SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Lower Kissimmee Basin

Groundwater Model Document

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SOUTH FLORIDA WATER MANAGEMENT DISTRICT

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Lower Kissimmee Basin Groundwater Model

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Dawn Rose and Debra Case assembled, formatted and cleaned-up the final draft document to make it readable and manageable.

EXECUTIVE SUMMARY

The Lower Kissimmee Basin Groundwater Model includes all of Okeechobee and Highlands counties and most of Glades County. It also includes portions of Polk, Osceola, Indian River, St Lucie, Martin, Palm Beach, Charlotte, DeSoto and Hardee counties. The Lower Kissimmee Basin Groundwater Model is a four-layer, steady-state MODFLOW model. The model was developed as a revision to the Glades, Okeechobee and Highlands model, which was developed for the 2000 Kissimmee Water Supply Plan. The new model revisits the hydrostratigraphy in area as a result of the recent investigations conducted in south Florida. The hydrostratigraphy data in the model region are still sparse and there are no data points in the Lower Floridan Aquifer.

The model was developed to provide support for the South Florida Water Management District's (SFWMD's) comprehensive regional water supply plan for the Kissimmee Basin. The model will be used to evaluate the effects of projected increases in groundwater withdrawals from the Upper and Middle Floridan aquifers. The model was calibrated using water use estimates from 1995. The calibration took place with the following criteria in mind: In the Surficial Aquifer System, the simulated heads were to be within 4 feet of the observed heads. For Upper and Middle Floridan aquifers the simulated heads were to be within 2.5 feet of the Average 1995 Upper Floridan Potentiometric Surface Map. The water levels in Surficial Aquifer System are not above land surface (except water bodies). The calibrated model produced simulated water levels generally in agreement with observation values.

A model is a tool used to represent an approximation of the field data and is built to assist in understanding of the ground flow system. The model is a steady-state model and therefore represents a state of equilibrium under averaged stress conditions. In reality, the stresses would vary with time. The model also averages the hydrologic properties and stresses for each cell in model grid. Despite these limitations the model should be a valuable tool to assess the behavior of the groundwater system under varying climatic conditions (1-in-10 rainfall, drought condition) or changes in water consumption (population growth or changes in agricultural crops).

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1
Introduction

BACKGROUND

In 1999, Jeff Herr developed the original Glades Okeechobee Highlands (GOH) Model. This model was included as Appendix H of the 2000 Kissimmee Basin Water Supply Plan. The current model, called the Lower Kissimmee Basin Groundwater Model (LKBGWM) is a revision of the Glades Okeechobee and Highlands Model. The steady-state, three-dimensional groundwater flow model was developed to simulate the Upper and Middle Floridan aquifers underlying the southern Kissimmee River Basin. In this version of the model, the Surficial Aquifer System was activated, so lakes, rivers (and canals), drains, evapotranspiration and recharge files were added. Many of the model input files were revised using data and/or processing methods that were not available in the earlier version of the model. The hydrostratigraphy was redefined using more sampling points. The Upper Floridan Aquifer was divided into two layers the Upper Floridan Aquifer and the Middle Floridan Aquifer with a confining unit between the two aquifers. The current version of the model was calibrated using 1995 land use, 1995 water level information and 2003 permitted water use (the assumption was made that there was not a significant change in permitted water use in these years). The calibrated model will be used to evaluate the effects of projected water use estimates in 2025. Water supply managers evaluate urban and agricultural water uses and must ensure current and future reasonable beneficial uses, while protecting and restoring the environment and water resources.

This model is a revision of the 1999 Glades Okeechobee and Highlands Model for this area. The 1999 Glades Okeechobee and Highlands Model was a steady-state model. The Surficial Aquifer System was not active in that version of the model, but held at steady-state. In addition to the Glades Okeechobee and Highlands Model, several other studies were done in portions of the model area and in regional studies, which included this model area. Sepulveda (2002) conducted a regional model using the results of most of the Intermediate and Floridan Aquifer groundwater modeling in peninsular Florida. The groundwater flows in Lake Wales Ridge area, were simulated by Yobbi (1996). Southwest Florida Water Management District (SWFWMD) (2002) conducted a study of saltwater intrusion in the southern water use caution area. Southwest Florida Water Management District Southern District Groundwater Flow Model included Lake Wales Ridge area near the boundaries of their model.

OBJECTIVES

The Lower Kissimmee Basin Groundwater Model was developed to provide support for the South Florida Water Management District's (SFWMD's) comprehensive regional water supply plan for the Kissimmee Basin (**Figure 1**). The purpose of the Lower Kissimmee Basin Groundwater Model is to be used as a tool to estimate the impact of changing water supply demands on the hydrologic systems of the basin.

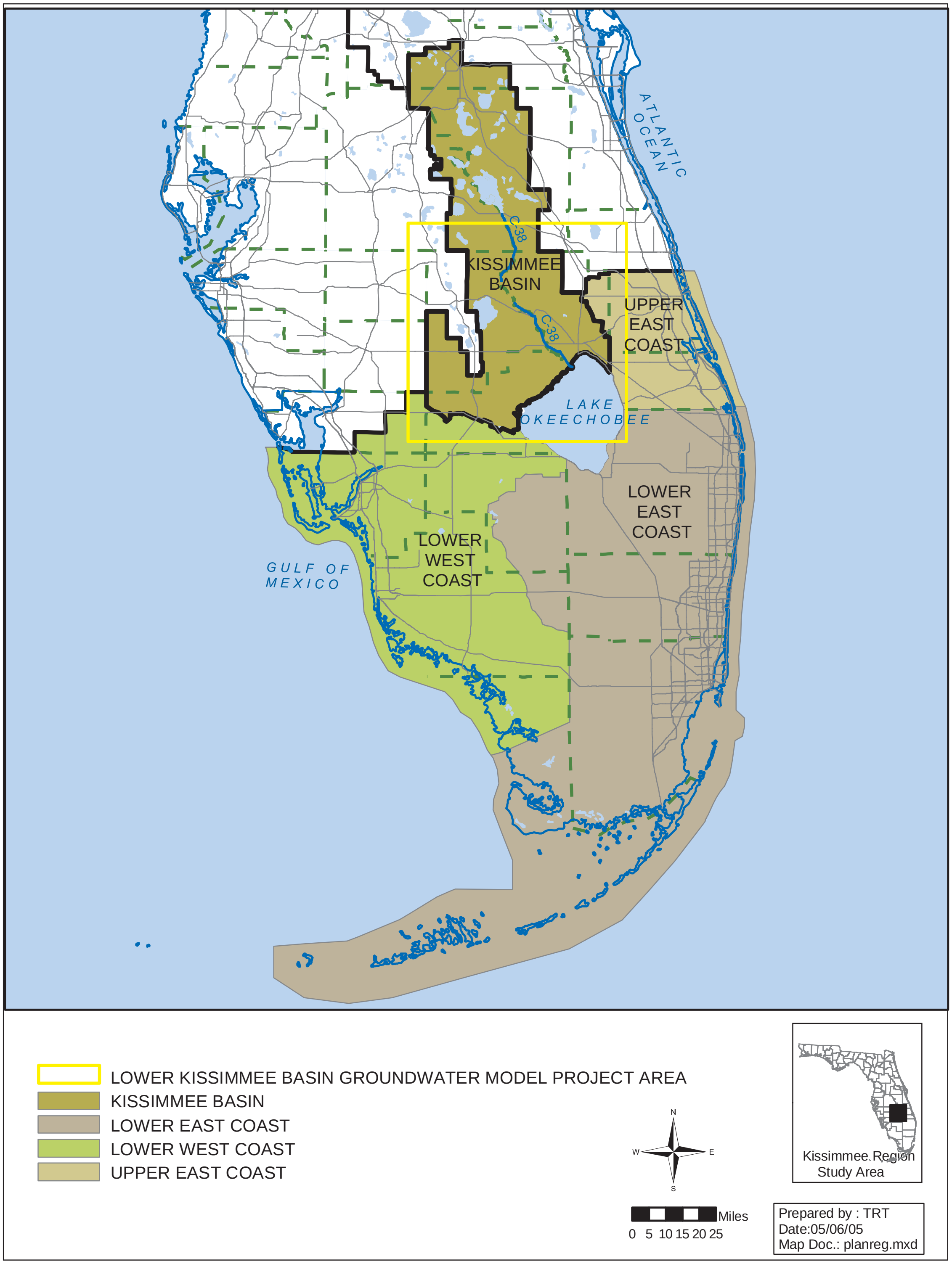

Figure 1. SFWMD Water Supply Planning Regions.

In order to achieve this goal, the steady-state conditions for 1995 were simulated by calibrating the model to 1995 stress conditions. The calibrated model can be used as a tool to predict impacts of future changes in land use and consumptive use on the water levels in the Surficial Aquifer System and Floridan Aquifer System. The calibrated model will be used to show the effects of projected water use estimates in 2025.

The Lower Kissimmee Basin Groundwater Model (**Figure 2**) includes all of Okeechobee and Highlands counties and most of Glades County. It also includes portions of Polk, Osceola, Indian River, St Lucie, Martin, Palm Beach, Charlotte, DeSoto and Hardee counties

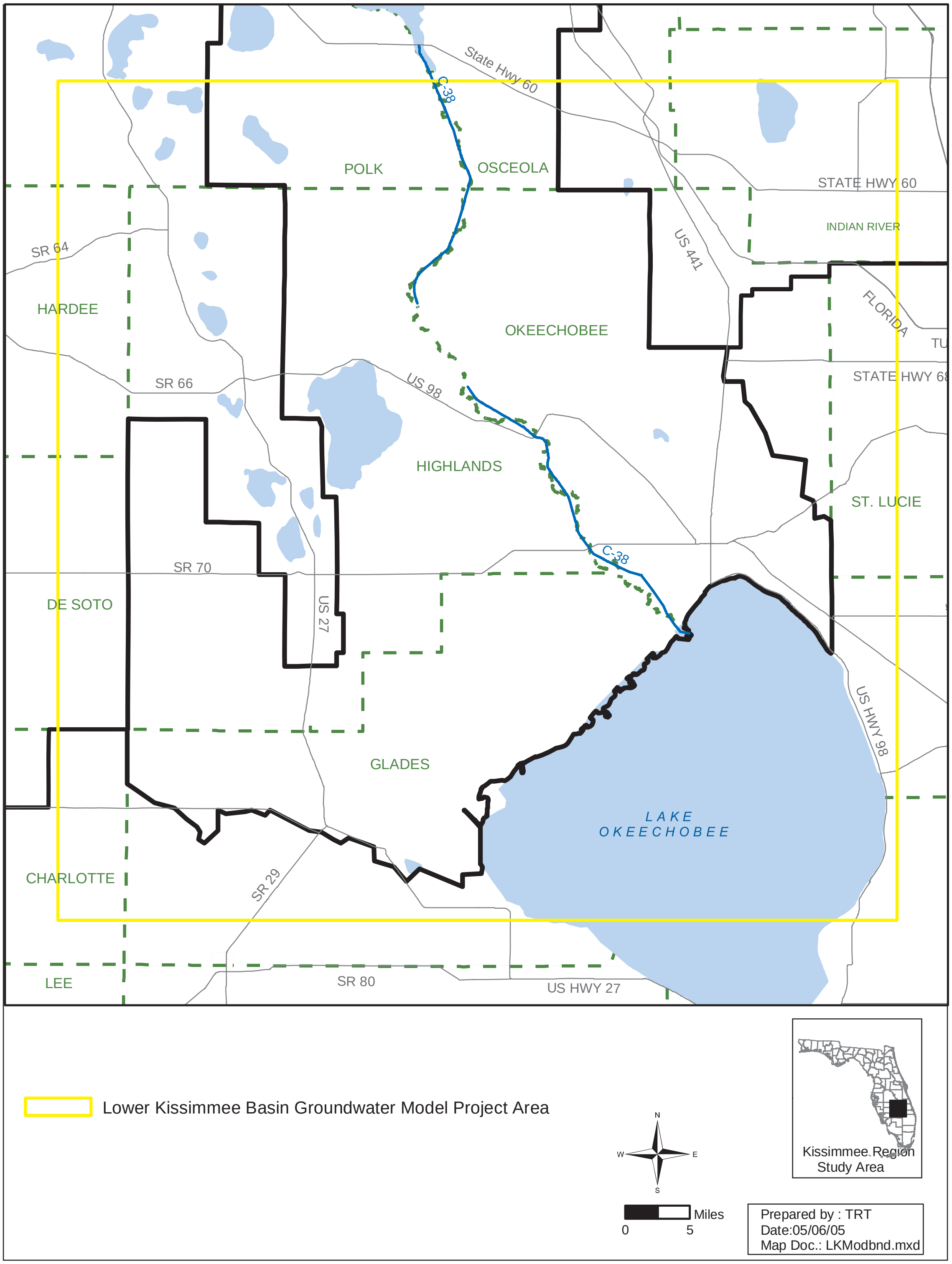

Figure 2. Lower Kissimmee Basin Groundwater Model Project Area.

With these objectives in mind, the scope of this document covers the development of the model in its entirety. **Chapter 1** introduces the purpose and scope of this study, and lists previous modeling studies done for the Lower Kissimmee Basin. **Chapter 2** reviews the geomorphology in the model area. **Chapter 3** reviews the hydrogeologic system in the model area. Simulating the flow system involves two aspects – code selection and model design, which are discussed in **Chapter 4**. **Chapter 5** details the processes of model calibration and verification. The focus is on reporting model results and sensitive model parameters.

A standard modeling protocol requires completing the steps in **Chapters 3**, **4** and **5** (Anderson and Woessner 1992). With model development complete, the next section of this document describes the performance of this model and its use in predictive applications. Conclusions and recommendations with respect to model capabilities and future improvements of this modeling study are given in **Chapter 6. Appendix D** describes the application of this model for use with predictive simulations.

DATA SOURCES

The hydrologic, meteorologic and lithologic data used for this project were collected from the following databases: South Florida Water Management District (DBHYDRO)[1] and Regulations, St. Johns Water Management District (SJRWMD)[2], Southwest Florida Water Management District (SWFWMD)[3] and U.S. Geological Survey (USGS)[4]. In addition, lake information was obtained from Web sites: IFAS LAKEWATCH[5] and Highlands[6] and Polk counties[7].

1 SFWMD DBHYDRO http://www.sfwmd.gov/site/index.php?id=38

2 SJRWMD http://www.sjrwmd.com/programs/data.html

3 SWFWMD http://www.swfwmd.state.fl.us/data/

4 USGS National Water Information System http://nwis.waterdata.usgs.gov/usa/nwis/

5 LAKEWATCH http://lakewatch.ifas.ufl.edu/

6 Highlands County http://www.highlandsswcd.org/

7 Polk County http://www.polk.wateratlas.usf.edu/navigator/

CHAPTER 2
Geomorphology

CLIMATE

The climate in south Florida is subtropical and humid. The winters are relatively dry and the summers are wet, with most of the rain occurring as late afternoon thunder storm showers. Average seasonal temperatures range from 60° F in the winter to 83° F in the summer (based on temperature measurements 1965–2000 in **Appendix A**). The annual average rainfall is 55 inches (This is the average of the rainfall for 1995 from all the stations used in the model see **Chapter 4**). Rainfall is the primary source of water into the hydrologic system, while evapotranspiration (ET) is the primary loss. There are very few data collection stations locations that measure evapotranspiration directly. The SFWMD has adopted the "South Florida Water Management District Simple Method" (Irizarry-Ortiz 2003) to estimate reference evapotranspiration. Based on the location and temperature data gathered from each rainfall station, a potential evapotranspiration is calculated. The Agricultural Field Scale Irrigation Requirements Simulation (AFSIRS), which was developed Smajstrla (1990) was used to estimate the maximum potential evapotranspiration rate for each crop type. The mean max evapotranspiration rate is 22 inches/year. The process is described in more detail in **Chapter 4.**

TOPOGRAPHY AND SURFACE WATER FEATURES

Land surface elevations in the model area range from -1 feet (in Lake Okeechobee) to 204 feet above the National Geodetic Vertical Datum of 1929 (NGVD). The highest elevations are on Lake Wales Ridge in Highlands County. In Indian River, Martin and St Lucie counties, the land surface is flat with the average elevation 23 feet (The Allapattah Flats) (**Figure 3**). Traveling westward, land surface rises 30 to 50 feet along the Holopaw-Indian Town Ridge to the hilly wetland terrain of the Kissimmee Valley on either side of the Kissimmee River. In the Northwestern portion of the model, there are two ridges. The narrow Avon Park Bombing Ridge has a maximum elevation of 132 feet NGVD: The larger Lake Wales Ridge has a maximum elevation of 204 feet NGVD. The Lake Wales Ridge features a series of north-south trending sand ridges separated by valleys (Yobbi 1996). There are many lakes and ponds along the Lake Wales Ridge. In portions of the Lake Wales Ridge, there are many karst features, sinkholes and sinkhole lakes (Yobbi 1996). The Lake Wales Ridge serves as a recharge area to the Surficial Aquifer System and to the Floridan Aquifer System. South of Lake Wales Ridge is the DeSoto Slope/Caloosahatchee Incline. North of Lake Okeechobee is the Lake Okeechobee Prairie with elevations of 20 to 40 feet NGVD. Due to the large number of lakes and ponds in the model area, many with little or no depth and lake level information, only those lakes over 30 acres were included in the model.

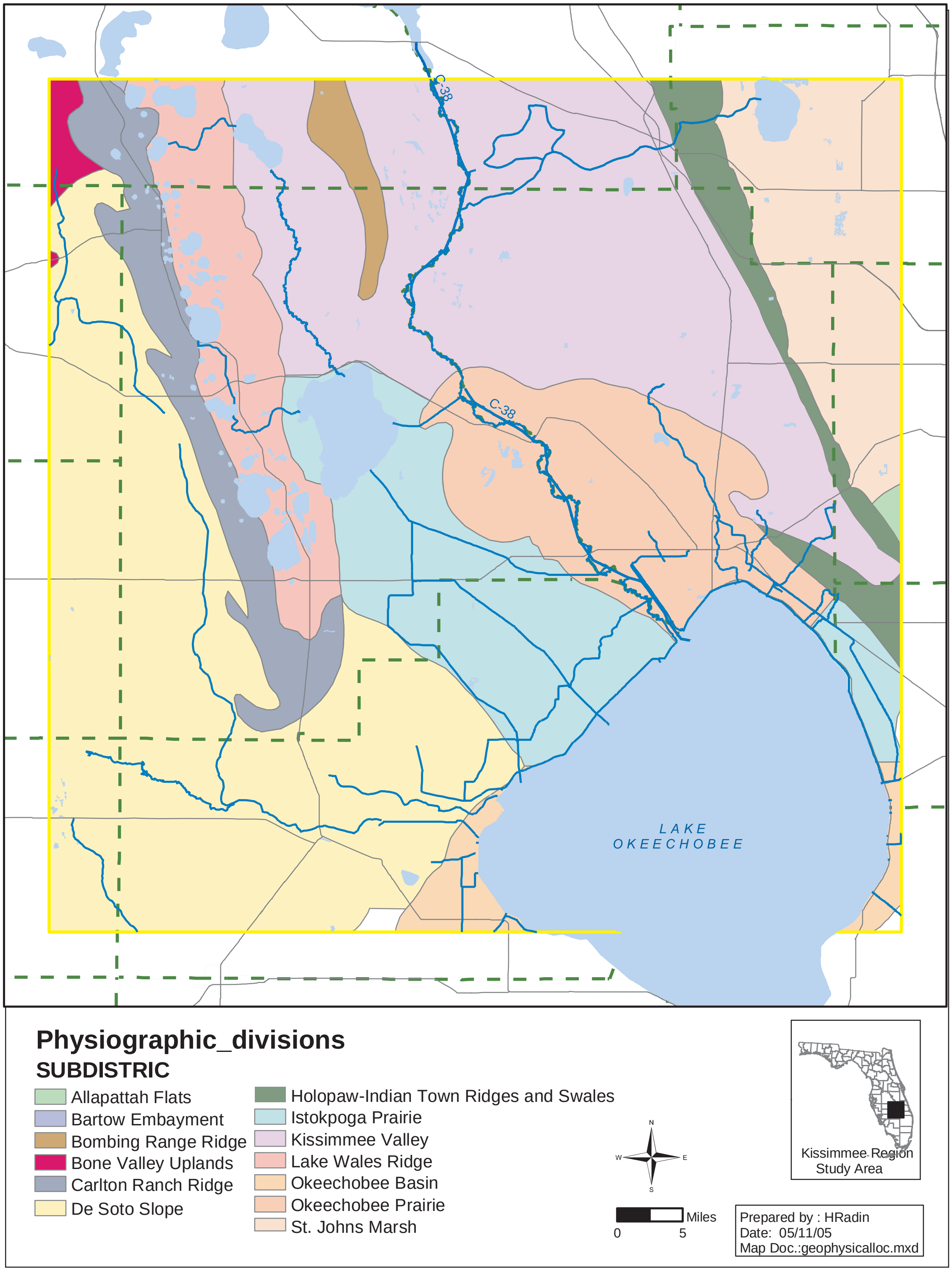

Figure 3. Physiographic Divisions in the Lower Kissimmee Groundwater Model Area. Shape File from SJRWMD (after Brooks 1981).

The topography data for the model were collected from three sources:

Highlands County Elevations (ew29_g100) is a grid of elevation data (**Figure 4**), created by T. Liebermann (SFWMD Communication June 2003), from contours, in NGVD29, includes all of Highlands County. This grid was derived from USGS 5 foot contours after editing to remove roads and other man made contours. Water bodies have been superimposed as flat surfaces. The cell size is 100 feet. Vertical datum is NGVD29.

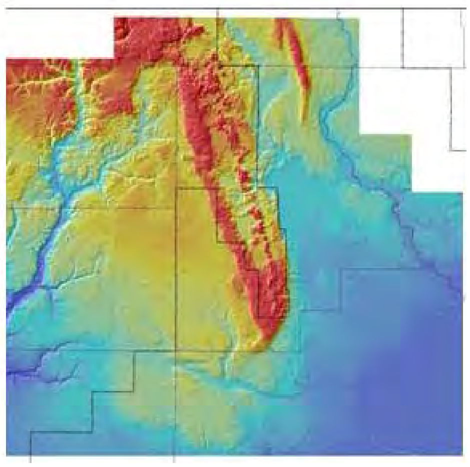

Figure 4. Highlands County Elevation Data (T. Liebermann, SFWMD Communication April 2004).

LFHYPG29 – (located in SFWMD GISDATABASE) SWFFS Topography – NGVD29 – GRID. This dataset was developed for the Southwest Florida Feasibility Study (SWFFS)[1].

LFHYP24K – (located in SFWMD GISDATABASE). This dataset is a subset of the USGS National Elevation Dataset (NED), which provides seamless 1:24,000-scale Digital Elevation Model (DEM) data for the conterminous U.S. (dem_24k_grid_100ft_cell.)

These raster files were merged and resampled to 2,640 ft^2 cells for inclusion in the model. **Figure 5** shows the aerial surface topography for the model area.

[1] Southwest Florida Feasibility Study http://www.evergladesplan.org/pm/studies/swfl.cfm

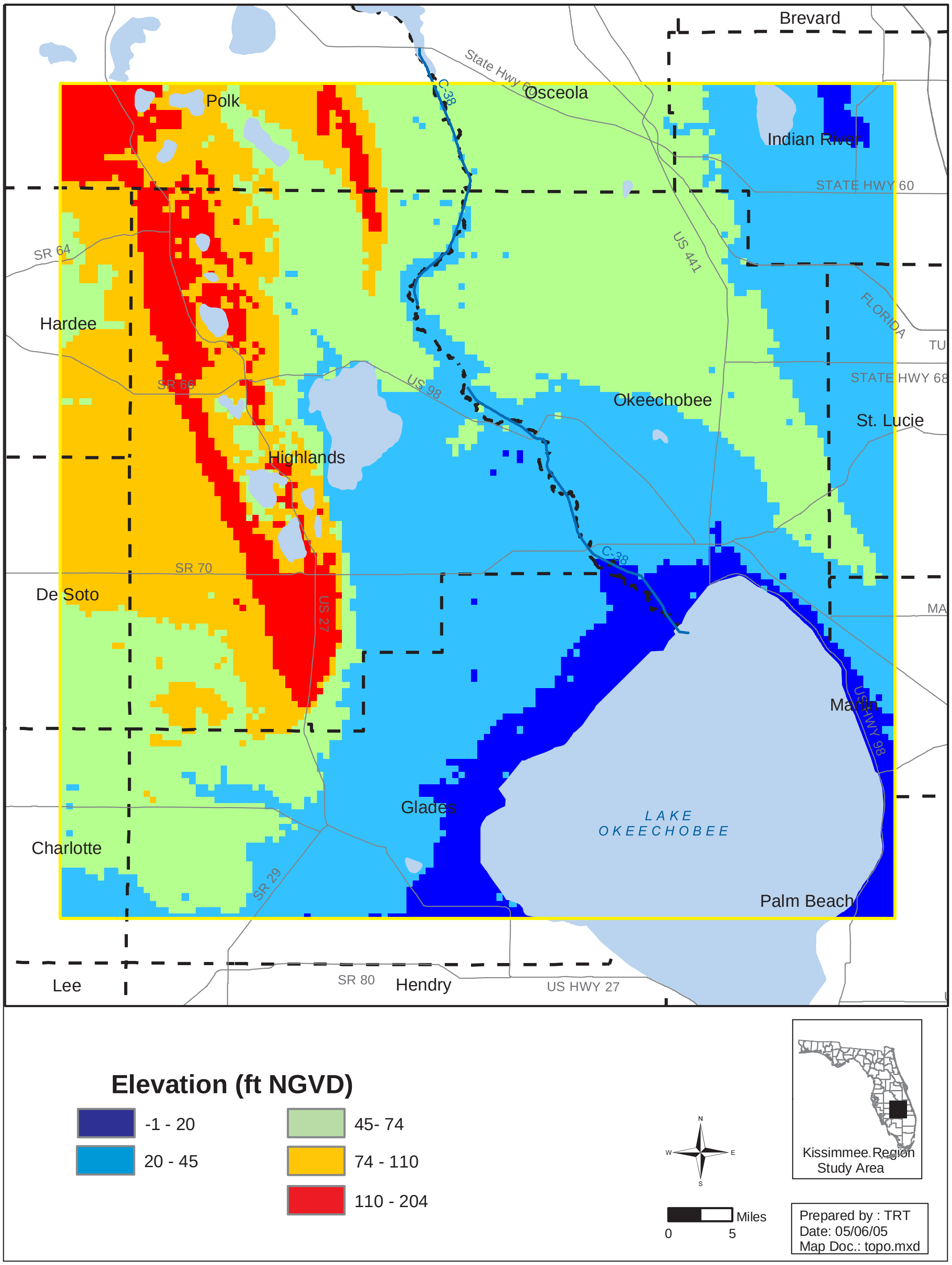

Figure 5. Topography.

The bathymetry data for Lake Okeechobee were superimposed on the topography. Other large water bodies were superimposed on the topography to reflect the bottom elevations of the lakes or rivers.

The Lower Kissimmee Basin includes the tributary watersheds of the Kissimmee River between the outlet of Lake Kissimmee (S-65) (see **Figure 6**) and Lake Okeechobee. The Kissimmee River and Lake Istokpoga are the major surface water features in the basin (**Figure 7**). Fisheating Creek and Taylor Creek/Nubbin Slough are prominent surface water features in the southern region of the Kissimmee basin Planning Area. Fisheating Creek marks the southernmost extent of the Kissimmee basin Planning Area and flows into Lake Okeechobee. Taylor Creek/Nubbin Slough is the site of one of the priority cleanup projects identified as part of the Lake Okeechobee Surface Water Improvement and Management (SWIM) Plan and Everglades restoration projects. There are no known large uses of water from either creek.

The Kissimmee River was originally 103 miles in length until it was channelized in the 1960s into a 56-mile canal (C-38). The Kissimmee River was divided into five pools (pools A-E) by a series of combined locks and spillways. The water level in each of these pools is regulated according to a regulation schedule. The Kissimmee River Restoration Project, underway, will backfill approximately 22 miles of the C-38 Canal, demolish two water control structures and recarve approximately 9 miles of river channel. These modifications will redirect flows through the historic river channel and restore ecological functions to the river/floodplain system. Backfilling began in the 1990s midway between S-65A and S-65B. There are areas north and south of Phase I to be backfilled. Information on the Kissimmee River Restoration effort is available from the SFWMD Web site: http://www.sfwmd.gov/org/erd/krr/.

Lake Istokpoga at 44 square miles is the fifth largest lake in Florida. The lake is connected to the Kissimmee River via the Istokpoga Canal and the C-41A Canal. The Istokpoga Canal consists of two reaches, one upstream and one downstream of the G-85 Structure. The Istokpoga Canal has minimum flow into the Kissimmee River through the S-68 structure, since the G-85 structure is no longer operational.

The main outlet for Lake Istokpoga is S-68, which regulates discharges from the lake to the C-40, C-41 and C-41A canals. The C-41A Canal discharges into the Kissimmee River below S-65E, passing through two additional water control structures (S-83 and S-84). The C-41 and C-40 canals discharge water from Lake Istokpoga to Lake Okeechobee. The C-40, C-41 and C-41A canals and associated structures make it possible to regulate the stages of Lake Istokpoga for irrigation water supply.

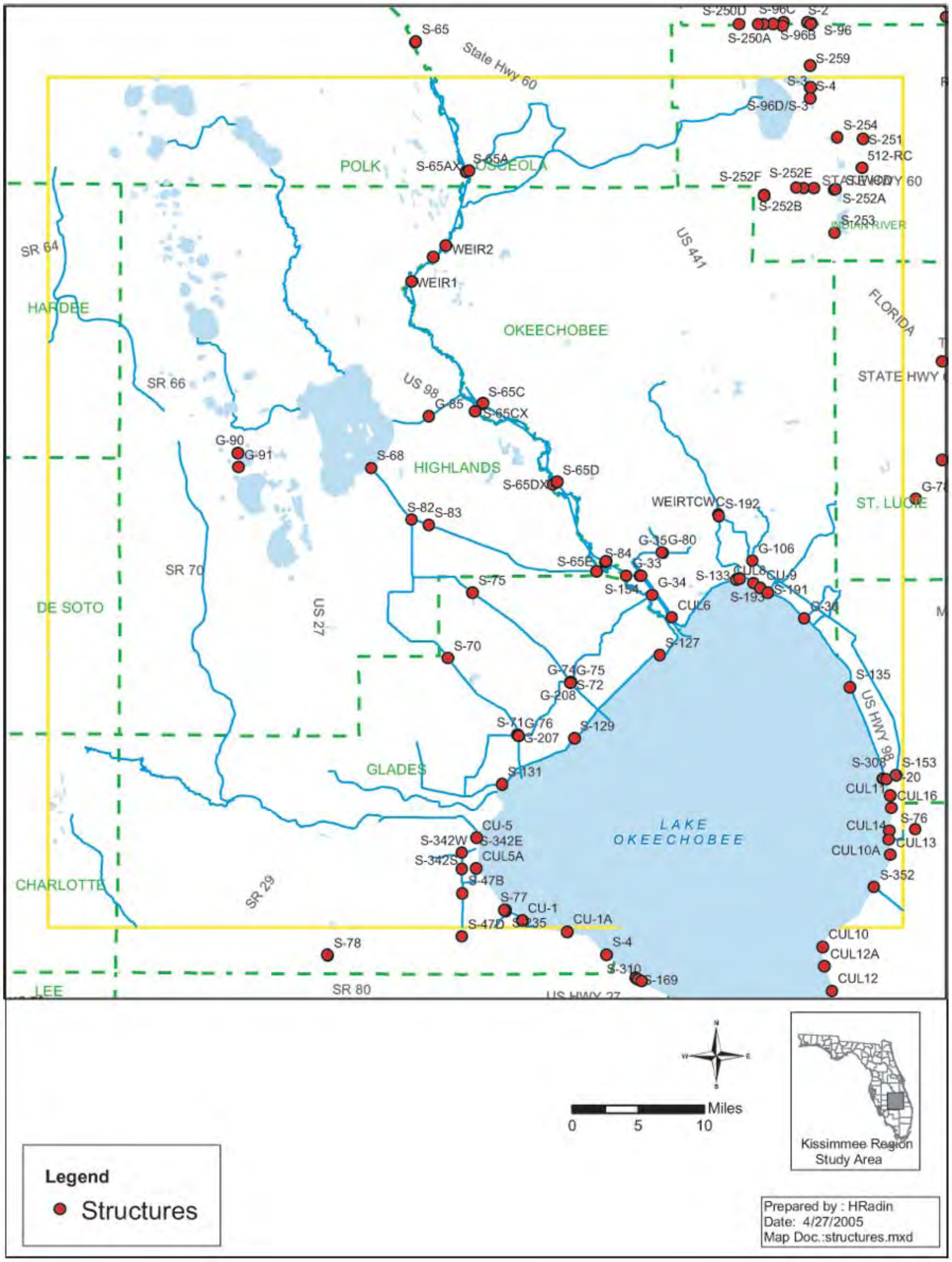

Figure 6. Major District Structures.

The model area contains numerous small lakes with little or no data available about them. For modeling purposes only those lakes over 30 acres were included.

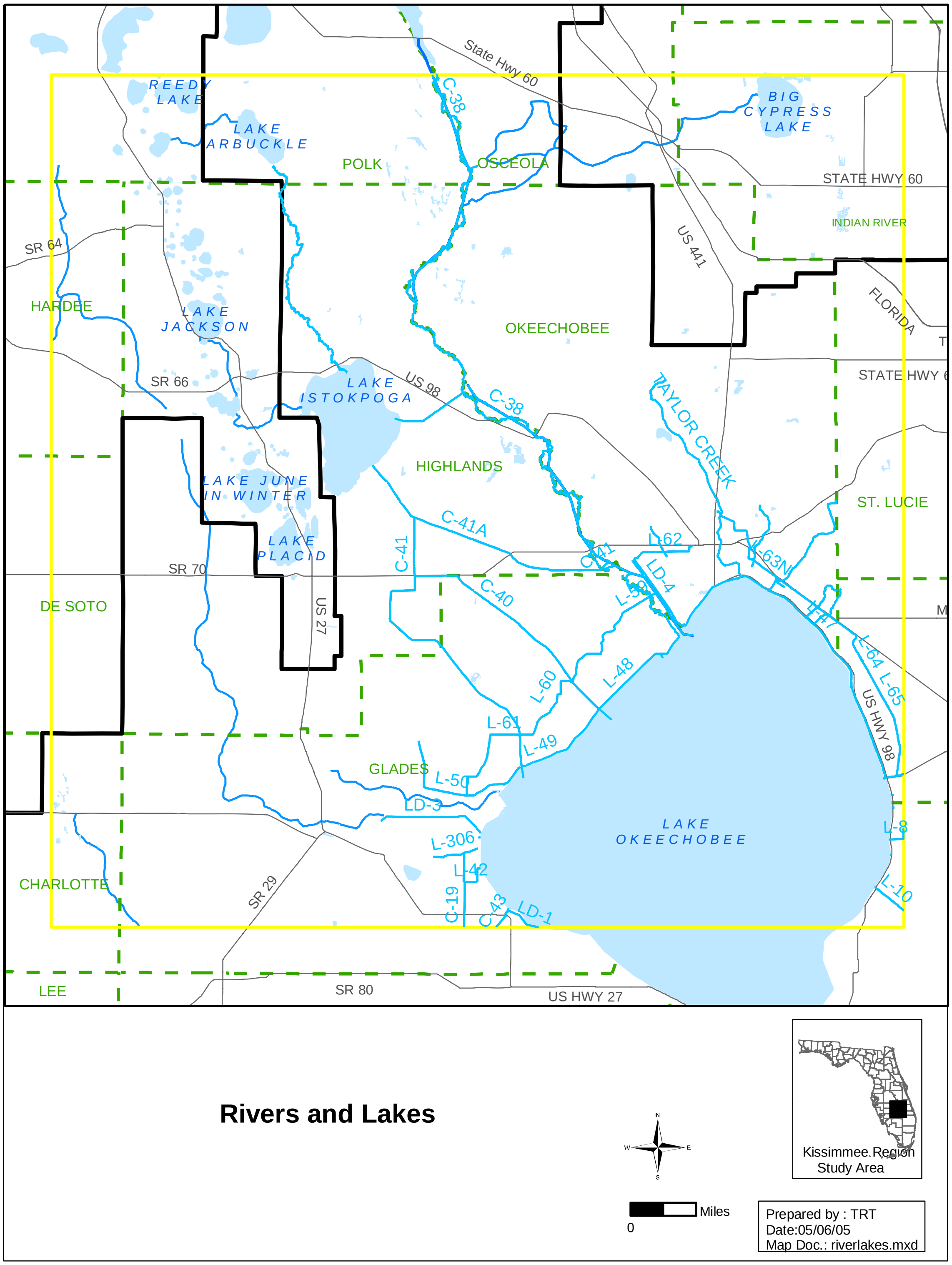

Figure 7. Rivers and Lakes Simulated in the Lower Kissimmee Groundwater Basin.

CHAPTER 3
Hydrogeologic System

GROUNDWATER FLOW

Hydrostratigraphy and Hydrogeology

The main groundwater resources in the model area are the Surficial Aquifer System, and the Floridan Aquifer System. These aquifer systems are separated by the Intermediate Confining Unit. The Floridan Aquifer System is divided into the upper, middle and lower sections separated by Middle Semi-Confining Units.

The general geology and hydrogeology for south Florida is given in the **Figure 8**. The abbreviations used in for aquifer systems, aquifers, permeable zones and confining units as defined in this study are the same as those shown in the second column of **Table 1** for the regional ASR study. The cross-sections and the hydrostratigraphic layers in the following section are all subsets of the data from Reese and Richardson 2004. The surfaces were developed in VIEWLOG SYSTEMS (VIEWLOG), an application of Earth*fx* Inc. VIEWLOG links to the SFWMD environmental database, DBHYDRO via Microsoft Access and uses kriging to create surfaces. The surfaces were converted to Environmental Systems Research Systems (ESRI) ArcGIS grids. Map calculations were done on the grids to obtain the layer thickness.

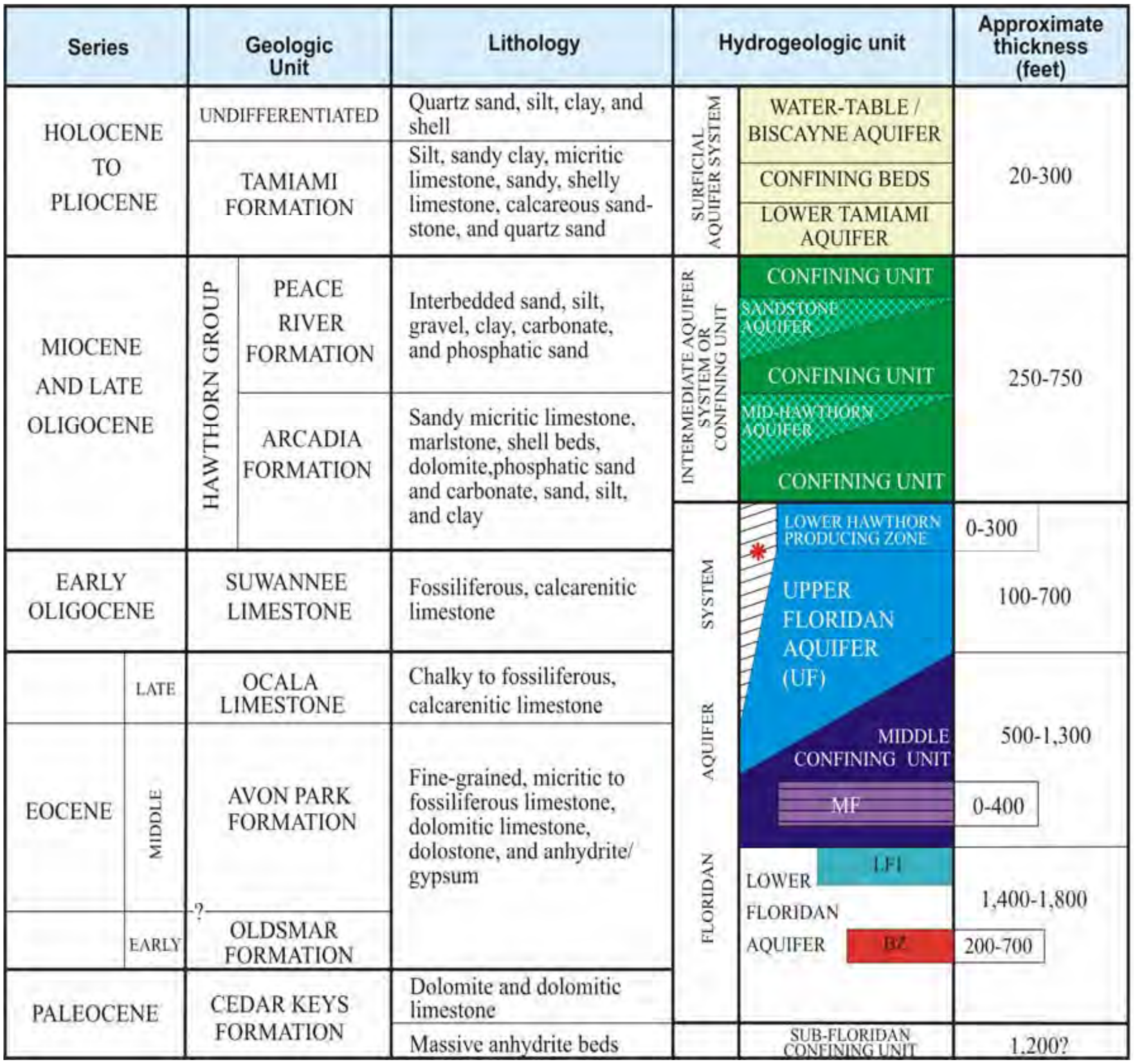

Figure 8. Relationship of Hydrogeologic Units in South Florida to Geologic Units and Their Lithology (Reese and Richardson 2004). *Geologic Units are missing in some areas.

Table 1. Schematic Cross-Reference to Cited Literature (Reese & Richardson 2004).

Thickness (feet) LKBGWM	**Regional Study-ASR (Reese & Richardson2004)**	**SWFWMD (2000)**	**WRIR 02-4193 (O Reilly *et al.* 2002)**	**SFWMD TP 92-03 (Lukasiewicz 1992)**	**Miller 1986**	**Miller 1986**
Lower Kissimmee Basin	Central, SW and SE Florida	Southwest Florida	East-Central Florida	Upper East Coast	Southwest Florida	Eastern and Southeast Florida
8-362	SU	SU	SU	SU	SU	SU
111-868	IC / IA	IC / IA	IC	IC	IC	IC
55-522	UF	UF - Upper Permeable Zone	UF - Zone A	UF		UF
140-840	MS / MC1	MS	UF - Zone B	MS	UF	Confining Unit I
92-246	MF	UF - Lower Permeable Zone		LF - Zone 1		LF
77-618	MC2	MC or SFCU	MS / MC	LC	Confining Unit II	Confining Unit VI
	LF1	LF (where present)	LF - Zone 1	LF - Zone 2	LF	LF
	LC		LC	LC	Confining Unit VI	Confining Unit VIII
	LF2 (LF3, etc.)		LF - Zone 2		LF	LF
	BZ	BZ (where present)		BZ	BZ	BZ

SU	Surficial Aquifer System
IC / IA	Intermediate Confining and/or Intermediate Aquifer System
UF	Upper Floridan Aquifer
MS / MC1	Upper Middle Semi and/or Confining Unit
MF	Middle Floridan Aquifer
MC2	Lower Middle Confining Unit (SFCU is Sub-Floridan Confining Unit)
LF1	Lower Floridan Aquifer - first permeable zone.
LC	Lower Confining Unit
Confining Unit VIII	Confining Units from Miller, 1986 - not always continuous within region. LF2, LF3, etc. are deeper permeable zones within the Lower Floridan Aquifer.
BZ	Boulder Zone - not continuous across study area

Figure 9 shows the location of several cross-sections showing the relative extent and thickness of the hydrostratigraphic units used in the Lower Kissimmee Basin Groundwater Model. **Figures 10** to **14** correspond to the lines in the base map of **Figure 9**. All the cross sections were created using VIEWLOG.

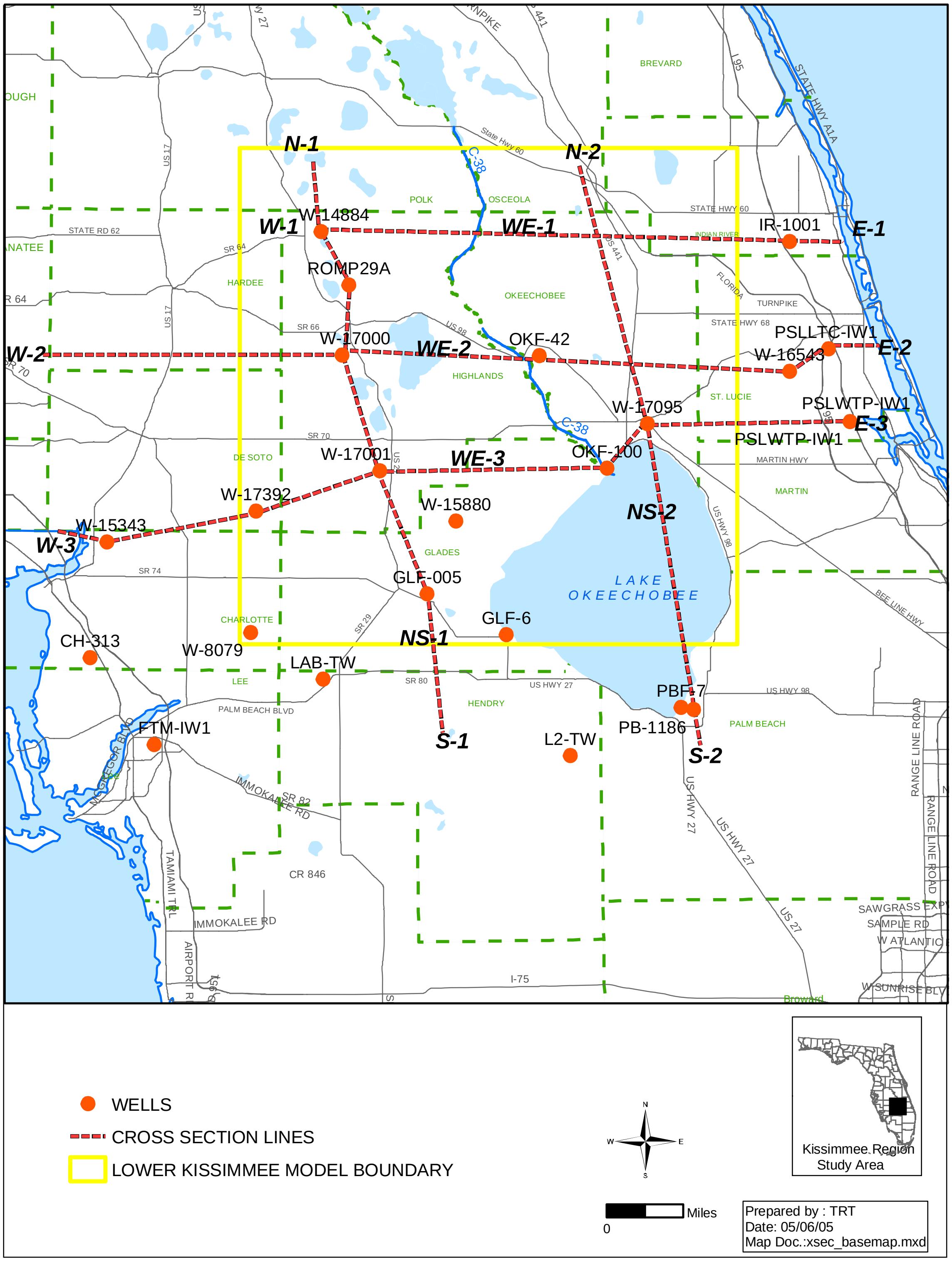

Figure 9. Base Map for Cross Sections.

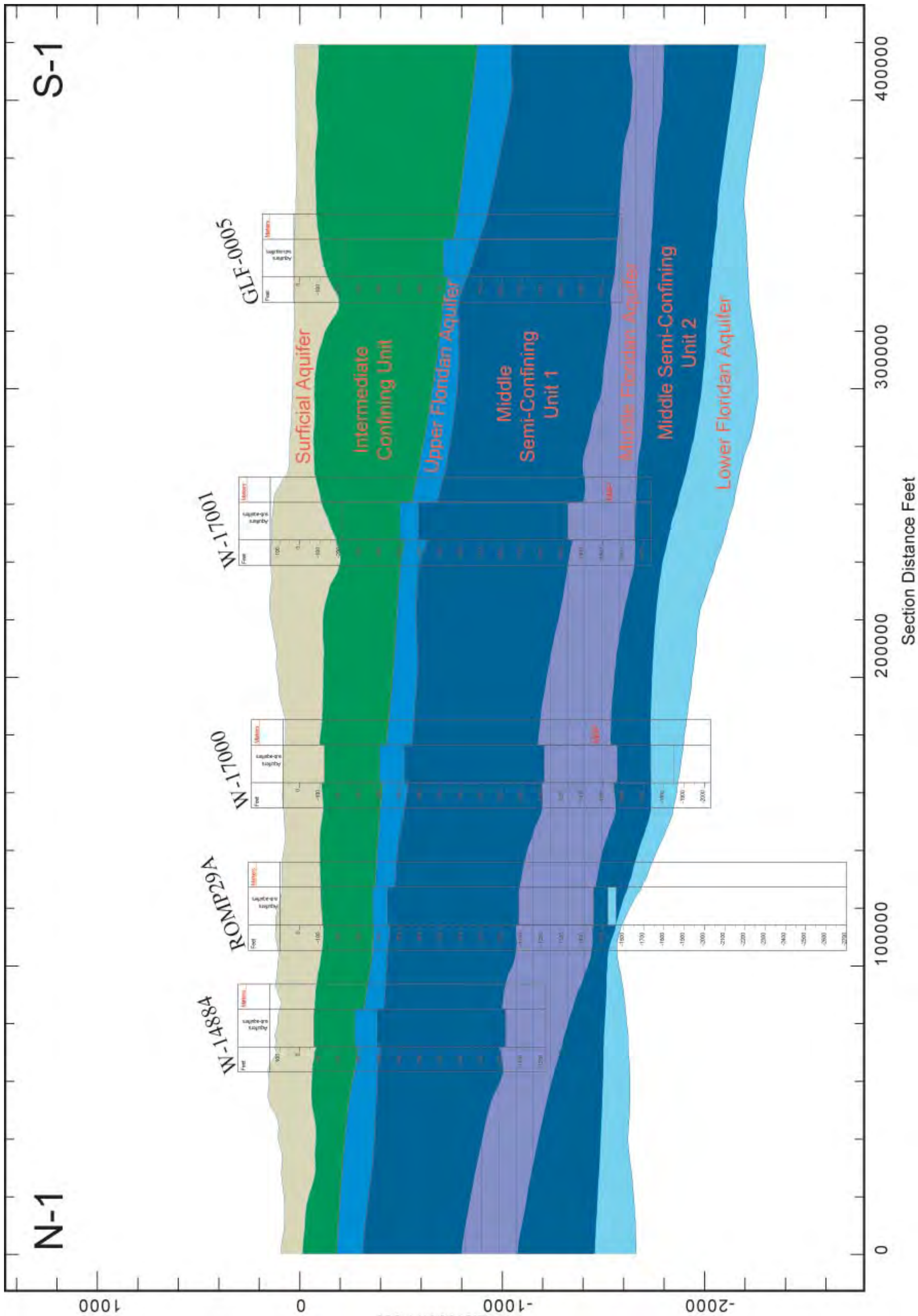

Figure 10. North South Cross Section 1 (Source Data is a Subset of Data from Reese & Richardson 2004).

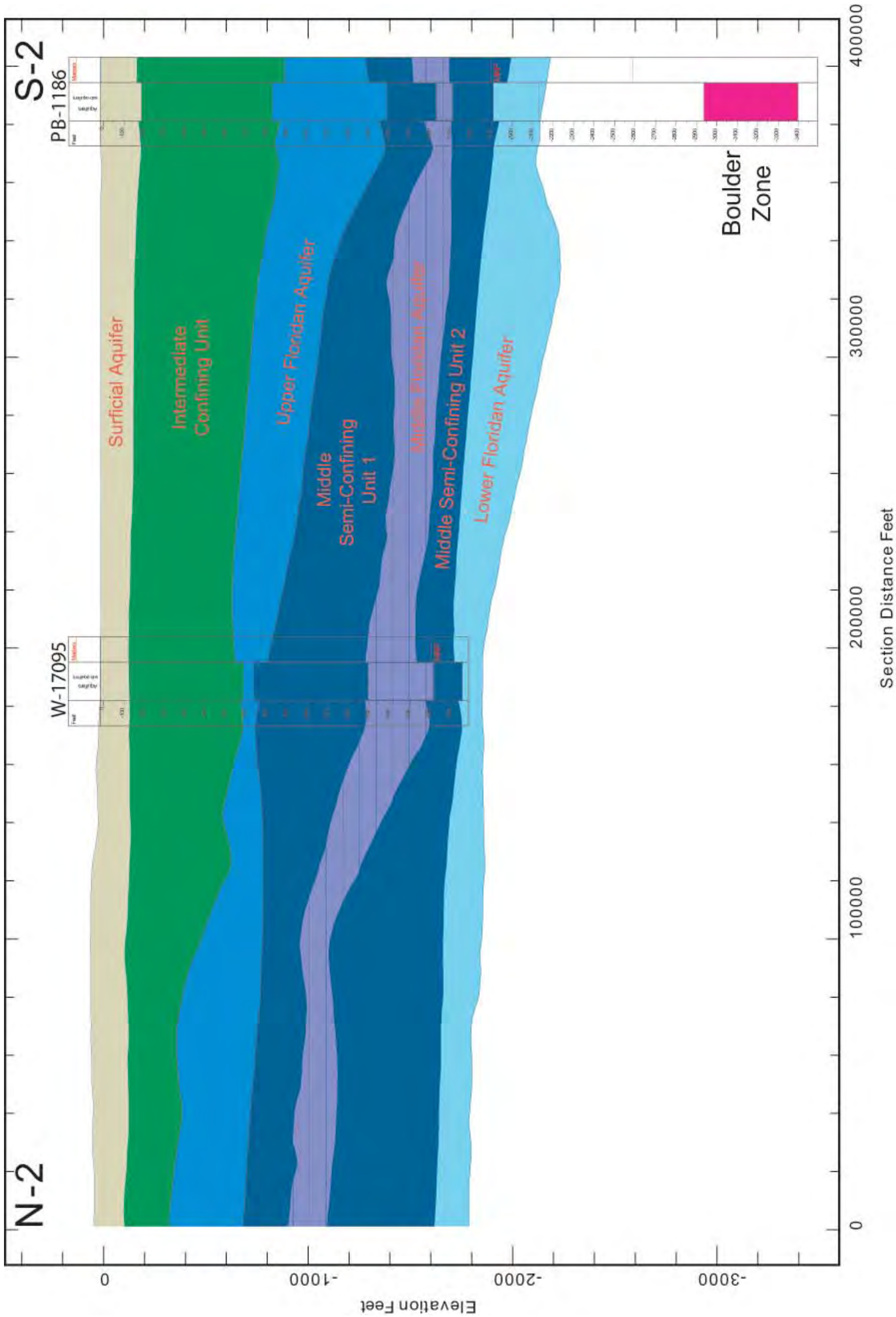

Figure 11. North South Cross Section 2 (Source Data is a Subset of Data from Reese & Richardson 2004).

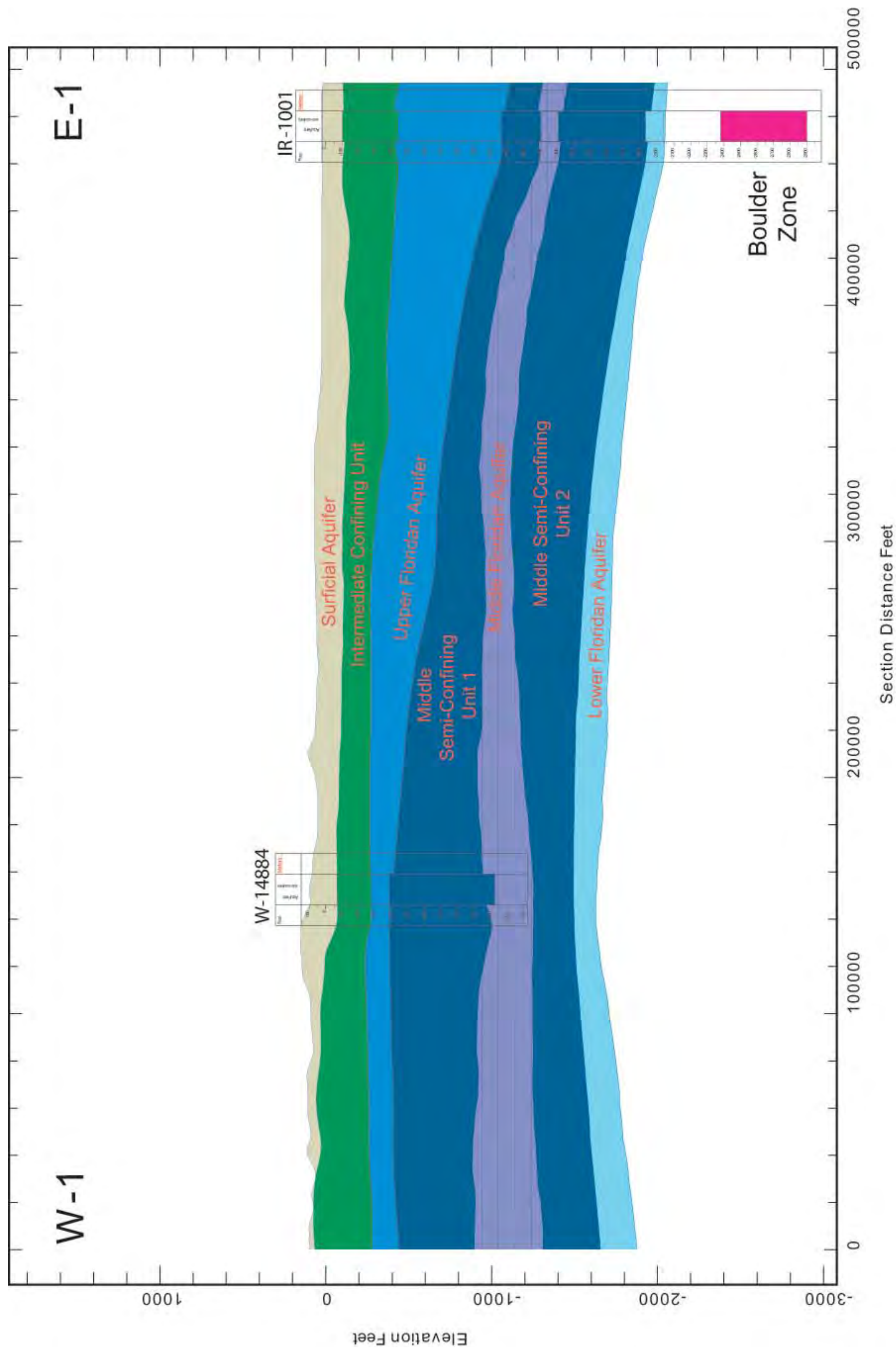

Figure 12. West East Cross Section 1. (Source Data is a Subset of Data from Reese & Richardson 2004).

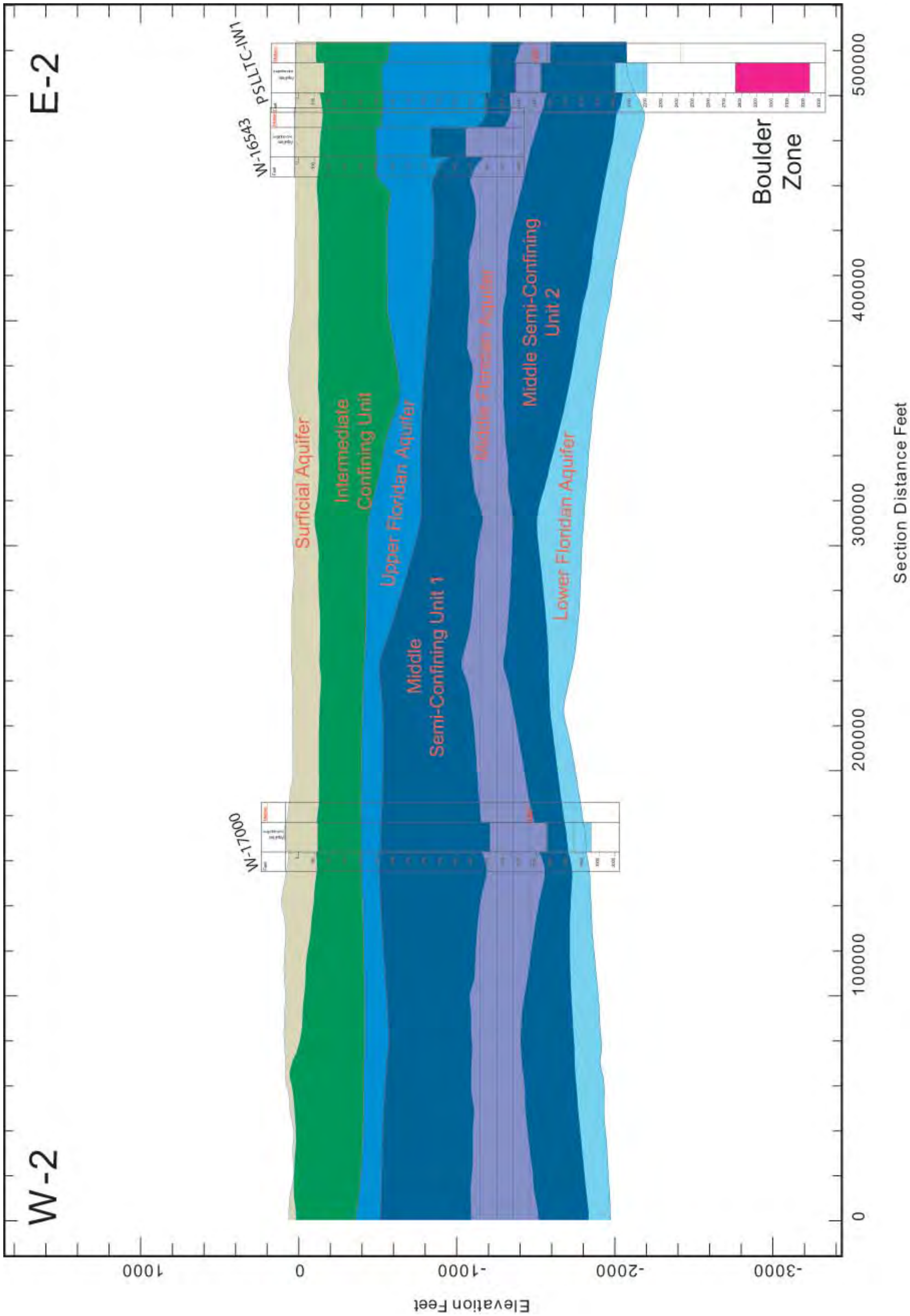

Figure 13. West East Cross Section 2. (Source Data is a Subset of Data from Reese & Richardson 2004).

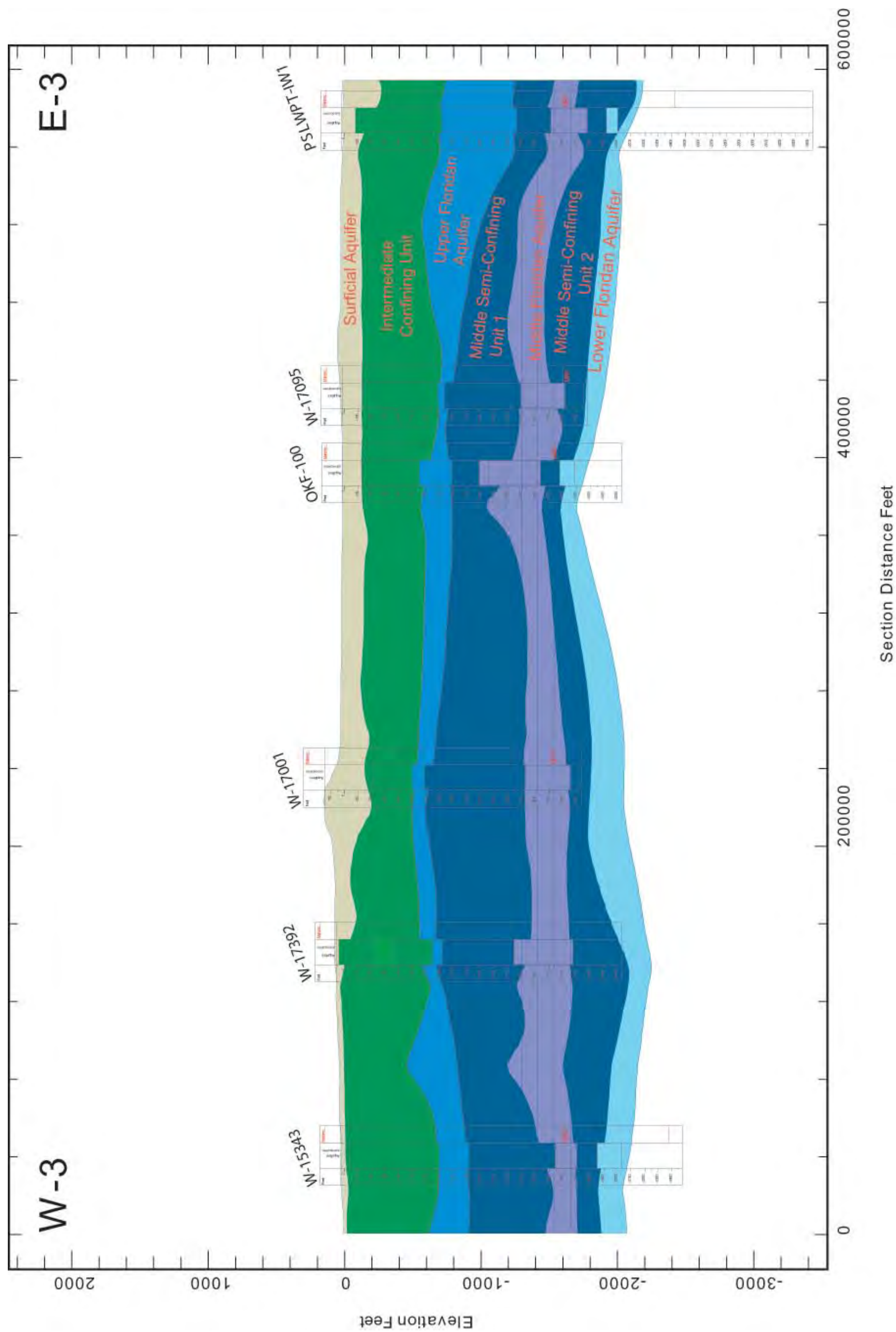

Figure 14. West East Cross Section 3. (Source Data is a Subset of Data from Reese & Richardson 2004).

Surficial Aquifer System

The Surficial Aquifer System is unconfined and consists of fine-to-medium grained quartz sand with varying amounts of silt, clay and crushed shell, of Holocene and Pleistocene age. This uppermost part of the Surficial Aquifer System is also called the Water Table Aquifer. The Surficial Aquifer System produces small quantities of good-to-fair quality water. It is generally soft, low in mineral content, slightly corrosive and often high in color and iron. The thickness of the Surficial Aquifer System varies from 8 to 362 feet in the model area.

Figures 15 and **16** show the bottom and thickness of the Surficial Aquifer System in the model domain. Station W-16969 in Okeechobee County has an average hydraulic conductivity K=41 ft/day. While W-16970 K=28 ft/day and W-16950 showed K=8 ft/day (DBHYDRO). Yobbi (1996) cited K values in the range of 2–8 ft/day for aquifer tests in Lake Wales Ridge. The hydraulic data for the model area were very limited so data from north of the model area in Lake Tohopekaliga were also looked at. The average hydraulic conductivity (K) there was 7 ft/day (Valdez 2000). The hydraulic conductivity for the Surficial Aquifer System was estimated at 14 ft/day for most of the model area. Originally higher values were estimated, resulting in water levels that were too low. The lower value of 14 ft/day was in the range of measured values and improved the calibration of the water levels in the Surficial Aquifer System. The river and lake area were set at 50 ft/day and were modified in Avon Park Ridge for calibration purposes. See **Figure 49** for the distribution of the hydraulic conductivities in the area.

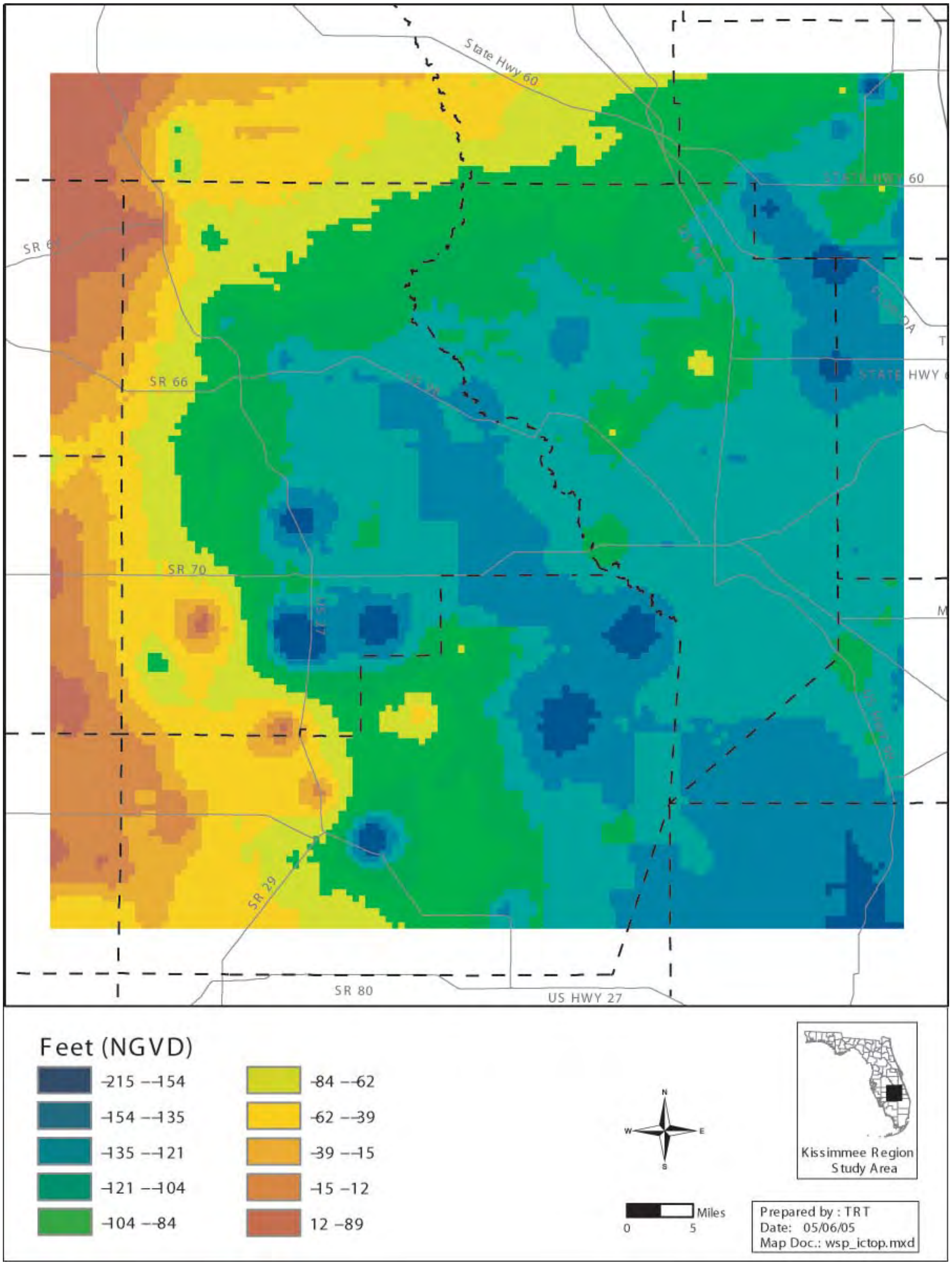

Figure 15. Elevation of the Base of the Surficial Aquifer System (Subset of Data Mapped in Reese & Richardson 2004).

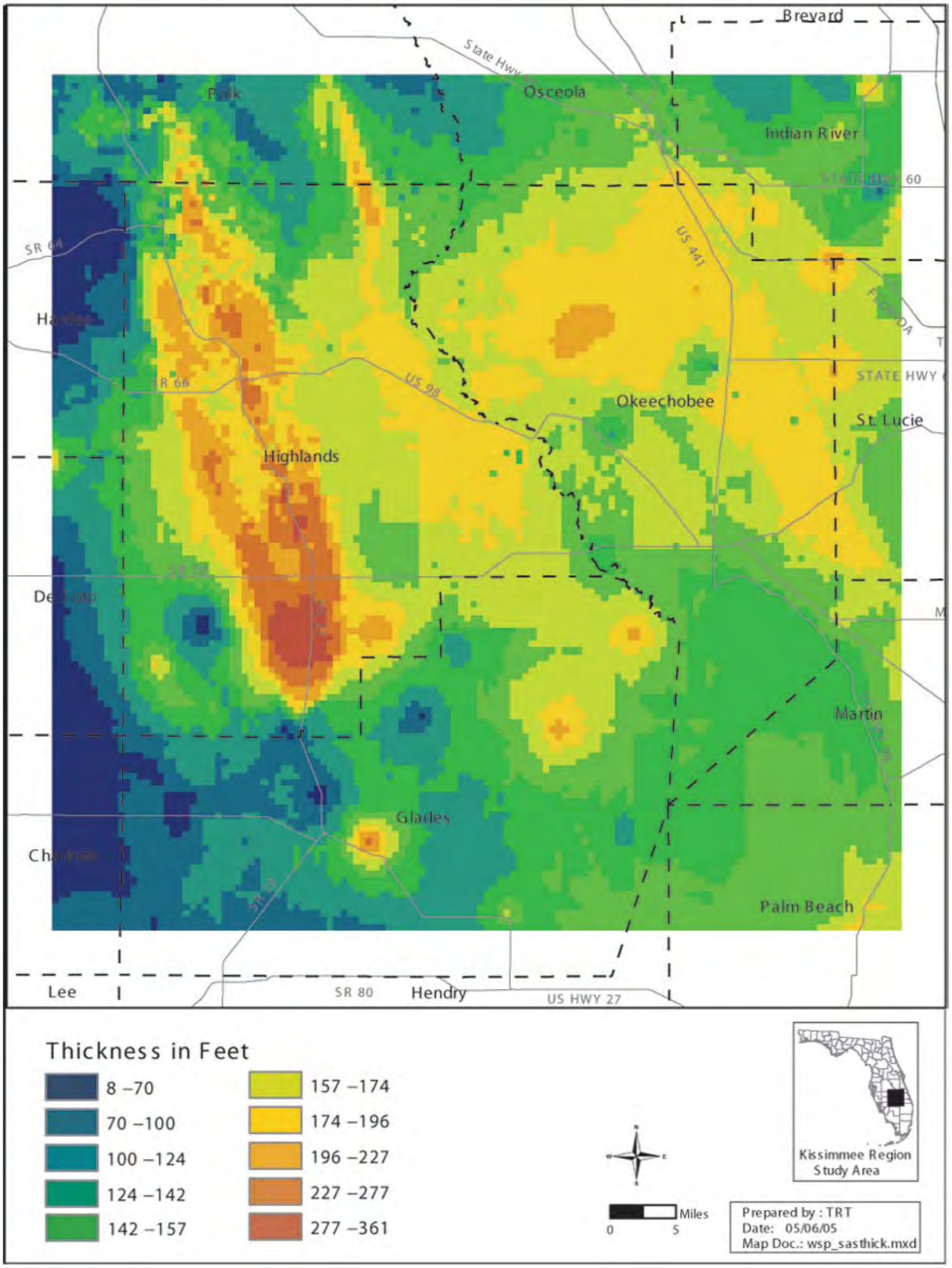

Figure 16. Thickness of the Surficial Aquifer System.

Intermediate Confining Unit

The Hawthorn Group of sediments consists of carbonate rocks inter-bedded with phosphatic silt, sand, clay and limestone. There is an unconformity that separates the Hawthorn Group from the Suwannee limestone below. There are a few minor permeable units within the Intermediate Aquifer System in the study area, but most of unit has very poor productivity. The Intermediate Confining Unit serves as a confining barrier between the Surficial Aquifer System and the Floridan Aquifer System for a large portion of the model area. The thickness of the Intermediate Confining Unit is highly variable. Along Lake Wales Ridge there are sinkhole depressions where the Intermediate Confining Unit is thin and it pinches out north of the model area in Polk Count (O'Reilly 2002, Choquette 2000, Yobbi 1996). The Intermediate Confining Unit thickens southward. Preliminary data from Krupa *et al*. 2005 shows that the Kissimmee River Valley has higher levels of connectivity between the Surficial Aquifer System and the Upper Floridan Aquifer System. **Figures 17** and **18** show the bottom and thickness of the Intermediate Confining Unit.

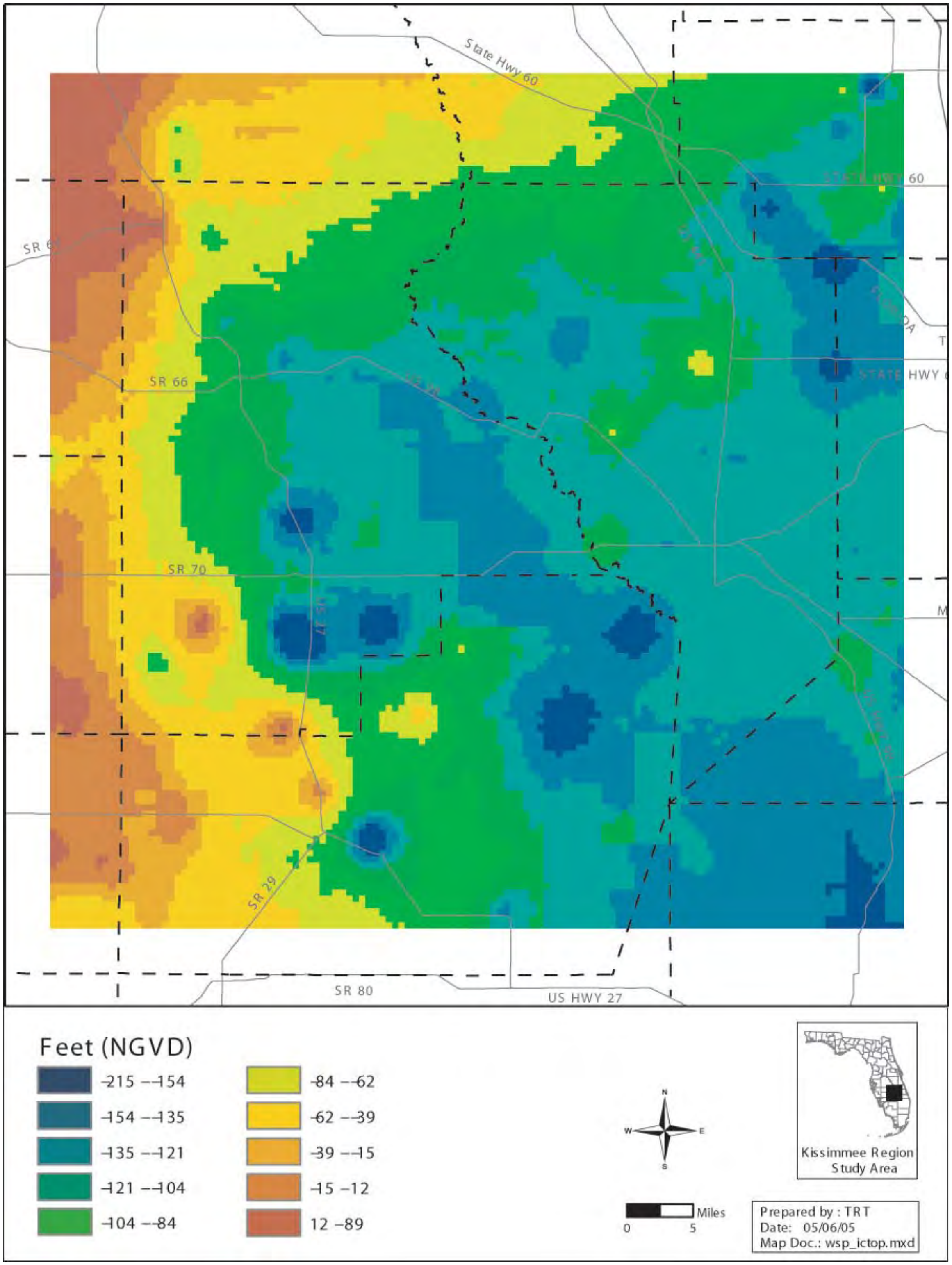

Figure 17. Elevation of the Top of the Intermediate Confining Unit (Subset of Data Mapped in Reese & Richardson 2004).

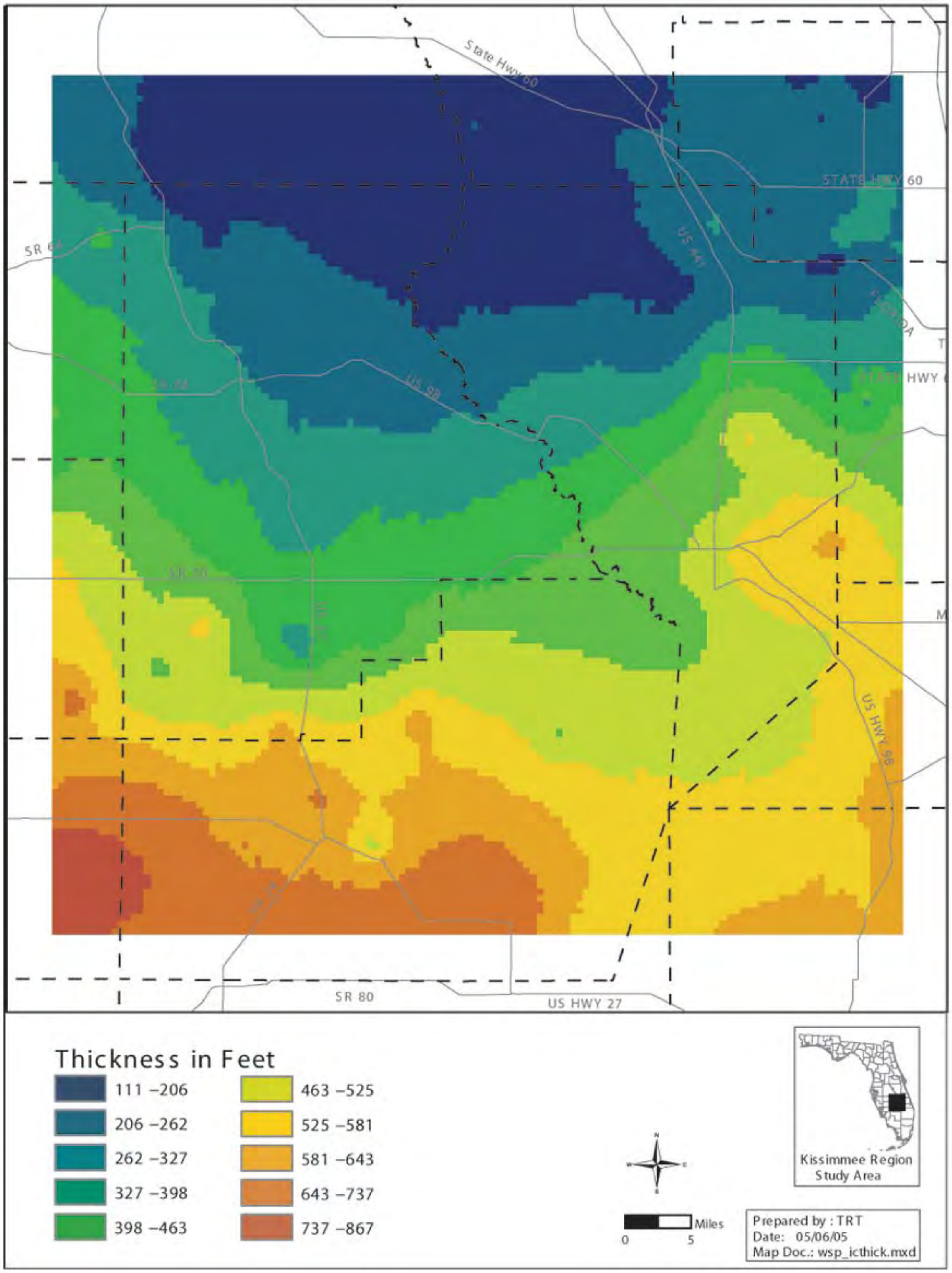

Figure 18. Thickness of the Intermediate Confining Unit.

Floridan Aquifer System

The Floridan Aquifer System is a thick system consisting of the Upper, Middle and Lower Floridan aquifers, separated by confining units. The Upper and Middle Floridan aquifers are the main production zones for consumptive use purposes. There are no wells that penetrate the Lower Floridan Aquifer in the model area. The Floridan Aquifer System is a confined system, with the exception of some sinkholes along Lake Wales Ridge (Beach and Chan 2003). The Floridan Aquifer System is composed of a thick sequence of carbonate rocks over lain by clastic sedimentary layers in the Intermediate and Surficial Systems.

Upper Floridan Aquifer

The Upper Floridan Aquifer begins with the Suwannee Limestone, and the base often coincides with the top of the Avon Park Formation and is marked with a drop in the permeability Reese and Richardson (2004). The transmissivity map presented in Reese and Richardson (2004) was used for the Lower Kissimmee Groundwater Model area. Due to the limited amount of aquifer performance tests in the model region the kriging program generated some low and negative values. All values less than 1,000 ft^2/day were assigned the value of 1,000 ft^2/day. The transmissivity range of the Upper Floridan Aquifer is 1,000 ft^2/day to 72,250 ft^2/day, **Figures 19** and **20** show the top and thickness of the Upper Floridan Aquifer. **Figure 21** displays the transmissivity

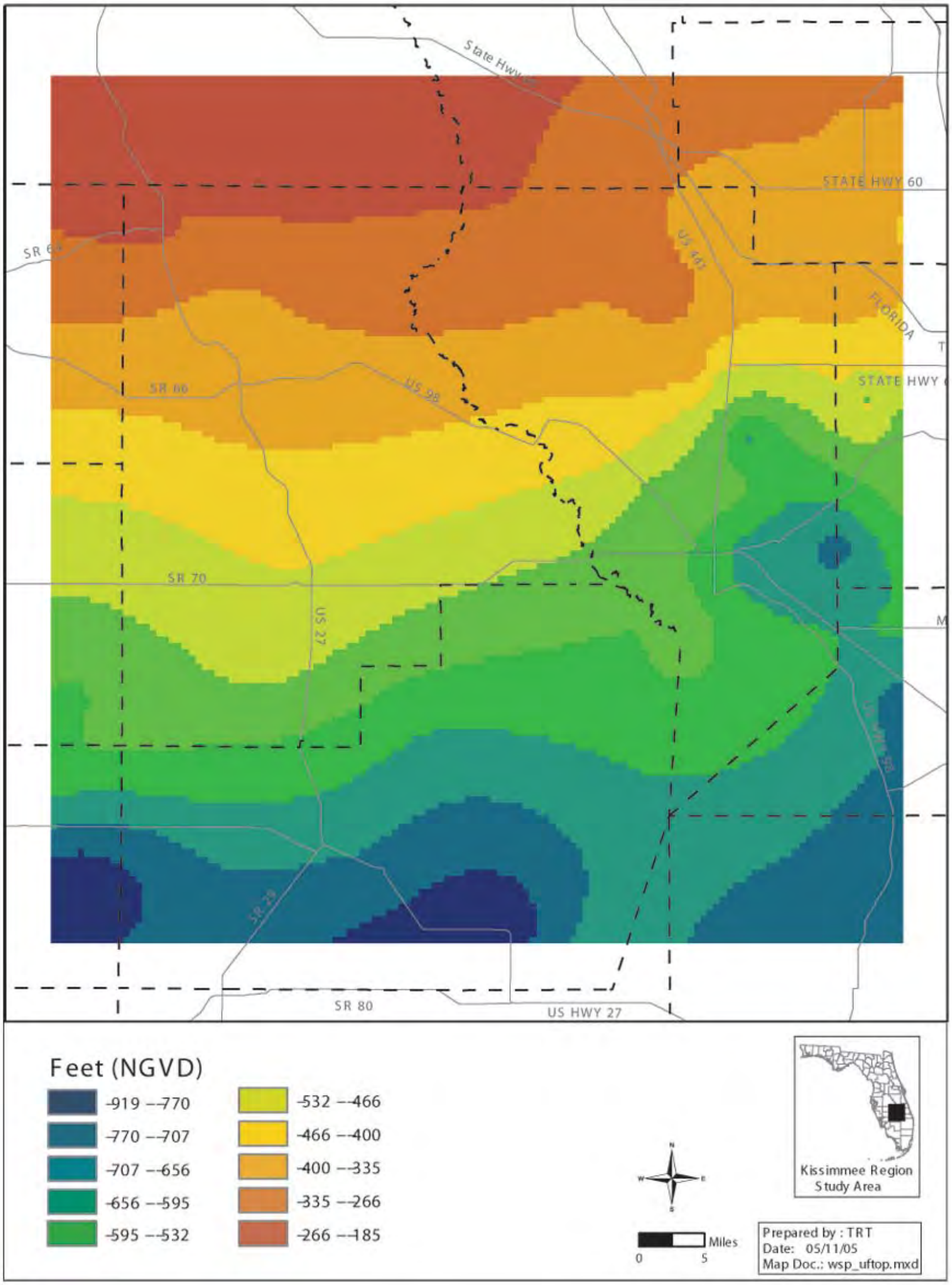

Figure 19. Elevation of the Top of the Upper Floridan Aquifer (Subset of Data Mapped in Reese & Richardson 2004).

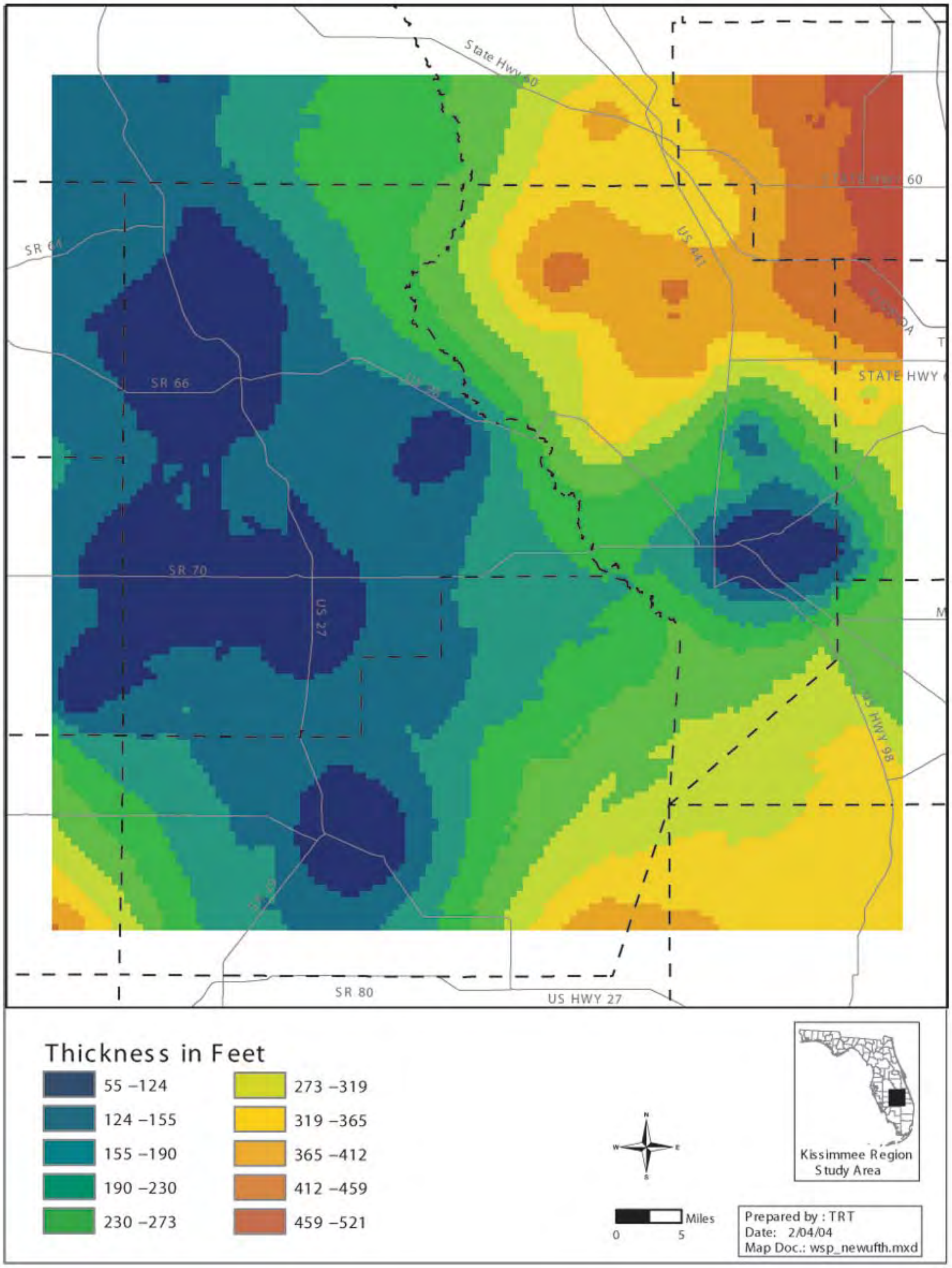

Figure 20. Thickness of the Upper Floridan Aquifer.

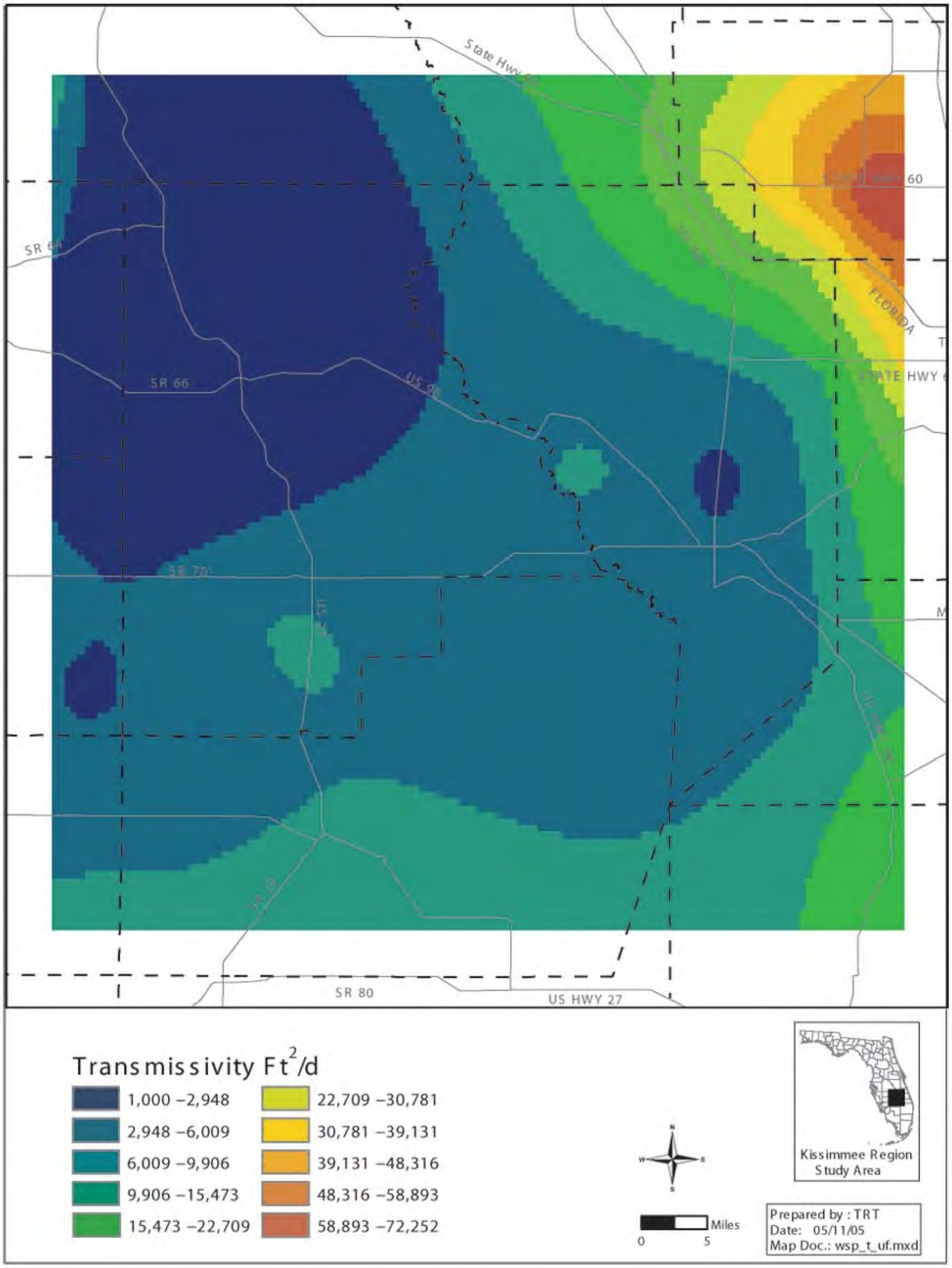

Figure 21. Transmissivity in the Upper Floridan Aquifer (ft^2/day) (Subset of Data Mapped in Reese & Richardson 2004).

Middle Confining Unit 1

The top of the Middle Confining Unit 1 (MC1) is often identified as the top of the Ocala Limestone (Reese and Richardson (2004). The unit is composed of fine-grained, poorly cemented limestone of relatively low permeability. The confining unit may be fractured in some areas (Reese and Richardson 2004). Hickey (1990) noted upward flow through the Middle Confining Unit. The thickness varies from 140 to 840 feet. **Figures 22** and **23** show the top and thickness of the Middle Confining Unit.

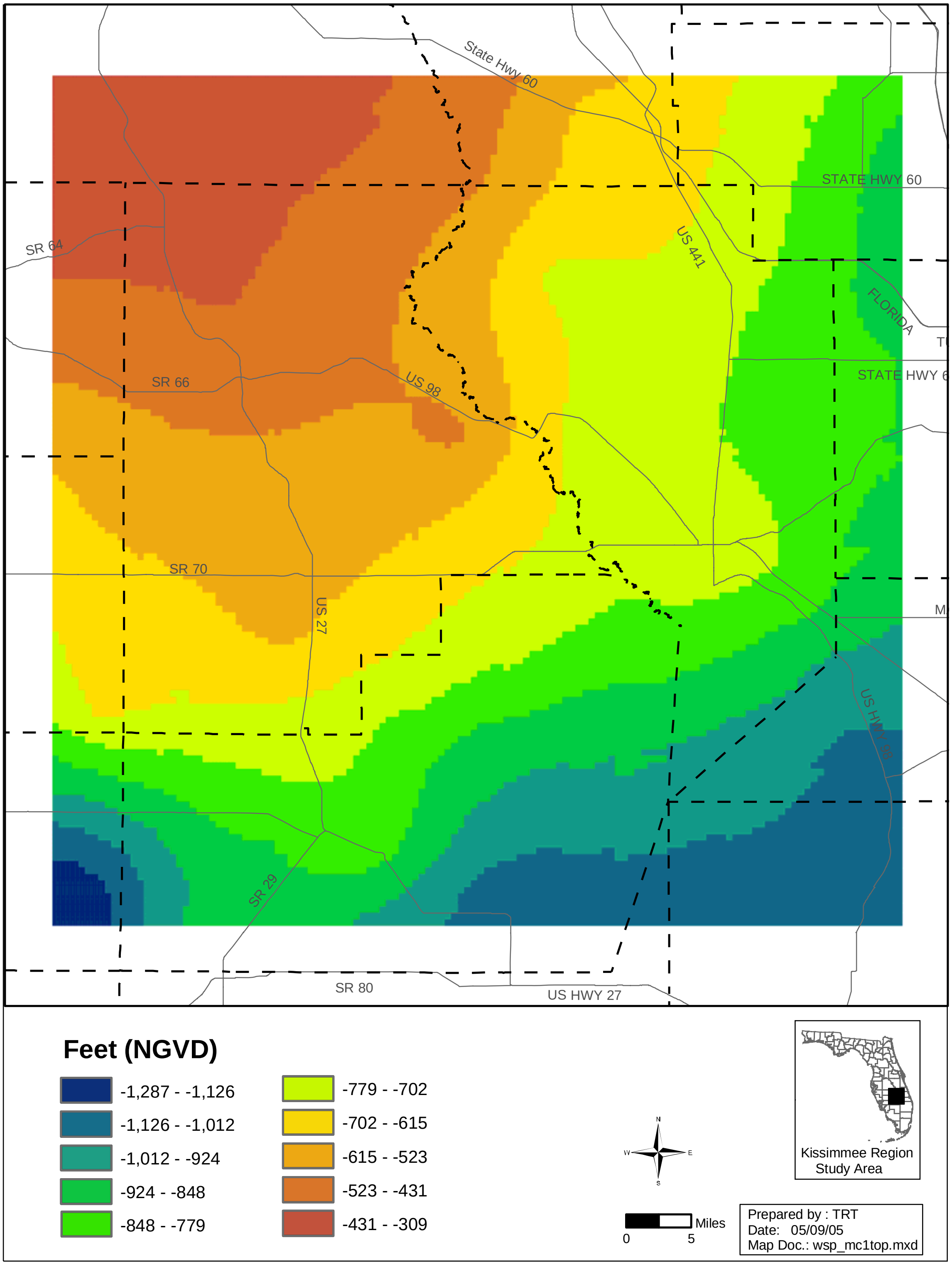

Figure 22. Elevation of the Top of the Middle Confining Unit 1 (Subset of Data Mapped in Reese & Richardson 2004).

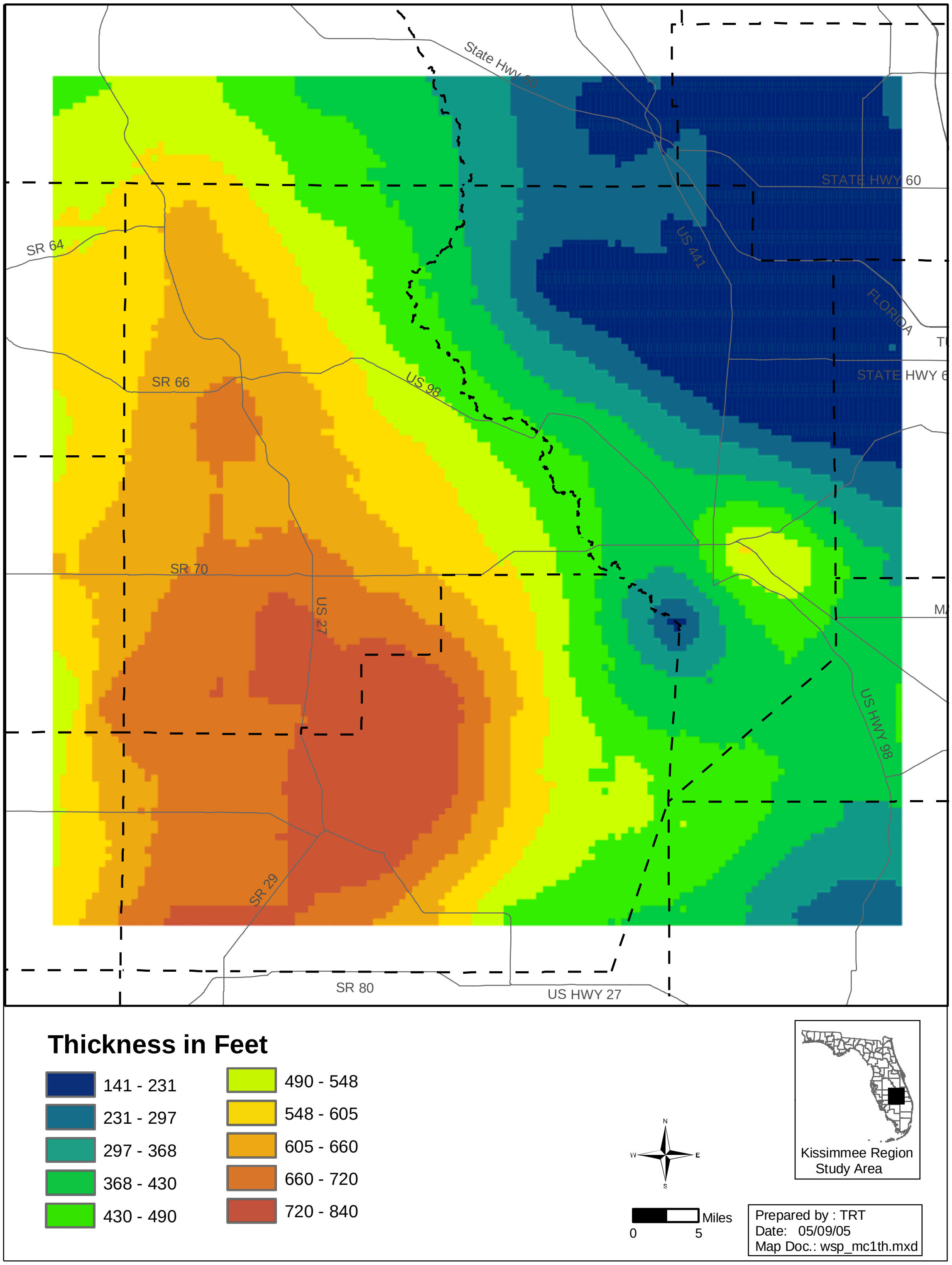

Figure 23. Thickness of the Middle Confining Unit 1.

Middle Floridan Aquifer

The Middle Floridan Aquifer begins no higher than the top of the Avon Park Formation and usually does not extend beyond the Middle Avon Park Formation (Reese and Richardson 2004). The Middle Floridan Aquifer is a thick permeable and highly transmissive dolostone sequence, previously included within the Lower Floridan Aquifer (Lukasiewicz 1992) as Upper Floridan Zone B (Beach and Chan 2003), or the lower permeable zone, or lower part of the Upper Floridan. Reese and Richardson (2004) reviewed the previous studies and identified the Middle Floridan as a highly permeable unit that is regionally continuous. The dolostone sequence is fractured and cavernous permeability can also be present (Reese and Richardson 2004). In the model area, the thickness of the Middle Floridan Aquifer varies from 92 to 446 feet. The transmissivities in the Middle Floridan Aquifer range from 25,766 (ft^2/day) up to 1,272,354 (ft^2/day). This aquifer is sometimes referred to as the High T Zone (Beach and Chan 2003).

Figures 24, **25 and 26** show the top, thickness and transmissivity of the Middle Floridan Aquifer.

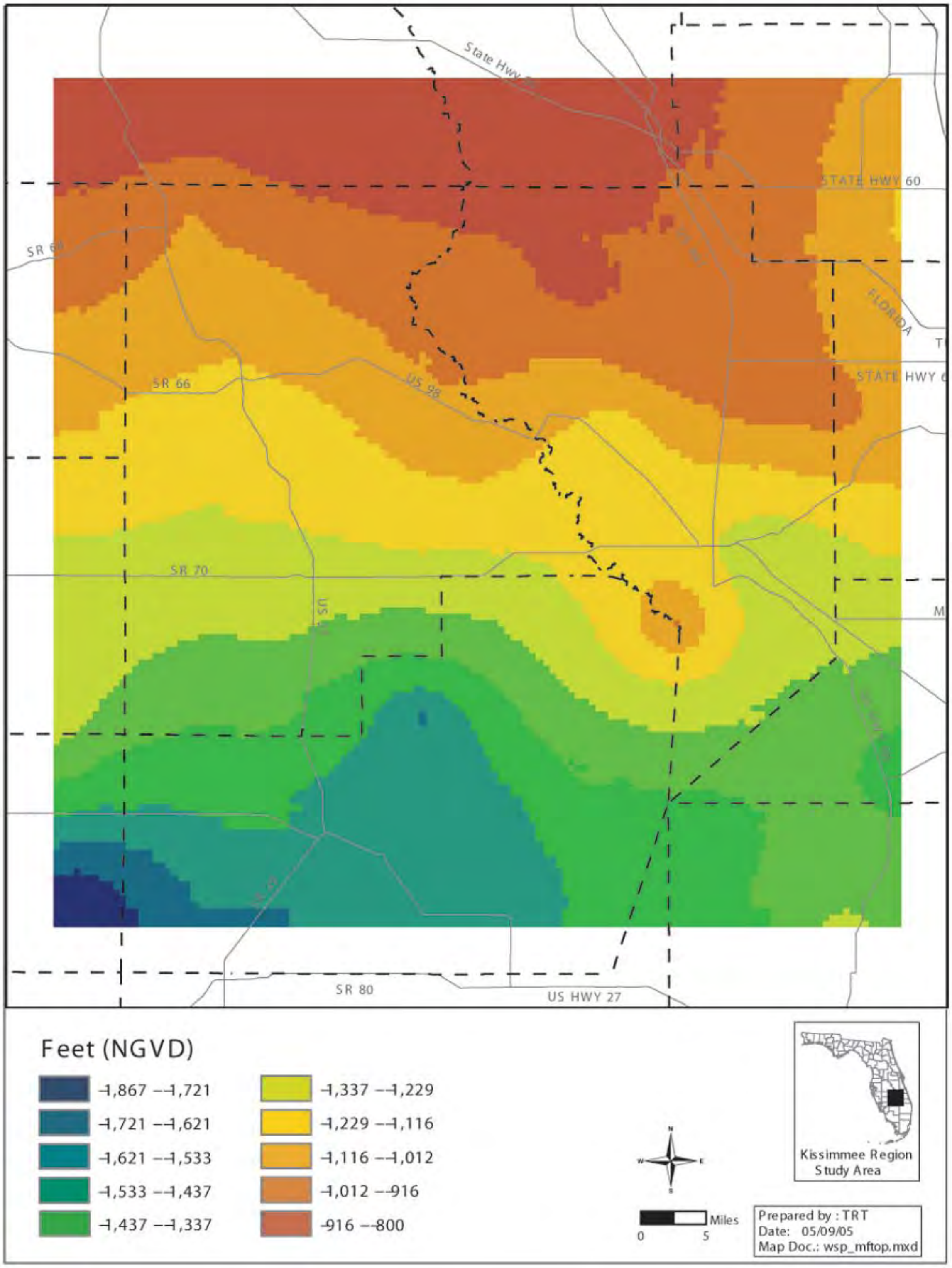

Figure 24. Elevation of the Top of the Middle Floridan Aquifer (Subset of Data Mapped in Reese & Richardson 2004).

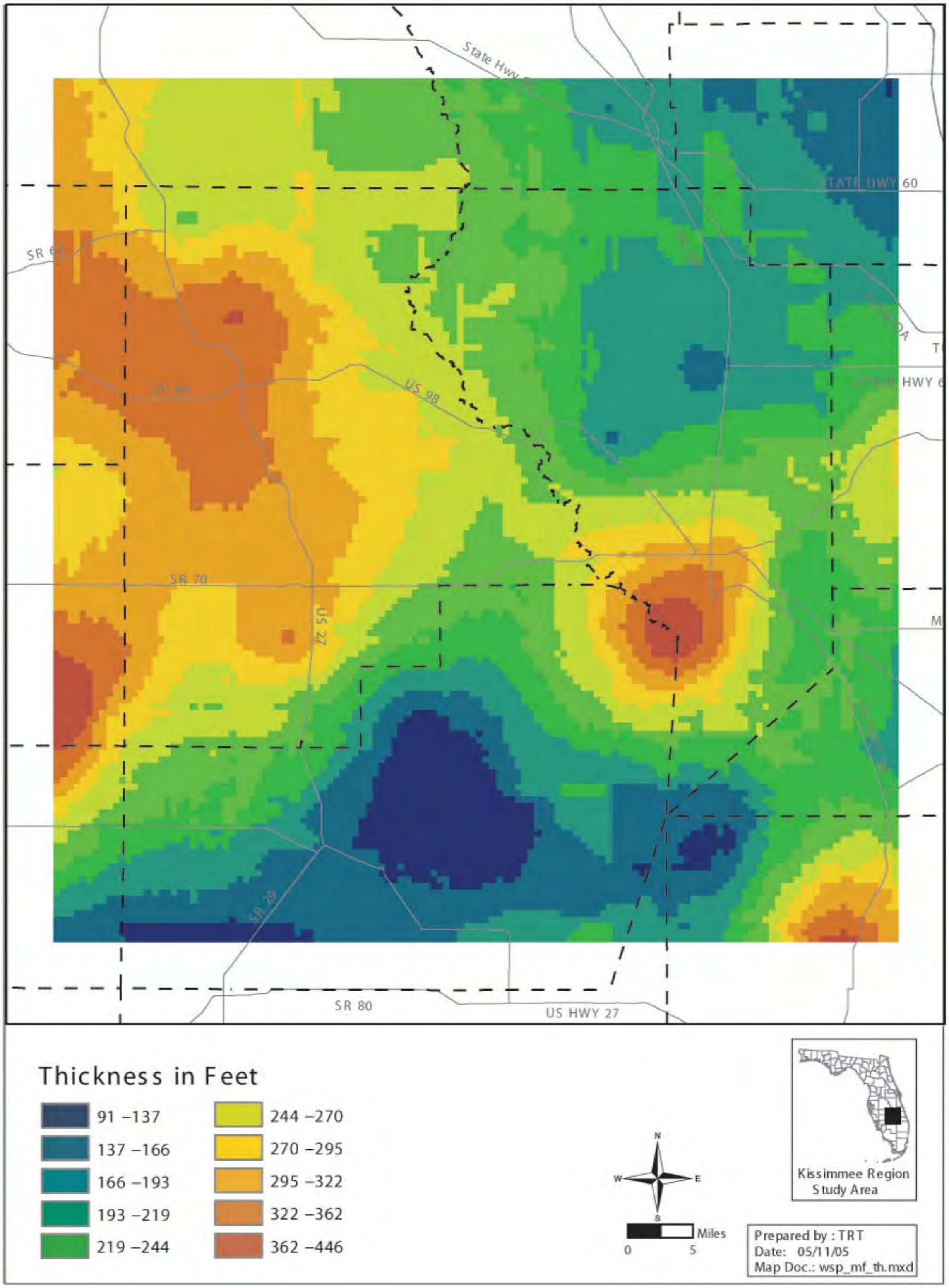

Figure 25. Thickness of the Middle Floridan Aquifer.

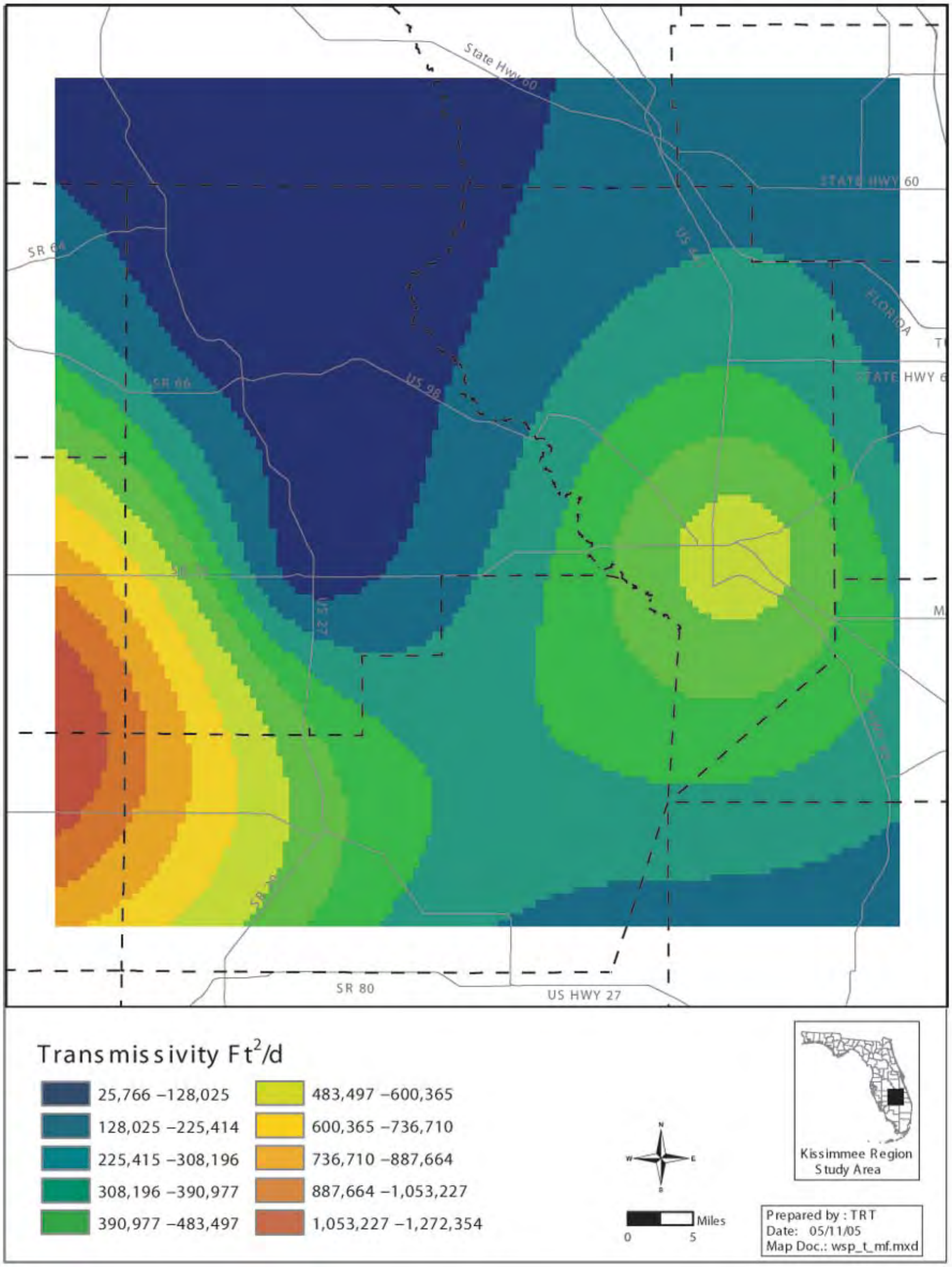

Figure 26. Transmissivity in the Middle Floridan Aquifer (ft²/day) (Subset of Data Mapped in Reese & Richardson 2004).

Middle Confining Unit 2

The Middle Confining Unit 2 (MC2) is comprised of a thin dense dolomite unit in the Middle Avon Park Formation. In the model area, the thickness varies from 77 to 618 feet. In some locations, the confining unit may be fractured. **Figures 27** and **28** show the top and thickness of the Middle Confining Unit 2.

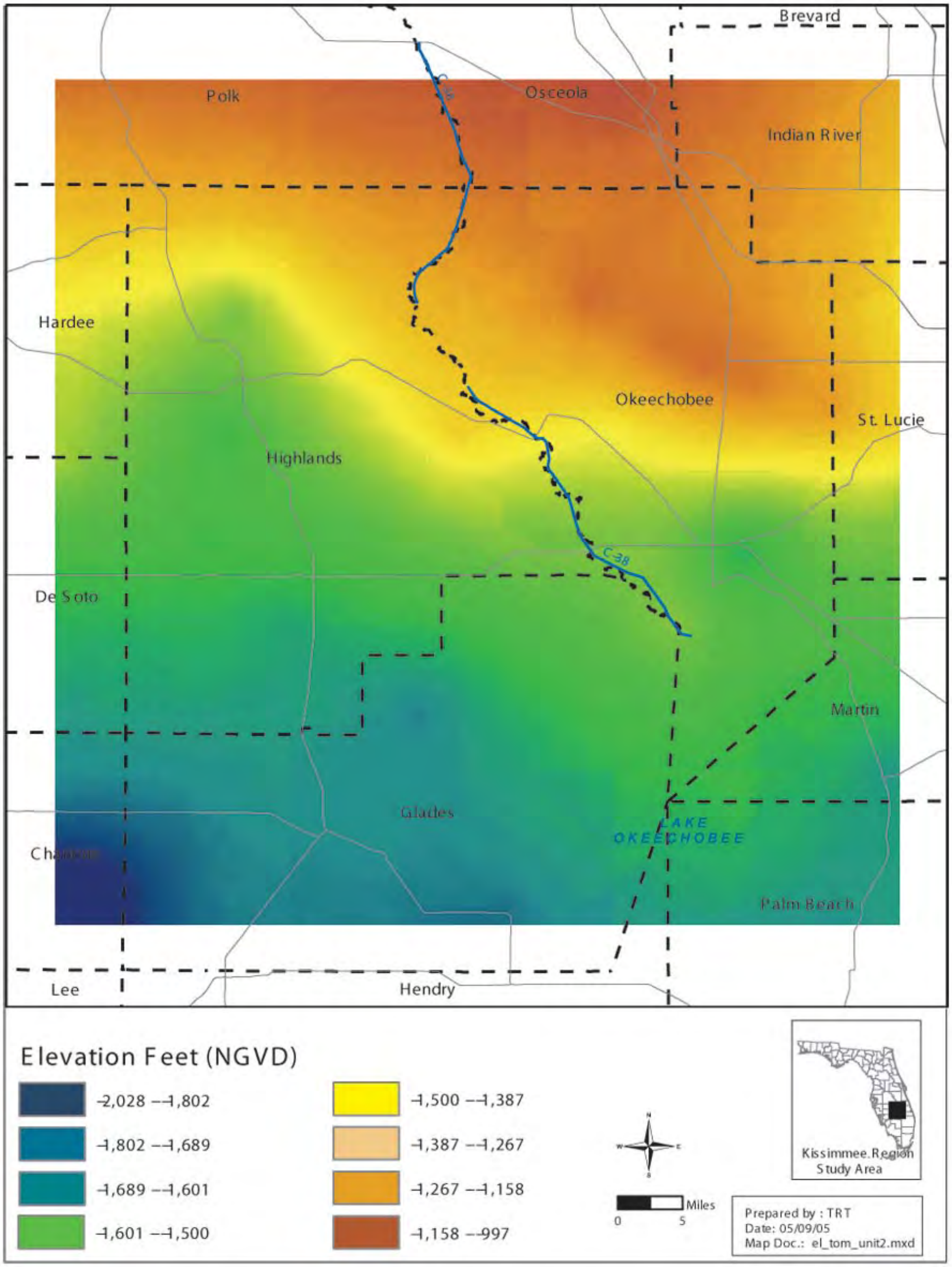

Figure 27. Elevation of Top of Middle Confining Unit 2 (Subset of Data Mapped in Reese & Richardson 2004).

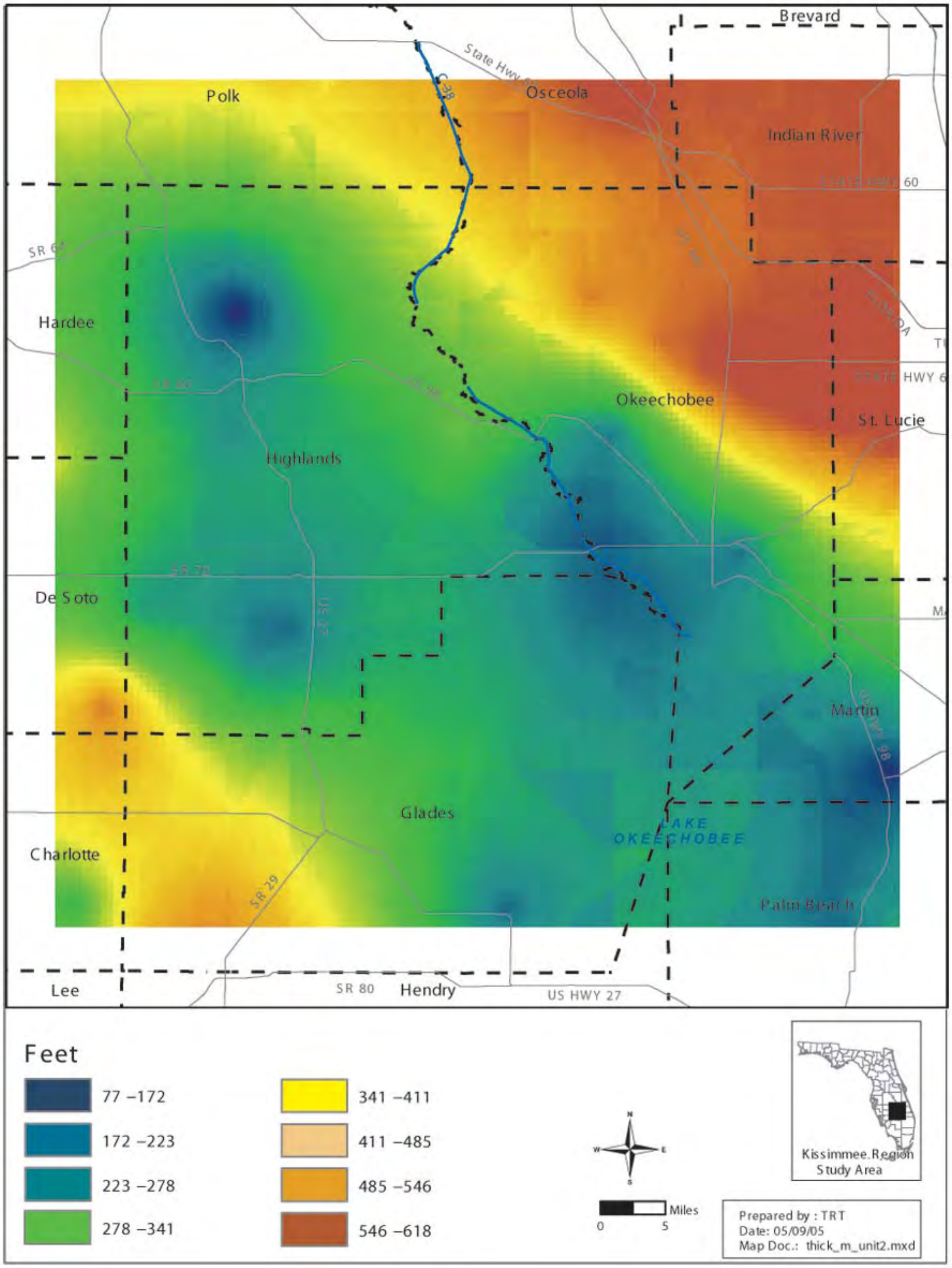

Figure 28. Thickness of the Middle Confining Unit 2.

Lower Floridan Aquifer

The top of the Lower Floridan Aquifer (LF) is the lower part of the Avon Park Formation. Included in the Lower Floridan Aquifer are the Oldsmar and Cedar Key Formations. It is identified as the first permeable zone below the Middle Confining Unit 2. The base of the Floridan Aquifer System is composed of a low permeability dolomite with gypsum layer. The dolostone in the Lower Floridan Aquifer, however, tends to be dense, massive and crystalline. It is not fractured as in the Middle Floridan Aquifer. Confinement between the Middle Floridan Aquifer and Lower Floridan Aquifer may not exist in some areas (Reese and Richardson 2004). There are no geophysical logs of Lower Floridan Aquifer wells in the model area to verify the local conditions. **Figure 29** shows the top of the Lower Floridan Aquifer .The transmissivity for the Lower Floridan Aquifer was estimated to be 300,000 (ft^2/day) based on lower Floridan sites outside the model boundary and calibrated model values presented in Sepulveda (2002).

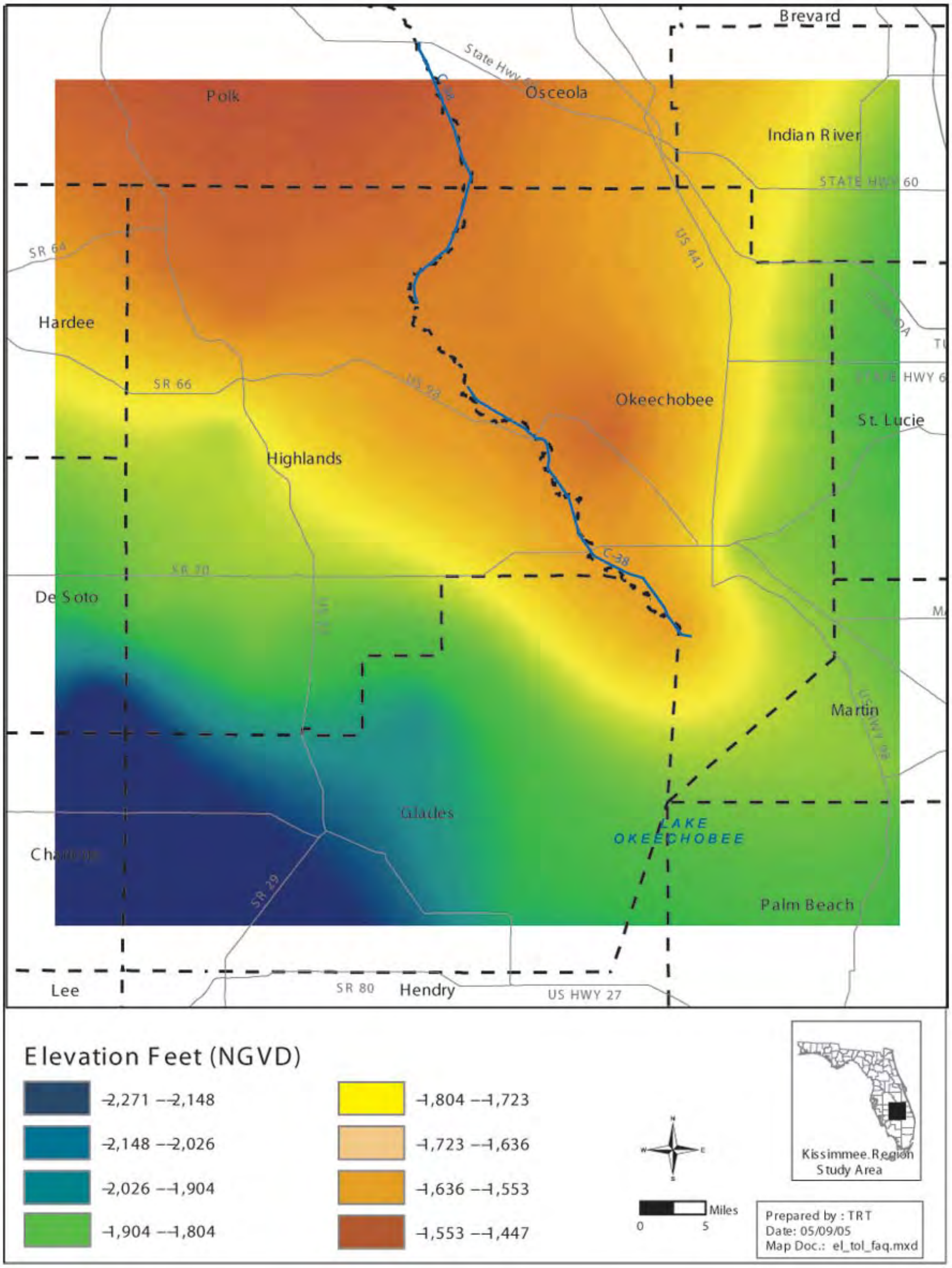

Figure 29. Elevation of Top of Lower Floridan Aquifer (Subset of Data Mapped in Reese & Richardson 2004).

Recharge and Discharge

Recharge to the Surficial Aquifer System is mainly from rainfall.

Most of recharge into the Upper Floridan Aquifer System is from the Surficial Aquifer System via the Intermediate Confining Unit. In the model area, most of this recharge occurs along Lake Wales Ridge in areas where there are sinkhole lakes, and the Intermediate Confining Unit is thin. The Confining Unit thins out and is absent in some portions of Lake Wales Ridge north of the model area (Beach and Chan 2003).

Recharge into the Middle Floridan Aquifer from the Lower Floridan Aquifer may be occurring in areas where the equivalent fresh water heads in the Middle Floridan Aquifer are lower than those in the Lower Floridan Aquifer.

In the eastern portion of the model, along the Kissimmee River and in the area surrounding northern Lake Okeechobee, artesian conditions exist in the Upper Floridan Aquifer. In **Chapter 5**, **Figure 94** shows the areas where the water levels in the Upper Floridan Aquifer exceed land elevation.

Watershed / Drainage Basins (dbasins)

Watersheds and drainage basins are often confused. Some use both terms interchangeably. A watershed is a divide separating one drainage area from another (sometimes called a drainage divide). In the United States, the area bounded by topographical divides is referred to as a watershed or drainage basin. Each large watershed can be broken into smaller sub-watersheds, which are referred to as drainage basins. The watershed is further defined as the area of land that drains water, sediment, dissolved materials and biota to a common outlet at some point along a stream channel, within the topographical divide. A drainage basin is drainage around an individual river. (Harper *et al.*[1] 2004, Gunpowder Watershed Clearinghouse Web site[2]).

The model includes portions of the following surface water watersheds (**Figure 30**): Peace River, Kissimmee River, Upper St. Johns River, Southeast Florida Coast, Caloosahatchee River, and all of Fisheating Creek and Taylor Creek. Each of these watersheds is divided into smaller drainage basins as displayed in **Figure 31**.

1 Hydrology, the Hydrologic Cycle, Watershed, Watershed Management and Watershed Water Balance http://danr.ucop.edu/uccelr/h33.htm

2 Gunpowder Watershed Clearinghouse http://www.towson.edu/gwc/

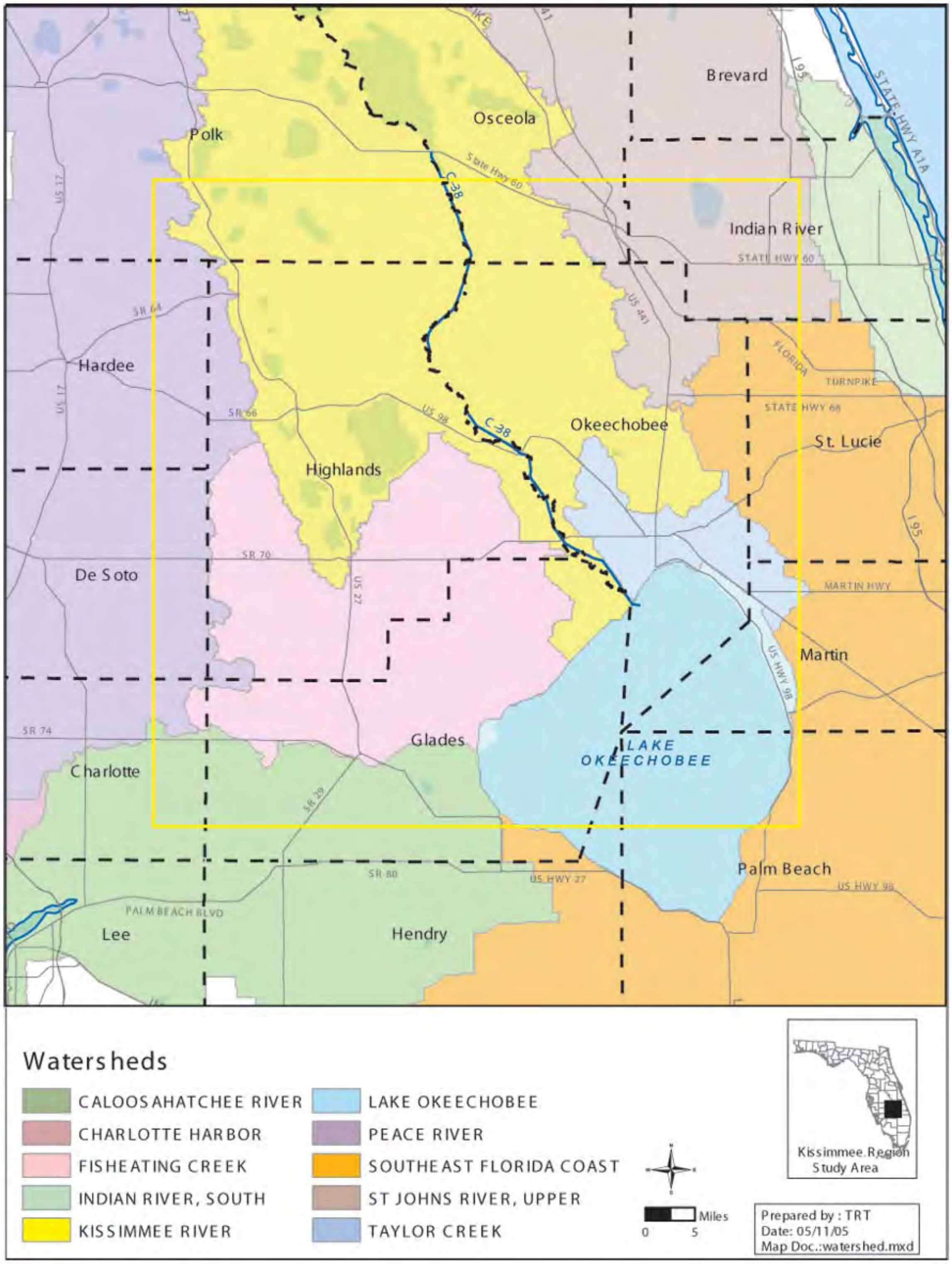

Figure 30. Watersheds.

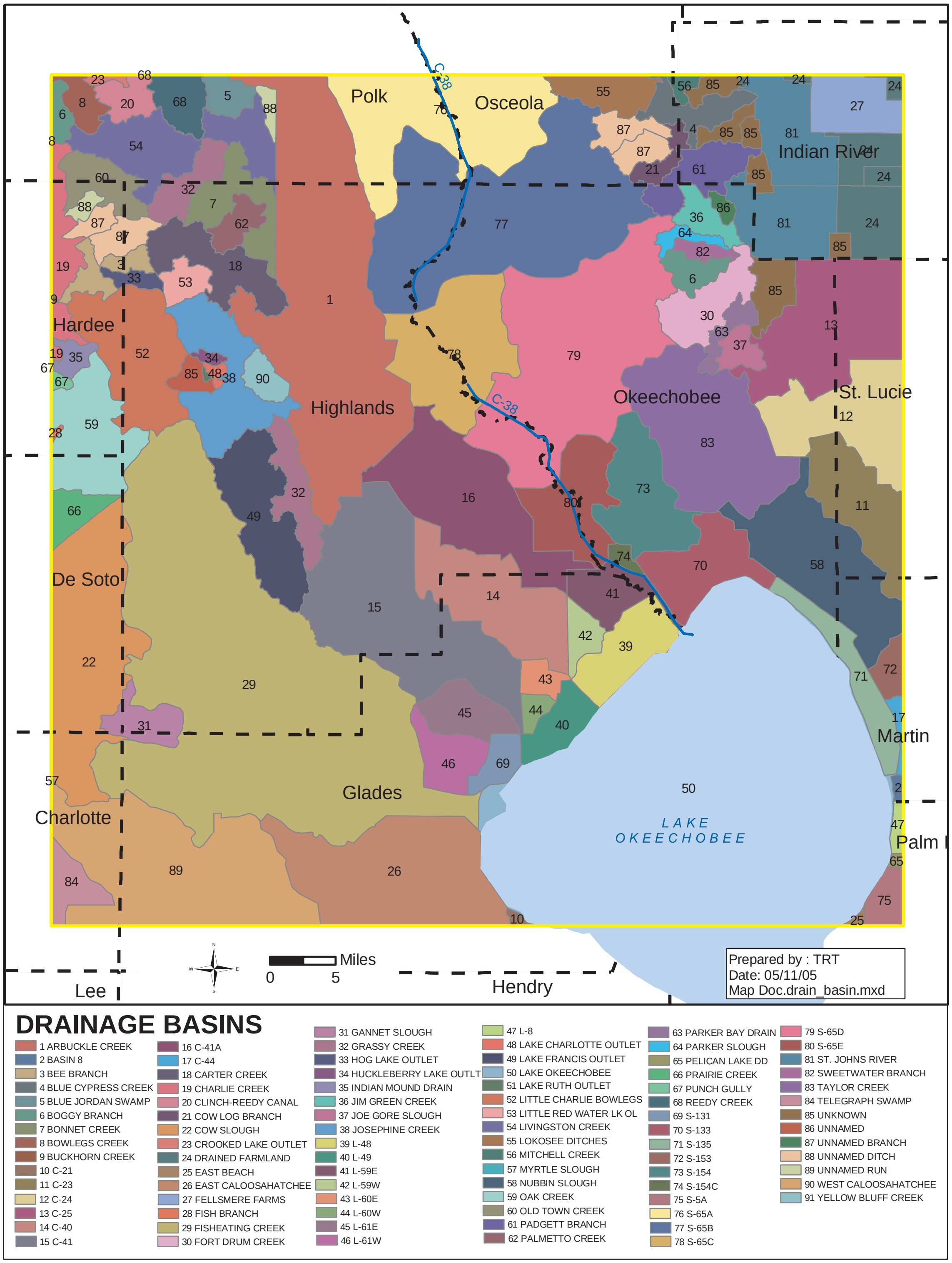

Figure 31. Drainage Basins.

Potentiometric Levels

The Floridan Aquifer System is confined or semi-confined in most portions of the model, however, recent work by Krupa *et al.* (2005) indicates that this may not be the case in the lower portion of the Lower Kissimmee River Basin. Using USGS potentiometric maps (both contours and data points were digitized) for the Upper Floridan Aquifer for September and May of 1995 (Knowles 1995) (**Figures 32** and **33**) the average 1995 potentiometric surface was calculated (**Figure 34**). The U.S. Geological Survey (USGS) did not divide the Upper Floridan Aquifer System into the Upper and Middle Floridan Aquifers, but some recently constructed nested wells along Lake Wales Ridge in Romp 28 show that the water levels in the Upper and Middle Floridan Aquifer are similar (**Figure 35**). There are no wells in the Lower Floridan Aquifer in the model area, but in east-central Florida, O'Reilly and others (2002) noted that the heads in the Lower Floridan Aquifer were 0 to 6 feet above those in the Upper Floridan Aquifer. Lukasiewicz (2001), observed water levels in the Lower Floridan Aquifer to be below the Upper Floridan Aquifer water levels, but when fresh water equivalent heads were calculated to compensate for the density differences, then the water levels in Lower Floridan Aquifer were higher than the Upper Floridan Aquifer. For the model, the starting heads for the Lower Floridan Aquifer were set to the same level as those in the Upper and Middle Floridan aquifers.

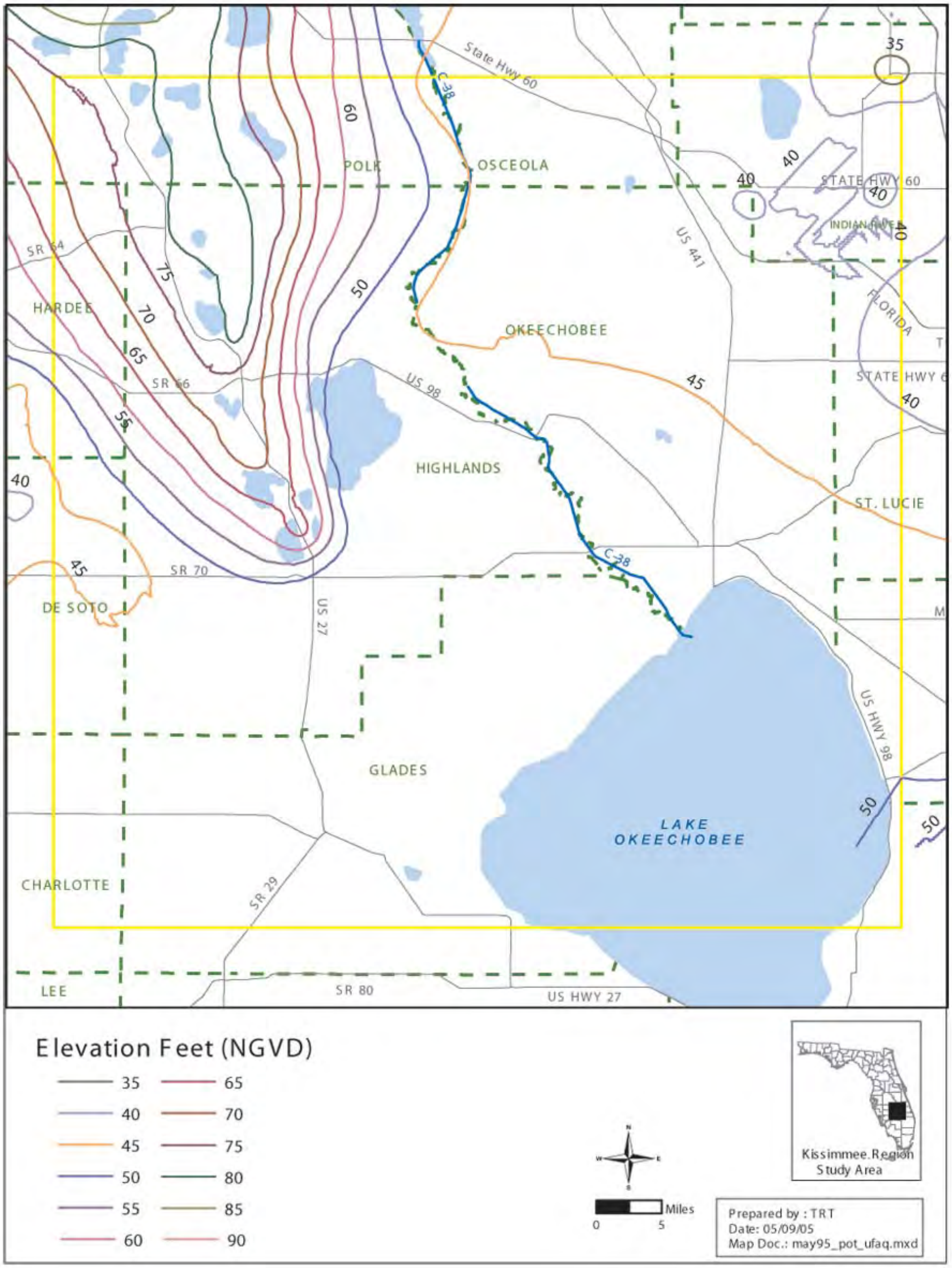

Figure 32. May 1995 Potentiometric Surface of the Upper Floridan Aquifer System (Adapted from USGS Potentiometric Maps, Knowles *et al*. 1995).

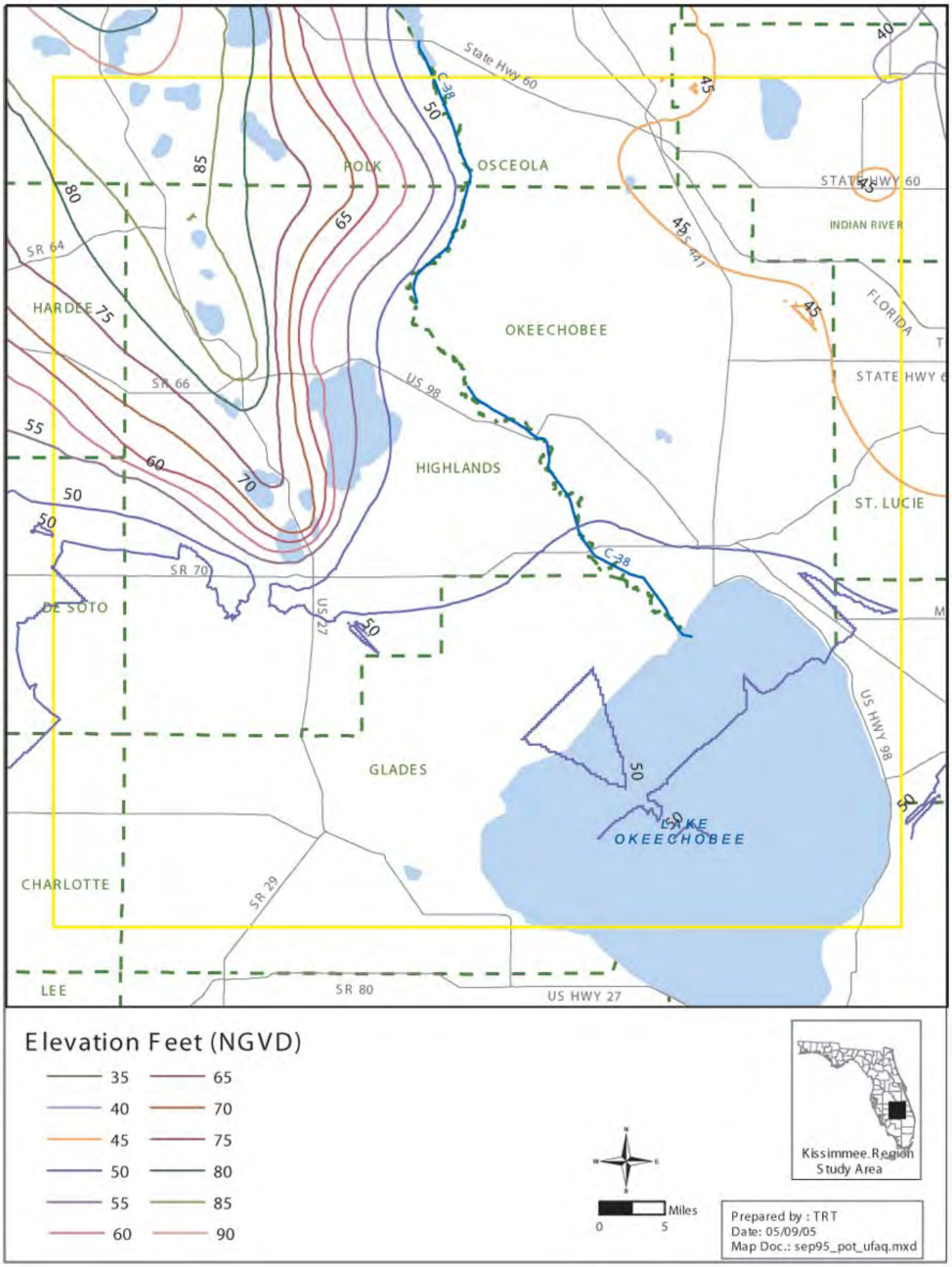

Figure 33. September 1995 Potentiometric Surface of the Upper Floridan Aquifer System (Adapted from USGS Potentiometric Maps, Knowles *et al*. 1995).

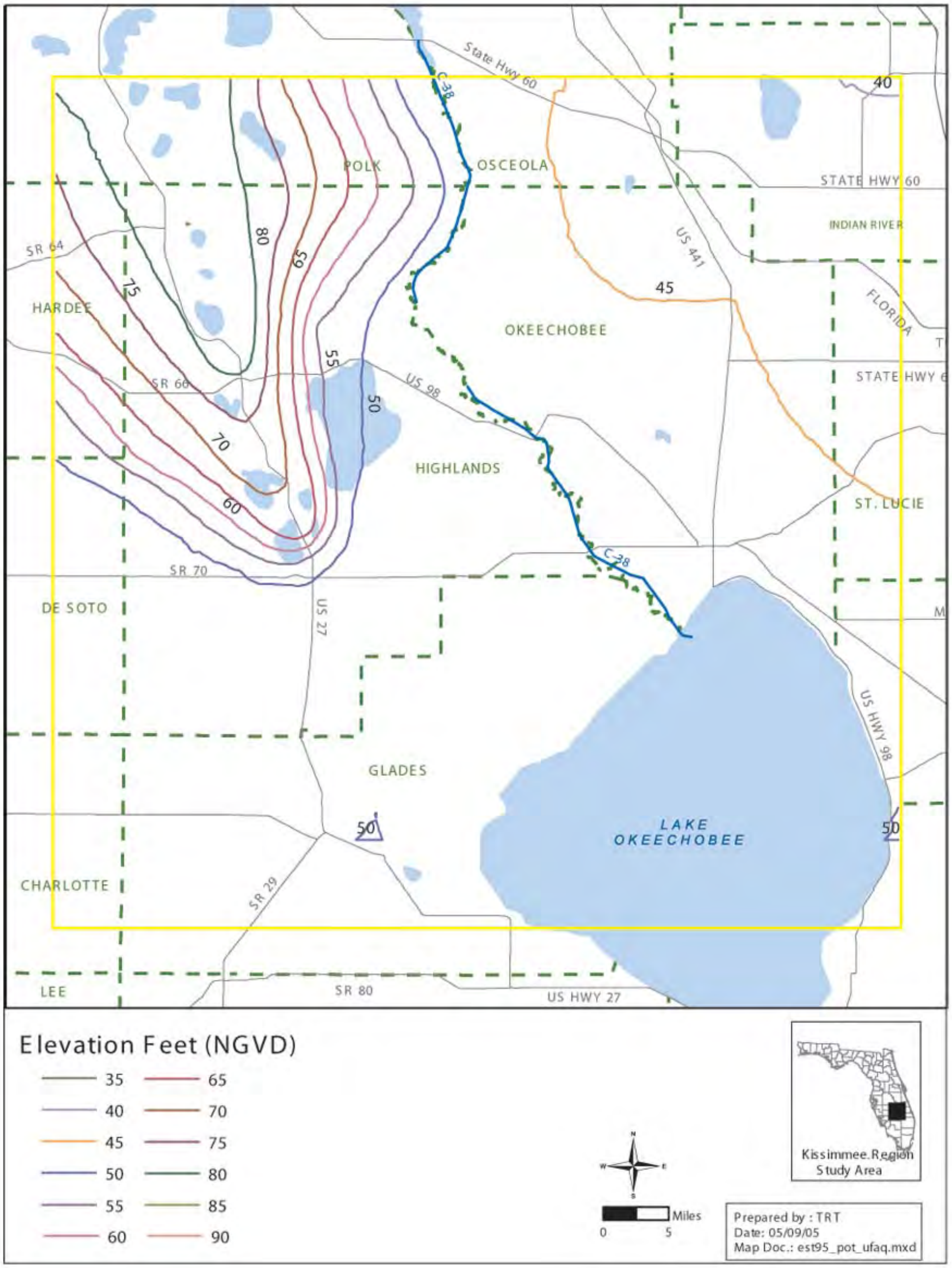

Figure 34. Estimated Average 1995 Potentiometric Surface of the Upper Floridan Aquifer System.

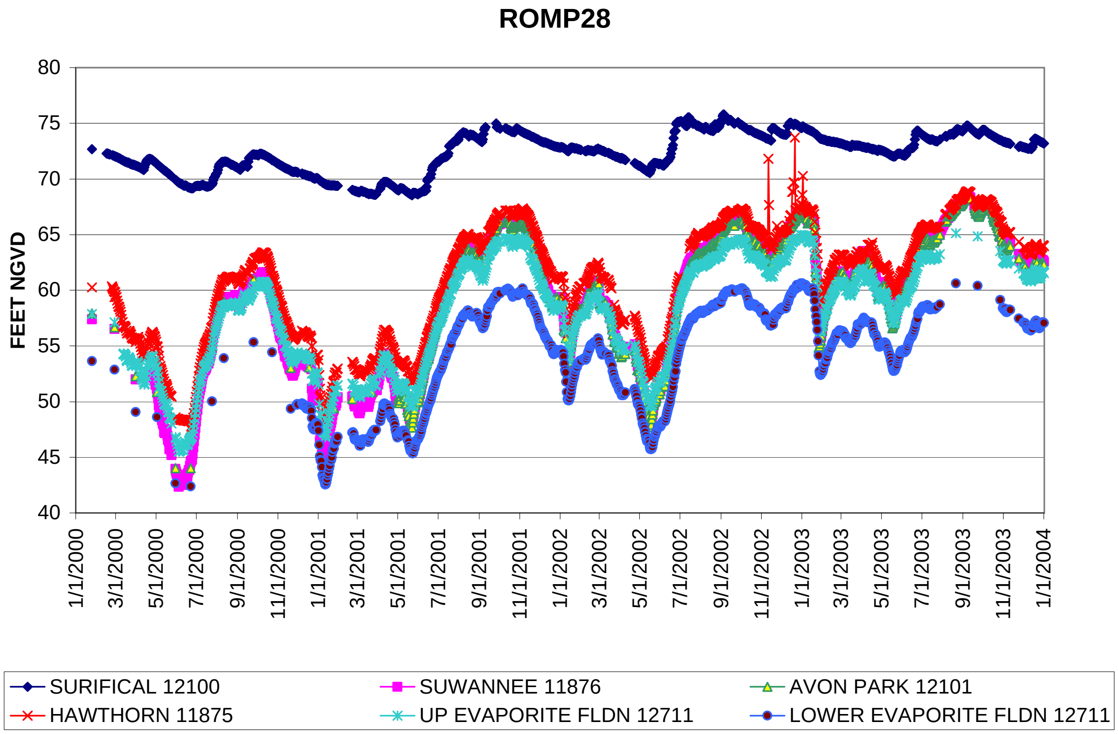

Figure 35. Compare Water Levels in Nested Well Romp 28 (Provisional Data from SWFWMD).

Historic and Projected Water Use

Agriculture is the predominant water use in the model area. Other water uses include mining and public water supply. Both surface water and groundwater are used. The Upper and Middle Floridan Aquifers are the main groundwater sources, with only 10 percent of the all the water coming from the Surficial Aquifer System. Within the Kissimmee Water Supply Plan area, the public water supply demands are projected to increase from 12 percent to 52 percent of total water consumption, while agricultural demands are projected to decrease from 43 percent to 29 percent of total water consumption. In the next 25 years, the population within the SFWMD portion of the Lower Kissimmee Groundwater Basin is projected to increase. Due to population growth urban water supply (both public water supply and domestic self-supply) will increase (SFWMD 2005). Public water supply for the Kissimmee Planning region is expected to increase by 84 percent with more residents who have private wells connecting to regional utilities and more people moving into the area. Although agricultural demands in the whole Kissimmee planning area are declining, the demands within the Lower Kissimmee Groundwater Model area have remained stable since the 2000 plan came out. Citrus and sugarcane crops have both expanded since 2000, but only citrus is expected to increase in the period through 2025 (SFWMD 2005)

Water Quality

A comprehensive study of the water quality in the region of the model domain has not been completed. Katz completed a geochemical study of the Upper Floridan Aquifer in Florida in 1992. Shaw and Trost (1984) addressed water quality of the Floridan Aquifer System in their Kissimmee Planning Area report. Data from the Surficial Aquifer were collected during 1997 to 2000 as part of a groundwater/surface water interaction study of Pools A and C in the Kissimmee River Basin (McGinnes, et al. 2003). It is recommended that a water quality sampling plan be developed and carried out prior to the next update of this model to ensure spatially distributed data are available from both the Surficial Aquifer System and the Floridan Aquifer System. This should include salinity profiles for selected Floridan Aquifer System wells with lengthy open hole or screened intervals.

The chemistry of water is classified in a number of ways. Water classification by salinity uses total dissolved solids (TDS) and is shown in **Table 2**. The TDS measurement represents all of the dissolved minerals in the water, but does not include suspended sediments, colloids or dissolved gases. Water that is considered fresh by this classification may still be unsuitable for human consumption. Primary and drinking water regulations have specifications for a number of individual parameters. A brief list of some of these parameters and their maximum allowable values are shown in **Table 3**. In this report, potable or fresh water is defined as water that meets the Florida Drinking Water Regulations. **Figure 36** presents water quality well sites by aquifer system.

Table 2. Water Classification by Salinity (Source: Kasenow 1997).

Water Classification	TDS (mg/L)
Fresh Water	< 1,000
Slightly Saline	1,000 to 3,000
Moderately Saline (Brackish)	3,000 to 10,000
Very Saline	10,000 to 35,000
Sea Water	35,000
Brine	> 35,000

Table 3. Some Parameters in the Primary and Secondary Drinking Water Regulations, Florida Administrative Code, 1982.

Parameter	Primary Standard (mg/L)	Secondary Standard (mg/L)
Sodium (Na)	160	--
Chloride (Cl)	--	250
Iron (Fe)	--	0.3
pH	--	6.5 to 8.5
Sulfate (SO4)	--	250
Total Dissolved Solids (TDS)	--	500

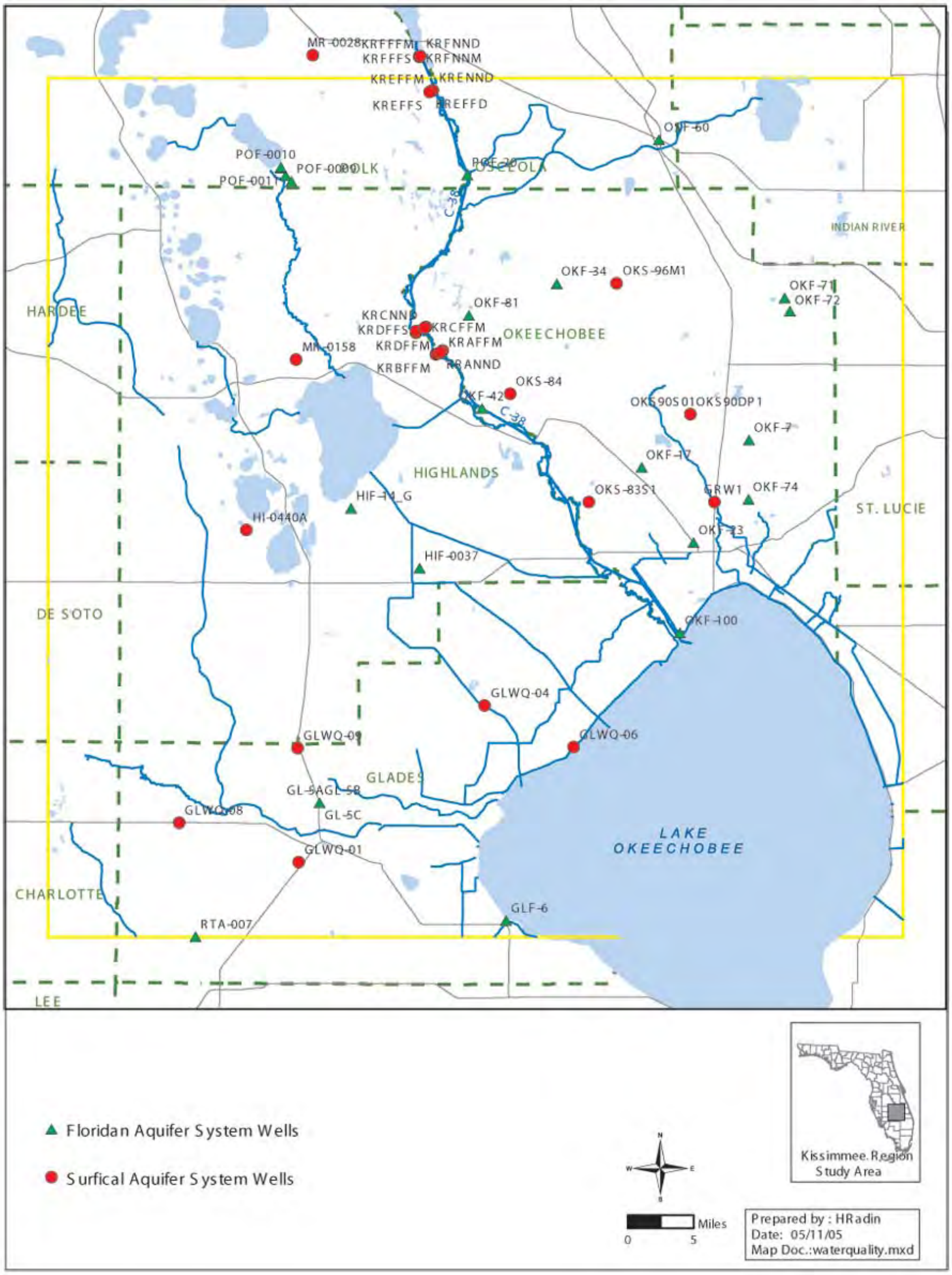

Figure 36. Water Quality Well Sites by Aquifer System.

Surficial Aquifer System

The water quality results from 41 Surficial Aquifer System wells were reviewed (see **Figure 36** and **Table 4**). The dominate ions in the water were calcium (Ca) and bicarbonate (HCO3). In fact, calcium was the primary cation in all wells reviewed, except for two wells in Glades County. Wells GLWQ-06 and GLWQ-09 both had Na-Ca-Mg water. Well GLWQ-06 is 46 feet below land surface (bls) deep and is located along the edge of Lake Okeechobee. The GLWQ-09 well is 33 feet bls and is central Glades County, just south of Highlands County.

Thirty-three of these wells have TDS levels less than 500 mg/L; the mean value for all these wells is 347 mg/L. Eight wells had TDS values greater than 500 mg/L. Five of these are shallow (< 40 feet bls) wells situated along the Kissimmee River and the remaining three are in central Glades County. The mean TDS level for all 41 Surficial Aquifer System wells was 466 mg/L.

One well exceeded the state secondary drinking water standard for chlorides; GLWQ-06 had a chloride level of 334 mg/L. Three wells, KRAFFS, KRFFFM and KRFFFS exceeded the sulfate standards with measurements of 916, 271 and 266 mg/L respectively. GLWQ-06 also exceeded the sodium standard with a measurement of 222 mg/L. The mean chloride, sulfate and sodium values for all Surficial Aquifer System wells were 35 mg/L, 51 mg/L and 33 mg/L respectively. Generally, the wells surrounding Lake Okeechobee had TDS levels greater than 1000 mg/L. Total iron measurements varied greatly from well to well and sometimes, from sampling event to sampling event. It was apparent that several wells displayed seasonal changes in the water chemistry; generally the shallow wells installed closest to the river for the Kissimmee River Groundwater/Surface Water Interaction Study showed variation of at least an order of magnitude in total iron. Sulfate levels at some of these wells, including KRDNNS1, also showed this variation.

Data from these SFWMD wells were compared to results included in the Florida Geological Survey Background Geochemistry Report (Maddox 1992) and are summarized for each county in **Tables 5, 6, 7** and **8**. Generally the SFWMD data showed more variation with lower minimums and higher maximums than the Florida Geological Survey results.

Table 4. Water Quality of the Wells in the Surficial Aquifer System.

	Type of Water	Temp (°C)	Sp Cond (uS/cm)	pH	Cl (mg/L)	SO4 (mg/L)	Alka (mg/L)	Na (mg/L)	Ca (mg/L)	K (mg/L)	Mg (mg/L)	TDS (mg/L)	Fe (mg/L)	Depth (feet bls)	Period of Record
Glades															
GLWQ-09	Na-Ca-Mg	25.7	111	5.6	12	2.4	19	9	5	0.8	2.1	90	3.4	33	05/85–11/90
GLWQ-06	Na-Ca-Mg	24.5	1,778	7.3	334	104.8	373	222	122	6.1	31.4	1,052	0.3	46	05/85–10/90
GLWQ-01	Ca-Na-H3O3	24.9	146	5.8	12	7.5	52	12	16	0.8	2.6	100	0.5	54	05/85–10/89
GLWQ-04	Ca-Na-H3O3	25.3	1,264	6.8	133	13.2	430	114	135	3.2	23.8	791	0.3	75	05/85–10/90
GLWQ-08	Ca-Na-Mg	25.4	1,555	6.8	113	171.8	434	125	125	3.1	51.7	977	0.3	85	05/85–10/90
Highlands															
MR-0158	Na-Cl-HCO3	25.3	74.5	5.5	5	6.6	7	9	6	0.1	0.2	62	2.4	10	07/85–02/93
HI-0440A	Na-Cl-SO4	25.8	163	5.9	10	4.9	4	3	1	1.3	0.4	97	37.4	23	07/85–07/90
KRDFFS	Ca-HCO3	23.8	487	6.3	33	3.9	207	23	72	1.6	7.5	418	8.2	25	09/97–01/01
KRDNNS1	Ca-HCO3	24.2	696	7.0	22	25.4	310	23	121	2.9	8.6	451	1.2	25	09/97–01/01
KRBFFS	Ca-HCO3	23.7	586	6.8	22	0.7	262	21	93	1.7	6.4	374	0.5	26	09/97–01/01
KRBNNS	Ca-HCO3	24.1	632	7.2	17	2.5	307	21	103	1.8	8.2	380	0.4	30	09/97–01/01
KRBFFM	Ca-HCO3	24.0	596	7.2	15	0.5	321	19	113	2.2	7.9	397	0.2	46	09/97–01/01
KRBNNM	Ca-HCO3	24.3	624	7.3	16	0.6	322	20	111	2.3	7.9	398	0.2	49	09/97–01/01
KRDFFM	Ca-HCO3	23.9	565	7.3	19	1.0	309	26	103	2.7	5.0	375	0.6	51	09/97–01/01
KRDNNM1	Ca-HCO3	24.3	604	7.5	19	0.5	299	25	100	2.9	6.2	370	0.3	52	09/97–01/01
KRDNND1	Ca-HCO3	24.0	602	7.3	17	0.3	296	24	115	3.3	6.0	375	0.1	83	09/97–01/01
KRBNND	Ca-HCO3	24.0	617	7.2	17	0.4	306	19	108	2.7	7.7	388	0.4	98	09/97–01/01
Okeechobee															
GRW1	Ca-HCO3	23.1	320	5.5	13	5.6	106	12	38	2.3	3.1	285	3.2	17	11/01–09/03
KRCNNS	Ca-HCO3	24.2	757	7.0	31	40.7	305	30	118	1.6	11.5	459	2.0	20	09/97–01/01
OKS-83S1	Na-Cl--HCO3	24.6	95	5.4	11	1.7	10	17	3	0.1	0.7	103	8.1	20	04/93–10/93
OKS90S01	Ca-Na-HCO3-Cl	23.4	186	5.8	17	1	55	10	19	2.4	2.5	118	4.9	21	12/92–10/93
KRAFFS	Ca-SO4-HCO3	24.1	2,231	6.5	21	916	436	29	482	2.4	31.7	1,696	18.0	24	10/97–01/01
KRANNS	Ca-HCO3-SO4	24.9	1,284	6.6	11	227	460	9	262	3.4	10.6	767	0.4	24	10/97–01/01
KRCFFS	Ca-HCO3	23.9	753	7.2	30	20.8	345	31	122	1.8	9.8	491	0.9	25	09/97–01/01
KRAFFM	Ca-Na-HCO3	24.3	605	7.1	34	2.3	273	31	91	1.9	6.4	352	1.3	40	10/97–01/01
KRCFFM	Ca-Na-HCO3	23.8	618	7.2	26	0.5	283	31	94	1.7	8.0	382	0.7	42	09/97–01/01
KRCNNM	Ca-Na-HCO3	24.1	572	7.4	32	0.7	244	41	74	1.7	6.9	345	0.1	43	09/97–01/01
KRANNM	Ca-Na-HCO3-Cl	25.0	641	7.3	50	1.4	245	33	90	2.0	6.7	382	0.3	49	10/97–01/01
OKS-96M1	Ca-Na-HCO3-Cl	24.2	756	6.9	73	1.7	259	46	106	0.5	14.0	480	0.4	51	04/93–10/93
KRCNND	Ca-Na-HCO3	23.9	560	7.4	26	1.5	247	32	77	2.3	7.2	339	0.0	86	09/97–01/01
OKS90DP1	Ca-HCO3	22.9	514	7.0	10	1.0	180	14	57	7.4	4.2	327	0.2	93	04/93–10/93
KRANND	Ca-Na-HCO3	24.4	612	7.4	43	5.2	238	34	83	2.2	7.8	356	0.2	96	10/97–01/01
OKS-84	Ca-Na-HCO3-Cl	25.3	840	7.4	64	9.8	287	68	103	1.8	8.6	482	0.4	178	04/93–10/93

Table 4. Water Quality of the Wells in the Surficial Aquifer System (Continued).

	Type of Water	Temp (°C)	Sp Cond (uS/cm)	pH	Cl (mg/L)	SO4 (mg/L)	Alka (mg/L)	Na (mg/L)	Ca (mg/L)	K (mg/L)	Mg (mg/L)	TDS (mg/L)	Fe (mg/L)	Depth (feet bls)	Period of Record
Polk															
MR-0028	Na-Ca-SO4-Cl	26.1	122	4.2	10	16.6	7	18	4	1.5	2	5	2.4	8	07/85–05/88
KREFFS	Ca-HCO3	24.6	584	6.5	5	1.4	298	5	109	1.5	6.3	380	0.1	21	10/97–01/01
KRFNNS	Ca-HCO3	24.3	701	6.7	6	27.5	337	10	125	2.0	14.9	464	0.0	21	10/97–01/01
KRENNS	Ca-HCO3	23.2	656	6.8	6	11.7	326	5	133	1.7	7.8	443	0.0	21	10/97–01/01
KRFFFS	Ca-HC03-SO4	23.0	1,552	6.5	34	266	554	29	293	0.9	34.5	961	26.0	21	10/97–01/01
KRFNNM	Ca-Mg-HCO3	24.2	1,023	6.6	21	29.7	523	26	160	2.1	30.1	743	0.1	34	10/97–01/01
KRFFFM	Ca-HC03-SO4	22.8	1,548	6.5	37	271	539	32	284	1.0	35.6	1,041	21.3	36	10/97–01/01
KRENNM1	Ca-HCO3	23.2	681	6.8	8	4.6	339	16	128	1.9	8.2	446	0.0	37	10/97–01/01
KREFFM	Ca-HCO3	24.5	621	6.7	11	0.7	290	24	105	1.9	5.3	340	0.9	41	10/97–01/01
KRENND	Ca-Na-HCO3	23.2	493	7.3	19	0.5	227	29	73	1.5	4.9	313	0.0	116	10/97–01/01
KRFNND	Ca-Na-HCO3	24.1	670	7.1	35	0.6	280	47	87	1.9	5.5	421	0.5	116	10/97–01/01
KREFFD	Ca-Na-HCO3	23.6	490	7.3	11	1.9	235	27	71	1.4	4.5	309	0.2	120	10/97–01/01

Glades County

Data were obtained from five Surficial Aquifer System wells in Glades County. Two wells had Na-Ca-Mg water and three had Ca-Na-HCO3 or Ca-Na-Mg water. The TDS levels in three wells was 791 mg/L or higher. The two wells with TDS < 500 mg/L had pH levels of 5.6 and 5.8. All wells had at least one total iron measurement that exceeded 0.3 mg/L and GLWQ-01 and GLWQ-09 had mean levels of 0.54 mg/L and 3.4 mg/L respectively.

Table 5. Comparison of Water Quality Parameters in the Surficial Aquifer System in Glades County

Parameter	SFWMD Data	Data from FGS Report
pH	5.6 to 7.3	6 to 7
Calcium (mg/L)	5 to 135	~ 50 to 100
Sodium (mg/L)	9 to 222	10 to 50
Total Iron (mg/L)	0.02 to 11	Non-detectable to 3.25
Chlorides (mg/L)	12 to 334	10 to 100
Sulfate (mg/L)	2 to 172	Generally < 10

Highlands County

Data from ten wells and two surface water sites along the Kissimmee River were reviewed. All wells had Ca-HCO3 water and TDS levels < 500 mg/L. All other drinking water standards were met, except well KRDFFS had a pH of 6.3. All wells had chloride levels less than 45 mg/L. The mean total iron for the Highlands county wells was 0.89 mg/L. Three wells, KRBFFM, KRDNND1 and KRDNNM1 had all total iron measurements less than 0.3 mg/L, while the mean iron at KRDFFS was 8.2 mg/L. Well KRDNNS1 displayed great variation with total iron ranging from 0.028 to 9.05 mg/L; this variation was also seen in the sulfate values. Some sulfate levels were below detection limits (BDL).

Table 6. Comparison of Water Quality Parameters in the Surficial Aquifer System in Highlands County

Parameter	SFWMD Data	Data from FGS Report
pH	6.6 to 7.5	6 to 6.5
Calcium (mg/L)	72 to 121	~ 50 to 100
Sodium (mg/L)	19 to 26	10 to 20
Total Iron (mg/L)	0.02 to 11	2.8 to 9.7
Chlorides (mg/L)	15 to 33	10 to 100
Sulfate (mg/L)	BDL to 25	Generally < 10

Okeechobee County

The most common water type seen in the 15 Surficial Aquifer System wells in Okeechobee County was Ca-Na-HCO3. All wells deeper than 40 feet bls, except for OKS90DP1, had Ca-Na-HCO3 or Ca-Na-HCO3-Cl water. All wells, except for two met primary and secondary drinking water standards. KRANNS had a TDS of 767 mg/L and a sulfate level of 227 mg/L. KRAFFS had a TDS level of 1696 mg/L and a sulfate level of 916 mg/L. The sulfate level at all other wells in the county was <41 mg/L. Total iron was measured at all wells, except GRW1 and OKS90S01; total dissolved iron was measured at these two sites. Wells KRCNND and KRCNNM had all total iron measurements lower than 0.3 mg/L. Wells KRANND and KRANNM had at least one measurement greater than 0.3 mg/L, but a mean total iron less than 0.3 mg/L. The remaining 11 wells had mean values greater than 0.3 mg/L. KRAFFS had a mean total iron of 18 mg/L.

Table 7. Comparison of Water Quality Parameters in the Surficial Aquifer System in Okeechobee County.

Parameter	SFWMD Data	Data from FGS Report
pH	5.4 to 7.4	6.5 to 7
Calcium (mg/L)	20 to 482	~ 50 to 100
Sodium (mg/L)	9 to 68	10 to 50
Total Iron (mg/L)	0.02 to 27	Less than 1
Chlorides (mg/L)	10 to 73	Generally ~10
Sulfate (mg/L)	1 to 916	Generally < 10

Polk County

Only a portion of Polk County is included in this model. However, water quality results from areas outside the model were included because parts of this county are recharge areas for the Floridan Aquifer System. Data were obtained from 11 Surficial Aquifer System wells in Polk County; all are located along the Kissimmee River. Seven of these wells are less than 41 feet bls. The most common water type of these seven wells is Ca-HCO3. Two of these have Ca-HCO3-SO4 water and one has Ca-Mg-HCO3. Three wells are deeper than 115 feet bls. These wells all had Ca-Na-HCO3 water. The wells in Polk County showed the greatest variation in total iron. The mean at KRFNNS was 0.017 mg/L and 26.0 at KRFFFS. Four wells, KREFFM, KREFFS, KRFFFS and KRFNND, had mean total iron greater than 0.3 mg/L. The total iron measurements at the other seven Polk County Surficial Aquifer System wells were all lower than 0.3 mg/L.

Table 8. Comparison of Water Quality Parameters in the Surficial Aquifer System in Polk County.

Parameter	SFWMD Data	Data from FGS Report
pH	4.2 to 7.3	6.0 to 6.5
Calcium (mg/L)	4 to 293	~ 10 to 100
Sodium (mg/L)	5 to 47	10 to 20
Total Iron (mg/L)		0.84 to 2.09
Chlorides (mg/L)	5 to 37	Generally ~10
Sulfate (mg/L)	BDL to 30	Generally ~10

Floridan Aquifer System

It is more difficult to analyze water from the Floridan Aquifer System because of the complexity of the aquifer and because of common methods used to construct Floridan wells. The aquifer has multiple production zones whose thicknesses vary spatially across the model domain. Many, if not most, Floridan wells are constructed with long open holes or screened intervals, which are open to more than one zone. As such, unless packers are used for water quality sampling, it is difficult to determine what zone the water sample is from. Water chemistry also varies based on the well site; wells located in the Floridan Aquifer System recharge areas generally have lower TDS and major ions levels than wells in the Floridan Aquifer System discharge regions.

For this model, water quality results were obtained from 25 Floridan wells located in the model domain. From four of these wells only TDS and chlorides were sampled. Major ions, TDS and field parameters were obtained at the remaining 21 wells (**Table 10**).

Shaw and Trost (1984) found the dominant water type in the recharge areas was calcium-bicarbonate water. They found sodium chloride waters in discharge areas, which can be indicative of connate water with higher chlorides and total dissolved solids. Analysis of SFWMD data found the five wells in the Floridan Aquifer System recharge areas of Polk County to have calcium-bicarbonate water. The primary water types in the remaining wells were sodium-chloride, sodium-bicarbonate and sodium-sulfate. OKF-81, located in the northern portion of Okeechobee County, also had calcium-bicarbonate water.

Katz (1992) indicates that chlorides in the Upper Floridan Aquifer are generally less than 50 mg/L because of the rainfall recharge. Five of the six SFWMD Upper Floridan wells had chloride measurements greater than 110 mg/L including OKF-74 with a mean chloride value of 1639 mg/L. Well OSF-60 had a mean chloride of 27 mg/L. In the Kissimmee area, deeper wells have higher concentration of sulfate because of contact with gypsum and connate seawater (Katz 1992). Three Floridan Aquifer System wells had sulfate levels in excess of 1,000 mg/L. One (OKF-74) is in the Upper Floridan Aquifer and the other two are in the Lower Floridan Aquifer.

The Southwest Florida Water Management District (SWFWMD) has installed a series of shallow and deep monitor and observation wells (ROMP 28) in Highlands County, south of Sebring and at ROMP 14, also in Highlands County, south of Lake Istokpoga. As a part of the installation, SWFWMD collected TDS, chlorides and SO4 measurements to depth. At ROMP 14, the values were low (<200 mg/L) until about 1,750 feet bls when all levels increased. At ROMP 28, TDS and SO4 values changes significantly from about 1,400 feet bls to the bottom of the hole about 2,100 feet bls. However, the chlorides varied minimally. These profiles are shown in **Figures 37** and **38**.

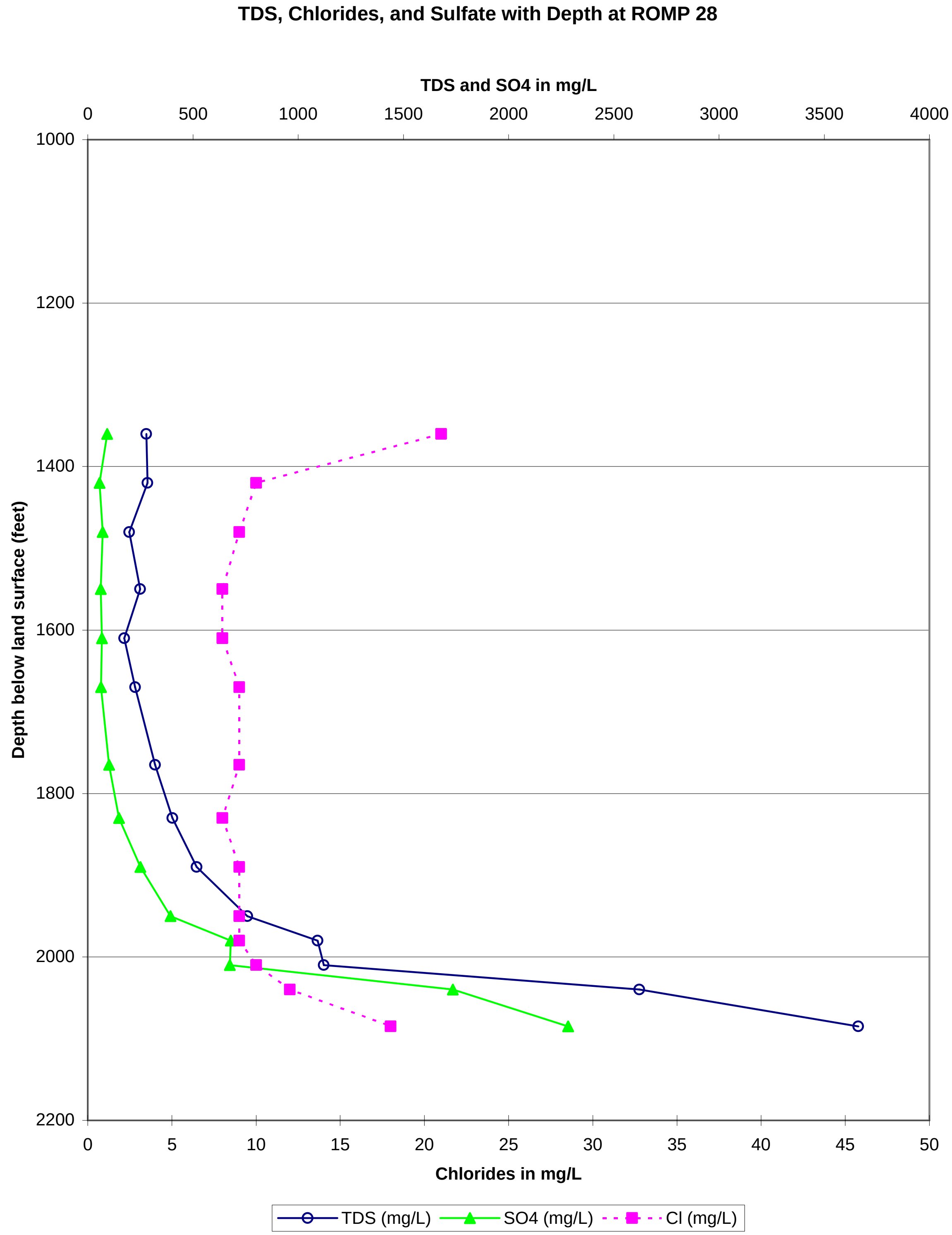

Figure 37. Water Quality Profile of SWFWMD ROMP Well 28.

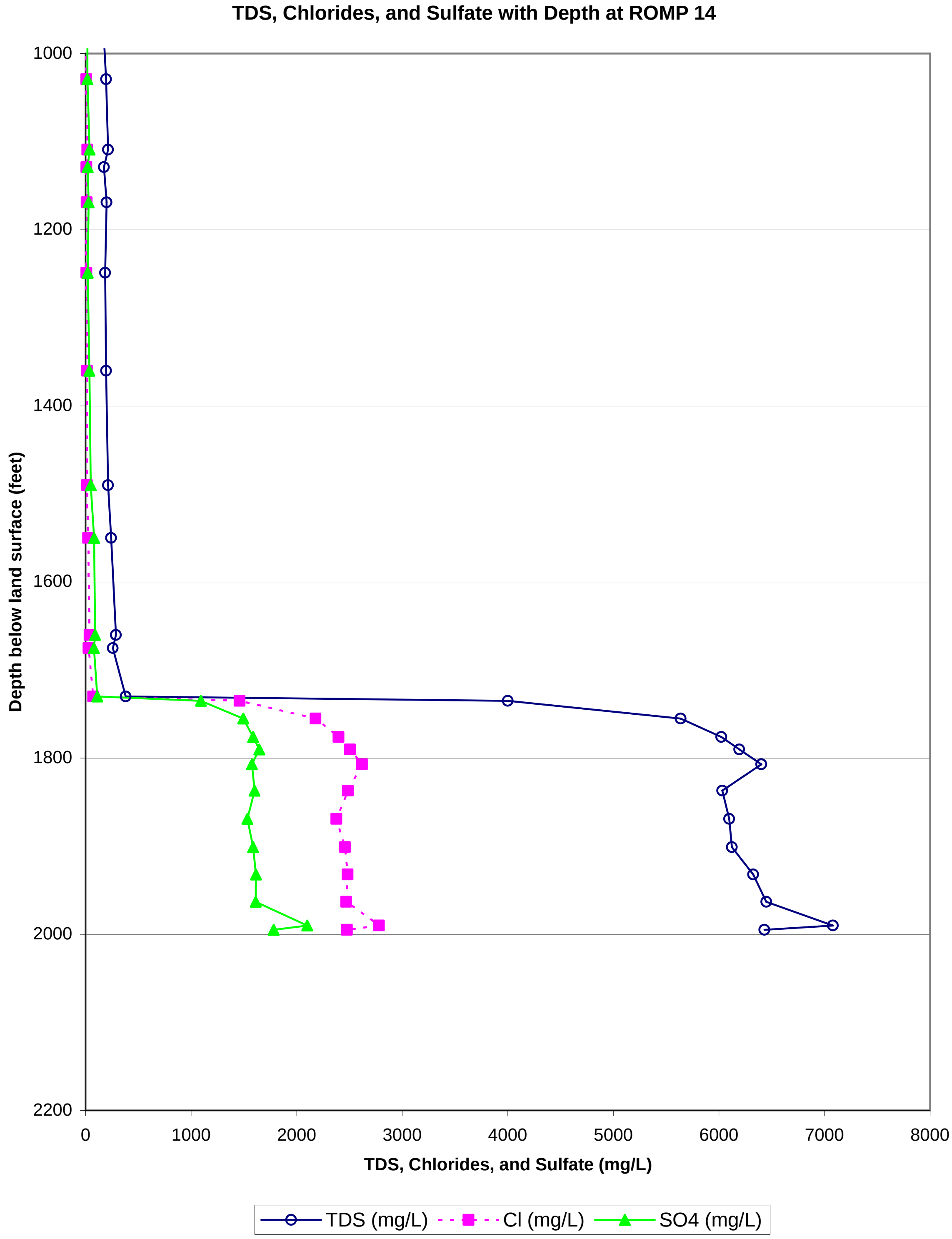

Figure 38. Water Quality Profile of SWFWMD ROMP Well 14.

In general, data from the 25 SFWMD Floridan Aquifer System wells (**Table 10**) did not appear to show patterns based on zone or depth. Generally, the wells in the area around Lake Okeechobee had TDS levels in excess of 1,000 mg/L and chlorides greater than 250 mg/L.

Piper diagrams were prepared for the Surficial Aquifer System wells in Glades, Highlands and Okeechobee counties and Floridan Aquifer System wells in Glades and Okeechobee counties, and are include in **Figures 39** through **43**. There was insufficient Floridan Aquifer System data in Highlands County to facilitate a Piper diagram. Expected patterns, based on which production zone is open to the well, were not identified. This could be because a number of the samples are from wells with a long open hole or screened interval and thus, the water is a mixture from several production zones.

Data from the SFWMD wells were compared to results from the Florida Geological Survey Background Geochemistry report (Maddox 1992) and are summarized in **Table 9**. Generally the SFWMD data showed more variation with lower minimums and higher maximums than the Florida Geological Survey (FGS) results.

Table 9. Comparison of Water Quality Parameters in the Floridan Aquifer System in Glades, Highlands and Okeechobee Counties.

Parameter	SFWMD Data	Data from FGS Report
pH	6.9 to 8.1	7 to 7.5
Calcium (mg/L)	15 to 550	~ 25 to 100
Sodium (mg/L)		
Glades	15 to 1,500	50 to 100
Highlands/Okeechobee	15 to 1,000	50 to 600
Chlorides (mg/L)		
Glades	25 to 2,900	100 to 500
Highlands	30 to 120	50 to 100
Okeechobee	15 to 4,600	50 to 500
Sulfate (mg/L)		
Glades/Okeechobee	1 to 1,900	100 to 250
Highlands	< 10	10 to 100

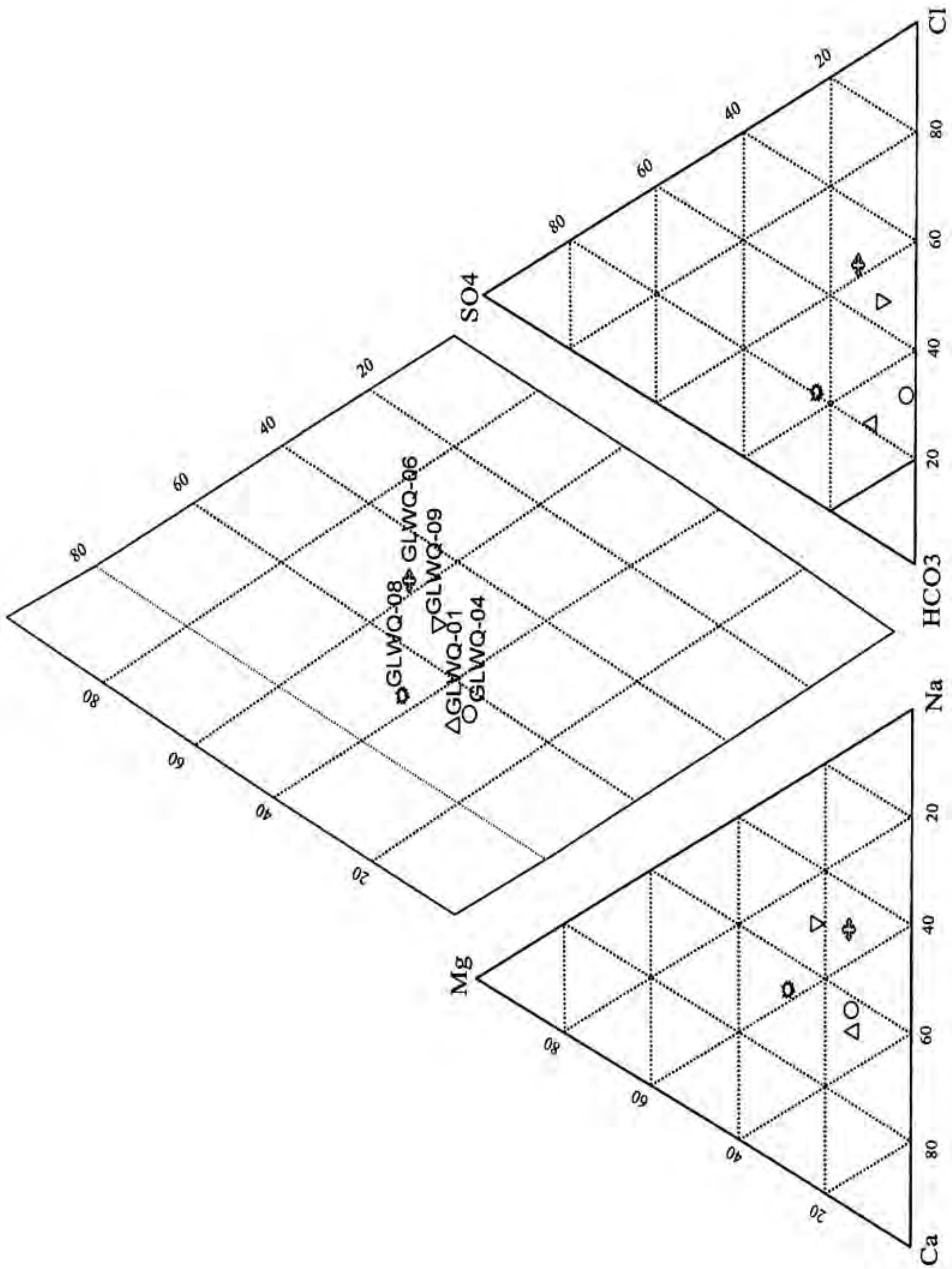

Figure 39. Piper Diagram of the Surficial Aquifer Wells in Glades County.

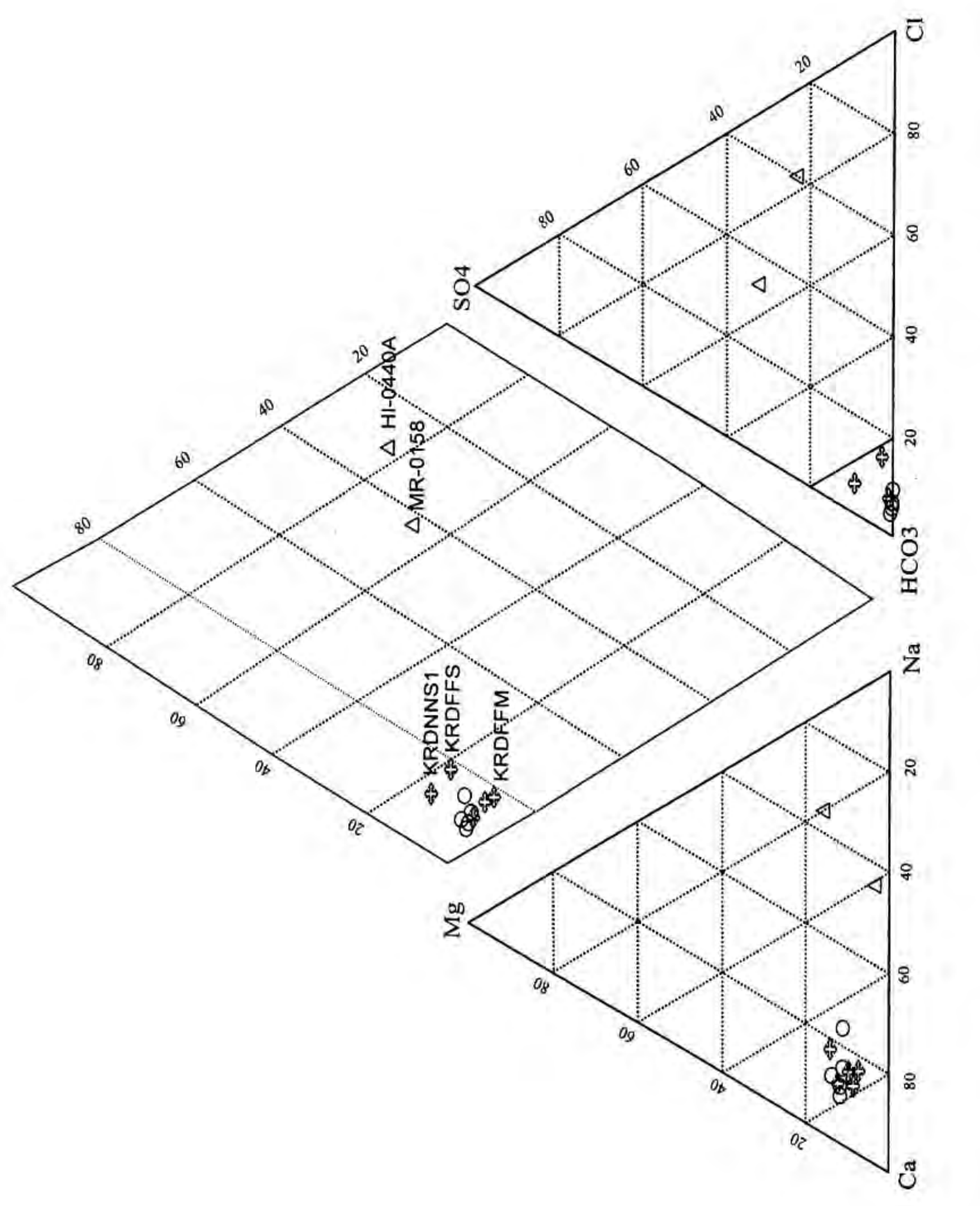

Figure 40. Piper Diagram of the Surficial Aquifer Wells in Highlands County.

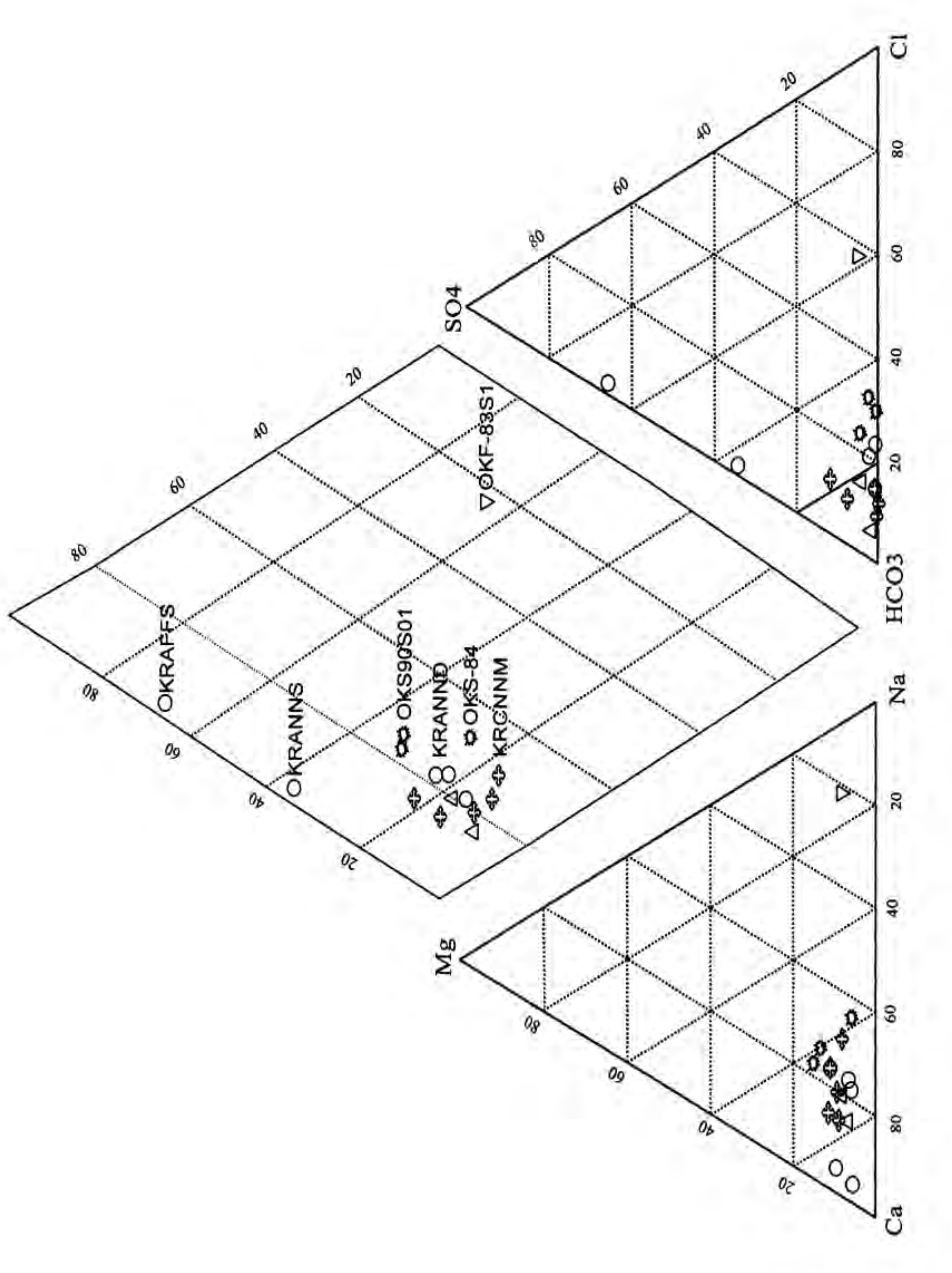

Figure 41. Piper Diagram of the Surficial Aquifer Wells in Okeechobee County.

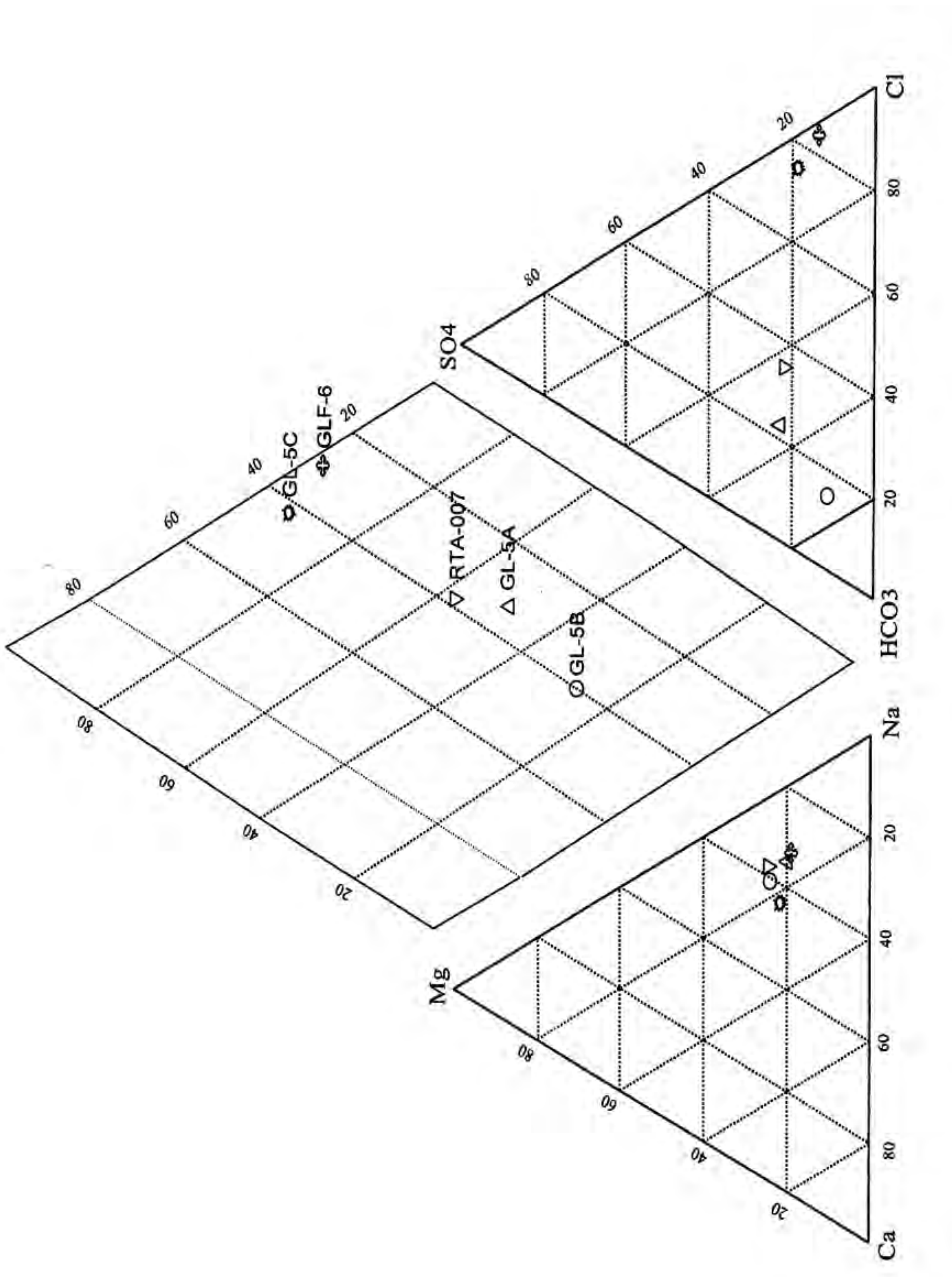

Figure 42. Piper Diagram of the Floridan Aquifer Wells in Glades County.

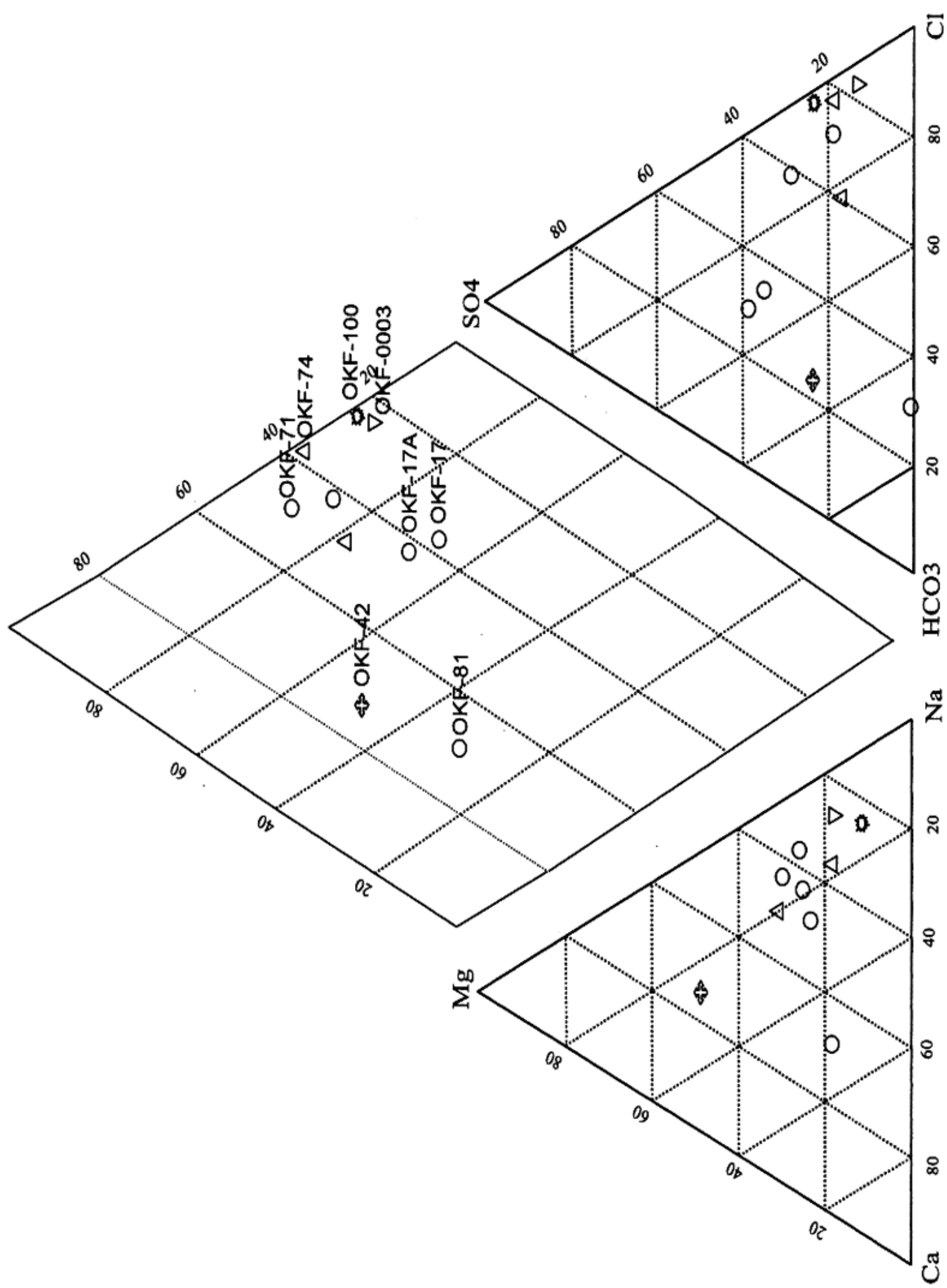

Figure 43. Piper Diagram of the Floridan Aquifer Wells in Okeechobee County.

Table 10. Water Quality of the Wells in the Floridan Aquifer System.

	Type of Water	Temp (°C)	Sp Cond (uS/cm)	pH	Cl (mg/L)	SO4 (mg/L)	Alka (mg/L)	Na (mg/L)	Ca (mg/L)	K (mg/L)	Mg (mg/L)	TDS (mg/L)	Zone/ Depth	Period of Record
Glades														
GL-5C	Na-Mg-Ca-Cl	27.8	2,113	7.7	540	186	74	251	84	5.8	51.3	1,263	uf	09/99
RTA-007	Na-Mg-HCO3-Cl	26.4	936	7.6	110	88	185	120	26	9.1	24.2	485	uf	05/85–11/90
GL-5A	Na-HCO3-Cl-SO4	26.0	525	8.0	45	60	138	84	15	3.9	12.8	310	ic	09/99
GL-5B	Na-Mg-HCO3-Cl	25.4	469	7.8	25	27	177	68	17	4.3	13.9	285	mc1	09/99
GLF-6	Na-Cl	30.5	10,295	7.5	2,871	609	80	1,459	247	41.0	203.0	5,907	lf	10/01–11/01
Highlands														
HIF-0037					118							315	uf	
HIF-14_G					30							174	mc2	
Okeechobee														
OKF-72	Na-Mg-Cl	27.0	1,593	7.4	283	115.5	145	161	56	8.1	51.4	802	uf	10/89–11/93
OKF-74	Na-Cl	27.7	6,590	6.9	1,639	543.8	100	974	253	25.6	150.4	3,929	uf	10/89–12/93
OKF-0003	Na-Cl	24.6	3,380	7.6	1,103	241.1	75	632	63	25.0	83.0	2,344	ic	
OKF-17	Na-Mg-SO4-HCO3	26.6	912	8.1	92	164.6	142	125	18	10.1	28.1	527	mc1	04/93–10/93
OKF-23	Na-Mg-Cl-SO4	25.9	1,656	7.4	323	205.3	99	211	61	8.4	44.9	953	mc1	04/93–11/93
OKF-7	Ca-HCO3	25.0	528	7.2	15	1.0	149	15	86	1.1	5.4	248	mc1	04/93–12/93
OKF-71	Na-Ca-Mg-Cl	26.5	2,790	7.1	677	242.8	135	277	110	7.8	63.8	1,622	mc1	10/89–11/93
OKF-81	Ca-Na-HCO3	24.5	815	6.9	82	2.4	262	50	69	3.7	15.7	410	mc1	09/87–02/05
OKF-42	Mg-Na-Ca-HCO3	25.7	710	7.6	60	86.6	194	42	34	5.4	40.1	417	mf	09/87–2/05
OKF-34					104							491	mf	
OKF-100	Na-Cl-SO4	29.2	15,611	7.5	4,557	1,896.5	89	3,203	541	68.8	268.1	10,549	lf	12/01–5/04
OSF-60					27							419	?–590	
Polk														
POF-20	Ca-Mg-HCO3	25.7	605		88	1.0	194	39	67	2.7	15.9	359	260–1000	07/04
POF-0012	Ca-Mg-HCO3	24.9	157	7.5	4	13.2	64	2	17	0.6	6.3	93	0–432	09/78–09/79
POF-0011	Ca-Mg-HCO3	23.7	158	7.5	5	10.0	65	0	17	0.6	6.7	101	0–930	09/78–09/79
POF-0010	Ca-Mg-HCO3	25.3	157	7.7	3	10.7	64	3	17	0.8	6.3	101	0–540	09/78–09/79
POF-0009	Ca-Na-Mg-HCO3	24.4	152	7.5	6	12.8	63	4	17	0.6	5.9	101	0–1045	09/78–09/79

CHAPTER 4
Model Development

SIMULATION OF GROUNDWATER FLOW

The Lower Kissimmee Basin Groundwater Model was developed to simulate 1995 average steady-state conditions. The model will be used to evaluate average steady-state changes to the groundwater levels using projected withdrawals for 2025.

Conceptual Model

In order to simulate the groundwater flow in the model domain, the hydrogeologic framework needed to be simplified for modeling purposes. The conceptual model consists of four aquifers separated by three semi-confining units and underlain by a confining unit. The flow in the aquifers is represented as purely horizontal flow, while the flow through the semi-confining units is only vertical. This gives a quasi-three dimensional model. Vertical flow from Layer 1 to Layer 2 (or Layer 2 to Layer 1), Layer 2 to Layer 3 and Layer 3 to Layer 4 occurs via the semi-confining units (See Vertical Discretization of Model Layers in **Figure 46**). The calibration run of this model simulates average 1995 steady-state conditions. The base run simulates 2000 1-in-10 rainfall conditions. A 1-in-10 rainfall condition or a 1-in-10 year drought event is defined as an event with a return frequency of once in ten years. The model is used to evaluate projected 1-in-10 rainfall conditions for 2025.

Computer Code Selection

Once modeling objectives have been established, and a preliminary understanding of the predominant hydrologic processes within the area of interest has been attained, a model code is selected, which can meet the model development and application objectives. MODFLOW, a code created by the U.S. Geological Survey (USGS), was selected for this purpose for the following primary reasons:

- It has been widely accepted in the groundwater modeling profession for over 15 years.
- The code is well documented and within the public domain.
- The code is readily adaptable to a variety of groundwater flow systems.
- The code is modular and easily facilitates any modifications required to enable its application to the types of unique groundwater flow problems encountered in south Florida

MODFLOW is a three-dimensional, finite difference groundwater flow program developed by McDonald and Harbaugh of the USGS in 1984. A revised version was published in 1988 and additional features were added in the 1996 version, called MODFLOW96.

The SFWMD has modified some of USGS modules to allow for additional functionality. MODFLOW96 simulates groundwater flow in both the anisotropic and heterogeneous layered aquifer systems using a finite-difference “block centered” approach. The SFWMD version of MODFLOW96 enhanced the well package to allow for multiple well files.

MODFLOW with SFWMD Source Code

MODFLOW simulates groundwater flow in aquifer systems using the finite-difference method. The aquifer system is divided into rectangular or quasi-rectangular blocks by a grid (**Figure 44**). The grid of blocks is organized by rows, columns and layers, and each block is commonly called a cell.

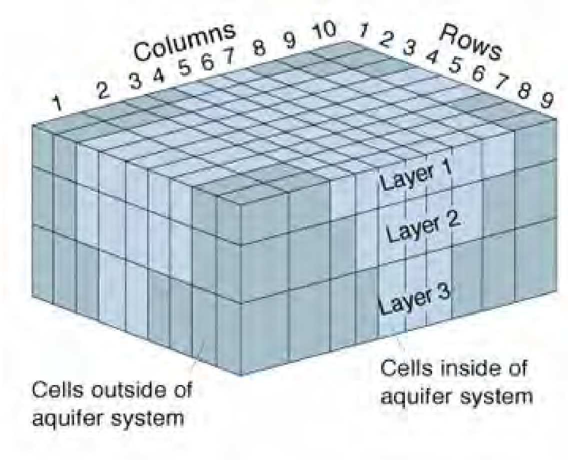

Figure 44. Example of Model Grid for Simulating 3-Dimensional Groundwater Flow.

For each cell within the aquifer system, the user must specify aquifer properties. Also, the user specifies information relating to wells, canals and other hydrologic features for the cells corresponding to the locations of the features. For example, if the interaction between a canal and an aquifer system is simulated, then for each cell traversed by the canal, the required input information includes layer, row and column indices; canal stage; and hydraulic properties of the channel bed. Also, MODFLOW allows the user to specify which cells within the grid are part of the groundwater flow system and which cells are inactive (i.e., outside of the groundwater flow system).

The MODFLOW model code consists of a main program and a series of independent subroutines called modules. The modules, in turn, have been grouped into packages, each dealing with a particular hydrologic process or solution algorithm. The packages used for Lower Kissimmee Basin Groundwater Model simulations, including those developed or enhanced by SFWMD staff and contractors, are shown in **Table 11**.

Table 11. MODFLOW96 Packages Used in the Model.

Package	Description	Notes
Core		
Basic and Output Control	Defines stress periods, time steps, starting heads, grid specifications, units and output specifications	Handles the primary administrative tasks associated with a simulation
Block-Centered Flow (BCF)	Specifies steady-state vs. transient flag, cell sizes, anisotropy, layer types and hydrogeologic data for each layer	Derived primarily from geologic data used to construct the model
Surface Water Stresses and Processes		
Recharge	Simulates areally distributed recharge to a water table during each stress period	Preprocessed using an Agricultural Field-Scale Irrigation Requirements Simulation (AFSIRS) based ET- Recharge Model
Evapotranspiration (ET)	Simulates removal of water from the water table via transpiration and direct evaporation	Preprocessed using an AFSIRS based ET-Recharge Model; ET rate diminishes with increasing water table depth
River (RIV)	Simulates groundwater interchanges with canals that can either recharge or drain the aquifer	Canal stages are usually based on measured stages or control elevations
Drain (DRN)	Essentially the same as the River package except canals can only drain the aquifer and water removed by the drains is removed permanently from the model	Canal stages are usually based on weir elevations
Water Supply and Management		
Well	Simulates withdrawals from wells	Includes Public Water Supply (PWS) and irrigation wells (Ag); enhanced by the SFWMD to read multiple input files
Solution Algorithms		
Strongly Implicit Procedure (SIP)	A mathematical solution algorithm internal to the model	Enhanced by District to improve model stability

Well Package Modifications and Additions

The well package was modified by the SFWMD staff in 1999 to allow wells to be read from multiple files. This is useful when changes are made frequently to certain types of wells (i.e., public supply wells), while other well data remain fairly static. The primary well file will allow up to two additional unit numbers to be included. The maximum wells identifier in the first file should be sized to accommodate the maximum number of wells in all well files. Additional well files are formatted exactly like the primary well file, except the first line is omitted. These changes allow the reuse flag (-1) to be invoked separately for each file (for transient models). For example, the first file may have 500 wells, the second 20 and the third 10 for the first stress period. In the second stress period, one might decide to reuse all the wells in the first two files, but specify 40 new wells in the third file. For the steady-state model, the multiple well package allowed the separation of the stress by type – Public Water Supply and Irrigation Wells – to ease modifying the files when the model is applied to future conditions.

Strongly Implicit Procedure Package Enhancements

Two alternative enhancements were developed by the SFWMD in 1998 for the Strongly Implicit Procedure (SIP) Package in order to improve or maintain model stability. Both alternatives have added optional variables. If the variables are not used, the Strongly Implicit Procedure package will function normally.

In Alternative 1, two optional variables are added to the second line of the Strongly Implicit Procedure input file. These are HCLOSEMAX and NOSTOP. When the maximum number of iterations is reached, and the maximum head change in a cell is less than HCLOSEMAX, Strongly Implicit Procedure continues to the next time step rather than aborting the simulation. This allows a tight closure criterion (via the original HCLOSE term) for most of the simulation, while tolerating a few problem stress periods. When NOSTOP is included and set equal to 1, the program will not terminate if HCLOSEMAX is violated. Instead, the problem cells are reset to their values at the end of the last time step and a warning message is written to the output file. This is helpful in trying to improve a model with stability problems.

In Alternative 2, four optional variables were added to the Strongly Implicit Procedure input file. These are MNITER and NITERSL on the first input line, and HCLOSEMAX and DACCL on the second input line. MNITER is the minimum number of iterations. NITERSL is the minimum number of iterations before deceleration is allowed. DACCL specifies the fraction by which the simulation will decelerate. HCLOSEMAX is the same as described in Alternative 1. HCLOSEMAX and HCLOSE together serve as an upper and lower bound. Deceleration allows the model to iterate slower, thereby helping maintain stability. The simulation will terminate if the closure criterion exceeds HCLOSEMAX.

Model Design

The model domain for the Lower Kissimmee Basin Groundwater Model is described as follows:

Table 12. Model Domain for the Lower Kissimmee Basin Groundwater Model.

In Decimal Degrees	In Projected Florida East NAD83 HARN Feet
West Corner: -81.654709	Left Corner: 444435.531250
East Corner: -80.593469	Right Corner: 787635.531250
North Corner: 27.764485	Top Corner: 1247082.062500
South Corner: 26.818899	Bottom Corner: 903882.062500

The Lower Kissimmee Basin Groundwater Model projects are in the following coordinate system: NAD 1983 State Plane Florida East FIPS 0901 Feet. The geographic coordinate system name is GCS North American 1983.

The Lower Kissimmee Basin Groundwater Model is composed of a grid containing 130 rows and 130 columns. Each cell is 2,640 feet x 2,640 feet (see **Figure 45**). Lake Okeechobee, Lake Istokpoga and the model cells southeast of the lake are inactive.

The Lower Kissimmee Basin Groundwater Model consists of four layers. The top layer represents the unconfined Surficial Aquifer System, the next layer represents the Upper Floridan Aquifer, the third layer is the Middle Floridan Aquifer and the bottom layer is the Lower Floridan Aquifer. The Intermediate Confining Unit/Aquifer and the Middle Confining Unit 1 and 2 are represented as vertical conductance values between the aquifer layers. (See Vertical Discretization of Model Layers in **Figure 46**.)

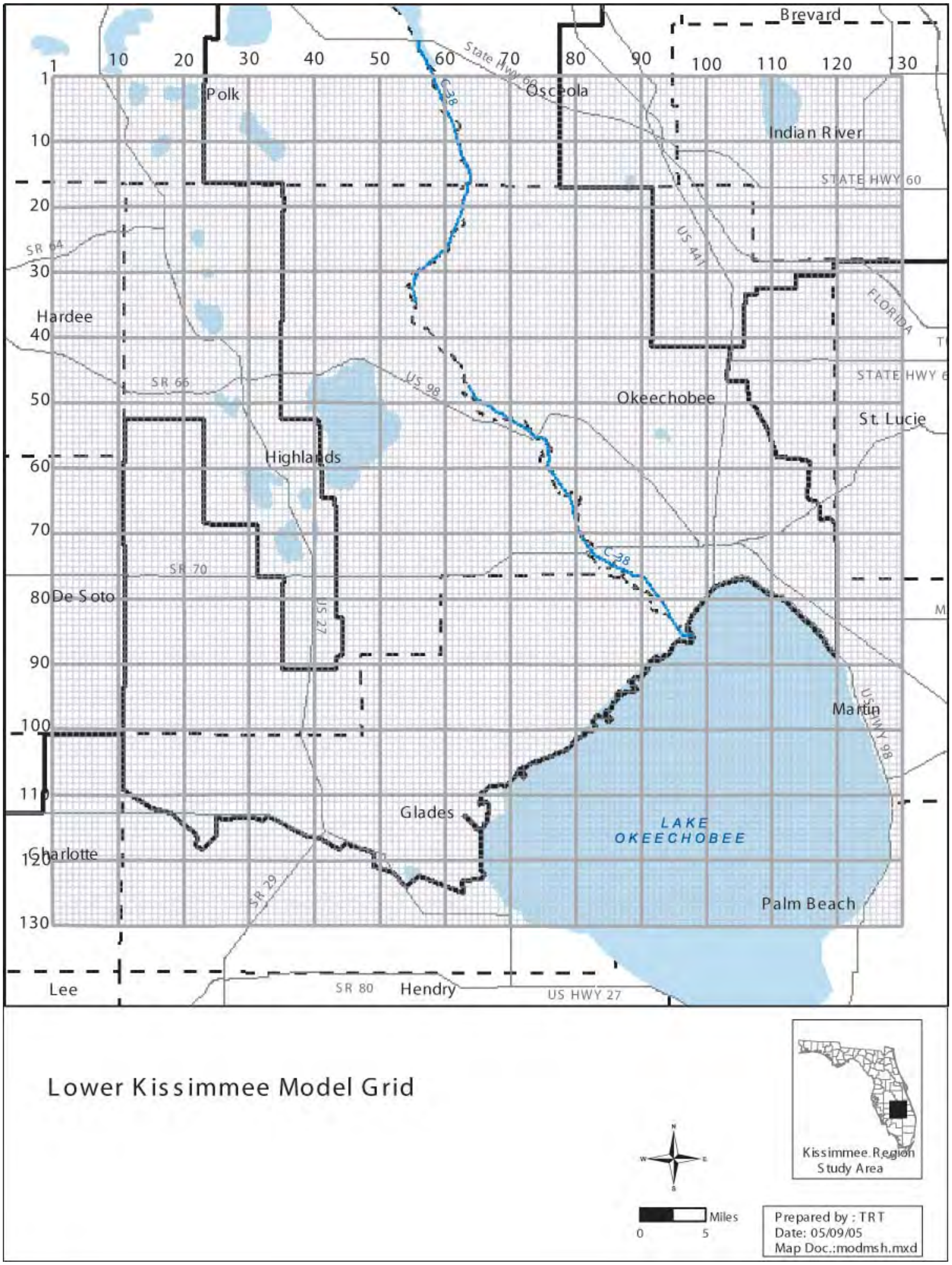

Figure 45. Model Mesh.

Hydrologic Data Input

Table 13 describes the data types needed to create the input files for model.

Table 13. Model Input.

Model Package	Type of Data Required for Active Model Cells	Comments	Figure #
BAS			
	IBOUND Layer 1	Constant along model boundaries; Lake Okeechobee and Lake Istokpoga inactive	47
	IBOUND Layer 2	Constant Heads on along all model boundaries	48
	IBOUND Layer 3	The same as Layer 2	48
	IBOUND Layer 4	Constant Head	N/A
	Starting Heads Layer 1	Used observed values (from Layer 1) where available. Elsewhere 1 foot below topography	50
	Starting Heads Layer 2	Created surface using inverse distance weighting on the average 1995 water levels	51
	Starting Heads Layer 3	Same Starting heads as Layer 2	51
	Starting Heads Layer 4	Same Starting heads as Layer 2	51
BCF			
	Horizontal Hydraulic Conductivity	Assumed 14 ft/day background, 50 ft/day in lakes and rivers; varied for Avon Park Ridge based on calibration	49
	Elevation of Aquifer Bottom	Hydrostratigraphy from kriged surfaces	15
	Vertical Hydraulic Conductivity – VCONT Intermediate Confining Unit	Estimated – Calibration	52
	Transmissivity Upper Floridan Aquifer	Kriged from logs	21
	VCONT Middle Confining 1	Assumed K=1 ft/day, thickness of layer from kriged hydrostratigraphy	92
	Transmissivity Middle Floridan Aquifer	Kriged from logs	26
	VCONT Middle Confining 2	Assumed K=0.5 ft/day, thickness of layer from kriged hydrostratigraphy	55
	Transmissivity Lower Floridan Aquifer	300,000 ft^2 /day	29
Well			
	Public Water Supply (Location, Depth, source, capacity)	Permit database	68
	Irrigation (Ag and Recreation)	Based on land use and permits	69

Table 13. Model Input (Continued).

Model Package	Type of Data Required for Active Model Cells	Comments	Figure #
River and Drains			
	Lake Stages	Web sources: LAKEWATCH, SFWMD DBHYDRO, SWFWMD	56
	River/Stream Stages	DBHYDRO or estimates from topography	56
	Canal Stages	DBHYDRO	56
	Streambed Conductance	Estimated K=1.72 ft/day	56
	Streambed Thickness	1 ft	56
	Canal Profiles	Used as designed books for canals	56
	River/ Stream Profiles	Rivers Estimated ½ slope and river depths. Small streams – estimated 2 ft depth, 20 ft wide	56
	Drain Profile	Estimated Slope 1/4, width estimated from aerial photos. Depth=Width/4	57
	Drain Elevation	Set to depth below land surface	57
	Drain Conductance	K 0.25–0.5 ft/day	57
Recharge			
	Rainfall Data from Gauges	Using NOAA and SFWMD DATA	64
	Rainfall Data applied to Thiessen Polygons		64
	Land Use - 1995 Land Use for Calibration. 2000 Land Use for Verification Run		67
	Soils Series Properties from County Soil Surveys (e.g., water content at specific retention, porosity)		66
ET			
	Land Use - 1995 Land Use for Calibration. 2000 Land Use for Verification Run		67
	ET Extinction Depth	The extinction depth was multiplied x 5 in the calibration process	59
	Topography		5
	Maximum ET Rate	The maximum et rate was multiplied X 1.2 in the calibration process	62
	ET Stations and Thiessen Polygons		61

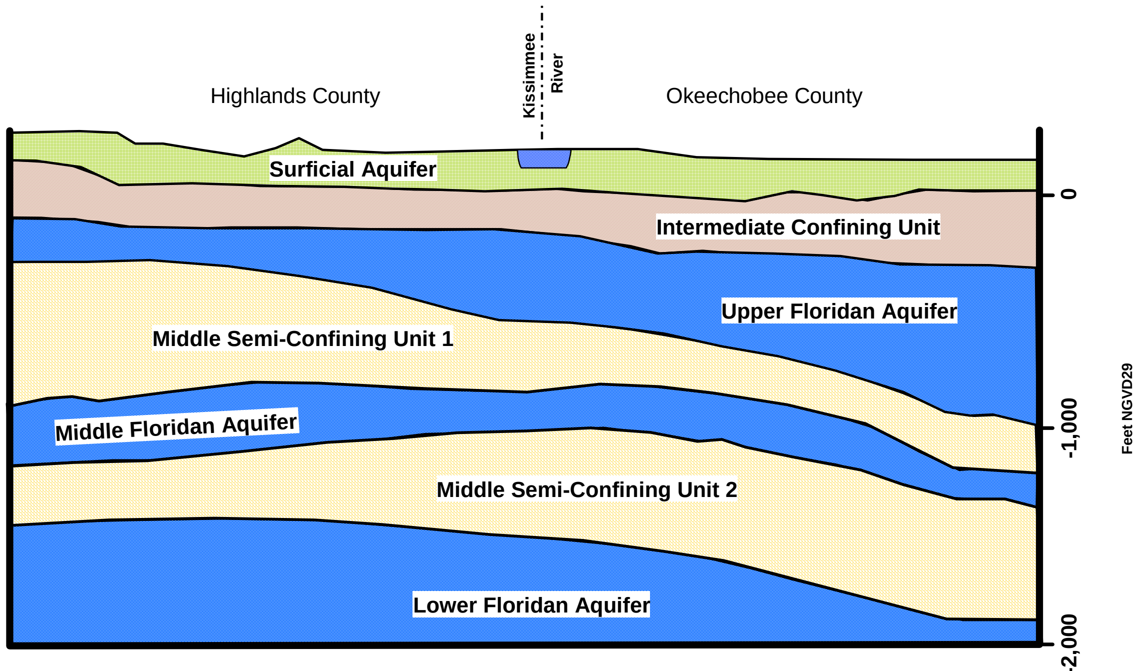

Figure 46. Vertical Discretization of Model Layers.

Boundary Conditions

In Layer1, the Surficial Aquifer System, all model boundaries were set to constant heads. Lake Okeechobee and Lake Istokpoga were inactivated in Layer 1 of the model and their shorelines were set as constant head (**Figure 47**).

In both Layer 2 and 3 (the Upper and Middle Floridan Aquifer layers), the model boundaries were set as constant head (**Figure 48**). The base of the model, the Lower Floridan Aquifer, was set as a constant head.

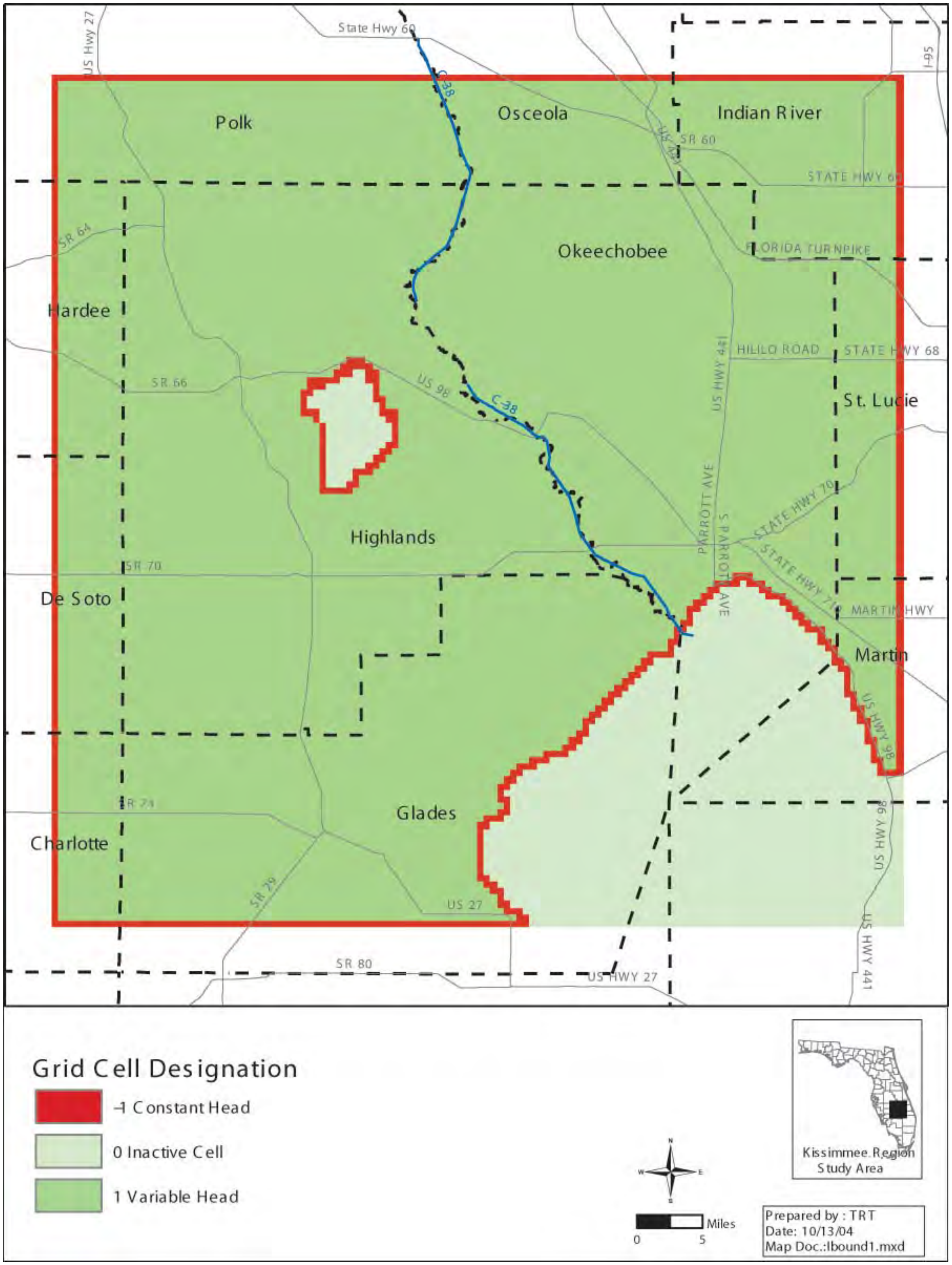

Figure 47. IBOUND Layer 1.

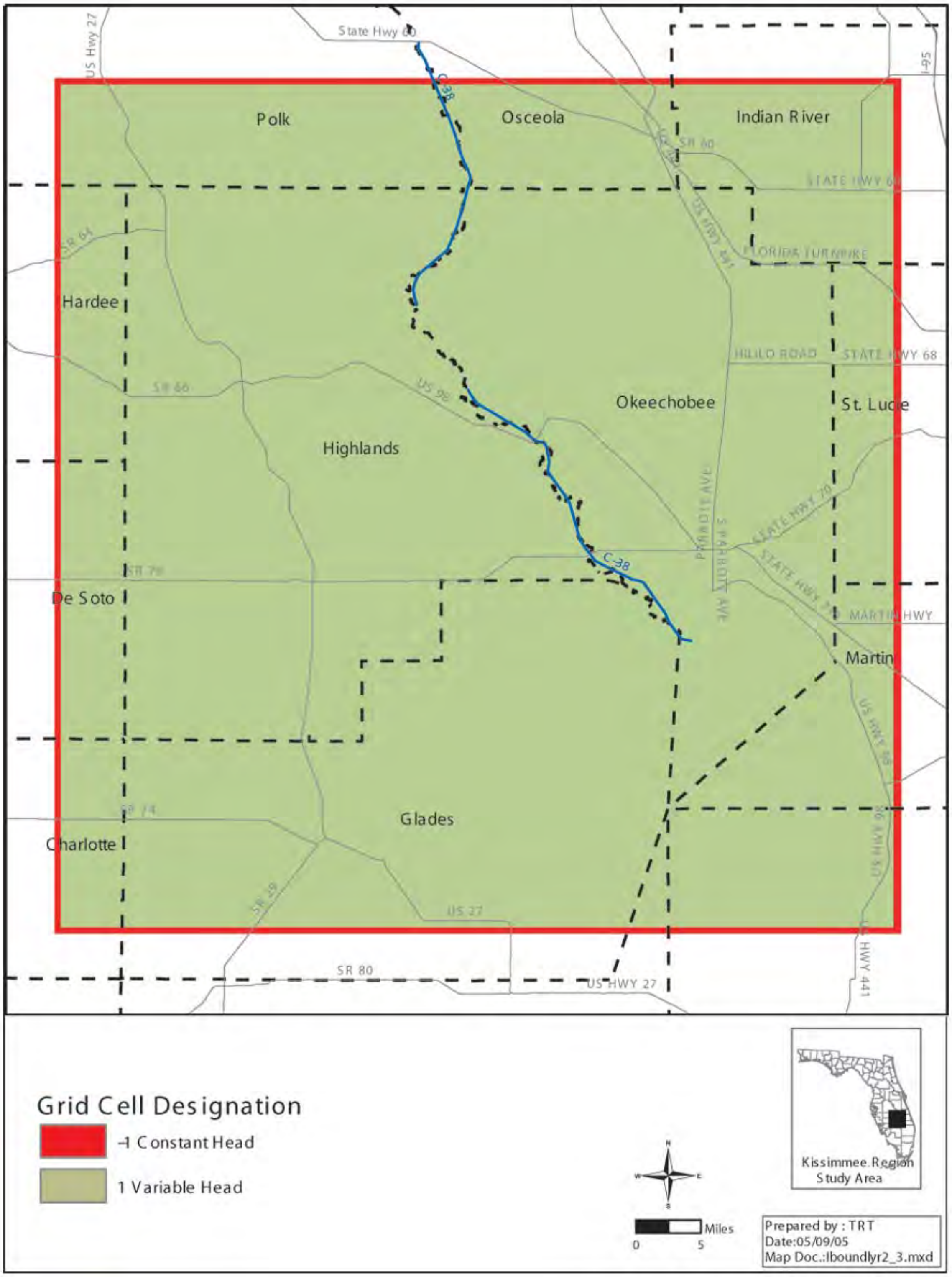

Figure 48. IBOUND Layer 2 and 3.

Hydraulic Conductivities

During the Lower Kissimmee Basin Groundwater Model calibration, various hydraulic conductivity values were tested. When the values were too high (30 ft/day in land areas, 100 ft/day on water), the water levels in the Surficial Aquifer System dropped too low, when the values were too high areas "flooded". Therefore hydraulic conductivity values were estimated at 14 ft/day for most of the model area. The river and lake area hydraulic conductivity values were set at 50 ft/day and were modified in the Avon Park Ridge for calibration purposes. See **Figure 49** for the distribution of the hydraulic conductivities in the area.

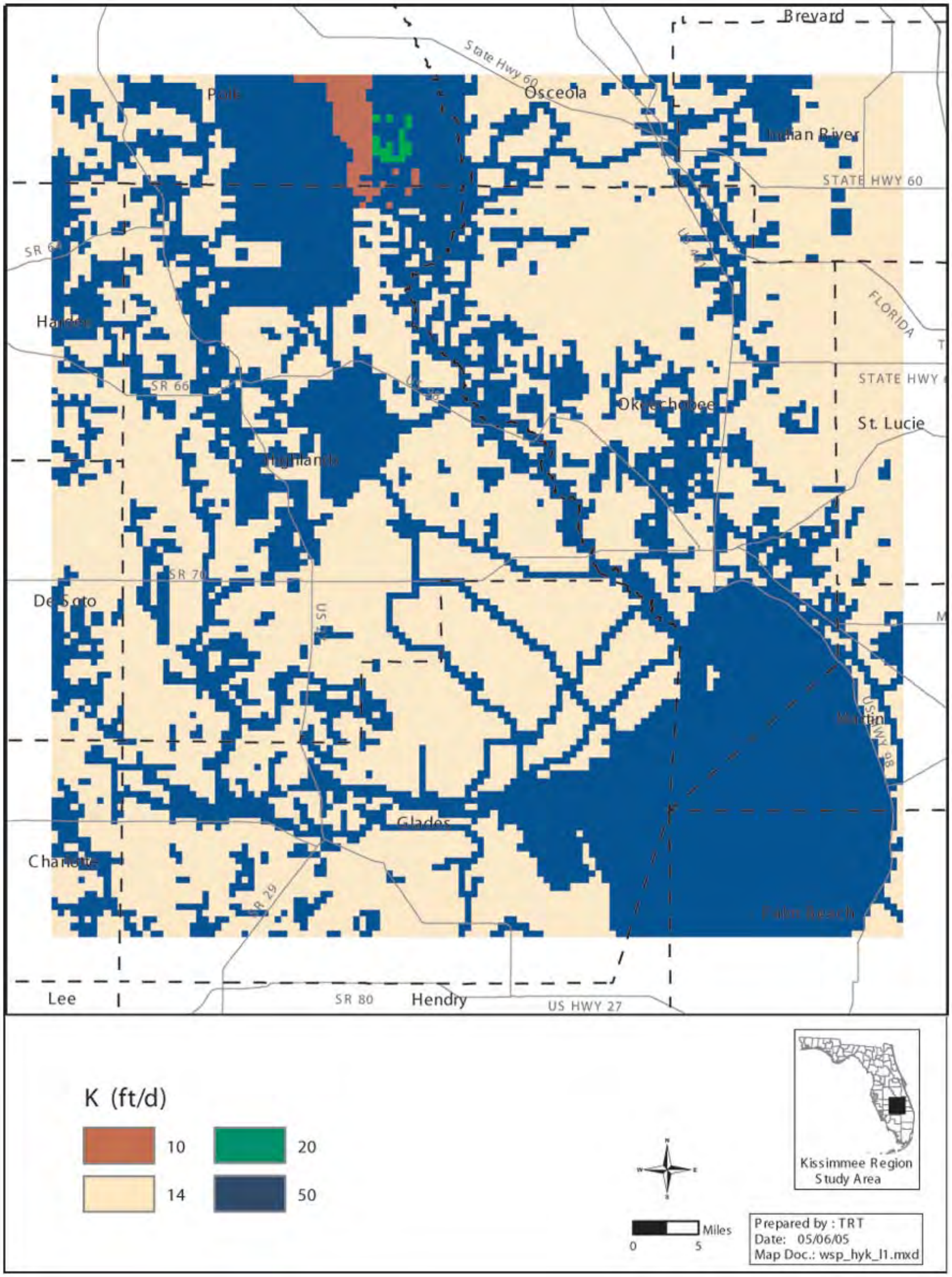

Figure 49. Hydraulic Conductivity K (ft/day) Values Used for Layer 1 (Surficial Aquifer System).

Starting Heads

Layer 1

Starting heads were set for 1 foot below land surface (bls) with the exception of surface water features and observation point sites, which were set to the average 1995 observed value (for locations of observation sites refer to **Figure 50**).

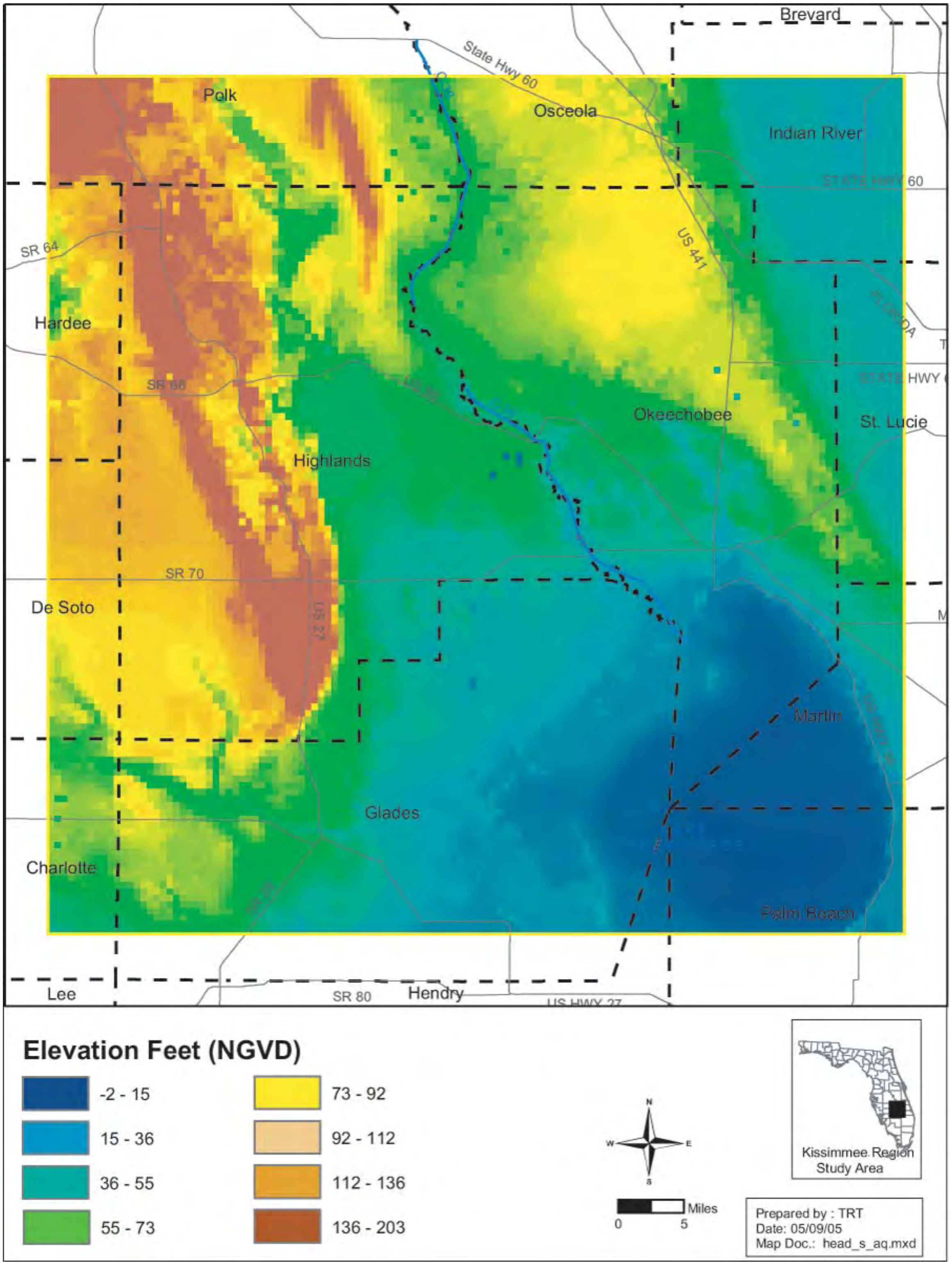

Figure 50. Starting Heads for the Surficial Aquifer Layer.

Layers 2 and 3

The average 1995 potentiometric surface for the Floridan Aquifer System varied from the observation points in the Floridan Aquifer System. Using all points from the contours from the Average 1995 Potentiometric Surface Map and all the observation points from the Floridan Aquifer System, the Inverse Distance Weighting function was applied in ArcGIS (Spatial Analysis) to create a new grid with starting heads for the Floridan Aquifer layers (**Figure 51**).

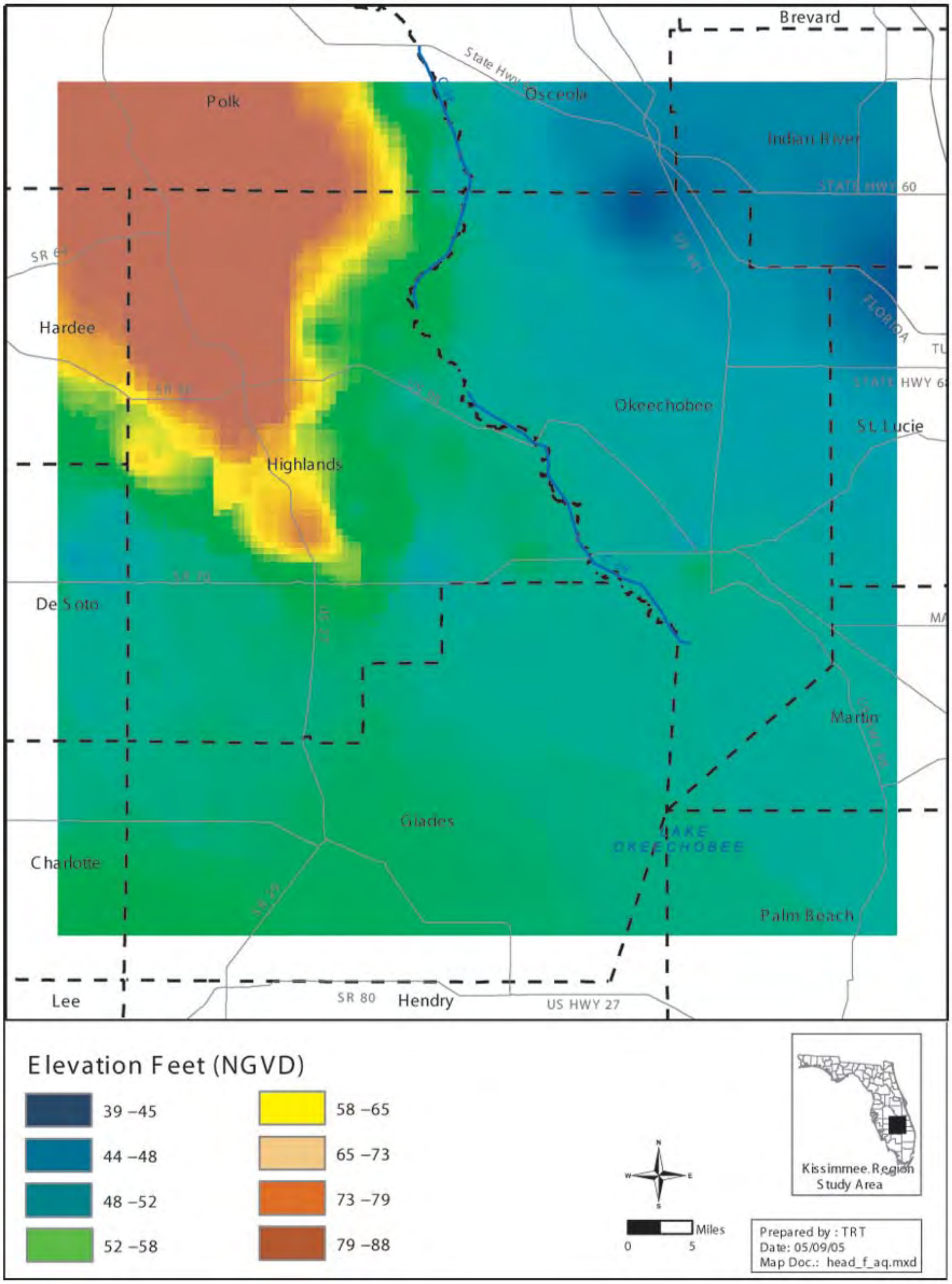

Figure 51. Starting Heads for the Floridan Aquifer Layers.

Vertical Conductance (Vcont)

Within the MODFLOW model, vertical flow between layers is controlled by the vertical conductance coefficient (Vcont), which is a composite term expressed in units of 1/day. Vcont is an expression of the vertical conductivity in confining unit and the thickness of confining unit in that model cell (McDonald and Harbaugh 1988). It is calculated for the two nodes located at vertically adjacent hydrogeologic units (i.e., layers) using the equation (McDonald and Harbaugh 1988):

$$\mathrm{V}_{CONT} = \frac{1}{\frac{\Delta z_u / 2}{K_{zu}} + \frac{\Delta z_c}{K_{zc}} \frac{\Delta z_l / 2}{K_{zl}}} \qquad \text{(Equation 1)}$$

Here, z_u and z_l are the thickness of the upper and lower layers (ft), z_c is the thickness of the confining unit (ft), K_{zu} and K_{zl} are the horizontal hydraulic conductivities for the upper and lower layers (ft/day) and Kz_c is the hydraulic conductivity for the confining unit.

When Kz_c is much smaller than K_{zu} or K_{zl}, then the terms using these values are negligible and Vcont becomes:

$$\mathrm{V}_{CONT} = \frac{1}{\frac{\Delta z_c}{K_{zc}}} = \frac{K_{zc}}{\Delta z_c}$$

The model area had very few hydraulic conductivity data for in the confining zones. The Vcont values for the Intermediate Semi-Confining Unit (**Figure 52**) needed to be adjusted as a calibration factor. The model was divided into zones to determine the appropriate Vcont values. For starting points, the Vcont values shown in Sepulveda, N 2002 were used. In some areas along Lake Wales Ridge, the Intermediate Confining Unit is breached by sinkholes. This is expressed as high Vcont values. In other areas, the unit is nearly completely confining. When Vcont values were too low, the water levels in the Surficial Aquifer System would rise to unacceptable levels and the water levels in the Upper Floridan Aquifer would be too low. The opposite would occur when Vcont values were too high. In areas where artesian conditions exist, the flow through the Intermediate Semi-Confining Unit is from Layer 2 to Layer 1. The Vcont values range from 0.0000001 (feet/day/feet) to 0.006 (feet/day/feet). The average is 0.0002 (feet/day/feet). Since the Vcont is a function of K_z, the calibrated Kz values can be calculated by multiplying by the layer thickness. The average K_z is 0.0046 ft/day. **Figure 53** shows the calibrated vertical hydraulic conductivity for the Intermediate Confining Unit.

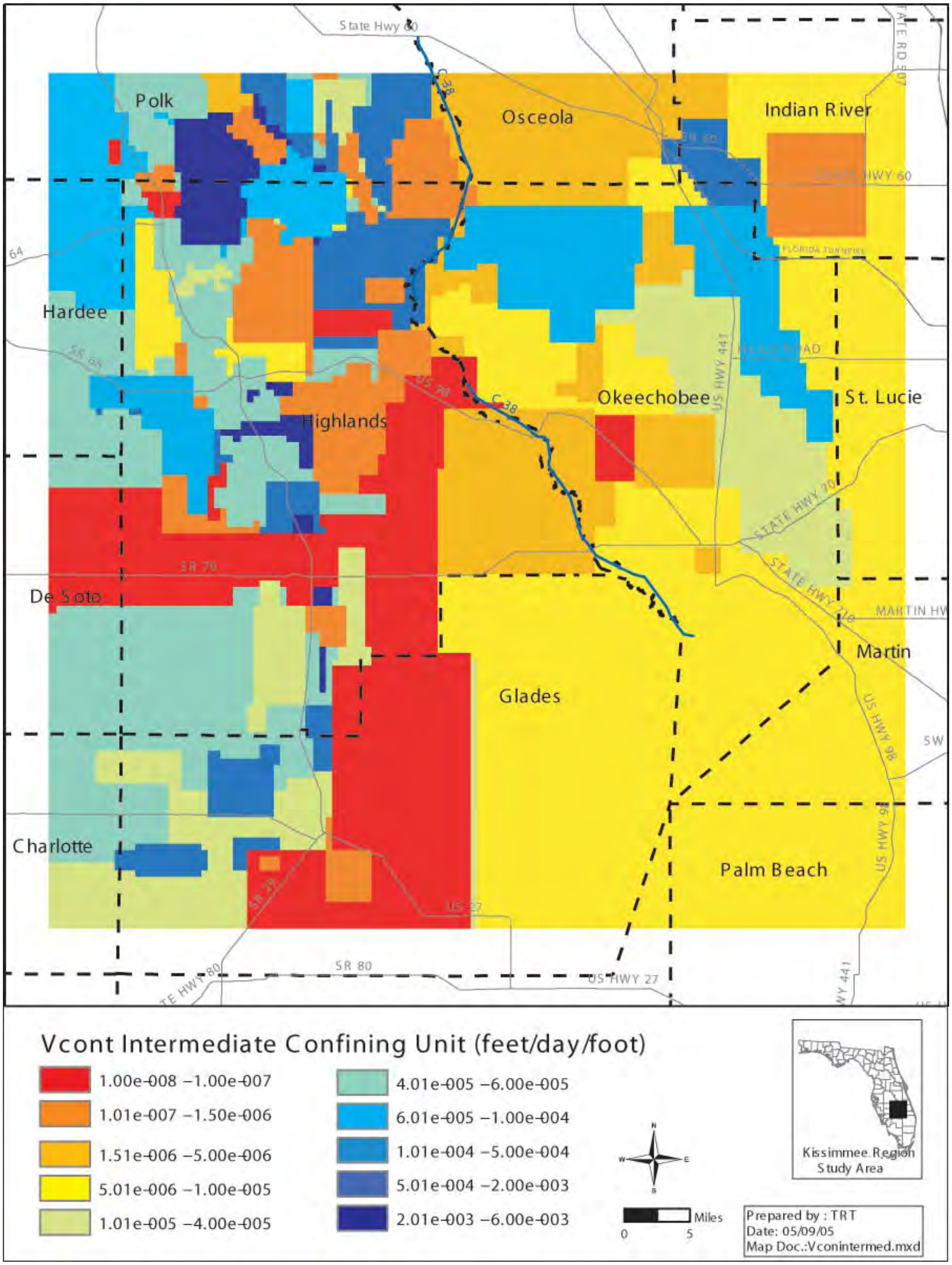

Figure 52. Calibrated Vcont Values for the Intermediate Confining Unit.

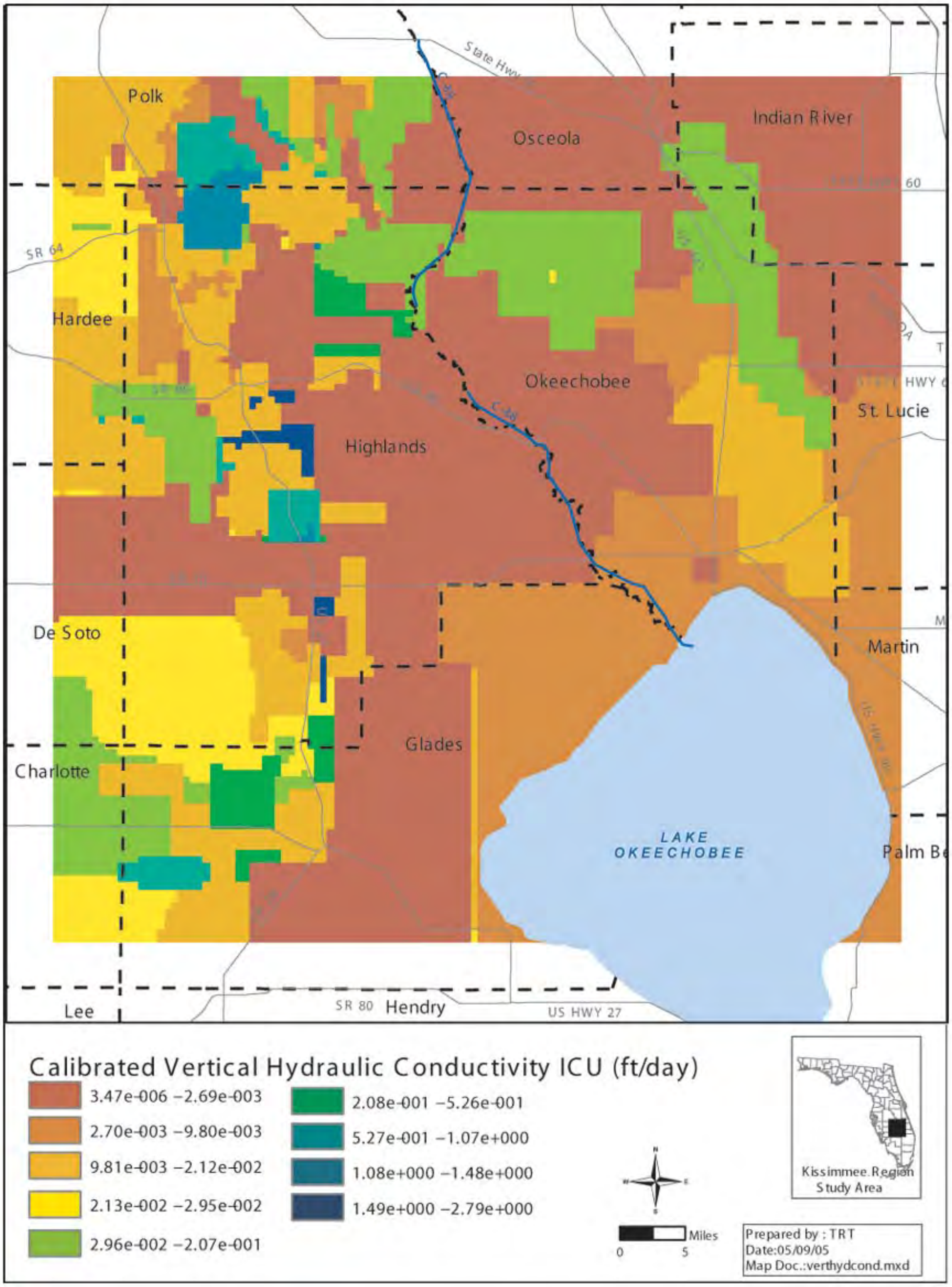

Figure 53. Calibrated Vertical Hydraulic Conductivity for the Intermediate Confining Unit.

For the Middle Confining Unit 1 (**Figure 54**), Kzc was assumed to be 1 and was divided by the thickness of the Middle Confining Unit 1 to obtain an array for Vcont23. For the Middle Confining Unit 2, Kzc was assumed to be 0.5 and it was divided by the thickness of the Middle Confining Unit 2 to obtain an array for Vcont34. **Figure 55** presents the estimated Vcont values for the Middle Confining Unit 2.

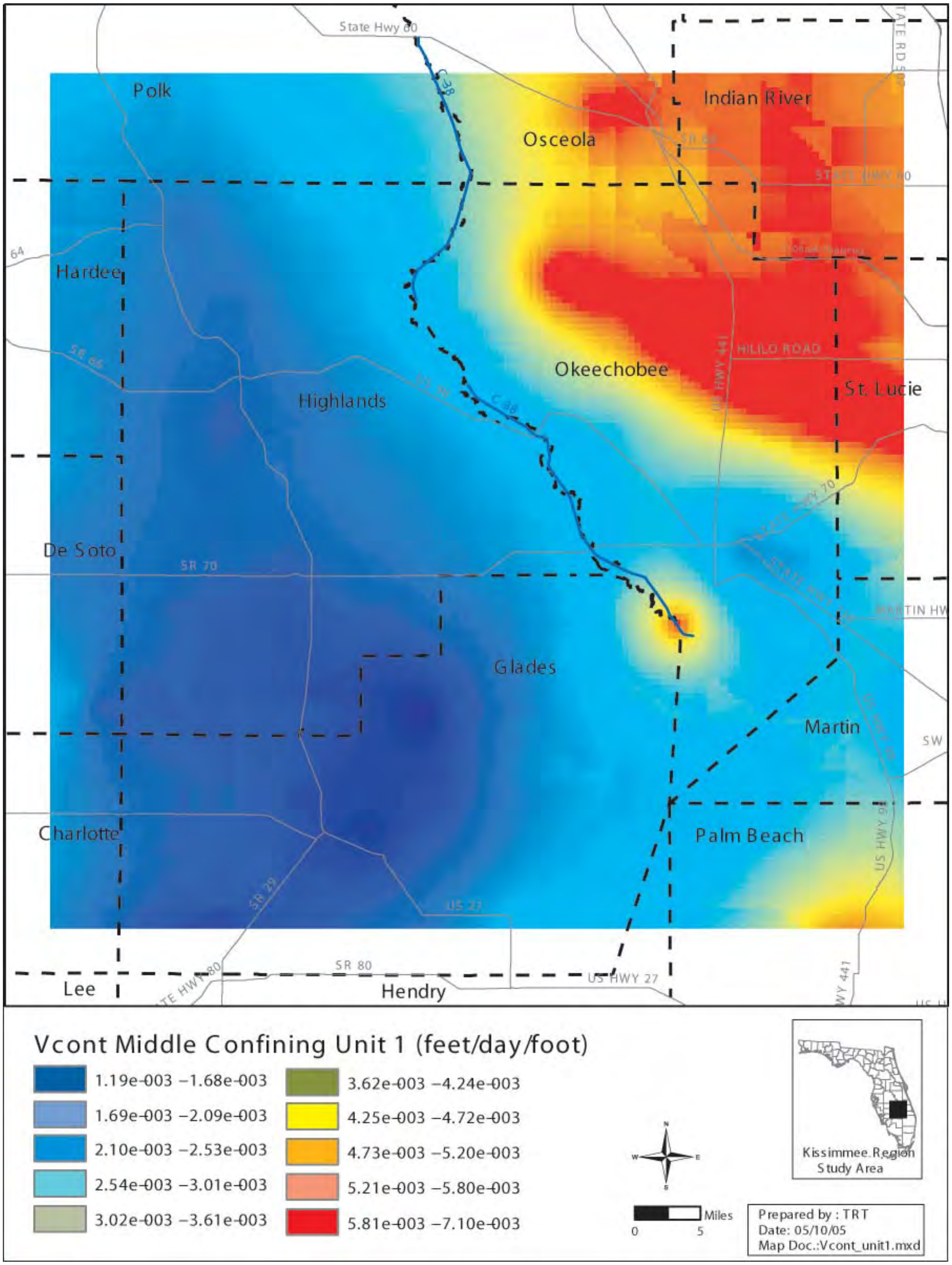

Figure 54. Estimated Vcont Values for the Middle Confining Unit 1.

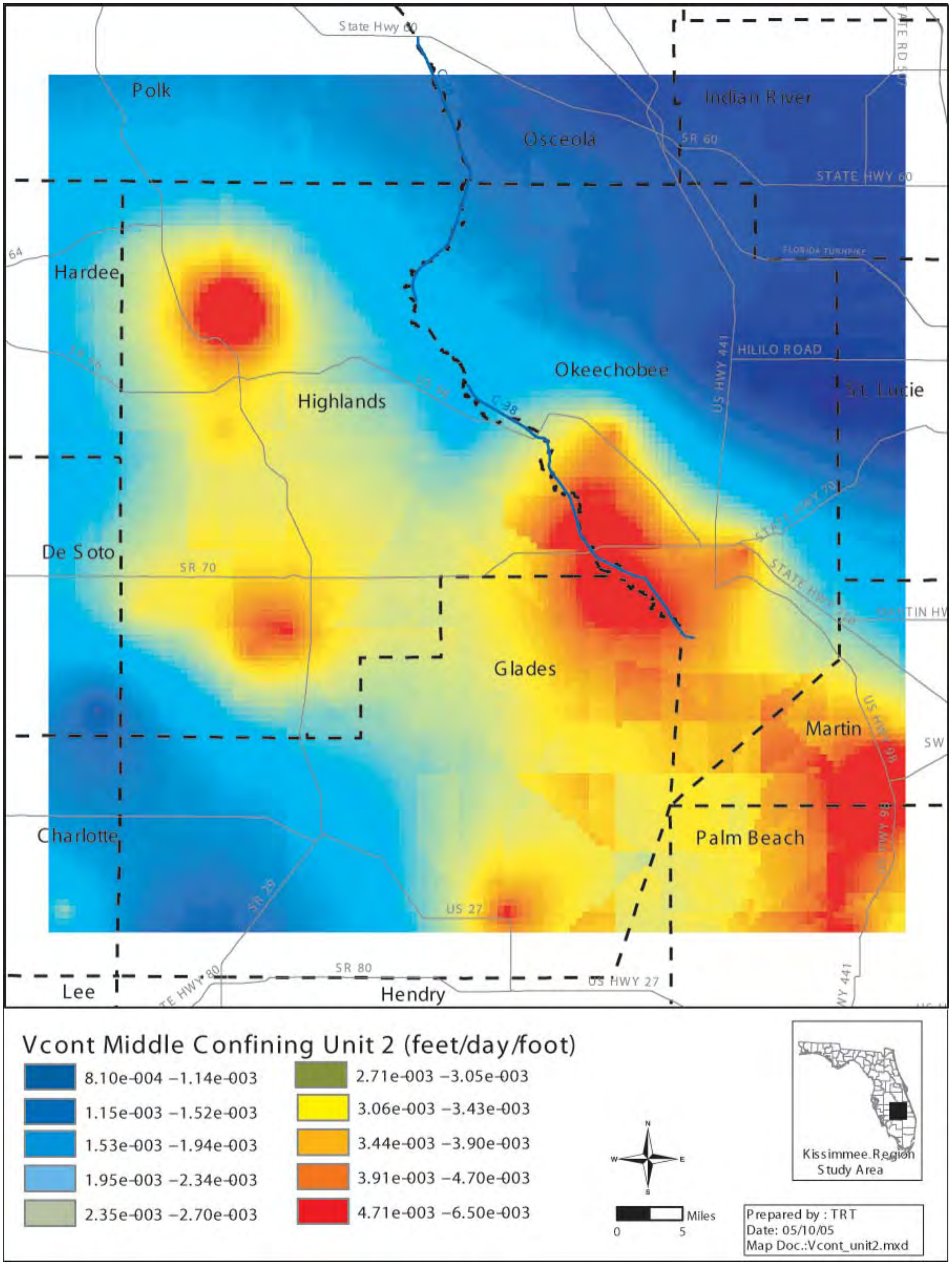

Figure 55. Estimated Vcont Values for the Middle Confining Unit 2.

River Package

Lakes, rivers, streams and canals (**Figure 56**) were represented in the model using the MODFLOW River package. The River package requires the row and column of each river segment, the stage (water level) in the river, the hydraulic conductance between the aquifer and the stream (C_{riv}) and the bottom elevation of the river (R_{bot}). The river module calculates (Q_{riv}) the discharge rate of the stream in ft^3/day, where $Q_{riv} = C_{riv} (H_{riv} - Hsr)$ for $Hsr > R_{bot}$

and $Q_{riv} = C_{riv} (H_{riv} - R_{bot})$ for $Hsr <= R_{bot}$

Where

$C_{riv} =$ KvLW/ M.

Where

$H_{riv} =$ The stage in the river.

Hsr = The simulated model head in the cell containing the river reach.

Kv = The vertical hydraulic conductivity of the streambed material ft/day. Initial vertical conductivity was estimated at 0.0864 ft/day, but with calibration, found the discharge rates were too low and raised the K value to 1.73 ft/day for all stream reaches.

L = The length of the river reach in that cell in feet.

W = The width of the river reach in feet.

M = The thickness of the streambed in feet (Assumed to be 1 ft for all the reaches).

The model calibration used average stages for 1995 where available.

Canals

Canal cross sections were obtained from the Design Manuals of the Army Corps of Engineers for the Kissimmee Basin (Region IV). From these manuals, the canal bottom width, bottom elevation and slope were obtained. The top width could be calculated from the other information. The average stages for 1995 were obtained for the structures along the canals and these were applied to the canal segments between the structures.

Rivers

Cross sections are not available for the rivers so the top width of the rivers was estimated by viewing aerial photos (The resolution of the image is 10 meters). If gauges were available along the river, they were used to estimate the stage of the river, otherwise the stage of the river was assumed to be at the surface elevation of that cell and river bottom calculated from any depth information available from the U.S. Geological Survey (USGS) or county Web sites. When depth information was not available, it was estimated between 3 and 5 feet below land surface (bls).

Streams

Streams were added using the National Hydrography Dataset (NHD[1]). The National Hydrography Dataset is a feature-based database, which interconnects and uniquely identifies the stream segments or reaches comprising the nation's surface water drainage system. It is based initially on the content of the USGS 1:100,000-scale Digital Line Graph (DLG) hydrography data, integrated with reach-related information from the U.S. Environmental Protection Agency Reach File Version 3.0 (RF3). More specifically, it contains reach codes for networked features and isolated lakes, flow direction, names, stream level and centerline representations for aerial water bodies. The National Hydrography Dataset also incorporates the National Spatial Data Infrastructure framework criteria set out by the Federal Geographic Data Committee. The steams for the Lower Kissimmee Basin were all estimated to be 25 feet wide and 2 feet deep.

Lakes

Lakes were delineated from the National Hydrography Dataset coverage. All the features labeled as "lakes or ponds" were selected. Due to the presence of numerous lakes within the model area, only those with a surface area greater than 30 acres were included in the model. Lake depths and bathymetric maps were obtained from the following Web sites: University of Florida Institute of Food and Agricultural Sciences (IFAS) LAKEWATCH[2]; the University of South Florida[3]; and Highlands County Soil and Water Conservation District[4]. When actual depth information was not available, Secchi depth readings were used as a starting point to estimate the depth – the water is at least as deep as the Secchi reading. Lake stages were obtained from South Florida Water Management District (SFWMD)[5], Southwest Florida Water Management District (SWFWMD)[6], St. Johns River Water Management District (SJRWMD)[7] and U.S. Geological Survey

[1] NHD http://nhd.usgs.gov/

[2] LAKEWATCH http://lakewatch.ifas.ufl.edu/maplist.htm

[3] Polk County http://www.polk.wateratlas.usf.edu/navigator/

[4] Highlands County http://www.highlandsswcd.org/

[5] SFWMD DBHYDRO http://www.sfwmd.gov/site/index.php?id=38

[6] SWFWMD http://www.swfwmd.state.fl.us/data/

[7] SJRWMD http://www.sjrwmd.com/programs/data.html

(USGS)[8] stage monitors and the previously mentioned Web sites. Many of the lakes are not gauged. When no measured water levels were available, the water levels were estimated based on the water levels in nearby lakes and the surface elevation of the cell/cells containing the lake. If a lake contained multiple cells all the cells, were set to one stage elevation. To calculate C_{riv} for the lakes, the “reach length” was assumed to be the square root of the lake area.

[8] USGS National Water Information System http://nwis.waterdata.usgs.gov/usa/nwis/

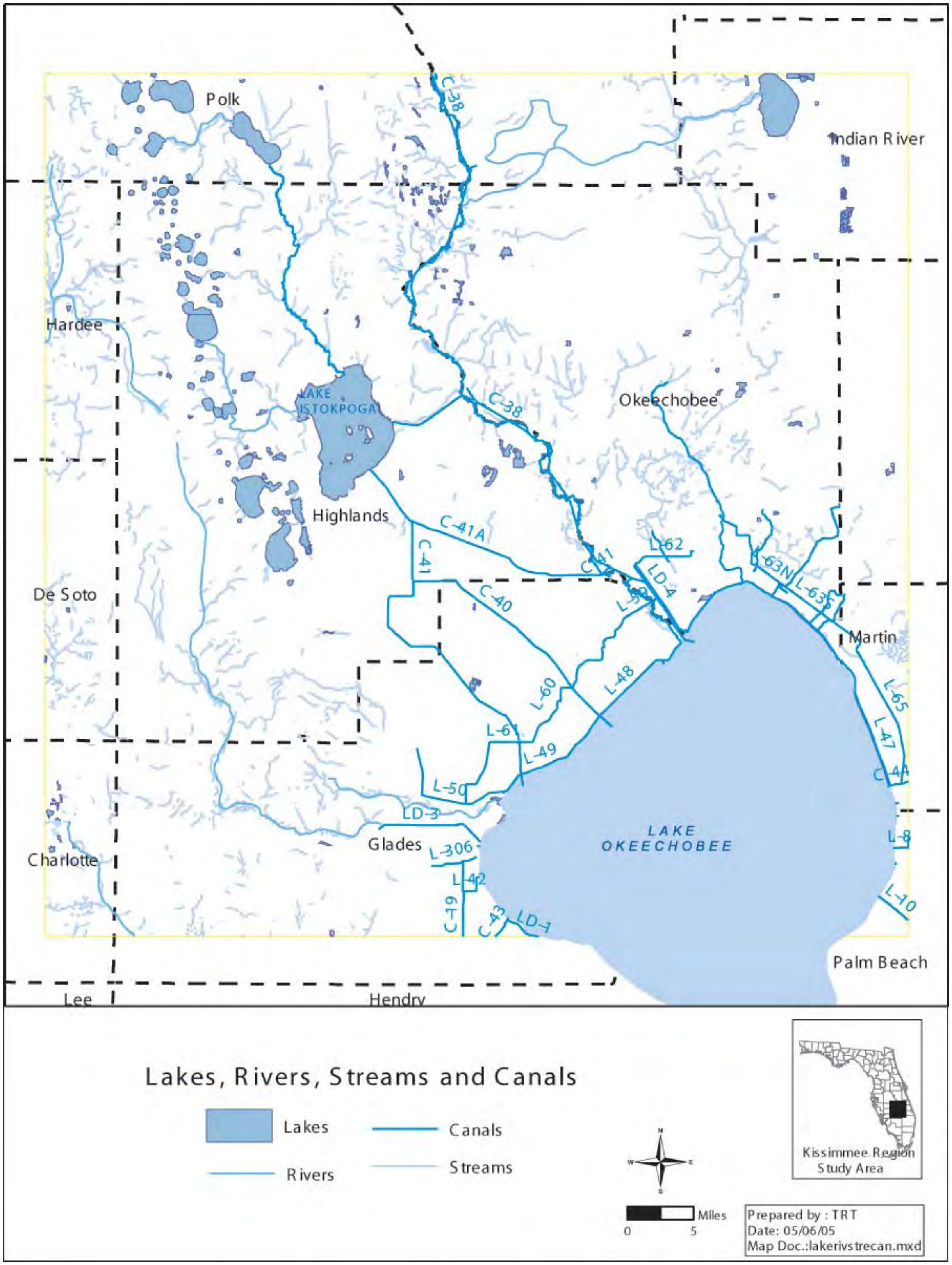

Figure 56. Lakes, Rivers, Streams and Canals.

Drain Package

The MODFLOW Drain module is similar to the Rivers module, but differs in that rivers allow water to flow in and out of the model, while drains only remove water from the system. As long at the head in the cell is above the drain elevation, water will be removed from the cell. Drains (**Figure 57**) require only a drain elevation and the conductance between the drain and the aquifer.

$C_{drain} = KvLW/ M$

Where

Kv = The vertical hydraulic conductivity of the drain material, was assumed to be 0.25 – 0.5 ft/day.

L = The length of the drain reach in that cell in feet.

W = The width of the drain reach in feet.

M = The thickness of the streambed in feet (Assumed to be 1 ft for all the reaches).

The drains were delineated from the National Hydrography Dataset coverage. All the features labeled as “ditches or canals” were added. These drains are mainly irrigation ditches. The width of the drains was estimated from aerial photos. The numbers prevented review of each ditch, but were estimated by sampling the aerial photos of ditches in area. The slope for all the ditches was assumed to be 1:4 since ditches tend to wide and shallow, thus the depth was assumed to be ¼ of the width. The stages were set to the surface elevation and the drain elevation was set to x feet below the surface depending on estimated depth.

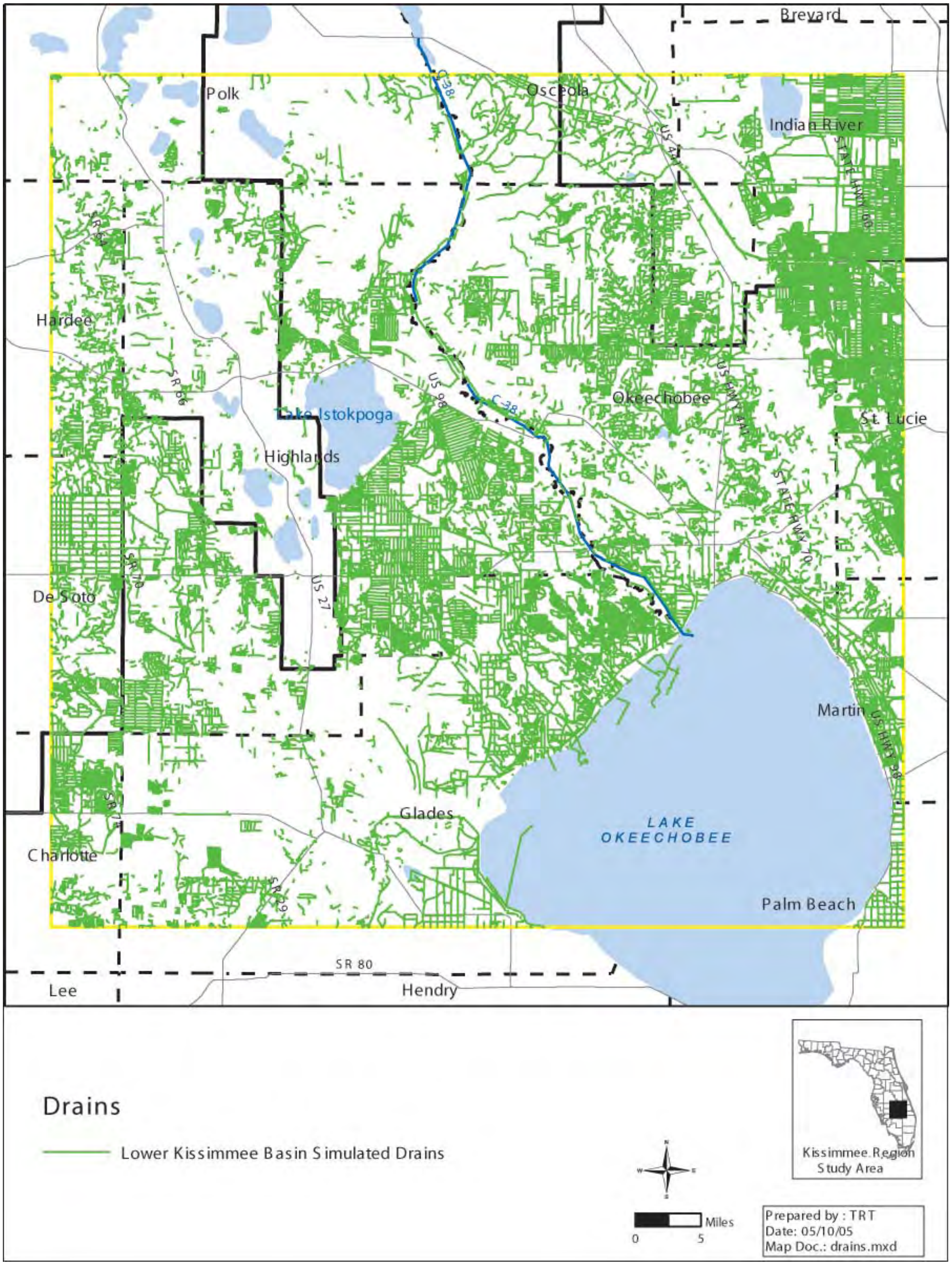

Figure 57. Drains.

Evapotranspiration (ET) Package

The evapotranspiration package includes the following input data:

1. An evapotranspiration surface array depicting the elevations above which evapotranspiration from the water table occurs at a maximum rate.
2. An array of extinction depths that represent the water depths below the evapotranspiration surface where evapotranspiration rates from the water table become negligible.
3. An array of maximum potential evapotranspiration rates.

MODFLOW uses the aforementioned arrays and estimates the evapotranspiration depth for the saturated zone. The MODFLOW package uses ground surface and an evapotranspiration extinction depth term to simulate the diminishing ability of vegetation to use water at increasing depth. In MODFLOW, the following assumptions are applied (McDonald and Harbaugh 1988):

When the water table is above the evapotranspiration surface, the evapotranspiration losses from the water table occurs at the maximum rate (evapotranspiration rate=maximum evapotranspiration rate). When the water table is below the extinction depth, no evapotranspiration occurs from the evapotranspiration surface. (ET Rate=0)

Evapotranspiration (**Figure 58**) from the water table varies linearly between the maximum (at the evapotranspiration surface) and minimum limits (at the extinction depth see definition next section)

The evapotranspiration surface array was based on topography. The evapotranspiration surface was set land surface elevation with the exception of Avon Park Ridge were set to 10 feet above land surface.

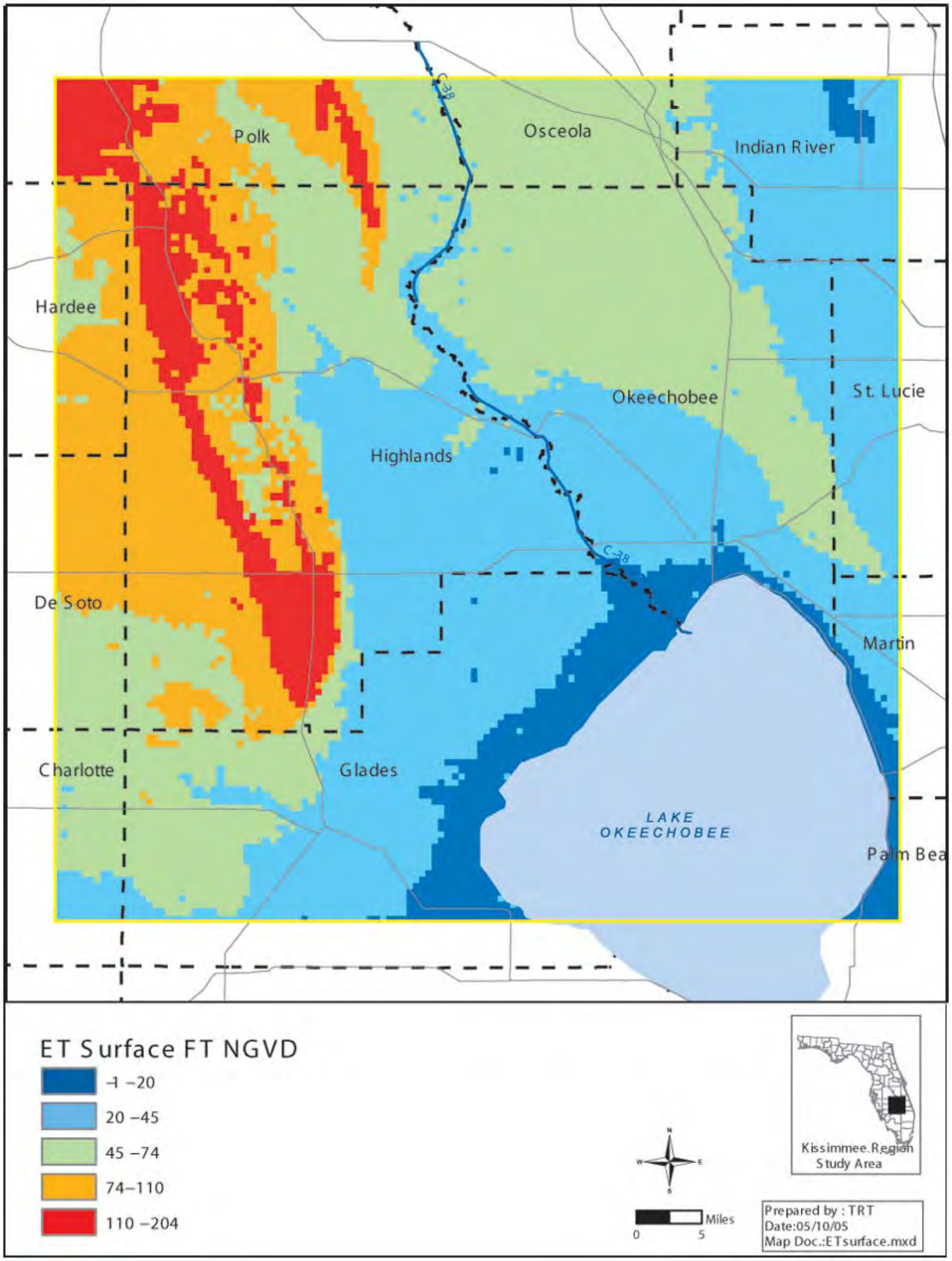

Figure 58. Evapotranspiration Surface (ft).

Extinction Depth

The extinction depth (**Figure 59**) array was based on shallow and deep root zone depths. As outlined in Restrepo and Giddings (1994), a daily water balance was conducted on each unique combination of land cover and soil type. A corresponding maximum evapotranspiration rate was assigned to each of these combinations. The deepest extinction depths correspond to lake areas and of surface water bodies. The extinction depths in the lakes and water bodies was set to 20 feet, essentially assuring that in these areas the maximum evapotranspiration rate will always be applied. (Lake Okeechobee is inactive in Layer 1 so the extinction depths were not used in that area.)

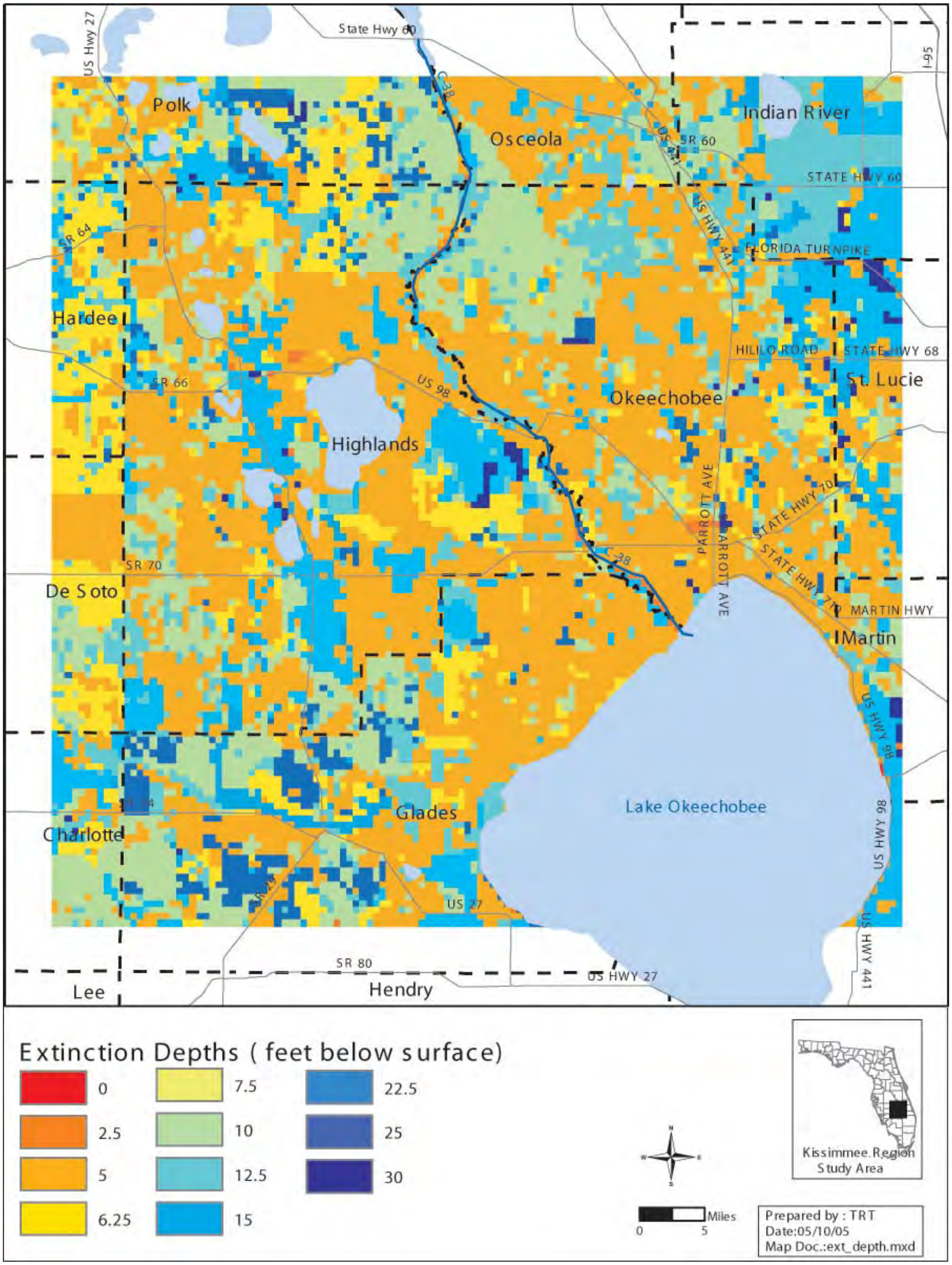

Figure 59. Extinction Depths.

Reference Evapotranspiration

The potential reference evapotranspiration was calculated by the "South Florida Water Management District Simple Method" using *wet marsh reference evapotranspiration*, as described in Irizarry-Ortiz (2003). The SFWMD Simple Method was developed as a modification to the Penman-Monteith method due to the lack of a comprehensive meteorological database for south Florida. The Penman-Monteith requires input from many meteorological variables, which are hard to measure or estimate. The SFWMD Simple Method (Equation 2) was developed to be a simpler yet equally accurate method for estimating the potential evapotranspiration for wetlands marsh Irizarry-Ortiz (2003).

$$ET_p = \frac{K_1 * R_s}{\lambda} \qquad \text{(Equation 2)}$$

ETp: Wet marsh potential evapotranspiration [mm d-1].

K1: Coefficient (0.53 for mixed marsh, open water and shallow lakes).

Rs: Solar radiation received at the land surface [MJ m-2 d-1].

λ: Latent heat of evaporation [MJ kg-1].

In order to calculate the wet marsh reference evapotranspiration, the solar radiation at land surface needed to be calculated from the average minimum and maximum temperatures. Daily wet marsh potential evapotranspiration values were calculated for years 1965–2001, and then only the values for 1995 were used to calculate the daily maximum potential evapotranspiration rate for each evapotranspiration station. The *wet marsh reference evapotranspiration* was calculated with the aid of the ETCALC program built into an Excel spreadsheet. The program required daily temperature data with no gap periods. Missing temperature data were estimated by comparing the temperature of nearby stations. For example the temperatures at Avon Park were compared to those at Wauchula (west of model boundary). See **Figure 60**.

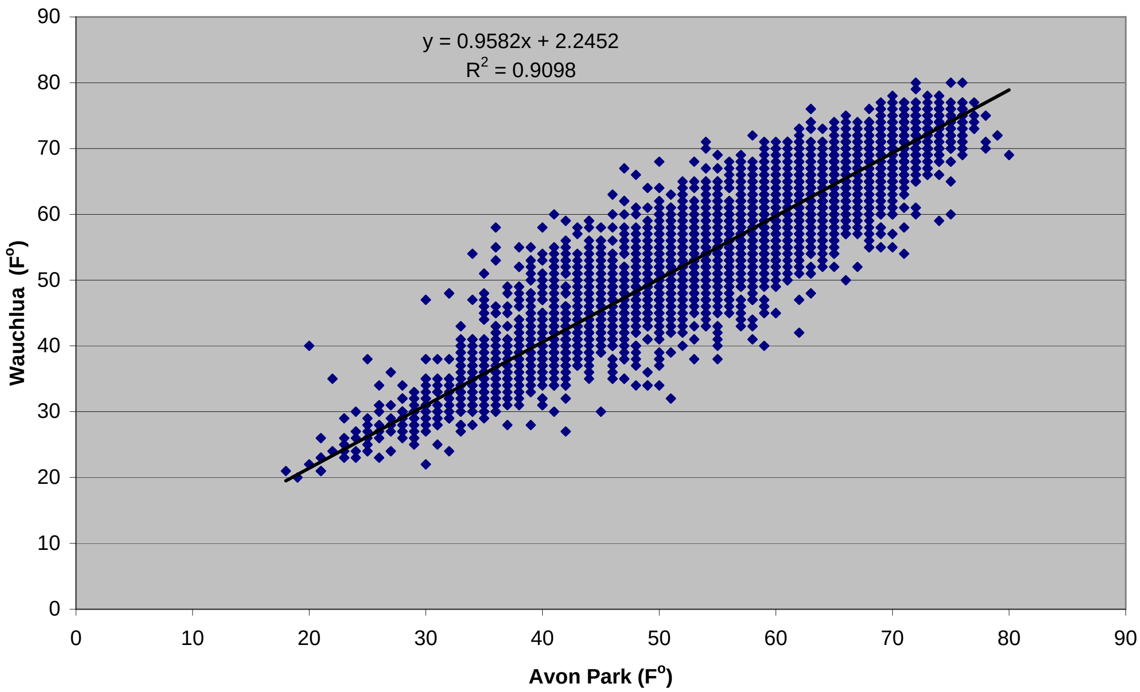

Figure 60. Comparison of Temperatures in Wauchula and Avon Park.

The ETCALC also required the average potential evapotranspiration for a given longitude and latitude based on Visher and Hughes, 1969.

$$R_s = \tau R_a = R_a K_r (T_{\max} - T_{\min})^{0.5} + B$$

Where

Rs: Solar radiation received at the land surface [MJ m-2 d-1 or W/m2] (MJ is micro-joules, W is Watts microjoules * square meters per day or watts per square meter).

τ: Atmospheric transmissivity.

Kr: Empirical coefficient.

Tmax: Mean daily maximum temperature over the period of interest [^{o}C].

Tmin: Mean daily minimum temperature over the period of interest [^{o}C].

Ra: Extraterrestrial solar radiation [MJ m-2 d-1 or W/m2].

B: Empirical term [MJ m-2 d-1 or W/m2].

K_r is empirical coefficient, which is used in the ETCALC program. For the model area the Kr was assumed to be equal to 0.22. The potential evapotranspiration for wetlands marsh was calculated for each National and Oceanographic and Atmospheric Administration (NOAA) station in the model vicinity. ETCALC program required only the following parameters from the end user – temperatures, Kr, the latitude and longitude of the evapotranspiration station and B. B is an empirical number adjusted for each station. Various numbers were tried to reach a resulting average annual ETp close to 50 inches/year.

Figure 61 shows the evaporation station locations and Thiessen polygons.

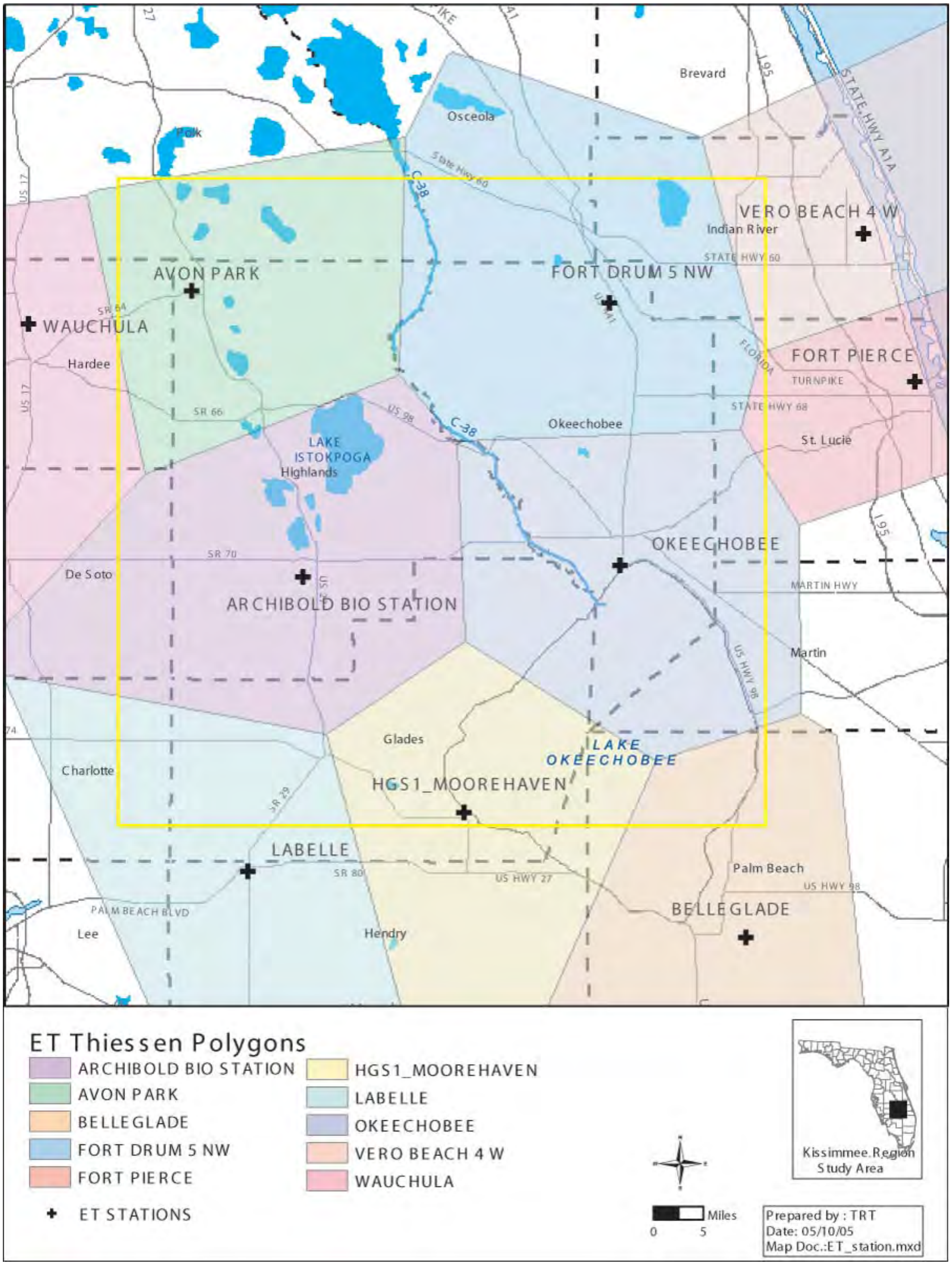

Figure 61. Evapotranspiration Station Locations and Thiessen Polygons.

Maximum Potential Evapotranspiration Rate

Potential evapotranspiration (ET) is defined as “the rate at which water, if available, would be removed from saturated soil in the form of latent heat per unit area or the equivalent depth of water (Giddings and Restrepo 1995).

The maximum potential saturated evapotranspiration rate (**Figure 62**) is estimated as:

$ET_{saturated\text{-}max} = ETp - ET_{UNSATURATED}$.

ETp is the potential ET for each crop.

ETp = kc x ETr.

Kc is a coefficient for each crop or land use type. The Kc is modified to the growth season of each crop. The Agricultural Field Scale Irrigation Requirements Simulation (AFSIRS), which was developed by Smajstrla (1990) to estimate crop irrigation demands for crops in South Florida and assigned a Kc for each crop.

ETr is the reference ET Depth for Wetland Marsh.

The ET of the unsaturated zone approaches zero because the water in the unsaturated zone is used by the plants and crops, if the water in the unsaturated zone is insufficient for the plant, then it uses more water from the saturated zone (Restrepo and Giddings 1994).

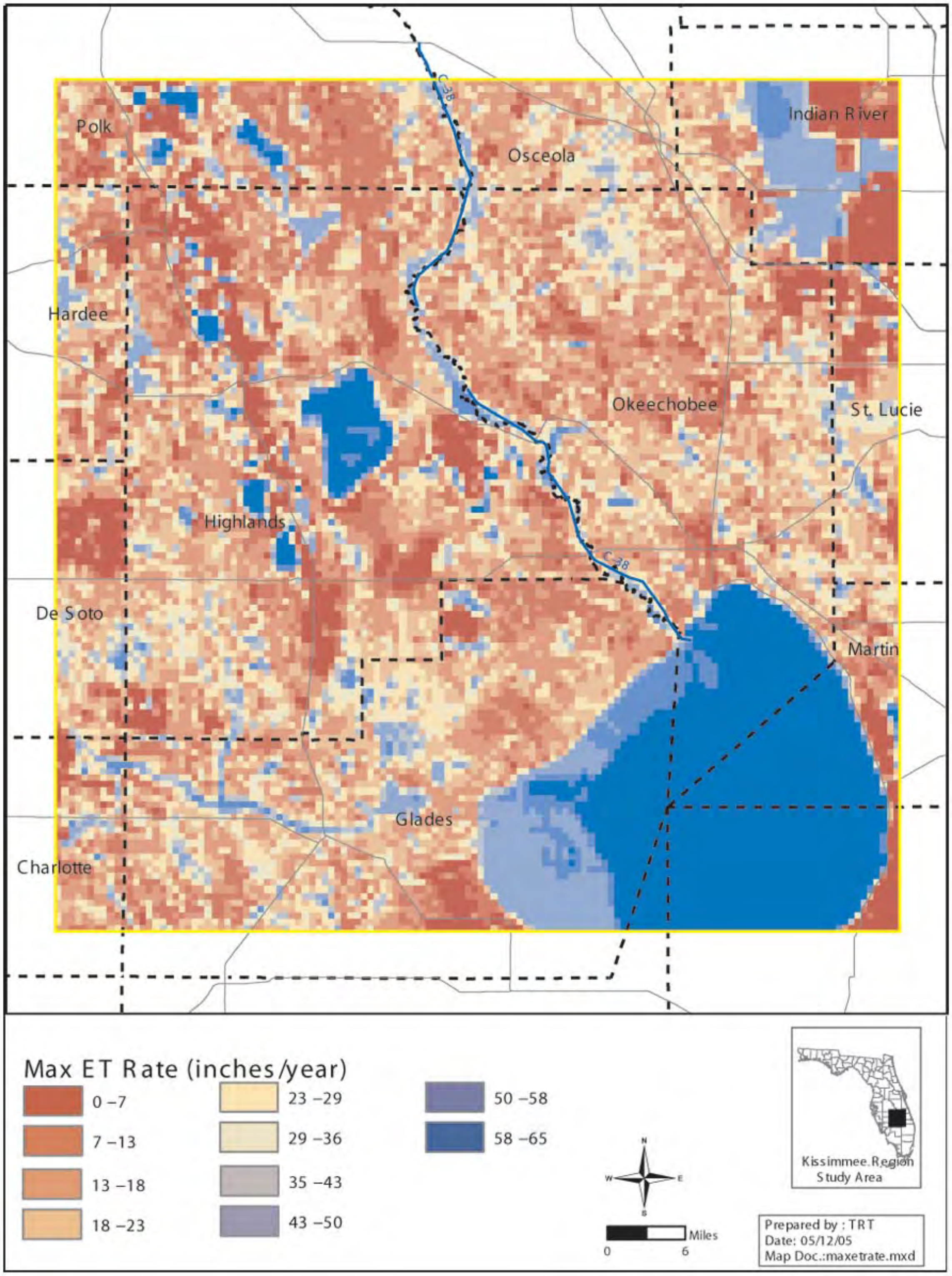

Figure 62. Max Potential Evapotranspiration Rate.

Recharge

In addition to estimating the maximum potential evapotranspiration rate, the ET-RECHARGE program (Giddings and Restrepo 1995) calculates the crop irrigation demands and the recharge into the Surficial Aquifer System (**Figure 63**). The program uses ArcGIS coverages of land use/land cover, soils, rainfall, evapotranspiration and irrigation demand to estimate the recharge in each model cell. The basic water budget for AFSIRS as stated in (Giddings and Restrepo 1995).

STO = RAIN +NIRR – DRAIN – RUNOFF – ET.

STO is the change in soil water storage, RAIN is the rainfall, NIRR is the net water irrigation requirement, DRAIN is Drainage, RUNOFF is the surface water runoff and ET is the evapotranspiration.

The AFSIRS program combines RUNOFF and DRAIN into one drainage component.

The daily water balance analysis yields the amount of recharge to the water table, which is input to the model.

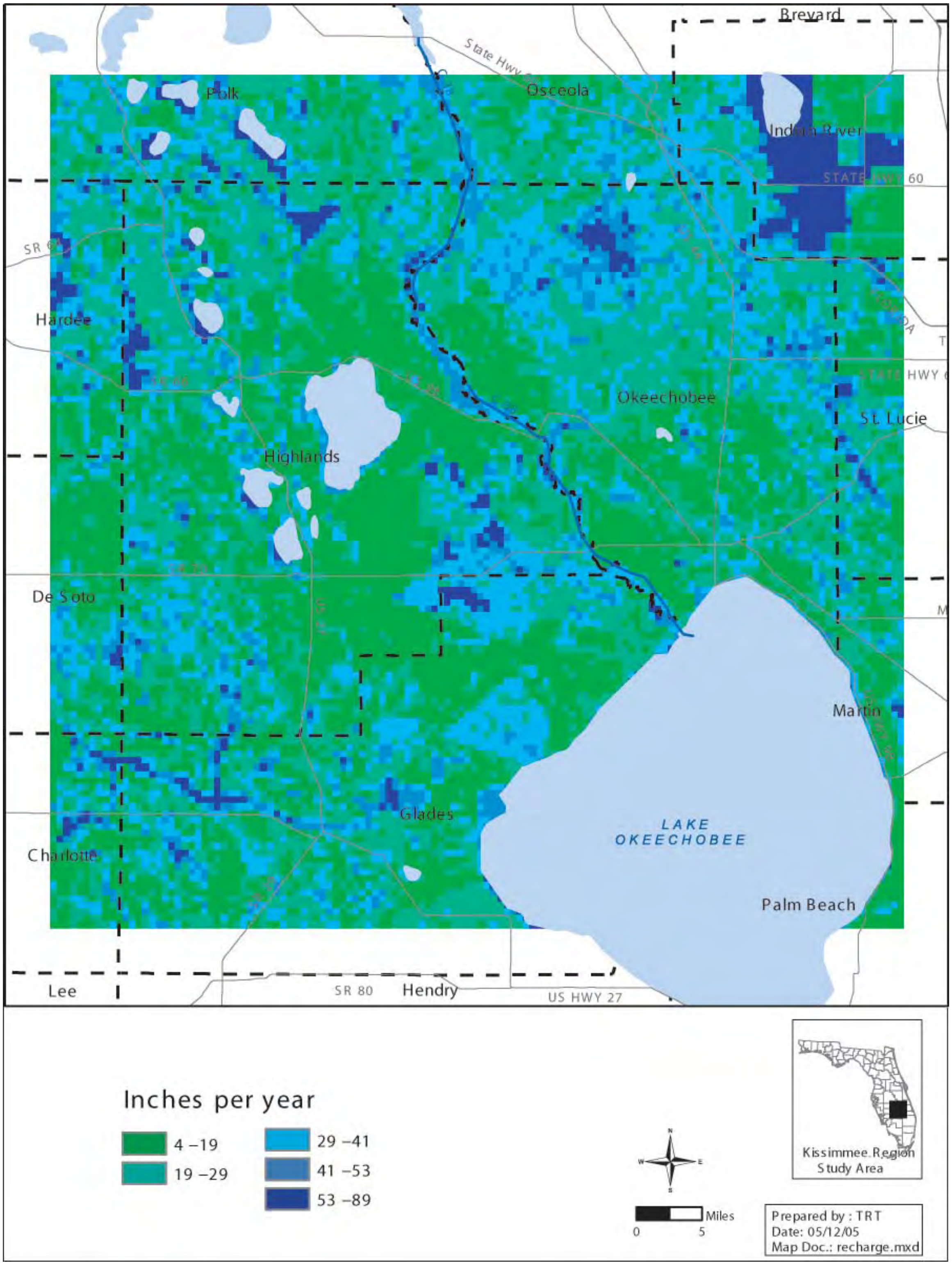

Figure 63. Recharge in the Model Area.

Rain

The average annual rainfall in the model area is 55 inches.

There are more rain stations available than weather stations, so the area was divided into more Thiessen polygons. The average daily 1995 rainfall values were assigned to each Thiessen polygon, and used in with the AFSIRS program to estimate recharge. Only rainfall stations having over 360 days of data for 1995 were used.

Figure 64 shows the rainfall station location and Thiessen polygons. **Figure 65** presents the average 1995 rainfall by station. **Table 14** shows the average 1995 rainfall for each station.

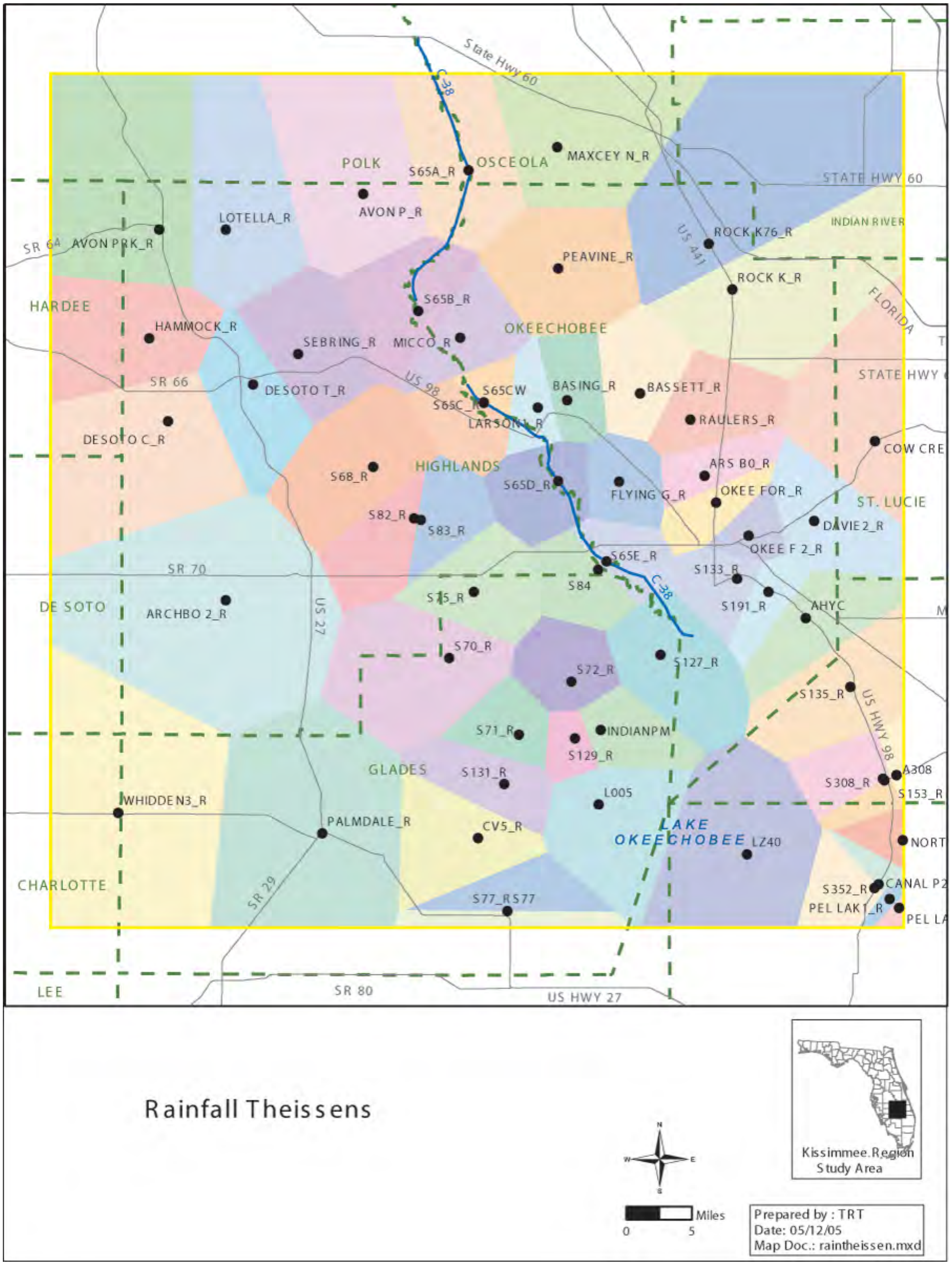

Figure 64. Rainfall Stations and Thiessen Polygons.

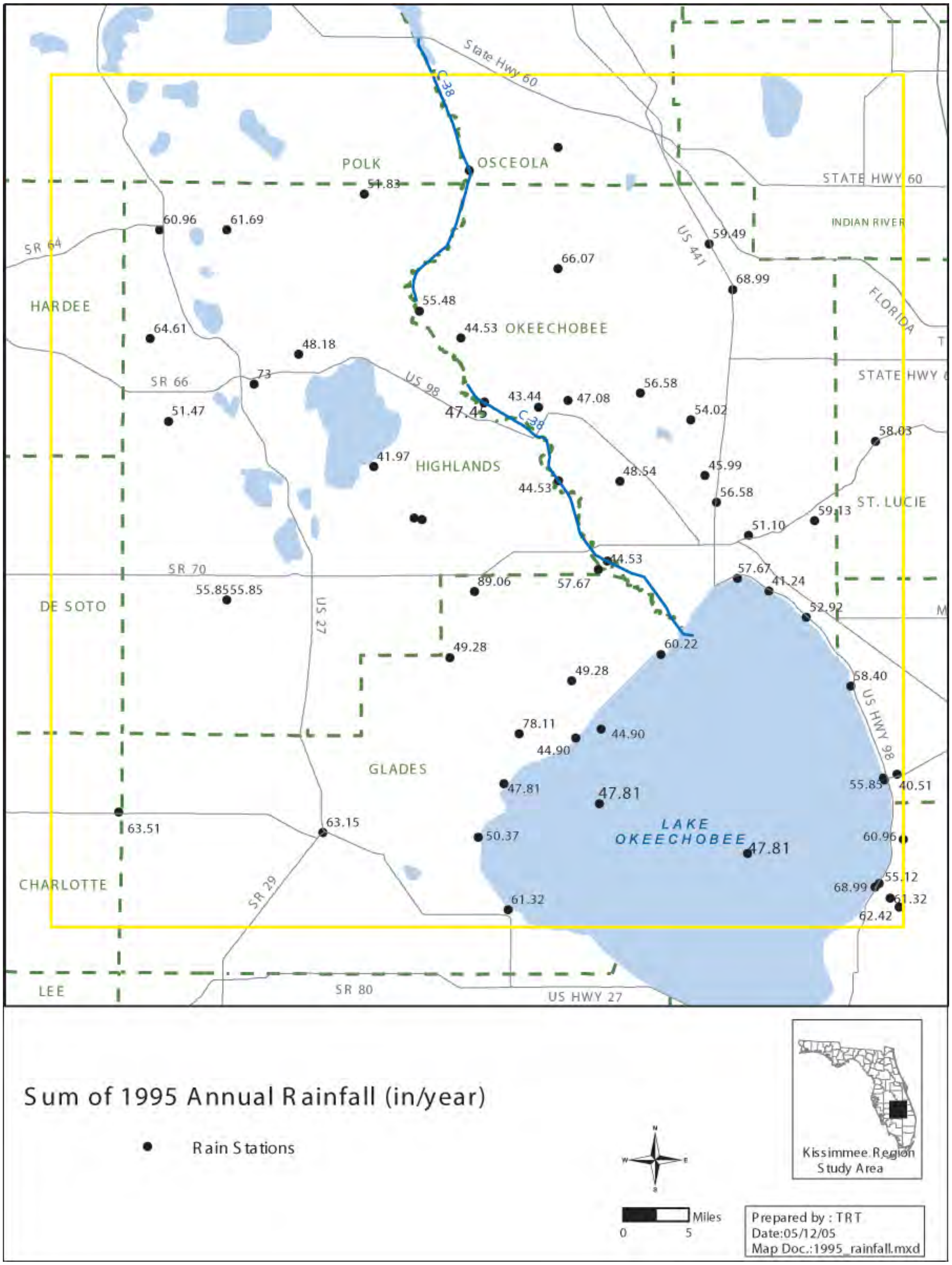

Figure 65. Average 1995 Rainfall by Station.

Table 14. Rainfall Stations and Average 1995 Daily Rain.

Station	DBKey	Average 1995 Rain	Sum Annual 1995 Rain
ARCHBO 2_R	16604	0.15	55.93
ARS B0_R	15582	0.13	45.87
AVON P_R	05854	0.14	51.68
BASING_R	05857	0.15	56.10
BASSETT_R	15577	0.15	56.53
DAVIE2_R	16192	0.16	59.25
DESOTO T_R	06096	0.20	72.62
FLYING G_R	07507	0.13	48.45
LOTELLA_R	05853	0.17	61.63
MAXCEY N_R	05871	0.13	48.75
MICCO_R	05856	0.12	44.51
OKEE F 2_R	16285	0.14	51.08
OKEE F 2_R	16697	0.14	51.08
OKEE FOR_R	06102	0.15	56.23
PEAVINE_R	05858	0.18	66.12
ROCK K_R	05844	0.19	69.06
ROCK K76_R	05866	0.16	59.37
S133_R	05845	0.16	57.75
S133_R	16576	0.16	57.75
S191_R	16669	0.11	41.22
S65A_R	05981	0.14	52.10
S65A_R	16572	0.14	52.10
S65B_R	16282	0.15	55.55
S65B_R	16620	0.15	55.55
S65C_R	06024	0.12	43.29
S65C_R	16657	0.12	43.29

Table 14. Rainfall Stations and Average 1995 Daily Rain (Continued).

Station	DBKey	Average 1995 Rain	Sum Annual 1995 Rain
S65CW	15473	0.13	47.46
S65D_R	16281	0.15	56.03
S65D_R	16658	0.15	56.03
S65E_R	16280	0.12	44.37
S65E_R	16621	0.12	44.37
S68_R	16654	0.12	42.10
S82_R	16655	0.11	40.92
S83_R	16656	0.20	71.28
SEBRING_R	05855	0.13	48.32

Soils

There are over 800 types of soils in south Florida. The U.S. Department of Agriculture (USDA) analyzed and numbered the soils in each county individually[9]. Each county has a unique set of Muid soil numbers, beginning with a county code, and then a soil number (numbers change by county, or year soil survey conducted) and a map unit name, which describes the soil. Using the USDA Soil Conservation Service's (SCS) Soil Surveys for each county, each Muid or map unit name was matched to a South Florida Soil Number. The Muid numbers were linked to the "Soil Survey Geographic" (SSURGO) soil coverage. This layer was derived from the soil surveys developed over many years by the U.S. Department of Agriculture, Soil Conservation Service (SCS), now called the Natural Resources Conservation Service (NRCS). These data are the highest resolution soil data available from the NRCS. The maps have a level of detail comparable with 7.5' USGS topography quads or National Wetlands Inventory (NWI) wetlands maps. The ET-RECHARGE program uses a file, which groups the soils by their properties and assigns a "South Florida Soil Number" to each soil group. The properties include the number of soil horizons, the depth in inches of each horizon and the water capacity of that horizon. The polygons for the 800 soil types used in model are too detailed to display here. The STATSGO soils[10] were also developed by the NRCS. The STATSGO data are a generalization of the SSURGO data. The SSURGO data for the SFWMD were also generalized for important soils within the District. The SFWMD generalization is more detailed than the STATSGO data, but less detailed than the SSURGO data. This generalization is displayed in **Figure 66**.

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[9] Published Soil Surveys for Florida http://soils.usda.gov/survey/printed_surveys/florida.html

[10] STATSGO http://www.ncgc.nrcs.usda.gov/products/datasets/statsgo/metadata/fl.html

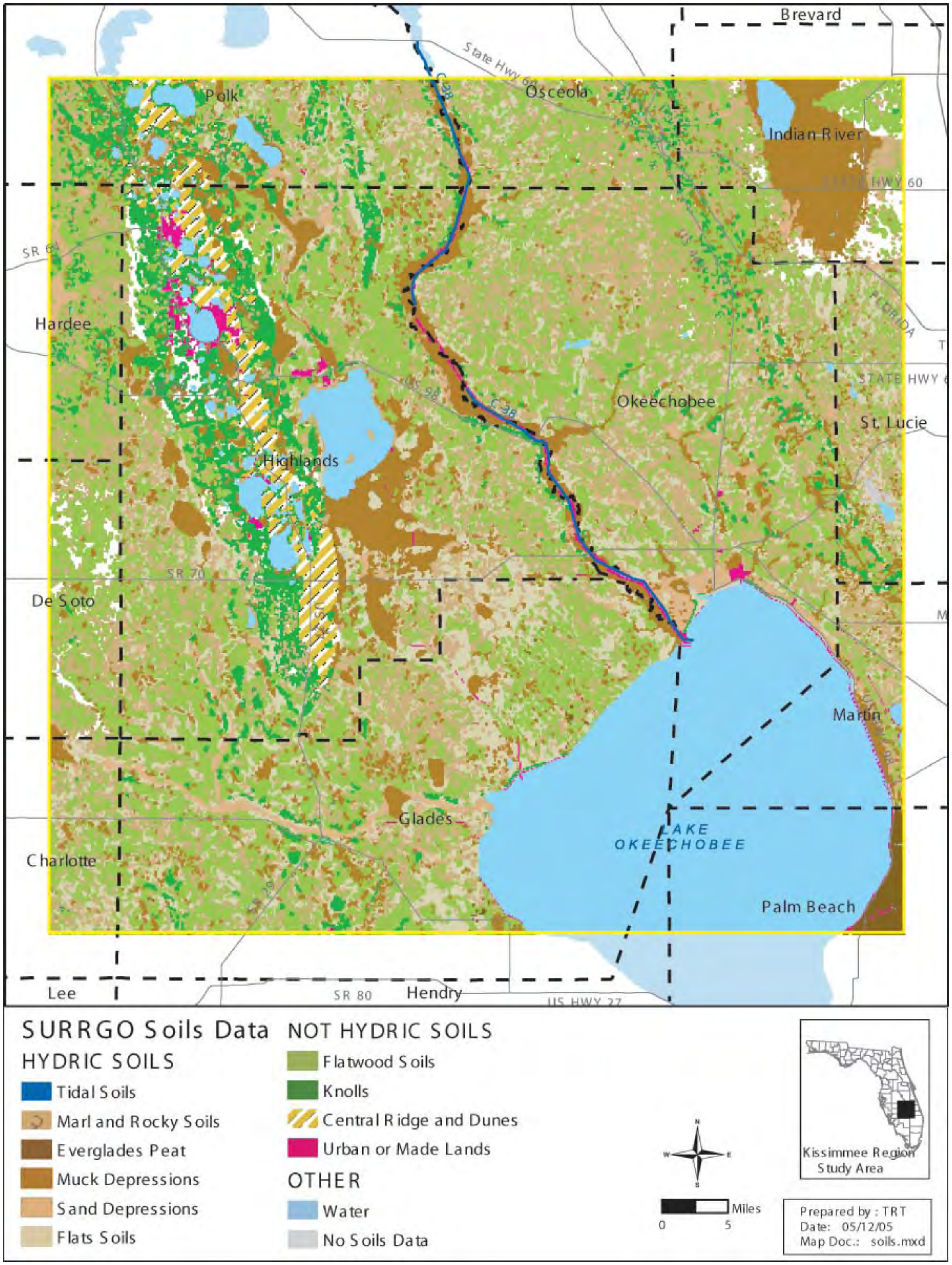

Figure 66. Generalized Soils in the SFWMD.

Land Use

The 1995 land use/land cover maps from the South Florida Water Management District (SFWMD), St. Johns River Water Management District (SJRWMD) and Southwest Florida Management District (SWFWMD) were combined for the model area. The land use/land cover maps were produced by photo interpretation of 1:40,000 USGS NAPP color infrared photography. All three water management districts used a modification of statewide Florida Land Use and Cover Classification System (FLUCCS), which is maintained by the Florida Department of Transportation (FDOT). This modified version uses classes that are mainly at the community level, but also includes a number of species of concern. Modifications and corrections have been made to the map since its creation. The SJRWMD and the SWFWMD used four numbers to identify Florida Land Use and Cover Classification System Level 3 where the SFWMD used three characters for Florida Land Use and Cover Classification System Level 3 and 4 characters for Florida Land Use and Cover Classification System Level 4. The SFWMD land use codes were converted to the system used by the other districts by changing the characters to numbers and multiplying the Florida Land Use and Cover Classification System number by ten. Since the coverages for the different districts have some overlap, the following procedure was established. The SFWMD data were used when available. When SFWMD data were missing or zero, SJRWMD land use code was used. Finally, in areas where neither of the other districts had data, SWFWMD data were used. **Table 15** shows the land use / land cover descriptions. **Figure 67** presents land use for 1995.

Table 15. Land Use / Land Cover Descriptions.

FLUCCS Code	FLUCCS Code Description	FLUCCS Code	FLUCCS Code Description
1000	Urban And Built-Up	1540	Oil and Gas Processing
1009	Mobile Home Units Any Density	1550	Other Light Industrial
1100	Residential Low Density <2 du/ac	1560	Other Heavy Industrial
1110	Fixed Single Family Units <2 du/ac	1590	Industrial Under Construction
1120	Mobile Home Units <2 du/ac	1600	Extractive
1130	Mixed Units (fixed and mobile home units) <2 du/ac	1610	Strip Mines
1190	Low Density Under Construction <2 du/ac	1620	Sand and Gravel Pits
1200	Residential Medium Density 2-5 du/ac	1630	Rock Quarries
1210	Fixed Single Family Units 2-5 du/ac	1640	Oil and Gas Fields
1220	Mobile Home Units 2-5 du/ac	1650	Reclaimed Land
1230	Mixed Units (fixed and mobile home units) 2-5 du/ac	1660	Holding Ponds
1290	Medium Density Under Construction 2-5 du/ac	1700	Institutional
1300	Residential High Density >5 du/ac	1710	Educational Facilities
1310	Fixed Single Family Units >5 du/ac	1720	Religious
1320	Mobile Home Units >5 du/ac	1730	Military
1330	Multiple Dwelling Units Low Rise 1-2 stories	1740	Medical and Health Care
1340	Multiple Dwelling Units High Rise >2 stories	1750	Governmental
1350	Mixed Units (fixed and mobile home units) >5 du/ac	1760	Correctional
1390	High Density Under Construction >5 du/ac	1770	Other Institutional
1400	Commercial and Services	1780	Commercial Child Care
1410	Retail Sales and Services	1790	Institutional Under Construction
1411	Retail Sales and Services - Shopping Centers	1800	Recreational
1420	Wholesale Sales and Services	1810	Swimming Beach
1423	Wholesale Sales and Services - Junk Yards	1820	Golf Courses
1430	Professional Services	1830	Race Tracks
1440	Cultural and Entertainment	1840	Marinas and Fish Camps
1450	Tourist Services	1850	Parks and Zoos
1460	Oil and Gas Storage	1860	Community Recreational Facilities
1470	Mixed Commercial and Services	1870	Stadiums
1480	Cemeteries	1880	Historical Sites
1490	Commercial and Services Under Construction	1890	Other Recreational
1500	Industrial	1900	Open Land <Urban>
1510	Food Processing	1910	Undeveloped Land within Urban Areas
1520	Timber Processing	1920	Inactive Land with Street Pattern
1530	Mineral Processing	1930	Urban Land in Transition

Table 15. Land Use / Land Cover Descriptions (Continued).

FLUCCS Code	FLUCCS Code Description	FLUCCS Code	FLUCCS Code Description
1940	Other Open Land <Urban>	3210	Palmetto Prairies
2000	Agriculture	3220	Coastal Scrub
2100	Cropland and Pastureland	3230	Scrub Jay Habitat
2110	Improved Pastures	3290	Other Shrubs and Brush
2120	Unimproved Pastures	3300	Mixed Rangeland
2130	Woodland Pastures	4000	Upland Forests
2140	Row Crops	4100	Upland Coniferous Forests
2150	Field Crops	4110	Pine Flatwoods
2156	Field Crops - Sugar Cane	4119	Pine Flatwoods - Melaleuca Infested
2200	Tree Crops	4120	Longleaf Pine - Xeric Oak
2210	Citrus Groves	4130	Sand Pine
2220	Fruit Orchards	4140	Pine - Mesic Oak
2230	Other Groves	4190	Other Pines
2300	Feeding Operations	4200	Upland Hardwood Forests
2310	Cattle Feeding Operations	4210	Xeric Oak
2320	Poultry Feeding Operations	4220	Brazilian Pepper
2330	Swine Feeding Operations	4230	Oak - Pine - Hickory
2400	Nurseries and Vineyards	4240	Melaleuca
2410	Tree Nurseries	4250	Temperate Hardwood
2420	Sod Farms	4260	Tropical Hardwoods
2430	Ornamentals	4270	Live Oak
2440	Vineyards	4280	Cabbage Palm
2450	Floriculture	4289	Cabbage Palm - Melaleuca Infested
2460	Timber Nursery	4290	Wax Myrtle - Willow
2500	Specialty Farms	4300	Upland Hardwood Forests - Continued
2510	Horse Farms	4310	Beech - Magnolia
2520	Dairies	4320	Sand Live Oak
2530	Kennels	4330	Western Everglades Hardwoods
2540	Aquaculture	4340	Hardwood Conifer Mixed
2590	Other Specialty Farms	4350	Dead Trees
2600	Other Open Land <Rural>	4370	Australian Pine
2610	Fallow Crop Land	4380	Mixed Hardwoods
3000	Rangeland	4390	Other Hardwoods
3100	Herbaceous	4400	Tree Plantations
3200	Shrub and Brushland	4410	Coniferous Plantations

Table 15. Land Use / Land Cover Descriptions (Continued).

FLUCCS Code	FLUCCS Code Description	FLUCCS Code	FLUCCS Code Description
4420	Hardwood Plantations	6219	Cypress with Wet Prairie
4430	Forest Regeneration Areas	6220	Pond Pine
4440	Experimental Tree Plots	6230	Atlantic White Cedar
4450	Seed Plantations	6240	Cypress - Pine - Cabbage Palm
5000	Water	6250	Hydric Pine Flatwoods
5100	Streams and Waterways	6280	Wet Pinelands
5200	Lakes	6300	Wetland Forested Mixed
5210	Lakes larger than 500 acres	6400	Vegetated Non-Forested Wetlands
5220	Lakes larger than 100 acres - less than 500 acres	6410	Freshwater Marshes
5230	Lakes larger than 10 acres - less than 100 acres	6411	Freshwater Marshes - Sawgrass
5240	Lakes less than 10 acres	6412	Freshwater Marshes - Cattail
5300	Reservoirs	6420	Saltwater Marshes
5310	Reservoirs larger than 500 acres	6430	Wet Prairies
5320	Reservoirs larger than 100 acres - less than 500 acres	6439	Wet Prairies - with Pine
5330	Reservoirs larger than 10 acres - less than 100 acres	6440	Emergent Aquatic Vegetation
5340	Reservoirs less than 10 acres	6450	Submergent Aquatic Vegetation
5400	Bays and Estuaries	6500	Non-Vegetated
5410	Embayments opening directly into Gulf or Ocean	6510	Tidal Flats
5420	Embayments not opening directly into Gulf or Ocean	6520	Shorelines
5500	Major Springs	6530	Intermittent Ponds
5600	Slough Waters	6540	Oyster Bars
6000	WETLANDS	7000	Barren Land
6100	Wetland Hardwood Forests	7100	Beaches Other Than Swimming Beaches
6110	Bay Swamps	7200	Sand Other Than Beaches
6120	Mangrove Swamps	7300	Exposed Rock
6130	Gum Swamps	7310	Exposed Rock with Marsh Grasses
6140	Titi Swamps	7400	Disturbed Lands
6150	Stream and Lake Swamps (Bottomland)	7410	Rural Land in Transition
6160	Inland Ponds and Sloughs	7420	Borrow Areas
6170	Mixed Wetland Hardwoods	7430	Spoil Areas
6171	Mixed Wetland Hardwoods - Willows	7440	Fill Areas (Highways - Railways)
6172	Mixed Wetland Hardwoods - Mixed Shrubs	7450	Burned Areas
6200	Wetland Coniferous Forests	8000	Transportation Communications And Utilities
6210	Cypress	8100	Transportation
6218	Cypress - Melaleuca Infested	8110	Airports

Table 15. Land Use / Land Cover Descriptions (Continued).

FLUCCS Code	FLUCCS Code Description	FLUCCS Code	FLUCCS Code Description
8110	Airports	8210	Transmission Towers
8120	Railroads	8220	Communication Facilities
8130	Bus and Truck Terminals	8290	Communication Facilities Under Construction
8140	Roads and Highways	8300	Utilities
8150	Port Facilities	8310	Electrical Power Facilities
8160	Canals and Locks	8320	Electrical Power Transmission Lines
8170	Oil Water or Gas Long Distance Transmission Lines	8330	Water Supply Plants
8180	Auto Parking Facilities	8340	Sewage Treatment
8190	Transportation Facilities Under Construction	8350	Solid Waste Disposal
8200	Communications	8390	Utilities Under Construction

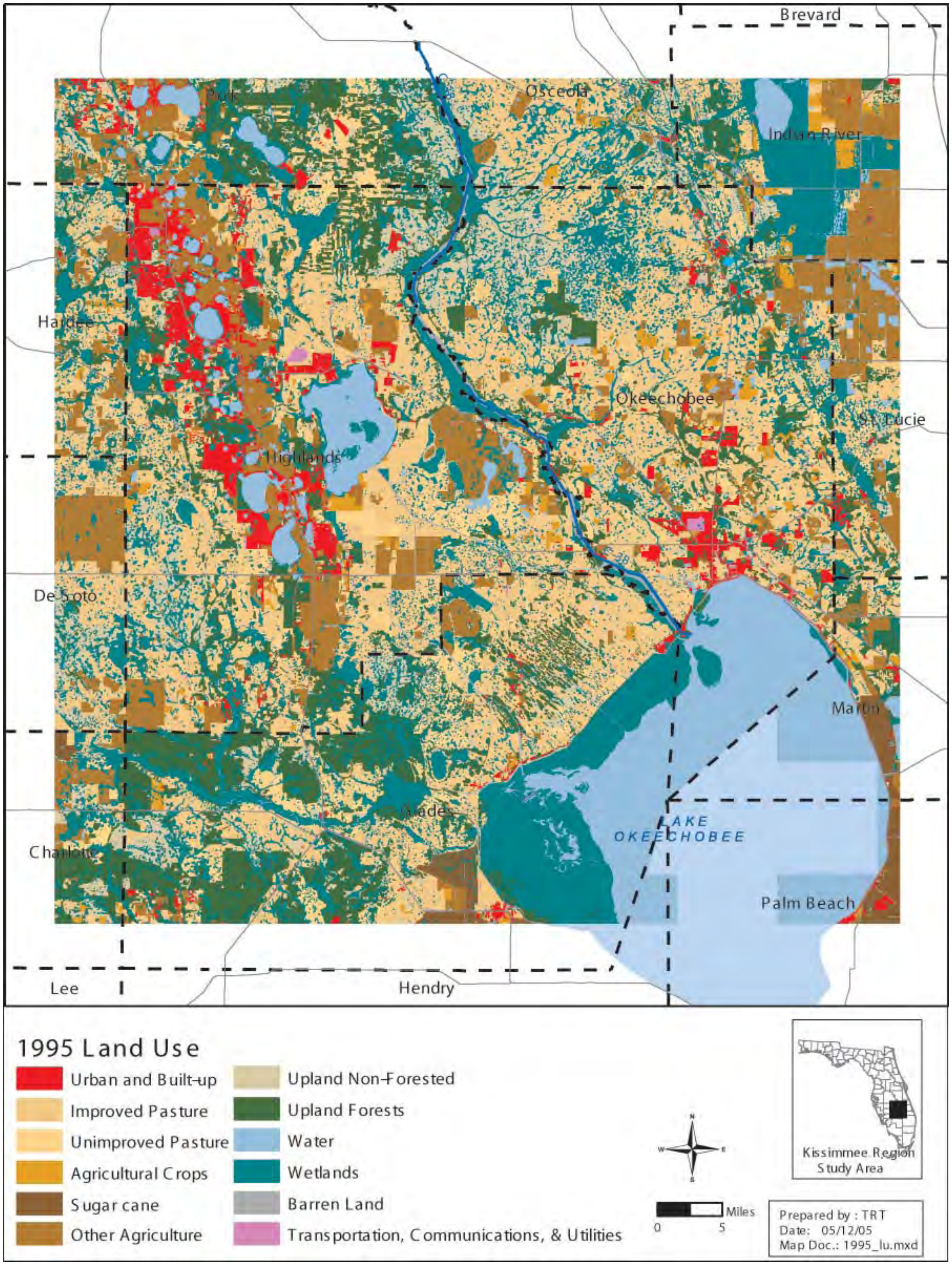

Figure 67. Land Use 1995.

Recharge for Irrigated Areas

The AFSIRS program has the ability to estimate irrigation demands for different land uses/crop types. The program requires input on the crop types, including information on monthly crop coefficients, root depths and allowable soil water depletion. The crop coefficient is a ratio of the evapotranspiration for a specific crop and the reference evapotranspiration. The program uses information on the efficiency of the irrigation systems to determine how much supplemental irrigation is required by the system. When an irrigation system is inefficient, the excess water is returned to the groundwater system as recharge (Giddings and Restrepo 1995). For the calibration run of the Lower Kissimmee Groundwater Model, the irrigation demands from AFSIRS were not used to estimate water use for irrigation, but instead used for recharge calculations. The permit database was used to calculate agricultural demands as further explained the Applied Stresses section, which follows. For the model simulation runs the consumptive water use for irrigation was recalculated using AFSIRS based on land use instead of on permit database values.

Applied Stresses

The groundwater system reacts to the stresses imposed on it. While recharge and irrigation add water to the Surficial Aquifer System, wells and pumps take water out of the system. The primary stress on deeper aquifers is from consumptive use. The consumptive use is divided into the categories of for public water supply, domestic self-supply and agricultural self-supply. For modeling purposes it was assumed that the domestic self-supply was an insignificant amount of the total water demand. The current model is a groundwater model so the demands to the surface water were subtracted from the total consumptive use demands, leaving only the demands from the groundwater system.

Public Water Supply

All of the water management districts assign a use type to their permits. Within the SFWMD boundaries in the model area, there are 67 permittees with 118 groundwater wells designated as public water supply wells (**Figure 68**). The public supply wells located in the SWFWMD serve the lake communities on Lake Wales Ridge.

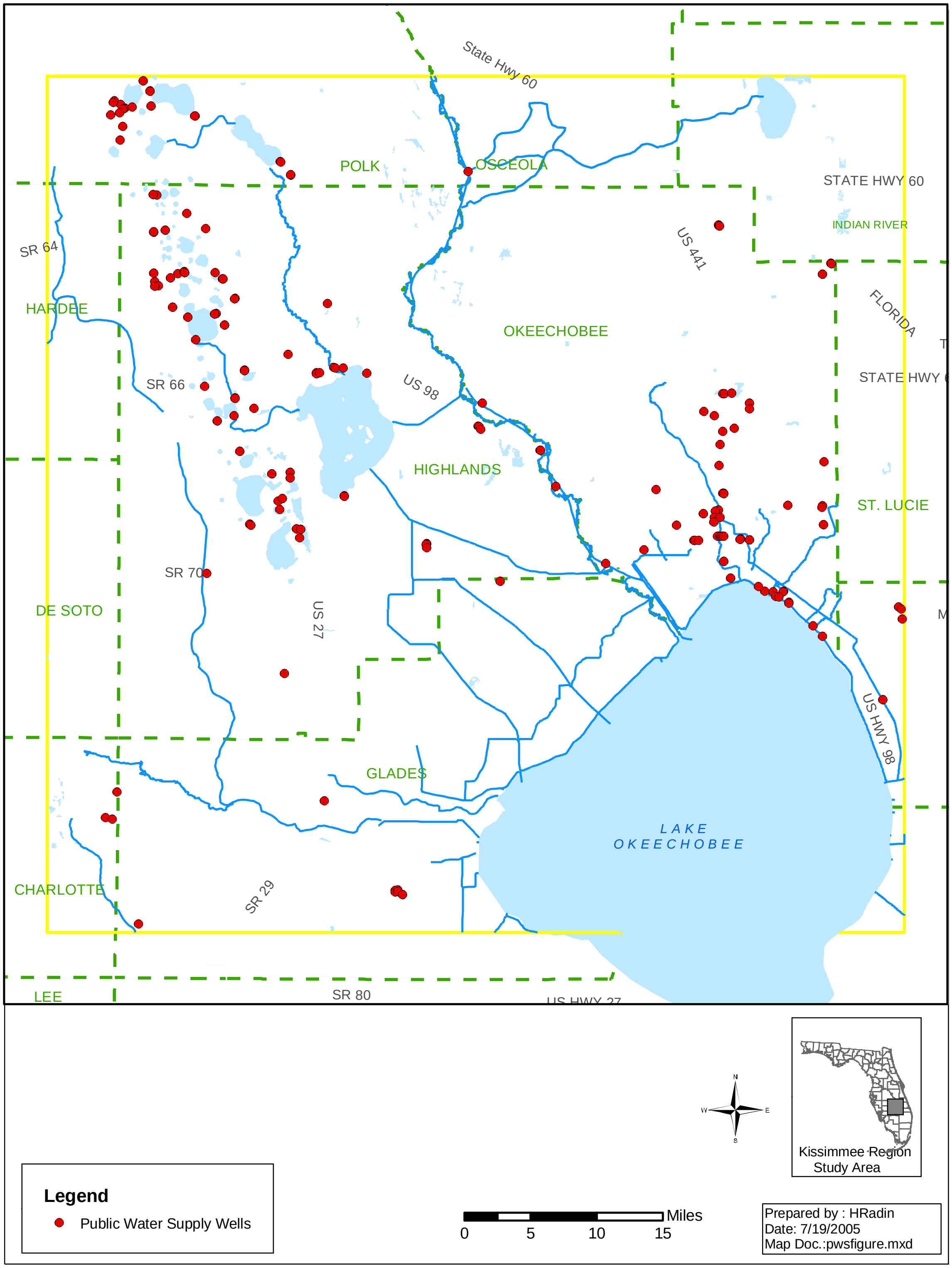

Figure 68. Public Water Supply Wells.

Agricultural Demands

Most of the wells in the model are used for irrigation purposes. Included in non-public water use are agriculture, industry, golf course, nursery and recreation areas. Most of the non-public water supply wells are not metered, so permitted pumpage was used. Many permittees obtain a permit for pasture, but in most cases the pasture areas are not irrigated. Therefore allocation to pastures was removed and those permits with multiple crops had their allocations distributed among their other facilities. The agricultural wells are displayed in **Figure 69** and more information on the agricultural wells used is available in **Appendix C**.

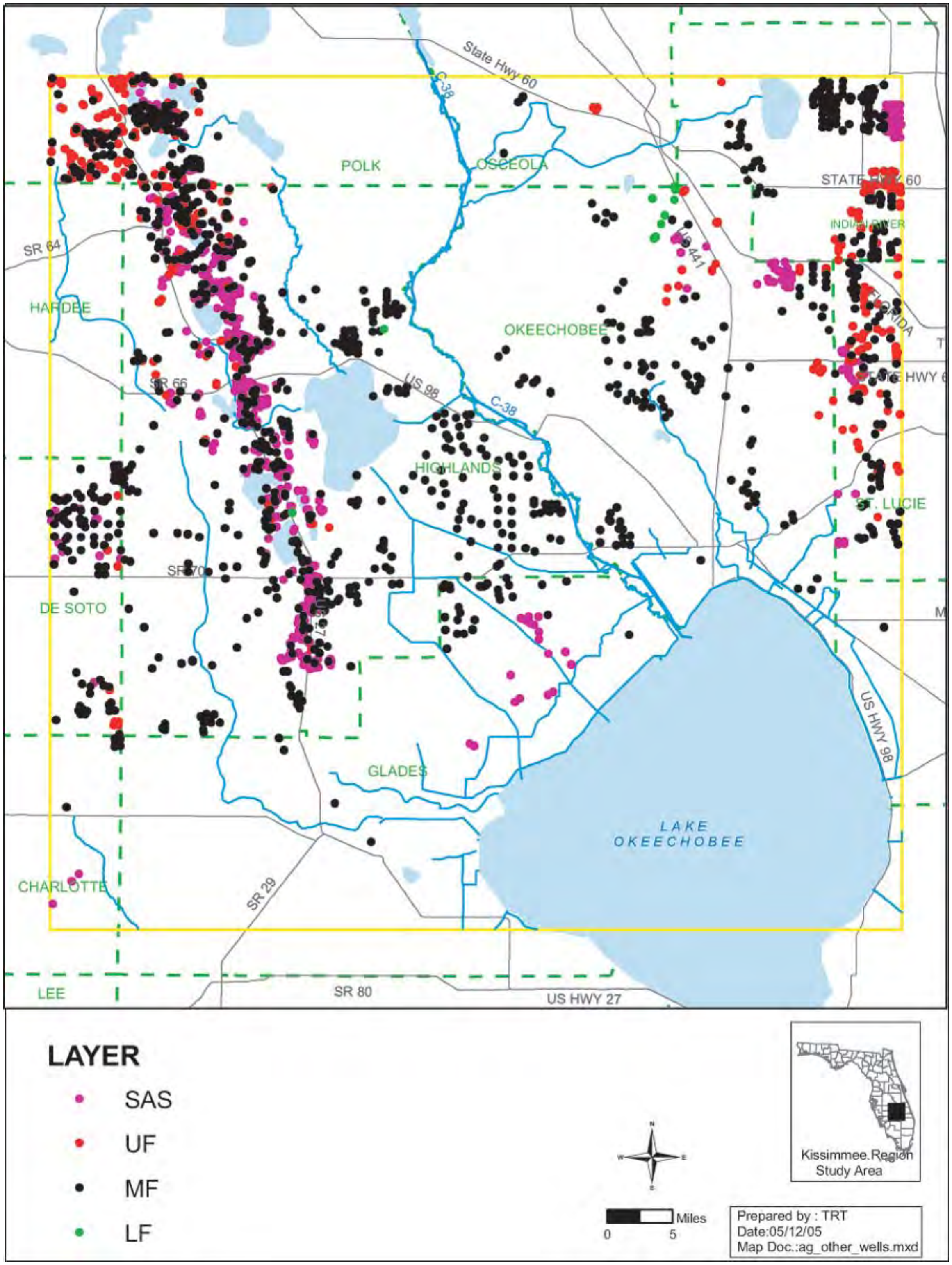

Figure 69. Agricultural and Other Irrigated Wells.

Groundwater Withdrawal

The model area includes areas in three water management districts – South Florida Water Management District, St. Johns River Water Management District and Southwest Florida Water Management District. Consumptive use data were gathered from all three districts. Consumptive use includes both public water supply and agricultural supply. Surface water consumption was not included in the model. Each district maintains their data differently. The databases were queried in 2003, so data provided represents the stress at that time. Based on the land use files from 1995 and 2000, it does not appear there was a significant change in the water use from 1995.

South Florida Water Management District

The South Florida Water Management District (SFWMD) issues consumptive use permits, which include both surface water and groundwater sources. The permits do not specify the distribution of the consumptive use between the surface and groundwater sources. The permits specify the maximum amount of water the permittee may use. Some of the permits assign the allocation by maximum per month, but most assign the use by year.

The average daily consumption was calculated and converted to the units of feet per day. The permits provide a list of the facilities (pumps and wells), the well depths and pump and well capacities. Most of the facilities are not metered. For the calibration of the Lower Kissimmee Basin Groundwater Model the permit database was used to estimate the water use. It was assumed that the permittees do not use their maximum allocation.

The water supply planning process needs to consider that the permittees may use their entire allocation, however, and impacts to aquifers should be carefully evaluated in that event. A limited amount of permits stipulate the allocation for both groundwater sources and the allocation for surface water sources, sometimes based on crop type. When the permits did not divide the allocation between groundwater and surface water sources, the allocation was divided based on the capacity of the facilities. Each facility in a permit was assigned a percentage of the allocation based on the percentage of the facility capacity/ total capacity of all the facilities in the permit. Once the allocations were assigned to all the facilities, the surface water sources were removed from the "well file", leaving only wells. The locations for most of the facilities were known, and were assigned to a cell within the permit boundary if unknown. If permit boundaries were not delineated, the withdrawal location was determined from the address or township/section/range in combination with land use. In order to distribute the groundwater allocation to the model layers, the depth of the facility was used and compared with the hydrostratigraphy layers. Some facilities list a source aquifer in the permit database. This was compared to resulting well depth to see if the depth of hydrostratigraphy matched the permit database assignment. If casing information was available and the well was open to more than one layer, the allocation was divided evenly between the layers. Wells coded as standby wells were removed from the dataset.

Special Case – Fort Basinger: The application of the previous estimated method to calculate groundwater withdrawals for Fort Basinger (Permit 28-00146W) resulted in simulated head values, which were much lower than observed water levels. Fort Basinger is one of the permittees submitting a report of water used. The consumption report for 1995 was only 1/5 of the permitted water use. The consumption report also includes how much water was used from each facility. Some of the wells were not being used at all. Therefore the actual water use for 1995 was used instead of the estimated use for this permit. The differences between simulated and observed water levels were now within calibration range.

Special Case – Brighton (Seminole Reserve): The Seminole Nation submitted a work plan with water use estimates for each of their reservations to the SFWMD. Only the Brighton reservation is within the model area. Murray Consultants, 1999 provided a table of information on the Tribe Facilities and an estimate of the Tribes water needs from each source. The groundwater use was divided among the wells based on the capacity of each facility. All the wells were in the Surficial Aquifer System.

Southwest Florida Water Management District

Southwest Florida Water Management District (SWFWMD) assigns the source allocation (groundwater/surface water) for each facility it permits. The groundwater wells were selected. Some of the wells were open to more than one aquifer. In those cases, the allocation was divided evenly between the layers. The well depths were compared with the model hydrostratigraphy to assign model layers. Wells with no assigned allocation were removed from the database.

If only total depth was provided, and no specific aquifer was designated, and the total depth indicated it was in the Floridan Aquifer System, the allocation was divided among the sub-aquifers above that total depth (usually Upper and Middle Floridan)

St. Johns River Water Management District

St. Johns River Water Management District (SJRWMD) collects the data in two spreadsheets. One includes permit information and maximum allocation to groundwater or surface water, and the other contains facility information. Often there are multiple wells or pumps for each permit. The groundwater uses were divided between the facilities based on capacity. If capacity information was not available, the allocation was divided evenly. When the depths of the wells and or casing information were available, the wells were compared with the model hydrostratigraphy to assign a model layer. If depths and or casing information were not available and the SJRWMD had assigned an aquifer, the assignment was used. Otherwise the well allocation was divided between the Upper Floridan Aquifer and Middle Floridan Aquifer.

CHAPTER 5
Model Calibration

STEADY-STATE MODEL CALIBRATION

Calibration Criteria and Targets

Calibration Targets included the following:

- Surficial Aquifer System <= ±4ft between model input data (or avg. observed values for 1995) and simulated heads.
- Upper and Middle Floridan <= ±2.5ft between model input data (or avg. observed values for 1995) and simulated heads.
- Water Levels in Surficial Aquifer are not above land surface (except water bodies).
- Simulated Contours and heads in Upper and Middle Floridan are similar to shape and gradient of those from the average 1995 Upper Floridan Potentiometric Surface Map.

The calibration criteria for the Surficial Aquifer System are not as rigorous as for the other aquifers. It is difficult for MODFLOW to react to rapid elevation changes, which occur between adjacent cells, and most of the observation sites are located along surface water features and not in the ridge areas. The calibration targets were set using the same criteria as used in the SJRWMD East Central Floridan Model expansion and revision (McGurk and Presley 2002). The starting heads for the Surficial Aquifer System were estimated base on the topography and observation stations, but in areas with high topography the water level may be deeper than in the plains.

Calibration Process

In order to test the calibration targets, than the following methods were used:

1. A program compared the water level at observation sites to those simulated by the model.
2. In ArcGIS, the surface (GRID) of the starting heads in each layer was compared to water level surfaces (GRID) generated from the model output.
3. Contours were created for the previously mentioned surfaces and plotted on the same map as the target contour.

The Vcont values for the Intermediate Confining Unit were adjusted in an iterative fashion until the differences in between simulated and observed heads were minimized. The Vcont values were highest in sinkhole areas. For more details, see the Vertical Conductance section earlier in this document.

Calibration Locations

Observation site data were collected from the SFWMD DBHYDRO environmental database and the USGS National Water Information System database. Wells in the area without depth or casing information could not be used. Most of the wells only had seasonal observations. The observation wells for the calibration run were limited to those sites having observations in 1995. The depth of the well assigned to the hydrostratigraphy layers. Some of the wells had a listed a source aquifer in the database. This was compared to model layer to see if the depth of hydrostratigraphy matched the database assignment. If casing information was available and the well was open cased in more than one layer, the observation well was assigned to the lower of those layers. If the bottom of the well was in a confining unit the observation well was assigned to the aquifer above the confining unit. Since there were only 16 groundwater wells in Layer 1, surface water features were used to assist in the calibration of the Surficial Aquifer System. Headwater values from structures in the model area were used as observation points, supplemented with a few lake water level from DBHYDRO and from lake gauges in the SFWMD. A total of 62 observation sites were used in the Surficial Aquifer System (**Figure 70**). There are 14 observation wells in the Upper Floridan Aquifer (**Figure 71**) and 23 in the Middle Floridan Aquifer (**Figure 72**). There are no wells in the Lower Floridan Aquifer. For more information on observation sites, see **Appendix E**.

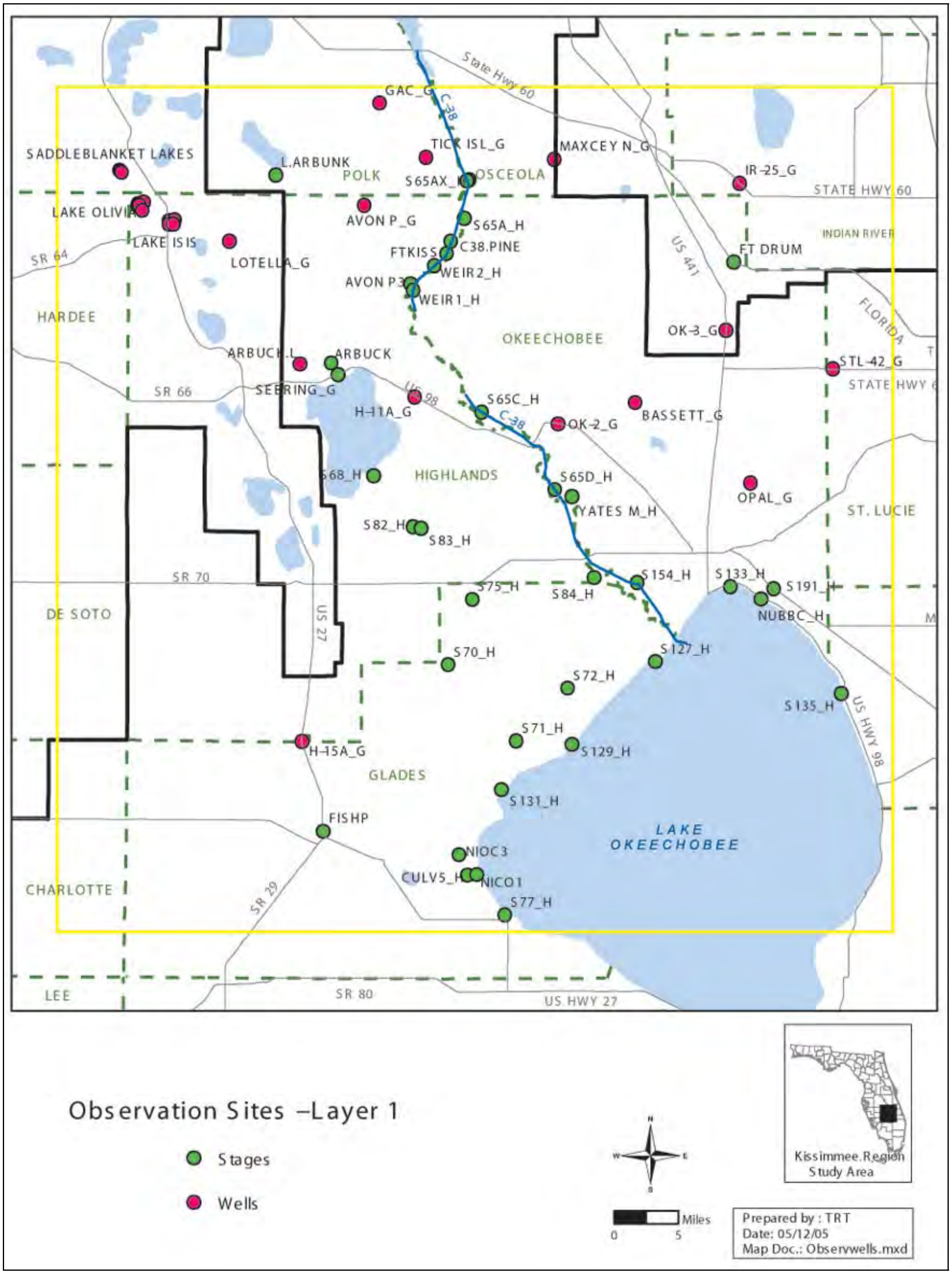

Figure 70. Observation Sites, Layer 1.

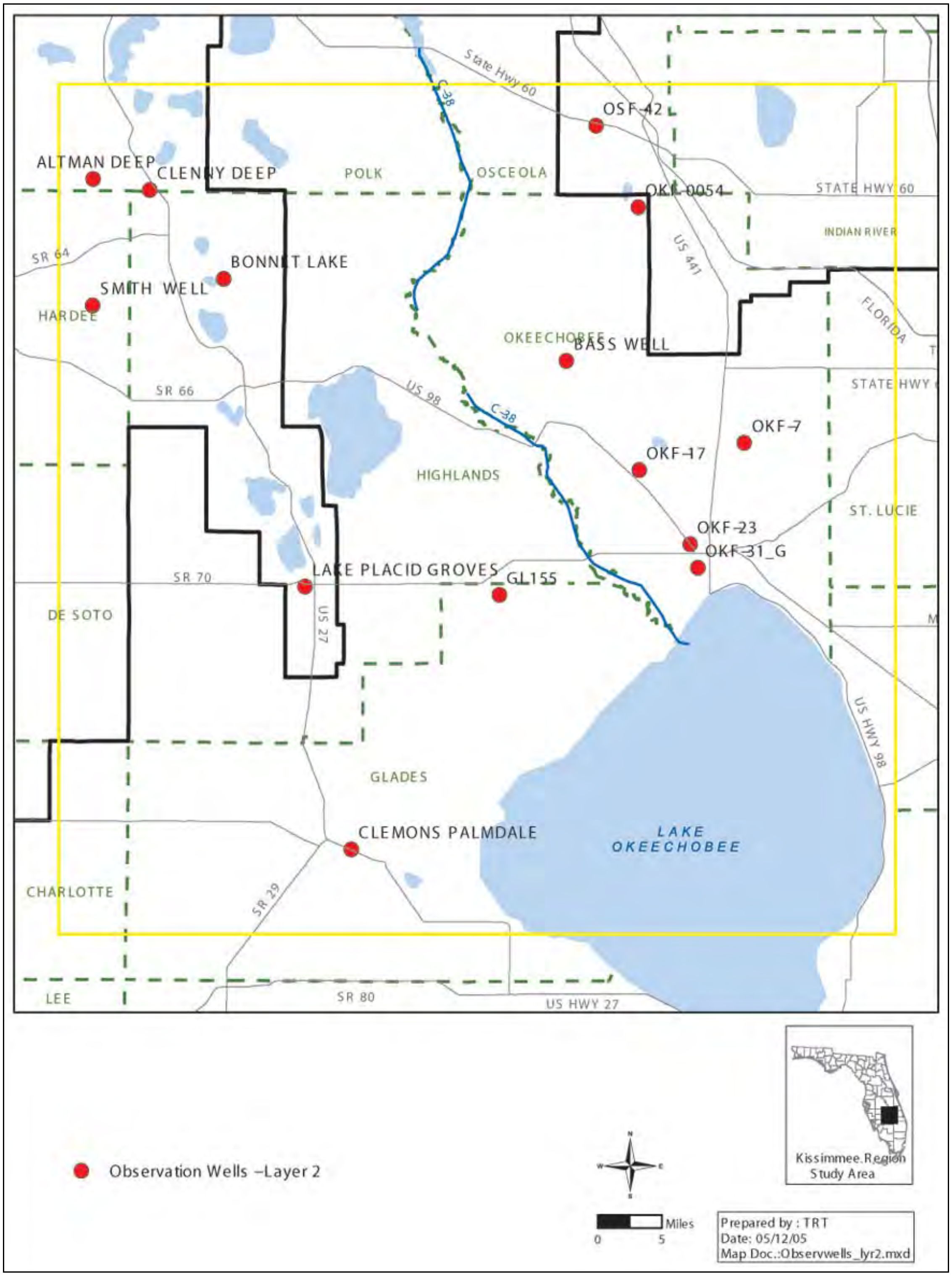

Figure 71. Observation Sites, Layer 2.

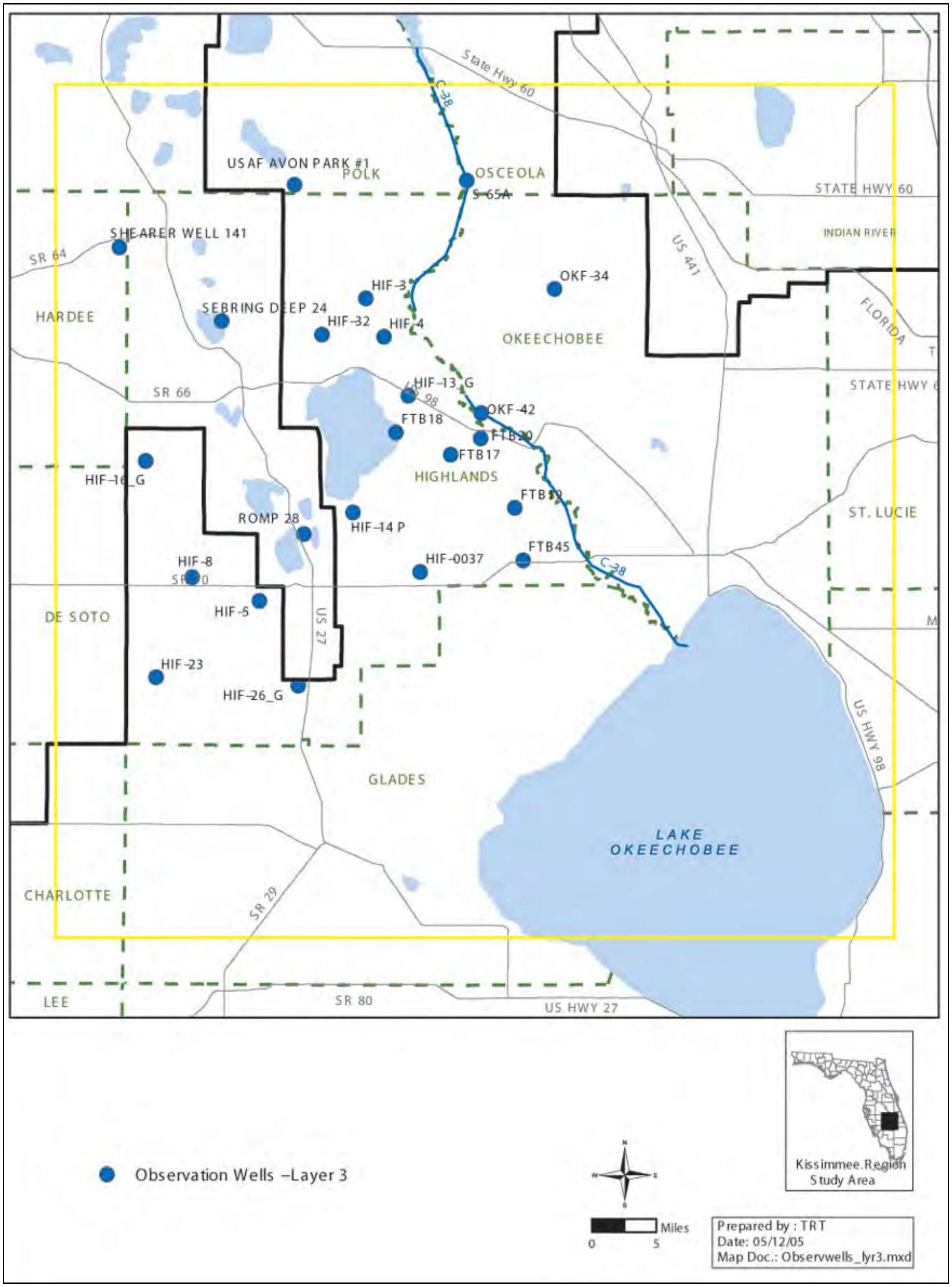

Figure 72. Observation Sites, Layer 3.

Calibration Results

The calibrated model produced simulated water levels, which are generally in agreement with observation values (**Table 16**, **Figures 73–77**). The weakest area for the model calibration in the Surficial Aquifer System was in the area near Avon Park Ridge. This area has rapid elevation changes from approximately 130 to approximately 80 feet in less than a mile. The other area that was difficult to calibrate was Lake Wales Ridge. Several of the lakes have a ring of monitoring wells around them. Saddle Blanket Lake has nine monitoring wells around it. MODFLOW will only allow one observation well per cell, so the observations of wells that fell within a cell were averaged to obtain the three observation values. The lakes were modeled as “river cells” so the water levels in the cell gravitated toward the given lake stage. In those cases where observation wells were further from the lake and the topography changed in a cell, it was not possible for all the modeled water levels to fall with the calibration criteria. A similar process was conducted to obtain the observation wells for Lake Olivia – 11 monitoring wells in five cells, and Lake Isis – nine monitoring wells in four cells (**Figure 78**, **Table 17**).

Table 16. Calibration Results Layer 1.

Station Name	Layer	Row	Col	Average 1995 Observed Water Level	Simulated Water Level	Difference in Water Levels	Met Calibration Criteria
GAC_G	1	3	51	60.79	56.28	4.51	
TICK ISL_G	1	11	58	48.85	52.34	-3.49	True
MAXCEY N_G	1	12	78	63.56	62.69	0.87	True
SADDLEBLANKET LAKES NORTH	1	13	10	118.91	111.24	7.67	
SADDLEBLANKET LAKES WEST	1	14	10	119.86	115.07	4.79	
SADDLEBLANKET LAKES EAST	1	14	11	121.34	116.51	4.83	
L.ARBUNK	1	14	34	54.44	53.00	1.44	True
S65A_H	1	15	64	46.33	41.99	4.34	
S65AX_H	1	15	65	46.40	45.52	0.88	True
IR-25_G	1	15	107	28.48	27.13	1.35	True
LAKE OLIVIA NORTH WEST	1	18	13	116.06	115.14	0.92	True
LAKE OLIVIA NORTH EAST	1	18	14	115.40	115.13	0.27	True
LAKE OLIVIA SOUTH WEST	1	19	13	117.73	115.14	2.59	True
LAKE OLIVIA SOUTH EAST	1	19	14	117.52	115.14	2.38	True
AVON P_G	1	19	48	128.78	114.14	14.64	
LAKE OLIVIA SOUTH	1	20	14	128.96	126.91	2.05	True
LAKE ISIS NORTH	1	21	18	112.66	112.66	0.00	True
LAKE ISIS EAST	1	21	19	110.99	111.22	-0.23	True

Table 16. Calibration Results Layer 1 (Continued).

Station Name	Layer	Row	Col	Average 1995 Observed Water Level	Simulated Water Level	Difference in Water Levels	Met Calibration Criteria
C38.PINE	1	21	64	43.08	44.08	-1.00	True
LAKE ISIS SOUTH	1	22	18	118.42	118.42	0.00	True
LAKE ISIS SOUTH EAST	1	22	19	114.85	114.05	0.80	True
LOTELLA_G	1	24	27	81.38	83.13	-1.75	True
FTKISS	1	24	62	42.31	41.81	0.50	True
WEIR3_H	1	26	61	42.24	42.37	-0.13	True
FT DRUM	1	27	106	35.53	34.76	0.77	True
WEIR2_H	1	28	59	41.95	41.84	0.11	True
AVON P3	1	31	55	41.71	40.90	0.81	True
WEIR1_H	1	32	56	41.39	41.39	0.00	True
OK-3_G	1	38	105	59.53	61.94	-2.41	True
SEBRING_G	1	43	38	55.86	58.65	-2.79	True
ARBUCK.L	1	43	43	40.16	41.98	-1.82	True
STL-42_G	1	44	121	25.79	25.30	0.49	True
ARBUCK	1	45	44	39.75	39.92	-0.17	True
H-11A_G	1	48	56	47.95	45.95	2.00	True
BASSETT_G	1	49	90	43.14	45.20	-2.06	True
S65C_H	1	51	67	33.81	33.49	0.32	True
OK-2_G	1	52	78	44.67	40.96	3.71	True
S68_H	1	60	50	39.12	39.12	0.00	True
OPAL_G	1	61	108	33.14	32.37	0.77	True
S65D_H	1	62	78	26.74	26.76	-0.02	True
YATES M_H	1	64	81	24.37	26.44	-2.07	True
S82_H	1	68	56	31.87	30.99	0.88	True
S83_H	1	68	57	31.97	34.31	-2.34	True
S84_H	1	76	84	24.71	23.22	1.49	True
S154_H	1	77	91	20.28	19.19	1.09	True
S133_H	1	77	105	13.57	13.57	0.00	True
NUBBC_H	1	78	112	19.36	18.98	0.38	True
S75_H	1	79	65	25.78	25.64	0.14	True
S191_H	1	79	110	19.12	19.12	0.00	True
S70_H	1	89	61	25.76	25.30	0.46	True

Table 16. Calibration Results Layer 1 (Continued).

Station Name	Layer	Row	Col	Average 1995 Observed Water Level	Simulated Water Level	Difference in Water Levels	Met Calibration Criteria
S127_H	1	89	94	13.56	13.56	0.00	True
S72_H	1	93	80	20.77	19.18	1.59	True
S135_H	1	94	122	13.60	13.60	0.00	True
H-15A_G	1	101	39	58.04	54.62	3.42	True
S71_H	1	101	72	19.92	18.28	1.64	True
S129_H	1	102	81	13.06	13.06	0.00	True
S131_H	1	109	70	13.04	13.04	0.00	True
FISHP	1	115	42	31.25	30.48	0.77	True
NIOC3	1	119	63	17.99	17.92	0.07	True
NICO1	1	122	64	13.99	12.07	1.92	True
CULV5_H	1	122	66	16.52	16.52	0.00	True
S77_H	1	128	70	16.39	16.39	0.00	True
					Average Difference	0.93	
					Count Calibrated	56	
					% Calibrated	90.32%	

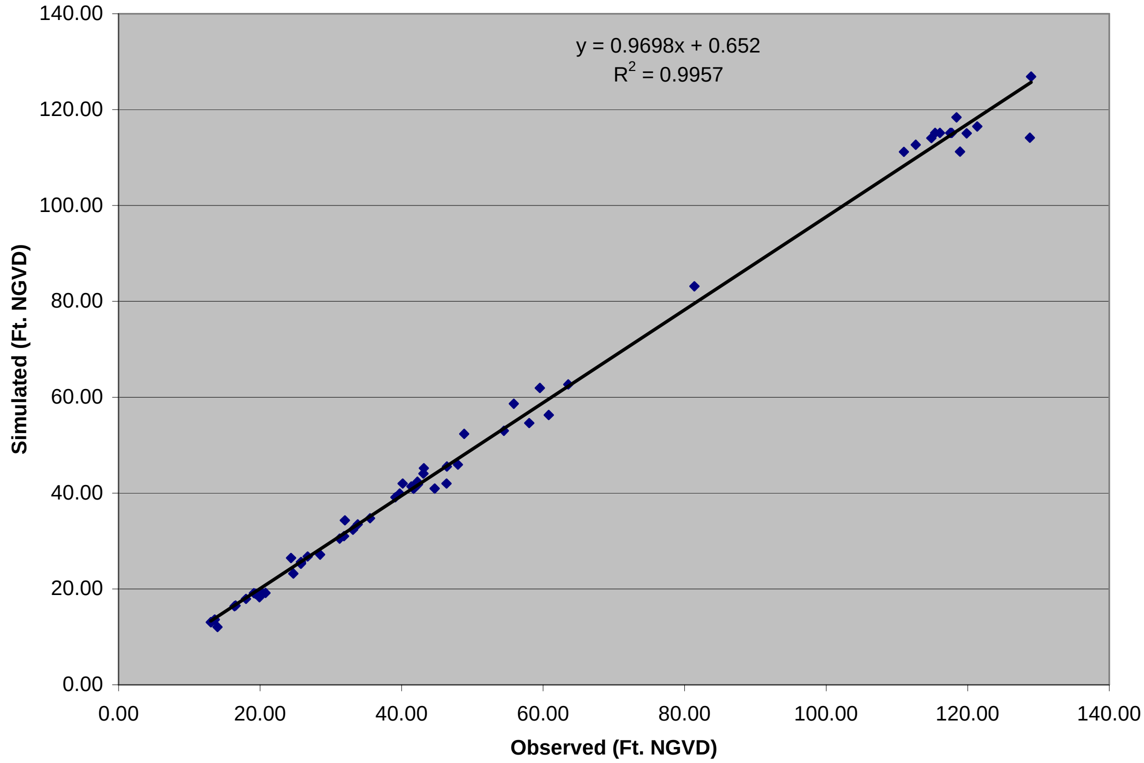

Figure 73. Observed Versus Simulated Layer 1 (Surficial Aquifer System) Water Levels, Average 1995 Conditions.

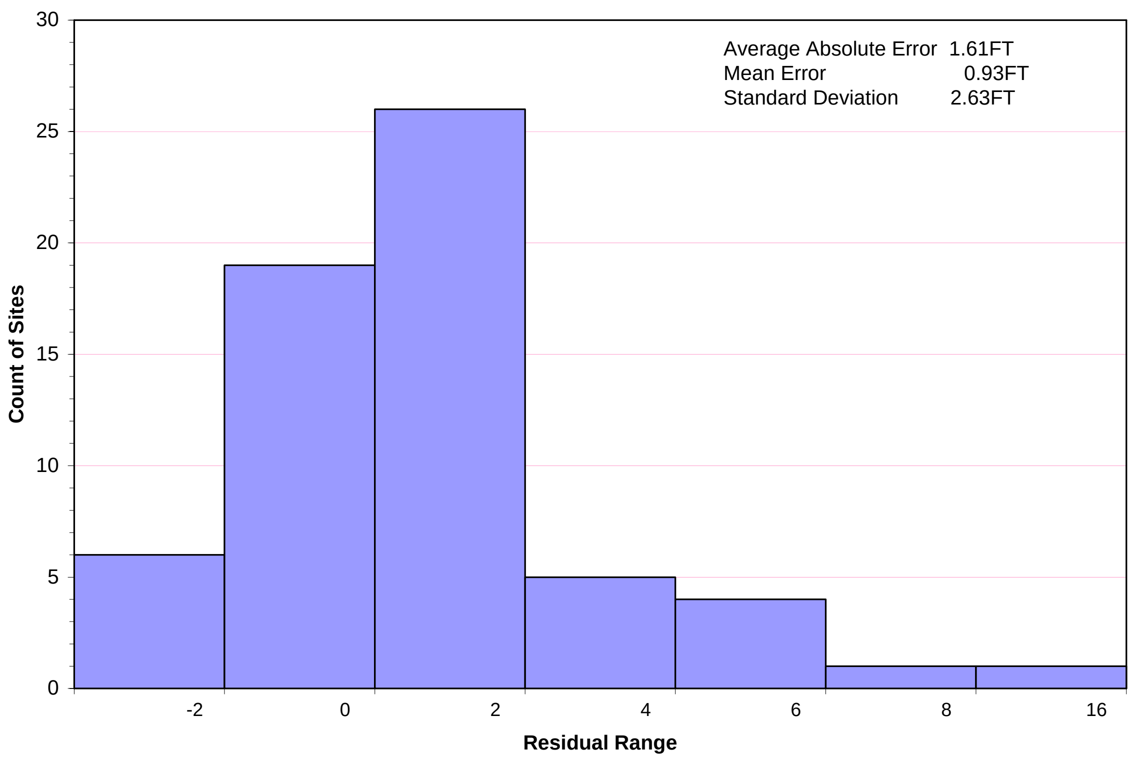

Figure 74. Layer 1 Water Level Residuals for 1995 Calibration.

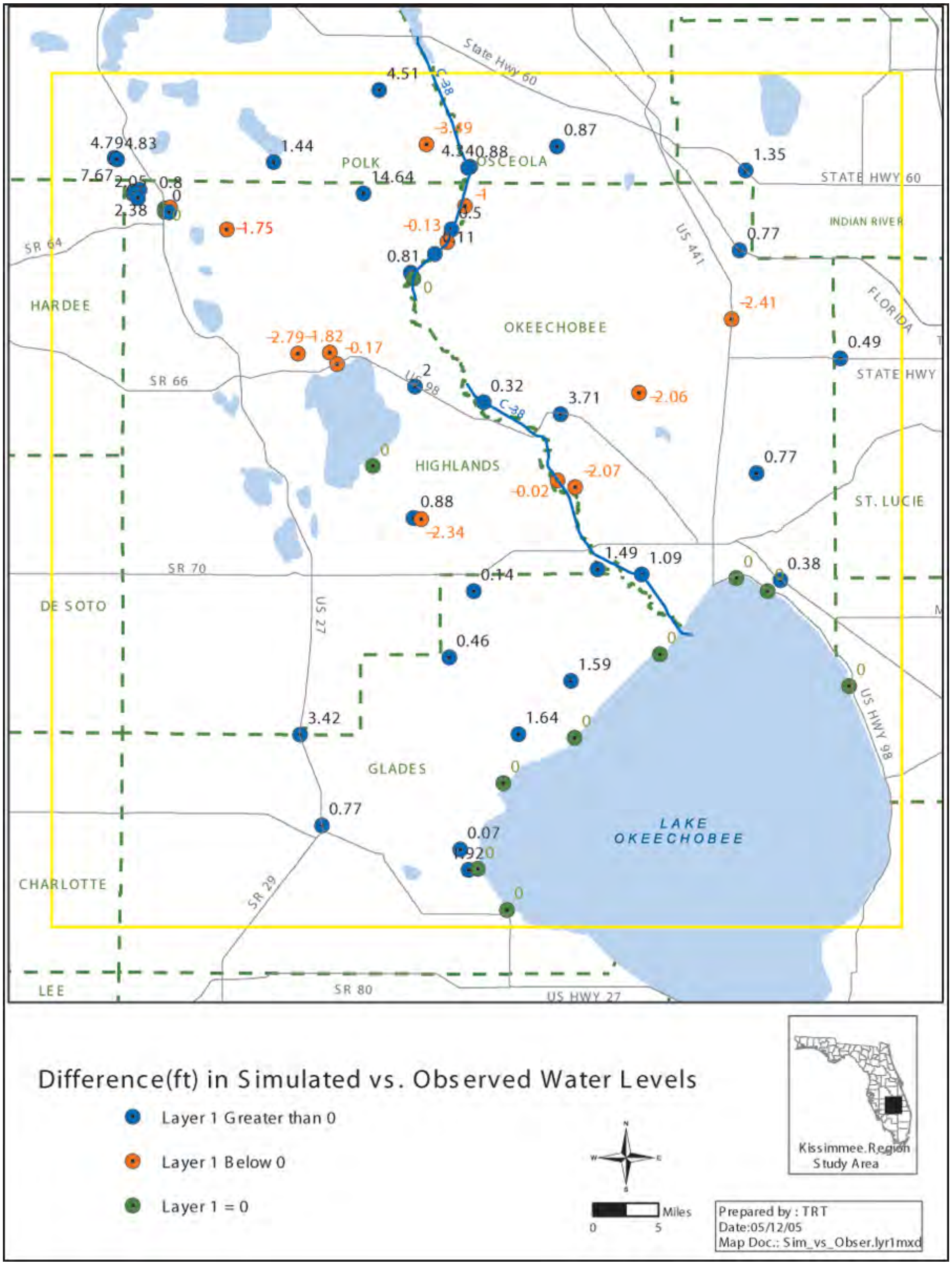

Figure 75. Layer 1 Water Level Residuals for 1995 Calibration (Map).

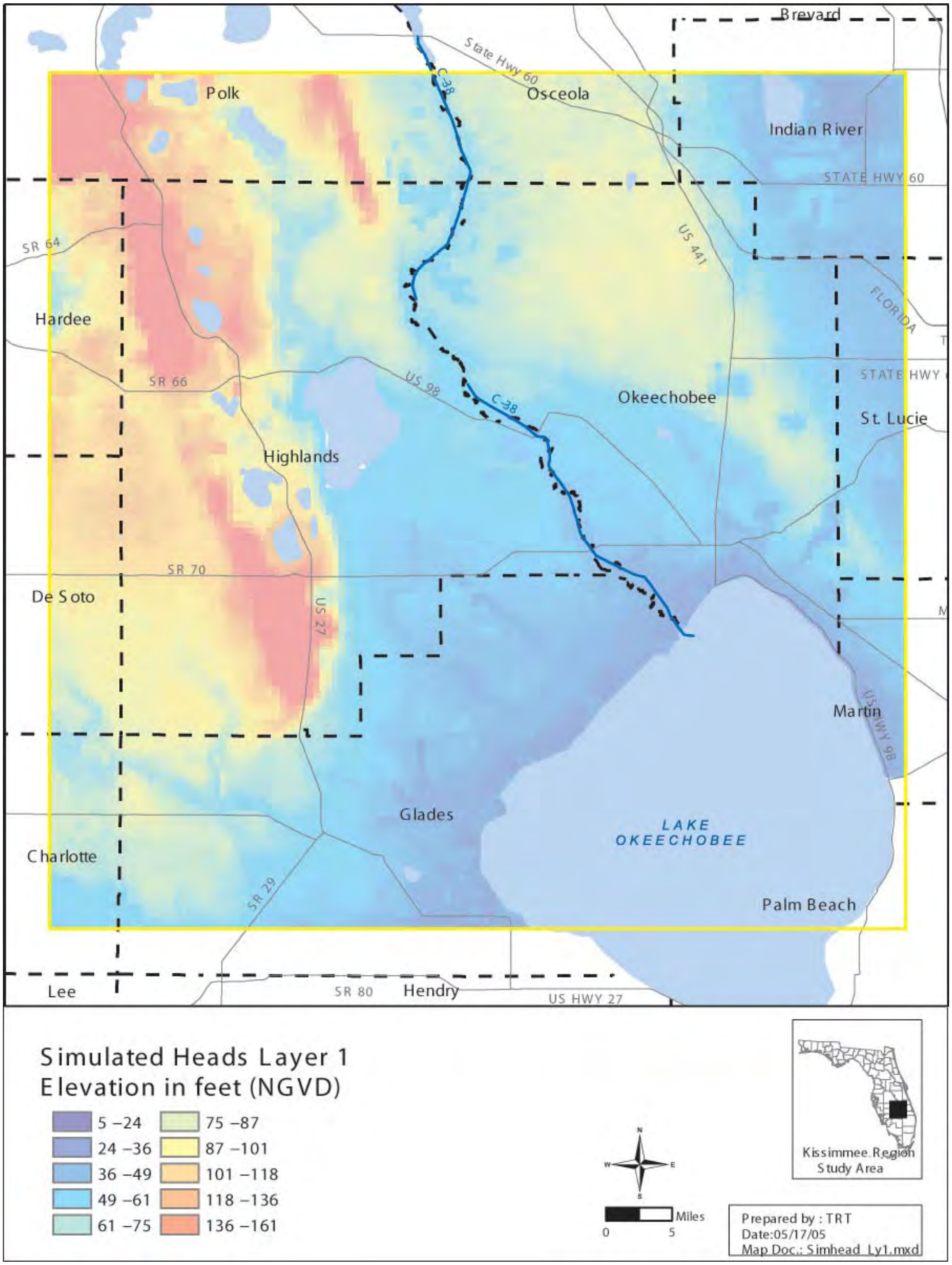

Figure 76. Simulated Heads Layer 1 (Elevation in ft NGVD).

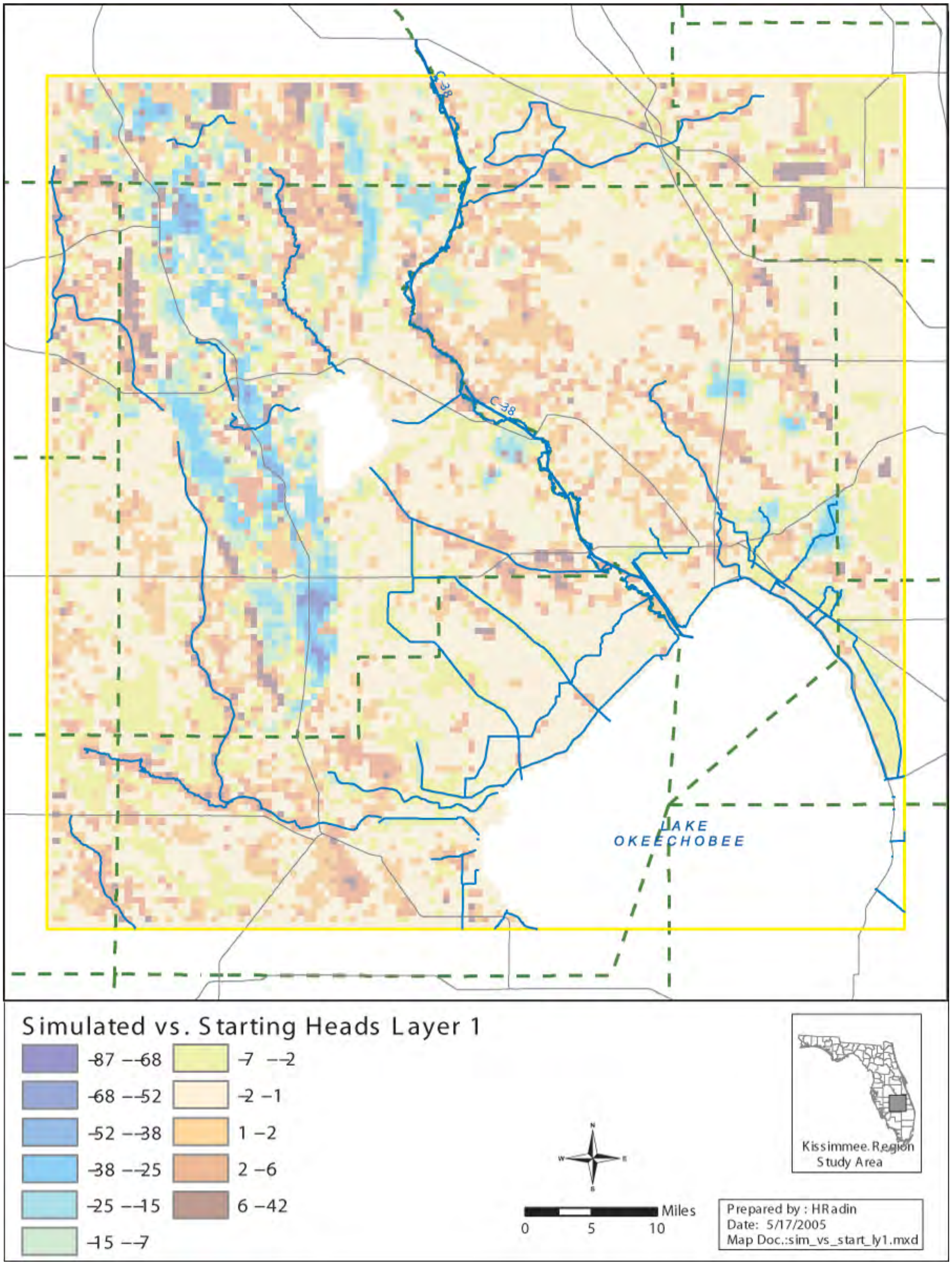

Figure 77. Difference in Simulated vs. Starting Head Water Levels (Map).

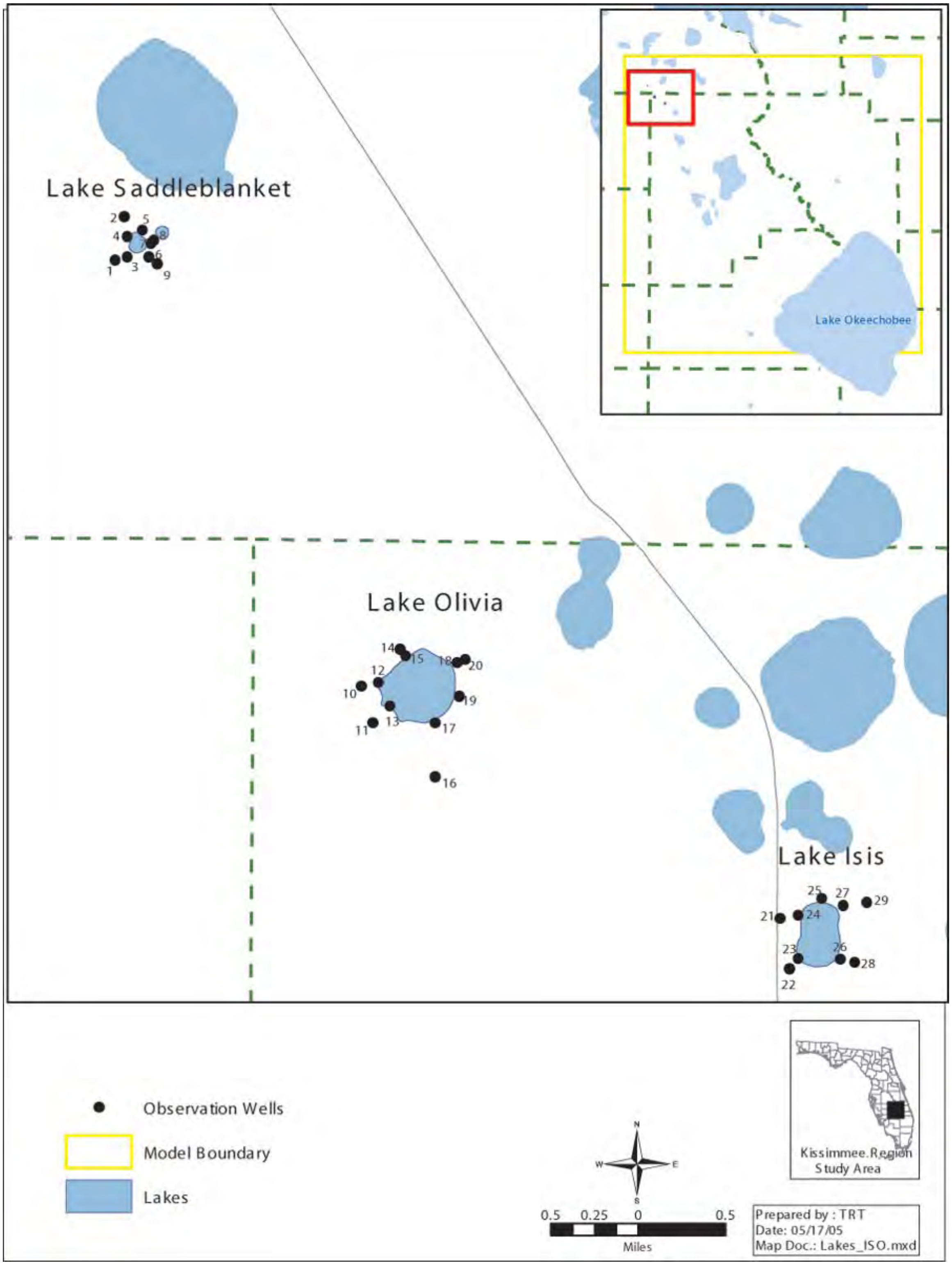

Figure 78. Inset with Lake Isis, Saddle Blanket and Lake Olivia.

Table 17. List of Observation Wells near Lake Isis, Saddle Blanket and Lake Olivia.

Number	Station	Total Depth BLS in Feet	Average Water Level
1	SADDLEBLANKET LKS SBUSW NRSD W NEAR FRO	19	120.61
2	SADDLEBLANKET LAKES SBUN NRSD W NEAR FR	19	118.83
3	SADDLEBLANKET LKS SBLSW NRSD W NEAR FRO	14	119.36
4	SADDLEBLANKET LKS SBLNW NRSD W NEAR FRO	14	118.92
5	SADDLEBLANKET LAKES SBLN NRSD W NEAR FR	10	119.27
6	SADDLEBLANKET LKS SBLSE NRSD W NEAR FRO	10	119.61
7	SADDLEBLANKET LKS SBLNE NRSD W NEAR FRO	18	119.14
8	SADDLEBLANKET LKS SBUNE NRSD W NEAR FRO	15	118.40
9	SADDLEBLANKET LKS SBUSE NRSD W NEAR FRO	27	121.34
10	LAKE OLIVIA OLUW NRSD WELL NEAR AVON PA	20	115.73
11	LAKE OLIVIA OLUSW NRSD WELL NEAR AVON P	25	118.67
12	LAKE OLIVIA OLLW NRSD WELL NEAR AVON PA	12	116.42
13	LAKE OLIVIA OLLSW NRSD WELL NEAR AVON P	15	116.79
14	LAKE OLIVIA OLUNW NRSD WELL NEAR AVON P	18	116.37
15	LAKE OLIVIA OLLNW NRSD WELL NEAR AVON P	14	115.71
16	LAKE OLIVIA OLUS NRSD WELL NEAR AVON PA	30	128.96
17	LAKE OLIVIA OLLS NRSD WELL NEAR AVON PA	15	118.18
18	LAKE OLIVIA OLLNE NRSD WELL NEAR AVON P	16	115.92
19	LAKE OLIVIA OLLE NRSD WELL NEAR AVON PA	12	116.86
20	LAKE OLIVIA OLUNE NRSD WELL NEAR AVON P	13	114.87
21	LAKE ISIS ISUNW NRSD WELL AT AVON PARK	38	115.63
22	LAKE ISIS ISUSW NRSD WELL AT AVON PARK	25	124.44
23	LAKE ISIS ISLSW NRSD WELL AT AVON PARK	10	118.28
24	LAKE ISIS ISLNW NRSD WELL AT AVON PARK	25	112.71
25	LAKE ISIS ISLN NRSD WELL AT AVON PARK F	23	110.77
26	LAKE ISIS ISLSE NRSD WELL AT AVON PARK	13	112.54
27	LAKE ISIS ISLNE NRSD WELL AT AVON PARK	19	111.54
28	LAKE ISIS ISUSE NRSD WELL AT AVON PARK	35	114.85
29	LAKE ISIS ISUNE NRSD WELL AT AVON PARK	25	110.99

It was more difficult to evaluate areas where the observation sites were scarce. The Vcont values for the Intermediate Aquifer were adjusted so “pooling” of water above land surface in the Surficial Aquifer System was minimized and concentrated in marsh and wetland areas or along waterways (**Figure 79**). When comparing the simulated water surface to the starting heads for the Surficial Aquifer System, it was assumed that if the water levels fell within the Surficial Aquifer System and the observation points calibrated the surface was a good approximation of reality. In most areas, the water levels were deeper than the starting heads, which were set at 1 foot bls (**Figure 50**). The simulated water levels were deepest below the areas with the highest elevations. The average difference between observed and simulated water levels in the Surficial Aquifer System is 0.93 feet, with 56 of the 63 observation site meeting the criteria of 4 feet or less.

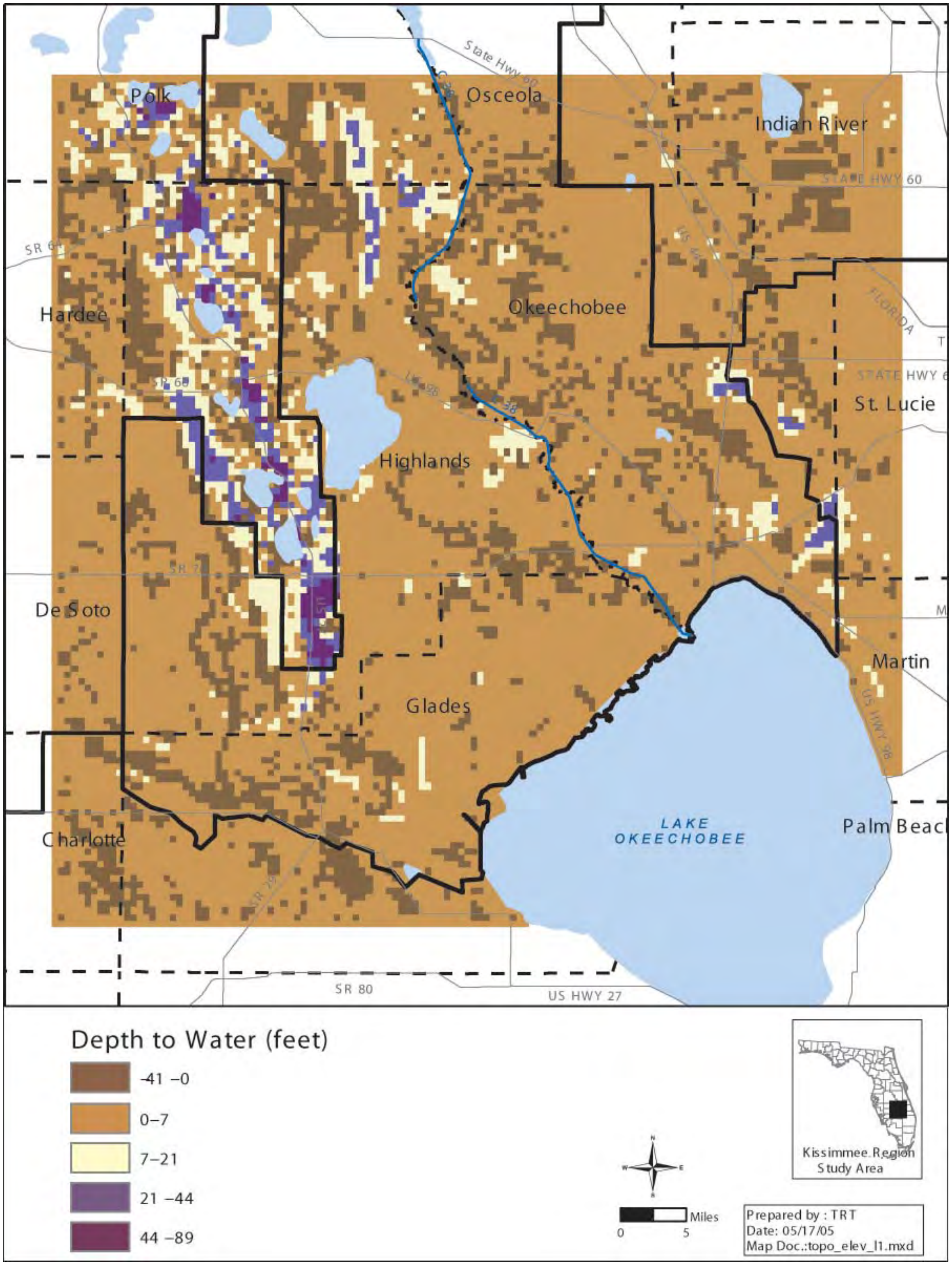

Figure 79. Depth to Water (Simulated Layer 1 Water Levels) for Average 1995 Conditions.

Water levels in the Upper Floridan Aquifer (**Figure 80**) and the Middle Floridan Aquifer (**Figure 81**) were both compared to one surface that was generated from the 1995 potentiometric maps (Knowles 1995). The potentiometric maps did not distinguish between wells in the Upper Floridan Aquifer and Middle Floridan Aquifer, but monitored them as one unit. As seen in Romp28 most of water levels in the Middle Floridan Aquifer are very similar to those in the Upper Floridan Aquifer. **Figure 82** shows the difference in the simulated water levels in Layer 2 and 3. The average head difference is 0.2 feet. Only two wells out of 14 in the Upper Floridan Aquifer did not meet the calibration criteria of within 2.5 feet (**Figure 88**), and OKF31 missed the target value by just 0.01 feet (**Table 18**). In the Middle Floridan Aquifer, only one well out of 23, HIF16 (**Figure 92**), did not fall in the calibration range. HIF16 is located southwest of the Lake Wales Ridge (**Table 19**).

The contours for the simulated heads from the Upper (**Figure 80**) and Middle (**Figure 81**) Floridan Aquifer match well with those from the average 1995 water levels in Upper Floridan Aquifer. The contours from Layer 3 (Middle Floridan Aquifer) are a better match than those from Layer 2) (Upper Floridan Aquifer). In the Upper Floridan Aquifer, the 60-foot contour deviates too far south, south of the Lake Wales Ridge. Attempts to modify the transmissivities south of the ridge did not improve the calibration, so the transmissivities were returned to the original values obtained from (Reese and Richardson 2004). It is apparent the flow along the ridge is faster than the flow off of the ridge toward the southwest.

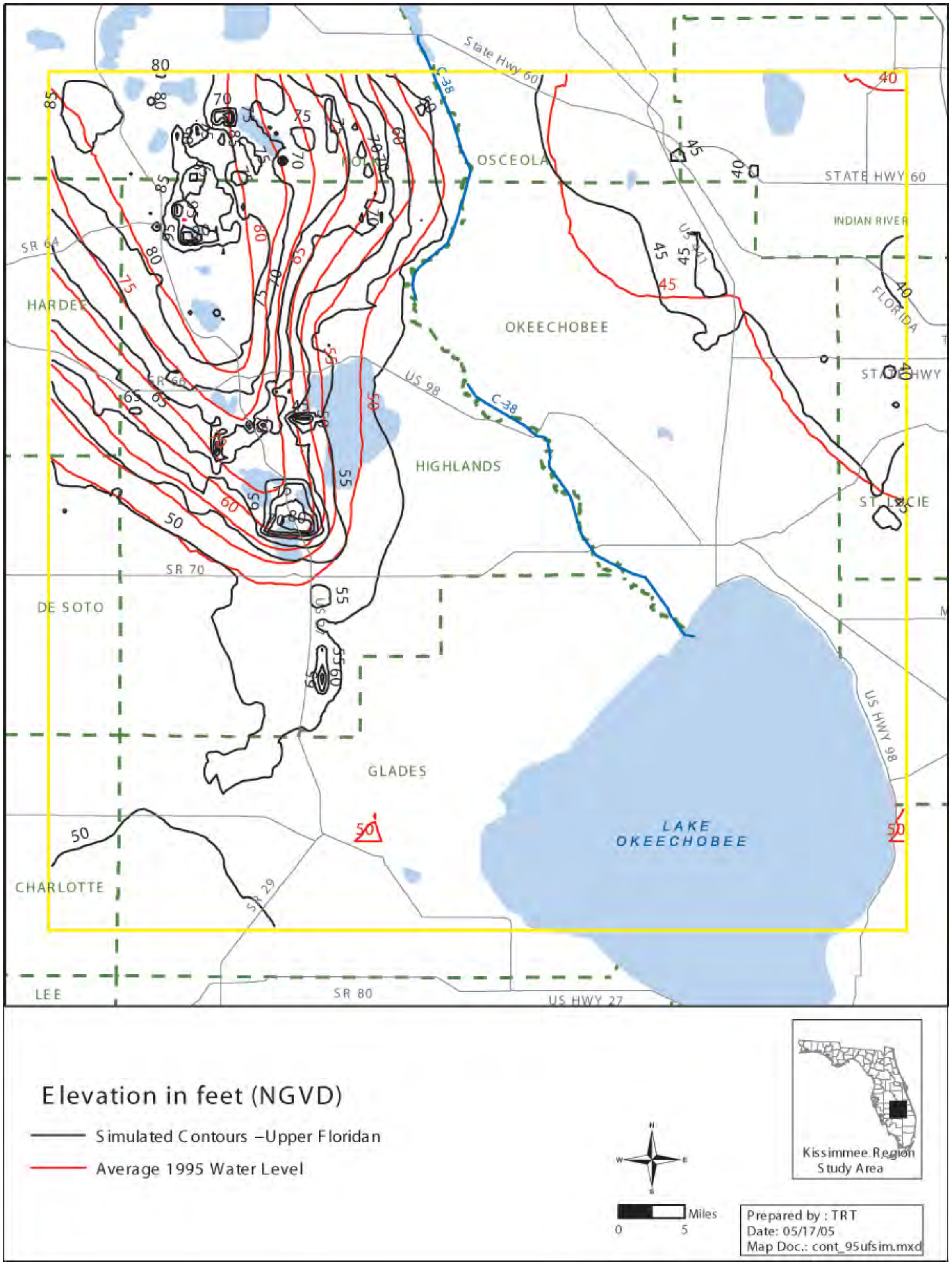

Figure 80. Contours Simulated Upper Floridan vs. Average 1995 Water Levels in Upper Floridan.

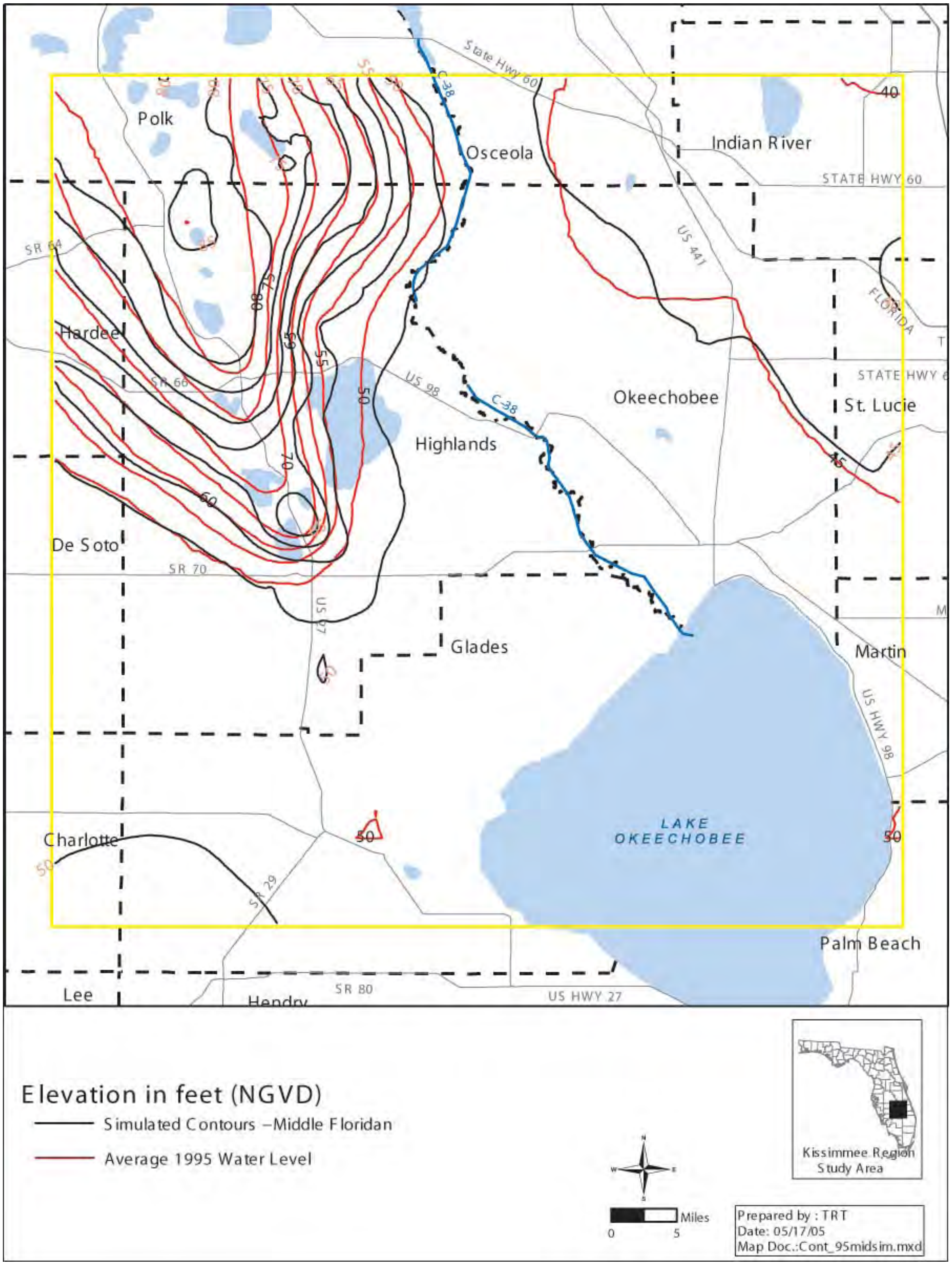

Figure 81. Contours Simulated Middle Floridan vs. Average 1995 Water Levels in Upper Floridan.

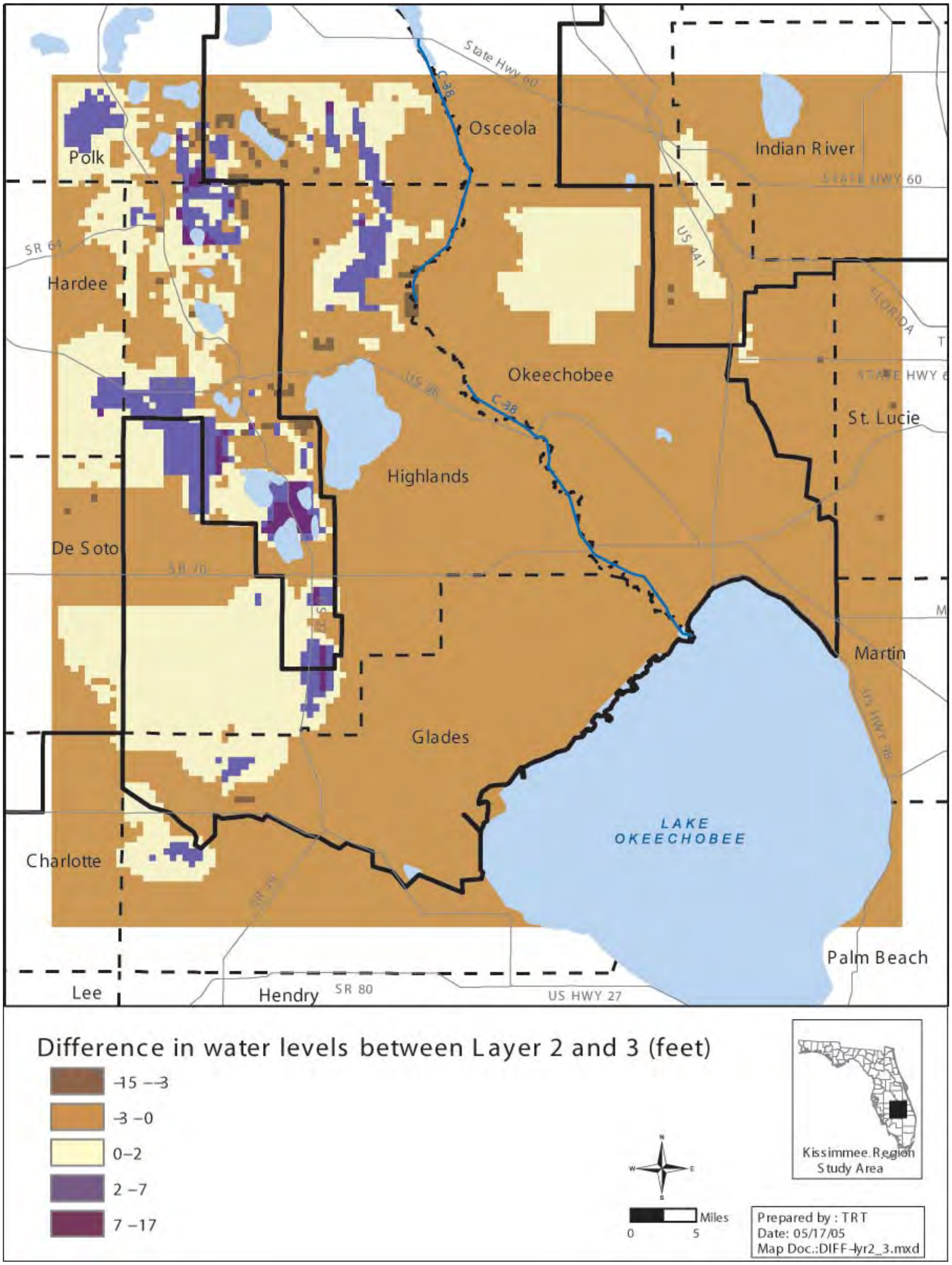

Figure 82. Difference between Water Levels in Layers 2 and 3.

Table 18. Calibration Results Layer 2.

Station Name	Layer	Row	Col	Average 1995 Observed Water Level	Simulated Water Level	Difference in Water Levels	Met Calibration Criteria
OSF-42	2	7	84	43.02	42.92	0.10	True
ALTMAN DEEP WELL NEAR WEST FROSTPROOF FL	2	15	6	84.20	83.39	0.81	True
CLENNY DEEP NW/O AVON PK FL	2	17	15	83.05	81.29	1.76	True
OKF-0054	2	19	91	39.08	43.08	-4.00	
BONNET LAKE DEEP NEAR SEBRING	2	30	26	83.21	82.38	0.83	True
SMITH DEEP WELL NO. 731136344333 NR LEMON GROVE FL	2	34	6	71.64	70.29	1.35	True
727100-- 35S33E02 BASS WELL N OF BASSINGER (okf18)	2	43	79	46.73	46.73	0.00	True
OKF-7	2	55	107	46.19	45.79	0.40	True
OKF-17 DIXIE RANCH	2	59	91	47.00	46.50	0.50	True
OKF-23	2	71	99	44.34	46.75	-2.41	True
OKF-31_G	2	74	100	49.85	47.34	2.51	
LAKE PLACID GROVES DEEP SOUTH OF LAKE PLACID FL	2	77	39	51.19	52.16	-0.97	True
71110501OBSER WELL GL155 NEAR BRIGHTON, FL.	2	79	69	48.01	47.37	0.64	True
65411601 41S30E12 CLEMONS PALMDALE	2	117	46	49.90	49.48	0.42	True
					Average Difference	1.12	
					Count Calibrated	12	
					% Calibrated	85.71%	

The simulated heads in Layers 2 and 3 were usually within ±2.5 feet of the starting heads (**Figures 85**, **89**). The starting heads were the average 1995 water levels. In areas that did not have observation points, it was difficult to calibrate.

The simulated water levels for the Upper Floridan Aquifer are very close to the observed values with a trend line of R^2=0.99 (**Figures 86** and **87**). The simulated water levels for the Middle Floridan Aquifer have a trend line of R^2=0.98. When compared to observations sites, the mean error was only 0.17 feet (**Figures 90** and **91**).

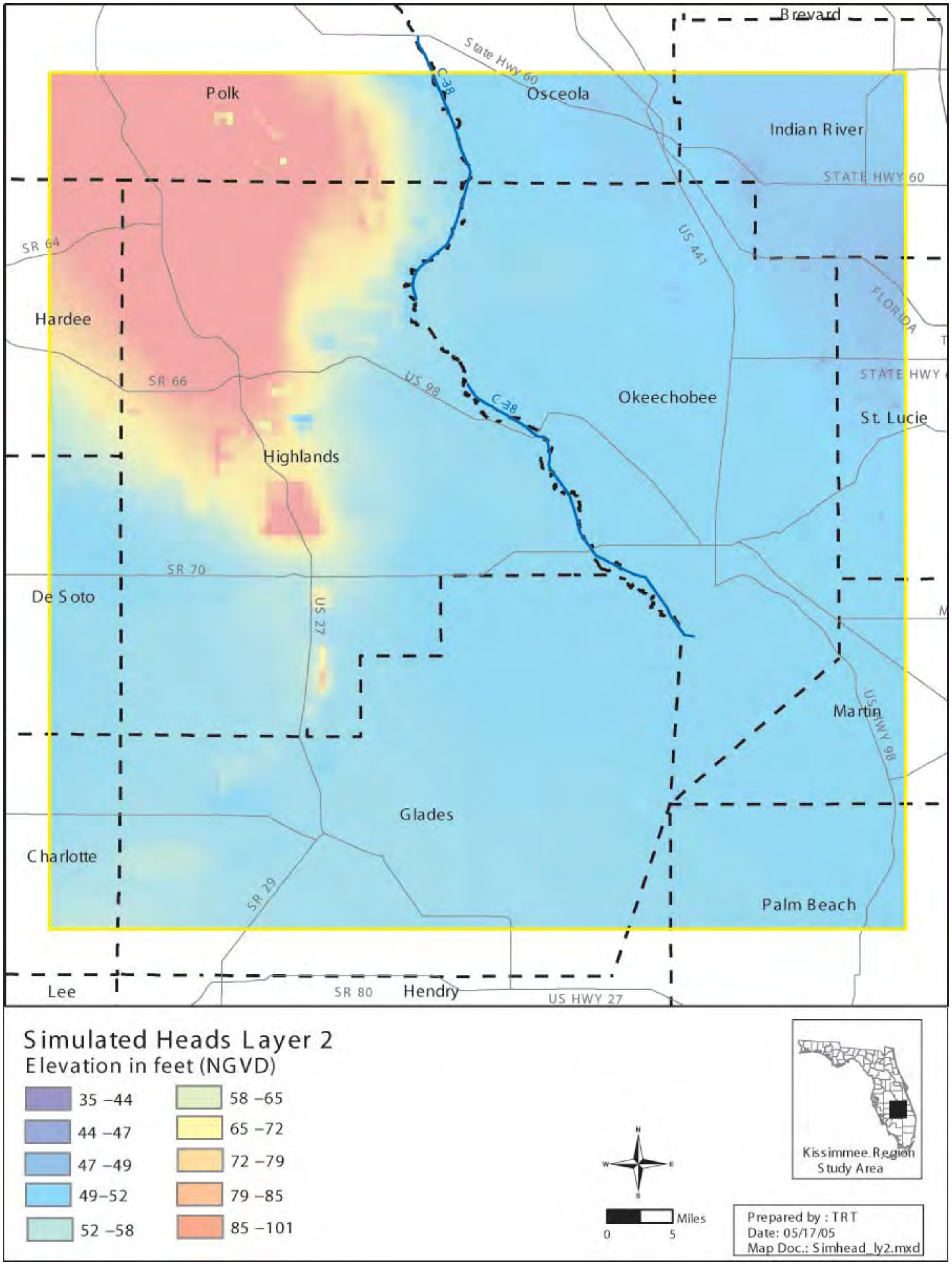

Figure 83. Simulated Heads Layer 2 - Elevations.

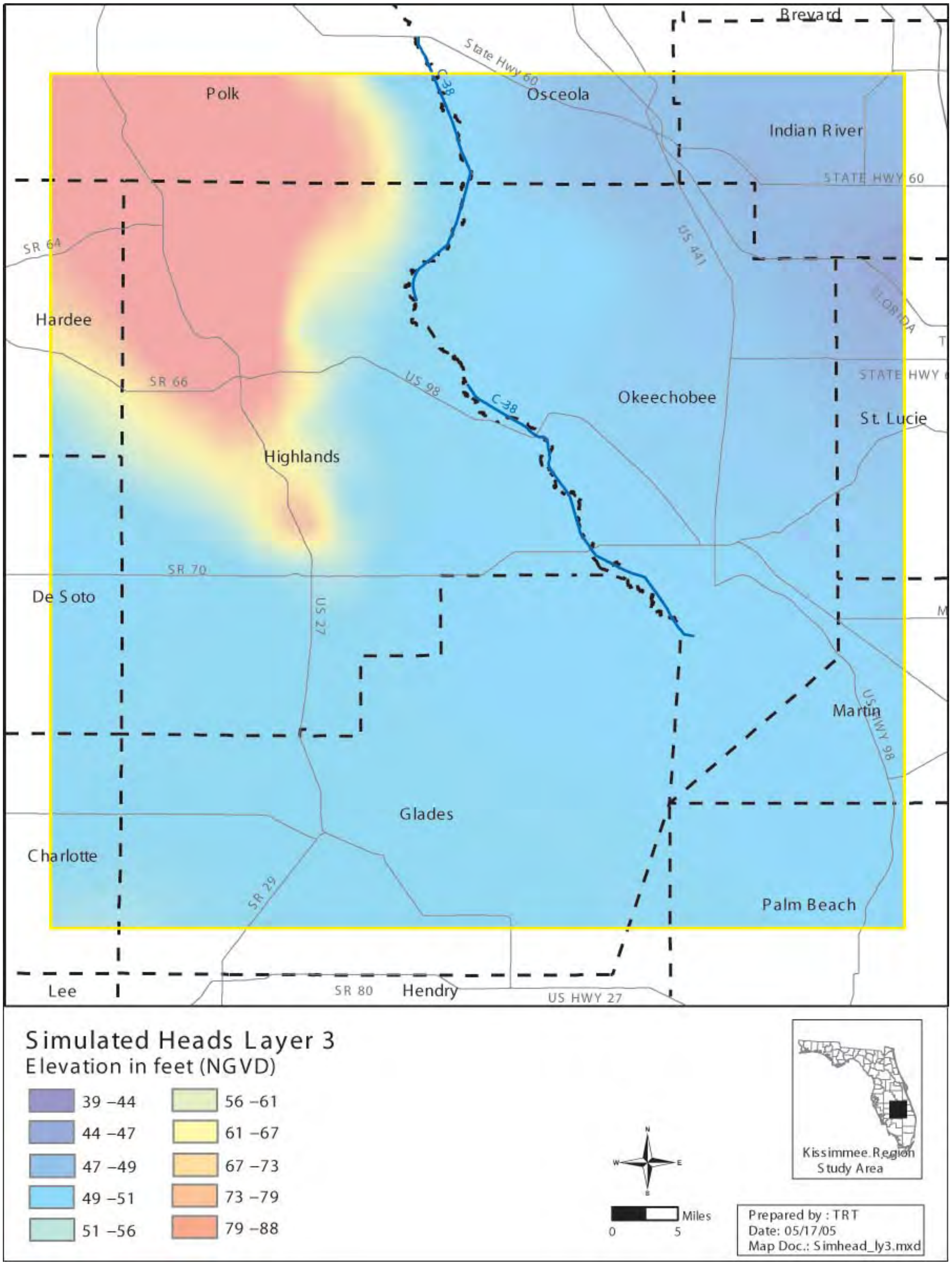

Figure 84. Simulated Heads Layer 3 - Elevations.

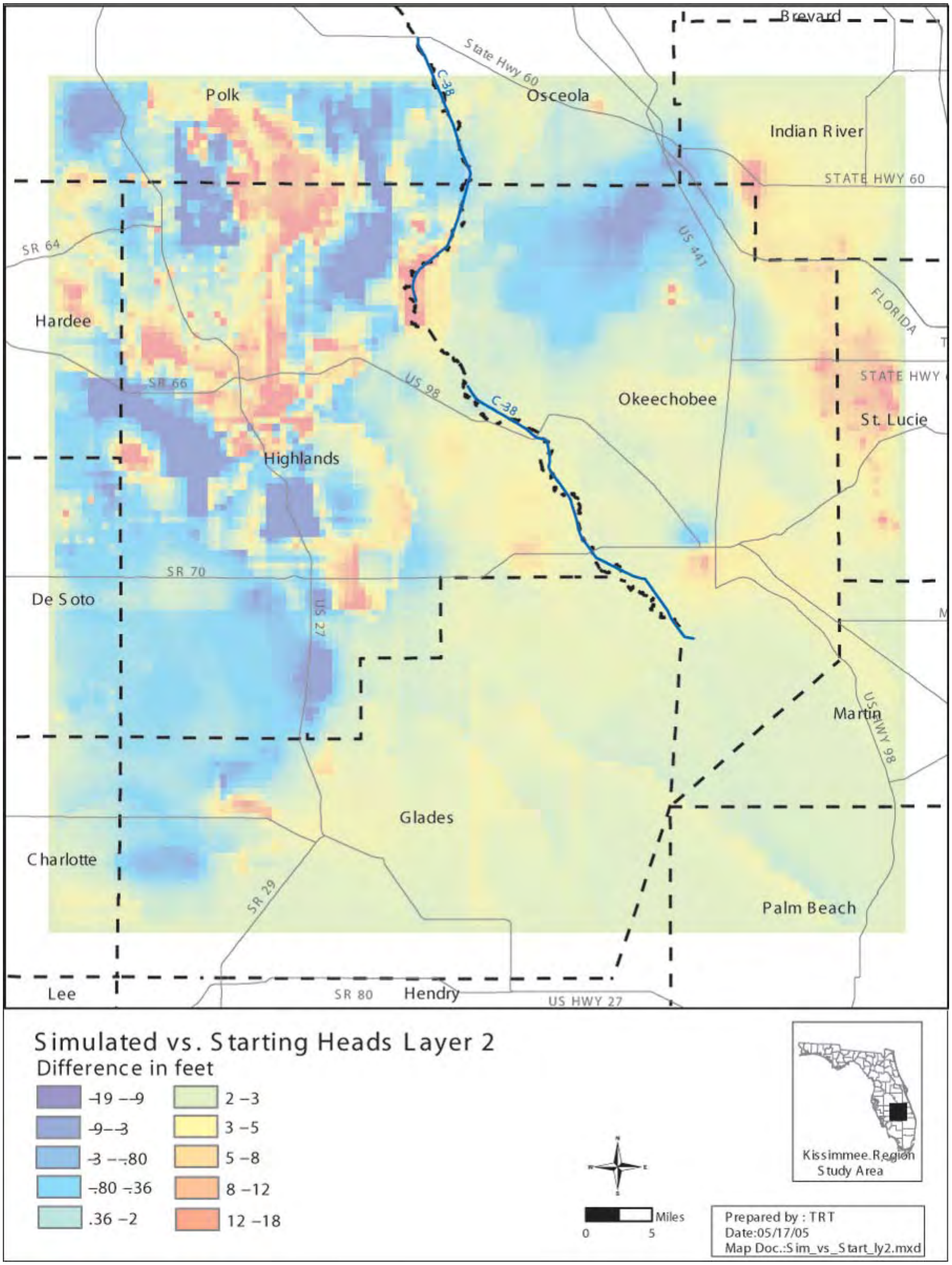

Figure 85. Simulated vs. Starting Heads Layer 2.

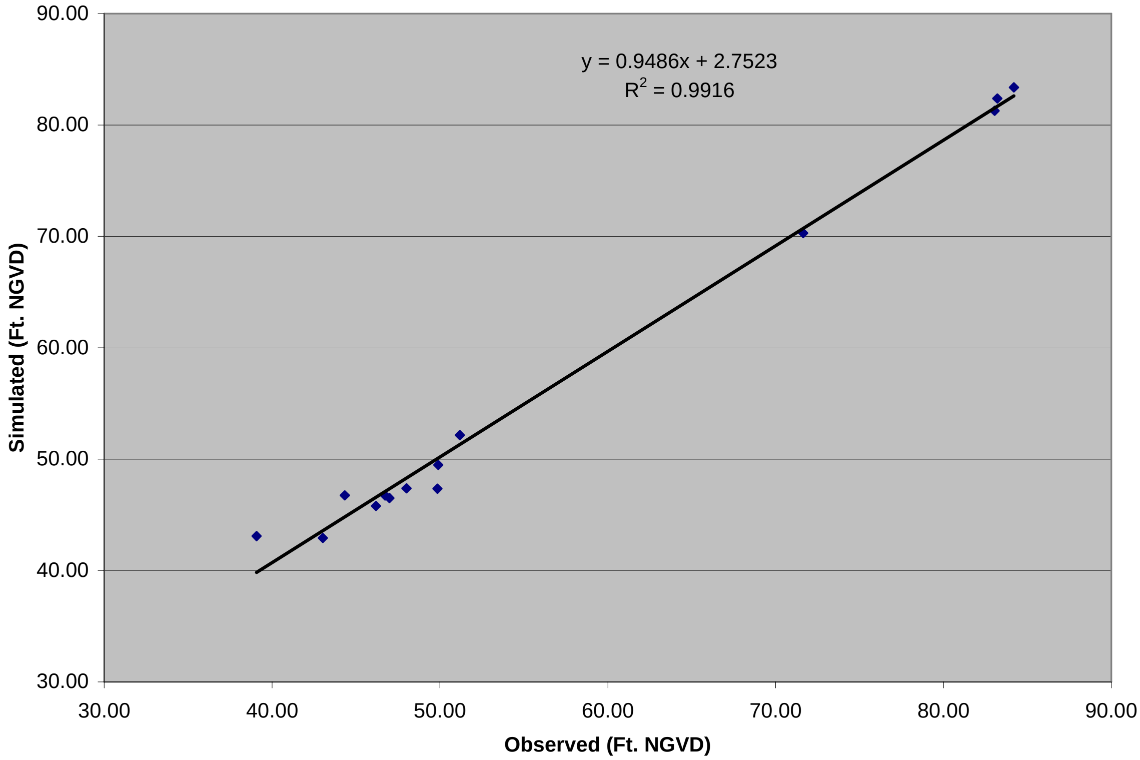

Figure 86. Observed Versus Simulated Layer 2 (Upper Floridan Aquifer) Water Levels, Average 1995 Conditions.

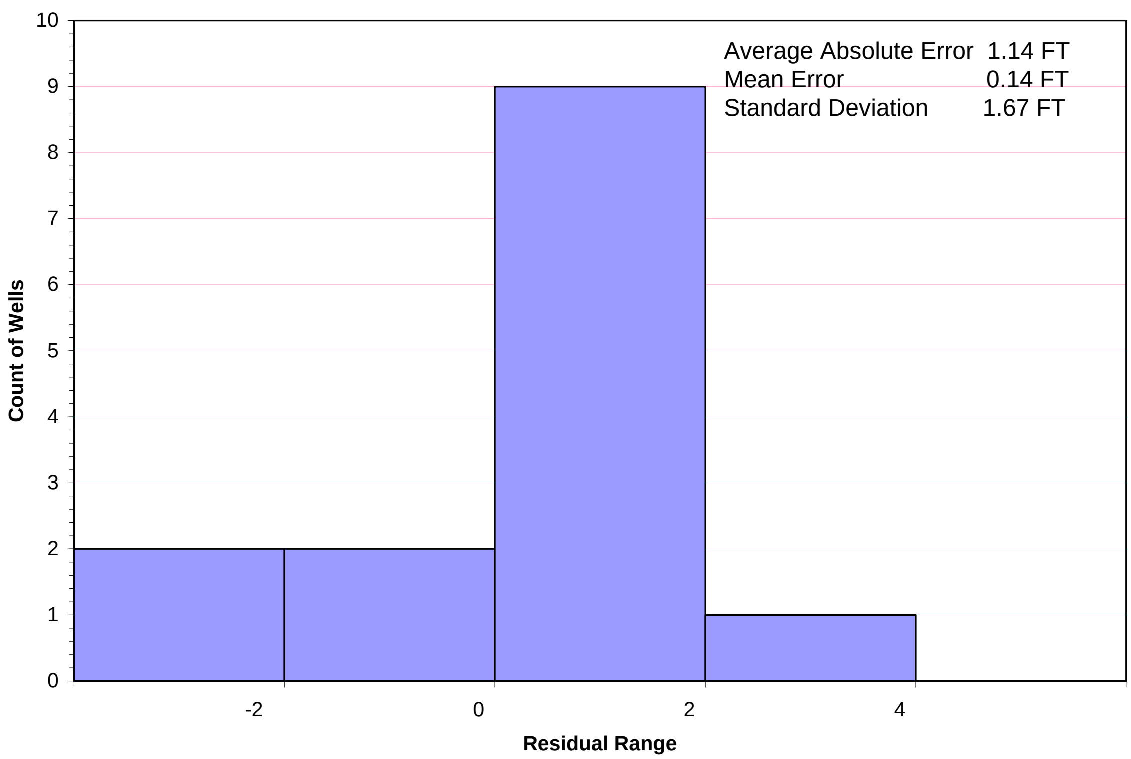

Figure 87. Layer 2 Water Level Residuals for 1995 Calibration.

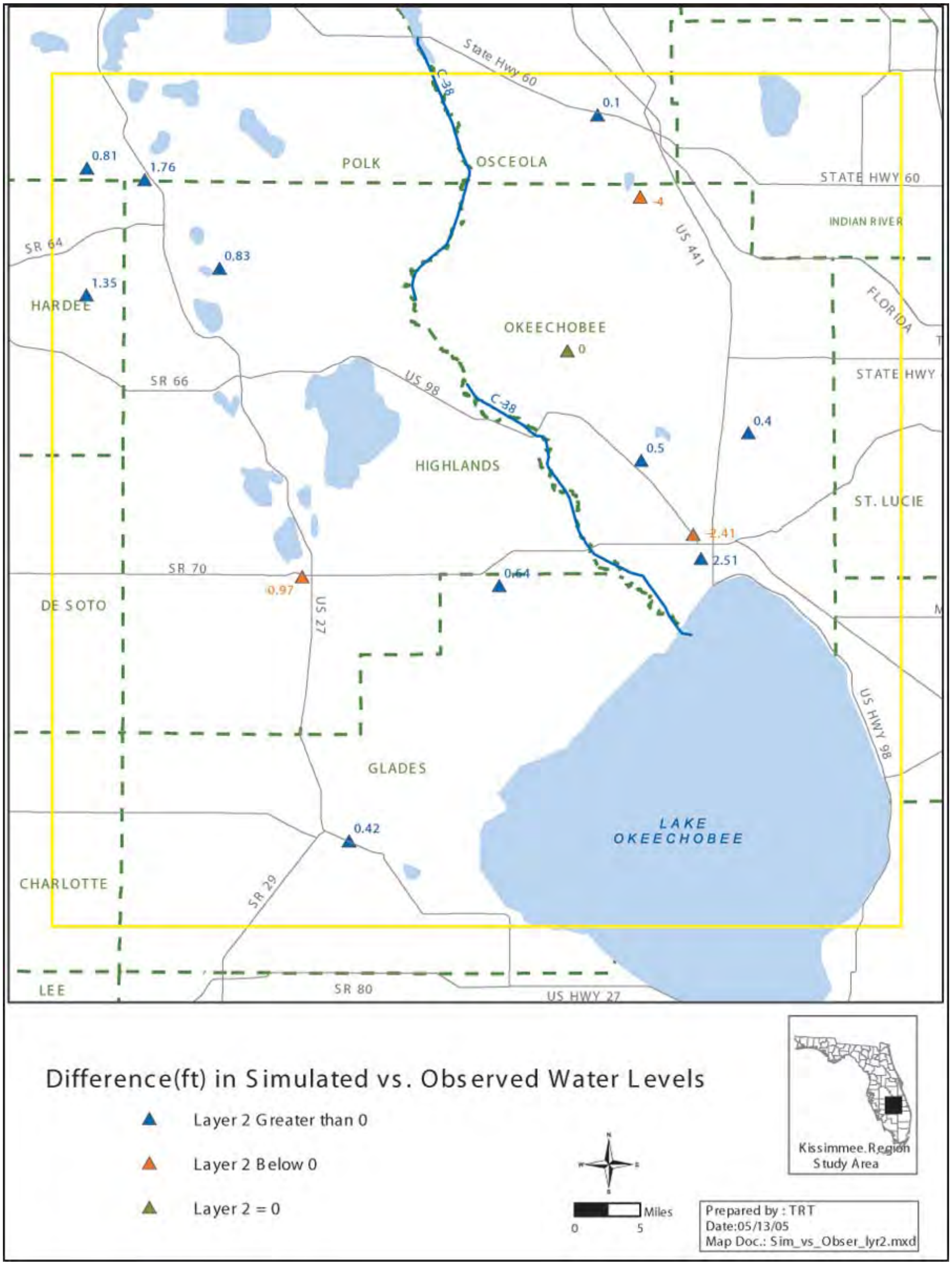

Figure 88. Layer 2 Water Level Residuals for 1995 Calibration (Map).

Table 19. Calibration Results Layer 3.

Station Name	Layer	Row	Col	Average 1995 Observed Water Level	Simulated Water Level	Difference in Water Levels	Met Calibration Criteria
S-65A(POF-20)WELL NR YEEHAW JUNCTION,FL	3	15	64	46.30	47.40	-1.10	True
73911801 33S30E06 USAF AVON PARK #1	3	16	38	77.79	75.35	2.44	True
SHEARER DEEP WELL NO 141 NEAR LEMON GROVE FL	3	25	10	78.10	78.36	-0.26	True
OKF-34	3	32	78	46.73	48.00	-1.27	True
HIF-3 73111501 HOWERTON'S WELL NR LORIDA,FL	3	33	49	53.85	54.67	-0.82	True
CITY SEBRING DEEP 24 AT SEBRING FL	3	37	26	83.49	82.10	1.39	True
HIF-32 GUILFORD TOMLINSON	3	39	42	53.62	54.46	-0.84	True
HIF-4 34S31E28 YUCAN RANCH NR LORIDA,FL	3	39	51	49.16	50.98	-1.82	True
HIF-13_G	3	48	55	47.53	48.50	-0.97	True
OKF-42	3	51	66	47.10	47.79	-0.69	True
FTB18	3	53	53	49.23	49.31	-0.08	True
FTB20	3	54	66	48.52	48.08	0.44	True
FTB17	3	57	62	49.80	48.65	1.15	True
HIF-16_G	3	58	14	61.92	56.80	5.12	
FTB19	3	65	72	48.92	48.17	0.75	True
HIF-14 P G PHYPERS	3	66	47	49.96	51.46	-1.50	True
ROMP 28 FLORIDAN WELL NR LAKE PLACID FL	3	69	39	70.13	68.37	1.76	True
FTB45	3	73	73	49.79	48.19	1.60	True
HIF-0037	3	75	57	47.16	47.34	-0.18	True
HIF-8 BOX RANCH	3	76	22	49.08	48.99	0.09	True
HIF-5 CHARLES STIDHAM	3	79	32	48.87	49.88	-1.01	True
HIF-23 GRAHAM CO DAIRY	3	91	16	48.68	48.49	0.19	True
HIF-26_G	3	92	38	49.19	49.59	-0.40	True
					Average Difference	1.50	
					Count Calibrated	22	
					% Calibrated	95.65%	

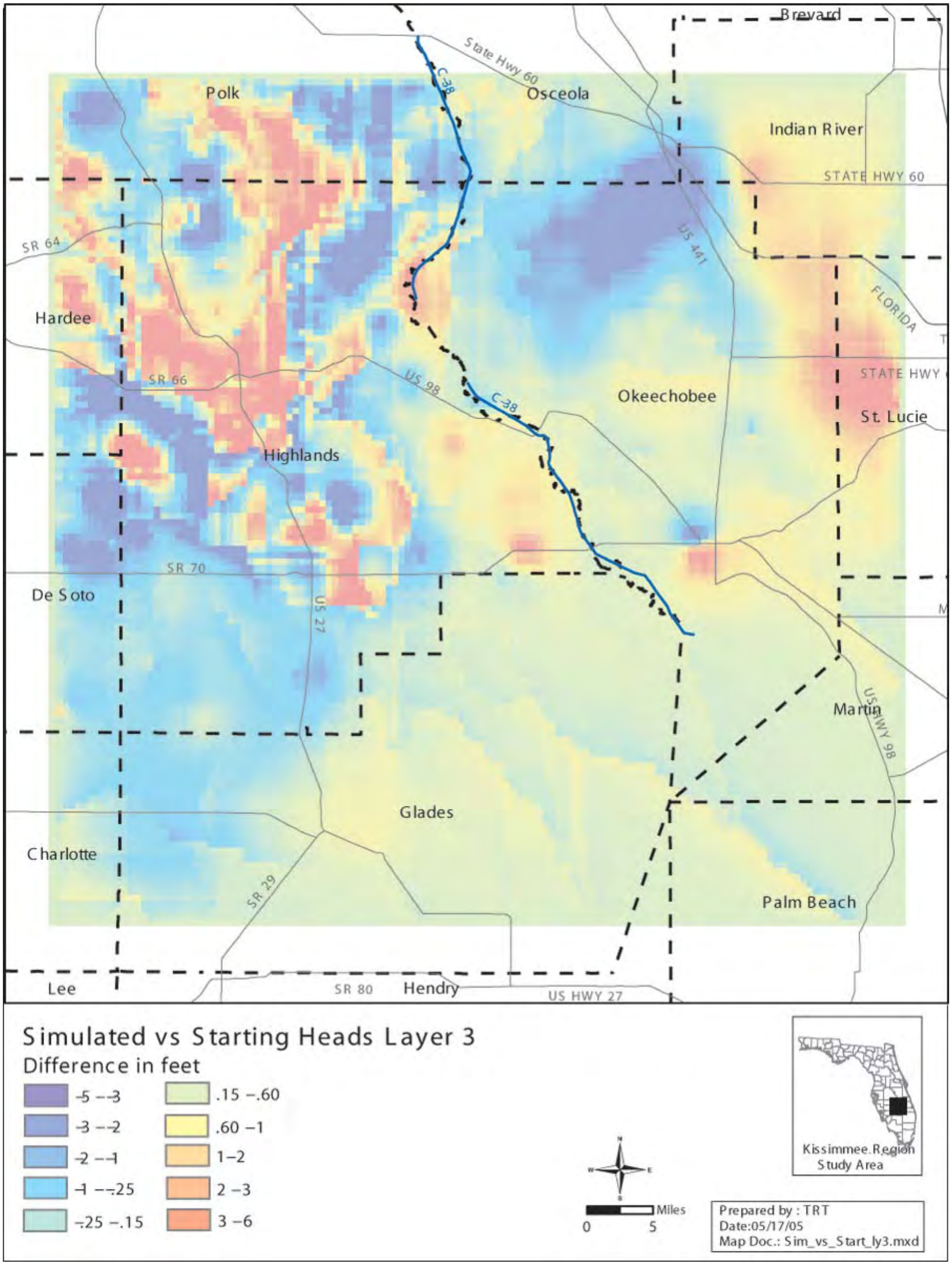

Figure 89. Simulated vs. Starting Heads Layer 3.

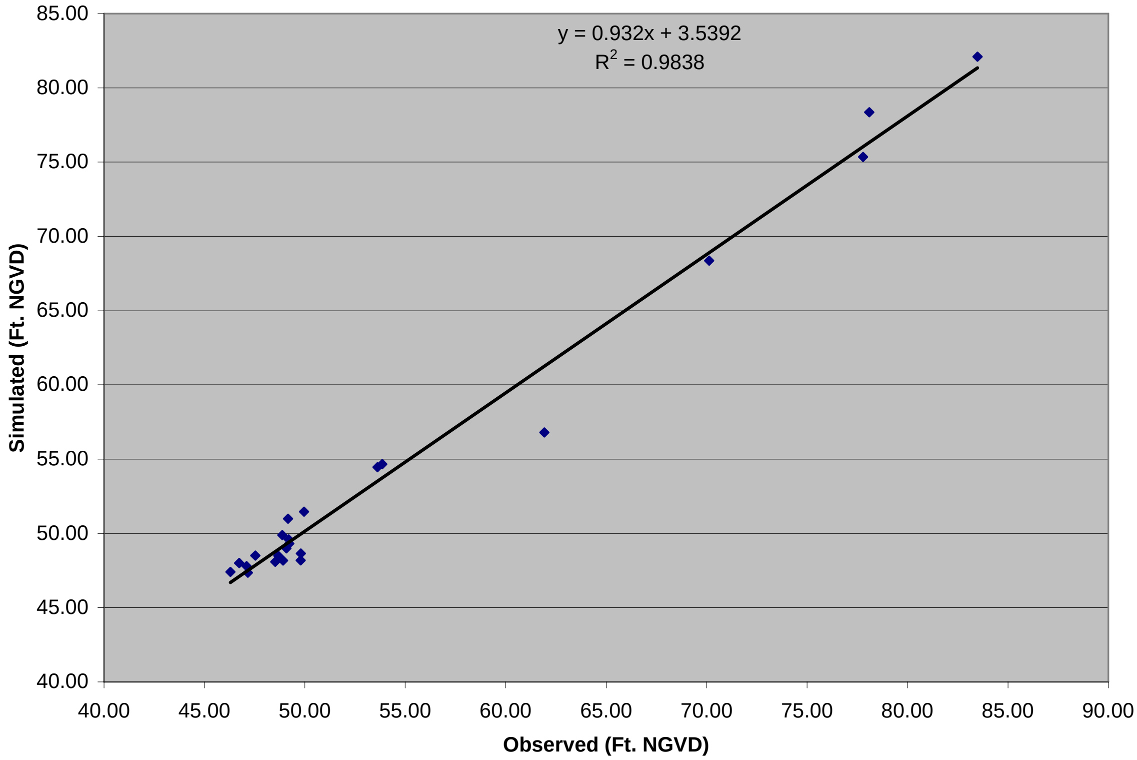

Figure 90. Observed Versus Simulated Layer 3 (Middle Floridan Aquifer) Water Levels, Average 1995 Conditions.

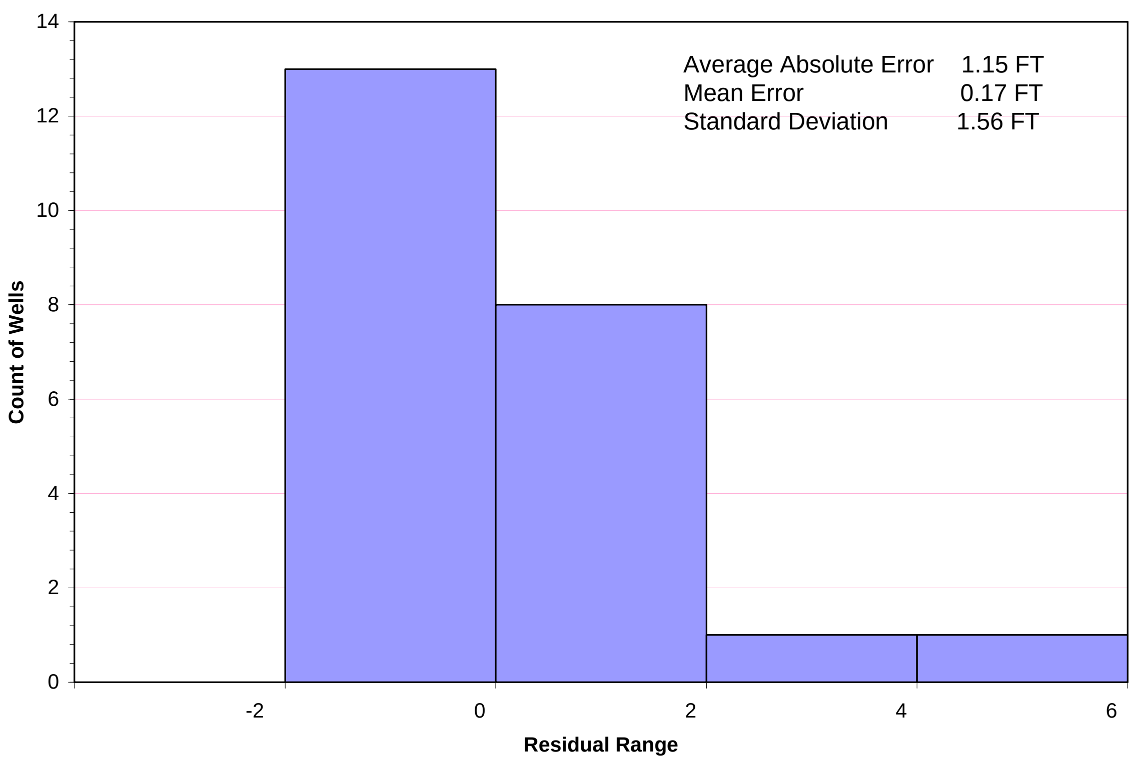

Figure 91. Layer 3 Water Level Residuals for 1995 Calibration.

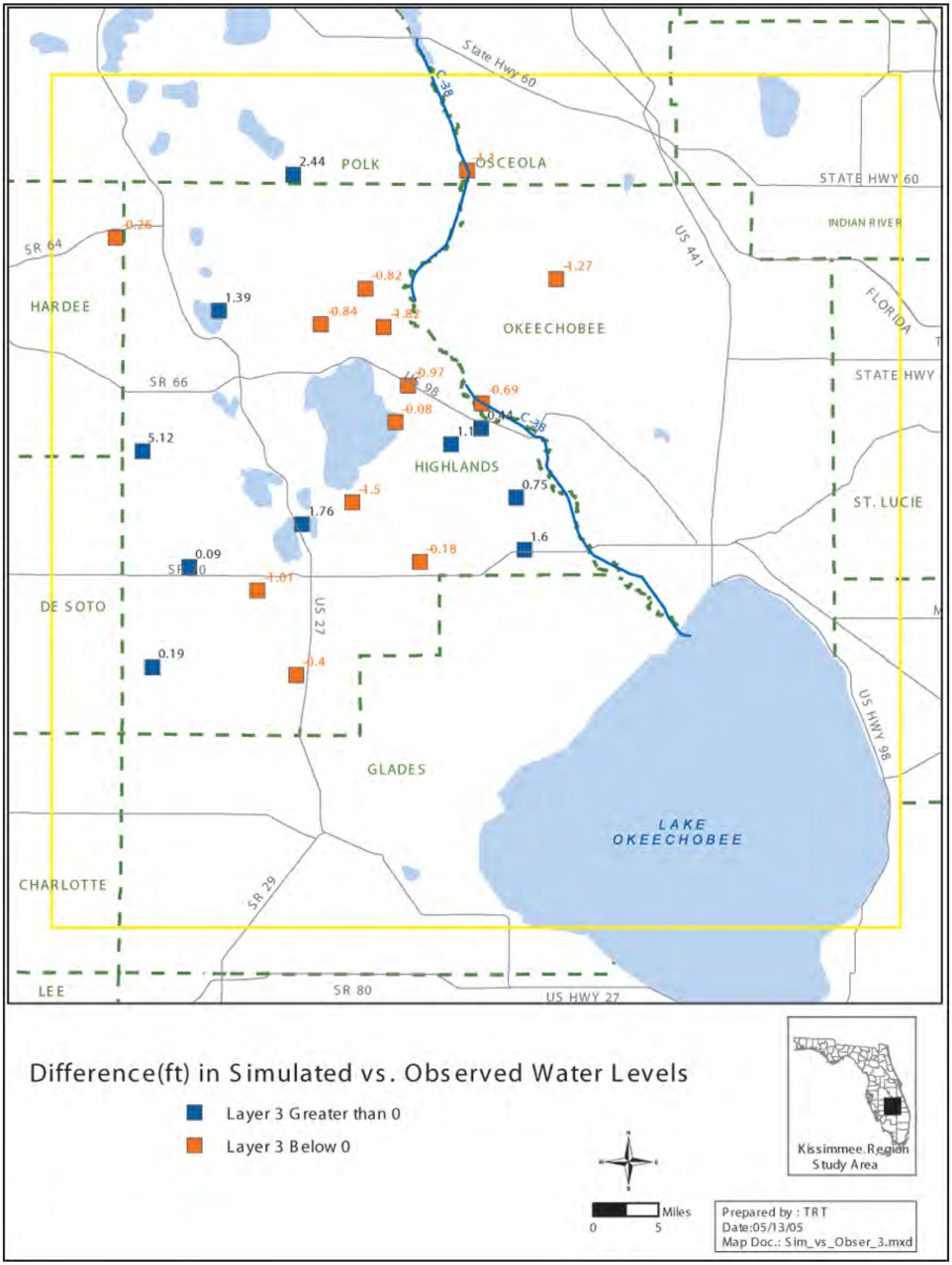

Figure 92. Layer 3 Water Level Residuals for 1995 Calibration (Map).

Some areas in St. Lucie, Martin and Indian River counties are in critical water supply problem areas (**Figure 93**). These areas must meet the special criteria outlined in (Chapter 40E-23, F.A.C). In areas where the water levels in the Floridan Aquifer System have a potentiometric head above land surface, there may be flowing wells (**Figure 94**). If a well flows at land surface, is required to have a valve pursuant to section 373.206, F.S. In addition, the Basis of Review 3.2.1D (SFWMD 2003) stipulates that flow in these flowing wells will be limited to flow, which is naturally emanated from the well. The model confirms that artesian condition exist in these areas.

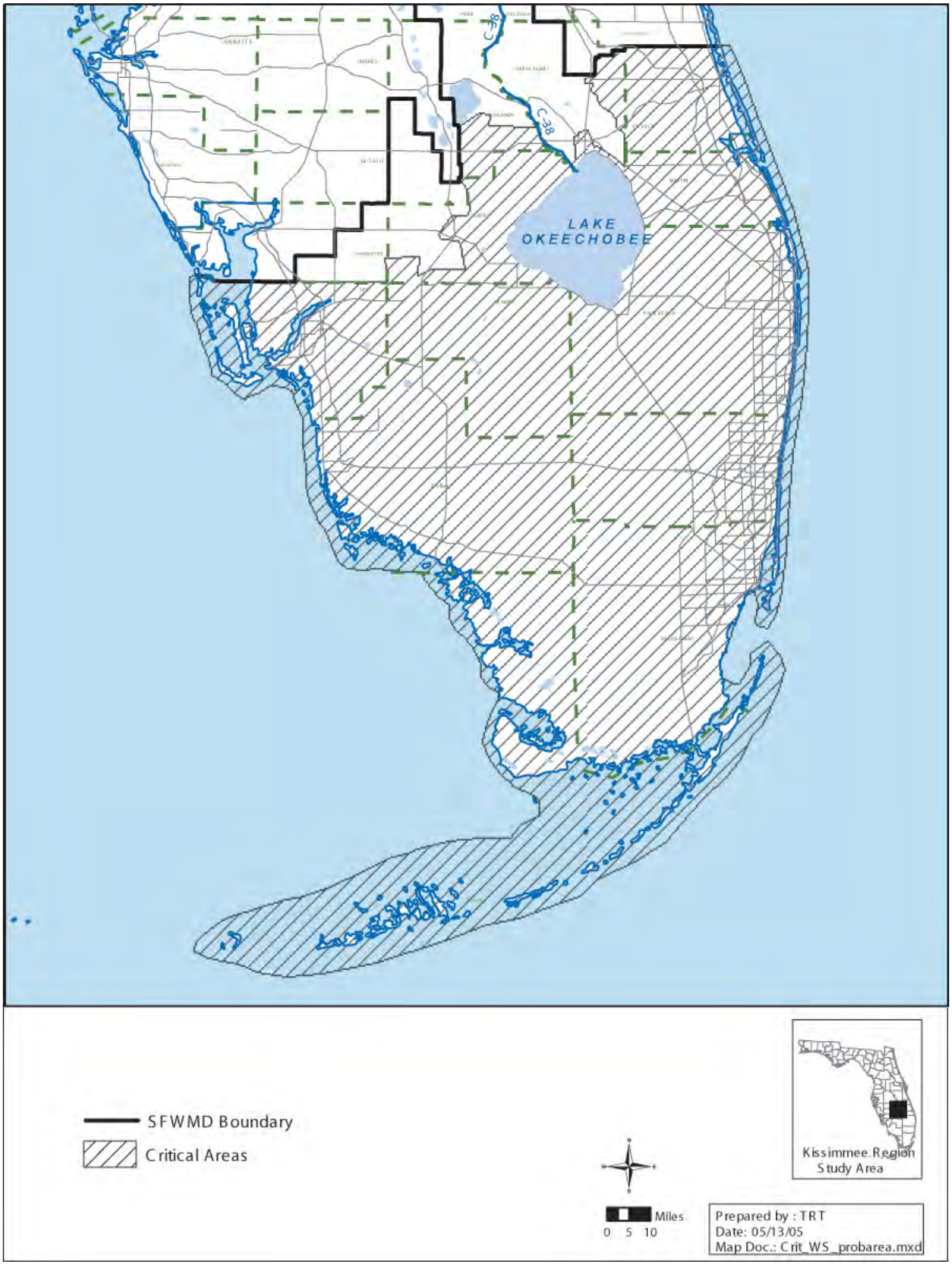

Figure 93. Critical Water Supply Problem Areas.

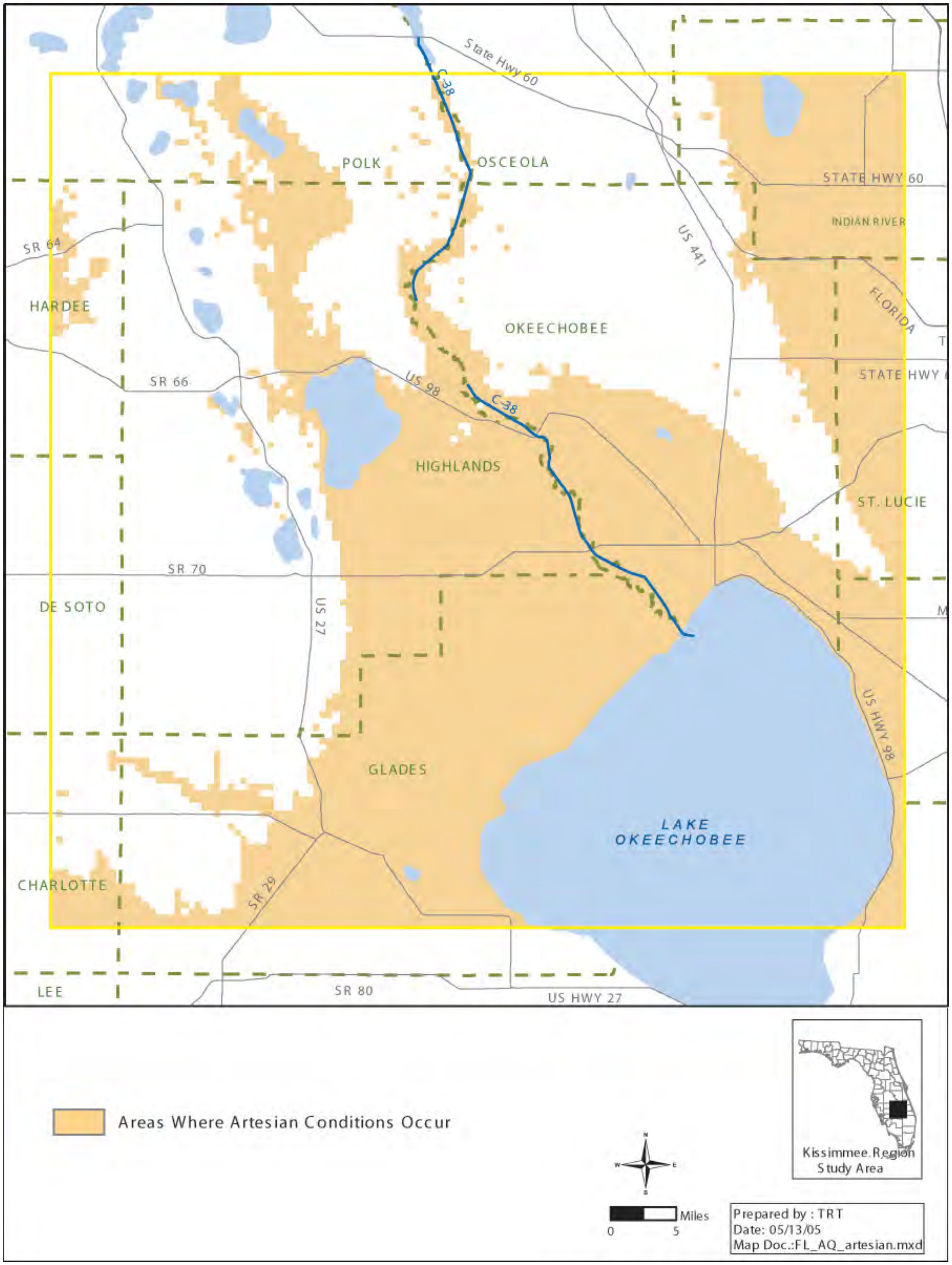

Figure 94. Areas Where the Floridan Aquifer is under Artesian Conditions.

The major source of water into Layer 1 is recharge. The major discharge of water from Layer 1 is evapotranspiration. Other water sources for the model are from rivers, while water discharges via drains, wells and constant heads. Layer 1 accounts for most of the volumetric water exchange in the model. Ninety-two percent of the water coming in to the model is coming in from Layer 1. Seventy-two percent of the water is leaving the model from Layer 1 via drains and evapotranspiration. The net vertical flow is downward with each successive layer receiving less water from the layer above. In 1995, wells represent only 4 percent of the overall volumetric budget. Most of the wells are in the Upper and Middle Floridan Aquifer and use 11 percent (**Table 20**), and 14 percent of the outflow in their respective layers. The simulated saturated evapotranspiration from the model is 13 inches/year this is equal to the total simulated saturated evapotranspiration volume divided by the model area. The mean maximum potential evapotranspiration is 22 inches/year. **Figure 95** shows the net flow cumulative volume by layer.

Table 20. Simulated Layer by Layer Volumetric Water Budgets for 1995 (in MGD).

	Cumulative Volume (MGD)				
Layer	**Layer 1 In**	**Layer 1 Out**	**Layer 1 Net**	**% In**	**% Out**
Constant Head	22.79	38.66	-15.87	0.39%	0.65%
Upper Boundary	0	0	0	0.00%	0.00%
Lower Boundary	148.60	561.66	-413.07	2.51%	9.49%
Wells	0	23.15	-23.15	0.00%	0.39%
Drains	0	1,838.30	-1,838.30	0.00%	31.06%
River Leakage	1,373.52	853.43	520.09	23.20%	14.42%
ET	0	2,603.08	-2,603.08	0.00%	43.98%
Recharge	4,374.53	0	4,374.53	73.90%	0.00%
TOTAL	5,919.44	5,918.28	1.15	100.00%	100.00%
Layer	**Layer 2 In**	**Layer 2 Out**	**Layer 2 Net**	**% In**	**% Out**
Constant Head	7.52	5.22	2.31	0.99%	0.68%
Upper Boundary	561.66	148.60	413.07	73.72%	19.48%
Lower Boundary	192.68	523.01	-330.33	25.29%	68.55%
Wells	0	86.18	-86.18	0.00%	11.29%
TOTAL	761.86	763.01	-1.13	100.00%	100.00%

Table 20. Simulated Layer by Layer Volumetric Water Budgets for 1995 (in MGD) (Continued).

Layer	Layer 3 In	Layer 3 Out	Layer 3 Net	% In	% Out
Constant Head	84.99	129.94	-44.94	8.78%	13.42%
Upper Boundary	523.01	192.68	330.33	54.04%	19.90%
Lower Boundary	359.81	506.80	-146.99	37.18%	52.34%
Wells	0	138.94	-138.94	0.00%	14.35%
TOTAL	967.81	968.36	-0.54	100.00%	100.00%
Layer	**Layer 4 In**	**Layer 4 Out**	**Layer 4 Net**	**% In**	**% Out**
Constant Head	364.59	510.14	-145.55	41.84%	58.64%
Upper Boundary	506.80	359.81	146.99	58.16%	41.36%
TOTAL	871.39	869.95	1.44	100.00%	100.00%
Layer	**All Layers In**	**All Layers Out**	**All Layers Net**	**% In**	**% Out**
Constant Head	479.9	683.96	-204.05	7.71%	10.98%
Wells	0	248.27	-248.27	0.00%	3.99%
Drains	0	1838.30	-1838.30	0.00%	29.52%
River Leakage	1373.52	853.43	520.09	22.05%	13.71%
ET	0	2603.08	-2603.08	0.00%	41.80%
Recharge	4374.53	0	4374.53	70.24%	0.00%
TOTAL	6227.95	6227.04	0.92	100.00%	100.00%

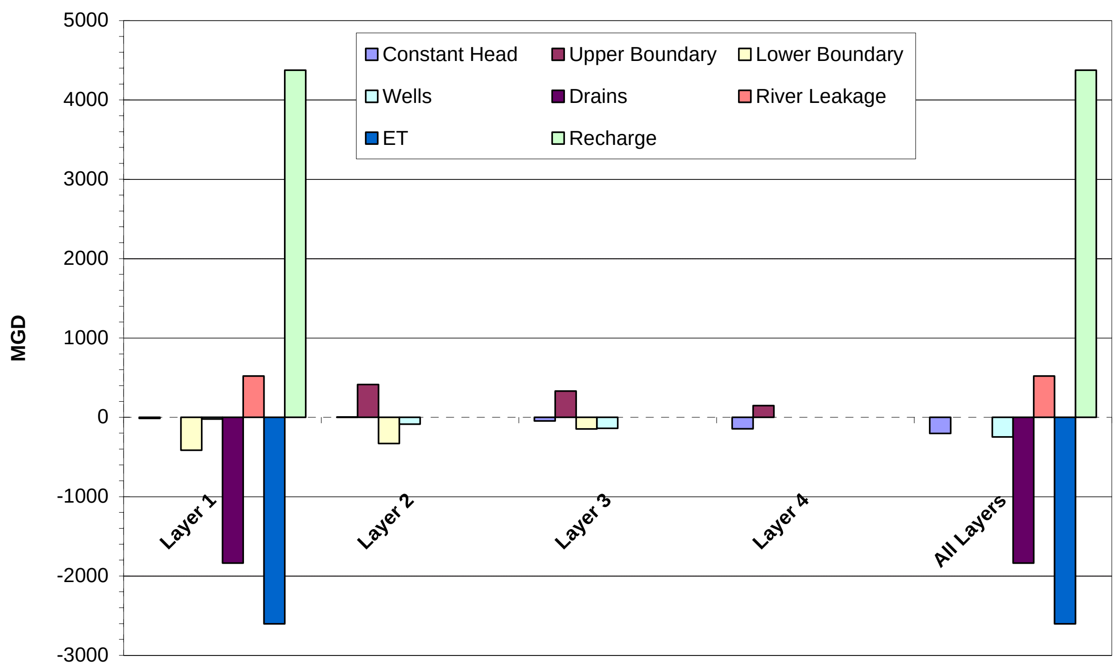

Figure 95. Net Flow - Cumulative Volume (MGD) by Layer.

The simulated vertical flows between Layers 1 and 2 (**Figure 96**) shows that the recharge areas are mainly in the western portion of the model, including Lake Wales Ridge and the area east of the Kissimmee River and west of the St. Johns Marsh, as well as the Allapattah Flats. The areas with artesian flow show upward flow from the Upper Floridan Aquifer into the Surficial Aquifer, but since the Intermediate Confining Unit is thick in those areas the volume of flow is much lower than in the recharge areas. The vertical gradient between Layers 2 and 3 (**Figure 97**) is similar to those mentioned between Layers 1 and 2, but there is a bit more flow through the Middle Confining Unit 1 than the Intermediate Confining Unit. The flow from Layer 3 to 4 (**Figure 98**), changes with some water flowing upward from the Lower Floridan Aquifer along the Lake Wales Ridge. There are no wells in the Lower Floridan Aquifer to prove this scenario, but this is consist with observations elsewhere in south Florida where the density equivalent heads in the Lower Floridan Aquifer are higher than those in the Middle and Upper Floridan Aquifer (Lukasiewicz 1999, 2001, Bennett 2003, Metz and Sacks 2002). The observation levels in Layers 2 and 3 were calibrated.

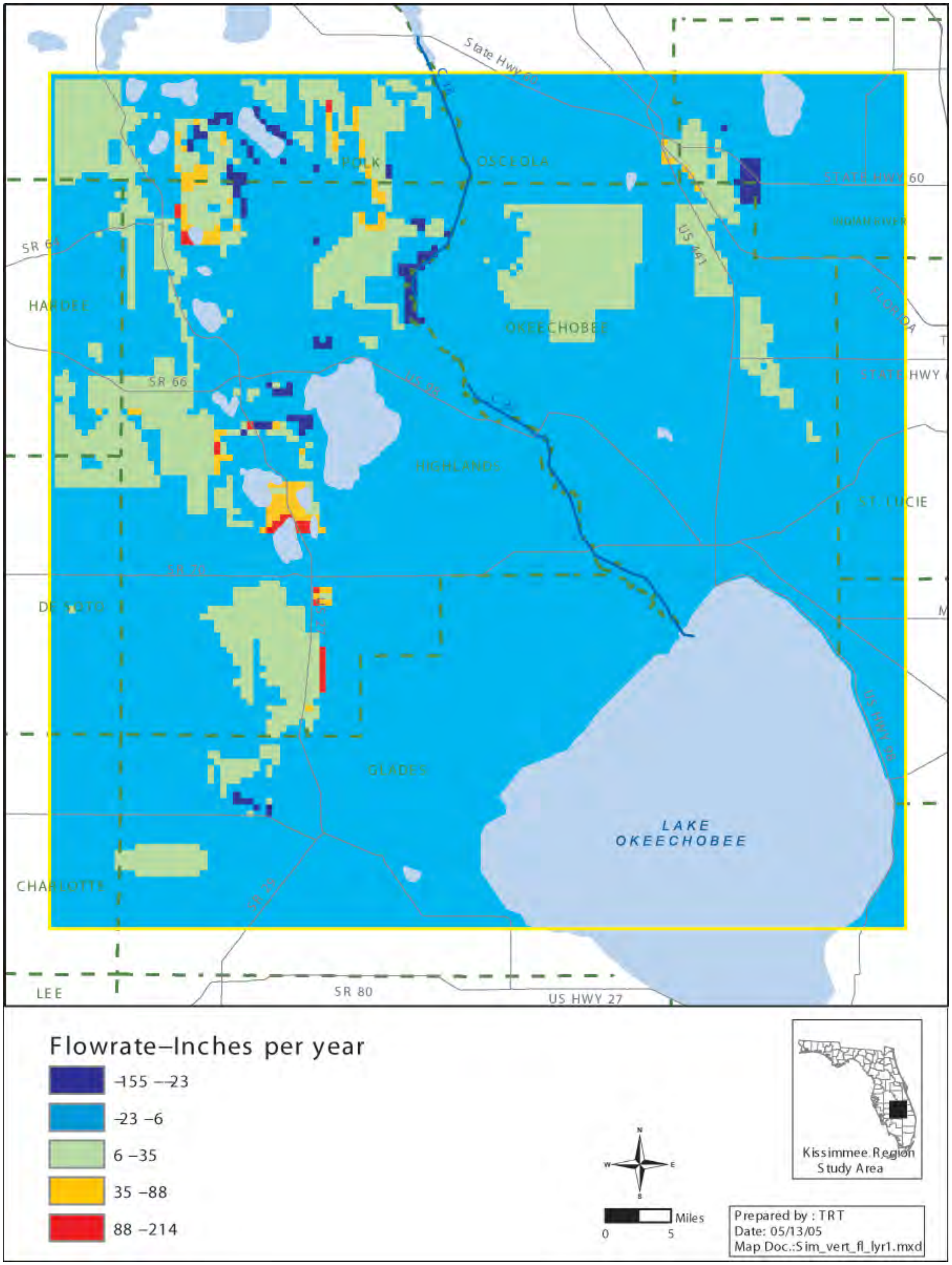

Figure 96. Simulated Vertical Flows between Layer 1 (Surficial Aquifer System) and Layer 2 (Upper Floridan Aquifer) for Average 1995 Conditions.

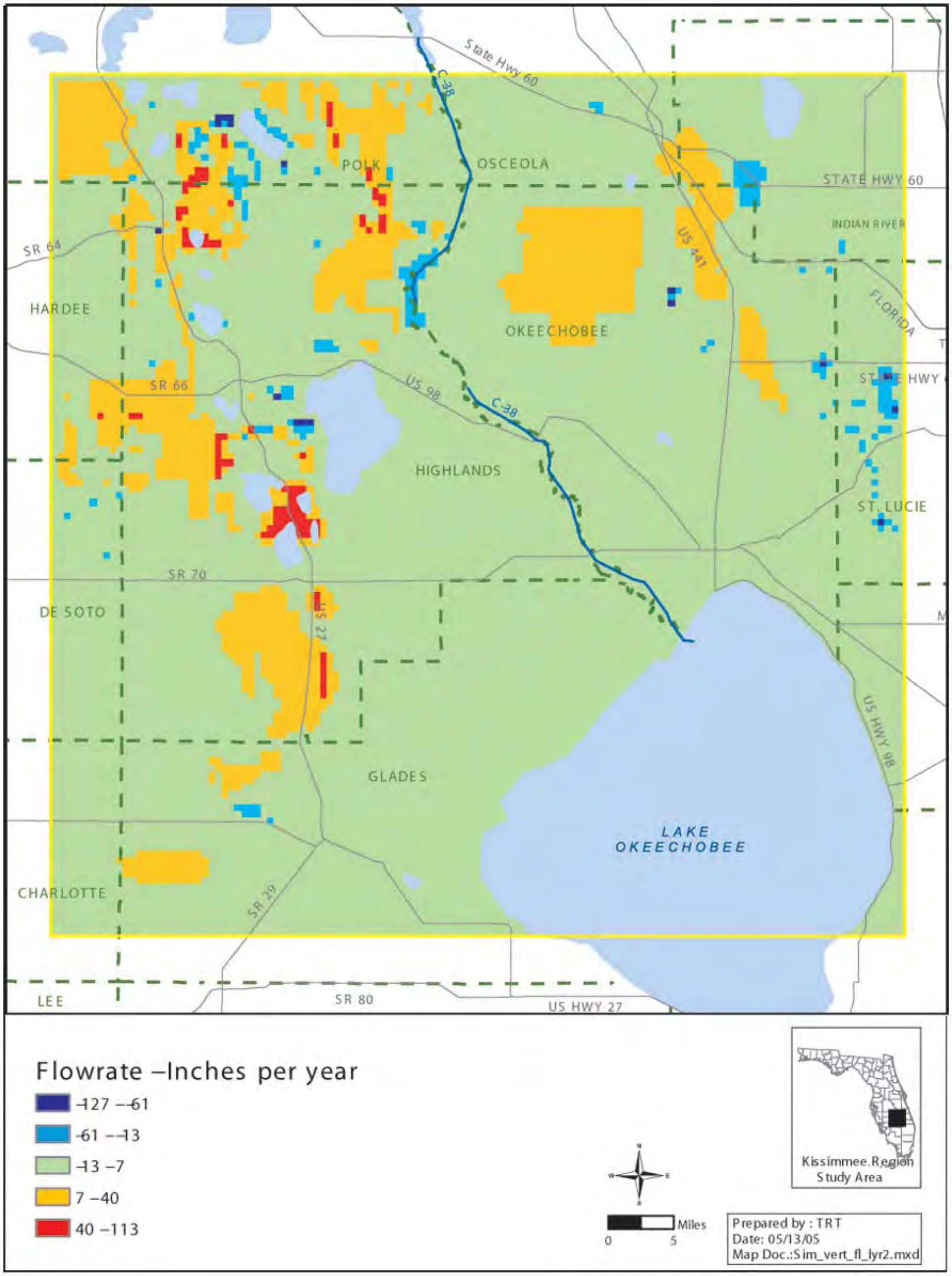

Figure 97. Simulated Vertical Flows between Layer 2 (Upper Floridan Aquifer) and Layer 3 (Middle Floridan Aquifer) for Average 1995 Conditions.

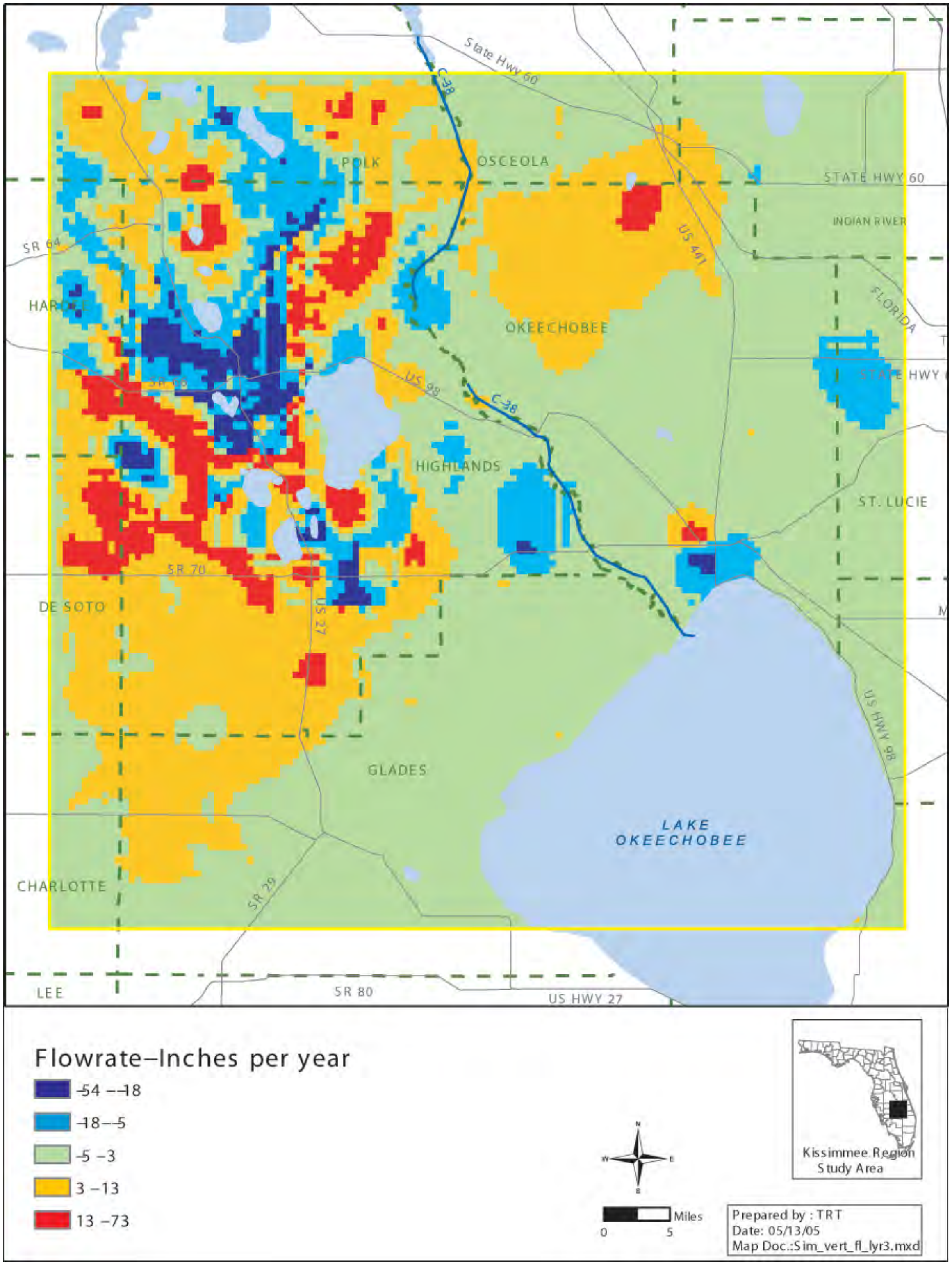

Figure 98. Simulated Vertical Flows between Layer 3 (Upper Floridan Aquifer) and Layer 4 (Middle Floridan Aquifer) for Average 1995 Conditions.

Sensitivity Analysis

The sensitivity analysis was conducted by changing one parameter at a time and assessing how it impacted all the layers (**Table 21**), how it impacted each layer individually and how it impacted the Upper and Middle Floridan aquifers combined (**Table 22**). **Table 22** assists is assessing which layer was influenced the most by each modification. When noted, the transmissivities for Layers 2 and 3 were both changed at the same time.

Layer 1 is sensitive to many parameters as it has more stresses applied to it. (ET Rate, Root Extinction Depth and ET Surface, Recharge and Rivers and Drains), which have little impact on the deeper aquifers. The vertical conductivity between the layers was most sensitive parameter for the Floridan Aquifer layers. The horizontal conductivity in Layer 1 and the transmissivities in the Floridan Aquifer layers were the next most sensitive parameters.

Table 21. Results of Sensitivity Analysis Lower Kissimmee Basin Groundwater Model (Composite for all Layers).

Parameter	Corresponding Change	Range of Head Difference			Notes
		Min	Max	Avg	
ET Rate	x 0.000028 (0.8 x calib)	-1.41	0.00	-0.06	
	x 0.000328 (1.2 x calib)	0.00	1.27	0.06	
ET Rate	x0.000301 (1.1 x calib rate)	0.00	0.65	0.03	
	x0.000246 (0.9 x calib rate)	-0.68	0.00	-0.03	
ET Surface	x 0.9	0.00	3.46	0.17	
	x 1.1	-2.63	0.00	-0.16	
ET Extinction Depth	x 2.0 (10 time original)	0.00	2.14	0.07	
	× 5.0 (25 times original)	0.00	4.30	0.18	
	× 0.1 (0.5 x original)	-2.16	0.00	-0.14	
Recharge	× 0.000456 (double rain in ft/day)	-12.53	0.00	-0.97	
	× 0.000114 (1/2 the rain in ft/day)	0.00	8.80	0.55	
Aquifer	**Corresponding Change**	**Range of Head Difference**			**Notes**
		Min	**Max**	**Avg**	
HK (Layer 1)	x 55	-892.08	19.12	-57.02	unrealistic head values in 800 - 900 ft range
	x 2.2	-46.94	0.00	-1.94	
	x 0.2				constant head cell went dry - simulation aborted

Table 21. Results of Sensitivity Analysis Lower Kissimmee Basin Groundwater Model (Composite for all Layers) (Continued).

Aquifer	Corresponding Change	Range of Head Difference			Notes
		Min	Max	Avg	
HK (Layer 1)	x0.5				constant head cell went dry - simulation aborted
	x0.9	-4.00	14.44	0.73	
	x 1.1	-3.91	0.00	-0.16	
Transmissivity (Layers 2, 3)	× 5.0	-2.93	7.00	0.01	
	× 0.5 (÷ 2)	-2.43	0.98	0.02	
	× 0.2 (÷ 5)	-4.59	2.15	0.05	
Transmissivity (Layers 2)	× 5.0	-1.03	0.39	-0.02	
	× 0.5 (÷ 2)	-0.05	0.20	0.01	
	× 0.2 (÷ 5)	-0.07	0.30	0.01	
Transmissivity (Layers 3)	× 5.0	-2.91	6.95	0.03	
	× 0.5 (÷ 2)	-2.36	0.96	0.01	
	× 0.2 (÷ 5)	-4.41	2.08	0.03	
VCONT (Layer 1_2)	× 10.0	-9.22	21.84	0.04	a few dry cells
	x1.1	-0.23	0.68	0.00	
	x 0.9	-0.68	0.23	0.00	
	× 0.1 (÷ 10)	-6.72	3.23	0.05	
VCONT (Layer 2_3)	x 0.9	-0.12	0.23	0.00	
	x1.1	-0.22	0.09	0.00	
	× 10.0	-4.31	0.92	-0.05	
	× 0.1 (÷ 10)	-6.57	3.45	-0.05	
VCONT (Layer 3_4)	x 0.9	-0.18	0.14	-0.01	
	x1.1	-0.11	0.17	0.01	
	× 10.0	-1.92	2.73	0.08	
	× 0.1 (÷ 10)	-4.07	4.18	-0.24	
River/Drain	**Corresponding Change**	**Range of Head Difference**			**Notes**
		Min	**Max**	**Avg**	
Conductance (both)	× 2.0	-13.73	2.76	-0.14	
	× 0.5 (÷ 2)	-4.51	14.18	0.37	one dry cell

Table 22. Results of Sensitivity Analysis Lower Kissimmee Basin Groundwater Model (by Layer).

	Layer 1			Layers 2 and 3			Layer 2			Layer 3		
	Min	**Max**	**Avg**	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**
etrate x1.1	0.00	0.65	0.04	0.00	0.04	0.00	0.00	0.02	0.01	0.00	0.04	0.00
etrate x0.9	-0.68	0.00	-0.05	-0.04	0.00	0.00	-0.02	0.00	0.00	-0.04	0.00	0.00
etrate x0.8	-1.41	0.00	-0.10	-0.09	0.00	-0.01	-0.04	0.00	-0.01	-0.09	0.00	-0.01
etrate x1.2	0.00	1.27	0.08	0.00	0.07	0.01	0.00	0.03	0.01	0.00	0.07	0.01
etsurface x 10	-8.18	0.00	-0.55	-0.58	0.00	-0.06	-0.24	-0.01	-0.06	-0.58	0.00	-0.06
etsurface x 0.8	0.00	6.80	0.47	0.00	0.24	0.04	0.00	0.12	0.04	0.00	0.24	0.05
etsurface x 0.1	0.00	6.88	0.54	0.00	0.32	0.06	0.00	0.15	0.05	0.00	0.32	0.06
etsurface x 0.5	0.00	6.88	0.54	0.00	0.32	0.05	0.00	0.14	0.05	0.00	0.32	0.06
etsurface x 5	-8.18	0.00	-0.55	-0.58	0.00	-0.06	-0.24	-0.01	-0.06	-0.58	0.00	-0.06
etsurface x 2	-8.18	0.00	-0.55	-0.58	0.00	-0.06	-0.24	-0.01	-0.06	-0.58	0.00	-0.06
etsurface x 1.5	-6.34	0.00	-0.51	-0.58	0.00	-0.06	-0.24	-0.01	-0.06	-0.58	0.00	-0.06
etsurface x 1.1	-2.63	0.00	-0.24	-0.21	0.00	-0.03	-0.11	0.00	-0.03	-0.21	0.00	-0.03
etsurface x 0.9	0.00	3.46	0.25	0.00	0.13	0.03	0.00	0.11	0.03	0.00	0.13	0.03
exd x5 (25 x original)	0.00	4.30	0.27	0.00	0.16	0.02	0.00	0.07	0.02	0.00	0.16	0.03
exd x 0.1 (0.5 x original)	-2.16	0.00	-0.21	-0.07	0.00	-0.01	-0.07	0.00	-0.01	-0.07	0.00	-0.01
exd x 2 (10 x original)	0.00	2.14	0.11	0.00	0.06	0.01	0.00	0.03	0.01	0.00	0.06	0.01
rch x2	-12.53	0.00	-1.48	-1.09	0.00	-0.12	-0.40	-0.01	-0.12	-1.09	0.00	-0.13
rch x0.5	0.00	8.80	0.84	0.00	0.51	0.07	0.00	0.23	0.07	0.00	0.51	0.07
k l1 x 55	-892.08	19.12	-91.68	-15.09	0.00	-0.82	-15.09	0.00	-1.21	-4.25	0.00	-0.57
k l1 x 2.2	-46.94	0.00	-3.10	-0.04	0.00	0.00	-0.04	0.00	0.00	-0.03	0.00	0.00
k l1 x 0.9	-3.44	14.44	1.08	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
k l1 x 1.1	-3.91	0.00	-0.26	-0.01	0.00	0.00	-0.01	0.00	0.00	-0.01	0.00	0.00
trans x 5 (Layers 2 & 3)	-0.28	0.34	0.00	-2.93	7.00	0.03	-1.15	1.96	0.05	-2.93	7.00	0.02
trans x 0.5 (Layers 2 & 3)	-0.10	0.15	0.00	-2.43	0.98	0.04	-0.83	0.70	0.06	-2.43	0.98	0.03
trans x 0.5 (Layers 2)	-0.04	0.06	0.00	-0.05	0.20	0.01	-0.05	0.20	0.02	-0.04	0.05	0.01
trans x 5 (Layers 2)	-0.21	0.13	0.00	-1.03	0.39	-0.06	-1.03	0.33	-0.14	-0.23	0.39	-0.01
trans x 0.5 (Layers 3)	-0.07	0.07	0.00	-2.36	0.96	0.03	-0.77	0.57	0.03	-2.36	0.96	0.03
trans x 5 (Layer 3)	-0.12	0.22	0.01	-2.91	6.95	0.07	-1.03	1.84	0.14	-2.91	6.95	0.03
trans x 0.2 (Layers 2 & 3)	-0.19	0.37	0.00	-4.59	2.15	0.12	-1.71	1.70	0.16	-4.59	2.15	0.10
trans x 0.2 (Layers 2)	-0.06	0.11	0.00	-0.07	0.30	0.02	-0.07	0.30	0.03	-0.06	0.08	0.01
trans x 0.2 (Layers 3)	-0.13	0.16	0.00	-4.41	2.08	0.08	-1.58	1.30	0.08	-4.41	2.08	0.08
vcont 1_2 x 10	-3.61	21.84	0.48	-9.22	2.67	-0.71	-9.22	1.29	-1.13	-3.12	2.67	-0.45
vcont 1_2 x 01	-6.72	1.98	-0.14	-0.76	3.23	0.36	-0.14	2.31	0.38	-0.76	3.23	0.35
vcont2_3x 01	-1.37	0.65	-0.04	-6.57	3.45	-0.07	-6.57	2.09	-0.55	-0.40	3.45	0.21
vcont2_3x 10	-0.29	0.31	0.00	-4.31	0.92	-0.13	-0.82	0.92	-0.03	-4.31	0.31	-0.19
vcont3_4x 10	-0.10	0.26	0.01	-1.92	2.73	0.19	-1.07	2.73	0.15	-1.92	1.79	0.22
vcont3_4x 0.1	-0.23	0.02	-0.02	-4.07	4.18	-0.61	-4.07	1.09	-0.50	-3.39	4.18	-0.68
vcont3_4x 0.9	-0.02	0.00	0.00	-0.18	0.14	-0.02	-0.18	0.04	-0.02	-0.12	0.14	-0.02
vcont1_2x 0.9	-0.68	0.17	-0.01	-0.06	0.23	0.03	-0.02	0.23	0.03	-0.06	0.16	0.02
vcont2_3x 0.9	-0.03	0.03	0.00	-0.12	0.23	0.01	-0.12	0.08	0.00	-0.01	0.23	0.01
vcont12x1.1	-0.16	0.68	0.01	-0.23	0.07	-0.03	-0.23	0.01	-0.03	-0.14	0.07	-0.02
vcont23x1.1	-0.02	0.02	0.00	-0.22	0.09	-0.01	-0.06	0.09	0.00	-0.22	0.02	-0.01
vcont34x1.1	0.00	0.01	0.00	-0.11	0.17	0.02	-0.04	0.17	0.01	-0.11	0.10	0.02
rivdarinx2	-13.73	2.76	-0.23	-0.13	0.06	0.00	-0.13	0.03	-0.01	-0.08	0.06	0.00
rivdrnx0.5	-4.51	14.18	0.57	-0.09	0.46	0.03	-0.05	0.14	0.01	-0.09	0.46	0.05

Model Verification

A model verification run was conducted for the year 2004. The only changes to model datasets were river, evapotranspiration, recharge, agricultural well and public water supply file modifications.

River

Stage data were collected for all the structures in the model area (from DBHYDRO) and the average 2004 values were applied to those cells in the model. Lake and river stages were collected from the SFWMD DBHYDRO database, the SWFWMD database and the USGS National Water Information System database. When stage data for lakes or rivers were unavailable for 2004 and for stream data where the stages were estimated from topography, the 1995 data were used.

Evapotranspiration, Recharge and Irrigation Demands

Not all of the rain stations used for the 1995 calibration were still monitoring data in 2004. When a station was not available, data from the nearest station were assigned to that rain station. Some sites had more than one monitoring device. Data from 61 devices (DBKeys) were used in 1995, 37 of these were available in 1995.

The year 2004 was drier than 1995. In 2004, the average annual rainfall for the stations in the model area was 43 inches vs. 53 inches of rain in 1995.

In the late 1990s, the SFWMD began installing weather stations. The potential evapotranspiration for these stations was calculated. The potential reference evapotranspiration was calculated by the "South Florida Water Management District Simple Method" using *wet marsh reference evapotranspiration*, as described in Irizarry-Ortiz (2003), these values are stored in DBHYDRO. The weather stations, which had potential evapotranspiration data calculated for 2004 were S65CW, S65DWX, S78W, CFSW and Belle Glade. The data from these stations were assigned to the nearest evapotranspiration Thiessen polygon used for the 1995 calibration run.

Estimates of agricultural demands were modified from the 1995 calibration run. Recharge, evapotranspiration and irrigation time series demands were computed using the ET-Recharge Model (Restrepo and Giddings 1994). This is an extension of the Agricultural Field-Scale Irrigation Requirements Simulation (AFSIRS) Program, which estimates irrigation demands on a daily basis for a specific crop and acreage due to soil, rainfall, evapotranspiration and other parameters (Smajstrla, 1990).

The agriculture well file was derived from the land use. Irrigation demands for each cell were determined by combining the GIS coverages for the land use, permitted areas, soil coverage, evapotranspiration and rainfall stations. The irrigation demand was then calculated for each individual polygon, and composite irrigation for each cell of the model is ultimately developed. This approach tends to result in a more accurate, seasonal representation of the irrigation demands, but the overall annual demand is not significantly different than that calculated using the Blaney-Criddle Method, which was used in the original 1995 calibration. For the 1995 calibration run, the agriculture well file was based on the consumptive use permits, which calculate irrigation demands based on the Blaney-Criddle Method. The water levels for each model layer from the AFSIRS run were compared to the water levels that were achieved in the 1995 calibration run using permitted values.

The total 1995 agriculture water use estimated from the permits was 248 MGD while 200 MGD was estimated with AFSIRS based on land use.

For 2004, the irrigation requirements for the agriculture wells were based on the 2000 land use. The total agriculture water use estimated from AFSIRS was 410 MGD.

The year 2004 was drier than 1995. In 2004, the average annual rainfall for the stations in the model area was 43 inches vs. 53 inches of rain in 1995.

Only 51 of the 99 observation sites used for the model calibration (1995) had usable data for 2004 (see **Table 23** for observation sites, see **Appendix E** for observation data). To supplement these observation sites, data were collected for sites that were added since 1995, and older sites that were missing observation points in 1995. A total of 112 observation sites were used for the verification run (see **Figure 99** for locations). Eighty-nine of the sites are in Layer 1, 13 in Layer 2 and 10 in Layer 3.

Of the 51 observation sites used in both the calibration and verification runs, 24 calibrated better than the calibration run. Fifty of the common sites met calibration criteria. **Figure 100** shows the trend lines for these observation sites and **Figure 101** shows the trend line for all the sites used in 2004. The trend line for 2004 falls on the same line as the 1995 permitted agriculture line. The permits assume 1-in-10 conditions when applications for water use are made. The 2004 rain conditions were close to a 1-in-10 year, thus the trend lines were similar.

Of the 89 wells and stage sites in Layer 1, 82 met the calibration criteria of ±4 (See **Table 24**; see **Figure 102** for trend line). Six wells did not meet the criteria, one of those is on Avon Park Ridge, which as explained in the calibration section, is difficult to calibrate, due to the steep topographical changes and limited information on the streams.

The other stations are near canals, which are input to the model as river cells. The modeled water levels in Layer 1 cells tend to be close to the input stages. When groundwater wells are further from the river cell, the water levels in the wells differ more from the river stages. **Figure 102** shows the trend line for Layer 1 sites.

There are thirteen observation wells in Layer 2 (Upper Floridan Aquifer), ten of these calibrated (See **Table 25**; see **Figure 103** for trend line). KRENND was simulated at 47 feet, while the average observation for that site was 50.62. The highest water level observed at this site since installation in 1997, was 53.86 feet in September, 2004. The lowest was 47.35 feet in June of 2000.

Lake Placid Grove well only had one reading for 2004. In other years, the water levels in this well fluctuated throughout the year by as much as 5 feet.

For Well GL267, near Palmdale, the model simulated water levels that were too high by over 8 feet. This well is 600 feet deep and is located below the Fisheating Creek flood plane. The creek may be supplying too much water to Layer 1, which is recharging into Layer 2.

There are ten observation sites in Layer 3 – the Middle Floridan Aquifer, nine of these calibrated (**Table 26**; See **Figure 104** for trend line). One well did not calibrate near S65A (POF20).

The verification run shows that in most areas the model accurately represented the observed water levels.

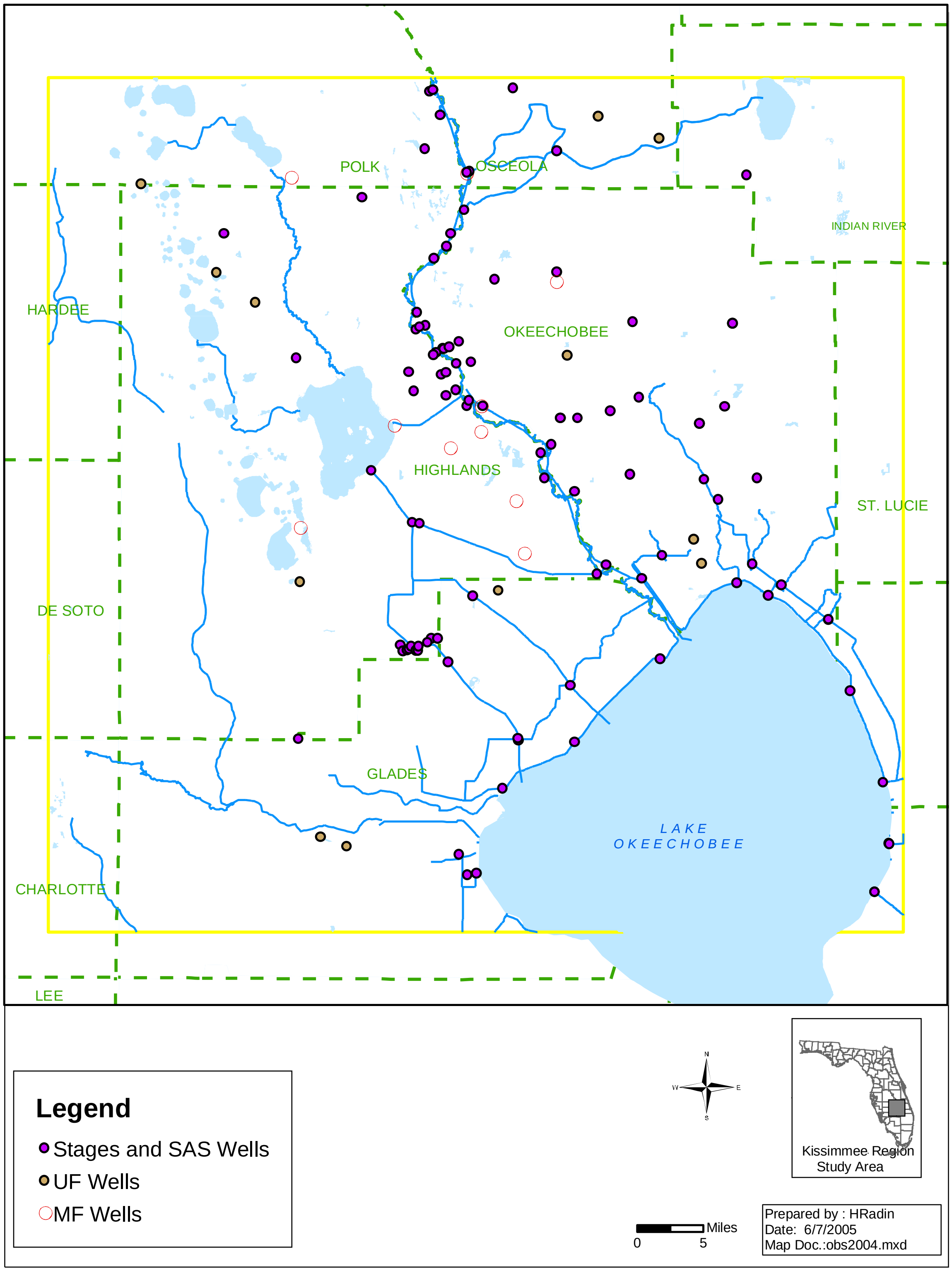

Figure 99. 2004 Observation Sites.

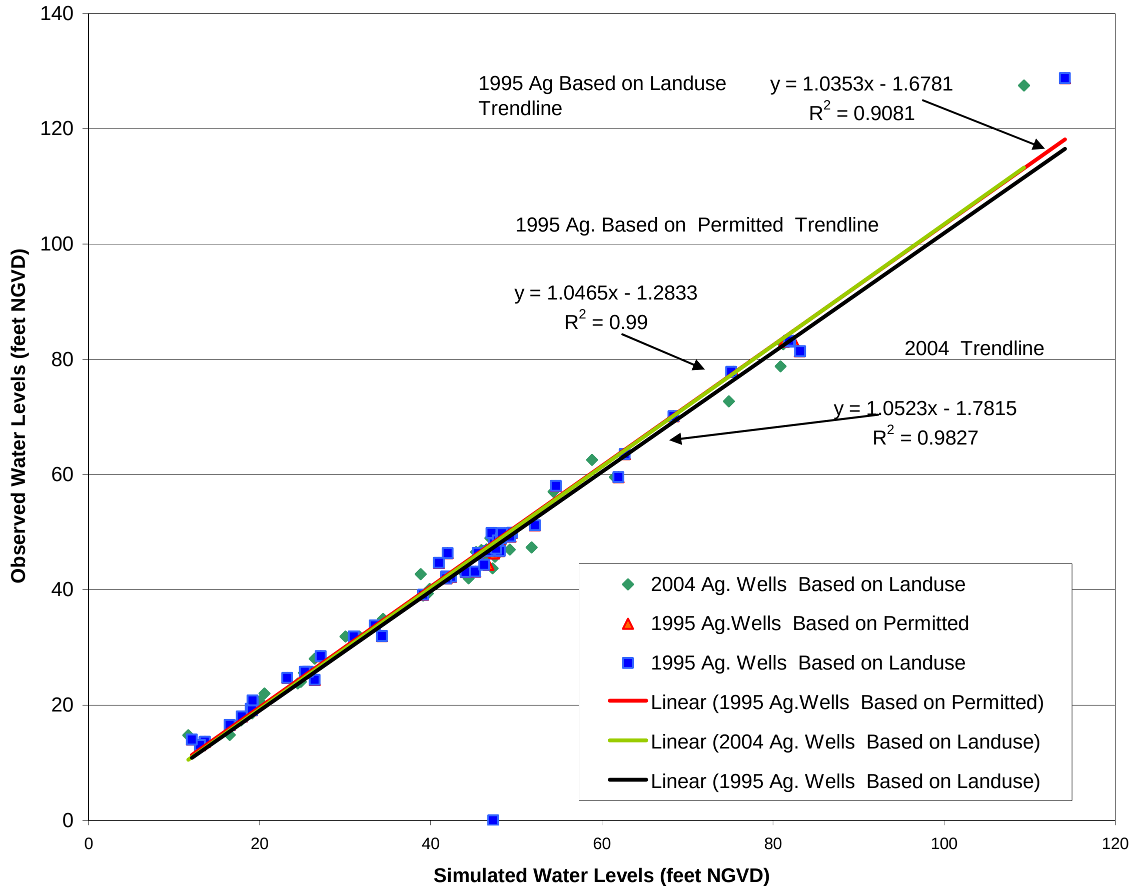

Figure 100. Observed vs. Simulated Water Levels in Observation Sites used for Calibration in 2004.

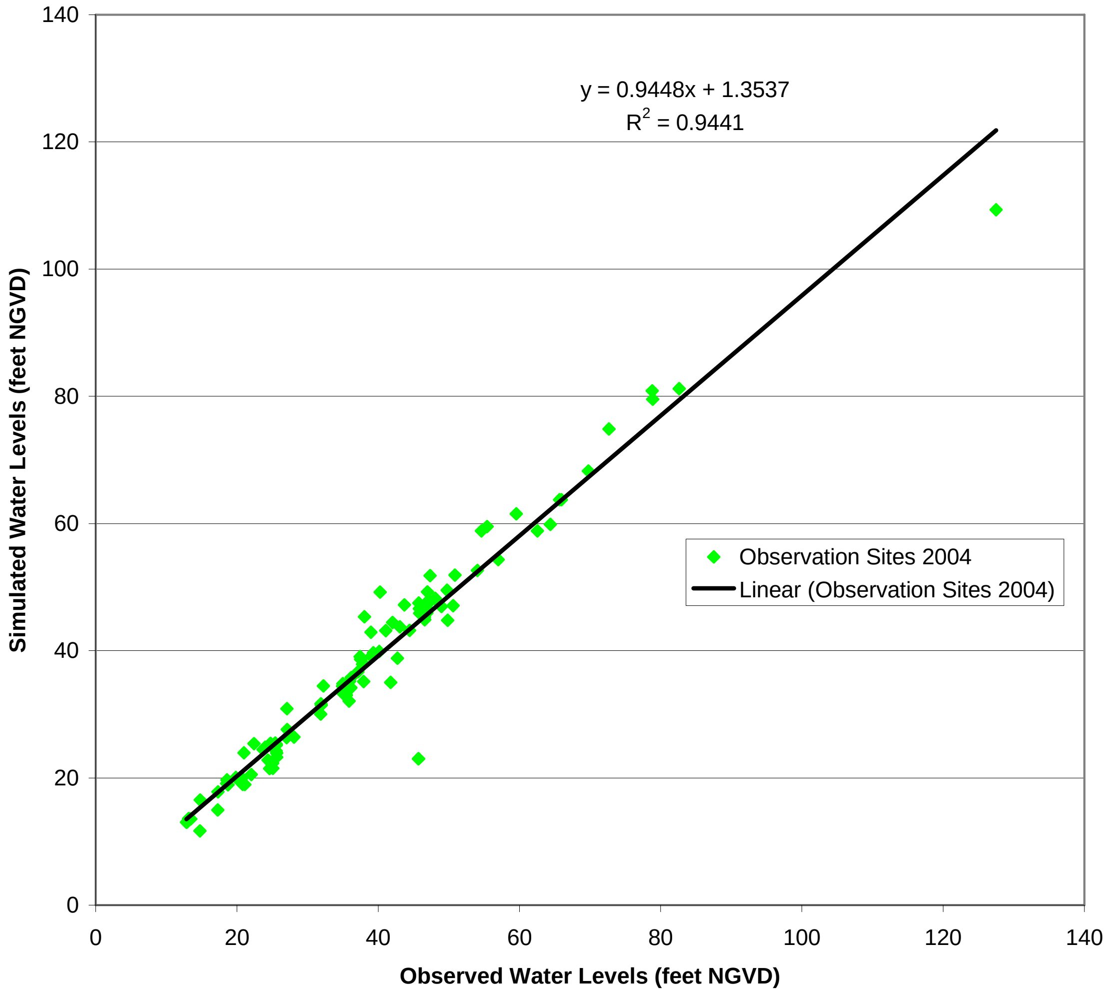

Figure 101. Observed vs. Simulated Water Levels in Observation Sites (2004 Conditions).

Table 23. Observation Sites 2004 vs. Observation Sites 1995.

Station	Average Observed Water Levels 2004	Simulated Water Levels 2004	Average Diff.	Average Observed Water Levels 1995	Simulated Water Levels 1995	Average Diff.
MAXCEY N_G	62.54	58.84	3.70	63.56	62.69	0.87
S65AX_H	47.00	46.51	0.49	46.33	41.98	4.35
S65A_H	46.55	45.29	1.26	46.40	45.51	0.89
IR-25_G	28.06	26.42	1.64	28.48	27.13	1.35
AVON P_G	127.51	109.34	18.17	128.78	114.14	14.64
C38.PINE	43.08	43.74	-0.66	43.08	44.08	-1.00
FTKISS	40.15	39.87	0.28	42.31	41.81	0.50
WEIR3_H	39.34	39.65	-0.31	42.24	42.37	-0.13
WEIR2_H	39.38	39.37	0.01	41.95	41.84	0.11
OK-3_G	59.56	61.53	-1.97	59.53	61.94	-2.41
BASSETT_G	42.02	44.42	-2.40	43.14	45.20	-2.06
S65C_H	34.97	34.42	0.55	33.81	33.48	0.33
OK-2_G	42.72	38.82	3.90	44.67	40.96	3.71
S68_H	39.01	39.12	-0.11	39.12	39.12	0
YATES M_H	23.72	24.45	-0.73	24.37	26.44	-2.07
S82_H	31.88	30.03	1.85	31.87	30.99	0.88
S83_H	31.89	31.66	0.23	31.97	34.31	-2.34
S84_H	24.04	24.83	-0.79	24.71	23.22	1.49
S154_H	22.02	20.55	1.47	20.28	19.19	1.09
S133_H	13.24	13.57	-0.33	13.57	13.57	0
NUBBC_H	18.73	18.90	-0.17	19.36	18.98	0.38
S75_H	25.57	25.31	0.26	25.78	25.64	0.14
S191_H	18.54	19.12	-0.58	19.12	19.12	0
S70_H	25.60	25.18	0.42	25.76	25.30	0.46
S127_H	13.46	13.56	-0.10	13.56	13.56	0
S72_H	20.68	20.00	0.68	20.77	19.18	1.59
S135_H	13.14	13.60	-0.46	13.60	13.60	0
H-15A_G	57.00	54.33	2.67	58.04	54.62	3.42
S129_H	12.97	13.06	-0.09	13.06	13.06	0
S131_H	12.87	13.04	-0.17	13.04	13.04	0
NIOC3	17.33	17.83	-0.50	17.99	17.92	0.07
NICO1	14.75	11.67	3.08	13.99	12.07	1.92
CULV5A_H	14.80	16.52	-1.72	16.52	16.52	0
CLENNY DEEP NW/O AVON PK FL	82.61	81.19	1.42	83.05	81.29	1.76
BONNET LAKE DEEP NEAR SEBRING FL	78.78	80.88	-2.10	83.21	82.38	0.83

Table 23. Observation Sites 2004 vs. Observation Sites 1995 (Continued).

Station	Average Observed Water Levels 2004	Simulated Water Levels 2004	Average Diff.	Average Observed Water Levels 1995	Simulated Water Levels 1995	Average Diff.
727100-- 35S33E02 BASS WELL N OF BASSINGER (okf18)	45.82	46.59	-0.77	46.73	46.73	0
OKF-23	46.88	45.91	0.97	44.34	46.75	-2.41
OKF-31_G	48.95	47.96	1.99	49.85	47.34	2.51
LAKE PLACID GROVES DEEP SOUTH OF LAKE PLACID FL	47.36	51.80	-4.44	51.19	52.16	-0.97
71110501OBSER WELL GL155 NEAR BRIGHTON, FL.	46.88	47.20	-0.32	48.01	47.37	0.64
65411601 41S30E12 CLEMONS PALMDALE	49.75	49.50	0.25	49.90	49.51	0.39
S-65A(POF-20)WELL NR YEEHAW JUNCTION,FL	43.74	47.22	-3.48	46.30	47.40	-1.10
73911801 33S30E06 USAF AVON PARK #1	72.69	74.84	-2.15	77.79	75.40	2.39
OKF-34	45.76	47.52	-1.76	46.73	48.00	-1.27
OKF-42	46.94	47.78	-0.54	47.10	47.79	-0.69
FTB18	46.99	49.24	-2.25	49.23	49.31	-0.08
FTB20	46.79	47.49	-0.70	48.52	48.08	0.44
FTB17	47.19	47.78	-0.59	49.80	48.65	1.15
FTB19	48.15	48.03	0.12	48.92	48.17	0.75
ROMP 28 FLORIDAN WELL NR LAKE PLACID FL	69.76	68.25	1.51	70.13	68.39	1.74
FTB45	48.09	48.25	-0.16	49.79	48.19	1.60

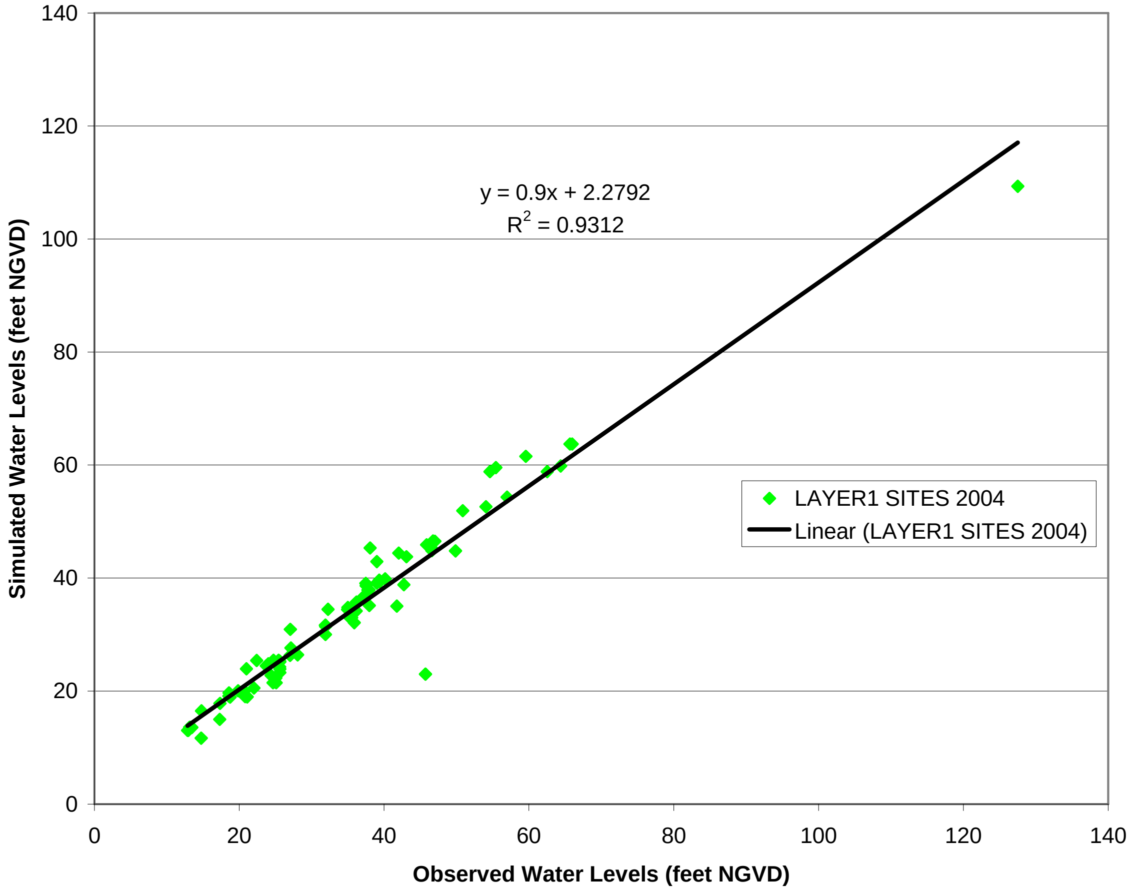

Figure 102. Observed vs. Simulated Water Levels in Observation Sites Layer 1 (2004 Conditions).

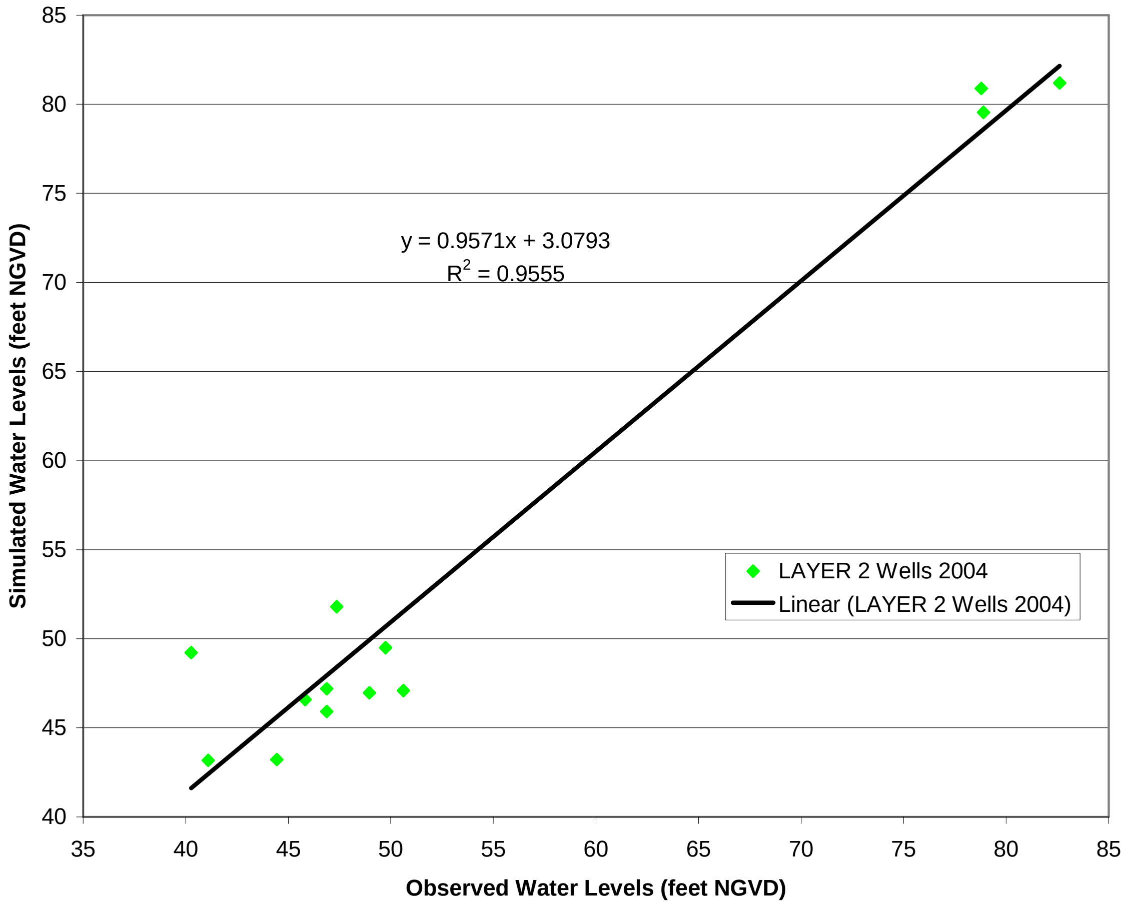

Figure 103. Observed vs. Simulated Water Levels in Observation Sites Layer 2 (2004 Conditions).

Table 24. Observed vs. Simulated Water Level 2004, Layer 1.

Layer	Row	Col	Station	Average Observed Water Levels 2004	Simulated Water Levels 2004	Avg Diff	Abs (Diff)	Met Calibration Criteria
1	2	59	KRENNM1	46.75	46.55	0.20	0.20	True
1	2	71	ELMAX_G	65.68	63.74	1.94	1.94	True
1	3	59	KREFFS	45.72	22.99	1.12	1.12	True
1	3	59	KREFFM	45.72	22.99	1.12	1.12	True
1	6	60	RATHAM	49.86	44.79	5.07	5.07	
1	12	78	MAXCEY N_G	62.54	58.84	3.70	3.70	True
1	15	64	S65AX_H	47.00	46.51	0.49	0.49	True
1	15	65	S65A_H	46.55	45.29	1.26	1.26	True
1	15	107	IR-25_G	28.06	26.42	1.64	1.64	True
1	19	48	AVON P_G	127.51	109.34	18.17	18.17	
1	21	64	C38.PINE	43.08	43.74	-0.66	0.66	True
1	24	62	FTKISS	40.15	39.87	0.28	0.28	True
1	26	61	WEIR3_H	39.34	39.65	-0.31	0.31	True
1	28	59	WEIR2_H	39.38	39.37	0.01	0.01	True
1	30	78	PEAVINE_G	64.39	59.84	4.55	4.55	
1	31	68	MAXCEYS_G	54.06	52.62	1.44	1.44	True
1	36	57	PC61_H	38.98	42.89	-3.91	3.91	True
1	38	57	PC53	37.79	37.86	-0.07	0.07	True
1	38	58	KRCFFM	37.90	37.95	-0.05	0.05	True
1	38	89	GRIFFITH_G	65.96	63.74	2.22	2.22	True
1	38	105	OK-3_G	59.56	61.53	-1.97	1.97	True
1	39	56	KRDNNM1	37.96	35.14	2.82	2.82	True
1	41	61	PC41	37.46	39.05	-1.59	1.59	True
1	41	63	MICCO_G	46.59	44.86	1.73	1.73	True
1	42	60	KRAFFS	41.76	35.02	6.74	6.74	
1	42	61	PC42	37.13	36.70	0.43	0.43	True
1	43	38	SEBRING_G	55.42	59.54	-4.12	4.12	.
1	43	59	PC44	36.19	35.77	0.42	0.42	True
1	44	63	PC32	35.96	35.20	0.76	0.76	True
1	44	65	PC31	37.93	37.88	0.05	0.05	True
1	45	55	MCARTH_G	50.87	51.90	-1.03	1.03	True
1	45	61	PC34	35.87	32.08	3.79	3.79	True
1	46	60	PC35	35.76	33.86	1.90	1.90	True
1	48	56	H-11A_G	45.85	45.88	-0.03	0.03	True
1	48	63	PC21	35.36	34.46	0.09	0.09	True
1	49	61	PC22	35.50	33.10	2.49	2.49	True
1	49	90	BASSETT_G	42.02	44.42	-2.40	2.40	True
1	50	64	PC12	35.06	33.25	1.81	1.81	True
1	50	65	PC11R	35.00	34.80	0.20	0.20	True
1	51	67	S65C_H	34.97	34.42	0.55	0.55	True
1	51	86	CYPRS	37.53	38.64	-1.11	1.11	True
1	51	103	TAYLC.O1_H	54.61	58.84	-4.23	4.23	

Table-24. Observed vs. Simulated Water Level 2004, Layer 1 (Continued).

Layer	Row	Col	Station	Average Observed Water Levels 2004	Simulated Water Levels 2004	Avg Diff	Abs (Diff)	Met Calibration Criteria
1	52	78	OK-2_G	42.72	38.82	3.90	3.90	True
1	52	81	CHAND1	32.26	34.47	-2.21	2.21	True
1	53	100	RUCKGW2	38.06	45.32	-7.26	7.26	
1	56	77	PD03F	27.13	27.62	-0.49	0.49	True
1	58	75	PD02R	27.07	30.89	-3.82	3.82	True
1	60	50	S68_H	39.01	39.12	-0.11	0.11	True
1	61	76	PD01F	27.03	26.31	0.72	0.72	True
1	61	89	FLYGW2	36.14	34.17	1.97	1.97	True
1	61	108	OPAL_G	31.95	31.44	0.51	0.51	True
1	62	100	ARS_B0_G	22.41	25.40	-2.99	2.99	True
1	64	81	YATES M_H	23.72	24.45	-0.73	0.73	True
1	65	102	TAYLC.WD	19.84	20.06	-0.22	0.22	True
1	68	56	S82_H	31.88	30.03	1.85	1.85	True
1	68	57	S83_H	31.89	31.66	0.23	0.23	True
1	73	94	G80_H	21.12	18.97	2.15	2.15	True
1	74	108	MOSQC_T	18.58	19.69	-1.11	1.11	True
1	75	85	S65E_H	20.99	23.95	-2.96	2.96	True
1	76	84	S84_H	24.04	24.83	-0.79	0.79	True
1	77	91	S154_H	22.02	20.55	1.47	1.47	True
1	77	105	S133_H	13.24	13.57	-0.33	0.33	True
1	78	112	NUBBC_H	18.73	18.90	-0.17	0.17	True
1	79	65	S75_H	25.57	25.31	0.26	0.26	True
1	79	110	S191_H	18.54	19.12	-0.58	0.58	True
1	83	119	L64C_H	20.82	19.02	1.80	1.80	True
1	86	58	BUCK13_G	24.41	22.78	1.63	1.63	True
1	86	59	BUCK15_G	24.64	21.47	3.17	3.17	True
1	86	60	BUCK19_G	24.88	21.63	3.25	3.25	True
1	87	54	BUCK01_G	25.57	24.26	1.31	1.31	True
1	87	55	BUCK06_G	25.44	25.26	0.18	0.18	True
1	87	56	BUCK07_G	25.44	25.48	-0.04	0.04	True
1	87	57	BUCK11_G	25.41	25.38	0.03	0.03	True
1	87	58	BUCK20_G	24.73	25.45	-0.72	0.72	True
1	88	54	BUCK04_G	25.62	23.91	1.71	1.71	True
1	88	55	BUCK05_G	25.63	23.26	2.37	2.37	True
1	88	56	BUCK09_G	25.05	22.32	2.73	2.73	True
1	88	57	BUCK10_G	25.09	21.50	3.59	3.59	True
1	89	61	S70_H	25.60	25.18	0.42	0.42	True
1	89	94	S127_H	13.46	13.56	-0.10	0.10	True
1	93	80	S72_H	20.68	20.00	0.68	0.68	True
1	94	122	S135_H	13.14	13.60	-0.46	0.46	True
1	101	39	H-15A_G	57.00	54.33	2.67	2.67	True
1	101	72	G76_H	17.30	14.96	2.34	2.34	True
1	102	81	S129_H	12.97	13.06	-0.09	0.09	True

Table 24. Observed vs. Simulated Water Level 2004, Layer 1 (Continued).

Layer	Row	Col	Station	Average Observed Water Levels 2004	Simulated Water Levels 2004	Avg Diff	Abs (Diff)	Met Calibration Criteria
1	109	70	S131_H	12.87	13.04	-0.17	0.17	True
1	119	63	NIOC3	17.33	17.83	-0.50	0.50	True
1	122	64	NICO1	14.75	11.67	3.08	3.08	True
1	122	66	CULV5A_H	14.80	16.52	-1.72	1.72	True
							92.13%	**82**

Table 25. Observed vs. Simulated Water Level 2004, Layer 2.

Layer	Row	Col	Station	Average Observed Water Levels 2004	Simulated Water Levels 2004	Avg Diff	Abs (Diff)	Met Calibration Criteria
2	2	59	KRENND	50.62	47.09	3.53	3.53	
2	6	84	OSF-42	44.44	43.21	1.23	1.23	True
2	10	93	OSF-60A TEST WELL AT YEEHAW JUNCTION,FL	41.10	43.17	-2.07	2.07	True
2	17	15	CLENNY DEEP NW/O AVON PK FL	82.61	81.19	1.42	1.42	True
2	30	26	BONNET LAKE DEEP NEAR SEBRING FL	78.78	80.88	-2.10	2.10	True
2	35	32	JOHN MCCULLOCH WELL 11 NEAR SEBRING FL	78.89	79.54	-0.65	0.65	True
2	43	79	727100-- 35S33E02 BASS WELL N OF BASSINGER (okf18)	45.82	46.59	-0.77	0.77	True
2	71	99	OKF-23	46.88	45.91	0.97	0.97	True
2	74	100	OKF-31_G	48.95	46.96	1.99	1.99	True
2	77	39	LAKE PLACID GROVES DEEP SOUTH OF LAKE PLACID FL	47.36	51.80	-4.44	4.44	
2	79	69	71110501OBSER WELL GL155 NEAR BRIGHTON, FL.	46.88	47.20	-0.32	0.32	True
2	116	42	65511803OBSER WELL GL267 NEAR PALMDALE, FL.	40.27	49.22	-8.95	8.95	
2	117	46	65411601 41S30E12 CLEMONS PALMDALE	49.75	49.50	0.25	0.25	True
							76.92%	**10**

Table 26. Observed vs. Simulated Water Level 2004, Layer 3.

Layer	Row	Col	Station	Average Observed Water Levels 2004	Simulated Water Levels 2004	Avg Diff	Abs (Diff)	Met Calibration Criteria
3	15	64	S-65A(POF-20)WELL NR YEEHAW JUNCTION,FL	43.74	47.22	-3.48	3.48	
3	16	38	73911801 33S30E06 USAF AVON PARK #1	72.69	74.84	-2.15	2.15	True
3	32	78	OKF-34	45.76	47.52	-1.76	1.76	True
3	51	66	OKF-42	46.94	47.48	-0.54	0.54	True
3	53	53	FTB18	46.99	49.24	-2.25	2.25	True
3	54	66	FTB20	46.79	47.49	-0.70	0.70	True
3	57	62	FTB17	47.19	47.78	-0.59	0.59	True
3	65	72	FTB19	48.15	48.03	0.12	0.12	True
3	69	39	ROMP 28 FLORIDAN WELL NR LAKE PLACID FL	69.76	68.25	1.51	1.51	True
3	73	73	FTB45	48.09	48.25	-0.16	0.16	True
							90.00%	**9**

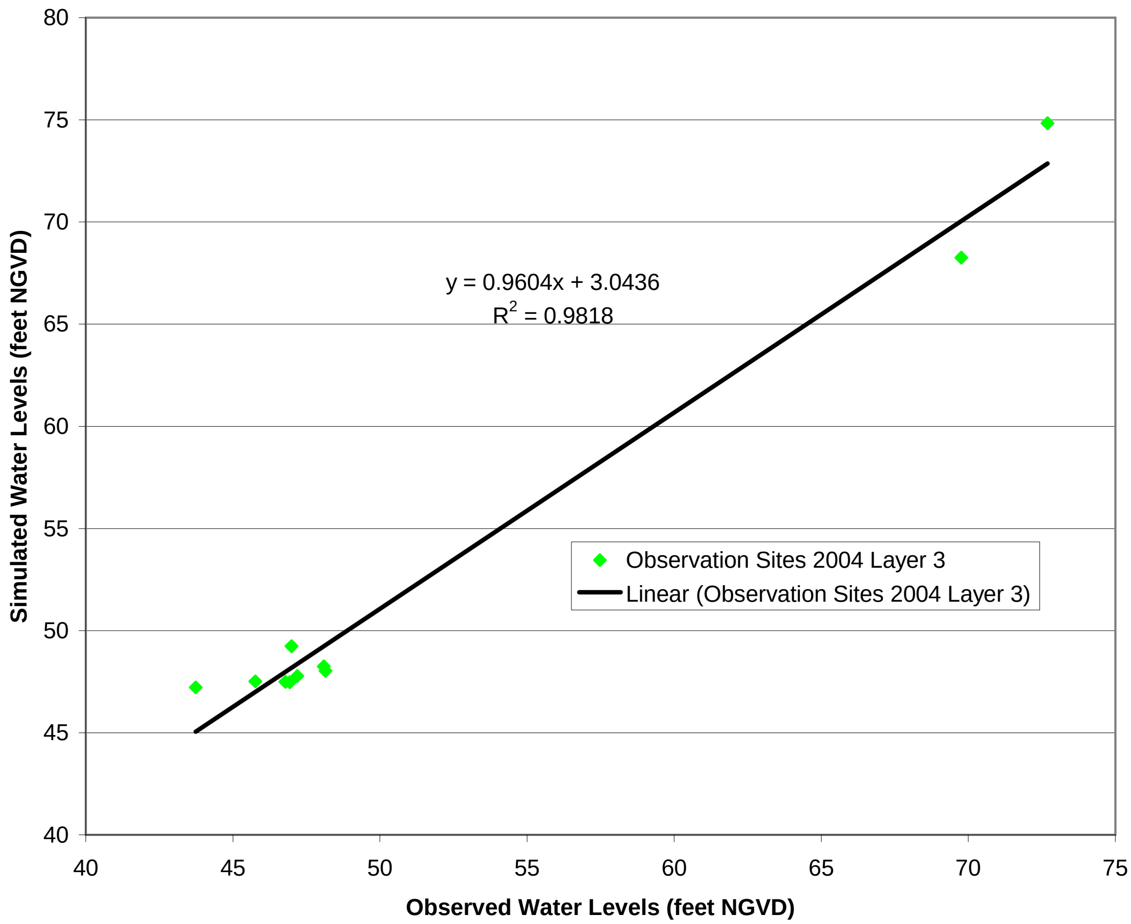

Figure 104. Observed vs. Simulated Water Levels in Observation Sites Layer 3 (2004 Conditions).

The water levels in the Surficial Aquifer System were lower in 2004 for most of the model area. Only some areas near Lake Wales Ridge had water levels that were higher in 2004 (**Figure 105**).

In the Upper Floridan Aquifer, the mean difference in water levels between 1995 and 2004 was 0.25 feet, with the water levels being lower in 2004 (**Figure 106**). In Blue Cypress Marsh, the water levels dropped by 0.75 feet for most of the marsh and up to 2 feet near the SFWMD district boundary and the boundaries of St. Lucie and Okeechobee counties.

In the Middle Floridan Aquifer, the mean difference in water levels between 1995 and 2004 was 0.14 feet, with the water levels being lower in 2004 (**Figure 107**).

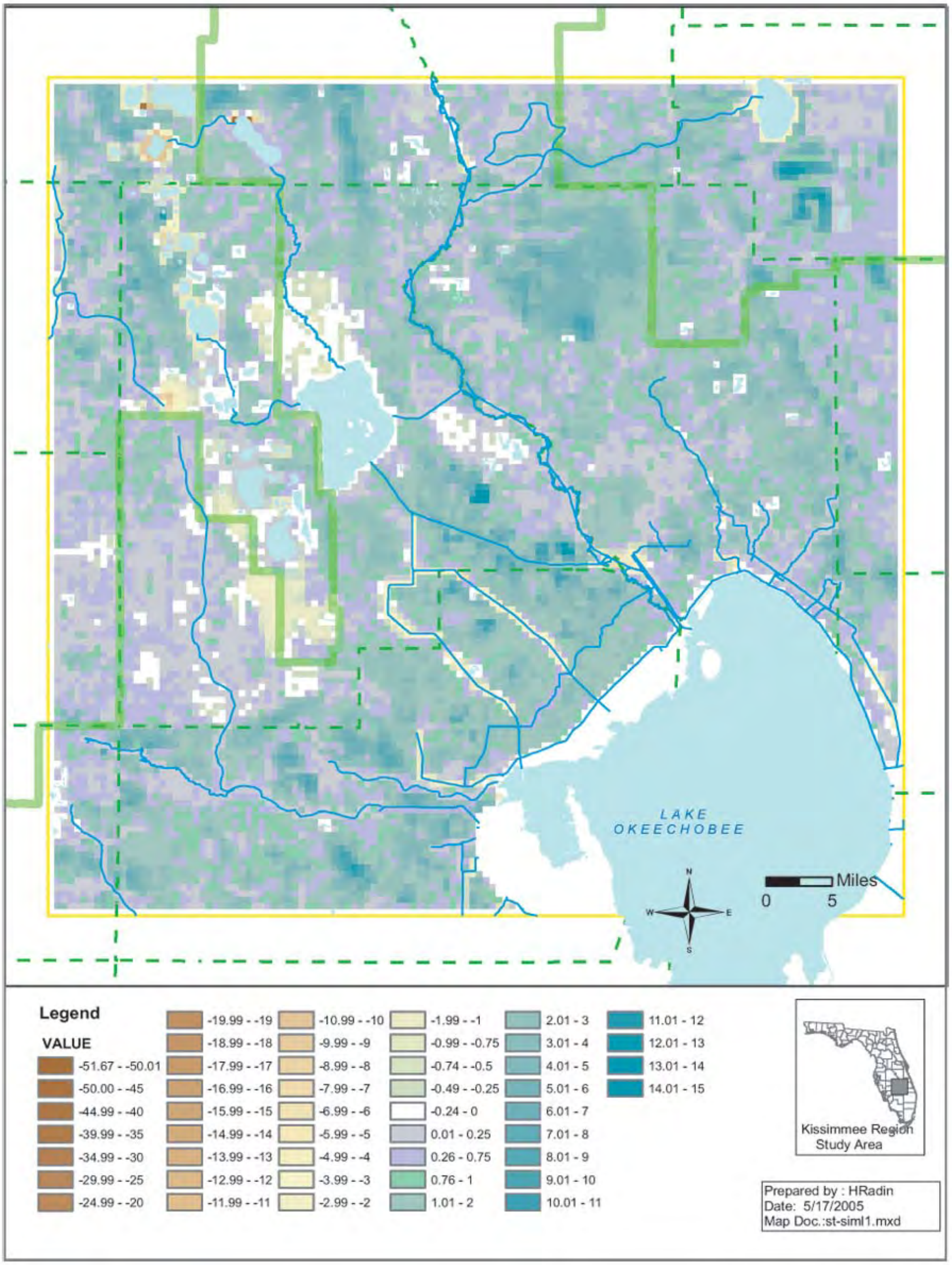

Figure 105. Difference in Water Levels 1995 AG and 2004 AG Surficial Aquifer.

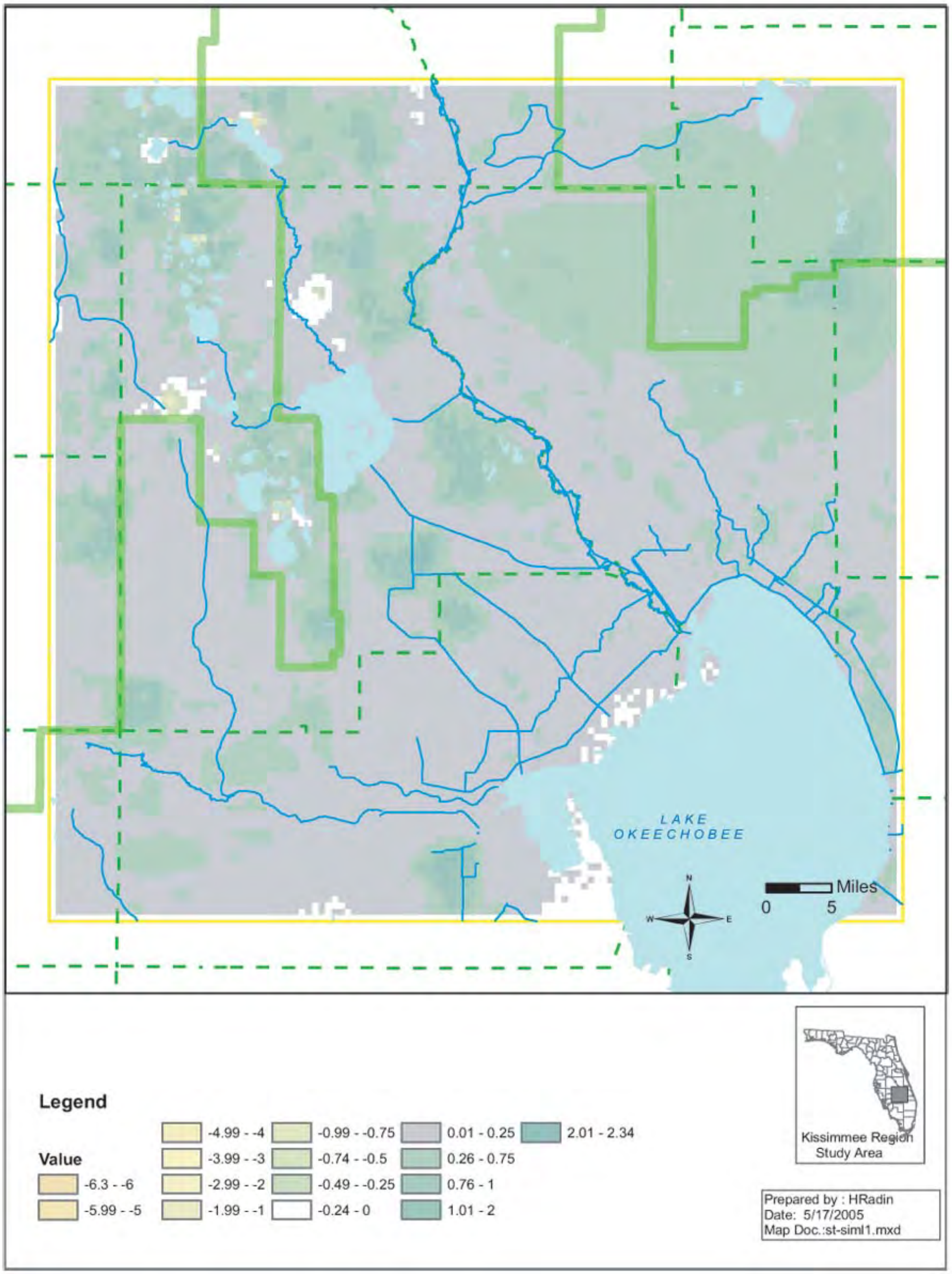

Figure 106. Difference in Water Levels 1995 AG and 2004 AG Upper Floridan Aquifer.

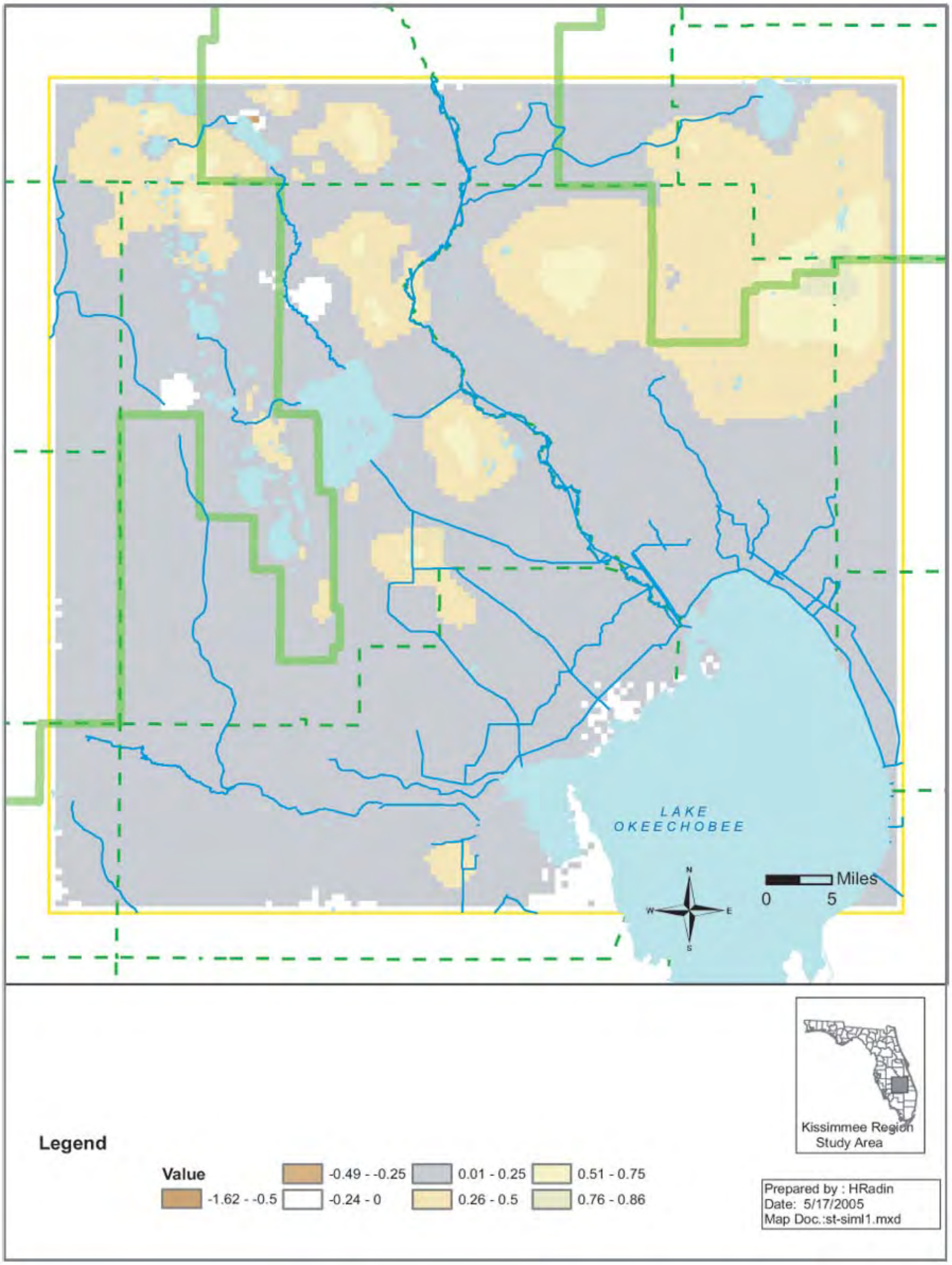

Figure 107. Difference in Water Levels 1995 AG and 2004 AG Middle Floridan Aquifer.

Model Limitations

A model is a tool used to represent an approximation of field data, and is built to assist in understanding the groundwater flow system. This model is a steady-state model and therefore, represents a state of equilibrium under averaged stresses. In reality, the stresses vary with time. The model also averages the hydrologic properties and stresses for each cell in model grid. Each cell of 2,640 ft^2 can only have one value for each property represented in the model. When the values do not vary much from the average, it does not matter, but in some cases there may be a large range of topographic relief or variability in soils that would affect evapotranspiration and recharge, and influence the simulation of the water levels in the Surficial Aquifer System. Variability of the evapotranspiration extinction depth and evapotranspiration surfaces averaged across a model cell would also have a bigger impact on the water levels in the Surficial Aquifer. The effects of the pumping stresses are also diminished when using large scale discretization vs. a finer discretization.

Another distortion occurs because MODFLOW assumes that all of the water is being pumped from the center of the cell. The MODFLOW model simplifies the hydrostratigraphy in the model area. The MODFLOW system assumes horizontal flow in the aquifers and vertical flow through the confining units. In some areas, there may be zones of preferential flow, which are not represented as layers themselves. The Intermediate Confining Unit was modeled as a confining unit, but in reality it may have areas of confinement and areas in which it behaves more as an aquifer.

The model results are limited by the accuracy of the input data. The evapotranspiration values were estimated using temperature data from points and applying the value for a whole Thiessen polygon. Average rainfall data for 1995 were used for the calibration and also were applied to Thiessen polygons. Agricultural consumptive use is not metered within the SFWMD, therefore stresses needed to be estimated. For model calibration, permitted water use values were used. For the predictive runs, the stresses were estimated based on land use and crop type. Few geologic logs were available in the model area to obtain hydrostratigraphic data, so most hydraulic conductivity, transmissivity and even the picks for the tops and bottom of the layers were estimated. The sparse point data available needed to be interpolated into surface data to be used in the models.

CHAPTER 6
Summary and Conclusions

SUMMARY AND CONCLUSIONS

The Lower Kissimmee Groundwater Model focuses on the Glades, Okeechobee and Highlands counties. The Floridan Aquifer System is the primary source of drinking water in the model area. The primary objective of this model was to create a modeling tool to assist in evaluating impacts on new stresses (increased consumptive use) on the Floridan Aquifer System. In order to effectively evaluate the Floridan Aquifer System, the Surficial Aquifer System was activated. The model assists in understanding the whole hydrologic water budget of the area. Although in most of model area the Intermediate Aquifer System serves as a barrier between the Surficial Aquifer System and the Floridan Aquifer System, the Intermediate Aquifer System is breached in some locations by sinkholes and other more permeable zones. In the breached areas, there is direct connection between the aquifers.

This model incorporates new information on the hydrostratigraphy in the model area. The Upper Floridan Aquifer System is now being modeled as two model layers the Upper Floridan Aquifer, which has low transmissivities, and the Middle Floridan Aquifer with very high transmissivities. In some portions of the model, these aquifers are connected, but in other area the aquifers are separated by a thick semi-confining unit.

The modeling efforts indicate that some water is coming into the Middle Floridan Aquifer from the Lower Floridan Aquifer. This agrees with the observation by Reese and Richardson (2004) that Middle Confining Unit 2 may be fractured in some locations. More data are needed from Lower Floridan Aquifer to validate and ascertain the extent of the interaction with the Middle Floridan Aquifer.

The resulting model is a four-layer, steady-state model calibrated to 1995 average conditions. Due to the model limitations, the scale of the grid cells and the highly variable topography within some model cells (especially along the Lake Wales Ridge), the model accuracy of the water levels in the Surficial Aquifers is limited in those areas. Despite this limitation the average head difference between simulated and observed water levels in the Surficial Aquifer was less than a foot. In the Upper Floridan Aquifer, the average difference was 1.12 feet and in the Middle Floridan 1.5 feet with only two observation wells in each of these layers not meeting the +2.5/-2.5 foot calibration criteria. R^2[1] is 0.99 and 0.98 respectively for the Upper and Middle Floridan Aquifers.

[1] R^2 is a number from 0 to 1 that reveals how closely estimated values for a trend line correspond to the actual data. A trend lane is most reliable when the R^2 is at or near 1.

Thus the calibrated model gives reasonable estimates of the water levels in the Upper and Middle Floridan Aquifers.

Further gathering of data for the area, especially hydraulic parameters and any data on the Lower Floridan would be helpful for future work and refinement of the model. Additional data might also enable modification of the model to a transient model, but this can not be done when water levels are only measured twice a year in most observation wells.

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APPENDIX A
Temperature and ET Stations

A-2

Table A-1. Temperature and ET Stations.

Station	NOAAID/DBKey	Source
WAUCHULA 2 N	89401	NOAA
VERO 4W_R	06192 & 16637	DBHYDRO
OKEECHOBEE HRCN GATE 6	86485	NOAA
FORT PIERCE	83207	NOAA
FORT PIERCE ARC	83209	NOAA
AVON PARK 2 W	80369	NOAA
MOUNTAIN LAKE	85973	NOAA
ARCHBOLD BIO STATION	80236	NOAA
BARTOW	80478	NOAA
FORT DRUM 5 NW	83137	NOAA
STUART 1_R	06187	DBHYDRO

A-4

APPENDIX B
Public Water Supply

Table B-1. Public Water Supply and Industrial Wells.

LAYER	ROW	COLUMN	PUMP CUBIC feet/ day	PERMIT _NO	PERMIT _NO	PERMIT _NO	PERMIT NO	WELL_ DEPTH	CASE_D EPTH	PERMIT_ TYPE	LU CODE	DISTRICT
1	4	11	-85.90	9326	0	2		-113.74			PWS	SWFWMD
1	6	10	-687.22	11070	1	1		-137.22	-7.22		PWS	SWFWMD
1	13	36	-5823.38	53-00090-W				1000	262	IND	PWS	SFWMD
1	14	36	-5823.38	53-00090-W				1000	262	IND	PWS	SFWMD
1	15	64	-4326.34	47-00381-W				100	0	GP	PWS	SFWMD
1	16	37	-5823.38	53-00090-W				1000	262	IND	PWS	SFWMD
1	23	102	-274.73	10864	2-093-0003ANM2FG		24915	-29.91	-21.91		ci	SJRWMD
1	23	102	-274.73	10864	2-093-0003ANM2FG		24916	-29.91	-21.91		ci	SJRWMD
1	23	102	-274.73	10864	2-093-0003ANM2FG		24917	-29.91	-19.91		ci	SJRWMD
1	23	102	-274.73	10864	2-093-0003ANM2FG		24918	-29.91	-21.91		ci	SJRWMD
1	24	25	-95.07	8504	0	1		-110.43	19.57		PWS	SWFWMD
1	29	119	-9671.58	47-00425-W				120	80	GP	PWS	SFWMD
1	29	119	-9671.58	47-00425-W				0	0	GP	PWS	SFWMD
1	29	119	-9671.58	47-00425-W				0	0	GP	PWS	SFWMD
1	31	118	-9671.58	47-00425-W				0	0	GP	PWS	SFWMD
1	31	118	-9671.58	47-00425-W				0	0	GP	PWS	SFWMD
1	35	43	-49247.30	28-00380-W				700	200	GP	PWS	SFWMD
1	45	44	-26523.00	28-00391-W				70	60	GP	PWS	SFWMD
1	45	44	-39338.90	28-00427-W				110	85	GP	PWS	SFWMD
1	45	45	0.00	28-00402-W				225	205	GP	PWS	SFWMD
1	46	41	-7094.77	28-00122-W				1150	350	IND	PWS	SFWMD
1	46	41	-11824.62	28-00122-W				900	300	IND	PWS	SFWMD
1	46	42	-11824.62	28-00122-W				1000	350	IND	PWS	SFWMD
1	46	49	0.00	28-00355-W				480	258	GP	PWS	SFWMD

Table B-1. Public Water Supply and Industrial Wells (Continued).

LAYER	ROW	COLUMN	PUMP CUBIC feet/ day	PERMIT _NO	PERMIT _NO	PERMIT _NO	PERMIT NO	WELL_ DEPTH	CASE_D EPTH	PERMIT_ TYPE	LU CODE	DISTRICT
1	49	103	-2209.84	47-00378-W				160	140	GP	PWS	SFWMD
1	49	103	-2209.84	47-00378-W				160	140	GP	PWS	SFWMD
1	49	104	-4420.93	47-00391-W				160	140	GP	PWS	SFWMD
1	49	104	-4420.93	47-00391-W				160	140	GP	PWS	SFWMD
1	50	67	-4326.34	47-00381-W				100	0	GP	PWS	SFWMD
1	50	107	-21392.00	47-00421-W				800	550	IND	PWS	SFWMD
1	51	100	-42.95	47-00485-W				100	0	GP	PWS	SFWMD
1	51	107	-21392.00	47-00421-W				800	550	IND	PWS	SFWMD
1	52	29	-4876.55	4167	1	1		10			PWS	SWFWMD
1	52	102	-54832.30	47-00369-W				120	100	GP	PWS	SFWMD
1	54	66	0.00	28-00290-W				300	230	GP	PWS	SFWMD
1	54	66	0.00	28-00290-W				230	200	GP	PWS	SFWMD
1	54	66	-114.54	28-00317-W				300	160	GP	PWS	SFWMD
1	54	103	-4805.99	47-00487-W				125	84	GP	PWS	SFWMD
1	54	105	-2031.51	47-00348-W				94	94	GP	PWS	SFWMD
1	56	103	-3966.02	47-00438-W				100	0	GP	PWS	SFWMD
1	57	75	0.00	28-00379-W				267	190	GP	PWS	SFWMD
1	57	75	0.00	28-00379-W				265	190	GP	PWS	SFWMD
1	59	118	-10131.70	47-00408-W				130	120	GP	PWS	SFWMD
1	60	102	-386.36	47-00306-W				84	84	GP	PWS	SFWMD
1	63	78	-4326.34	47-00381-W				100	0	GP	PWS	SFWMD
1	63	93	-27125.20	47-00380-W				120	100	GP	PWS	SFWMD
1	64	46	-57250.20	28-00375-W				170	70	GP	PWS	SFWMD

Table B-1. Public Water Supply and Industrial Wells (Continued).

LAYER	ROW	COLUMN	PUMP CUBIC feet/ day	PERMIT _NO	PERMIT _NO	PERMIT _NO	PERMIT NO	WELL_ DEPTH	CASE_D EPTH	PERMIT_ TYPE	LU CODE	DISTRICT
1	64	46	-57250.20	28-00375-W				170	70	GP	PWS	SFWMD
1	64	46	-57250.20	28-00375-W				170	70	GP	PWS	SFWMD
1	64	103	-343.61	47-00059-W				160	135	IND	PWS	SFWMD
1	64	103	-343.61	47-00059-W				160	135	IND	PWS	SFWMD
1	64	103	-343.61	47-00059-W				750	600	IND	PWS	SFWMD
1	66	102	-116884.00	47-00372-W				120	100	GP	PWS	SFWMD
1	66	102	-6777.55	47-00233-W				100	75	GP	PWS	SFWMD
1	66	113	-85.90	47-00483-W				125	105	GP	PWS	SFWMD
1	66	118	-148.03	47-00492-W				60	0	GP	PWS	SFWMD
1	66	118	-1636.48	47-00382-W				125	84	GP	PWS	SFWMD
1	66	118	-6807.56	47-00239-W				100	75	GP	PWS	SFWMD
1	67	100	-6047.47	47-00499-W				80	0	GP	PWS	SFWMD
1	67	100	-6047.47	47-00499-W				80	0	GP	PWS	SFWMD
1	67	102	-34716.00	47-00286-W				140	100	GP	PWS	SFWMD
1	67	103	-4131.17	47-00477-W				80	60	GP	PWS	SFWMD
1	68	102	-45095.20	47-00308-W				100	73	GP	PWS	SFWMD
1	69	96	-17541.80	47-00289-W				70	60	GP	PWS	SFWMD
1	69	118	-6293.86	47-00376-W				140	100	GP	PWS	SFWMD
1	69	118	-6293.86	47-00376-W				140	100	GP	PWS	SFWMD
1	70	102	-9385.74	47-00004-W				155	100	IND	PWS	SFWMD
1	70	102	-9385.74	47-00004-W				165	90	IND	PWS	SFWMD
1	70	102	-9385.74	47-00004-W				155	80	IND	PWS	SFWMD

Table B-1. Public Water Supply and Industrial Wells (Continued).

LAYER	ROW	COLUMN	PUMP CUBIC feet/ day	PERMIT _NO	PERMIT _NO	PERMIT _NO	PERMIT NO	WELL_ DEPTH	CASE_D EPTH	PERMIT_ TYPE	LU CODE	DISTRICT
1	70	103	-9385.74	47-00004-W				175	100	IND	PWS	SFWMD
1	70	103	-9385.74	47-00004-W				175	100	IND	PWS	SFWMD
1	70	103	-9385.74	47-00004-W				175	100	IND	PWS	SFWMD
1	70	103	-9385.74	47-00004-W				175	100	IND	PWS	SFWMD
1	71	58	0.00	28-00437-W				120	100	GP	PWS	SFWMD
1	71	99	-5523.76	47-00309-W				156	96	GP	PWS	SFWMD
1	71	99	-5523.76	47-00309-W				150	130	GP	PWS	SFWMD
1	71	99	-5523.76	47-00309-W				100	90	GP	PWS	SFWMD
1	71	99	-28.80	47-00424-W				90	80	GP	PWS	SFWMD
1	71	106	0.00	47-00480-W				200	0	GP	PWS	SFWMD
1	71	106	0.00	47-00480-W				200	0	GP	PWS	SFWMD
1	71	106	0.00	47-00480-W				200	0	GP	PWS	SFWMD
1	71	106	0.00	47-00480-W				200	0	GP	PWS	SFWMD
1	71	107	-4326.34	47-00381-W				100	0	GP	PWS	SFWMD
1	71	107	-4326.34	47-00381-W				100	0	GP	PWS	SFWMD
1	72	58	0.00	28-00437-W				120	100	GP	PWS	SFWMD
1	72	58	0.00	28-00437-W				120	100	GP	PWS	SFWMD
1	72	58	0.00	28-00437-W				120	100	GP	PWS	SFWMD
1	72	91	-10205.90	47-00240-W				100	90	GP	PWS	SFWMD
1	74	85	-4326.34	47-00381-W				100	0	GP	PWS	SFWMD
1	74	103	-12383.70	47-00280-W				160	130	IND	PWS	SFWMD
1	74	103	-12383.70	47-00280-W				160	130	IND	PWS	SFWMD
1	76	25	0.00	28-00344-W				550	500	GP	PWS	SFWMD

Table B-1. Public Water Supply and Industrial Wells (Continued).

LAYER	ROW	COLUMN	PUMP CUBIC feet/ day	PERMIT _NO	PERMIT _NO	PERMIT _NO	PERMIT NO	WELL_ DEPTH	CASE_D EPTH	PERMIT_ TYPE	LU CODE	DISTRICT
1	77	69	-26071.50	22-00183-W				1000	500	IND	PWS	SFWMD
1	77	69	-26071.50	22-00183-W				1000	480	IND	PWS	SFWMD
1	77	104	-1839.59	47-00251-W				180	140	GP	PWS	SFWMD
1	77	104	-1839.59	47-00251-W				60	50	GP	PWS	SFWMD
1	78	108	-5523.76	47-00324-W				84	63	GP	PWS	SFWMD
1	79	109	-95.07	47-00482-W				53	42	GP	PWS	SFWMD
1	79	111	-10205.90	47-00250-W				100	95	GP	PWS	SFWMD
1	79	111	-4131.17	47-00481-W				0	0	GP	PWS	SFWMD
1	79	112	-13156.80	47-00241-W				140	120	GP	PWS	SFWMD
1	79	112	-13156.80	47-00241-W				140	120	GP	PWS	SFWMD
1	80	111	-148.03	47-00486-W				40	30	GP	PWS	SFWMD
1	80	113	-3935.10	47-00411-W				78	58	GP	PWS	SFWMD
1	81	113	-3935.10	47-00392-W				96	76	GP	PWS	SFWMD
1	81	130	-26523.00	43-00659-W				0	0	GP	PWS	SFWMD
1	81	130	-26523.00	43-00659-W				100	80	GP	PWS	SFWMD
1	83	130	-26523.00	43-00659-W				1065	405	GP	PWS	SFWMD
1	84	117	-1687.23	47-00451-W				45	35	GP	PWS	SFWMD
1	86	118	-42.95	47-00484-W				50	48	GP	PWS	SFWMD
1	91	37	-57250.20	28-00461-W				170	100	GP	PWS	SFWMD
1	95	127	0.00	43-01061-W				100	60	GP	PWS	SFWMD
1	95	127	0.00	43-01061-W				105	95	GP	PWS	SFWMD
1	109	11	0.00	08-00077-W				120	100	GP	PWS	SFWMD
1	111	43	-12.04	22-00198-W				120	100	GP	PWS	SFWMD
1	113	9	0.00	08-00077-W				120	100	GP	PWS	SFWMD
1	113	10	0.00	08-00086-W				300	100	GP	PWS	SFWMD

Table B-1. Public Water Supply and Industrial Wells (Continued).

LAYER	ROW	COLUMN	PUMP CUBIC feet/ day	PERMIT _NO	PERMIT _NO	PERMIT _NO	PERMIT NO	WELL_ DEPTH	CASE_D EPTH	PERMIT_ TYPE	LU CODE	DISTRICT
1	124	53	0.00	22-00045-W				120	60	IND	PWS	SFWMD
1	124	53	0.00	22-00045-W				120	60	IND	PWS	SFWMD
1	124	54	0.00	22-00045-W				110	55	IND	PWS	SFWMD
1	124	54	0.00	22-00045-W				120	60	IND	PWS	SFWMD
1	125	54	-80.28	22-00184-W				200	145	GP	PWS	SFWMD
1	125	54	-80.28	22-00184-W				200	145	GP	PWS	SFWMD
1	129	14	-12.04	22-00194-W				45	25	GP	PWS	SFWMD
2	1	15	-34715.97	5870	6	4		-955	-80		PWS	SWFWMD
2	3	16	-17541.76	5870	6	1		-656	-69		PWS	SWFWMD
2	3	16	-386.36	5870	6	2		-656	-103		PWS	SWFWMD
2	4	11	-42.95	9326	0	3		-864			PWS	SWFWMD
2	5	12	-2209.84	6208	1	1		-760			PWS	SWFWMD
2	5	12	-28.80	7557	1	2		-260			PWS	SWFWMD
2	5	12	-4978.81	7557	1	4		-762	-176		PWS	SWFWMD
2	5	12	-4978.81	7557	1	1		-260			PWS	SWFWMD
2	5	12	-28.80	7557	1	3		-260			PWS	SWFWMD
2	5	13	-4326.34	6508	4	4		-852			PWS	SWFWMD
2	5	16	-45095.18	5870	6	5		-1079	-260		PWS	SWFWMD
2	6	11	-234.37	6508	4	9		-793	2		PWS	SWFWMD
2	7	23	-6293.86	6157	1	2		-605	-68		PWS	SWFWMD
2	7	23	-585.10	6157	1	1		-305			PWS	SWFWMD
2	8	12	-7320.96	6508	4	10		-685			PWS	SWFWMD
2	10	12	-1636.48	6508	4	11		-687	56		PWS	SWFWMD
2	15	37	-5823.38	53-00090-W				1035	288	IND	PWS	SFWMD

Table B-1. Public Water Supply and Industrial Wells (Continued).

LAYER	ROW	COLUMN	PUMP CUBIC feet/ day	PERMIT _NO	PERMIT _NO	PERMIT _NO	PERMIT NO	WELL_ DEPTH	CASE_D EPTH	PERMIT_ TYPE	LU CODE	DISTRICT
2	18	17	-4131.17	8063	1	1		-1052.02			PWS	SWFWMD
2	19	17	-343.61	4790	2	1		-226			PWS	SWFWMD
2	21	22	-4753.26	7990	1	2		-441	-91		PWS	SWFWMD
2	24	17	-54832.27	6029	2	4		-1195	-274		PWS	SWFWMD
2	24	17	-116884.21	6029	2	3		-843			PWS	SWFWMD
2	24	18	-2031.51	6029	2	1		-936			PWS	SWFWMD
2	30	17	-10031.61	4708	4	3		-891			PWS	SWFWMD
2	30	21	-9671.58	7811	2	2		-1211	-146		PWS	SWFWMD
2	30	21	-7191.95	7811	2	1		-1186	-153		PWS	SWFWMD
2	30	26	-4420.93	6804	1	2		-921	-354		PWS	SWFWMD
2	31	19	-12383.68	5786	3	1		-1169			PWS	SWFWMD
2	31	20	-1839.59	5786	3	2		-691	-381		PWS	SWFWMD
2	31	27	-6047.47	9516	0	2		-1309			PWS	SWFWMD
2	31	27	-6047.47	9516	0	3		-1309			PWS	SWFWMD
2	32	17	-37387.70	4708	4	2		-739			PWS	SWFWMD
2	32	17	-5564.80	4708	4	1		-364			PWS	SWFWMD
2	32	17	-40412.53	4708	4	4		-749			PWS	SWFWMD
2	34	29	-2657.24	4670	2	2		-290	-190		PWS	SWFWMD
2	34	29	-2657.24	4670	2	1		-732	-213		PWS	SWFWMD
2	36	20	-5523.76	5882	2	1		-1049			PWS	SWFWMD
2	37	22	-57250.20	4492	3	4		-1292			PWS	SWFWMD

Table B-1. Public Water Supply and Industrial Wells (Continued).

LAYER	ROW	COLUMN	PUMP CUBIC feet/ day	PERMIT _NO	PERMIT _NO	PERMIT _NO	PERMIT NO	WELL_ DEPTH	CASE_D EPTH	PERMIT_ TYPE	LU CODE	DISTRICT
2	37	26	-46555.61	4492	3	3		-1280			PWS	SWFWMD
2	37	26	-39338.93	4492	3	2		-1280			PWS	SWFWMD
2	38	27	-49247.33	4492	3	5		-1364			PWS	SWFWMD
2	40	23	-26523.04	4492	3	6		-1398			PWS	SWFWMD
2	43	37	-274.73	28-00139-W				1000	500	IND	PWS	SFWMD
2	45	30	-1687.23	7938	1	1		-1398	-778		PWS	SWFWMD
2	45	30	-3966.02	7938	1	2		-1483	-878		PWS	SWFWMD
2	48	24	-114.54	4260	1	1		-719			PWS	SWFWMD
2	49	29	-10131.68	7139	1	1		-1278	-409		PWS	SWFWMD
2	49	29	-3935.10	7139	1	2		-1278	-415		PWS	SWFWMD
2	51	32	-515.41	10926	1	1		-1107	-437		PWS	SWFWMD
2	53	26	-4145.09	4167	1	3		-1321	-470		PWS	SWFWMD
2	57	30	-1979.10	6456	1	1		-1445			PWS	SWFWMD
2	61	35	-27125.19	6326	3	1					PWS	SWFWMD
2	61	37	-4386.25	11364	0	2		-420	-215		PWS	SWFWMD
2	61	37	-4386.25	11364	0	3		-1100	-410		PWS	SWFWMD
2	65	36	-10205.89	5270	3	4		-1228	-463		PWS	SWFWMD
2	65	36	-13156.84	5270	3	3		-443			PWS	SWFWMD
2	66	36	-40894.76	5270	3	1		-886			PWS	SWFWMD
2	69	31	-6777.55	4980	4	2		-1185			PWS	SWFWMD
2	69	31	-6807.56	4980	4	1		-1185			PWS	SWFWMD
2	69	38	-148.03	9490	0	1		-1278			PWS	SWFWMD

Table B-1. Public Water Supply and Industrial Wells (Continued).

LAYER	ROW	COLUMN	PUMP CUBIC feet/ day	PERMIT _NO	PERMIT _NO	PERMIT _NO	PERMIT NO	WELL_ DEPTH	CASE_D EPTH	PERMIT_ TYPE	LU CODE	DISTRICT
2	69	39	-4805.99	9490	0	2		-1295			PWS	SWFWMD
2	71	39	-1488.97	10930	0	2		-410	-230		PWS	SWFWMD
3	1	15	-34715.97	5870	6	4		-955	-80		PWS	SWFWMD
3	4	11	-42.95	9326	0	3		-864			PWS	SWFWMD
3	5	16	-45095.18	5870	6	5		-1079	-260		PWS	SWFWMD
3	18	17	-4131.17	8063	1	1		-1052			PWS	SWFWMD
3	24	17	-54832.27	6029	2	4		-1195	-274		PWS	SWFWMD
3	24	18	-2031.51	6029	2	1		-936			PWS	SWFWMD
3	30	17	-10031.61	4708	4	3		-891			PWS	SWFWMD
3	30	21	-9671.58	7811	2	2		-1211	-146		PWS	SWFWMD
3	30	21	-7191.95	7811	2	1		-1186	-153		PWS	SWFWMD
3	31	19	-12383.68	5786	3	1		-1169			PWS	SWFWMD
3	31	27	-6047.47	9516	0	2		-1309			PWS	SWFWMD
3	31	27	-6047.47	9516	0	3		-1309			PWS	SWFWMD
3	36	20	-5523.76	5882	2	1		-1049			PWS	SWFWMD
3	37	22	-57250.20	4492	3	4		-1292			PWS	SWFWMD
3	37	26	-46555.61	4492	3	3		-1280			PWS	SWFWMD
3	37	26	-39338.93	4492	3	2		-1280			PWS	SWFWMD
3	38	27	-49247.33	4492	3	5		-1364			PWS	SWFWMD
3	40	23	-26523.04	4492	3	6		-1398			PWS	SWFWMD
3	45	30	-1687.23	7938	1	1		-1398	-778		PWS	SWFWMD

Table B-1. Public Water Supply and Industrial Wells (Continued).

LAYER	ROW	COLUMN	PUMP CUBIC feet/ day	PERMIT _NO	PERMIT _NO	PERMIT _NO	PERMIT NO	WELL_ DEPTH	CASE_D EPTH	PERMIT_ TYPE	LU CODE	DISTRICT
3	45	30	-3966.02	7938	1	2		-1483	-878		PWS	SWFWMD
3	49	29	-10131.68	7139	1	1		-1278	-409		PWS	SWFWMD
3	49	29	-3935.10	7139	1	2		-1278	-415		PWS	SWFWMD
3	53	26	-4145.09	4167	1	3		-1321	-470		PWS	SWFWMD
3	57	30	-1979.10	6456	1	1		-1445			PWS	SWFWMD
3	61	35	-27125.19	6326	3	1					PWS	SWFWMD
3	65	36	-10205.89	5270	3	4		-1228	-463		PWS	SWFWMD
3	69	31	-6777.55	4980	4	2		-1185			PWS	SWFWMD
3	69	31	-6807.56	4980	4	1		-1185			PWS	SWFWMD
3	69	38	-148.03	9490	0	1		-1278			PWS	SWFWMD
3	69	39	-4805.99	9490	0	2		-1295			PWS	SWFWMD

APPENDIX C
Agricultural Water Supply

Most of the water consumption in the Lower Kissimmee Basin Ground Water Model area is for agricultural use. Water consumption is an output of water from the model and it is expressed as negative numbers.

The consumption in the Middle Floridan Aquifer is the greatest (**Table C-1**). Fifty-five percent of the agricultural water consumption is from the Middle Floridan Aquifer, 34 percent is from the Upper Floridan Aquifer and 10 percent from the Surficial Aquifer System. The Lower Floridan uses only 0.35 percent of the agricultural water supply consumption.

In the Surficial Aquifer most of the wells use up to 0.25 MGD and are located on Lake Wales Ridge (**Figure C-1**). The largest use from one model cell is located in DeSoto County with -1.28 MGD.

In the Upper Floridan water use continues on Lake Wales Ridge, but more water use is seen in Indian River, St. Lucie and DeSoto counties (**Figure C-2**). In the Middle Floridan the Istokpoga Prairie and the Okeechobee areas (**Chapter 1**, **Figure 3**) regions are also used for irrigation in addition to the areas named in Layers 1 and 2 (**Figure C-3**).

Very little water (0.88 MGD) is being used from the Lower Floridan Aquifer (**Table C-1**).

Table C-1. Statistics on Agricultural Consumption (MGD) by Layer.

Layer	Aquifer	Average	Max	Min	Sum	Number of Wells
1	Surficial Aquifer	-0.04	-1.28	0.00	-25.22	668
2	Upper Floridan Aquifer	-0.09	-5.04	0.00	-85.63	1002
3	Middle Floridan Aquifer	-0.12	-5.04	0.00	-136.87	1112
4	Lower Floridan Aquifer	-0.07	-0.08	-0.07	-0.88	12
All Layers		-0.09	-5.04	0.00	-248.61	2794

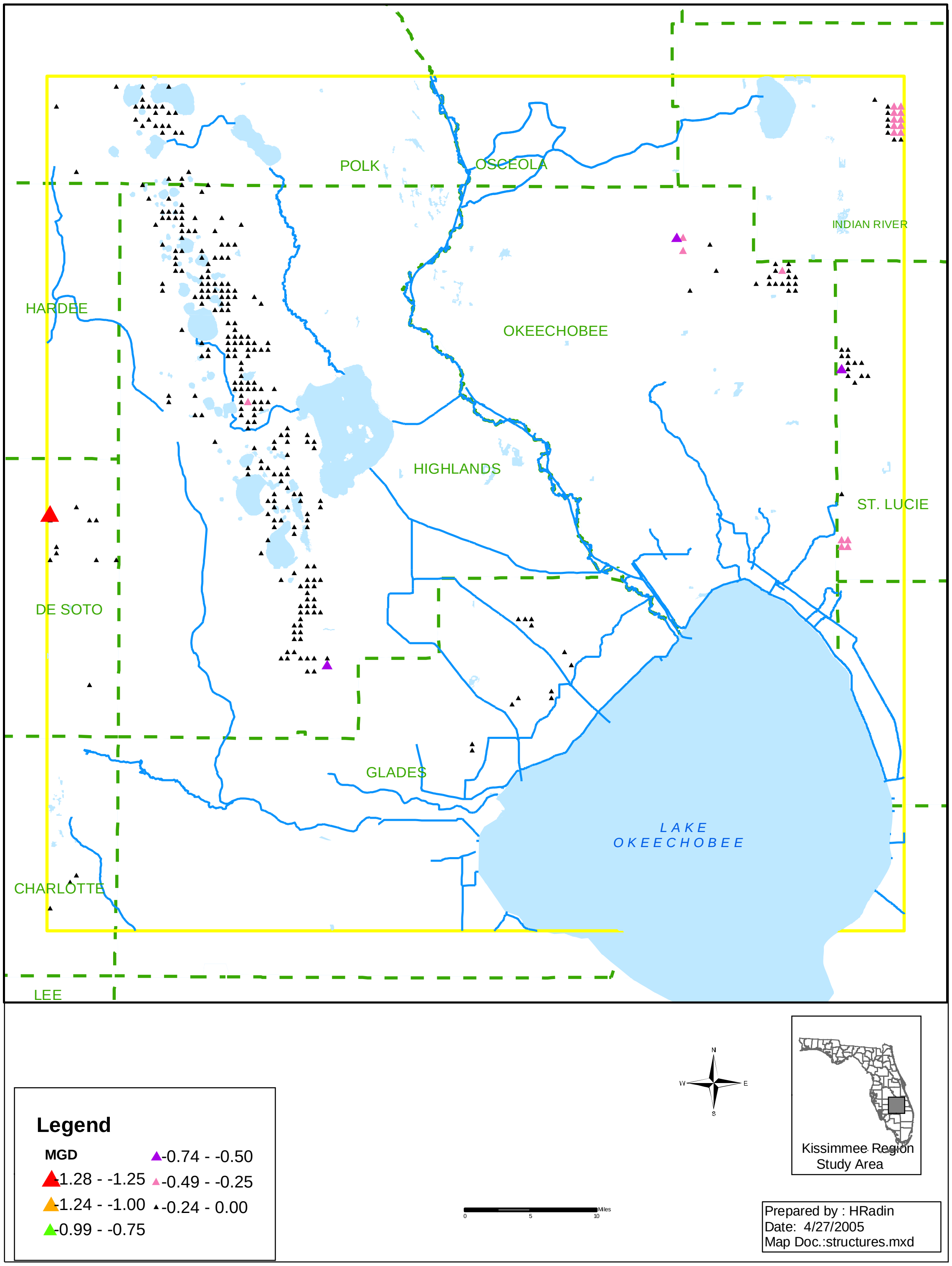

Figure C-1. Agricultural Consumption for the Surficial Aquifer System (MGD).

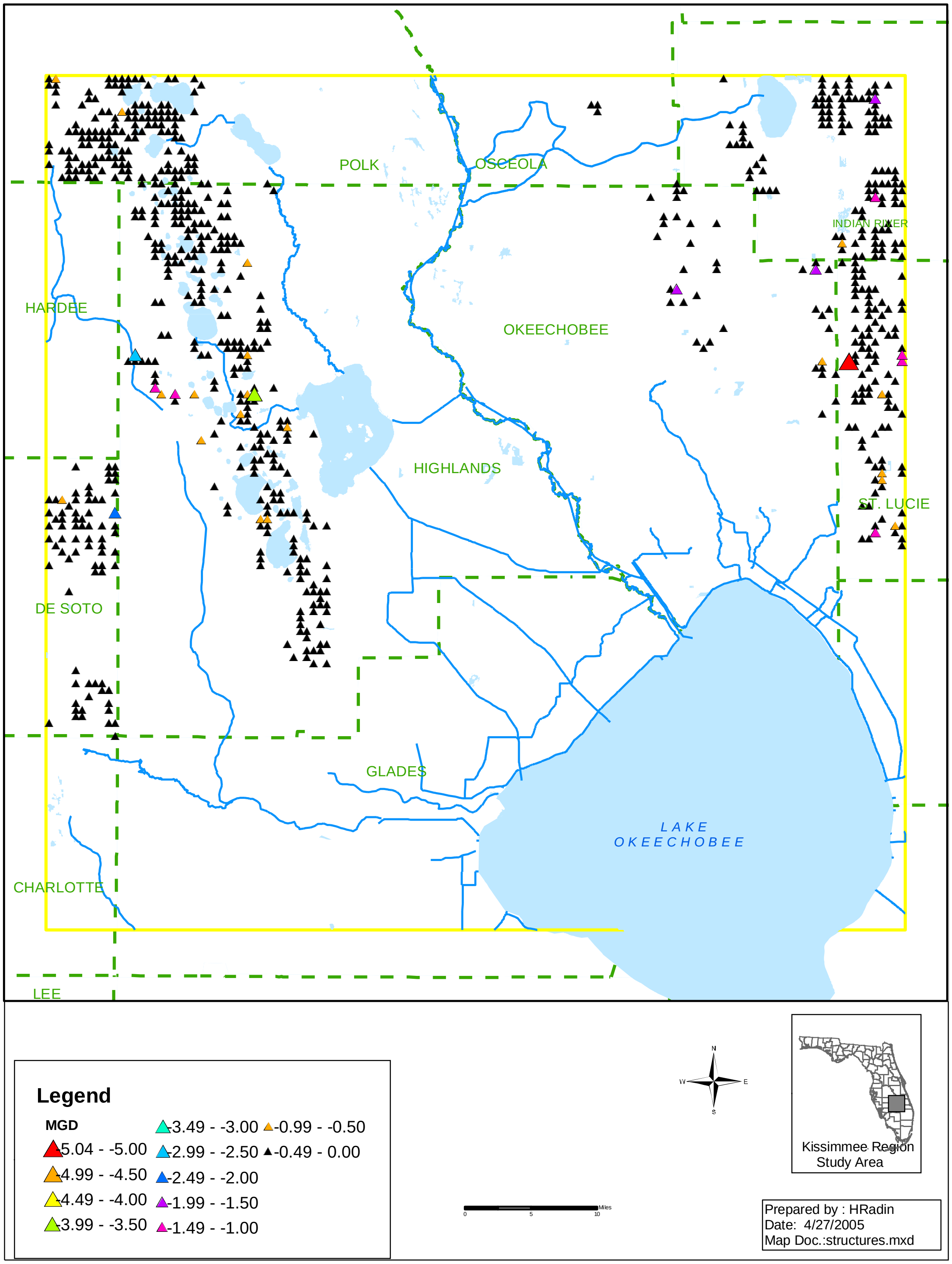

Figure C-2. Agricultural Consumption for the Upper Floridan Aquifer (MGD).

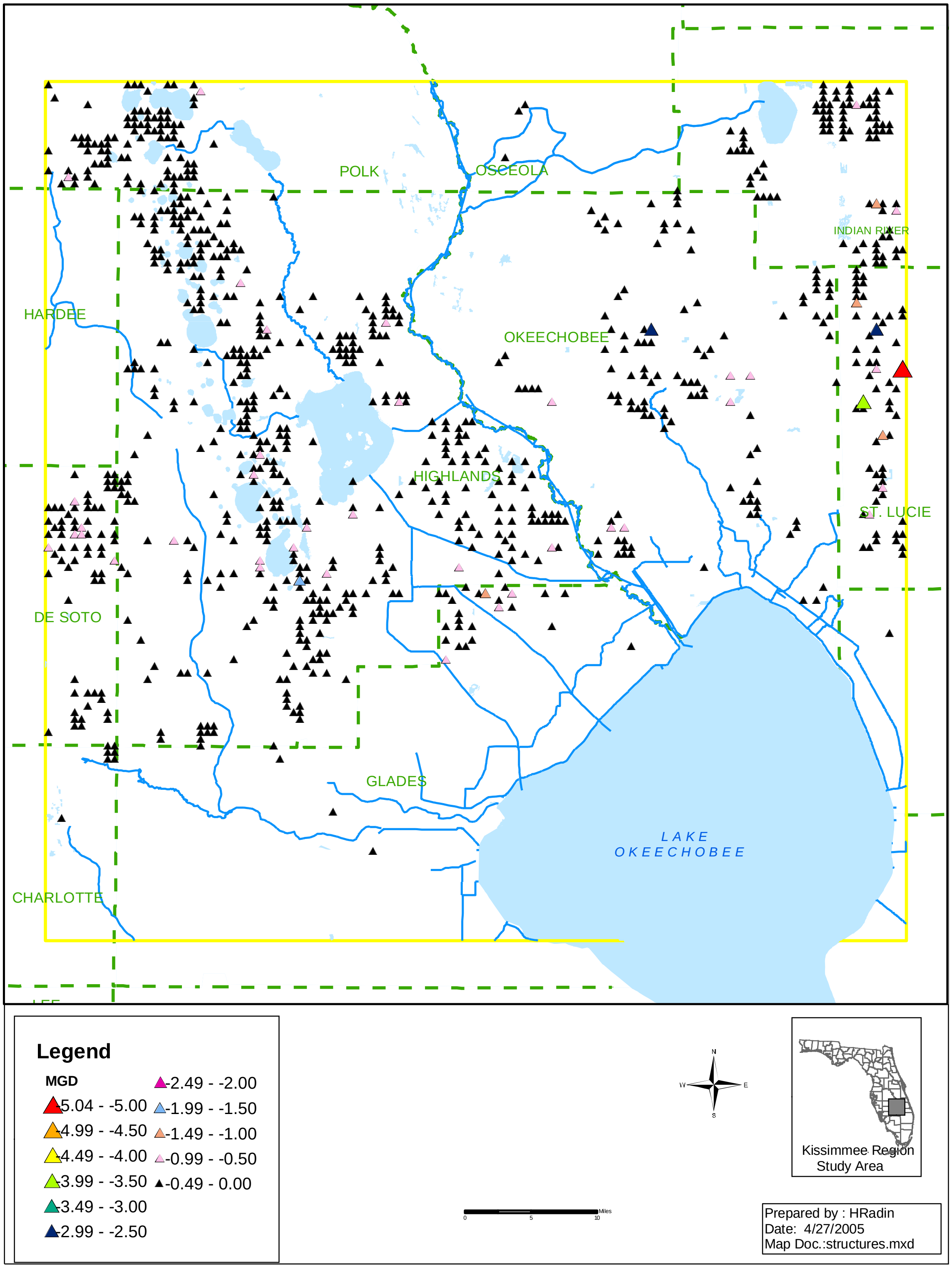

Figure C-3. Agricultural Consumption for the Middle Floridan Aquifer (MGD).

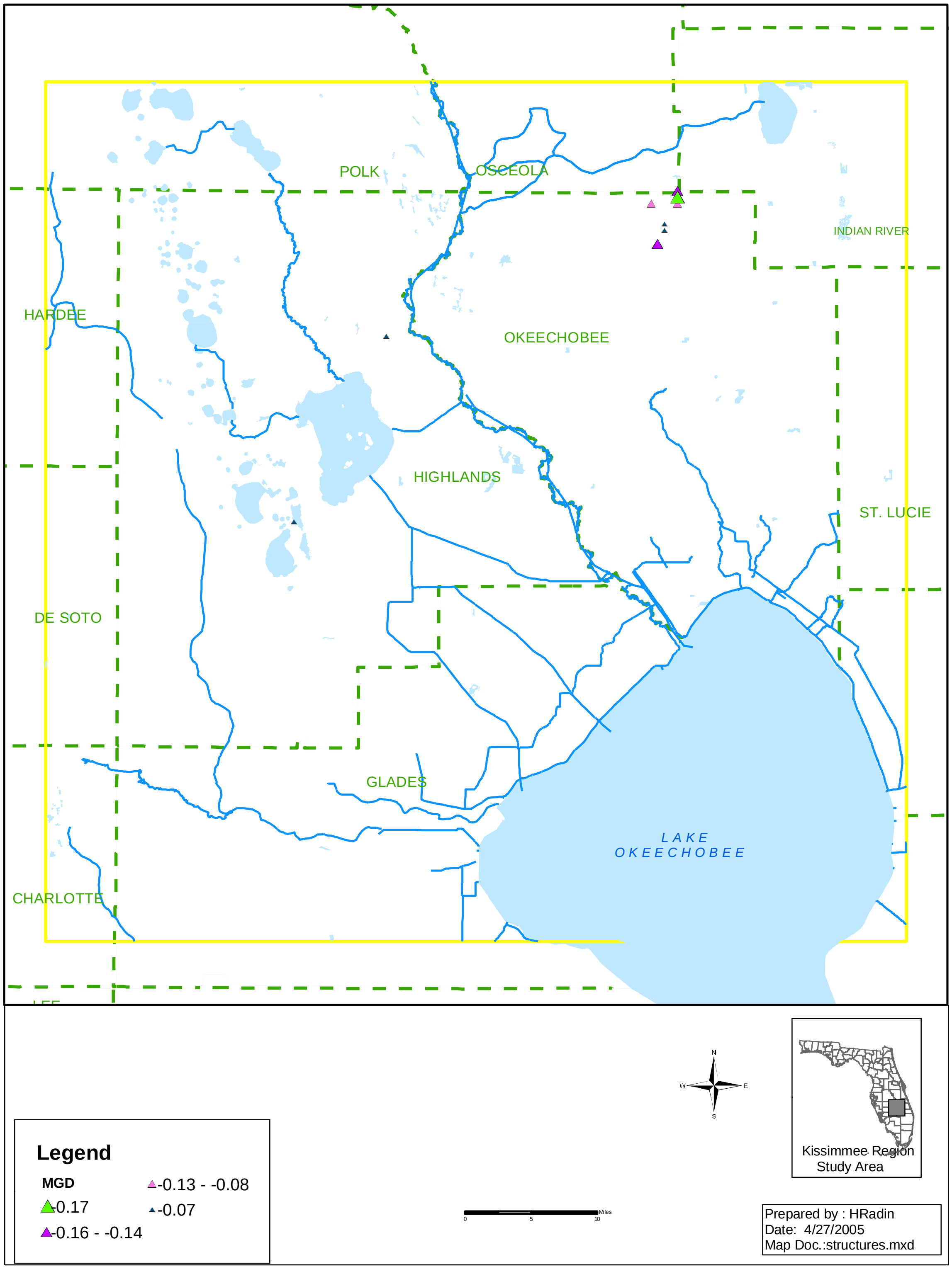

Figure C-4. Agricultural Consumption for the Lower Floridan Aquifer (MGD).

APPENDIX D
Model Simulations

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The Lower Kissimmee Basin Groundwater Model includes all of Okeechobee and Highlands counties and most of Glades County. It also includes portions of Polk, Osceola, Indian River, St Lucie, Martin, Palm Beach, Charlotte, De Soto and Hardee counties (see **Figure D-1**). The Lower Kissimmee Basin Groundwater Model (Radin 2005) is a four-layer, steady-state model, using the USGS MODFLOW application (Harbaugh, A.W. and M.G. McDonald 1996). The model was developed as a revision to the Glades, Okeechobee and Highlands Model developed for the 2000 Kissimmee Water Supply Plan. The new model revisits the hydrostratigraphy data in the Lower Kissimmee Basin as a result of the recent investigations conducted in south Florida. The hydrostratigraphy in the model region is still sparse, however, and there are no data points in the Lower Floridan Aquifer.

The model was developed to provide support for the South Florida Water Management District (SFWMD) 2005 Kissimmee Basin Water Supply Plan Update. The model will be used to evaluate the effects of projected increases in groundwater withdrawals from the Upper and Middle Floridan aquifers. The model was calibrated using water use estimates from 1995. The calibration took place using the following criteria:

- In the Surficial Aquifer System, the simulated heads are to be within 4 feet of the observed heads.
- In the Upper and Middle Floridan aquifers, the simulated heads are to be within 2.5 feet of the levels in the Average 1995 Upper Floridan Potentiometric Surfaces Map. The Average 1995 Potentiometric Map was calculated using Knowles September 1995 and May 1995 maps as starting points.
- The calibrated model produced simulated water levels that met the calibration criteria.

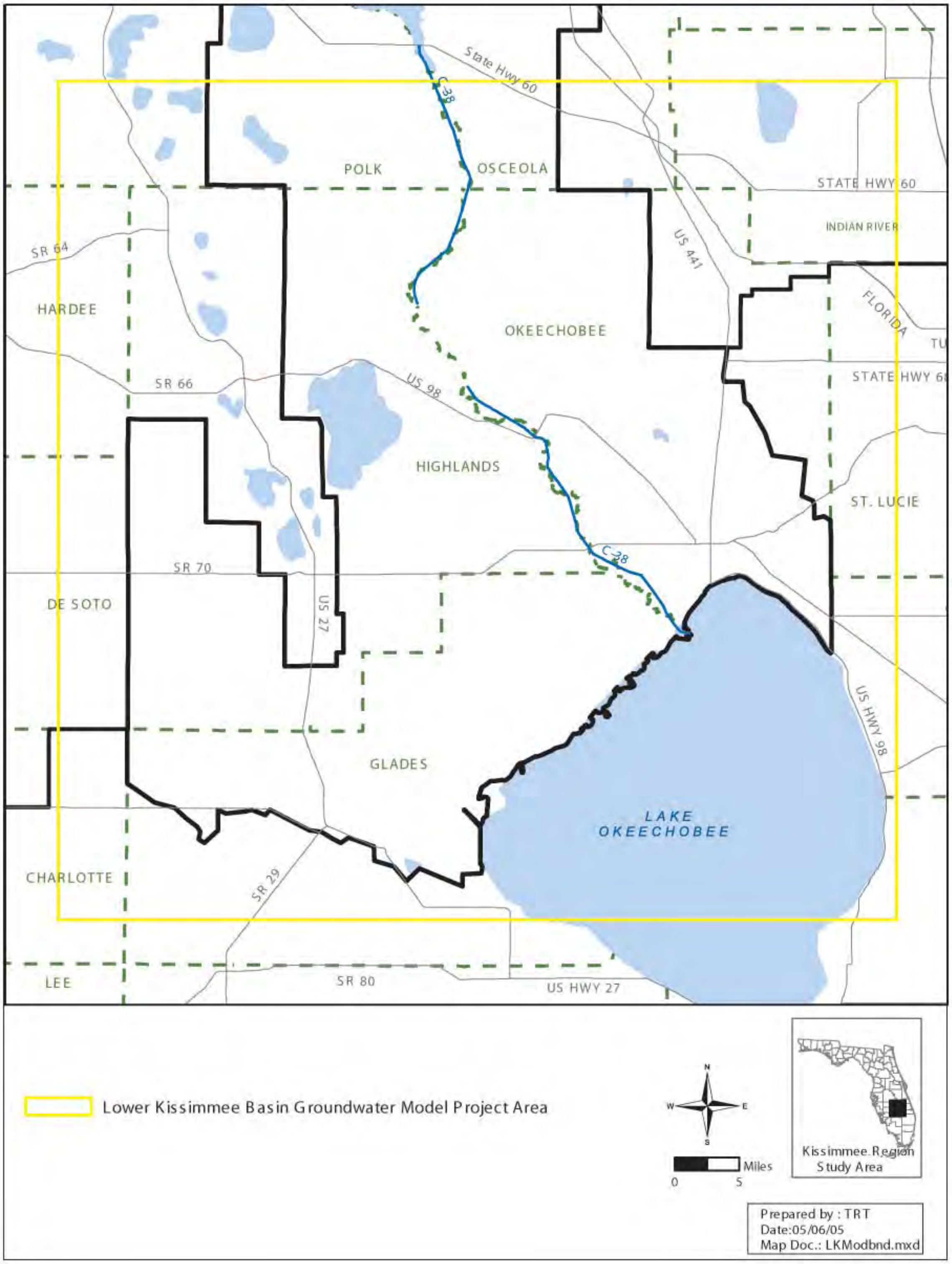

Figure D-1. Lower Kissimmee Basin Groundwater Model.

Purpose

A model is a tool used to represent an approximation of the field data to assist in understanding the groundwater flow system. This model is a steady-state model, and therefore, represents a state of equilibrium under averaged stress conditions. In reality, the stresses would vary with time. The model also uses average values for the hydrologic properties and stresses for each cell in the model grid. Despite these limitations, the model is a valuable tool to assess the behavior of the groundwater system under varying conditions, both climatic and consumption, such as a 1-in-10 year drought, or changes in water consumption due to population growth or changes in agricultural use.

Scope

The model is a tool for projecting water needs for the Kissimmee Basin Water Supply Plan. One objective of the model is to analyze the impact of wellfields proposed by the Heartland Water Alliance (**Figure D-2**). The Heartland Water Alliance is looking for sources of public water supply for the future needs (2025) of Polk, Hardee, DeSoto and Highlands counties. Three of the proposed wellfields – G62, G63 and G64, fall within the Lower Kissimmee Basin Groundwater Model boundaries. The remaining proposed projects are outside of the SFWMD boundaries, and are located in the Southwest Florida Water Management District (SWFWMD) area. Each of these proposed wellfields were modeled as withdrawals from the Upper Floridan Aquifer (Layer 2, see **Table D-1**). In each of these modeled scenarios, there are existing Middle Floridan Aquifer wells located in the same cell, or in at a distance of one or two cells (**Figure D-3**).

Table D-1. Assumptions on Wellfields.

Well	Layer	Row	Column	MGD*	Ft^3/day
G62	2	73	12	2.00	267,400.00
G63	2	34	38	2.00	267,400.00
G64	2	77	55	5.00	668,500.00

* Million Gallons per Day

Each of these wellfields was simulated in the model one at a time. Local impacts were observed and are detailed in this document. Due to the proximity of these wells to the SWFWMD boundaries, impacts were seen in SWFWMD areas as well. This document makes no claim as how to the SWFWMD perceives these impacts.

The Lower Kissimmee Basin Groundwater Model simulated 12 scenarios (runs). Each run was based on 1995 climatic conditions, 1995 1-in-10 rain conditions or 2025 1-in-10 conditions. The impact of the wellfields was simulated with these runs.

Three alternative scenarios were run placing the proposed wellfields in Layer 3 – the Middle Floridan Aquifer. These runs simulated the effects of all three wellfields at once. The runs were conducted for 1995 climatic conditions, 1995 1-in-10 rain conditions or 2025 1-in-10 conditions.

Two runs were conducted with wells turned off to evaluate the impact of the changing land use between 1995 and 2025; both of these assumed 1-in-10 climatic conditions.

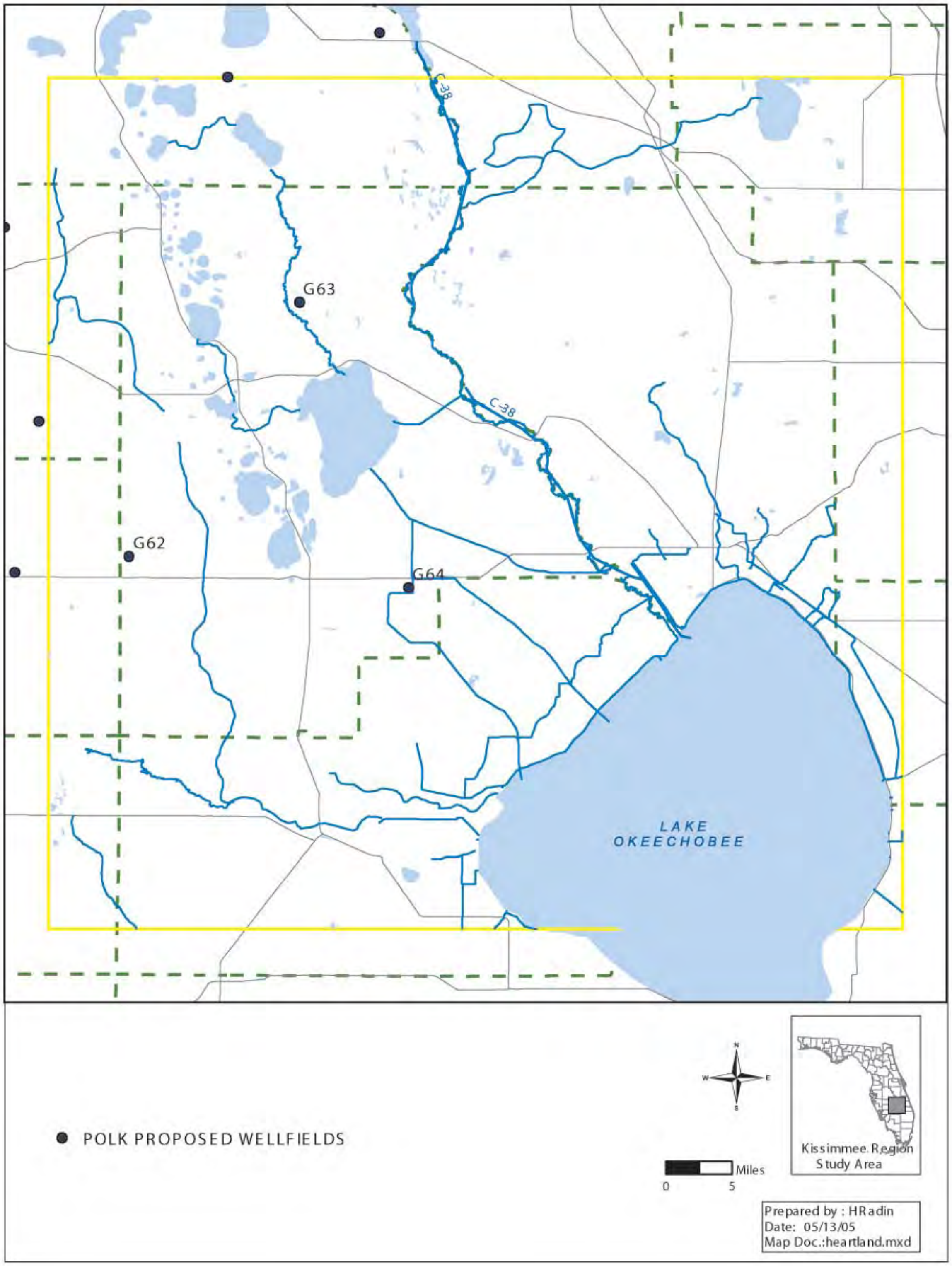

Figure D-2. Proposed Wellfields from Heartland Water Alliance.

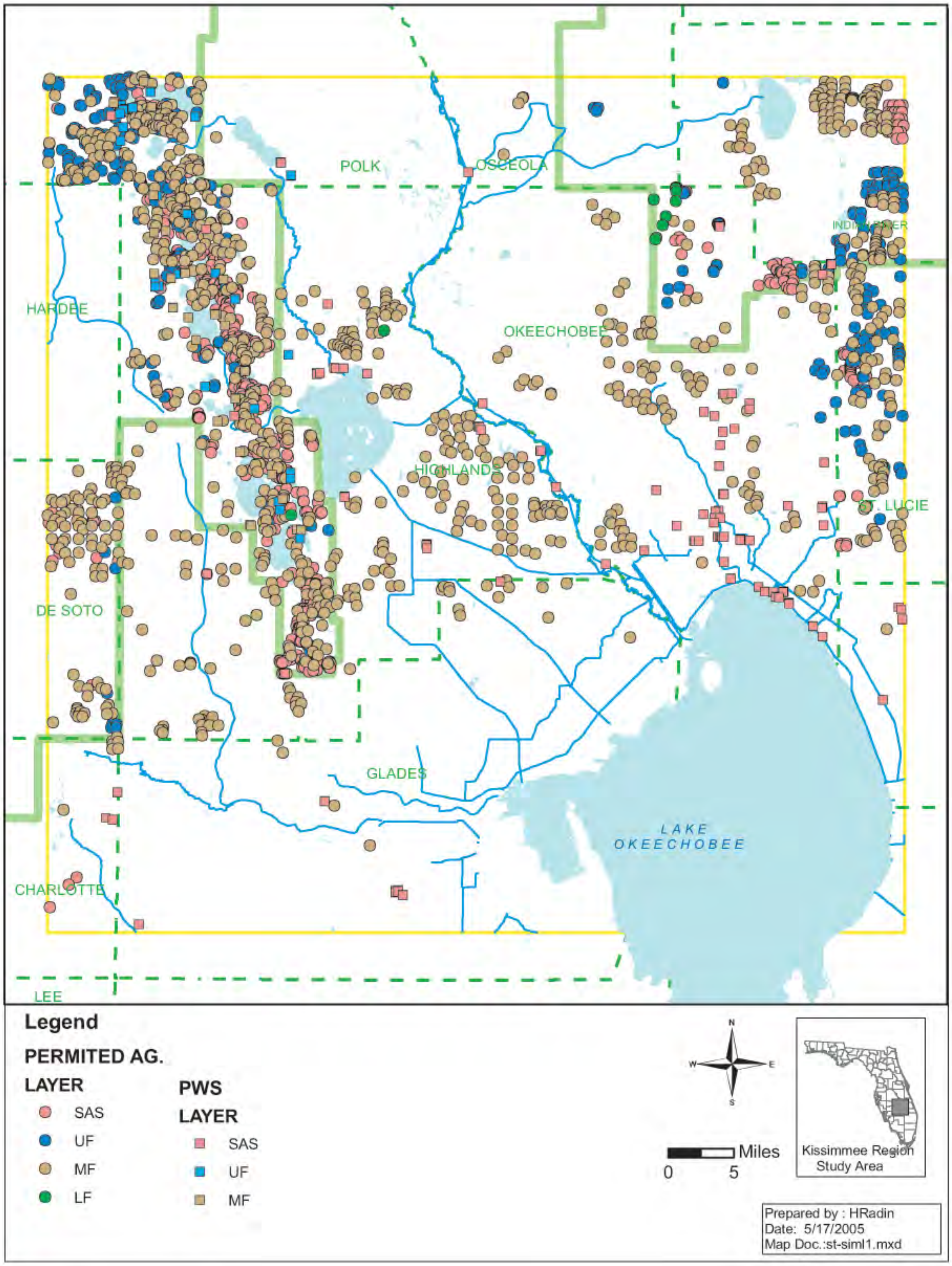

Figure D-3. Consumptive Use Wells.

General Features of MODFLOW

Once modeling objectives have been established, and a preliminary understanding of the predominant hydrologic processes within the area of interest has been attained, a model code, which can meet the model development and application objectives, is selected. MODFLOW, a code created by the U.S. Geological Survey (USGS), was selected for this purpose because the code:

- Has been widely accepted in the groundwater modeling profession for over 15 years.
- Is well documented and within the public domain.
- Is readily adaptable to a variety of groundwater flow systems.
- Is modular and easily facilitates any modifications required to enable its application to the types of unique groundwater flow problems encountered in south Florida.

MODFLOW, a three-dimensional finite difference groundwater flow program, was developed by McDonald and Harbaugh of the USGS in 1984, and a revised version was published in 1988. Additional features were added to in 1996, and that version was named MODFLOW96 (Harbaugh and McDonald. 1996).

The SFWMD has modified some of USGS modules to allow for additional functionality. MODFLOW96 simulates groundwater flow in both the anisotropic and heterogeneous layered aquifer systems using a finite-difference “block centered” approach. The SFWMD version of MODFLOW96 enhanced the Well Package to allow for multiple well files.

MODFLOW with District Source Code

MODFLOW simulates groundwater flow in aquifer systems using the finite-difference method. The aquifer system is divided into rectangular or quasi-rectangular blocks by a grid (**Figure D-4**). The grid of blocks is organized by rows, columns and layers, and each block is commonly called a cell.

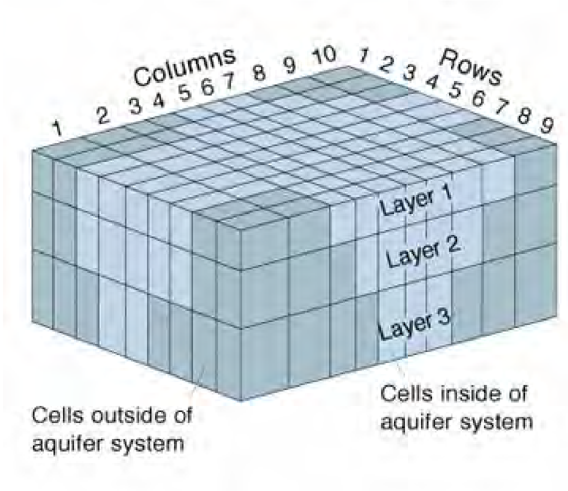

Figure D-4. Example of Model Grid for Simulating 3-Dimensional Groundwater Flow.

For each cell within the aquifer system, the user must specify aquifer properties. Also, the user specifies information relating to wells, canals and other hydrologic features for the cells corresponding to the locations of the features. For example, if the interaction between a canal and an aquifer system is simulated, then for each cell traversed by the canal, the required input information includes layer, row and column indices; canal stage; and hydraulic properties of the channel bed. Also, MODFLOW allows the user to specify which cells within the grid are part of the groundwater flow system and which cells are inactive (i.e., outside of the groundwater flow system).

The MODFLOW model code consists of a main program and a series of independent subroutines called modules. The modules, in turn, have been grouped into packages, which each deal with a particular hydrologic process or solution algorithm. The packages used for Lower Kissimmee Basin Groundwater Model simulations, including those developed or enhanced by SFWMD staff and contractors, are shown in **Table D-2**.

Table D-2. MODFLOW96 Packages Used in the Model.

Package	Description	Notes
Core		
Basic and Output Control	Defines stress periods, time steps, starting heads, grid specifications, units and output specifications	Handles the primary administrative tasks associated with a simulation
Block-Centered Flow (BCF)	Specifies steady-state vs. transient flag, cell sizes, anisotropy, layer types and hydrogeologic data for each layer	Derived primarily from geologic data used to construct the model
Surface Water Stresses and Processes		
Recharge	Simulates areally distributed recharge to a water table during each stress period	Preprocessed using an Agricultural Field-Scale Irrigation Requirements Simulation (AFSIRS) based ET- Recharge Model
Evapotranspiration (ET)	Simulates removal of water from the water table via transpiration and direct evaporation	Preprocessed using an AFSIRS based ET-Recharge Model; ET rate diminishes with increasing water table depth
River (RIV)	Simulates groundwater interchanges with canals that can either recharge or drain the aquifer	Canal stages are usually based on measured stages or control elevations
Drain (DRN)	Essentially the same as the River package, except canals can only drain the aquifer and water removed by the drains is removed permanently from the model	Canal stages are usually based on weir elevations
Water Supply and Management		
Well	Simulates withdrawals from wells	Includes Public Water Supply (PWS) and irrigation wells (Ag); enhanced by the SFWMD to read multiple input files
Solution Algorithms		
Strongly Implicit Procedure (SIP)	A mathematical solution algorithm internal to the model	Enhanced by District to improve model stability

Conceptual Model

In order to simulate the groundwater flow in the model domain, the hydrogeologic framework needed to be simplified for modeling purposes. The conceptual model consists of four aquifers separated by three semi-confining units and underlain by a confining unit. The flow in the aquifers is represented as purely horizontal flow, while the flow through the semi-confining units is only vertical. This gives a quasi three-dimensional model. Vertical flow from Layer 1 to Layer 2 (or Layer 2 to Layer 1), Layer 2 to Layer 3 and Layer 3 to Layer 4 occurs via the semi-confining units (See Vertical Discretization of Model Layers in **Figure D-5**).

Model Design

The model domain for the Lower Kissimmee Basin Groundwater Model is described as follows:

Table D-3. Model Domain for the Lower Kissimmee Basin Groundwater Model.

In Decimal Degrees	In Projected Florida East NAD83 HARN Feet
West Corner: -81.654709	Left Corner: 444435.531250
East Corner: -80.593469	Right Corner: 787635.531250
North Corner: 27.764485	Top Corner: 1247082.062500
South Corner: 26.818899	Bottom Corner: 903882.062500

The Lower Kissimmee Basin Groundwater Model projects in the following coordinate system: NAD 1983 State Plane Florida East FIPS 0901 Feet. The geographic coordinate system name is GCS North American 1983.

The Lower Kissimmee Basin Groundwater Model is composed of a grid containing 130 rows and 130 columns. Each cell is 2,640 feet x 2,640 feet. Lake Okeechobee, Lake Istokpoga and the model cells southeast of the lake are inactive.

The Lower Kissimmee Basin Groundwater Model consists of four layers. The top layer represents the unconfined Surficial Aquifer System, the next layer represents the Upper Floridan Aquifer, the third layer is the Middle Floridan Aquifer and the bottom layer is the Lower Floridan Aquifer. The Intermediate Confining Unit/Aquifer and the Middle Confining Unit 1 and 2 are represented as vertical conductance values between the aquifer layers. (See Vertical Discretization of Model Layers in **Figure D-5**.)

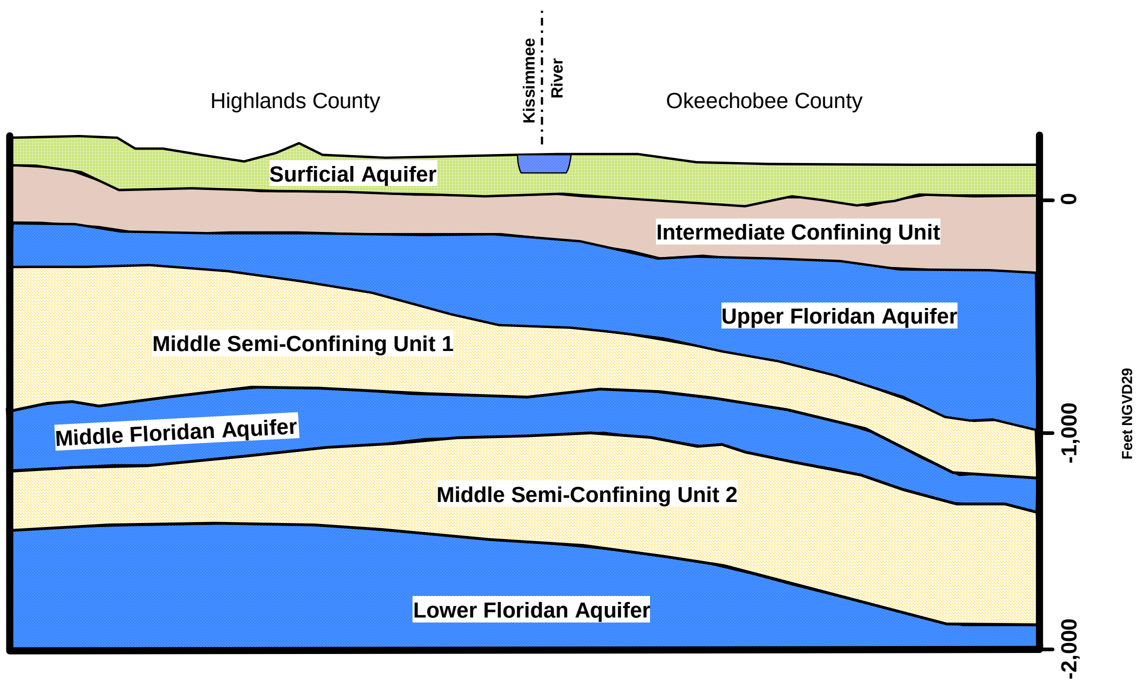

Figure D-5. Vertical Discretization of Model Layers.

Surface water features are modeled in Lower Kissimmee Basin Groundwater Model. A discussion of these features, such as rivers, canals and drains, can be found in the model documentation (Radin 2005)

Model Calibration

The calibration run of this model simulates average 1995 steady state conditions. The base run simulates 1995 1-in-10 rainfall conditions. The 1-in-10 rainfall conditions or a 1-in-10 year drought event is defined as an event with a return frequency of once in 10 years. The model is used to evaluate projected 1-in-10 rainfall conditions for 2025.

PREDICTIVE SIMULATIONS

For the model simulations, the consumptive agricultural use was calculated based on land use, irrigated acreage, crops and climatic conditions instead of on permit allocations, which were used for the initial calibration of the original model. Since agricultural water use is not metered, basing the water consumption on the permits alone was not considered to be accurate enough for modeling purposes.

The groundwater model is being used as a tool to evaluate the impact of 1-in-10 year drought conditions as part of the criteria, which were identified as Resource Protection Constraints for water supply planning purposes. A 1-in-10 year drought condition is defined as below normal rainfall with a 90 percent probability of being exceeded over a 12-month period. This means there is a 10 percent chance than less than this amount will be received in any year.

Gamma distribution was used to determine monthly and annual 1-in-10 rainfall amounts for the period of January 1965 through December 2000. Gamma distribution is a statistical function using study variables, which may have a skewed distribution. The gamma distribution is commonly used in queuing analysis. The values for the statistical 1-in-10 rainfalls are shown in **Table D-4**, which presents the gamma 1-in-10 statistics for each of the 12 months, the sum of the 12 months and the annual 1-in-10 statistics. The annual gamma 1-in-10 statistic is higher than the sum of the monthly 1-in-10 rainfall months. For the model, the data for actual months and years were selected by proximity of the actual monthly rainfall to the 1-in-10 statistic. **Table D-5** shows the actual years and rainfall values used in the model. For example, the 1-in-10 rainfall for Avon Park in January was 0.32 inches and the actual dataset for January 1974 was 0.38 inches. That month's rainfall was closet to the statistical 1-in-10 value. The daily values for January 1974 from Avon Park were used to calculate irrigation demands.

Table D-4. Statistical 1-in-10 Rainfall (in inches) for Seven Rainfall Stations.

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	Annual
Avon Park	0.32	0.56	0.74	0.32	1.32	3.35	4.71	3.92	3.00	0.80	0.24	0.45	19.73	40.94
Archbold	0.31	0.56	0.74	0.34	1.44	3.34	4.73	3.89	3.04	0.84	0.25	0.44	19.92	40.93
Belle Glade	0.63	0.60	0.82	0.48	1.56	3.79	4.50	3.57	4.13	1.72	0.59	0.40	22.79	48.85
Fort Drum	0.41	0.74	0.54	0.40	0.71	3.39	4.00	3.70	2.75	0.93	0.59	0.39	18.55	40.49
LaBelle	0.35	0.59	0.65	0.23	1.38	4.91	4.44	5.17	3.40	0.83	0.25	0.20	22.40	42.74
Moore Haven	0.26	0.46	0.50	0.26	0.97	2.96	2.99	2.75	2.23	0.70	0.16	0.24	14.48	36.97
Okeechobee	0.38	0.56	0.70	0.46	0.84	2.70	3.78	3.32	3.35	1.25	0.36	0.45	18.15	35.47

Note: Based on Gamma Distribution.

Table D-5. Actual Rainfall/Months with Values Close to 1-in-10 Rain Values.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum of Rain in 1-in-10 months (in.)	Statistical 1-in-10 Rain/ Station (in.)
Avon Park	Year	1974	1976	1966	1977	1992	1990	1980	1996	1974	1997	1996	1981		
	Sum of Rain in inches	0.38	0.54	0.77	0.26	1.24	3.22	4.60	4.03	3.22	0.76	0.24	0.55	19.81	40.94
Archbold	Year	1974	1977	1999	1978	1993	1987	1977	1970	1988	1979	2000	2000		
	Sum of Rain in inches	0.33	0.53	0.76	0.43	1.33	3.27	4.68	4.24	2.41	0.96	0.24	0.38	19.56	40.93
Belle Glade	Year	1968	1995	1967	1973	2000	1977	1969	1965	1973	1981	1990	1975		
	Sum of Rain in inches	0.69	1.11	0.87	0.56	1.56	3.78	4.48	3.58	4.93	1.94	0.68	0.28	22.79	48.85
Fort Drum	Year	1965	1997	1977	1987	1967	2000	1999	1979	1980	1977	1965	1966		
	Sum of Rain in inches	0.38	0.75	0.53	0.38	0.47	3.27	4.02	3.80	2.92	0.84	0.69	0.39	18.44	40.50
Labelle	Year	1984	1985	1974	1986	1992	1976	1972	1983	1990	1978	2000	1996		
	Sum of Rain in inches	0.47	0.61	0.70	0.27	1.35	4.68	4.56	4.62	3.39	0.84	0.26	0.19	21.95	42.75
Moore Haven	Year	1971	1971	1966	1986	1965	1988	1998	1965	1990	1988	1970	1968		
	Sum of Rain in inches	0.25	0.51	0.42	0.24	1.11	2.87	2.86	2.78	2.77	0.80	0.13	0.21	14.95	37.00
Okeechobee	Year	1965	1999	1977	1971	1965	1981	1982	1999	1977	1975	1995	1990		
	Sum of Rain in inches	0.34	0.56	0.69	0.48	0.84	2.70	3.94	3.46	3.08	1.16	0.41	0.48	18.14	35.50

The model estimated average reference evapotranspiration values for each day of years 1965–2000. The average evapotranspiration values were used with the 1-in-10 rainfall to predict the irrigation demands with the AFSIRS program (Giddings and Restrepo 1995).

The same stations were used for both 1-in-10 rainfall and for the reference evapotranspiration, since both theses datasets required 36 years of data.

The same climatic conditions were simulated with two sets of stresses: consumption based on 1995 land use and consumption based on the future land use. For future simulations, an assumption was made that public water supply demands for the SWFWMD would remain the same. Only public water supply changes within the SFWMD were simulated. The main difference between the 1995 and 2025 1-in-10 simulations was the agricultural consumption, which varies based on land use changes. For these calculations, water use was not assigned to areas with a land use designation of unimproved pasture. For all other land uses, the irrigation crop demand based on AFSIRS was applied to the permitted areas.

Estimates of agricultural demands were also modified from the 1995 calibration run. Recharge, evapotranspiration and irrigation time series demands were computed using the ET-Recharge Model (Restrepo and Giddings 1994). This is an extension of the Agricultural Field Scale Irrigation Requirements Simulation (AFSIRS) Program, which estimates irrigation demands on a daily basis for a specific crop and acreage due to soil, rainfall, evapotranspiration and other parameters (Smajstrla 1990). Irrigation demands for each cell are determined by combining the GIS coverages for the land use, permitted areas, soil coverage, evapotranspiration and rainfall stations. The irrigation demand is then calculated for each individual polygon, and composite irrigation for each cell of the model is ultimately developed. This approach tends to result in a more accurate seasonal representation of the irrigation demands, but the overall annual demand is not significantly different than that calculated using the Blaney-Criddle Method, which was used in the original 1995 calibration run.

The Future Land Use/Land Cover

Future land use (2025, see **Figure D-6**) was developed by a technical team at the SFWMD using the following general procedure:

The base coverage for the future land use update is the 2000 land use update for the desired area. The future land use data were gathered by contacting planning departments for each county in the model. In some cases, it was necessary to contact individual city planning department to gather data. County Web sites were often a good place to begin gathering information. The gathered data were analyzed and quality checked. All data were converted into coverages for processing. Missing data were added. This future land use coverage was developed for incorporation into the South Florida Water Management Model (SFWMM) as a 2050 future land use layer (without project). The coverage is based on the recently updated 2000 land use and the most recent comprehensive plans (future land use coverage) from each county. Since the comprehensive plan maps from the counties show only land use and the SFWMM requires land cover, several assumptions and decisions were made during the generation of the county coverages:

- All areas considered "developable" in 2000 are assigned the future code from the comprehensive plan's future land use coverage. This includes areas under construction, open lands, agricultural land and forests.
- All areas indicated as water in 2000 remain water in the future.
- All wetlands areas in 2000 remain wetlands in the future.
- All agricultural areas in 2000 and anticipated to be agricultural in the future are left unchanged (no change in crop types).
- All areas coded as conservation in the comprehensive plan are assigned the natural land use, which existed at that location.
- In areas that allow for higher densities in the future, the higher density is used.
- Areas owned or pending ownership by the SFWMD are assumed to remain in their natural state and not be infested with exotics, such as Melaleuca and Brazilian Pepper.
- Future land use maps for each county were generated representing conditions roughly around 2020 or 2030.
- Statistical analysis was used to approximate the populations of each county in the future. These numbers were then compared to population estimates from the Bureau of Economic and Business Research (BEBR) and the U.S. Army Corps of Engineers (USACE).

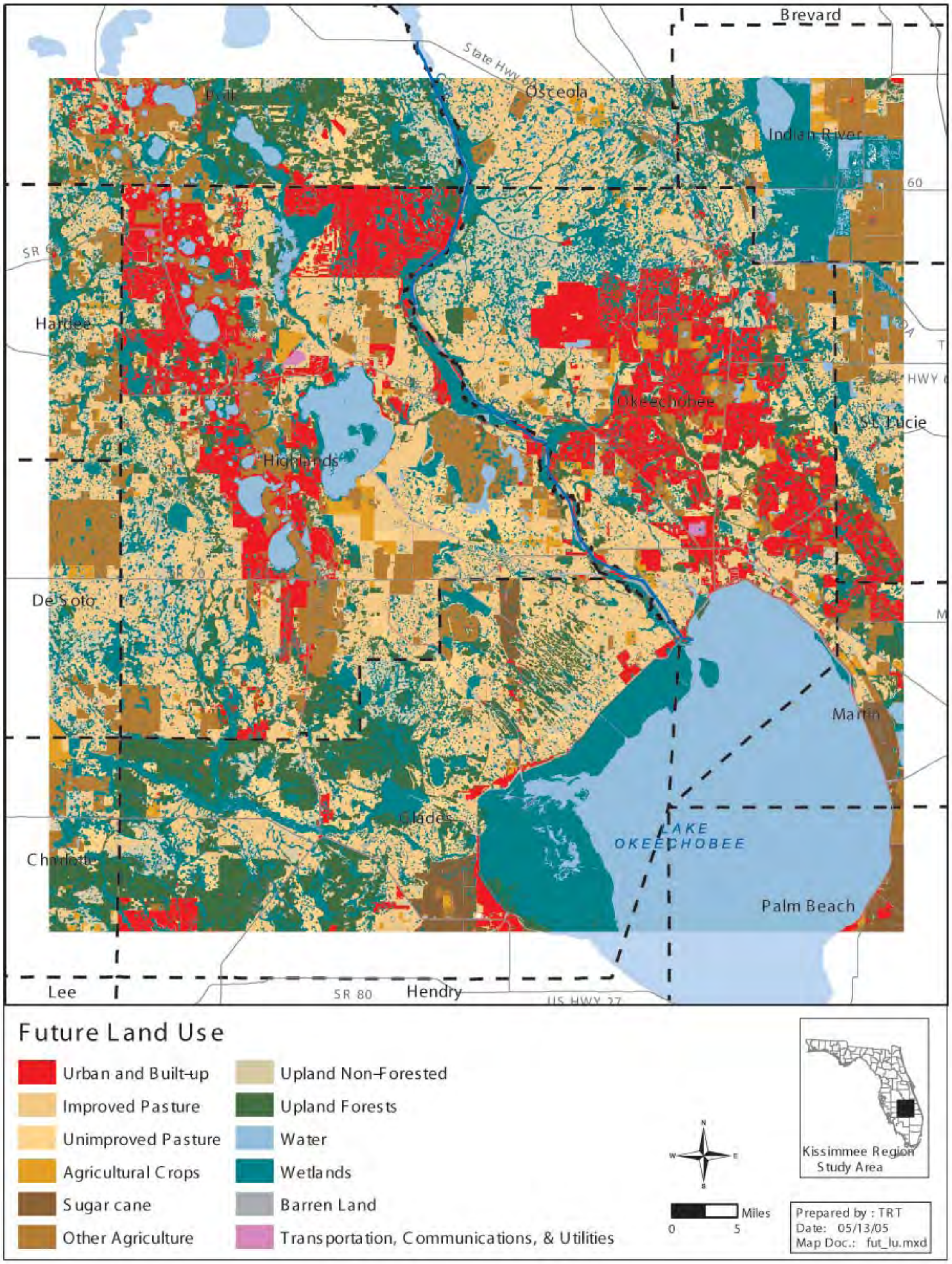

Figure D-6. Future Land Use / Land Cover.

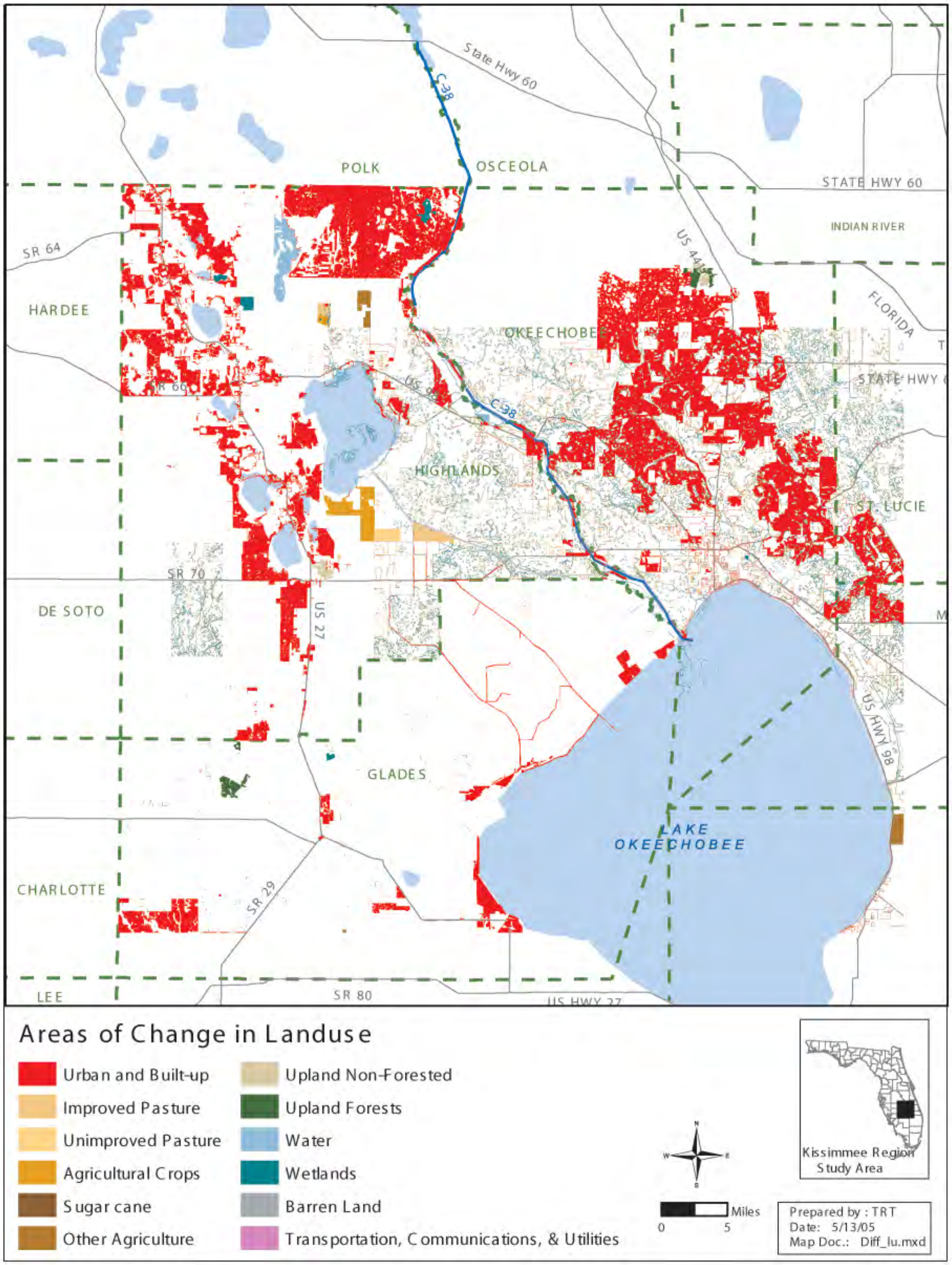

Figure D-7. Areas with Changes in Land Use.

Most of the land use changes (**Figure D-7**) between 2000 and 2025 are the result of conversion of land to urban areas. These changes occur in areas around Lake Wales Ridge, northeastern Polk County and a large portion of Okeechobee County. There are only a few parcels of land that change crop types – mainly converting unimproved pasture to improved pasture or other crops.

Projected Withdrawals

The only modifications made to the predictive simulation runs were changes to the Pubic Water Supply well file within the SFWMD portion of the Lower Kissimmee Basin Groundwater Model to include the proposed new wellfields by the Heartland Water Alliance. In addition, the public water supply demands will change due to projected growth in the population from 2000 and 2025.

The following assumptions were made to create the future public water supply demands:

- Spring Lake District will increase water use from 0.23 MGD to 0.31 MGD.
- Brighton Reservation wells under permit number 22-00183 will increase pumpage from 0.39 MGD to 0.47 MGD.
- Okeechobee Utility Authority used 2.34 MGD in 2000 (0.49 MGD of that from groundwater). They will not use any groundwater in 2025.
- The remaining public water supply wells are not expected to change from 2000 to 2025. No changes were made to wells outside of the SFWMD.
- The agricultural water consumption for 2025 will change with modifications in the land use.

SIMULATION RUNS

Drawdown maps were made to evaluate the changes in water levels between the model runs the unit for all of the figures displaying drawdowns is feet.

All the surface water features remained the same in all the simulated runs.

The following modeling simulations were run:

1. 1995 climatic conditions with agricultural water use assumed from land use (1995 AFSIRS[1] Ag.).
2. 1995 AFSIRS Ag and well G62.
3. 1995 AFSIRS Ag and well G63.
4. 1995 AFSIRS Ag and well G64.
5. 1995 land use, and AFSIRS agriculture well file, under 1-in-10 rainfall conditions – i.e. Drought conditions (1995 1-in-10 simulation).
6. 1995 1-in-10 simulation with well G62.
7. 1995 1-in-10 simulation with well G63.
8. 1995 1-in-10 simulation with well G64.
9. 2025 land use, and AFSIRS agriculture with under 1-in-10 rainfall conditions – i.e. Drought conditions (2025 1-in-10 simulation).
10. 2025 1-in-10 simulation with well G62.
11. 2025 1-in-10 simulation with well G63.
12. 2025 1-in-10 simulation with well G64.
13. 1995 AFSIRS Ag with G62, G63 and G64 in the Middle Floridan.
14. 1995 1-in-10 G62, G63 and G64 in the Middle Floridan.
15. 2025 1-in-10 G62, G63 and G64 in the Middle Floridan.
16. 1995 1-in-10 with wells off.
17. 2025 1-in-10 with wells off.

[1] Agricultural Field Scale Irrigation Requirements Simulation (AFSIRS), by Smajstrla (1990) estimates crop irrigation demands in south Florida.

1995 AFSIRS Agriculture Simulation Run

For this model run, the consumptive use in the agricultural wells was estimated based on AFSIRS calculations for the land use. All the other files were the same as those used for the 1995 calibration run, which were based on the permitted allocations (Radin 2005). The water levels for each model layer from the AFSIRS run were compared to the water levels, which were achieved in the 1995 calibration run using permitted values.

There was not much difference in the simulated water levels at the observation sites between the 1995 run using the permitted agriculture well file and the 1995 run used the agricultural wells based on the land use (see **Table D-6**).

The total agricultural water use estimated from the permits was 248 MGD, while 200 MGD was estimated with AFSIRS based on land use.

Table D-6. Observation Sites Statistics.

Station Name	1995 Hist_Avg	Ag Wells Based on Permits		Ag Wells Based on Land Use	
		Model_Avg	Diff	Model_Avg	Diff
GAC_G	60.79	56.28	4.51	56.27	4.52
TICK ISL_G	48.85	52.34	-3.49	52.34	-3.49
MAXCEY N_G	63.56	62.69	0.87	62.69	0.87
SADDLEBLANKET LAKES NORTH	118.91	111.24	7.67	111.24	7.67
SADDLEBLANKET LAKES WEST	119.86	115.07	4.79	115.98	3.88
SADDLEBLANKET LAKES EAST	121.34	116.51	4.83	117.09	4.25
L.ARBUNK	54.44	53.00	1.44	53.00	1.44
S65A_H	46.33	41.98	4.35	41.98	4.35
S65AX_H	46.40	45.51	0.89	45.51	0.89
IR-25_G	28.48	27.13	1.35	27.15	1.33
LAKE OLIVIA NORTH WEST	116.06	115.14	0.92	115.14	0.92
LAKE OLIVIA NORTH EAST	115.4	115.13	0.27	115.13	0.27
LAKE OLIVIA SOUTH WEST	117.73	115.14	2.59	115.14	2.59
LAKE OLIVIA SOUTH EAST	117.52	115.14	2.38	115.14	2.38
AVON P_G	128.78	114.14	14.64	114.14	14.64
LAKE OLIVIA SOUTH	128.96	126.91	2.05	126.90	2.06
LAKE ISIS NORTH	112.66	112.66	0	112.66	0
LAKE ISIS EAST	110.99	111.22	-0.23	111.35	-0.36
C38.PINE	43.08	44.08	-1.00	44.08	-1.00
LAKE ISIS SOUTH	118.42	118.42	0	118.42	0
LAKE ISIS SOUTH EAST	114.85	114.05	0.80	113.73	1.12
LOTELLA_G	81.38	83.13	-1.75	83.19	-1.81
FTKISS	42.31	41.81	0.50	41.81	0.50
WEIR3_H	42.24	42.37	-0.13	42.37	-0.13
FT DRUM	35.53	34.76	0.77	34.76	0.77
WEIR2_H	41.95	41.84	0.11	41.84	0.11
AVON P3	41.71	40.90	0.81	40.90	0.81
WEIR1_H	41.39	41.39	0	41.39	0
OK-3_G	59.53	61.94	-2.41	61.94	-2.41
SEBRING_G	55.86	58.65	-2.79	58.73	-2.87
ARBUCK.L	40.16	41.98	-1.82	41.98	-1.82
STL-42_G	25.79	25.30	0.49	25.40	0.39
ARBUCK	39.75	39.84	-0.09	39.84	-0.09
H-11A_G	47.95	45.95	2.00	45.95	2.00
BASSETT_G	43.14	45.20	-2.06	45.20	-2.06
S65C_H	33.81	33.48	0.33	33.48	0.33
OK-2_G	44.67	40.96	3.71	40.96	3.71
S68_H	39.12	39.12	0	39.12	0
OPAL_G	33.14	32.37	0.77	32.37	0.77
S65D_H	26.74	26.76	-0.02	26.76	-0.02
YATES M_H	24.37	26.44	-2.07	26.44	-2.07
S82_H	31.87	30.99	0.88	30.99	0.88

Table D-6. Observation Sites Statistics (Continued).

Station Name	1995 Hist_Avg	Ag Wells Based on Permits		Ag Wells Based on Land Use	
		Model_Avg	Diff	Model_Avg	Diff
S83_H	31.97	34.31	-2.34	34.31	-2.34
S84_H	24.71	23.22	1.49	23.22	1.49
S154_H	20.28	19.19	1.09	19.19	1.09
S133_H	13.57	13.57	0	13.57	0
NUBBC_H	19.36	18.98	0.38	18.98	0.38
S75_H	25.78	25.64	0.14	25.64	0.14
S191_H	19.12	19.12	0	19.12	0
S70_H	25.76	25.30	0.46	25.3	0.46
S127_H	13.56	13.56	0	13.56	0
S72_H	20.77	19.18	1.59	19.18	1.59
S135_H	13.60	13.60	0	13.60	0
H-15A_G	58.04	54.62	3.42	54.62	3.42
S71_H	19.92	18.28	1.64	18.28	1.64
S129_H	13.06	13.06	0	13.06	0
S131_H	13.04	13.04	0	13.04	0
FISHP	31.25	30.48	0.77	30.48	0.77
NIOC3	17.99	17.92	0.07	17.92	0.07
NICO1	13.99	12.07	1.92	12.07	1.92
CULV5_H	16.52	16.52	0	16.52	0
S77_H	16.39	16.39	0	16.39	0
OSF-42	43.02	42.92	0.10	43.23	-0.21
ALTMAN DEEP WELL NEAR WEST FR	84.20	83.39	0.81	83.47	0.73
CLENNY DEEP NW/O AVON PK FL	83.05	81.29	1.76	81.99	1.06
OKF-0054	39.08	43.08	-4.00	43.23	-4.15
BONNET LAKE DEEP NEAR SEBRING	83.21	82.38	0.83	81.89	1.32
SMITH DEEP WELL NO. 731136344	71.64	70.29	1.35	70.19	1.45
727100-- 35S33E02 BASS WELL N	46.73	46.73	0	46.80	-0.07
OKF-7	46.19	45.79	0.40	45.85	0.34
OKF-17 DIXIE RANCH	47.00	46.50	0.50	46.42	0.58
OKF-23	44.34	46.75	-2.41	46.27	-1.93
OKF-31_G	49.85	47.34	2.51	47.12	2.73
LAKE PLACID GROVES DEEP SOUTH	51.19	52.16	-0.97	52.18	-0.99
71110501OBSER WELL GL155 NEAR	48.01	47.37	0.64	47.40	0.61
65411601 41S30E12 CLEMONS PAL	49.90	49.51	0.39	49.53	0.37
S-65A(POF-20)WELL NR YEEHAW J	46.30	47.40	-1.10	47.30	-1.00
73911801 33S30E06 USAF AVON P	77.79	75.40	2.39	75.13	2.66
SHEARER DEEP WELL NO 141 NEAR	78.10	78.36	-0.26	78.20	-0.10
OKF-34	46.73	48.00	-1.27	48.07	-1.34
HIF-3 73111501 HOWERTON'S WEL	53.85	54.67	-0.82	54.67	-0.82
CITY SEBRING DEEP 24 AT SEBRI	83.49	82.10	1.39	82.01	1.48
HIF-32 GUILFORD TOMLINSON	53.62	54.46	-0.84	55.15	-1.53

Table D-6. Observation Sites Statistics (Continued).

Station Name	1995 Hist_Avg	Ag Wells Based on Permits		Ag Wells Based on Land Use	
		Model_Avg	Diff	Model_Avg	Diff
HIF-4 34S31E28 YUCAN RANCH NR	49.16	50.98	-1.82	50.78	-1.62
HIF-13_G	47.53	48.50	-0.97	48.60	-1.07
OKF-42	47.1	47.79	-0.69	47.68	-0.58
FTB18	49.23	49.31	-0.08	49.29	-0.06
FTB20	48.52	48.08	0.44	47.85	0.67
FTB17	49.8	48.65	1.15	48.32	1.48
HIF-16_G	61.92	56.80	5.12	56.94	4.98
FTB19	48.92	48.17	0.75	48.22	0.70
HIF-14 P G PHYPERS	49.96	51.46	-1.50	51.41	-1.45
ROMP 28 FLORIDAN WELL NR LAKE	70.13	68.39	1.74	68.37	1.76
FTB45	49.79	48.19	1.60	48.32	1.47
HIF-0037	47.16	47.34	-0.18	47.14	0.02
HIF-8 BOX RANCH	49.08	48.99	0.09	49.20	-0.12
HIF-5 CHARLES STIDHAM	48.87	49.88	-1.01	50.04	-1.17
HIF-23 GRAHAM CO DAIRY	48.68	48.49	0.19	48.50	0.18
HIF-26_G	49.19	49.59	-0.40	49.61	-0.42

For the Surficial Aquifer System, most of the model showed no difference between the run using pumpage based on land use and the pumpage based on the permit database (**Figure D-8**). There were differences of up to 2 feet in the Lake Wales Ridge area, an urban residential area around lakes. The AFSIRS model predicts more consumption for landscape irrigation than is noted from the actual permitted use obtained from SWFWMD permit databases. Other than that area only Nubbin Slough had the AFSIRS model predicting much lower water levels than those with the permitted dataset.

In the Upper Floridan Aquifer, the 1995 AFSIRS simulation predicted more water use around Lake Okeechobee and in citrus areas (**Figure D-9**). The water levels in those areas were up 1.6 feet higher than the water levels simulated with the permitted agricultural consumption. In portions of western St. Lucie County, and near the SFWMD's eastern boundary in Okeechobee County, there was more water consumption based on the AFSIRS than based on the permitted water use. Most of these areas had a difference of less than a foot, but a couple of cells had a difference of up to 8 feet.

The Middle Floridan Aquifer (**Figure D-10**) showed similar areas to the Upper Floridan Aquifer where the AFSIRS predicted less water use than the permitted agricultural consumption run.

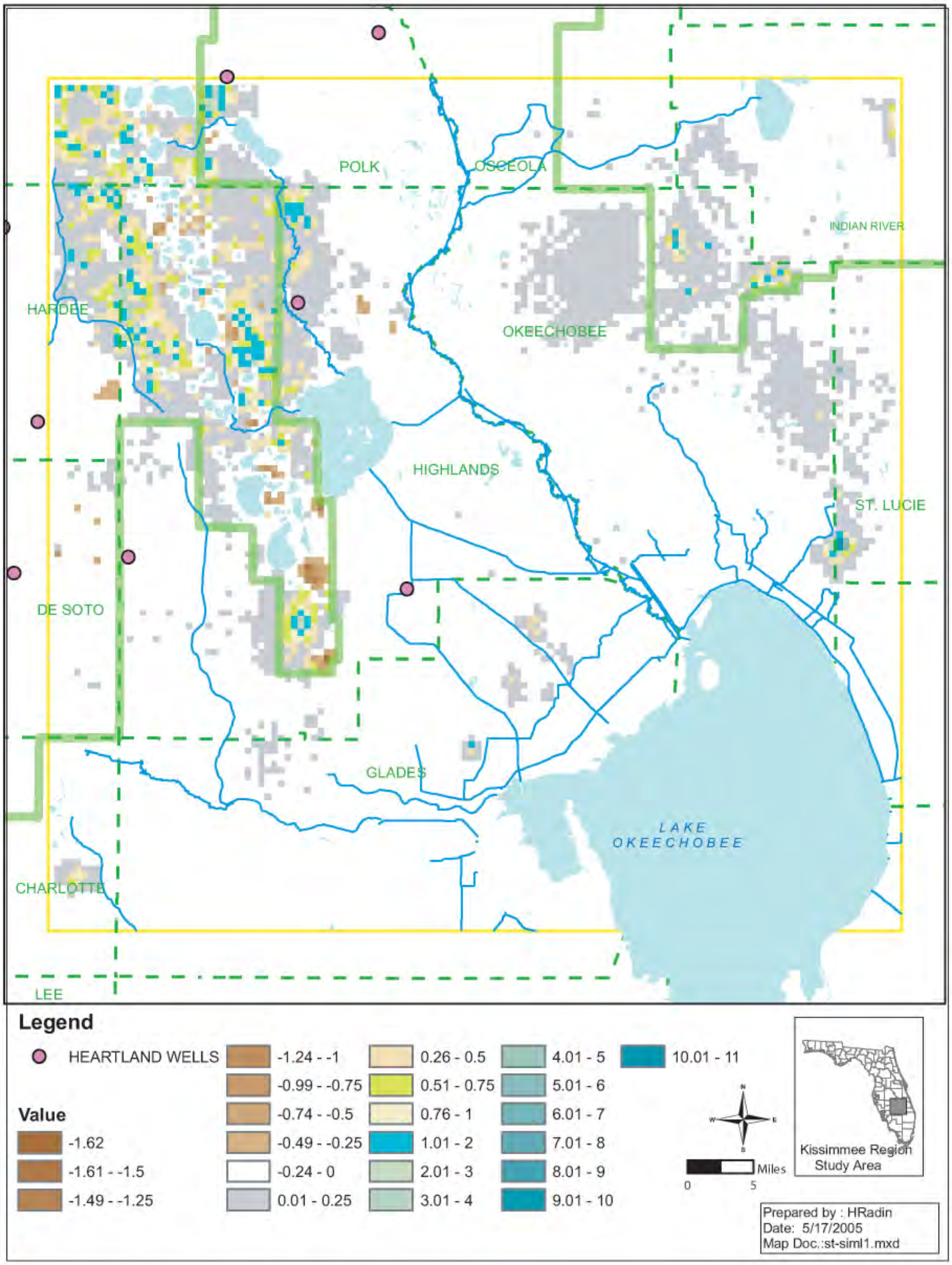

Figure D-8. Difference AFSIRS Ag – Permitted Surficial Aquifer.

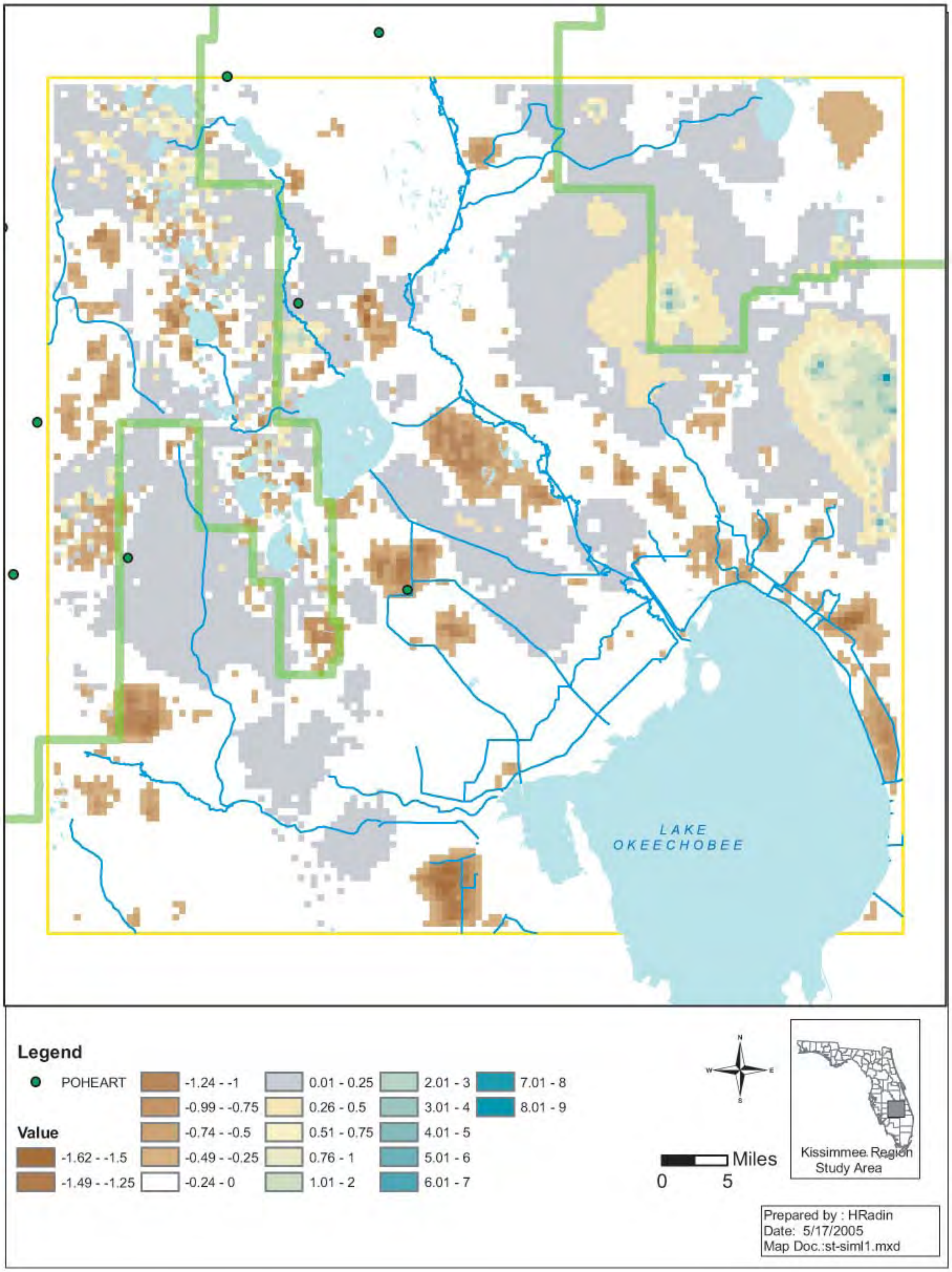

Figure D-9. Difference 1995 AFSIRS Ag – Permitted Upper Floridan Aquifer.

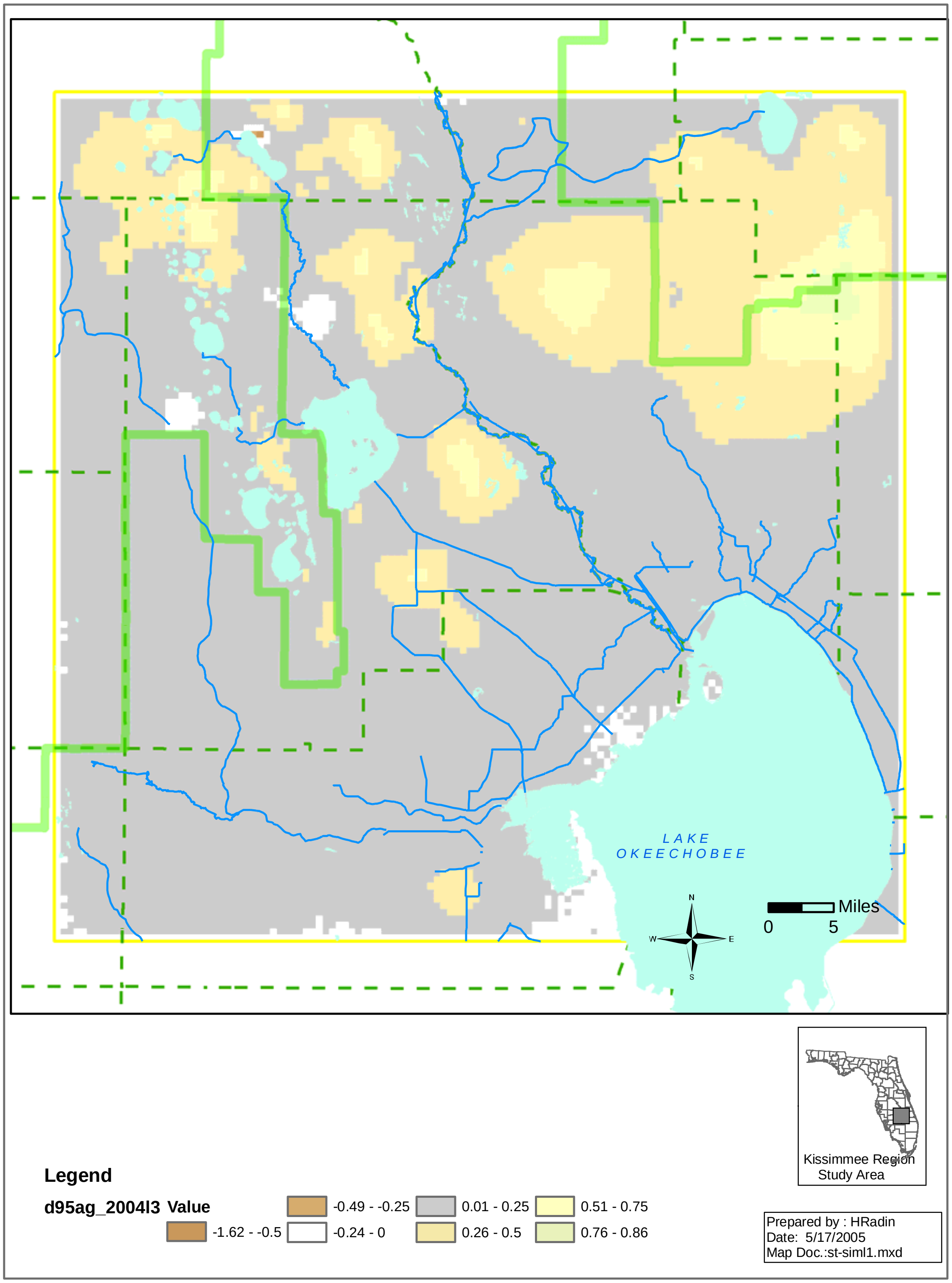

Figure D-10. Difference 1995 AFSIRS Ag – Permitted Middle Floridan Aquifer.

1995 AFSIRS Ag and Well G62

This simulation run uses the same files as the 1995 AFSIRS Ag Run with the addition of one more wellfield – G62 in the Upper Floridan Aquifer. For modeling purposes, the proposed wellfield was placed in Layer 2, Row 73 and Column 12. The model assumes that all the consumption is from one well in the center of the cell. This well was simulated by pumping 2 MGD or 267,400 ft^3/day. The proposed site for G62 places it near the SFWMD/SWFWMD boundary on the Highlands/De Soto county line. The purpose of this simulation is to evaluate the impact of this well on the water levels. This is done by creating drawdown maps, which compare the water levels without well G62 – in this case, the 1995 AFSIRS Ag run – to the water levels with the G62 well.

The local drawdown in the Upper Floridan Aquifer in cell 2, 73 and 12 is 13.31 feet. One cell away (2,640 feet away); the drawdown ranges from 0.5 to 2 feet. A mile away this the drawdown decreases to 0.33 feet. For nearly a 10-mile radius, there is a drawdown of nearly 0.25 feet. Half of the drawdown area falls within the SWFWMD (**Figure D-11**).

No impact was seen in the Surficial Aquifer System – the water levels throughout the model changed by a maximum of 0.01 feet (**Figure D-12**).

The Middle Floridan Aquifer showed a drawdown of up to 0.2 feet with the same drawdown cone “footprint” as in the Upper Floridan Aquifer (**Figure D-13**).

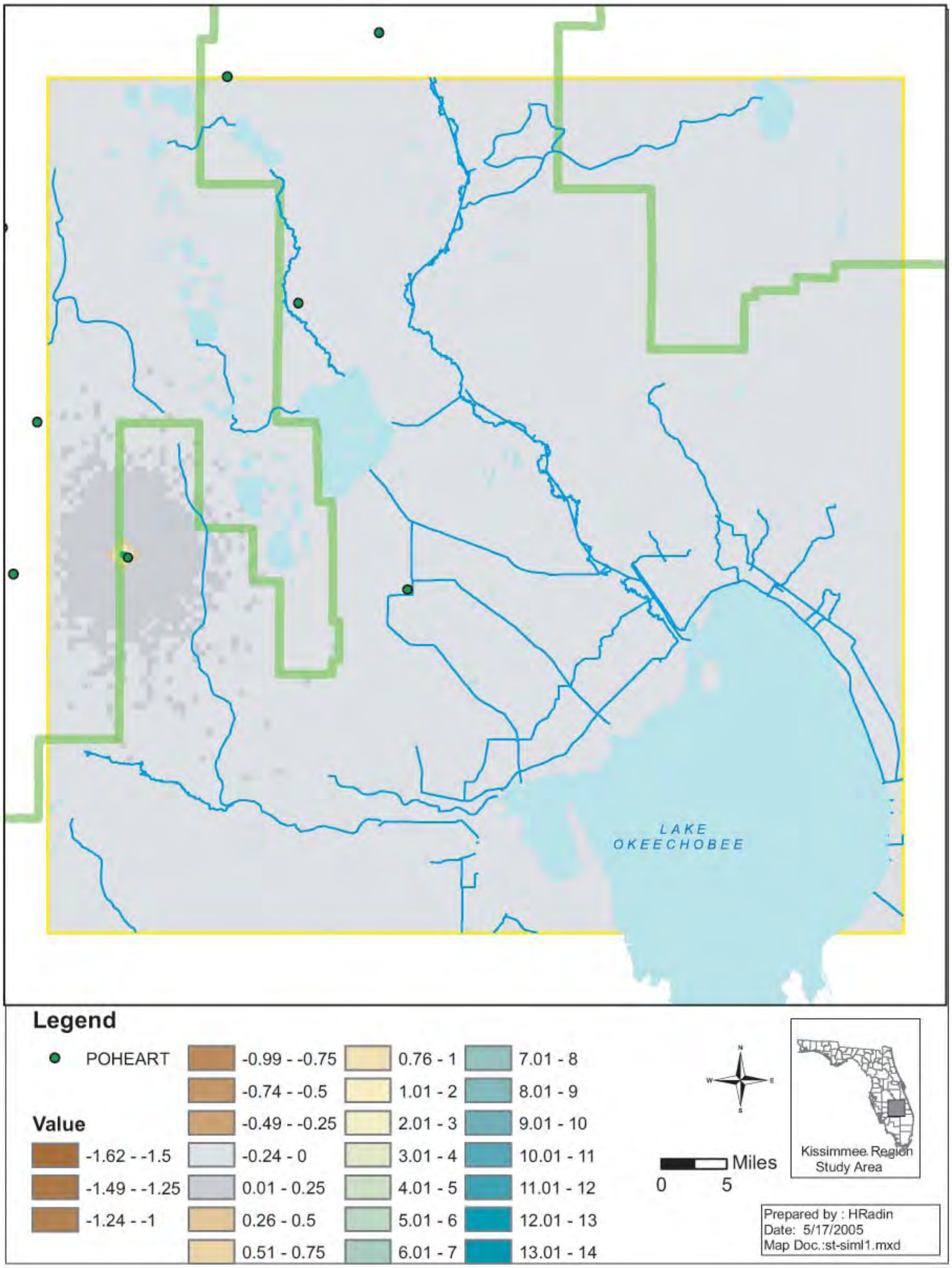

Figure D-11. Difference AFSIRS Ag – G62 Wellfield Upper Floridan Aquifer.

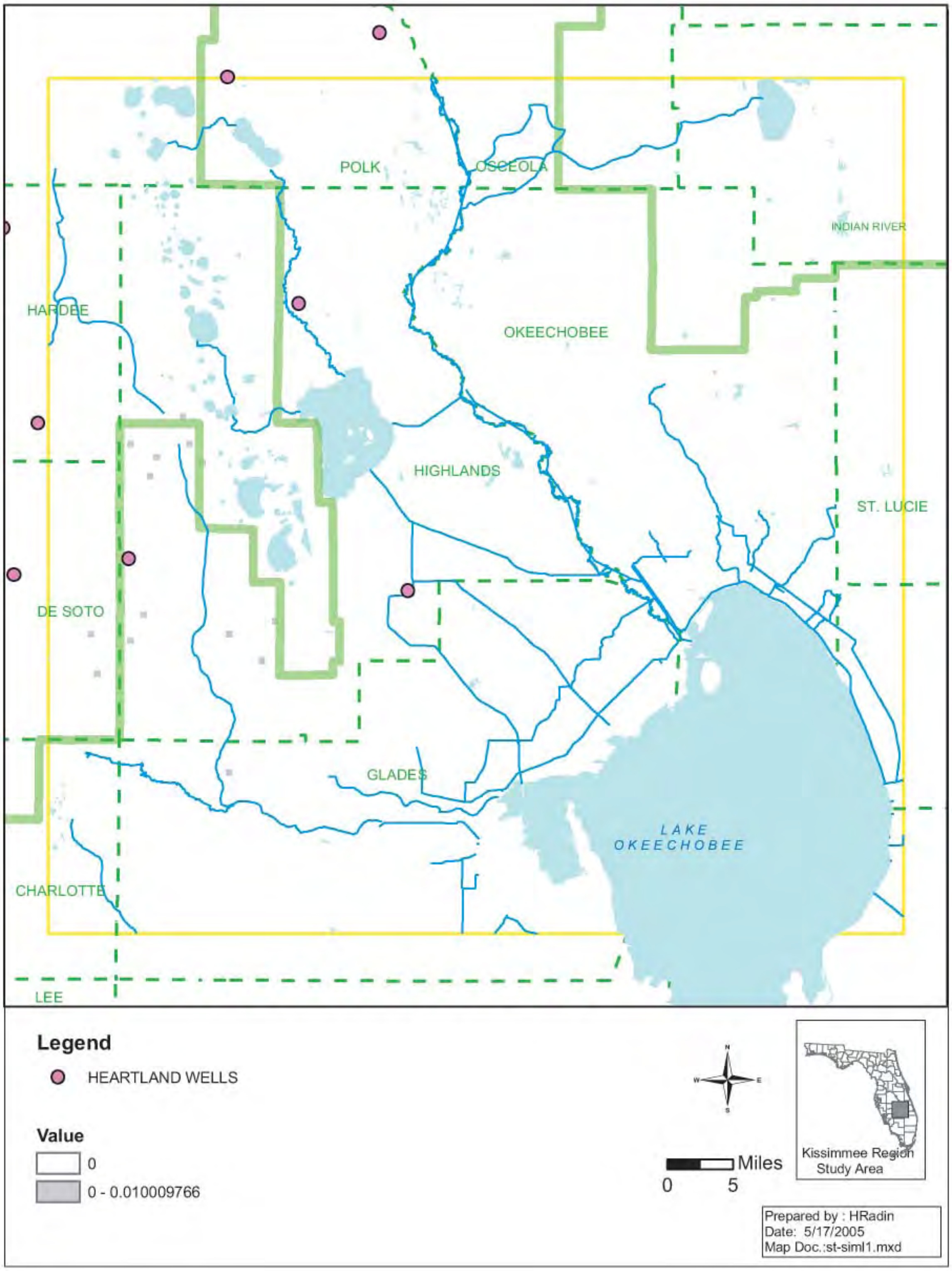

Figure D-12. Difference AFSIRS Ag – G62 Wellfield Surficial Aquifer.

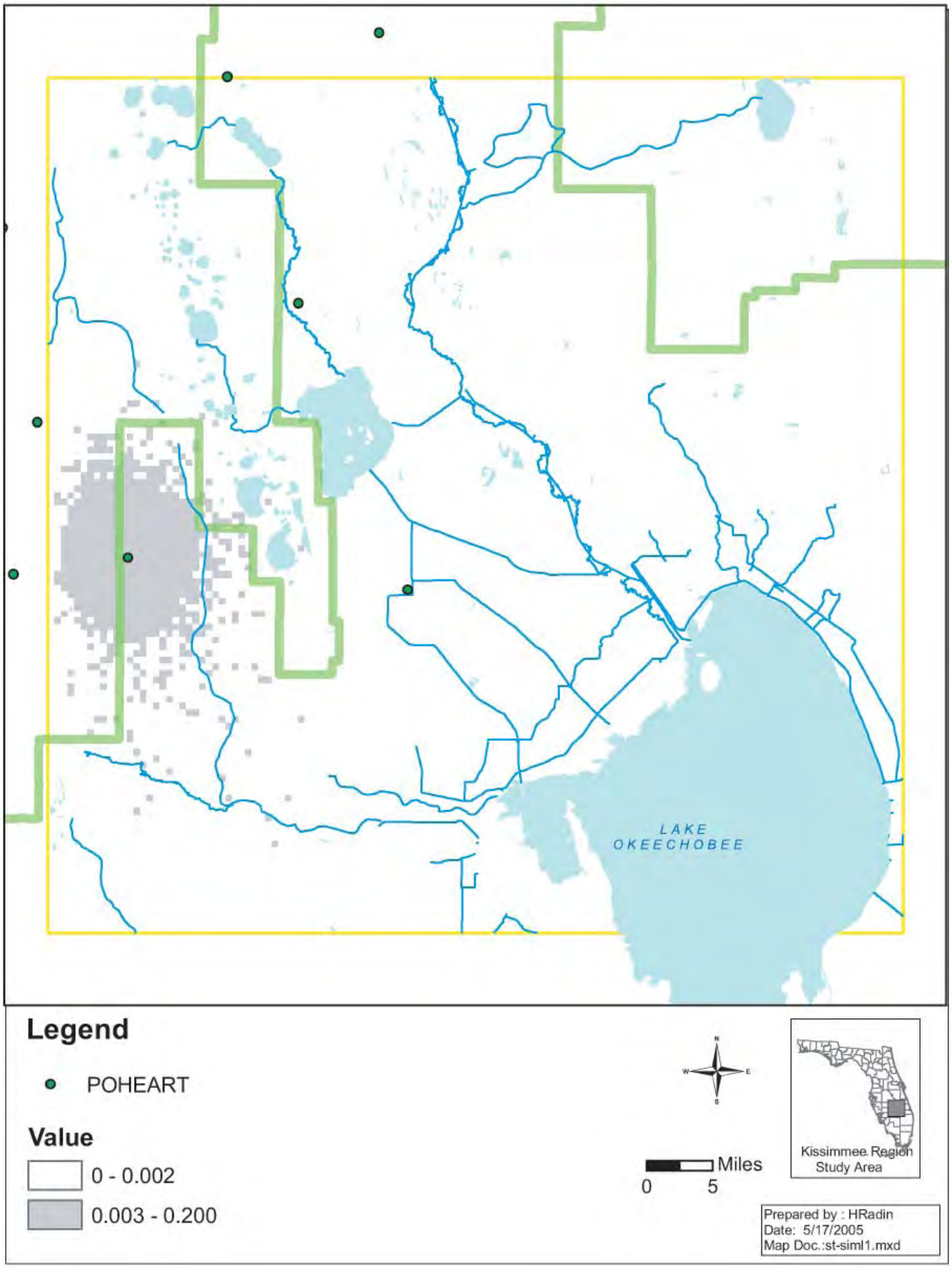

Figure D-13. Difference AFSIRS Ag – G62 Wellfield Middle Floridan Aquifer.

1995 AFSIRS Ag and Well G63

This simulation run uses the same files as the 1995 AFSIRS Ag Run with the addition of one more wellfield – G63 in the Upper Floridan Aquifer. For modeling purposes, the proposed wellfield was placed in Layer 2, Row 34 and Column 38. The model assumes that all the consumption is from one well in the center of the cell. This wellfield was simulated pumping 2 MGD or 267,400 ft^3/day. The proposed site for G63 places it in Highlands County near the SFWMD/SWFWMD boundary near Arbuckle Creek, north of Lake Istokpoga. The purpose of this simulation is to evaluate the impact of this well on the water levels. This is done by creating drawdown maps, which compare the water levels without well G63 – in this case, the 1995 AFSIRS Ag run, to the water levels with the G63 well.

The drawdown in the Upper Floridan Aquifer in cell 2, 34 and 38 is 18.3 feet. One cell away (2,640 feet away); the drawdown ranges from 0.6 to 1.8 feet. A mile away the drawdown decreases to 0.25 feet. For a 5-mile radius around G63, there is a drawdown of about 0.25 feet. This drawdown area extends into the SWFWMD (**Figure D-14**).

No impact from this wellfield was seen in the Surficial Aquifer System – the water levels in four cells east of the wellfield changed by a maximum of 0.04 feet (**Figure D-15**).

The Middle Floridan Aquifer showed a drawdown of up to 2 feet in cell 3, 34 and 38, 0.75 feet one cell over and up to 0.5 feet in an area slightly larger than the drawdown cone “footprint” seen in the Upper Floridan Aquifer (**Figure D-16**).

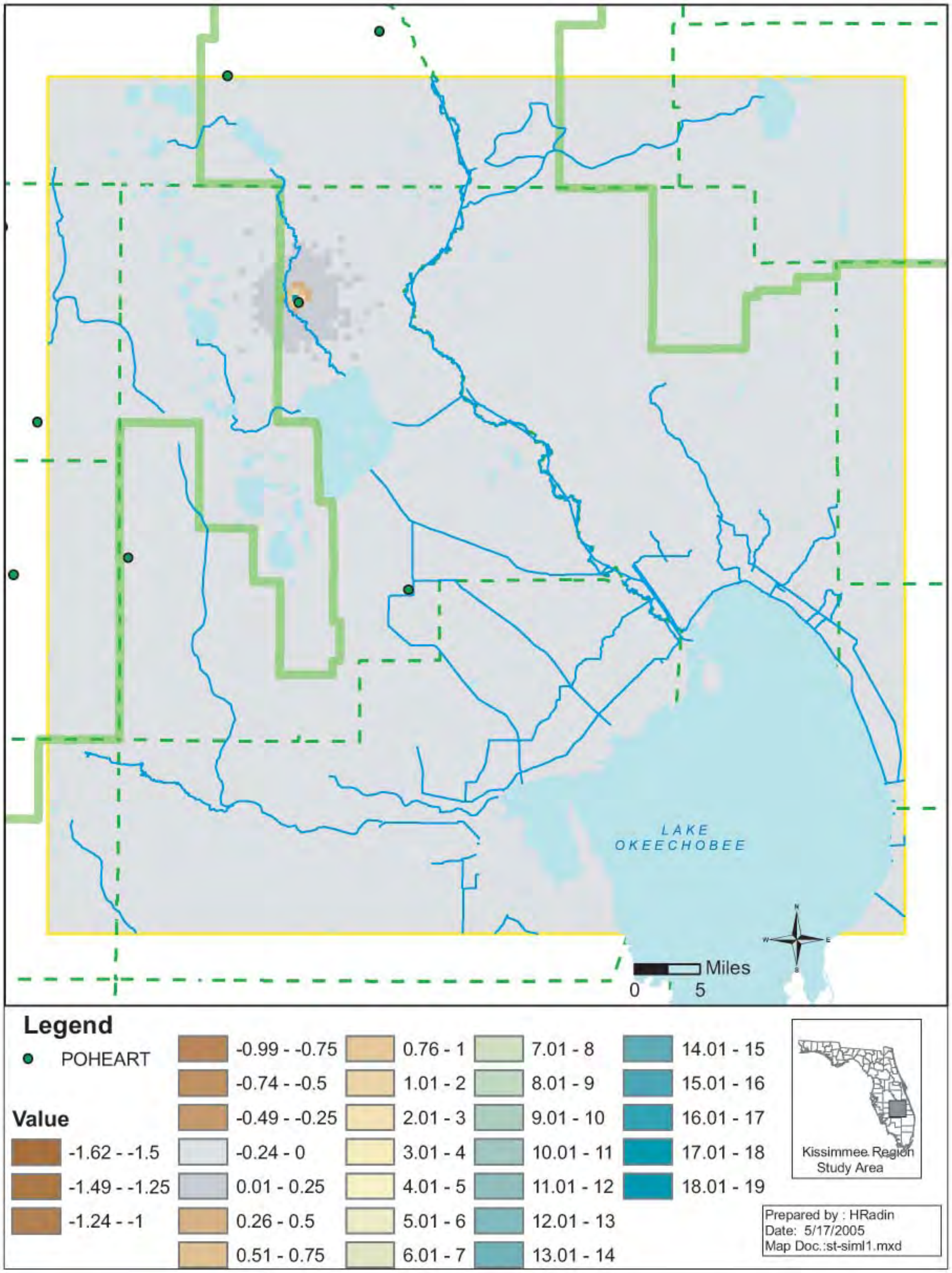

Figure D-14. Difference AFSIRS Ag – G63 Wellfield Upper Floridan Aquifer.

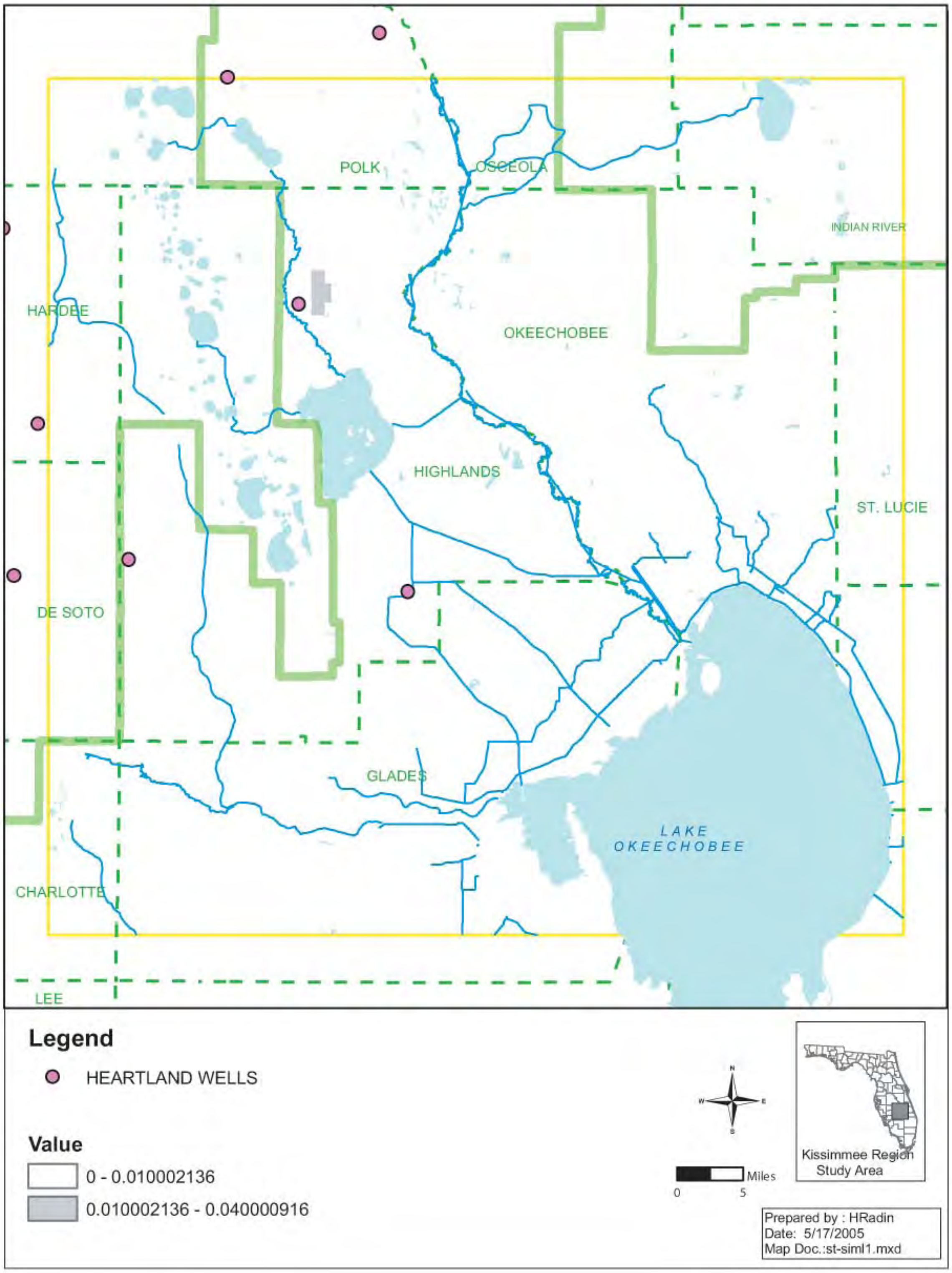

Figure D-15. Difference AFSIRS Ag – G63 Wellfield Surficial Aquifer.

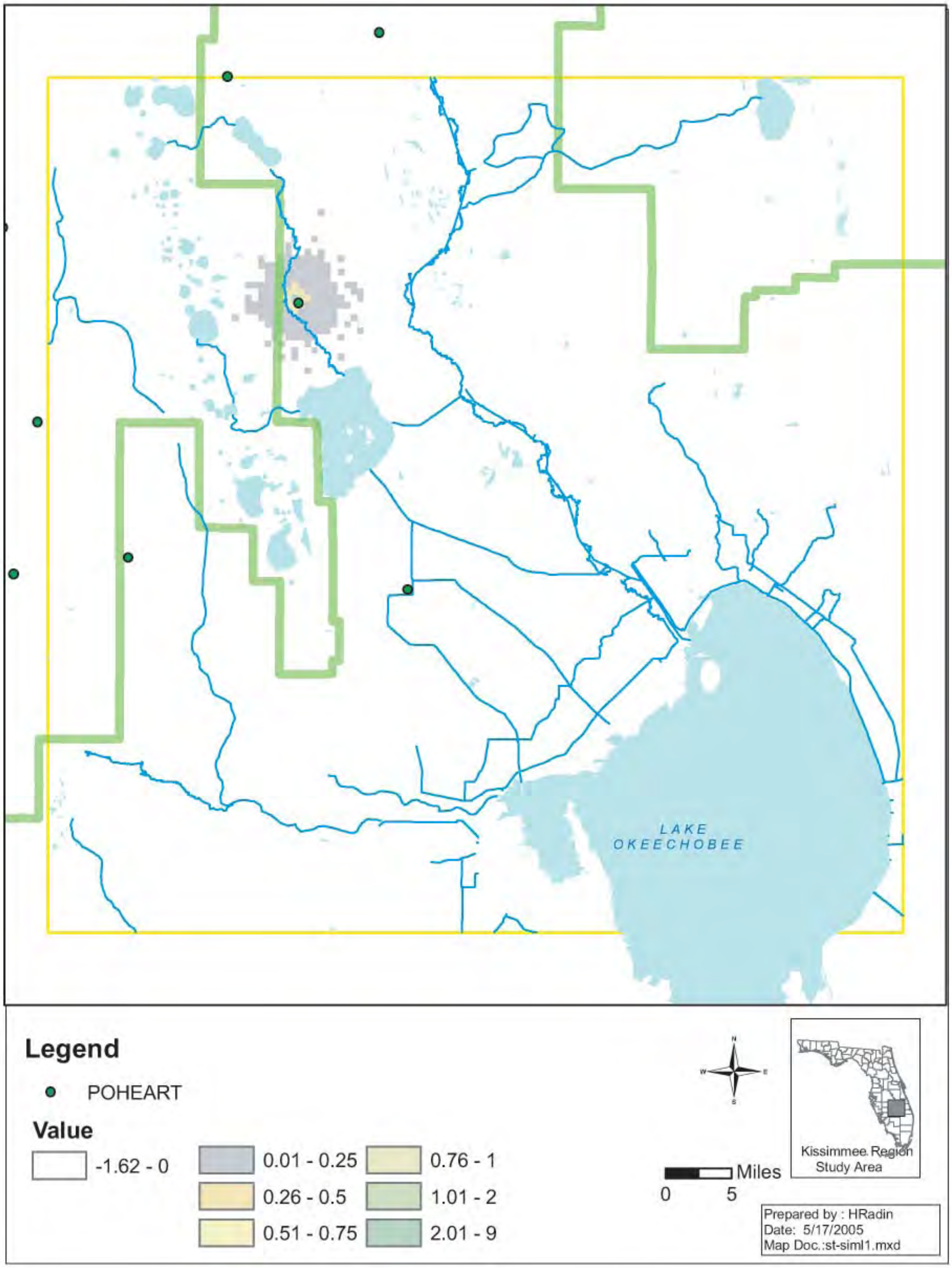

Figure D-16. Difference AFSIRS Ag – G63 Wellfield Middle Floridan Aquifer.

1995 AFSIRS Ag and Well G64

This simulation run uses the same files as the 1995 AFSIRS Ag run with the addition of one more wellfield – G64 in the Upper Floridan Aquifer. For modeling purposes, the proposed wellfield was placed in Layer 2, Row 77 and Column 55. The model assumes that all the consumption is from one well in the center of the cell. This well simulates pumping 5 MGD or 668,500 ft^3/day. The proposed site for G64 places it in Highlands County near the C-41 Canal. The purpose of this simulation is to evaluate the impact of this well on the water levels. This is done by creating drawdown maps, which compare the water levels without well G64 – in this case, the 1995 AFSIRS Ag Run, to the water levels with the G64 well.

The local drawdown in the Upper Floridan Aquifer in cell 2, 77 and 55 is 25.63 feet. One cell away (2,640 feet away); the drawdown ranges from 2 to 5 feet. A mile away the drawdown decreases to 0.8–1.3 feet. At a 1.5-mile radius from G64, the drawdown is 0.5 feet. For about an 8-mile radius, there is a drawdown of about 0.25 feet. This drawdown area extends into the SWFWMD (**Figure D-17**).

No significant impact was seen in the Surficial Aquifer System – the water levels in a few scattered cells changed by up to 0.1 feet (**Figure D-18**).

The Middle Floridan Aquifer showed a drawdown of up to 1.18 feet in cell 3, 77 and 55. A 0.5 foot drawdown occurred a mile further out from G64. The area of the drawdown cone "footprint," seen in the Upper Floridan Aquifer, showed drawdowns of up to 0.25 feet (**Figure D-19**).

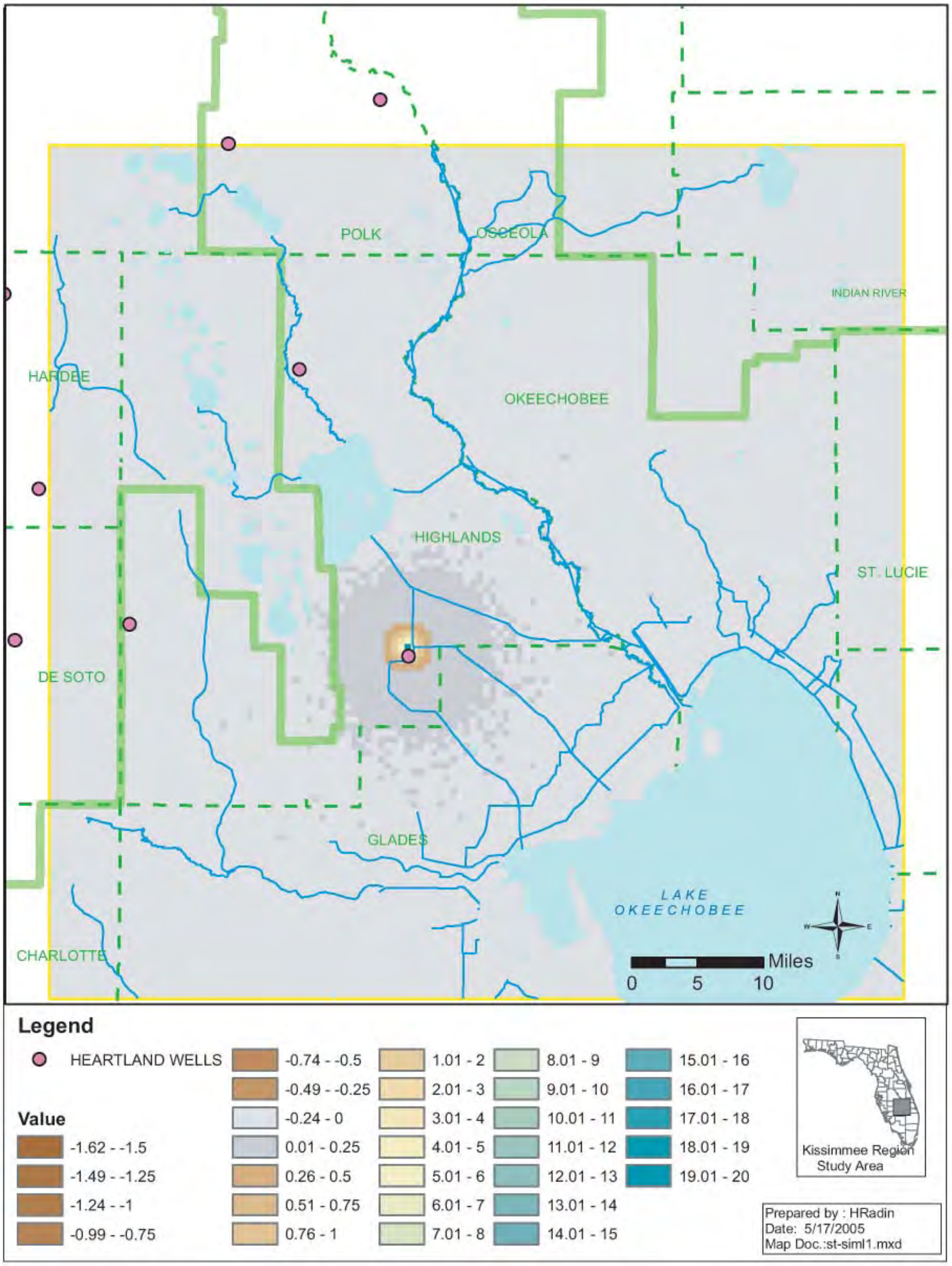

Figure D-17. Difference AFSIRS Ag – G64 Wellfield Upper Floridan Aquifer.

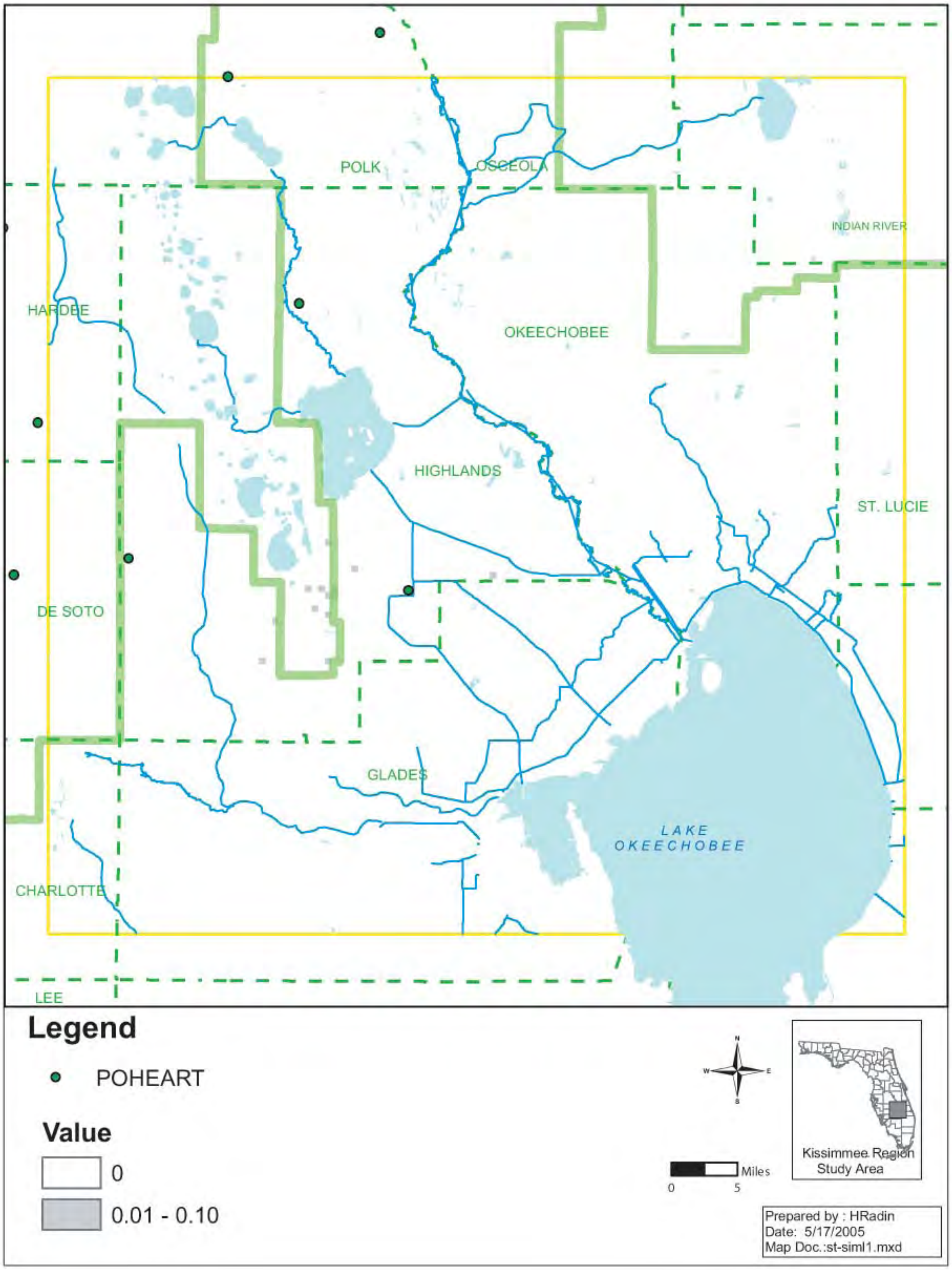

Figure D-18. Difference AFSIRS Ag – G64 Wellfield Surficial Aquifer.

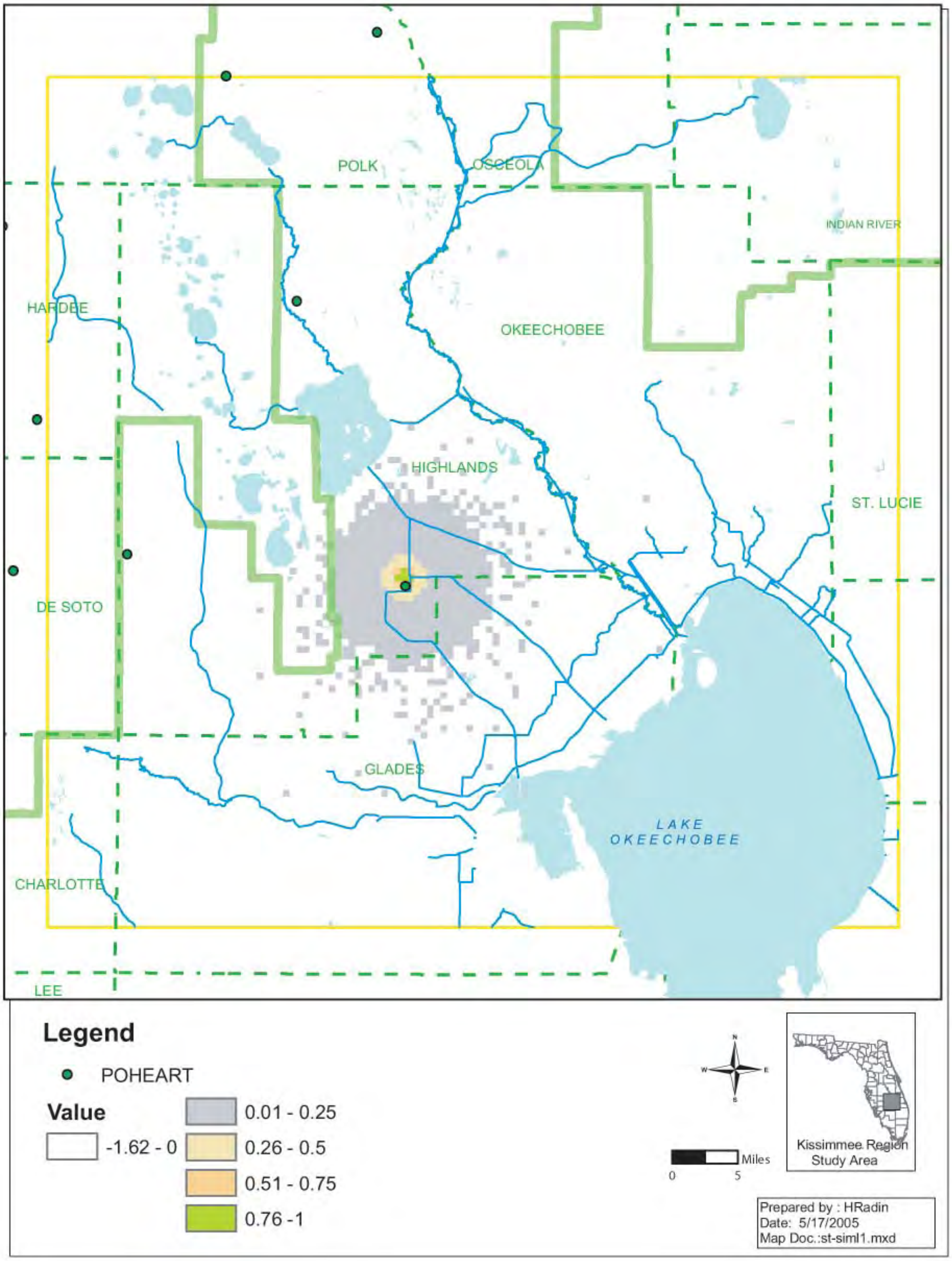

Figure D-19. Difference AFSIRS Ag – G64 Wellfield Middle Floridan Aquifer.

1995 1-in-10 Simulation Run

The 1995 1-in-10 simulation run used the same files as the 1995 AFSIRS run, with the exception of the Evapotranspiration, Recharge and Agriculture consumption well files. These files were modified for the 1-in-10 rainfall conditions. These files are still based on the 1995 land use conditions.

During the 1-in-10 year simulation, the irrigation demands for all the wells in the model area was increased to 316 MGD, while with average 1995 water conditions the demand was only 200 MGD.

The water levels in the Surficial Aquifer System drop significantly during the 1-in-10 simulations (**Figure D-20**). The areas that changed the most were the wetlands and other non-irrigated areas (Blue Cypress marsh, and the urban areas on Lake Wales Ridge).

The water levels in the Upper Floridan Aquifer do not change as much (**Figure D-21**). Some of the irrigated areas show water levels up to 1.5 feet higher during the 1-in-10 rainfall conditions than during the average 1995 conditions. The water levels in Blue Cypress Marsh and under Avon Park Ridge decreased by up to 4 feet. Most areas declined by less than 2 feet.

The water levels in the Middle Floridan Aquifer show the same general pattern as the Upper Floridan, but the impact is only 0.25 feet in most of the model area and up to 2.5 feet in Blue Cypress Marsh (**Figure D-22**).

For most of the model area, the simulated water levels in the Middle Floridan Aquifer are up to 2 feet higher than in the Upper Floridan Aquifer (**Figure D-23**). Close to the Kissimmee River, the water levels in the Upper Floridan may be higher than those in the Middle Floridan by up to 2 feet. In some areas along Lake Wales Ridge, the water levels in the Middle Floridan may be up to 5 feet higher than the Upper Floridan Aquifer.

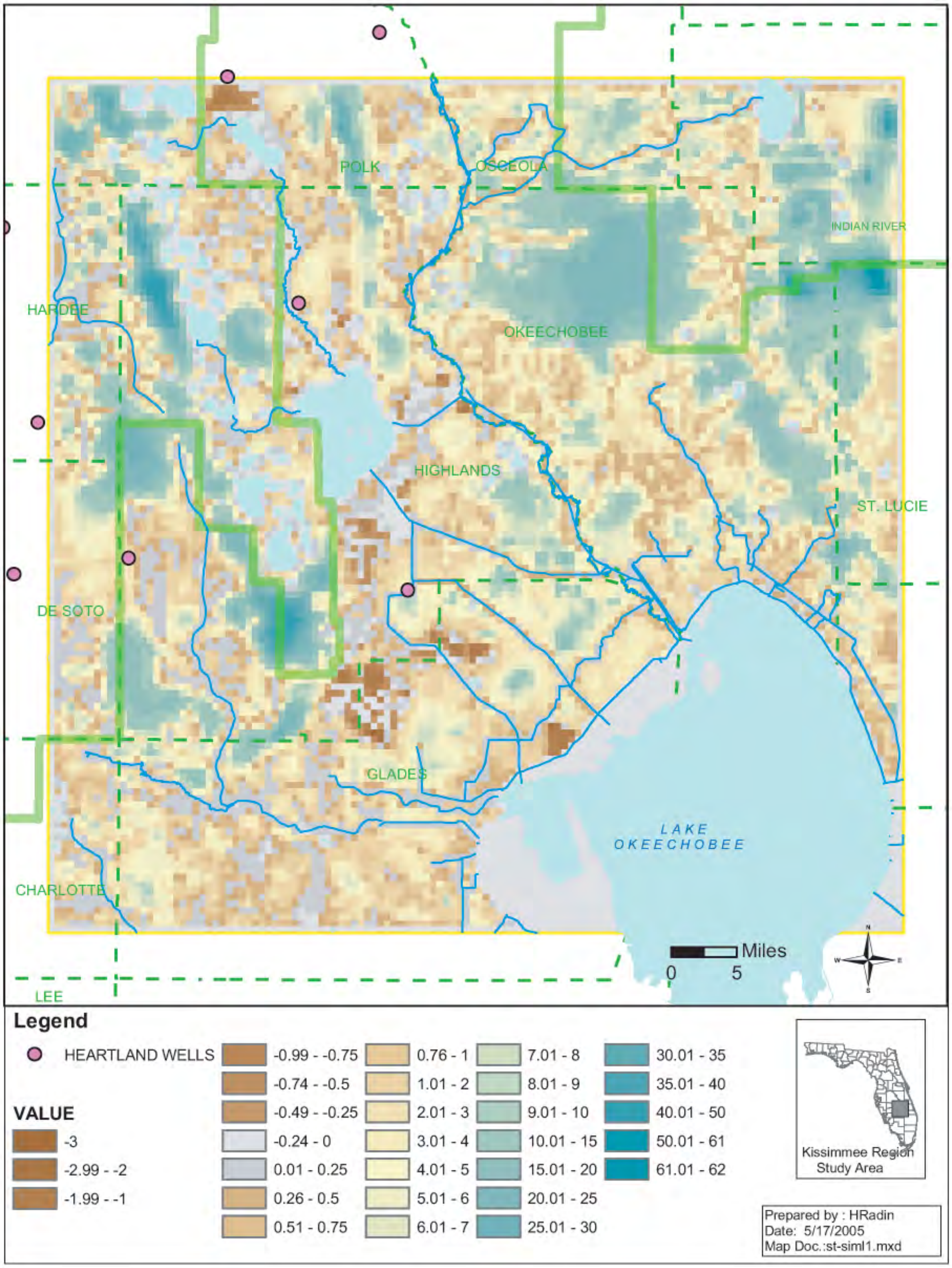

Figure D-20. Difference in Water Levels 1995 Ag and 1995 1-in-10 Surficial Aquifer.

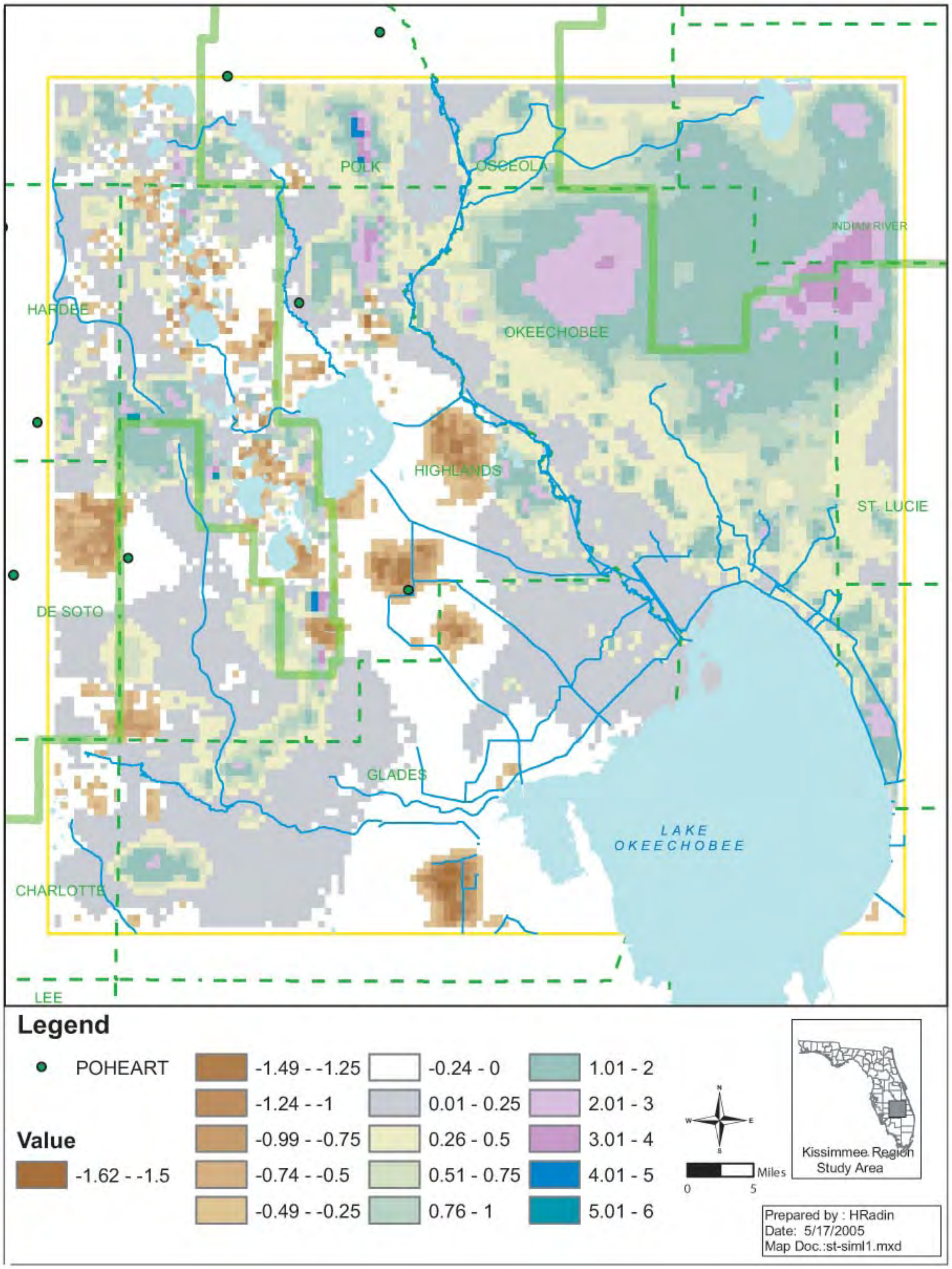

Figure D-21. Difference in 1995 AFSIRS Ag and 1995 1-in-10 Water Levels Upper Floridan Aquifer.

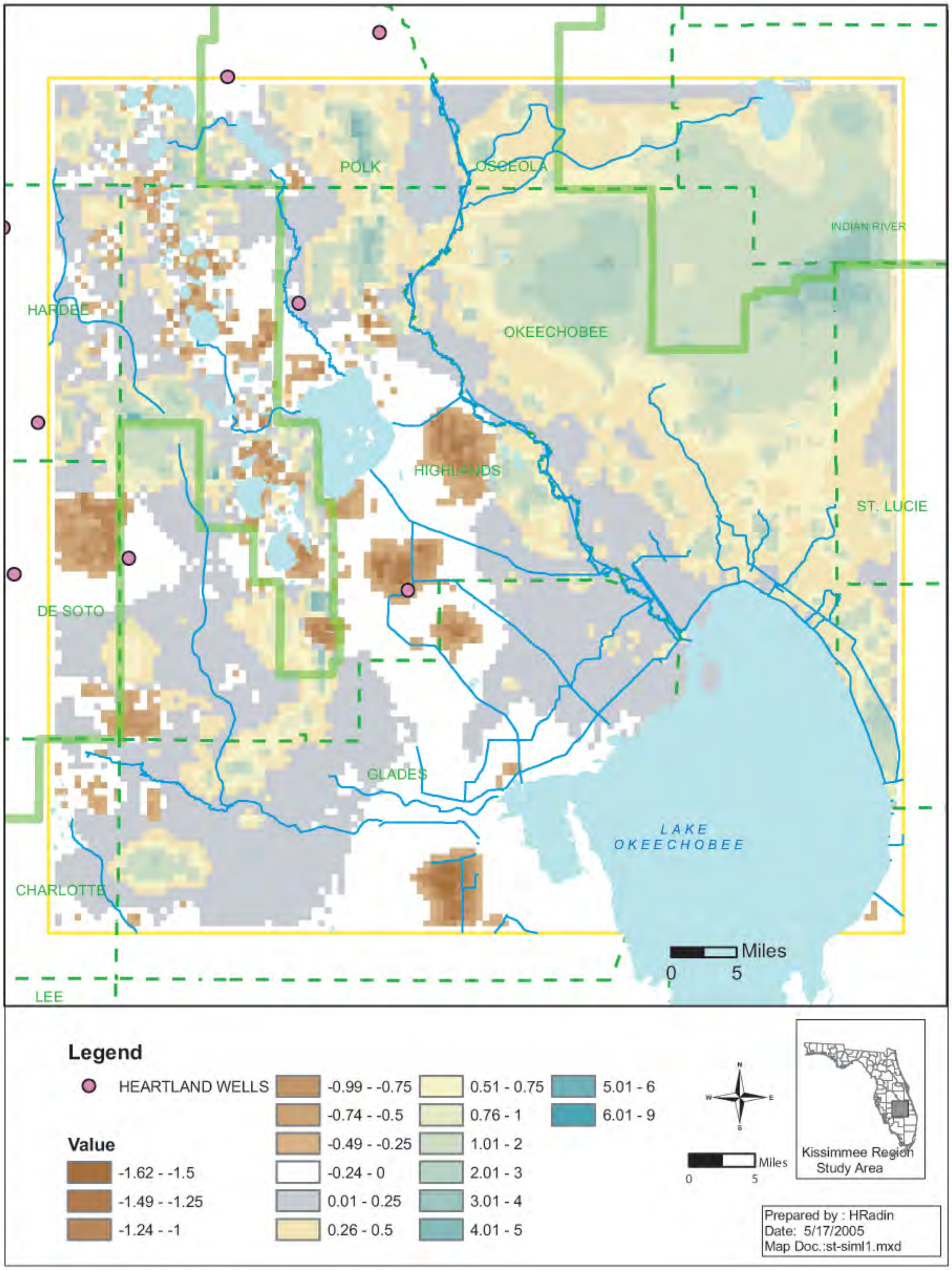

Figure D-22. Difference in Water Levels 1995 Ag and 1995 1-in-10 Upper Floridan Aquifer.

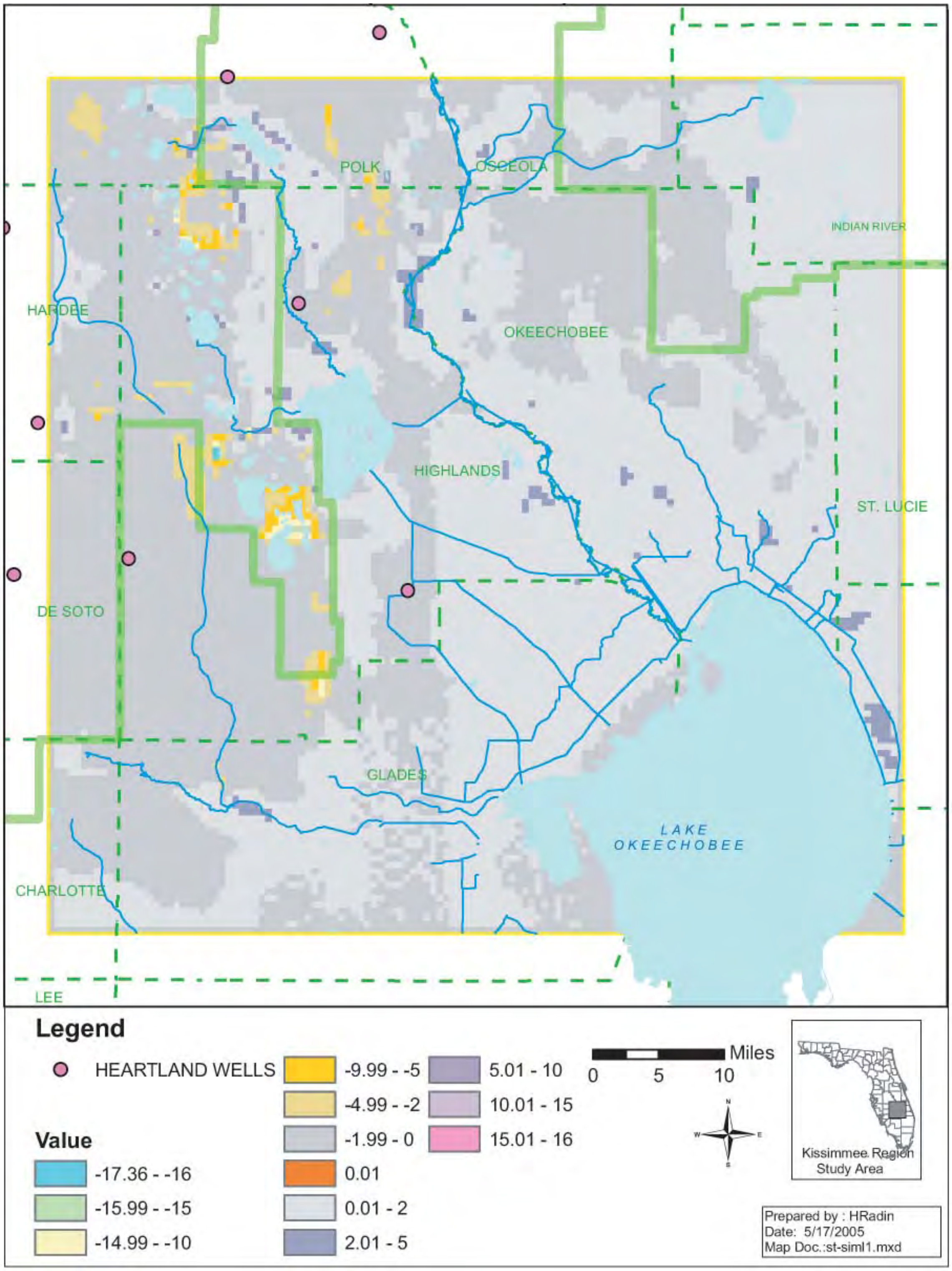

Figure D-23. Difference in Water Levels 1995 1-in-10 Run Layer 3 – Layer 2 (MF – UF).

1995 1-in-10 and Well G62

This simulation run uses the same files as the 1995 1-in-10 run with the addition of one more wellfield – G62 in the Upper Floridan Aquifer. For modeling purposes, the proposed wellfield was placed in Layer 2, Row 73 and Column 12. The model assumes that all the consumption is from one well in the center of the cell. This well simulates pumping 2 MGD or 267,400 ft^3/day. The proposed site for G62 places it near the SFWMD/SWFWMD boundary on the Highlands/De Soto county line. The purpose of this simulation is to evaluate the impact of this well on the water levels. This is done by creating drawdown maps, which compare the water levels without well G62 – in this case, the 1995 1-in-10 simulation – to the water levels with the G62 well. The results of this simulation are nearly identical to those seen in the 1995 AFSIRS + G62 simulation. This indicates there is not very much recharge from the Surficial Aquifer System in the area of this proposed well.

The local drawdown in the Upper Floridan Aquifer in cell 2, 73 and 12 is 13.31 feet. One cell away (2,640 feet), the drawdown ranges from 0.5 to 2 feet. At a mile radius the drawdown decreases to 0.33 feet. For nearly a 10-mile radius there is a drawdown of about 0.25 feet. Half of the drawdown area falls in the SWFWMD (**Figure D-24**).

No impact was seen in the Surficial Aquifer System – the water levels throughout the model changed by a maximum of 0.01 feet (**Figure D-25**).

The Middle Floridan Aquifer showed a drawdown of up to 0.2 feet for a radius of about 3 miles (**Figure D-26**).

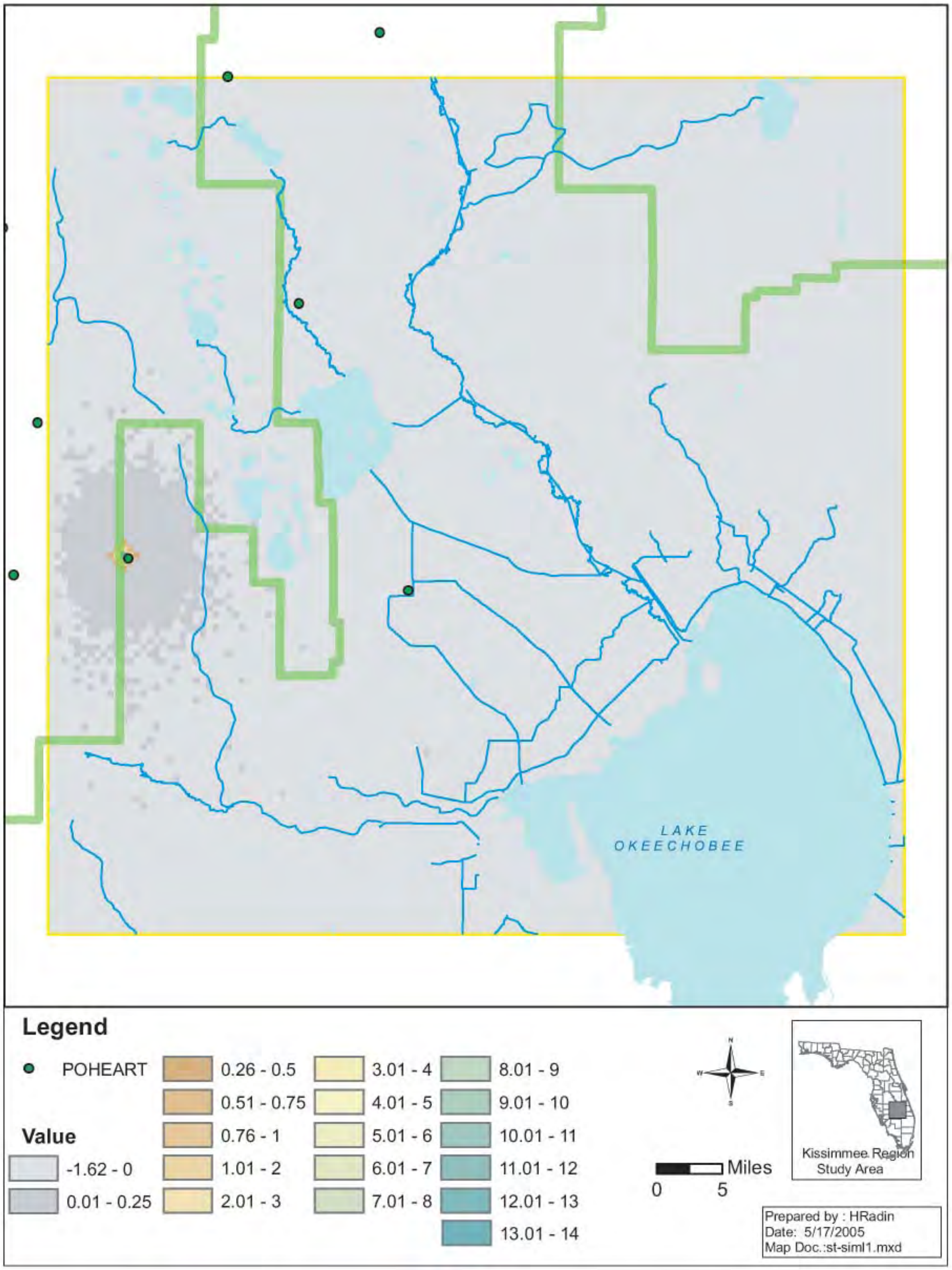

Figure D-24. Difference 1995 1-in-10 – G62 Wellfield Upper Floridan Aquifer.

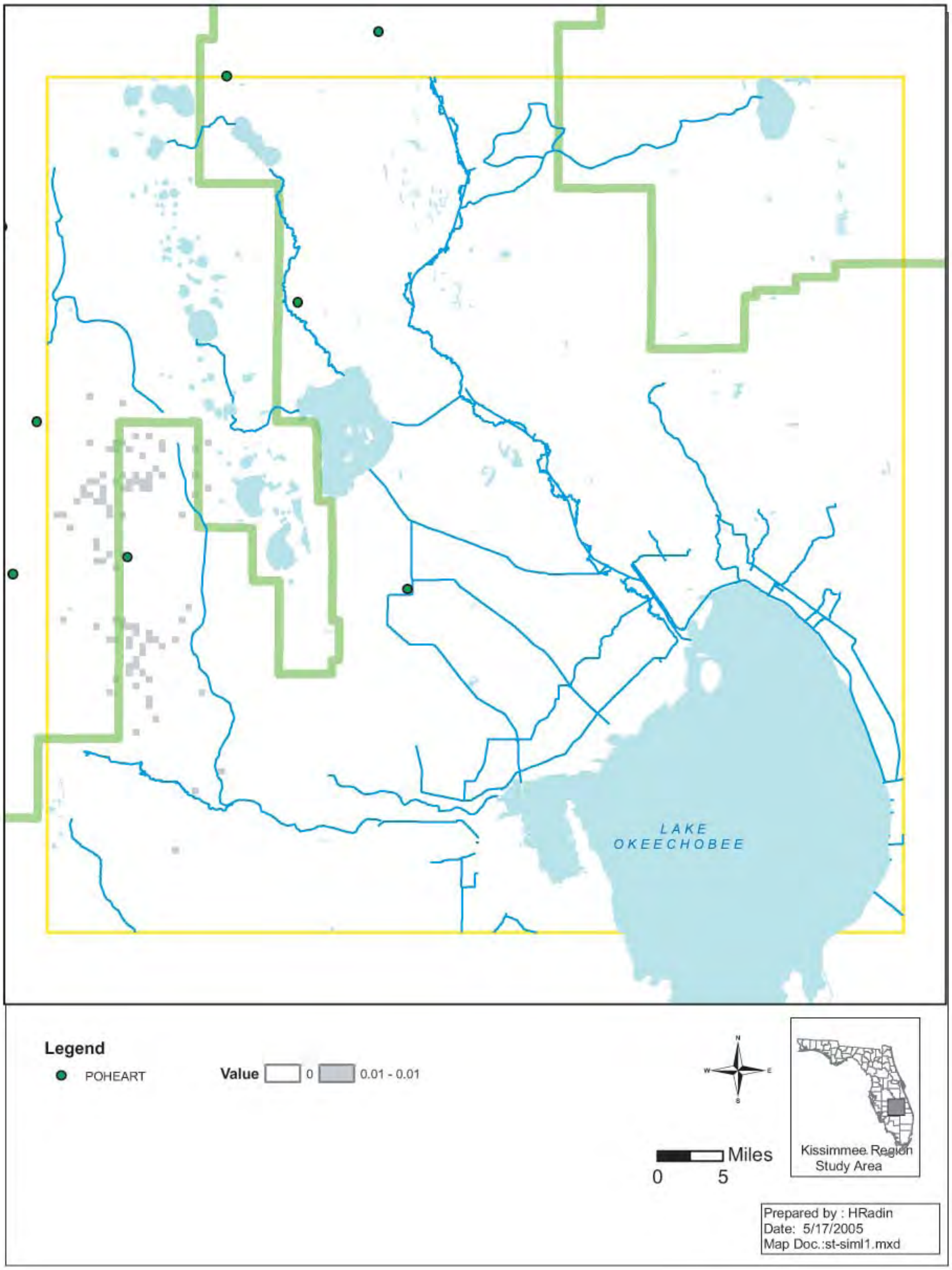

Figure D-25. Difference 1995 1-in-10 – G62 Wellfield Surficial Aquifer.

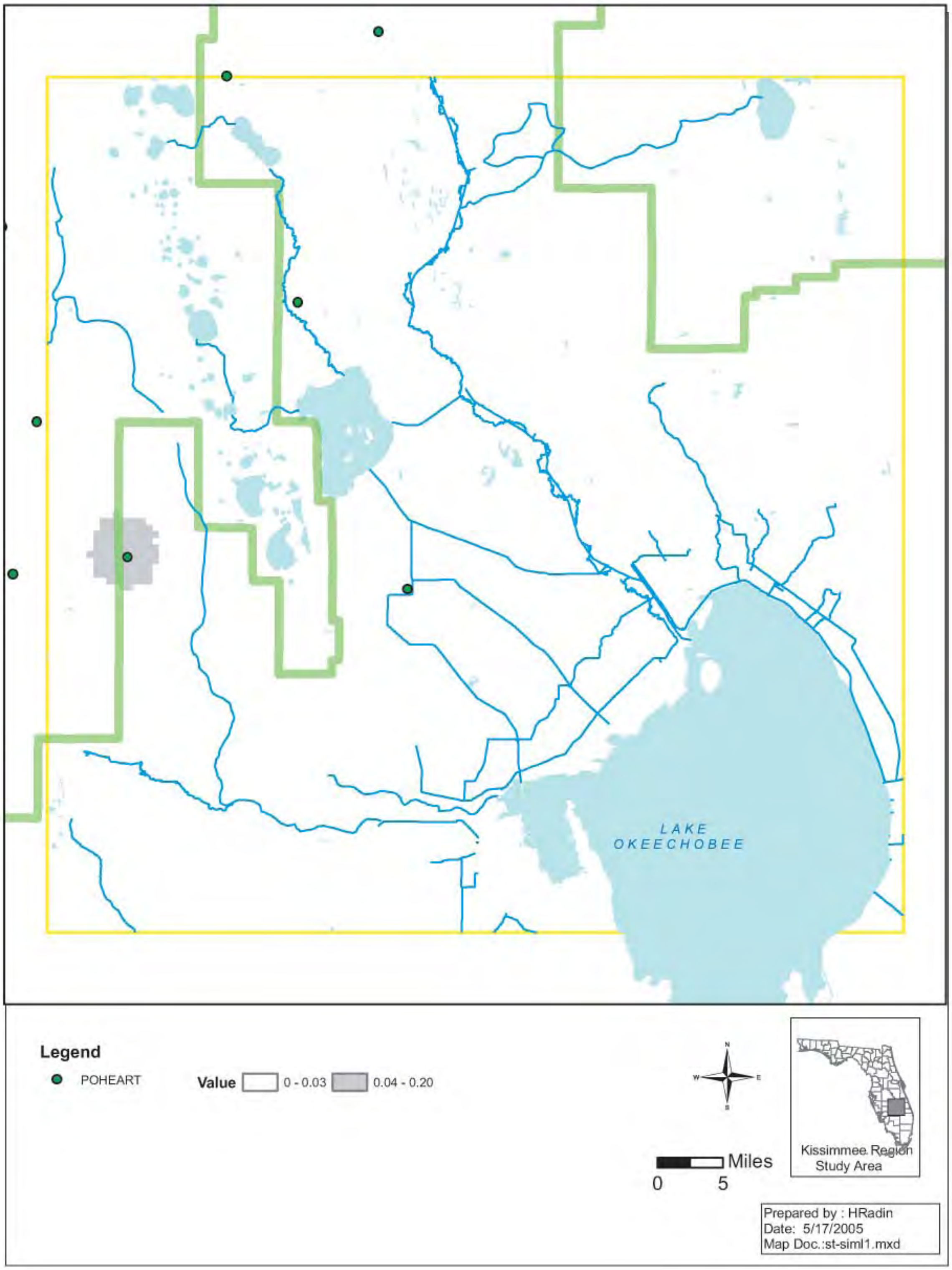

Figure D-26. Difference 1995 1-in-10 – G62 Wellfield Middle Floridan Aquifer.

1995 1-in-10 and Well G63

This simulation run uses the same files as the 1995 1-in-10 Ag run with the addition of one more wellfield – G63 in the Upper Floridan Aquifer. For modeling purposes, the proposed wellfield was placed in Layer 2, Row 34 and Column 38. The model assumes that all the consumption is from one well in the center of the cell. This well will pump 2 MGD or 267,400 ft^3/day. The proposed site for G63 places it in Highlands County near the SFWMD/SWFWMD boundary near Arbuckle Creek, north of Lake Istokpoga. The purpose of this simulation is to evaluate the impact of this well on the water levels. This is done by creating drawdown maps, which compare the water levels without well G63 – in this case, the 1995 1-in-10 Ag run – to the water levels with the G63 well. The impact seen with this simulation is nearly identical to that seen in the 1995 AFSIRS + G63 simulation. This indicates there is not very much recharge from the Surficial Aquifer System in the area of this proposed well.

The local drawdown in the Upper Floridan Aquifer in cell 2, 34 and 38 is 18.29 feet. One cell away (2,640 feet), the drawdown ranges from 0.6 to 1.8 feet. A mile away this decreases to 0.25 feet. For a 5-mile radius, there is a drawdown of about 0.25 feet. This drawdown area extends into the SWFWMD (**Figure D-27**).

No impact was seen in the Surficial Aquifer System – some cells east of the wellfield changed by a maximum of 0.04 feet. The area with drawdown in the Surficial Aquifer System is larger than that seen in the average 1995 year simulation (**Figure D-28**).

The Middle Floridan Aquifer showed a drawdown of up to 2 feet in cell 3, 34 and 38, a 0.75 foot drawdown one cell over (2,640 feet) and up to 0.5 in an area slightly larger than the drawdown cone "footprint" seen in the Upper Floridan Aquifer (**Figure D-29**).

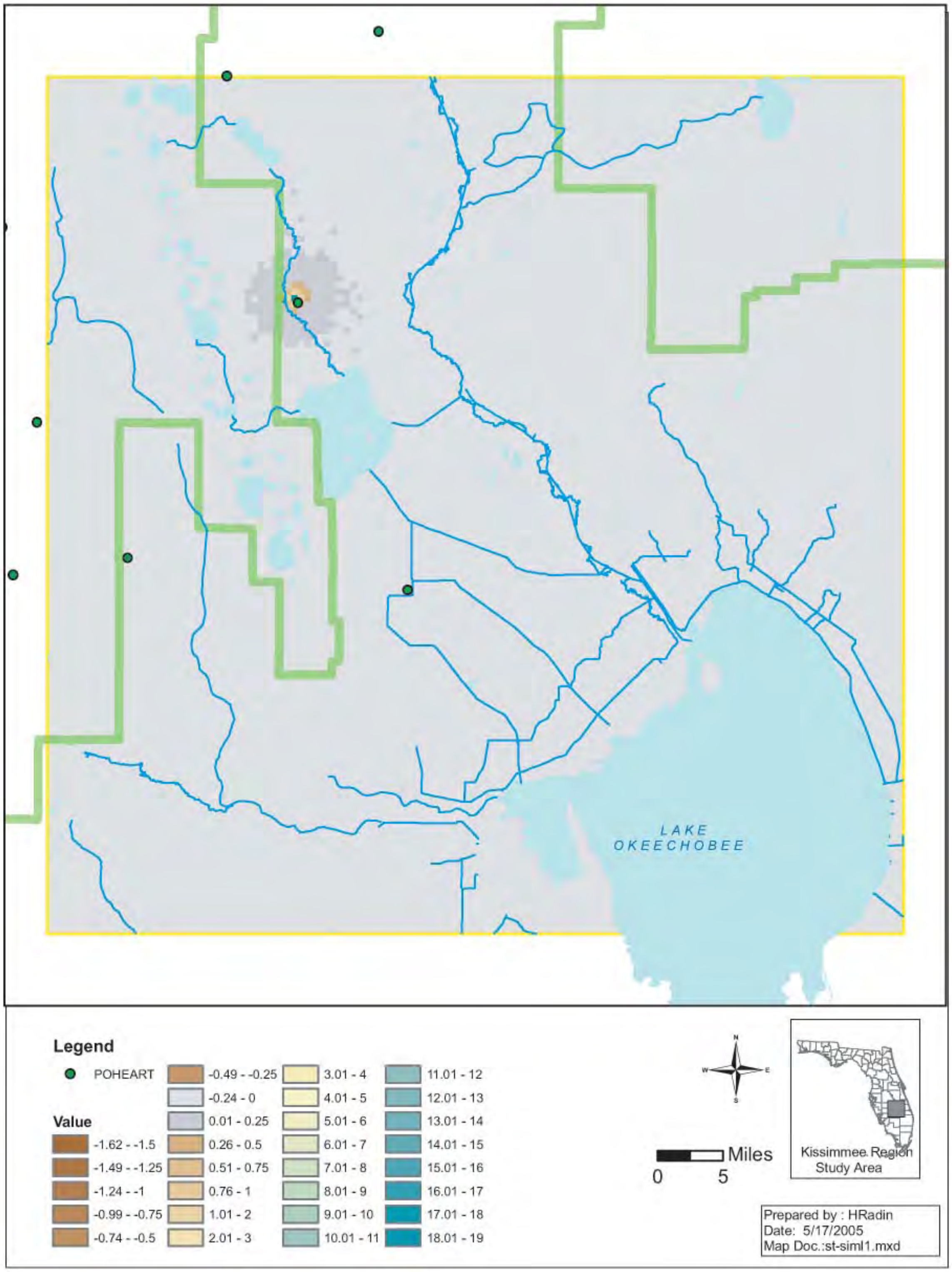

Figure D-27. Difference 1995 1-in-10 – G63 Wellfield Upper Floridan Aquifer.

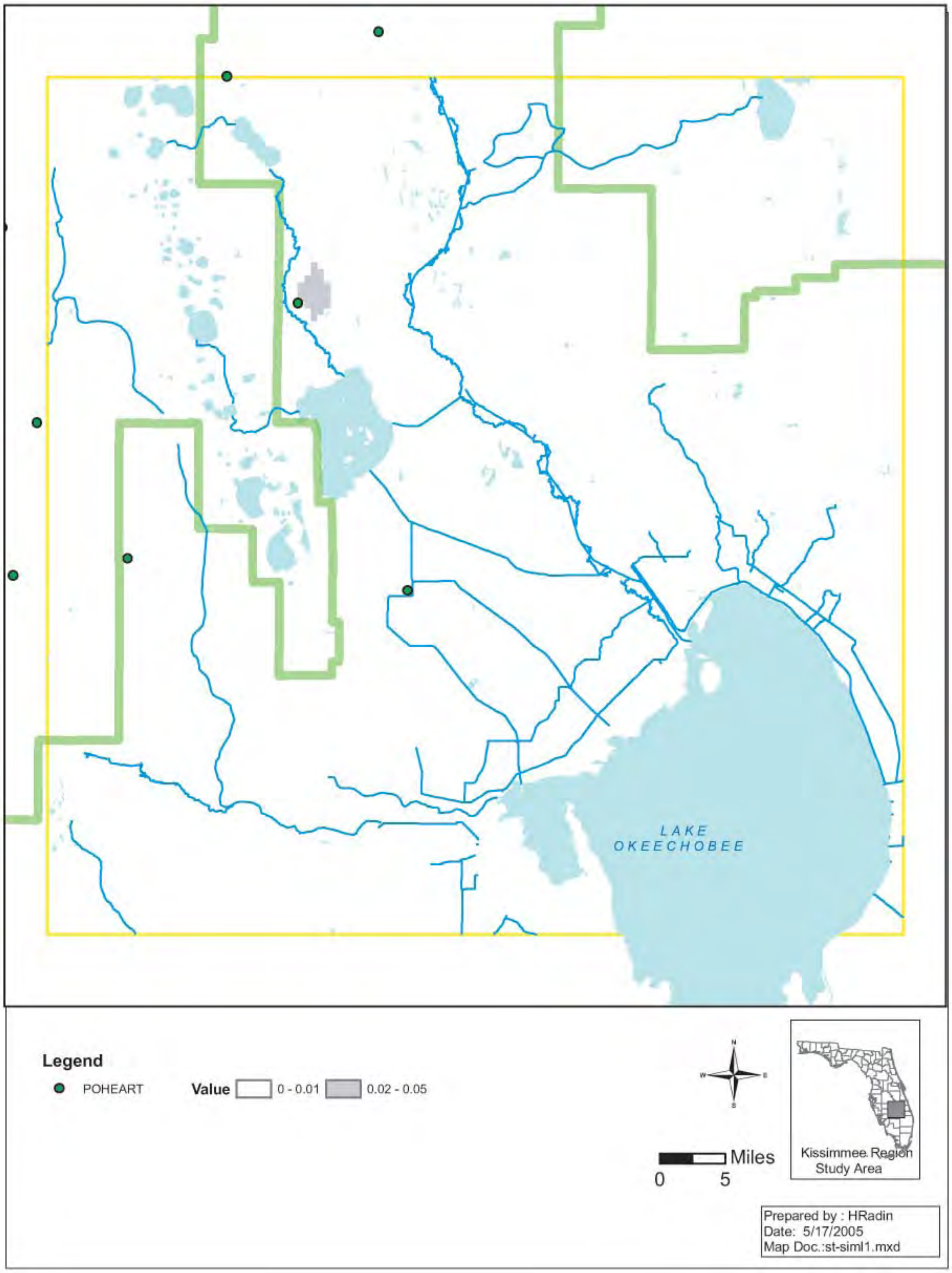

Figure D-28. Difference 1995 1-in-10 – G63 Wellfield Surficial Aquifer.

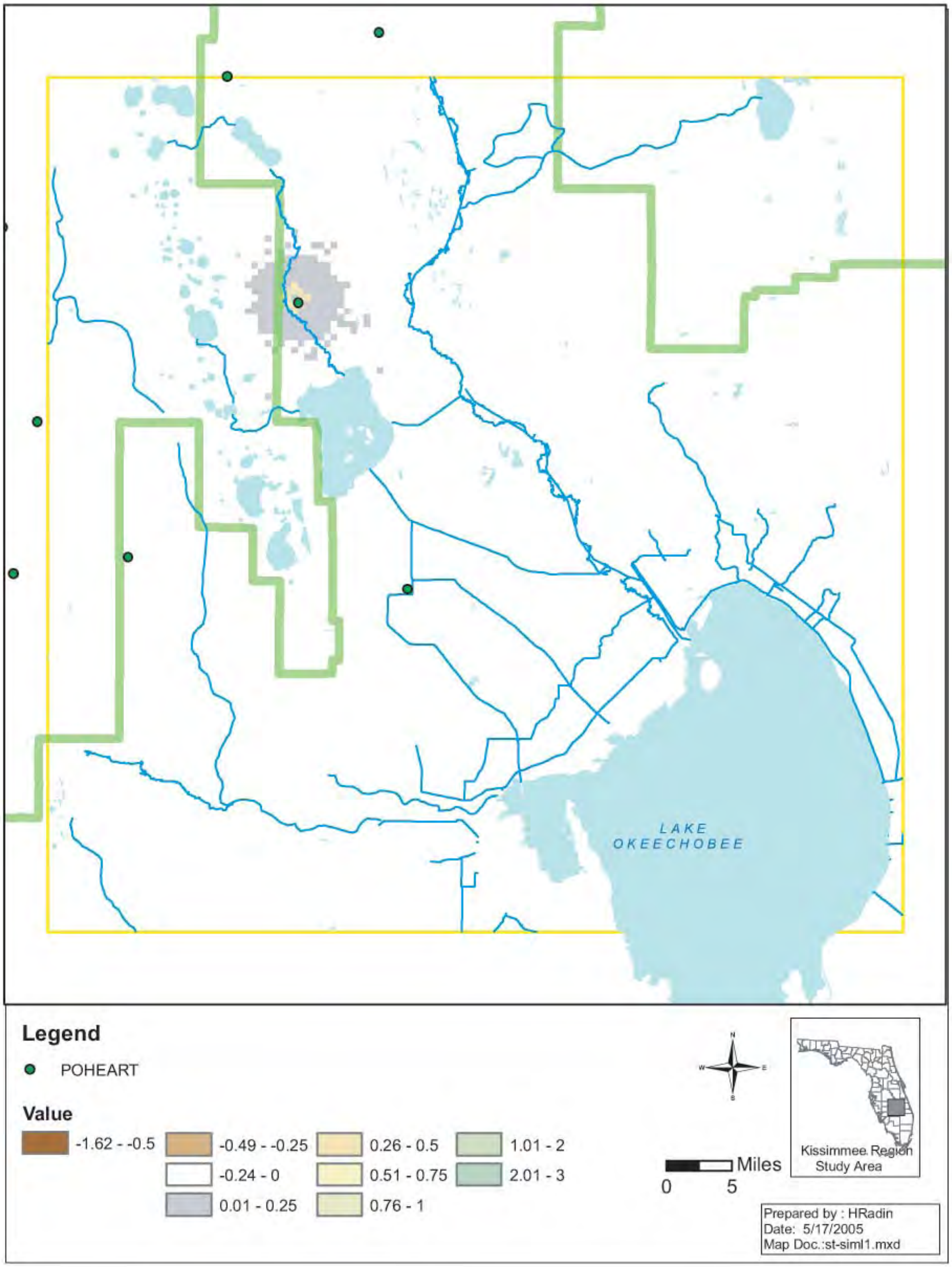

Figure D-29. Difference 1995 1-in-10 – G63 Wellfield Middle Floridan Aquifer.

1995 1-in-10 and Well G64

This simulation run uses the same files as the 1995 1-in-10 run with the addition of one more wellfield – G64 in the Upper Floridan Aquifer. For modeling purposes, the proposed wellfield was placed in Layer 2, Row 77 and Column 55. The model assumes that all the consumption is from one well in the center of the cell. This well will pump 5 MGD or 668,500 ft^3/day. The proposed site for G64 places it in Highlands County near the C-41 Canal. The purpose of this simulation is to evaluate the impact of this well on the water levels. This is done by creating drawdown maps, which compare the water levels without well G64 – in this case the 1995 1-in-10 run – to the water levels with the G64 well. The impact resulting impacts seen with this simulation are nearly identical to those seen in the 1995 AFSIRS + G64 simulation. This indicates there is not very much recharge from the Surficial Aquifer System in the area of this proposed well.

The local drawdown in the Upper Floridan Aquifer in cell 2, 77 and 55 is 25.63 feet. One cell away (2,640 feet), the drawdown ranges from 2 to 5 feet. A mile away this drawdown decreases to 0.8–1.3 feet. At a 1.5-mile radius, the drawdown decreases to 0.5 feet. For about an 8-mile radius, there is a drawdown of about 0.25 feet. This drawdown area extends into the SWFWMD (**Figure D-30**).

No impacts were seen in the Surficial Aquifer System – the water levels in a few scattered cells changed by up to 0.1 feet (**Figure D-31**).

The Middle Floridan Aquifer showed a drawdown of up to 1.18 feet in cell 3, 77 and 55, a drawdown of 0.5 feet over the next mile, then up to 0.25 feet drawdown in the drawdown cone “footprint,” seen in the Upper Floridan Aquifer (**Figure D-32**).

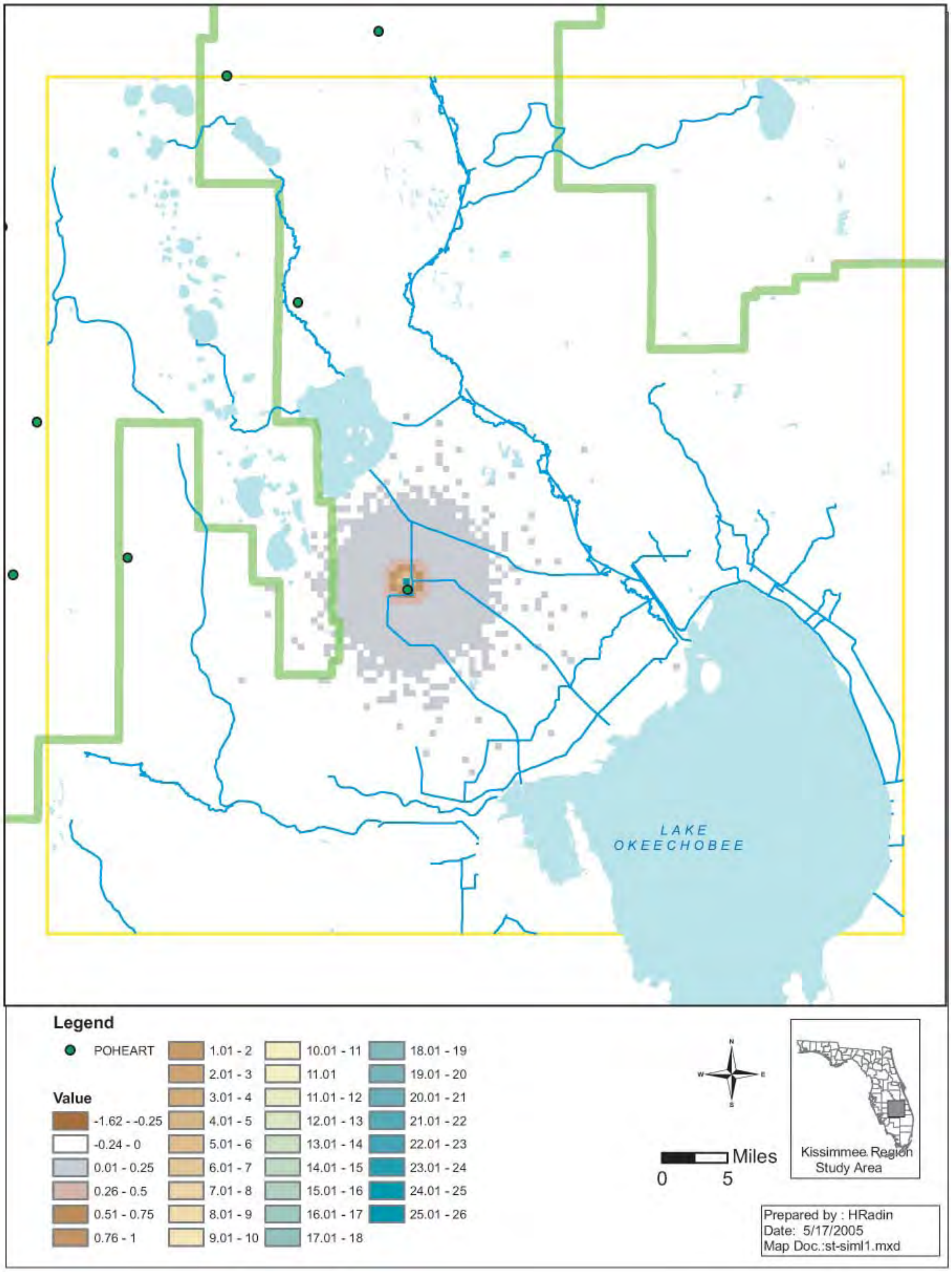

Figure D-30. Difference 1995 1-in-10 – G64 Wellfield Upper Floridan Aquifer.

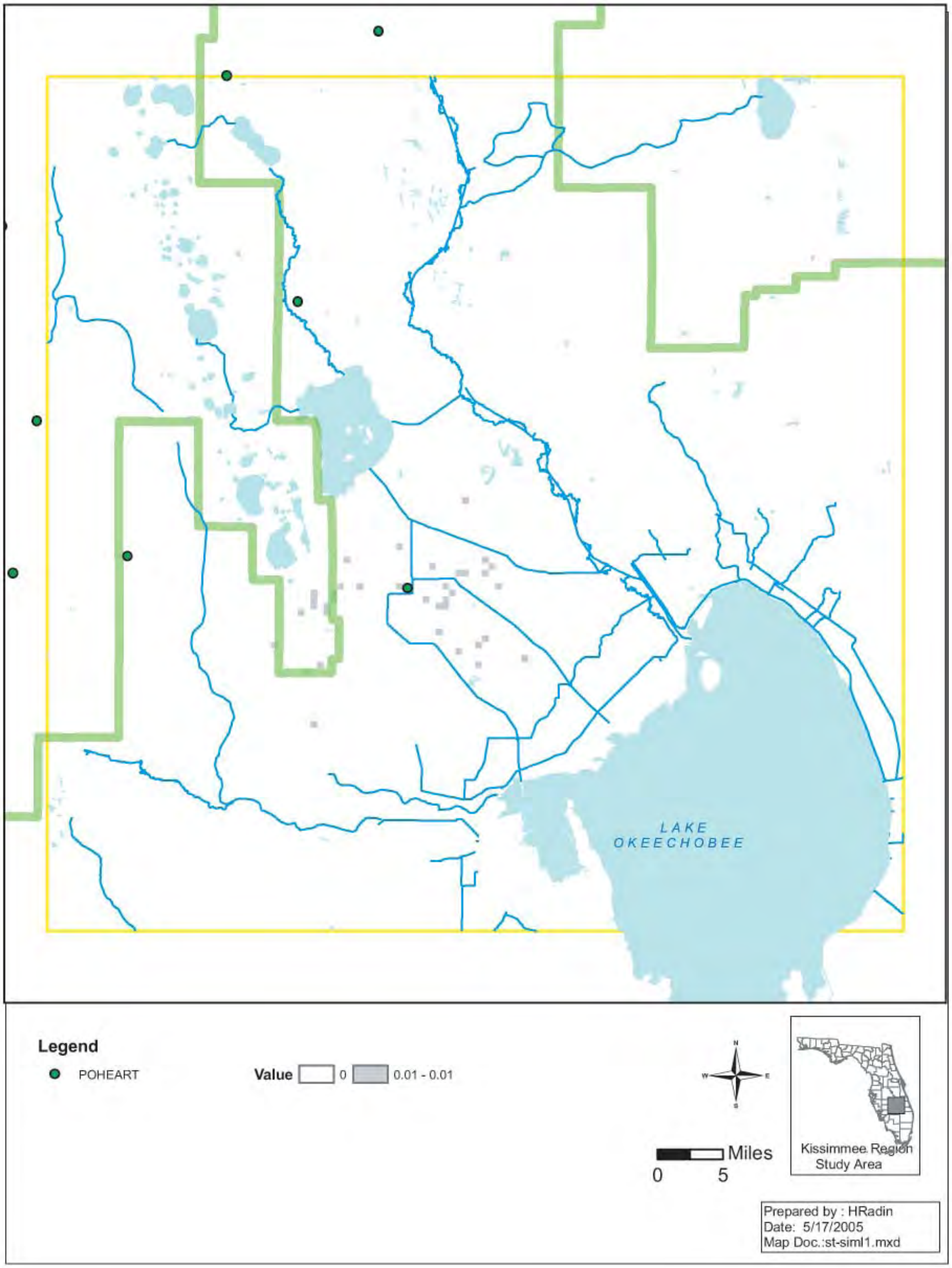

Figure D-31. Difference 1995 1-in-10 – G64 Wellfield Surficial Aquifer.

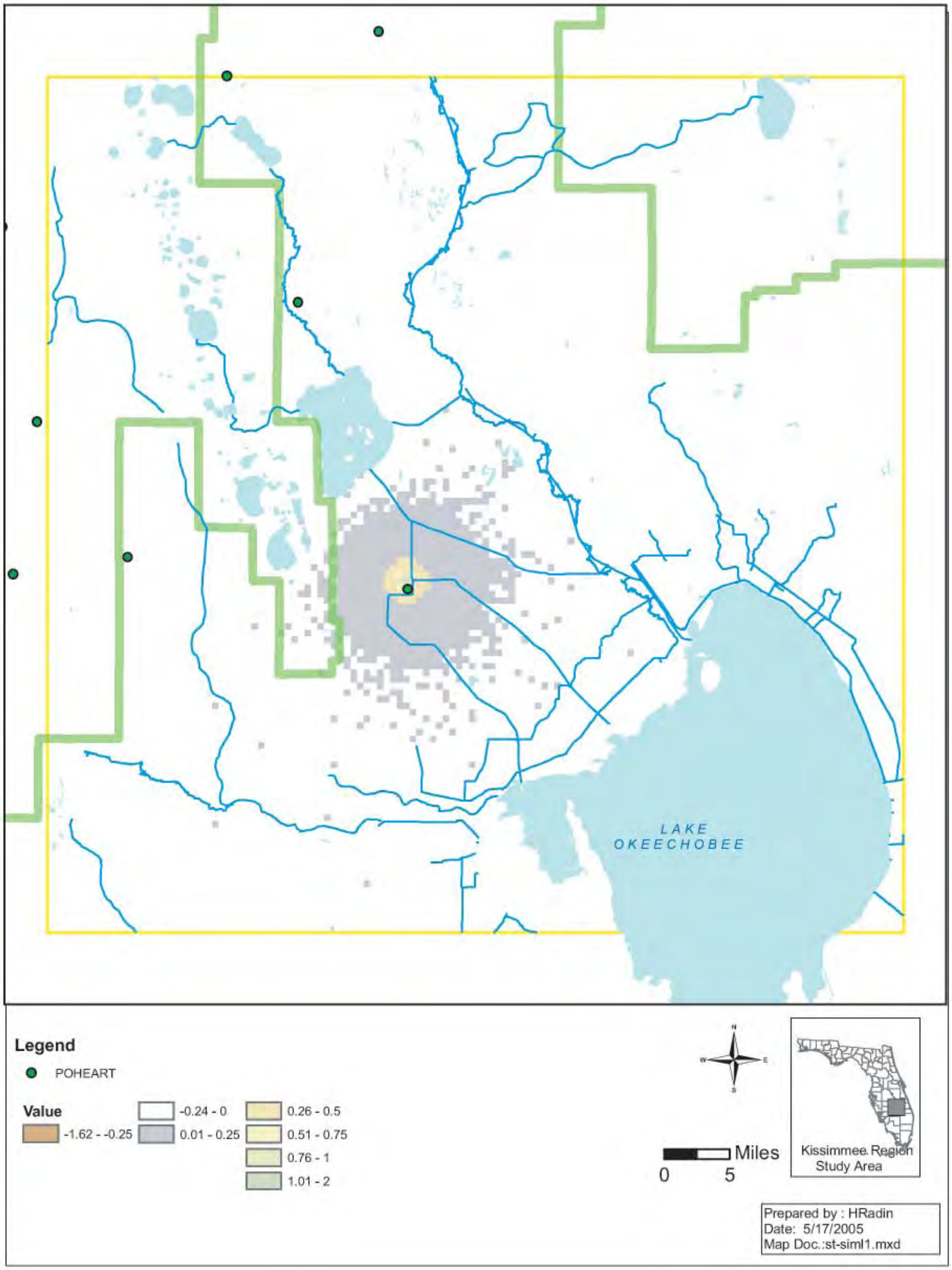

Figure D-32. Difference 1995 1-in-10 – G64 Wellfield Middle Floridan Aquifer.

2025 1-in-10 Simulation Run

The 2025 1-in-10 simulation run used the same files as the 1995 base run, with the exception of the Public Water Supply well file (detailed in the previous projected withdrawal section) and the Evapotranspiration, Recharge and Agriculture consumption well files. The Evapotranspiration, Recharge and Agriculture well files were modified for the 1-in-10 rainfall conditions. These files are based on the predicted 2025 land use conditions. In 2025, due to the urbanization of the land use, the predicted agricultural consumption based on AFSIRS is 477 MGD as compared to 316 MGD in 1995 with 1-in-10 conditions.

The areas where flowing artesian conditions exist in the Upper Floridan Aquifer remain unchanged from the areas displayed in the calibration run (Radin 2005) (**Figure D-33**).

The simulated water levels for the Middle Floridan Aquifer are within 2 feet of the simulated water levels for the Upper Floridan Aquifer (**Figure D-34**). In the areas where the confining unit between these layers is thinner (east of the Kissimmee River), and west of Lake Wales Ridge, the water levels in the Middle Floridan are higher than in the Upper Floridan Aquifer. In the area just west of the Kissimmee River, the water levels in the Middle Floridan are higher or the same as in the Upper Floridan Aquifer.

When comparing water levels for the 2025 1-in-10 simulation run and the 1995 1-in-10 run for the Upper Floridan Aquifer, there appears to be a clear divide (**Figure D-35**). The water level east of the Kissimmee River – mainly in areas that are predicted to urbanize by 2025 – show water levels are higher in 2025 by up to 1.6 feet as compared with the agricultural areas west of the Kissimmee River, which show water levels declining from 0.25 to 5 feet in 2025.

A similar divide is seen in the Middle Floridan Aquifer, where the water levels are up to 1.5 feet higher west of the Kissimmee River, and up to 1.5 feet lower east of the Kissimmee River (**Figure D-36**).

The greatest differences are seen in the Surficial Aquifer System (**Figure D-37**), which is influenced by the changes in land use, and more directly influenced by the modified Rain, Evapotranspiration and Recharge values. The standard deviation of water level differences is 3.74 feet. Some areas in Okeechobee County showed changes of 15 feet, with the water levels in 2025 being higher. In the Fisheating Creek area, the water levels are 5 to 10 feet lower in 2025. In the Lakes Wales Ridge area, water levels were higher west of the ridge and lower east of it.

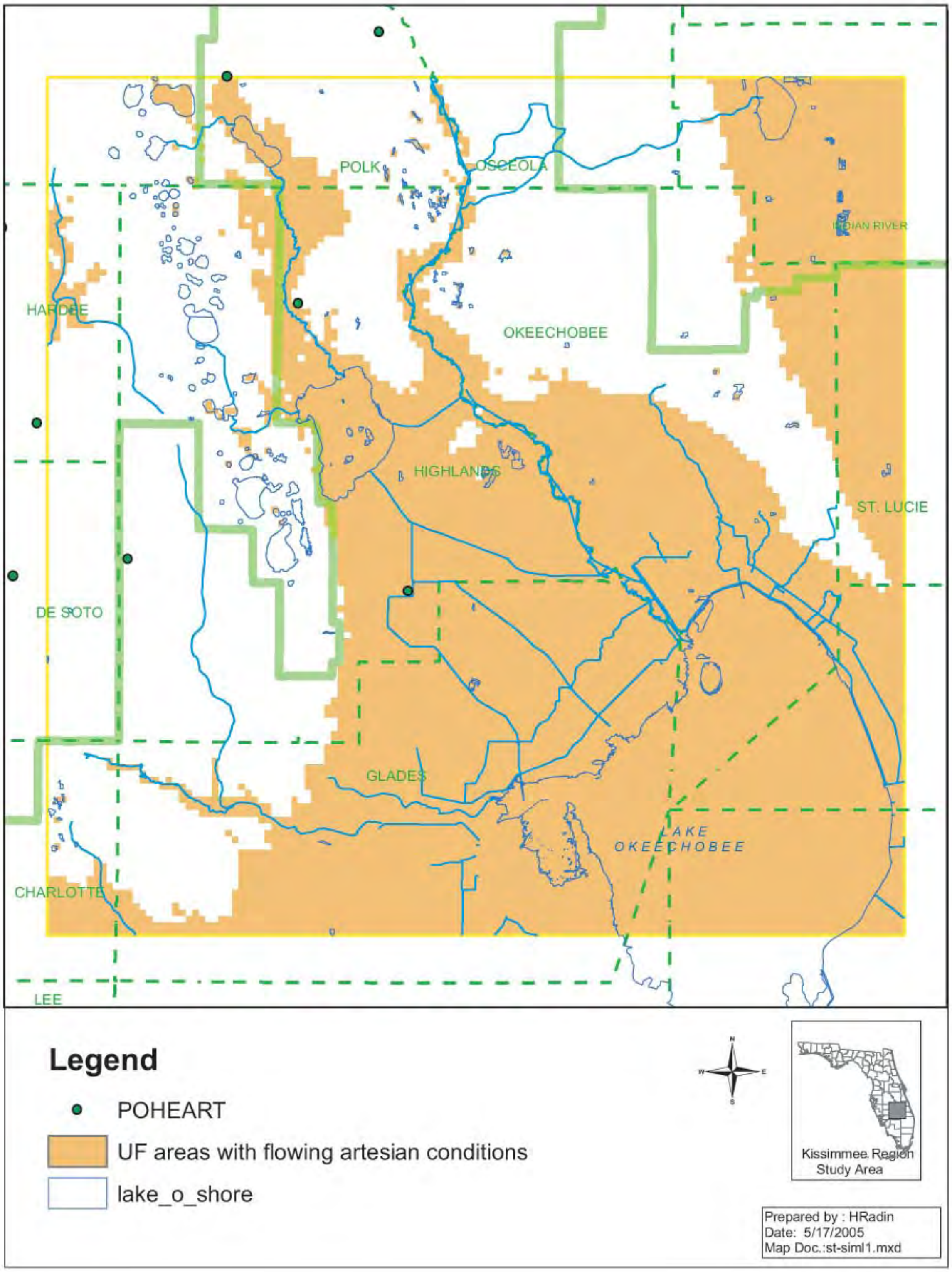

Figure D-33. Upper Floridan Areas with Flowing Artesian Conditions.

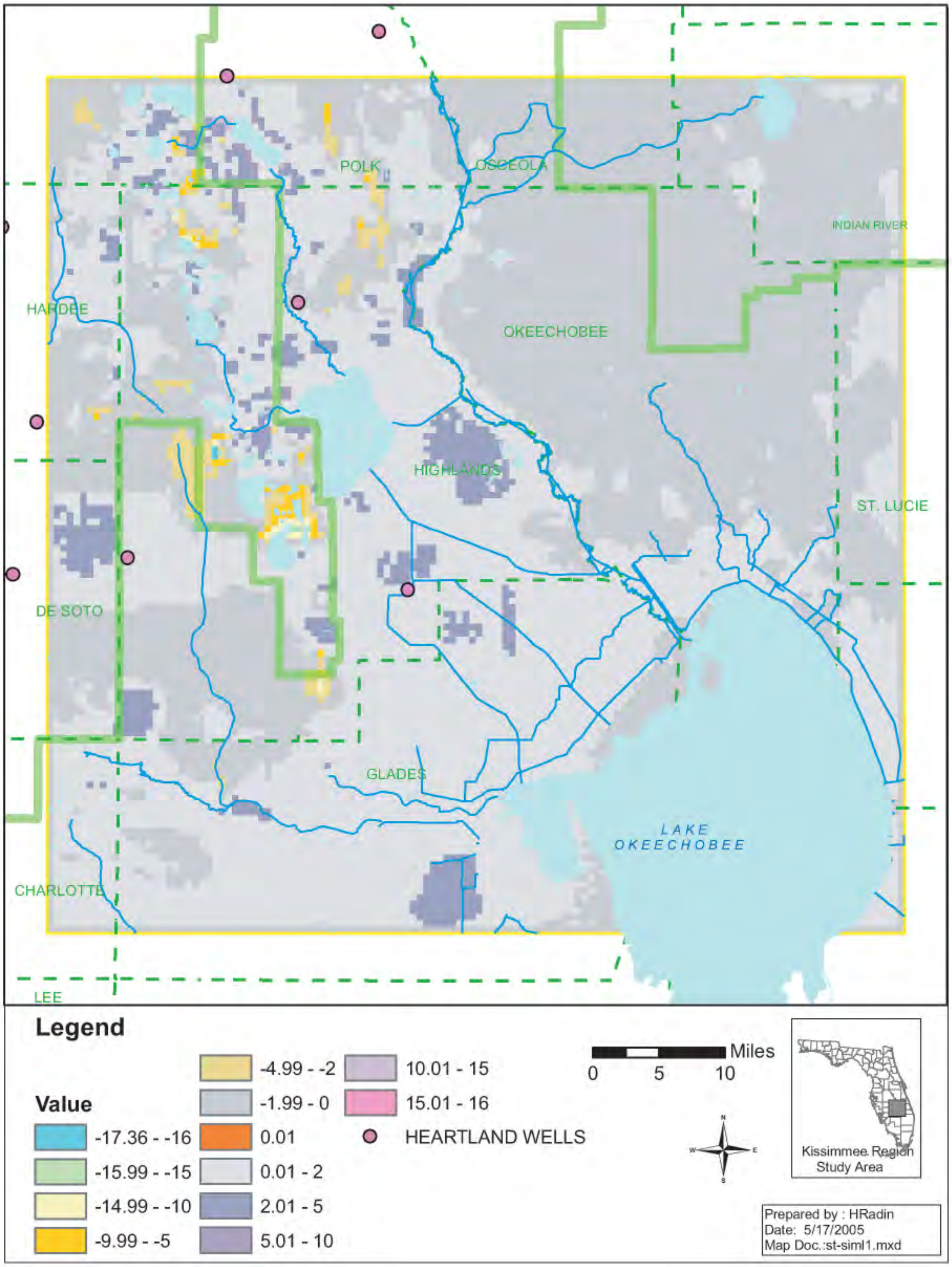

Figure D-34. Difference in Water Levels Layer 3 – Layer 2 (MF – UF).

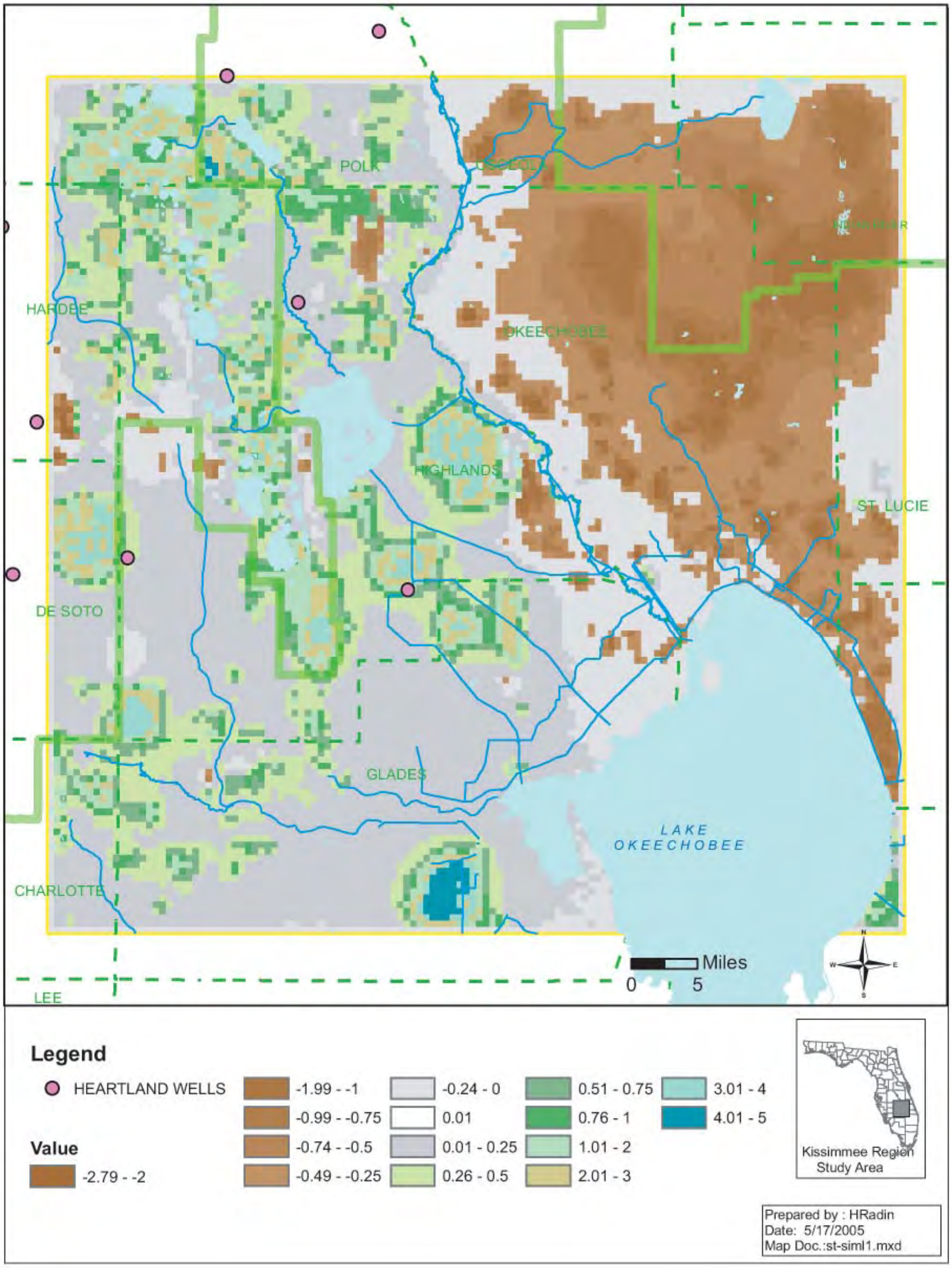

Figure D-35. Difference in Water Levels 1995 1-in-10 and 2025 1-in-10 Upper Floridan Aquifer.

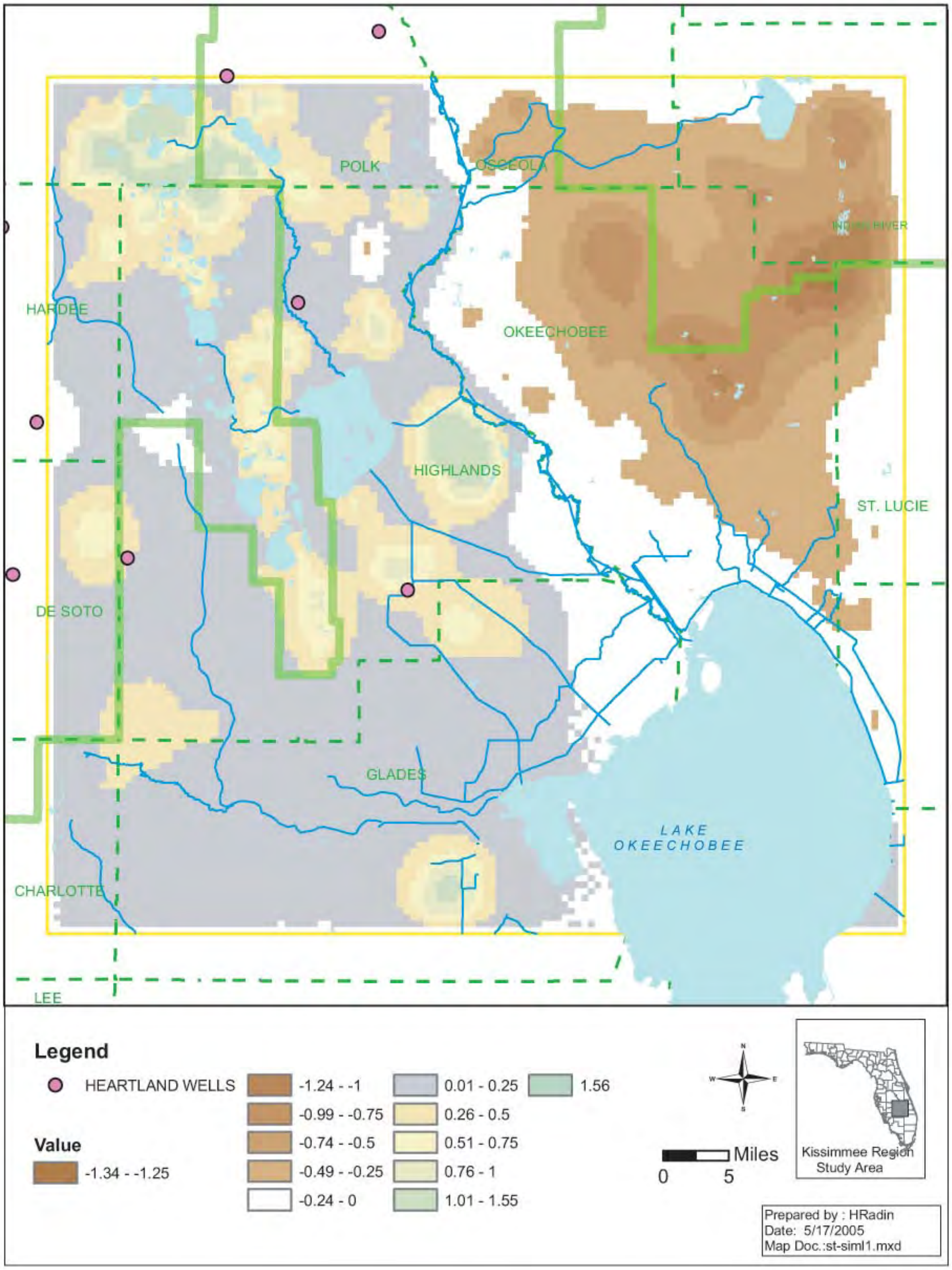

Figure D-36. Difference in Water Levels 1995 1-in-10 and 2025 1-in-10 Middle Floridan Aquifer.

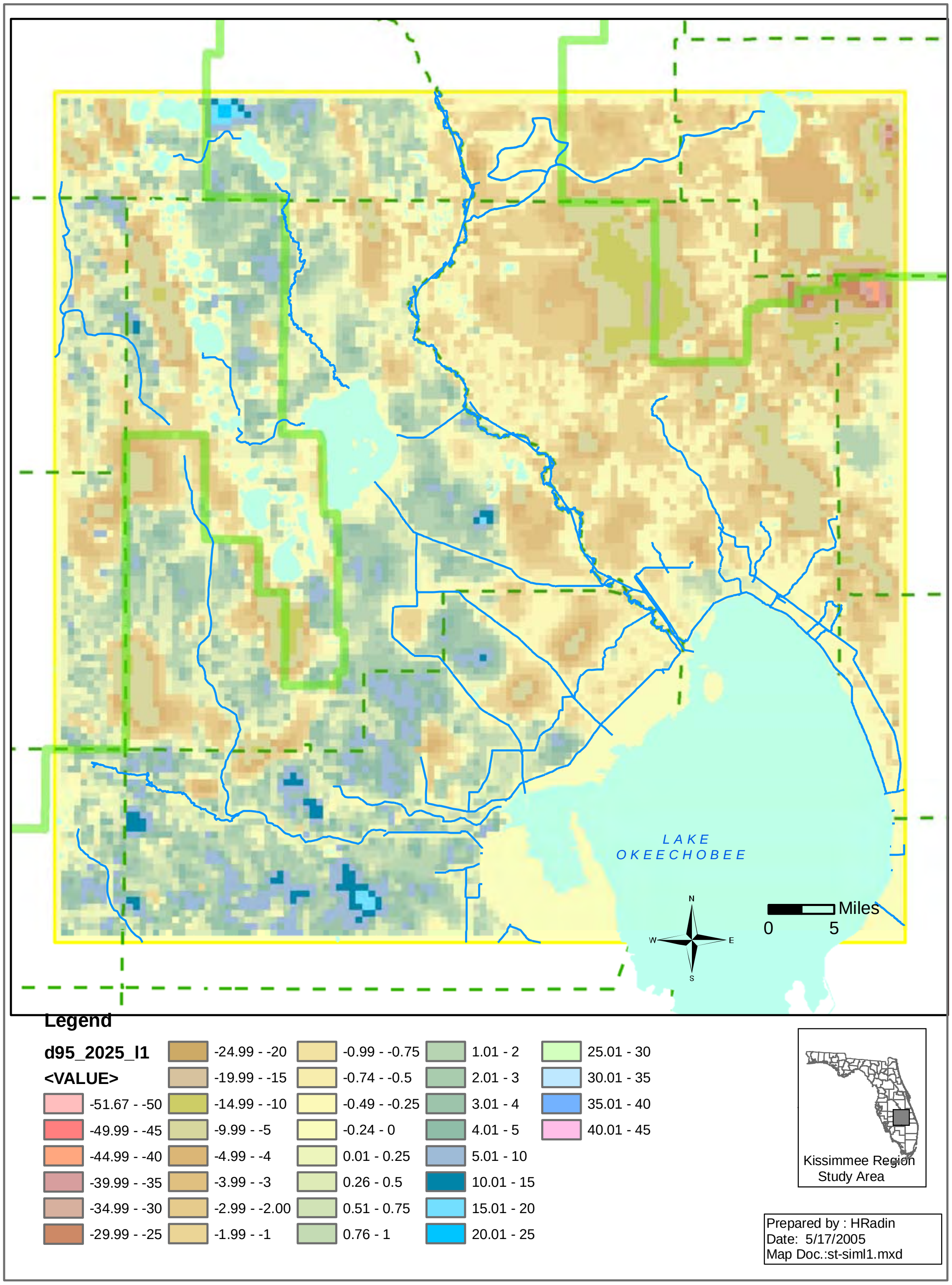

Figure D-37. Difference in Water Levels 1995 1-in-10 and 2025 1-in-10 Surficial Aquifer.

2025 1-in-10 and Well G62

This simulation run uses the same files as the 2025 1-in-10 run with the addition of one more wellfield – G62 in the Upper Floridan Aquifer. For modeling purposes, the proposed wellfield was placed in Layer 2, Row 73 and Column 12. The model assumes that all the consumption is from one well in the center of the cell. This well will pump 2 MGD or 267,400 ft^3/day. The proposed site for G62 places it near the SFWMD/SWFWMD boundary on the Highlands/De Soto county line. The purpose of this simulation is to evaluate the impact of this well on the water levels. This is done by creating drawdown maps, which compare the water levels without well G62 – in this case, the 2025 1-in-10 simulation – to the water levels with the G62 well. The impacts of this simulation are nearly identical to those seen in the 1995 1-in-10 + G62 simulation, and in the 1995 AFSIRS + G62 run. This indicates there is not very much recharge from the Surficial Aquifer System in the area of this proposed well.

The local drawdown in the Upper Floridan Aquifer in cell 2, 73 and 12 is 13.31 feet. One cell away (2,640 feet), the drawdown ranges from 0.5 to 2 feet. At a mile radius, the drawdown decreases to 0.33 feet. For nearly a 10-mile radius there is a drawdown of about 0.25 feet. Half of the drawdown area falls within the SWFWMD (**Figure D-38**).

No impact was seen in the Surficial Aquifer System – the water levels throughout the model changed by a maximum of 0.01 feet (**Figure D-39**).

The Middle Floridan Aquifer showed a drawdown of up to 0.2 feet with the same drawdown cone for a radius of about 3 miles (**Figure D-40**).

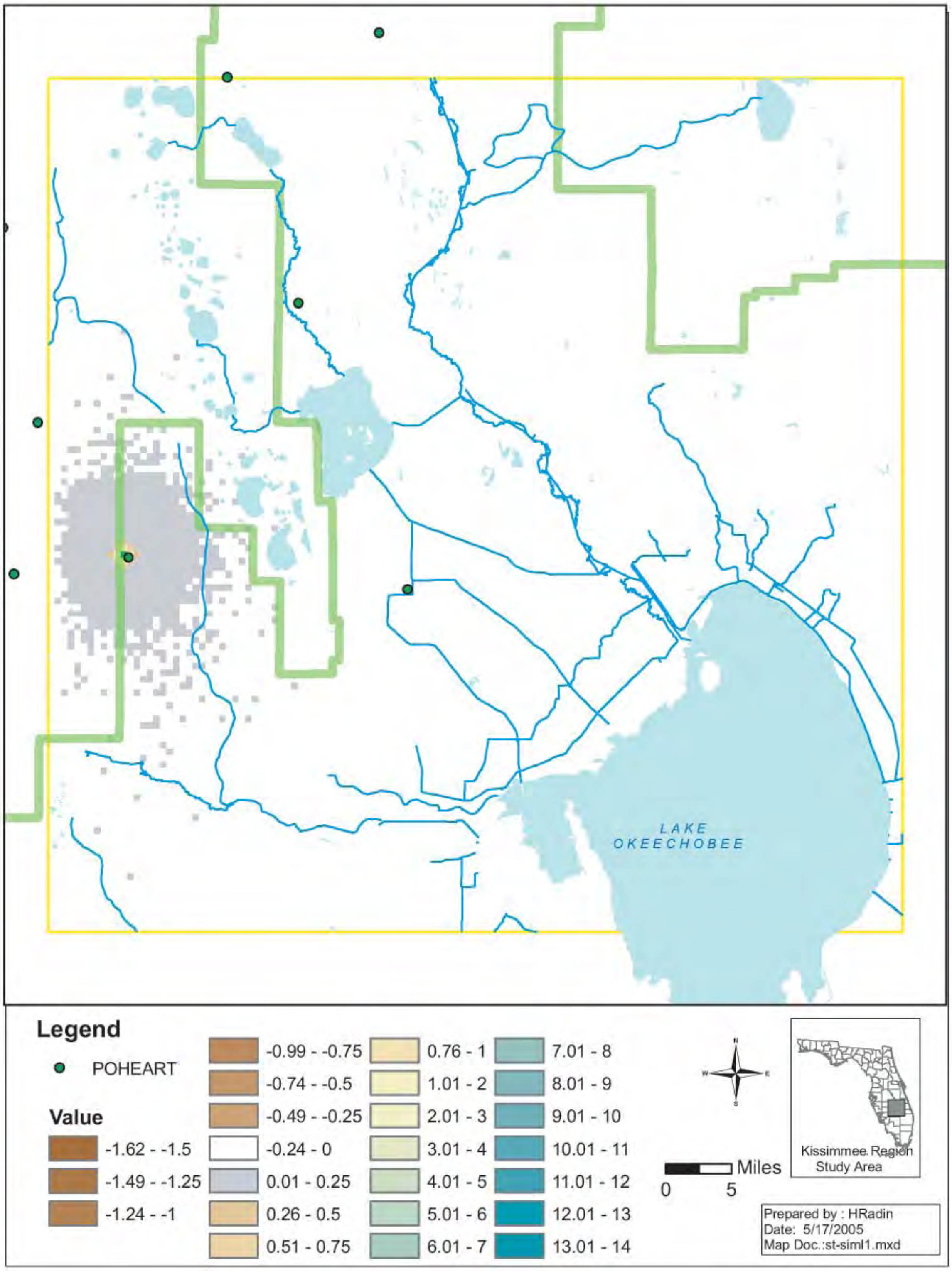

Figure D-38. Difference 2025 – G62 Wellfield Upper Floridan Aquifer.

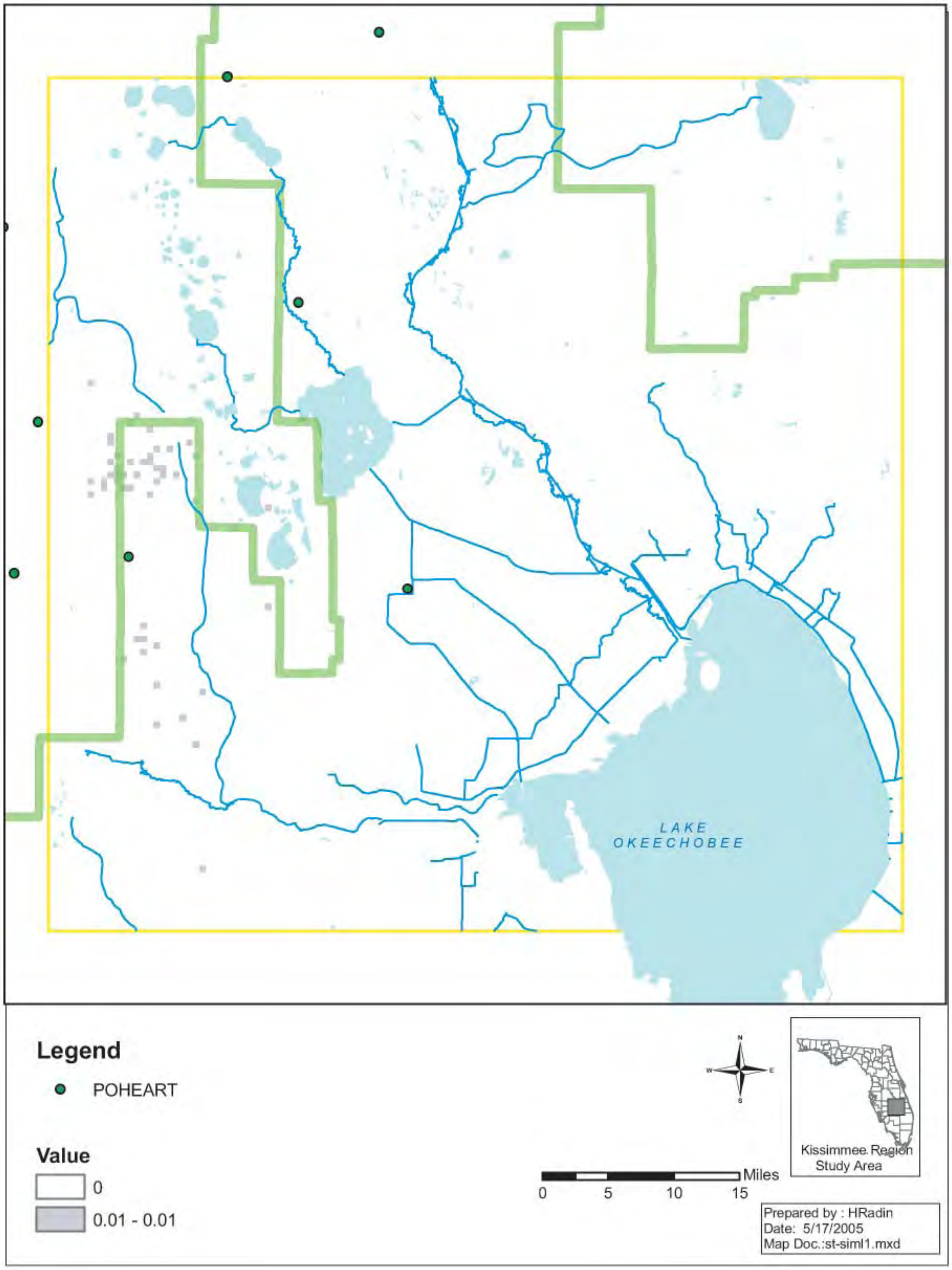

Figure D-39. Difference 2025 – G62 Wellfield Surficial Aquifer.

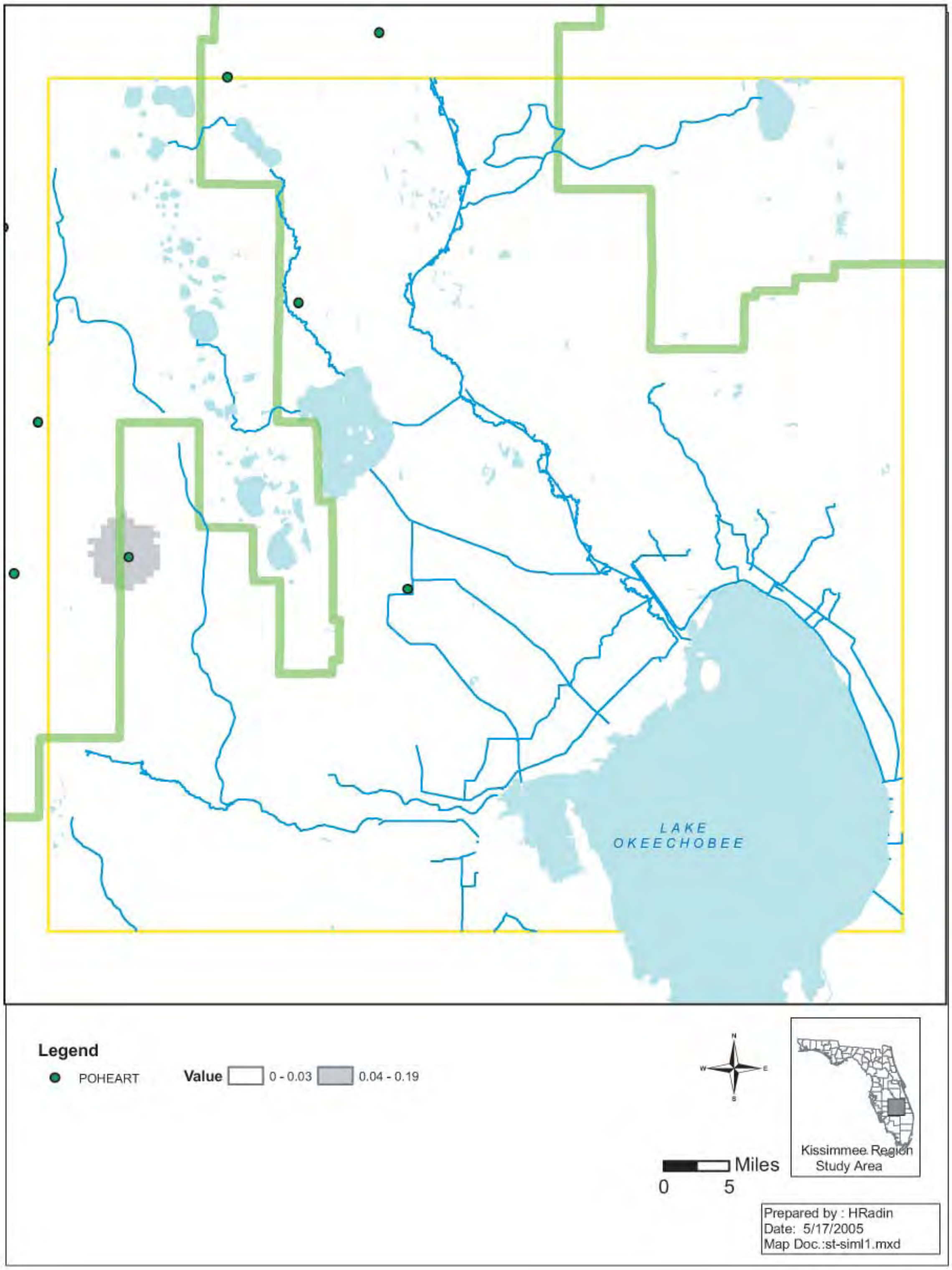

Figure D-40. Difference 2025 – G62 Wellfield Middle Floridan Aquifer.

2025 1-in-10 and Well G63

This simulation run uses the same files as the 2025 1-in-10 Ag run with the addition of one more wellfield – G63 in the Upper Floridan Aquifer. For modeling purposes, the proposed wellfield was placed in Layer 2, Row 34 and Column 38. The model assumes that all the consumption is from one well in the center of the cell. This well will pump 2 MGD or 267,400 ft^3/day. The proposed site for G63 places it in Highlands County near the SFWMD/SWFWMD boundary near Arbuckle Creek, north of Lake Istokpoga. The purpose of this simulation is to evaluate the impact of this well on the water levels. This is done by creating drawdown maps, which compare the water levels without well G63 – in this case, the 2025 1-in-10 Ag run – to the water levels with the G63 well. The impact seen with this simulation is nearly identical to that seen in the 1995 1-in-10 run + G63, and in the 1995 AFSIRS + G63 simulation. This indicates there is not very much recharge from the Surficial Aquifer System in the area of this proposed well.

The local drawdown in the Upper Floridan Aquifer in cell 2, 34 and 38 is 18.29 feet. One cell away (2,640 feet), the drawdown ranges from 0.6 to 1.8 feet. At a mile radius this decreases to 0.25 feet. For nearly a 5-mile radius, there is a drawdown of about 0.25 feet. This area extends into the SWFWMD (**Figure D-41**).

No impact was seen in the Surficial Aquifer System – some cells east of the wellfield changed by a maximum of 0.04 feet. The area with drawdown in the Surficial Aquifer System is larger than in the average 2025 year simulation (**Figure D-42**).

The Middle Floridan Aquifer showed a drawdown of up to 2 feet in cell 3, 34 and 38, a drawdown of 0.75 feet one cell over and drawdowns of up to 0.5 in an area slightly larger than the drawdown cone “footprint,” seen in the Upper Floridan Aquifer (**Figure D-43**).

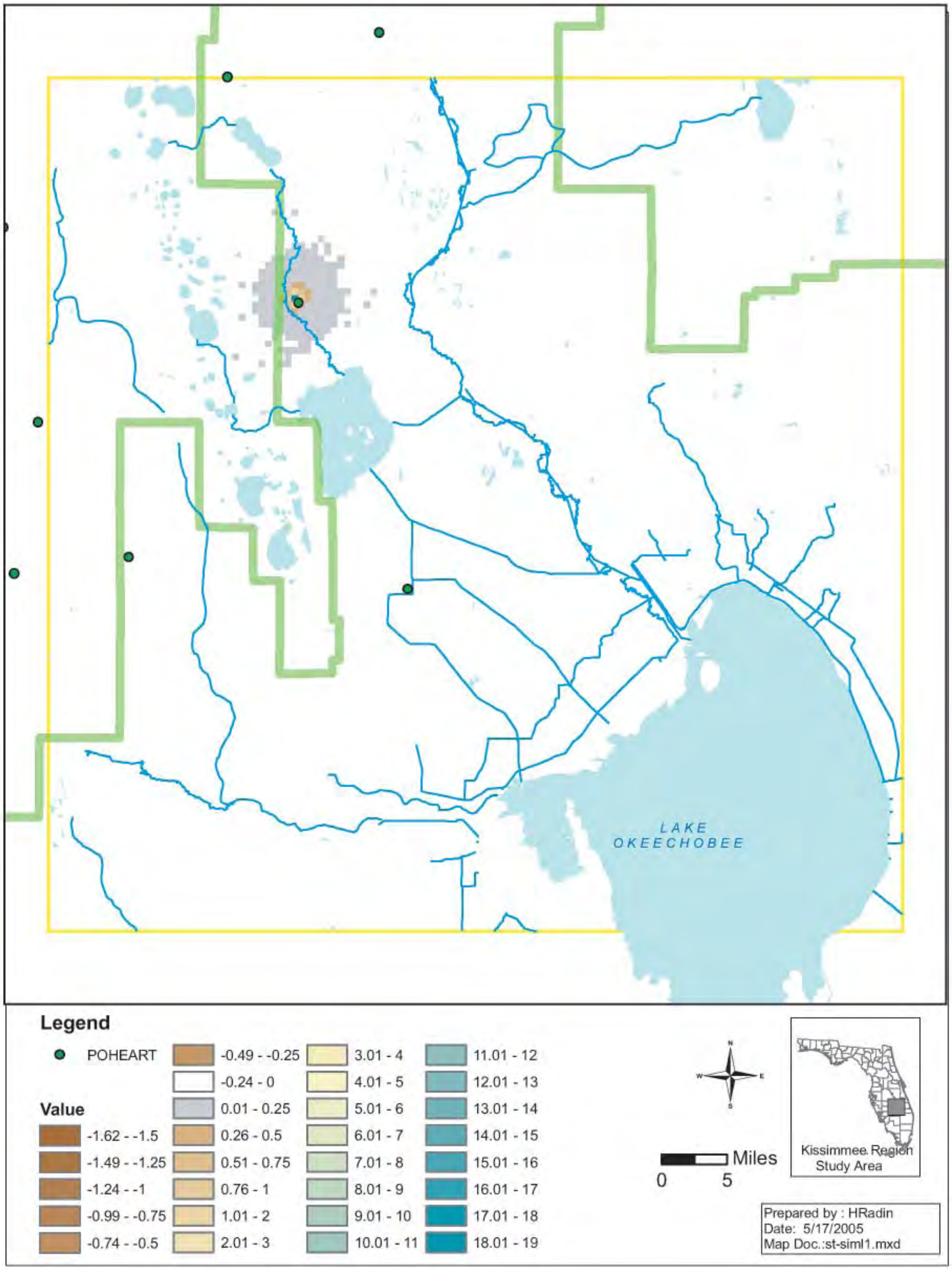

Figure D-41. Difference 2025 – G63 Wellfield Upper Floridan Aquifer.

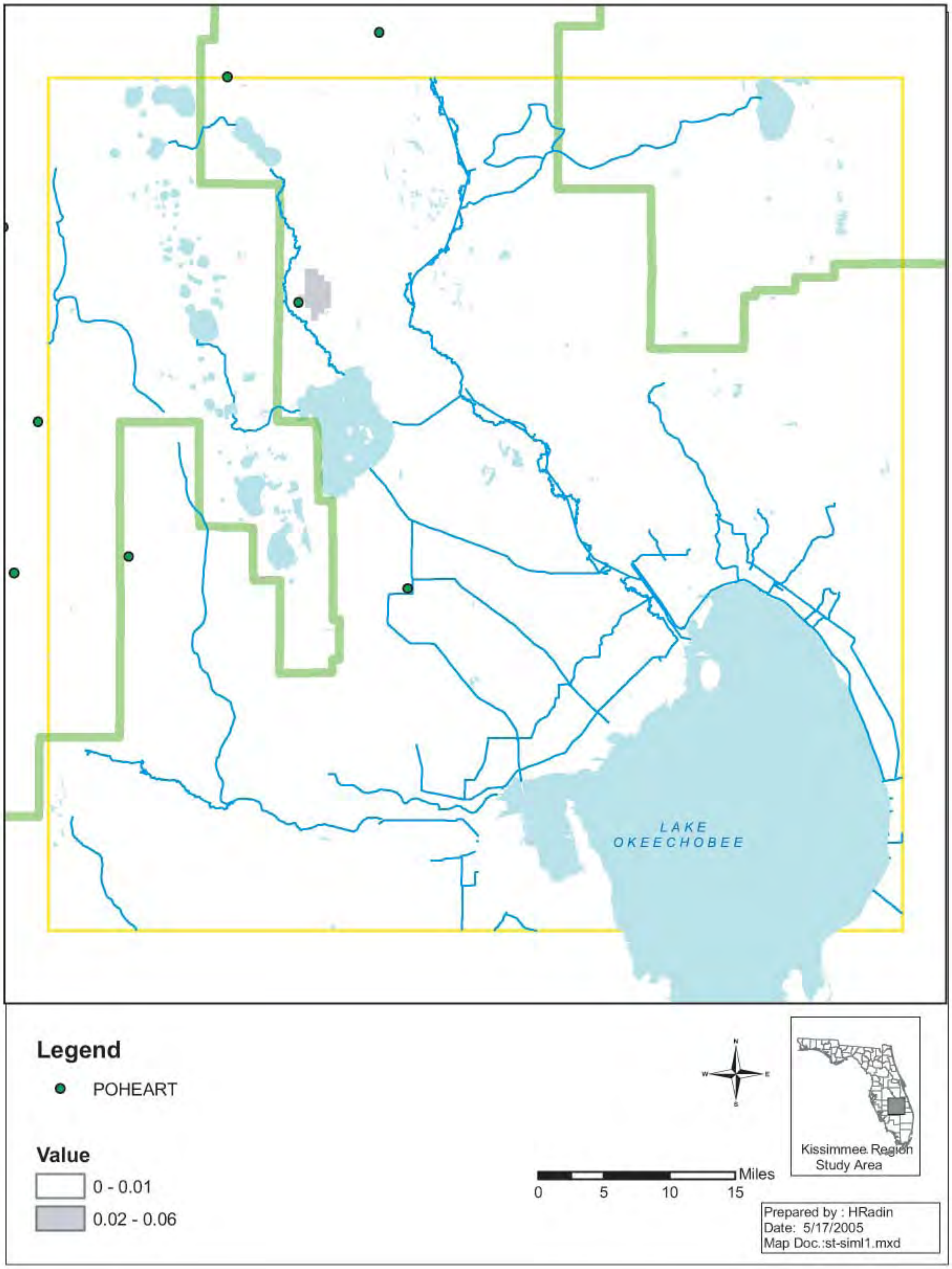

Figure D-42. Difference 2025 – G63 Wellfield Surficial Aquifer.

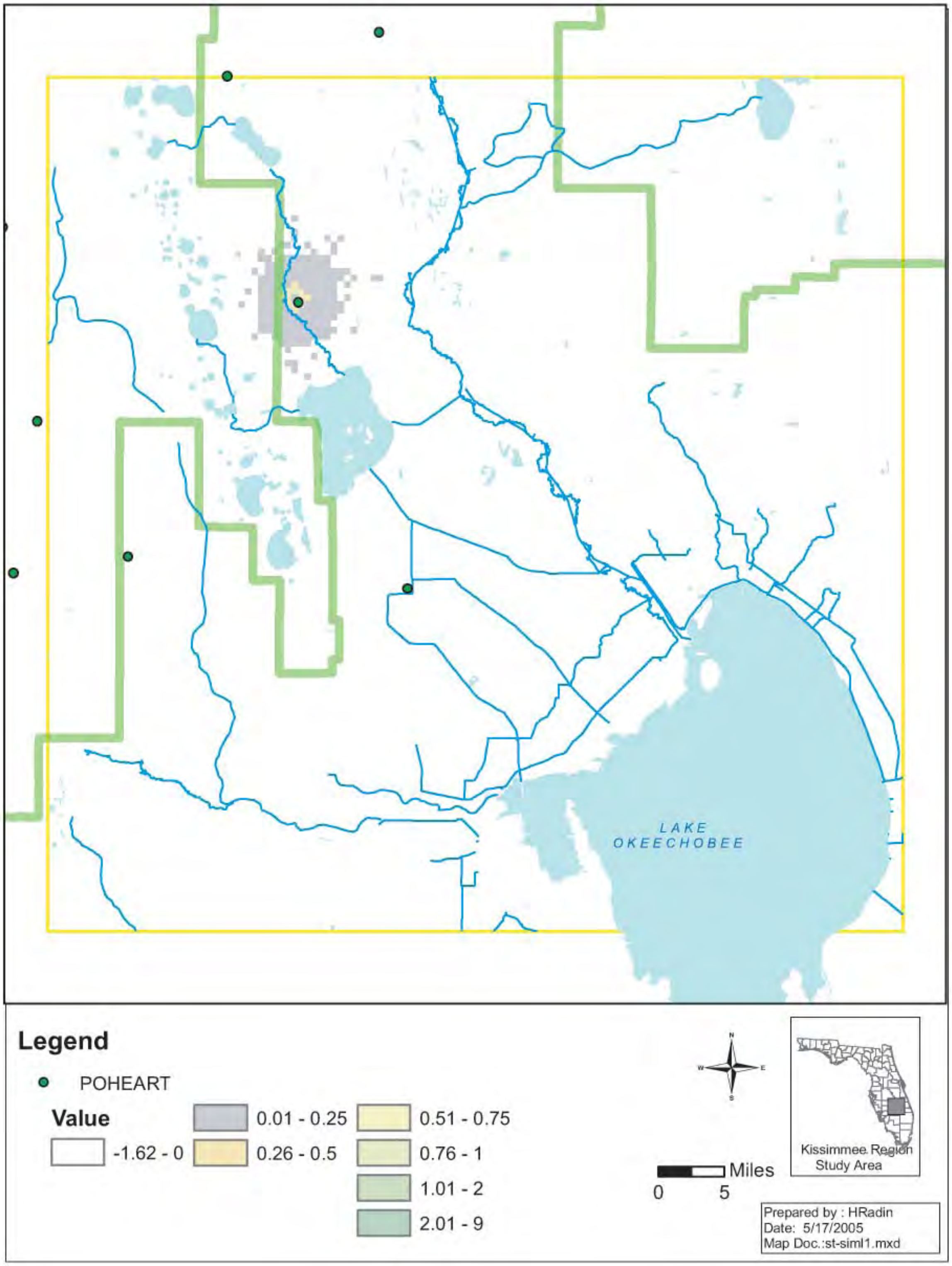

Figure D-43. Difference 2025 – G63 Wellfield Middle Floridan Aquifer.

2025 1-in-10 and Well G64

This simulation run uses the same files as the 2025 1-in-10 run with the addition of one more wellfield – G64 in the Upper Floridan Aquifer. For modeling purposes, the proposed wellfield was placed in Layer 2, Row 77 and Column 55. The model assumes that all the consumption is from one well in the center of the cell. This well will pump 5 MGD or 668,500 ft^3/day. The proposed site for G64 places it in Highlands County near the C-41 Canal. The purpose of this simulation is to evaluate the impact of this well on the water levels. This is done by creating drawdown maps, which compare the water levels without well G64 – in this case, the 2025 1-in-10 run – to the water levels with the G64 well. The impacts seen with this simulation are nearly identical to those seen in the 1995 1-in-10 run with well G64, and in the 1995 AFSIRS + G64 simulation. This indicates there is not very much recharge from the Surficial Aquifer System in the area of this proposed well.

The local drawdown in the Upper Floridan Aquifer in cell 2, 77 and 55 is 25.63 feet. One cell away (2,640 feet), the drawdown ranges from 2 to 5 feet. At a mile away, this decreases to 0.8–1.3 feet. At a 1.5-mile radius, the drawdown decreases to 0.5 feet. For about an 8-mile radius, there is a drawdown of about 0.25 feet. This area extends into the SWFWMD (**Figure D-44**).

No impact was seen in the Surficial Aquifer System – the water levels in a few scattered cells changed by up to 0.1 feet (**Figure D-45**).

The Middle Floridan Aquifer showed a drawdown of up to 1.18 feet in cell 3, 77 and 55, a 0.5-foot drawdown for the next mile, then up to 0.25 feet of drawdown in the area of the drawdown cone “footprint,” seen in the Upper Floridan Aquifer (**Figure D-46**).

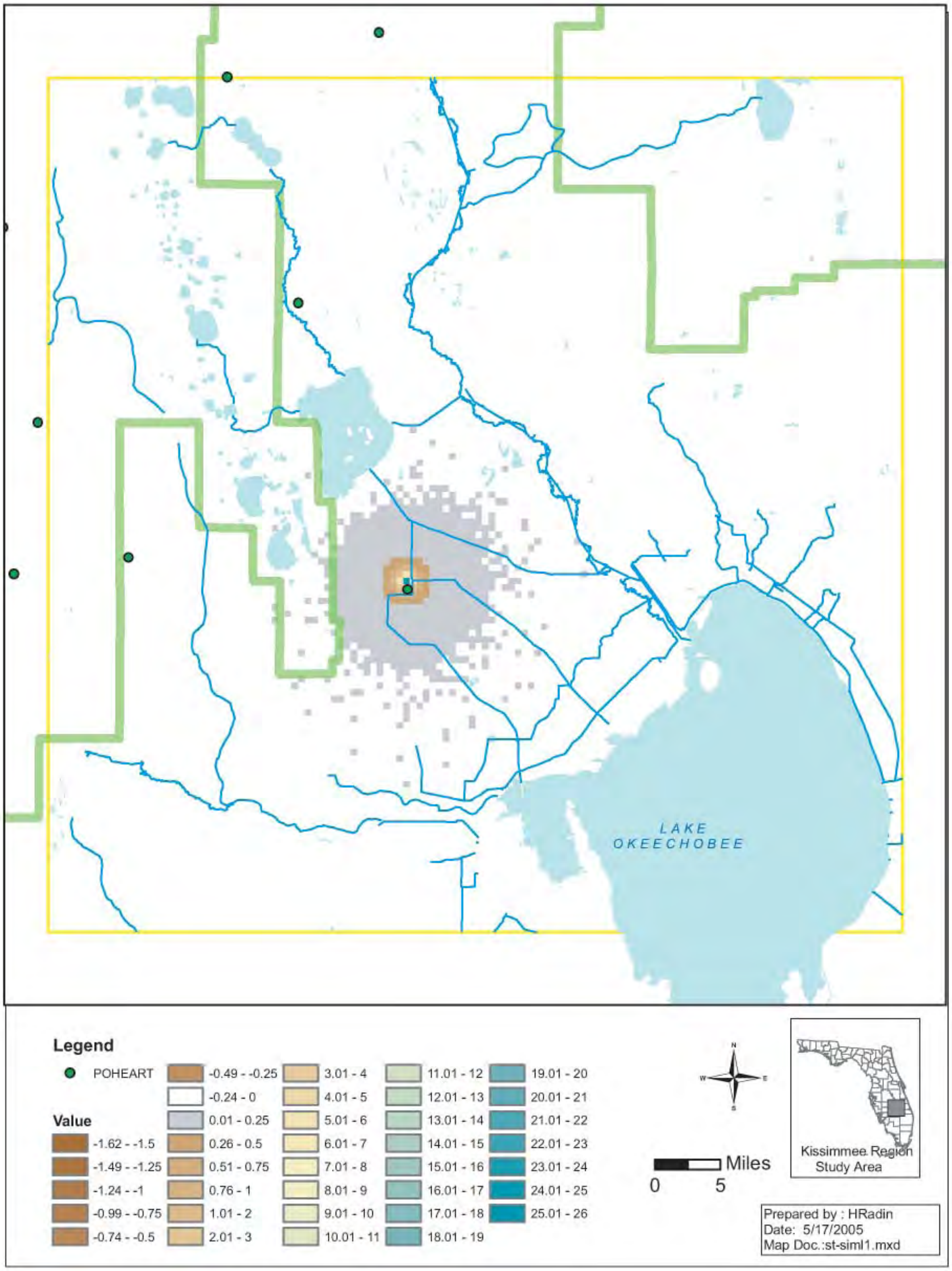

Figure D-44. Difference 2025 – G64 Wellfield Upper Floridan Aquifer.

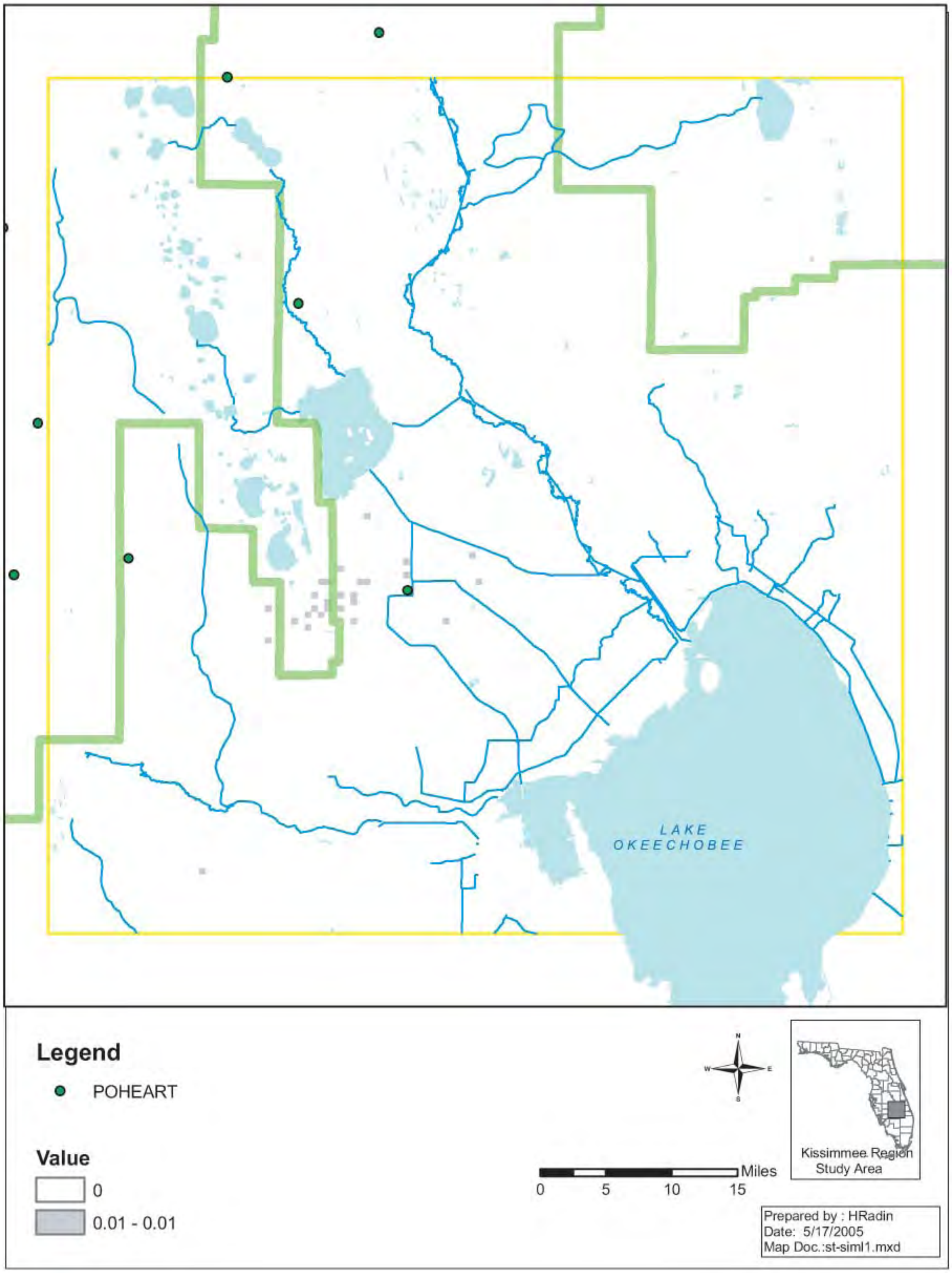

Figure D-45. Differences 2025 – G64 Wellfield Surficial Aquifer.

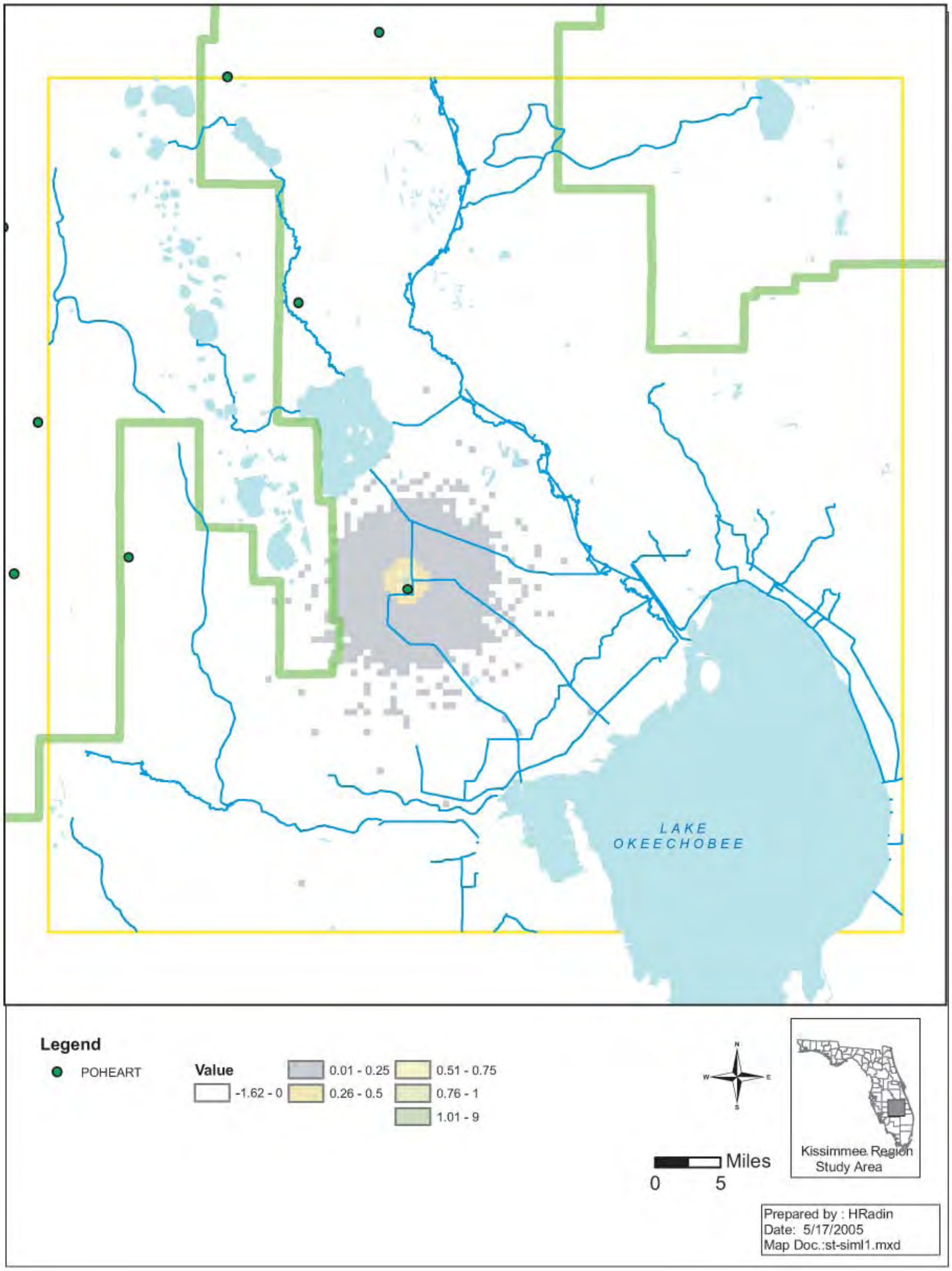

Figure D-46. Differences 2025 – G64 Wellfield Middle Floridan Aquifer.

ALTERNATIVE SIMULATIONS

As most of consumptive use wells in the proposed areas are located in the Middle Floridan Aquifer and not the Upper Floridan Aquifer, therefore location of the wells may need to be reconsidered. The thickness of the Upper Floridan Aquifer in the proposed areas is only 100 feet at G62 and 135 feet at G63 and G64 and the Middle Semi-Confining Unit 1, is 550–650 feet thick in these locations. The transmissivity at G62 in the Middle Floridan Aquifer is 586,000 ft^2/day, at G63 37,000 ft^2/day and at G64 162,000 ft^2/day. In the Upper Floridan Aquifer, the transmissivities at these locations were 2,800 ft^2/day, 1,000 ft^2/day and 4,900 ft^2/day respectively. This would make the production rates of 2 to 5 MGD at these sites in the Upper Floridan unlikely to be obtained and sustained.

The very high transmissivity value for the Middle Floridan Aquifer in Desoto County comes solely from one APT at ROMP 12 Prairie Creek. The SWFWMD got a value of 1,640,000 ft^2/day from their pump test on this zone (Reese and Richardson 2004). This site is nearest to the proposed site for G62.

For the following simulations the proposed wellfields were modeled in the Middle Floridan Aquifer.

Table D-7. Assumptions on Wellfields.

Well	Layer	Row	Column	MGD*	Ft^3/day
G62	3	73	12	2.00	267,400.00
G63	3	34	38	2.00	267,400.00
G64	3	77	55	5.00	668,500.00

* Millions Gallons per day.

1995 AFSIRS Ag with Wellfields in Middle Floridan Aquifer

For this model run, the consumptive use in the agricultural wells was estimated based on AFSIRS calculations for the land use. The three wellfields G62, G63 and G64 were all placed in Layer 3 in the Middle Floridan Aquifer. Impacts were seen to both the Middle Floridan Aquifer and to the Upper Floridan Aquifer.

As seen in **Figure 47**, in the Middle Floridan Aquifer at G62, the drawdown was 0.26 feet. For a radius of 8 miles the drawdown was up to 0.25 feet. At G63 the drawdown was 2.41 feet. At a mile distance the drawdown decreases to 0.5–0.8 feet. For about a 5-mile radius, there is a drawdown of about 0.25 feet. At G64 the drawdown is 1.89 feet. At a mile distance the drawdown decreases to 0.8, and at 2 miles distance to 0.5 feet. For about a 7-mile radius, there is a drawdown of about 0.25 feet.

The drawdowns in the Upper Floridan Aquifer (**Figure D-48**) have a similar "footprint" to those in the Middle Floridan Aquifer. At G64 the drawdown is 1.18 feet and at G63 the drawdown is 2.02 feet. All other cells have a drawdown within 0.03 feet of those seen in the Middle Floridan Aquifer.

The drawdown in the Surficial Aquifer System (**Figure D-49**) is minimal with the most change seen near G63, where there is a drawdown of up to 0.04 feet.

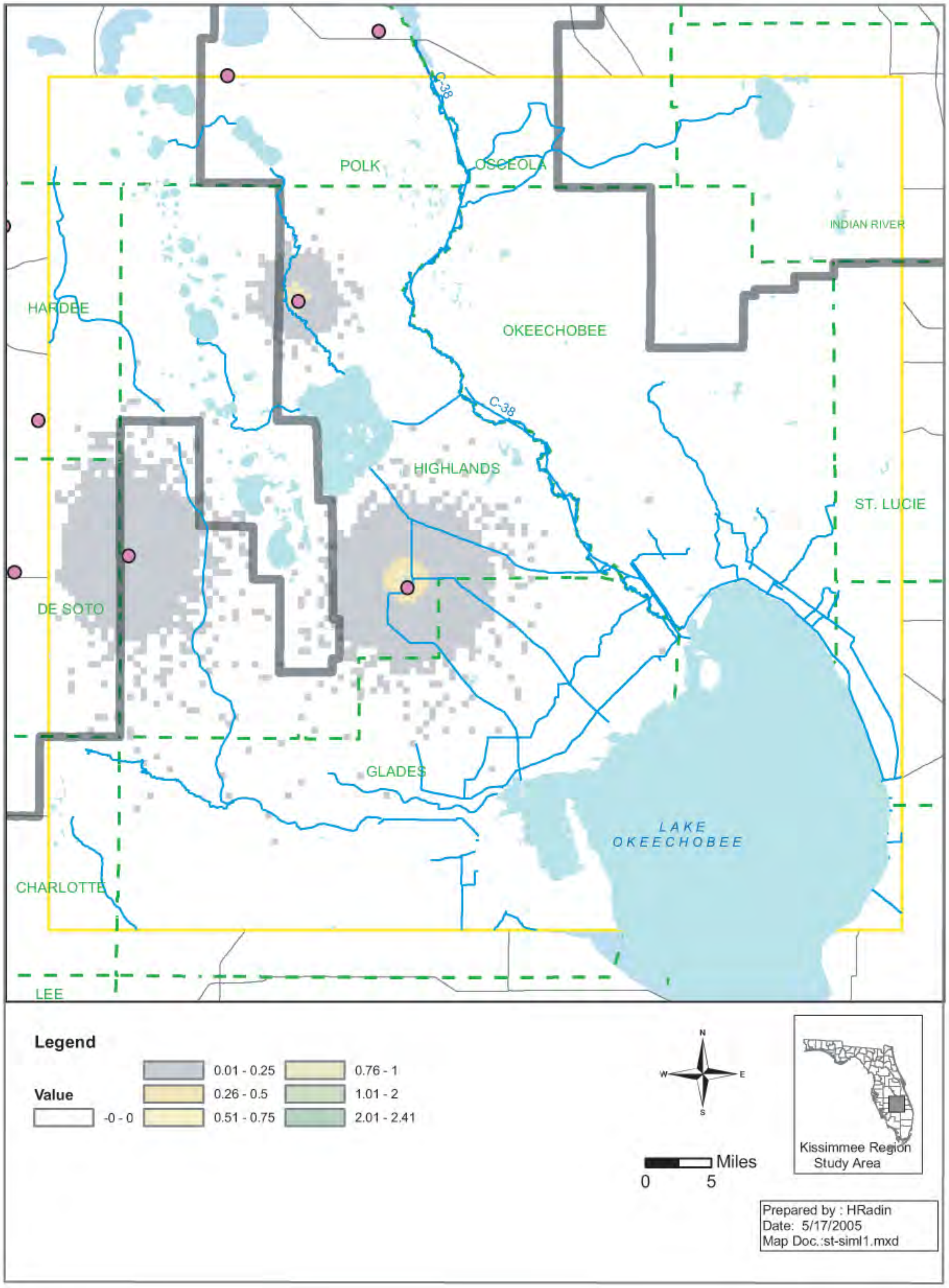

Figure D-47. Drawdown (feet) in Middle Floridan Aquifer – 1995 AFSIRS Ag with Wellfields G62, G63 and G64 in Middle Floridan Aquifer.

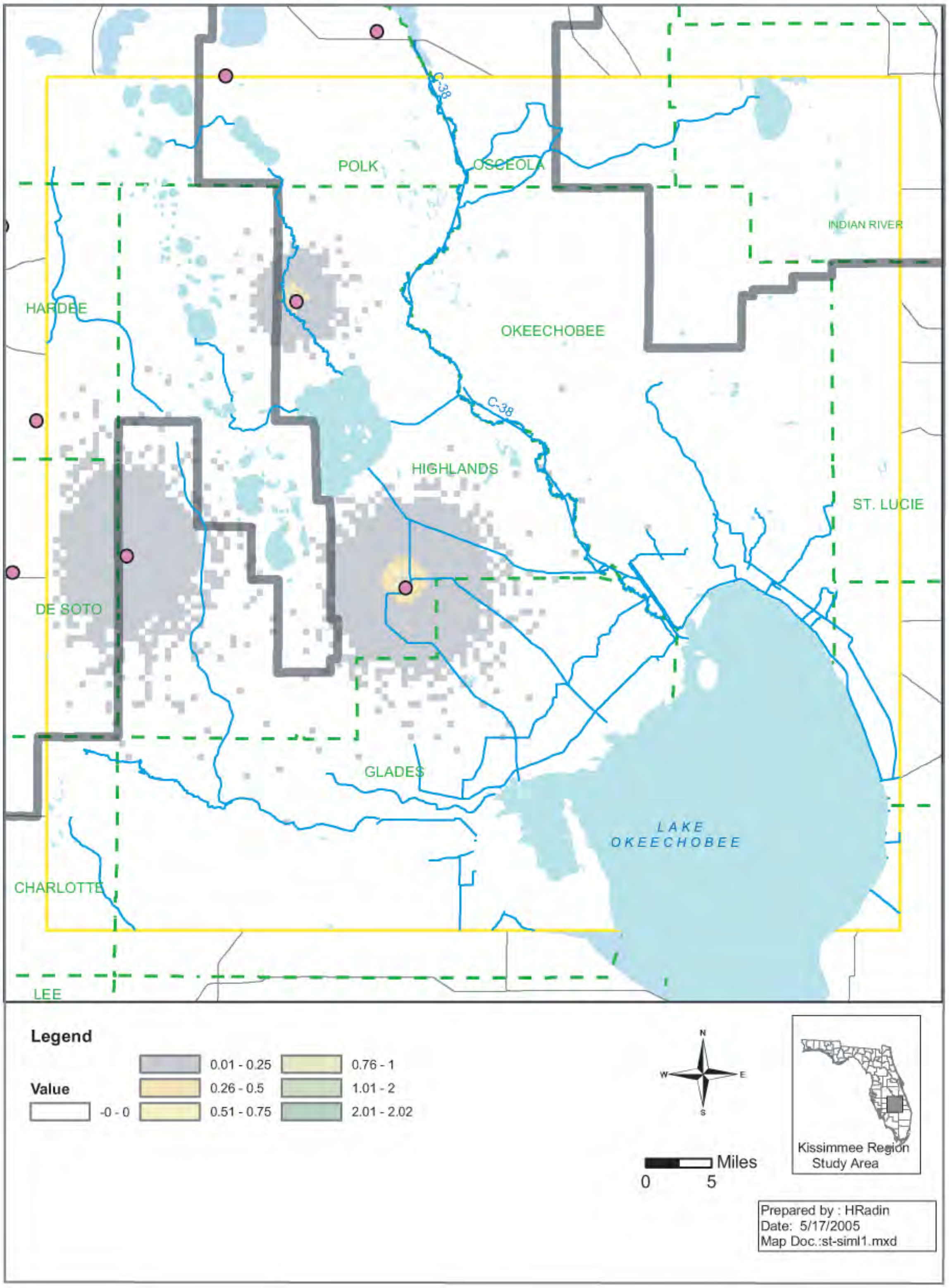

Figure D-48. Drawdown (feet) in Upper Floridan Aquifer – 1995 AFSIRS Ag with Wellfields G62, G63 and G64 in Middle Floridan Aquifer.

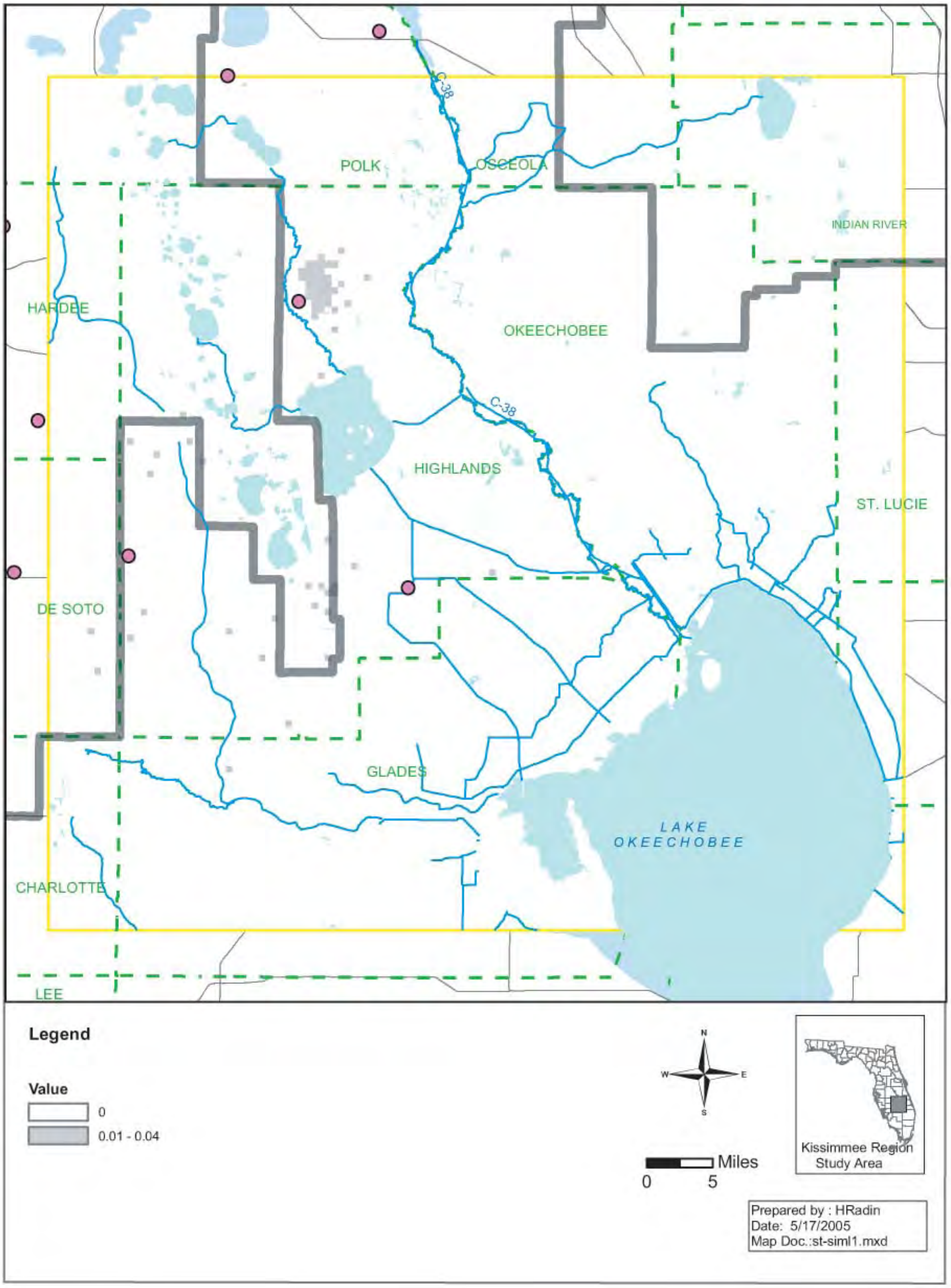

Figure D-49. Drawdown (feet) in Surficial Aquifer – 1995 AFSIRS Ag with Wellfields G62, G63 and G64 in Middle Floridan Aquifer.

1995 1-in-10 with Wellfields in Middle Floridan Aquifer

The 1995 1-in-10 simulation run used the same files as the 1995 AFSIRS run, with the exception of the Evapotranspiration, Recharge and Agriculture consumption well files. These files were modified for the 1-in-10 rainfall conditions. These files are still based on the 1995 land use conditions. Three wellfields were added to these files. Wellfields G62, G63 and G64 were all placed in Layer 3 in the Middle Floridan Aquifer.

The impacts of the wellfields are the same (less than 0.01 feet difference in water levels between simulation runs) as those previously seen in the 1995 AFSIRS Ag with wellfields (**Figures 50–52**).

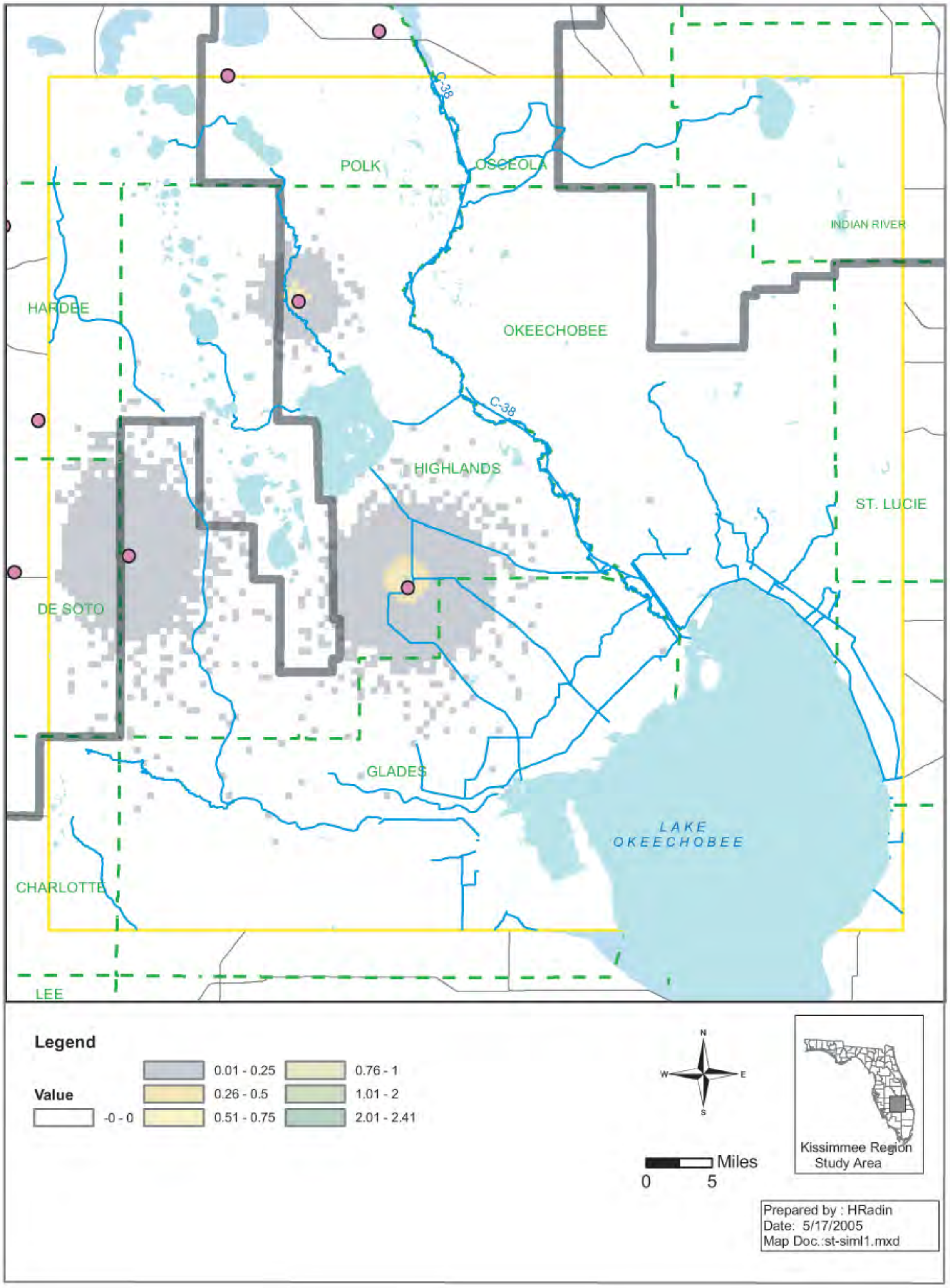

Figure D-50. Drawdown (feet) in Middle Floridan Aquifer – 1995 AFSIRS 1-in-10 with Wellfields G62, G63 and G64 in Middle Floridan Aquifer.

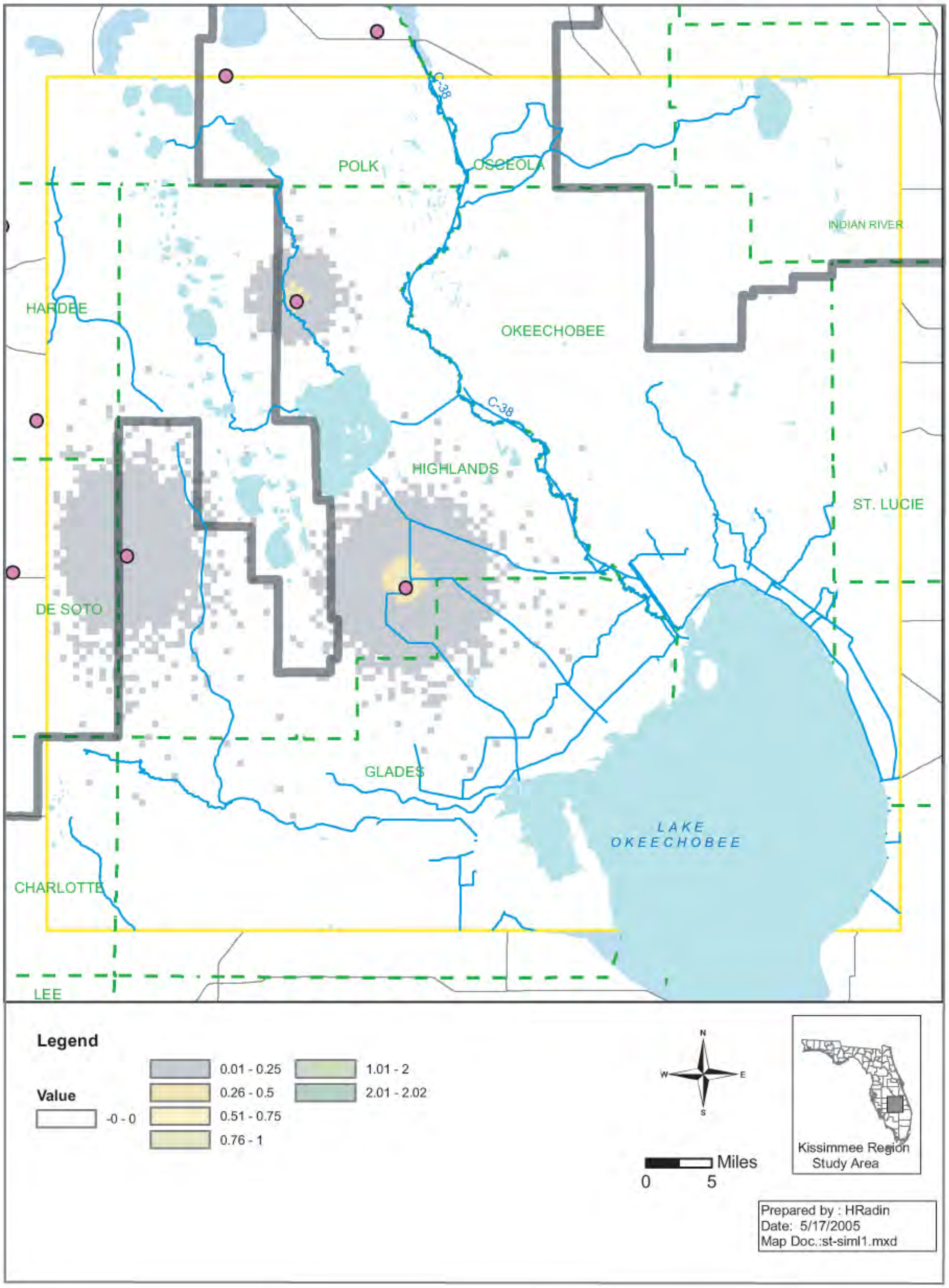

Figure D-51. Drawdown (feet) in Upper Floridan Aquifer – 1995 1-in-10 with Wellfields G62, G63 and G64 in Middle Floridan Aquifer.

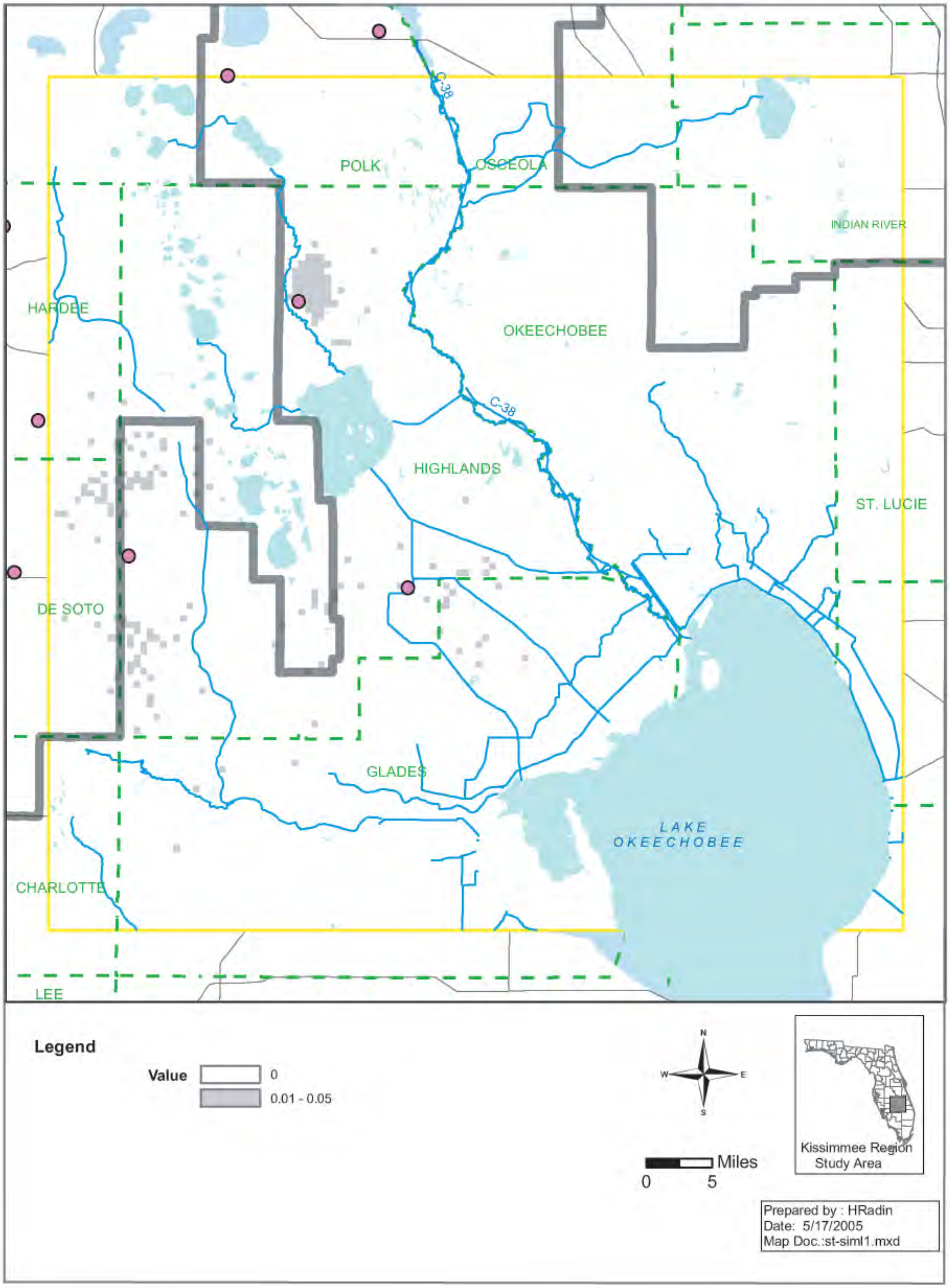

Figure D-52. Drawdown (feet) in Surficial Aquifer – 1995 1-in-10 with Wellfields G62, G63 and G64 in Middle Floridan Aquifer.

2025 1-in-10 with Wellfields in Middle Floridan Aquifer

This simulation run uses the same files as the 2025 1-in-10 run with the addition of the three wellfields. Wellfields G62, G63 and G64 were all placed in Layer 3 in the Middle Floridan Aquifer. The impacts of the wellfields are the same (less than 0.01 feet difference in water levels between simulation runs) as those previously seen in the 1995 AFSIRS Ag with wellfields (**Figure 53–55**).

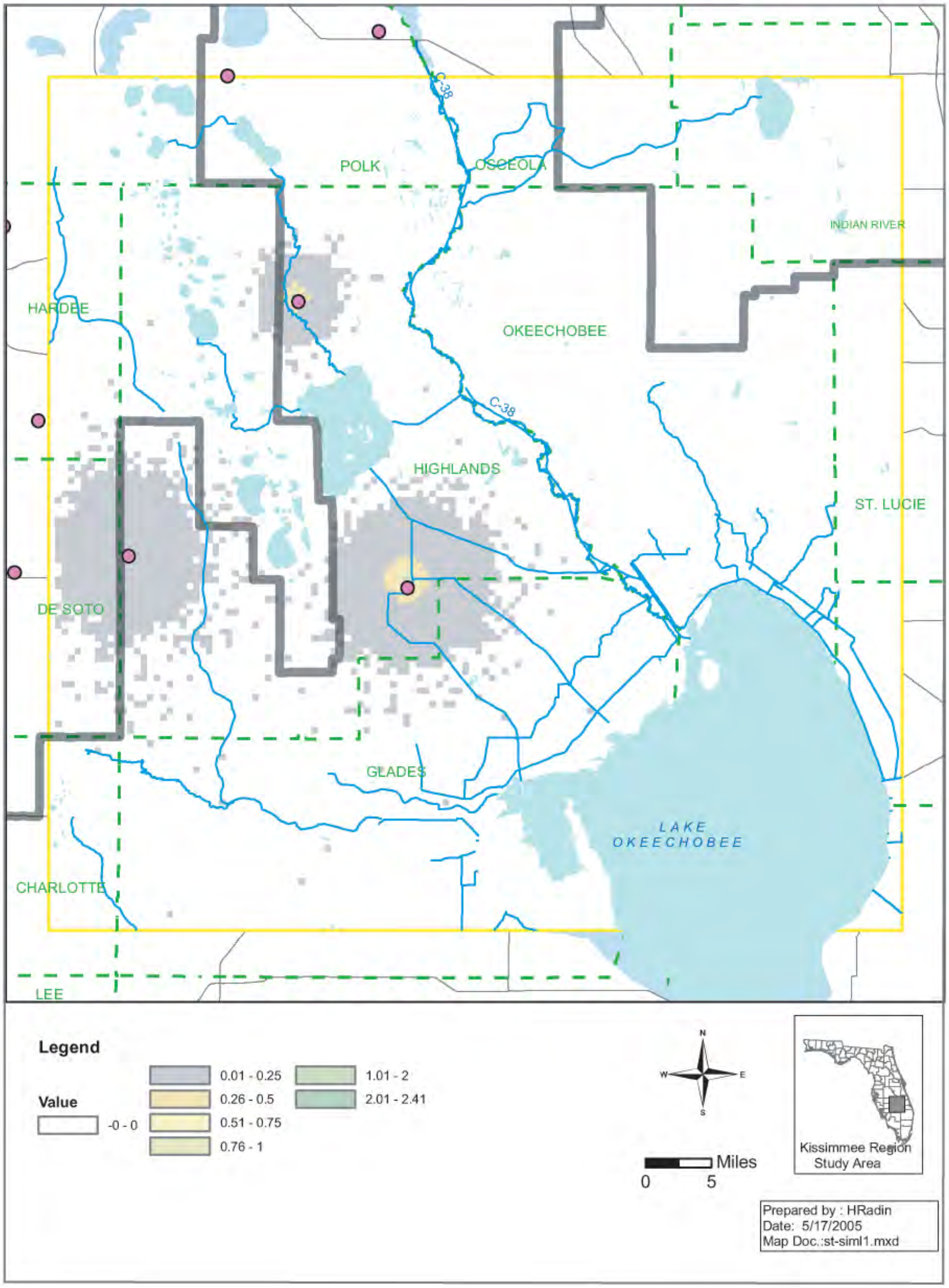

Figure D-53. Drawdown (feet) in Middle Floridan Aquifer – 2025 1-in-10 with Wellfields G62, G63 and G64 in Middle Floridan Aquifer.

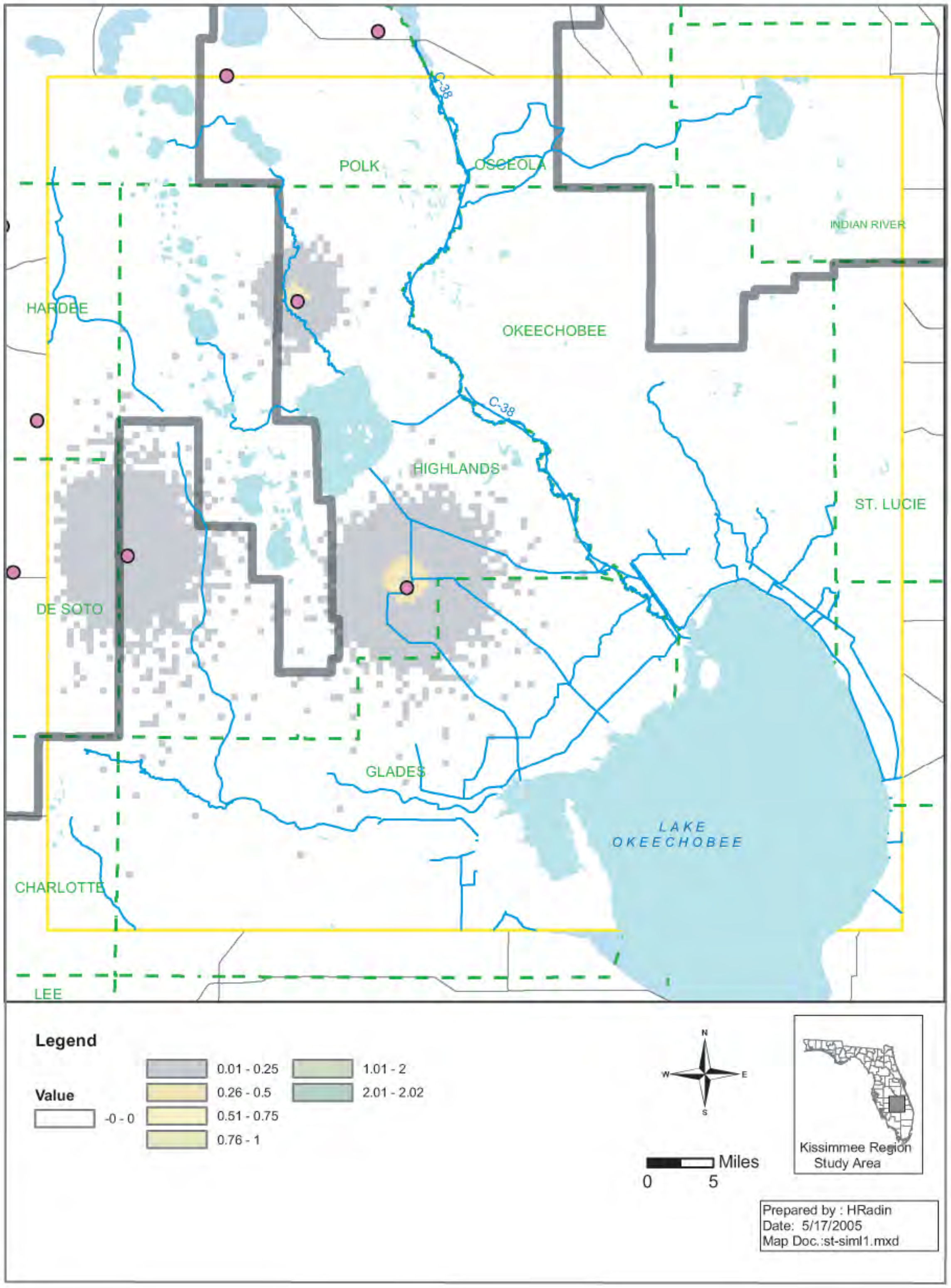

Figure D-54. Drawdown (feet) in Upper Floridan Aquifer – 2025 1-in-10 with Wellfields G62, G63 and G64 in Middle Floridan Aquifer.

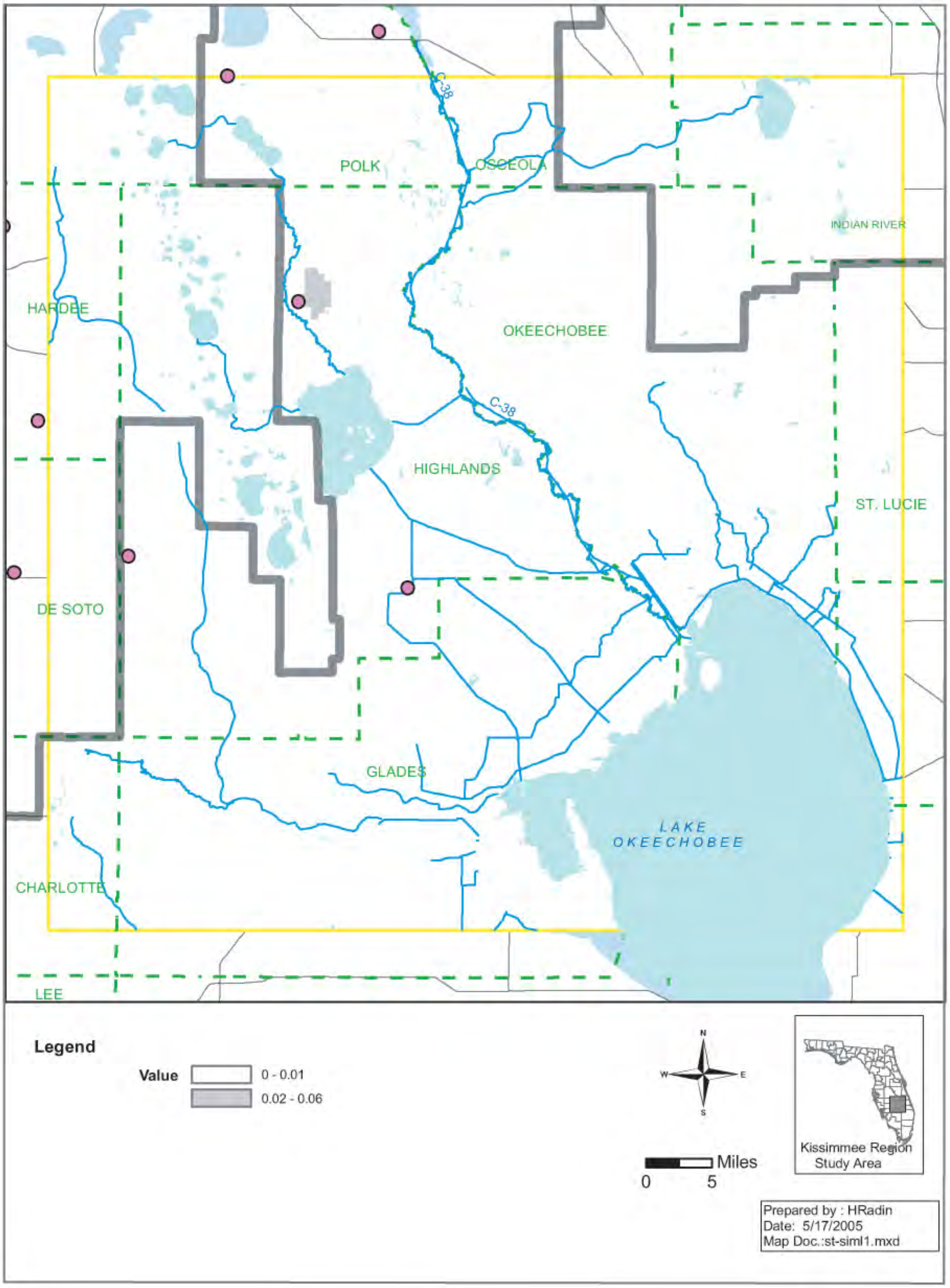

Figure D-55. Drawdown (feet) in Surficial Aquifer – 2025 1-in-10 with Wellfields G62, G63 and G64 in Middle Floridan Aquifer.

NO WELLS RUN

Two simulations were conducted with the wells turned off – 1995 1-in-10 and 2025 1-in-10. These runs were conducted to evaluate the impact of the changing land use from 1995 to 2025.

The Surficial Aquifer was impacted the most by the changes in land use (**Figure D-56**). In east Okeechobee and northwest St. Lucie counties, the water levels in 2025 were up to 44 feet higher in 2025. In most of the model area, the water levels in 2025 were within 5 feet of the water levels observed with the 1995 simulation. West of the Kissimmee River, except for west of Lake Wales Ridge, the water levels were lower in 2025 than in 1995.

In the Upper Floridan Aquifer, most water levels changed by less than 0.25 feet (**Figure D-57**). In eastern Okeechobee County, and in portions of the Avon Park Bombing Range, the water levels were higher by up to 2 feet in 2025. In the Fisheating Creek region, the water levels were up to 0.5 feet lower in 2025.

Most of the Middle Floridan Aquifer showed no water level changes between the two runs (**Figure D-58**). Only the area in east Okeechobee County was higher by up to 0.9 feet in 2025. Polk County water levels were lower by up to 1.26 feet in 2025.

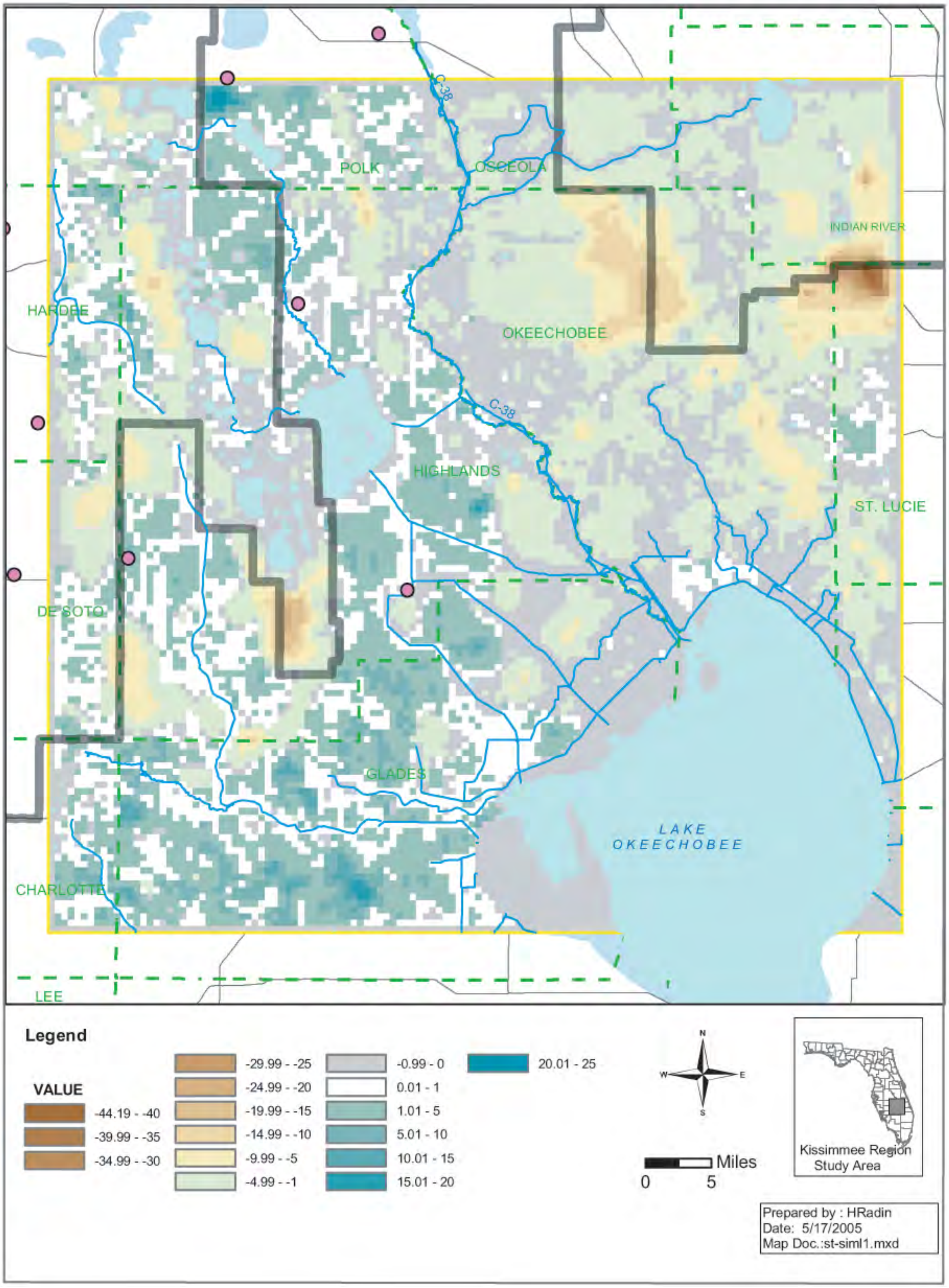

Figure D-56. Drawdown (feet) in Surficial Aquifer – 1995 1-in-10 and 2025 1-in-10 with Wells Off.

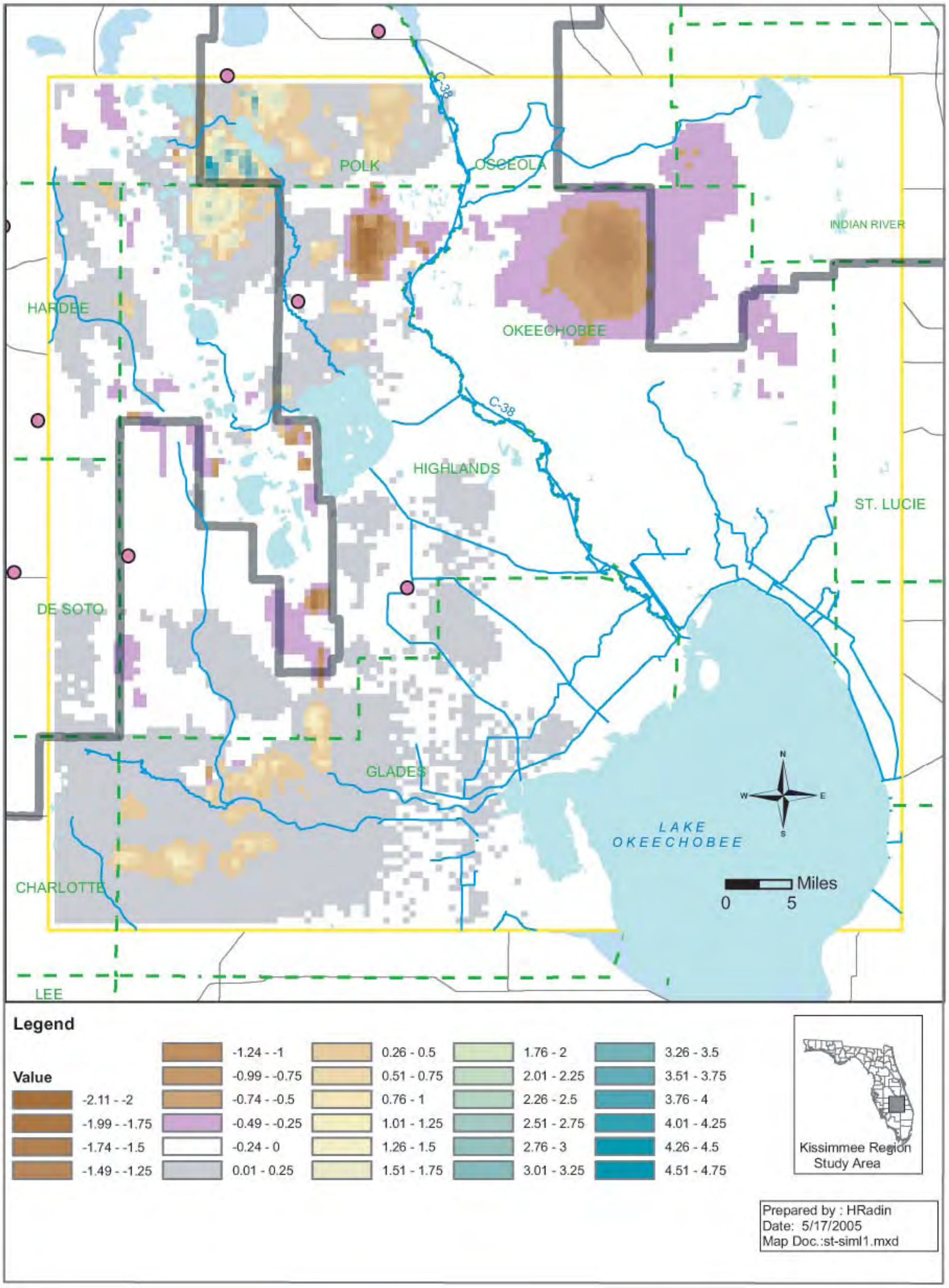

Figure D-57. Drawdown (feet) in Upper Floridan Aquifer – 1995 1-in-10 and 2025 1-in-10 with Wells Off.

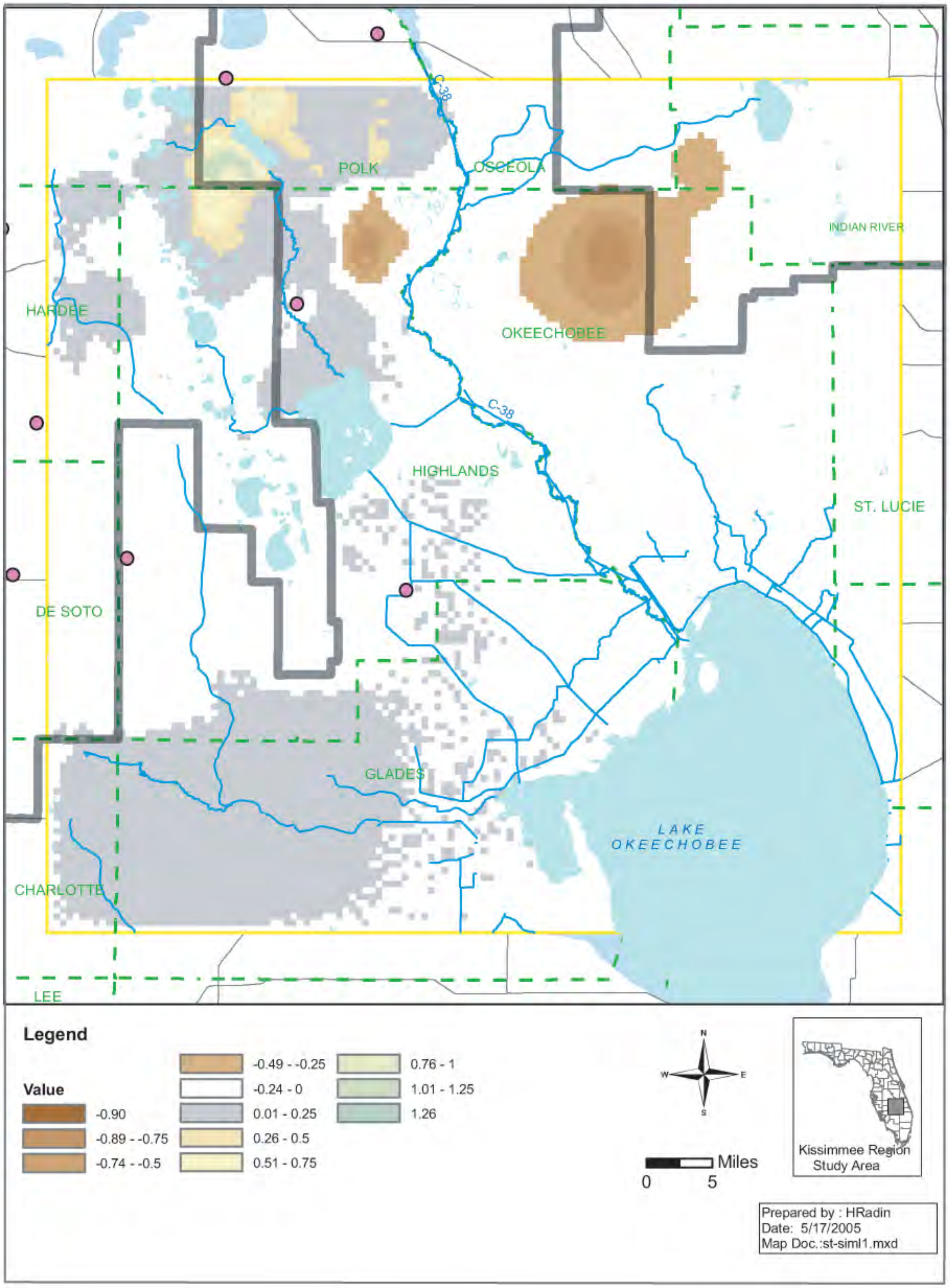

Figure D-58. Drawdown (feet) in Middle Floridan Aquifer – 1995 1-in-10 and 2025 1-in-10 with Wells Off.

MODELING CONCLUSIONS

In general, there is not a significant change (up to 2 feet in most areas) in the water levels simulated with permitted agricultural 1995 demands and the those simulated based on irrigation demands of the crops (AFSIRS).

The Surficial Aquifer is impacted the most by drought conditions.

Consumptive use goes up in 2025. In areas that have landscape irrigation in 2025, where there was no irrigation in 1995, the water levels in 2025 are higher than in 1995. Most of the model area had little change in water levels between the 1995 simulation and the 2025 simulation. In some agricultural areas, the consumption in 2025 is expected to increase, lowering water levels in the Upper Floridan Aquifer by up to 5 feet. The Surficial Aquifer is impacted even more by the changes between 1995 and 2025.

The impacts of the proposed Heartland wells, when placed in the Upper Floridan Aquifer are concentrated in the Upper Floridan Aquifer, with the greatest impacts occurring within a 2-mile radius of the wells. At the wells themselves the drawdowns were 13, 18 and 25 feet respectively for wells G62, G63 and G64. Residual impacts to water levels of the proposed wellfield pumpage are observed in the Upper Floridan simulated layers for up to 10 miles around the wells. The wells had little impact on the Surficial Aquifer System due to presence of the intermediate confining layer in these locations. It is recommended that SWFWMD will review and evaluated wellfield impacts within SWFWMD boundaries. Impacts within the SWFWMD will need to be evaluated by their staff.

When the proposed wells were placed in the Middle Floridan Aquifer, the impacts lessened at the well sites themselves by only being 0.26 feet, 2.41 feet and 1.86 feet respectively for wells G62, G63 and G64 in the Middle Floridan, but they impacted the Upper Floridan too, up to 0.5 feet less drawdown at well site, but similar drawdowns elsewhere. The radius of impact was nearly the same as when wells were placed in Upper Floridan.

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APPENDIX E
Observation Sites

Table E-1. Data Used for Observation Sites.

STATION	TOTAL _DEPT	AVERAGEWL _1995	SFWMD _DBKEY	USGS_ID_NU	LAT	LONG	AQUIFER_US
65411601 41S30E12 CLEMONS PALMDALE	1,100	50		265452081165401	27	-81	
65511803OBSER WELL GL267 NEAR PALMDALE, FL.	600	42		265529081185201	27	-81	
71110501OBSER WELL GL155 NEAR BRIGHTON, FL.	600	48		271150081054401	27	-81	
727100-- 35S33E02 BASS WELL N OF BASSINGER (okf18)	1,015	47		272726081003901	27	-81	
73911801 33S30E06 USAF AVON PARK #1	1,035	78		273903081185201	28	-81	
ALTMAN DEEP WELL NEAR WEST FROSTPROOF FL	700	84		273929081363801	28	-82	120FLRD
ARBUCK	0	40	00209				SURFACE WATER
ARBUCK.L	0	40	00207				SURFACE WATER
AVON P_G	26	129	5093/5094				
AVON P3	0	42	T8310				SURFACE WATER
BASSETT_G	10	43	15576				
BASSETT_G	11	43	IW806				
BONNET LAKE DEEP NEAR SEBRING FL	1,029	83		273252081264101	28	-81	120FLRD
C38.PINE	0	43	T8327				SURFACE WATER
CITY SEBRING DEEP 24 AT SEBRING FL	1,400	83		273007081263901	28	-81	120FLRD
CLENNY DEEP NW/O AVON PK FL	1,050	83		273845081321901	28	-82	120FLRD
CULV5_H	0	17	15449				SURFACE WATER
FISHP	0	31	00088				SURFACE WATER
FLOYD DEVANE WELL 18 NEAR AVON PARK FL	340	87		273353081294201	28	-81	122HTRNN
FT DRUM	0	36	00000				SURFACE WATER
FTB17	1,300	50					
FTB18	1,300	49					
FTB19	1,300	49					
FTB20	1,300	49					
FTB45	1,300	50					
FTKISS	0	42	T8348				SURFACE WATER
GAC_G	10	61	5083				
H-11A_G	16	48	3201				
H-15A_G	15	58	3026				
HIF-0037	1,450	47					
HIF-13_G	1,106	48					

Table E-1. Data Used for Observation Sites (Continued).

STATION	TOTAL _DEPT	AVERAGEWL _1995	SFWMD _DBKEY	USGS_ID_NU	LAT	LONG	AQUIFER_US
HIF-14 P G PHYPERS	1,500	50		271726081163901	27	-81	120FLRD
HIF-16_G	1,225	62	09400				
HIF-23 GRAHAM CO DAIRY	1,560	49		270627081313101	27	-82	120FLRD
HIF-26_G	1,610	49	09392				
HIF-3 73111501 HOWERTON'S WELL NR LORIDA,FL	1,280	54		273138081154201	28	-81	
HIF-32 GUILFORD TOMLINSON	1,360	54		272915081190201	27	-81	120FLRD
HIF-4 34S31E28 YUCAN RANCH NR LORIDA,FL	1,300	49		272906081142001	27	-81	
HIF-5 CHARLES STIDHAM	1,510	49		271134081234301	27	-81	120FLRD
HIF-6 LYKES BROW 4IN FLOW	520	49		271456081074701	27	-81	120FLRD
HIF-8 BOX RANCH	1,450	49		271306081284801	27	-81	120FLRD
IR-25_G	19	28	3280				
JOHN MCCULLOCH WELL 11 NEAR SEBRING FL	370	81		273054081234701	28	-81	122LMSN
L.ARBUNK	0	54	00199				SURFACE WATER
LAKE ISIS ISLN NRSD WELL AT AVON PARK FL	23	111		273654081303701	28	-82	110NRSD
LAKE ISIS ISLNE NRSD WELL AT AVON PARK FL	19	112		273652081303001	28	-82	110NRSD
LAKE ISIS ISLNW NRSD WELL AT AVON PARK FL	25	113		273649081304501	28	-82	110NRSD
LAKE ISIS ISLSE NRSD WELL AT AVON PARK FL	13	113		273636081303101	28	-82	110NRSD
LAKE ISIS ISLSW NRSD WELL AT AVON PARK FL	10	118		273636081304501	28	-82	110NRSD
LAKE ISIS ISUNE NRSD WELL AT AVON PARK FL	25	111		273653081302201	28	-82	110NRSD
LAKE ISIS ISUNW NRSD WELL AT AVON PARK FL	38	116		273648081305101	28	-82	110NRSD
LAKE ISIS ISUSE NRSD WELL AT AVON PARK FL	35	115		273635081302601	28	-82	110NRSD
LAKE ISIS ISUSW NRSD WELL AT AVON PARK FL	25	124		273633081304801	28	-82	110NRSD
LAKE OLIVIA OLLE NRSD WELL NEAR AVON PARK FL	12	117		273754081323901	28	-82	110NRSD
LAKE OLIVIA OLLNE NRSD WELL NEAR AVON PARK FL	16	116		273804081324001	28	-82	110NRSD
LAKE OLIVIA OLLNW NRSD WELL NEAR AVON PARK FL	14	116		273806081325701	28	-82	110NRSD
LAKE OLIVIA OLLS NRSD WELL NEAR AVON PARK FL	15	118		273746081324701	28	-82	110NRSD
LAKE OLIVIA OLLSW NRSD WELL NEAR AVON PARK FL	15	117		273751081330201	28	-82	110NRSD
LAKE OLIVIA OLLW NRSD WELL NEAR AVON PARK FL	12	116		273758081330601	28	-82	110NRSD
LAKE OLIVIA OLUNE NRSD WELL NEAR AVON PARK FL	13	115		273805081323701	28	-82	110NRSD
LAKE OLIVIA OLUNW NRSD WELL NEAR AVON PARK FL	18	116		273808081325901	28	-82	110NRSD
LAKE OLIVIA OLUS NRSD WELL NEAR AVON PARK FL	30	129		273730081324701	28	-82	110NRSD

Table E-1. Data Used for Observation Sites (Continued).

STATION	TOTAL _DEPT	AVERAGEWL _1995	SFWMD _DBKEY	USGS_ID_NU	LAT	LONG	AQUIFER_US
LAKE OLIVIA OLUSW NRSD WELL NEAR AVON PARK FL	25	119		273746081330801	28	-82	110NRSD
LAKE OLIVIA OLUW NRSD WELL NEAR AVON PARK FL	20	116		273757081331201	28	-82	110NRSD
LAKE PLACID GROVES DEEP SOUTH OF LAKE PLACID FL	1,300	51		271223081202601	27	-81	120FLRD
LOTELLA_G	10	81	5091				
M-933 2_G	15	21	3063				
MAXCEY N_G	9	64	5090				
NICO1	0	14	TA231				SURFACE WATER
NIOC3	0	18	150099				SURFACE WATER
NUBBC_H	0	19	12440				SURFACE WATER
OK-2_G	21	45	5131				
OK-3_G	22	60	5133				
OKF-0054	973	39					
OKF-17 DIXIE RANCH	986	47		272010080550801	27	-81	120FLRD
OKF-23	925	44					
OKF-31_G	1,079	50					
OKF-34	1,143	47					
OKF-42	1,152	47					
OKF-42 EXP WELL S65C	1,152	47		273007081114601	28	-81	120FLRD
OKF-7	963	46					
OPAL_G	10	33	15579				
OSF-42	767	43		274307080582401	28	-81	120FLRD
OSF-60A TEST WELL AT YEEHAW JUNCTION,FL	325	42		274149080534801	28	-81	120FLRD
ROBERT RICHARDS WELL 25 NEAR AVON PARK FL	260	74		273704081245501	28	-81	122HTRNN
ROMP 28 FLORIDAN WELL NR LAKE PLACID FL	1,385	70		271559081202301	27	-81	120FLRD
S127_H	0	14	15817				SURFACE WATER
S129_H	0	13	15821				SURFACE WATER
S131_H	0	13	15719				SURFACE WATER
S133_H	0	14	15825				SURFACE WATER
S135_H	0	14	15803				SURFACE WATER
S154_H	0	20	15920				SURFACE WATER

Table E-1. Data Used for Observation Sites (Continued).

STATION	TOTAL _DEPT	AVERAGEWL _1995	SFWMD _DBKEY	USGS_ID_NU	LAT	LONG	AQUIFER_US
S191_H	0	19	15805				SURFACE WATER
S-65A(POF-20)WELL NR YEEHAW JUNCTION,FL	1,000	46		273929081080601	28	-81	120FLRD
S65A_H	0	46	06799				SURFACE WATER
S65AX_H	0	46	12568				SURFACE WATER
S65C_H	0	34	06957				SURFACE WATER
S65D_H	0	27	06960				SURFACE WATER
S65E_H	0	21	08064				SURFACE WATER
S68_H	0	39	15956				SURFACE WATER
S70_H	0	26	TA232				SURFACE WATER
S71_H	0	20	15948				SURFACE WATER
S72_H	0	21	15768				SURFACE WATER
S75_H	0	26	15771				SURFACE WATER
S77_H	0	16	00852				SURFACE WATER
S82_H	0	32	15961				SURFACE WATER
S83_H	0	32	15963				SURFACE WATER
S84_H	0	25	15958				SURFACE WATER
SADDLEBLANKET LAKES SBLN NRSD W NEAR FROSTPROOF FL	10	119		274013081342601	28	-82	110NRSD
SADDLEBLANKET LAKES SBUN NRSD W NEAR FROSTPROOF FL	19	119		274017081343201	28	-82	110NRSD
SADDLEBLANKET LKS SBLNE NRSD W NEAR FROSTPROOF FL	18	119		274009081342301	28	-82	110NRSD
SADDLEBLANKET LKS SBLNW NRSD W NEAR FROSTPROOF FL	14	119		274011081343101	28	-82	110NRSD
SADDLEBLANKET LKS SBLSE NRSD W NEAR FROSTPROOF FL	10	120		274005081342401	28	-82	110NRSD
SADDLEBLANKET LKS SBLSW NRSD W NEAR FROSTPROOF FL	14	119		274005081343101	28	-82	110NRSD
SADDLEBLANKET LKS SBUNE NRSD W NEAR FROSTPROOF FL	15	118		274010081342201	28	-82	110NRSD
SADDLEBLANKET LKS SBUSE NRSD W NEAR FROSTPROOF FL	27	121		274003081342101	28	-82	110NRSD
SADDLEBLANKET LKS SBUSW NRSD W NEAR FROSTPROOF FL	19	121		274004081343501	28	-82	110NRSD
SEBRING_G	10	56	5070				
SHEARER DEEP WELL NO 141 NEAR LEMON GROVE FL	1,093	78		273458081342601	28	-82	120FLRD

STATION	TOTAL _DEPT	AVERAGEWL _1995	SFWMD _DBKEY	USGS_ID_NU	LAT	LONG	AQUIFER_US
SMITH DEEP WELL NO. 731136344333 NR LEMON GROVE FL	849	72		273103081363701	28	-82	120FLRD
STL-42_G	13	26	3226				
TICK ISL_G	9	49	5086				
WEIR1_H	0	41	T8323				SURFACE WATER
WEIR2_H	0	42	T8319				SURFACE WATER
WEIR3_H	0	42	T8315				SURFACE WATER
YATES M_H	0	24	T8311				SURFACE WATER

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