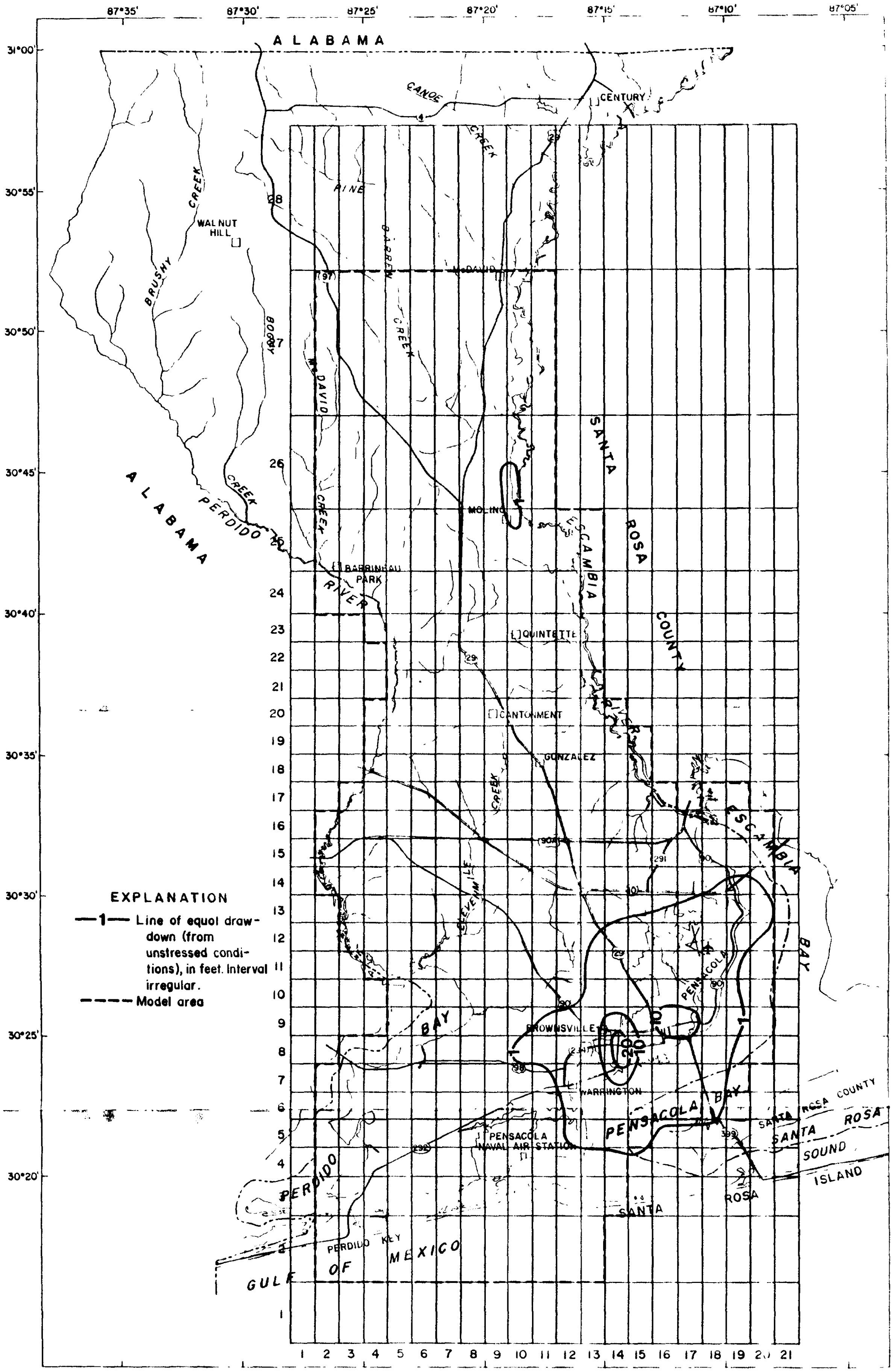

Figure 8.--Drawdown for layer 1, pumping period 2 (January 1939-March 1940).

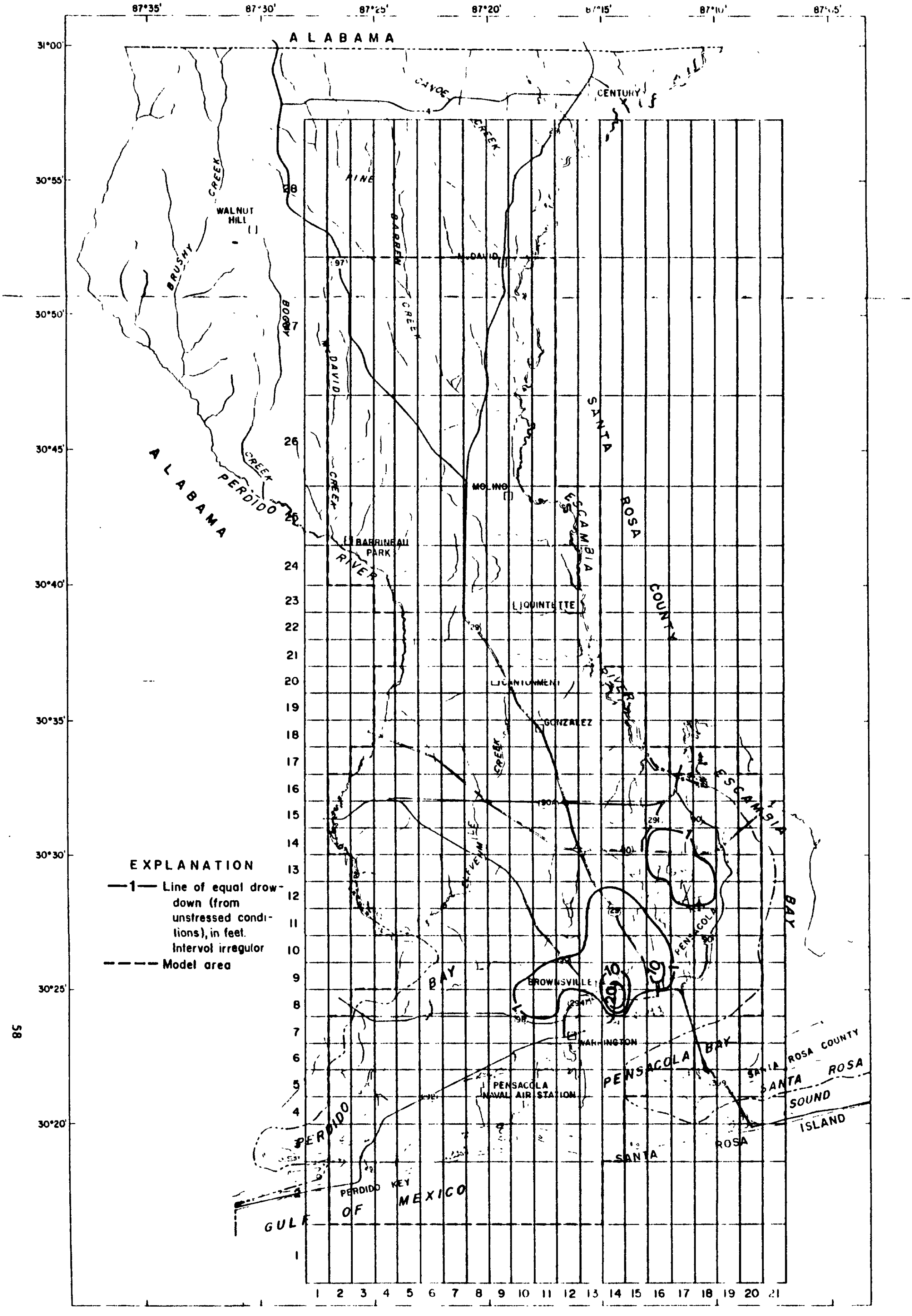

Figure 9.--Drawdown for layer 2, pumping period 2 (January 1939-March 1940).

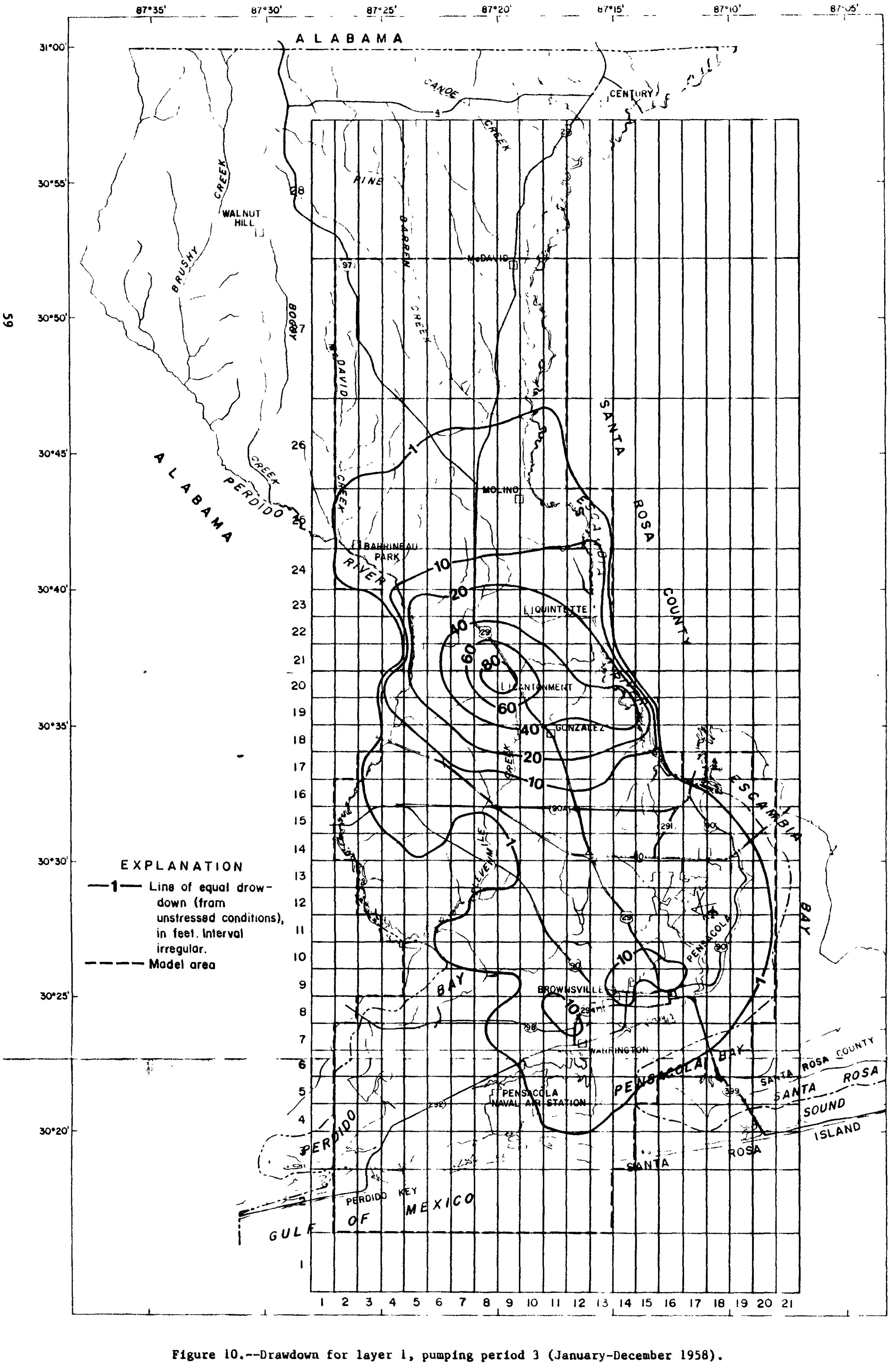

Figure 10.--Drawdown for layer 1, pumping period 3 (January-December 1958).

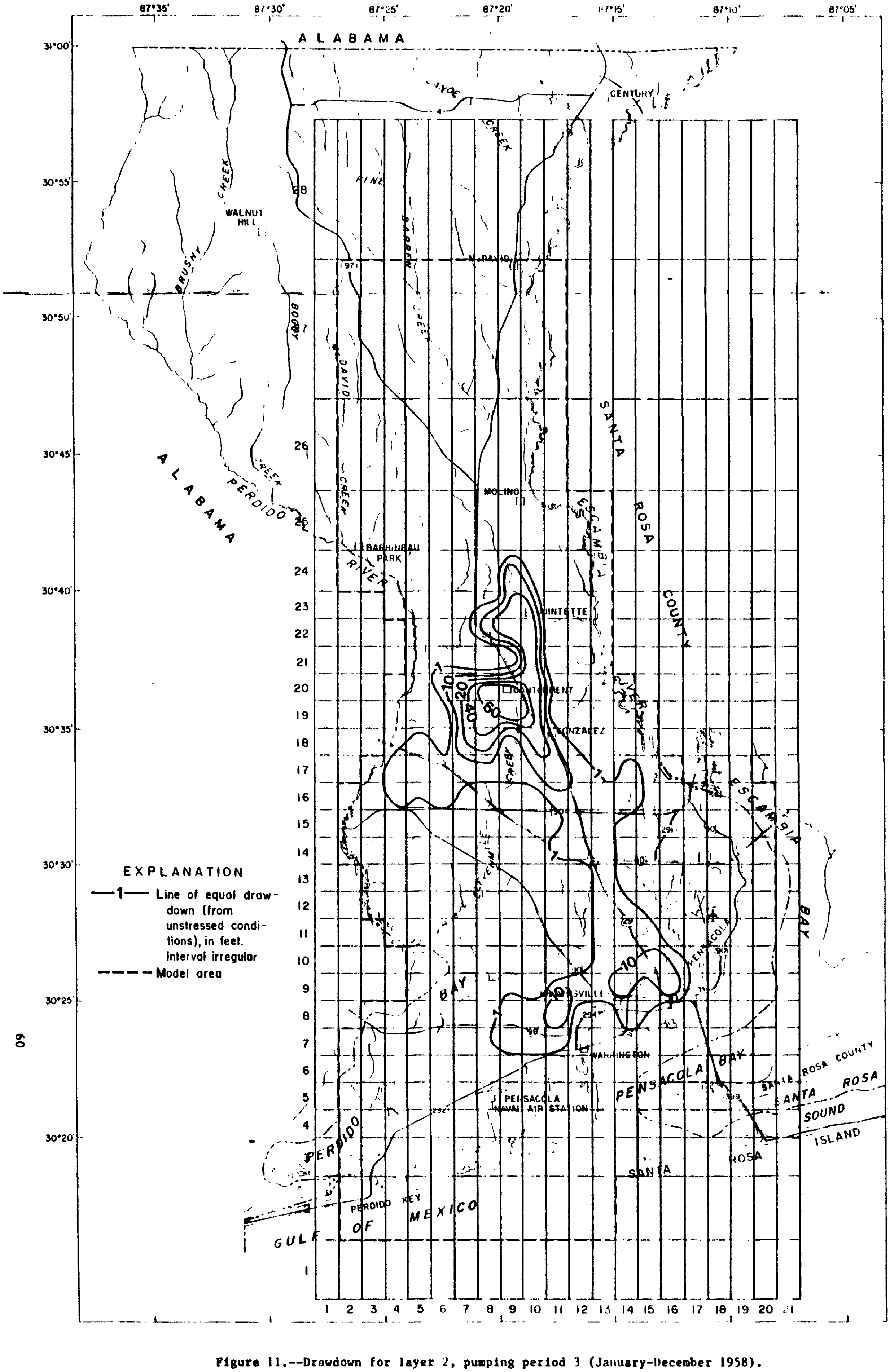

Figure 11.--Drawdown for layer 2, pumping period 3 (January-December 1958).

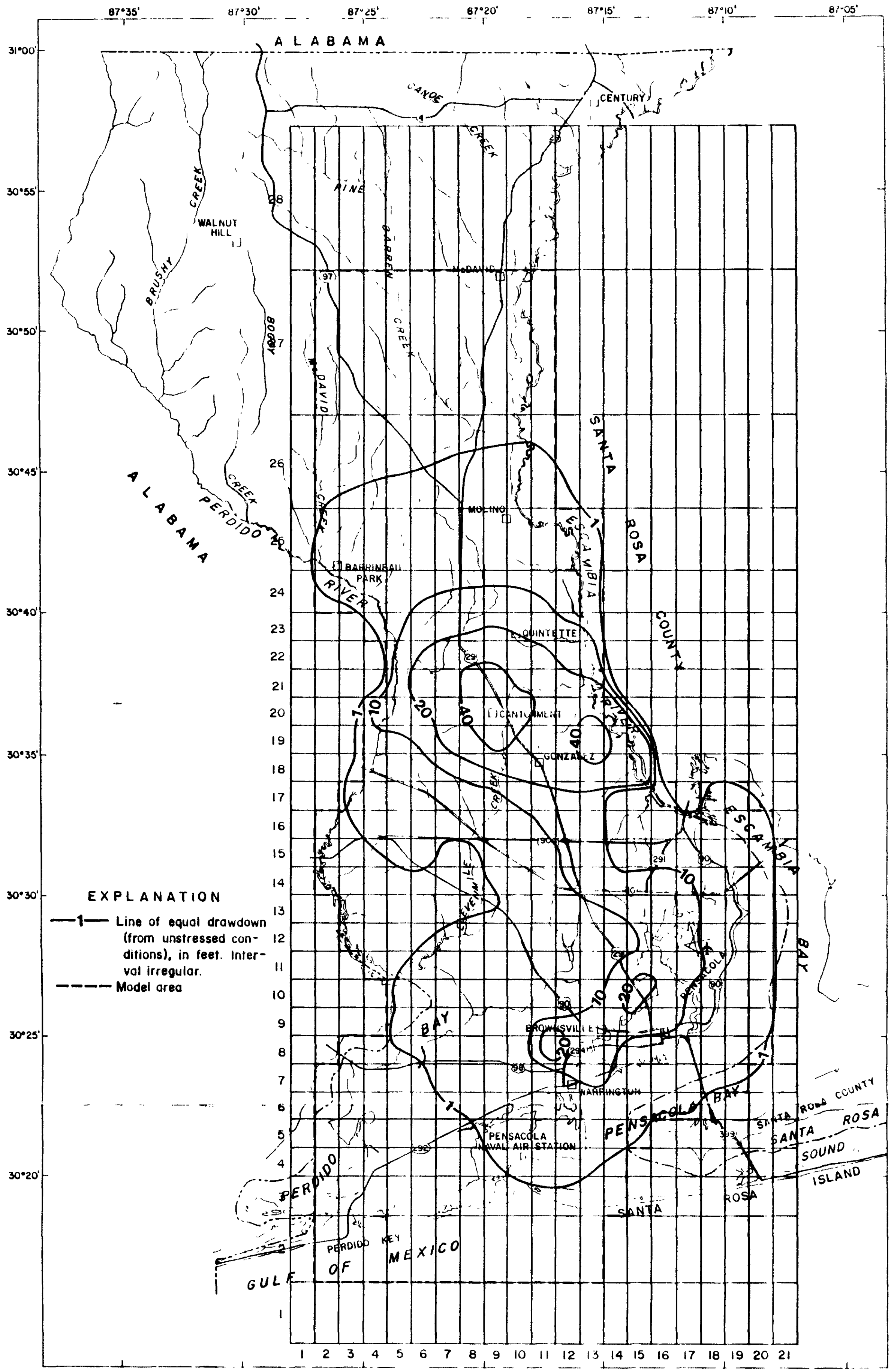

Figure 12.--Drawdown for layer 1, pumping period 4 (January-December 1972).

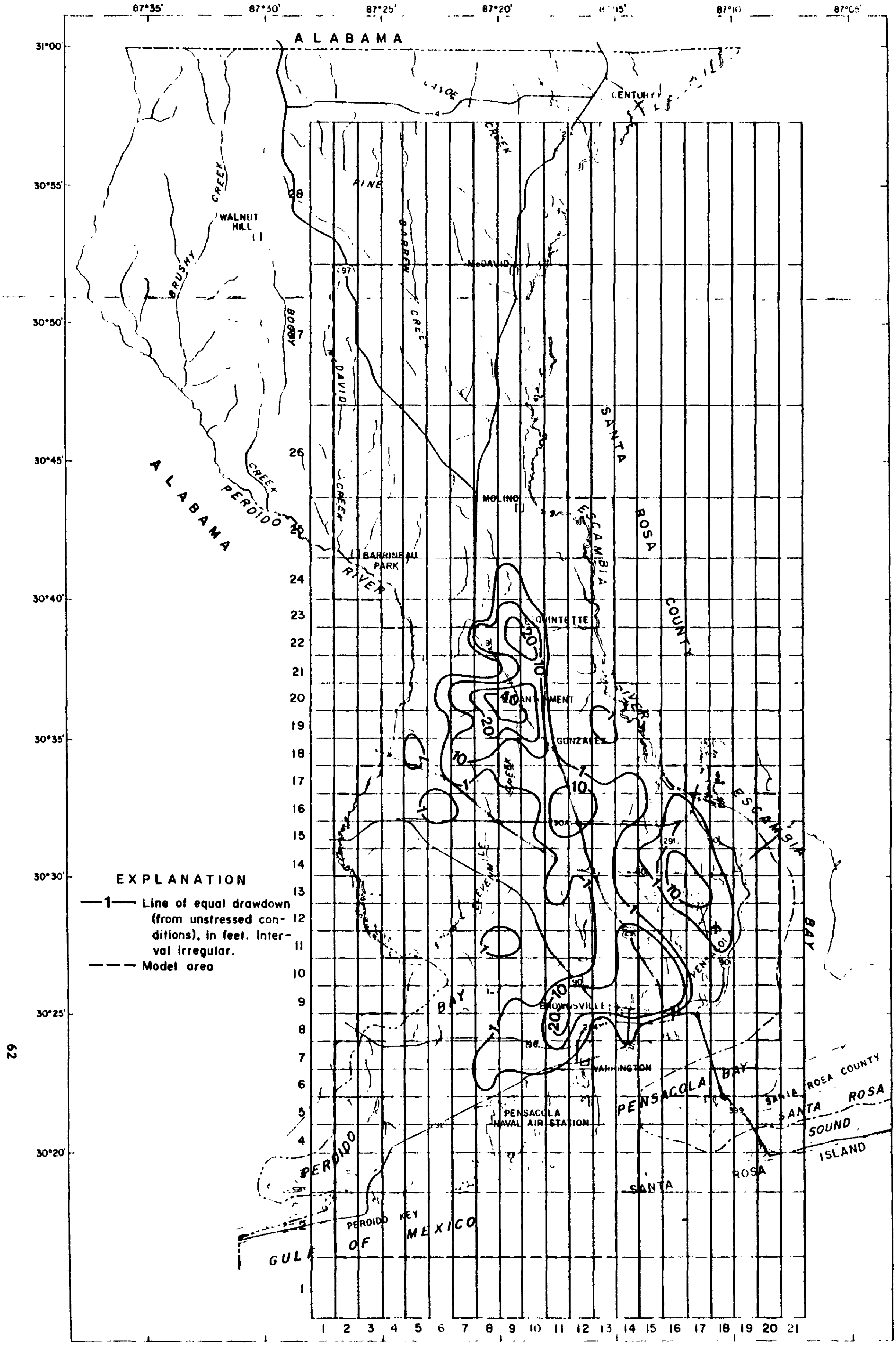

Figure 13.--Drawdown for layer 2, pumping period 4 (January-December 1972).

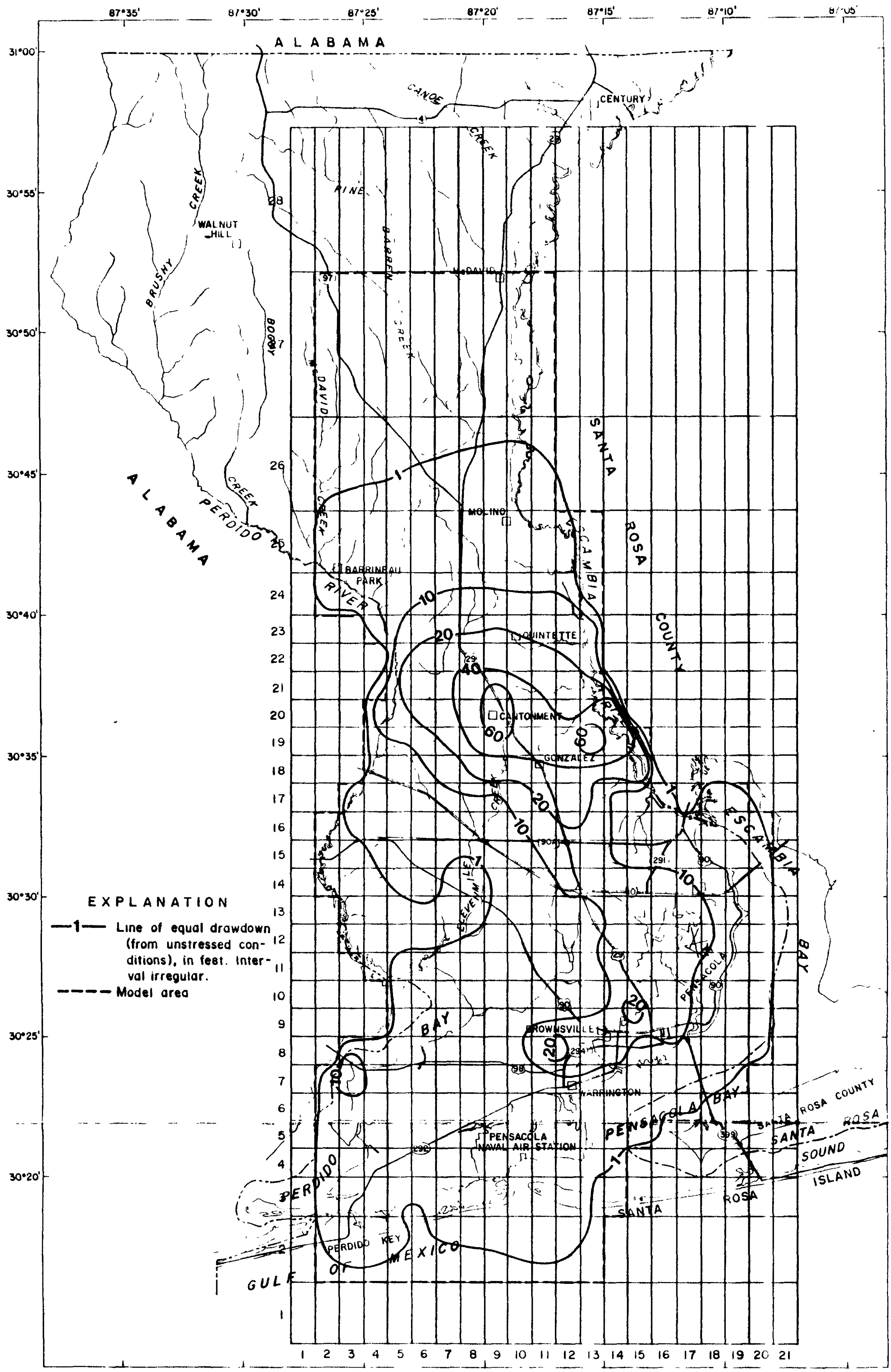

Figure 14.--Drawdown for layer 1, pumping period 5 (January-December 1977).

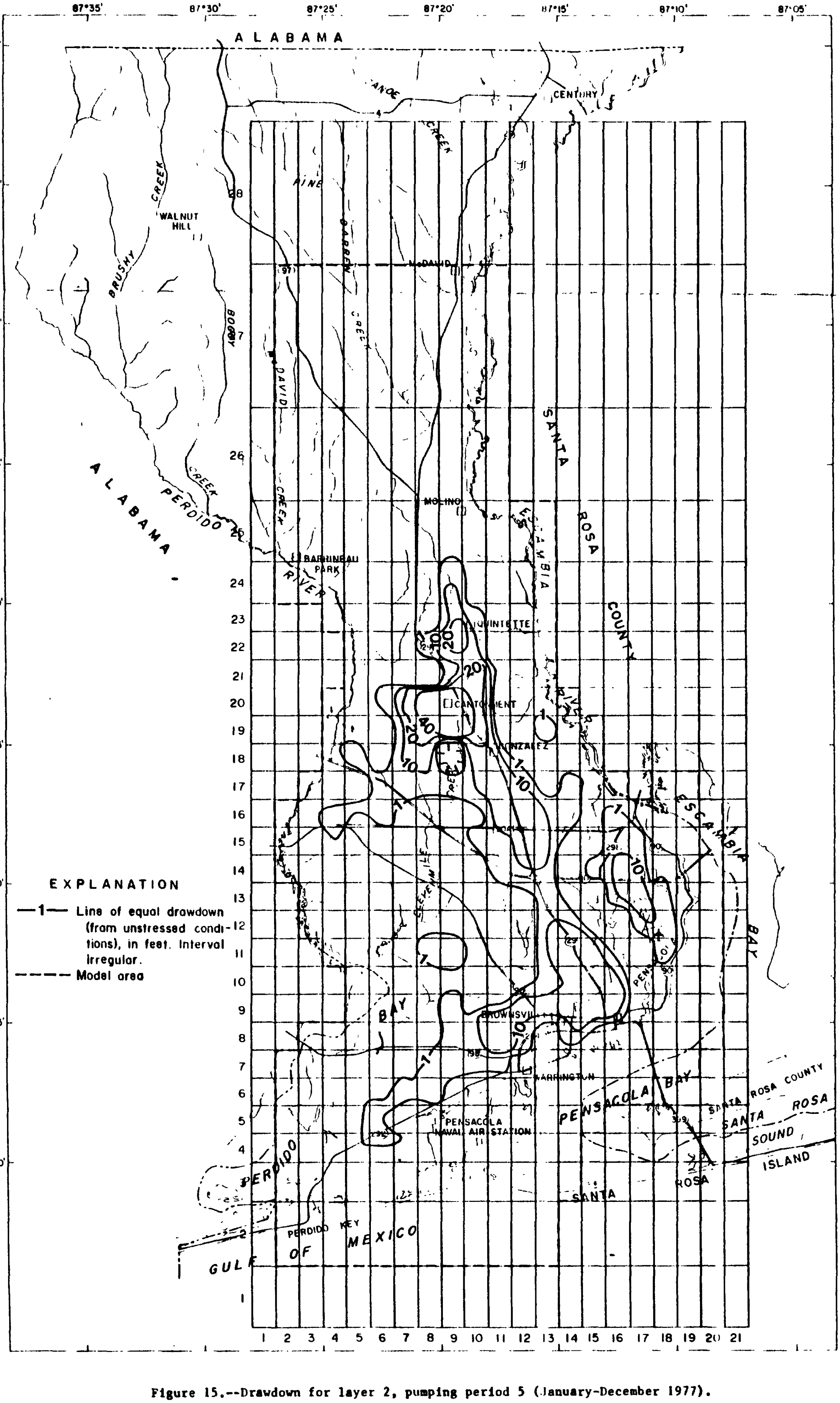

Figure 15.--Drawdown for layer 2, pumping period 5 (January-December 1977).

Table 17.--Control-node observed and computed head values for layer 1, pumping period 2 (January 1939-March 1940)

Node	Lat.-Long quad[1]	Site I.D. No.[2]	Name	Reported or mean observed head (feet)	Period of obervation	Node head: Estimated from observed values (feet)	Node head: From model (feet)	Node head: From model minus estimated from observation (feet)
8,26	046-720	3046520872023.01	Mt.Calvary Camp	63.5	02/12/40	43	80.28	[5]37.28
9,20	036-719	3036140871909.01	USGS Escambia 45	64.5	01-04/40	66	64.92	-1.08
		-------------.--	[3]036-719-6	65	12/01/40			
10,25	043-718	-------------.--	[3]043-718-3	61	02/27/40	51	58.69	7.69
[4]11,8	024-717	3024290871716.01	USN Corry 2	18.5	02/29/40	20	15.45	-4.55
[4]12,7	023-716	3023080871635.01	USGS Escambia 39	4	03/18/40	4	4.38	.38
		3023090871647.01	Peoples Water 1 (old)	5	03/06/40			
12,8	024-716	3024340871653.01	USN Corry 4	11.7	02/28/40	16	7.70	-8.30
12,15	031-716	3031080871623.01	USGS Escambia 46	62	01-04/40	63	62.7	-0.30
12,16	032-716	-------------.--	[3]032-716-2	64.4	02/26/40	62	61.14	-.86
13,7	023-715	-------------.--	[3]023-715-3	1.1	03/18/40	3	-.62	-3.62
13,8	024-715	3024320871517.01	USGS Escambia 62	-4	05/40	3	1.29	-1.71
14,8	024-714	3024080871426.01	Pensacola Tool and Supply	-12	03/18/40	-18	-18.19	-.19
		3024330871451.02	Newport 3	-22.6	02/14/40			

See footnotes at end of table.

Table 17.--Control-node observed and computed head values for layer 1, pumping period 2 (January 1939-March 1940)--Continued

Node	Lat.-Long. quad[1]	Site I.D. No.[2]	Name	Reported or mean observed head (feet)	Period of obervation	Node head: Estimated from observed values (feet)	Node head: From model (feet)	Node head: From model minus estimated from observation (feet)
[4]16,9	025-712	-------------.--	Escambia 5,[5] Pensacola 5	21.8	02/22/40	11	8.32	-9.68
			USGS Escambia 61	25	04/40			
18,15	031-710	-------------.--	Escambia 48[6]	5.5	03/09/40	4	13.48	9.48
19,13	029-709	-------------.--	[3]029-709-2	0.5	03/09/40	3	9.03	6.03

[1]Abbreviated designation of 1-minute latitude and longitude quadrangles as described by Musgrove and others, 1965, p. 8-9.

[2]Unique USGS ground-water site identification number based on approximate latitude and longitude; well data in computer storage.

[3]Musgrove and others, 1966, table 7.

[4]Pumping node.

[5]Large discrepancy could be caused by: (1) difficulty in estimating node head from observed head in very long grid rectangle, (2) observed head may be inaccurate because of inaccurate altitude control, (3) observed head may not be representative of mean head at well site (only one measurement), or (4) calibration of the model may be off at this node, which is near the model's north boundary (but, in pumping period 3, the discrepancy for another control well in this node rectangle was 15.46 feet).

[6]Jacob and Cooper, 1940, tables 1 and 5.

Table 18.--Control-node observed and computed head values for layer 1, pumping period 3 (January-December 1958)

Node	Lat.-Long. quad[1]	Site I.D. No.[2]	Name	Reported or mean observed head (feet)	Period of obervation	Node head: Estimated from observed values (feet)	Node head: From model (feet)	Node head: From model minus estimated from observation (feet)
8,11	027-720	3027530872034.01	USN Saufley 4	27.7	08/58	18	15.87	-2.13
8,26	046-720	3046370872006.01	046-720-1	63	06/10/58	63	78.46	15.46
[3]9,20	036-719	3036140871909.01	USGS Escambia 45	25.5	01-12/58	-10	-18.71	-8.71
		-------------.--	[4]036-719-9	22	12/58			
9,26	045-719	3045100871916.01	Herbert Hicks	62	09/05/58	62	70.43	8.43
9,27	050-719	3050330871929.01	S.G. Hall	52	06/16/58	52	71.21	19.21
10,25	043-718	-------------.--	[4]043-718-1	50.8	05/07/58	48	51.87	3.87
11,9	025-717	-------------.--	[4]025-717-1	5	12/58	9	16.16	7.16
12,7	023-716	3023080871635.01	USGS Escambia 39	4.5	01-12/58	-9	-2.67	6.00
12,9	025-716	3025340871603.01	Pensacola West Pensacola Plant	20	11/01/58	13	17.34	4.34
12,15	031-716	3031080871623.01	USGS Escambia 46	58.3	01-12/58	60	57.15	-2.85
12,20	036-716	3036100871650.01	Monsanto 74	8.9	01-12/58	9	2.32	-6.68
13,8	024-715	3024320871517.01	USGS Escambia 62	-0.6	01-12/58	-2	-.95	1.05
13,13	029-715	3029550871558.01	Leonard Brothers	39	05/26/58	36	47.35	11.35
13,19	035-715	3035560871510.01	Monsanto, Escambia 72	-2.1	08/25/58	-3	-14.17	-12.17
		3035350871501.01	Monsanto 4	-7.9	09/25/58			
		3035580871555.01	Monsanto, Escambia 73	-1.8	01-12/58			
14,8	024-714	3024020871405.01	USGS Escambia 60	0.6	01-12/58	1	.76	-.24

See footnotes at end of table.

Table 18.--Control-node observed and computed head values for layer 1, pumping period 3 (January-December 1958)--Continued

Node	Lat.-Long quad[1]	Site I.D. No.[2]	Name	Reported or mean observed head (feet)	Period of obervation	Node head: Estimated from observed values (feet)	Node head: From model (feet)	Node head: From model minus estimated from observation (feet)
14,9	025-714	3025140871403.01	Pensacola West Plant	11	11/01/58	13	14.62	1.62
14,19	035-714	3035270871400.01	Monsanto, Escambia 83	-1.6	01-12/58	0	-7.73	-7.73
15,10	026-713	3026020871307.01	Pensacola 9	14	11/01/58	21	22.09	1.09
16,9	025-712	3025230871256.01	Pensacola 6	7	11/01/58	6	6.78	.78
		3025350871257.01	Pensacola 8	6	11/01/58			
16,10	026-712	3026460871227.01	Pensacola 12th Ave. Plant	13	11/01/58	12	6.19	-5.81
16,16	032-712	-------------.--	[4]032-712-1	12	04/28/58	10	18.34	8.34
17,11	027-711	3027570871119.01	Pensacola Hagler Plant	22	09/16/58	10	13.69	3.69
17,13	029-711	3029300871128.01	Pensacola McAllister	34	05/58	24	26.95	2.95
17,16	032-711	3032460871141.01	L.C. Smith Fish Camp	8	04/25/58	8	13.60	5.60

[1]Abbreviated designation of 1-minute latitude and longitude quadrangles as described by Musgrove and others, 1965, p. 8-9.

[2]Unique USGS ground-water site identification number based on approximate latitude and longitude; well data in computer storage.

[3]Pumping node; six wells. Calculated 35.5 feet drawdown at node.

[4]Musgrove and others, 1966, table 7.

Table 19.--Control-node observed and computed head values for layer 1, pumping period 5 (January-December 1977)

Node	Lat.-Long quad[1]	Site I.D. No.[2]	Name	Reported or mean observed head (feet)	Period of obervation	Node head: Estimated from observed values (feet)	Node head: From model (feet)	Node head: From model minus estimated from observation (feet)
3,7	020-720	3023020872525.01	USGS TH 107	4.8	05-12/77	3	-1.26	-4.26
4,16	032-724	3032080872411.01	USGS 032-724-1	30.4	01-12/77	32	29.77	-2.23
5,4	020-723	3020520872341.01	USGS TH 25	15	01-12/77	9	7.93	-1.07
5,13	029-723	3029580872300.01	USGS TH 8	25	01-12/77	18	17.51	-.49
5,20	036-723	3036420872323.01	USGS TH 12	39	01-12/77	37	31.27	-5.73
5,23	039-723	3039580872332.01	USGS TH 13	48	01-09/77	40	44.10	4.10
6,17	033-722	3033550872232.01	USGS TH 19	46	02-10/77	46	43.64	2.36
7,7	023-721	3023540872105.01	USGS TH 9	10	01-12/77	11	11.35	.35
7,12	028-721	3028200872114.01	USGS TH 22	14	01-12/77	15	14.10	-.90
7,24	040-721	3040080872116.01	USGS TH 27	41	01-12/77	46	60.48	14.48
8,4	020-720	3020330872028.01	USGS TH 23	2	01-12/77	3	6.09	3.09
8,7	023-720	3023550872003.01	USGS TH 31	11	01-12/77	12	9.72	-2.28
8,14	030-720	3030060872052.01	USGS TH 7	23	01-12/77	24	23.92	-.08
[3]9,14	030-719	3030180871922.01	USGS TH 5	26	01-12/77	28	35.3	7.3
9,16	032-719	3032160871941.01	USGS TH 29	42	01-12/77	43	44.01	1.01
[3]9,20	036-719	3036140871909.01	USGS Escambia 45	40.5	01-12/77	12	3.09	-8.91
10,8	024-718	3024320871826.01	USGS TH 3	18	01-12/77	20	8.67	-11.33
10,17	033-718	3033460871854.01	USGS TH 18	48	01-12/77	48	41.90	-6.10
10,21	037-718	3037230871826.01	USGS TH 28	26	01-12/77	28	16.81	-11.19
[3]12,7	023-716	3023080871635.01	USGS Escambia 39	1.2	01-12/77	1	-6.50	-7.5

See footnotes at end of table.

Table 19.--Control-node observed and computed head values for layer 1, pumping period 5 (January-December 1977)--Continued

Node	Lat.-Long. quad[1]	Site I.D. No.[2]	Name	Reported or mean observed head (feet)	Period of obervation	Node head: Estimated from observed values (feet)	Node head: From model (feet)	Node head: From model minus estimated from observation (feet)
[3]12,15	031-717	3031080871623.01	USGS Escambia 46	54.1	01-12/77	45	47.39	2.39
[3]12,20	036-716	3036100871650.01	Monsanto 74	5.99	10-12/77	6	2.98	-3.02
13,10	026-715	3026430871536.01	USGS TH 2	40	01-12/77	36	27.58	-8.42
		3026170871524.01	USGS TH 100	32	01-12/77			
13,16	032-715	3032510871502.01	USGS TH 20	36.2	01-12/77	45	39.05	-5.95
[3]13,19	035-715	3035580871555.01	Monsanto, Escambia 73	-5.48	10-11/77	-6	-23.30	17.30
14,16	032-714	3032490871408.01	USGS TH 21	24.2	01-12/77	33	32.99	-.01
14,18	033-714	3033480871410.01	Pensacola Sewage Mon. 99	9.4	04-10/77	6	-.09	-6.09
[3]14,19	035-714	3035270871400.01	Monsanto, Escambia 83	-5.4	01-11/77	-10	-15.22	-5.22
[3]15,10	026-713	3026580871303.01	USGS 026-713-5	27	01-12/77	12	15.56	3.56
15,15	031-713	3031060871348.01	USGS TH 32	36	01-12/77	34	32.24	1.76
15,16	032-713	3032080871327.01	USGS TH 6	23.8	01-12/77	22	20.79	-1.21
[3]15,17	033-714	3033130871400.02	USGS TH 98A	11.1	02-10/77	2	1.79	-.21
		3033270871354.01	USGS TH 101	3.1	01-10/77			
		3033310871358.02	USGS TH 102A	2.8	07,10/77			
17,9	025-711	3025410871145.01	USGS TH 1	3	01-12/77	2	2.55	.55
19,12	028-709	3028420870956.01	USGS TH 106	8	04-12/77	6	6.13	.13

[1]Abbreviated designation of 1-minute latitude and longitude quadrangles as described by Musgrove and others, 1965, p. 8-9.

[2]Unique USGS ground-water site identification number based on approximate latitude and longitude; well data in computer storage.

[3]Pumping node.

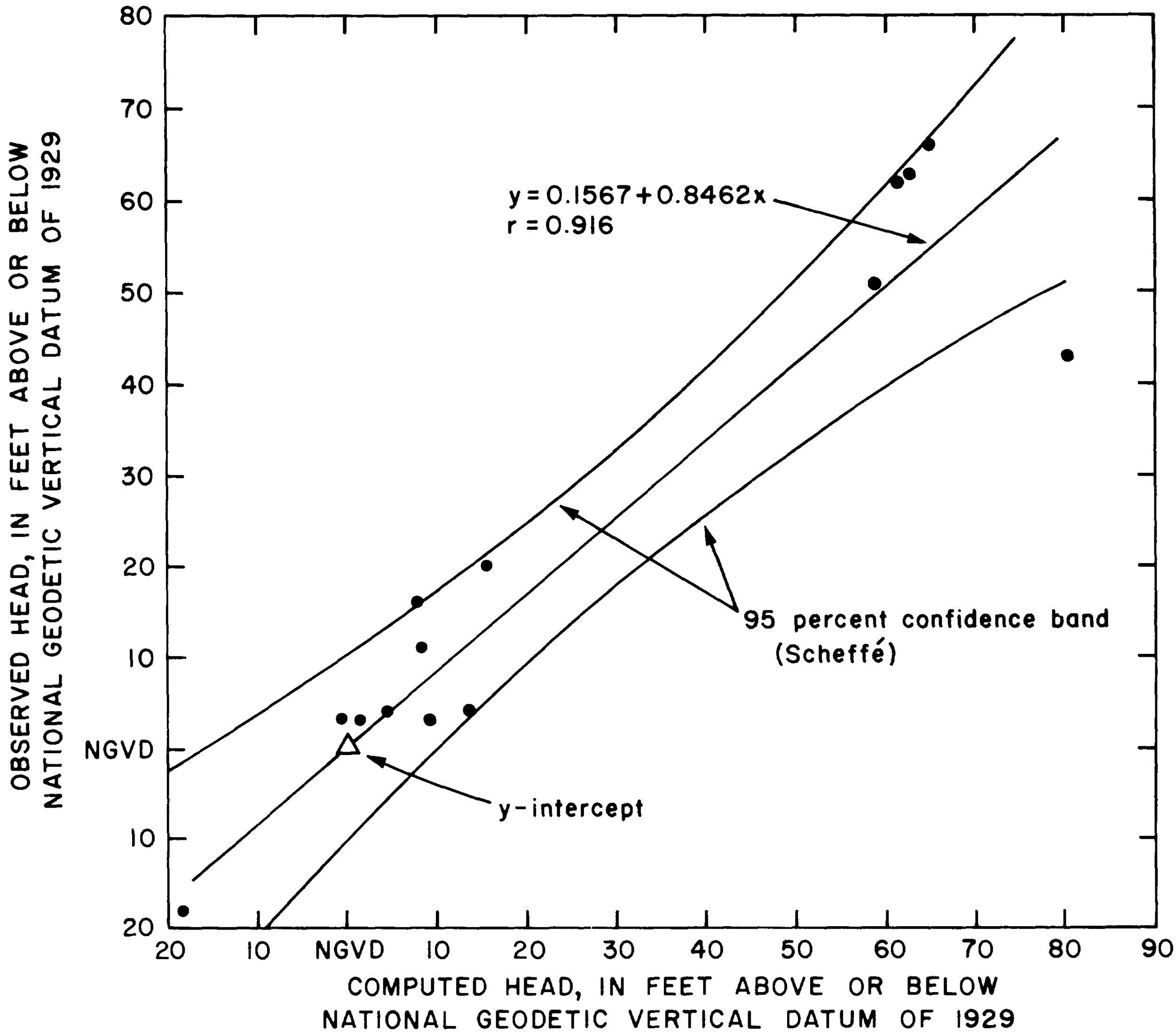

Figure 16.--Observed versus calculated head values, regression line, and confidence band for layer 1 for pumping period 2 (January 1939-March 1940).

The sensitivity analysis results for the recharge parameter are most clearly shown through graphic representation. Inasmuch as the model was most sensitive to recharge, only those results are shown. One north-south and one east-west cross section of the model area were included in the analysis. The north-south section (section A-A', fig. 1) along row 9 was chosen since it runs parallel to the Escambia and Perdido Rivers. The east-west section (section B-B', fig. 1) was chosen along column 7, which includes major pumping and an observation well. Each figure depicting either layer 1 or layer 2 shows a generalized land surface using the mean altitude of the node rectangles and significant topographic features. Also shown are plots of computed heads from pumping period 4 with one line showing the heads as calibrated and two other lines showing the effects on the head predicted by increasing and decreasing recharge. Control values, which are adjusted observed heads for layer 1, are shown by large triangles.

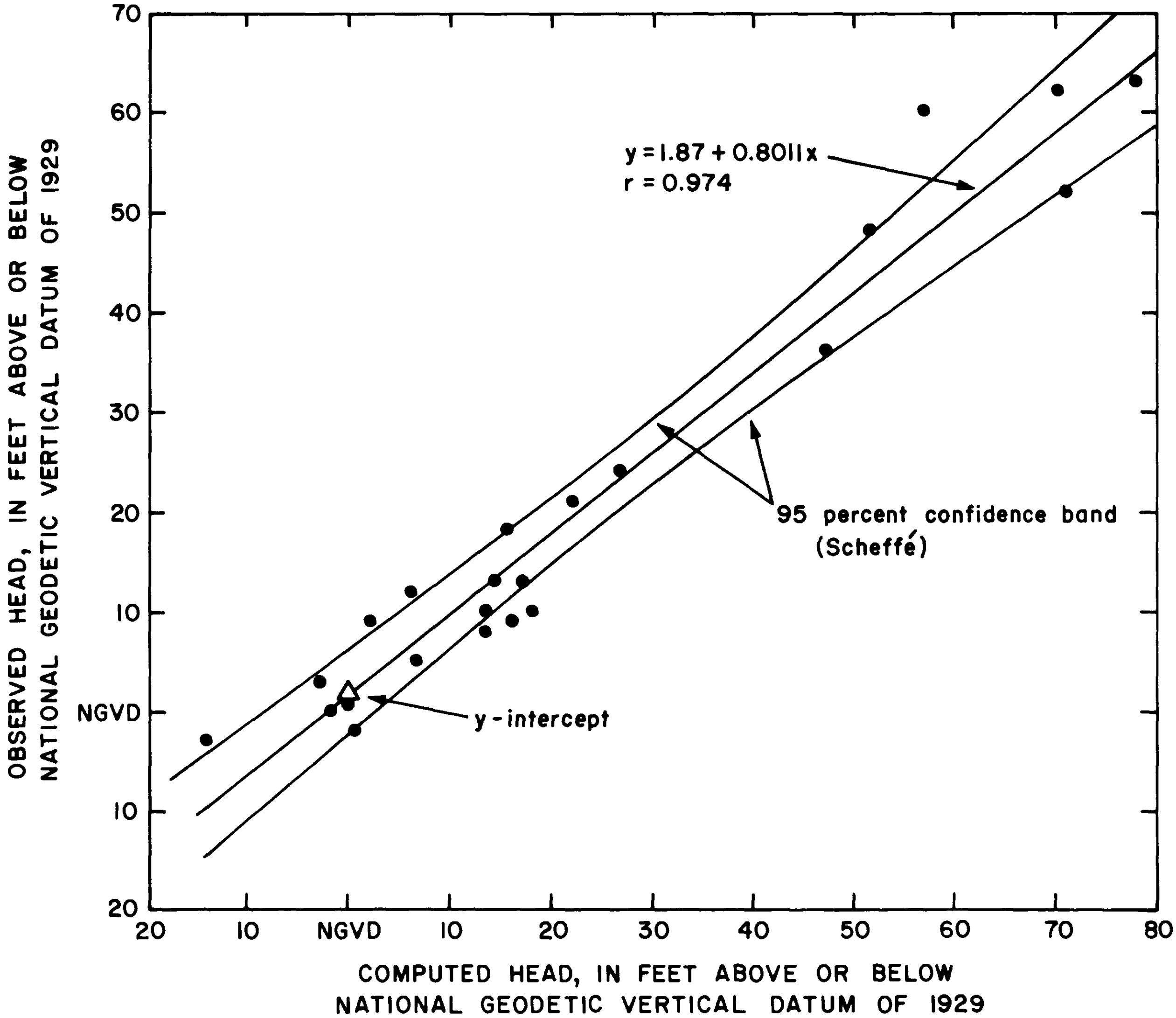

Figure 17.--Observed versus calculated head values, regression line, and confidence band for layer 1 for pumping period 3 (January-December 1940).

Whenever a node in layer 2 goes dry or the head drops below the bottom of the layer, the head plotted is the value of the altitude of the bottom of the layer for that node. When this happens, the node is footnoted, since the head plotted is not meaningful at that point. Also, although the figures may show a certain number of nodes, not all are within the model boundaries. No values are plotted for nodes outside the boundaries.

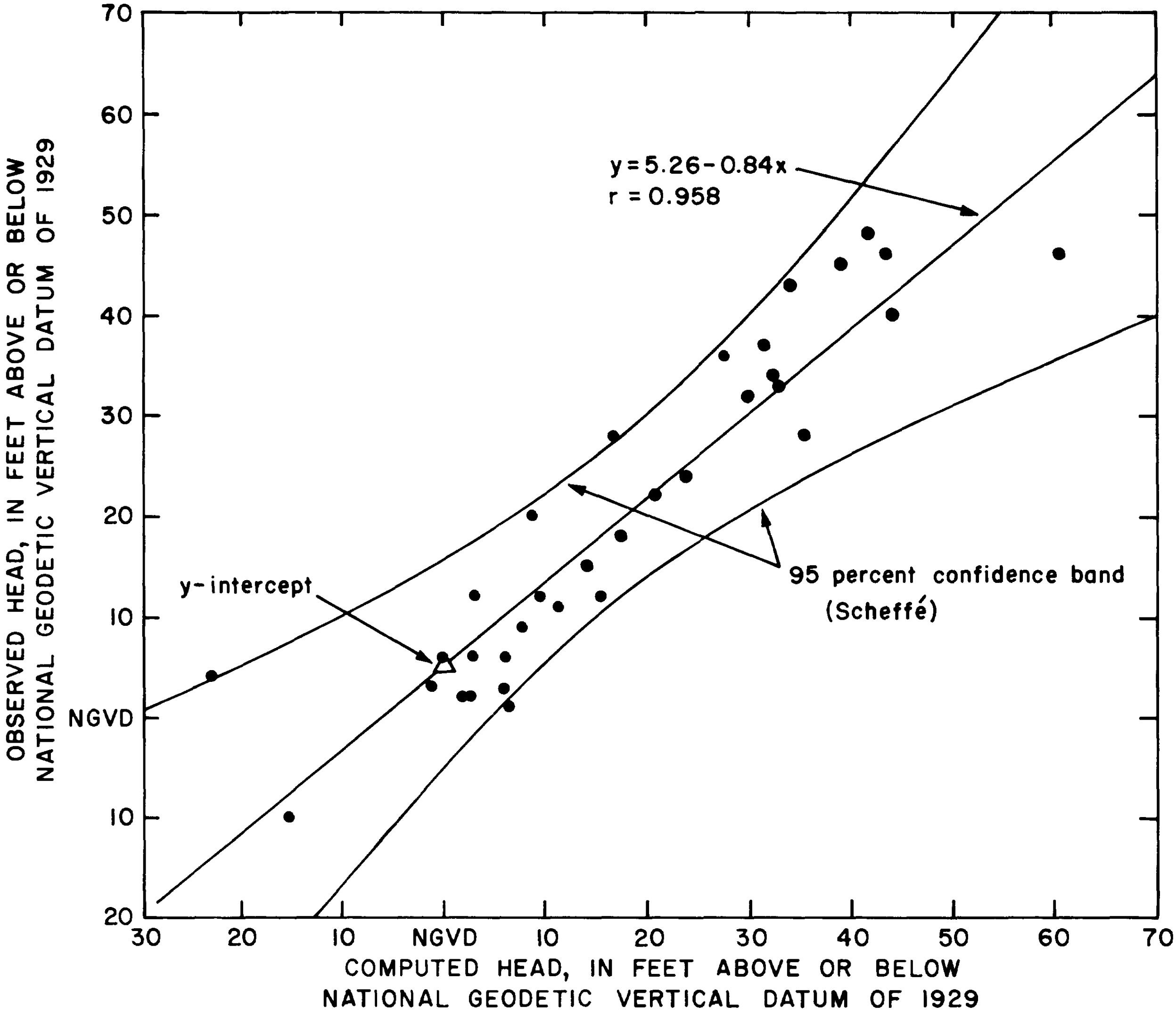

Figure 18.--Observed versus calculated head values, regression line, and confidence band for layer 1 for pumping period 5 (January-December 1977).

Figures 19 through 22 show fluctuations in water levels caused by doubling recharge or by decreasing recharge by one half. Figure 19 shows the effect of varying recharge on heads in layer 1 along row 9. Figure 20 shows the effect on heads in layer 2 along row 9. In this figure, nodes 19 and 20 go dry under decreased recharge. Figure 21 shows the effect of varying recharge on heads in layer 1 along column 7. Figure 22 shows the effect on heads in layer 2 along column 7. Figures 21 and 22 show water levels above ground surface in some areas, under an increased recharge rate.

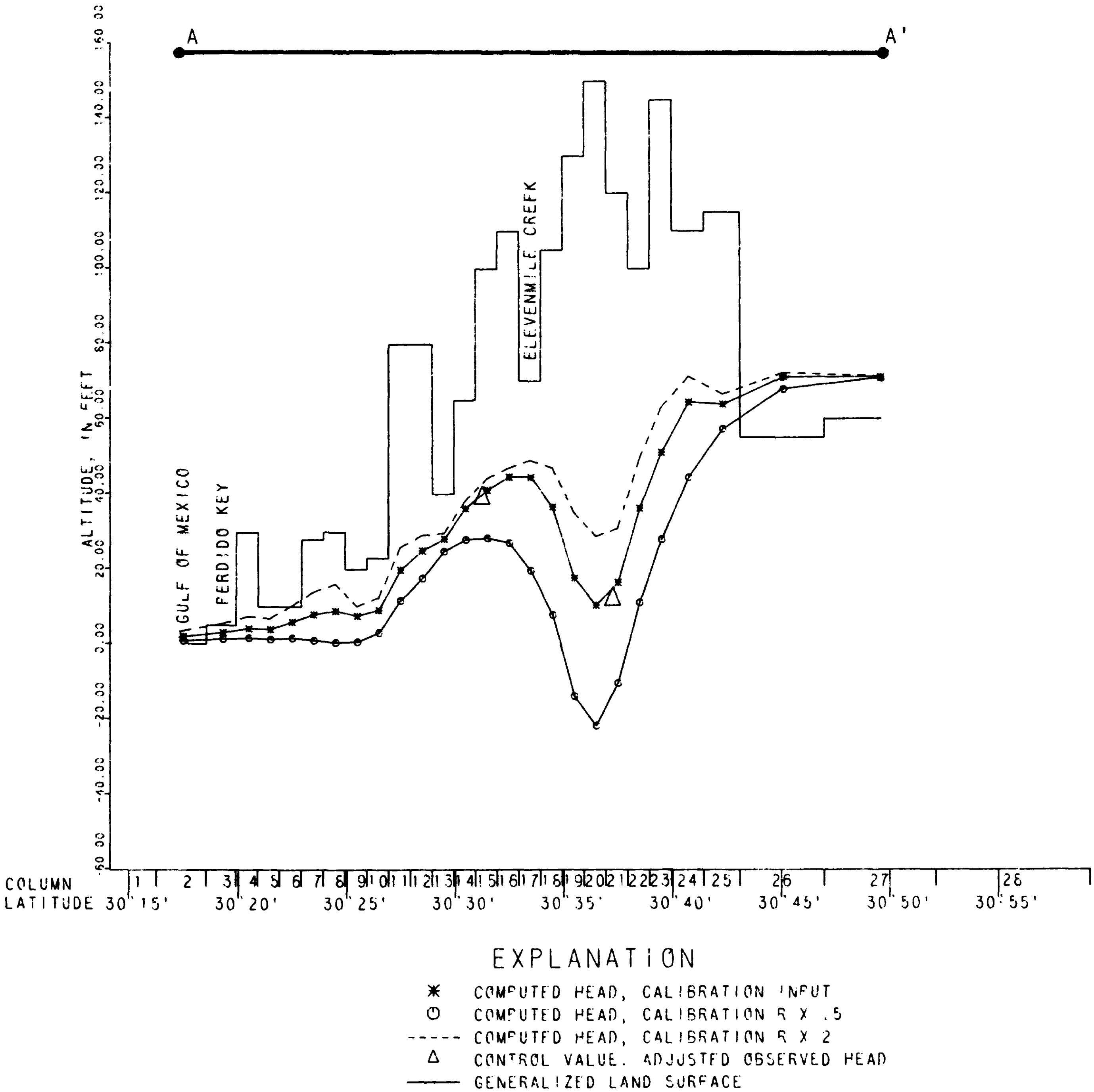

Figure 19.--Effect of varying recharge on heads in layer 1 along row 9.

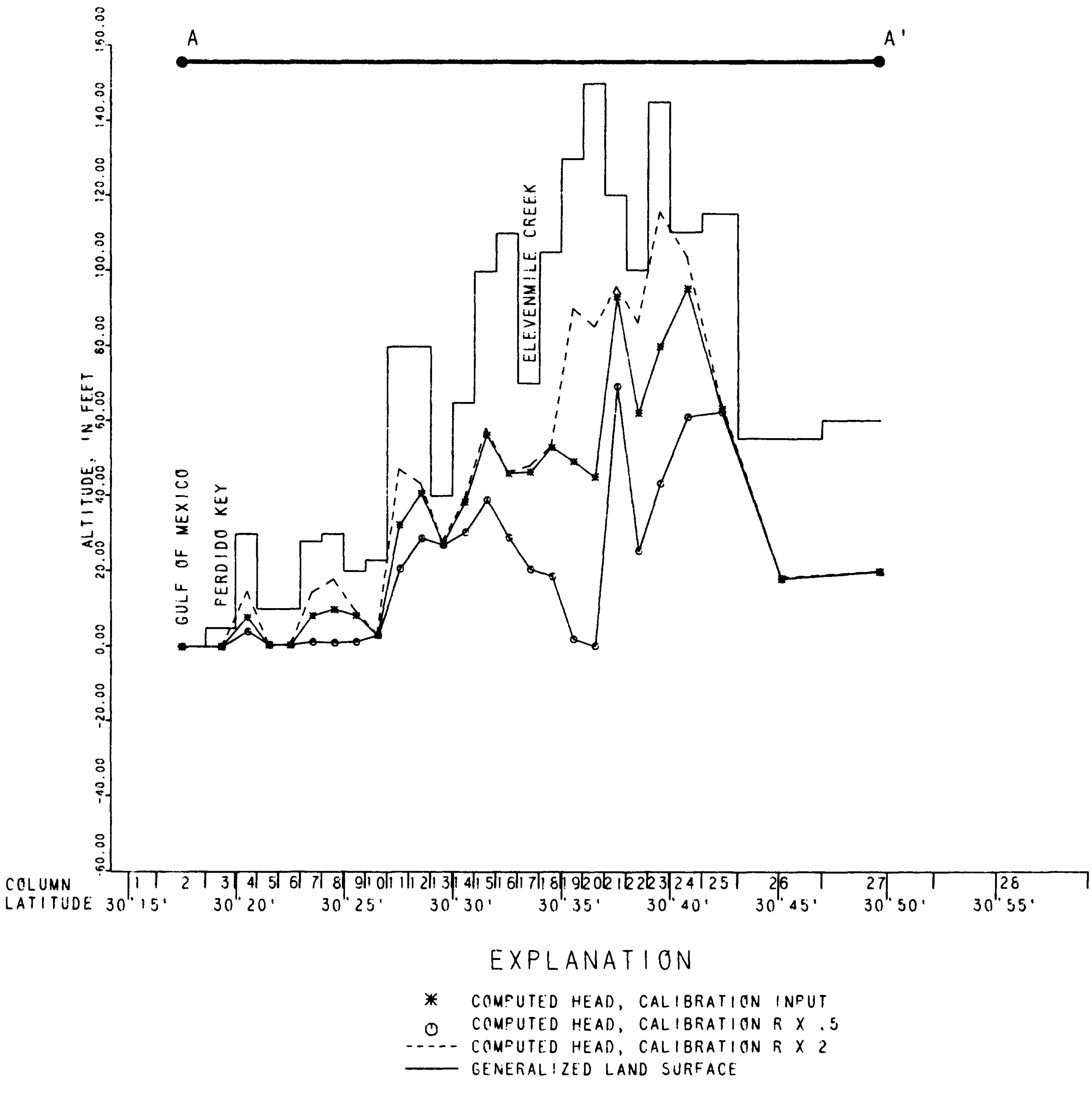

Figure 20.--Effect of varying recharge on heads in layer 2 along row 9.

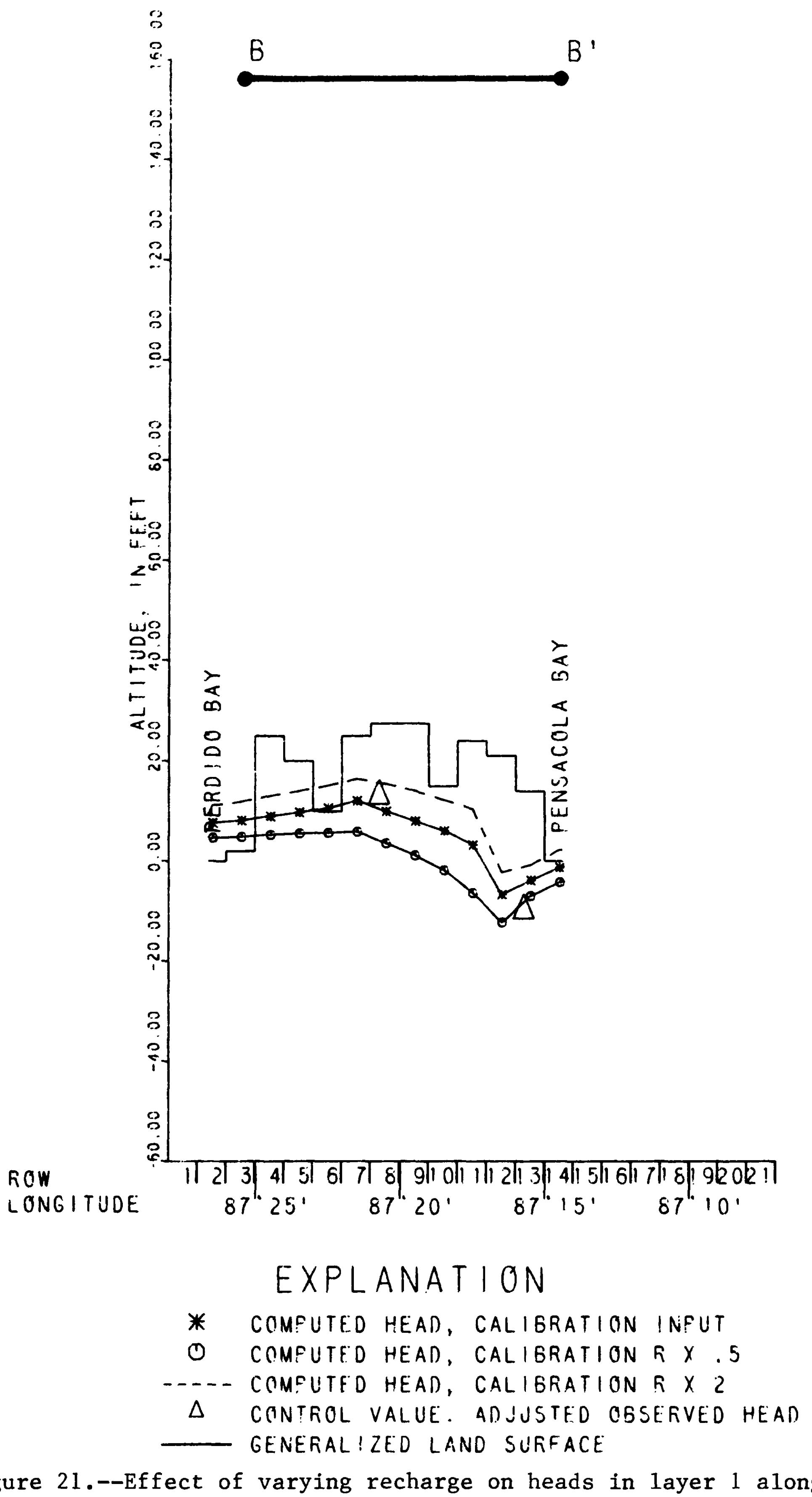

Figure 21.--Effect of varying recharge on heads in layer 1 along row 7.

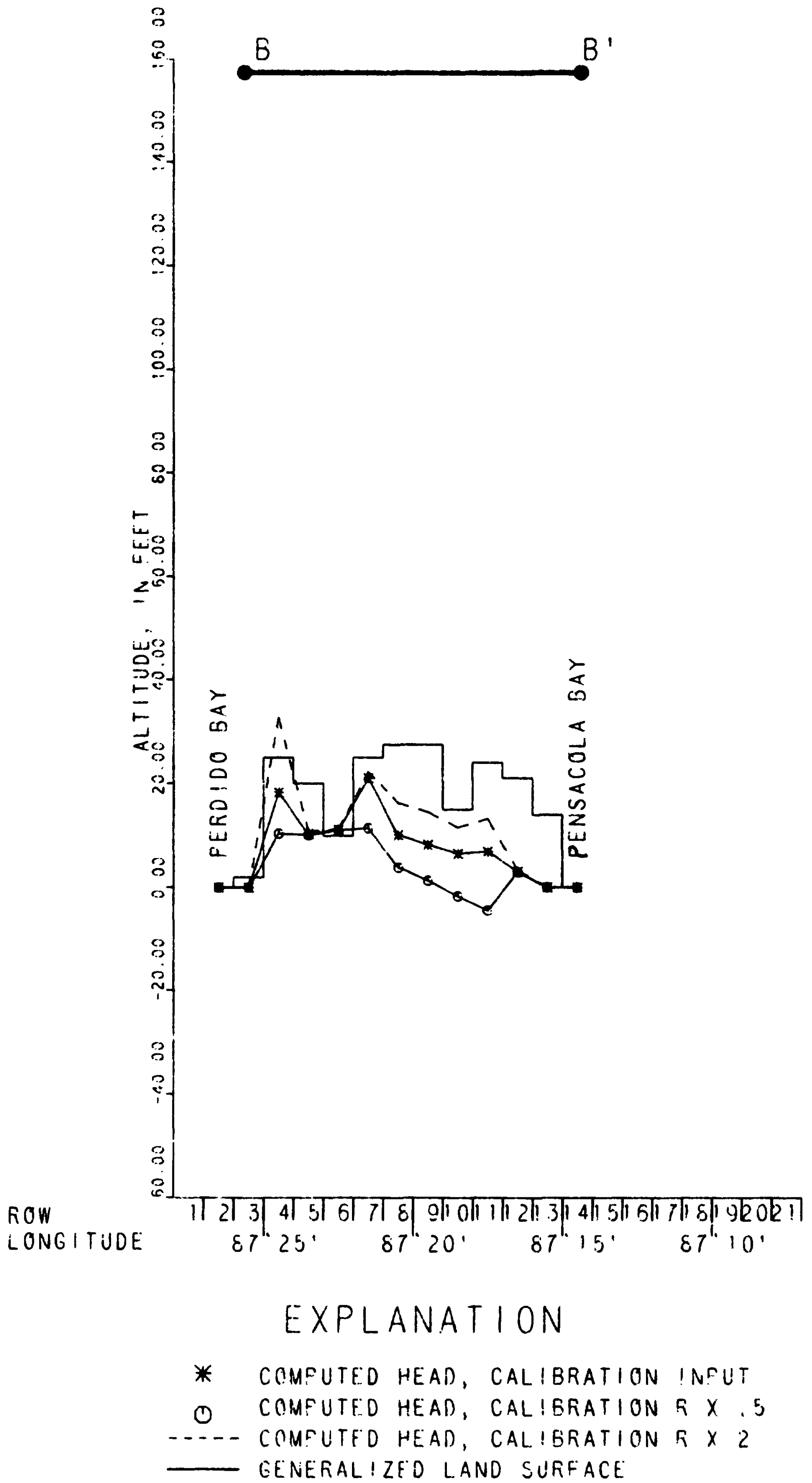

Figure 22.--Effect of varying recharge on heads in layer 2 along row 7.

Model Sensitivity to Changes in Boundaries

Testing indicated that the model, over most of its area, is not very sensitive to the limited extension of the eastern and western no-flow boundaries, either with or without simulated pumping, at least for present rates and patterns of pumping.

The test procedure included extending matrix values of transmissivity of layer 1, TK, hydraulic conductivity of layer 2, and altitude of the bottom of layer 2 to the outermost row and column of the grid. In layer 2, the northern constant-head boundary was extended eastward and additional constant-head nodes were added to simulate sea level at Escambia Bay. The simulation of river drainage was not extended into the previously unmodeled areas, but recharge to these areas was adjusted during trial no-pumping model runs until heads in layer 2 roughly approximated the water table, as estimated from topography. The water table thus generated was too high in many of the nodes representing the lowlands along the Escambia and Perdido Rivers and probably too low in many of the nodes representing the highlands, but further refinement would have required changing other parameters, for which data were lacking. Another reason for not continuing to improve the fit of the simulated water table to the topography was that the trial process had already shown that the head in the original modeled area did not change much in response to changes in water table in the extended areas.

In addition to the no-pumping case (pumping period 1), the sensitivity of the model to expanding the no-flow boundaries was tested for the conditions of pumping period 5 (representing 1977), and also pumping period 5 with the addition of two hypothetical pumping nodes outside the original modeled area: 1.1 ft^3/s at node 2,8 and 11.3 ft^3/s at 20,19.

The three sensitivity runs showed that from 2 to 8 nodes in layer 1 in the original model area changed 10 feet or more as compared to the final head of the corresponding calibration run, the maximum change being an increase of 21 feet. About half of these nodes were outside the area of principal interest. Most of them immediately adjoined the eastern no-flow boundary; the others were the second node from the boundary. Most of the other nodes had head changes of 3 feet or less; many had no change. The changes were predominantly increases in head. The run with no pumping showed the greatest change, and the run with the outside pumping nodes changed the least. In all the runs, none of the nodes in layer 2 had head changes exceeding 10 feet; most changed 1 foot or less.

The sensitivity analysis showed that the east and west no-flow boundaries affect simulated heads in layer 1 of the model, but that the effect is moderate, at least for present rates and patterns of pumping, and largely concentrated in the nodes immediately adjoining the eastern no-flow boundary. The extent of sensitivity testing of the west boundary was limited because only 1 to 4 nodes were available along each column on the existing grid to expand the western boundary. The areas of greatest concern for boundary effects are to the east and west of the St. Regis pumping near Cantonment during the 1958, 1972, and 1977 simulations. If the model is used for predictive runs, additional pumping near the boundaries may result in larger errors, at least locally. The results of the sensitivity testing suggest that model boundaries are reasonable, but better simulations could be achieved by expanding both the east and west boundaries.

FURTHER DEVELOPMENT OF THE MODEL

Storage Coefficients

The present model is suitable only for steady-state simulations. For transient-state simulations (those involving the effects of stresses before steady state is reached), storage-coefficient values must be added. Aquifer tests have indicated a storage coefficient of about $6x10^{-4}$ for layer 1. Storage coefficients for layer 2, on the other hand, may range anywhere from a confined aquifer value of about $6x10^{-4}$ to an unconfined clean-sand storage coefficient of as much as 0.3.

A drought period with no ground-water recharge would provide the best opportunity to estimate storage coefficient. Under these conditions, various values of storage coefficient and computed ground-water-level recessions may be compared to observed recessions. Use of a drought period eliminates the need to estimate recharge.

Refinement and Expansion of Grid

Heads would be better defined, and comparison of measured to calculated heads could be more precise, if the model grid were finer in the area of interest. The existing grid rectangles could be subdivided into quarters in part of the grid. New input matrices would be required, but they could be coded easily in most cases by repeating the present node values. In order to obtain full benefit from increased precision after subdividing the grid, the model would require recalibration.

The simulation would be improved in some areas if boundaries were moved to include western Santa Rosa County; eastern Baldwin County, Alabama; and northern Escambia County. Although well and test-hole data have been collected covering parts of this expanded area, some additional data collection would be required.

Infiltration Basins

Infiltration basins have been developed for surface drainage around Pensacola by minor modifications to existing natural topography and abandoned sand and clay pits. This is a convenient way of disposing of excess storm water. The basins locally concentrate and increase recharge and affect the water budget and distribution of heads. Infiltration basins are not considered in the existing model, but could be simulated as: (1) recharge wells in layer 2, (2) locally increased recharge (QRE matrix), or (3) as rivers. Only recharge wells would be time-dependent, but a constant recharge rate would have to be estimated and applied for a whole pumping period. The effect of a constant head over a small area could be simulated with the RIVERS option, with the rate and direction of flow depending on the position of the head in layer 2.

Simulation of Streams

The present model treats most stream nodes so that they can receive discharge from layer 2 if the head in layer 2 is above the river water level RH(NRIV), but cannot recharge the aquifer, because they have zero water depth:

altitude of river bottom RB(NRIV) is set equal to the altitude of river water level, RH(NRIV). Streams that gain water under natural conditions may either cease to flow or lose water where they overlie cones of depression produced by pumping wells. If the water table is drawn down below the stream level, the stream will no longer receive discharge from the aquifer and may cease flowing (except for storms) unless sufficient streamflow is available from upstream to maintain it. If this occurs, such a stream will then recharge the aquifer. These streams might be simulated better by coding the altitude of the river bottom below the water level.

Elevenmile Creek was treated in the same manner as other creeks in the model, with the altitude of the bottom set equal to the water level over most of its length, using the RIVERS option. Its discharge, however, does not represent natural conditions; it carries large volumes of treated industrial wastewater that originated as ground water pumped from layer 1 around Cantonment. Its upper reaches consist of a series of settling basins for treatment of the wastewater. Refinement of the model may require further study of this stream and its effect on recharge.

SUMMARY AND CONCLUSIONS

- A two-layer three-dimensional digital model has been applied to the sand-and-gravel aquifer in Escambia County with certain simplifying assumptions. The principal assumption is that all large-capacity wells in central and southern Escambia County tap a single, continuous traceable zone within the aquifer (the main-producing zone) that can be treated as a discrete, leaky confined aquifer (layer 1). Layer 2 represents the overlying remainder of the aquifer, which includes discontinuous unconfined, leaky confined, perched, and confining zones. The two layers are hydraulically coupled in the model by a leakance (TK) matrix, in which storage and horizontal flow in the discontinuous confining beds are assumed to be negligible.

- Flow in layer 2 results from: (a) recharge that represents precipitation less direct runoff and evapotranspiration, (b) constant-head nodes, (c) upward leakage from layer 1, and (d), under stress, from rivers. Flow is discharged to layer 1, to constant-head nodes, and to rivers.

- Flow in layer 1 results from vertical leakage from layer 2 and from constant-head nodes. Flow is discharged into layer 2, into wells, and into constant-head nodes.

- Storage coefficients were set at zero for the present version of the model; thus, it is designed for steady-state simulations only. This modeling technique is justified because steady-state conditions have been approached within a few days in aquifer tests on layer 1 because of leakage.

- The model was calibrated originally for natural, prepumping conditions. It was then recalibrated for stress representing average pumping for 1972.

- The model was tested by simulations of pumping for 1939-40, 1958, and 1977. Computed water levels fit observed data about as well as for 1972 average pumping. The model can now be used for prediction of the effects of future pumping where steady-state conditions are reached. If applied to a situation in which steady-state conditions were not reached, the model would tend to predict drawdowns greater than those observed. For maximum accuracy, simulated pumping should not greatly exceed existing rates, should be restricted to areas of the model for which there are adequate data, and should not be located in nodes adjoining no-flow or constant-head boundaries in layer 1.

- Sensitivity analysis shows that, with no storage, heads in both layers respond readily to changes in the rate of recharge. After recharge, layer 1 is most sensitive to changes in TK, its own transmissivity, and horizontal hydraulic conductivity of layer 2, in that order; and after recharge, layer 2 is most sensitive to its own horizontal conductivity, followed by changes in TK. Neither layer was very sensitive to changes in river-bed leakance.

- Over most of its area, the model is not very sensitive to the eastern and western no-flow boundaries with present rates and patterns of pumping. Nodes along the eastern boundary show moderate sensitivity to its presence.

- In the further development and refinement of the model, a change to a finer grid and expansion of the grid to cover all of Escambia County and adjoining parts of Baldwin County, Alabama, and Santa Rosa County should be considered.

- Although control is lacking for storage coefficients for layer 2, values could be derived empirically by trial-and-error simulation of an actual drought period. The addition of storage-coefficient matrices would permit use of the model for transient simulations.

- Additional stream data should be collected and studied for the model. More extensive base-runoff data could be used to refine the values used for the recharge matrix and total stream discharge. The behavior of streams crossing cones of depression should be investigated. Elevenmile Creek has been treated as a normal stream in the model, although it is a wastewater-discharge channel.

- The effects of present and future infiltration basins should be considered in further development of the model.

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GLOSSARY

Aquifer.--A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Aquifer test.--The quantitative determination of the hydraulic properties of an aquifer by the analysis of data from a field experiment. Typically, a well is pumped at a carefully controlled rate and the resulting changes in head in it and nearby observation wells are noted. The data are then used to calculate properties such as transmissivity, storage coefficient, and leakance.

Base runoff.--Sustained flow in a stream, composed largely of ground-water discharge. Unit base runoff is the rate of base runoff per unit drainage area.

Calibration (of a model).--The adjustment of model parameters to obtain "best fit" of model simulations to a set of observations of prototype behavior.

Carbon-14 dating.--A measurement of the age of a carbon-bearing substance by determining the ratio of the concentration of the radioactive isotope of carbon with atomic weight 14 to the concentration of carbon 12. Carbon 14 is produced by collisions between neutrons and atmospheric nitrogen and forms a small part of living bodies. It decays to nitrogen at a constant rate. The method is useful in determining the age of material younger than 30,000 years.

Cone of depression.--The depression produced in the water table or other potentiometric surface by the withdrawal of water from one or more wells. If the aquifer is nearly uniform in shape or texture in the vicinity of the well, this depression has somewhat the form of an inverted cone whose apex is at the water level in the well while discharge is in progress, whose height is equal to the drawdown, and whose base is the original water table or other potentiometric surface within the area of influence.

Confidence interval, confidence band.--A confidence interval is a group of adjacent values which tends to include the true value of a statistical parameter a predetermined percentage of the time. A confidence band surrounds a regression line to show the range of possible positions of the line at a given confidence interval.

Confined, confined aquifer, confined conditions.--Confined is synonymous with artesian. A confined aquifer is bounded by one or more confining beds. An artesian well is a well deriving its water from an artesian or confined aquifer. The water level in an artesian well stands above the top of the confined aquifer that the well taps. Confined conditions and confinement refer to the characteristic behavior of confined aquifers.

Confining bed.--A body of relatively impermeable material stratigraphically adjacent to one or more aquifers. The hydraulic conductivity may range from nearly zero to some value distinctly lower than that of the aquifer.

Constant-head node.--An imaginary point on a model grid at which the head is assigned a value that is not allowed to change during the computational process.

Correlation coefficient (r).--"An index of the degree of magnitude of linear relationship between two variables. The maximum positive relationship is indicated by a value of +1.00, absence of relationship yields r = 0.00, and a maximum negative (inverse) relationship provides a value of -1.00" (taken from Brewer, J. K., 1978, "Everything you always wanted to know about statistics but didn't know how to ask").

Dampening factor.--A value in the numerical approximations of a digital model which controls the rate of convergence (attainment of a numerical approximation).

Digital model.--The mathematical simulation of a real or hypothetical system by a series of numerical approximations. A computer is used in the application of all but the simplest digital models.

Discharge.--Outflow; can be applied to describe the flow of water from a pipe or from a drainage basin.

Drainage area.--That area, measured in a horizontal plane, which is enclosed by a topographic divide such that direct surface runoff from precipitation normally would drain by gravity into the drainage basin.

Drawdown (of a well from which water is being discharged).--The lowering of the water level or the equivalent reduction of pressure of the water in the well caused by withdrawal of water. The term is also applied to the lowering of water levels or pressures in other wells or in the area affected by the discharging well.

In the model output, drawdown refers to change in head from starting position after a particular time step or pumping period. Positive numbers indicate lowering of head; negative numbers indicate a rise.

Error criterion.--In the aquifer-model program used in this study, the specified maximum change in head at any node from one iteration to the next for an acceptable degree of convergence (attainment of a numerical approximation).

Evaporation.--The process by which water is changed from the liquid or solid state into the vapor state. In hydrology, evaporation is vaporization that takes place at a temperature below the boiling point.

Evapotranspiration.--Water withdrawn from a land area by evaporation from water surfaces and moist soil and plant transpiration.

Geophysical log.--A graphic representation, obtained by the lowering of a sensing device into a hole, that can be interpreted in terms of the characteristics of the geologic formations and their contained fluids.

Gradient.--Change in the value of a quantity per unit distance in a specified direction.

Harmonic mean.--The reciprocal of the arithmetic mean of the reciprocals of a finite series of numbers.

Head (hydraulic head).--The height above a standard datum of the surface of a column of water (or other liquid) that can be supported by the static pressure at a given point. The total head of a liquid at a given point is the sum of three components: (1) elevation head, equal to the elevation of the point above the datum, (2) pressure head, the height of a column of static water that can be supported by the static pressure at the point, (3) velocity head, which is the height to which the kinetic energy of the water is capable of lifting the water. Under usual conditions of ground-water flow, the velocity head is negligible.

Hydraulic conductivity.--A measure of the capacity of a material to transmit water. The hydraulic conductivity of a medium is the volume of water at the existing viscosity that will move in unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow.

Hydrograph.--A graph showing stage, flow, velocity, or other property of water with respect to time.

Isotropic.--That condition in which all significant properties are independent of direction.

Iteration, iteration parameter.--Iteration is a computational procedure in which replication of a cycle of operations produces improved estimates of the solution. In the digital model used in this study, iteration parameters control the process of iteration.

Leakance.--The ratio of the vertical hydraulic conductivity of a confining bed to its thickness.

Leaky confined aquifer, leaky confined conditions.--A confined aquifer that receives a significant inflow from adjacent beds. This occurrence constitutes leaky confined conditions.

Lithologic log.--A written or graphic representation of the rock materials penetrated in the drilling of a well.

Mass balance.--In adherence to the Laws of Conservation of Mass and Energy, water cannot be "lost" in the system; therefore, the rate of inflow must equal the rate of outflow. (Mass must be "in balance.") In the output of the digital model used in this study, mass balance refers to a listing of rates and cumulative totals of inflow and outflow of water from various sources and to various sinks, and the difference between calculated inflow and outflow.

Neutron log.--A graphic representation of the variation of gamma radiation with depth induced by a neutron source as it is moved up or down a well or borehole. The gamma radiation so induced is related to the hydrogen content (and therefore water-saturated porosity) of the rock.

Node.--An imaginary point on a digital model grid at which input parameter values are assigned and output values are calculated.

Observation well.--A well in which repeated or continuous measurements are made of some variable, most commonly water level, or a well used for repeated sampling of ground water.

Parameter.--Any of a set of variables whose values determine the characteristics or behavior of a system.

Partially penetrating drain.--A linear channel cut part way into an aquifer so that it serves as a sink or elongated discharge area.

Perched ground-water zone, perched water table.--Unconfined ground water separated from an underlying body of ground water by an unsaturated zone. Its water table is a perched water table.

Permeability.--A measure of the ability of a rock or soil to transmit a fluid, such as water, under a potential gradient. Permeability is a property of the medium alone and is independent of the nature or properties of the fluid.

Potentiometric surface.--An imaginary surface defined by the levels to which water would rise in tightly cased wells penetrating the same aquifer.

Recharge.--"The entry into the saturated zone of water made available at the water-table surface, together with the associated flow away from the water table within the saturated zone" (Freeze and Cherry, 1979, p. 211).

Regression, regression line.--A functional relation between two or more correlated variables which is often empirically determined from data. If the relation between two variables may be expressed by a straight line, the line is a regression line and the regression is linear.

Runoff.--That part of the precipitation which appears in surface streams.

Runoff in inches.--The depth, in inches, to which the drainage area would be covered if all the runoff for a given time period were uniformly distributed on it.

Saturated zone.--Part of the Earth's crust beneath the deepest water table in which all voids, large and small, are ideally filled with water under pressure greater than atmospheric.

Sensitivity analysis.--A test of the effects on the output of a model of varying each input parameter while keeping other parameters constant.

Specific capacity.--The specific capacity of a well is the rate of discharge of water from the well divided by the drawdown of water level within the well. It varies slowly with duration of discharge, which should be stated when known.

Steady-state.--"Occurs when at any point in a flow field, the magnitude and direction of the flow velocity are constant with time" (taken from Freeze and Cherry, 1979, "Groundwater").

Storage coefficient.--The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head.

Three-dimensional model.--A model used to simulate both vertical and horizontal ground-water flow.

Transmissivity.--The rate at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient. It is equal to the average hydraulic conductivity of the aquifer multiplied by its thickness. In this report, transmissivity is expressed in units of ft^2/d (feet squared per day). Transmissivity was formerly called the coefficient of transmissibility, and expressed in (gal/d)/ft (gallons per day per foot). Values expressed in the old units can be converted to the new units by dividing by 7.48.

Transpiration.--The quantity of water absorbed, transpired, and used directly in the building of plant tissue in a specified time. It is the process by which water vapor escapes from the living plant, principally the leaves, and enters the atmosphere. It does not include evaporation.

Two-dimensional aquifer model.--A model in which the ground-water flow system is simulated by a single layer having length and width or, alternately, by a section having height and width.

Unconfined zone.--An aquifer or part of an aquifer that has a water table.

Unsaturated zone.--The zone between the land surface and the deepest water table.

Water table.--That surface in a ground-water body at which the water pressure is atmospheric. It is defined by the levels at which water stands in wells that penetrate the water body just far enough to hold standing water.

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C     ------------------------------------------------------------------
C     FINITE-DIFFERENCE MODEL FOR SIMULATION OF GROUND-WATER FLOW IN
C     THREE DIMENSIONS, SEPTEMBER, 1975 BY P.C. TRESCOTT, U. S. G. S.
C     WITH CONTRIBUTIONS TO MAIN, DATAI AND SOLVE BY S.P. LARSON
C     ------------------------------------------------------------------
C
C     SPECIFICATIONS:
      REAL *8YSTR
C
      DIMENSION Y(060000), L(32), HEADNG(33), NAME(42), INFT(2,2), IOFT(
     19,4), DUM(3)
C
      EQUIVALENCE (YSTR,Y(1))
C
      COMMON /INTEGR/ I0,J0,K0,I1,J1,K1,I,J,K,NPER,KTH,ITMAX,LENGTH,KP,N
     1WEL,NUMT,IFINAL,IT,KT,IHEAD,IDRAW,IFLO,IERR,I2,J2,K2,IMAX,ITMX1,NC
     2H,IDK1,IDK2,IWATER,IQRE,IP,JP,IQ,JQ,IK,JK,K5,IPU1,IPU2,ITK
      COMMON /SPARAM/ TMAX,CDLT,DELT,ERR,TEST,SUM,SUMP,QR,IOK
      COMMON /SARRAY/ ICHK(13),LEVEL1(9),LEVEL2(9)
C
      DATA NAME/2*4H    ,4H   S,4HTART,4HING ,4HHEAD,4H    ,4H STO,4HRAG
     1E,4H COE,4HFFIC,4HIENT,2*4H    ,4H  TR,4HANSM,4HISSI,4HVITY,5*4H
     2    ,4H  TK,4H  HY,4HDRAU,4HLIC ,4HCOND,4HUCTI,4HVITY,2*4H    ,4HBOT
     3T,4HOM E,4HLEVA,4HTION,2*4H    ,4H   R,4HECHA,4HRGE ,4HRATE/
      DATA INFT/4H(20F,4H4.0),4H(8F1,4H0.4)/
      DATA IOFT/4H(1H0,4H,I2,,4H2X,2,4H0F6.,4H1/(5,4HX,20,4HF6.1,4H)),
     14H    ,4H(1H0,4H,I5,,4H14F9,4H.5/(,4H1H ,,4H5X,1,4H4F9.,4H5)) ,4H
     2    ,4H(1H0,4H,I5,,4H10F1,4H2.5/,4H(1H ,4H,5X,,4H10E1,4H2.5),4H)
     3,4H(1H0,4H,I5,,4H10E1,4H1.3/,4H(1H ,4H,5X,,4H10E1,4H1.3),4H)   /
C
      DEFINE FILE 2(8,1520,U,KKK)
C     ..................................................................
C
C     ---READ TITLE, PROGRAM SIZE AND OPTIONS---
    5 READ(5,200) HEADNG
      WRITE (6,190) HEADNG
      READ (5,160) I0,J0,K0,ITMAX,NCH,ND,NRIV,IOK
      WRITE (6,180) I0,J0,K0,ITMAX,NCH,ND,NRIV
      READ (5,210) IDRAW,IHEAD,IFLO,IDK1,IDK2,IWATER,IQRE,IPU1,IPU2,ITK
     1,IEQN
      WRITE (6,220) IDRAW,IHEAD,IFLO,IDK1,IDK2,IWATER,IQRE,IPU1,IPU2,ITK
     1,IEQN
      IERR=0
C
C     ---COMPUTE DIMENSIONS FOR ARRAYS---
      J1=J0-1
      I1=I0-1
      K1=K0-1
      I2=I0-2
      J2=J0-2
      K2=K0-2
      IMAX=MAX0(I0,J0)
      NCD=MAX0(1,NCH)
      ITMX1=ITMAX+1
      ISIZ=I0*J0*K0
      IK1=I0*J0
      IK2=MAX0(IK1*K1,1)
      ISUM=2*ISIZ+1
      L(1)=1
      DO 30 I=2,14
      IF (I.NE.8) GO TO 20
```

```
      L(8)=ISUM
      ISUM=ISUM+IK2
      IF (IK2.EQ.1) GO TO 10
      IK=I0
      JK=J0
      K5=K1
      GO TO 30
   10 IK=1
      JK=1
      K5=1
      GO TO 30
   20 L(I)=ISUM
      ISUM=ISUM+ISIZ
   30 CONTINUE
      L(15)=ISUM
      ISUM=ISUM+J0
      L(16)=ISUM
      ISUM=ISUM+I0
      L(17)=ISUM
      ISUM=ISUM+K0
      L(18)=ISUM
      ISUM=ISUM+IMAX
      L(19)=ISUM
      ISUM=ISUM+K0*3
      L(20)=ISUM
      ISUM=ISUM+ITMX1
      L(21)=ISUM
      ISUM=ISUM+3*NCD
      L(22)=ISUM
      ISUM=ISUM+NCD
      L(23)=ISUM
      IF (IWATER.NE.ICHK(6)) GO TO 40
      ISUM=ISUM+IK1
      L(24)=ISUM
      ISUM=ISUM+IK1
      IP=I0
      JP=J0
      GO TO 50
   40 ISUM=ISUM+1
      L(24)=ISUM
      ISUM=ISUM+1
      IP=1
      JP=1
   50 L(25)=ISUM
      IF (IQRE.NE.ICHK(7)) GO TO 60
      ISUM=ISUM+IK1
      IQ=I0
      JQ=J0
      GO TO 70
   60 ISUM=ISUM+1
      IQ=1
      JQ=1
   70 IF(ND.EQ.0) GO TO 75
      L(26)=ISUM
      ISUM=ISUM+IK1
      L(27)=ISUM
      ISUM=ISUM+ND
      L(28)=ISUM
      ISUM=ISUM+ND
      GO TO 76
   75 L(26)=ISUM
```

```
      ISUM=ISUM+1
      L(27)=ISUM
      ISUM=ISUM+1
      L(28)=ISUM
      ISUM=ISUM+1
   76 IF(NRIV.EQ.0) GO TO 77
      L(29)=ISUM
      ISUM=ISUM+IK1
      L(30)=ISUM
      ISUM=ISUM+NRIV
      L(31)=ISUM
      ISUM=ISUM+NRIV
      L(32)=ISUM
      ISUM=ISUM+NRIV
      GO TO 78
   77 L(29)=ISUM
      L(30)=ISUM+1
      L(31)=ISUM+2
      L(32)=ISUM+3
      ISUM=ISUM+4
   78 WRITE(6,170) ISUM
C                                                                       MAN1130
C     ---PASS INITIAL ADDRESSES OF ARRAYS TO SUBROUTINES---             MAN1140
      CALL DATAI(Y(L(1)),Y(L(2)),Y(L(3)),Y(L(4)),Y(L(5)),Y(L(6)),Y(L(7))MAN1150
     1,Y(L(8)),Y(L(9)),Y(L(15)),Y(L(16)),Y(L(17)),Y(L(19)),Y(L(23)),Y(L(MAN1160
     224)),Y(L(25)),Y(L(26)),Y(L(27)),Y(L(28)),Y(L(29)),Y(L(30)),
     3 Y(L(31)),Y(L(32)))
      CALL STEP(Y(L(1)),Y(L(2)),Y(L(3)),Y(L(4)),Y(L(5)),Y(L(6)),Y(L(7)),MAN1180
     1Y(L(8)),Y(L(9)),Y(L(15)),Y(L(16)),Y(L(17)),Y(L(19)),Y(L(18)),Y(L(2MAN1190
     20)))                                                              MAN1200
      CALL SOLVF(Y(L(1)),Y(L(2)),Y(L(3)),Y(L(4)),Y(L(5)),Y(L(6)),Y(L(7))MAN1210
     1,Y(L(8)),Y(L(9)),Y(L(15)),Y(L(16)),Y(L(17)),Y(L(19)),Y(L(10)),Y(L(MAN1220
     211)),Y(L(12)),Y(L(13)),Y(L(14)),Y(L(20)),Y(L(25)),Y(L(23)),
     3 Y(L(26)),Y(L(27)),Y(L(28)),Y(L(29)),Y(L(30)),Y(L(31)),Y(L(32)),
     4 ND,NRIV)
      CALL COEF(Y(L(1)),Y(L(2)),Y(L(3)),Y(L(4)),Y(L(5)),Y(L(6)),Y(L(7)),MAN1240
     1Y(L(8)),Y(L(9)),Y(L(15)),Y(L(16)),Y(L(17)),Y(L(19)),Y(L(23)),Y(L(2MAN1250
     24)),Y(L(25)))                                                     MAN1260
      CALL CHECKI(Y(L(1)),Y(L(2)),Y(L(3)),Y(L(4)),Y(L(5)),Y(L(6)),Y(L(7)MAN1270
     1),Y(L(8)),Y(L(9)),Y(L(15)),Y(L(16)),Y(L(17)),Y(L(19)),Y(L(21)),Y(LMAN1280
     2(22)),Y(L(25)),                                                   MAN1290
     3 Y(L(26)),Y(L(27)),Y(L(28)),Y(L(29)),Y(L(30)),Y(L(31)),Y(L(32)),
     4 ND,NRIV)
      CALL PRNTAI(Y(L(1)),Y(L(2)),Y(L(4)),Y(L(5)),Y(L(9)),Y(L(15)),Y(L(1MAN1300
     16)))                                                              MAN1310
C                                                                       MAN1320
C     ---START COMPUTATIONS---                                          MAN1330
C     ************************                                          MAN1340
C     ---READ AND WRITE DATA FOR GROUPS II AND III---                   MAN1350
      CALL DATAIN                                                       MAN1360
      IRN=1                                                             MAN1370
      NIJ=I0*J0                                                         MAN1380
      DO 80 K=1,K0                                                      MAN1390
      LOC=L(2)+(K-1)*NIJ                                                MAN1400
   80 CALL ARRAY(Y(LOC),INFT(1,2),IOFT(1,1),NAMF(1),IRN,DUM)            MAN1410
      DO 90 K=1,K0                                                      MAN1420
      LOC=L(5)+(K-1)*NIJ                                                MAN1430
   90 CALL ARRAY(Y(LOC),INFT(1,1),IOFT(1,2),NAMF(7),IRN,DUM)            MAN1440
      DO 100 K=1,K0                                                     MAN1450
      LOC=L(4)+(K-1)*NIJ                                                MAN1460
      L1=L(19)+K-1                                                      MAN1470
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```
      L2=L(19)+K0+K-1                                                   MAN1480
      L3=L(19)+2*K0+K-1                                                 MAN1490
      CALL ARRAY(Y(LOC),INFT(1,1),IOFT(1,2),NAME(13),IRN,DUM)           MAN1500
      Y(L1)=DUM(1)                                                      MAN1510
      Y(L2)=DUM(2)                                                      MAN1520
      Y(L3)=DUM(3)                                                      MAN1530
  100 WRITE (6,230) K,Y(L1),Y(L2),Y(L3)                                 MAN1540
      IF (ITK.NE.ICHK(10)) GO TO 120                                    MAN1550
      DO 110 K=1,K1                                                     MAN1560
      LOC=L(8)+(K-1)*NIJ                                                MAN1570
  110 CALL ARRAY(Y(LOC),INFT(1,1),IOFT(1,3),NAME(19),IRN,DUM)           MAN1580
  120 IF (IWATER.NE.ICHK(6)) GO TO 130                                  MAN1590
      K=K0                                                               MAN1595
      CALL ARRAY(Y(L(23)),INFT(1,1),IOFT(1,4),NAME(25),IRN,DUM)         MAN1600
      CALL ARRAY(Y(L(24)),INFT(1,1),IOFT(1,1),NAME(31),IRN,DUM)         MAN1610
  130 IF (IQRE.EQ.ICHK(7)) CALL ARRAY(Y(L(25)),INFT(1,1),IOFT(1,4),NAME(MAN1620
     137),IRN,DUM)                                                      MAN1630
      CALL MDAT                                                         MAN1640
      IF(ND.NE.0) CALL DDAT(ND)
      IF(NRIV.NE.0) CALL DDAT2(NRIV)
C                                                                       MAN1650
C     ---COMPUTE TRANSMISSIVITY FOR UNCONFINED LAYER---                 MAN1660
      IF (IWATER.EQ.ICHK(6)) CALL TRANS(1)                              MAN1670
C                                                                       MAN1680
C     ---COMPUTE T COEFFICIENTS---                                      MAN1690
      CALL TCOF                                                         MAN1700
C                                                                       MAN1710
C     ---COMPUTE ITERATION PARAMETERS---                                MAN1720
      CALL ITER                                                         MAN1730
C                                                                       MAN1740
C     ---READ TIME PARAMETERS AND PUMPING DATA FOR A NEW PUMPING PERIOD-MAN1750
  140 CALL NEWPER                                                       MAN1760
C                                                                       MAN1770
      KT=0                                                              MAN1780
      IFINAL=0                                                          MAN1790
C                                                                       MAN1800
C     ---START NEW TIME STEP COMPUTATIONS---                            MAN1810
  150 CALL NEWSTP                                                       MAN1820
C                                                                       MAN1830
C     ---START NEW ITERATION IF MAXIMUM NO. ITERATIONS NOT EXCEEDED---  MAN1840
      CALL NEWITA                                                       MAN1850
      IF(IERR.EQ.2)GO TO 151
C                                                                       MAN1860
C     ---PRINT OUTPUT AT DESIGNATED TIME STEPS---                       MAN1870
      CALL OUTPUT                                                       MAN1880
      IF(IERR.EQ.2) GO TO 151
C                                                                       MAN1890
C     ---LAST TIME STEP IN PUMPING PERIOD ?---                          MAN1900
      IF (IFINAL.NE.1) GO TO 150                                        MAN1910
C                                                                       MAN1920
C     ---CHECK FOR NEW PUMPING PERIOD---                                MAN1930
      IF (KP.LT.NPER) GO TO 140                                         MAN1940
C                                                                       MAN1950
C     ---CHECK FOR NEW PROBLEM---
  151 READ(5,160,END=152) NEXT
      IF(NEXT.EQ.0) GO TO 5
  152 STOP
C                                                                       MAN1970
C     ---FORMATS---                                                     MAN1980
C                                                                       MAN1990
C                                                                       MAN2000
```

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C                                                                       MAN2010
  160 FORMAT (8I10)                                                     MAN2020
  170 FORMAT ('0',54X,'WORDS OF VECTOR Y USED =',I7)                    MAN2030
  180 FORMAT ('0',62X,'NUMBER OF ROWS =',I5/60X,'NUMBER OF COLUMNS =',I5MAN2040
     1/61X,'NUMBER OF LAYERS =',I5//39X,'MAXIMUM PERMITTED NUMBER OF ITEMAN2050
     2RATIONS =',I5//48X,'NUMBER OF CONSTANT HEAD NODES =',I5,          MAN2060
     3 /,56X,'NUMBER OF DRAIN NODES =',I5,
     4 /,56X,'NUMBER OF RIVER NODES=',I5)
  190 FORMAT ('1',33A4)                                                 MAN2070
  200 FORMAT (20A4)                                                     MAN2080
  210 FORMAT (16(A4,1X))                                                MAN2090
  220 FORMAT ('-SIMULATION OPTIONS:  ',11(A4,4X))                       MAN2100
  230 FORMAT (1H0,44X,'DIRECTIONAL TRANSMISSIVITY MULTIPLICATION FACTORSMAN2110
     1 FOR LAYER',I3,/,76X,'X =',G15.7/76X,'Y =',G15.7/76X,'Z =',G15.7) MAN2120
      END                                                               MAN2130-
      SUBROUTINE DATAI(PHI,STRT,OLD,T,S,TR,TC,TK,WELL,DELX,DELY,DELZ,FACDAT0010
     1T,PERM,BOTTOM,QRE,ID,LD,ELD,IDR,RH,RC,RB)
C     ------------------------------------------------------------------DAT0030
C     READ AND WRITE DATA                                               DAT0040
C     ---------------------------------------------------------- -------DAT0050
C                                                                       DAT0060
C     SPECIFICATIONS:                                                   DAT0070
      REAL *8PHI                                                        DAT0080
      REAL *8XLABEL,YLABEL,TITLE,XN1,MESUR                              DAT0090
      REAL*4 LD
C                                                                       DAT0100
      DIMENSION PHI(I0,J0,K0), STRT(I0,J0,K0), OLD(I0,J0,K0), T(I0,J0,K0DAT0110
     1), S(I0,J0,K0), TR(I0,J0,K0), TC(I0,J0,K0), TK(IK,JK,K5), WELL(I0,DAT0120
     2J0,K0), DELX(J0), DELY(I0), DELZ(K0), FACT(K0,3), PERM(IP,JP), BOTDAT0130
     3TOM(IP,JP), QRE(IQ,JQ), TF(3), A(I0,J0), IN(6), IOFT(9), INFT(2)  DAT0140
     4 ,ID(I0,J0),LD(1),ELD(1),IDR(I0,J0),RH(1),RC(1),RB(1)
C                                                                       DAT0150
      COMMON /INTEGR/ I0,J0,K0,I1,J1,K1,I,J,K,NPER,KTH,ITMAX,LENGTH,KP,NDAT0160
     1WEL,NUMT,IFINAL,IT,KT,IHEAD,IDRAW,IFLO,IERR,I2,J2,K2,IMAX,ITMX1,NCDAT0170
     2H,IDK1,IDK2,IWATER,IQRE,IP,JP,IQ,JQ,IK,JK,K5,IPU1,IPU2,ITK          DAT0180
      COMMON /SPARAM/ TMAX,CDLT,DELT,ERR,TEST,SUM,SUMP,QR,IOK           DAT0190
      COMMON /SARRAY/ ICHK(13),LEVEL1(9),LEVEL2(9)
      COMMON /CK/ ETFLXT,STORT,QRET,CHST,CHDT,FLUXT,PUMPT,CFLUXT,FLXNT  DAT0210
      COMMON /PR/ XLABEL(3),YLABEL(6),TITLE(6),XN1,MESUR,PRNT(122),BLANKDAT0220
     1(60),DIGIT(122),VF1(6),VF2(6),VF3(7),XSCALE,DINCH,SYM(17),XN(100),DAT0230
     2YN(13),NA(4),N1,N2,N3,YSCALE,FACT1,FACT2                          DAT0240
      COMMON /EVAPO/ ETDIST,QET,GRND(50,50)
      COMMON /B/ BETA
      RETURN                                                            DAT0250
C     ..................................................................DAT0260
C     ********************                                              DAT0270
      ENTRY DATAIN                                                      DAT0280
C     ********************                                              DAT0290
C                                                                       DAT0300
C     ---READ AND WRITE SCALAR PARAMETERS---                            DAT0310
      READ (5,330) NPER,KTH,ERR,LENGTH,QET,ETDIST,BETA                  DAT0320
      WRITE (6,340) NPER,KTH,ERR,LENGTH,QET,ETDIST                      DAT0330
      WRITE(6,346) BETA
      READ (5,460) XSCALE,YSCALE,DINCH,FACT1,(LEVEL1(I),I=1,9),FACT2,(LEDAT0340
     1VEL2(I),I=1,9),MESUR                                              DAT0350
      IF (XSCALE.NE.0.) WRITE (6,470) XSCALE,YSCALE,MESUR,MESUR,DINCH,FADAT0360
     1CT1,LEVEL1,FACT2,LEVEL2                                           DAT0370
C                                                                       DAT0380
C     ---READ CUMULATIVE MASS BALANCE PARAMETERS---                     DAT0390
      READ (5,450) SUM,SUMP,PUMPT,CFLUXT,QRET,CHST,CHDT,FLUXT,STORT,ETFLDAT0400
     1XT,FLXNT                                                          DAT0410
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      IF (IDK1.EQ.ICHK(4)) GO TO 20                                     DAT0420
      IF (IPU1.NE.ICHK(8)) GO TO 50                                     DAT0430
C                                                                       DAT0440
C     ---READ INITIAL HEAD VALUES FROM CARDS---                         DAT0450
      DO 10 K=1,K0                                                      DAT0460
      DO 10 I=1,I0                                                      DAT0470
   10 READ (5,360) (PHI(I,J,K),J=1,J0)                                  DAT0480
      GO TO 30                                                          DAT0490
C                                                                       DAT0500
C     ---READ INITIAL HEAD AND MASS BALANCE PARAMETERS FROM DISK---     DAT0510
   20 READ (4) PHI,SUM,SUMP,PUMPT,CFLUXT,QRET,CHST,CHDT,FLUXT,STORT,ETFLDAT0520
     1XT,FLXNT                                                          DAT0530
      REWIND 4                                                          DAT0540
   30 WRITE (6,430) SUM                                                 DAT0550
      DO 40 K=1,K0                                                      DAT0560
      WRITE (6,440) K                                                   DAT0570
      DO 40 I=1,I0                                                      DAT0580
   40 WRITE (6,350) I,(PHI(I,J,K),J=1,J0)                               DAT0590
C                                                                       DAT0600
   50 DO 60 K=1,K0                                                      DAT0610
      DO 60 I=1,I0                                                      DAT0620
      DO 60 J=1,J0                                                      DAT0630
      WELL(I,J,K)=0.                                                    DAT0640
      TR(I,J,K)=0.                                                      DAT0650
      TC(I,J,K)=0.                                                       AT0660
      IF (K.NE.K0) TK(I,J,K)=0.                                         DAT0670
   60 CONTINUE                                                          DAT0680
      IF(QET.EQ.0)GO TO 69
      READ (5,330) FAC,IPRN
      DO 65 I=1,I0
      READ (5,66) (GRND(I,J),J=1,J0)
      DO 65 J=1,J0
   65 GRND(I,J)=GRND(I,J)*FAC
   66 FORMAT (20F4.0)
      IF(IPRN.EQ.1) GO TO 69
      WRITE(6,345)
      DO 67 I=1,I0
   67 WRITE (6,350) I,(GRND(I,J),J=1,J0)
   69 CONTINUE
      RETURN                                                            DAT0690
C     ********************                                              DAT0700
      ENTRY ARRAY(A,INFT,IOFT,IN,IRN,TF)                                DAT0710
C     ********************                                              DAT07 0
      READ (5,330) FAC,IVAR,IPRN,TF,IRECS,IRECD                         DAT0730
      IC=4*IRECS+2*IVAR+IPRN+1                                          DAT0740
      GO TO (70,70,90,90,120,120), IC                                   DAT0750
   70 DO 80 I=1,I0                                                      DAT0760
      DO 80 J=1,J0                                                      DAT0770
   80 A(I,J)=FAC                                                        DAT0780
      WRITE (6,280) IN,FAC,K                                            DAT0790
      GO TO 140                                                         DAT0800
   90 IF (IC.EQ.3) WRITE (6,290) IN,K                                   DAT0810
      DO 110 I=1,I0                                                     DAT0820
      READ (5,INFT) (A(I,J),J=1,J0)                                     DAT0830
      DO 100 J=1,J0                                                     DAT0840
  100 A(I,J)=A(I,J)*FAC                                                 DAT0850
  110 IF (IC.EQ.3) WRITE (6,IOFT) I,(A(I,J),J=1,J0)                     DAT0860
      GO TO 140                                                         DAT0870
  120 READ (2'IRN) A                                                    DAT0880
      IF (IC.EQ.6) GO TO 140                                            DAT0890
      WRITE (6,290) IN,K                                                DAT0900
```

```
      DO 130 I=1,I0
  130 WRITE (6,IOFT) I,(A(I,J),J=1,J0)
  140 IF (IRECD.EQ.1) WRITE (2'IRN) A
      IRN=IRN+1
      RETURN
C     **********************
      ENTRY MDAT
C     **********************
      DO 150 K=1,K0
      DO 150 I=1,I0
      DO 150 J=1,J0
      IF (I.EQ.1.OR.I.EQ.I0.OR.J.EQ.1.OR.J.EQ.J0) T(I,J,K)=0.
      IF (IDK1.NE.ICHK(4).AND.IPU1.NE.ICHK(8)) PHI(I,J,K)=STRT(I,J,K)
      IF (K.NE.K0.OR.IWATER.NE.ICHK(6)) GO TO 150
      IF (I.EQ.1.OR.I.EQ.I0.OR.J.EQ.1.OR.J.EQ.J0) PERM(I,J)=0.
  150 CONTINUE
C     ............................. DELX ..............................
      READ (5,330) FAC,IVAR,IPRN
      IF (IVAR.EQ.1) READ (5,330) (DELX(J),J=1,J0)
      DO 170 J=1,J0
      IF (IVAR.NE.1) GO TO 160
      DELX(J)=DELX(J)*FAC
      GO TO 170
  160 DELX(J)=FAC
  170 CONTINUE
      IF (IVAR.EQ.1.AND.IPRN.NE.1) WRITE (6,370) (DELX(J),J=1,J0)
      IF (IVAR.EQ.0) WRITE (6,300) FAC
C     ............................. DELY ..............................
      READ (5,330) FAC,IVAR,IPRN
      ETQ=0.0
      IF (IVAR.EQ.1) READ (5,330) (DELY(I),I=1,I0)
      DO 190 I=1,I0
      IF (IVAR.NE.1) GO TO 180
      DELY(I)=DELY(I)*FAC
      GO TO 190
  180 DELY(I)=FAC
  190 CONTINUE
      IF (IVAR.EQ.1.AND.IPRN.NE.1) WRITE (6,380) (DELY(I),I=1,I0)
      IF (IVAR.EQ.0) WRITE (6,310) FAC
C     ............................. DELZ ..............................
      READ (5,330) FAC,IVAR,IPRN
      IF (IVAR.EQ.1) READ (5,330) (DELZ(K),K=1,K0)
      DO 210 K=1,K0
      IF (IVAR.NE.1) GO TO 200
      DELZ(K)=DELZ(K)*FAC
      GO TO 210
  200 DELZ(K)=FAC
  210 CONTINUE
      IF (IVAR.EQ.1.AND.IPRN.NE.1) WRITE (6,390) (DELZ(K),K=1,K0)
      IF (IVAR.EQ.0) WRITE (6,320) FAC
C
C     ---INITIALIZE VARIABLES---
      B=0.
      D=0.
      F=0.
      H=0.
      SU=0.
      Z=0.
      IF (XSCALE.NE.0.) CALL MAP
      RETURN
C     **************
```

```
      ENTRY DDAT(ND)
C     **************
      NK=1
      DO 500 I=1,I0
      READ 510, (ID(I,J),J=1,J0)
  510 FORMAT (80I1)
      DO 500 J=1,J0
      IF(ID(I,J).EQ.0) GO TO 500
      ID(I,J)=NK
      NK=NK+1
  500 CONTINUE
      NK=NK-1
      IF(NK.EQ.ND) GO TO 520
      PRINT 515,NK,ND
  515 FORMAT ('  ERROR****NK.NE.ND   NK=',I5,5X,'ND=',I5)
      STOP
  520 READ 330, FAC
      READ 530, (LD(I),I=1,ND)
  530 FORMAT(40F2.0)
      PRINT 540,(LD(I),I=1,ND)
  540 FORMAT(/,(20(1X,F5.0)))
      DO 550 I=1,I0
      DO 550 J=1,J0
      K=ID(I,J)
      IF(K.EQ.0) GO TO 550
      LD(K)=LD(K)*FAC*T(I,J,K0)/(DELX(J)*DELY(I))
  550 CONTINUE
      READ 330, FAC
      READ 560,(ELD(I),I=1,ND)
      PRINT 540,(ELD(I),I=1,ND)
  560 FORMAT (20F4.0)
      DO 570 I=1,ND
  570 ELD(I)=ELD(I)*FAC
      RETURN
C     **************
      ENTRY DDAT2(NRIV)
C     **************
      NK=1
      DO 580 I=1,I0
      READ 510,(IDR(I,J),J=1,J0)
      DO 580 J=1,J0
      IF(IDR(I,J).EQ.0) GO TO 580
      IDR(I,J)=NK
      NK=NK+1
  580 CONTINUE
      NK=NK-1
      IF(NK.EQ.NRIV) GO TO 600
      PRINT 585,NK,NRIV
  585 FORMAT('   ERROR****NK.NE.NRIV    NK=',I5,5X,'NRIV=',I5)
      STOP
  600 READ 330,FAC
      READ 560,(RH(I),I=1,NRIV)
      DO 610 I=1,NRIV
  610 RH(I)=RH(I)*FAC
      PRINT 539
  539 FORMAT(/,5X,'RIVER WATER LEVEL',/,5X,17('-'))
      PRINT 540,(RH(I),I=1,NRIV)
      READ 330,FAC
      READ 560,(RB(I),I=1,NRIV)
      DO 620 I=1,NRIV
  620 RB(I)=RB(I)*FAC
```

```
      PRINT 538
  538 FORMAT(/,5X,'RIVER BOTTOM ELEVATION',/,5X,22('-'))
      PRINT 540,(RB(I),I=1,NRIV)
      READ 330,FAC
      READ 625,(RC(I),I=1,NRIV)
  625 FORMAT(10F8.0)
      DO 630 I=1,NRIV
  630 RC(I)=RC(I)*FAC
      PRINT 634
  634 FORMAT(/,5X,'RIVER LEAKANCE',/,5X,14('-'))
      PRINT 635,(RC(I),I=1,NRIV)
  635 FORMAT(/(14(1X,E8.2)))
      RETURN
C     ..................................................................
C     ---READ TIME PARAMETERS AND PUMPING DATA FOR A NEW PUMPING PERIOD-
C     *********************
      ENTRY NEWPER
C     *********************
C
      READ (5,330) KP,KPMI,NWEL,TMAX,NUMT,CDLT,DELT,IRECH
      IF(IRECH.EQ.1) READ(3) QRE
C
C     ---COMPUTE ACTUAL DELT AND NUMT---
      DT=DELT/24.
      TM=0.0
      DO 220 I=1,NUMT
      DT=CDLT*DT
      TM=TM+DT
      IF (TM.GE.TMAX) GO TO 230
  220 CONTINUE
      GO TO 240
  230 DELT=TMAX/TM*DELT
      NUMT=I
  240 WRITE (6,400) KP,TMAX,NUMT,DELT,CDLT
      DELT=DELT*3600.
      TMAX=TMAX*86400.
      SUMP=0.0
C
C     ---READ AND WRITE WELL PUMPING RATES---
      WRITE (6,410) NWEL
      IF (NWEL.EQ.0) GO TO 260
      DO 245 K=1,K0
      DO 245 I=1,I0
      DO 245 J=1,J0
  245 WELL(I,J,K)=0.0
      DO 250 II=1,NWEL
      READ (5,330) K,I,J,WELL(I,J,K)
      WRITE (6,420) K,I,J,WELL(I,J,K)
  250 WELL(I,J,K)=WELL(I,J,K)/(DELX(J)*DELY(I))
  260 RETURN
C
C     ---FORMATS---
C
C
C
  280 FORMAT (1H0,52X,6A4,' =',G15.7,' FOR LAYER',I3)
  290 FORMAT (1H1,45X,6A4,' MATRIX, LAYER',I3/46X,41('-'))
  300 FORMAT ('0',72X,'DELX =',G15.7)
  310 FORMAT ('0',72X,'DELY =',G15.7)
  320 FORMAT ('0',72X,'DELZ =',G15.7)
  330 FORMAT (8G10.0)
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  340 FORMAT ('0',51X,'NUMBER OF PUMPING PERIODS =',I5/49X,'TIME STEPS BDAT1930
     1ETWEEN PRINTOUTS =',I5//51X,'ERROR CRITERIA FOR CLOSURE =',G15.7//DAT1940
     257X,'ITERATION PARAMETERS=',I5//62X,'MAXIMUM ET RATE=',G15.7//53X,DAT1945
     3'DEPTH AT WHICH ET CEASES=',G15.7/)                               DAT1946
  345 FORMAT('1',45X,'LAND SURFACE ALTITUDE'/45X,21('-')//)
  346 FORMAT('0',72X,'BETA = ',F4.2)
  350 FORMAT ('0',I2,2X,20F6.1/(5X,20F6.1))                             DAT1950
  360 FORMAT (8F10.4)                                                   DAT1960
  370 FORMAT (1H1,46X,40HGRID SPACING IN PROTOTYPE IN X DIRECTION/47X,40DAT1970
     1('-')//('0',12F10.0))                                             DAT1980
  380 FORMAT (1H-,46X,40HGRID SPACING IN PROTOTYPE IN Y DIRECTION/47X,40DAT1990
     1('-')//('0',12F10.0))                                             DAT2000
  390 FORMAT (1H-,46X,40HGRID SPACING IN PROTOTYPE IN Z DIRECTION/47X,40DAT2010
     1('-')//('0',12F10.0))                                             DAT2020
  400 FORMAT ('-',50X,'PUMPING PERIOD NO.',I4,':',F10.2,' DAYS'/51X,38('DAT2030
     1-')//53X,'NUMBER OF TIME STEPS=',I6//59X,'DELT IN HOURS =',F10.3//DAT2040
     253X,'MULTIPLIER FOR DELT =',F10.3)                                DAT2050
  410 FORMAT ('-',63X,I4,' WELLS'/65X,9('-')//50X,'K',9X,'I',9X,'J    PUDAT2060
     1MPING RATE'/)                                                     DAT2070
  420 FORMAT (41X,3I10,2F13.2)                                          DAT2080
  430 FORMAT ('-',40X,' CONTINUATION - HEAD AFTER ',G20.7,' SEC PUMPING DAT2090
     1'/42X,58('-'))                                                    DAT2100
  440 FORMAT ('1',55X,'INITIAL  HEAD MATRIX, LAYER',I3/56X,30('-'))     DAT2110
  450 FORMAT (4G20.10)                                                  DAT2120
  460 FORMAT (3G10.0,2(G10.0,9I1,1X),A8)                                DAT2130
  470 FORMAT ('0',30X,'ON ALPHAMERIC MAP:'/40X,'MULTIPLICATION FACTOR FODAT2140
     1R X DIMENSION =',G15.7/40X,'MULTIPLICATION FACTOR FOR Y DIMENSION DAT2150
     2=',G15.7/55X,'MAP SCALE IN UNITS OF  ',A11/50X,'NUMBER OF ',A8,' PDAT2160
     3ER INCH =',G15.7/43X,'MULTIPLICATION FACTOR FOR DRAWDOWN =',G15.7,DAT2170
     4' PRINTED FOR LAYERS',9I2/47X,'MULTIPLICATION FACTOR FOR HEAD =',GDAT2180
     515.7,' PRINTED FOR LAYERS',9I2)                                   DAT2190
      END                                                               DAT2200-
      SUBROUTINE STEP(PHI,STRT,OLD,T,S,TR,TC,TK,WELL,DELX,DELY,DELZ,FACTSTP  10
     1,DDN,TEST3)                                                       STP  20
C     ------------------------------------------------------------------STP  30
C     INITIALIZE DATA FOR A NEW TIME STEP AND PRINT RESULTS             STP  40
C     ------------------------------------------------------------------STP  50
C                                                                       STP  60
C     SPECIFICATIONS:                                                   STP  70
      REAL *8PHI                                                        STP  80
      REAL *8XLABEL,YLABEL,TITLE,XN1,MESUR                              STP  90
C                                                                       STP 100
      DIMENSION PHI(I0,J0,K0), STRT(I0,J0,K0), OLD(I0,J0,K0), T(I0,J0,K0STP 110
     1), S(I0,J0,K0), TR(I0,J0,K0), TC(I0,J0,K0), TK(IK,JK,K5), WELL(I0,STP 120
     2J0,K0), DELX(J0), DELY(I0), DELZ(K0), FACT(K0,3), DDN(IMAX), TEST3STP 130
     3(ITMX1), ITTO(50)                                                 STP 140
C                                                                       STP 150
      COMMON /INTEGR/ I0,J0,K0,I1,J1,K1,I,J,K,NPER,KTH,ITMAX,LENGTH,KP,NSTP 160
     1WEL,NUMT,IFINAL,IT,KT,IHEAD,IDRAW,IFLO,IERR,I2,J2,K2,IMAX,ITMX1,NCSTP 170
     2H,IDK1,IDK2,IWATER,IORE,IP,JP,IQ,JQ,IK,JK,K5,IPU1,IPU2,ITK        STP180
      COMMON /SPARAM/ TMAX,CDLT,DELT,ERR,TEST,SUM,SUMP,QR,IOK           STP 190
      COMMON /SARRAY/ ICHK(13),LEVEL1(9),LEVEL2(9)
      COMMON /CK/ ETFLXT,STORT,QRET,CHST,CHDT,FLUXT,PUMPT,CFLUXT,FLXNT  STP 210
      COMMON /PR/ XLABEL(3),YLABEL(6),TITLE(6),XN1,MESUR,PRNT(122),BLANKSTP 220
     1(60),DIGIT(122),VF1(6),VF2(6),VF3(7),XSCALE,DINCH,SYM(17),XN(100),STP 230
     2YN(13),NA(4),N1,N2,N3,YSCALE,FACT1,FACT2                          STP 240
      RETURN                                                            STP 250
C     ..................................................................STP 260
C     ********************                                              STP 270
      ENTRY NEWSTP                                                      STP 280
C     ********************                                              STP 290
```

```
      KT=KT+1                                                           STP 300
      IT=0                                                              STP 310
      DO 10 K=1,K0                                                      STP 320
      DO 10 I=1,I0                                                      STP 330
      DO 10 J=1,J0                                                      STP 340
   10 OLD(I,J,K)=PHI(I,J,K)                                             STP 350
      DELT=CDLT*DELT                                                    STP 360
      SUM=SUM+DELT                                                      STP 370
      SUMP=SUMP+DELT                                                    STP 380
      DAYSP=SUMP/86400.                                                 STP 390
      YRSP=DAYSP/365.                                                   STP 400
      HRS=SUM/3600.                                                     STP 410
      SMIN=HRS*60.                                                      STP 420
      DAYS=HRS/24.                                                      STP 430
      YRS=DAYS/365.                                                     STP 440
      RETURN                                                            STP 450
C                                                                       STP 460
C     ---PRINT OUTPUT AT DESIGNATED TIME STEPS---                       STP 470
C     *********************                                             STP 480
      ENTRY OUTPUT                                                      STP 490
C     *********************                                             STP 500
      IERR=1
      IF (KT.EQ.NUMT) IFINAL=1                                          STP 510
      ITTO(KT)=IT                                                       STP 520
      IF (IT.LE.ITMAX) GO TO 20                                         STP 530
      IT=IT-1                                                           STP 540
      ITTO(KT)=IT                                                       STP 550
      IERR=2                                                            STP 560
C                                                                       STP 570
C     ---IF MAXIMUM ITERATIONS EXCEEDED,WRITE RESULTS ON DISK OR CARDS--STP 580
      IF (IDK2.EQ.ICHK(5)) WRITE (4) PHI,SUM,SUMP,PUMPT,CFLUXT,QRET,CHSTSTP 590
     1,CHDT,FLUXT,STORT,ETFLXT,FLXNT                                    STP 600
      IF (IPU2.EQ.ICHK(9)) WRITE (7,230) SUM,SUMP,PUMPT,CFLUXT,QRET,CHSTSTP 610
     1,CHDT,FLUXT,STORT,ETFLXT,FLXNT                                    STP 620
C                                                                       STP 630
   20 IF (IFLO.EQ.ICHK(3)) CALL CHECK                                   STP 640
      IF (IERR.EQ.2) GO TO 30                                           STP 650
      IF (MOD(KT,KTH).NE.0.AND.IFINAL.NE.1) RETURN                      STP 660
   30 WRITE (6,210) KT,DELT,SUM,SMIN,HRS,DAYS,YRS,DAYSP,YRSP            STP 670
      IF (IFLO.EQ.ICHK(3)) CALL CWRITE                                  STP 680
      IT=IT+1                                                           STP 690
      WRITE (6,180) (TEST3(J),J=1,IT)                                   STP 700
      I3=1
      I5=0
  352 I5=I5+40
      I4=MIN0(KT,I5)
      WRITE (6,240) (I,I=I3,I4)                                         STP 710
      WRITE (6,260)                                                     STP 720
      WRITE (6,250) (ITTO(I),I=I3,I4)                                   STP 730
      WRITE (6,260)                                                     STP 740
      IF(KT.LE.I5) GO TO 353
      I3=I3+40
      GO TO 352
                                                                        STP 750
      ---PRINT MAPS---                                                  STP 760
  353 IF (XSCALE.EQ.0.) GO TO 70                                        STP 770
      IF (FACT1.EQ.0.) GO TO 50                                         STP 780
      DO 40 IA=1,9                                                      STP 790
      II=LEVEL1(IA)                                                     STP 800
      IF (II.EQ.0) GO TO 50                                             STP 810
   40 CALL PRNTA(1,II)                                                  STP 820
```

```
   50 IF (FACT2.EQ.0.) GO TO 70                                          STP 830
      DO 60 IA=1,9                                                       STP 840
      II=LEVEL2(IA)                                                      STP 850
      IF (II.EQ.0) GO TO 70                                              STP 860
   60 CALL PRNTA(2,II)                                                   STP 870
   70 IF (IDRAW.NE.ICHK(1)) GO TO 100                                    STP 880
C                                                                        STP 890
C     ---PRINT DRAWDOWN---                                               STP 900
      DO 90 K=1,K0                                                       STP 910
      WRITE (6,200) K                                                    STP 920
      DO 90 I=1,I0                                                       STP 930
      DO 80 J=1,J0                                                       STP 940
   80 DDN(J)=STRT(I,J,K)-PHI(I,J,K)                                      STP 950
      IF(K.EQ.1) WRITE(6,169) I,(DDN(J),J=1,J0)
      IF(K.NE.1) WRITE(6,170) I,(DDN(J),J=1,J0)
   90 CONTINUE
  100 IF (IHEAD.NE.ICHK(2)) GO TO 120                                    STP 970
C                                                                        STP 980
C     ---PRINT HEAD MATRIX---                                            STP 990
      DO 110 K=1,K0                                                      STP1000
      WRITE (6,190) K                                                    STP1010
      DO 110 I=1,I0                                                      STP1020
  110 WRITE (6,170) I,(PHI(I,J,K),J=1,J0)                                STP1030
C                                                                        STP1040
C     ---WRITE ON DISK---                                                STP1050
  120 IF (IERR.EQ.2) GO TO 130                                           STP1060
      IF (KP.LT.NPER.OR.IFINAL.NE.1) RETURN                              STP1070
      IF (IDK2.EQ.ICHK(5)) WRITE (4) PHI,SUM,SUMP,PUMPT,CFLUXT,QRET,CHSTSTP1080
     1,CHDT,FLUXT,STORT,ETFLXT,FLXNT                                     STP1090
C                                                                        STP1100
C     ---PUNCHED OUTPUT---                                               STP1110
  130 IF (IPU2.NE.ICHK(9)) GO TO 160                                     STP1120
      IF (IERR.EQ.2) GO TO 140                                           STP1130
      WRITE (7,230) SUM,SUMP,PUMPT,CFLUXT,QRET,CHST,CHDT,FLUXT,STORT,ETFSTP1140
     1LXT,FLXNT                                                          STP1150
  140 DO 150 K=1,K0                                                      STP1160
      DO 150 I=1,I0
  150 WRITE (7,220) (PHI(I,J,K),J=1,J0)
  160 RETURN
C                                                                        STP1200
C     ---FORMATS---                                                      STP1210
C                                                                        STP1220
C                                                                        STP1230
C                                                                        STP1240
  169 FORMAT('0',I4,20F6.1/(5X,20F6.1))
  170 FORMAT ('0',I4,20F6.2/(5X,20F6.2))                                 STP1250
  180 FORMAT ('0MAXIMUM HEAD CHANGE FOR EACH ITERATION:'/' ',39('-')/('0STP1260
     1',10F12.4))                                                        STP1270
  190 FORMAT ('1',55X,'HEAD MATRIX, LAYER',I3/56X,21('-'))               STP1280
  200 FORMAT ('1',55X,'   DRAWDOWN, LAYER',I3/59X,18('-'))               STP1290
  210 FORMAT (1H1,44X,57('-')/45X,'I',14X,'TIME STEP NUMBER =',I9,14X,'ISTP1300
     1'/45X,57('-')//50X,29HSIZE OF TIME STEP IN SECONDS=,F14.2//55X,'TOSTP1310
     2TAL SIMULATION TIME IN SECONDS=',F14.2/80X,8HMINUTES=,F14.2/82X,6HSTP1320
     3HOURS=,F14.2/83X,5HDAYS=,F14.2/82X,'YEARS=',F14.2///45X,'DURATION STP1330
     4OF CURRENT PUMPING PERIOD IN DAYS=',F14.2/82X,'YEARS=',F14.2//)    STP1340
  220 FORMAT (8F10.4)                                                    STP1350
  230 FORMAT (4G20.10)                                                   STP1360
  240 FORMAT ('0TIME STEP :',40I3)                                       STP1370
  250 FORMAT ('0ITERATIONS:',40I3)                                       STP1380
  260 FORMAT (' ',10('-'))                                               STP1390
      END                                                                STP1400-
```

```
      SUBROUTINE SOLVE(PHI,STRT,OLD,T,S,TR,TC,TK,WELL,DELX,DELY,DELZ,FAC
     1T,EL,FL,GL,V,XI,TEST3,QRE,PERM,ID,FLD,ELD,IDR,RH,RC,RB,IDRAIN,
     2 IRIV)
C     ------------------------------------------------------------------
C     SOLUTION BY THE STRONGLY IMPLICIT PROCEDURE
C     ------------------------------------------------------------------
C
C     SPECIFICATIONS:
      REAL *8PHI,RHO,B,D,F,H,Z,SU,RHOP,W,WMIN,RHO1,RHO2,RHO3,XPART,YPART
     1,ZPART,DMIN1,WMAX,XT,YT,ZT,DABS,DMAX1,DEN,TXM,TYM,TZM
      REAL*8 UX,UXR
      REAL *8E,AL,BL,CL,A,C,G,WU,TU,U,DL,RES,SUPH,GLXI,ZPHI
C
      DIMENSION PHI(1), STRT(1), OLD(1), T(1), S(1), TR(1), TC(1), TK(1)
     1, WELL(1), DELX(1), DELY(1), DELZ(1), FACT(K0,3), RHOP(20), TEST3(
     21), EL(1), FL(1), GL(1), V(1), XI(1), QRE(1)
     3,ID(1),FLD(1),ELD(1),PERM(1),IDR(1),RH(1),RC(1),RB(1)
C
      COMMON /INTEGR/ I0,J0,K0,I1,J1,K1,I,J,K,NPER,KTH,ITMAX,LENGTH,KP,N
     1WEL,NUMT,IFINAL,IT,KT,IHEAD,IDRAW,IFLO,IERR,I2,J2,K2,IMAX,ITMX1,NC
     2H,IDK1,IDK2,IWATER,IQRE,IP,JP,IQ,JQ,IK,JK,K5,IPU1,IPU2,ITK
      COMMON /SPARAM/ TMAX,CDLT,DELT,ERR,TEST,SUM,SUMP,QR,IOK
      COMMON /SARRAY/ ICHK(13),LEVEL1(9),LEVEL2(9)
      COMMON /EVAPO/ ETDIST,QET,GRND(50,50)
      COMMON /B/ BETA
      RETURN
C     ..................................................................
C     **********************
      ENTRY ITER
C     **********************
C     ---COMPUTE AND PRINT ITERATION PARAMETERS---
      WRITE (6,240)
      WMIN=1.D0
      DELT=1.
      P2=LENGTH-1
      NT=I0*J0*K0
      NIJ=I0*J0
      XT=3.141593**2/(2.*J2*J2)
      YT=3.141593**2/(2.*I2*I2)
      ZT=3.141593**2/(2.*K0*K0)
      RHO1=0.D0
      RHO2=0.D0
      RHO3=0.D0
      DO 40 K=1,K0
      DO 40 I=2,I1
      DO 40 J=2,J1
      N=I+(J-1)*I0+(K-1)*NIJ
      IF (T(N).EQ.0.) GO TO 40
      D=TR(N-I0)/DELX(J)
      F=TR(N)/DELX(J)
      B=TC(N-1)/DELY(I)
      H=TC(N)/DELY(I)
      SU=0.D0
      Z=0.D0
      IF (K.NE.1) Z=TK(N-NIJ)/DELZ(K)
      IF (K.NE.K0) SU=TK(N)/DELZ(K)
      RHO=S(N)/DELT
      QR=0.
      IF (K.NE.K0) GO TO 10
      IF (IQRE.EQ.ICHK(7)) QR=QRE(I+(J-1)*I0)
   10 CONTINUE
```

```
      TXM=DMAX1(D,F)
      TYM=DMAX1(B,H)
      TZM=DMAX1(SU,Z)
      DEN=DMIN1(D,F)
      IF (DEN.EQ.0.D0) DEN=TXM
      IF (DEN.EQ.0.D0) GO TO 20
      RHO1=DMAX1(RHO1,TYM/DEN)
   20 DEN=DMIN1(B,H)
      IF (DEN.EQ.0.D0) DEN=TYM
      IF (DEN.EQ.0.D0) GO TO 30
      RHO2=DMAX1(RHO2,TXM/DEN)
   30 DEN=DMIN1(SU,Z)
      IF (DEN.EQ.0.D0) DEN=TZM
      IF (DEN.EQ.0.D0) GO TO 40
      RHO3=DMAX1(RHO3,TXM/DEN)
   40 CONTINUE
      XPART=XT/(1.D0+RHO1)
      YPART=YT/(1.D0+RHO2)
      ZPART=ZT/(1.D0+RHO3)
      WMIN=DMIN1(WMIN,XPART,YPART,ZPART)
      WMAX=1.D0-WMIN
      PJ=-1.
      DO 50 I=1,LENGTH
      PJ=PJ+1.
   50 RHOP(I)=1.D0-(1.D0-WMAX)**(PJ/P2)
      WRITE (6,230) LENGTH,BETA,(RHOP(J),J=1,LENGTH)
      RETURN
C     ..............................................................
C
C     ---INITIALIZE DATA FOR A NEW ITERATION---
   60 IT=IT+1
      IF (IT.LE.ITMAX) GO TO 70
      WRITE (6,220)
      CALL OUTPUT
      RETURN
   70 IF (MOD(IT,LENGTH)) 80,80,90
C     ********************
      ENTRY NEWITA
C     ********************
   80 NTH=0
   90 NTH=NTH+1
      W=RHOP(NTH)
      TEST3(IT+1)=0.
      TEST=0.0
      BIG=0.
      DO 100 I=1,NT
      EL(I)=0.
      FL(I)=0.
      GL(I)=0.
      V(I)=0.
  100 XI(I)=0.
C
C     ---COMPUTE TRANSMISSIVITY AND T COEFFICIENTS FOR UPPER
C     HYDROLOGIC UNIT WHEN IT IS UNCONFINED---
      IF (IWATER.NE.ICHK(6)) GO TO 110
      CALL TRANS(0)
C
C     ---CHOOSE SIP NORMAL OR REVERSE ALGORITHM---
  110 IF (MOD(IT,2)) 120,120,170
  120 DO 150 K=1,KO
      DO 150 I=2,I1
```

```
      DO 150 J=2,J1                                                     SP31170
      N=I+(J-1)*I0+(K-1)*NIJ                                            SP31180
      NIA=N+1                                                           SP31190
      NIB=N-1                                                           SP31200
      NJA=N+I0                                                          SP31210
      NJB=N-I0                                                          SP31220
      NKA=N+NIJ                                                         SP31230
      NKB=N-NIJ                                                         SP31240
C                                                                       SP31250
C     ---SKIP COMPUTATIONS IF NODE OUTSIDE MODEL---                     SP31260
      IF (T(N).EQ.0..OR.S(N).LT.0.) GO TO 150                           SP31270
C                                                                       SP31280
C     ---COMPUTE COEFFICIENTS---                                        SP31290
      D=TR(NJB)/DELX(J)                                                 SP31300
      F=TR(N)/DELX(J)                                                   SP31310
      B=TC(NIB)/DELY(I)                                                 SP31320
      H=TC(N)/DELY(I)                                                   SP31330
      SU=0.D0                                                           SP31340
      Z=0.D0                                                            SP31350
      IF (K.NE.1) Z=TK(NKB)/DELZ(K)                                      SP31360
      IF (K.NE.K0) SU=TK(N)/DELZ(K)                                      SP31370
      RHO=S(N)/DELT                                                      SP31380
      ETQB=0.
      ETQD=0.
      IF(K.NE.K0) GO TO 126
      IF(QET.EQ.0.) GO TO 126
      IF(PHI(N).LE.GRND(I,J) - ETDIST) GO TO 126
      IF (PHI(N).GT.GRND(I,J)) GO TO 125
      ETQB=QET/ETDIST
      ETQD=ETQB*(ETDIST-GRND(I,J))
      GO TO 126
  125 ETQD=QET
  126 CONTINUE
      QR=0.                                                             SP31390
      UXR=0.
      UX=0.
      IF (K.NE.K0) GO TO 130                                            SP31400
      IF (IQRE.EQ.ICHK(7)) QR=QRE(I+(J-1)*I0)                           SP31410
C                                                                       SP31420
      IF(IRIV.LE.0) GO TO 128
      ND=IDR(I+(J-1)*I0)
      IF(ND.EQ.0) GO TO 128
      IF(PHI(N).GT.RB(ND)) GO TO 124
      QR=QR+RC(ND)*(RH(ND)-RB(ND))
      GO TO 128
  124 UXR=RC(ND)
      QR=QR+RC(ND)*RH(ND)
  128  IF(IDRAIN.LE.0) GO TO 130
      ND=ID(I+(J-1)*I0)
       IF(ND.EQ.0) GO TO 130
       IF(ELD(ND).GT.PHI(N)) GO TO 130
       UX=FLD(ND)
       QR=QR+FLD(ND)*ELD(ND)
C     ---SIP NORMAL ALGORITHM---                                        SP31430
C     ---FORWARD SUBSTITUTE, COMPUTING INTERMEDIATE VECTOR V---         SP31440
  130 E=-B-D-F-H-SU-Z-RHO-ETQB-UX-UXR                                   SP31450
      BL=B/(1.+W*(EL(NIB)+GL(NIB)))                                     SP31460
      CL=D/(1.+W*(FL(NJB)+GL(NJB)))                                     SP31470
      C=BL*EL(NIB)                                                      SP31480
      G=CL*FL(NJB)                                                      SP31490
      WU=CL*GL(NJB)                                                     SP31500
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```
      U=BL*GL(NIB)
      IF (K.EQ.1) GO TO 140
      AL=Z/(1.+W*(FL(NKB)+FL(NKB)))
      A=AL*EL(NKB)
      TU=AL*FL(NKB)
      DL=E+W*(A+C+G+WU+TU+U)-CL*FL(NJB)-BL*FL(NIB)-AL*GL(NKB)
      EL(N)=(F-W*(A+C))/DL
      FL(N)=(H-W*(G+TU))/DL
      GL(N)=(SU-W*(WU+U))/DL
      SUPH=0.D0
      IF (K.NE.K0) SUPH=SU*PHI(NKA)
      RES=-B*PHI(NIB)-D*PHI(NJB)-E*PHI(N)-F*PHI(NJA)-H*PHI(NIA)-SUPH-Z*P
     1HI(NKB)-WELL(N)-RHO*OLD(N)-QR+FTQQ
      RES=BETA*RES
      V(N)=(RES-AL*V(NKB)-BL*V(NIB)-CL*V(NJB))/DL
      GO TO 150
  140 DL=E+W*(C+G+WU+U)-CL*FL(NJB)-BL*FL(NIB)
      EL(N)=(F-W*C)/DL
      FL(N)=(H-W*G)/DL
      GL(N)=(SU-W*(WU+U))/DL
      SUPH=0.D0
      IF (K.NE.K0) SUPH=SU*PHI(NKA)
      RES=-B*PHI(NIB)-D*PHI(NJB)-E*PHI(N)-F*PHI(NJA)-H*PHI(NIA)-SUPH-WEL
     1L(N)-RHO*OLD(N)-QR
      RES=BETA*RES
      V(N)=(RES-BL*V(NIB)-CL*V(NJB))/DL
  150 CONTINUE
C
C     ---BACK SUBSTITUTE FOR VECTOR XI---
      DO 160 K=1,K0
      K3=K0-K+1
      DO 160 I=1,I2
      I3=I0-I
      DO 160 J=1,J2
      J3=J0-J
      N=I3+(J3-1)*I0+(K3-1)*NIJ+I-I
      IF (T(N).EQ.0..OR.S(N).LT.0.) GO TO 160
      GLXI=0.D0
      IF (K3.NE.K0) GLXI=GL(N)*XI(N+NIJ)
      XI(N)=V(N)-EL(N)*XI(N+I0)-FL(N)*XI(N+1)-GLXI
C
C     ---COMPARE MAGNITUDE OF CHANGE WITH CLOSURE CRITERIA---
      TCHK=ABS(XI(N))
      IF (TCHK.GT.BIG) BIG=TCHK
      PHI(N)=PHI(N)+XI(N)
  160 CONTINUE
      IF (BIG.GT.ERR) TEST=1.
      TEST3(IT+1)=BIG
      IF (TEST.EQ.0.) RETURN
      GO TO 60
C     ..............................................................
  170 DO 200 KK=1,K0
      K=K0-KK+1
      DO 200 II=1,I2
      I=I0-II
      DO 200 J=2,J1
      N=I+(J-1)*I0+(K-1)*NIJ
      NIA=N+1
      NIB=N-1
      NJA=N+I0
      NJB=N-I0
```

```
      NKA=N+NIJ
      NKB=N-NIJ
C
C     ---SKIP COMPUTATIONS IF NODE OUTSIDE AQUIFER---
      IF (T(N).EQ.0..OR.S(N).LT.0.) GO TO 200
C
C     ---COMPUTE COEFFICIENTS---
      D=TR(NJB)/DELX(J)
      F=TR(N)/DELX(J)
      B=TC(NIB)/DELY(I)
      H=TC(N)/DELY(I)
      SU=0.D0
      Z=0.D0
      IF (K.NE.1) Z=TK(NKB)/DELZ(K)
      IF (K.NE.K0) SU=TK(N)/DELZ(K)
      RHO=S(N)/DELT
      ETQB=0.
      ETQD=0.
      IF(K.NE.K0) GO TO 176
      IF(PHI(N).LE.GRND(I,J) - ETDIST) GO TO 176
      IF (PHI(N).GT.GRND(I,J)) GO TO 175
      ETQB=QET/ETDIST
      ETQD=ETQB*(ETDIST-GRND(I,J))
      GO TO 176
  175 ETQD=QET
  176 CONTINUE
      QR=0.
      UXR=0.
      UX=0.
      IF (K.NE.K0) GO TO 180
      IF (IQRE.EQ.ICHK(7)) QR=QRE(I+(J-1)*I0)
      IF(IRIV.LE.0) GO TO 178
      ND=IDR(I+(J-1)*I0)
      IF(ND.EQ.0) GO TO 178
      IF(PHI(N).GT.RB(ND)) GO TO 174
      QR=QR+RC(ND)*(RH(ND)-RB(ND))
      GO TO 178
  174 UXR=RC(ND)
      QR=QR+RC(ND)*RH(ND)
  178 IF(IDRAIN.LE.0) GO TO 180
      ND=ID(I+(J-1)*I0)
      IF(ND.EQ.0) GO TO 180
      IF(FLD(ND).GT.PHI(N)) GO TO 180
      UX=FLD(ND)
      QR=QR+FLD(ND)*ELD(ND)
C
C     ---SIP REVERSE ALGORITHM---
C     ---FORWARD SUBSTITUTE, COMPUTING INTERMEDIATE VECTOR V---
  180 E=-B-D-F-H-SU-Z-RHO-ETQB-UX-UXR
      BL=H/(1.+W*(EL(NIA)+GL(NIA)))
      CL=D/(1.+W*(FL(NJB)+GL(NJB)))
      C=BL*EL(NIA)
      G=CL*FL(NJB)
      WU=CL*GL(NJB)
      U=BL*GL(NIA)
      IF (K.EQ.K0) GO TO 190
      AL=SU/(1.+W*(EL(NKA)+FL(NKA)))
      A=AL*EL(NKA)
      TU=AL*FL(NKA)
      DL=E+W*(C+G+A+WU+TU+U)-AL*GL(NKA)-BL*FL(NIA)-CL*FL(NJB)
      EL(N)=(F-W*(C+A))/DL
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      FL(N)=(B-W*(G+TU))/DL                                             SP32450
      GL(N)=(Z-W*(WU+U))/DL                                             SP32460
      ZPHI=0.D0                                                         SP32470
      IF (K.NE.1) ZPHI=Z*PHI(NKB)                                       SP32480
      RES=-B*PHI(NIB)-D*PHI(NJB)-E*PHI(N)-F*PHI(NJA)-H*PHI(NIA)-SU*PHI(NSP32490
     1KA)-ZPHI-WELL(N)-RHO*OLD(N)-QR                                    SP32500
      RES=BETA*RES
      V(N)=(RES-AL*V(NKA)-BL*V(NIA)-CL*V(NJB))/DL                       SP32510
      GO TO 200                                                         SP32520
  190 DL=E+W*(C+G+WU+U)-BL*FL(NIA)-CL*EL(NJB)                           SP32530
      EL(N)=(F-W*C)/DL                                                  SP32540
      FL(N)=(B-W*G)/DL                                                  SP32550
      GL(N)=(Z-W*(WU+U))/DL                                             SP32560
      ZPHI=0.D0                                                         SP32570
      IF (K.NE.1) ZPHI=Z*PHI(NKB)                                       SP32580
      RES=-B*PHI(NIB)-D*PHI(NJB)-E*PHI(N)-F*PHI(NJA)-H*PHI(NIA)-ZPHI-WELSP32590
     1L(N)-RHO*OLD(N)-QR+ETQD                                           SP32600
      RES=BETA*RES
      V(N)=(RES-BL*V(NIA)-CL*V(NJB))/DL                                 SP32610
  200 CONTINUE                                                          SP32620
C                                                                       SP32630
C     ---BACK SUBSTITUTE FOR VECTOR XI---                               SP32640
      DO 210 K=1,KO                                                     SP32650
      DO 210 I=2,I1                                                     SP32660
      DO 210 J=1,J2                                                     SP32670
      J3=J0-J                                                           SP32680
      N=I+(J3-1)*I0+(K-1)*NIJ                                           SP32690
      IF (T(N).EQ.0..OR.S(N).LT.0.) GO TO 210                           SP32700
      GLXI=0.D0                                                         SP32710
      IF (K.NE.1) GLXI=GL(N)*XI(N-NIJ)                                  SP32720
      XI(N)=V(N)-EL(N)*XI(N+I0)-FL(N)*XI(N-1)-GLXI                      SP32730
C                                                                       SP32740
C     ---COMPARE MAGNITUDE OF CHANGE WITH CLOSURE CRITERIA---           SP32750
      TCHK=ABS(XI(N))                                                   SP32760
      IF (TCHK.GT.BIG) BIG=TCHK                                         SP32770
      PHI(N)=PHI(N)+XI(N)                                               SP32780
  210 CONTINUE                                                          SP32790
      IF (BIG.GT.ERR) TEST=1.                                           SP32800
      TEST3(IT+1)=BIG                                                   SP32810
      IF (TEST.EQ.0.) RETURN                                            SP32820
      GO TO 60                                                          SP32830
C     ..................................................................SP32840
C                                                                       SP32850
C     ---FORMATS---                                                     SP32860
C                                                                       SP32870
C                                                                       SP32880
C                                                                       SP32890
  220 FORMAT ('0EXCEEDED PERMITTED NUMBER OF ITERATIONS'/' ',39('*'))   SP32900
  230 FORMAT (///1H0,I5,5X,F4.2,22H ITERATION PARAMETERS:,6E15.7/(/28X,6
     1E15.7/))
  240 FORMAT ('-',44X,'SOLUTION BY THE STRONGLY IMPLICIT PROCEDURE'/45X,SP32920
     143('_'))                                                          SP32930
      END                                                               SP32940-
      SUBROUTINE COEF(PHI,STRT,OLD,T,S,TR,TC,TK,WELL,DELX,DELY,DELZ,FACTCOF   10
     1,PERM,BOTTOM,QRE)                                                 COF   20
C     ------------------------------------------------------------------COF   30
C     COMPUTE COEFFICIENTS                                              COF   40
C     ------------------------------------------------------------------COF   50
C                                                                       COF   60
C     SPECIFICATIONS:                                                   COF   70
      REAL *8PHI                                                        COF   80
```

```
C
      DIMENSION PHI(I0,J0,K0), STRT(I0,J0,K0), OLD(I0,J0,K0), T(I0,J0,K0
     1), S(I0,J0,K0), TR(I0,J0,K0), TC(I0,J0,K0), TK(IK,JK,K5), WELL(I0,
     2J0,K0), DELX(J0), DELY(I0), DELZ(K0), FACT(K0,3), PERM(IP,JP), BOT
     3TOM(IP,JP), QRE(IQ,JQ)
C
      COMMON /INTEGR/ I0,J0,K0,I1,J1,K1,I,J,K,NPER,KTH,ITMAX,LENGTH,KP,N
     1WEL,NUMT,IFINAL,IT,KT,IHEAD,IDRAW,IFLO,IERR,I2,J2,K2,IMAX,ITMX1,NC
     2H,IDK1,IDK2,IWATER,IQRE,IP,JP,IQ,JQ,IK,JK,K5,IPU1,IPU2,ITK
      COMMON /SPARAM/ TMAX,CDLT,DELT,ERR,TEST,SUM,SUMP,QR,IOK
      COMMON /SARRAY/ ICHK(13),LEVEL1(9),LEVEL2(9)
      RETURN
C     ..................................................................
C     ---COMPUTE TRANSMISSIVITY FOR UPPER HYDROLOGIC UNIT WHEN
C     IT IS UNCONFINED---
C     *********************
      ENTRY TRANS(N3)
C     *********************
      DO 10 I=2,I1
      DO 10 J=2,J1
      IF (PERM(I,J).EQ.0.) GO TO 10
      T(I,J,K0)=PERM(I,J)*(PHI(I,J,K0)-BOTTOM(I,J))
      IF (T(I,J,K0).GT.0.) GO TO 10
      IF (WELL(I,J,K0).LT.0.) WRITE (6,60) I,J,K0
      IF (WELL(I,J,K0).GE.0.) WRITE (6,70) I,J,K0
      PERM(I,J)=0.
      T(I,J,K0)=0.
      TR(I,J-1,K0)=0.
      TR(I,J,K0)=0.
      TC(I,J,K0)=0.
      TC(I-1,J,K0)=0.
      IF (K0.NE.1) TK(I,J,K1)=0.
      PHI(I,J,K0)=1.D30
   10 CONTINUE
      IF (N3.EQ.1) RETURN
      N1=K0
      N2=K0
      N4=K1
      GO TO 20
C     ---COMPUTE T COEFFICIENTS---
C     *********************
      ENTRY TCOF
C     *********************
      N1=1
      N2=K0
      N4=1
   20 DO 40 K=N1,N2
      DO 40 I=1,I1
      DO 40 J=1,J1
      IF (T(I,J,K).EQ.0.) GO TO 40
      IF (T(I,J+1,K).EQ.0.) GO TO 30
      TR(I,J,K)=(2.*T(I,J+1,K)*T(I,J,K))/(T(I,J,K)*DELX(J+1)+T(I,J+1,K)*
     1DELX(J))*FACT(K,1)
   30 IF (T(I+1,J,K).EQ.0.) GO TO 40
      TC(I,J,K)=(2.*T(I+1,J,K)*T(I,J,K))/(T(I,J,K)*DELY(I+1)+T(I+1,J,K)*
     1DELY(I))*FACT(K,2)
   40 CONTINUE
      IF (K0.EQ.1.OR.ITK.EQ.ICHK(10)) RETURN
      DO 50 K=N4,K1
      DO 50 I=2,I1
      DO 50 J=2,J1
```

```
      IF (T(I,J,K+1).EQ.0.) GO TO 50
      T1=T(I,J,K)*FACT(K,3)
      T2=T(I,J,K+1)*FACT(K+1,3)
      TK(I,J,K)=(2.*T2*T1)/(T1*DELZ(K+1)+T2*DELZ(K))
   50 CONTINUE
      RETURN
C
C
   60 FORMAT('-',20('*'),'WELL',2I3,' IN LAYER',I3,' GOES DRY',2X,'(DURI
     1NG NEXT TIME STEP)')
   70 FORMAT('-',20('*'),'NODE',2I3,' IN LAYER',I3,' GOES DRY',2X,'(DURI
     1NG NEXT TIME STEP)')
      END
      SUBROUTINE CHECKI(PHI,STRT,OLD,T,S,TR,TC,TK,WELL,DELX,DELY,DELZ,FA
     1CT,JFLO,FLOW,QRE,ID,FLD,ELD,IDR,RH,RC,RB,IDRAIN,IRIV)
C     ------------------------------------------------------------------
C     COMPUTE A VOLUMETRIC BALANCE
C     ------------------------------------------------------------------
C
C     SPECIFICATIONS:
      REAL *8PHI
C
      DIMENSION PHI(I0,J0,K0), STRT(I0,J0,K0), OLD(I0,J0,K0), T(I0,J0,K0
     1), S(I0,J0,K0), TR(I0,J0,K0), TC(I0,J0,K0), TK(IK,JK,K5), WELL(I0,
     2J0,K0), DELX(J0), DELY(I0), DELZ(K0), FACT(K0,3), JFLO(NCH,3), FLO
     3W(NCH), QRE(IQ,JQ), IQQ(40,38),XRAY(50,50),YRAY(50,50)
     4,ID(I0,J0),FLD(1),ELD(1),IDR(I0,J0),RH(1),RC(1),RB(1)
C
      COMMON /INTEGR/ I0,J0,K0,I1,J1,K1,I,J,K,NPER,KTH,ITMAX,LENGTH,KP,N
     1WEL,NUMT,IFINAL,IT,KT,IHEAD,IDRAW,IFLO,IERR,I2,J2,K2,IMAX,ITMX1,NC
     2H,IOK1,IOK2,IWATER,IQRE,IP,JP,IQ,JQ,IK,JK,K5,IPU1,IPU2,ITK
      COMMON /SPARAM/ TMAX,CDLT,DELT,ERR,TEST,SUM,SUMP,QR,IOK
      COMMON /SARRAY/ ICHK(13),LEVEL1(9),LEVEL2(9)
      COMMON /CK/ ETFLXT,STORT,QRET,CHST,CHDT,FLUXT,PUMPT,CFLUXT,FLXNT
      COMMON /EVAPO/ ETDIST,QET,GRND(50,50)
      RETURN
C     ..................................................................
C     ********************
      ENTRY CHECK
C     ********************
C     ---INITIALIZE VARIABLES---
      PUMP=0.
      STOR=0.
      FLUXS=0.0
      CHD1=0.0
      CHD2=0.0
      QREFLX=0.
      CFLUX=0.
      FLUX=0.
      ETFLUX=0.
      FLXN=0.0
      II=0
C     ..................................................................
C
C     ---COMPUTE RATES,STORAGE AND PUMPAGE FOR THIS STEP---
      DO 220 K=1,K0
      DO 220 I=2,I1
      DO 220 J=2,J1
      IF (T(I,J,K).EQ.0.) GO TO 220
      AREA=DELX(J)*DELY(I)
      VOLUME=AREA*DELZ(K)
```

```
      IF (S(I,J,K).GE.0.) GO TO 180                                      CHK 460
C                                                                        CHK 470
C     ---COMPUTE FLOW RATES TO AND FROM CONSTANT HEAD BOUNDARIES---      CHK 480
      II=II+1                                                            CHK 490
      FLOW(II)=0.                                                        CHK 500
      JFLO(II,1)=K                                                       CHK 510
      JFLO(II,2)=I                                                       CHK 520
      JFLO(II,3)=J                                                       CHK 530
      IF (S(I,J-1,K).LT.0..OR.T(I,J-1,K).EQ.0.) GO TO 30                 CHK 540
      X=(PHI(I,J,K)-PHI(I,J-1,K))*TR(I,J-1,K)*DELY(I)                    CHK 550
      IF(IEQN.EQ.ICHK(11)) X=X*DELZ(K)                                    CHK 555
      FLOW(II)=FLOW(II)+X                                                CHK 560
      IF (X) 10,30,20                                                    CHK 570
   10 CHD1=CHD1+X                                                        CHK 580
      GO TO 30                                                           CHK 590
   20 CHD2=CHD2+X                                                        CHK 600
   30 IF (S(I,J+1,K).LT.0..OR.T(I,J+1,K).EQ.0.) GO TO 60                 CHK 610
      X=(PHI(I,J,K)-PHI(I,J+1,K))*DELY(I)*TR(I,J,K)                      CHK 620
      IF(IEQN.EQ.ICHK(11)) X=X*DELZ(K)                                    CHK 625
      FLOW(II)=FLOW(II)+X                                                CHK 630
      IF (X) 40,60,50                                                    CHK 640
   40 CHD1=CHD1+X                                                        CHK 650
      GO TO 60                                                           CHK 660
   50 CHD2=CHD2+X                                                        CHK 670
   60 IF (K.EQ.1) GO TO 90                                               CHK 680
      IF (S(I,J,K-1).LT.0..OR.T(I,J,K-1).EQ.0.) GO TO 90                 CHK 690
      X=(PHI(I,J,K)-PHI(I,J,K-1))*TK(I,J,K-1)*AREA*2./(DELZ(K)+DELZ(K-1) CHK 700
     1)                                                                    CHK710
      FLOW(II)=FLOW(II)+X                                                CHK 720
      IF (X) 70,90,80                                                    CHK 730
   70 CHD1=CHD1+X                                                        CHK 740
      GO TO 90                                                           CHK 750
   80 CHD2=CHD2+X                                                        CHK 760
   90 IF (K.EQ.KO) GO TO 120                                             CHK 770
      IF (S(I,J,K+1).LT.0..OR.T(I,J,K+1).EQ.0.) GO TO 120                CHK 780
      X=(PHI(I,J,K)-PHI(I,J,K+1))*TK(I,J,K)*AREA*2./(DELZ(K)+DELZ(K+1))   CHK 790
      FLOW(II)=FLOW(II)+X                                                CHK 800
      IF (X) 100,120,110                                                 CHK 810
  100 CHD1=CHD1+X                                                        CHK 820
      GO TO 120                                                          CHK 830
  110 CHD2=CHD2+X                                                        CHK 840
  120 IF (S(I-1,J,K).LT.0..OR.T(I-1,J,K).EQ.0.) GO TO 150                CHK 850
      X=(PHI(I,J,K)-PHI(I-1,J,K))*TC(I-1,J,K)*DELX(J)                    CHK 860
      IF(IEQN.EQ.ICHK(11)) X=X*DELZ(K)                                    CHK 865
      FLOW(II)=FLOW(II)+X                                                CHK 870
      IF (X) 130,150,140                                                 CHK 880
  130 CHD1=CHD1+X                                                        CHK 890
      GO TO 150                                                          CHK 900
  140 CHD2=CHD2+X                                                        CHK 910
  150 IF (S(I+1,J,K).LT.0..OR.T(I+1,J,K).EQ.0.) GO TO 220                CHK 920
      X=(PHI(I,J,K)-PHI(I+1,J,K))*TC(I,J,K)*DELX(J)                      CHK 930
      IF(IEQN.EQ.ICHK(11)) X=X*DELZ(K)                                    CHK 935
      FLOW(II)=FLOW(II)+X                                                CHK 940
      IF (X) 160,220,170                                                 CHK 950
  160 CHD1=CHD1+X                                                        CHK 960
      GO TO 220                                                          CHK 970
  170 CHD2=CHD2+X                                                        CHK 980
      GO TO 220                                                          CHK 990
C                                                                        CHK1000
C     ---RECHARGE AND WELLS---                                            CHK1010
  180 IF (K.EQ.KO.AND.IQRE.EQ.ICHK(7)) QREFLX=QREFLX+QRE(I,J)*AREA        CHK1020
```

```
      IF (WELL(I,J,K)) 190,210,200
  190 PUMP=PUMP+WELL(I,J,K)*AREA
      GO TO 210
  200 CFLUX=CFLUX+WELL(I,J,K)*AREA
C
C     ---COMPUTE VOLUME FROM STORAGE---
  210 STOR=STOR+S(I,J,K)*(OLD(I,J,K)-PHI(I,J,K))*AREA
      IF(K.NE.K0.OR.IRIV.LE.0) GO TO 212
C     COMPUTE LEAKAGE TO RIVER
      ND=IDR(I,J)
      IF(ND.EQ.0) GO TO 212
      IF(PHI(I,J,K).GT.RB(ND)) GO TO 211
      FLXN=RC(ND)*(RH(ND)-RB(ND))*AREA+FLXN
      GO TO 212
  211 FLXN=RC(ND)*(RH(ND)-PHI(I,J,K))*AREA+FLXN
  212 IF(K.NE.K0.OR.IDRAIN.LE.0) GO TO 213
C     COMPUTE LEAKAGE TO DRAIN
      ND=ID(I,J)
      IF(ND.EQ.0) GO TO 220
      IF(ELD(ND).GT.PHI(I,J,K)) GO TO 220
      FLUX=FLUX+FLD(ND)*AREA*(ELD(ND)-STRT(I,J,K))
      FLXN=FLXN+FLD(ND)*AREA*(ELD(ND)-PHI(I,J,K))
      FLUXS=FLXN
  213 IF(K.NE.K0)GO TO 220
C     COMPUTE EVAPOTRANSPIRATION
      IF(PHI(I,J,K).GE.GRND(I,J)-ETDIST) GO TO 215
      GO TO 217
  215 IF(PHI(I,J,K).LE.GRND(I,J)) GO TO 216
      ETQ=QET
      GO TO 217
  216 ETQ=QET/ETDIST*(PHI(I,J,K)+ETDIST-GRND(I,J))
  217 ETFLUX=ETFLUX-ETQ*AREA
      FLUXS=FLXN
  220 CONTINUE
C     ..................................................................
C
C     ---COMPUTE CUMULATIVE VOLUMES, TOTALS, AND DIFFERENCES---
      FLXPT=0.0
      FLXNT=FLXNT-FLXN*DELT
      ETFLXT=ETFLXT-ETFLUX*DELT
      STORT=STORT+STOR
      STOR=STOR/DELT
      QRET=QRET+QREFLX*DELT
      CHDT=CHDT-CHD1*DELT
      CHST=CHST+CHD2*DELT
      PUMPT=PUMPT-PUMP*DELT
      CFLUXT=CFLUXT+CFLUX*DELT
      TOTL1=STORT+QRET+CFLUXT+CHST+FLXPT
      TOTL2=CHDT+PUMPT+ETFLXT+FLXNT
      SUMR=QREFLX+CFLUX+CHD2+CHD1+PUMP+ETFLUX+FLUXS+STOR
      DIFF=TOTL2-TOTL1
      PERCNT=0.0
      IF (TOTL2.EQ.0.) GO TO 230
      PERCNT=DIFF/TOTL2*100.
  230 RETURN
C     ..................................................................
C
C     ---PRINT RESULTS---
C     ************************
      ENTRY CWRITE
C     ************************
```

```
C                                                                       CHK1360
      WRITE (6,260) STOR,QREFLX,STORT,CFLUX,QRET,PUMP,CFLUXT,ETFLUX,CHSTCHK1370
     1,FLXPT,CHD2,TOTL1,CHD1,FLUX,FLUXS,ETFLXT,CHDT,SUMR,PUMPT,FLXNT,TOTCHK1380
     2L2,DIFF,PERCNT                                                    CHK1390
      IF (NCH.EQ.0) GO TO 240                                           CHK1400
      WRITE (6,270)                                                     CHK1410
      WRITE (6,280) ((JFLO(I,J),J=1,3),FLOW(I),I=1,NCH)                 CHK1420
C                                                                       CHK1430
C     ---COMPUTE VERTICAL FLOW---                                       CHK1440
  240 X=0.                                                              CHK1450
      Y=0.                                                              CHK1460
      IF (K0.EQ.1) RETURN                                               CHK1470
      DO 250 I=2,I1                                                     CHK1480
      DO 250 J=2,J1                                                     CHK1490
      XRAY(I,J)=0.0
      YRAY(I,J)=0.0
      Z=0
      Z=(PHI(I,J,1)-PHI(I,J,2))*TK(I,J,1)*DELX(J)*DELY(I)*2./(DELZ(1)+DE
     1LZ(2))
      X=X+Z
      XRAY(I,J)=Z
      Z=0
      Z=(PHI(I,J,K1)-PHI(I,J,K0))*TK(I,J,K1)*DELX(J)*DELY(I)*2./(DELZ(K1
     1)+DELZ(K0))
      Y=Y+Z
  250 YRAY(I,J)=Z
      IF(IOK.EQ.0)GO TO 251
      WRITE(6,297)
      DO 252 I=2,I1
  252 WRITE(6,296) I,(XRAY(I,J),J=2,J1)
      WRITE(6,298)
      DO 253 I=2,I1
  253 WRITE(6,296) I,(YRAY(I,J),J=2,J1)
  251 WRITE(6,290) Y,X
      RETURN                                                            CHK1550
C                                                                       CHK1560
C     ---FORMATS---                                                     CHK1570
C                                                                       CHK1580
C     -----------------------------------------------------------------CHK1590
C                                                                       CHK1600
C                                                                       CHK1610
C                                                                       CHK1620
  260 FORMAT ('0',10X,'CUMULATIVE MASS BALANCE:',16X,'L**3',23X,'RATES FCHK1630
     1OR THIS TIME STEP:',16X,'L**3/T'/11X,24('-'),43X,25('-')//20X,'SOUCHK1640
     2RCES:',69X,'STORAGE =',F20.4/20X,8('-'),68X,'RECHARGE =',F20.4/27XCHK1650
     3,'STORAGE =',F20.2,35X,'CONSTANT FLUX =',F20.4/26X,'RECHARGE =',F2CHK1660
     40.2,41X,'PUMPING =',F20.4/21X,'CONSTANT FLUX =',F20.2,30X,'EVAPOTRCHK1670
     5ANSPIRATION =',F20.4/21X,'CONSTANT HEAD =',F20.2,34X,'CONSTANT HEACHK1680
     6D:'/27X,'LEAKAGE =',F20.2,46X,'IN =',F20.4/21X,'TOTAL SOURCES =',FCHK1690
     720.2,45X,'OUT =',F20.4/96X,'LEAKAGE:'/20X,'DISCHARGES:',45X,'FROM CHK1700
     8PREVIOUS PUMPING PERIOD =',F20.4/20X,11('-'),60X,'RIVER LEAKAGE ='CHK1710
     9,F20.4/16X,'EVAPOTRANSPIRATION =',F20.2/21X,'CONSTANT HEAD =',F20.CHK1720
     &2,36X,'SUM OF RATES =',F20.4/19X'QUANTITY PUMPED =',F20.2/21X,'RIVCHK1730
     &ER LEAKAGE =',F20.2/19X,'TOTAL DISCHARGE =',F20.2//17X,'DISCHARGE-CHK1740
     &SOURCES =',F20.2/15X,'PER CENT DIFFERENCE =',F20.2//)             CHK1750
  270 FORMAT (' FLOW RATES TO CONSTANT HEAD NODES:'/' ',34('-')//' ',3(9CHK1760
     1X,'K',4X,'I',4X,'J',5X,'RATE (L**3/T)')/' ',3(9X,'-',4X,'-',4X,'-'CHK1770
     2,5X,13('-'))/)                                                    CHK1780
  280 FORMAT (/(1X,3(I10,2I5,G18.7)))                                   CHK1790
  290 FORMAT ('0FLOW TO TOP LAYER =',G15.7,'   FLOW TO BOTTOM LAYER =',GCHK1800
     115.7,'      POSITIVE UPWARD')                                     CHK1810
```

```
  296 FORMAT('0',1X,I2,10F12.7,3(/4X,10F12.7))
  297 FORMAT('1',52X,'FLOW TO BOTTOM LAYER BY NODE'//)
  298 FORMAT('1',52X,'FLOW TO TOP LAYER BY NODE'//)
      END
      SUBROUTINE PRNTAI(PHI,STRT,T,S,WELL,DELX,DELY)
C     ----------------------------------------------------------------
C     PRINT MAPS OF DRAWDOWN AND HYDRAULIC HEAD
C     ----------------------------------------------------------------
C
C     SPECIFICATIONS:
      REAL *8PHI,Z,XLABEL,YLABEL,TITLE,XN1,MESUR
      REAL *4K
C
      DIMENSION PHI(I0,J0,K0), STRT(I0,J0,K0), S(I0,J0,K0), WELL(I0,J0,K
     10), DELX(J0), DELY(I0), T(I0,J0,K0)
C
      COMMON /INTEGR/ I0,J0,K0,I1,J1,K1,I,J,K,NPER,KTH,ITMAX,LENGTH,KP,N
     1WEL,NUMT,IFINAL,IT,KT,IHEAD,IDRAW,IFLO,IERR,I2,J2,K2,IMAX,ITMX1,NC
     2H,IDK1,IDK2,IWATER,IQRE,IP,JP,IQ,JQ,IK,JK,K5,IPU1,IPU2,ITK
      COMMON /PR/ XLABEL(3),YLABEL(6),TITLE(6),XN1,MESUR,PRNT(122),BLANK
     1(60),DIGIT(122),VF1(6),VF2(6),VF3(7),XSCALE,DINCH,SYM(17),XN(100),
     2YN(13),NA(4),N1,N2,N3,YSCALE,FACT1,FACT2
      RETURN
C     ................................................................
C
C     ---INITIALIZE VARIABLES FOR PLOT---
C     ********************
      ENTRY MAP
C     ********************
      YDIM=0.
      WIDTH=0.
      DO 10 J=2,J1
   10 WIDTH=WIDTH+DELX(J)
      DO 20 I=2,I1
   20 YDIM=YDIM+DELY(I)
   30 XSF=DINCH*XSCALE
      YSF=DINCH*YSCALE
      NYD=YDIM/YSF
      IF (NYD*YSF.LE.YDIM-DELY(I1)/2.) NYD=NYD+1
      IF (NYD.LE.12) GO TO 40
      DINCH=YDIM/(12.*YSCALE)
      WRITE (6,330) DINCH
      IF (YSCALE.LT.1.0) WRITE (6,340)
      GO TO 30
   40 NXD=WIDTH/XSF
      IF (NXD*XSF.LE.WIDTH-DELX(J1)/2.) NXD=NXD+1
      N4=NXD*N1+1
      N5=NXD+1
      N6=NYD+1
      N8=N2*NYD+1
      NA(1)=N4/2-1
      NA(2)=N4/2
      NA(3)=N4/2+3
      NC=(N3-N8-10)/2
      ND=NC+N8
      NE=MAX0(N5,N6)
      VF1(3)=DIGIT(ND)
      VF2(3)=DIGIT(ND)
      VF3(3)=DIGIT(NC)
      XLABEL(3)=MESUR
      YLABEL(6)=MESUR
```

```
      DO 60 I=1,NE
      NNX=N5-I
      NNY=I-1
      IF (NNY.GE.N6) GO TO 50
      YN(I)=YSF*NNY/YSCALE
   50 IF (NNX.LT.0) GO TO 60
      XN(I)=XSF*NNX/YSCALE
   60 CONTINUE
      RETURN
C     ...................................................................
C
C     ********************
      ENTRY PRNTA(NG,LA)
C     ********************
C     ---VARIABLES INITIALIZED EACH TIME A PLOT IS REQUESTED---
      DIST=WIDTH-DELX(J1)/2.
      JJ=J1
      LL=1
      Z=NXD*XSF
      IF (NG.EQ.1) WRITE (6,300) (TITLE(I),I=1,3),LA
      IF (NG.EQ.2) WRITE (6,300) (TITLE(I),I=4,6),LA
      DO 290 I=1,N4
C
C     ---LOCATE X AXES---
      IF (I.EQ.1.OR.I.EQ.N4) GO TO 70
      PRNT(1)=SYM(12)
      PRNT(N8)=SYM(12)
      IF ((I-1)/N1*N1.NE.I-1) GO TO 90
      PRNT(1)=SYM(14)
      PRNT(N8)=SYM(14)
      GO TO 90
C
C     ---LOCATE Y AXES---
   70 DO 80 J=1,N8
      IF ((J-1)/N2*N2.EQ.J-1) PRNT(J)=SYM(14)
   80 IF ((J-1)/N2*N2.NE.J-1) PRNT(J)=SYM(13)
C
C     ---COMPUTE LOCATION OF NODES AND DETERMINE APPROPRIATE SYMBOL---
   90 IF (DIST.LT.0..OR.DIST.LT.Z-XN1*XSF) GO TO 240
      YLEN=DELY(2)/2.
      DO 220 L=2,I1
      J=YLEN*N2/YSF+1.5
      IF (T(L,JJ,LA).EQ.0.) GO TO 160
      IF (S(L,JJ,LA).LT.0.) GO TO 210
      INDX3=0
      GO TO (100,110), NG
  100 K=(STRT(L,JJ,LA)-PHI(L,JJ,LA))*FACT1
C     -TO CYCLE SYMBOLS FOR DRAWDOWN, REMOVE C FROM COL. 1 OF NEXT CARD-
C     K=AMOD(K,10.)
      GO TO 120
  110 K=PHI(L,JJ,LA)*FACT2
  120 IF (K) 130,160,140
  130 IF (J-2.GT.0) PRNT(J-2)=SYM(13)
      N=-K+.5
      IF (N.LT.100) GO TO 150
      GO TO 190
  140 N=K+.5
      IF (N.LT.100) GO TO 150
      IF (N.GT.999) GO TO 190
      INDX3=N/100
      IF (J-2.GT.0) PRNT(J-2)=SYM(INDX3)
```

```
      N=N-INDX3*100                                                     PRN1190
  150 INDX1=MOD(N,10)                                                   PRN1200
      IF (INDX1.EQ.0) INDX1=10                                          PRN1210
C     -TO CYCLE SYMBOLS FOR DRAWDOWN, REMOVE C FROM COL. 1 OF NEXT CARD-PRN1220
C     IF (NG.EQ.1) GO TO 170                                            PRN1230
      INDX2=N/10                                                        PRN1240
      IF (INDX2.GT.0) GO TO 180                                         PRN1250
      INDX2=10                                                          PRN1260
      IF (INDX3.EQ.0) INDX2=15                                          PRN1270
      GO TO 180                                                         PRN1280
  160 INDX1=15                                                          PRN1290
  170 INDX2=15                                                          PRN1300
  180 IF (J-1.GT.0) PRNT(J-1)=SYM(INDX2)                                PRN1310
      PRNT(J)=SYM(INDX1)                                                PRN1320
      GO TO 220                                                         PRN1330
  190 DO 200 II=1,3                                                     PRN1340
      JI=J-3+II                                                         PRN1350
  200 IF (JI.GT.0) PRNT(JI)=SYM(11)                                     PRN1360
  210 IF (S(L,JJ,LA).LT.0.) PRNT(J)=SYM(16)                             PRN1370
  220 YLEN=YLEN+(DELY(L)+DELY(L+1))/2.                                  PRN1380
  230 DIST=DIST-(DELX(JJ)+DELX(JJ-1))/2.                                PRN1390
      JJ=JJ-1                                                           PRN1400
      IF (JJ.EQ.0) GO TO 240                                            PRN1410
      IF (DIST.GT.7-XN1*XSF) GO TO 230                                  PRN1420
  240 CONTINUE                                                          PRN1430
C                                                                       PRN1440
C     ---PRINT AXES,LABELS, AND SYMBOLS---                              PRN1450
      IF (I-NA(LL).EQ.0) GO TO 260                                      PRN1460
      IF ((I-1)/N1*N1-(I-1)) 270,250,270                                PRN1470
  250 WRITE (6,VF1) (BLANK(J),J=1,NC),(PRNT(J),J=1,N8),XN(1+(I-1)/6)    PRN1480
      GO TO 280                                                         PRN1490
  260 WRITE (6,VF2) (BLANK(J),J=1,NC),(PRNT(J),J=1,N8),XLABEL(LL)       PRN1500
      LL=LL+1                                                           PRN1510
      GO TO 280                                                         PRN1520
  270 WRITE (6,VF2) (BLANK(J),J=1,NC),(PRNT(J),J=1,N8)                  PRN1530
C                                                                       PRN1540
C     ---COMPUTE NEW VALUE FOR Z AND INITIALIZE PRNT---                 PRN1550
  280 Z=Z-2.*XN1*XSF                                                    PRN1560
      DO 290 J=1,N8                                                     PRN1570
  290 PRNT(J)=SYM(15)                                                   PRN1580
C                                                                       PRN1590
C     ---NUMBER AND LABEL Y AXIS AND PRINT LEGEND---                    PRN1600
      WRITE (6,VF3) (BLANK(J),J=1,NC),(YN(I),I=1,N6)                    PRN1610
      WRITE (6,320) (YLABEL(I),I=1,6)                                   PRN1620
      IF (NG.EQ.1) WRITE (6,310) FACT1                                  PRN1630
      IF (NG.EQ.2) WRITE (6,310) FACT2                                  PRN1640
      RETURN                                                            PRN1650
C                                                                       PRN1660
C     ---FORMATS---                                                     PRN1670
C                                                                       PRN1680
C     ------------------------------------------------------------------PRN1690
C                                                                       PRN1700
C                                                                       PRN1710
  300 FORMAT ('1',49X,3A8,'LAYER',I4//)                                 PRN1720
  310 FORMAT ('0EXPLANATION'/' ',11('-')//' R = CONSTANT HEAD BOUNDARY'/PRN1730
     1' *** = VALUE EXCEEDED 3 FIGURES'/' MULTIPLICATION FACTOR =',F8.3)PRN1740
  320 FORMAT ('0',39X,6A8)                                              PRN1750
  330 FORMAT ('0',25X,10('*'),' TO FIT MAP WITHIN 12 INCHES, DINCH REVISPRN1760
     1ED TO',G15.7,1X,10('*'))                                          PRN1770
  340 FORMAT ('0',45X,'NOTE: GENERALLY SCALE SHOULD BE > OR = 1.0')     PRN1780
      END                                                               PRN1790-
```

```
      BLOCK DATA
C     ----------
C
C     SPECIFICATIONS:
      REAL *8XLABEL,YLABEL,TITLE,XN1,MESUR
C
      COMMON /SARRAY/ ICHK(13),LEVEL1(9),LEVEL2(9)
      COMMON /PP/ XLABEL(3),YLABEL(6),TITLE(6),XN1,MESUR,PRNT(122),BLANK
     1(60),DIGIT(122),VF1(6),VF2(6),VF3(7),XSCALE,DINCH,SYM(17),XN(100),
     2YN(13),NA(4),N1,N2,N3,YSCALE,FACT1,FACT2
C     ******************************************************************
C
      DATA ICHK/'DRAW','HEAD','MASS','DK1','DK2','WATE','RECH','PUN1','P
     1UN2','ITKP','EQN3',2*0/
      DATA SYM/'1','2','3','4','5','6','7','8','9','0','*','|','-','+','
     1 ','R','W'/
      DATA PRNT/122*' '/,N1,N2,N3,XN1/6,10,133,.83333333D-1/,BLANK/60*'
     1 '/,NA(4)/1000/
      DATA XLABEL/' X DIS- ','TANCE IN','  MILES '/,YLABEL/'DISTANCE',' 
     1FROM OR','IGIN IN ','Y DIRECT','ION, IN ','MILES   '/,TITLE/'PLOT 
     2OF ','DRAWDOWN',' ','PLOT OF ','HYDRAULI','C HEAD'/
      DATA DIGIT/'1','2','3','4','5','6','7','8','9','10','11','12','13'
     1,'14','15','16','17','18','19','20','21','22','23','24','25','26',
     2'27','28','29','30','31','32','33','34','35','36','37','38','39','
     340','41','42','43','44','45','46','47','48','49','50','51','52','5
     43','54','55','56','57','58','59','60','61','62','63','64','65','66
     5','67','68','69','70','71','72','73','74','75','76','77','78',' 79
     6','80','81','82','83','84','85','86','87','88','89','90','91','92'
     7,'93','94','95','96','97','98','99','100','101','102','103',' 104'
     8,'105','106','107','108','109','110','111','112','113','114','115'
     9,'116','117','118','119','120','121','122'/
      DATA VF1/'(1H ',',','     ','A1,F','10.2',')'/
      DATA VF2/'(1H ',',','     ','A1,1','X,A8',')'/
      DATA VF3/'(1H0',',','     ','A1,F','3.1,','12F1','0.2)'/
C     ******************************************************************
      END
//
```

SUPPLEMENTARY DATA II--DATA INPUT INSTRUCTIONS

[Modified from Trescott, 1975; Trescott and Larson, 1976]

Group I: Title, simulation options, and problem dimensions

This group contains data required to dimension the model. To specify an option on line 4, key in the characters underlined in the definition. For an option not used, that variable can be left blank.

Line	Columns	Format	Variable	Definition
1	1-80	20A4	HEADING	Any title the user wishes to print on one line at the start of output.
2	1-52	13A4	HEADING	
3	1-10	I10	IO	Number of rows.
	11-20	I10	JO	Number of columns.
	21-30	I10	KO	Number of layers.
	31-40	I10	ITMAX	Maximum number of iterations per step.
	41-50	I10	NCH	Number of constant head nodes.
	51-60	I10	ND	Number of drain nodes.[1]
	61-70	I10	NRIV	Number of river nodes.[1]
	71-80	I10	IOK	To print vertical flow at each node enter a 1.
4	1-4	A4	IDRAW	DRAW to print drawdown.
	6-9	A4	IHEAD	HEAD to print hydraulic head.
	11-14	A4	IFLOW	MASS to compute a mass balance.
	16-18	A3	IDK1	DK1 to read initial head, elapsed time, and mass balance parameters from unit 4 on disk.
	21-23	A3	IDK2	DK2 to write computed head, elapsed time, and mass balance parameters on unit 4 (disk).

[1]Set Dimension Y. If either or both of these parameters is zero, the subsequent data corresponding to that parameter can be omitted.

Group I: Title, simulation options and problem dimensions--Continued

Line	Columns	Format	Variable	Definition
	26-29	A4	IWATER	WATE if the upper hydrologic unit is confined.
	31-34	A4	IQRE	RECH for a constant (with time) recharge that may be a function of space--for RECH data set 8 is needed.
	36-39	A4	IPU1	PUN1 to read initial head, elapsed time, and mass balance parameters on subsequent lines.
	41-44	A4	IPU2	PUN2 to punch computed head, elapsed time, and mass balance parameters on subsequent lines.
	46-49	A4	ITK	ITKR to read the value of TK(I, J, K) for simulations in which confining layers are not represented by layers of nodes. TK(I, J, K) = K_{zz}/b.
	51-54	A4	IEQN	EQN3 if eqn. 3 is being solved; otherwise it is assumed that eqn. 4 is being solved. (leave blank for three-dimensional.)

Group II: Scalar parameters

The parameters required in every problem are underlined. The other parameters are required as noted; when not required, their location on the line can be left blank. The G format is used to read E, F, and I format data. Minimize mistakes by always right-justifying data in the field. If F format data do not contain significant figures to the right of the decimal point, the decimal point can be omitted.

Line	Columns	Format	Variable	Definition
1	1-10	G10.0	NPER	Number of pumping periods for the simulation.
	11-20	G10.0	KTH	Number of time steps between printouts. (Experiment for accuracy when stress is large, for example, try more time steps.)

Group II: Scalar parameters--Continued

Line	Columns	Format	Variable	Definition
NOTE: To print only the results for the final time step in a pumping period, make KTH greater than the expected number of time steps. The program always prints the results for the final time step.				
	21-30	G10.0	ERR	Error criterion for closure (L). (Experiment--too high a number can cause errors in the Mass Balance.)
NOTE: When the head change at all nodes on subsequent iterations is less than this value (for example, 0.01 foot), the program has converged to a solution for the time step.				
	31-40	G10.0	LENGTH	Number of iteration parameters.
	41-50	G10.0	QET	Maximum ET rate (in ft/sec).
	51-60	G10.0	ETDIST[2]	Depth at which ET ceases below land surface (ft).
	61-70	G10.0	BETA[2]	Dampening parameter less than 1.0.
2	1-10	G10.0	XSCALE	Factor to convert model length unit used in X direction on maps. (That is, to convert from feet to miles, XSCALE = 5280).
NOTE: For no maps, line 2 is blank.				
	11-20	G10.0	YSCALE	Factor to convert model length unit to unit used in Y direction on maps.
	21-30	G10.0	DINCH	Number of map units per inch.
	31-40	G10.0	FACT1	Factor to adjust value of drawdown printed.[3]

[2]Must be coded non-zero.

[3]

Value of drawdown or head	FACT1 or FACT2	Printed value
	0.01	1
	0.1	5
52.57	1.0	53
	10.0	526
	100.0	***

Group II: Scalar parameters--Continued

Line	Columns	Format	Variable	Definition
	41-49	9I1	LEVEL1(I)	Layers for which drawdown maps are to be printed. List the layers starting in col. 41; the first zero entry terminates the printing of drawdown maps.
	51-60	G10.0	FACT2	Factor to adjust value of head printed.[3]
	61-69	9I1	LEVEL2(I)	Layers for which head maps are to be printed. List layers starting in col. 61; the first zero entry terminates the printing of head maps.
	71-78	A8	MESUR	Name of map length unit.
3	1-20	G20.10	SUM	Parameters in which elapsed time and cumulative volumes for mass balance are stored. For the start of a simulation simulation insert three blank lines. For continuation of a previous run, replace the three blank lines with output from the previous run.
	21-40	G20.10	SUMP	
	41-60	G20.10	PUMPT	
	61-80	G20-10	CFLUXT	
4	1-20	G20.10	QRET	
	21-40	G20.10	CHST	
	41-60	G20.10	CHDT	
	61-80	G20.10	FLUXT	
5	1-20	G20.10	STORT	
	21-40	G20.10	ETFLXT	
	41-60	G20.10	FLXNT	

[3]

Value of draw-down or head	FACT1 or FACT2	Printed value
	0.01	1
	0.1	5
52.57	1.0	53
	10.0	526
	100.0	***

Group III: Array data

Each of the following data sets (except data set 1) consists of a parameter line and, if the data set contains variable data, a set of data lines. If the data set requires data for each layer, a parameter line and data lines (for layers with variable data) are required for each layer. Each parameter line contains at least five variables.

Group III: Array data--Continued

Foot-note	Columns	Format	Variable	Definition
(4)	1-10	G10.0	FAC	If IVAR = 0, FAC is the value assigned to every element of the matrix for this layer. If IVAR = 1, FAC is the multiplication factor for the following set of data lines for this layer.
	11-20	G10.0	IVAR	= 0 if no data lines are to be read for this layer. = 1 if data lines for this layer follow.
	21-30	G10.0	IPRN	= 0 if input data for this layer are to be printed. = 1 if input data for this layer are not to be printed.
(5)	31-40	G10.0	FACT(K,1)[6]	Multiplication factor for transmissivity in X direction.
(5)	41-50	G10.0	FACT(K,2)[6]	Multiplication factor for transmissivity in Y direction.
(5)	51-60	G10.0	FACT(K,3)[7]	Multiplication factor for hydraulic conductivity in the Z direction. (Not used when confining bed nodes are eliminated and TK values are read.)
(4)	61-70	G10.0	IRECS	= 0 if the matrix is input on subsequent lines or if each element is being set equal to FAC. = 1 if the matrix is to be read from disk (unit 2).
	71-80	G10.0	IRECD	= 0 if the matrix is not to be atored on disk. = 1 if the matrix being read from subsequent lines or set equal to FAC is to be stored on disk (unit 2) for later retrieval.

[4] Every parameter line.
[5] Transmissivity parameter lines also have these variables.
[6] Anisotropy.
[7] Use only for the confining bed represented by layer of nodes.

Group III: Array data--Continued

When data lines are included, start each row on a new line. To prepare a set of data lines for an array that is a function of space, the general procedure is to overlay the finite-difference grid on a contoured map of the parameter and record the average value of the parameter for each finite-difference block on coding forms according to the appropriate format. In general, record only significant digits and no decimal points (except for data set 2); use the multiplication factor to convert the data to their appropriate values. For example, if DELX ranges from 1,000 to 15,000 feet, coded values should range from 1-15; the multiplication factor (FAC) would be 1,000.

Data set	Columns	Format	Variable	Definition
1	1-80	8F10.4	PHI(I, J, K)	Head values for continuation of a previous run (L).

NOTE: For a new simulation this data set is omitted. Do not include a parameter line with this data set.

Data set	Columns	Format	Variable	Definition
2	Factor card for ET option (GRND)			
	1-10	G10.0	FAC	FAC is the multiplication factor for the following set of data.
	11-20	G10.0	IPRN	= 0 if input is to be printed. = 1 if input not to be printed.
	Data set for GRND (Ground elevation)			
	1-80	20F4.0	GRND(I, J)	Land surface elevation in feet.

NOTE: If QET on line 1 of group II is equal to 0 then data set 2 should be omitted.

Data set	Columns	Format	Variable	Definition
3	1-80	8F10.4	STRT(I, J, K)	Starting head matrix (L).
4	1-80	20F4.0	S(I, J, K)	Storage coefficient (dimensionless).

NOTE: This matrix is also used to locate constant head boundaries by coding a negative number at constant head nodes. At these nodes T must be greater than zero. If equation 3 is to be solved, read specific storage instead of storage coefficient.

Data set	Columns	Format	Variable	Definition
5	1-80	20F4.0	T(I, J, K)	Transmissivity (L^2/t).

Group III: Array data--Continued

Data set	Columns	Format	Variable	Definition

NOTE:

1. Zero values are required around the perimeter of the T matrix for each layer for reasons inherent in the computational scheme. This is done automatically by the program.
2. See the previous page for the additional requirements on the parameter lines for this data set.
3. If the upper active layer is unconfined and PERM and BOTTOM are to be read for this layer, insert a parameter line for this layer with only the values for FACT on it.
4. If solving equation 3, read hydraulic conductivity--not T.

6	1-80	20F4.0	TK(I, J, K)	K_{zz}/b (sec^{-1}).

NOTE: This data set is read only if specified in the options (ITK on line 4 in Group I). The number of layers of TK values = K'-1. See the discussion of the treatment of confining layers. K' being the number of layer of nodes.

7	1-80	20F4.0	PERM(I, J)	Hydraulic conductivity (L/T). (See note 1 for data set 5.)
8	1-80	20F4.0	BOTTOM(I, J)	Elevation of bottom of water-table unit (L).

NOTE: Data sets 7 and 8 are required only for simulating unconfined conditions in the upper hydrologic unit.

9	1-80	20F4.0	QRE(I, J)	Recharge rate (L/T).

NOTE: Omit if not used.

10	1-80	8G10.0	DELX(J)	Grid spacing in X direction (L).
11	1-80	8G10.0	DELY(I)	Grid spacing in Y direction (L).
12	1-80	8G10.0	DELZ(K)	Grid spacing in Z direction (L).

Group IV: River and drain node parameter and data set lines of input

Each data set has a separate factor line (except sets 1 and 4). The first line is the factor line while the second and subsequent lines are the data lines for each data set.

Data set	Columns	Format	Variable	Definition
1	1-80	80I1	ID(IO, JO)	Indicator array for drain nodes in top layer; 1 for drain, zero for no drain. Start each row on a new line.
2	1-10	8G10.0	FAC	Multiplier for subsequent drain coefficient values. Each value is multiplied by FAC.
	1-80	40F2.0	LD(ND)	ND values of drain length (in hundreds of feet) for each node containing a drain. Values are coded continuously, 40 per line, row by row.
3	1-10	8G10.0	FAC	Multiplier for subsequent drain elevation values.
	1-80	20F4.0	ELD(ND)	ND values of drain elevation for each node containing a drain. Values are coded continuously, 20 per line, row by row.
4	1-80	80I1	IDR(IO, JO, KO)	Indicator array for river nodes in top layer; 1 for river node, zero for no river. Start each row on a new line.
5	1-10	8G10.0	FAC	Multiplier for subsequent values of river water level.
	1-80	20F4.0	RH(NRIV)	NRIV values of river water level for each node containing a river. Values coded continuously, 20 per line, row by row.
6	1-10	8G10.0	FAC	Multiplier for subsequent values of river bed bottom elevation.
	1-80	20F4.0	RB(NRIV)	NRIV values of river bed bottom elevation for each node containing a river. Leakage gradient limited to RH-RB if PHI is less than RB. Values are coded continuously, 20 per line, row by row.

Group IV: River and drain node parameter and data set lines of input--Continued

Data set	Columns	Format	Variable	Definition
7	1-10	8G10.0	FAC	Multiplier for subsequent values of river leakage coefficient.
	1-80	10F8.0	RC(NRIV)	NRIV values of river leakage coefficient (commonly $k'A_{stream}/b'A_{node}$) for each node containing a river. Values are coded continuously, 10 per line, row by row.

Group V: Parameters that change with the pumping period

The program has two options for the simulation period:

1. To simulate a given number of time steps, set TMAX to a value larger than the expected simulation period. The program will use NUMT, CDLT, and DELT as coded. If NUMT is greater that 50, change the dimensions of ITTO in subroutine STEP to the appropriate size.

2. To simulate a given pumping period, set NUMT larger than the number required for the simulation period (for example, 50). The program will compute the exact DELT (which will be less than or equal to DELT coded) and NUMT to arrive exactly at TMAX on the last time step.

Line	Columns	Format	Variable	Definition
1	1-10	G10.0	KP	Number of the pumping period.
	11-20	G10.0	KPM1	Number of the previous pumping period.
NOTE: KPM1 is currently not used.				
	21-30	G10.0	NWEL	Number of wells for this pumping period.
	31-40	G10.0	TMAX	Number of days in this pumping period.
	41-50	G10.0	NUMT	Number of time steps.
	51-60	G10.0	CDLT	Multiplying factor for DELT.
NOTE: 1.5 is commonly used.				

Group V: Parameters that change with the pumping period--Continued

Line	Columns	Format	Variable	Definition
	61-70	G10.0	DELT	Initial time step in hours.
	71-80	NON	IRECH	Leave zero.

If NWEL = 0 the following set of data lines is omitted.

Data set	Columns	Format	Variable	Definition
[6]1	1-10	G10.0	K	Layer in which well is located.
	11-20	G10.0	I	Row location of well.
	21-30	G10.0	J	Column location of well.
	31-40	G10.0	WELL (I, J, K)	Pumping rate (L^3/t), negative for pumping well.

For each additional pumping period, another set of group V data lines is required (that is, NPER sets of group V lines are required).

If another simulation is included in the same job, insert a blank line before the next group I lines.

[6]NWEL data lines--one for each well.

SUPPLEMENTARY DATA III--INPUT MATRICES AND RESULTS

Starting head matrix, layer 1 for pumping period 1

Starting head matrix, layer 2 for pumping period 1

Bottom elevation matrix, layer 2 for pumping period 1

Relative values of recharge (QRE)

Grid spacing in prototype in X direction

Head matrix, layer 1 for pumping period 2

Head matrix, layer 2 for pumping period 2

Head matrix, layer 1 for pumping period 3

Head matrix, layer 2 for pumping period 3

Head matrix, layer 1 for pumping period 4

Head matrix, layer 2 for pumping period 4

Head matrix, layer 1 for pumping period 5

Head matrix, layer 2 for pumping period 5

SUPPLEMENTARY DATA III--INPUT MATRICES AND RESULTS

Starting head matrix, layer 1 for pumping period 1

STARTING HEAD MATRIX, LAYER 1

1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
2	0.0	4.2	5.3	6.6	7.5	8.2	8.3	0.0	0.0	0.0	0.0	0.0	0.0	1.0	3.0	3.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	55.7	75.1	107.3	140.0	0.0												
3	0.0	4.2	5.4	7.0	8.1	8.7	8.3	8.9	0.0	0.0	0.0	1.5	2.8	8.9	17.0	19.3	24.8	0.0	0.0	0.0
	0.0	0.0	0.0	60.6	75.7	108.7	190.0	0.0												
4	0.0	4.1	5.4	7.9	9.2	9.6	9.8	9.5	0.0	0.0	7.7	5.3	5.5	18.4	27.4	32.0	33.2	34.2	38.0	42.5
	0.0	0.0	50.2	62.2	78.7	107.8	150.0	0.0												
5	0.0	4.1	4.8	9.5	10.6	10.6	10.7	10.2	10.3	10.4	9.8	9.6	18.0	26.2	34.5	38.8	40.0	40.1	39.1	46.5
	53.7	56.1	54.2	65.2	31.0	103.1	95.0	0.0												
6	0.0	4.0	5.9	9.9	11.4	11.6	11.7	10.9	10.8	11.4	12.1	12.9	23.4	30.3	40.6	47.0	49.3	48.4	48.7	53.9
	58.4	60.0	61.2	68.3	79.5	94.5	95.0	0.0												
7	0.0	3.9	6.1	10.1	9.7	12.7	13.3	11.0	11.3	12.8	14.9	15.1	21.9	28.9	39.8	47.0	55.0	59.1	59.8	61.6
	61.3	62.5	65.1	70.8	77.9	85.9	110.0	0.0												
8	0.0	3.4	5.2	7.5	7.3	11.2	12.1	9.3	11.3	14.5	19.7	20.0	22.9	24.6	32.5	41.5	53.3	60.7	64.7	66.3
	63.3	64.4	67.6	74.6	75.1	80.7	107.4	0.0												
9	0.0	2.7	4.1	5.6	5.5	8.2	11.7	13.8	10.7	14.7	24.7	28.0	29.1	37.5	43.7	47.4	51.7	59.0	64.7	64.9
	62.1	64.8	69.4	74.9	67.8	73.3	71.4	0.0												
10	0.0	2.3	3.1	4.4	5.3	6.7	11.8	17.3	10.9	17.8	26.0	31.4	38.1	47.9	53.1	56.2	58.2	60.1	61.6	59.0
	56.2	55.7	60.0	63.0	59.4	66.6	67.1	0.0												

11	0.0	1.8	2.3	3.5	4.5	5.6	12.5	18.8	21.7	17.9	28.1	35.4	45.5	55.3	59.3	61.4	59.9	56.1	54.4	50.8
	45.8	43.0	44.7	49.9	52.0	63.1	64.8	0.0												
12	0.0	1.1	1.5	2.5	3.4	3.8	6.8	9.2	25.4	27.5	31.1	40.0	51.8	60.6	62.8	61.2	54.5	49.7	46.6	41.5
	34.1	30.4	28.3	40.2	45.9	0.0	0.0	0.0												
13	0.0	0.4	0.6	1.5	2.2	2.7	4.6	6.0	27.0	34.4	41.9	46.7	51.1	58.9	58.8	53.1	43.0	41.4	39.6	36.2
	29.3	25.7	22.9	35.6	42.9	0.0	0.0	0.0												
14	0.0	0.0	0.4	0.3	1.3	2.2	5.0	9.5	27.3	38.4	44.1	44.0	45.6	49.7	47.0	41.1	23.7	31.4	34.0	35.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
15	0.0	0.0	0.0	0.0	1.0	1.7	3.4	4.7	23.1	34.4	36.3	36.3	40.2	44.7	39.4	24.6	9.2	23.9	29.3	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
16	0.0	0.0	0.0	0.0	0.0	1.5	3.1	7.1	19.2	25.0	25.2	29.6	36.3	40.0	33.9	19.9	4.7	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
17	0.0	0.0	0.0	0.0	0.0	1.3	2.5	5.5	10.3	14.2	18.4	27.5	32.0	32.1	24.3	14.3	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
18	0.0	0.0	0.0	0.0	0.0	0.0	1.8	3.4	6.2	8.9	13.9	19.6	23.1	20.5	13.9	8.9	5.1	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
19	0.0	0.0	0.0	0.0	0.0	0.0	1.3	2.2	3.9	5.6	8.1	10.6	12.0	10.9	8.2	5.9	4.4	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	3.0	4.1	5.6	7.0	7.7	7.2	5.9	4.7	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												

SUPPLEMENTARY DATA III--INPUT MATRICES AND RESULTS--Continued

Starting head matrix, layer 2 for pumping period 1

STARTING HEAD MATRIX, LAYER 2

1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	3.0	3.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	32.0	35.0	80.0	140.0	0.0												
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	2.0	8.2	18.4	20.5	7.0	0.0	0.0	0.0
	0.0	0.0	0.0	29.0	67.2	110.3	190.0	0.0												
4	0.0	0.0	4.4	3.0	2.0	10.1	18.5	0.0	0.0	0.0	1.0	5.0	3.2	21.1	37.5	48.3	38.6	3.0	12.0	15.0
	0.0	0.0	22.0	24.0	79.1	117.1	150.0	0.0												
5	0.0	0.0	1.0	12.8	12.2	13.2	10.4	0.0	0.0	0.0	0.0	9.0	18.9	61.0	80.6	81.9	45.7	38.7	19.5	17.0
	18.0	18.0	20.0	65.3	90.2	117.1	95.0	0.0												
6	0.0	0.0	0.0	11.2	19.0	17.5	11.1	1.0	0.0	0.0	0.0	12.2	35.4	47.1	57.8	77.3	67.7	45.2	38.5	51.7
	54.0	37.2	53.1	100.1	104.6	147.0	85.0	0.0												
7	0.0	0.0	0.5	15.5	3.2	23.6	21.2	4.5	0.0	0.0	2.0	2.0	12.3	31.8	42.3	60.8	80.2	95.6	61.2	114.0
	57.3	54.2	58.4	97.2	150.1	76.2	110.0	0.0												
8	0.0	0.0	0.0	10.0	1.0	17.9	12.6	7.8	1.0	5.0	21.8	4.1	12.0	17.1	26.2	37.1	66.2	80.2	84.7	96.3
	75.7	64.5	65.4	91.4	138.2	30.1	160.0	0.0												
9	0.0	0.0	0.0	7.8	0.5	0.5	11.9	14.7	9.5	3.2	35.0	41.2	27.6	38.6	56.6	46.2	48.1	53.1	90.0	89.2
	94.7	86.0	95.8	103.0	63.7	18.1	20.0	0.0												
10	0.0	0.0	0.0	0.0	2.6	1.0	11.3	19.3	6.0	6.0	37.1	46.6	58.2	55.4	69.7	71.5	75.2	79.2	86.6	61.9
	58.4	54.1	64.3	48.0	7.0	11.0	25.0	0.0												

11	0.0	0.0	0.0	0.0	7.2	1.0	13.2	21.6	24.5	13.2	29.1	43.9	62.2	74.8	75.2	89.9	91.5	107.0	52.7	52.3
	33.2	24.5	39.2	9.1	5.0	6.0	18.0	0.0												
12	0.0	0.0	0.0	0.0	4.8	1.0	3.2	5.1	28.3	27.8	27.4	38.6	65.4	84.1	88.8	91.0	73.6	68.1	40.7	28.1
	13.1	3.8	4.0	4.0	3.0	0.0	0.0	0.0												
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	29.7	35.0	44.8	50.5	86.8	86.2	87.0	79.0	40.4	24.3	52.1	3.0
	3.3	3.7	3.9	4.0	6.0	0.0	0.0	0.0												
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.2	29.6	41.2	47.4	45.4	55.7	79.4	76.6	46.0	16.5	9.0	2.0	2.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.2	37.3	52.3	22.3	43.2	70.2	58.2	19.6	1.0	1.1	1.6	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.4	38.4	2.0	6.2	47.6	63.9	54.8	20.6	1.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	46.6	50.7	54.8	29.1	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.6	26.2	35.0	23.1	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												

SUPPLEMENTARY DATA III--INPUT MATRICES AND RESULTS--Continued

Bottom elevation matrix, layer 2 for pumping period 1

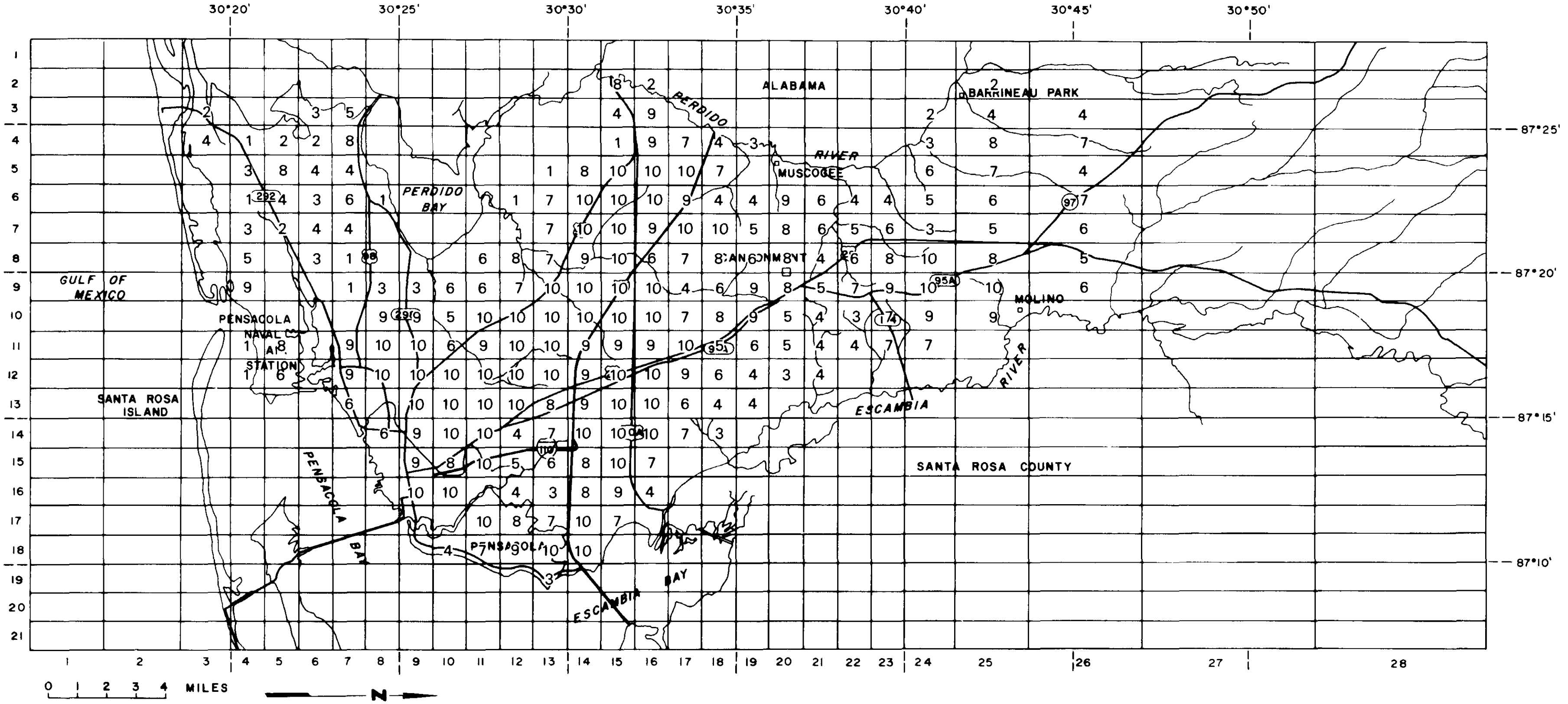
BOTTOM ELEVATION MATRIX, LAYER 2

1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
2	0.0	-78.0	-78.0	-78.0	-107.0	-110.0	-84.0	-84.0	0.0	0.0	0.0	0.0	-57.0	-50.0	-55.0	-65.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	-18.0	-18.0	-55.0	-55.0	0.0												
3	0.0	-78.0	-78.0	-78.0	-107.0	-110.0	-84.0	-84.0	0.0	0.0	-84.0	-75.0	-57.0	-50.0	-55.0	-65.0	-69.0	-94.0	0.0	0.0
	0.0	0.0	0.0	-18.0	-55.0	-55.0	-55.0	0.0												
4	0.0	-78.0	-78.0	-78.0	-107.0	-135.0	-116.0	-84.0	-84.0	0.0	-84.0	-75.0	-57.0	-50.0	-55.0	-65.0	-69.0	-94.0	-146.0	-172.0
	0.0	0.0	-18.0	-18.0	-55.0	-55.0	-55.0	0.0												
5	0.0	-78.0	-78.0	-78.0	-100.0	-126.0	-113.0	-84.0	-84.0	-84.0	-84.0	-75.0	-57.0	-50.0	-55.0	-65.0	-69.0	-94.0	-146.0	-172.0
	-133.0	-56.0	-18.0	-18.0	-55.0	-55.0	-55.0	0.0												
6	0.0	-97.0	-97.0	-97.0	-97.0	-116.0	-100.0	-84.0	-84.0	-84.0	-84.0	-62.0	-42.0	-29.0	-47.0	-65.0	-69.0	-94.0	-105.0	-117.0
	-90.0	-54.0	-36.0	-55.0	-55.0	-55.0	-55.0	0.0												
7	0.0	-100.0	-100.0	-100.0	-100.0	-100.0	-74.0	-84.0	-80.0	-80.0	-84.0	-38.0	-34.0	0.0	-13.0	-42.0	-53.0	-57.0	-47.0	-62.0
	-59.0	-57.0	-55.0	-55.0	-55.0	-55.0	-55.0	0.0												
8	0.0	-100.0	-100.0	-100.0	-100.0	-100.0	-97.0	-84.0	-84.0	-84.0	-84.0	-35.0	-27.0	0.0	-16.0	-48.0	-49.0	-20.0	0.0	-7.0
	-19.0	-43.0	-55.0	-55.0	-55.0	-55.0	-55.0	0.0												
9	0.0	-116.0	-116.0	-116.0	-116.0	-116.0	-96.0	-84.0	-84.0	-84.0	-84.0	-50.0	-58.0	-48.0	-48.0	-48.0	-49.0	-13.0	0.0	0.0
	-34.0	-45.0	-55.0	-55.0	-55.0	-55.0	-55.0	0.0												
10	0.0	-116.0	-116.0	-116.0	-136.0	-121.0	-106.0	-94.0	-87.0	-72.0	-57.0	-57.0	-42.0	-35.0	-16.0	-23.0	-24.0	-50.0	-26.0	-26.0
	-34.0	-115.0	-85.0	-55.0	-55.0	-55.0	-55.0	0.0												

11	0.0	-116.0	-110.0	-110.0	-116.0	-116.0	-102.0	-92.0	-76.0	-61.0	-40.0	-23.0	-23.0	0.0	0.0	0.0	-52.0	-52.0	-47.0	-47.0
	-90.0	-85.0	-85.0	-55.0	-55.0	-55.0	-55.0	0.0												
12	0.0	-110.0	-100.0	-105.0	-111.0	-111.0	-100.0	-88.0	-64.0	-41.0	-21.0	-10.0	-6.0	0.0	0.0	0.0	-55.0	-55.0	-58.0	-61.0
	-58.0	-55.0	-55.0	-55.0	-55.0	-55.0	0.0	0.0												
13	0.0	-76.0	-76.0	-76.0	-76.0	-36.0	-87.0	-87.0	-59.0	-31.0	-10.0	0.0	0.0	0.0	-7.0	-7.0	-48.0	-58.0	-58.0	-61.0
	-58.0	-55.0	-55.0	-55.0	-55.0	0.0	0.0	0.0												
14	0.0	-76.0	-76.0	-76.0	-76.0	-76.0	-36.0	-86.0	-26.0	-46.0	-6.0	0.0	0.0	-30.0	-66.0	-66.0	-60.0	-52.0	-44.0	-50.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
15	0.0	0.0	0.0	0.0	-55.0	-55.0	-55.0	-65.0	-65.0	-54.0	-26.0	0.0	-2.0	-1.0	-3.0	-3.0	-66.0	-47.0	-28.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
16	0.0	0.0	0.0	0.0	0.0	-52.0	-52.0	-52.0	-52.0	-40.0	-17.0	0.0	0.0	-2.0	-12.0	-17.0	-42.0	-47.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
17	0.0	0.0	0.0	0.0	0.0	0.0	-36.0	-46.0	-46.0	-40.0	-2.0	0.0	-9.0	0.0	-5.0	-11.0	-42.0	-47.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
18	0.0	0.0	0.0	0.0	0.0	0.0	-43.0	-43.0	-43.0	-40.0	-38.0	-38.0	-26.0	-12.0	-3.0	-11.0	-32.0	-37.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
19	0.0	0.0	0.0	0.0	0.0	0.0	-43.0	-43.0	-43.0	-30.0	-41.0	-63.0	-63.0	-12.0	-8.0	-11.0	-32.0	-37.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
20	0.0	0.0	0.0	0.0	0.0	0.0	-43.0	-43.0	-43.0	-30.0	-41.0	-63.0	-63.0	-12.0	-3.0	-11.0	-32.0	-37.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												

SUPPLEMENTARY DATA III--INPUT MATRICES AND RESULTS--Continued

Relative values of recharge (QRE)



Explanation: Blanks equal zero values.
Multiply values above by $7.48x10^{-7}$ to obtain recharge rate in ft/sec. at each node, or by 2.831 for in./yr.

GRID SPACING IN PROTOTYPE IN X DIRECTION

13603.	13603.	9069.	6046.	6046.	6046.	6046.	6046.	6046.	6046.	6046.	6046.
6046.	6046.	6046.	6046.	6046.	6046.	6046.	6046.	6046.	6046.	6046.	9069.
13603.	20404.	30606.	30606.								

DELY = 5246.000

DELZ = 1.000000

RIVER WATER LEVEL

1.	3.	3.	32.	35.	80.	1.	1.	2.	8.	20.	7.	29.	67.	110.	3.	2.	3.	21.	8.
12.	15.	22.	24.	79.	117.	12.	13.	10.	45.	19.	17.	18.	18.	20.	65.	90.	117.	17.	11.
1.	45.	57.	66.	45.	38.	50.	54.	37.	53.	99.	103.	146.	3.	21.	2.	12.	30.	42.	60.
80.	60.	57.	54.	58.	97.	150.	75.	1.	7.	1.	4.	12.	17.	26.	37.	66.	80.	75.	64.
65.	91.	138.	30.	1.	1.	9.	3.	41.	27.	38.	56.	46.	48.	53.	90.	94.	86.	103.	62.
18.	11.	5.	6.	36.	40.	58.	55.	68.	71.	75.	79.	61.	58.	54.	61.	47.	7.	11.	13.
13.	29.	43.	62.	74.	92.	52.	51.	33.	24.	39.	9.	5.	6.	3.	5.	27.	27.	38.	64.
73.	67.	40.	28.	13.	4.	4.	30.	79.	40.	24.	52.	3.	3.	4.	4.	4.	55.	79.	76.
46.	13.	9.	2.	2.	22.	43.	58.	19.	1.	1.	2.	2.	6.	1.	1.	1.	0.	23.	

RIVER BOTTOM ELEVATION

0.	0.	0.	27.	30.	80.	0.	0.	0.	8.	20.	2.	24.	67.	110.	1.	0.	1.	21.	3.
9.	10.	17.	19.	79.	117.	12.	13.	10.	45.	19.	12.	13.	13.	15.	65.	90.	117.	17.	11.
0.	45.	57.	66.	45.	38.	50.	54.	37.	53.	99.	103.	146.	2.	21.	1.	12.	30.	42.	60.
80.	60.	57.	54.	58.	97.	150.	75.	0.	7.	0.	4.	12.	17.	26.	37.	66.	80.	75.	64.
65.	91.	138.	30.	0.	0.	9.	3.	41.	27.	38.	56.	46.	48.	53.	90.	94.	86.	103.	62.
18.	11.	5.	6.	36.	40.	53.	55.	68.	71.	75.	79.	61.	58.	54.	61.	47.	2.	6.	13.
13.	29.	43.	62.	74.	92.	52.	51.	33.	24.	39.	9.	0.	1.	2.	5.	27.	27.	38.	64.
73.	67.	40.	28.	13.	0.	0.	30.	79.	40.	24.	52.	0.	0.	0.	0.	0.	55.	79.	76.
46.	13.	9.	0.	0.	22.	43.	58.	19.	0.	0.	0.	0.	6.	0.	0.	0.	-9.	23.	

RIVER LEAKANCE

0.35E-04	0.14E-04	0.68E-05	0.19E-05	0.14E-05	0.32E-07	0.26E-04	0.47E-04	0.19E-04	0.10E-06	0.15E-06	0.64E-05	0.43E-05	0.19E-06
0.52E-07	0.12E-05	0.15E-05	0.38E-06	0.12E-06	0.49E-05	0.33E-05	0.24E-05	0.38E-05	0.36E-05	0.44E-06	0.20E-06	0.29E-06	0.12E-06
0.78E-07	0.13E-06	0.11E-06	0.32E-05	0.38E-05	0.62E-05	0.23E-05	0.13E-06	0.18E-06	0.31E-07	0.45E-07	0.36E-06	0.94E-06	0.36E-07
0.60E-07	0.11E-07	0.23E-06	0.11E-06	0.45E-07	0.10E-05	0.22E-06	0.21E-06	0.25E-07	0.31E-07	0.28E-07	0.19E-06	0.35E-07	0.59E-05
0.98E-07	0.39E-07	0.76E-07	0.43E-07	0.56E-07	0.43E-07	0.18E-06	0.25E-06	0.13E-06	0.15E-06	0.17E-06	0.63E-07	0.37E-05	0.41E-07
0.23E-05	0.11E-05	0.17E-05	0.18E-05	0.15E-05	0.11E-05	0.13E-06	0.70E-07	0.46E-07	0.10E-06	0.18E-06	0.10E-06	0.17E-06	0.46E-06
0.17E-04	0.99E-05	0.85E-07	0.51E-06	0.25E-07	0.28E-06	0.13E-06	0.48E-07	0.64E-06	0.11E-05	0.53E-06	0.26E-06	0.28E-07	0.11E-06
0.97E-07	0.53E-07	0.40E-06	0.29E-07	0.18E-06	0.12E-05	0.53E-07	0.11E-07	0.87E-07	0.18E-06	0.70E-08	0.71E-07	0.84E-07	0.15E-06
0.50E-07	0.73E-07	0.22E-06	0.13E-07	0.73E-07	0.26E-05	0.86E-05	0.25E-06	0.76E-06	0.53E-06	0.88E-07	0.39E-06	0.36E-07	0.73E-07
0.87E-07	0.27E-07	0.18E-06	0.66E-07	0.22E-06	0.57E-06	0.77E-05	0.62E-05	0.40E-06	0.23E-05	0.87E-07	0.50E-06	0.16E-06	0.42E-07
0.45E-07	0.39E-07	0.53E-07	0.21E-06	0.36E-06	0.14E-05	0.88E-05	0.13E-07	0.44E-06	0.13E-06	0.13E-06	0.71E-07	0.67E-04	0.15E-04
0.10E-04	0.87E-05	0.55E-05	0.10E-06	0.14E-06	0.84E-07	0.19E-06	0.60E-07	0.42E-05	0.12E-04	0.95E-05	0.28E-06	0.21E-06	0.23E-06
[illegible]	0.88E-05	0.26E-04	0.76E-05	0.10E-04	0.39E-06	0.18E-04	0.44E-04	0.26E-05	0.18E-04	0.93E-06			

SOLUTION BY THE STRONGLY IMPLICIT PROCEDURE

Head matrix, layer 1 for pumping period 2

HEAD MATRIX, LAYER 1

1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
2	0.0	4.16	5.32	6.58	7.48	8.12	8.27	0.0	0.0	0.0	0.0	0.0	0.0	1.00	3.00	3.00	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	55.68	75.09	107.23	140.00	0.0												
3	0.0	4.15	5.38	6.97	8.04	8.69	8.78	8.89	0.0	0.0	0.0	1.55	2.75	8.85	17.02	19.34	24.81	0.0	0.0	0.0
	0.0	0.0	0.0	60.58	75.68	108.69	190.00	0.0												
4	0.0	4.12	5.40	7.83	9.11	9.56	9.71	9.39	0.0	0.0	7.64	5.30	5.48	18.36	27.36	32.00	33.17	34.17	38.02	42.50
	0.0	0.0	50.16	62.19	78.66	107.81	150.00	0.0												
5	0.0	4.05	4.82	9.43	10.56	10.57	10.61	10.09	10.17	10.25	9.71	9.60	17.99	26.19	34.43	38.79	39.95	40.05	39.10	46.53
	53.66	56.06	54.13	65.13	80.90	103.01	95.00	0.0												
6	0.0	4.04	5.85	9.36	11.38	11.56	11.61	10.83	10.65	11.21	11.92	12.83	23.39	30.27	40.60	46.99	49.29	48.44	48.70	53.85
	58.36	59.92	61.18	68.24	79.36	94.37	95.00	0.0												
7	0.0	3.90	6.03	10.01	9.59	12.65	13.24	10.92	11.09	12.58	14.56	14.93	21.83	28.86	39.79	46.98	55.02	59.10	59.76	61.60
	61.30	62.44	65.05	70.76	77.73	85.63	110.00	0.0												
8	0.0	3.39	5.15	7.46	7.23	11.12	11.98	9.16	11.10	14.17	19.01	19.78	22.81	24.59	32.46	41.49	53.34	60.69	64.66	66.26
	63.25	64.38	67.55	74.47	74.88	80.28	107.43	0.0												
9	0.0	2.73	4.01	5.44	5.36	8.04	11.45	13.34	10.49	14.47	24.39	27.82	29.07	37.53	43.67	47.37	51.72	58.97	64.67	64.92
	62.06	64.74	69.38	74.79	67.50	72.52	71.34	0.0												
10	0.0	2.09	3.03	4.12	4.93	6.43	11.45	16.04	10.47	17.47	25.67	31.12	37.91	47.81	[illegible]	56.15	58.19	60.09	61.57	59.00
	56.18	55.71	59.95	62.77	58.69	65.95	[illegible]	0.0												

11	0.0	1.49	2.15	3.03	3.69	5.00	11.94	15.45	20.16	17.[illegible]0	[illegible]7.78	35.06	45.24	55.70	59.26	61.38	59.92	56.10	54.39	50.79
	45.74	42.98	44.63	49.67	51.48	62.51	64.72	0.0												
12	0.0	0.91	1.30	1.91	2.41	2.38	4.38	7.70	23.16	26.90	30.75	39.41	51.46	60.37	62.70	61.14	54.44	49.71	46.54	41.44
	34.13	30.32	28.19	42.03	4[illegible].49	0.0	0.0	0.0												
13	0.0	0.34	0.42	0.34	0.92	0.31	-0.62	1.29	22.21	32.41	40.64	45.77	50.44	58.61	58.65	53.05	43.02	41.38	39.62	36.21
	29.26	25.69	22.83	35.40	42.50	0.0	0.0	0.0												
14	0.0	0.0	0.19	0.23	-0.01	-1.22	-5.14	-18.19	17.23	33.79	41.70	42.61	44.80	49.23	46.80	41.09	23.65	31.42	34.02	34.96
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
15	0.0	0.0	0.0	0.0	-0.23	-0.78	-1.93	-0.93	15.71	29.59	33.62	34.92	39.38	44.19	39.11	24.58	9.20	23.89	29.29	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
16	0.0	0.0	0.0	0.0	0.0	-0.28	-0.34	0.62	8.32	20.23	22.92	28.26	35.30	39.35	33.53	19.75	4.71	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
17	0.0	0.0	0.0	0.0	0.0	0.04	0.50	1.91	5.81	11.40	16.65	26.18	30.83	31.35	23.88	14.60	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
18	0.0	0.0	0.0	0.0	0.0	0.0	0.68	1.72	4.07	7.26	12.58	18.35	21.61	19.69	13.48	8.66	4.92	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
19	0.0	0.0	0.0	0.0	0.0	0.0	0.66	1.38	2.35	4.61	7.09	9.28	9.03	9.84	7.77	5.63	4.20	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.27	2.25	3.39	4.83	6.01	6.25	6.35	5.42	4.45	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												

SUPPLEMENTARY DATA III--INPUT MATRICES AND RESULTS--Continued

Head matrix, layer 2 for pumping period 2

```
                                                HEAD MATRIX, LAYER  2
                                                ---------------------

  1   0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
      0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0

  2   0.0    0.0    0.0    0.0    0.0    0.00   0.0    0.0    0.0    0.0    0.0    0.0    0.0    1.00   3.01   3.01   0.0    0.0    0.0    0.0
      0.0    0.0    0.0   32.03  35.03  80.00140.00    0.0

  3   0.0    0.0    0.00   0.0    0.0    0.01   0.01   0.0    0.0    0.0    1.00   1.00   2.00   8.24  13.43  20.49   7.01   0.0    0.0    0.0
      0.0    0.0    0.0   29.01  67.21110.26190.00    0.0

  4   0.0    0.0    4.39   3.01   2.02  10.06  18.48   0.0    0.0    0.0    1.00   5.01   3.21  21.12  37.45  48.26  38.56   8.03  12.01  15.00
      0.0    0.0   22.02  24.01  79.13117.15150.00    0.0

  5   0.0    0.0    1.00  12.75  12.19  13.23  10.38   0.00   0.0    0.0    0.0    8.98  18.84  60.96  80.58  81.85  45.72  38.69  19.54  17.00
     18.00  18.00  20.03  65.34  90.18117.14  95.00    0.0

  6   0.0    0.0    0.0   11.22  18.97  17.49  11.13   1.01   0.0    0.0    0.0   12.11  35.38  47.10  57.80  77.32  67.67  45.21  38.46  51.72
     54.03  37.16  53.14100.09104.57147.02  85.00    0.0

  7   0.0    0.0    0.50  15.48   3.20  23.51  21.17   4.46   0.0    0.0    2.00   2.01  12.82  31.77  42.32  60.85  80.21  85.59  61.19114.03
     57.30  54.15  58.38  97.18150.09  76.15110.00    0.0

  8   0.0    0.0    0.0    9.98   1.00  17.77  12.39   7.73   1.01   4.90  21.47   4.10  12.05  17.13  26.16  37.13  66.18  80.19  84.67  96.27
     75.68  64.46  65.38  91.41138.24  30.11160.00    0.0

  9   0.0    0.0    0.0    7.84   0.50   0.50  11.60  14.19   9.43   3.17  34.78  41.21  27.58  38.63  56.57  46.18  48.11  53.13  90.03  89.24
     94.74  36.02  95.79103.04  63.67  18.13  20.00    0.0

 10   0.0    0.0    0.0    0.0    2.57   1.00  11.16  18.60   5.98   6.04  37.13  46.55  58.20  55.44  69.73  71.53  75.17  79.15  86.64  61.95
     58.39  54.13  64.32  48.00   7.03  11.00  25.00    0.0
```

11	0.0	C.0	0.C	C.00	7.20	1.00	13.10	18.53	23.01	13.20	29.14	43.87	62.17	74.78	75.21	89.83	91.52	107.00	52.68	52.26
	33.17	24.51	39.21	9.11	5.0C	6.00	18.0C	C.0												
12	0.0	C.0	0.C	C.00	4.77	1.00	3.18	5.06	26.16	27.63	27.34	38.62	65.37	83.93	88.73	9C.90	73.63	68.06	40.71	28.11
	13.15	3.75	4.C4	3.98	3.0C	0.0	0.0	C.0												
13	0.0	C.0	0.0	C.0	0.0	0.0	0.00	1.00	25.C4	33.72	43.53	49.57	36.64	86.02	86.88	79.02	40.44	24.32	52.06	3.00
	3.27	3.74	3.9C	3.97	6.00	0.0	0.0	C.0												
14	0.0	C.0	0.C	C.0	0.0	0.C	0.0	-11.34	19.74	36.63	45.C5	44.11	55.65	79.43	76.60	46.02	16.52	9.01	2.00	2.00
	0.0	C.0	0.C	C.0	0.C	0.0	0.0	C.0												
15	0.0	0.0	0.C	C.0	0.C	0.0	0.0	-C.00	17.57	32.53	49.79	22.27	43.21	69.82	58.16	19.55	1.C2	1.11	1.63	0.0
	0.0	C.0	0.C	C.0	0.0	0.0	0.0	C.0												
16	0.0	C.0	0.C	C.0	0.C	0.0	0.0	C.0	11.77	34.27	2.C1	6.21	46.75	63.30	54.48	20.50	1.C1	0.0	0.0	0.0
	0.0	C.0	0.C	C.0	0.0	0.0	0.0	0.0												
17	0.0	C.0	0.C	C.0	0.0	0.0	0.0	C.0	1.00	1.00	1.C4	45.65	49.76	54.20	28.86	0.05	0.CC	0.0	0.0	0.0
	C.0	C.0	0.C	C.0	0.0	C.0	0.0	C.0												
18	0.0	C.0	0.C	C.0	0.0	0.0	0.0	C.0	0.C	0.00	15.15	25.66	34.27	23.06	0.C	0.0	0.C	C.0	0.C	0.0
	0.0	C.0	0.C	C.0	0.C	0.0	0.0	0.0												
19	0.0	C.0	0.C	C.0	0.0	0.0	0.0	C.0	0.C	C.0	0.C	0.C0	0.C0	C.0	0.C	0.0	0.C	C.0	0.0	0.0
	0.0	C.0	0.C	C.0	0.0	0.0	0.0	C.0												
20	0.0	0.0	0.0	C.0	0.0	C.0	0.0	C.0	0.C	C.0	0.C	C.C	0.0	0.0	0.C	0.0	0.C	C.0	0.0	C.0
	0.0	0.0	0.C	C.0	0.0	0.0	0.C	C.0												
21	0.0	C.0	0.C	C.0	0.C	C.0	0.0	C.0	0.C	C.0	0.0	C.C	0.C	0.0	0.C	C.0	0.C	C.0	0.0	C.0
	0.0	C.0	0.C	C.0	0.0	0.0	0.0	C.0												

Head matrix, layer 1 for pumping period 3

HEAD MATRIX, LAYER 1

1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
2	0.0	4.00	5.09	6.23	6.99	7.45	7.38	0.0	0.0	0.0	0.0	0.0	0.0	1.00	3.00	3.00	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	52.81	73.21	106.64	140.00	0.0												
3	0.0	3.99	5.16	6.63	7.56	8.02	7.67	8.01	0.0	0.0	0.0	1.53	2.73	8.72	16.27	17.86	21.89	0.0	0.0	0.0
	0.0	0.0	0.0	56.22	73.78	108.16	190.00	0.0												
4	0.0	3.96	5.20	7.55	8.71	9.00	8.97	8.65	0.0	0.0	7.26	5.14	5.39	17.74	25.79	29.18	28.54	26.74	25.78	24.80
	0.0	0.0	40.53	55.58	76.20	107.19	150.00	0.0												
5	0.0	3.91	4.68	9.21	10.25	10.11	10.03	9.46	9.51	9.56	9.16	9.30	17.58	25.11	32.26	34.93	33.82	31.30	26.07	24.29
	23.23	30.66	39.57	56.21	77.37	102.17	95.00	0.0												
6	0.0	3.90	5.68	9.64	11.08	11.14	11.10	10.24	9.95	10.37	11.07	12.39	22.87	29.30	38.77	42.82	41.50	35.51	28.13	23.25
	18.96	28.08	40.00	55.24	73.91	93.13	95.00	0.0												
7	0.0	3.75	5.84	9.78	9.31	12.23	12.77	10.37	10.34	11.44	13.05	14.24	21.35	28.30	38.88	42.87	43.63	35.69	20.54	5.83
	7.77	24.56	40.02	56.02	71.29	84.23	110.00	0.0												
8	0.0	3.24	4.93	7.16	6.90	10.58	11.29	8.75	10.34	12.69	15.87	18.77	22.33	24.23	31.61	38.63	39.93	29.50	7.87	-16.29
	-15.65	20.79	41.76	60.29	68.41	78.46	107.36	0.0												
9	0.0	2.57	3.73	5.01	4.89	7.38	10.33	11.78	9.95	13.34	22.82	26.82	28.68	36.78	41.59	43.99	39.58	25.17	-6.60	-18.71
	-7.78	20.46	40.92	58.68	61.98	70.43	71.21	0.0												
10	0.0	1.93	2.69	3.49	4.05	5.52	9.81	12.55	9.30	15.75	24.24	29.78	36.51	45.66	49.17	48.56	41.53	27.80	9.18	-2.69
	3.52	17.92	36.63	47.53	51.87	63.58	66.76	0.0												

11	0.0	1.34	1.79	2.22	2.46	3.70	9.61	6.70	16.16	16.71	26.58	33.52	43.19	52.58	54.18	51.52	41.85	25.36	10.97	3.86
	6.29	13.16	23.97	35.87	44.01	59.99	64.40	0.0												
12	0.0	0.80	1.01	1.19	1.07	0.69	-2.67	2.27	17.34	25.71	29.85	37.64	49.27	56.79	57.15	51.20	37.38	20.21	4.20	2.32
	5.76	8.76	14.26	28.08	37.55	0.0	0.0	0.0												
13	0.0	0.30	0.31	0.49	0.35	-0.33	-2.37	-0.95	17.17	30.17	38.00	43.21	47.35	54.88	53.66	45.16	28.57	11.03	-14.17	-3.25
	3.37	6.87	11.18	24.45	34.42	0.0	0.0	0.0												
14	0.0	0.0	0.14	0.17	0.11	-0.13	-0.45	0.76	14.62	29.71	38.15	39.31	40.71	45.37	42.84	36.55	17.44	6.51	-7.73	-4.89
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
15	0.0	0.0	0.0	0.0	0.08	0.12	0.38	1.65	13.50	22.09	29.22	31.12	33.73	40.32	36.32	22.91	5.96	3.51	-2.84	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
16	0.0	0.0	0.0	0.0	0.0	0.26	0.63	1.62	6.78	15.74	19.42	24.62	29.58	35.69	30.88	18.34	3.99	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
17	0.0	0.0	0.0	0.0	0.0	0.33	0.79	2.02	4.88	9.24	13.69	23.27	26.95	28.83	22.24	13.60	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
18	0.0	0.0	0.0	0.0	0.0	0.0	0.73	1.62	3.49	6.19	11.16	16.96	20.30	18.65	12.68	8.13	4.63	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
19	0.0	0.0	0.0	0.0	0.0	0.0	0.64	1.25	2.50	4.08	6.52	9.10	10.51	9.83	7.48	5.35	3.97	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.14	2.01	3.08	4.56	6.02	6.79	6.46	5.31	4.29	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												

Head matrix, layer 2 for pumping period 3

HEAD MATRIX, LAYER 2

1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
2	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	3.01	3.01	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	32.02	35.03	80.00	140.00	0.0												
3	0.0	0.0	0.00	0.0	0.0	0.01	0.01	0.0	0.0	0.0	1.00	1.00	2.00	8.21	17.75	20.45	7.01	0.0	0.0	0.0
	0.0	0.0	0.0	29.01	67.19	110.24	190.00	0.0												
4	0.0	0.0	4.39	3.01	2.02	10.04	18.46	0.0	0.0	0.0	1.00	4.87	3.20	21.10	36.45	46.86	36.80	8.03	12.01	15.00
	0.0	0.0	22.01	24.01	79.12	117.14	150.00	0.0												
5	0.0	0.0	1.00	12.62	12.19	13.23	10.38	0.00	0.0	0.0	0.0	8.70	18.46	60.73	80.00	80.82	45.67	35.71	19.26	17.00
	18.00	18.00	20.02	65.19	90.14	117.09	95.00	0.0												
6	0.0	0.0	0.0	11.07	18.78	17.49	11.13	1.01	0.0	0.0	0.0	11.73	35.02	47.08	57.72	74.38	66.36	45.06	38.04	50.22
	54.03	37.14	53.12	100.03	104.55	147.02	85.00	0.0												
7	0.0	0.0	0.50	15.32	3.19	23.17	21.14	4.41	0.0	0.0	2.00	2.01	12.81	31.74	42.12	60.62	74.33	66.22	43.56	93.75
	57.25	54.13	58.36	97.17	150.08	76.11	110.00	0.0												
8	0.0	0.0	0.0	9.97	1.00	17.34	11.70	7.58	1.00	4.62	20.16	4.10	12.05	17.13	26.14	37.08	61.83	56.95	29.74	23.03
	75.29	43.89	65.06	91.10	138.24	30.10	160.00	0.0												
9	0.0	0.0	0.0	7.83	0.50	0.50	10.49	12.65	9.31	3.17	33.80	41.12	27.55	38.52	56.46	46.06	41.41	46.68	25.52	14.20
	94.01	47.23	70.75	90.26	63.45	18.12	20.00	0.0												
10	0.0	0.0	0.0	0.0	2.54	1.00	9.75	15.16	5.84	6.04	37.12	46.54	58.20	55.40	69.04	71.27	65.00	58.53	40.51	19.09
	21.36	30.43	58.23	47.95	7.03	11.00	25.00	0.0												

11	0.0	0.0	0.0	0.00	7.18	1.00	11.87	10.38	19.06	13.17	29.14	43.87	62.16	73.22	74.73	81.28	76.75	97.01	52.50	51.69
	33.13	24.41	39.20	9.10	5.00	6.00	18.00	0.0												
12	0.0	0.0	0.0	0.00	4.75	1.00	3.14	5.01	20.59	27.38	27.30	38.61	65.21	81.34	84.75	83.23	68.76	67.87	40.61	28.09
	12.00	3.74	4.02	3.98	3.00	0.0	0.0	0.0												
13	0.0	0.0	0.0	0.0	0.0	0.0	0.00	1.00	20.26	32.24	40.98	47.10	85.68	83.65	83.71	75.29	40.19	24.29	50.07	3.00
	3.27	3.74	3.90	3.97	6.00	0.0	0.0	0.0												
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.59	17.58	32.57	41.51	40.88	55.63	79.40	76.50	41.36	14.89	9.00	2.00	2.00
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	15.38	25.69	45.92	22.24	43.15	67.11	58.13	19.43	1.01	1.11	1.63	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.25	30.67	2.01	6.19	41.99	60.17	52.55	19.76	1.00	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	1.00	1.04	43.42	46.80	52.18	28.02	0.04	0.00	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	14.65	24.87	33.35	23.05	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												

Head matrix, layer 1 for pumping period 4

HEAD MATRIX, LAYER 1

1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
2	0.0	3.96	5.08	6.26	7.09	7.66	7.77	0.0	0.0	0.0	0.0	0.0	0.0	1.00	3.00	3.00	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	53.84	73.89	106.35	140.00	0.0												
3	0.0	3.95	5.14	6.65	7.63	8.20	8.22	8.25	0.0	0.0	0.0	1.53	2.74	8.77	16.55	18.42	22.99	0.0	0.0	0.0
	0.0	0.0	0.0	57.79	74.46	108.35	190.00	0.0												
4	0.0	3.91	5.17	7.51	8.69	9.02	9.07	8.66	0.0	0.0	7.08	5.09	5.40	17.96	26.38	30.25	30.29	29.52	30.28	31.24
	0.0	0.0	44.00	57.96	77.08	107.41	150.00	0.0												
5	0.0	3.84	4.62	9.12	10.13	9.96	9.84	9.17	9.02	9.08	8.87	9.21	17.62	25.46	33.06	36.41	36.16	34.59	30.88	32.35
	34.19	39.82	44.81	59.42	78.64	102.47	95.00	0.0												
6	0.0	3.81	5.57	9.48	10.86	10.81	10.69	9.72	9.29	9.71	10.66	12.23	22.85	29.55	39.43	44.43	44.54	40.41	35.83	34.29
	33.10	39.58	47.63	59.91	75.87	93.57	95.00	0.0												
7	0.0	3.65	5.68	9.55	9.00	11.71	12.15	9.68	9.36	10.40	12.49	13.89	21.21	28.34	39.16	44.45	48.25	44.56	35.45	25.84
	26.91	38.31	49.02	61.32	73.60	84.73	110.00	0.0												
8	0.0	3.11	4.70	6.80	6.44	9.72	10.06	8.03	8.79	10.77	15.35	18.02	22.02	24.13	31.69	39.63	45.30	40.89	28.09	12.90
	12.29	37.07	50.90	65.39	70.72	79.10	107.38	0.0												
9	0.0	2.42	3.42	4.47	4.18	6.19	8.11	9.06	7.68	9.22	19.96	25.04	28.18	36.29	41.22	44.67	44.64	36.71	17.73	10.51
	16.53	36.40	51.14	64.55	63.93	71.17	71.25	0.0												
10	0.0	1.77	2.31	2.74	2.90	3.86	6.14	7.59	6.64	5.03	19.40	26.52	34.21	43.50	47.52	48.33	44.84	36.19	24.79	17.73
	21.59	31.43	45.11	52.94	54.23	64.41	66.85	0.0												

11	0.0	1.19	1.40	1.36	1.00	1.62	3.33	-3.49	10.83	14.13	22.62	29.84	39.31	47.81	50.19	48.71	42.25	29.19	19.98	16.35
	18.05	22.55	30.74	40.51	46.52	60.86	64.51	0.0												
12	0.0	0.69	0.70	0.43	-0.19	-0.90	-6.69	-7.18	10.47	23.74	26.81	33.72	44.43	46.87	48.58	43.21	34.74	18.20	8.27	9.30
	12.45	14.50	18.32	31.37	40.16	0.0	0.0	0.0												
13	0.0	0.25	0.18	0.02	-0.41	-1.22	-3.80	-1.43	13.27	27.39	33.56	38.70	41.76	47.93	47.59	40.35	25.60	6.19	-12.19	1.32
	8.18	11.22	14.24	27.78	37.03	0.0	0.0	0.0												
14	0.0	0.0	0.05	-0.05	-0.24	-0.61	-1.24	0.18	7.71	24.17	33.02	34.13	34.31	39.14	38.14	33.68	16.14	5.49	-3.31	-0.43
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
15	0.0	0.0	0.0	0.0	-0.14	-0.17	-0.11	1.07	9.92	14.33	23.60	25.40	25.58	33.61	32.25	21.15	3.82	3.17	-0.50	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
16	0.0	0.0	0.0	0.0	0.0	0.05	0.23	0.76	6.63	12.38	14.33	18.55	20.02	26.77	26.32	16.22	3.37	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
17	0.0	0.0	0.0	0.0	0.0	0.16	0.50	1.43	3.98	6.46	6.95	16.97	17.53	22.55	18.70	11.35	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
18	0.0	0.0	0.0	0.0	0.0	0.0	0.51	1.18	2.63	4.37	7.73	12.95	15.31	15.18	10.51	6.76	3.84	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
19	0.0	0.0	0.0	0.0	0.0	0.0	0.46	0.91	1.84	2.93	4.70	6.89	8.05	7.28	6.12	4.41	3.29	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.84	1.47	2.24	3.34	4.55	5.23	5.14	4.31	3.51	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												

SUPPLEMENTARY DATA III--INPUT MATRICES AND RESULTS--Continued

Head matrix, layer 2 for pumping period 4

HEAD MATRIX, LAYER 2

1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
2	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	3.01	3.01	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	32.02	35.03	80.00	140.00	0.0												
3	0.0	0.0	0.00	0.0	0.0	0.01	0.01	0.0	0.0	0.0	1.00	1.00	2.00	8.22	18.01	20.47	7.01	0.0	0.0	0.0
	0.0	0.0	0.0	29.01	67.20	110.25	190.00	0.0												
4	0.0	0.0	4.39	3.01	2.02	10.04	18.46	0.0	0.0	0.0	1.00	4.83	3.21	21.11	36.82	47.39	37.47	8.03	12.01	15.00
	0.0	0.0	22.01	24.01	79.12	117.14	150.00	0.0												
5	0.0	0.0	1.00	12.57	12.19	13.23	10.38	0.00	0.0	0.0	0.0	8.63	13.49	60.79	80.22	81.22	45.69	36.84	19.36	17.00
	18.00	18.00	20.03	65.25	90.15	117.11	95.00	0.0												
6	0.0	0.0	0.0	10.96	18.65	17.49	11.13	1.01	0.0	0.0	0.0	11.59	35.00	47.09	57.75	75.51	66.91	45.12	38.21	50.73
	54.03	37.14	53.13	100.05	104.56	147.02	85.00	0.0												
7	0.0	0.0	0.50	15.17	3.19	22.73	21.10	4.34	0.0	0.0	2.00	2.01	12.81	31.74	42.18	60.71	78.44	74.12	56.48	96.85
	57.27	54.14	58.37	97.17	150.09	76.12	110.00	0.0												
8	0.0	0.0	0.0	9.95	1.00	16.64	10.48	7.31	1.00	4.53	19.72	4.10	12.05	17.13	26.15	37.10	66.02	67.47	50.09	51.41
	75.42	58.65	65.17	91.21	138.24	30.11	160.00	0.0												
9	0.0	0.0	0.0	7.83	0.50	0.50	8.28	9.98	8.33	3.15	32.36	40.79	27.51	38.45	56.43	46.09	46.43	53.02	49.27	45.00
	93.22	62.14	79.93	95.47	63.53	18.12	20.00	0.0												
10	0.0	0.0	0.0	0.0	2.50	1.00	6.13	10.27	5.54	6.04	37.09	46.49	58.19	55.35	68.73	71.26	68.21	66.24	54.99	38.78
	38.66	43.03	61.92	47.97	7.03	11.00	25.00	0.0												

11	0.0	0.0	0.0	0.00	7.16	1.00	6.04	0.52	13.84	13.10	29.14	43.86	62.16	70.56	74.31	78.65	77.07	98.93	52.54	51.88
	33.14	24.45	39.20	9.10	5.00	6.00	18.00	0.0												
12	0.0	0.0	0.0	0.00	4.74	1.00	3.10	-3.08	13.90	26.83	27.16	38.58	64.87	75.49	79.19	76.82	66.29	67.87	40.62	28.09
	13.02	3.74	4.03	3.98	3.00	0.0	0.0	0.0												
13	0.0	0.0	0.0	0.0	0.0	0.0	0.00	1.00	16.38	30.40	36.72	42.74	84.01	79.30	79.51	70.88	40.13	24.29	50.33	3.00
	3.27	3.74	3.90	3.97	6.00	0.0	0.0	0.0												
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.96	11.12	27.07	36.42	35.80	55.61	79.34	76.40	39.08	14.54	9.00	2.00	2.00
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	11.98	18.44	41.22	22.19	43.05	62.16	58.09	19.32	1.01	1.11	1.63	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.91	27.66	2.00	6.16	33.36	52.83	49.03	18.59	1.00	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	1.00	1.03	38.41	39.66	47.30	26.21	0.04	0.00	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	13.41	22.76	30.47	23.04	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												

SUPPLEMENTARY DATA III--INPUT MATRICES AND RESULTS--Continued

Head matrix, layer 1 for pumping period 5

HEAD MATRIX, LAYER 1

1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
2	0.0	2.96	3.52	3.80	3.48	2.41	0.31	0.0	0.0	0.0	0.0	0.0	0.0	1.00	3.00	3.00	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	53.67	73.74	106.74	140.00	0.0												
3	0.0	3.00	3.72	4.39	4.20	3.09	-1.26	1.70	0.0	0.0	0.0	1.52	2.73	8.74	16.39	18.15	22.57	0.0	0.0	0.0
	0.0	0.0	0.0	57.54	74.32	108.24	190.00	0.0												
4	0.0	3.06	4.03	5.73	6.10	5.23	3.89	4.00	0.0	0.0	7.02	5.08	5.39	17.81	26.01	29.64	29.66	28.80	29.44	30.26
	0.0	0.0	43.51	57.59	76.89	107.24	150.00	0.0												
5	0.0	3.09	3.90	7.94	8.53	7.49	6.94	6.58	7.79	8.60	8.77	9.20	17.56	25.20	32.50	35.25	35.27	33.72	30.01	31.24
	32.81	38.64	44.10	58.93	78.34	102.17	95.00	0.0												
6	0.0	3.12	4.83	8.57	9.69	9.24	9.01	8.29	8.46	9.48	10.74	12.28	22.81	29.34	39.03	43.63	43.54	39.17	34.42	32.97
	31.40	38.11	46.59	59.19	75.39	93.30	95.00	0.0												
7	0.0	2.99	4.96	8.82	8.22	10.79	11.36	8.96	8.91	10.62	13.03	14.11	21.22	28.20	38.99	43.83	46.80	42.26	32.58	23.36
	24.69	36.53	47.79	60.48	72.94	84.50	110.00	0.0												
8	0.0	2.47	3.95	6.10	5.91	9.20	9.72	7.88	8.43	11.73	16.84	18.51	22.05	23.93	31.49	39.18	43.40	37.45	23.36	11.75
	9.05	34.77	49.65	64.52	69.86	78.84	107.37	0.0												
9	0.0	1.76	2.49	3.62	3.61	5.88	8.09	9.10	6.53	11.52	21.65	25.75	28.14	35.30	40.62	44.01	42.15	32.05	7.82	3.08
	11.78	33.40	49.37	63.44	63.33	70.89	71.24	0.0												
10	0.0	1.09	1.02	1.44	1.66	3.56	6.58	8.67	7.64	12.83	21.85	27.43	34.25	42.89	46.70	46.96	41.90	31.32	17.68	11.26
	16.80	28.15	43.32	51.76	53.55	64.12	66.82	0.0												

11	0.0	0.54	-0.55	-0.59	-1.64	1.06	4.27	-0.73	12.57	15.43	23.27	30.12	39.21	47.31	49.23	47.01	39.11	24.18	13.33	10.31
	13.62	19.42	28.75	39.26	45.79	60.57	64.47	0.0												
12	0.0	0.22	-0.51	-1.64	-4.03	-1.76	-6.50	-2.47	12.68	24.07	25.23	33.28	44.20	46.65	47.39	41.68	31.65	12.83	0.70	2.98
	8.50	11.77	16.73	30.66	39.36	0.0	0.0	0.0												
13	0.0	0.06	-0.25	-1.11	-2.02	-1.66	-3.40	0.51	14.48	27.58	32.61	38.32	41.43	47.69	46.84	39.05	23.17	1.77	-23.30	-6.35
	3.97	8.55	12.75	26.60	36.21	0.0	0.0	0.0												
14	0.0	0.0	-0.20	-0.51	-0.81	-0.97	-1.79	-2.11	7.97	24.62	32.96	34.10	34.45	39.14	37.78	32.98	14.75	-0.09	-15.22	-9.63
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
15	0.0	0.0	0.0	0.0	-0.42	-0.38	-0.41	0.68	9.00	15.56	24.07	25.69	26.26	34.02	32.24	20.78	1.79	-2.33	-9.53	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
16	0.0	0.0	0.0	0.0	0.0	-0.05	0.14	0.93	2.09	11.78	14.64	18.84	20.88	27.77	26.58	16.20	3.03	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
17	0.0	0.0	0.0	0.0	0.0	0.09	0.37	1.09	2.55	6.14	7.90	16.81	18.04	23.01	18.98	11.77	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
18	0.0	0.0	0.0	0.0	0.0	0.0	0.40	0.93	2.07	4.06	7.40	10.82	15.00	15.25	10.64	6.92	3.93	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
19	0.0	0.0	0.0	0.0	0.0	0.0	0.37	0.76	1.57	2.68	4.35	6.13	7.76	7.83	6.16	4.48	3.35	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.72	1.29	2.03	3.08	4.17	5.02	5.06	4.31	3.54	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												

SUPPLEMENTARY DATA III--INPUT MATRICES AND RESULTS--Continued

Head matrix, layer 2 for pumping period 5

HEAD MATRIX, LAYER 2

1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0												
2	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	3.01	3.01	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	32.02	35.03	80.00	140.00	0.0												
3	0.0	0.0	0.00	0.0	0.0	0.01	0.01	0.0	0.0	0.0	1.00	1.00	2.00	8.21	17.86	20.46	7.01	0.0	0.0	0.0
	0.0	0.0	0.0	29.01	67.19	110.24	190.00	0.0												
4	0.0	0.0	4.37	3.01	2.02	9.88	18.29	0.0	0.0	0.0	1.00	4.81	3.20	21.10	36.60	47.11	37.21	8.03	12.01	15.00
	0.0	0.0	22.01	24.01	79.12	117.14	150.00	0.0												
5	0.0	0.0	1.00	11.93	12.17	13.23	10.38	0.00	0.0	0.0	0.0	8.62	18.43	60.75	80.09	81.00	45.68	36.54	19.34	17.00
	18.00	18.00	20.03	65.24	90.15	117.09	95.00	0.0												
6	0.0	0.0	0.0	10.33	17.93	17.48	11.13	1.01	0.0	0.0	0.0	11.63	34.97	47.09	57.73	74.95	66.73	45.10	38.18	50.67
	54.03	37.14	53.13	100.05	104.56	147.02	85.00	0.0												
7	0.0	0.0	0.50	14.65	3.18	22.03	21.05	4.31	0.0	0.0	2.00	2.01	12.81	31.73	42.14	60.68	77.21	72.08	53.93	96.08
	57.26	54.14	58.37	97.17	150.09	76.12	110.00	0.0												
8	0.0	0.0	0.0	9.89	1.00	16.21	10.16	7.26	1.00	4.68	20.43	4.10	12.05	17.12	26.14	37.09	65.17	64.45	45.43	49.65
	75.41	56.55	65.16	91.19	138.24	30.11	160.00	0.0												
9	0.0	0.0	0.0	7.81	0.50	0.50	8.28	10.02	7.29	3.16	33.30	41.03	27.51	38.31	56.40	46.06	43.97	53.00	40.03	38.07
	91.87	59.28	78.35	94.49	63.51	18.12	20.00	0.0												
10	0.0	0.0	0.0	0.0	2.45	1.00	6.57	11.32	5.64	6.04	37.11	46.51	58.19	55.34	68.58	71.21	65.39	61.90	48.52	32.65
	34.04	40.04	61.62	47.97	7.03	11.00	25.00	0.0												

11	0.0	C.0	0.C	C.00	7.12	1.00	6.94	3.23	15.53	13.14	29.14	43.86	62.16	70.33	74.22	77.13	74.17	97.06	52.52	51.81
	33.14	24.44	39.2C	9.10	5.CC	6.00	18.C0	C.0												
12	0.0	C.0	0.C	C.00	4.7C	1.00	3.11	1.33	16.C8	27.03	27.1C	38.58	64.85	75.22	78.43	75.40	63.72	67.83	40.6C	28.09
	13.0C	3.74	4.C2	3.98	3.CC	0.0	0.0	C.0												
13	0.0	C.0	0.C	0.0	0.0	0.0	0.0C	1.00	17.54	3C.53	35.84	42.36	83.91	79.06	78.99	69.76	40.C8	24.28	48.86	3.00
	3.27	3.74	3.9C	3.97	6.00	0.0	0.0	C.0												
14	0.0	C.0	0.C	C.0	0.C	0.0	0.C	C.33	11.3C	27.51	36.37	35.76	55.61	79.34	76.39	38.41	14.18	9.C0	2.CC	2.00
	0.0	C.0	0.C	C.0	0.0	0.0	0.0	C.0												
15	0.0	C.0	0.C	C.0	0.0	0.0	0.0	C.00	11.17	19.46	41.61	22.19	43.06	62.50	58.C9	19.29	1.CC	1.11	1.63	C.C
	0.0	0.0	0.C	C.0	0.C	0.0	0.0	C.0												
16	0.0	C.0	0.C	C.0	0.0	0.0	0.0	C.0	5.91	27.22	2.0C	6.16	34.12	53.63	49.26	18.61	1.C0	C.0	0.0	0.0
	0.0	C.0	0.C	0.0	0.0	C.0	0.0	C.0												
17	0.0	C.0	0.C	0.0	0.0	0.0	0.0	0.0	1.C0	1.00	1.03	38.23	40.C0	47.66	26.35	C.04	0.CC	C.0	0.0	0.0
	0.0	C.0	0.C	C.0	0.0	0.0	0.0	C.0												
18	0.0	0.0	0.C	C.0	0.0	0.0	0.0	C.0	0.C	C.00	13.24	22.09	30.32	23.04	0.0	C.0	0.0	0.0	0.0	0.0
	0.0	C.0	0.C	0.0	0.C	0.0	0.0	C.0												
19	0.0	C.0	0.0	C.0	0.C	0.0	0.0	C.0	0.C	C.0	0.C	0.00	0.C0	0.0	0.C	C.0	0.C	0.0	0.C	C.0
	0.0	C.0	0.C	C.0	0.C	0.0	0.0	C.0												
20	0.0	0.0	0.0	C.0	0.C	0.0	0.0	C.0	0.C	C.0	0.C	C.0	0.0	0.0	0.0	C.0	0.C	0.0	0.0	C.0
	0.0	0.0	0.C	C.0	0.0	0.0	0.0	C.0												
21	0.0	C.0	0.0	C.0	0.C	0.0	0.0	0.0	0.C	C.0	0.C	C.C	0.0	C.0	0.C	0.0	0.C	C.0	0.C	0.0
	C.0	C.0	0.C	C.0	0.C	0.0	0.0	C.0												