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GEOLOGICAL SURVEY
WATER RESOURCES DIVISION
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June 20, 1994

Mr. Joel Murphy Code 1853
U.S. Department of the Navy, Southern Division
Naval Facilities Engineering Command
Post Office Box 190010
Charleston, SC 29419-9010

Dear Joel:

This letter summarizes the work that has been accomplished at OU1 and outlines the data necessary to complete the projected ground-water and contaminant transport modeling. Briefly, the following items have been accomplished: 1) the hydrologic system has been described, 2) field measurements necessary for model calibration have been collected, 3) the USGS MODFLOW model has been calibrated, 4) the calibrated model has been used to determine the naturally occurring ground-water flow patterns, and 5) the model has been used to predict ground-water flow patterns for several remediation scenarios. Each of these items is discussed below.

HYDROLOGIC SYSTEM

The hydrogeologic system at the base consists of the Surficial aquifer, the Hawthorn Group, and the Floridan aquifer. At OU1, the Surficial aquifer is approximately 30 feet thick and is exposed at land surface. The sediments of the Surficial aquifer consist of fine sand, silt, and clay. The Surficial aquifer is recharged by rainfall; ground water is discharged from the Surficial aquifer into small creeks that drain the interior of the base and to the St. Johns River on the eastern boundary of the base. The Surficial aquifer is not used for municipal water supply due to the low permeability and low yield.

The Hawthorn Group underlies the Surficial aquifer. The Hawthorn Group is a massive clay layer with occasional sand stringers. The low permeability of the Hawthorn Group is believed to severely restrict the downward migration of ground water. The Floridan aquifer underlies the Hawthorn Group and consists of interbedded limestones.

FIELD MEASUREMENTS

The USGS measured streamflows in the creeks draining the base on December 16, 1993 and on January 27, 1994. ABB, Inc. measured water levels in the monitoring wells at the base during these same times. These measurements were used to calibrate the MODFLOW model.

MODEL DESCRIPTION

Ground-water flow was simulated only in the Surficial aquifer. The model grid is shown in Figure 1, the smallest grid cells overlie OU1 and are 100 feet x 100 feet, the largest grid cells are 500 feet x 500 feet. The grid spacing was chosen so that each monitoring well or well nest would lie within a single cell and for accuracy at the scale of interest. The St. Johns River and the small creeks were simulated using the river package, this package allows water to drain from the aquifer when the water level in the aquifer exceeds the water level in the creek or river. The effect of Ortega creek, to the west, was simulated using the general head boundary package in the areas where Ortega Creek lies outside the modeled area.

MODEL CALIBRATION

The model was calibrated by varying the rate of recharge and the aquifer permeability until the streamflows calculated by the model matched the flows measured in the field, and the model predicted water levels matched the measured values. The permeability value for the calibrated model was 7.2 ft./day and the recharge value was 6.13 in/year. The model was run assuming steady-state conditions.

GROUND-WATER FLOW DIRECTIONS

After the model was calibrated, the post processing program MODPATH was used to delineate the ground-water flow directions. MODPATH allows particles to be placed anywhere in the ground-water flow field, then the paths of the particles are tracked as they move with the ground-water. Figure 2, shows the ground-water flow directions as they naturally occur. A ground-water divide is present east of the contaminant plume. The ground-water flow direction is toward the southeast in the vicinity of the plume (except for a small portion of the northern end of the plume); ground-water is discharged into the small creeks east and southeast of OU1. The ground-water flow at the northern tip of the plume is toward east and northeast.

Ground-water flow paths caused by three proposed pumping wells are shown in Figure 3. These pathlines were created by placing particles around each well and then tracking the particles backwards to the recharge areas. The pathlines thus delineate the capture zones for each of the wells. The pumping, however, is not sufficient to capture all the water moving toward the creeks. Therefore, some contaminated water may still seep into the creeks depending on the recovery well design and the distribution of contaminants within the Surficial aquifer.

Figure 4 shows the ground-water flow paths created by installing a drain field 10 feet below the small creeks east of the plume. Such a drain field would capture the all ground-water moving toward the creeks (the creeks would go dry.)

FUTURE DATA NEEDS

The quality of the model calibration and accuracy of the flow line prediction depends on how well the model parameters, such as storativity, vertical permeability, and horizontal permeability are estimated. This is especially true when the model is used to predict aquifer response to stress, such as, in predicting water levels and capture zones around pumping wells or drain fields. A multiple well aquifer test is the best method for the determination of these parameters.

A layout of the suggested test is shown in the enclosed Figure 5. Water-level monitoring well nests should be drilled at distances of 5, 10, and 25 feet (in a straight line) from the pumping well. Each nest should consist of a shallow and deep well. To ensure a good connection with the aquifer, the pumping well and monitoring well screens should be as permeable as feasible. This is especially true for the pumping well. If possible, wire wrapped PVC over slotted screen would be preferred.

Pumping well: The pumping well should be screened from the Hawthorn to one half the distance to the water table. This well should be at least 4 inches in diameter.

Well nest 5 feet from the pumping well: The shallow well should be screened from just above the water table to approximately10 feet below the water table. The deep well should be screened from 5 feet above the Hawthorn to the Hawthorn.

Well nests 10 and 25 feet from the pumping well. The shallow wells should be screened from just above the water table to approximately 5 feet below the water table. The deep wells should be screened from 5 feet above the Hawthorn to the Hawthorn.

During well installation, the pumping well and the most distinct deep observation well should be drilled first. The statigraphic section should be similar for the two wells. If is not, then an observation well should be drilled on the opposite side of the pumping well and the statigraphic sections again compared. The purpose of this is to ensure the test is conducted in an area of "typical" lithology.

Before the aquifer test, the pumping well should be tested to determine the range of pumping rates it can sustain. This can be done by pumping the well at successively higher pumping rates and measuring the drawdown in the pumping well. The well should be pumped at 5gpm, 10 gpm, 15 gpm, and 20 gpm (and higher rates if it can sustain them). During pumping, the water level should be measured using the following scheme:

Measure every minute through 10 minutes;
Measure every 2 minutes through 20 minutes;
Measure every 5 minutes through 60 minutes.

The measurements can be stopped and the next pumping rate begun at the end of one hour or when the measurements have stabilized for 4 successive measurements. The results of this test will be used to choose a pumping rate for the aquifer test.

If feasible, a 24 hour aquifer test would be best. The times for the water-level measurements for the aquifer test will be the same as for the previously discussed test, except the following measurements would be added.

Measure every 10 minutes through 100 minutes;
Measure every 20 minutes through 200 minutes;
Measure every 50 minutes through 500 minutes;
Measure every 100 minutes through 1440 minutes.

We plan to be on site during the test and can help with the measurements. If you have any questions or comments about this test, please do not hesitate to call.

Sincerely,
For the District Chief

Hal Davis

Hal Davis
Hydrologist

Enclosures - as cited

cc: Fred Bragdon, ABB - Orange Park, FL
Willard Murray, ABB -Wakefield, MA
Tom Trainor, ABB - Orange Park, FL
Greg Brown, ABB - Tallahassee, FL

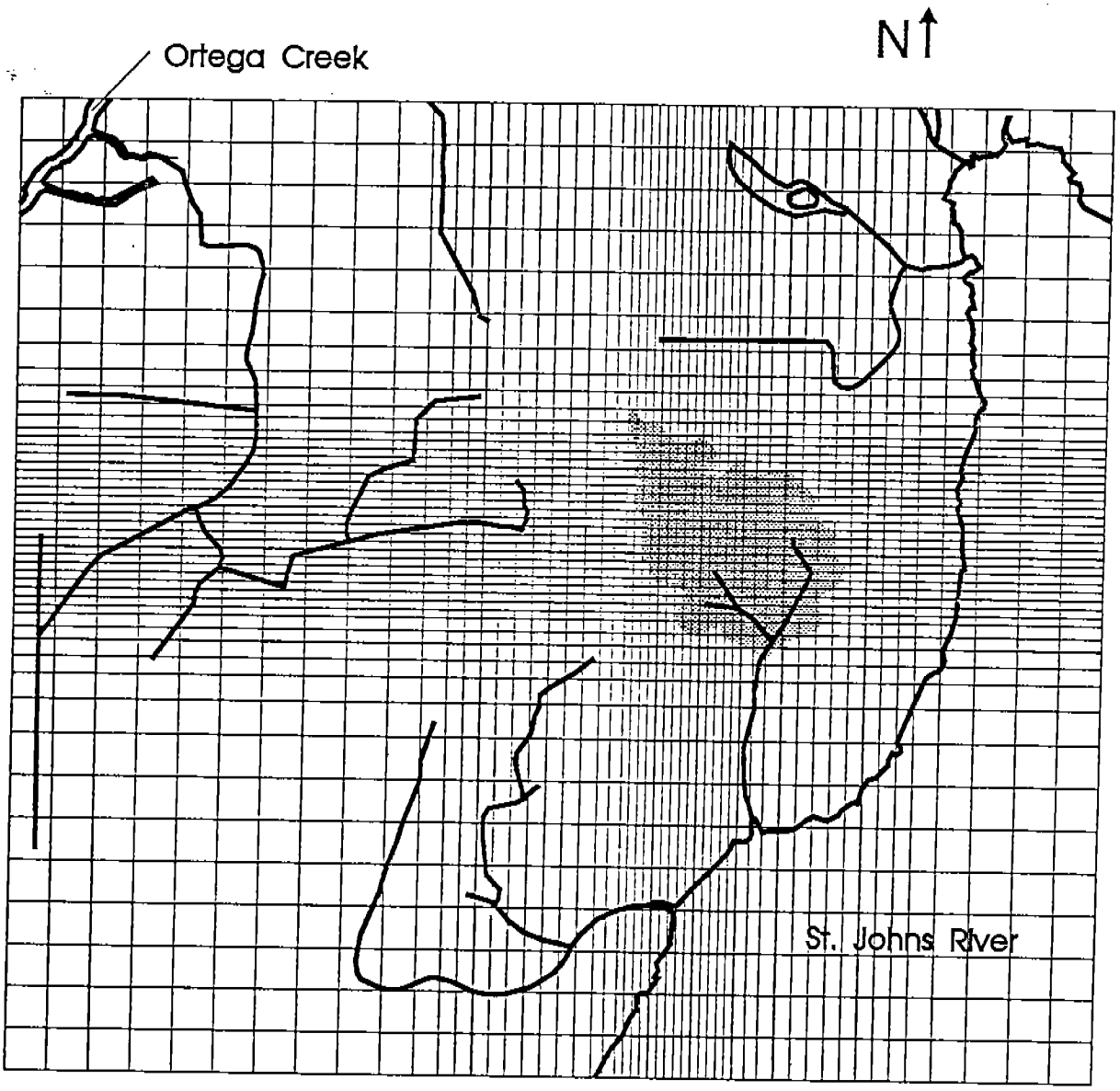

Figure 1. Model grid, area of contamination, and creeks draining the base.

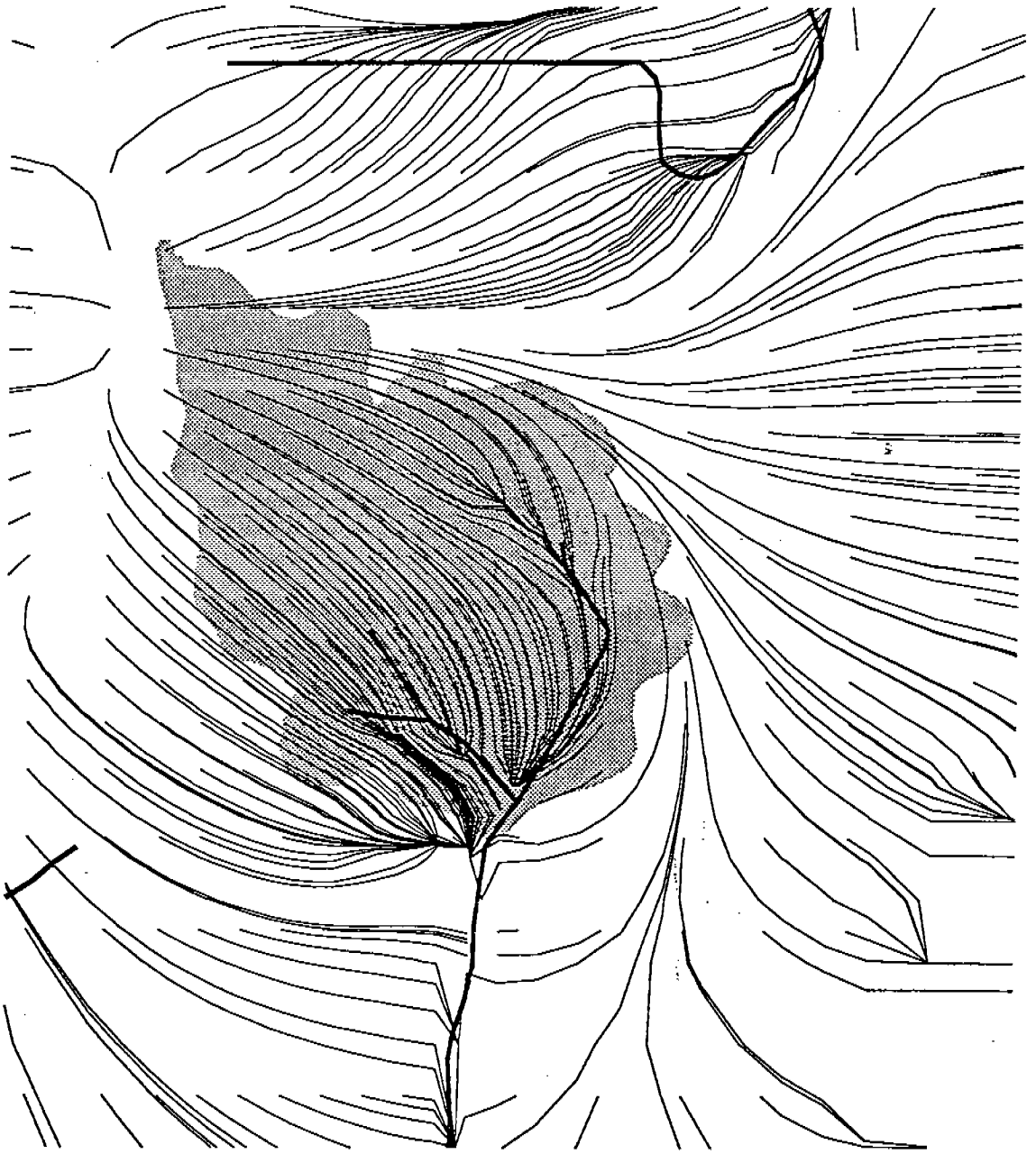

Figure 2. Ground-water pathlines and area of contamination at OU1.

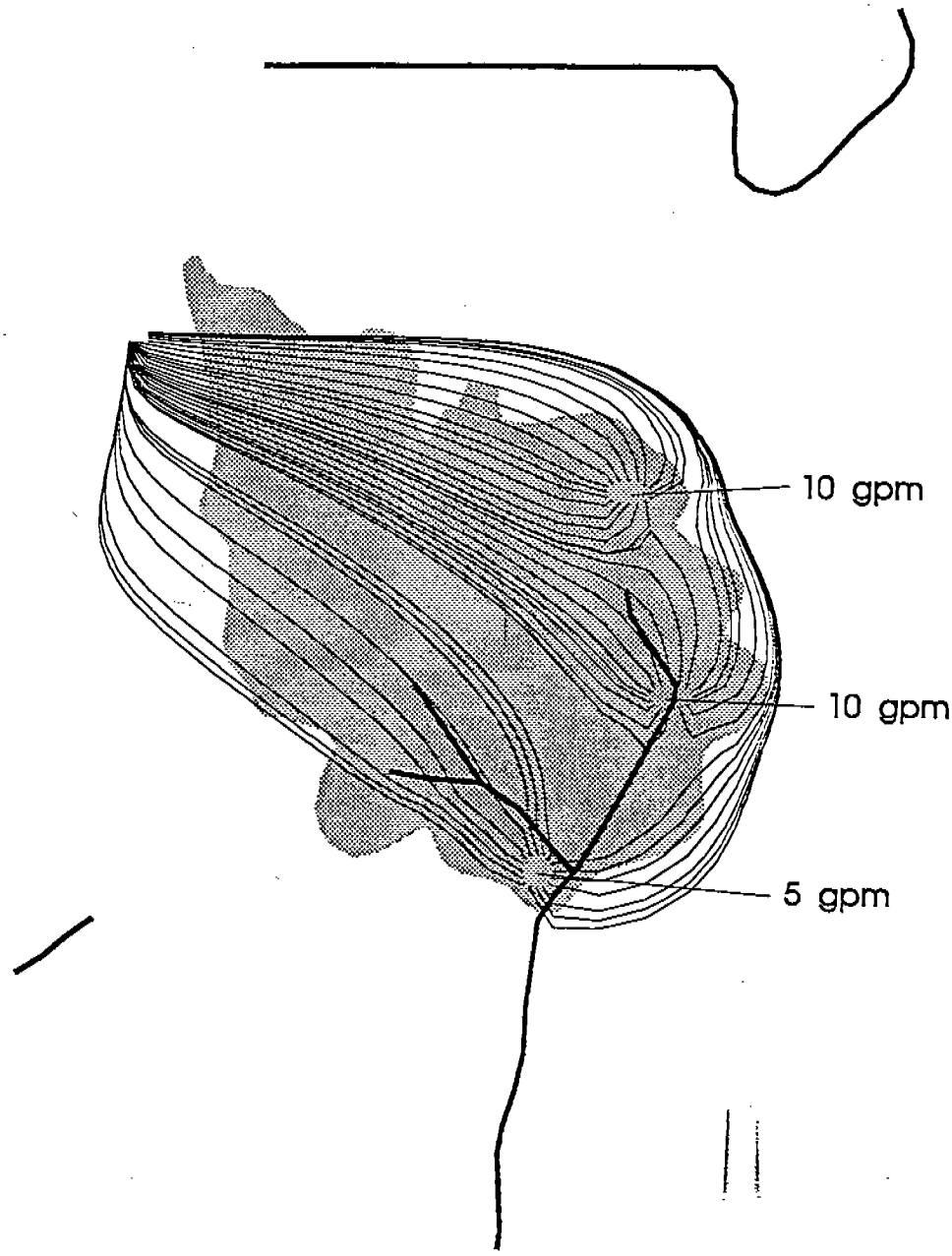

Figure 3. Ground-water flow paths to three pumping wells at OU1.

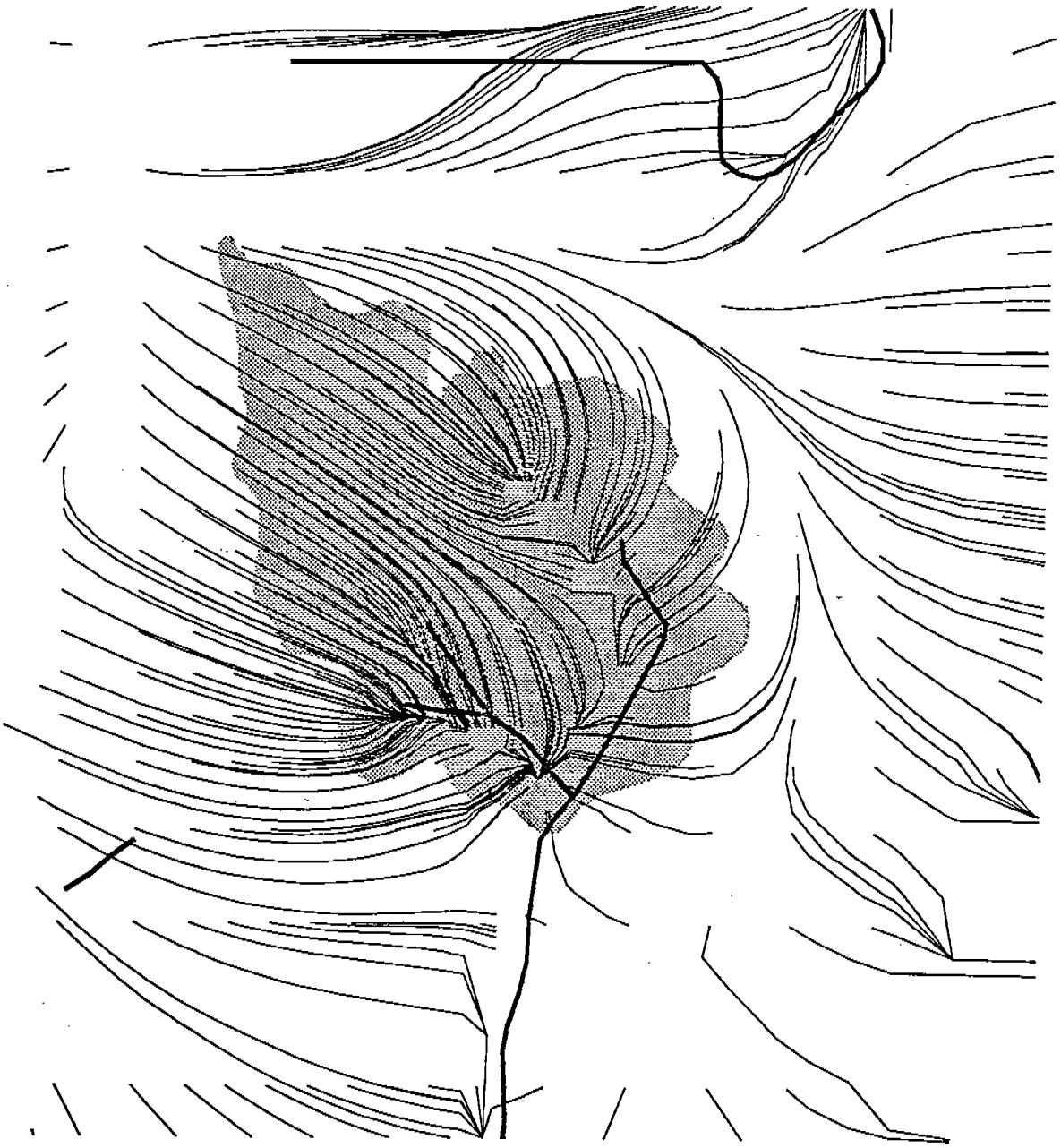

Figure 4. Ground-water flow paths to a drain field installed below the creeks.

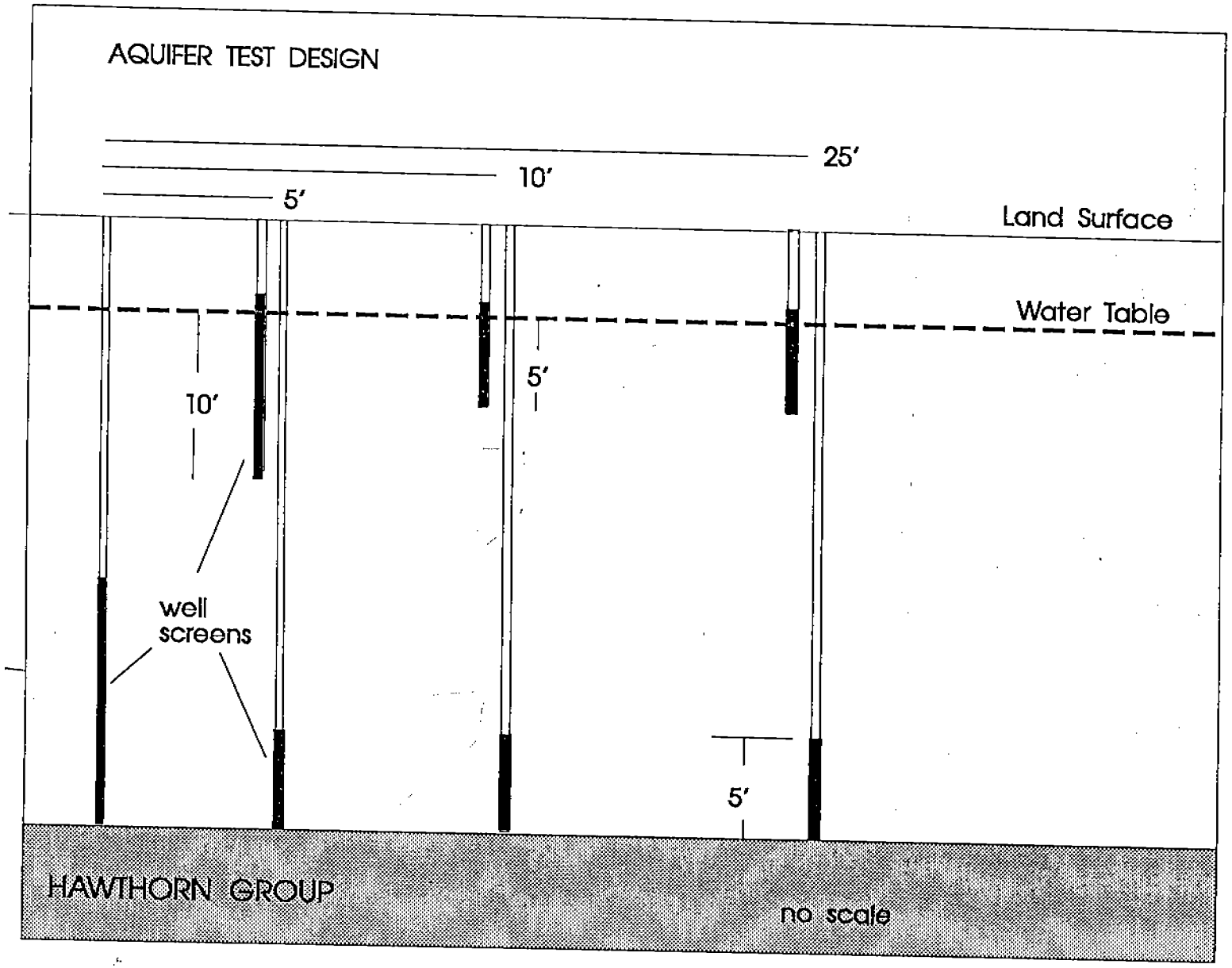

Figure 5. Diagram of aquifer test.