ESTIMATION OF FLOW MODEL

To evaluate the magnitude of vertical leakage between the Okefenokee Swamp and the underlying Floridan Aquifer, a linear, vertical hydraulic transfer model was hypothesized that relates water levels in the swamp to water levels in the underlying aquifer. Nine years (1985 to 1983) of mean monthly discharges in the Suwannee River at Fargo (USGS Station 02314500) were used as an index of swamp water levels. Coincident mean monthly water levels in the Floridan Aquifer were obtained from USGS Well 304942072213801-27E004 located in Stephen Foster Park near the center of the swamp.

A unit response function was estimated using regression deconvolution of the swamp and aquifer time series. Convolution is a concept widely used in hydrologic modeling to relate an input time series (in this case the water level in the swamp, x) to an output time series (i.e., the water level in the aquifer, y). The convolution summation was written in the form:

$$y(t) = y_o + \sum_{\tau=0}^{n} u(\tau)\, x(t-\tau) \qquad (1)$$

where $u(\tau)$ is the impulse response function. The step response function, $U(\tau)$ is the cumulative sum of the input response function, and is found using (Carslaw and Jaeger, 1959, Equation 3.3.8):

$$U(\tau) = \frac{4}{\pi} \sum_{j=1,3,5,\ldots}^{\infty} \frac{(-1)^{(j-1)/2}}{j} \exp(-j^2\pi^2 v) \qquad (2)$$

and $v = \tau D_z/4L^2$ is a dimensionless diffusivity coefficient that incorporates the vertical hydraulic diffusivity, D_z, the lag, τ, between the impulse and response and the thickness of the aquitard. For the nine years of record, an average response lag of one month was found between swamp and aquifer water levels, with swamp water levels leading aquifer water levels. Most of the water level perturbations within the swamp were due to variations in seasonal evapotranspiration losses and precipitation inputs. These perturbations were also observed in the underlying aquifer, only lagged by approximately one month. Figure 1 presents the estimated impulse response function for the period of record. The vertical hydraulic diffusivity coefficient that best matches the response function was found to be $D_z = 3.83 \times 10^{-3}\ m^2\ s^{-1}$.

Determining vertical flow rates requires that the vertical hydraulic conductivity be estimated. The one-dimensional vertical hydraulic diffusivity coefficient for the aquitard is the ratio of the vertical hydraulic conductivity, K_z, to the vertical specific storage coefficient, S_s, within the aquitard:

$$D_z = K_z / S_s \qquad (3)$$

Equation (3) can be used to estimate the hydraulic conductivity if the specific storage is known. A sensitivity analysis was used to estimate the hydraulic conductivity by varying the specific storage over two orders of magnitude. The estimates of specific storage range from 10^{-3} to 10^{-5} for plastic clay and medium-hard clay, respectively. Using this range results in hydraulic conductivity estimates of 3.83×10^{-6} to 3.83×10^{-8} m s^{-1}. The vertical flow rate between the swamp and aquifer is calculated using Darcy's law assuming a total head difference of 14 meters and an aquitard thickness of 140 m. The flow rate was found to range from 0.12 to 12 m yr^{-1} for the low and high storage coefficients, respectively. An intermediate value of 1.2 m yr^{-1} is a likely estimate for the regional loss of water from the swamp to the underlying Floridan Aquifer.

LITERATURE CITED

Carslaw, H.S. and J.C. Yaeger, 1959. Conduction of Heat in Solids, Second Edition, Clarendon Press.

Yu, Keun Bai, 1986. The Hydrology of the Okefenokee Swamp Watershed with Emphasis on Groundwater Flow, Ph.D. Dissertation, The University of Georgia.

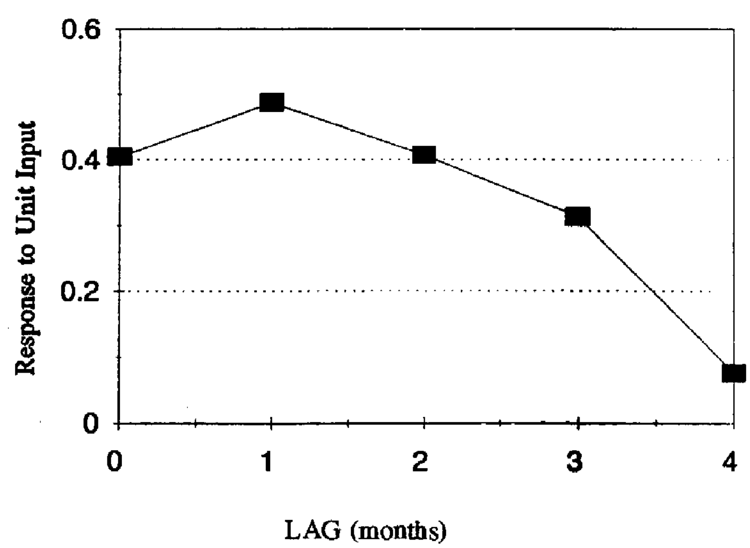

Figure 1. Estimated response in the Floridan Aquifer to a unit change in Okefenokee Swamp water levels.