Section 4
Northwestern Georgia: Numerical Groundwater Flow Model

4.1 Modeling Approach

A numerical model of confined and unconfined Paleozoic rock aquifers in northwestern Georgia was developing using existing, available data on water levels and aquifer heads (the elevation to which water will rise in a well), aquifer properties, the spatial extents and folding of the aquifers, confining units, and the thickness of each stratigraphic unit (geologic subdivisions in the rocks), as well as estimates of average annual withdrawals and stream baseflow. The model was checked against available groundwater head data and streamflows in a qualitative manner, but there was generally insufficient data to develop a quantitatively calibrated model.

Model simulation results were compared against streamflow data and regional water level elevation data to determine whether simulated results were generally representative of observed field conditions. Transient (time variable) and steady state (equilibrium) simulations were conducted during model development and for the sustainable yield analysis. The area modeled covered several watersheds within the Valley and Ridge physiographic province in Floyd, Polk, Bartow and Paulding counties where the largest spatial extent of Knox Group outcrops. The study area is shown in **Figure S-3**.

A transient model simulation based on 2007 data was conducted to represent drought year conditions. Drought year conditions were used to assess sustainable yield. The model was used to help assess the sustainability of proposed or hypothesized groundwater withdrawals by simulating streamflow and drawdown impacts of the withdrawals and comparing to selected sustainability metrics as described in Section 2 and below.

4.2 Estimated Range of Sustainable Yield

For the northwestern Georgia model, the following sustainable yield criteria were used to estimate an upper and lower bound for sustainable yield of the Paleozoic rock aquifer in the study basin:

- Restrict the reduction in total streamflow and spring flow due to additional withdrawals to 10 percent of mean annual discharge. An upper bound yield can be estimated by limiting the drought year baseflow reduction to 10 percent of mean annual baseflow (higher withdrawals are possible because a greater decline in streamflow is allowed). A lower bound yield can be estimated by limiting the drought year baseflow reduction to 10 percent of drought year mean annual baseflow (lower withdrawals are possible because a smaller decline in streamflow is allowed). The allowable percentage reduction of 10 percent was set conservatively low because allowing a higher percentage would not have maintained opportunities for surface water use, and because the accuracy of the qualitatively calibrated model is not known.

- Restrict the reduction in total streamflow in any single stream and single spring due to additional withdrawals above current conditions to 15 percent of mean annual discharge under a drought year scenario.

- Restrict water table declines due to additional withdrawals above current conditions within the model area to less than 30 feet between pumping wells.

- Avoid drawing the water table down to within 10 feet of the top of a confined aquifer to avoid creating unconfined aquifer conditions.

A baseline no pumping simulation was completed for comparison with the simulations of hypothetical withdrawals. This was selected for the basis of comparison for the sustainable yield analysis because the number of existing pumping locations within the model area was generally small. Furthermore, the existing wells were not uniformly distributed and tended to be clustered near streams and rivers. Hypothetical groundwater withdrawals were simulated from uniformly distributed wells that were added to the model. The simulated withdrawals were divided evenly among the hypothetical wells and were held constant over time.

Figures S-4 and S-5 show hydrographs of simulated stream baseflow for the pumping and no-pumping conditions over a period of one year for the entire study area. According to the first sustainability metric, the drought year baseflow with pumping (solid red line) should not fall below the no-pumping baseflow (solid blue line) by more that 10 percent of mean annual baseflow (dashed blue line). This is further described below for each hydrograph.

Figure S-4 shows the results of the one year drought condition transient simulation for pumping at the upper limit of sustainable yield, estimated to be 70 mgd. There are three lines on the upper graph:

- Simulated stream baseflow during a drought year without groundwater withdrawals (solid blue line). Dry-year stream baseflow was simulated with no groundwater withdrawals and plotted as cubic feet per second (CFS) versus the day of the year.

- Drought year streamflow reduced by 10% of mean annual baseflow for a normal year of precipitation (dashed blue line). Simulated dry-year baseflow minus 10% of simulated average year baseflow was plotted as CFS versus the day of the year.

- Simulated stream baseflow with 70 mgd of pumping from the aquifer system (solid red line). Baseflow with groundwater withdrawals was simulated to fall within the envelope to determine the sustainable yield for an average year.

Figure S-5 shows the results of the one year dry condition transient simulation for pumping at the lower limit of sustainable yield, estimated to be 27 mgd. There are three lines on the lower graph:

- Simulated stream baseflow during a drought year without groundwater withdrawals (solid blue line). Dry-year stream baseflow was simulated with no groundwater withdrawals and plotted as cubic feet per second (CFS) versus the day of the year.
- More conservative – drought year streamflow reduced by 10% of mean annual baseflow for a drought year of precipitation (dashed blue line). Simulated dry-year baseflow minus 10% of simulated dry-year baseflow was plotted as CFS versus the day of the year.
- Simulated stream baseflow with 27 mgd of pumping from the aquifer system (solid red line). Baseflow with groundwater withdrawals was simulated to fall within the envelope to determine the sustainable yield for a dry year.

The fact that the simulated baseflow under pumping conditions (the red lines) approaches the upper and lower bounds of the allowable reduction in streamflow (the dashed blue lines) in the two graphs suggest that, based on the sustainable criteria selected, the range of sustainable yield falls somewhere between 27 mgd and 70 mgd. There is less baseflow and less groundwater recharge from surface water during a dry year than an average year, leading to the lower range of the sustainable yield.

Two other criteria must also be met to remain below the sustainable yield threshold:

- Drought year baseflow for any individual spring or stream should not be reduced by more than 15 percent of mean annual baseflow. Even at the maximum end of the range of sustainable yield (70 mgd), all of the simulated individual sub-watershed baseflows (used to represent spring flows in the model) declined by less than 15%.
- The water table decline (drawdown) due to withdrawals should not exceed 30 feet except in the immediate vicinity of a pumping well. Simulated areas of water table decline greater than 30 feet due to the evenly distributed 70 MGD withdrawals were negligible, so this metric did not affect the sustainable yield assessment.

In all cases during the northwest Georgia model runs, the streamflow sustainable yield metric was the only one encountered by the simulations.

In summary, model results indicate a range of sustainable yield of 27 to 70 MGD for the model domain. As indicated by the range, assessments of sustainable yield depend very significantly on the criteria selected. Sustainable yield will also depend on other factors, particularly the actual location and timing of withdrawals.