Water Demand Simulation for a Houston Subdivision and Pumping Station

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Abstract

The Chasewood Pump Station / Residential Area in southwest Houston was selected for a detailed analysis of ground and surface storage water pumping by a University of Houston and City of Houston team. The recently improved KYPIPE2 computer simulation program from the University of Kentucky was utilized for the Chasewood Pump Station Area, Geographic Information System (G.I.S.) maps were also made for the pipe networks. Water pressures, flow rates, well fields and booster pumps were simulated for a variety of system conditions to study energy management alternatives.

Introduction

For the southwest Houston area, the Atlas- Geographic Information System (G.I.S.) provided a system map of water pipes 12 inches (30.48cm) or larger. The skeletonized G.I.S. water and freeway system is shown in Figure 1.

For the Chasewood residential area, various water pipes larger than four inches (10.16cm) and pipe length were obtained from water block maps. The skeletonized pipe network for the Chasewood area is shown in Figure 2. (Some of the sequential node numbers were omitted to avoid diagram clutter.) The Chasewood Pumping Station is in the middle of the pipe network and has two pumps simulated with three centrifugal pumps installed.

The recently improved KYPIPE2 computer simulation program from the University of Kentucky (Wood, 1988, 1992) was adopted for the initial Chasewood area pipe simulations.

Selected literature reviewed for the analyses and simulation included Ormsbee and Wood (1985), Zessler and Shamir (1989), Brion and Mays (1991), Chase and Ormsbee (1990), Helweg and Jacob (1991), Cullinane, Lansy and Mays (1992).

Conditions for the Simulation Program

For the Chasewood area, water demands of 250 gpcd and 2.6 persons per lot were applied for lot groupings and grouped area demands. Water usage was simulated in multiples such as two to four times the assumed average demands. From USGS topography maps for flat terrain, the pipe elevations were estimated at five feet below ground elevation. Roughness coefficients were initially assumed for asbestos cement pipe (100), cast iron pipes (110), and recent PVC pipe (140).

Pump Characteristics

Pump capacity is noted as the flow and head delivered by the pump at its maximum efficiency. The relationship between head and flow is represented by a head characteristic or performance curve. Three data points for head and discharge were specified for each pump. Two centrifugal pumps in parallel were placed at the pumping station node to simulate the pump station although three pumps were available.

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Take-off Points and Simulation Conditions

Around the pipe network, pipes extending to the next areas were cut-off and flows were simulated as take-off points. The total demand required by the service area was calculated. An estimated discharge of 3 mgd was assumed to be leaving the pump station. The difference in the pump station discharge and the demand was distributed among the take-off points proportional to the pipe diameters as a first approximation. The City of Houston specifies maximum pressure of 65 psi at the pump station or reservoir and minimum 35 psi in the residential service line to meet Texas standards.

Results

Table 1 contains the results obtained when the Chasewood area was simulated with fixed demands at take-off points and an elevated tank at 220 feet head at the pump station. Pressures were compiled at selected junction nodes (194 (pump station), 88, 1, 189, 287) for comparison. For 1 times the demand (1D), the pump station (194) had a pressure of 66.63 psi. Since this was simulated as a fixed grade node, the pressures were about the same for 2 times the demand (2D)(66.60 psi) at node 194 (pump station). Node 189, which was farther away, had the lowest pressure at 66.28 psi for 1D while the pressure dropped to 64.42 psi for 2D. For 1D, the net system inflow was 2087.09 gpm and equal to the net system demand with no net system outflow.

Table 2 contains the results for two reservoirs at two take-off points with a reservoir head of 160 feet rather than the 220 ft. head in Table 1. The pump station (194) pressure dropped from 66.63 psi for 1D in Table 1 to 40.18 psi in Table 2. The lowest pressure in Table 2 was at node 88 at 38.23 psi due to the supply arriving from the nearer reservoir (274) rather than from the pump station (194). The net system inflow and demand dropped from 2087.09 gpm to 1819.19 gpm due to the dropping of demand at the two take-off points with reservoirs. Other simulation trials were performed with one pump closed, with reservoirs at two and all take-off points, and with regulating valves in two pipes.

Future Studies

Future studies of the Chasewood and southwest Houston pipe networks will involve ground water pumping, energy computations and optimization considerations. The framework for pump stations and water distribution pipe analyses in southwest Houston has been established in this phase.

Appendix. References

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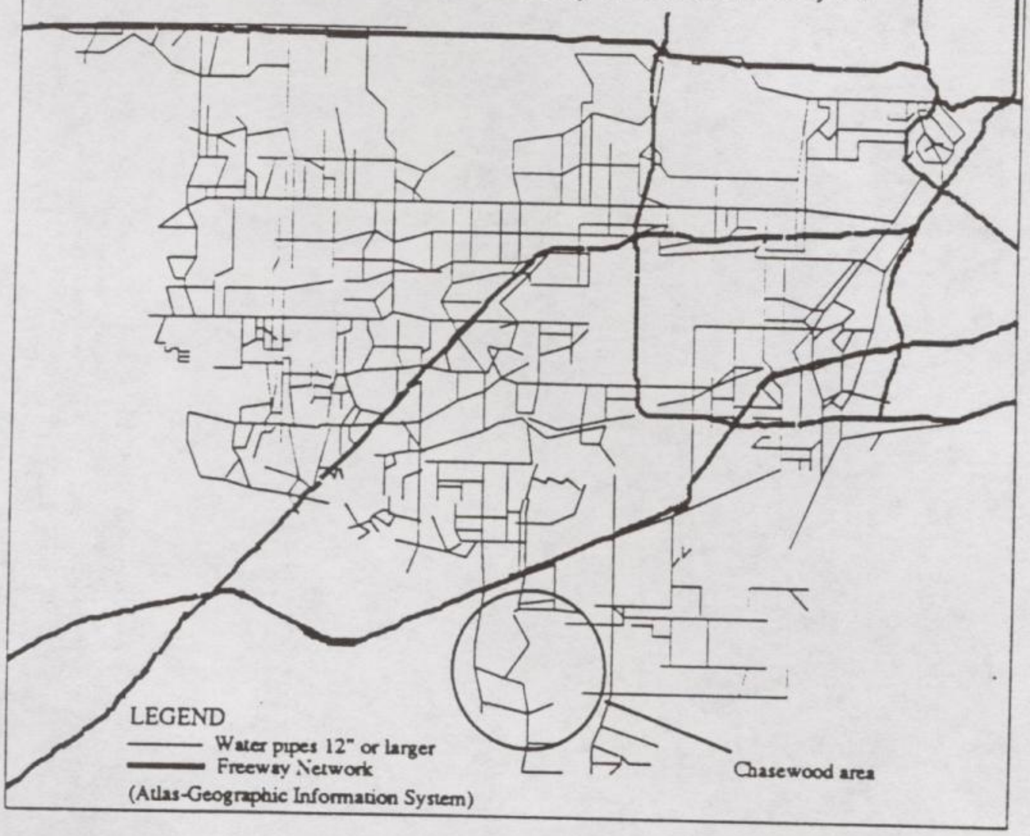
Figure 1. Southwest Houston Water Distribution System for City of Houston/University of Houston Analyses



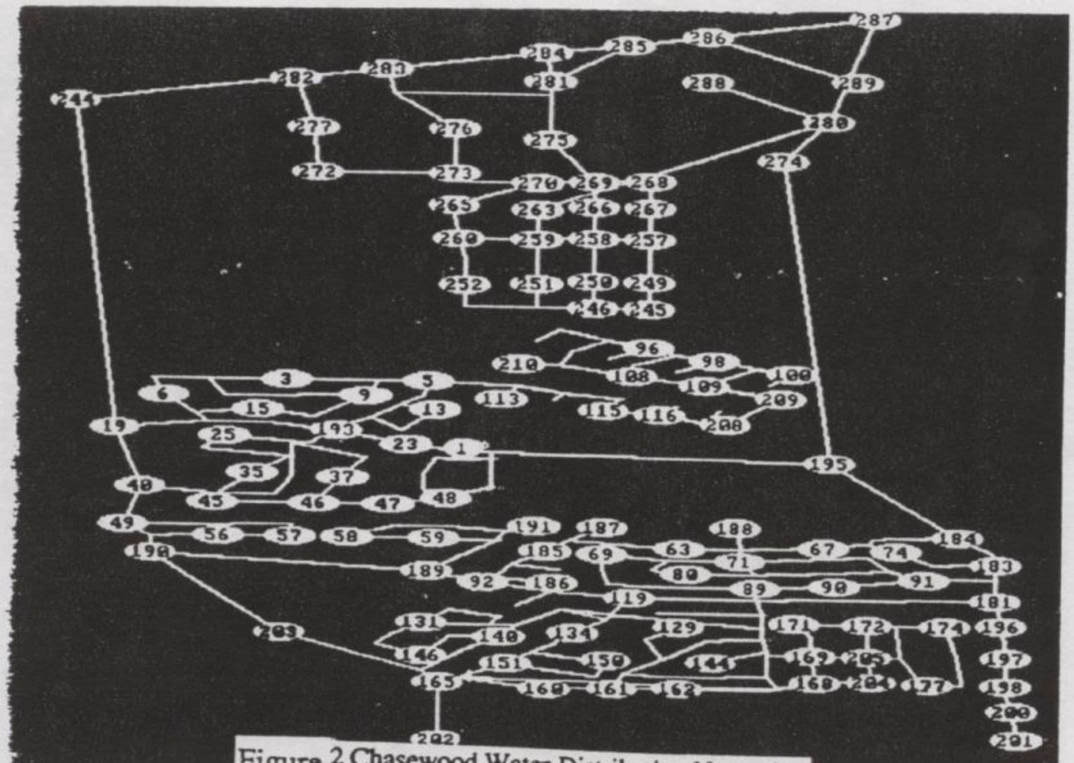


Figure 2 Chasewood Water Distribution Network