HYDRAULIC EVIDENCE FOR VERTICAL FLOW FROM OKEFENOKEE SWAMP TO THE UNDERLYING FLORIDAN AQUIFER IN SOUTHEAST GEORGIA

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Abstract. A rapid response is observed between water level fluctuations in the Okefenokee Swamp and water levels in the underlying Floridan Aquifer. A lag of approximately one month is common, and a hydraulic diffusivity of 3.83 x 10^{-3} m^2 s^{-1} best matches the calculated aquifer response to the swamp water level perturbations. The magnitude of leakage between the swamp and the aquifer is uncertain because of a lack of knowledge about the specific storage coefficient in the aquitard separating the swamp and the aquifer which has not been explicitly measured. An intermediate value of specific storage within the likely range of values results in a downward vertical flow of 1.2 meters of water per year. This induced recharge can significantly alter the natural water balance within the swamp. Such a large loss of water from the swamp may be responsible for observed pH and water level changes, and increased heavy metal accumulations in aquatic organisms in the swamp.

INTRODUCTION

The Okefenokee Swamp is situated near several large pumping nodes along the southeastern coast of Georgia. Groundwater extraction from the Brunswick and St. Marys regions have caused a substantial lowering of the piezometric surface in the Floridan aquifer which serves as the source of water for municipal and industrial water demands. Long-term water-level declines in the Okefenokee Swamp have generally been attributed to the exclusion of fire, which is assumed to have caused a substantial increase in forested areas and associated evapotranspiration losses. The fire-exclusion hypothesis has recently lost credibility because significant areas of the swamp burned during the late-1980s and early-1990s with no concomitant rise in water levels. In addition to decreased water levels in the swamp, a substantial lowering of swamp pH, increases in lead and mercury contamination in fish, and a reduction in fish numbers and species have recently been noted.

Vertical flow from the swamp to the aquifer has previously been discounted for two reasons: A lack of a geochemical signature that indicates discharge of calcium-rich aquifer water to the swamp; and the assumption that the intervening aquitard has a low leakance (Yu, 1986). Both of these reasons can be easily rebutted. While the first reason indicates that aquifer water is not flowing upward into the swamp, it can not be used to prove the absence of downward flow from the swamp to the aquifer. In fact, isotopic evidence suggests that groundwater in the aquifer below the swamp is different from groundwater in the same aquifer away from the swamp. Also, water levels in the swamp are higher than in the aquifer, indicating that the direction of movement must be downward; the only issue to be resolved being the magnitude of the downward flux.

The second reason can be discounted because aquitard hydraulic properties have not been estimated in the swamp. Regional estimates based on values from other areas are extrapolated under the swamp and lack sufficient accuracy to exclude the possibility that higher flow rates through the aquitard may be present. Another line of evidence that suggests rapid interaction between the Floridan aquifer and Okefenokee Swamp lies in age-dates of basal peat deposits in the swamp. The ages of basal peats appear to be less than 10,000 years, indicating that a riverine system was present prior to that time. A plausible explanation for the existence of the riverine system is the global lowering of sea levels during the ice ages that induced a regional lowering of the potentiometric surface in the Floridan aquifer. A substantial lowering of the water levels in the Floridan aquifer can cause a lowering of the swamp potentiometric surface only if substantial flow through the intervening aquitard can occur.

Lowering of water levels within the swamp can alter the chemistry of the swamp by introducing oxygen into swamp sediments. Increasing pE results in the biological conversion of reduced forms of sulfur to sulfuric acid, causing a substantial reduction in pH, which is what has been observed. A change in pE and pH can also result in the formation of soluble forms of heavy metals, including lead and mercury, which has also been noted. Thus, many of the environmental problems associated with the Okefenokee Swamp can be attributed to aquifer dewatering if a hydraulic connection can be established between the swamp and the underlying aquifer.