Groundwater Study in South Florida
(Conceptual Model Setup for Hardee, DeSoto, and Highlands Counties)

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Introduction

Groundwater is the main source of water supply in Florida, which is at risk due to the high demands on available water, and the high levels of nutrients flowing into the water system. Therefore, it is important to protect the groundwater resources. As the demand for water in the county increases, additional data and study about local groundwater resources is needed to manage and develop the water supply effectively. To address this need, a study is being conducted to evaluate the hydrogeology and groundwater quality of three counties of Desoto, Hardee and Highlands (Figure 1).

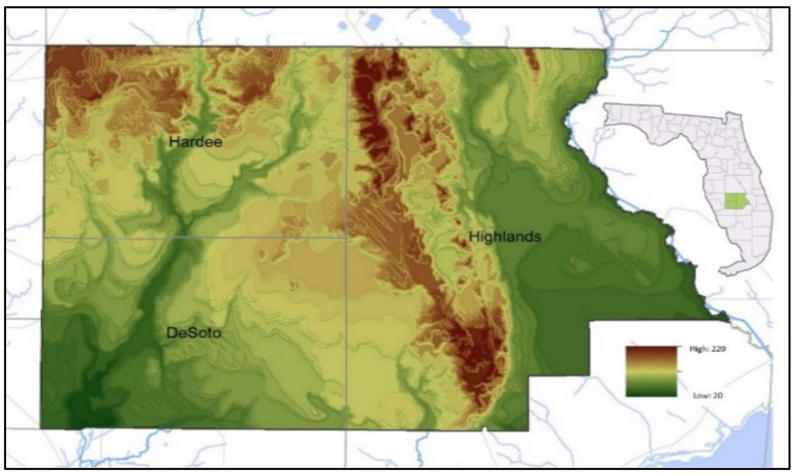

Figure 1. Topography of the Study area (Hardee, De Soto, and Highlands Counties)

Data used in this study are derived from the publications, documents, and files of the USGS, South Florida Water Management District (SFWMD), Southwest Florida Water Management District (SWFWMD), Florida Geological Survey (FGS), Florida Department of Environmental Protection (FDEP), and the reports prepared by private consultants.

Water level and quality Data collection

Water-level data from a network of wells distributed across Highlands and adjacent counties were used to construct generalized potentiometric surface maps of the Upper Floridan aquifer (Figure 2). Potentiometric surface maps of the Upper Floridan aquifer in northern and central Florida are published semiannually by the USGS in cooperation with the SFWMD, SJRWMD, SWFWMD, and other local agencies.

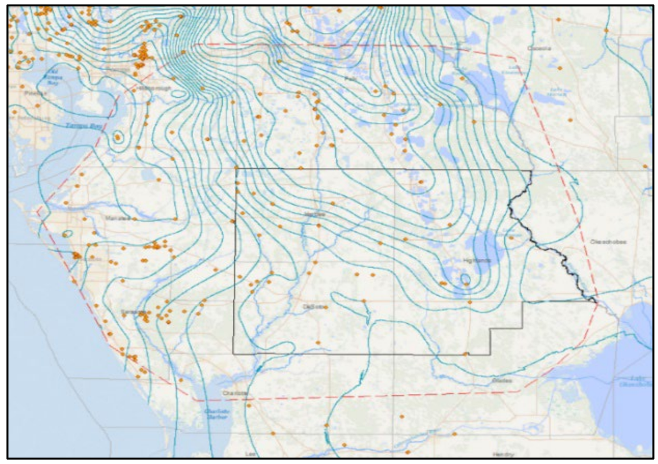

Figure 2. potentiometric surface map

Additionally, water-quality data from more than 70 wells collected by the FDEP, SFWMD, SWFWMD, and DeSoto, Hardee, and Highlands counties will be used for the next phase of this study.

Hydrogeology

The landforms, geology, and the hydrogeology of Florida have been shaped by the sea (Schmidt 1997; Metz, 1995). The ocean levels have risen and fallen over the last 5 million years, causing alternating periods of inundation of the Florida peninsula. Florida has gone from a narrow peninsula almost entirely covered by oceans to one that was about twice as wide as today about 20,000 years ago when sea level was much lower (Schmidt 1997; Metz, 1995; Bittner et al., 2017).

Hardee, DeSoto, and Highlands Counties, a 2,476 square-mile area of west-central Florida, are underlain by three principal hydro geologic units. The uppermost water-bearing unit is the surficial aquifer system (SAS), which is underlain by the intermediate aquifer system/intermediate confining unit (Table 1). The lowermost hydrogeologic unit is the Floridan aquifer system (FAS), which consists of the Upper Floridan aquifer, as many as three middle confining units, and the Lower Floridan aquifer (Bush and Johnston 1988; Wilson and Gerhart, 1982).

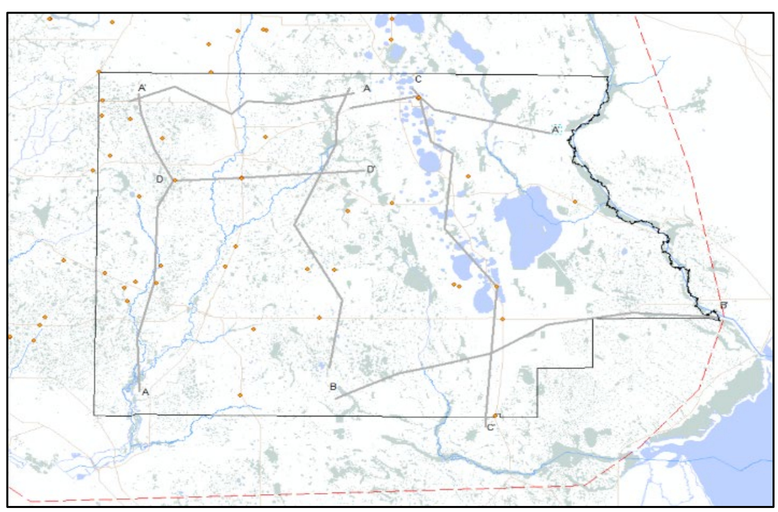

Figure 3. Geological logs

The SAS is located at the surface of Florida and the thickness ranges from almost a 100 to more than 400 ft across the study area (SFWMD 2001). The FAS includes a thick sequence of carbonate rocks of Tertiary age (Stringfield and LeGrand 1966; Miller 1999; SFWMD 2001). Miller (1986) sub-divided the FAS into upper (UFA) and lower (LFA) Floridan aquifers separated by a middle confining unit (MCU) of variable permeability and underlain by massive beds of nearly impermeable beds of anhydrite.

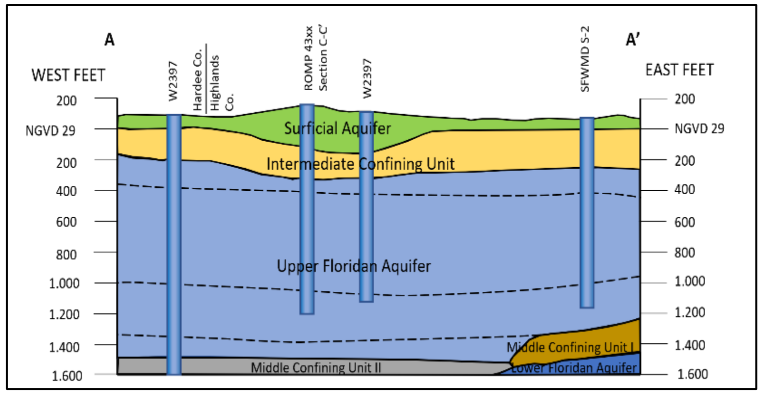

Figure 4. Generalized hydrogeologic sections A–A'.

The base of the Floridan aquifer system is marked by low-permeability limestone and dolostone that contain considerable gypsum and anhydrite of the upper Cedar Keys Formation. Variations in the distribution, thickness, and dip of the hydrogeologic units are generally assessed based on geophysical and geologic logs. The location of logs are shown in figure 3. One generalized hydrogeologic section (AA') is shown in figure 4.

Table 1. Hydrogeologic framework

<table>
<tr><th>Series/stage</th><th>Formation</th><th>Geology and lithology</th><th>Aquifer</th></tr>
<tr><td>Holocene and Pleistocene</td><td rowspan="3">Undifferentiated Sand surficial deposits</td><td rowspan="2">Sand</td><td rowspan="2">Surficial aquifer</td></tr>
<tr><td rowspan="2">Pliocene</td></tr>
<tr><td>Sand, clay</td><td rowspan="2">Upper Confining Unit</td></tr>
<tr><td rowspan="5">Miocene</td><td rowspan="6">Hawthorn Group</td><td rowspan="6">Phosphate, clay, sand, limestone, and dolostone</td></tr>
<tr><td>upper Arcadia aquifer (Zone 2)</td></tr>
<tr><td>Confining unit</td></tr>
<tr><td>lower Arcadia aquifer (Zone 3)</td></tr>
<tr><td rowspan="2">Confining unit</td></tr>
<tr><td rowspan="2">Oligocene</td></tr>
<tr><td>Suwannee Limestone</td><td rowspan="2">Limestone and dolostone</td><td>Upper permeable zone</td></tr>
<tr><td>Eocene</td><td>Ocala</td><td>Semi-confining</td></tr>
</table>

	Limestone		unit
	Avon Park Formation		Lower permeable Zone (Avon Park permeable zone)
			Middle confining units I, II, and/or VI
		Limestone and dolostone with some intervals containing inclusions of gypsum and anhydrite	Lower Floridan aquifer
	Oldsmar Formation		
Paleocene	Cedar Keys Formation	Limestone and dolostone with beds of gypsum and anhydrite	Sub-Floridan confining unit

Conceptual Model

In the study, a conceptual model of the area has been developed. The conceptual numerical modelling framework reflects the fundamental hydrogeological concepts with respect to an objective while considering pertinent geological, hydrogeological, and hydrological data. The conceptual modelling work also includes understanding boundary conditions and how they may be entered into a numerical model. Ideally, the initial conceptual model is to be created in the simplest form able to simulate the key identified processes with complexities added when necessary. In this area, recharge enters the SAS at higher topographic elevations in Polk County. Along the Lake Wales Ridge, the surficial, intermediate and Floridan Aquifer systems are fairly connected vertically (Spechler, 2010). This means that recharged water moves downward to provide a source of freshwater to the underlying aquifers and potential energy to drive flows in the system. This resulted in lowest concentrations of total dissolved solids (TDS) in these areas (Bittner, 2017). Within the FAS, groundwater flows away in all directions radially from the Polk County recharge ‘‘high’’ and discharges to the Gulf of Mexico or the Atlantic Ocean with considerable amounts intercepted by pumping withdrawals in the area. Waters flowing toward the south reach a gradient transition point at Lake Okeechobee where the vertical gradient becomes upward. In deep zones in the Floridan Aquifer System, seawater may control the freshwater discharge and TDS concentrations within the FAS. Groundwater elevations within the Upper Floridan Aquifer range from about 120 ft NGVD 1929 at the Polk County high (Bush and Johnston 1988) to less than 0 m in areas of heavy pumping near Tampa, Florida (Kinnaman and Dixon 2011).

Numerical Model

The overall population growth also leads into water quality challenges including the allocation of scarce natural resources, especially water, and development pressures on natural ecosystems (Simenstad et al. 2005; EDR 2013). Therefore, a comprehensive assessment tools to make value judgments to allocate resources efficiently is necessary. Numerical simulation models will need to be developed for just such purposes.

In this study a new numerical model is being developed using MODFLOW. The MODFLOW model is one of the most reliable and widely used groundwater simulation codes in groundwater level simulation utilizing finite difference methods (Harbaugh et al., 2000). This model simulates the groundwater conditions within the FAS and incorporates estimated pumping stresses, density-dependent flow, temperature dependence, and a detailed hydrogeologic framework. The model domain in southern Florida is shown in Figures 2. The preliminary numerical model grid includes variable cell sizes with finer resolution focused in areas of the three counties and the wells around Lake Okeechobee. The model temporal discretization was selected based upon available data, project objectives, and computational considerations.

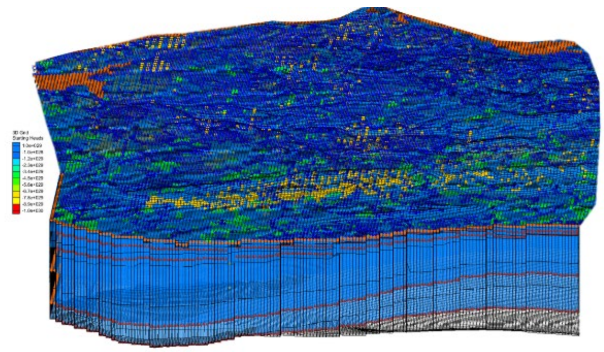

Figure 5. Schematic of preliminary development of a numerical model

Future Work

In the next phase of this study, the numerical model will be calibrated and verified, based on the water level. The Modular 3-Dimensional Transport model (MT3D) will be used to verify the model for water quality data collected from the wells. The verified model will be considered as the base model, and it will be used for further analysis of potential alternative scenarios, and evaluation of their impacts on hydrology and water quality.

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