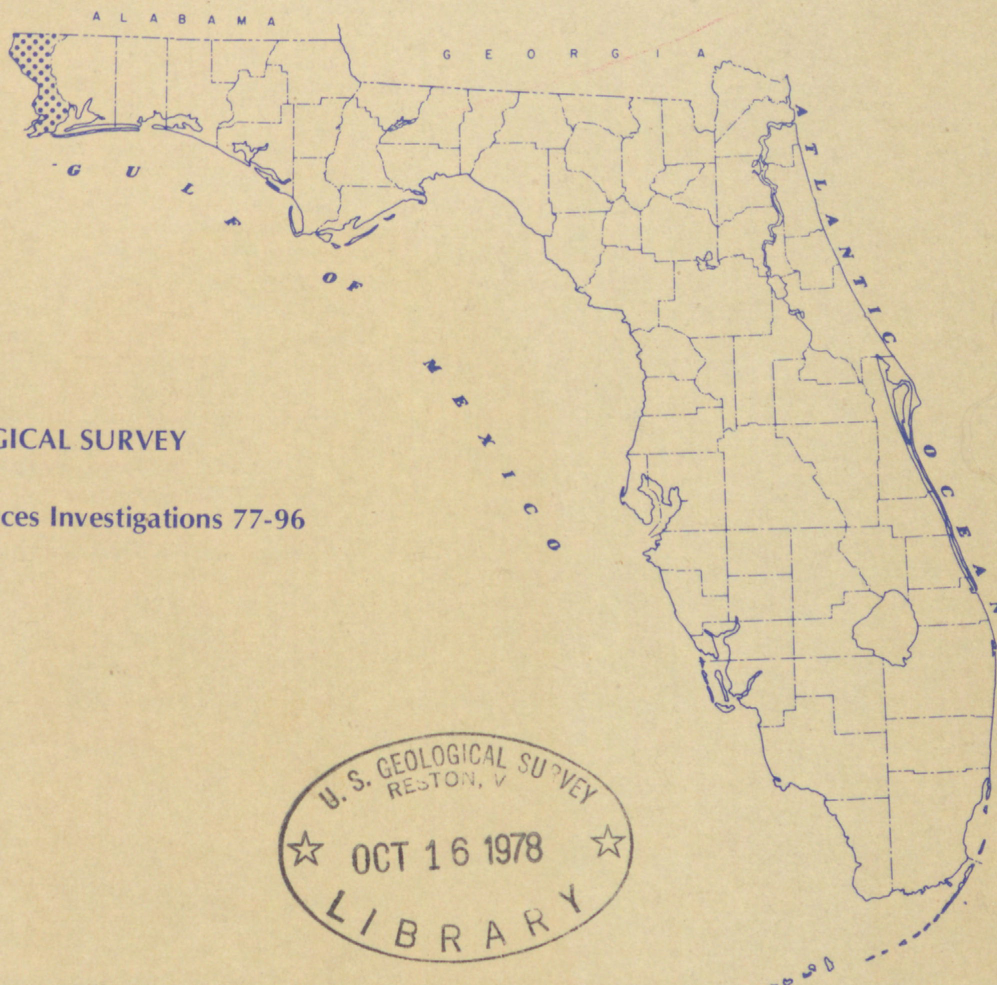
WRI 77-96

PRELIMINARY HYDROLOGIC BUDGET OF THE SAND-AND-GRAVEL AQUIFER UNDER UNSTRESSED CONDITIONS, WITH A SECTION ON WATER-QUALITY MONITORING, PENSACOLA, FLORIDA



U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 77-96

Prepared in cooperation with
CITY OF PENSACOLA, FLORIDA

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16. Abstracts The sand-and-gravel aquifer is the only freshwater aquifer in southern Escambia County. Problems related to the development of the aquifer include sustained yield, contamination, and saltwater intrusion. A digital model was applied to the sand-and-gravel aquifer in central and southern Escambia County treating the aquifer's "main producing zone" as a discrete, leaky, confined aquifer. Under conditions of no pumping, most values for the final-head matrix agreed with assumed values within 4 feet in the area of principal interest. Discharge per unit land area was 1.04 cubic feet per second per square mile, in close agreement with the base runoff of streams maintained by the aquifer. Total natural aquifer discharge within the area of principal interest determined by the model was 159 million gallons per day. The applicability of the present non-unique calibration for predicting the effects of pumping is questionable; a multilayered model may be required. Effluent infiltrating from holding lagoons for spray irrigation at the Scenic Hills Sewage Plant may have affected the quality of local perched ground water in the sand-and-gravel aquifer. Observation wells drilled near areas of heavy pumping around Bayou Chico indicated no saltwater intrusion.

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PRELIMINARY HYDROLOGIC BUDGET OF THE SAND-AND-GRAVEL AQUIFER UNDER UNSTRESSED CONDITIONS, WITH A SECTION ON WATER-QUALITY MONITORING PENSACOLA, FLORIDA

By

Henry Trapp, Jr.

ABSTRACT

The sand-and-gravel aquifer is the only freshwater aquifer in southern Escambia County. Problems related to the development of the aquifer include determination of sustained yield, contamination, and saltwater intrusion.

This report, prepared in cooperation with the city of Pensacola, summarizes the hydrologic budget of the sand-and-gravel aquifer in central and southern Escambia County under unstressed conditions. A digital model was used, treating the aquifer's "main producing zone" as a discrete, leaky, confined aquifer. Under conditions of no pumping, most values for the final-head matrix agreed with assumed values within 4 feet in the area of principal interest, but the calibration is non-unique. Discharge per unit land area was 1.04 cubic feet per second per square mile, in close agreement with the base runoff of streams maintained by the aquifer. Total natural aquifer discharge within the area of principal interest, as determined by the model, was 159 million gallons per day.

The applicability of the present calibration for predicting the effects of pumping is questionable; a multilayered model may be required.

Effluent infiltrating from holding lagoons for spray irrigation at the Scenic Hills Sewage Plant may have affected the quality of local perched ground water in the sand-and-gravel aquifer.

Observation wells drilled near areas of heavy pumping around Bayou Chico indicated no saltwater intrusion.

THE PROBLEM

Earlier hydrologic studies show that ample quantities of soft water of low dissolved-solids concentration are obtainable from the sand-and-gravel aquifer in central and southern Escambia County. Some wells drilled for the city of Pensacola have yielded water with unacceptably high amounts of iron and carbon dioxide, and some wells have had disappointingly low yields. The city has been seeking hydrologic information, including water-quality data, in an effort to avoid well abandonments and to plan for future expansion of the water-supply system. In order to plan for expansion, the city needs a basis for predicting the effects of various concentrations of pumping on water levels and for predicting ground-water flow (and thus the movement of contaminants or of saltwater intrusion).

OBJECTIVES AND APPROACH

This investigation is intended to provide information on the quality and quantity of water available from the sand-and-gravel aquifer, the only freshwater aquifer in central and southern Escambia County.

The area of investigation extends from the western end of Santa Rosa Island, through Pensacola to State Road 196 (S-196) north of Quintette (fig. 1). The investigation was scheduled to be accomplished in three 3-year phases; two have been completed. The first phase concentrated on well inventory, water sampling, test drilling, and preliminary interpretation (Trapp, 1972, 1973, 1975). The second phase concentrated on construction and calibration of a preliminary digital model of the aquifer, test drilling, and monitoring the effects of effluent-spray disposal, summarized in this report. The third phase will stress the refinement, verification, and sensitivity analysis of the model, while continuing the monitoring of effluent-spray disposal, sampling of public-supply wells, collection of hydrologic data, including water-level measurements and test drilling, and checking leveling records for possible land subsidence.

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, director, and William A. Duynslager and Charlie C. Crowder, former Water Division superintendents, Pensacola Department of Public Utilities. The cooperation of Roger Dubble, superintendent, Pensacola Sewage Division, and John Deyton, operator, in the sampling program around the Scenic Hills Sewage Plant is gratefully acknowledged. Larry J. Slack, U.S. Geological Survey, advised on water-quality aspects of the investigation, collected most of the water samples, and assisted in other fieldwork. Peter C. Trescott and Larry F. Land, U.S. Geological Survey, made helpful suggestions with respect to the aquifer model.

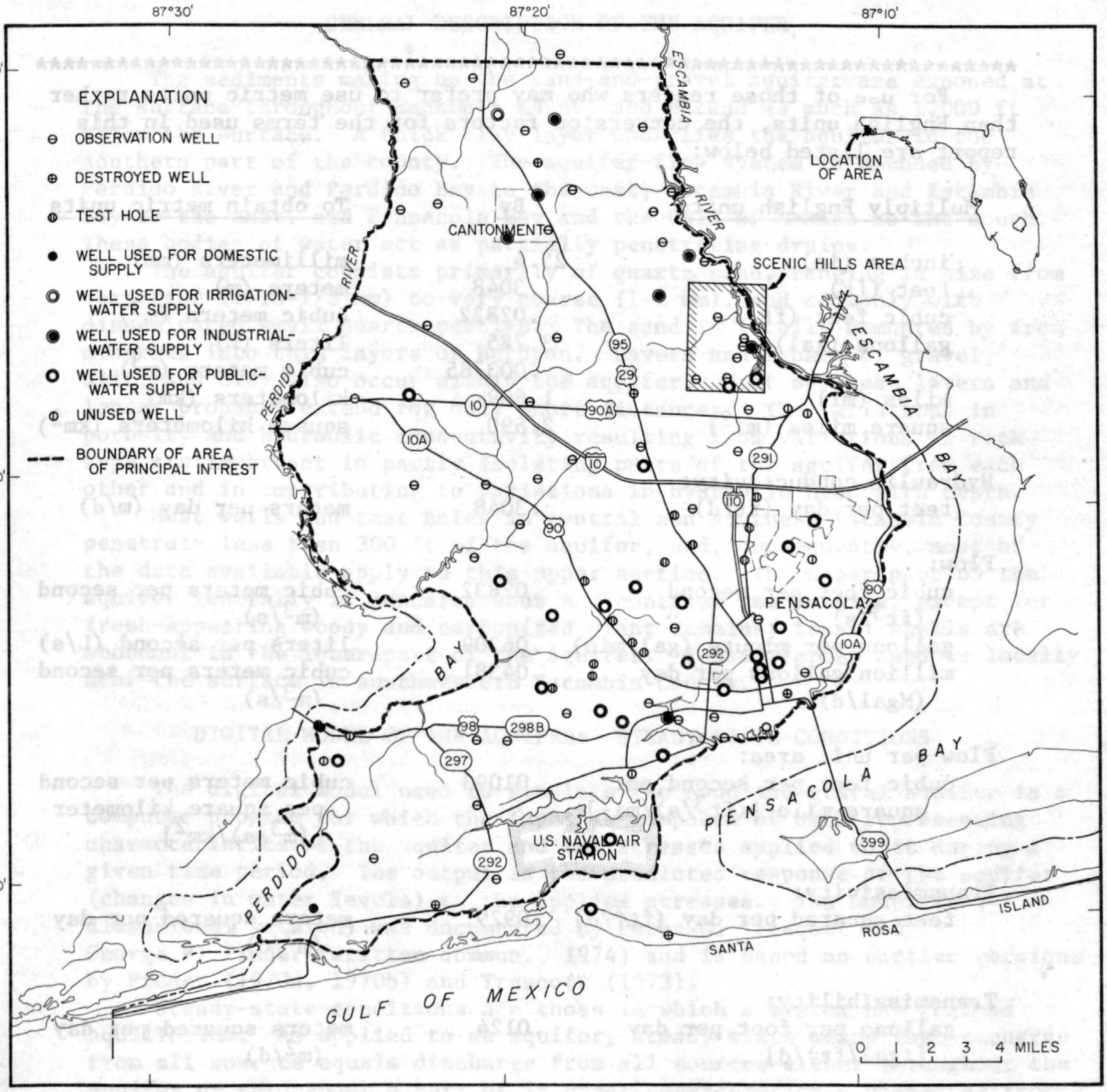

FIGURE 1.--Area of investigation, location of the Scenic Hills area, and location of test holes and wells used as control points for the aquifer model or referred to in the report.

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For use of those readers who may prefer to use metric units rather than English units, the conversion factors for the terms used in this report are listed below:

Multiply English units	By	To obtain metric units
inches (in)	25.4	millimeters (mm)
feet (ft)	.3048	meters (m)
cubic feet (ft^3)	.02832	cubic meters (m^3)
gallons (gal)	3.785	liters (L)
	.003785	cubic meters (m^3)
miles (mi)	1.609	kilometers (km)
square miles (mi^2)	2.590	square kilometers (km^2)
Hydraulic conductivity:		
feet per day (ft/d)	.3048	meters per day (m/d)
Flow:		
cubic feet per second (ft^3/s)	.02832	cubic meters per second (m^3/s)
gallons per minute (gal/min)	.06309	liters per second (L/s)
million gallons per day (Mgal/d)	.04381	cubic meters per second (m^3/s)
Flow per unit area:		
cubic feet per second per square mile [$(ft^3/s)/mi^2$]	.01093	cubic meters per second per square kilometer [$(m^3/s)/km^2$]
Transmissivity:		
feet squared per day (ft^2/d)	.0929	meters squared per day (m^2/d)
Transmissibility:		
gallons per foot per day [(gal/ft)/d]	.0124	meters squared per day (m^2/d)
Specific capacity:		
gallons per minute per foot [(gal/min)/ft]	2.07×10^{-4}	cubic meters per second per meter [$(m^3/s)/m$]
	.207	liters per second per meter [(L/s)/m]

****

GENERAL DESCRIPTION OF THE AQUIFER

The sediments making up the sand-and-gravel aquifer are exposed at the surface throughout Escambia County and extend as much as 1,000 ft below the surface. A thick clay layer underlies the aquifer in the southern part of the county. The aquifer-flow system is bounded by Perdido River and Perdido Bay to the west, Escambia River and Escambia Bay to the east, and Pensacola Bay and the Gulf of Mexico to the south. These bodies of water act as partially penetrating drains.

The 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 with 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 and lenses probably extend for only short distances. The variations in porosity and hydraulic conductivity resulting from variations in rock type are important in partly isolating parts of the aquifer from each other and in contributing to variations in hydraulic head with depth.

Most wells and test holes in central and southern Escambia County penetrate less than 300 ft 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 is locally near the surface in southwestern Escambia County.

DIGITAL MODEL OF THE AQUIFER: STEADY-STATE CONDITIONS

The digital model used to simulate the sand-and-gravel aquifer is a computer program for which the input is composed of data representing characteristics of the aquifer and the stresses applied to it during a given time period. The output is the predicted response of the aquifer (changes in water levels) to the applied stresses. The model (two-dimensional version) was documented by Peter C. Trescott and George F. Pinder (written commun., 1974) and is based on earlier versions by Pinder (1970a, 1970b) and Trescott (1973).

Steady-state conditions are those in which a system has reached equilibrium. As applied to an aquifer, steady state means that recharge from all sources equals discharge from all sources either throughout the aquifer or throughout a part of it under consideration. Discharge from transmission through the aquifer, from upward leakage through confining beds into streams, from pumping, and from evapotranspiration exactly balances recharge from precipitation, from streams, from transmission through the aquifer, from leakage through confining layers into the aquifer, and from recharge wells, so that water levels, or storage, at all points do not change with time. The steady-state conditions assumed for the first stage in the development of the aquifer model are the conditions before pumping began in the study area.

Basic Assumptions

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, hereafter called the "main producing zone," is both overlain and underlain by parts of the sand-and-gravel aquifer having lower permeability. (2) The "main producing zone" can be treated as a discrete, leaky confined aquifer. (3) The "main producing zone" is laterally isotropic. (4) The "main producing zone" within the project area is bounded by constant-head boundaries (boundaries along which the head does not change, regardless of head changes adjoining them). The head at these boundaries, where they underlie bodies of saltwater, is virtually at sea level. Elsewhere, the head along the constant-head boundaries is above sea level. (5) The "main producing zone" is recharged by water entering along constant-head boundaries and through the overlying confining bed. (6) The "main producing zone" is discharged through constant-head boundaries and the overlying confining bed. (7) Discharge and recharge through the underlying confining bed is negligible. Any such discharge or recharge is accounted for by assuming that it takes place through the <u>overlying</u> confining bed. (8) The head in the section above the overlying confining bed equals the water table. Perched water tables are excluded. The water table remains constant.

Assumptions 1 through 3 are based on insufficient evidence, but the data for simulating a more complex system are also lacking. Any model of only part of an extensive aquifer needs some assumption regarding boundaries, such as 4, that does not correspond to physical reality. The problem is to select and locate boundaries in the model so that they do not distort its response. Assumptions 6 through 8 are not strictly true, but are necessary unless a more complex model is applied, for which input data are lacking.

Application

<u>Selection of grid</u>.--The Trescott-Pinder model (Trescott, P. G., 1973; Trescott, P. G., and Pinder, G. F., U.S. Geol. Survey, written commun., January 1974) uses a block-centered grid. That is, the map of the study area is divided into a grid of rectangles. A value is assigned to each parameter in each rectangle at each stage of calculation, and a value is computed for the average head in each rectangle in the output. A set of numbers arranged on the grid is called a matrix.

The grid 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 ft for each minute of latitude and 5,254 ft 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 to a maximum of 20,275 ft at the north end and 19,500 ft at the south end to move the constant-head boundaries back from the area of principal interest without adding unnecessary nodes. The model grid (fig. 2) covers an area substantially larger than the project area (fig. 1) but parts of Santa Rosa Island, Perdido Key, and Inerarity Point are cut off.

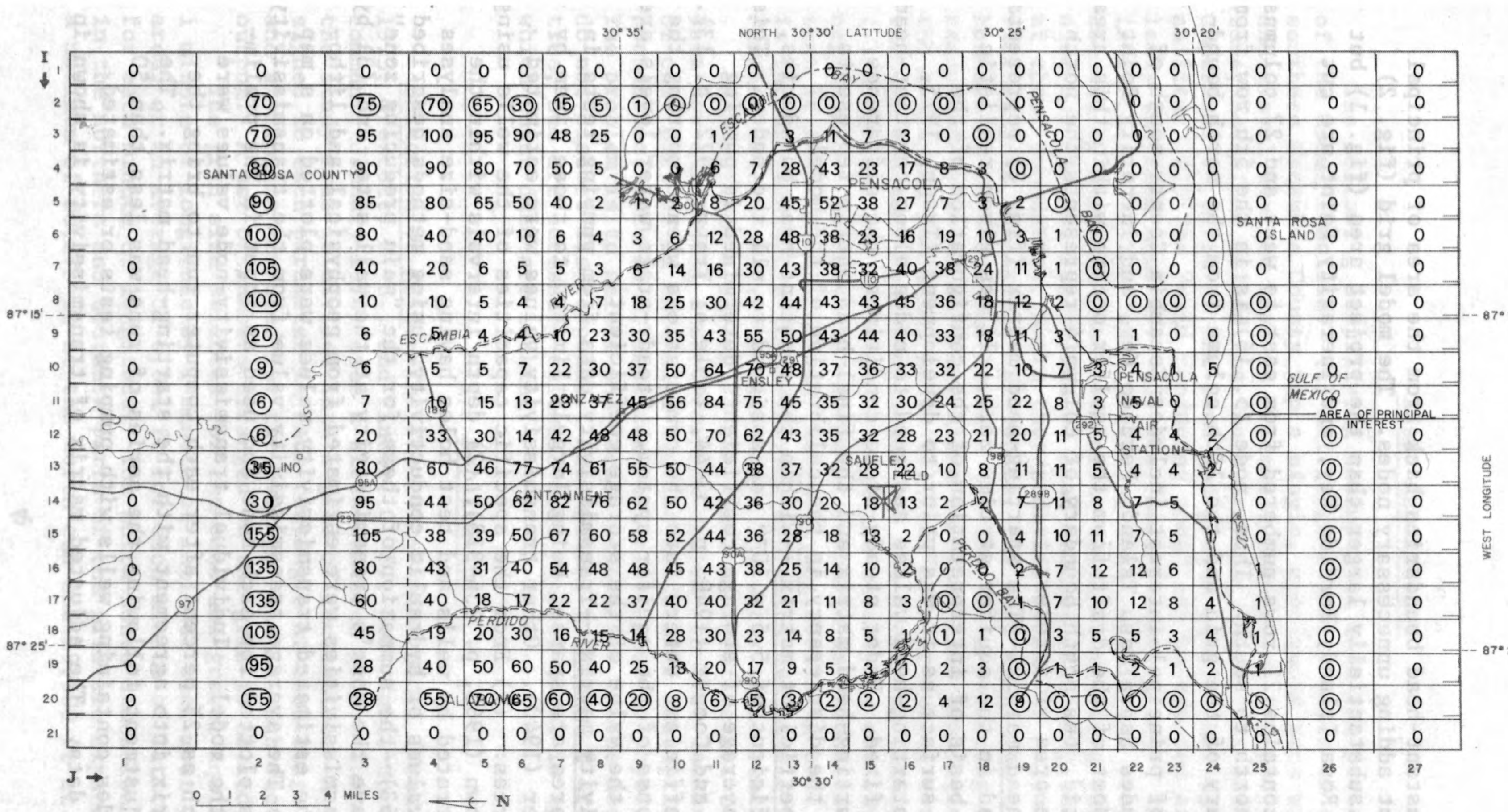
The grid contains 21 rows numbered from east to west and 27 columns numbered from north to south. Thus, node (5, 16) is in the 5th row from the east boundary of the grid and the 16th column from the north boundary.

The area of principal interest includes Escambia County south of S-196 but excludes Santa Rosa Island, Perdido Key, and Inerarity Point (figs. 1-2). Most of the draft from the aquifer occurs within this area. On the model grid, the north boundary of column 4 represents the north boundary of the area of interest.

Starting-head matrix.--The starting-head matrix (fig. 2) represents the initial head in the aquifer at time zero. It was given realistic values, on the basis of interpretation of the configuration of the potentiometric surface as it was prior to development (Trapp, 1975, fig. 8). The starting-head values assigned to nodes along constant-head boundaries are fixed. Under steady-state conditions, the difference between the starting-head matrix and the final-head matrix represents one measure of the discrepancy in the calibration of the model.

Storage-coefficient matrix.--Within the constant-head boundaries, a storage coefficient of 5.5×10^{-4} was assigned to all the nodes. This value was the average of storage coefficients determined in pumping tests by Jacob and Cooper (1940, p. 33-44, table 4; Trapp, 1972, p. 13). The storage coefficient enters into the computations when computing the transient response of the aquifer system. Steady-state water levels are independent of the value of the storage coefficient.

Transmissivity matrix.--Transmissivity data from pumping tests in the Pensacola area are sparse, being largely limited to those given by Jacob and Cooper (1940). Other transmissivity values were estimated from three sources: (1) From the specific capacities of the wells using a method by Brown (1963, p. 336-338); (2) depth intervals within the materials penetrated by wells and test holes having sand-size analyses were assigned values of hydraulic conductivity, using methods described by Johnson (1963)--the summation of these for the "main producing zone" in each well gave the zone's transmissivity at the well site; and (3) by extension, transmissivities were estimated from geophysical and lithologic logs. The estimated transmissivity values were plotted on a map and contoured. The average transmissivity value from the transmissivity-contour map was plotted for each node and used as input in the preliminary runs of the model. Individual transmissivity-node values were adjusted as much as 25 percent after each computer run to bring the final-head matrix into agreement with the starting-head matrix. The maximum net adjustment following the series of runs was less than 50 percent for nodes containing wells with pumping tests or estimated transmissivity data. The adjusted matrix of transmissivity is shown in figure 3.

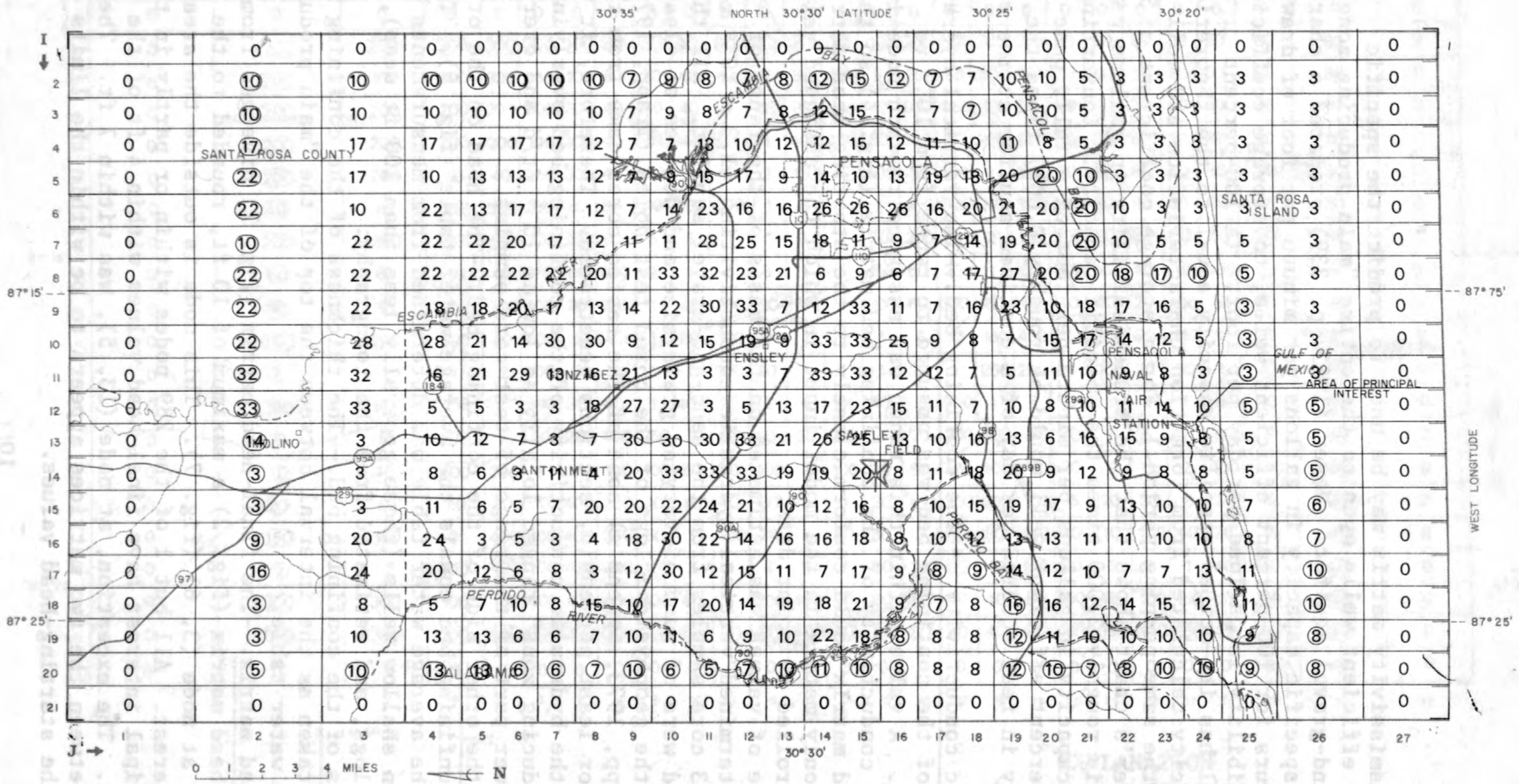


.IGURE 2.--Starting-head matrix and constant-head boundaries.

EXPLANATION

70--Numbers represent head to nearest foot above mean sea level.

(28) -Constant-head boundary node.



I \ J	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
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
2	0	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(7)	(9)	(8)	(7)	(8)	(12)	(15)	(12)	(7)	7	10	10	5	3	3	3	3	3	0
3	0	(10)	10	10	10	10	10	10	7	9	8	7	8	12	15	12	7	(7)	10	10	5	3	3	3	3	3	0
4	0	(17)	17	17	17	17	17	12	7	7	13	10	12	12	15	12	11	10	(11)	8	5	3	3	3	3	3	0
5	0	(22)	17	10	13	13	13	12	7	8	15	17	9	14	10	13	19	18	20	(20)	(10)	3	3	3	3	3	0
6	0	(22)	10	22	13	17	17	12	7	14	23	16	16	26	26	26	16	20	21	20	(20)	10	3	3	3	3	0
7	0	(10)	22	22	22	20	17	12	11	11	28	25	15	18	11	9	7	14	19	20	(20)	10	5	5	5	3	0
8	0	(22)	22	22	22	22	22	20	11	33	32	23	21	6	9	6	7	17	27	20	(20)	(18)	(17)	(10)	(5)	3	0
9	0	(22)	22	18	18	20	17	13	14	22	30	33	7	12	33	11	7	16	23	10	18	17	16	5	(3)	3	0
10	0	(22)	28	28	21	14	30	30	9	12	15	19	9	33	33	25	9	8	7	15	17	14	12	5	(3)	3	0
11	0	(32)	32	16	21	29	13	16	21	13	3	3	7	33	33	12	12	7	5	11	10	9	8	3	(3)	3	0
12	0	(33)	33	5	5	3	3	18	27	27	3	5	13	17	23	15	11	7	10	8	10	11	14	10	(5)	(5)	0
13	0	(14)	3	10	12	7	3	7	30	30	30	33	21	26	25	13	10	16	13	6	16	15	9	8	5	(5)	0
14	0	(3)	3	8	6	3	11	4	20	33	33	33	19	19	20	8	11	18	20	9	12	9	8	8	5	(5)	0
15	0	(3)	3	11	6	5	7	20	20	22	24	21	10	12	16	8	10	15	19	17	9	13	10	10	7	(6)	0
16	0	(9)	20	24	3	5	3	4	18	30	22	14	16	16	18	8	10	12	13	13	11	11	10	10	8	(7)	0
17	0	(16)	24	20	12	6	8	3	12	30	12	15	11	7	17	9	(8)	(9)	14	12	10	7	7	13	11	(10)	0
18	0	(3)	8	5	7	10	8	15	10	17	20	14	19	18	21	9	(7)	8	(16)	16	12	14	15	12	11	(10)	0
19	0	(3)	10	13	13	6	6	7	10	11	6	9	10	22	18	(8)	8	8	(12)	11	10	10	10	10	9	(8)	0
20	0	(5)	(10)	(13)	(13)	(6)	(6)	(7)	(10)	(6)	(5)	(7)	(10)	(11)	(10)	(8)	8	8	(12)	(10)	(7)	(8)	(10)	(10)	(9)	(8)	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

FIGURE 3.--Matrix of transmissivity of the main producing zone of the sand-and-gravel aquifer.

EXPLANATION

21--Numbers represent transmissivity in thousands of feet squared per day.

(8)-Constant-head boundary node.

The transmissivity matrix may be used to predict the specific capacities of efficient wells open to the entire "main producing zone" of the sand-and-gravel aquifer. Meyer (1963, p. 339) prepared a chart relating the specific capacity in gallons per minute per foot of drawdown in 24 hours for 100-percent efficient wells, to storage coefficient and transmissibility in gallons per day per foot. (A 100-percent efficient well has its actual specific capacity equal to the theoretical specific capacity calculated from formation characteristics and well geometry for the same pumping period.) For a storage coefficient of 5. 5×10^{-4}, Meyer's chart shows that the transmissibility in gallons per day per foot is roughly 2,000 times the specific capacity. Converting, the specific capacity in gallons per minute per foot of a fully penetrating 100-percent efficient well would be roughly 0.0037 times the transmissivity in feet squared per day of a confined aquifer at the well site.

Hydraulic conductivity of the confining bed.--The vertical hydraulic conductivity of the confining bed was assumed to range from 10^{-4} to 4×10^{-1} ft/d. A value within this range was assigned to each node in the hydraulic conductivity of the confining bed matrix (fig. 4) so that the final-head matrix would conform closely to the starting-head matrix. This was the only matrix in the model input in which the assigned values were not controlled by point data.

The range of values was estimated on the basis of the range of laboratory-determined vertical hydraulic conductivities (1.8×10^{-2} to 82 ft/d) of 13 core samples from the sand-and-gravel aquifer. All the samples tested were of sand of varying grain size and degrees of cleanness. According to the geophysical logs of the cored test holes (Trapp, 1972, Appendix; Trapp, 1973, Appendix) none of the tested cores came from the most clayey, or least permeable, sections penetrated. Therefore, it was assumed that the hydraulic conductivity of the confining bed overlying the "main producing zone" ranged locally as low as 10^{-4} ft/d and overlapped the lower part of the range of test core samples.

Head on the other side of the confining bed.--The head on the other side of the confining bed equals the average water table (fig. 5). The position of the average water table was determined from measurements of water level in shallow wells (those generally less than 100 ft deep), from neutron logs, and estimated from the topography.

Thickness of the confining bed.--The thickness of the confining bed (fig. 6) was taken as the interval between the top of the "main producing zone" and the water table.

Final-head matrix.--The final-head matrix (fig. 7) diverges from the starting-head matrix (fig. 2) a maximum of 10 ft, rounded to the nearest foot, at node (3, 6) (fig. 7). This node is outside the area of principal interest. All but 1 of the 289 nodes within or partly in the area of principal interest have final-head values within 4 ft of the starting head. The exception, at node (13, 5), was within 7 ft. The discrepancy between the two matrices appears to be within the limits of accuracy of the starting-head values.

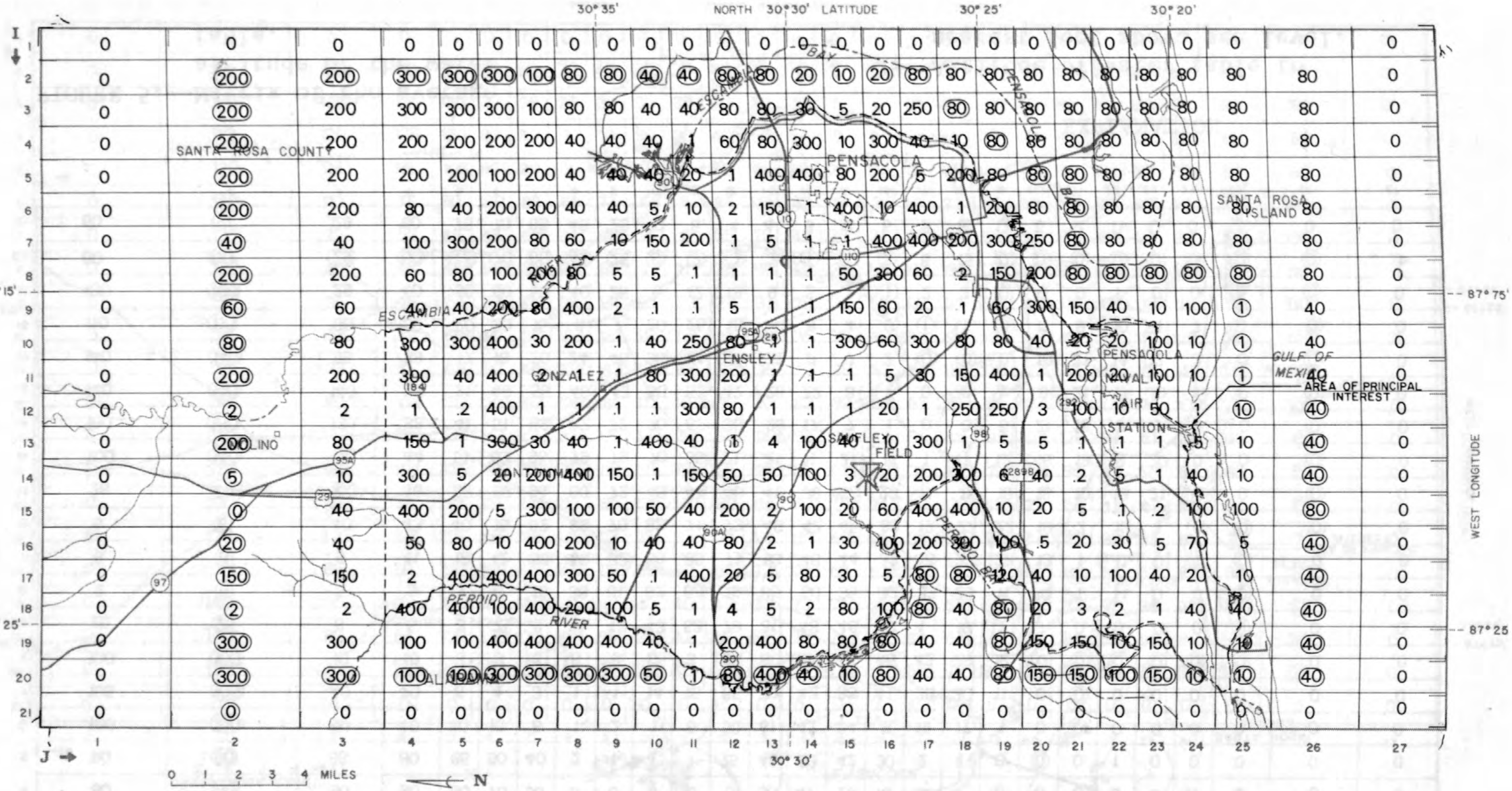


FIGURE 4.--Matrix of the hydraulic conductivity of the confining bed.

EXPLANATION

5.--Numbers show vertical hydraulic conductivity in (feet per day) x 10^3

(80) -Constant-head boundary node.

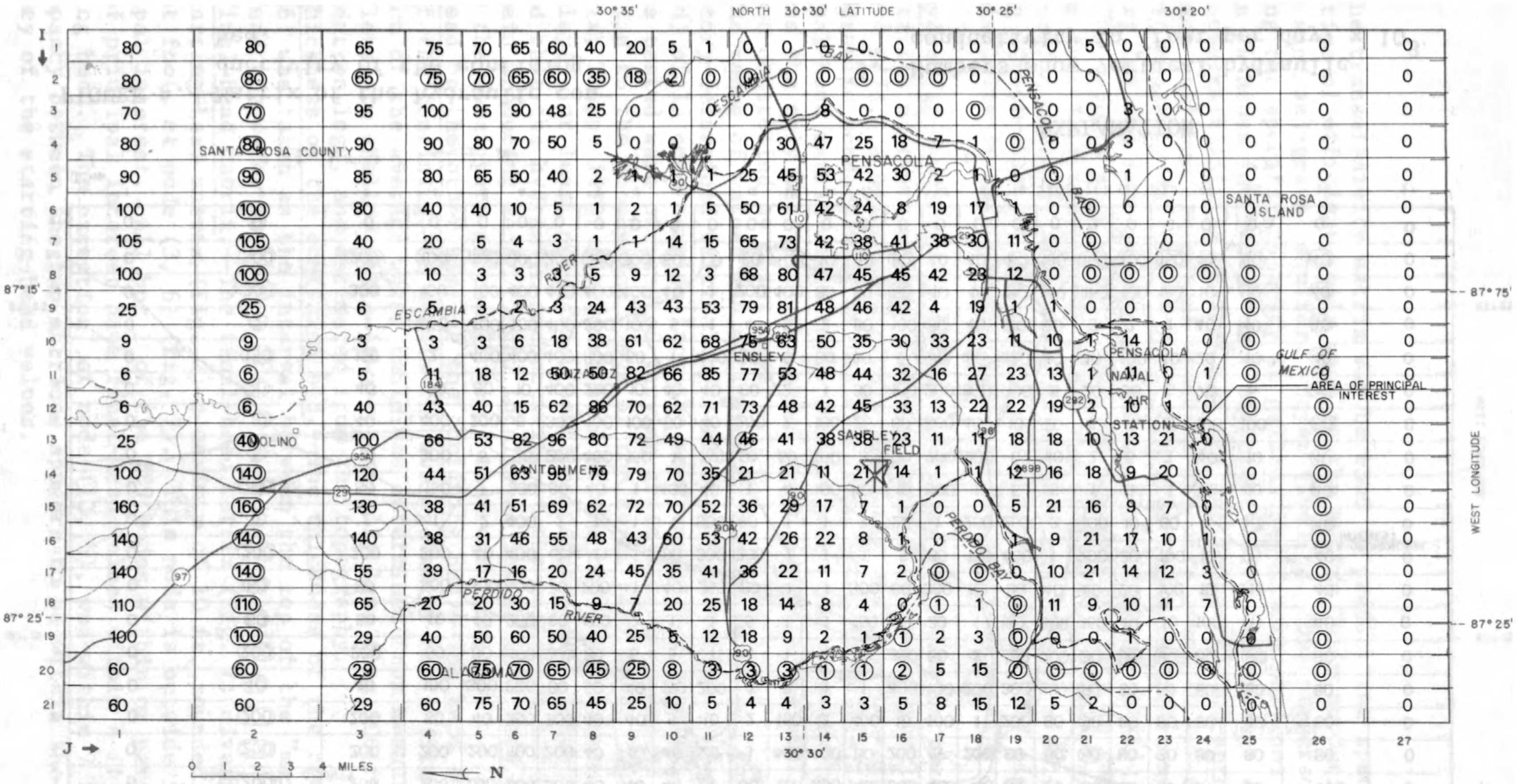


FIGURE 5.--Matrix of the average altitude of the water table.

EXPLANATION

29--Altitude of water table to nearest foot above sea level.

(0)-Constant-head boundary node.

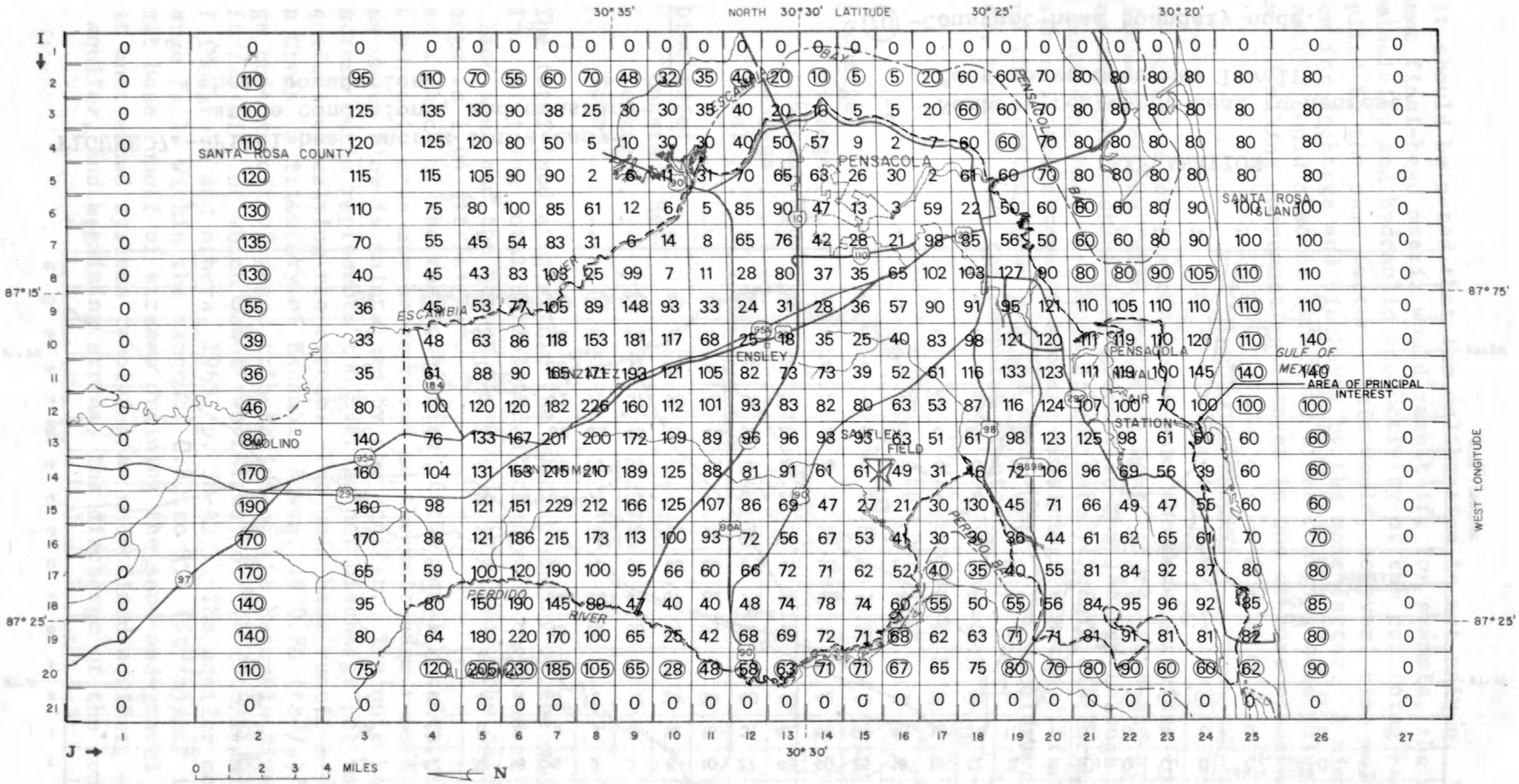


FIGURE 6.--Matrix of the thickness of the confining bed.

EXPLANATION

90--Numbers represent the thickness, in feet, of the interval between the top of the main producing zone of the sand-and-gravel aquifer and the water table.

(90) -Constant-head boundary node.

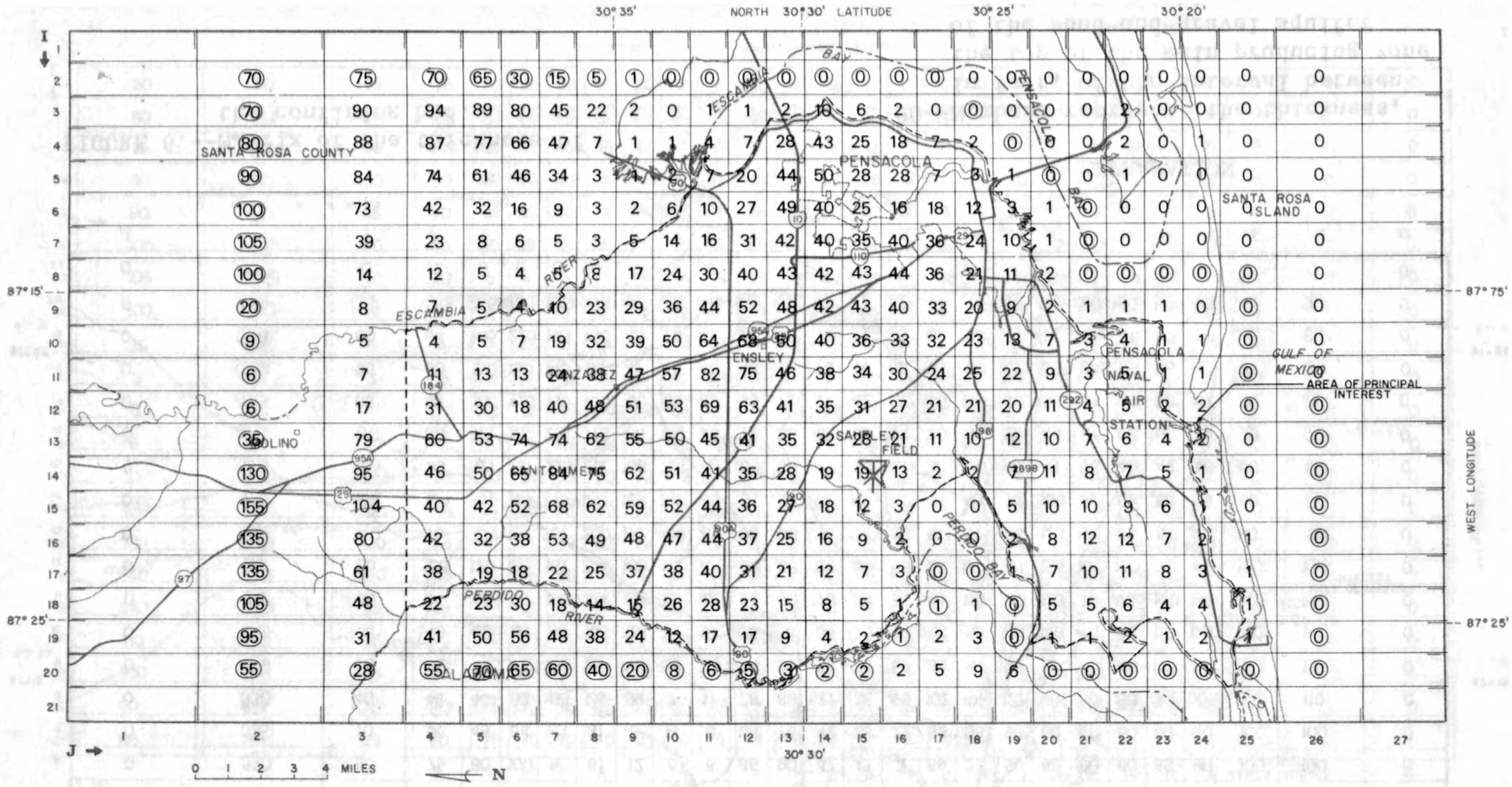


FIGURE 7.--Final head matrix for steady-state conditions, and constant-head boundaries.

EXPLANATION

7.--Numbers represent head to nearest foot above mean sea level.

(70) -Constant-head boundary node.

It should be noted that the calibration is not unique. That is, the same final-head matrix would result if, for example, the matrices of transmissivity and hydraulic conductivity of the confining bed were multiplied by the same factor. This would, however, also multiply the figures for recharge and discharge by the same factor. A similar final-head matrix could also be generated after changing some values in one matrix and making compensating changes in one or more other matrices.

HYDROLOGIC BUDGET

As stated under Basic Assumptions, the model provides for recharge and discharge of the "main producing zone" of the sand-and-gravel aquifer through constant-head boundaries and leakage through the overlying confining bed. Recharge approximately equals discharge; the small difference is the change in storage resulting from the difference between the starting head and the final head. The cumulative mass balance, rounded from the computer printout, is:

	Million cubic feet per year	Percent
Recharge:		
Storage	0.742	0.005
Constant Head	1,000	7.1
Leakage	13,100	92.9
Total	14,100	100.0
Discharge:		
Constant Head	1,400	9.9
Leakage	12,700	90.1
Total	14,100	100.0

The total land area within the outer boundary of the model is about 431 mi^2. Dividing total calculated discharge by the product of the total land area and the number of seconds in a year, the calculated discharge is 1.04 $(ft^3/s)/mi^2$.

As a check of the reasonableness of the model results, the discharge per unit area may be compared to the unit base runoff of typical streams whose flow is maintained by the aquifer. The unit base runoff of a stream basin represents the average net discharge per unit area of the aquifers underlying the stream. The unit base runoff of Pine Barren Creek, a tributary of Escambia River, is 0.80 $(ft^3/s)/mi^2$. The average unit runoff of gaged tributaries of the Escambia River is 2.1 $(ft^3/s)/mi^2$, of which about two thirds, or 1.4 $(ft^3/s)/mi^2$ is base runoff (Musgrove and others, 1965, p. 38-45). The aquifer model's discharge falls within the range of 0.80 to 1.4 $(ft^3/s)/mi^2$ indicated by the unit base runoff of streams draining the sand-and-gravel aquifer. In most unstressed systems involving an unconfined aquifer, a leaky confined aquifer, and a gaining stream, the discharge of the confined aquifer would be less than the unit base runoff of the stream because the unconfined aquifer would supply part, and perhaps most, of the streamflow. In the model of the sand-and-gravel aquifer, however, the confining bed is defined so as to comprise the unconfined part of the aquifer (not including perched zones). Under these conditions, the discharge of the "main producing zone" plus the undetermined discharge of perched zones should equal the base runoff of streams. Since the discharge from perched zones is probably small compared to discharge from below the true water table, the calculated discharge from the "main producing zone" may be assumed to fall in the lower range of unit base runoff of streams.

The area of principal interest contains about 237 mi^2. Multiplying this times the model's unit discharge of 1.04 $(ft^3/s)/mi^2$ gives 246 ft^3/s or 159 Mgal/d as the calculated natural discharge of the aquifer within the principal area of interest under the conditions represented by the model. However, recalibration and other modifications of the preliminary model will produce different values for the calculated discharge.

The discharge per unit area from the model output is substantially higher than that estimated by Jacob and Cooper (1940, p. 51-54). They estimated that "the normal rate of recharge into the lower sands is of the order of magnitude of 40,000 gallons a day per square mile" [0.06 $(ft^3/s)/mi^2$] for southern Escambia County from the gradient of the potentiometric surface and transmissivity.

Explanations for the discrepancy between the model-derived discharge and Jacob and Cooper's estimate are: (1) Their estimate may be low because the gradient of the potentiometric surface was measured at an angle to the true direction of flow, owing to lack of sufficient water-level control; (2) their estimate included only the net increase in ground-water flow downgradient and did not take into account the base runoff of streams; and (3) their estimate included only the "lower sands," whereas in the model the unconfined part of the aquifer is included in the confining bed, as defined.

FURTHER DEVELOPMENT OF THE MODEL

After the model was calibrated as described, stress representing historic pumping was applied. The Trescott-Pinder model simulates pumping by assuming wells at nodes in areas of pumping. A well node may represent more than one real well in the rectangle represented by the node, or the pumpage of one real well may be distributed among as many as four nodes, if the well were located between them. When pumping was applied to the model in the version described in this report, simulated drawdowns generally seemed to be less than those observed. This was difficult to check, however, because of the large size of the rectangles represented by the nodes and the fact that most of the pumping wells and observation wells are not located at the nodes.

A new grid, 33 x 41 nodes (not shown) was prepared, with nodes in the old grid subdivided into four in pumping areas. Values derived from the matrices of the old version were applied to the new, and the model recalibrated. J. F. Daniel and J. V. Brahana (U.S. Geol. Survey, written commun., June 1976) and S. P. Larson (U.S. Geol. Survey, written commun., August 1976) questioned aspects of the model and suggested modifications and tests. These included:

1. Further checking of the reasonableness of the range of values used for hydraulic conductivity of the confining bed and of the large variation (from node to node) in the matrix (fig. 4).

A method of estimating the hydraulic conductivity of the confining bed was tried. This method involved assigning values (based in part on a few core analyses) to each recognizable lithologic layer in the confining bed at the site of a logged well. The vertical conductivity of a series of superimposed layers, each having a different hydraulic conductivity and thickness, may be expressed by:

$$k_t = \frac{b_t}{\frac{b_1}{k_1} + \frac{b_2}{k_2} + \frac{b_3}{k_3} \cdots + \frac{b_n}{k_n}}$$

where k_t = total vertical conductivity (L/T, where L denotes length and T time, in appropriate units),

$k_1, k_2, k_3 \ldots k_n$ = vertical hydraulic conductivity of each layer (L/T),

b_t = total thickness (L),

and $b_1, b_2, b_3 \ldots b_n$ = thickness of each layer (L).

Preliminary values of k_t ranged from 0.2 to 4,030 x 10^{-3} ft/d. The values were tested by substitution into Darcy's Law in the form:

$$q = (dh/dl)k_t$$

in which q = leakage (L/T) and dh/dl = change in head per unit length (L/L). When k_t is expressed in feet per day, the right-hand side of the equation may be multiplied by 4,380 to convert to inches per year. The term dh/dl is derived by dividing the difference between the water level in the well and the water table by the thickness of the confining bed. Head is lost through the confining bed. so the change is negative, canceling the minus sign.

This method is most sensitive to the hydraulic conductivity of the least conductive bed. The higher values of k_t gave unrealistically high values of leakage. Data were inadequate for full application so efforts were abandoned.

Setting q equal to 14.1 in/yr, equivalent to the average unit base flow of streams in the area, and substituting in Darcy's Law gives values of k_t ranging from 3.3 to 480 x 10^{-3} ft/d. Setting q equal to 25 in/yr gives a maximum value of k_t of about 850 x 10^{-3} ft/d for the confining beds in the wells and test holes studied. Twenty-five in/yr equals average precipitation minus evapotranspiration at Pensacola (Musgrove and others, 1965, p. 25), and ordinarily should be the upper limit to leakage in the area of investigation. Exceptions might include areas where bodies of surface water provide recharge, or perhaps where k_t divided by thickness is much higher than it is immediately upgradient, so that water originating as precipitation over a wide area is concentrated as leakage in a small area.

Inasmuch as q at any point may be less than the average q over the larger area, the lowest value of k_t (3.3 x 10^{-3} ft/d) found by substituting an average value of q into Darcy's Law is probably not the lowest k_t in the area. However, present data are insufficient to establish the lowest value of k_t.

Abrupt lateral changes in lithology are characteristic of the upper part of the sand-and-gravel aquifer (Musgrove and others, 1965, p. 13-16, fig. 8). These changes substantiate the reasonableness of abrupt changes in the matrix of hydraulic conductivity of the confining bed (fig. 4) although the values shown are not controlled by data. The upper limit of the range of values used (400 x 10^{-3} ft/d) appears to be conservative, based on the preceding discussion. Data are insufficient to show whether the lower limit is as low as 0.1 x 10^{-3} ft/d. In view of the sensitivity of k_t to the hydraulic conductivity of the least permeable layer of a sequence of layers, coring and determination of the hydraulic conductivity of the least permeable clays would provide a better basis for estimating the lower limit of k_t.

2. A modification could be added to the model program so that the leakage at each node would be printed out for each pumping period as a test for reasonableness. This was done to the latest version of the model, and downward leakage was found to exceed 25 in/yr at 109 nodes within the approximately 720 making up the area of principal interest. These nodes must be checked for reasonableness of input values. A probable cause for some of these leakage values in the model is adjustment of input to raise the head locally to what may be only a perched water table.

3. The assumption of constant-head boundaries might cause the model to predict unrealistically large quantities of recharge through the constant-head boundaries if cones of depression intersect them. Constant-flux boundaries can be substituted on the north, east, and west edges of the area and a no-flux boundary on the south in a future run, and the results can be compared to those using the present boundaries.

4. The present assumption that the water table does not change with development may result in unrealistically high computed rates of leakage under conditions of heavy pumping. After the model has been recalibrated for conditions of no pumping without excessive leakage, it

can be run with historic pumping and the leakage checked again at each node for reasonableness. The model then can be run assuming that no additional leakage can be obtained (water table changes simultaneously with the head in the "main producing zone," or constant recharge at each node). The head distributions for the two runs can be compared with observation-well records. If neither assumption gives satisfactory results, it may be necessary to simulate the water-table zone with a multilayer model (Trescott, 1975; Trescott and Larson, 1976).

MONITORING OF QUALITY OF WATER IN THE SCENIC HILLS AREA

In 1973 the city of Pensacola placed its Scenic Hills Sewage Plant in operation. The plant, 10 mi north of the Pensacola Post Office and 3 mi northwest of the mouth of the Escambia River (fig. 1), is designed for spray disposal of secondary-treated effluent along two Gulf Power Co. powerline rights-of-way (fig. 8). The effluent is run into unlined lagoons from which, according to the design, it is to be pumped for spraying. The design capacity of the plant is 1,000,000 gal/d, but the load through mid-1974 was only 110,000 gal/d. Until mid-1976 the effluent was not of sufficient volume to require spray disposal--it infiltrated the sand-and-gravel aquifer underlying the lagoons. By fall 1976, however, the effluent had increased to about 230,000 gal/d and 100,000 to 200,000 gal was being sprayed four times a week.

The sewage plant is situated at the crest of a ridge, from which drainage is south and southeast to Thompson Bayou, a tributary of the Escambia River, and north to Clear Creek, a tributary of Governors Bayou, which drains into the Escambia River. Some drainage may run directly east or northeast to Governors Bayou and the Escambia River.

Under natural conditions, ground water moves roughly parallel to surface drainage to the Escambia River and its tributaries. Eastward movement of ground water is probably accentuated by a cone of depression around the industrial wells at the Gulf Power plant, the closest being Gulf Power well 3.

Table 1 shows chemical analyses of water from TH 21, 21A, 98A, 101, 101A, 102A, 102B, and Monitor well 99, the Scenic Hills Sewage Plant supply well, the Scenic Hills Sewage Plant effluent, the Scenic Hills Country Club well, the University of West Florida Well No. 2, Gulf Power Co. well 3, and from three surface-water sites.

Wells Used for Monitoring

Two monitor wells, numbers 98 and 99 (fig. 8), were constructed as part of the original plant design. U.S. Geological Survey test holes 20, 20A, 21, and 21A were drilled before construction of the sewage plant for the current investigation of the hydrology of the sand-and-gravel aquifer (Trapp, 1972, A30-36). (In the series of reports prepared for this investigation, Test Hole __ (a number) abbreviated TH__, refers to a U.S. Geological Survey test hole or test well drilled

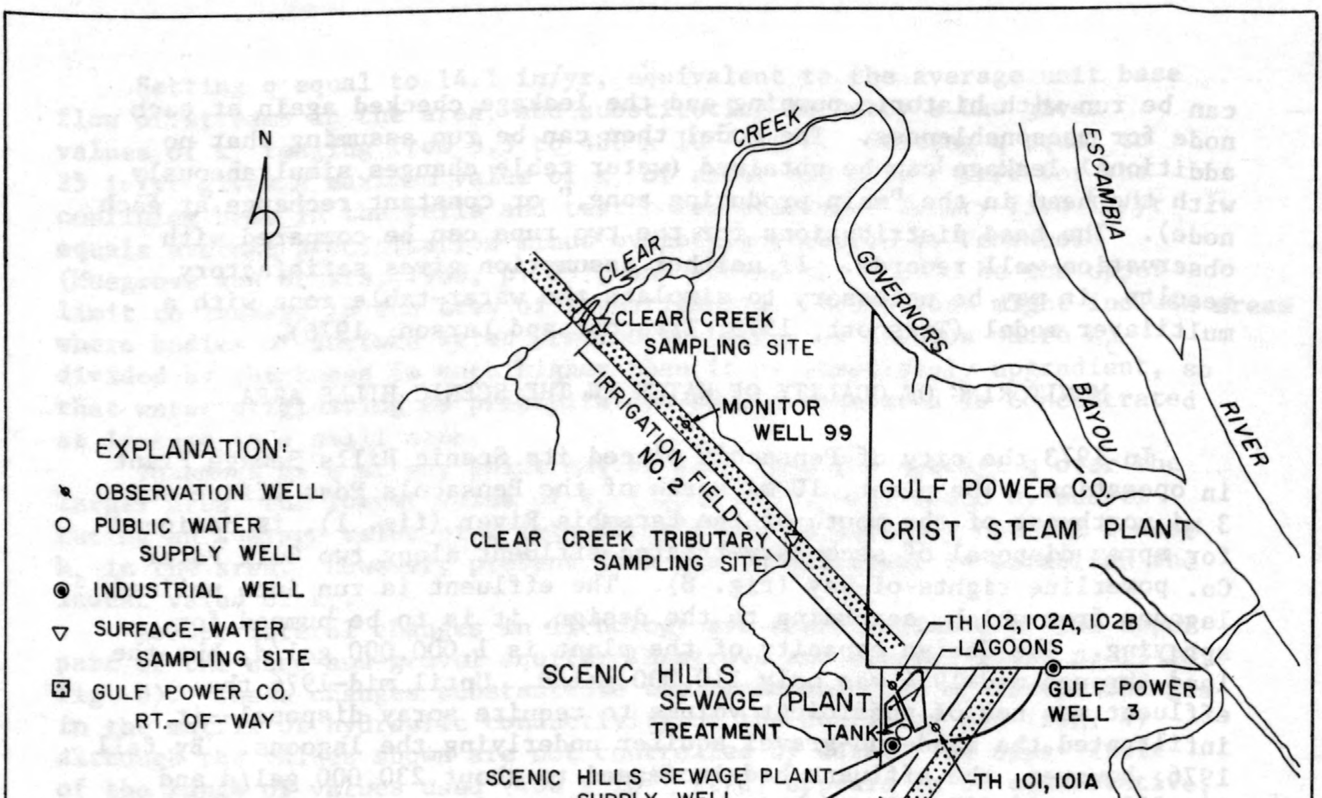


FIGURE 8.--Scenic Hills Sewage Plant and surrounding area.

TABLE 1.-- CHEMICAL ANALYSES OF WATERS FROM WELLS, TEST HOLES, AND OTHER SITES AROUND THE SCENIC HILLS SEWAGE PLANT.

STATION NUMBER	LOCAL IDENT-I-FIER	DATE OF SAMPLE	TEMPER-ATURE (DEG C)	PH (UNITS)	DIS-SOLVED SILICA (SIO2) (MG/L)	DIS-SOLVED CAL-CIUM (CA) (MG/L)	DIS-SOLVED MAG-NE-SIUM (MG) (MG/L)	DIS-SOLVED SODIUM (NA) (MG/L)	DIS-SOLVED PO-TAS-SIUM (K) (MG/L)
303236087131301	UNIV. W. FLA. WELL 2	71-11-17	21.0	4.9	--	--	--	--	--
		73-09-19	21.0	5.3	9.3	1.7	.4	2.9	.6
303240087135701	PENS. SCENIC HILLS C.C.	68-04-03	20.0	5.0	--	1.0	1.0	--	--
		71-11-30	20.0	5.8	--	--	--	--	--
303249087140801	USGS TH21 GREENBRIAR RD	72-04-06	23.0	5.0	8.6	1.5	.3	2.6	.3
303249087140802	USGS TH21A GREENBRIAR RD	72-04-05	28.0	5.5	4.8	2.0	.4	4.1	.4
303254087133600	THOMPSON BAYOU NEAR PENS	73-06-20	30.5	7.1	6.3	2.4	.7	3.9	.5
		73-09-19	21.5	5.9	7.0	--	--	--	--
		76-03-11	19.5	5.8	--	--	--	--	--
303313087140002	USGS TH98A	74-03-20	21.0	5.6	--	1.0	.1	5.1	.1
		74-05-23	21.6	5.6	--	--	--	--	--
		74-11-21	21.5	5.7	--	2.6	.2	2.1	.1
		76-03-12	23.0	4.9	--	--	--	--	--
		76-06-02	22.0	--	--	--	--	2.6	--
		76-08-04	23.5	5.3	--	--	--	2.7	--
303326087135601	PENS.S.H.SEWAGE SUPPLY	74-03-22	21.5	5.4	--	.5	.3	2.7	1
		74-07-23	21.0	5.3	--	--	--	--	--
		75-03-17	21.0	5.2	7.5	.5	.3	2.4	.2
		75-08-27	21.5	4.8	8.3	--	--	--	--
303327087135401	USGS TH101.S.H.NE GATE	74-03-21	21.5	5.4	--	.0	.1	4.3	.1
		75-08-28	21.0	5.0	6.7	--	--	--	--
		76-03-10	21.5	4.9	--	--	--	--	--
		76-06-03	21.0	--	--	--	--	2.9	--
		76-08-03	21.5	4.9	--	--	--	3.0	--
303327087135402	USGS TH101A.S.H. NE GATE	75-08-28	26.0	5.0	6.5	--	--	--	--
		75-12-22	27.0	5.4	--	--	--	--	--
		76-03-10	29.5	5.7	--	--	--	--	--
		76-06-03	27.5	--	--	--	--	14	--
		76-08-03	31.5	5.8	--	--	--	12	--
303327087135500	PENS.S.H.SEWAGE EFFLUENT	74-03-22	21.0	6.6	--	12	1.1	36	7.4
		74-07-23	30.0	6.6	--	--	--	--	--
		74-12-12	14.0	6.6	13	15	.5	36	7.0
		75-03-17	24.0	6.1	14	15	1.7	36	7.0
		75-08-27	30.0	6.4	15	--	--	--	--
		76-06-04	25.5	--	--	--	--	--	--
303331087135802	USGS TH102A S.H.N.LAGOON	74-07-24	22.0	5.6	9.1	1.0	.1	6.6	.2
		74-12-11	22.5	5.5	7.7	1.5	.2	2.2	.1
303331087135803	USGS TH102B S.H.N.LAGOON	74-08-01	22.0	5.7	6.0	7.3	.3	30	1.1
		75-08-28	23.0	5.2	--	--	--	--	--
		76-03-11	27.5	5.4	--	--	--	--	--

TABLE 1.-- CHEMICAL ANALYSES OF WATERS FROM WELLS, TEST HOLES, AND OTHER SITES AROUND THE SCENIC HILLS SEWAGE PLANT (CONTINUED).

STATION NUMBER	DATE OF SAMPLE	BICAR-BONATE (HCO3) (MG/L)	DIS-SOLVED SULFATE (SO4) (MG/L)	DIS-SOLVED CHLO-RIDE (CL) (MG/L)	DIS-SOLVED FLUO-RIDE (F) (MG/L)	TOTAL NITRATE (N) (MG/L)	TOTAL NITRITE (N) (MG/L)	TOTAL AMMONIA NITRO-GEN (N) (MG/L)	TOTAL ORGANIC NITRO-GEN (N) (MG/L)	TOTAL ORTHO PHOS-PHORUS (P) (MG/L)	TOTAL PHOS-PHORUS (P) (MG/L)
303236087131301	71-11-17	3	--	4.8	--	.11	--	--	--	--	--
	73-09-19	4	1.2	3.5	.0	.99	.01	.01	.01	.00	.00
303240087135701	68-04-03	4	<1.0	6.8	.0	--	--	--	--	--	--
	71-11-30	6	--	4.5	--	.38	<.01	--	--	--	--
303249087140801	72-04-06	5	.8	3.0	.0	.04	.01	.09	.16	.00	.00
303249087140802	72-04-05	6	1.2	5.5	.1	.03	.00	.08	.37	.00	.00
303254087133600	73-06-20	6	1.2	4.0	.1	.10	.01	.03	.43	.00	.02
	73-09-19	6	.4	4.7	--	.27	.00	.01	.15	.01	.01
	76-03-11	8	3.0	5.9	.2	.17	.00	--	--	--	--
303313087140002	74-03-20	6	--	3.0	--	.07	.03	.05	.47	.05	.06
	74-05-23	3	--	--	--	--	--	--	--	--	--
	74-11-21	4	.5	2.8	.4	.06	.01	.03	.00	.01	.01
	76-03-12	2	1.2	4.9	.3	.05	.00	--	--	--	--
	76-06-02	--	.8	3.9	--	.08	.00	.01	.00	.00	.01
	76-08-04	4	.0	3.8	--	.06	.01	.04	.00	--	.01
303326087135601	74-03-22	3	--	3.4	--	.06	.00	.01	.02	.00	.00
	74-07-23	3	1.4	4.2	--	.11	.00	.00	.00	.00	.03
	75-03-17	2	.0	3.0	.0	.08	.01	.02	.00	.00	.00
	75-08-27	1	1.4	3.6	.1	.12	.00	.02	.00	.00	.05
303327087135401	74-03-21	4	--	3.2	--	.09	.00	.04	.19	.00	.01
	75-08-28	2	.6	3.0	.1	.15	.00	.02	.01	.00	.03
	76-03-10	2	.2	4.3	.0	.07	.00	--	--	--	--
	76-06-03	--	.5	4.1	--	.15	.00	.01	.14	--	.01
	76-08-03	4	.8	3.9	--	.12	.00	.02	.19	--	.00
303327087135402	75-08-28	4	1.0	19	.1	3.2	.00	.02	.11	.00	.03
	75-12-22	12	1.2	13	--	3.8	.02	.01	.17	.00	.01
	76-03-10	10	4.5	14	.1	2.1	.00	--	--	--	--
	76-06-03	--	.8	16	--	3.1	.00	.01	.18	--	.01
	76-08-03	16	1.4	14	--	2.9	.01	.02	.24	--	.02
303327087135500	74-03-22	20	--	21	--	9.0	.01	.11	1.7	7.5	8.5
	74-07-23	30	24	26	--	7.7	.08	.27	1.5	14	14
	74-12-12	32	23	25	1.6	12	.01	.10	1.2	5.3	5.5
	75-03-17	18	20	23	2.9	11	.02	.19	1.4	8.0	8.0
	75-08-27	16	24	24	2.1	16	.02	.02	1.3	9.5	10
	76-06-04	--	14	18	--	9.5	.04	.20	1.3	8.0	8.0
303331087135802	74-07-24	6	3.2	4.8	.1	--	--	--	--	--	--
	74-12-11	4	1.2	3.3	.2	.11	.01	.12	.10	.11	.11
303331087135803	74-08-01	22	19	27	.2	.02	.02	1.3	.10	.01	.04
	75-03-28	10	--	--	--	1.1	.00	1.2	.12	.00	.03
	76-03-11	10	30	27	.1	2.5	.00	--	--	--	--

TABLE 1.-- CHEMICAL ANALYSES OF WATERS FROM WELLS, TEST HOLES, AND OTHER SITES AROUND THE SCENIC HILLS SEWAGE PLANT (CONTINUED).

STATION NUMBER	DATE OF SAMPLE	TOTAL ORGANIC CARBON (C) (MG/L)	TOTAL IN-ORGANIC CARBON (C) (MG/L)	BIO-CHEM-ICAL OXYGEN DEMAND 5 DAY (MG/L)	CHEM-ICAL OXYGEN DEMAND (HIGH LEVEL) (MG/L)	DIS-SOLVED OXYGEN (MG/L)	CARBON DIOXIDE (CO2) (MG/L)	COLOR (PLAT-INUM-COBALT UNITS)	TUR-BID-ITY (JTU)	HARD-NESS (CA,MG) (MG/L)	NON-CAR-BONATE HARD-NESS (MG/L)
303236087131301	71-11-17	--	--	--	--	--	18	--	--	4	--
	73-09-19	.0	4.0	.3	--	--	17	5	1	6	2
303240087135701	68-04-03	--	--	--	--	--	--	<5	--	4	0
	71-11-30	--	--	--	--	--	6.3	--	--	6	--
303249087140801	72-04-06	.0	3.0	--	--	--	15	0	20	5	2
303249087140802	72-04-05	.0	3.0	--	--	--	17	5	1	6	3
303254087133600	73-06-20	5.5	3.0	2.6	8	8.5	3.0	50	10	9	4
	73-09-19	1.5	3.0	.1	33	--	19	--	8	--	--
	76-03-11	1.0	--	.8	--	--	10	--	--	--	--
303313087140002	74-03-20	--	--	--	--	--	14	--	48	3	0
	74-05-23	.1	--	--	--	--	15	--	--	--	--
	74-11-21	4.0	--	--	--	--	15	--	8	7	4
	76-03-12	.0	--	.3	--	--	15	--	--	--	--
	76-06-02	.0	--	.2	4	--	--	--	--	--	--
	76-08-04	.0	--	--	6	--	18	--	--	--	--
303326087135601	74-03-22	--	--	--	--	--	11	--	1	2	0
	74-07-23	.0	3.0	.2	0	--	16	--	0	--	--
	75-03-17	1.0	--	.0	17	--	22	0	2	3	1
	75-08-27	.0	--	--	6	--	20	--	1	--	--
303327087135401	74-03-21	.0	3.0	--	--	--	16	--	4	0	0
	75-08-28	.0	--	--	6	--	24	--	1	--	--
	76-03-10	4.0	--	.0	--	--	16	--	--	--	--
	76-06-03	.0	--	.2	12	--	--	--	--	--	--
	76-08-03	1.0	--	.0	16	--	23	--	--	--	--
303327087135402	75-08-28	.0	--	--	1	--	96	--	8	--	--
	75-12-22	.0	--	--	--	--	50	--	6	--	--
	76-03-10	3.0	--	.0	--	--	44	--	--	--	--
	76-06-03	.0	--	.2	6	--	--	--	--	--	--
	76-08-03	2.0	--	.4	16	--	34	--	--	--	--
303327087135500	74-03-22	--	--	--	--	--	14	--	6	35	19
	74-07-23	4.0	5.0	.4	29	--	26	--	--	--	--
	74-12-12	17	6.0	4.0	32	--	18	5	7	40	13
	75-03-17	6.0	5.0	3.4	32	--	25	20	5	47	32
	75-08-27	4.0	--	--	5	--	16	--	6	--	--
	76-06-04	3.0	--	--	--	--	--	--	8	--	--
303331087135802	74-07-24	--	--	.2	0	--	19	2	--	3	0
	74-12-11	3.0	--	2.1	2	--	18	7	11	5	1
303331087135803	74-08-01	9.0	5.0	.2	2	--	--	2	--	20	1
	75-08-28	.0	--	--	1	--	68	--	--	--	--
	76-03-11	3.0	--	.6	--	--	49	--	--	--	--

TABLE 1.-- CHEMICAL ANALYSES OF WATERS FROM WELLS, TEST HOLES, AND OTHER SITES AROUND THE SCENIC HILLS SEWAGE PLANT (CONTINUED).

STATION NUMBER	DATE OF SAMPLE	SPECIFIC CONDUCTANCE (MICROMHOS)	DISSOLVED SOLIDS (RESIDUE AT 180 C) (MG/L)	DISSOLVED SOLIDS (SUM OF CONSTITUENTS) (MG/L)	DISSOLVED ALUMINUM (AL) (UG/L)	DISSOLVED ARSENIC (AS) (UG/L)	TOTAL ARSENIC (AS) (UG/L)	DISSOLVED BORON (B) (UG/L)	TOTAL BORON (B) (UG/L)	TOTAL CADMIUM (CD) (UG/L)	HEXAVALENT CHROMIUM (CR6) (UG/L)
303236087131301	71-11-17	24	--	--	--	--	--	--	--	--	--
	73-09-19	28	31	22	50	9	--	--	--	--	0
303240087135701	68-04-03	--	--	--	--	--	--	--	--	--	--
	71-11-30	23	--	--	--	--	--	--	--	--	--
303249087140801	72-04-06	22	19	20	--	0	--	--	--	--	1
303249087140802	72-04-05	37	20	22	--	0	--	--	--	--	1
303254087133600	73-06-20	39	26	25	--	8	9	--	15	1	0
	73-09-19	33	--	--	--	--	--	--	--	--	--
	76-03-11	38	25	--	--	--	0	0	--	--	--
303313087140002	74-03-20	26	--	--	--	--	0	0	--	0	--
	74-05-23	--	--	--	--	--	--	--	--	--	--
	74-11-21	20	14	--	--	--	--	0	--	--	--
	76-03-12	55	11	--	--	--	0	0	--	--	--
	76-06-02	18	--	--	--	--	--	--	--	--	--
	76-08-04	20	--	--	--	--	--	--	--	--	--
303326087135601	74-03-22	24	--	--	--	--	2	20	--		--
	74-07-23	19	--	--	--	--	--	--	--	--	--
	75-03-17	23	22	15	--	--	0	0	--	--	--
	75-08-27	22	16	--	--	--	--	--	--	--	--
303327087135401	74-03-21	25	--	--	--	--	0	5	--	3	--
	75-08-28	32	16	--	--	--	0	--	--	0	--
	76-03-10	22	16	--	--	--	0	0	--	--	--
	76-06-03	20	--	--	--	--	--	--	--	--	--
	76-08-03	21	--	--	--	--	--	--	--	--	--
303327087135402	75-08-28	120	72	--	--	--	0	--	--	2	--
	75-12-22	--	--	--	--	--	--	50	--	--	--
	76-03-10	100	52	--	--	--	0	380	--	--	--
	76-06-03	96	--	--	--	--	--	--	--	--	--
	76-08-03	95	--	--	--	--	--	--	--	--	--
303327087135500	74-03-22	250	--	--	--	--	0	600	--	1	--
	74-07-23	326	--	--	--	--	--	--	--	--	--
	74-12-12	200	168	137	--	2	2	240	--	0	0
	75-03-17	328	232	131	30	1	--	--	--	--	0
	75-08-27	360	32	--	--	--	1	--	--	0	--
	76-06-04	--	--	--	--	--	1	--	--	0	--
303331087135802	74-07-24	35	21	28	--	2	3	20	--	1	0
	74-12-11	22	16	19	--	0	1	2	--	1	1
303331087135803	74-08-01	181	107	103	--	0	1	230	--	2	0
	75-08-28	200	--	--	--	--	0	--	--	1	--
	76-03-11	200	116	--	--	--	0	110	--	--	--

TABLE 1.-- CHEMICAL ANALYSES OF WATERS FROM WELLS, TEST HOLES, AND OTHER SITES AROUND THE SCENIC HILLS SEWAGE PLANT (CONTINUED).

STATION NUMBER	DATE OF SAMPLE	TOTAL CHRO-MIUM (CR) (UG/L)	TOTAL COBALT (CO) (UG/L)	DIS-SOLVED COPPER (CU) (UG/L)	TOTAL COPPER (CU) (UG/L)	DIS-SOLVED IRON (FE) (UG/L)	TOTAL IRON (FE) (UG/L)	DIS-SOLVED LEAD (PB) (UG/L)	TOTAL LEAD (PB) (UG/L)	TOTAL LITHIUM (LI) (UG/L)	DIS-SOLVED MAN-GANESE (MN) (UG/L)
303236087131301	71-11-17	--	--	--	--	--	20	--	--	--	--
	73-09-19	--	--	10	--	10	--	4	--	--	10
303240087135701	68-04-03	--	--	--	--	20	--	--	--	--	--
	71-11-30	--	--	--	--	--	0	--	--	--	--
303249087140801	72-04-06	--	--	0	--	50	--	0	--	--	10
303249087140802	72-04-05	--	--	0	--	440	--	5	--	--	20
303254087133600	73-06-20	0	0	--	0	--	990	--	6	0	--
	73-09-19	--	--	--	--	--	--	--	--	--	--
	76-03-11	--	--	--	--	180	--	10	--	--	20
303313087140002	74-03-20	--	--	--	--	0	--	0	--	--	0
	74-05-23	--	--	--	--	--	--	--	--	--	--
	74-11-21	--	--	18	--	30	--	--	--	--	--
	76-03-12	--	--	--	--	40	--	70	--	--	10
	76-06-02	--	--	--	--	--	130	--	--	--	--
	76-08-04	--	--	--	--	--	250	--	--	--	--
303326087135601	74-03-22	--	--	2	--	30	100	3	8	--	0
	74-07-23	--	--	--	--	--	--	--	--	--	--
	75-03-17	--	--	--	--	20	--	11	--	--	0
	75-08-27	--	--	--	--	0	--	--	--	--	--
303327087135401	74-03-21	--	--	--	--	10	--	0	--	--	0
	75-08-28	10	0	--	4	--	450	--	40	4	--
	76-03-10	--	--	--	--	20	--	11	--	--	0
	76-06-03	--	--	--	--	--	0	--	--	--	--
	76-08-03	--	--	--	--	--	10	--	--	--	--
303327087135402	75-08-28	<10	0	--	250	--	210	--	50	4	--
	75-12-22	--	--	--	--	--	--	--	--	--	--
	76-03-10	--	--	--	--	130	--	40	--	--	10
	76-06-03	--	--	--	--	--	500	--	--	--	--
	76-08-03	--	--	--	--	--	870	--	--	--	--
303327087135500	74-03-22	--	--	--	--	30	--	6	--	--	17
	74-07-23	--	--	--	--	--	--	--	--	--	--
	74-12-12	--	--	15	--	10	90	22	34	--	10
	75-03-17	--	--	8	--	50	--	7	--	--	30
	75-08-27	<10	0	--	13	--	50	--	26	5	--
	76-06-04	10	0	--	12	--	220	--	18	0	--
303331087135802	74-07-24	--	--	1	--	0	8900	3	6	--	13
	74-12-11	--	--	63	--	70	930	51	200	--	0
303331087135803	74-08-01	--	--	1	--	220	1100	4	7	--	50
	75-08-28	10	0	--	3	--	130	--	18	5	--
	76-03-11	--	--	--	--	80	--	23	--	--	10

TABLE 1.-- CHEMICAL ANALYSES OF WATERS FROM WELLS, TEST HOLES, AND OTHER SITES AROUND THE SCENIC HILLS SEWAGE PLANT (CONTINUED).

STATION NUMBER	DATE OF SAMPLE	TOTAL MAN-GANESE (MN) (UG/L)	TOTAL MERCURY (HG) (UG/L)	TOTAL NICKEL (NI) (UG/L)	TOTAL SELE-NIUM (SE) (UG/L)	DIS-SOLVED STRON-TIUM (SR) (UG/L)	DIS-SOLVED ZINC (ZN) (UG/L)	TOTAL ZINC (ZN) (UG/L)	CON-FIRMED COLI-FORM (MPN)	FECAL COLI-FORM (MPN)
303236087131301	71-11-17	--	--	--	--	--	--	--	--	--
	73-09-19	--	--	--	--	--	110	--	--	--
303240087135701	68-04-03	--	--	--	--	--	--	--	--	--
	71-11-30	--	--	--	--	--	--	--	--	--
303249087140801	72-04-06	--	--	--	--	--	690	--	--	--
303249087140802	72-04-05	--	--	--	--	--	520	--	--	--
303254087133600	73-06-20	40	.0	0	--	40	--	100	--	--
	73-09-19	--	--	--	--	--	--	--	--	--
	76-03-11	--	--	--	--	--	10	--	540	130
303313087140002	74-03-20	--	.1	--	--	--	--	--	--	--
	74-05-23	--	--	--	--	--	--	--	--	--
	74-11-21	--	--	--	--	--	30	--	--	--
	76-03-12	--	--	--	--	--	150	--	<2	<2
	76-06-02	--	--	--	--	--	--	--	--	<2
	76-08-04	--	--	--	--	--	--	--	--	<2
303326087135601	74-03-22	30	.2	8	--	--	240	--	--	--
	74-07-23	--	--	--	--	--	--	--	--	--
	75-03-17	--	--	--	--	200	20	--	--	--
	75-08-27	--	--	--	--	--	--	--	--	--
303327087135401	74-03-21	--	.1	--	--	--	--	--	--	--
	75-08-28	3	.1	0	0	--	--	50	--	--
	76-03-10	--	--	--	--	--	20	--	14	5
	76-06-03	--	--	--	--	--	--	--	--	<2
	76-08-03	--	--	--	--	--	--	--	<2	<2
303327087135402	75-08-28	3	.3	4	0	--	--	200	--	--
	75-12-22	--	--	--	--	--	--	--	<2	<2
	76-03-10	--	--	--	--	--	1100	--	5	<2
	76-06-03	--	--	--	--	--	--	--	--	<2
	76-08-03	--	--	--	--	--	--	--	23	<2
303327087135500	74-03-22	--	.1	--	--	--	--	--	--	--
	74-07-23	--	--	--	--	--	--	--	--	--
	74-12-12	19	.1	0	--	30	80	--	--	--
	75-03-17	--	--	--	--	2400	80	--	--	--
	75-08-27	10	.1	0	0	--	--	90	--	--
	76-06-04	10	.0	5	0	--	--	60	--	--
303331087135802	74-07-24	50	.1	5	--	60	70	--	--	--
	74-12-11	24	.0	6	--	0	260	--	--	--
303331087135803	74-08-01	37	.2	5	--	60	1000	--	--	--
	75-08-28	3	.3	0	1	--	--	80	--	--
	76-03-11	--	--	--	--	--	230	--	<2	<2

TABLE 1.-- CHEMICAL ANALYSES OF WATERS FROM WELLS, TEST HOLES, AND OTHER SITES AROUND THE SCENIC HILLS SEWAGE PLANT (CONTINUED).

STATION NUMBER	LOCAL IDENT-I-FIER	DATE OF SAMPLE	TEMPER-ATURE (DEG C)	PH (UNITS)	DIS-SOLVED SILICA (SIO2) (MG/L)	DIS-SOLVED CAL-CIUM (CA) (MG/L)	DIS-SOLVED MAG-NE-SIUM (MG) (MG/L)	DIS-SOLVED SODIUM (NA) (MG/L)	DIS-SOLVED PO-TAS-SIUM (K) (MG/L)
303331087135803 USGS TH102B S.H.N.LAGOON		76-06-02	23.0	--	--	--	--	32	--
		76-08-03	23.5	5.4	--	--	--	33	--
303338087132801 GULF POWER WELL 3		71-12-07	21.5	5.2	--	--	--	--	--
		73-09-20	21.5	5.7	8.8	1.7	.4	2.2	.6
		74-04-17	21.0	5.6	--	--	--	--	--
		75-05-22	22.0	4.9	8.4	.6	.3	2.5	.3
		75-08-28	22.0	5.1	8.4	--	--	--	--
303342087140400 CLEAR CREEK TRIB.NR.PENS		73-09-19	21.5	5.1	4.5	--	--	--	--
		74-03-21	17.5	5.1	--	1.5	.5	6.7	.2
		74-06-19	25.7	--	--	--	--	--	--
		74-11-22	16.0	5.9	--	1.5	.4	9.8	.1
		75-02-13	16.0	5.7	--	1.1	.5	7.9	.1
		75-08-28	24.0	5.4	4.2	--	--	--	--
		75-12-22	9.0	5.2	--	--	--	--	--
		76-03-11	17.0	5.2	--	--	--	--	--
		76-06-02	22.0	4.0	--	--	--	4.2	--
		76-08-04	24.5	5.4	--	--	--	5.6	--
303348087141001 PENS.S.H.SEWAGE 99 N.MON		74-03-21	21.0	4.9	--	.5	.3	3.2	.1
		74-06-19	20.0	--	--	--	--	--	--
		74-11-22	22.5	5.0	--	--	--	--	--
		75-02-13	21.0	4.9	--	.7	.2	2.8	.1
		75-08-28	20.5	4.6	5.6	--	--	--	--
		76-03-11	20.5	4.2	--	--	--	--	--
		76-06-02	20.0	--	--	--	--	3.5	--
		76-08-04	20.5	4.9	--	--	--	3.6	--
303402087140100 CLEAR CREEK NR.PENSACOLA		73-06-20	30.5	7.0	3.3	1.7	.8	4.2	.6

TABLE 1.-- CHEMICAL ANALYSES OF WATERS FROM WELLS, TEST HOLES, AND OTHER SITES AROUND THE SCENIC HILLS SEWAGE PLANT (CONTINUED).

STATION NUMBER	DATE OF SAMPLE	BICAR-BONATE (HCO3) (MG/L)	DIS-SOLVED SULFATE (SO4) (MG/L)	DIS-SOLVED CHLO-RIDE (CL) (MG/L)	DIS-SOLVED FLUO-RIDE (F) (MG/L)	TOTAL NITRATE (N) (MG/L)	TOTAL NITRITE (N) (MG/L)	TOTAL AMMONIA NITRO-GEN (N) (MG/L)	TOTAL ORGANIC NITRO-GEN (N) (MG/L)	TOTAL ORTHO PHOS-PHORUS (P) (MG/L)	TOTAL PHOS-PHORUS (P) (MG/L)
303331087135803	76-06-02	--	26	26	--	3.4	.00	1.2	.00	.00	.01
	76-08-03	12	33	26	--	.71	.00	1.3	.07	--	.01
303338087132801	71-12-07	3	--	4.0	--	.05	<.01	--	--	--	--
	73-09-20	4	.9	3.2	.0	.02	.01	.02	.05	.00	.02
	74-04-17	2	2.4	4.0	--	.07	.00	.04	.07	.00	.00
	75-05-22	1	.1	3.5	.0	.21	.01	.00	.05	.00	.00
	75-08-28	2	1.4	6.3	.1	.24	.00	.02	.00	.02	.02
303342087140400	73-09-19	1	.4	6.0	--	.02	.00	.03	.11	.00	.00
	74-03-21	2	--	7.8	--	.45	.00	.02	.51	.01	.02
	74-06-19	--	1.5	13	--	1.7	.01	.06	.49	.01	.02
	74-11-22	2	4.3	13	.2	.76	.00	.03	.14	.00	.01
	75-02-13	4	3.6	10	.1	.42	.00	.01	.12	--	.01
	75-08-28	2	4.0	5.1	.1	.23	.00	.03	.26	.00	.02
	75-12-22	10	3.6	7.7	--	.23	.02	.02	.14	.00	.01
	76-03-11	1	2.0	6.9	.1	.09	.00	--	--	--	--
	76-06-02	0	3.7	5.9	--	.08	.00	.01	.09	.00	.01
	76-08-04	3	3.4	6.3	--	.11	.01	.04	.16	--	.01
303348087141001	74-03-21	3	--	4.7	--	.01	.02	.03	.01	.01	.01
	74-06-19	--	.3	5.0	--	.01	.00	.05	.27	.00	.01
	74-11-22	2	1.5	4.9	.1	.01	.00	.02	.02	.00	.00
	75-02-13	2	.6	4.6	.0	.02	.00	.00	.03	.00	.00
	75-08-28	1	.7	4.6	.1	.08	.00	.02	.02	.00	.03
	76-03-11	0	.2	5.8	.0	.02	.00	--	--	--	--
	76-06-02	--	.8	5.4	--	.04	.00	01	.00	--	.01
	76-08-04	2	.8	5.1	--	.04	.00	03	.00	--	.01
303402087140100	73-06-20	4	2.4	6.5	.1	.03	.00	.01	.32	.00	.01

TABLE 1.-- CHEMICAL ANALYSES OF WATERS FROM WELLS, TEST HOLES, AND OTHER SITES AROUND THE SCENIC HILLS SEWAGE PLANT (CONTINUED).

STATION NUMBER	DATE OF SAMPLE	TOTAL ORGANIC CARBON (C) (MG/L)	TOTAL IN-ORGANIC CARBON (C) (MG/L)	BIO-CHEM-ICAL OXYGEN DEMAND 5 DAY (MG/L)	CHEM-ICAL OXYGEN DEMAND (HIGH LEVEL) (MG/L)	DIS-SOLVED OXYGEN (MG/L)	CARBON DIOXIDE (CO2) (MG/L)	COLOR (PLAT-INUM-COBALT UNITS)	TUR-BID-ITY (JTU)	HARD-NESS (CA,MG) (MG/L)	NON-CAR-BONATE HARD-NESS (MG/L)
303331087135803	76-06-02	.0	--	.4	6	--	--	--	--	--	--
	76-08-03	3.0	--	.1	20	--	60	--	--	--	--
303338087132801	71-12-07	--	--	--	--	--	30	--	--	3	1
	73-09-20	.0	2.0	.5	--	--	12	5	2	6	0
	74-04-17	.0	1.0	.9	2	--	8.0	--	2	--	--
	75-05-22	.0	--	--	0	--	24	0	2	3	2
	75-08-28	.0	--	--	4	--	14	--	1	--	--
303342087140400	73-09-19	3.0	1.0	.1	--	--	13	--	6	--	--
	74-03-21	3.0	1.0	.3	15	--	3.0	--	10	6	4
	74-06-19	3.0	.0	1.0	12	--	--	--	12	--	--
	74-11-22	5.0	1.0	--	--	--	2.0	--	4	5	4
	75-02-13	3.0	.0	.5	10	--	3.0	--	--	5	3
	75-08-28	1.0	--	--	17	--	9.0	--	3	--	--
	75-12-22	2.0	1.0	--	--	--	3.0	--	2	--	--
	76-03-11	2.0	--	1.8	--	--	4.0	--	--	--	--
	76-06-02	5.0	2.0	.5	5	--	20	--	--	--	--
	76-08-04	4.0	--	.2	9	--	6.0	--	--	--	--
303348087141001	74-03-21	.0	5.0	.1	8	--	20	--	1	2	0
	74-06-19	1.0	4.0	.1	24	--	--	--	1	--	--
	74-11-22	6.0	--	--	--	--	23	--	2	--	--
	75-02-13	.0	--	.1	2	--	27	--	1	3	1
	75-08-28	.0	--	--	6	--	30	--	1	--	--
	76-03-11	4.0	--	.3	--	--	22	--	--	--	--
	76-06-02	.0	--	.2	4	--	--	--	--	--	--
	76-08-04	2.0	--	--	18	--	20	--	--	--	--
303402087140100	73-06-20	3.0	2.5	1.1	15	6.0	5.1	40	10	8	4

TABLE 1.-- CHEMICAL ANALYSES OF WATERS FROM WELLS, TEST HOLES, AND OTHER SITES AROUND THE SCENIC HILLS SEWAGE PLANT (CONTINUED).

STATION NUMBER	DATE OF SAMPLE	SPECIFIC CONDUCTANCE (MICROMHOS)	DISSOLVED SOLIDS (RESIDUE AT 180 C) (MG/L)	DISSOLVED SOLIDS (SUM OF CONSTITUENTS) (MG/L)	DISSOLVED ALUMINUM (AL) (UG/L)	DISSOLVED ARSENIC (AS) (UG/L)	TOTAL ARSENIC (AS) (UG/L)	DISSOLVED BORON (B) (UG/L)	TOTAL BORON (B) (UG/L)	TOTAL CADMIUM (CD) (UG/L)	HEXAVALENT CHROMIUM (CR6) (UG/L)
303331087135803	76-06-02	207	--	--	--	--	--	--	--	--	--
	76-08-03	205	--	--	--	--	--	--	--	--	--
303338087132801	71-12-07	21	--	--	--	--	--	--	--	--	--
	73-09-20	24	21	24	10	7	--	--	--	1	0
	74-04-17	12	--	--	--	--	--	--	--	--	--
	75-05-22	23	22	16	0	--	--	--	--	--	0
	75-08-28	35	32	--	--	--	0	--	--	1	--
303342087140400	73-09-19	33	--	--	--	--	--	--	--	--	--
	74-03-21	40	--	--	--	--	23	60	--	1	--
	74-06-19	105	--	--	--	0	--	--	--	--	--
	74-11-22	60	45	--	--	0	--	50	--	--	--
	75-02-13	62	--	--	--	1	--	--	--	--	--
	75-08-28	50	32	--	--	--	0	--	--	0	--
	75-12-22	37	--	--	--	--	--	30	--	--	--
	76-03-11	30	17	--	--	--	0	20	--	--	--
	76-06-02	32	--	--	--	--	--	--	--	--	--
	76-08-04	35	--	--	--	--	--	--	--	--	--
303348087141001	74-03-21	25	--	--	--	--	0	20	--	1	--
	74-06-19	80	--	--	--	0	--	--	--	--	--
	74-11-22	40	19	--	--	--	--	0	--	--	--
	75-02-13	34	--	--	--	0	--	--	--	--	--
	75-08-28	28	24	--	--	--	0	--	--	0	--
	76-03-11	24	9	--	--	--	0	0	--	--	--
	76-06-02	21	--	--	--	--	--	--	--	--	--
	76-08-04	24	--	--	--	--	--	--	--	--	--
303402087140100	73-06-20	43	31	22	--	3	7	--	1	1	0

TABLE 1.-- CHEMICAL ANALYSES OF WATERS FROM WELLS, TEST HOLES, AND OTHER SITES AROUND THE SCENIC HILLS SEWAGE PLANT (CONTINUED).

STATION NUMBER	DATE OF SAMPLE	TOTAL CHRO-MIUM (CR) (UG/L)	TOTAL COBALT (CO) (UG/L)	DIS-SOLVED COPPER (CU) (UG/L)	TOTAL COPPER (CU) (UG/L)	DIS-SOLVED IRON (FE) (UG/L)	TOTAL IRON (FE) (UG/L)	DIS-SOLVED LEAD (PB) (UG/L)	TOTAL LEAD (PB) (UG/L)	TOTAL LITHIUM (LI) (UG/L)	DIS-SOLVED MAN-GANESE (MN) (UG/L)
303331087135803	76-06-02	--	--	--	--	--	0	--	--	--	--
	76-08-03	--	--	--	--	--	50	--	--	--	--
303338087132801	71-12-07	--	--	--	--	0	--	--	--	--	--
	73-09-20	0	0	20	--	10	--	2	--	--	10
	74-04-17	--	--	--	--	--	--	--	--	--	--
	75-05-22	--	--	0	--	0	--	1	--	--	10
	75-08-28	<10	0	--	4	--	30	--	8	3	--
303342087140400	73-09-19	--	--	--	--	--	--	--	--	--	--
	74-03-21	--	--	--	--	150	--	1	--	--	17
	74-06-19	--	--	--	--	--	--	--	--	--	--
	74-11-22	--	--	4	--	90	--	--	--	--	--
	75-02-13	--	--	1	--	70	--	--	--	--	--
	75-08-28	10	0	--	3	--	260	--	12	4	--
	75-12-22	--	--	--	--	--	--	--	--	--	--
	76-03-11	--	--	--	--	40	--	6	--	--	10
	76-06-02	--	--	--	--	--	140	--	--	--	--
	76-08-04	--	--	--	--	--	250	--	--	--	--
303348087141001	74-03-21	--	--	--	--	10	--	0	--	--	0
	74-06-19	--	--	--	--	--	--	--	--	--	--
	74-11-22	--	--	--	--	--	--	--	--	--	--
	75-02-13	--	--	19	--	90	--	--	--	--	--
	75-08-28	<10	0	--	2	--	10	--	12	5	--
	76-03-11	--	--	--	--	0	--	20	--	--	0
	76-06-02	--	--	--	--	--	0	--	--	--	--
	76-08-04	--	--	--	--	--	50	--	--	--	--
303402087140100	73-06-20	0	0	--	0	--	830	--	4	0	--

TABLE 1.-- CHEMICAL ANALYSES OF WATERS FROM WELLS, TEST HOLES, AND OTHER SITES AROUND THE SCENIC HILLS SEWAGE PLANT (CONTINUED).

STATION NUMBER	DATE OF SAMPLE	TOTAL MAN-GANESE (MN) (UG/L)	TOTAL MERCURY (HG) (UG/L)	TOTAL NICKEL (NI) (UG/L)	TOTAL SELE-NIUM (SE) (UG/L)	DIS-SOLVED STRON-TIUM (SR) (UG/L)	DIS-SOLVED ZINC (ZN) (UG/L)	TOTAL ZINC (ZN) (UG/L)	CON-FIRMED COLI-FORM (MPN)	FECAL COLI-FORM (MPN)
303331087135803	76-06-02	--	--	--	--	--	--	--	--	<2
	76-08-03	--	--	--	--	--	--	--	2	<2
303338087132601	71-12-07	--	--	--	--	--	--	--	--	--
	73-09-20	--	--	--	--	--	20	--	--	--
	74-04-17	--	--	--	--	--	--	--	--	--
	75-05-22	--	--	--	--	80	5	--	--	--
	75-08-28	10	.2	0	0	--	--	30	--	--
303342087140400	73-09-19	--	--	--	--	--	--	--	--	--
	74-03-21	--	.1	--	--	--	--	--	--	--
	74-06-19	--	--	--	--	--	--	--	--	--
	74-11-22	--	--	--	--	--	5	--	--	--
	75-02-13	--	--	--	--	--	0	--	1600	<2
	75-08-28	10	.2	2	0	--	--	20	--	--
	75-12-22	--	--	--	--	--	--	--	540	<2
	76-03-11	--	--	--	--	--	10	--	240	8
	76-06-02	--	--	--	--	--	--	--	--	<2
	76-08-04	--	--	--	--	--	--	--	--	23
303348087141001	74-03-21	--	.1	--	--	--	--	--	--	--
	74-06-19	--	--	--	--	--	--	--	--	--
	74-11-22	--	--	--	--	--	--	--	--	--
	75-02-13	--	--	--	--	--	6	--	<2	<2
	75-08-28	0	.2	0	0	--	--	20	--	--
	76-03-11	--	--	--	--	--	10	--	13	<2
	76-06-02	--	--	--	--	--	--	--	--	<2
	76-08-04	--	--	--	--	--	--	--	--	<2
303402087140100	73-06-20	30	.0	0	--	40	--	170	--	--

during the course of the investigation.) TH 98A, 101, 102, 102A, and 102B were drilled for the monitoring segment of the investigation. Combined geophysical and interpretative lithologic logs of these wells and test holes are in the Records and Logs of Test Holes and Wells section of this report.

The water table near the sewage plant's lagoons is 105 to 110 ft below land surface. A perched water table was found at a depth of 24 ft in TH 101 at the south edge of the lagoons and at a depth of 26 ft in 102 at the north edge. TH 101A and 102B were screened in the perched zone. The perched water may drain naturally to the north through tributaries of Clear Creek. Evidence of perched water tables is less distinct at the other logged holes.

Surface-Water Sites Used for Monitoring

A surface-water sampling station on Clear Creek (fig. 8) was established to monitor the possible contamination of the creek from surface runoff or ground-water discharge originating from Irrigation Field No. 2 or from the lagoons. This station was replaced by the Clear Creek tributary station because of possible tidal effects on Clear Creek itself. A sampling station was also set up on Thompson Bayou to monitor possible contamination of the bayou, which drains Irrigation Field No. 1. The chemical analyses available through August 1976 from the sampling sites are given in table 1.

The surface-water samples have been collected at times when little or no rain had fallen for the previous 12 hours or more. Thus, the samples were taken when streamflow was maintained mostly by ground-water discharge.

Quality of Water, Scenic Hills Area

Water from wells.--The water sampled from most wells in the Scenic Hills area was typical of water from the sand-and-gravel aquifer in that it has low dissolved-solids concentration [less than 50 milligrams per liter (mg/L)], low pH (below 6.0), low hardness (less than 10 mg/L), low sulfate and chloride (each less than 5 mg/L), and high dissolved carbon dioxide (from 5 to 20 mg/L). Water sampled from TH 101A and 102B, however, had dissolved-solids concentrations of 52 to 116 mg/L, hardness of 20 mg/L from TH 102B, chloride concentrations of 13-27 mg/L, and sulfate as high as 33 mg/L from TH 102B. Chloride and sulfate concentrations in samples from TH 102B are as high as or slightly higher than those of the effluent. Total nitrate concentrations generally have been three times as high in TH 101A and 102B as in the other wells, but only about a third as high as in the effluent.

The U.S. Environmental Protection Agency's current standards (1975, p. 59570) for inorganic chemicals in drinking water are as follows:

Nitrate (as N)	10	mg/L
Fluoride (for Pensacola's average maximum daily air temperature of 76.9°F)	1.6	mg/L
Arsenic	50	ug/L (micrograms per liter)
Barium	1,000	ug/L
Cadmium	10	ug/L
Chromium	50	ug/L
Lead	50	ug/L
Mercury	2	ug/L
Selenium	10	ug/L
Silver	50	ug/L

Of this group, barium and silver have not been run in samples from Scenic Hills. None of the other constituents have exceeded the recommended limits when determined except for lead in the December 1974 sample from TH 102A and in the March 1976 sample from TH 98A, and mercury in the August 1975 samples from TH 101A and 102B. Coliform counts have been mostly less than two per 100 mL in samples collected from the wells.

Water from streams.--The surface-water samples were similar to most of the ground-water samples, except for slightly higher pH and dissolved-solids concentrations. The carbon dioxide concentrations, though lower in the surface-water samples than in the ground-water samples, were high enough to indicate that the surface water had not traveled far from its point of discharge as ground water. None of the analyzed inorganic constituents in the surface-water samples exceeded the Environmental Protection Agency's standards for drinking water.

Occasional high confirmed coliform counts have been found in samples from the two surface sites, but fecal coliform counts were generally less than two per 100 mL. The times of collection of samples having high coliform counts did not correspond to periods of effluent spraying.

Evidence for changes in quality.--No distinct change in chemical quality was noted at any of the sampled wells, test holes or surface-water sites during the period of record. However, no analyses of samples from wells at the plant were run before the plant began to operate. The concentrations of constituents in the earliest samples from some of the sites may be affected by infiltration of effluent from the lagoons. This seems especially likely in TH 101A and 102B, which tap the perched water within a few feet of the lagoons. The perched water must be a source of recharge to the deeper water, and it probably did not contain substantially higher chloride and sulfate than the deeper water under natural conditions. The similarity in chloride and sulfate concentrations in TH 101A and 102B and the effluent suggests that the perched water at the sites of those wells is derived largely from effluent. Higher chloride and sulfate and lower nitrate concentrations in TH 101A and 102B samples than in the effluent may be explained as follows: The effluent is sampled at the outflow of the treatment tank. In the lagoons, evaporation may concentrate the chloride and sulfate at certain seasons and biological processes may break down part of the nitrogen compounds before the effluent in the lagoons infiltrates to the well sites.

The only deeper well whose samples showed a possibly significant change was Gulf Power well 3, in which nitrate concentrations were three times higher in 1975 than previously, and the chloride also was higher in August 1975 than in earlier samples. However, the well was not sampled in 1976.

No clear changes in chemical composition attributable to spraying of effluent was discerned in samples collected during the period of record. TH 98A, 101, and 101A are located close to the spray fields used in 1976. The north spray field, adjoining well 99, was not in regular use in 1976.

A possible path for contaminants from the sewage effluent would be infiltration from the lagoons to the perched water table, then discharge to Clear Creek tributary. Samples from the tributary have had higher chloride and nitrate concentrations than those from the deeper wells, and no sources of contamination other than the sewage plant are known to exist in the tributary's drainage basin above the sampling point.

Through summer 1976, there was no evidence to indicate substantial coliform contamination of either surface or ground water as a result of the operation of the Scenic Hills Sewage Plant.

TEST DRILLING PROGRAM

From December 1973 through March 1975, six test holes were drilled at the Scenic Hills Sewage Plant: TH 98A (77 ft deep), 101 (134 ft), 101A (30 ft), 102 (111 ft), 102A (141 ft), and 102B (28 ft). No cores were taken. The holes were cased for use as observation wells with 4-in PVC (polyvinyl chloride) pipe and 5-ft lengths of PVC well screen. Radioactivity surveys were run on TH 98A, 101, and 102, and on Monitor Well 99.

TH 103 and 104 (fig. 1) were drilled in areas where water levels in wells are being affected by heavy pumping near Bayou Chico, southwest of Pensacola. They are being used to monitor possible saltwater intrusion. Both were cased with 200 ft of galvanized-iron pipe and with 4 ft of stainless steel screen. Electric and caliper logs were run in TH 104 before casing was set. After the casing was set, radioactivity logs were obtained on TH 103 and TH 104.

The wells were developed by backwashing with the mud pump on the drill rig (except for TH 101A, which was augered) and then pumped by air lift.

Chloride concentrations in water samples from TH 103 and 104 were 6.9 and 7.5 mg/L, respectively, showing no evidence of saltwater contamination. Periodic measured water levels have been consistently above mean sea level, which indicates no seawater intrusion.

Records and logs of the test holes are included in this report.

Radioactivity Logging

A gamma-ray log indicates the natural gamma radiation of the material penetrated and is plotted on a scale with radioactivity increasing to the right. In general, clay and shale are more radioactive than clean sand and gravel so the log can be used to interpret the types and thicknesses of material penetrated (Schlumberger Ltd., 1972, p. 57-59).

The neutron log provides a measure of the hydrogen content of the formation. Hydrogen content is a function of the amount of water present in water-saturated material, and this, in turn, depends on the porosity of the material and the amount of water absorbed or chemically bound up in it. The neutron probe utilizes a radioactive source and a detector. The source bombards the formation opposite the device with neutrons. When the hydrogen concentration of the material surrounding the neutron source is large, most of the neutrons are slowed or captured within a short distance of the source. The neutron count at the detector increases for decreased hydrogen concentration (therefore, decreased water) and decreases as the hydrogen concentration increases.

Increased water content is shown by deflection to the left on the neutron log. Clay beds have a high water content and, therefore, are represented by deflections to the extreme left on the neutron log. Dense materials with very low porosity are depicted by deflections to the right. In the sand-and-gravel aquifer, these dense materials might be hardpan layers. Sand falls between these extremes. Sand with either a high effective porosity or high clay content causes deflections to the left on the log. Thus, the neutron log must be interpreted in conjunction with a gamma-ray log showing the degree of "cleanness" of sand beds (Schlumberger Ltd., 1972, p. 49-55).

A qualitative interpretation method, adapted from one developed by the Lane-Wells Company (McGaha, Mellies, and Terry, no date) for oil-bearing limestone, has been applied where feasible to the project's gamma-ray and neutron logs. A vertical line is drawn on the gamma-ray log 20 percent of the distance between the minimum and maximum radioactivities recorded on the log (TH 103). This is labeled "20 Percent Gamma Reference Line," and the parts of the curve to the left of the line represent the cleanest sand zones. Similarly, a line is drawn on the neutron log half way between the maximum and minimum values below the sharp deflection to the right at the top of the water-saturated zone (approximately the water table). This is the "50 Percent Neutron Reference Line." The parts of the neutron curve representing the highest water saturation are left of this line. These parts of the curve represent clay, clayey silt, and clayey sand as well as sand with high effective porosity. However, those zones that are represented both on the gamma-ray log by deflections to the left of the 20 Percent Gamma Reference Line and on the neutron log to the left of the 50 Percent Neutron Reference Line are potentially the most productive sand zones in the well. This method was not applicable to the wells logged at the Scenic Hills Sewage Plant because of the short water-saturated sections penetrated. The method did not delineate any especially favorable zones in TH 104.

Electric Logging

An electric survey, consisting of an SP (spontaneous-potential) log, a single-point resistance log, and a multiple-electrode resistivity log was run on TH 104. Only a brief mention of electric-log qualitative interpretation can be made here; a detailed treatment may be found in Schlumberger (1972) documents. In general, the SP (or left) curve is convex outward (to the left) opposite permeable zones, and approaches a vertical line close to the center when opposite impermeable material. The resistance increases (curve moves outward or right) opposite sands and sandstones and decreases (curve moves inward) opposite clays and shales. The SP curve tends to run roughly parallel to the gamma-ray curve. In a sand-clay sequence, the resistance curve (right) may run roughly parallel to the neutron curve.

SUMMARY AND CONCLUSIONS

1. A digital model has been applied to the sand-and-gravel aquifer in Escambia County, Florida, 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. Under conditions of no pumping, recharge and discharge of the "main producing zone" take place through constant-head boundaries and through the overlying confining bed.

2. After calibration of the model, a run representing steady-state conditions with no pumping gave values for the final-head matrix which agreed with the values derived from contouring within 4 ft at all but one node, (value within 7 ft), in the area of principal interest. The discrepancy appears to be within the limits of error of the contour values. However, the calibration is non-unique.

3. The cumulative mass balance from the computer printout shows that the total discharge is 14.1×10^9 ft^3/yr or, for the land area, 1.04 $(ft^3/s)/mi^2$. The discharge per unit area compares reasonably with the unit base runoff of typical streams whose flow is maintained by the aquifer: 0.80 to 1.4 $(ft^3/s)/mi^2$.

4. Total natural aquifer discharge within the area of principal interest is 159 Mgal/d, according to the model results.

5. The original grid used for the model is probably too coarse (1 minute of latitude and longitude) to make adequate comparisons with observation-well data under conditions of pumping.

6. The matrix of hydraulic conductivity of the confining bed is the only matrix in the model input not controlled by point data. The upper limit of the range of values used (10^{-4} to 4×10^{-1} ft/d) appears conservative, but data to substantiate the lower limit are lacking at present.

7. Leakage is unrealistically high at some nodes of the present version of the model, compared to unit runoff and precipitation. Recalibration is needed.

8. The effects of the constant-head boundaries should be checked by substituting constant-flux and no-flux boundaries.

9. Results using the present assumption of an unchanging water table should be compared to those obtained under the assumption that the water table changes simultaneously with the head in the "main producing zone" (constant recharge).

10. If neither the assumption of constant water table nor constant recharge in the two-dimensional Trescott-Pinder model gives satisfactory results, it may be necessary to apply a three-dimensional model.

11. Sewage effluent at the Scenic Hills Sewage Plant averaged 110,000 gal/d through mid-1974, increasing to 230,000 gal/d by fall 1976. The design capacity is 1,000,000 gal/d. Because of the small volume, regular spray irrigation did not begin until 1976; rather, the effluent infiltrated the sand-and-gravel aquifer through unlined lagoons.

12. No distinct change in chemical quality of the water was noted from the sampled wells, test holes, or surface-water sampling sites for the period of record. However, sampling did not begin at the monitor sites at the Scenic Hills Sewage Plant until after operations began and the lagoons were filled. Samples of water from shallow wells adjoining the lagoon have chloride and sulfate concentrations resembling those of the effluent rather than typical sand-and-gravel aquifer water, and also have somewhat higher nitrate concentrations.

13. The effluent is probably percolating to a perched ground-water body underlying the lagoons, which discharges to a tributary of Clear Creek on the north.

14. Chemical analyses of water samples and water-level measurements indicate no saltwater intrusion at the sites of TH 103 and TH 104, which were drilled in heavily pumped areas near Bayou Chico, southwest of Pensacola.

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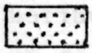
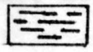
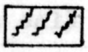
RECORDS AND LOGS OF TEST HOLES AND WELLS

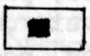
The accompanying logs are graphic representations of the materials and conditions encountered in drilling, sampling, and geophysical testing of the test holes and wells discussed. The following symbols are used:

Sand: 

Clay or shale: 

Silt: 

Gravel or scattered pebbles: 

Iron cementation or staining: 

The locations of test holes and wells discussed here are shown in figure 1.

TH 98A (303313N0871400.2)

TH 98A was drilled in the Scenic Hills Sewage Plant Irrigation Field No. 1, approximately 1,670 ft southwest of the road to Gulf Power Co.'s Crist Steam Plant. It is located 12 ft north-northwest of Monitor Well 98, which is dry at 53 ft under current conditions of no spray irrigation. TH 98A was screened from 72 to 77 ft. The hole penetrated mostly clean sand from 14 to 75 ft according to the gamma-ray log, but vertical hydraulic conductivity varied sufficiently to produce a perched water table at 24 ft.

The following interpretative lithologic log is based on examination of cuttings and radioactivity logs:

	Thickness (feet)	Depth (feet)
Silt, clayey, with very fine sand	8	8
Clay, silty	2	10
Sand, fine to very coarse, poorly sorted, subangular to subrounded, clayey, with clay inclusions	4	14
Sand as above but less clayey with fine gravel	6	20
Sand, fine to very coarse, poorly sorted, clayey, with fine gravel	6	26
Sand, fine to very coarse, poorly sorted, slightly clayey, with trace of gravel . .	7	33
Sand, fine to very coarse, poorly sorted. clean	5	38
Sand, as above but slightly clayey	12	50
Sand, fine to coarse, predominantly medium, less clayey than above, and fine angular quartz gravel	8	58
Sand, fine to coarse, predominantly coarse, and gravel as above	14	72
Sand, fine to coarse, predominantly medium, slightly clayey, with less gravel than above	8	80

A water sample taken March 20, 1974, had a pH of 5.6 and a carbon dioxide concentration of 14 mg/L (table 1). Specific conductance was 26 umho/cm (micromhos per centimeter) at 25°C (Celsius). Concentrations of trace metals determined were no greater than 0.1 ug/L and concentrations of nutrients were less than 1 mg/L. A partial analysis of a sample taken May 22, 1974, showed little change in the constituents determined as compared to the March 20, 1974 sample.

TH 98A

Well Name: U.S.G.S. TH 98A

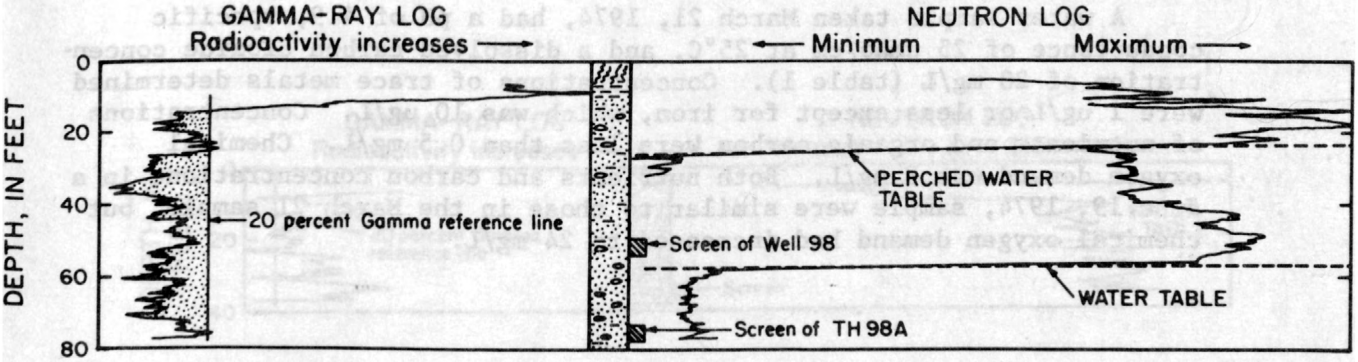
Location Number: 303313N0871400.2

Location Description Approx. 1670 ft. SW of road to Gulf Power Plant along power line

Alt. 67.87 feet Diam 4 inches

Depth: 77 feet Depth to top of screen: 72 feet

Water level: 57.9 feet below LSD Date meas.: 2/21/74



Monitor Well 99 (303348N0871410.1)

Monitor Well 99 was drilled in Scenic Hills Sewage Plant Irrigation Field No. 2, approximately 4,100 ft northwest of the road to the Gulf Power Co.'s Crist Steam Plant. The following lithologic log is based on interpretation of radioactivity logs:

	Thickness (feet)	Depth (feet)
No record (sand observed at surface) . . .	7	7
Sand, clean	2	9
Silt	5	14
Sand, thinly interbedded clean to slightly clayey layers	10	24
Sand, clayey or silty	6	30
Sand, clean	2	32
Clay	2	34
Sand	3	37

A water sample taken March 21, 1974, had a pH of 4.9, specific conductance of 25 umho/cm at 25°C, and a dissolved carbon dioxide concentration of 20 mg/L (table 1). Concentrations of trace metals determined were 1 ug/L or less except for iron, which was 10 ug/L. Concentrations of nutrients and organic carbon were less than 0.5 mg/L. Chemical oxygen demand was 8 mg/L. Both nutrients and carbon concentrations in a June 19, 1974, sample were similar to those in the March 21 sample, but chemical oxygen demand had increased to 24 mg/L.

Monitor Well 99

Well Name: Pensacola Sewage North Monitor (99)

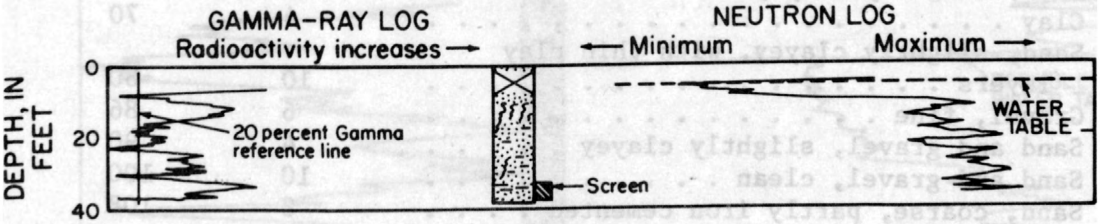
Location Number 303348N0871410.1

Location Description Approx. 4100 ft. NW of road to Gulf Power plant along power line

Alt. LSD: 15.69 feet Diam.: 4 inches

Depth: 37 feet Depth to top of screen 32 feet

Water level: 6.2 feet below LSD Date meas.: 9/19/73



TH 101 and 101A (303327N0871354.1, .2)

TH 101 was drilled 5 ft east of the east gate of the Scenic Hills Sewage Plant or 95 ft north of the road to the Gulf Power Co.'s Crist Steam Plant. The first significant thickness of clean sand or gravel was encountered at 80 ft. The water table is at 108 ft and a perched water table at 24 ft. TH 101A was drilled 8 ft north of TH 101 with a screen set from 25 to 30 ft.

An interpretative lithologic log follows. It is based on the driller's log and radioactivity logs:

	Thickness (feet)	Depth (feet)
Sand (observed at surface)	2	2
Clay	9	11
Sand, clayey	5	16
Silt	4	20
Sand, slightly clayey	8	28
Clay, with thin layers of silt and clayey sand	34	62
Sand, slightly clayey	4	66
Clay	4	70
Sand, slightly clayey, with thin clay layers	10	80
Gravel, fine	6	86
Sand and gravel, slightly clayey	4	90
Sand and gravel, clean	10	100
Sand, coarse, partly iron cemented	8	108
Sand, coarse, partly iron cemented, thinly interbedded with gravel and clayey sand	7	115
Sand, clayey	5	120
Gravel interbedded with sand and clayey sand	18	138
Clay	2	140

A water sample taken March 21, 1974, had a pH of 5.4, a specific conductance of 25 umho/cm at 25°C, and a dissolved carbon dioxide concentration of 16 mg/L (table 1). Nutrients and organic carbon concentrations were less than 0.5 mg/L. Concentrations of the trace metals determined were no higher than 0.1 ug/L except for iron, which was 10 ug/L, and cadmium, which was 3 ug/L.

TH 101

Well Name: U.S.G.S. TH 101

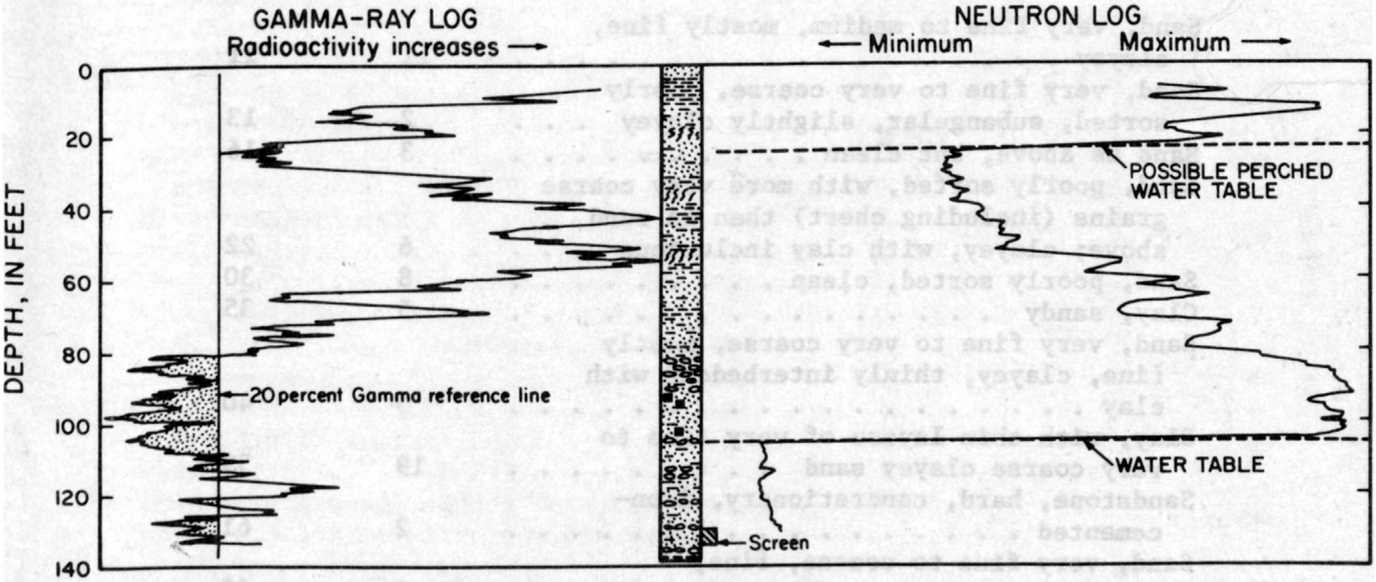
Location Number: 303327N0871354.1

Location Description: 95' N of road to Gulf Power plant, 5' E of east gate to Scenic Hills Sewage Plant

Alt. LSD: 107.2 feet Diam.: 4 inches

Depth: 134 feet Depth to top of screen: 129 feet

Water level: 105.7 feet below LSD Date meas.: 2/21/74



TH 102, 102A, and 102B (303331N0871358.1, .2, .3)

TH 102 is 71 ft north of the Scenic Hills Sewage Plant lagoons. It was drilled to 140 ft, but the driller was unable to run the casing and screen below 111 ft. At this depth, there was only 2 ft of water in the well on February 21, 1974, and the well has not been developed or pumped. Geophysical logs were run February 15, 1974, in TH 102, showing the water table at 106 ft and a perched water table at 14 ft. TH 102A was drilled 5 ft north of TH 102 and a screen set at 136 to 141 ft. TH 102B was drilled 7 ft northwest of TH 102 and a screen set below the perched water table, from 23 to 28 ft. Two zones of mostly clean sand, from 11 to 30 ft and from 65 to 144 ft, were penetrated at the site.

The following interpretative lithologic log is based on a composite of the radioactivity logs of TH 102 and the cuttings and driller's comments of TH 102:

	Thickness (feet)	Depth (feet)
Sand, very fine to medium, mostly fine, clayey	11	11
Sand, very fine to very coarse, poorly sorted, subangular, slightly clayey . . .	2	13
Sand as above, but clean	3	16
Sand, poorly sorted, with more very coarse grains (including chert) than in sand above; clayey, with clay inclusions . . .	6	22
Sand, poorly sorted, clean	8	30
Clay, sandy	5	35
Sand, very fine to very coarse, mostly fine, clayey, thinly interbedded with clay	5	40
Clay, with thin layers of very fine to very coarse clayey sand	19	59
Sandstone, hard, concretionary, iron-cemented	2	61
Sand, very fine to coarse, fine, subangular, clayey	4	65
Sand as above, but clean	5	70
Sand, very fine to coarse, mostly fine, clayey	5	75
Sand, very fine to very coarse, predominantly medium and coarse, with some very fine gravel; clean except for thin layers of clayey sand and clay . . .	9	84

TH 102 (Continued)

	Thickness (feet)	Depth (feet)
Sand, as above but clayey	4	88
Sand, fine to very coarse, mostly coarse. grading to very fine gravel	12	100
Sand, predominantly coarse, subangular, with a trace of very fine gravel	10	110
Sand, medium to very coarse, predominantly medium and coarse, with a trace of very fine gravel.	10	120
Sand, medium to very coarse, predominantly coarse, subangular	10	130
Sand, fine to very coarse, medium and coarse	14	144
Clay	1	145

TH 102, 102A

Well Name: U.S.G.S. TH 102, 102A composite

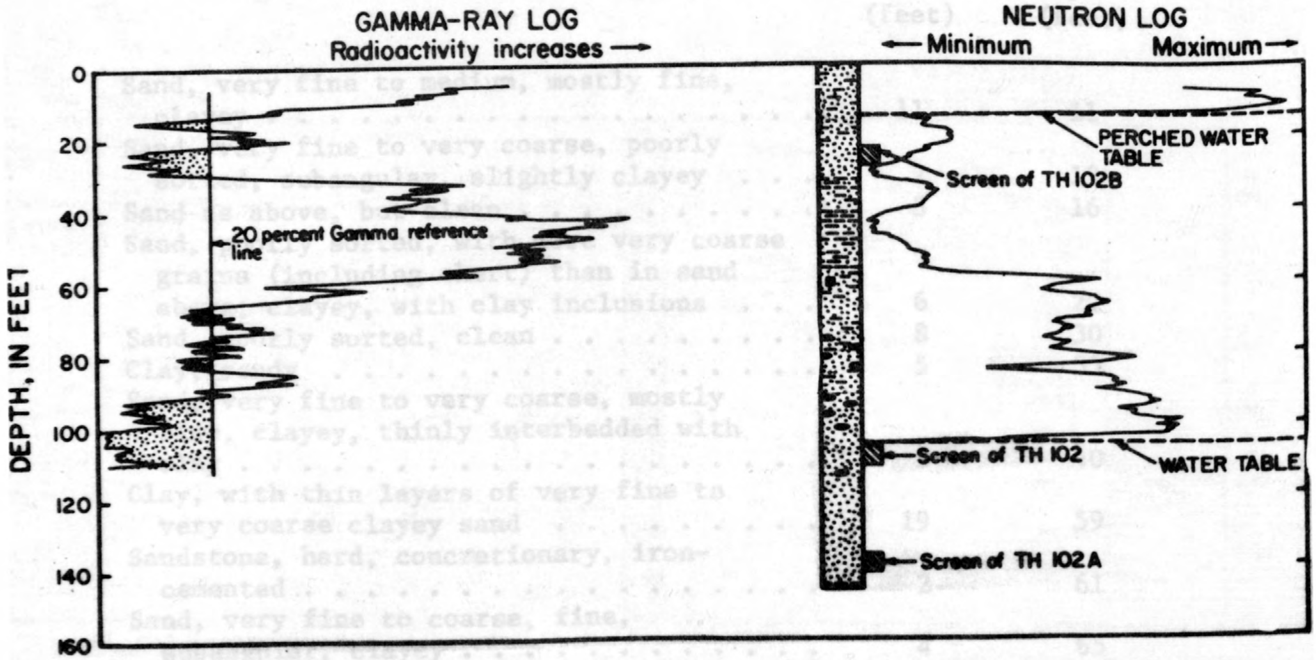
Location Number: 303331N0S71358.1.2

Location Description: 71-76 ft. N of Scenic Hills Sewage lagoons, midway between them.

Alt. LSD: 109 feet Diam.: 4 inches

Depth: 102: 111 / 102A: 141 feet Depth to top of screen: 106 / 136 feet

Water level: 109.2 feet below LSD Date meas.: 2/21/74



TH 103 (302459N0871544.1)

TH 103 is north of Bayou Chico, at the end of Keys Court, and 110 ft north of the Frisco Railway. It was drilled as an observation well to monitor water levels and water quality in an area of heavy pumping that is vulnerable to saltwater intrusion. Water-level measurements and a partial chemical analysis show no evidence of saltwater intrusion at the well site through mid-1977. Five feet of potentially most productive sand were penetrated between 50 and 70 ft.

A condensed interpretative lithologic log follows. It is based on examination of cuttings, driller's comments, and radioactivity logs:

	Thickness (feet)	Depth (feet)
Sand (observed at surface)	2	2
Sand, very fine to very coarse, predominantly medium, clean, thinly interbedded with clayey sand and some fine angular quartz gravel, becoming increasingly clayey downward. Interval includes 5 ft of potentially most productive sand	85	87
Clay, sandy, with thin layers of clayey, poorly sorted sand	19	106
Sand, very fine to very coarse, poorly sorted, somewhat clayey	12	118
Clay, sandy, with a few thin layers of clayey sand	12	130
Sand, very fine to very coarse, poorly sorted, slightly clayey	13	143
Sand, very fine to very coarse, mostly medium, subround to subangular, thinly interbedded with clayey sand and fine subangular quartz gravel	34	177
Clay, sandy	7	184
Gravel, sand, and clayey sand interbedded.	9	193
Sand, fine to coarse, predominantly medium, subangular with trace of fine gravel	7	200
Sand, fine to very coarse, predominantly coarse, subangular, and very fine to fine subangular quartz gravel	5	205

A water sample taken by air lift on March 19, 1974, had a chloride concentration of 6.9 mg/L, nitrate (as nitrogen) of 3.2 mg/L, and a specific conductance of 59 umho/cm at 25°C.

Well Name: U.S.G.S. TH 103

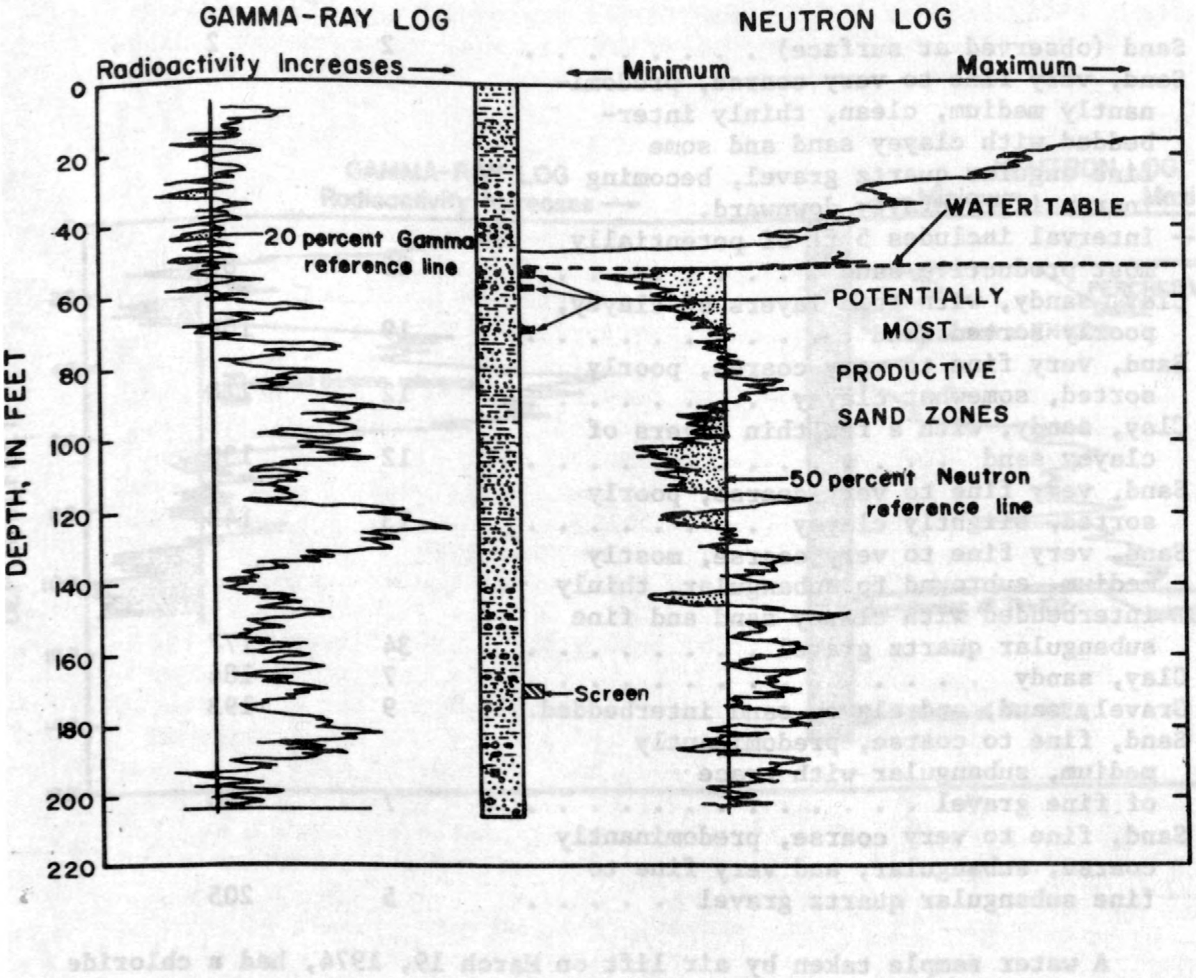
Location Number 302459N0871544.1

Location Description North of Bayou Chico West of Pensacola; 20' W of Keys Ct., 110' N of Frisco Rwy.

Alt. LSD: 53.7 feet Diam.: 2 inches

Depth: 204 feet Depth to top of screen: 168 feet

Water level: 50.2 feet below LSD Date meas.: 3/22/74



TH 104 (302435N0871416.1)

TH 104 is in Pensacola on the south side of Romana Street, 105 ft west of its intersection with K Street. It was drilled as an observati well to monitor water levels and water quality in an area of heavy pumping that was vulnerable to saltwater intrusion. Water-level measurements and a partial chemical analysis show no evidence of saltwater intrusion at the well site through mid-1977.

In addition to radioactivity surveys, the hole was logged with caliper, electric single-point, and electric multiple-electrode probes. Gamma, neutron, electric spontaneous potential, and single-point resistance logs are shown on the accompanying graphic log.

The following condensed interpretative log is based on the examination of cuttings and the various geophysical logs:

	Thickness (feet)	Depth (feet)
Sand, fine, subrounded to subangular, well-sorted, clayey	8	8
Sand, very fine to very coarse, poorly sorted, subangular, mostly clean, with interbedded clayey sand	34	42
Sand, clayey	3	45
Sand, fine to very coarse, predominantly coarse, subangular, clean	6	51
Sand, fine to very coarse, predominantly coarse, but slightly clayey, interbedded with clayey sand	14	65
Sand, fine to coarse, predominantly medium, clayey, interbedded with very clayey sand	25	90
Sand as above, interstitial clay content increases downward	12	102
Clay, fine to medium sandy	4	106
Sand, very fine to very coarse, poorly sorted, clayey, interbedded with sandy clay	19	125
Clay, sandy	13	138
Sand, fine to very coarse, predominantly coarse, subangular to subrounded, clean to slightly clayey	12	150
Sand, very fine to very coarse, predominantly fine and medium, subangular, slightly clayey, thinly interbedded with very clayey sand	15	165
Gravel, fine, subangular, quartz, interbedded with poorly sorted sand, clayey in part	8	173

	Thickness (feet)	Depth (feet)
Sand, very fine to very coarse, predominantly fine and medium, slightly clayey, thinly interbedded with very clayey sand	26	199
Clay, sandy	5	204

A water sample collected March 20, 1974, by means of an air lift had a chloride concentration of 7.5 mg/L, nitrate (as nitrogen) of 0.35 mg/L, and a specific conductance of 62 umho/cm at 25°C.

TH 104

Well Name: U.S.G.S. TH 104

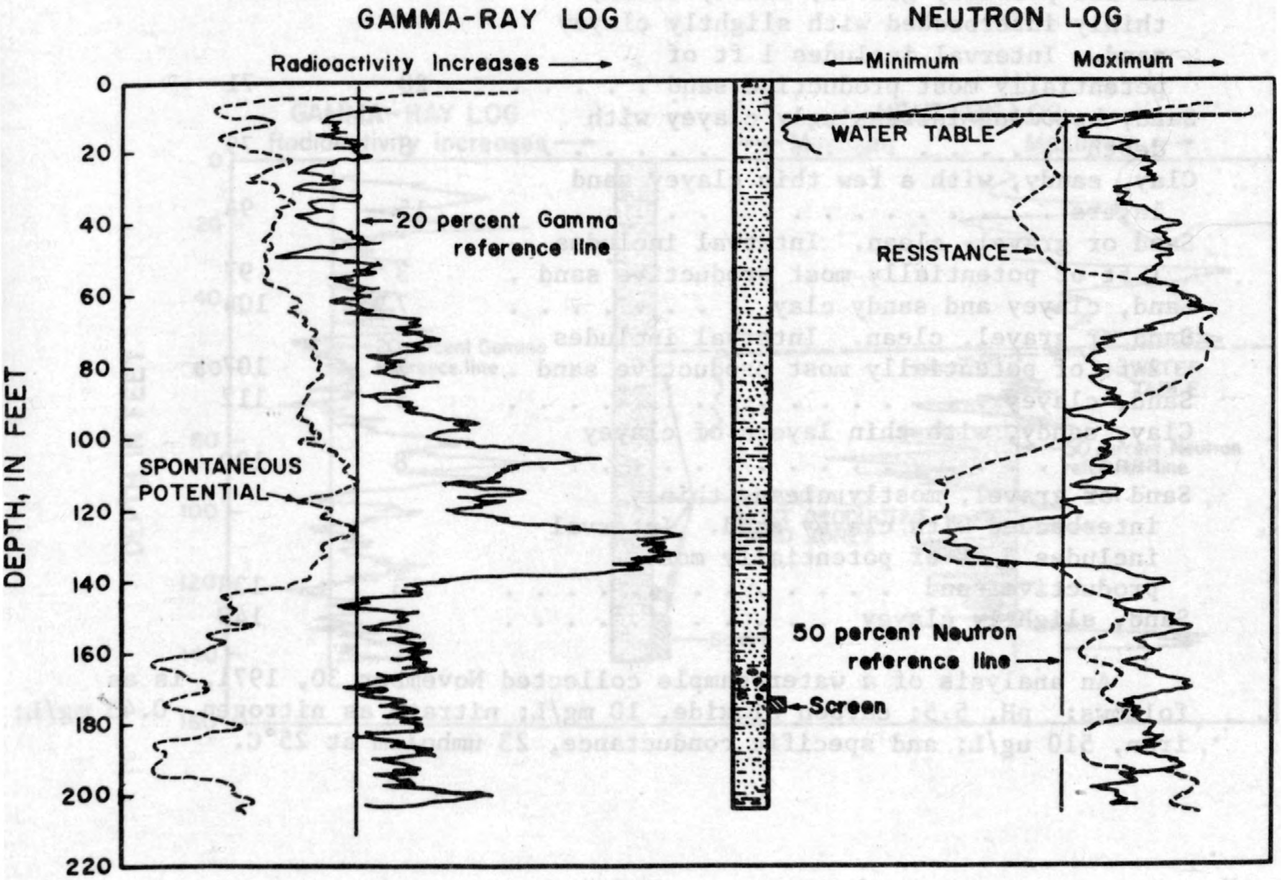
Location Number 302435N0871416.1

Location Description 105 ft. W of K Street, 24 ft. S of Romana St. in Pensacola

Alt. LSD: 23 feet Diam.: 2 inches

Depth: 204 feet Depth to top of screen 173 feet

Water level: 20.4 feet below LSD Date meas.: 3/22/74



Pensacola River Gardens Well (303206N0871150.1)

The River Gardens well is located 1 mi south of the U.S. 90 bridge across the Escambia River, 140 ft west of Crabapple Lane and 275 ft south of Brevity Boulevard. The city of Pensacola drilled this well in 1971 as a temporary public-supply well. It is not currently used. The following lithologic log is based on interpretation of radioactivity logs:

	Thickness (feet)	Depth (feet)
Sand, slightly clayey, interbedded with sandy clay	51	51
Sand and possibly gravel, fairly clean, thinly interbedded with slightly clayey sand. Interval includes 1 ft of potentially most productive sand	20	71
Sand, becoming increasingly clayey with depth	8	79
Clay, sandy, with a few thin clayey sand layers	15	94
Sand or gravel, clean. Interval includes 1 ft of potentially most productive sand .	3	97
Sand, clayey and sandy clay	7	104
Sand or gravel, clean. Interval includes 2 ft of potentially most productive sand .	3	107
Sand, clayey	5	112
Clay, sandy, with thin layers of clayey sand	8	120
Sand or gravel, mostly clean, thinly interbedded with clayey sand. Interval includes 3 ft of potentially most productive sand	13	133
Sand, slightly clayey	7	140

An analysis of a water sample collected November 30, 1971, is as follows: pH, 5.5; carbon dioxide, 10 mg/L; nitrate as nitrogen, 0.43 mg/L; iron, 510 ug/L; and specific conductance, 23 umho/cm at 25°C.

Pensacola River Gardens Well

Well Name: Pensacola River Gardens Well

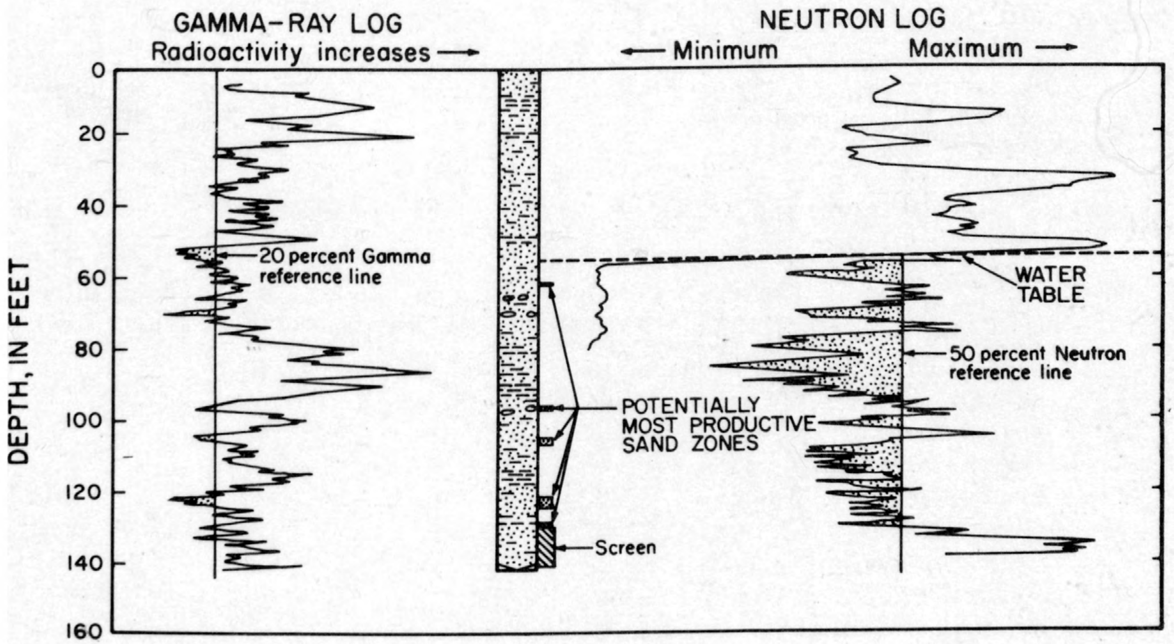
Location Number 303206N0871150.1

Location Description 1 mi. S of U.S. 90 Escambia River bridge, 140' W of Crabapple Lane, 275' S of Brevity Blvd.

Alt. LSD: approx. 63 feet Diam.: 4 inches

Depth: 140 feet Depth to top of screen 130 feet

Water level: 58.13 feet below LSD Date meas.: 2/14/74



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