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MEMORANDUM SIMULATION OF EXCAVATION DEWATERING FOR CULVERT CONSTRUCTION AT SITE 12 NAB LITTLE CREEK VA

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Simulation of Excavation Dewatering for Culvert Construction at Little Creek Naval Amphibious Base, Site 12

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The three-dimensional groundwater flow model developed by Virginia Tech University for Site 12 has been applied to estimate the volume of groundwater pumping required to dewater an excavation for construction of a new culvert where Third Street crosses the drainage canal. Particle tracking was also used to determine whether the dewatering operation is likely to draw in contaminated groundwater from the Site 12 TCE plume.

The Site 12 groundwater flow model is constructed with six layers, 100 rows, and 80 columns of finite-difference cells to provide a three-dimensional representation in of flow in the unconfined surficial aquifer. Horizontally, the model cells are 20-foot squares. Vertically, they are arranged in layers having thicknesses ranging from 2.5 to 3 feet thick. This modeling grid is used to represent a homogeneous aquifer with a horizontal component of hydraulic conductivity of 130 feet per day and a vertical hydraulic conductivity component of 5 feet per day. These hydraulic parameters are based on an aquifer test performed at site 12 in the mid 1990s.

The excavation required for culvert construction was assumed to be 60 feet wide and 80 feet long. The water table under the excavation is expected to be lowered to an elevation of 1.65 feet below mean sea level (msl) by a system of temporary well points. This dewatering operation was simulated in the model by assigning 12 model cells at the culvert location as head-dependent sink cells using the MODFLOW "general head boundary" (GHB) option. The GHB cells, were assigned a fixed head of –1.65 feet msl, which is the target water table elevation for the dewatering operation in the excavation area. Flow to the cells is computed by the MODFLOW model using the following equation:

$$Q_{ghb} = C_{ghb} (H_{ghb} - h)$$

Where, Q_{ghb} = groundwater flow to the GHB cell
C_{ghb} = the assigned GHB conductance value
H_{ghb} = the fixed head assigned to the cell
h = the potentiometric head computed by the model for that cell

The intention in assigning GHB cell conductance values was to avoid any flow limitations to the excavation except those imposed by the aquifer itself. This was done by using conductances that were so high that increasing them further would not significantly change the computed rate of flow to the excavation.

The calibrated steady-state flow model was further modified for transient flow simulation by assigning values for the aquifer specific yield and specific storativity. The storativity controls the elastic storage properties of the aquifer, and the specific yield describes the storage and release of groundwater in the soil voids as the water table rises and falls. For this simulation, a specific

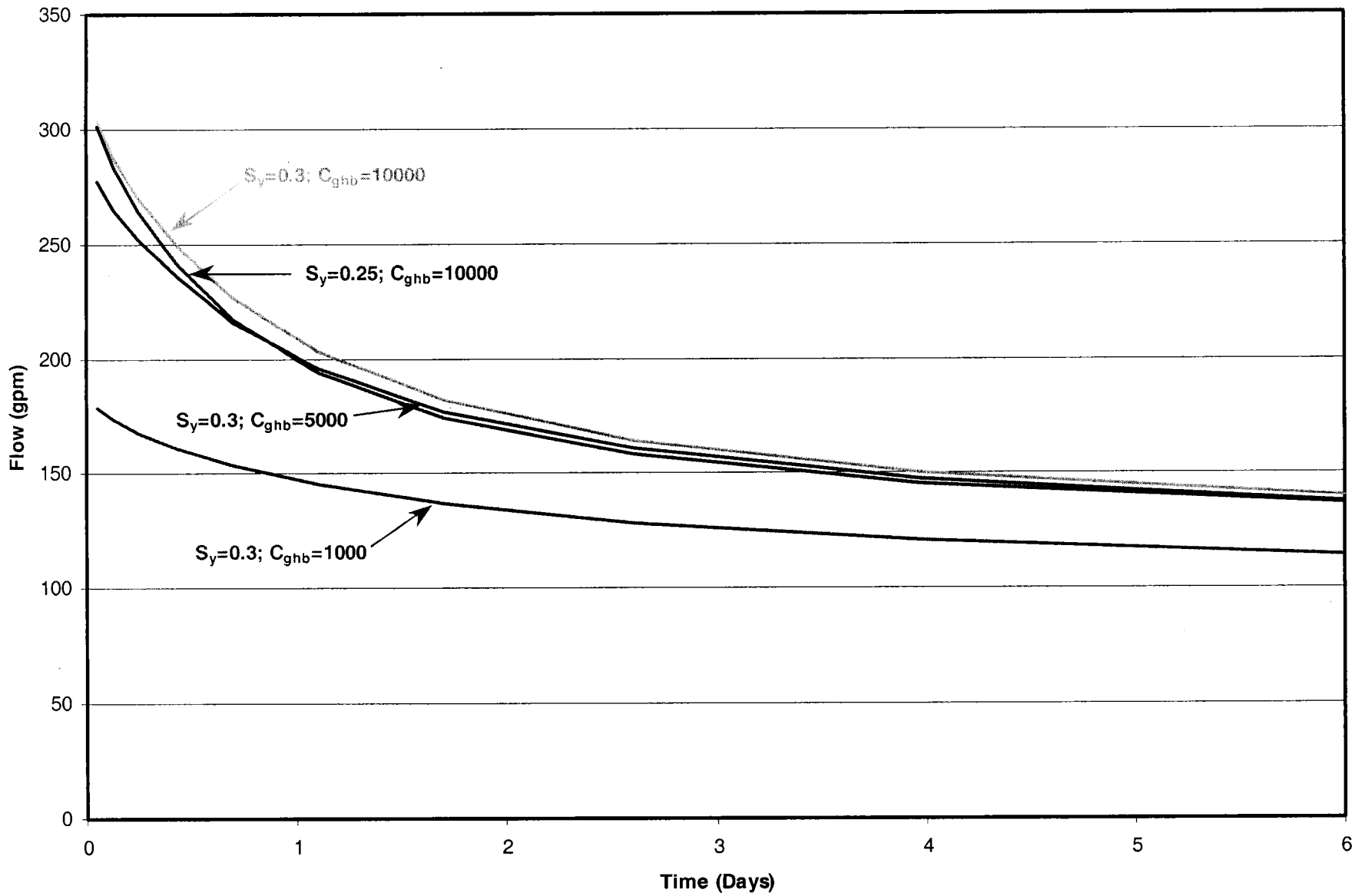
storativity of 0.0001 per foot was used. The specific yield was varied from 0.25 to 0.3 in separate model runs to investigate the sensitivity of the solution to this parameter.

The transient flow model was started from an initial condition corresponding to the calibrated steady-state solution. It was then run for 10 time steps covering a period of six days. A relatively small time step of approximately 75 minutes was used at the beginning of the simulation when rapid changes were expected as the flow field began to adjust to the start of dewatering. Subsequent time steps were increased in length using an expansion factor of 1.5.

Figure 1 shows the simulated variation of the dewatering flow rate with time for four different combinations of GHB cell conductance and specific yield. The simulation done with a GHB conductance of 1,000 square feet per day (ft^2/day) gave significantly lower flow rates than the others. This indicates that the conductance was too low and caused a hydraulic obstruction to flow entering the simulated excavation. Simulations done with GHB conductance values of 5,000 and 10,000 (ft^2/day) show very similar flow rates. This shows that a conductance of 10,000 (ft^2/day) is high enough to permit flow to the trench without any artificial limitation. Figure 1 also shows that the flow solution was not very sensitive to the value of specific yield used in the simulation.

In general, the modeling results shown in Figure 1 suggest that a pumping rate of 250 to 300 gallons per minute (gpm) may be required at the start of dewatering. This rate should decline to around 150 gpm in two to four days.

Figures 2 and 3 show the simulated water table elevations after about 1 day and 6 days of dewatering, respectively. They also show the simulated movement of particles injected into the aquifer near the downgradient end of the Site 12 TCE plume. The plume is presently believed to be captured by a leaking sanitary sewer, which is shown in figures 2 and 3 by a green line surrounded by green dots. Under normal flow conditions, the sewer controls the groundwater flow in this area , and contamination approaching from the east is captured by it. During dewatering, the drawdown caused by pumping will overshadow the hydraulic effects of the sewer line and cause some groundwater movement toward the excavation. The red lines shown in the figures on the west and south sides of the sewer are simulated particle traces showing the distance contaminated groundwater is expected to migrate during 6 days of excavation dewatering. The 6-day migration distances range from about 15 to 45 feet. Therefore, the excavation is not expected to pump contaminated groundwater. However, if the construction lasts much longer than 6 days, contamination could be drawn in.



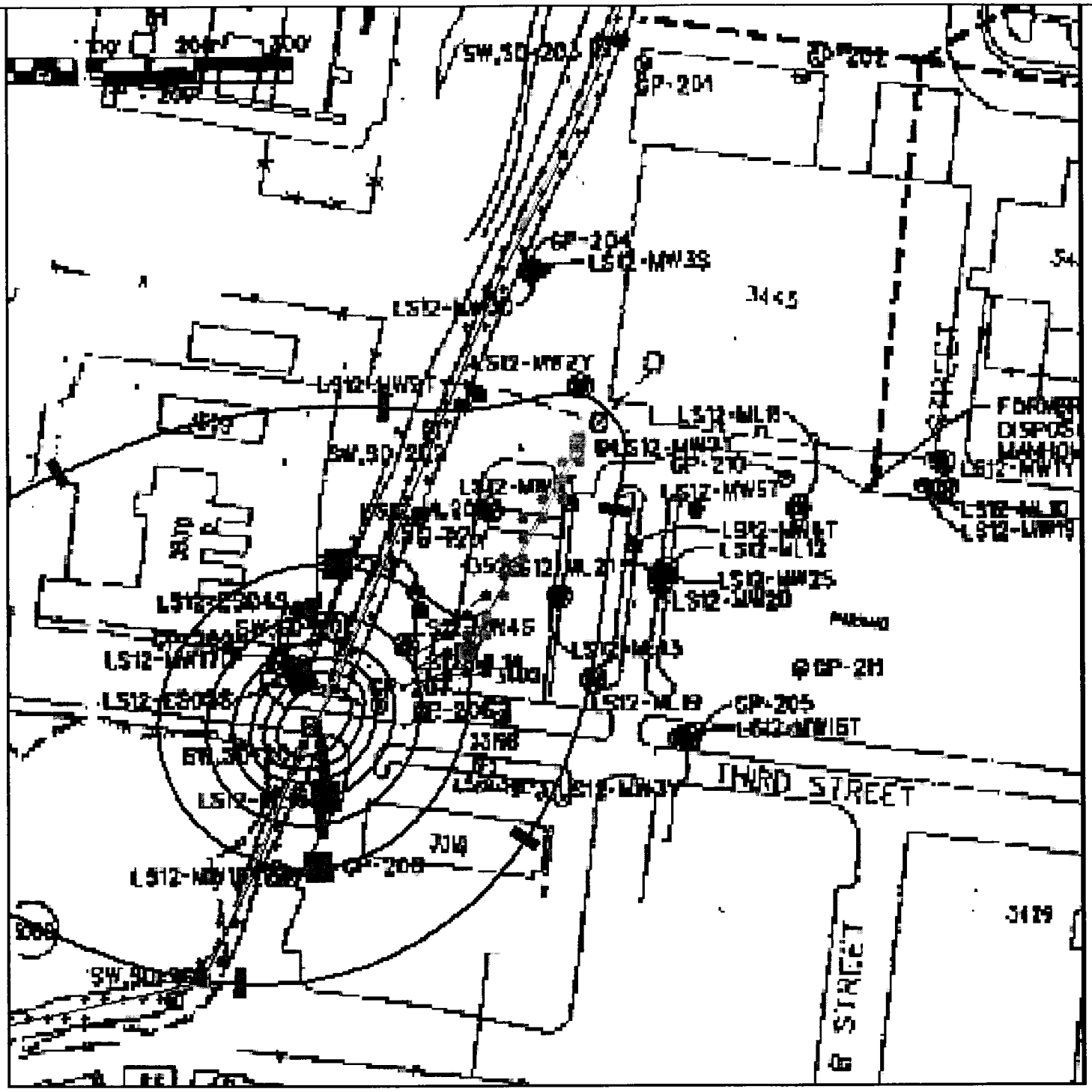
Notes

S_y = Aquifer Specific Yield

C_{ghb} = Fixed-Head Cell Conductance

Figure 1

Simulated Variation of Pumping Rate versus Time for Culvert Dewatering Operation Showing Sensitivity to Parameter Variations



N

0 50 100 200 300

Scale in Feet

Legend

- Water Table Elevation (Feet MSL)
- 6-Day Particle Track
- MODFLOW River Cell (Represents Canal)l
- MODFLOW Drain Cell (Represents Sewer)

Figure 2
Simulated Water Table After 1.1 Days of Dewatering

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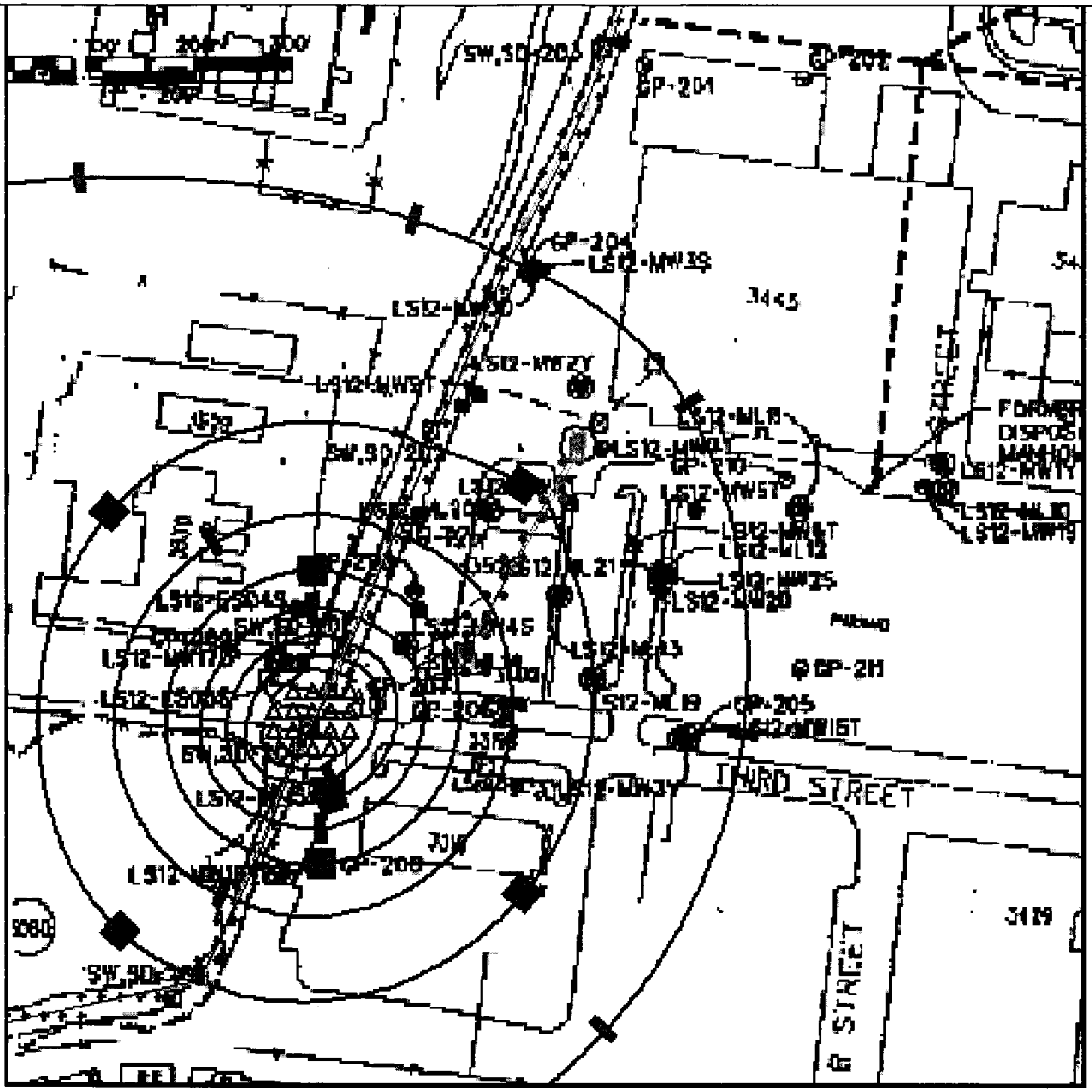

N

0 50 100 200 300

Scale in Feet

Legend

- Water Table Elevation (Feet MSL)
- 6-Day Particle Track
- MODFLOW River Cell (Represents Canal)l
- MODFLOW Drain Cell (Represents Sewer)
- Dry Cell in Top Model Layer

Figure 3
Simulated Water Table After 6 Days of Dewatering

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