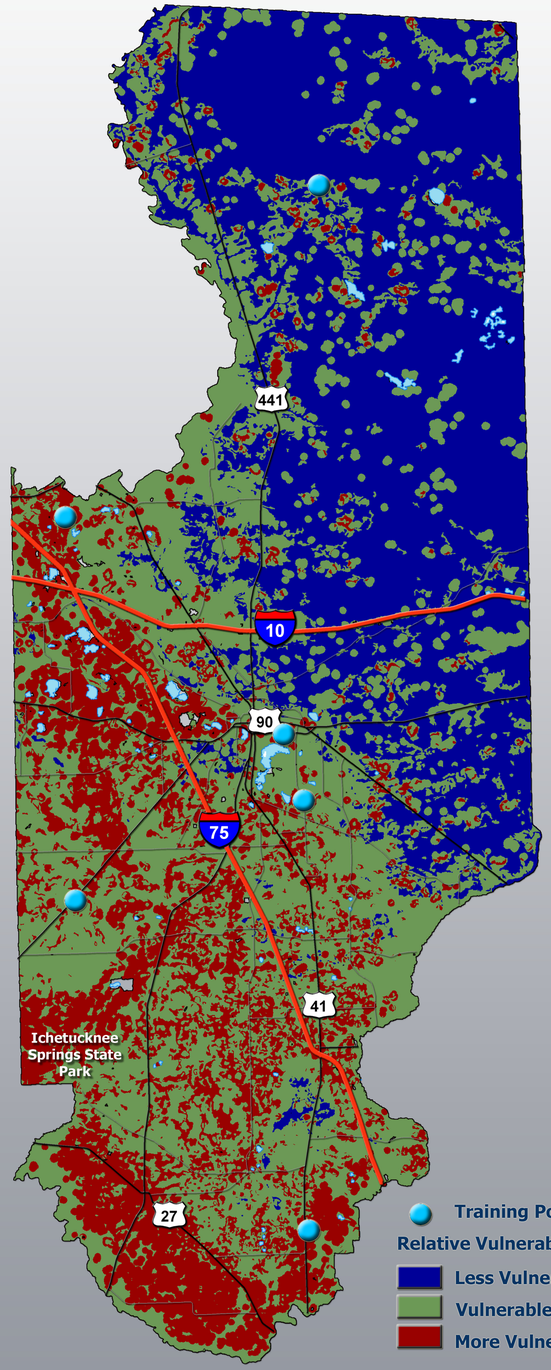
Columbia County Aquifer Vulnerability Assessment
A Groundwater Protection and Management Tool



INTRODUCTION

The Floridan aquifer system is the most important and prolific source of freshwater in Columbia County. According to the United States Geological Survey (USGS) groundwater use from the Floridan aquifer system in Columbia County is estimated at 12.28 million gallons of water per day for public supply, agriculture, and other uses. All of Columbia County's 65,000 residents (Bureau of Economic and Business Research, University of Florida, 2007) rely to some degree on the Floridan aquifer system (FAS) for their fresh water needs.

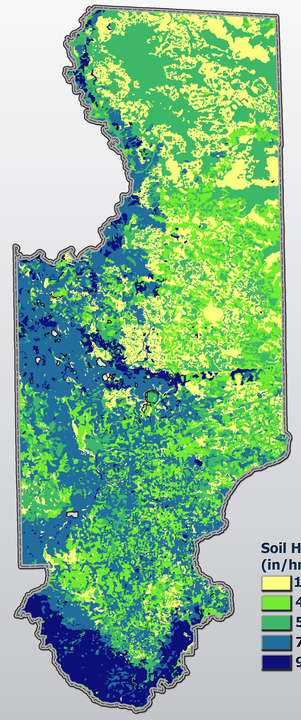
Columbia County, which lies mainly within the Northern Highland province, is underlain by thick and highly permeable carbonate rocks which comprise the Floridan aquifer system. These carbonate rocks consist of the Suwannee and Ocala limestones. The extreme southern end of the county transitions into the Gulf Coastal Lowlands and corresponds with a significant elevation break at the cody scarp (Meyer, 1962). Sediments overlying this aquifer system vary from very thick in the northern part of the county to thin or absent and breached by sinkholes as you progress southward across the county. Karst features are prominent throughout the study area, however, they are more abundant as you move from northeast to southwest within the county, reaching a peak as you approach the Santa Fe River. These features include sinkholes, swallets, and springs such as the Ichetucknee Springs Group, Columbia Spring, Santa Fe Spring and many others (Scott et al., 2004).

Identifying areas of Columbia County where the Floridan aquifer system is more vulnerable to contamination from activities at land surface is a critical component of a comprehensive groundwater management program. Protection of the Floridan aquifer system is an important measure to take in helping ensure viable, fresh water is available from the Floridan aquifer system for continued future use in Columbia County. Aquifer vulnerability modeling allows for a pro-active approach to protection of aquifer systems, which can save significant time and increase the value of protection efforts.

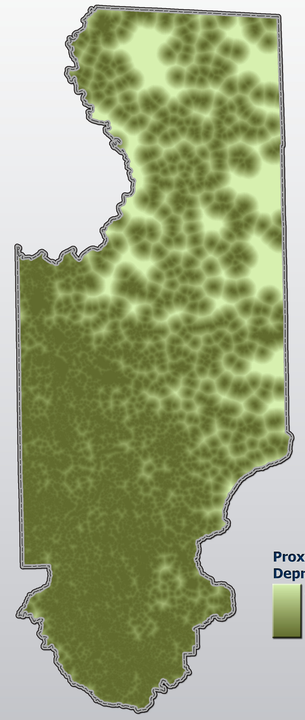
APPROACH

The primary purpose of the Columbia County Aquifer Vulnerability Assessment, or CCAVA, is to provide a science-based, water-resource management tool that can be used to help minimize adverse impacts on groundwater quality, including focused protection of sensitive areas such as springsheds and groundwater recharge areas. The modeling process used for the CCAVA project is "weights of evidence" and is based in a geographic information system (GIS). The main benefits of applying this technique to the CCAVA project is that it is data-driven, rather than expert-driven, and model output is dependent upon training site datasets which produce self-validated model output. For CCAVA, training sites are groundwater wells with water quality indicative of a good connection between the aquifer and land surface, or simply, aquifer vulnerability.

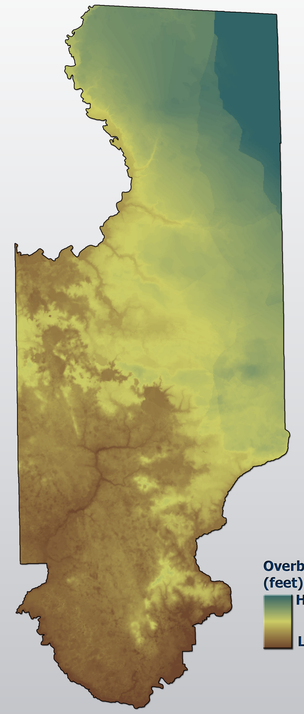
Model generation is accomplished by associating training site locations with data layers representing natural conditions which control aquifer vulnerability. Data layers used for the CCAVA project are described in the adjacent section and include potential karst features, aquifer confinement or overburden, and soil hydraulic conductivity. The model helps determine which areas of each data layer share a greater association with aquifer vulnerability based on the location of the training sites, and then combine them in a map as shown to the left. The CCAVA model output map indicates that the areas of highest vulnerability are associated with relatively thin to absent sediments overlying the Floridan aquifer, close proximity to potential karst features and higher soil hydraulic conductivity.



Soil Hydraulic Conductivity (in/hr)
1.30 - 4.94
4.94 - 5.83
5.83 - 7.67
7.67 - 9.84
9.84 - 27.97



Proximity to Closed Depressions (meters)
3,000+
30



Overburden Thickness (feet)
High: 300+
Low: 0

Soil Hydraulic Conductivity Theme

The rate that water moves through soil is a critical component of any aquifer vulnerability analysis, as soil is an aquifer system's first line of defense against potential contamination. Soil hydraulic conductivity is the "amount of water that would move vertically through a unit area of saturated soil in unit time under unit hydraulic gradient" (U.S. Department of Agriculture, 2005). In 2006, Columbia County soils data were redesigned for the study area by the Natural Resources Conservation Service. As a result, more detailed information is available for analysis for the CCAVA project than during previous projects.

Potential Karst Feature Theme

Karst features, or sinkholes and depressions, can provide preferential pathways for movement of groundwater into the underlying Floridan aquifer system and increase an area's aquifer vulnerability where present. The closer an area is to a karst feature, the more vulnerable it may be considered. Karst features tend to be generally circular in nature (in contrast to non-karstic depressional features which may not be circular) and can be identified and extracted from a digital elevation model based on this characteristic. These resulting effective karst features can be buffered into 30 meter zones to allow for a proximity analysis.

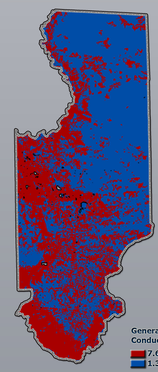
Aquifer Confinement Thickness or Overburden

Aquifer confinement is an estimate or measure of how well buried or 'covered' an aquifer system is. Where this confinement is thick and continuous and the Floridan aquifer system is deeply buried, as in the northern part of Columbia County, aquifer vulnerability is generally lower. On the other hand, in areas of the county where aquifer confinement is thin to absent or breached by sinkholes, the vulnerability of the underlying aquifer is generally higher, primarily because it is present at or near the land surface. This occurs in the south and southwestern areas of the county.

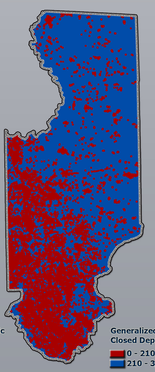
Generalization of Input Data

The modeling process involves generalizing input layers to evaluate which areas of each data layer share a greater association with locations of training sites, or, simply, aquifer vulnerability. Essentially, this process helps to determine the threshold or thresholds that maximize the spatial association between the patterns in the input data layers and the training sites pattern. For the CCAVA project, a binary break was typically defined by the modeling analysis for each data layer which creates two spatial categories: one with stronger association with the training points and one with weaker association.

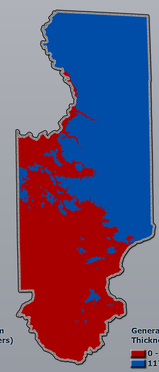
Soil hydraulic conductivity ranges from 1.30 to 27.97 inches per hour (in/hr) across the study area. Modeling indicated that areas underlain by conductivity ranges between 27.97 to 7.66 in/hr were more associated with higher aquifer vulnerability. The overburden thickness ranges from absent to just over 300 feet thick across the study area, and the analysis revealed that areas underlain by less than 117 feet of overburden were more associated with higher aquifer vulnerability. Finally, the analysis indicated that areas within 210 meters of a karst feature were more associated with higher aquifer vulnerability. These generalized themes are used to generate the final model output as shown above.



Generalized Soil Hydraulic Conductivity (in/hr)
7.66 - 27.97
1.30 - 7.66



Generalized Distance from Closed Depressions (meters)
0 - 210
210 - 3,000



Generalized Overburden Thickness (feet)
0 - 117
117 - 304

Map developed for Suwannee River Water Management District per SRWMD Project No. 08/09-057 by Advanced GeoSpatial Inc.: www.adgeo.net
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