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Impact of land use change on the hydrology of the Green Swamp

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Problem: The impacts of existing and planned future human development on the hydrology of the Green Swamp are poorly known. However, quantification of these impacts is critical to prudent land management in this area of diverse ecosystems and hydrologic importance.

Background: The Green Swamp is a largely undeveloped mosaic of cypress domes, hardwood forests, pine forests, prairies, and sandhills in central Florida. The Swamp occupies about 870 square miles in five Florida Counties - Polk, Sumter, Lake, Hernando, and Pasco. Land surface elevations vary between 75 and 200 feet. The Green Swamp is vitally important to both surface and ground water resources in central Florida and is a rich reservoir of biological diversity. The Swamp includes the headwaters of several important rivers including the Ocklawaha, Withlacoochee, Little Withlacoochee, Hillsborough, and Peace. The Swamp is also the “headwaters” of much of the ground water flow system in central Florida as the highest potentiometric levels of the Floridan aquifer in peninsular Florida occur within this area. Substantial recharge of the Floridan aquifer occurs within the Swamp and Floridan aquifer water moves laterally from the Swamp to supply downgradient parts of the aquifer in other parts of central Florida. Proposals have been made to further develop (sand mines, urban centers, etc.) within the Swamp; however, the impact of this development on the water resources of the Swamp and surrounding “downstream” areas has not been fully explored. Possible hydrologic impacts from development includes changes in the magnitude and timing of streamflow and changes in aquifer recharge. These possible hydrologic changes will likely produce associated changes in the viability of the Green Swamp ecosystem.

Objective: Develop a quantitative tool capable of adequately simulating the impact of proposed land use changes on the hydrology of the Green Swamp and adjacent parts of central Florida.

Methods: The primary tool for addressing the impact of land use changes on the hydrology of central Florida will be a quantitative (numerical/computer) hydrologic flow model. The model will be calibrated over an historical period based on an adequate transient simulation of streamflows and ground water levels within the Green Swamp area. The calibrated model will then be applied in predictive mode to evaluate the impact of proposed land use changes (e.g., sand mines). Perhaps the primary means by which land use change will impact hydrology is through a change in evapotranspiration. Evapotranspiration returns most (about 75 percent) of Florida's rainfall to the atmosphere; however, large land cover-based variations in evapotranspiration exist, with evapotranspiration ranging from about 25 inches per year for deep water table sand hills up to 60 inches per year for open-water bodies. Therefore, land use changes can produce changes in water availability through the associated change in evapotranspiration. The predictive hydrologic model will be executed using stochastic atmospheric forcing (rainfall and evapotranspiration) because of the future uncertainty of these hydrologic terms. Such a stochastic predictive model will incorporate a wide range of possibilities in atmospheric forcing allowing robust anticipation of the range of hydrologic impacts resulting from the proposed land use changes. For example, the impact of a forested wetland-to-sand mine land use conversion on streamflow might be slight under an "average" rainfall year, but extreme during a "dry" year.

The integrated hydrologic simulation tool chosen for this investigation is the USGS GSFLOW model. GSFLOW is described (http://water.usgs.gov/nrp/gwsoftware/gsflow/Summary_gsflow.txt) as "a coupled Groundwater and Surface-water FLOW model based on the integration of the U.S. Geological Survey Precipitation-Runoff Modeling System (PRMS, Leavesley and others, 1983) and the U.S. Geological Survey Modular Groundwater Flow Model (MODFLOW-2005, Harbaugh, 2005). … GSFLOW was developed to simulate coupled groundwater/surface-water flow in one or more watersheds by simultaneously simulating flow across the land surface, within subsurface saturated and unsaturated materials, and within streams and lakes. … GSFLOW can be used to evaluate the effects of such factors as land-use change, climate variability, and groundwater withdrawals on surface and subsurface flow. The model incorporates well documented methods for simulating runoff and infiltration from precipitation; balancing energy and mass budgets of the plant canopy, snowpack, and soil zone; and simulating the interaction of surface water with ground water, in watersheds that range from a few square kilometers to several thousand square kilometers, and for time periods that range from months to several decades. An important aspect of GSFLOW is its ability to conserve water mass and to provide comprehensive water budgets."

Products: A USGS Scientific Investigations Report (SIR) documenting the calibration and application of the integrated ground water/surface water hydrologic flow model. The flow model will be available for future scenario applications not identified within the initial investigation.

Funding and timeframe: To be determined based on discussions between possible funding partners including the USGS, SWFWMD, SJRWMD, Lake County Water Authority (LCWA) and others.