# Simulation of the 2013 and 2040 Scenarios Using the East Coast Floridan Model Upper East Coast Water Supply Plan

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# TABLE OF CONTENTS

List of Tables ..... ii

List of Figures ..... ii

Acronyms and Abbreviations ..... iii

1.0 Abstract ..... 1

2.0 Introduction ..... 1

3.0 Improvements to the ECFM for the UEC Plan Update ..... 2

4.0 Input Datasets for the UEC Plan Update ..... 4

4.1 Simulated FAS Demands ..... 4

4.1.1 Upper East Coast Planning Area ..... 6

4.1.2 Adjacent Areas ..... 9

5.0 Model Scenarios Conducted Under this Review ..... 13

5.1 Floridan Aquifer Simulation Results ..... 13

5.1.1 Discussion of Water Level Variations ..... 14

5.1.2 Discussion of Water Quality Variations ..... 17

5.1.3 Flow Vectors ..... 22

5.1.4 Reduction in Heads of Flowing Wells ..... 25

6.0 Conclusions and Recommendations ..... 27

7.0 References ..... 29

Appendix A ..... 30

Appendix B ..... 47

# LIST OF TABLES


Table 1. St. Lucie County simulated irrigated acres and withdrawals. ..... 6
Table 2. St. Lucie County PWS demands from the FAS. ..... 6
Table 3. Martin County estimated agricultural acres and simulated FAS withdrawals. ..... 8
Table 4. Martin County PWS FAS demands. ..... 8
Table 5. NE Okeechobee County FAS irrigation demands. ..... 9
Table 6. Okeechobee County PWS demands. ..... 9
Table 7. Irrigation acres and demands from the FAS in Indian River County. ..... 10
Table 8. Indian River County PWS FAS demands. ..... 10
Table 9. Northern Palm Beach County FAS irrigation demands. ..... 12
Table 10. Northern Palm Beach County PWS FAS demands. ..... 12
Table 11. UEC Planning Area ECFM scenarios. ..... 13
Table 12. UEC Planning Area ECFM scenario demands. ..... 13


# LIST OF FIGURES


Figure 1. Location of the Upper East Coast Planning Area. ..... 2
Figure 2. Deviation (in inches) from historical (1931 to 2014) average annual rainfall in St. Lucie County for the ECFM calibration and simulation period (1989 to 2012). ..... 5
Figure 3. Change in water levels between the initial condition and of the end of the 2040 simulation (month 288) in the UFA (Layer 1). ..... 14
Figure 4. Results of 2013 and 2040 simulation head and TDS differences in the UFA at the proposed St. Lucie County Utilities North wellfield. ..... 15
Figure 5. Results of 2013 and 2040 simulation head and TDS differences in the APPZ at the Indian River County Utilities Oslo wellfield. ..... 16
Figure 6. Water level change between the initial condition and the end of the 2040 simulation (month 288) in the APPZ (Layer 3). ..... 17
Figure 7. Change in water quality between the initial condition and the end of the 2040 simulation (month 288) in the UFA (Layer 1). ..... 18
Figure 8. Changes in water quality in the UFA (Layer 1) during the 2040 simulation compared to the initial condition. ..... 18
Figure 9. Results of the 2013 and 2040 simulated changes in water quality in Indian River County at Well IRF-USDA. ..... 19
Figure 10. Water quality conditions in the APPZ at the end of the 2040 simulation. ..... 20
Figure 11. Change in water quality in the APPZ from the initial condition to the end of the 2040 simulation. ..... 21
Figure 12. Change in water level and water quality for 2013 and 2040 in the APPZ at the MCSU-F1 monitoring well in Martin County. ..... 21
Figure 13. UFA flow vectors in the final month of the 2013 simulation. ..... 22
Figure 14. UFA flow vectors in the final month of the 2040 simulation. ..... 23
Figure 15. APPZ flow vectors in the final month of the 2013 simulation. ..... 23
Figure 16. APPZ flow vectors in the final month of the 2040 simulation. ..... 24
Figure 17. Potentiometric surface of the UFA relative to land surface at the end of the 2013 simulation. ..... 26
Figure 18. Potentiometric surface of the UFA relative to land surface at the end of the 2040 simulation. ..... 27

# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| 3D | three-dimensional |
| AFSIRS | Agricultural Field-Scale Irrigation Requirements Simulation |
| APPZ | Avon Park Permeable Zone |
| ASR | aquifer storage and recovery |
| CFWI | Central Florida Water Initiative |
| District | South Florida Water Management District |
| ECFM | East Coast Floridan Model |
| ET | evapotranspiration |
| FAS | Floridan aquifer system |
| FDEP | Florida Department of Environmental Protection |
| FPL | Florida Power & Light |
| FPUA | Fort Pierce Utilities Authority |
| ICI | Industrial/Commercial/Institutional Self-Supply |
| LFA | Lower Floridan Aquifer |
| MC1 | Middle Confining Unit 1 |
| MGD | million gallons per day |
| mg/L | milligrams per liter |
| NE | northeastern |
| NGVD | National Geodetic Vertical Datum |
| PWS | public water supply |
| RO | reverse osmosis |
| SAS | surficial aquifer system |
| SFWMD | South Florida Water Management District |
| SJRWMD | St. Johns River Water Management District |
| SMRU | South Martin Regional Utility |
| SUA | Seacoast Utility Authority |
| TDS | total dissolved solids |
| UEC | Upper East Coast |
| UFA | Upper Floridan aquifer |
| USDA | U.S. Department of Agriculture |
| USGS | U.S. Geological Survey |

# 1.0 ABSTRACT

The South Florida Water Management District (SFWMD or District) is required to provide periodic updates of the Upper East Coast (UEC) Water Supply Plan, which covers Martin and St. Lucie counties, and the northeastern portion of Okeechobee County. During the update process, demand projections are developed 20 years into the future by use type and water source. This study utilized the East Coast Floridan Model (ECFM) to evaluate the existing and projected future UEC demands on the Floridan aquifer system (FAS). Demands on the FAS are projected to increase by approximately 24 million gallons per day (MGD). The results of the ECFM simulations indicate that no widespread impacts are projected to occur. However, several localized areas were identified where water quality degradation may occur and water volume obtained from free-flowing wells may diminish.

# 2.0 INTRODUCTION

The South Florida Water Management District (SFWMD or District) is required to provide 5-year regional water supply plan updates for each of the five planning regions within its jurisdictional boundaries. As part of the plan updates, groundwater simulations are conducted to identify potential water supply or water resource issues that may occur during the planning period. Modeling tools are used to assess conditions 20 or more years into the future using projected population and water demand estimates.

Encompassing Martin, St. Lucie, and northeastern (NE) Okeechobee counties, the Upper East Coast (UEC) Planning Area's (**Figure 1**), primary sources of water are fresh surface water and brackish groundwater from the Floridan aquifer system (FAS). The availability of fresh groundwater from the surficial aquifer system (SAS) in the UEC Planning Area is limited, which has led to widespread use of the FAS over the last two decades. The need for better modeling tools to analyze potential changes in water levels and water quality in the FAS has been recognized since the late 1990s.

Two accomplishments have enabled a more detailed analysis of FAS withdrawals as part of the UEC water supply planning process. First, Reese and Richardson (2008) provided a hydrogeologic re-evaluation of the FAS for south Florida, including the UEC Planning Area, allowing for a sufficient framework of the FAS for groundwater model application. Second, Giddings et al. (2014) developed the East Coast Floridan Model (ECFM), a fully three-dimensional (3D) density-dependent groundwater flow and solute transport model for southeastern Florida, including the UEC Planning Area, based partially on Reese and Richardson (2008). The ECFM allows for a regional evaluation of water level and water quality conditions in the FAS from Sebastian Inlet south to the Straits of Florida. The ECFM was used to provide an analysis of FAS groundwater conditions for the UEC Planning Area in support of the 2016 UEC Water Supply Plan Update.

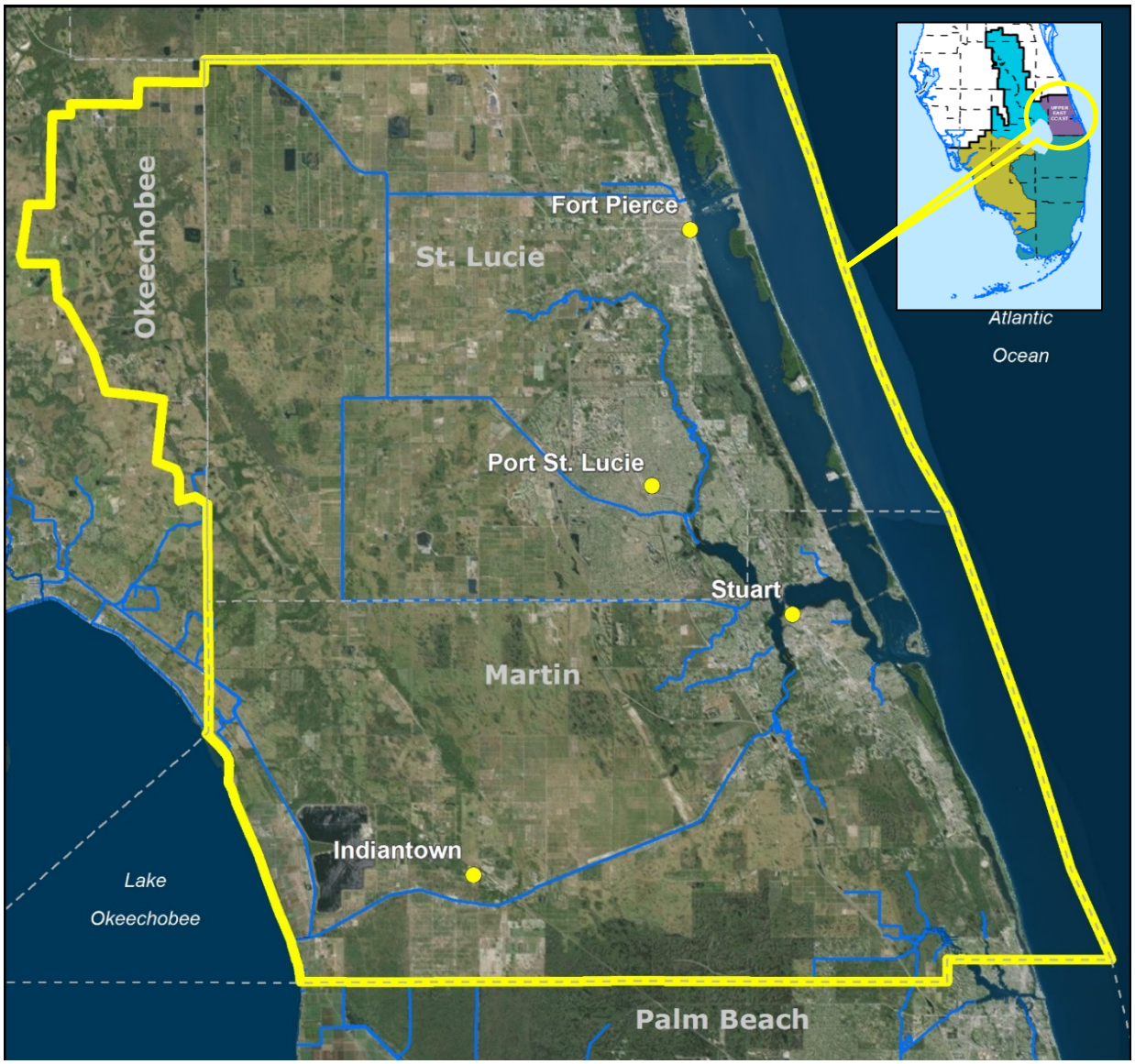



Figure 1. Location of the Upper East Coast Planning Area.

The ECFM was developed using the United States Geological Survey's (USGS's) SEAWAT model code. The ECFM covers a large area extending from central Florida to the Straits of Florida and from approximately the center line of the Florida peninsula to the Florida Straits and Atlantic Ocean. This area was divided into a uniform grid with spacing of 2,400 feet. The ECFM has seven primary layers: Upper Floridan Aquifer (UFA), Middle Confining Unit 1, Avon Park Permeable Zone (APPZ), Middle Confining Unit 2, Lower Floridan Aquifer (LFA) (first permeable zone), Lower Confining Unit, and Boulder Zone. The ECFM can simulate the response of the aquifers to stresses such as proposed wellfield pumpage, aquifer storage and recovery (ASR) systems, reductions in recharge, and increasing sea level.

## 3.0 IMPROVEMENTS TO THE ECFM FOR THE UEC PLAN UPDATE

HydroGeoLogic, Inc. (2006) developed the predecessor to the ECFM that included Miami-Dade, Broward, and Palm Beach counties. Golder and Associates (2008) expanded the model to include Martin and St. Lucie counties. In 2011, both versions underwent an external peer review by experts, which resulted

in 10 key recommendations. A subsequent contract was coordinated between SFWMD staff and Schlumberger Water Services to develop a plan for incorporation of the peer-review recommendations into the development of the revised ECFM. This plan required a substantial revision to the model, resulting in the current version completed by the SFWMD in 2014, which supersedes the two previous versions.

The 2014 calibrated version of the ECFM was used to develop the initial conditions for the 2013 and future 2040 simulations to support the UEC water supply planning effort. During development of the input files for the 2013 and 2040 simulations, additional data were received from the public water supply (PWS) utilities in the region, which were not included in the original calibration of the model. This section discusses the changes made to the 2014 version of the ECFM as a result of this additional information.

There were three modifications made to the ECFM input datasets incorporated during the application of the model to the UEC planning process: 1) an update to the demand distribution by well and aquifer for the PWS users; 2) additional water quality information from PWS production wells; and 3) well construction information with revised locations for newly constructed production wells. The primary issue encountered was the utilities relying on the APPZ of the FAS to meet a portion of their demands. Historical data indicate that sustained use of the APPZ results in water quality deterioration. As a result, the utilities have implemented pumping strategies to minimize water quality changes in APPZ wells such as rotating wells, reducing withdrawals, shutting down wells for extended periods of time, or permanently taking the well offline. Detailed information of actual well withdrawals and operational schedules was incorporated into the model for selected utilities.

In addition to improving the distribution of demands within a wellfield, updated well construction information (e.g., casing and total depths) and locations were obtained from PWS utilities. The main issue encountered for this exercise was that several wells are open to portions of the UFA and the APPZ. This required further adjustments at the individual well level to estimate the percentage of water produced by the well from each aquifer. Because of the observed water quality degradation in the APPZ, Port St. Lucie plugged the lower portion of three production wells so they now only penetrate the UFA when previously they were open to the APPZ. The wells were updated in the well input file to reflect this.

During the modeling process, utilities provided monthly water quality data from most or all of their production wells. The additional information required minor changes to the initial water quality and horizontal hydraulic conductivities to improve the model's predictive capabilities. Overall, the introduced changes did not noticeably change the water level calibration because most of the monitor wells are not located in the middle of the PWS wellfields where the changes occurred. However, some slight improvement in the performance of the model as it relates to water quality was observed in the vicinity of the PWS wellfields due to the additional data.

A key assumption is required when evaluating the ECFM simulation results: the ECFM extent includes all of southeastern Florida, not just the UEC Planning Area. As a result, FAS withdrawals outside of the UEC Planning Area are not updated to 2013 or 2040 demands. The only exceptions are areas adjacent to the UEC Planning Area that might influence the FAS uses in the region. For example, demands were updated for northern Palm Beach County, areas east of Taylor Creek in Okeechobee County, and in a portion of the St. Johns River Water Management District (SJRWMD) that is adjacent to the UEC Planning Area. No other SFWMD user demands on the FAS within the model domain were updated. This creates a problem because the initial water levels and water quality for the 2013 and 2040 simulations use the last month of the calibration period (December 2012) as the starting point. Therefore, the initial water quality and water levels reflect all demands that were operational in December 2012. The issue arises for a wellfield

outside of the UEC Planning Area that did not become operational until late in the calibration period (e.g., 2009). In those cases, even though the wellfield existed in 2013, it is assumed that in the baseline simulations, the withdrawals would be zero for the first 20 years and operational (at pre-2013 use rates) for the remaining 4 years of the simulation. However, the initial water level and water quality assumed that the well is on at the beginning of the simulation. The net result is that the simulations were not intended to, and in fact, do not provide meaningful information for any users south of Jupiter/Palm Beach Gardens or west of Taylor Creek. Because of this assumption, results for areas where demands were not updated (i.e., outside of the UEC Planning Area boundaries and adjacent areas) are not reported here and should not be considered.

# 4.0 INPUT DATASETS FOR THE UEC PLAN UPDATE

## 4.1 Simulated FAS Demands

Simulated demands generally can be divided into two categories: PWS and agricultural/landscape irrigation demands. All utilities in the UEC Planning Area drawing from the FAS use reverse osmosis (RO) treatment to remove minerals, particularly salts, from brackish raw water so it can be used for PWS. For this discussion, landscape irrigation includes areas associated with golf courses. Agricultural and landscape irrigation demands are based on estimated total crop acreage, which is modified to reflect the percentage of irrigated acreage at the project level that is met from the FAS and adjusted for irrigation type. PWS demands generally are calculated from historical per capita use and projected population estimates by service area, which is further adjusted to reflect the SAS to FAS ratio at the utility level. Monthly simulated demands were based on historical patterns to reflect changes in demands associated with climatic conditions and normalized to a single population projection for the entire 24-year simulation period. Distribution of demands by well within a wellfield generally were evenly distributed unless specific well withdrawal knowledge was available to override this assumption.

Irrigated acreage was obtained from District permit databases and includes the crop type, crop acreage, irrigation efficiency, withdrawal facilities, and sources of irrigation water. Acreage and permits were cross-checked against existing land use cover/satellite images, as necessary, to verify acres and determine if the permit is still in existence or has been converted to a different use classification. Improved pasture is only irrigated when it is directly specified in the permit and can be justified. Otherwise, pasture demands were based on water required per livestock as specified in the permits and remains fixed with no projected increase/decrease in the size of the herd. This assumption is important because a planning region may project several thousands of acres of pasture but the number of acres actually irrigated in the simulation is restricted to the number of acres specified in the permits for the baseline condition.

Simulated irrigation demands were calculated using the University of Florida Institute of Food and Agricultural Sciences Agricultural Field-Scale Irrigation Requirements Simulation (AFSIRS) model. The majority of farms in the UEC Planning Area use a combination of surface water and FAS water to meet crop irrigation needs. The distribution between the two sources was estimated from actual farm operations, site-specific model calibration results at individual observation wells, and water supply plan estimates. In general, the assumption for the simulations was that approximately 67 percent of irrigation occurs from surface water and 33 percent occurs from the FAS for multiple source users. Actual percentage of surface water to FAS withdrawals varies for individual farms. FAS demands also increase above these percentages when the C-23, C-24, and C-25 canals are at low levels (e.g., 14 feet National Geodetic Vertical Datum [NGVD]).

Irrigation demands developed from the AFSIRS model are calculated using actual daily rainfall and evapotranspiration (ET) for the simulation period. This differs from the average annual and 1-in-10 year rainfall deficit statistical numbers discussed in the SFWMD water supply plans and updates. The ECFM simulation period runs from January 1989 through December 2012. In St. Lucie County for example, historical rainfall was below average for the second half of the simulation period, which resulted in above-average irrigation demands (**Figure 2**) compared to the average irrigation demands identified in the 2016 UEC Plan Update.

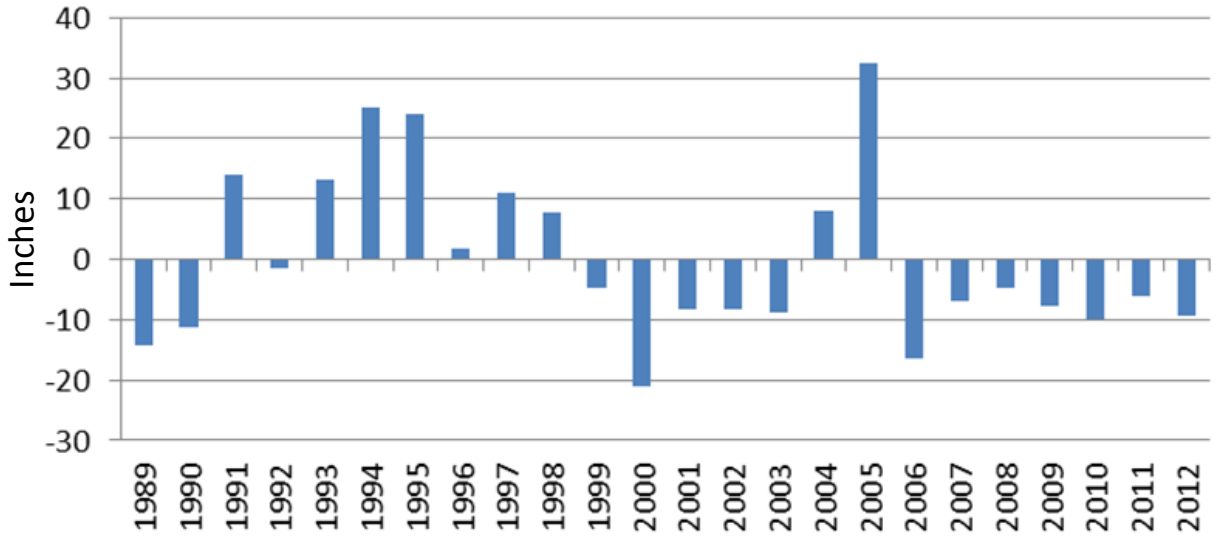



Figure 2. Deviation (in inches) from historical (1931 to 2014) average annual rainfall in St. Lucie County for the ECFM calibration and simulation period (1989 to 2012).

The uncertainty associated with the estimation of simulated withdrawals can be divided into three categories: high, moderate, and low. In general, there was a high degree of confidence in modeled PWS withdrawal as a result of the permit conditions from the Florida Department of Environmental Protection (FDEP) and the SFWMD requiring each utility to submit both treated and raw water data, respectively, to the agencies monthly. A moderate degree of confidence was assumed for the simulated Industrial/Commercial/Institutional Self-Supply (ICI) uses. Demands for these types of uses generally are well known at the time of permit issuance and normally are consistent or predictable. In south Florida, large ICI users usually are associated with packaging plants and recycling facilities.

Another factor adding uncertainty is the location of FAS wells for two of three proposed PWS wellfields. Each of the 17 wells in Port St. Lucie's proposed Southwest wellfield has a specific site and is oriented east-west along two lines. The well locations are contained within 16 different model cells. St. Lucie County Utilities, on the other hand, has two proposed wellfields considered in this evaluation, but had identified only a single site for multiple wells at each wellfield. This resulted in the FAS withdrawals for the North (Airport) wellfield and Central (Fairgrounds) wellfield each being pulled from a single model cell. This concentration of withdrawals may overestimate the local declines in water levels and water quality, including potential impacts to other users and magnified impacts with other nearby large users for both of the St. Lucie County wellfields. Future updates of the UEC Plan will be able to relook at these areas using the ECFM once the county determines specific well sites at both locations.

Daily irrigation demands were calculated from the AFSIRS model using observed climatic conditions and summed into monthly values for model input. Irrigation demands were further adjusted to reflect

site-specific operations when conditions warranted. A moderate degree of confidence for modeled irrigation demands that solely utilize the FAS and are fully operational can be expected. Lower degrees of confidence for modeled irrigation demands can be expected for farms and groves that utilize a combination of surface water and FAS water because of the assumptions used for estimating the percentage and timing when each source is utilized. Additional uncertainty is introduced for citrus operations, which have experienced damage from floods and storms as well as diseases, including citrus greening and citrus canker, which approximately began in 2000.

### *4.1.1 Upper East Coast Planning Area*

#### 4.1.1.1 St. Lucie County Simulated FAS Demands

The central and western parts of St. Lucie County have abundant citrus crops, although some crops were badly damaged by hurricanes in 2005 and have been further affected by disease in recent years. Pasture is the second largest irrigated crop in the county, followed by vegetables, landscaping, golf courses, and nurseries. For the 2013 and 2040 simulations, there was almost no increase in the acres irrigated for most crop types (**Table 1**). The only crop that had a small increase was vegetables, which went from 968 acres in the 2013 simulation to 1,153 acres in the 2040 simulation. Irrigation for vegetable crops typically comes from surface water and the FAS.

Table 1. St. Lucie County simulated irrigated acres and withdrawals.

| Crop Type | 2013 Simulated FAS Irrigated Acres | 2013 Simulated Average FAS Withdrawals (MGD) | 2040 Simulated FAS Irrigated Acres | 2040 Simulated Average FAS Withdrawals (MGD) |
|---|---|---|---|---|
| Citrus | 12,685 | 30.77 | 12,598 | 30.59 |
| Pasture | 5,022 | 12.22 | 5,022 | 12.22 |
| Nursery | 28 | 0.10 | 28 | 0.10 |
| Vegetables | 968 | 2.13 | 1,153 | 2.53 |
| Golf Courses | 152 | 0.53 | 152 | 0.53 |
| Landscaping | 215 | 0.76 | 215 | 0.76 |
| **Total** | **19,070** | **46.51** | **19,168** | **46.73** |

Four PWS primary utilities deliver water to St. Lucie County: Fort Pierce Utilities Authority (FPUA), Port St. Lucie Utility, St. Lucie County Utility, and St. Lucie West Utility. A fifth utility operation serves a single development, the Ocean Towers community. **Table 2** provides the 2013 and 2040 breakdown for the St. Lucie County PWS demands for each utility from the FAS.

Table 2. St. Lucie County PWS demands from the FAS.

| Utility | 2013 Base Simulated Average FAS Withdrawals (MGD) | 2040 Base Simulated Average FAS Withdrawals (MGD) |
|---|---|---|
| Fort Pierce Utilities Authority | 3.22 | 3.92 |
| Port St. Lucie | 14.24 | 25.38 |
| St. Lucie County | 0.00 | 6.21 |
| St. Lucie West | 2.03 | 2.78 |
| Ocean Towers | 0.05 | 0.05 |
| **Total** | **19.54** | **38.34** |

The FPUA uses a combination of SAS and FAS water to meet their demands. Historically, approximately 40 percent of the total demand came from the FAS with the remaining 60 percent withdrawn from the SAS. For the 2040 simulation, 3.92 million gallons per day (MGD) were projected to be required from the FAS, signifying no noticeable shift between sources. The FPUA's 22 existing wells are completed in the UFA with demands distributed equally for the 2013 and 2040 simulations. Some of the wells began to be rotated by FPUA several years ago to avoid water quality degradation in the aquifer because of upconing.

Port St. Lucie Utility has two existing wellfields, the JEA wellfield located in central St. Lucie County and the Prineville wellfield in southern St. Lucie County, and one proposed wellfield. The proposed Southwest wellfield will be located just west of I-95 and north of the C-23 Canal. It was not operational for the 2013 simulation but was simulated as operational for the 2040 future simulation. For 2013, the simulated demand for Port St. Lucie Utility was 14.24 MGD from the FAS. Port St. Lucie Utility was projected to provide approximately 25.39 MGD of FAS water to almost 291,000 people by 2040. Production wells 1 through 5 are located in Prineville wellfield, wells 6 through 19 are in JEA wellfield, and wells 20 to 36 are proposed for the Southwest wellfield. In the last few years, Port St. Lucie Utility has plugged the lower portion of some of its wells in the APPZ because of water quality issues; therefore, most of the existing wells are pumping water from the UFA. For the proposed Southwest wellfield in the 2040 simulation, the water demands were distributed equally between UFA and APPZ.

St. Lucie County Utility has proposed four wellfields, of which two are considered in this version of the UEC water supply planning process. Neither wellfield was operational in the 2013 simulation. For the 2040 simulation, one wellfield was located at the St. Lucie County Fairgrounds and the other at the Treasure Coast International Airport and Business Park (formerly known as the St. Lucie County International Airport); the well locations were estimated because the exact locations have not been determined by the utility. This resulted in five wells within a single model cell at each site. By 2040, St. Lucie County Utility is projecting to service approximately 46,000 people with a projected FAS demand of 6.21 MGD. A total of 10 UFA wells were proposed by the utility. The five wells located at the Airport would pump approximately 4.2 MGD, and the five wells at the Fairgrounds would provide another 2.0 MGD from the FAS to meet service area demands.

St. Lucie West Utility provided water to 17,000 people in the 2013 simulation, with 100 percent of the water being withdrawn from the FAS. It was projected that the population would increase by approximately 1,000 people by 2040 with a projected demand of 2.79 MGD from the FAS. The three production wells are located in the APPZ, but the depth interval of the wells could be somewhere between the Middle Confining Unit 1 (MC1) and the APPZ.

Ocean Towers Utility is a small condominium utility located on Hutchinson Island. This utility only supplies water to the condominium community with two wells pumping water from the UFA and with water demands of 0.05 MGD established for both the 2013 and 2040 simulations.

#### 4.1.1.2 Martin County Simulated FAS Demands

Irrigation from the FAS generally is limited in Martin County because of the poorer water quality experienced compared to St. Lucie and Okeechobee counties. The two primary irrigation users are citrus and golf course/landscaping. Because of the proximity of the C-44 Canal to the agricultural areas, most use occurs from surface water directly or indirectly from the canal. Use of the FAS for golf course/landscaping irrigation generally is restricted to the barrier islands or along Indian River Lagoon in

areas where the SAS may not be productive or has historically experienced saltwater intrusion**. Table 3** provides a breakdown for the 2013 and 2040 FAS irrigation demands.

Table 3. Martin County estimated agricultural acres and simulated FAS withdrawals.

| Crop Type | 2013 Simulated FAS Irrigated Acres | 2013 Simulated Average FAS Withdrawals (MGD) | 2040 Simulated FAS Irrigated Acres | 2040 Simulated Average FAS Withdrawals (MGD) |
|---|---|---|---|---|
| Citrus | 798 | 2.79 | 805 | 2.82 |
| Pasture | 176 | 0.34 | 176 | 0.34 |
| Vegetables | 198 | 0.45 | 323 | 0.73 |
| Sod Farms | 62 | 0.22 | 63 | 0.22 |
| Golf Courses | 523 | 2.28 | 523 | 2.28 |
| Landscaping | 237 | 1.01 | 237 | 1.01 |
| **Total** | **1,994** | **7.09** | **2,127** | **7.40** |

**Table 4** shows the Martin County PWS demands for the 2013 and 2040 simulations. The utilities that use the FAS are Martin County Utilities, South Martin Regional Utility (SMRU), Indian River Plantation Utility, and Sailfish Point Utility.

Table 4. Martin County PWS FAS demands.

| Utility | 2013 Base Simulated Average FAS Withdrawals (MGD) | 2040 Base Simulated Average FAS Withdrawals (MGD) |
|---|---|---|
| Martin County Utilities | 9.14 | 11.55 |
| South Martin Regional Utility | 1.01 | 2.50 |
| Sailfish Point Utility | 0.20 | 0.23 |
| Indian River Plantation Utility | 0.20 | 0.20 |
| **Total** | **10.55** | **14.48** |

Martin County Utilities currently has two wellfields, Tropical Farms and Jensen Beach, which will provide water to almost 105,000 people by 2040. The total water demand for 2013 was 10.9 MGD and it was projected that the demand would increase to 13.58 MGD in 2040. Approximately 86 percent of the water at Tropical Farms wellfield and 80 percent at Jensen Beach wellfield are pumped from the FAS. Tropical Farms wellfield has eight wells completed in the APPZ, and Jensen Beach has five wells with several tapping both the UFA and APPZ.

SMRU has two existing FAS wells withdrawing water from APPZ and one proposed APPZ well. The two existing wells are located within the APPZ but may be partially open to the MC1. SMRU also has an SAS wellfield that supplies the majority of the water to the service area. In 2013, the historical water demand from the FAS was approximately 1.01 MGD; the estimated water demand for the 2040 simulation was projected to be 2.50 MGD.

Indian River Plantation Utility is a small operation that treats water for almost 4,500 people and a 70-acre golf course within the service area. Two FAS wells provide 100 percent of the water being pumped from the UFA. This utility requires 0.2 MGD of water for both simulations considering it is near build-out.

Sailfish Point Utility has two existing wells that pump exclusively from the FAS. The 2013 and 2040 water demands for the simulations are held constant at 0.23 MGD.

#### 4.1.1.3 NE Okeechobee County (UEC Planning Area) FAS Demands

Demand estimates for Okeechobee County are separated into three different water supply planning regions. Extreme northeastern Okeechobee County is covered by the SJRWMD water supply plan, the majority of Okeechobee County is covered in the Lower Kissimmee Basin water supply plan, and NE Okeechobee County is included in the UEC water supply plan. For the model simulations conducted under this study, the demands for western Okeechobee remain at the historical withdrawals, the SJRWMD portion of Okeechobee County uses the demands from that plan, and the simulated demands for the UEC portion of the county are discussed here. The principal crops receiving irrigation water from the FAS are citrus and vegetables. Pasture is a dominant crop within Okeechobee County but demands for those areas are determined by the number of cattle and not the area irrigated. Overall, the vegetable areas were projected to remain constant while citrus was projected to increase by approximately 20 percent, as shown in **Table 5**.

Table 5. NE Okeechobee County FAS irrigation demands.

| Crop Type | 2013 Simulated FAS Irrigated Acres | 2013 Simulated Average FAS Withdrawals (MGD) | 2040 Simulated FAS Irrigated Acres | 2040 Simulated Average FAS Withdrawals (MGD) |
|---|---|---|---|---|
| Citrus | 3,183 | 6.91 | 3,800 | 8.25 |
| Vegetables | 1,030 | 1.66 | 1,030 | 1.66 |
| **Total** | **4,213** | **8.57** | **4,830** | **9.91** |

The only public water supplier in NE Okeechobee County is the Okeechobee Correctional Institution. The Okeechobee Correctional Institution has two wells that pump water from the UFA. The simulated demands were projected to remain constant through the planning period (**Table 6**).

Table 6. Okeechobee County PWS demands.

| Utility | 2013 Base Simulated Average FAS Withdrawals (MGD) | 2040 Base Simulated Average FAS Withdrawals (MGD) |
|---|---|---|
| Okeechobee Correctional Institution | 0.17 | 0.17 |

### *4.1.2 Adjacent Areas*

#### 4.1.2.1 Indian River County Simulated FAS Demands

The ECFM simulated the FAS in Indian River County using existing and future projected irrigated acreage and demand estimations. Analysis of historical data and model simulations for Indian River County suggested a low to moderate threat of saltwater intrusion. Although the county is located in the SJRWMD, it abuts St. Lucie County and has substantial demands located along the SFWMD border. Additionally, Florida Power & Light (FPL) is proposing a facility located near the border of Indian River and Okeechobee counties just beyond SFWMD boundaries that may require large volumes of FAS water. As a result, an understanding of conditions in Indian River County is required to provide an evaluation of potential

changes in water levels and water quality for existing and future conditions along the northern edge of the UEC Planning Area.

**Tables 7** and **8** provide a breakdown by use type for the projected 2013 and 2040 conditions in Indian River County and are based on the SJRWMD (2013) Draft District Water Supply Plan (SJRWMD Plan) planning acreages and PWS projections. For these model simulations, irrigation demand estimates were based on the standard AFSIRS irrigation estimation model (Smajstrla 1990), which differs from the SJRWMD AFSIRS model used to estimate demands for their water supply plan. The standard AFSIRS model was utilized to ensure consistency across the model domain and has been used for numerous simulations to support water supply planning and other large-scale projects in the SFWMD. Large agricultural areas exist along the border between St. Lucie and Indian River counties, and it is unrealistic to assume that irrigation demands change appreciably across a county line, especially if it is the same property owner. Consequently, irrigated acreages were used from the SJRWMD Plan and demands calculated by the SFWMD using the standard version of the AFSIRS model.

Table 7. Irrigation acres and demands from the FAS in Indian River County.

| Crop Type | 2013 Simulated FAS Irrigated Acres | 2013 Simulated Average FAS withdrawals (MGD) | 2040 Simulated FAS Irrigated Acres | 2040 Simulated Average FAS Withdrawals (MGD) |
|---|---|---|---|---|
| Golf Course | 3,109 | 12 | 3,109 | 12 |
| Landscaping | 1,184 | 4 | 1,184 | 4 |
| Citrus | 22,382 | 57 | 19,843 | 49 |
| Greenhouse/Nursery | 338 | 1 | 262 | 1 |
| Pasture | 5,620 | 14 | 4,983 | 12 |
| Sod | 861 | 3 | 763 | 2 |
| Vegetables | 127 | 0 | 113 | 0 |
| **Total** | **33,621** | **90** | **30,258** | **80** |

Table 8. Indian River County PWS FAS demands.

| Utility | 2013 Base Simulated Average FAS Withdrawals (MGD) | 2040 Base Simulated Average FAS Withdrawals (MGD) |
|---|---|---|
| Indian River County Utilities | 7.76 | 18 |
| City of Vero Beach | 1.96 | 1.79 |
| **Total** | **9.72** | **19.79** |

Agricultural irrigation is by far the dominant use of the FAS in Indian River County. Demand acres used in the model were consistent with the SJRWMD Plan; the total irrigated agricultural acreage from all sources was projected to decrease from approximately 89,702 acres in 2015 to 79,523 acres in 2035. Agriculture in the county uses a combination of surface water and groundwater, with groundwater making up approximately one-third of total demand. Therefore, the model simulated approximately 29,300 acres of agriculture using the FAS in 2013 and reduced the number to approximately 26,000 acres by 2040. Agricultural groundwater withdrawals utilized the acres given above but were calculated using the standard version of the AFSIRS model and not the SJRWMD Plan version. The result was noticeable in that the total agricultural FAS demand for the 2013 simulation was approximately 74 MGD using the SFWMD version and 51 MGD using the SJRWMD Plan version. The Central Florida Water Initiative (CFWI 2013) also

simulated central and western Indian River County, which includes the majority of the agricultural lands in the county. Simulated demands from that plan suggested that the 2015 simulated FAS demand is approximately 86 MGD and will be reduced to 55 MGD by 2035. The period simulated for the CFWI Plan includes climatic conditions from 1995 through 2006, or a subset of the 24 years simulated for the UEC planning process. Demands simulated in the UEC Plan Update for groundwater withdrawals from the FAS in Indian River County generally fell between the SJRWMD Plan projections and the CFWI groundwater demand estimates for Indian River County and were more consistent with the transient demands utilized in the CFWI Plan.

Four primary use types exist in the urban areas of Indian River County: PWS, industrial, golf course, and landscaping. Indian River County Utilities and the City of Vero Beach are the primary providers of FAS water in the county. Future demand projections for PWS users were obtained from the SJRWMD Plan and represented treated volumes. For this analysis, no attempt was made to convert these demands to raw water withdrawals; therefore, the simulated values assume no treatment losses (SJRWMD 2013). FAS PWS demands in Indian River County were projected to increase from 9.72 MGD in 2013 to 19.79 MGD in 2040. The City of Vero Beach uses a combination of SAS and FAS withdrawals to meet the needs of the service area. They presently utilize an RO plant with a rated capacity of 3.3 MGD supplied from the FAS, which was not projected to increase in capacity for these simulations. Therefore, the simulated 2013 demand was based on historic records of 1.96 MGD in 2013 and projected to remain fairly constant with a simulated demand of 1.79 MGD for the 2040 simulation.

Indian River County Utilities is the largest PWS user of the FAS in Indian River County and has two wellfields to meet demands. One is located near the St. Lucie County border in Oslo (south of Vero Beach), and the other (called Hobart) is located in north Vero Beach. The Oslo wellfield is the larger of the two and was simulated at 5.12 MGD for the 2013 simulation and increased to 11.9 MGD for the 2040 simulation. All Oslo withdrawals were assumed to come from a single model cell. The existing wells in the 2013 simulation were tightly clustered and fell within a single model cell. No additional wells were reflected in the county's consumptive use permit, which led to the assumption that future withdrawals would come from the existing wellfield. This assumption may intensify water level drawdowns and water quality degradation. The Hobart wellfield increased from 2.64 MGD in 2013 to 6.1 MGD in 2040. Industrial demands are small in the county (less than 0.5 MGD). The City of Fellsmere was not included because their existing and future demands were projected to remain from the SAS.

Golf courses and landscaping are the other two major users of the FAS in the urban areas of Indian River County. Existing and future acreages for landscaping were not identified in the SJRWMD Plan but data were obtained from SJRWMD permits and adjusted to 1,100 acres for 2013 during the model calibration process. This acreage was assumed to remain constant through 2040. Golf course acreage simulated in the model noticeably differed from that identified in the SJRWMD Plan. The SJRWMD Plan lists a total of 1,425 acres of golf courses in Indian River County for 2013. A review of the SJRWMD permit database, cross-checked against aerial and satellite imagery, and a land use coverage analysis suggested this number had grown. The golf course acreage utilized in the 2013 simulation was adjusted to 3,109 acres, which was more consistent with the acreage identified in the analysis of aerial and satellite imagery and land use coverage maps. The simulated golf course acreage for 2040 was held constant at 3,109 acres to provide consistency with the projected 2035 acreage of 2,842 acres identified in the SJRWMD Plan.

### 4.1.2.2 Northern Palm Beach County Simulated FAS Demands

Several large existing and projected uses occur along the southern edge of the UEC Planning Area in northern Palm Beach County. The Town of Jupiter, Village of Tequesta, and Seacoast Utility Authority (SUA) meet or are proposed to meet a portion of the PWS demands by utilizing the FAS. Additionally, two coastal golf courses use the FAS for irrigation. There is no existing or projected FAS use by the agriculture or ICI sectors in this area. **Table 9** shows the golf course acreage that utilizes the FAS in northern Palm Beach County; additional golf courses were not anticipated to use the FAS in the near future. **Table 10** displays the PWS utilities that distribute potable water to northern Palm Beach County (the Town of Jupiter, Village of Tequesta, and SUA) with their corresponding demands.

Table 9. Northern Palm Beach County FAS irrigation demands.

| Crop Type | 2013 Simulated FAS Irrigated Acres | 2013 Simulated Average FAS Withdrawals (MGD) | 2040 Simulated FAS Irrigated Acres | 2040 Simulated Average FAS Withdrawals (MGD) |
|---|---|---|---|---|
| Golf Course/Landscape | 264 | 0.78 | 264 | 0.78 |

Table 10. Northern Palm Beach County PWS FAS demands.

| Utility | 2013 Simulated Average FAS Withdrawals (MGD) | 2040 Simulated Average FAS Withdrawals (MGD) |
|---|---|---|
| Town of Jupiter | 9.80 | 11.37 |
| Village of Tequesta | 1.43 | 2.20 |
| Seacoast Utility Authority | 0.00 | 2.03 |
| **Total** | **11.23** | **15.60** |

The Town of Jupiter pumps water from the SAS and FAS. Thirteen wells are drilled into the FAS; four wells are located in the UFA and nine wells are in the APPZ. For the 2013 simulation, FAS water demand was 9.80 MGD, approximately 53 percent of the total demand from the SAS and FAS wellfields. The 2040 simulation projected FAS demand increasing to 11.37 MGD. In both simulations, all demands from the wells were distributed equally.

The Village of Tequesta meets the service area demands by using SAS and FAS wellfields. In the 2013 simulation, 1.43 MGD of the water was pumped from the FAS, and for the 2040 simulation, the FAS demand increased to 2.20 MGD. Demands for this utility were evenly distributed between the wells for both simulations.

SUA has three existing wells in the FAS. Two other wells were proposed for construction but only one is expected to be constructed near its permitted location because of ownership issues. SUA presently is not using the FAS as a source of water to meet PWS demands and thus was not included in the 2013 simulation. The population for the 2040 simulation was projected to be 115,800 with a total water demand of 22.57 MGD. Of this projected demand, approximately 2.03 MGD will be met by using the FAS.

# 5.0 MODEL SCENARIOS CONDUCTED UNDER THIS REVIEW

To evaluate potential changes within the FAS as a result of projected groundwater withdrawals in the UEC Planning Area, the ECFM (Giddings et al. 2014) was used. The ECFM simulates the three primary production intervals with usable water in the FAS, including the UFA, the APPZ, and the upper portion of the LFA. In the UEC Planning Area, the LFA generally is too saline and no users are presently withdrawing water from this aquifer.

Two scenarios were simulated using the ECFM (**Table 11**): the existing condition in 2013 and the projected demand condition in 2040. **Table 12** summarizes the demand breakdown within the UEC Planning Area by use type for both simulations. Model simulations are conducted for 24 years of varying climatic conditions to understand the aquifer response to variations in irrigation and PWS demands and also to allow the model sufficient time to simulate potential changes in water quality. Simulated demands utilized in these scenarios are discussed in **Section 4** of this report.

Table 11. UEC Planning Area ECFM scenarios.

| Simulation | Description |
|---|---|
| 2013 | ECFM – 2013 demands |
| 2040 | ECFM – 2040 projected demands |

Table 12. UEC Planning Area ECFM scenario demands.

| Utility | 2013 Simulated Average FAS Withdrawals (MGD) | 2040 Simulated Average FAS Withdrawals (MGD) |
|---|---|---|
| Agricultural Irrigation | 57.59 | 59.46 |
| Golf Course and Landscape Irrigation | 4.58 | 4.58 |
| Industrial* | 0.18 | 0.18 |
| Public Water Supply | 30.26 | 52.99 |
| **Total** | **92.61** | **117.21** |

*Industrial withdrawals are primarily in Martin County.

## 5.1 Floridan Aquifer Simulation Results

The results of the simulations are presented in four different categories:

- Changes to water levels (**Figures 3** to **6**);
- Changes in water quality, including horizontal or vertical movement (upconing) of poorer quality water within or between aquifers (**Figures 7** to **12**);
- Changes in horizontal and vertical flow direction and magnitude within a single aquifer layer or between aquifers through the confining units (**Figures 13** to **16**); and
- Changes in groundwater head related to land surface and the ability of a well to produce water under free-flowing conditions (**Figures 17** and **18**).

Individual monitor well results, by county and utility, can be found in **Appendix A**. **Appendix B** provides additional water level and water quality graphics.

### *5.1.1 Discussion of Water Level Variations*

The differences in water levels between the 2013 and 2040 simulations in the UFA and APPZ are illustrated in **Figure 3** through **Figure 6**. Changes in water levels show the last month (month 288) of the 2040 simulation minus the last month for the 2013 simulation. Because it takes time for changes in water quality to occur, the last month was selected for the standard evaluation for each category of performance. As a result, a lowering of the aquifer water level from 2013 to 2040 results in a negative change in head in the figures.

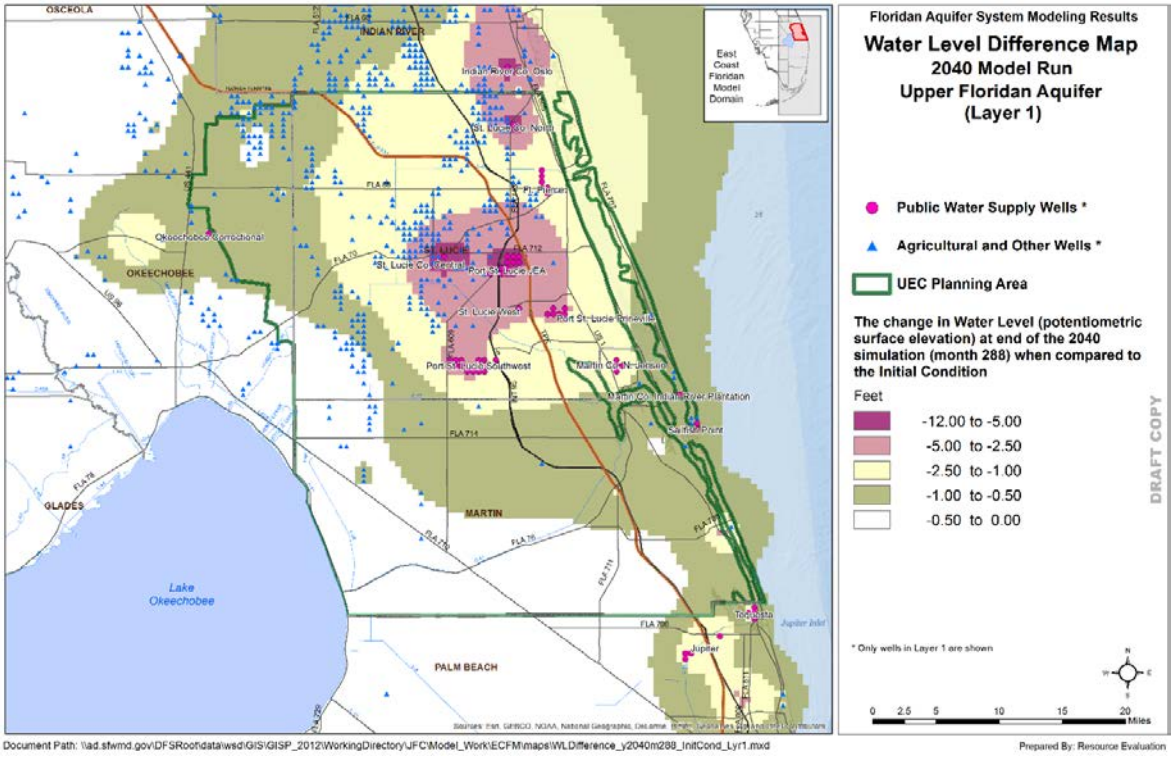



Figure 3. Change in water levels between the initial condition and of the end of the 2040 simulation (month 288) in the UFA (Layer 1).

The largest head differences between the simulations in the UFA were observed in St. Lucie County in the area of the proposed Port St. Lucie Southwest wellfield and in the two St. Lucie County Utilities proposed wellfields (North and Central) shown in **Figure 3**. The substantial head differences at the St. Lucie County Utilities Central wellfield, located at the St. Lucie County Fairgrounds, resulted from the tight clustering of the wells, with all withdrawals occurring from a single model cell, and from the interaction of the wellfield with the Port St. Lucie UFA wells of the JEA wellfield located immediately to the east. A second noticeable cone of influence occurred along the SJRWMD and SFWMD boundary. Head differences on the order of -5.72 to -16.68 feet in the UFA were caused by the proximity and the aquifer interaction of Indian River County Utilities Oslo wellfield and the proposed St. Lucie County Utilities North wellfield. Oslo and the St. Lucie North wellfields each have their withdrawals located in a single model cell. A discussion of the resulting influences of the single-cell assumptions is found in **Section 4.1**.

**Figure 3** also shows a third, smaller area with water level reductions less than 2.5 feet occurred in northeastern Palm Beach County and appeared to be associated with the interaction between the proposed SUA wellfield and the Town of Jupiter's wellfield to the north. A smaller reduction in water levels

was observed along the coast in central Martin County, resulting from the SMRU APPZ wells pulling water down from the UFA into the APPZ. The slight increase in water levels noted in NE Okeechobee County was related to the demand distribution between the 2013 and 2040 simulations, resulting in improved water quality and water levels in the UFA in the area, which is explained in the water quality discussion. An understanding of the other changes occurring in this area is required to fully explain the observed increased water levels and will continue to be discussed in the following sections.

**Figures 4** through **6** present changes in head and total dissolved solids (TDS) for individual wells for the two simulations. **Figure 4** shows the proposed St. Lucie County Utilities North wellfield head changes in the UFA. The heads in the North wellfield were projected to decrease an average of almost 10 feet. Greater spacing between the proposed wells may reduce the observed drawdowns. Similar head variations are seen in **Figure 5**, which charts a well located close to the Oslo wellfield in Indian River County. However, the head differences are not as drastic as those at the proposed St. Lucie County Utilities North wellfield. Although the projected increases between the 2013 and 2040 simulations at these two wellfields were similar, the difference in the reduction of water levels can be attributed to the distance between the monitor well and the Oslo wellfield, and to the aquifer parameters that were similar but not necessarily the same. This suggests that the greater the number and spacing between the production wells, the lower the maximum drawdown.

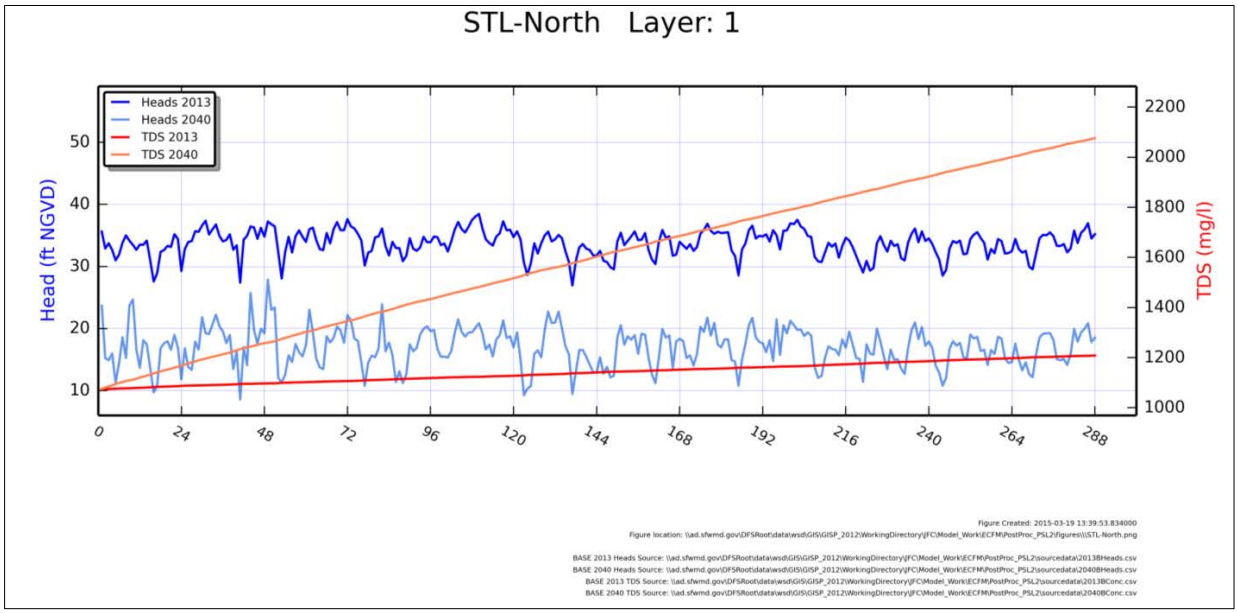



Figure 4. Results of 2013 and 2040 simulation head and TDS differences in the UFA at the proposed St. Lucie County Utilities North wellfield.

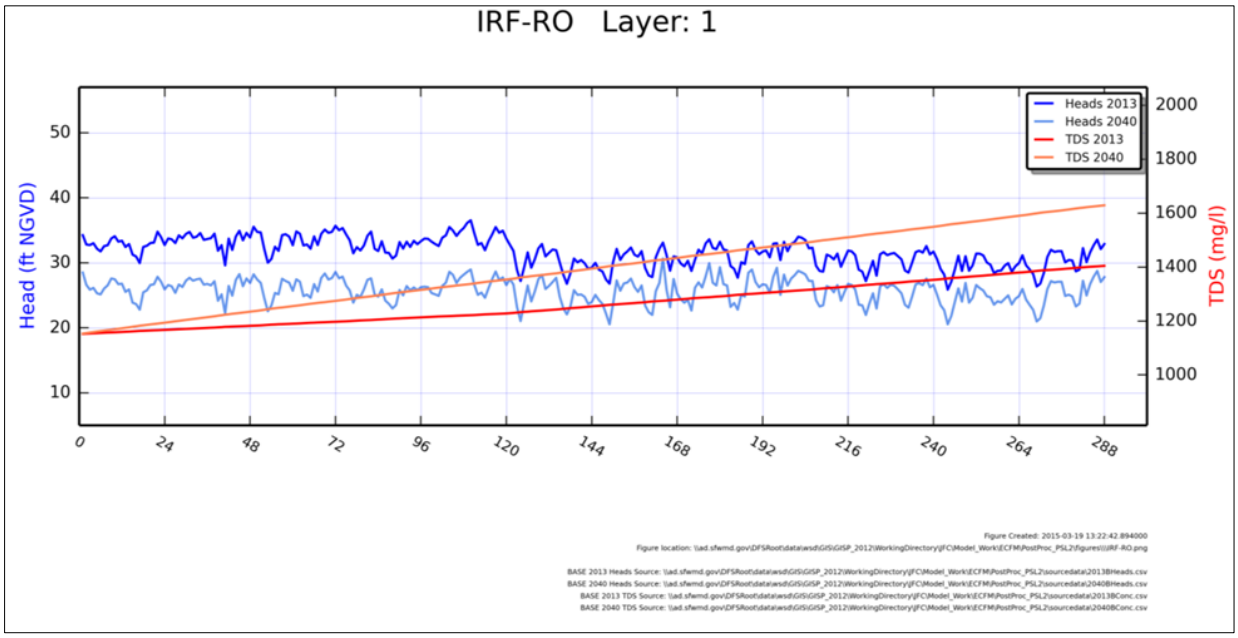



Figure 5. Results of 2013 and 2040 simulation head and TDS differences in the APPZ at the Indian River County Utilities Oslo wellfield.

The larger withdrawals in the UFA at the wellfields discussed earlier caused reductions in water levels in the APPZ (**Figure 6**). A similar distribution of head reduction is experienced in northern St. Lucie and southern Indian River counties, resulting from increased UFA withdrawals at the Indian River County Utilities Oslo wellfield and St. Lucie County Utilities proposed North and Central wellfields. Water at these wellfield sites moved up from the APPZ into the UFA to meet a portion of the demands, which resulted in the observed head reductions. A similar situation occurred at the Village of Tequesta, which pumps water out of the UFA and creates upconing from underlying APPZ, decreasing groundwater levels in the area. Utilities that directly withdraw water from the APPZ cause reductions in water levels. Drawdowns of 5 feet or more were projected to occur in the APPZ at the SMRU wellfield in Hobe Sound, Martin County's Tropical Farms and Jenson Beach wellfields, and in northern Palm Beach County at the Town of Jupiter and SUA wellfields. A small area of drawdown is also occurring in NE Okeechobee County in the same area that was experiencing increased water levels in the UFA.

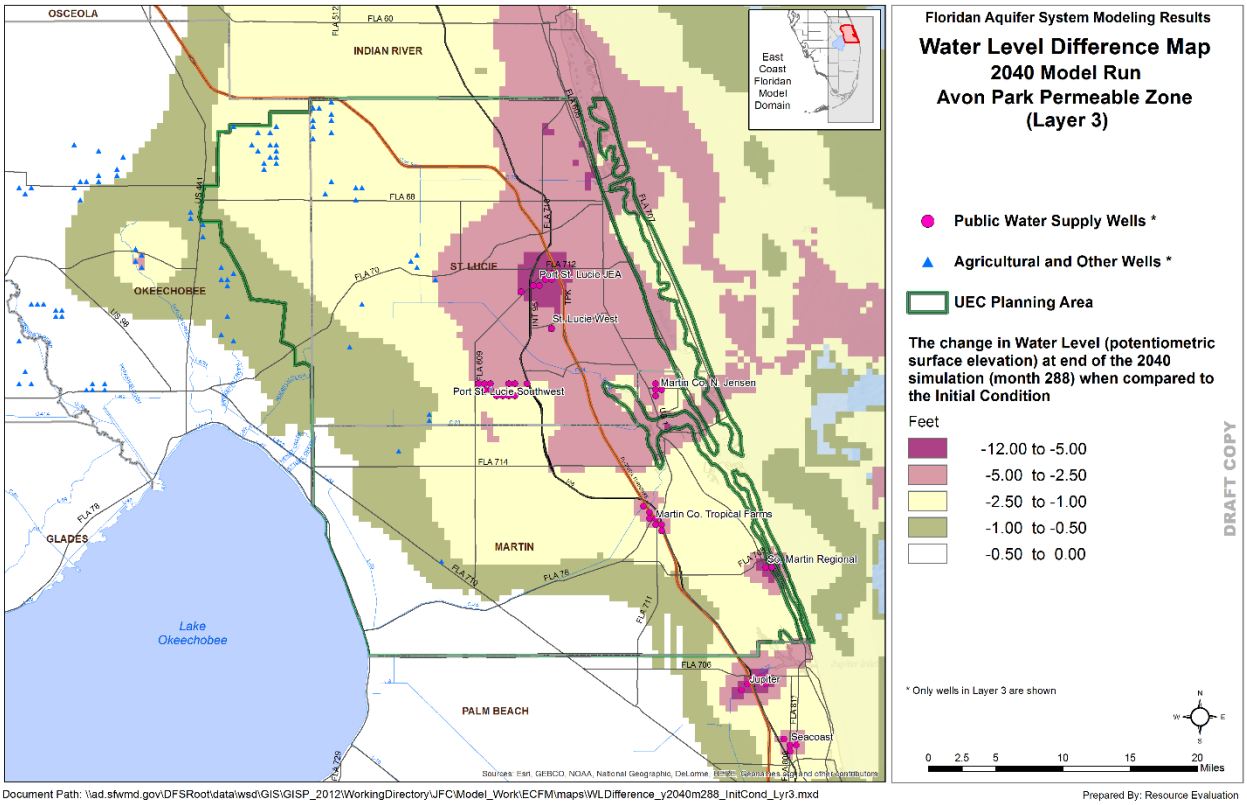



Figure 6. Water level change between the initial condition and the end of the 2040 simulation (month 288) in the APPZ (Layer 3).

### *5.1.2 Discussion of Water Quality Variations*

In general, TDS concentrations were projected to remain steady or slightly increased in the UFA with the 2040 demands for most of the UEC Planning Area. **Figure 7** shows the water quality in the UFA at the end of the 2040 simulation. Changes in water quality show the last simulation month (month 288) of the 2040 simulation minus the initial condition. As a result, increasing withdrawals and lowering of the aquifer water levels from the initial condition to 2040 may result in an increase in TDS concentrations, which indicates degrading water quality. Water quality changes of less than 100 milligrams per liter (mg/L) at the end of simulation period were experienced in the majority of the counties, suggesting no major issues with changes in water quality for the UEC Planning Area (**Figure 8**), resulting from increased demands. However, the northeast corner of St. Lucie County experienced TDS changes of 500 to 1,000 mg/L, which may be problematic for some agricultural operations. The Indian River County Utilities Oslo wellfield is one of the areas where water quality was projected to degrade in the UFA and could influence conditions within the SFWMD. The region appears to be a potential problem area where SFWMD and SJRWMD demands may interact with each other.

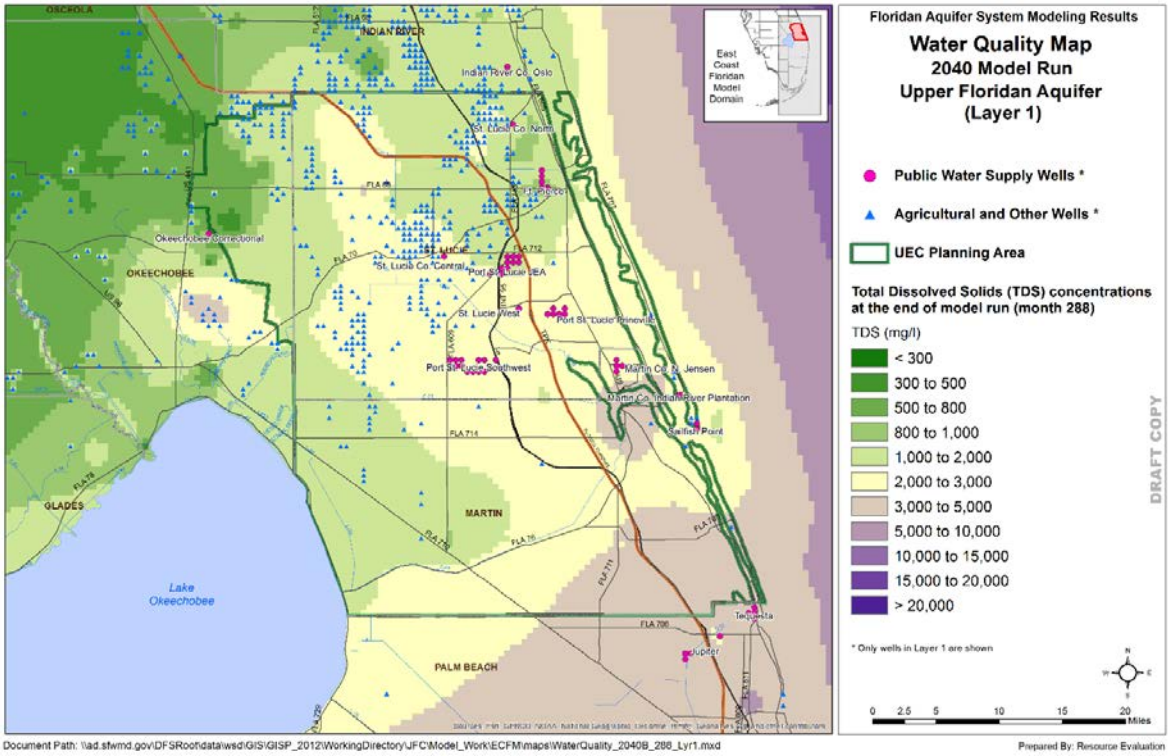



Figure 7. Change in water quality between the initial condition and the end of the 2040 simulation (month 288) in the UFA (Layer 1).

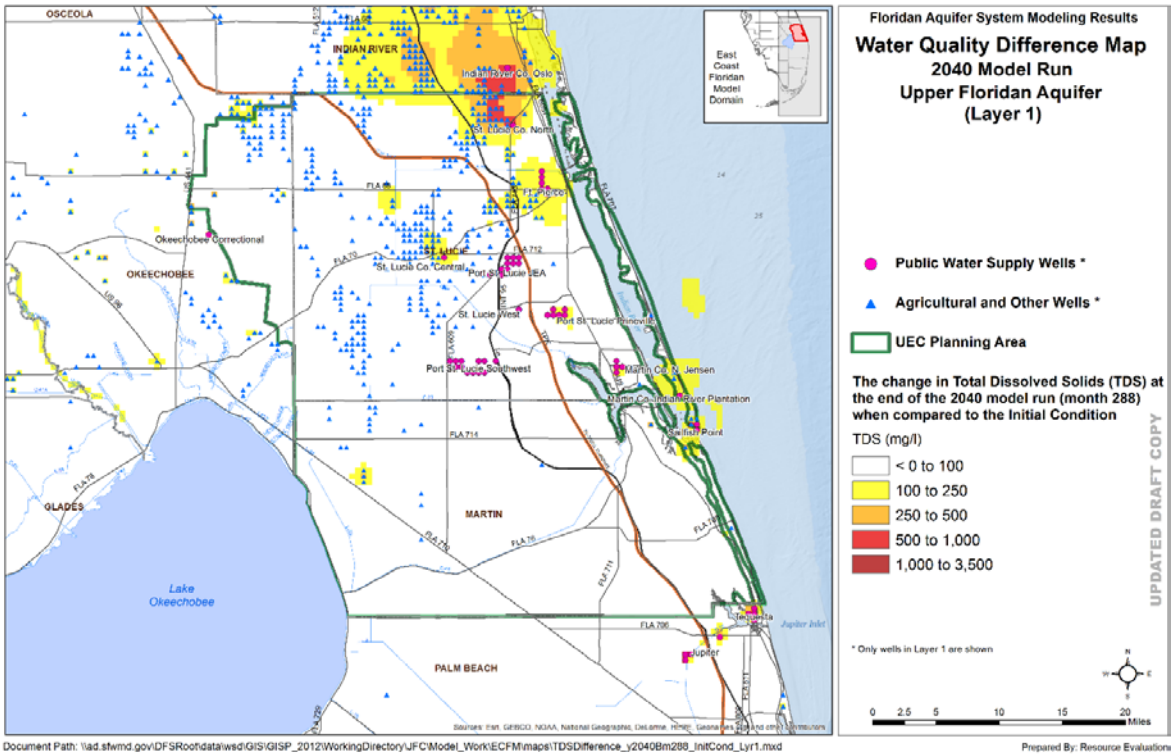



Figure 8. Changes in water quality in the UFA (Layer 1) during the 2040 simulation compared to the initial condition.

**Figure 9** shows the simulated TDS concentration increase at Well IRF-RO located at the U.S. Department of Agriculture (USDA) offices. The TDS concentration was projected to increase from 950 mg/L to approximately 1,300 mg/L if existing conditions continue for the next 25 years, or increase to 1,500 mg/L resulting from the projected increase in demands at the Oslo wellfield. Water quality degradation of this magnitude is not significant to a PWS utility but could be a concern if the water is a sole source for irrigating nursery stock and salt intolerant plants.

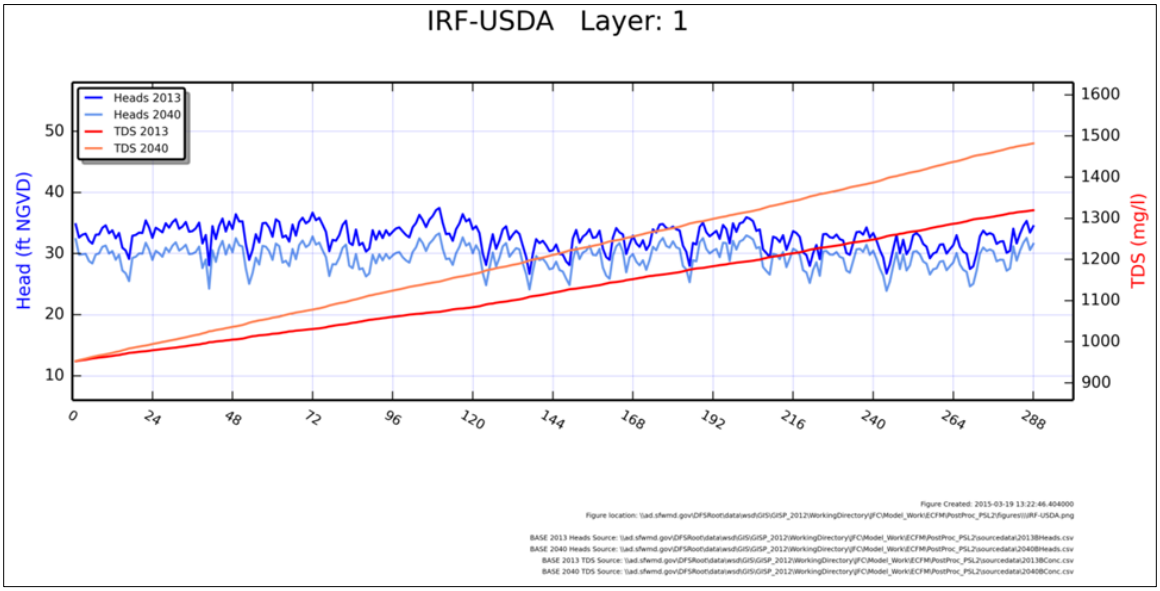



Figure 9. Results of the 2013 and 2040 simulated changes in water quality in Indian River County at Well IRF-USDA.

An area of improving water quality was noted in NE Okeechobee County, which is where the UFA water levels were projected to increase and the APPZ water levels were projected to decrease, as discussed in **Section 5.1.1**. As noted in **Table 5**, citrus acreage in NE Okeechobee County was projected to increase by approximately 600 acres. The additional citrus acreage was simulated in the same area where the changes in water levels and water quality were occurring. Wells located in this area utilize both the UFA and APPZ because of the reasonable water quality experienced in both zones. The APPZ is preferred for larger irrigated areas because of the greater volume of water a well can produce. Because this area is projected to increase in citrus acreage, the ECFM assumptions utilized in distributing demands results in a net increase in withdrawals from the APPZ and a net decrease in withdrawals from the UFA. As a result of this assumption, water levels in the APPZ were reduced; however, because of the good connection between the APPZ and UFA at the site, water from the UFA moved down into the APPZ, helping restrict water quality degradation in the APPZ. Additionally, a recharge area that receives water from rainfall exists immediately west of the site. This high-quality water moves east to NE Okeechobee County, replacing the water lost to irrigation when the sole source for the citrus was the UFA and mixing with UFA water, which results in improved water quality and a slight increase in water levels in the UFA in the area.

**Figure 10** shows the resulting water quality in the APPZ at the end of the 2040 simulation, while **Figure 11** shows the increase in TDS concentrations of the 2040 simulation compared to the initial condition. Most of the UEC Planning Area showed TDS increasing by 500 to 2,000 mg/L from the change in withdrawals between the initial condition and 2040. TDS concentrations increased by 2,000 to 3,500 mg/L in areas where PWS utilities are withdrawing directly from the APPZ. In northeast St Lucie County, 2040 withdrawals from the UFA appear to be causing changes of 2,000 mg/L or greater in the APPZ.

SMRU in Hobe Sound is one of the areas making direct withdrawals from the APPZ. SMRU historically has experienced water quality degradation during periods of high groundwater withdrawals, and this was predicted to continue should the utility continue to rely on existing facilities to meet the projected future demand of 2.5 MGD from the APPZ. The broader area of water quality change in the APPZ along the coast occurred in the 2013 simulation, suggesting that issues may arise if current facilities and operational practices continue for 24 years. A review of water quality results for individual APPZ wells indicated that some PWS facilities could see TDS concentrations more than double and reach 8,000 mg/L or higher (**Figure 12**). In some cases, the simulated increase in TDS concentrations could approach the treatability limits of existing water treatment plants.

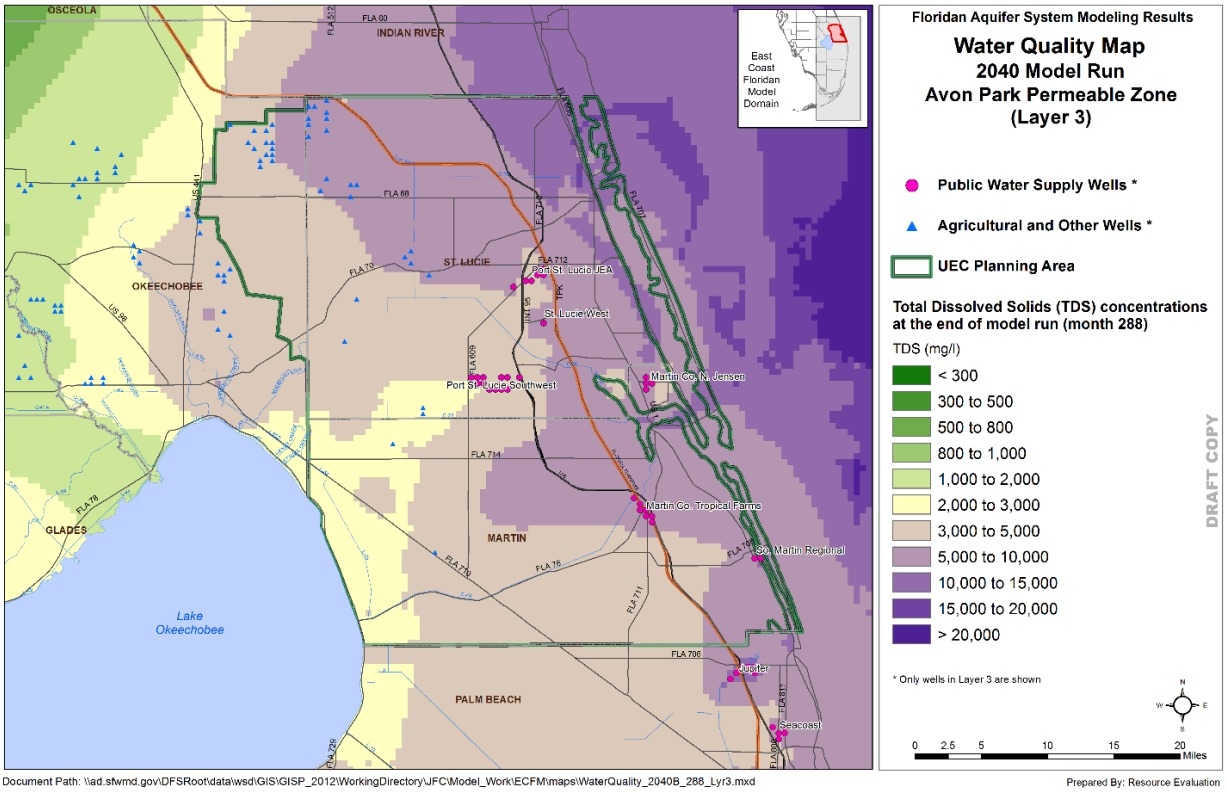



Figure 10. Water quality conditions in the APPZ at the end of the 2040 simulation.

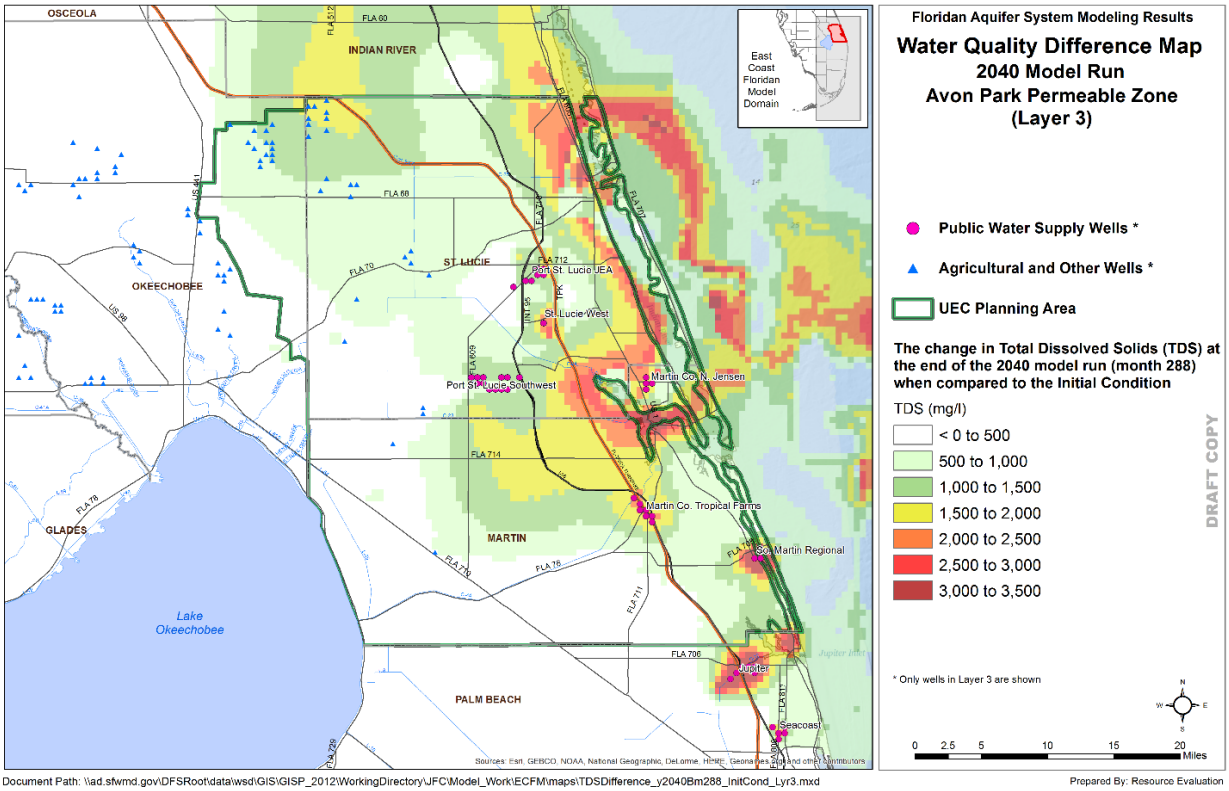



Figure 11. Change in water quality in the APPZ from the initial condition to the end of the 2040 simulation.

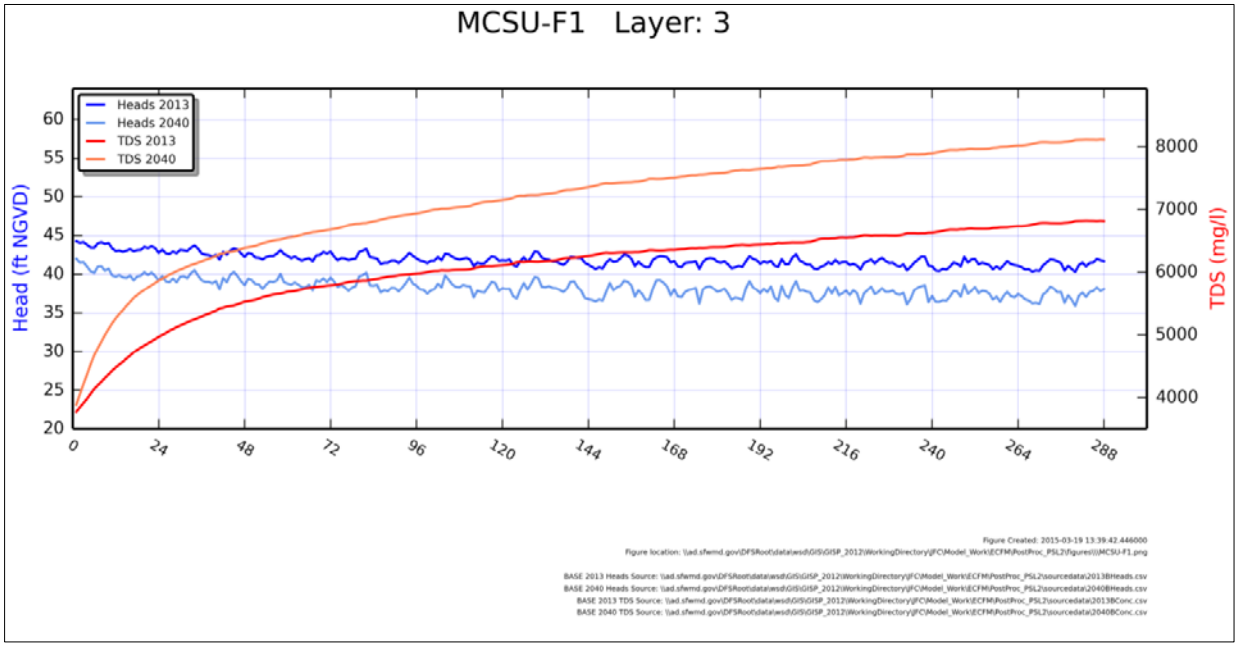



Figure 12. Change in water level and water quality for 2013 and 2040 in the APPZ at the MCSU-F1 monitoring well in Martin County.

### *5.1.3 Flow Vectors*

Horizontal flow and magnitude are presented for the last simulation month for both the 2013 and 2040 simulations. A side-by-side comparison is needed to understand changes in flow and direction resulting from the different applied stresses. The vertical flow figures show the difference between the 2013 and 2040 simulations within the confining units between the principal aquifers.

Two sets of figures show the horizontal flow vectors for the 2013 and 2040 simulations in the UEC Planning Area. Respectively, **Figures 13** and **15** display the horizontal flow vectors in the UFA and APPZ for the 2013 simulation, and **Figures 14** and **16** illustrate the horizontal flow vectors in the UFA and APPZ for the 2040 simulation. Most of the water being pumped was from vicinity areas and not from a recharge source. The primary recharge area for the FAS in south Florida is located in Polk County. A secondary recharge area is found closer to the UEC Planning Area in eastern Osceola and Okeechobee counties.

There was a noticeable trend when comparing the flow vectors for the 2013 (**Figure 13**) and 2040 (**Figure 14**) simulations for the UFA. In areas such as the Oslo and FPUA wellfields, flow vectors were coming onshore from the ocean with a relatively large magnitude, which is an indication of seawater entering the aquifer horizontally and possibly causing water quality degradation. In the Oslo and FPUA wellfields, horizontal flow vectors vary between 70,000 and 200,000 $ft^3$/day in the 2013 simulation, and in the 2040 simulation, the flow vectors reached values of 480,000 $ft^3$/day. High-volume movement of water was visible in two of the Port St. Lucie wellfields (JEA and Prineville), although the direction of flow was from the south/southwest. Pumpage in these areas caused a high gradient of water to move from nearby areas in the UFA in both the 2013 and 2040 simulations. However, St. Lucie County is proposing to construct the Central wellfield near Port St. Lucie's JEA wellfield, which would alter the flow vectors in the 2040 simulation.

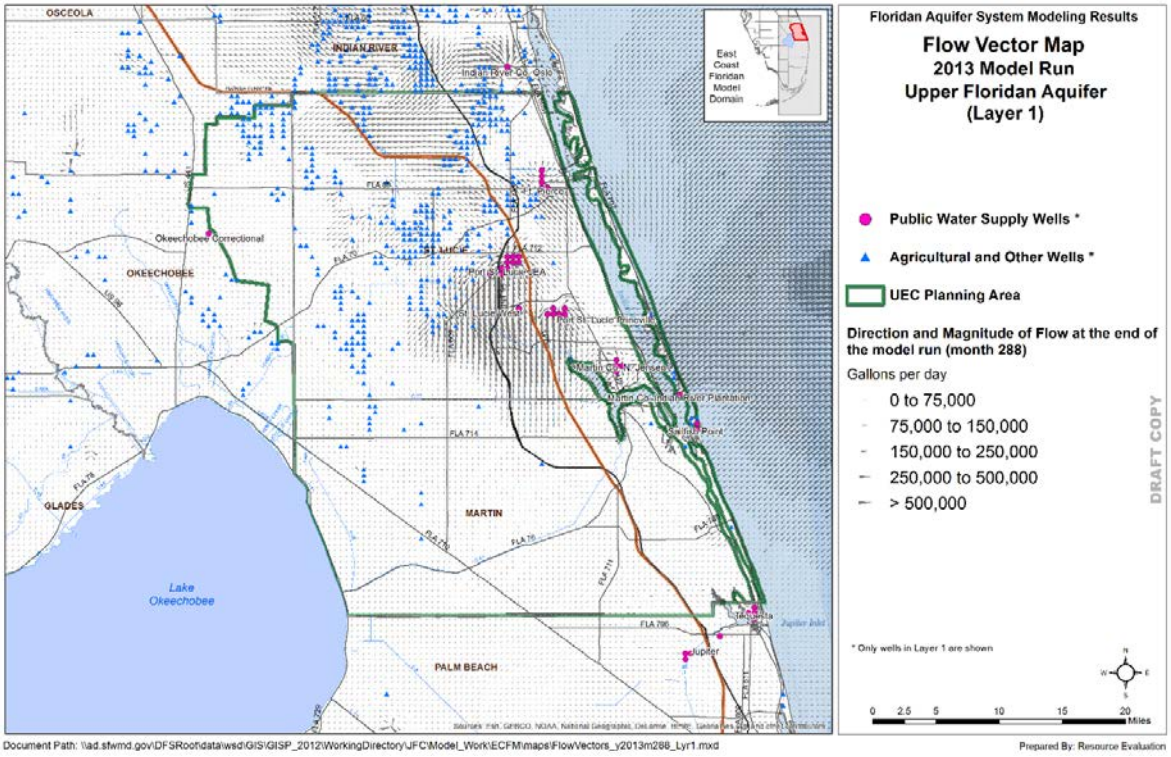
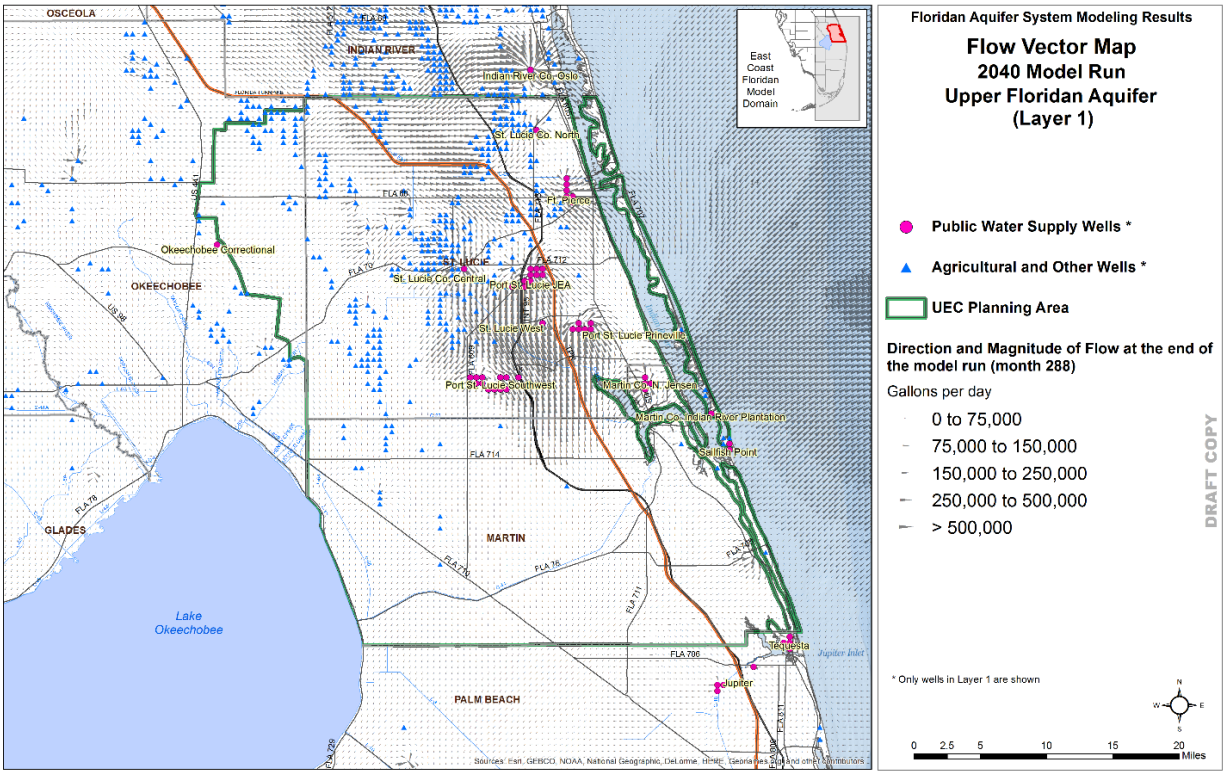



Figure 13. UFA flow vectors in the final month of the 2013 simulation.

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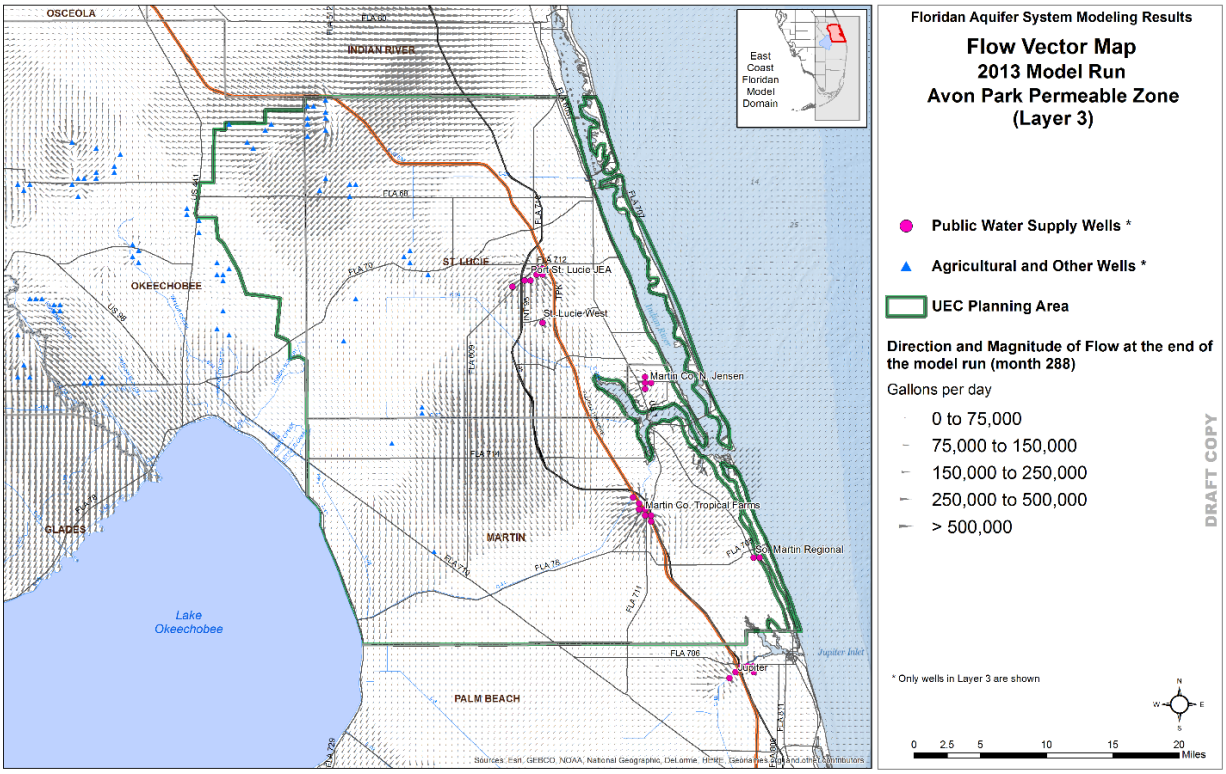
Prepared By: Resource Evaluation

Figure 14. UFA flow vectors in the final month of the 2040 simulation.

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Prepared By: Resource Evaluation

Figure 15. APPZ flow vectors in the final month of the 2013 simulation.

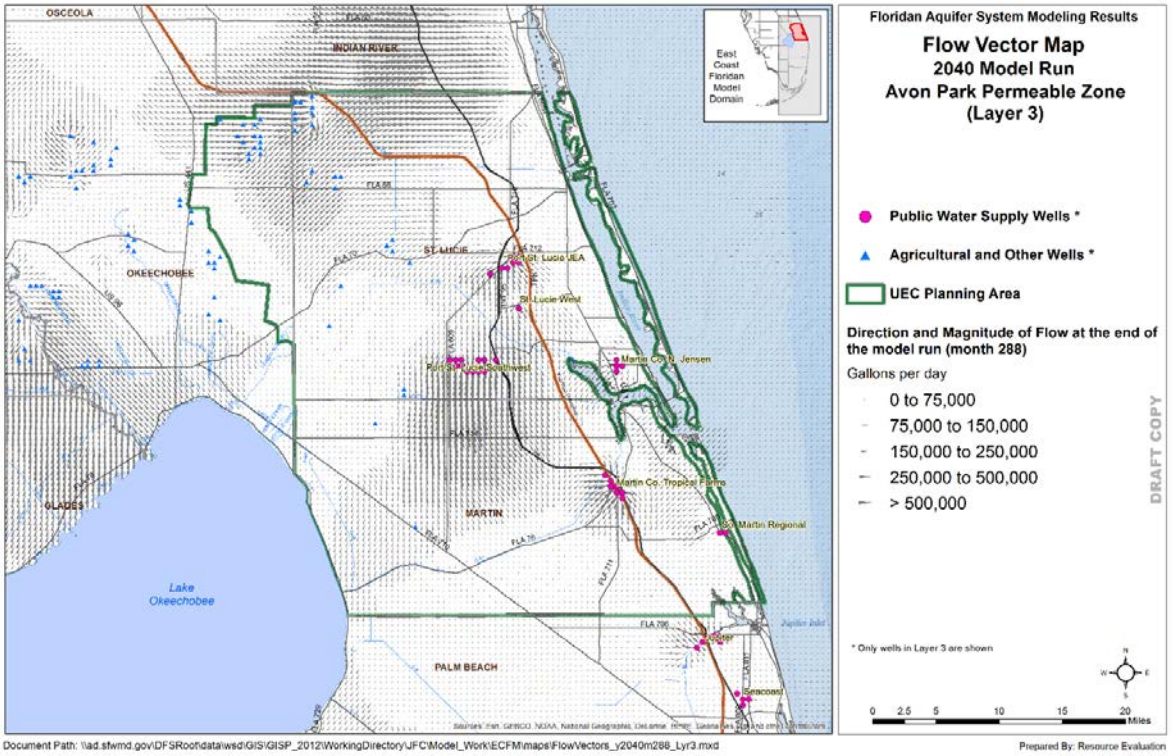


Figure 16. APPZ flow vectors in the final month of the 2040 simulation.

For some of the larger agricultural users of the FAS such as Adams Ranch, Inc., flow vectors can be redirected by groundwater withdrawals. For example, the area south of FLA-68 and west of the C-24 Canal showed vectors indicating flow towards some of the wells withdrawing water from the UFA. This behavior can vary from month to month depending on how much water is needed for irrigation. On average, approximately 20 percent of the supplemental irrigation demand is being withdrawn from the UFA to meet the water demands (16 to 20 MGD) of Adams Ranch for irrigation. The remainder of the demands is met from surface water sources. Similar situations were observed along the NE Okeechobee County boundary of the UEC model domain and along the northeastern area of the St. Lucie County and Indian River County boundary where larger agricultural operations are redirecting flow paths. In the northeastern area of St. Lucie County, a cluster of agricultural and PWS wells are concentrated in the same area as the proposed St. Lucie County Utility North wellfield, causing flow vectors of up to 18,000 $ft^3$/day, indicating flow towards the area.

A small horizontal movement was observed where the Martin County Tropical Farms wellfield is located. The Tropical Farms wellfield only has wells pumping from the APPZ, but water movement towards the wells was noticed in the UFA in both simulations, suggesting a good connection between the UFA and APPZ in this area.

Flow vectors in the APPZ generally were not as dramatic as flow vectors in the UFA for the 2013 and 2040 simulations, corresponding to the greater number of UFA wells than APPZ wells. Treatment of water being pumped from the APPZ is costly because the water quality in the APPZ has high TDS concentrations; therefore, specialized (RO) water treatment is needed to obtain potable water. Some existing and proposed PWS utility wellfields in the UEC Planning Area pump water from the APPZ, but only a few agricultural wells use the APPZ for irrigation because the water quality is not desirable for most crops.

Horizontal movement of local aquifer water in St. Lucie County was observed by pumpage at the Port St. Lucie JEA wellfield and the St. Lucie West wellfields for both of the simulations in the APPZ. Similarly, SMRU and Martin County Utilities (Jensen Beach and Tropical Farms) wellfields as well as the Town of Jupiter and SUA wellfields in North Palm Beach County caused water to flow towards the utility wells that were pumping water from the APPZ. Because most of the SUA's 2013 water demands are being met by SAS wells (not included in these simulations), the difference between it and the 2040 simulation indicated that new FAS wells have come online in the 2040 simulation.

### *5.1.4 Reduction in Heads of Flowing Wells*

The final set of graphics shows changes in the artesian water level above land surface. Current SFWMD water use rules afford protection for artesian wells flowing at land surface in Martin and St. Lucie counties. The rules were designed to protect a legal user that relies on a sufficient water level above land surface to meet crop demand without the need of a pump. Proposed increases in demands may cause additional drawdowns to occur, which may reduce or eliminate flow from these wells. These graphics were designed to provide an evaluation of that potential.

The SFWMD promotes and protects free flow of water above land surface in Martin and St. Lucie counties without pumping to meet crop demands. However, some of the simulated water demand increases predicted additional drawdown to occur between the 2013 and 2040 simulations. The additional pumpage could result in a reduction in head, which may cause artesian wells flowing at land surface to diminish or even cease flowing.

**Figure 17** illustrates the head reduction in the initial condition versus the end of the simulation period for the 2013 simulation for the UFA. For this section, the graphics presented illustrate the additional reduction in water level above land surface compared to the conditions that existed in December 2012. The end of the simulation period (month 288) incorporates the same climatic conditions that existed in December 2012 to allow for a comparison in which only the projected demands, and no other factor, are causing the head reduction. In addition, only changes in the UFA are presented because the permitted uses afford protection under this rule are restricted to Martin and St. Lucie counties and utilize the UFA as their source because of the poor water quality associated with the APPZ. For the 2013 simulation comparison, the only area slightly affected is in the vicinity of the Port St. Lucie JEA wellfield where a few agricultural operations west of the wellfield may see reductions of starting heads. The northwestern corner of **Figure 17** indicates that artesian well water levels are below land surface. This is the southern tip of the ridge where land surface elevations are substantially higher than areas to the east. Surface elevations on the ridge are well above the artesian water level of the UFA, including areas where there are no groundwater withdrawals.

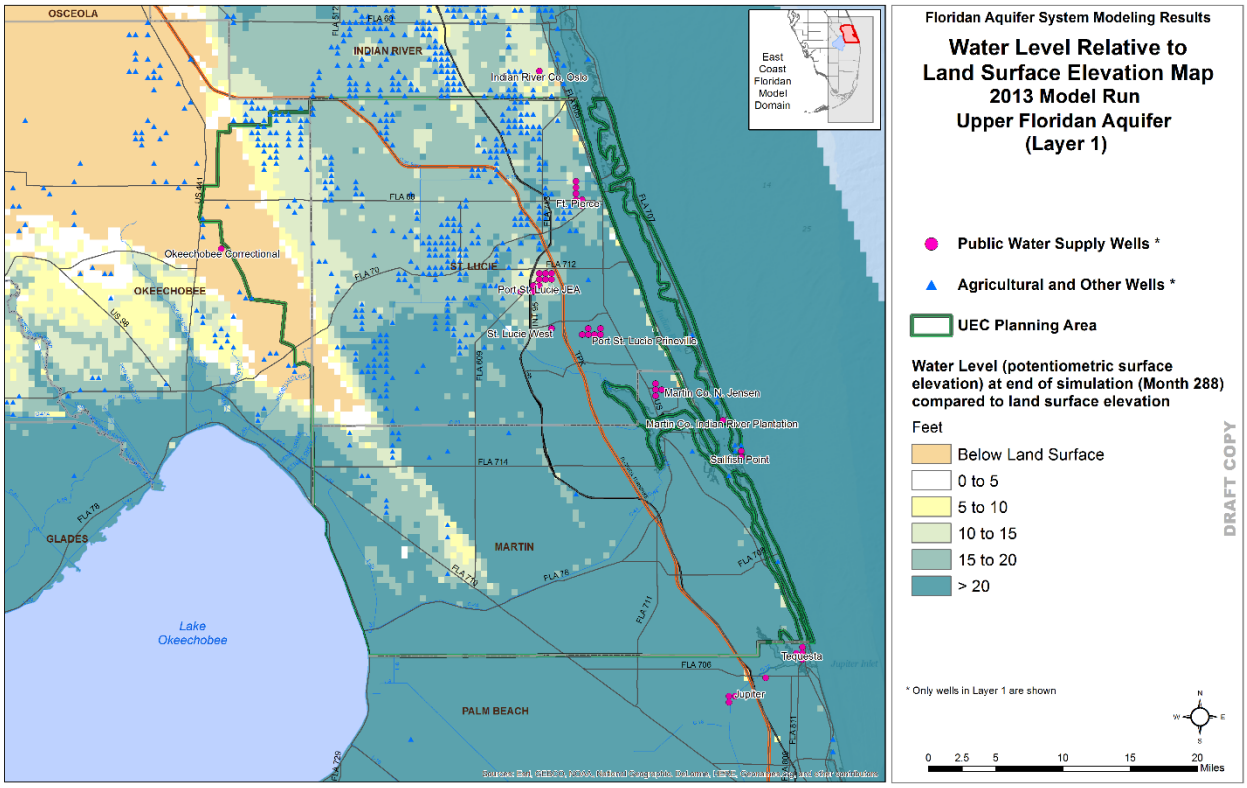


Figure 17. Potentiometric surface of the UFA relative to land surface at the end of the 2013 simulation.

In the 2040 simulation, the head reductions compared to land surface became more widespread (**Figure 18**). Martin County did not experience a noticeable reduction in heads relative to ground surface primarily because the projected 2040 demands did not differ for most of the users in the county except for the PWS demands, which were primarily from the APPZ or SAS. A similar condition existed in western St. Lucie County because the agricultural demands were projected to remain flat from current withdrawals. However, in eastern St. Lucie County, a large head reduction area extends along the edge of the county stretching from just north of the Martin County border into Indian River County. The area of reduction was associated with the increased demands at the Port St. Lucie JEA and Southwest wellfields, both of the proposed St. Lucie County wellfields, and in the vicinity of Indian River County Utility's eastern wellfields. The highest head reductions are visible where the Port St. Lucie JEA wellfield and the St. Lucie County proposed Central wellfield interact with each other.

A second area that experienced head reduction of similar magnitudes occurred along the St. Lucie County and Indian River County border, caused by the interaction of the St. Lucie County proposed North wellfield and the Indian River County Utilities Oslo and Hobart wellfields. Additionally, head reductions were predominant in the surrounding areas of the St. Lucie County North and Central wellfields, Port St. Lucie JEA wellfield, and Indian River County Oslo wellfield. Due to the proximity of some wellfields, a head reduction was perceived as a circular trend around these wellfields. A good illustration of this phenomenon was observed near the St. Lucie County Central and Port St. Lucie wellfields as well as the St. Lucie County North wellfield and Indian River County Oslo wellfield.

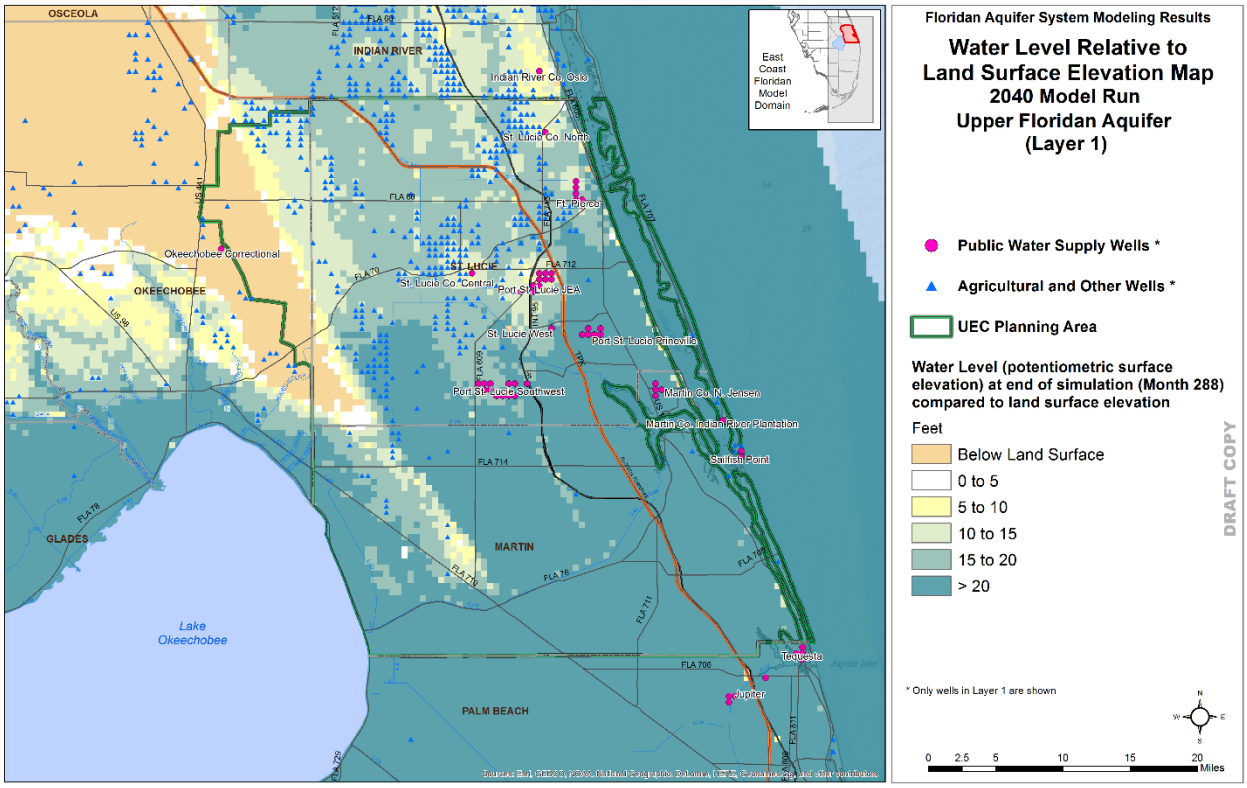


Figure 18. Potentiometric surface of the UFA relative to land surface at the end of the 2040 simulation.

# 6.0 CONCLUSIONS AND RECOMMENDATIONS

The October 2014 ECFM was used to simulate 2013 and projected 2040 demands from the FAS within the UEC Planning Area. Agricultural, urban, and recreational irrigation demands within the region were projected to remain fairly constant from the FAS; however, the PWS demands were projected to noticeably increase. Overall, demands for the UEC Planning Area were projected to increase approximately 26 percent, from 93 to 117 MGD from the FAS.

Groundwater model simulations were conducted to evaluate changes in water levels and water quality as a result of the overall net increase in reliance on the FAS. The primary findings, with recommendations when appropriate, included the following:

1) The St. Lucie County Utilities proposed North and Central wellfields were projected to cause localized issues that may be of concern. In their presently proposed configuration, the wellfields could cause upconing of poor-quality water into the wellfield and surrounding areas as well as reductions in the ability of nearby wells to flow naturally. It is recommended that the utility provide a clear picture of the actual design of the wellfields and the number, capacity, depth, location, and spacing of the wells at each proposed site. With this information, further analysis should be conducted to understand the potential interference between the proposed wellfields and the adjacent existing permitted users.

2) A conservative approach is recommended for future users that are targeting the APPZ as their primary source of water for the eastern coastal counties of the SFWMD. Model simulations and observed data suggest that sustained withdrawals from this aquifer generally result in water quality degradation in these areas, sometimes reaching or exceeding TDS concentrations of 8,000 to 10,000 mg/L. Utilities have had to backfill wells, install additional wells to improve well spacing, implement adaptive management strategies for well rotation, and take other measures to compensate for changing water quality issues associated with prolonged withdrawals from the APPZ. It is recommended that exploratory well drilling and aquifer testing be conducted at the time of wellfield construction to provide a better understanding of the water quality beneath the target zone. In addition, wellfields should be designed to minimize well interference even at higher transmission costs, and flexibility should be built into the design of water treatment plants to accommodate higher TDS concentrations.

3) Port St. Lucie should be encouraged to continue construction of the Southwest wellfield, targeting the UFA when possible, and continue evaluation of other non-Floridan source options as demands increase.

4) Additional analysis of the interaction between the Town of Jupiter, the Village of Tequesta, SUA, and the two UFA golf courses in the general vicinity is suggested.

5) The interaction of the coastal St. Lucie County proposed North wellfield and the southeastern Indian River County wellfields causes issues when evaluating flowing artesian wells. Noticeable reduction in heads is projected to be experienced along the Indian River and St. Lucie County border. SFWMD staff should continue to coordinate with stakeholders and the SJRWMD regarding the use of the FAS in this area.

# 7.0 REFERENCES


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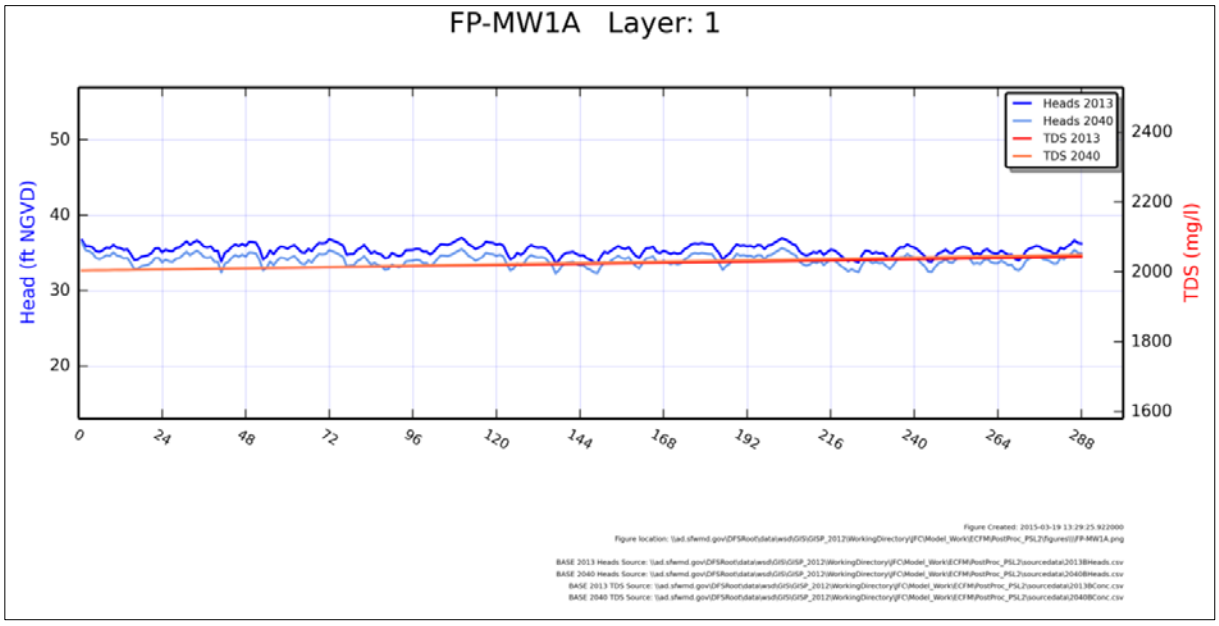
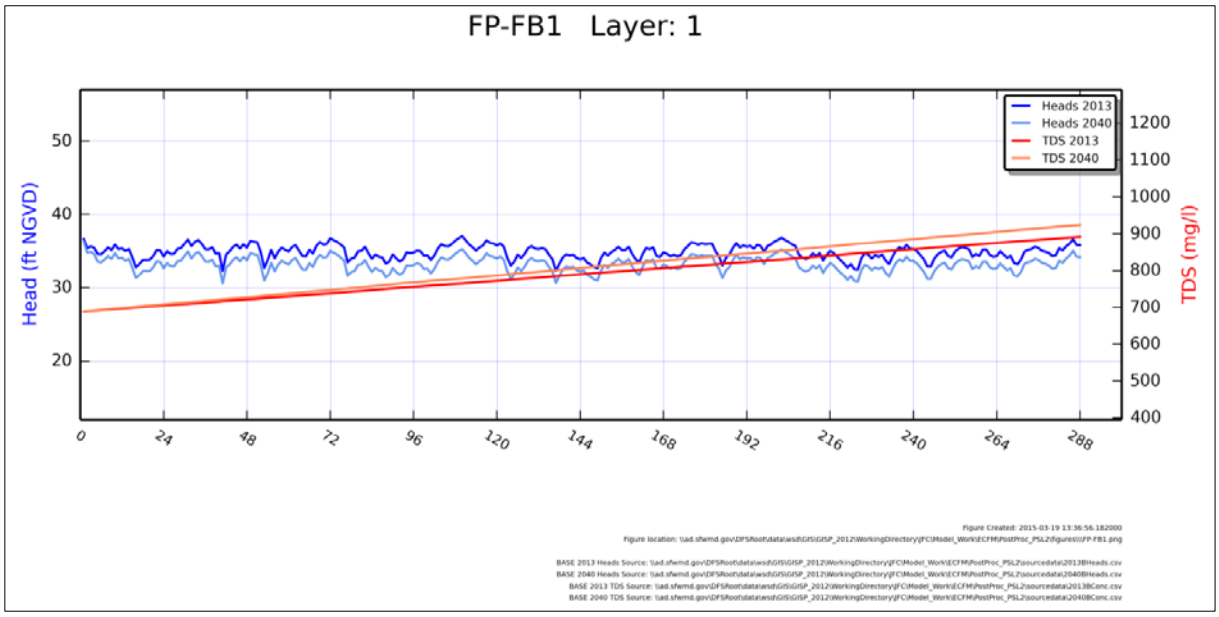
SJRWMD. 2013. *Draft District-Wide Water Supply Plan*. St. Johns River Water Management District. Palatka, FL.

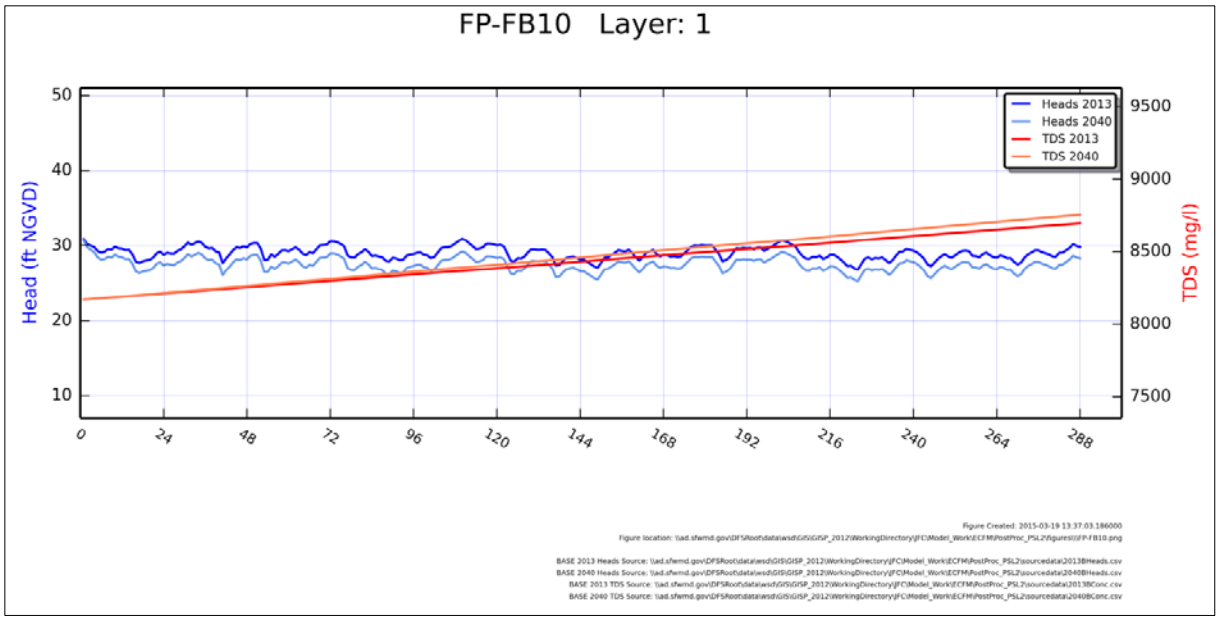
# APPENDIX A

## St. Lucie County

### *Fort Pierce Utilities Authority*






***Port St. Lucie Utility***

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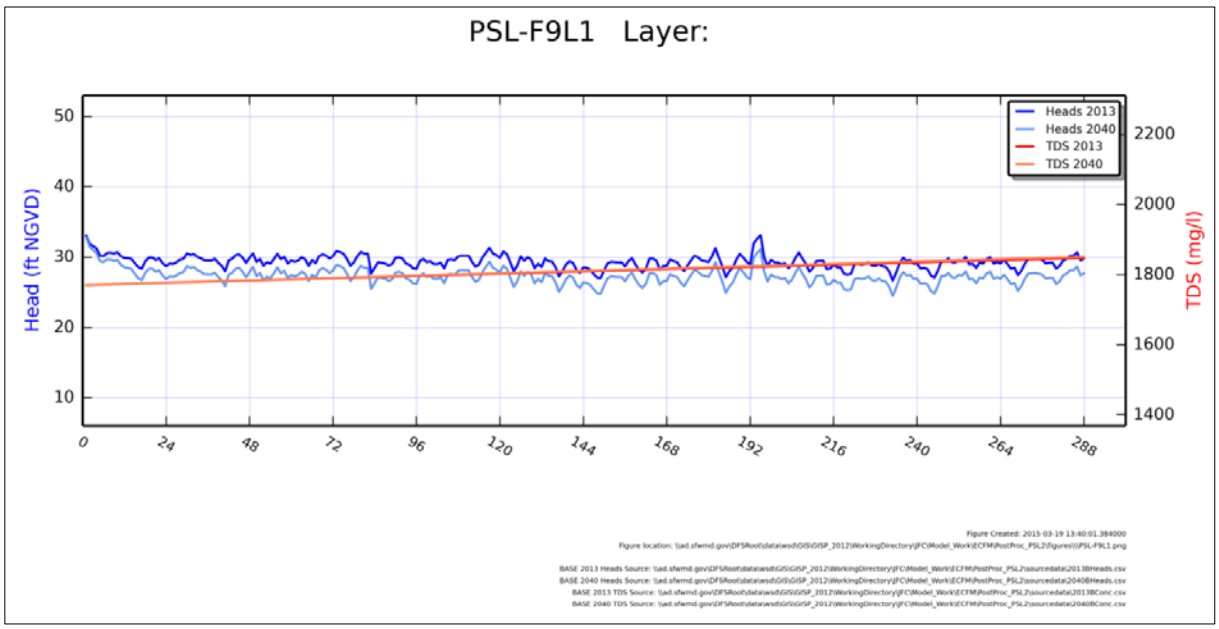

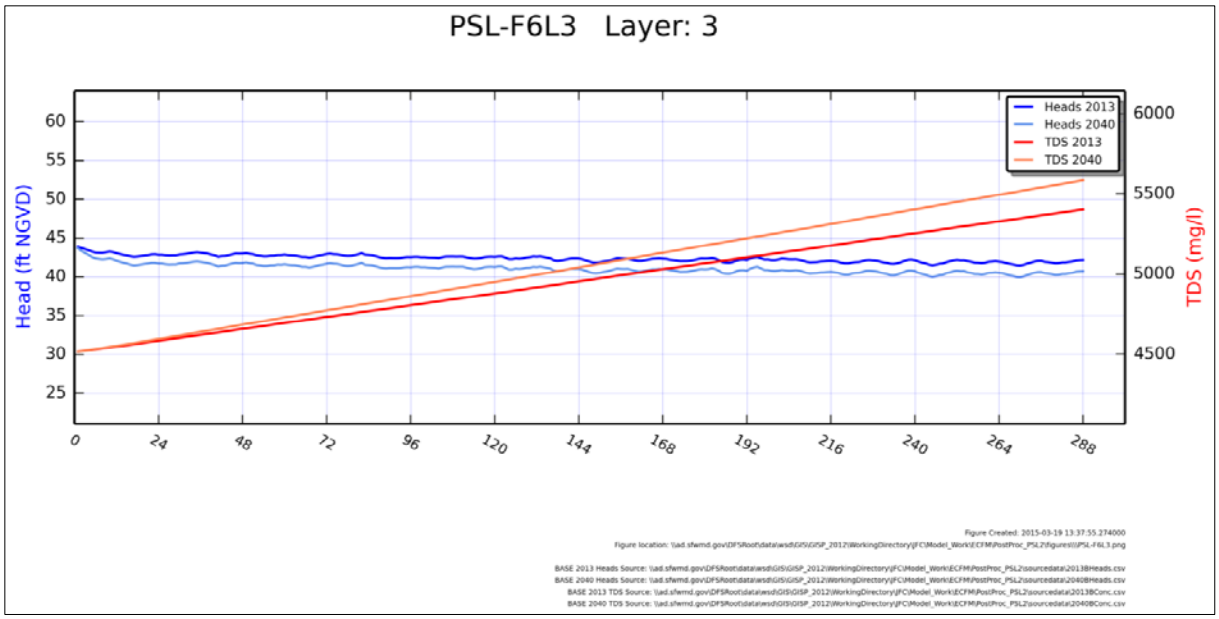
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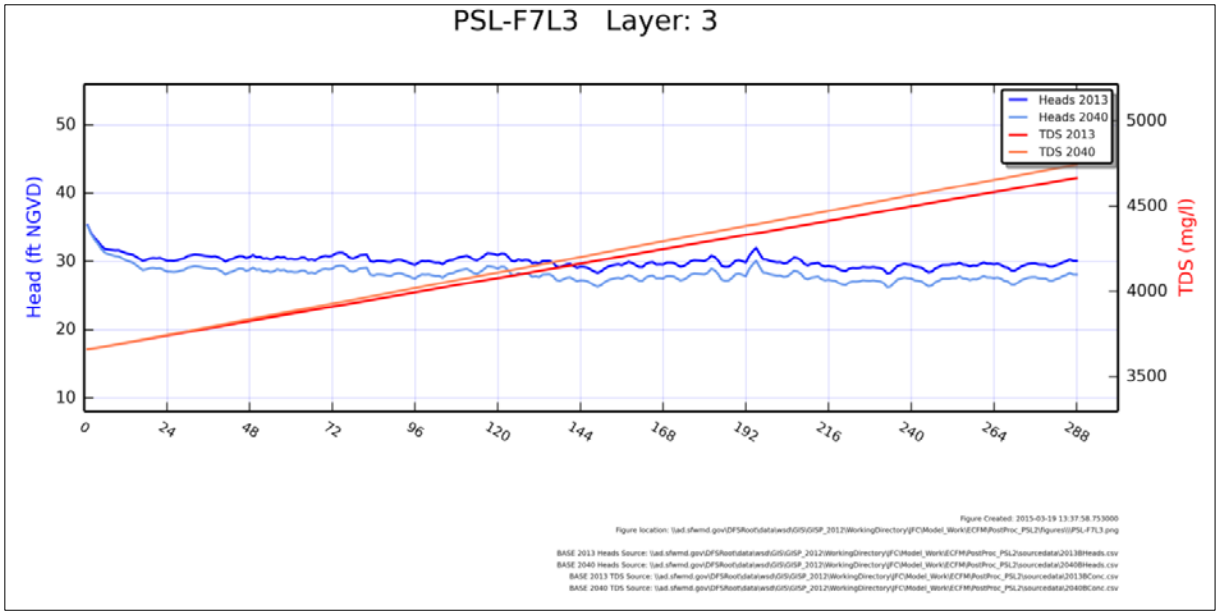
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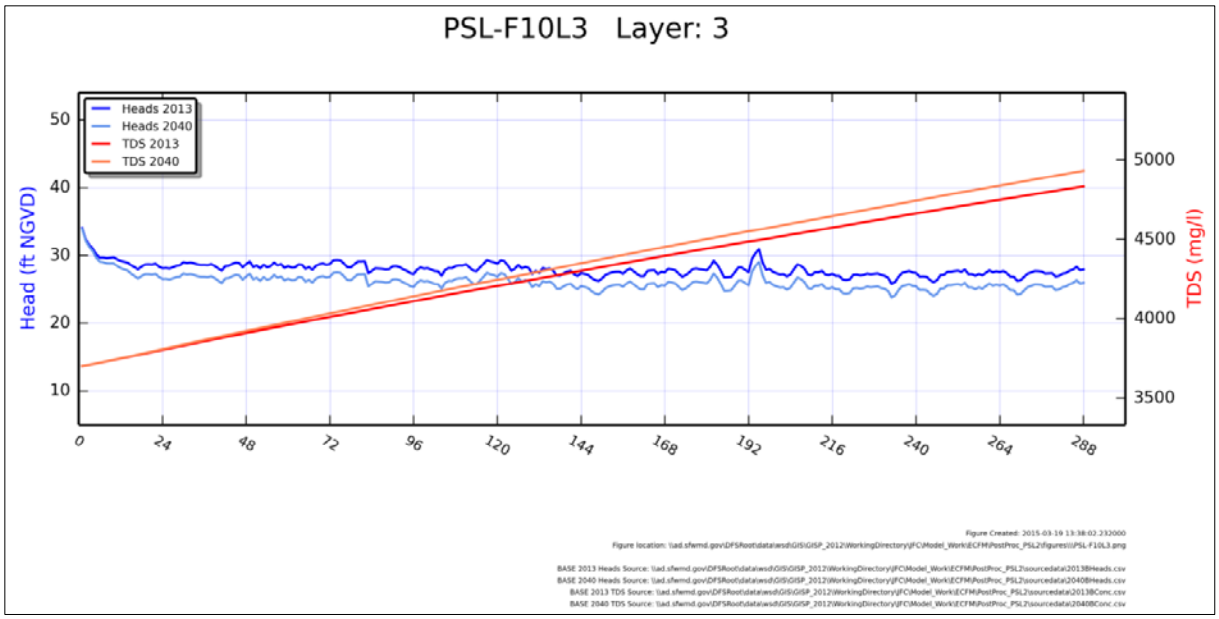
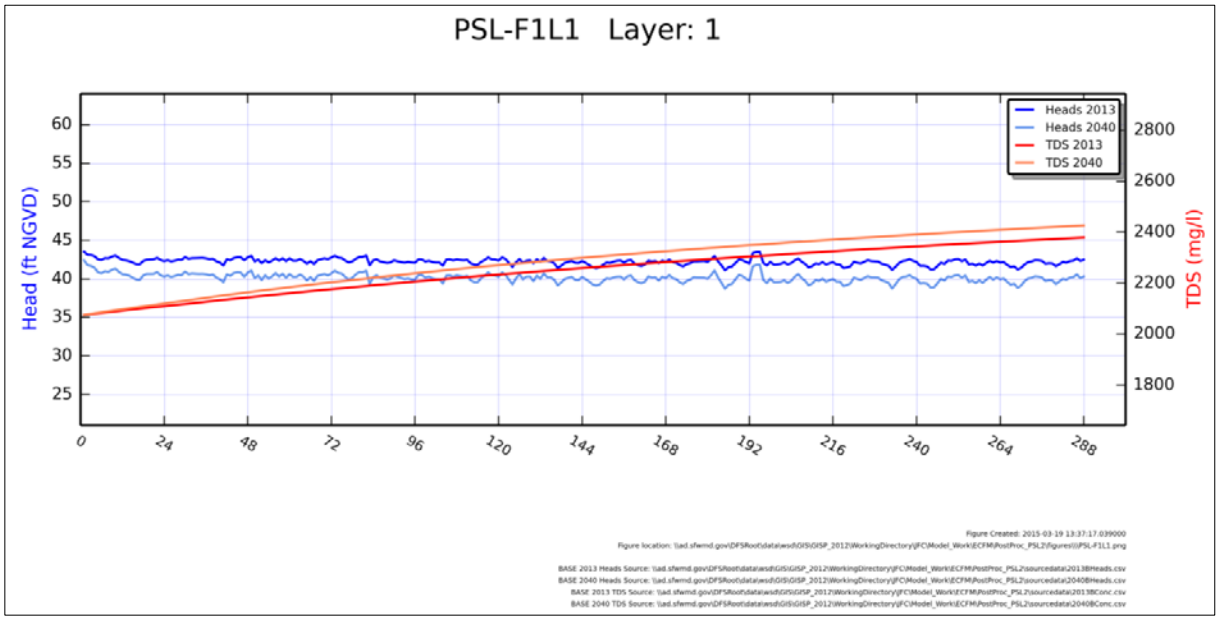
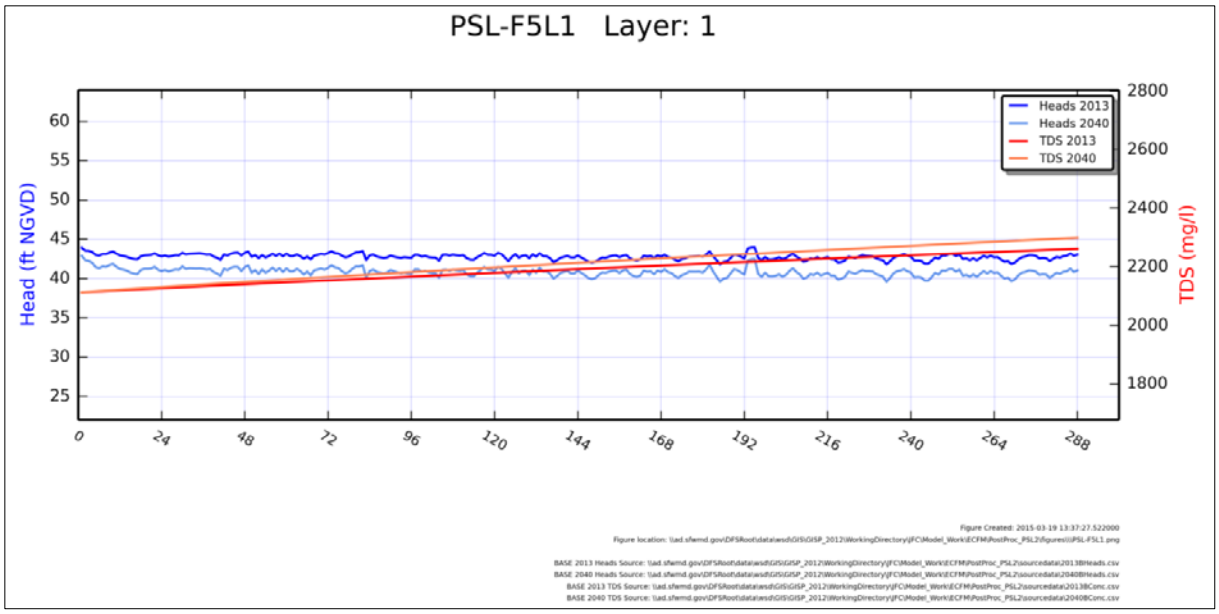



Prineville Wellfield



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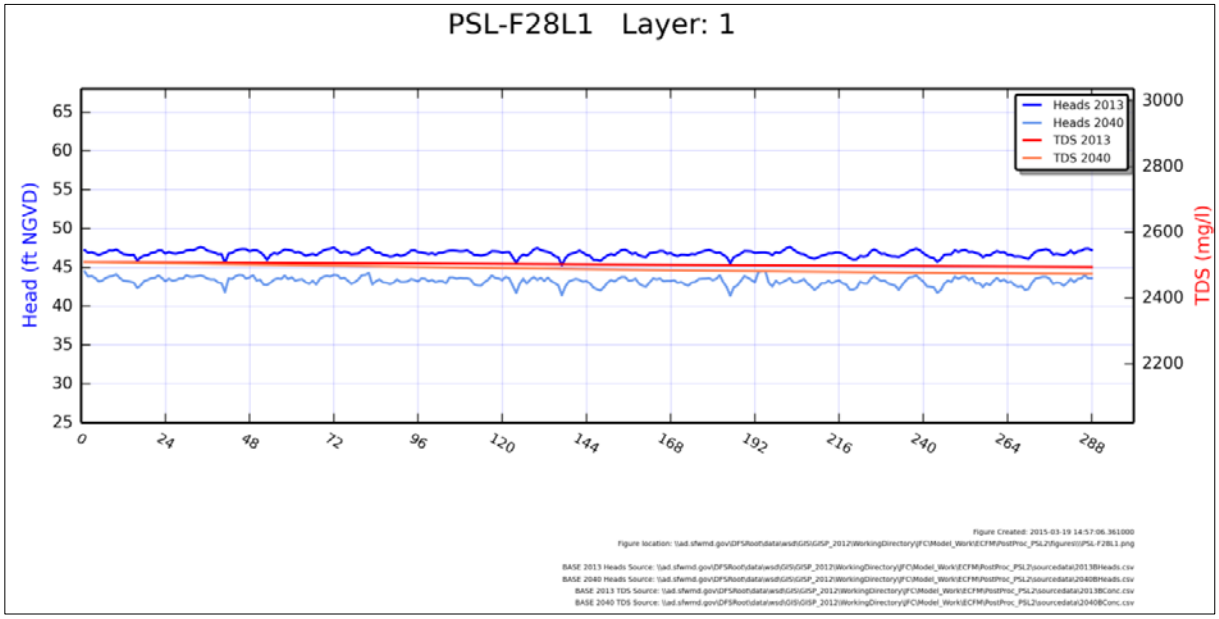
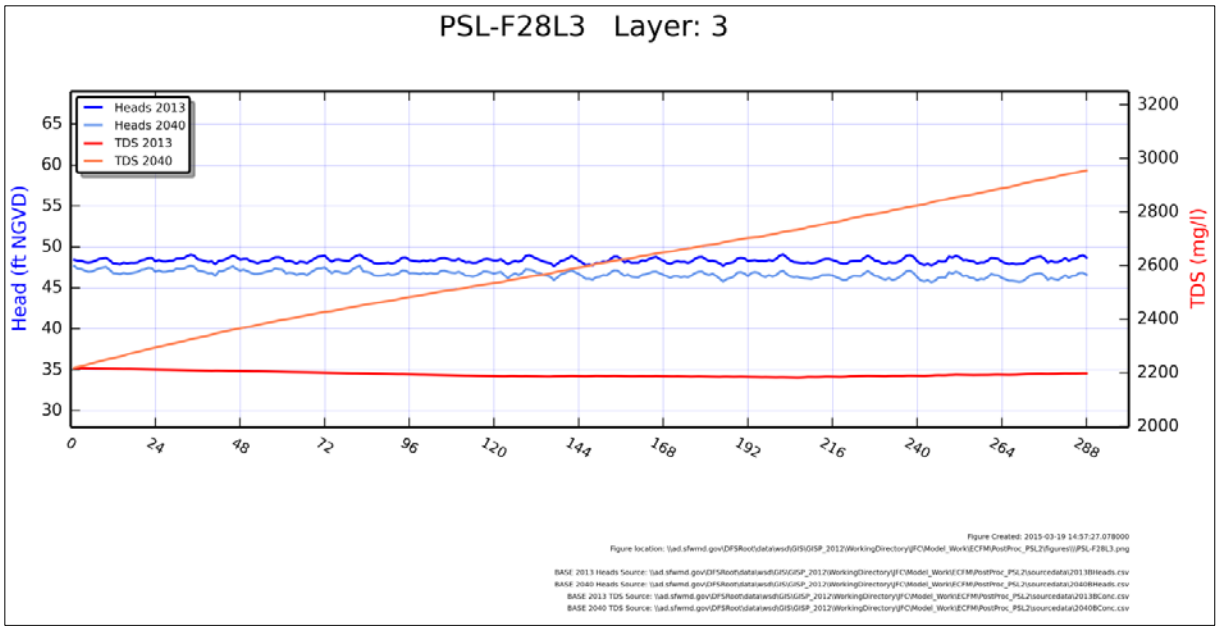
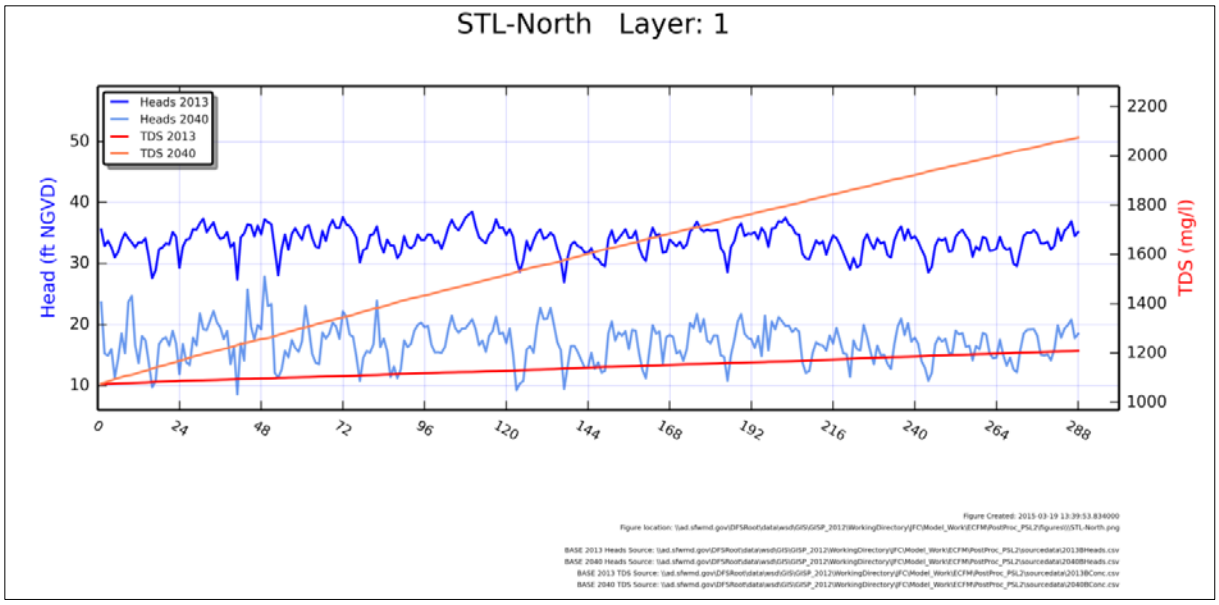


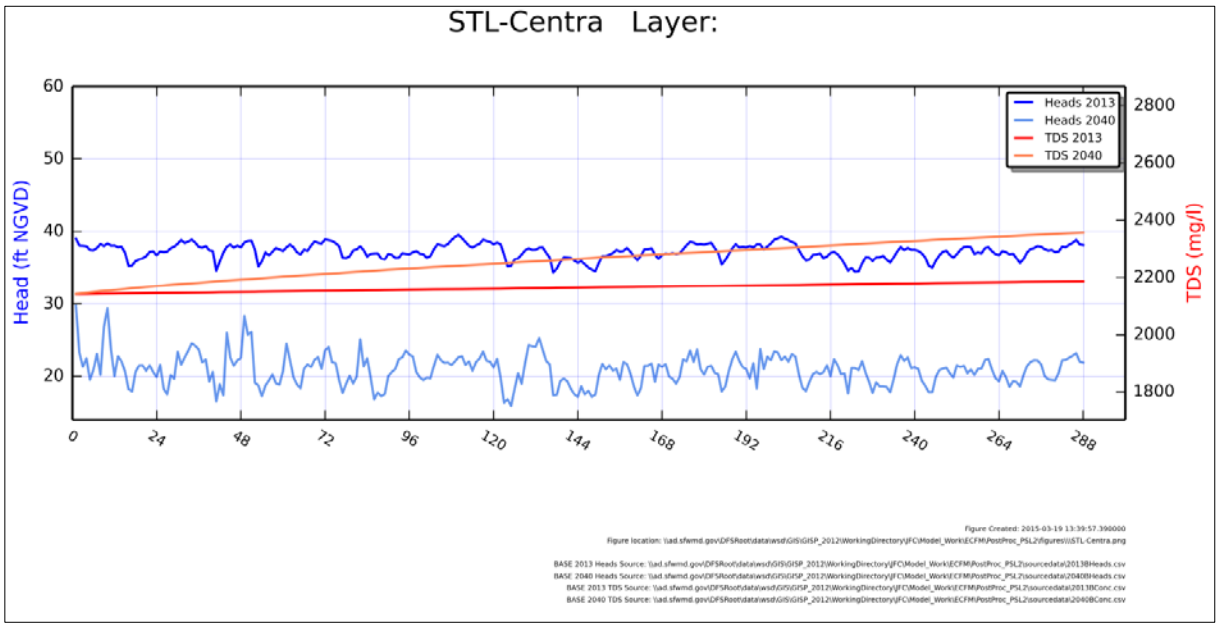



***St. Lucie County Utility***

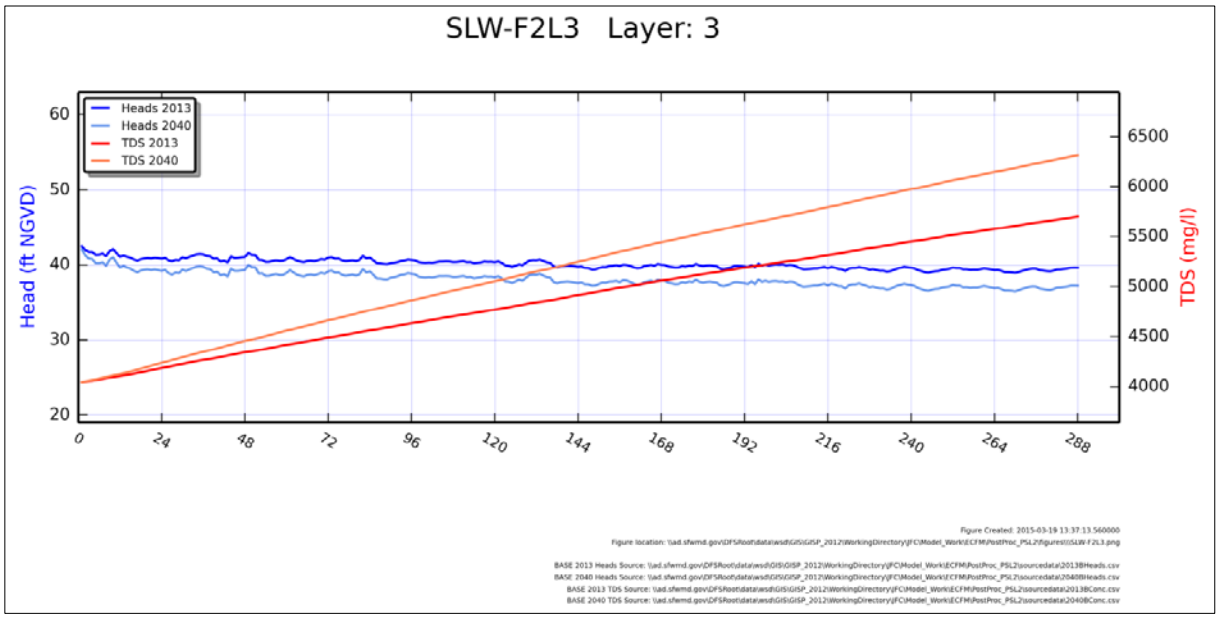
North Wellfield (Airport)



Central Wellfield (Fairgrounds)




***St. Lucie West Utility***



# Martin County

## *Martin County Utilities*

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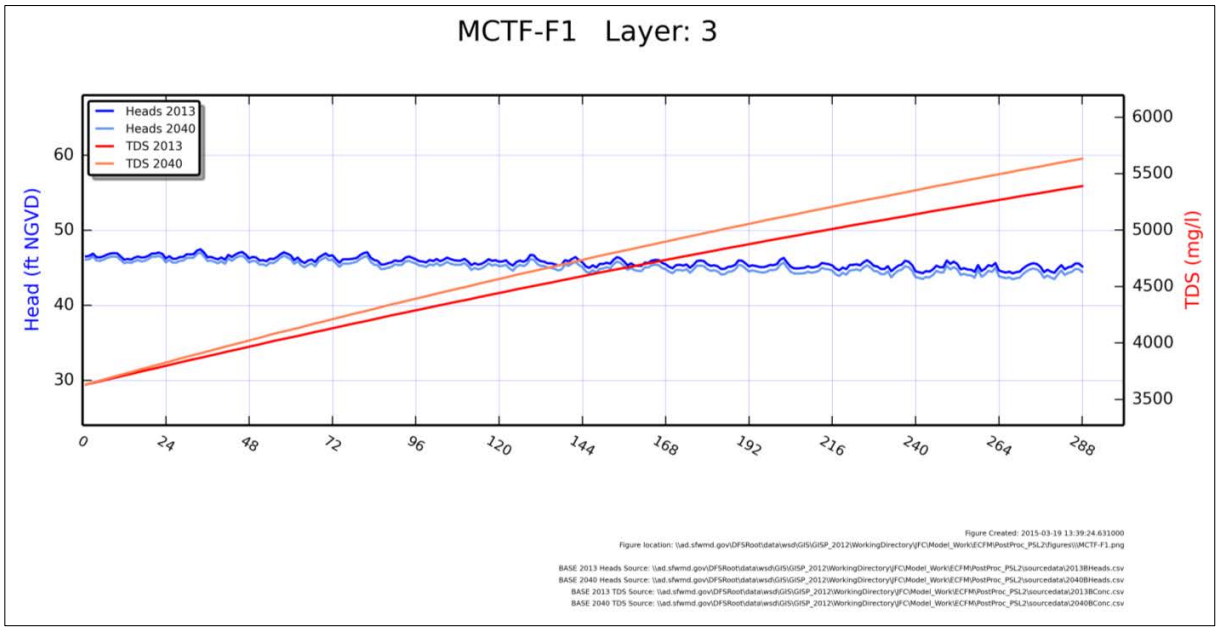
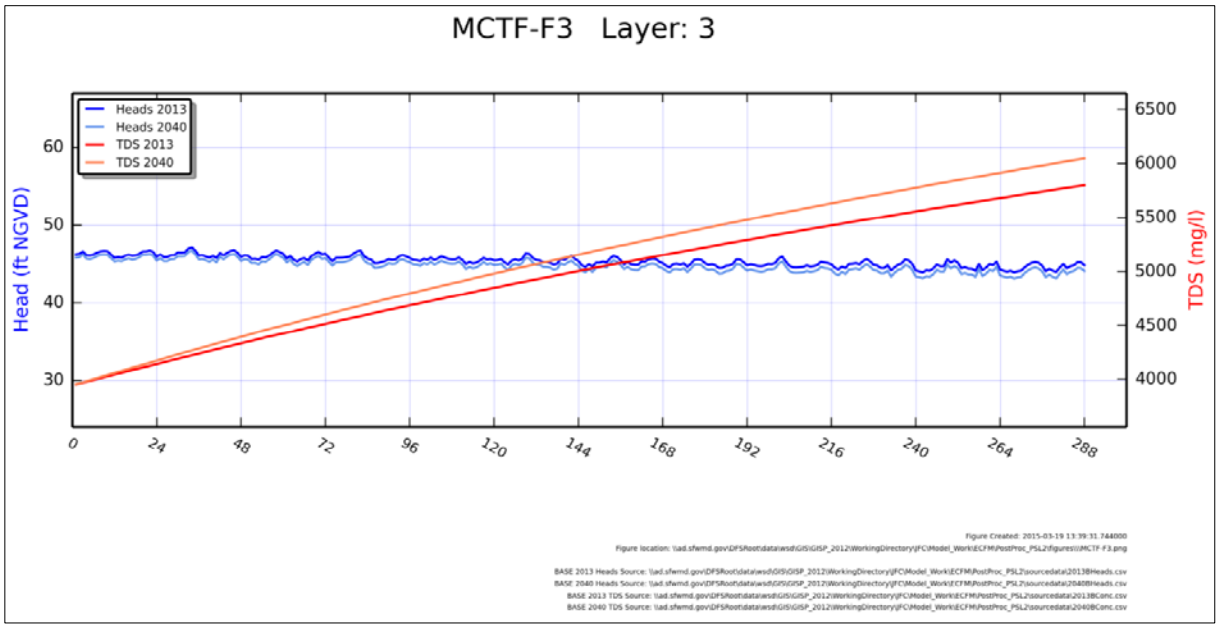
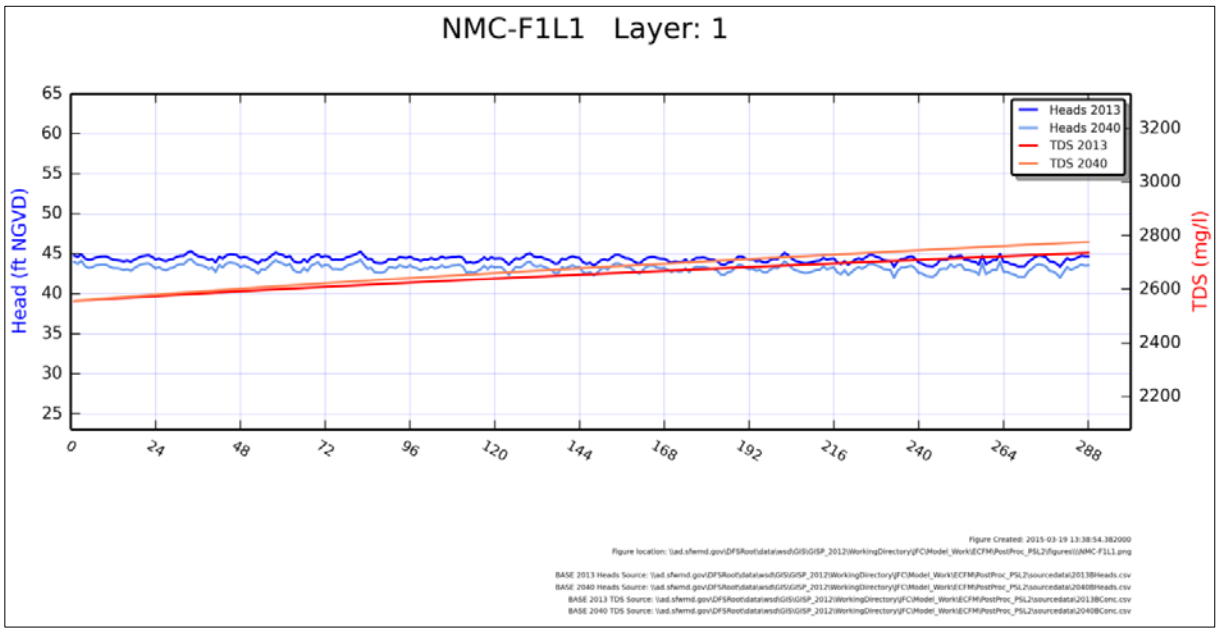
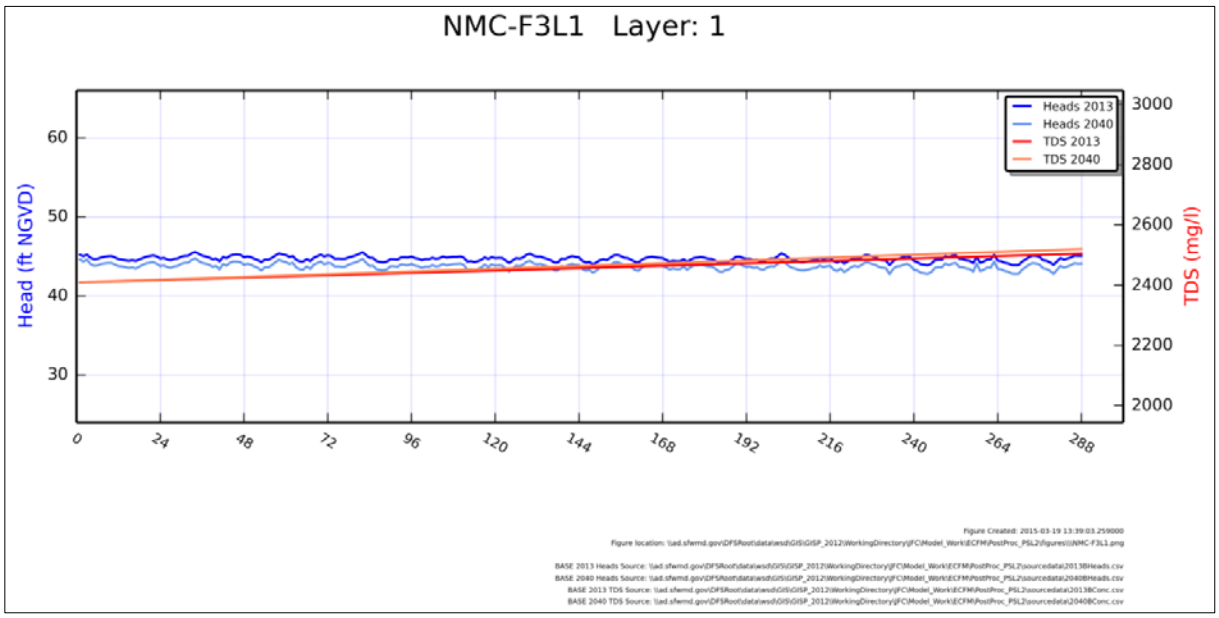
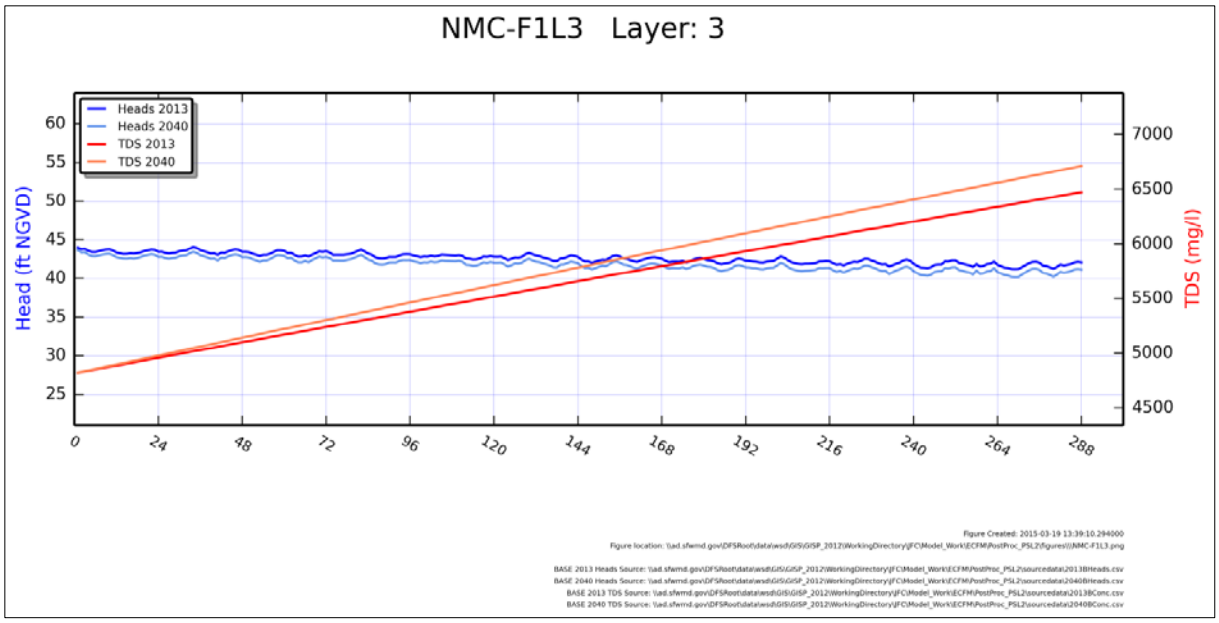


Jensen Wellfield

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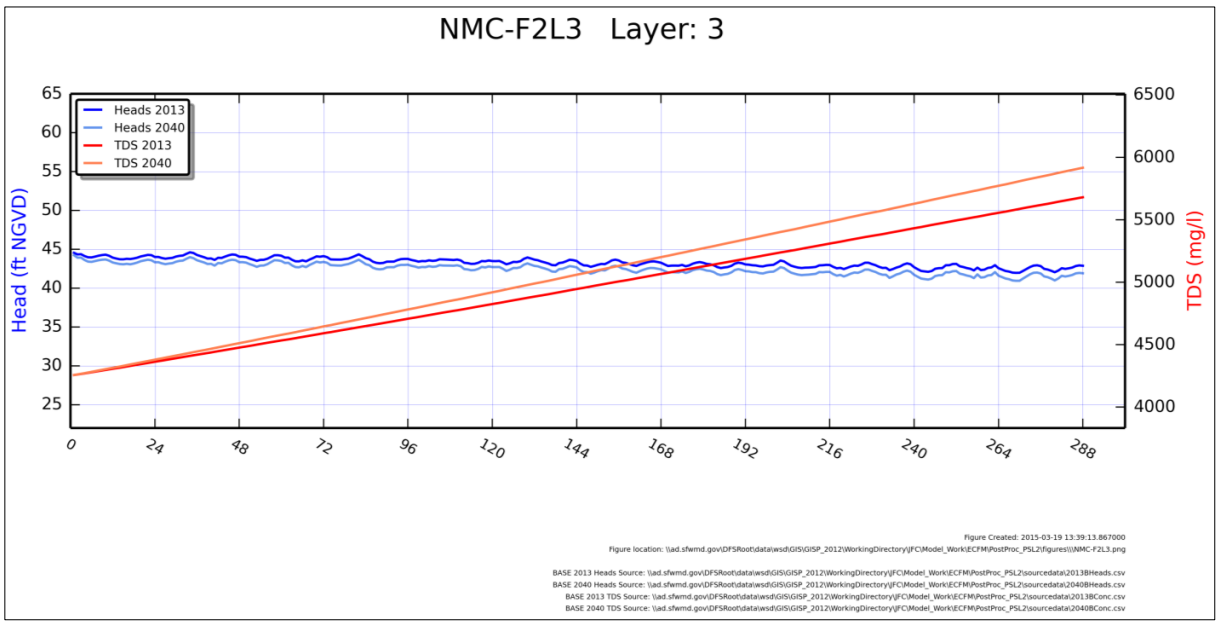
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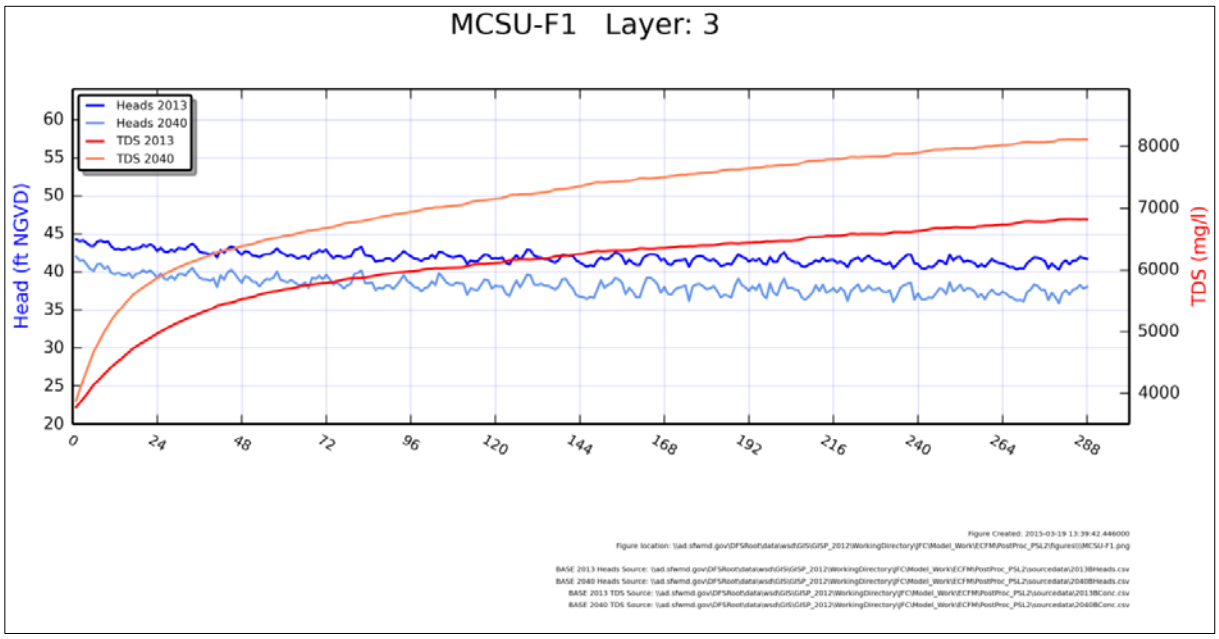


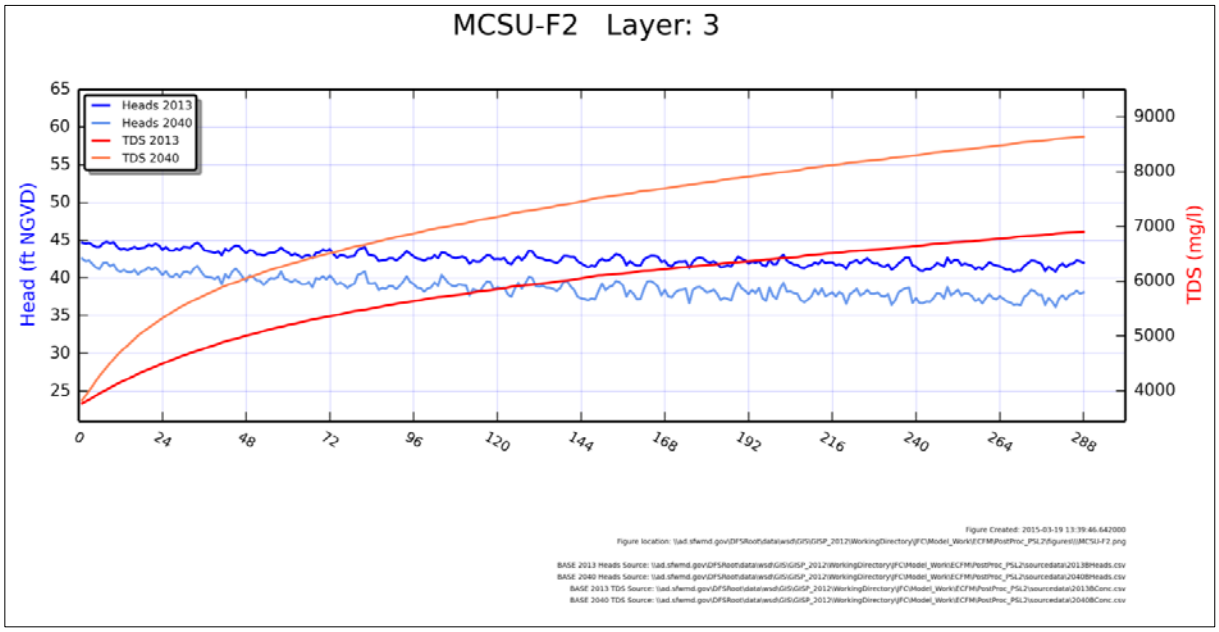

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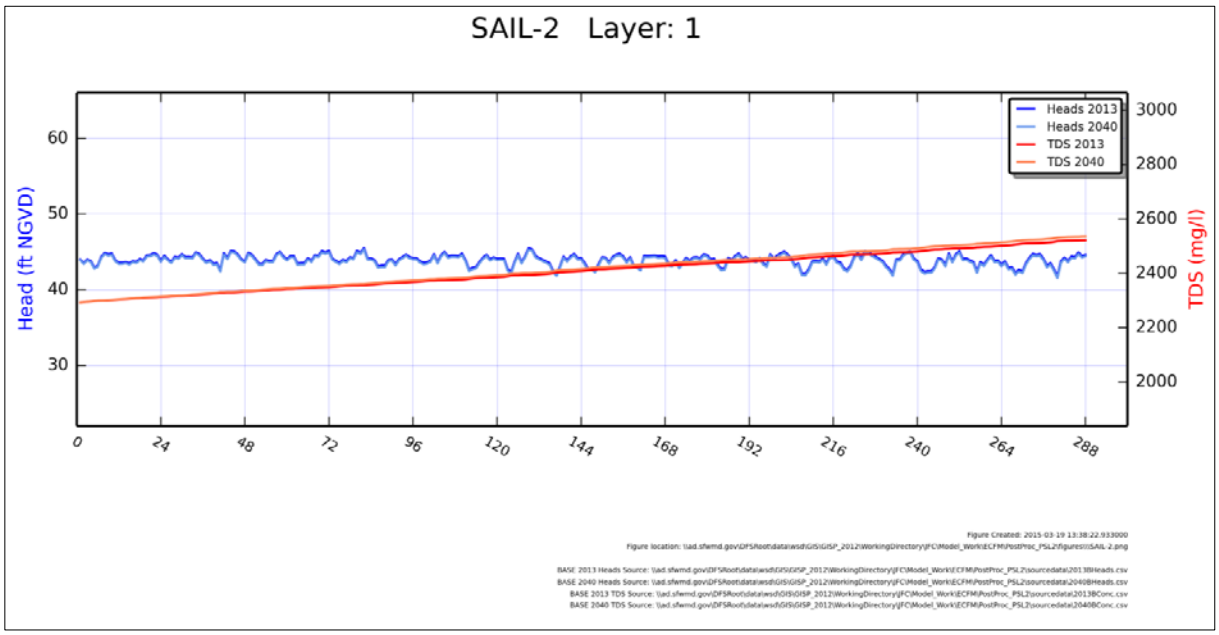


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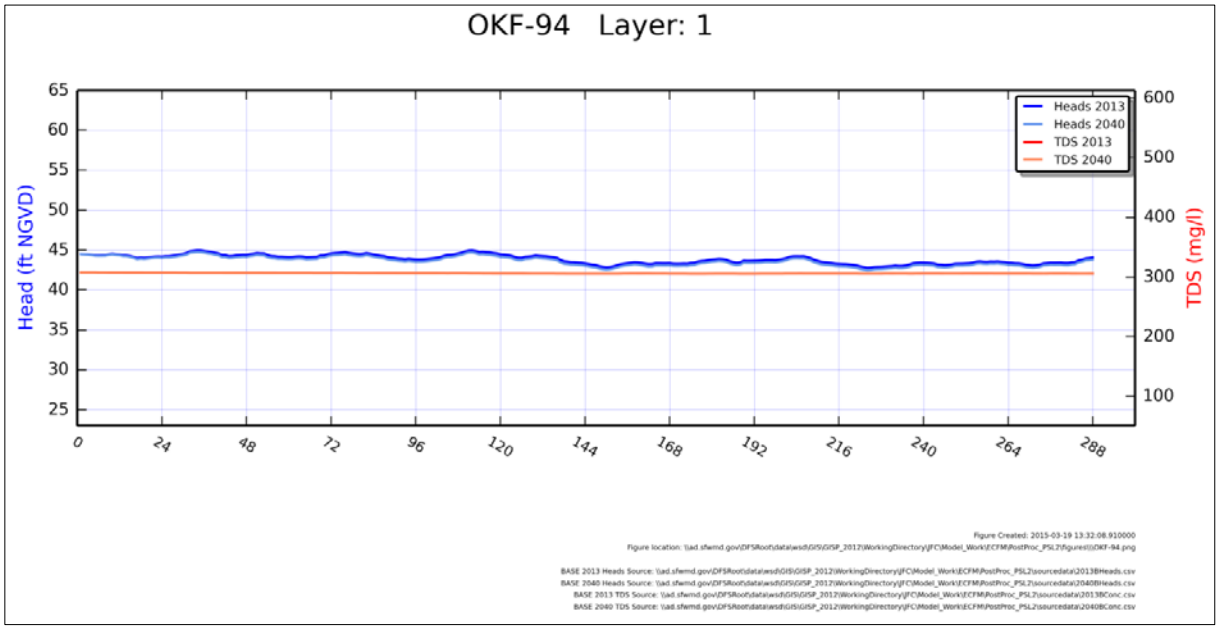
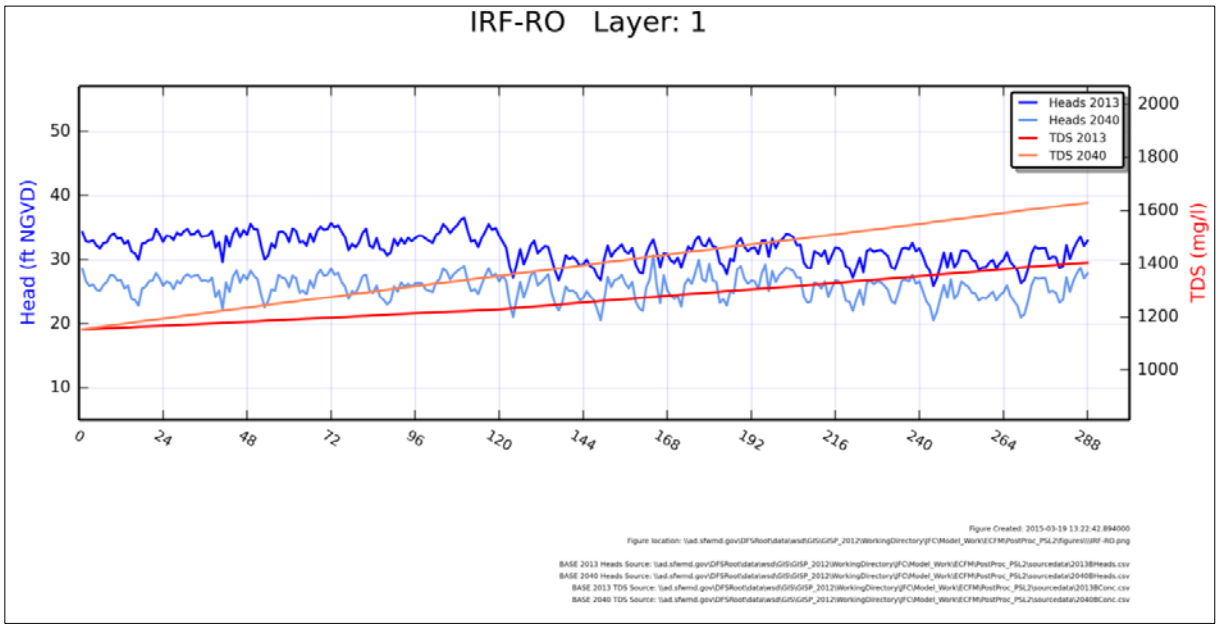
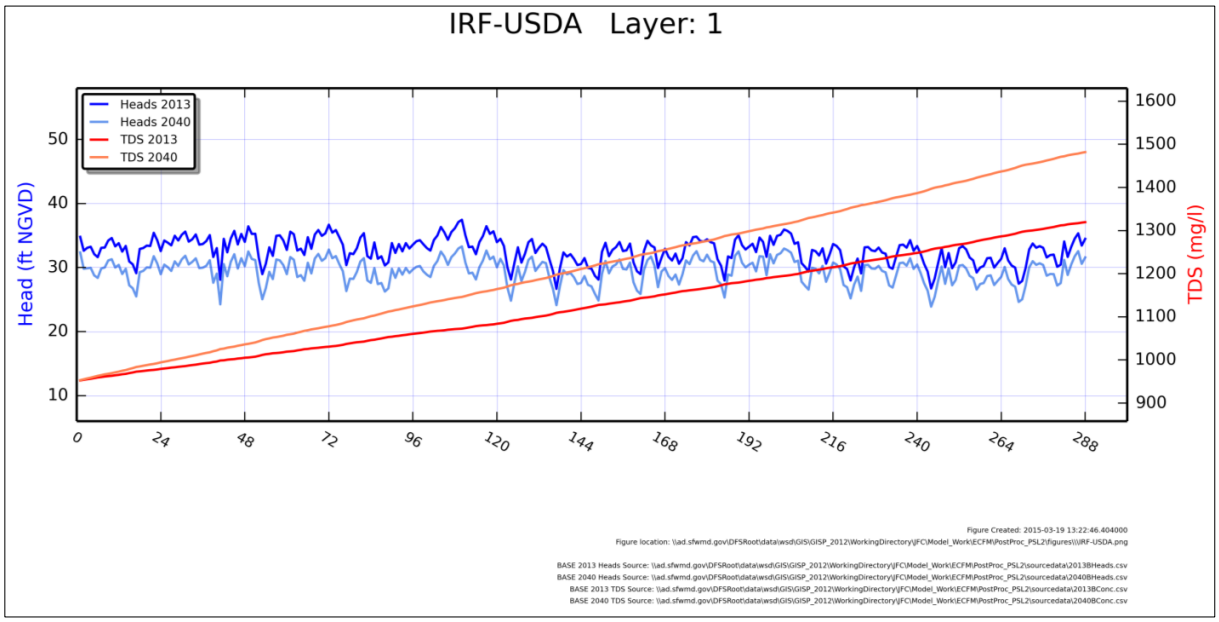


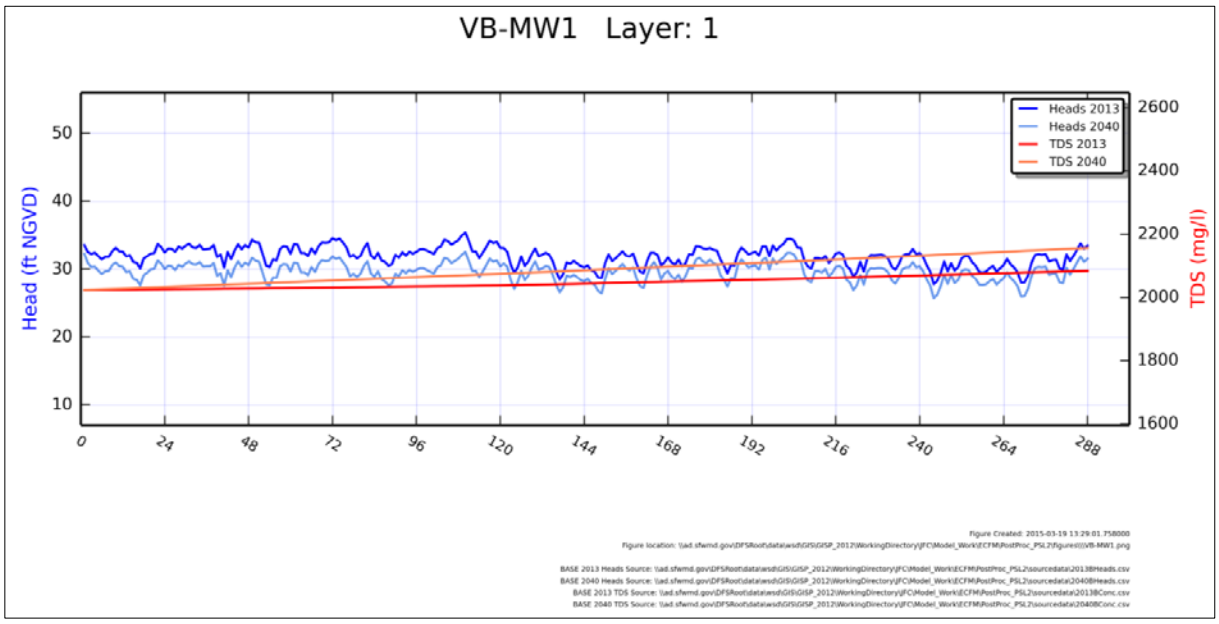
## Indian River County

Oslo Wellfield



City of Vero Beach Wellfield




## North Palm Beach County

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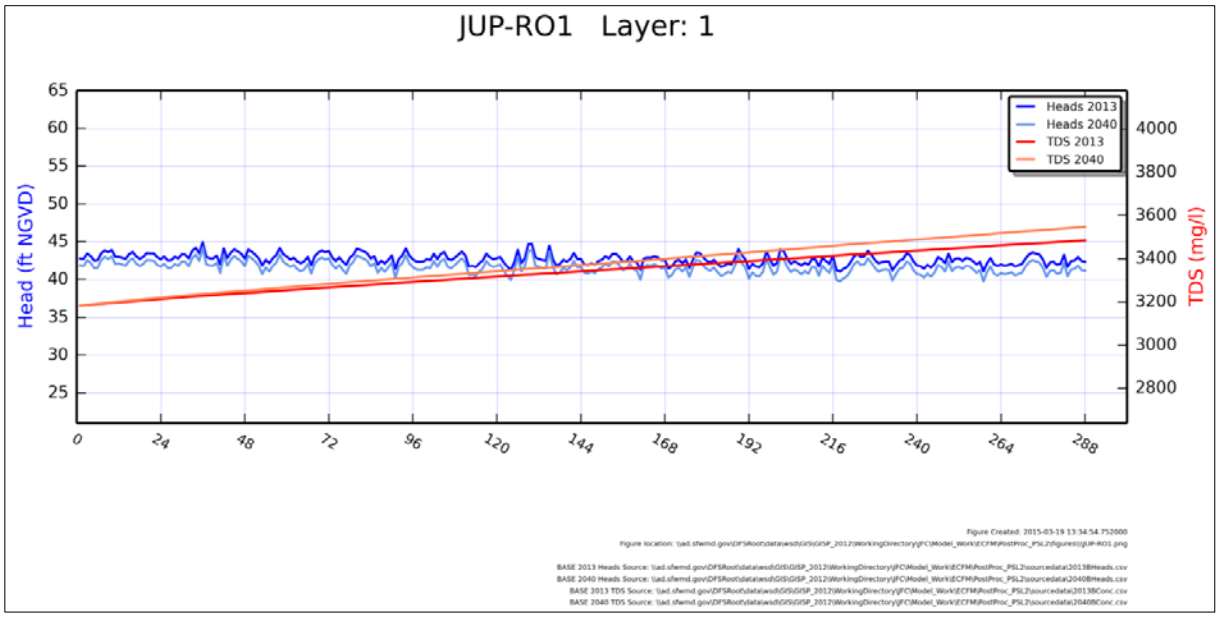

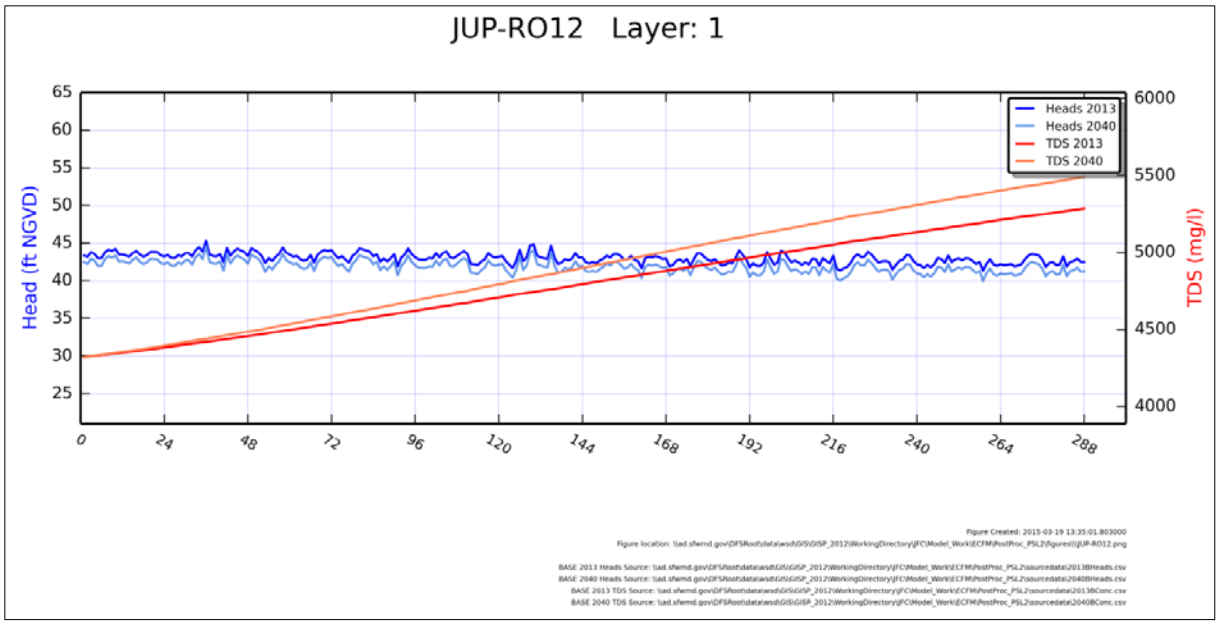
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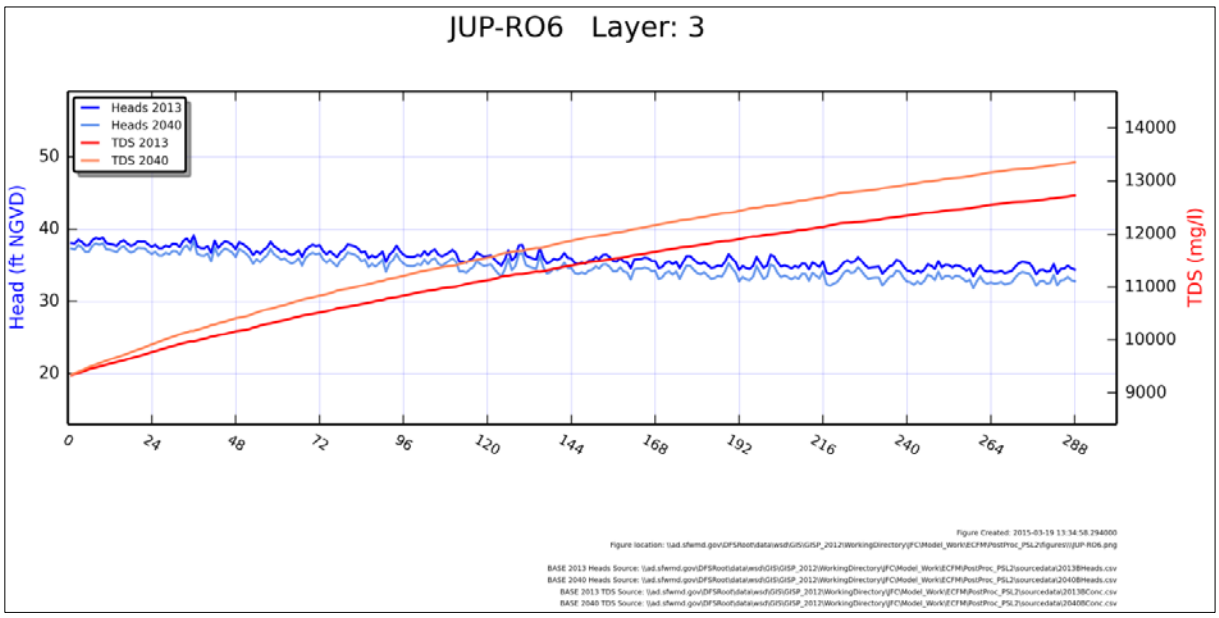
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Head (ft NGVD)
TDS (mg/l)
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Heads 2040
TDS 2013
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40
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13000
12000
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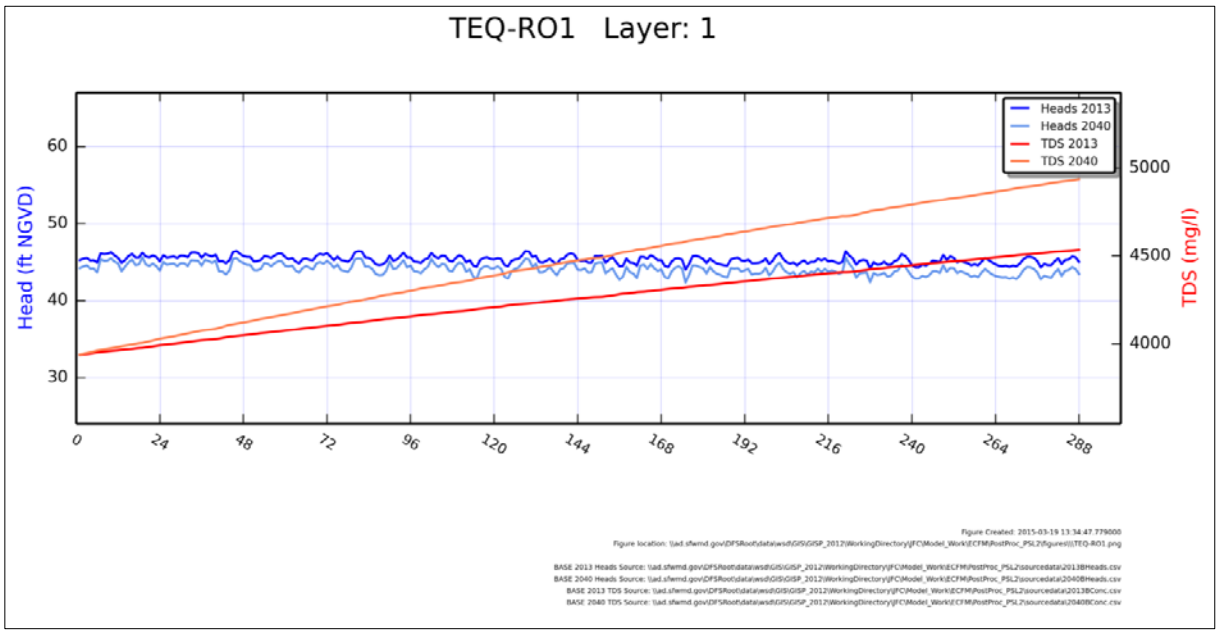
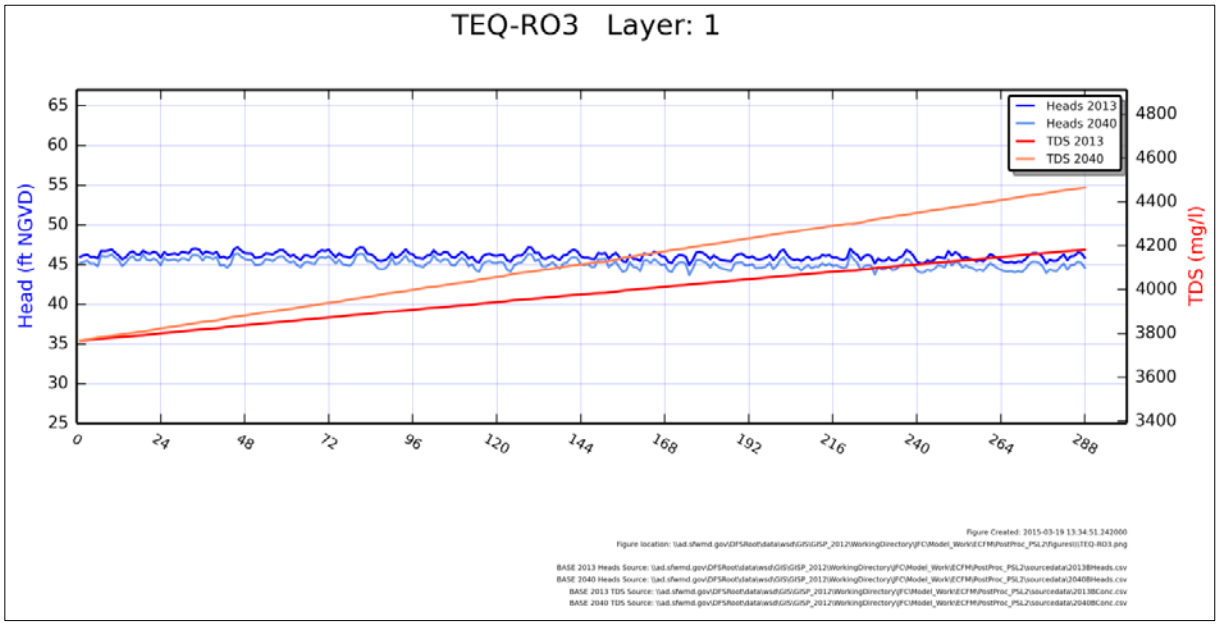
264
288

## *Village of Tequesta*



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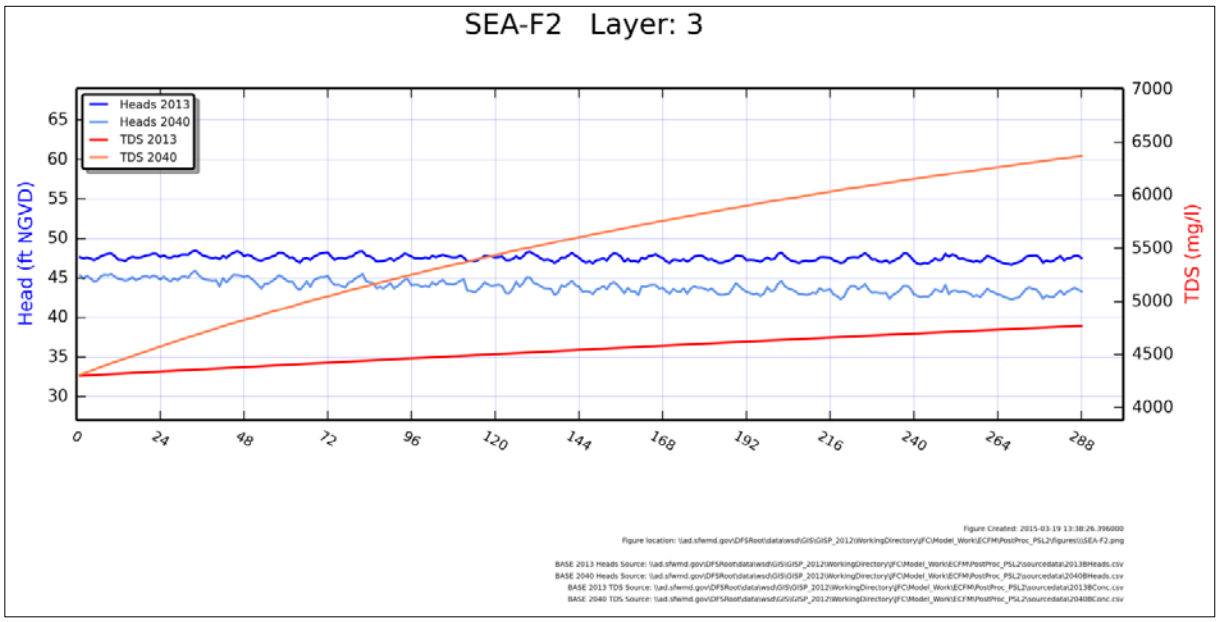
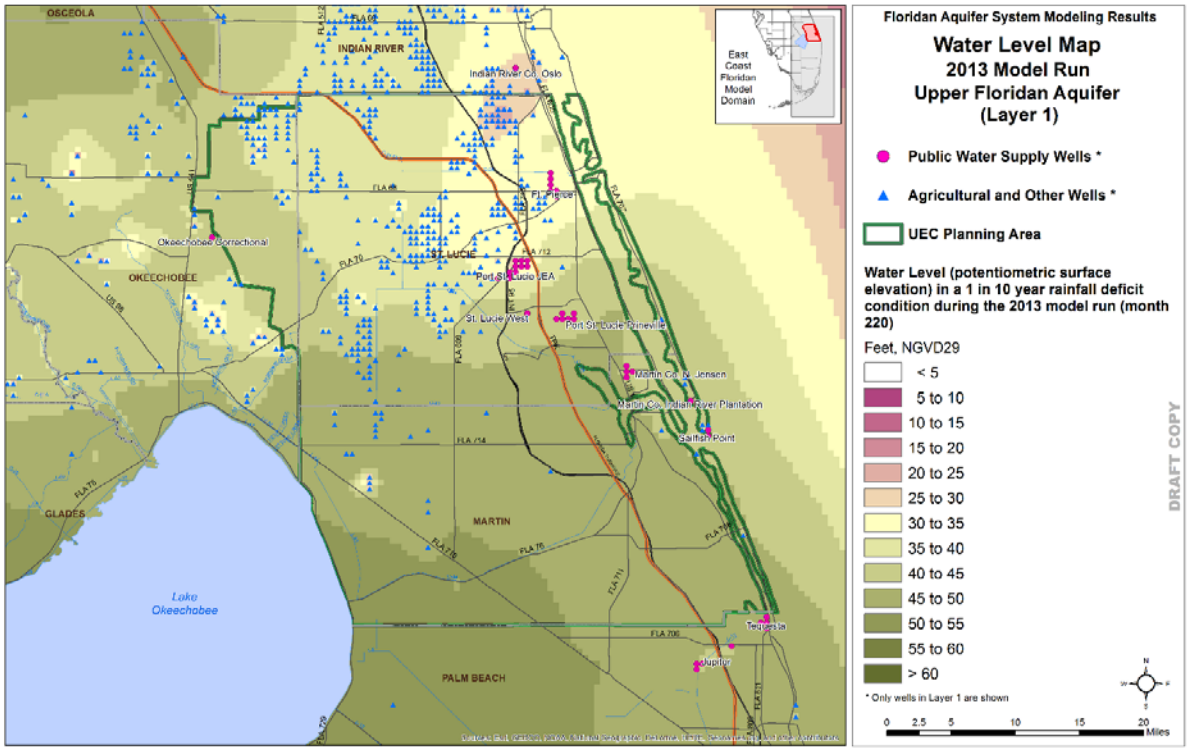
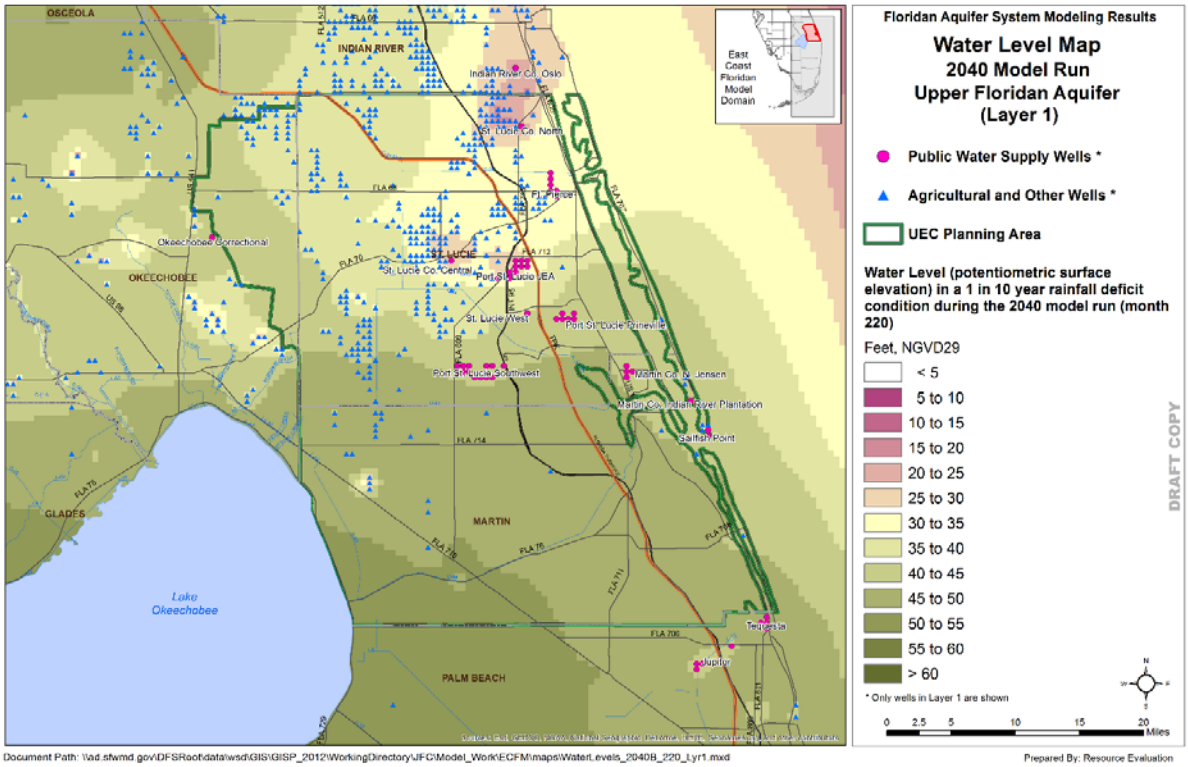
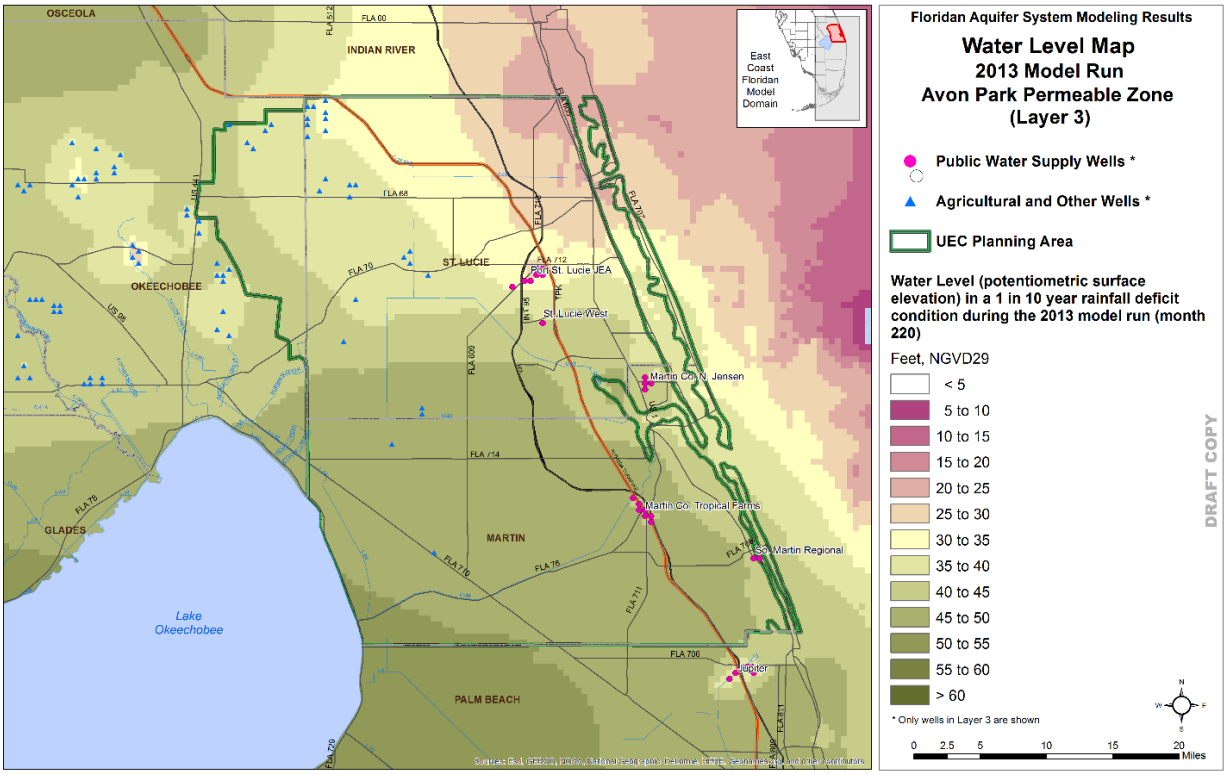


# APPENDIX B

## Water Levels



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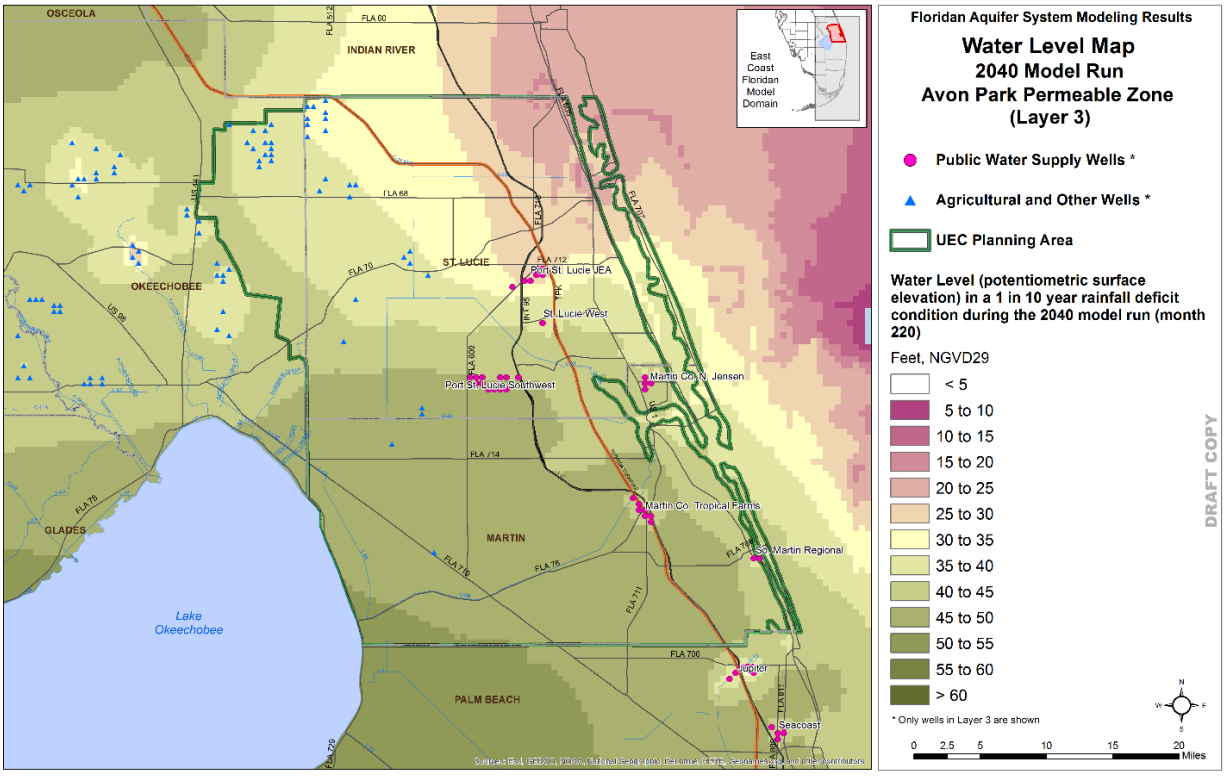


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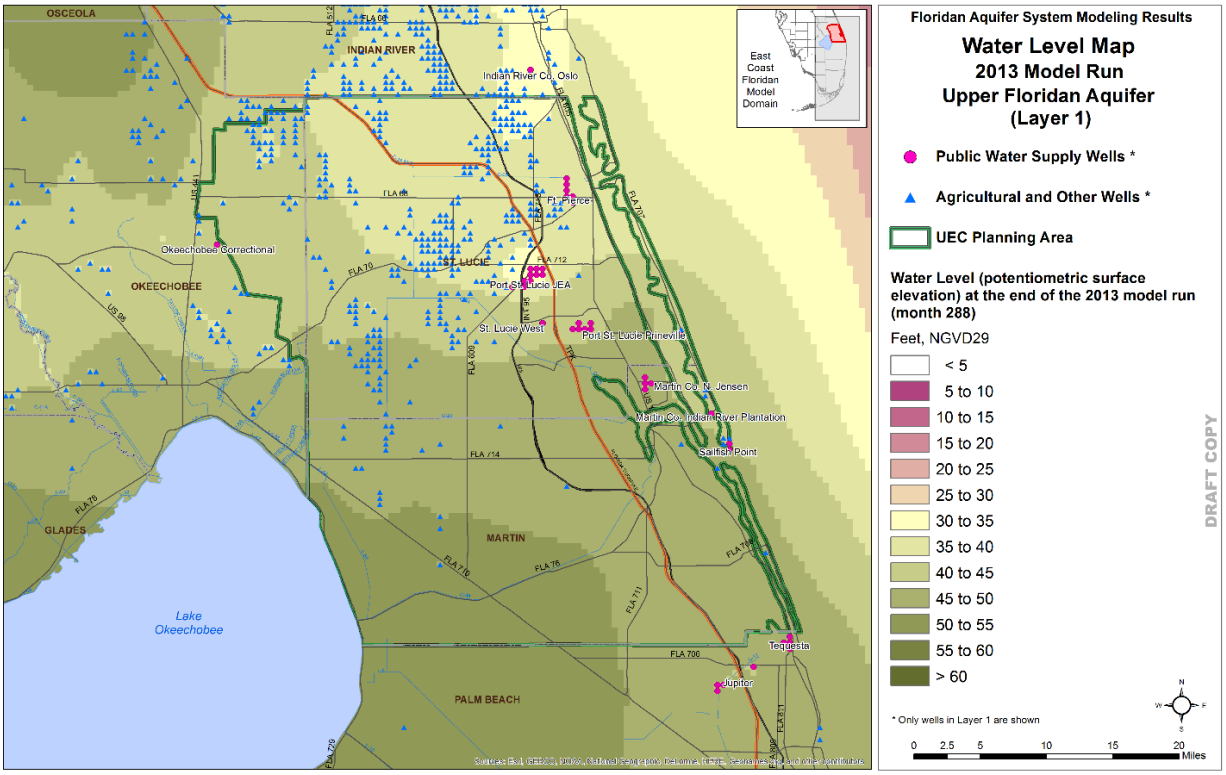


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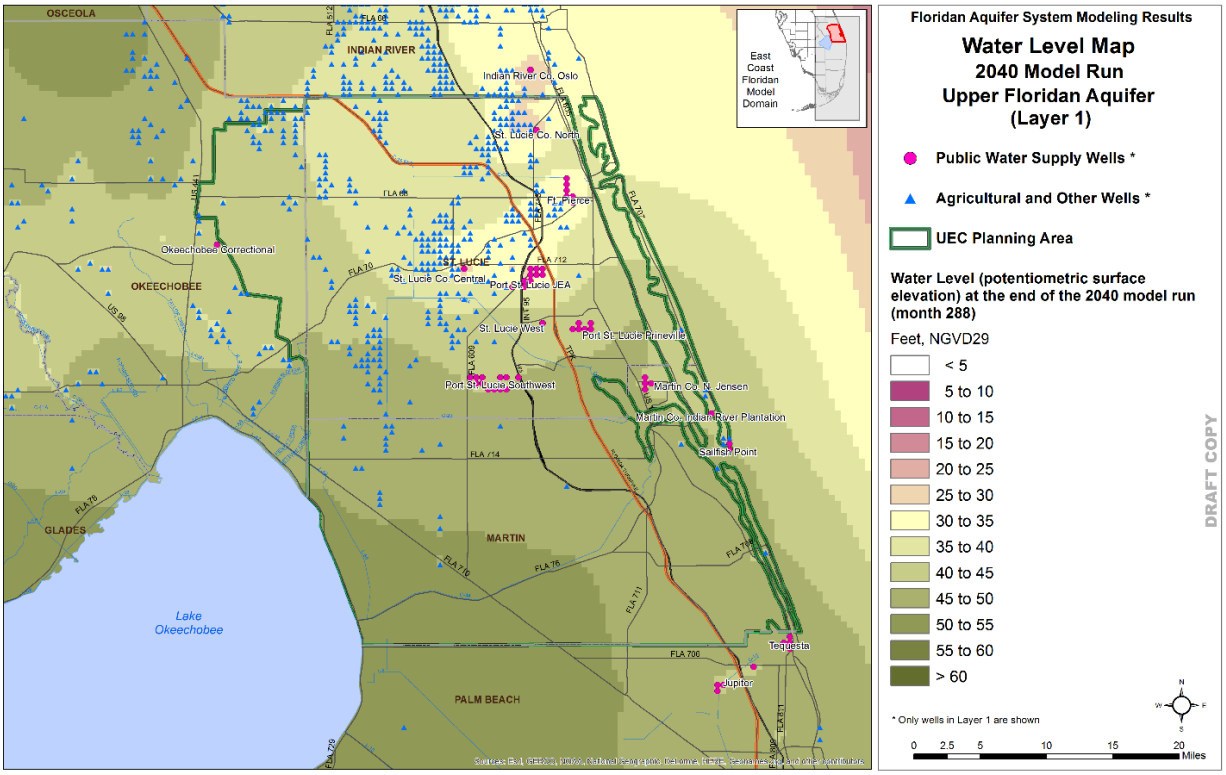


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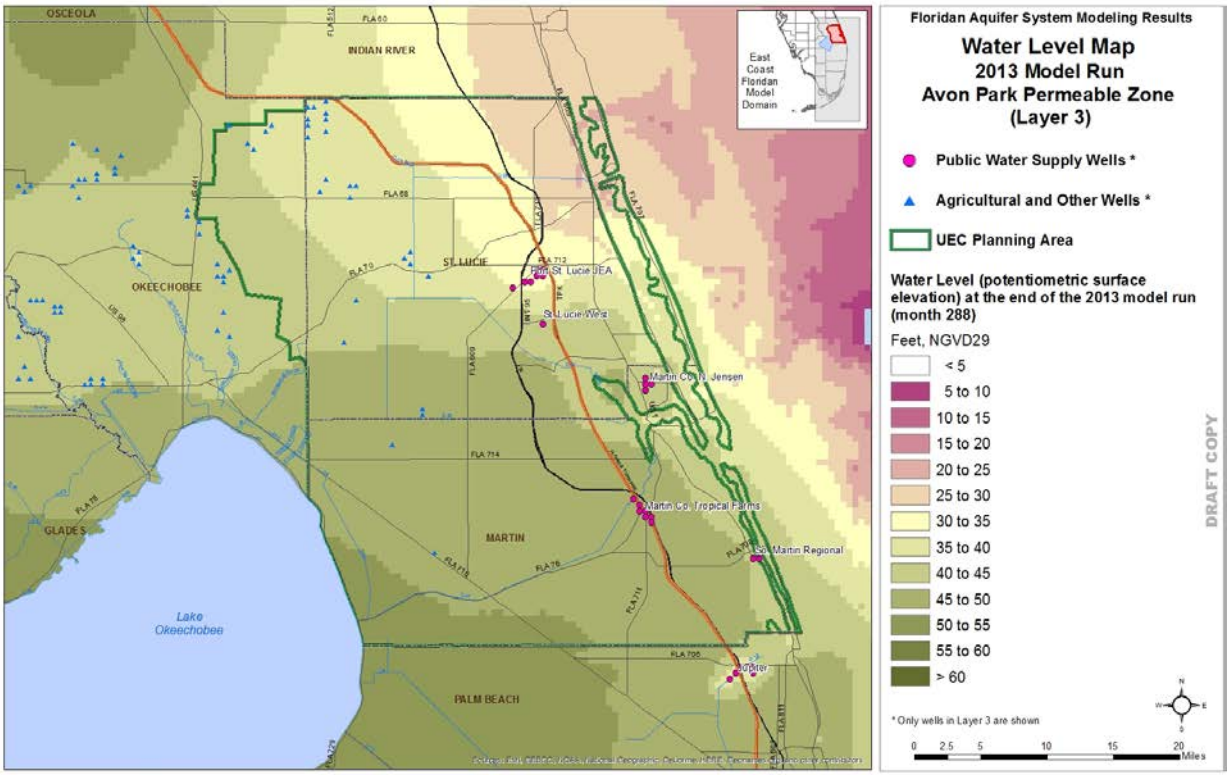


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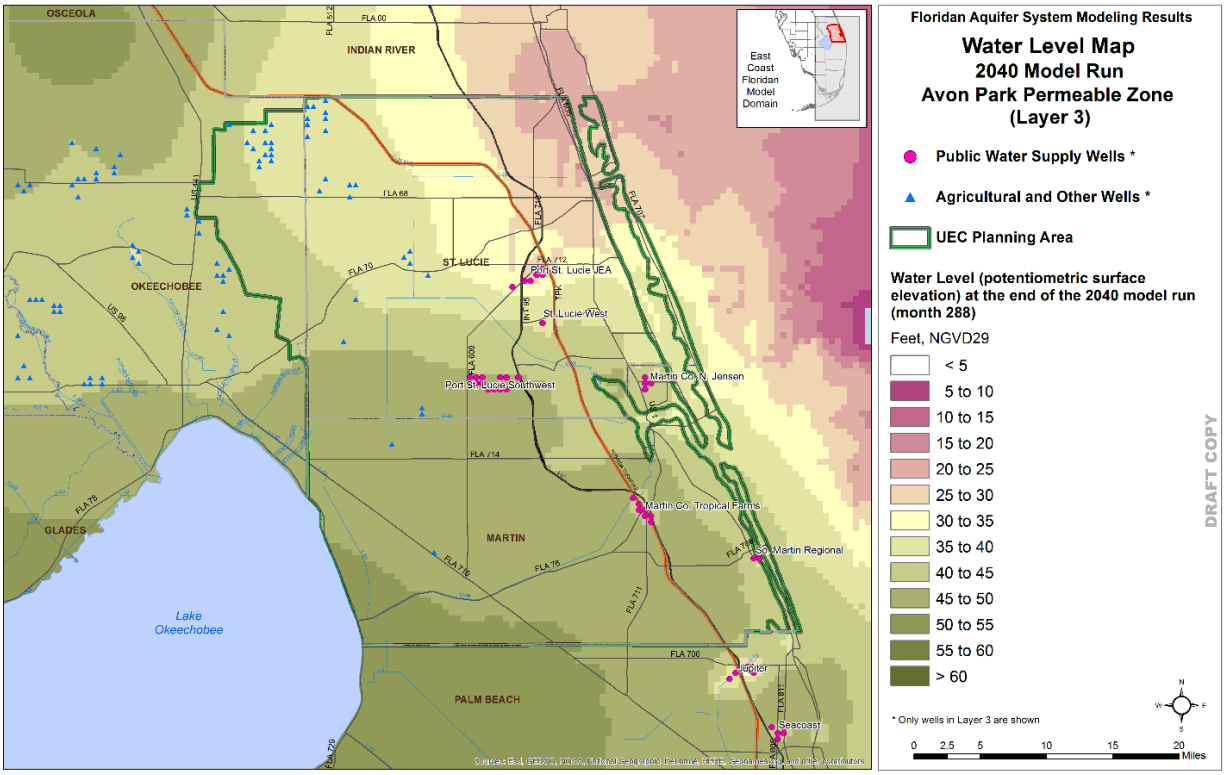


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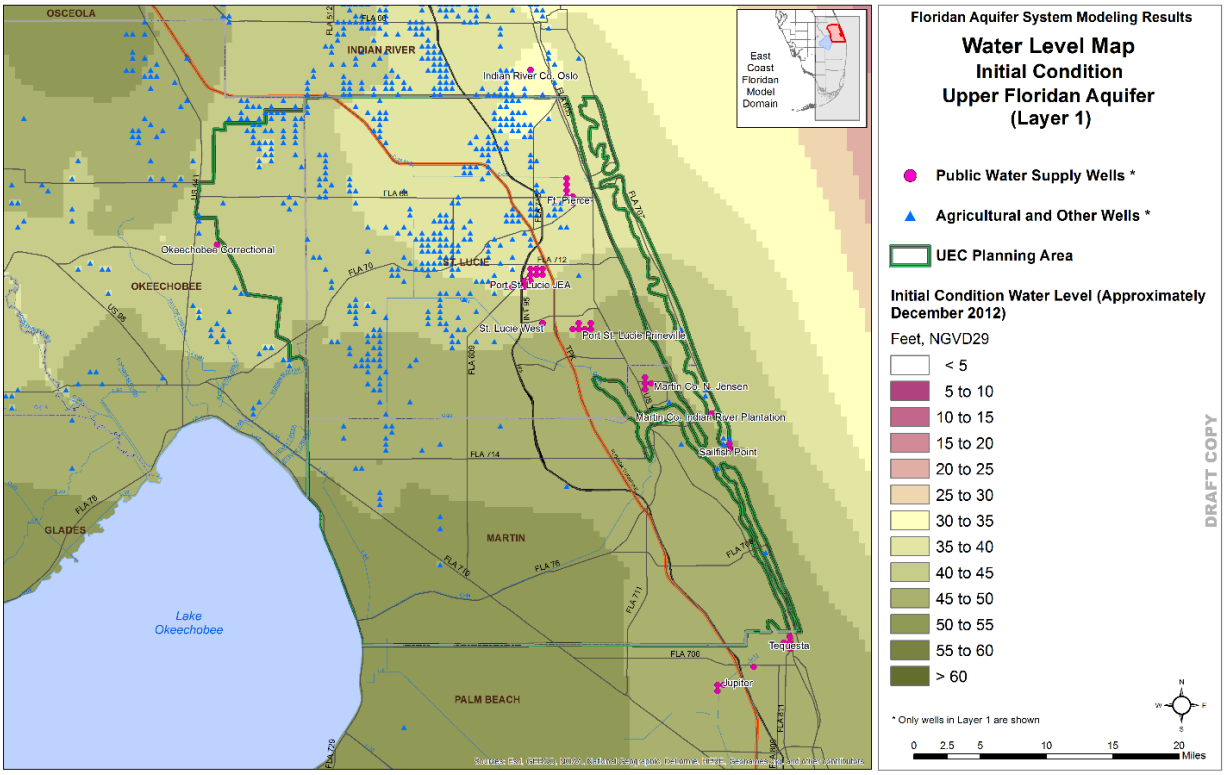


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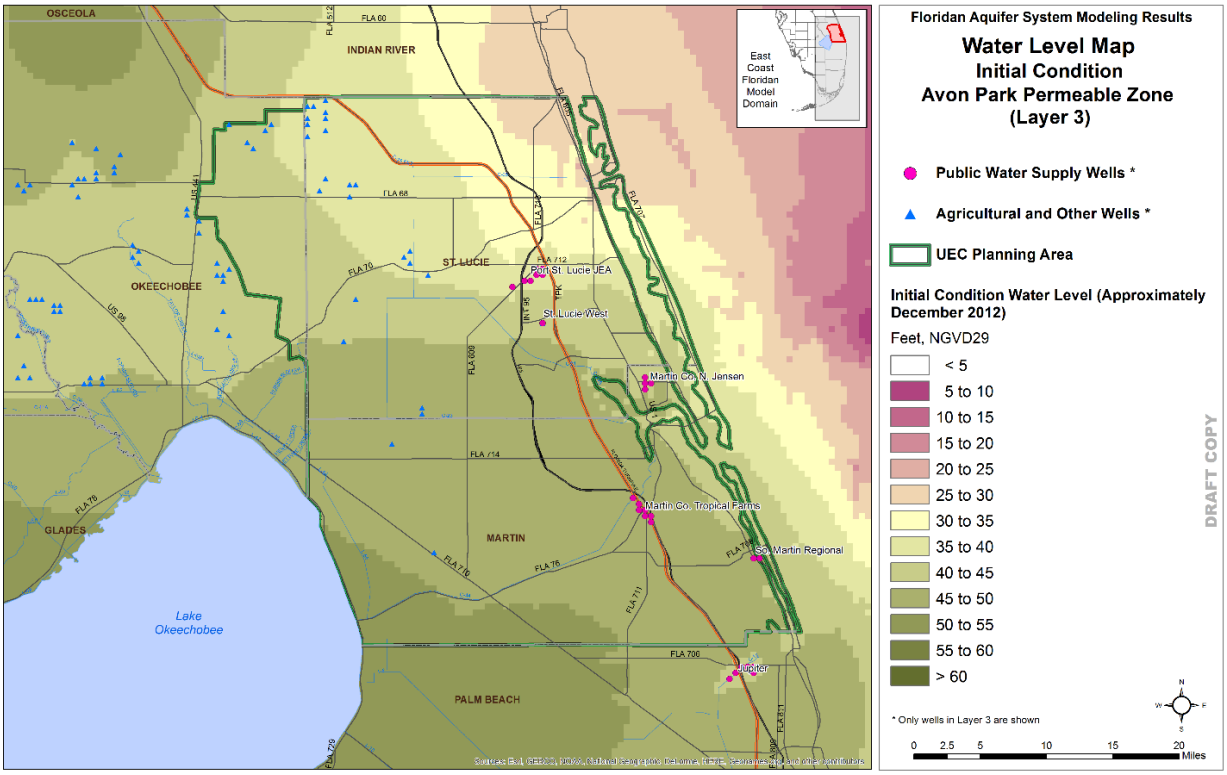


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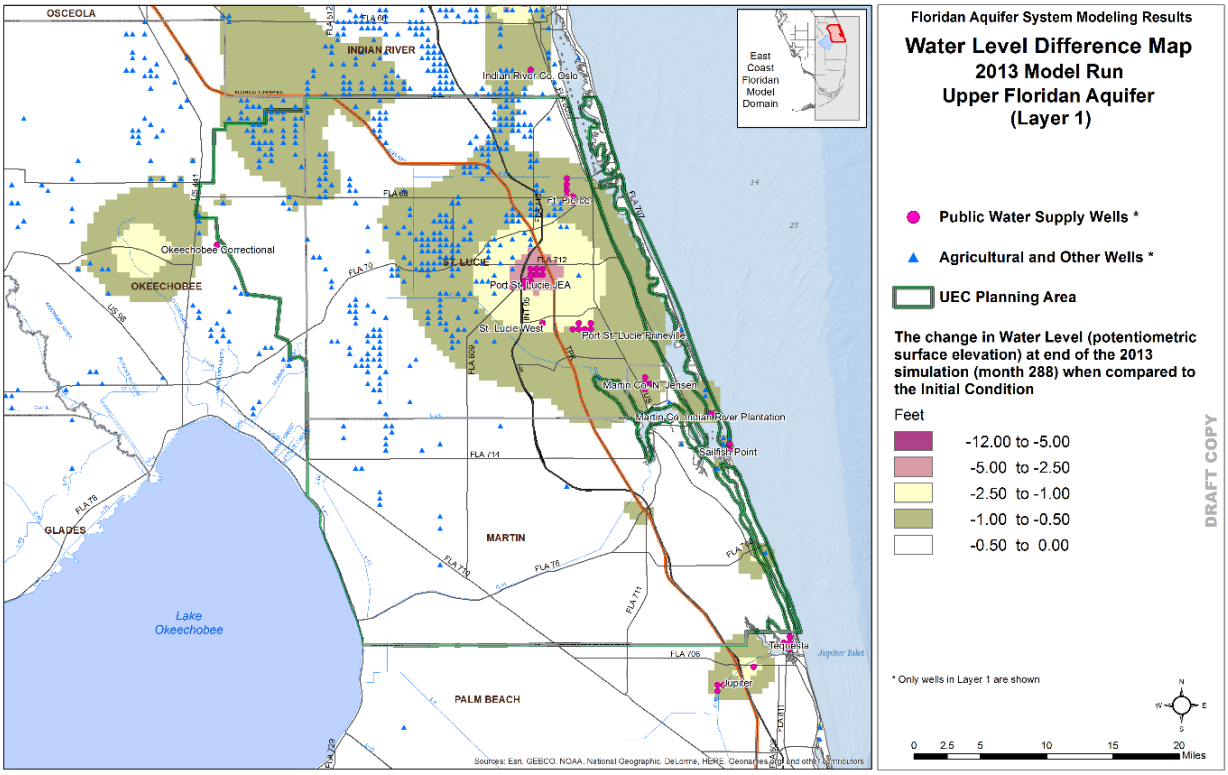
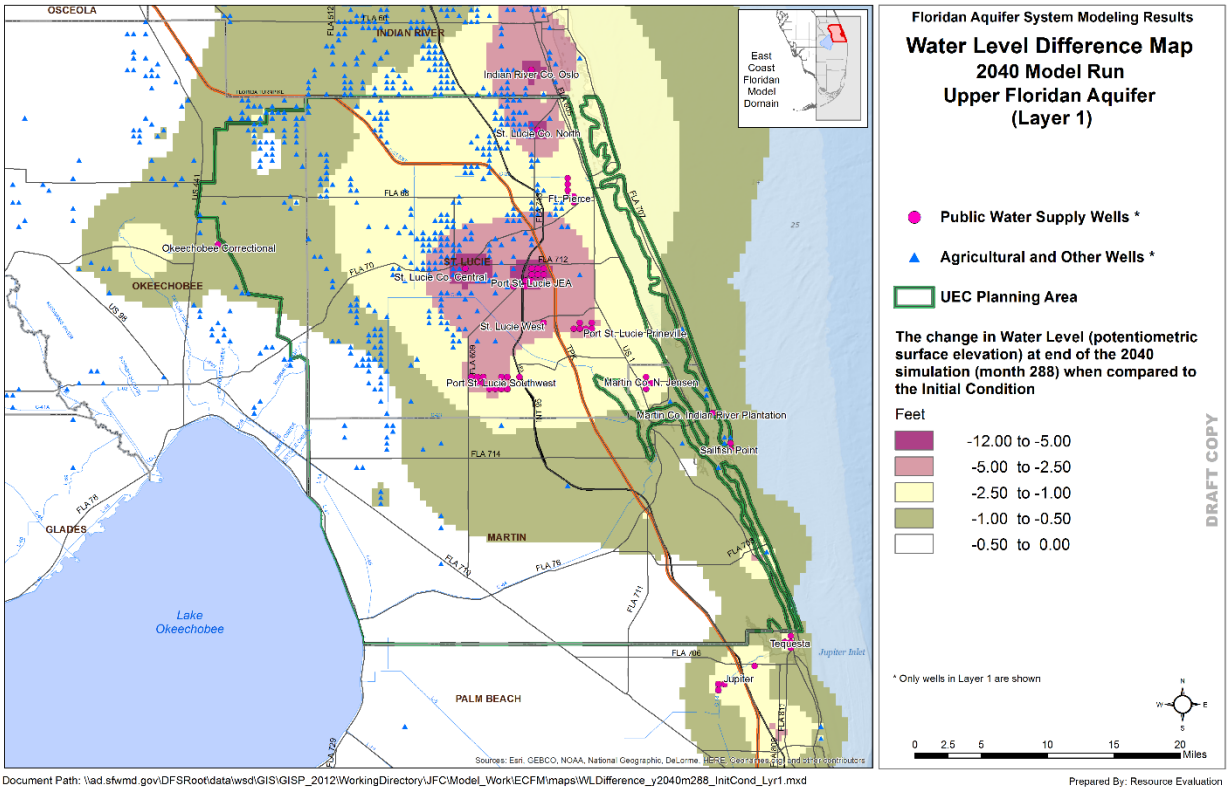
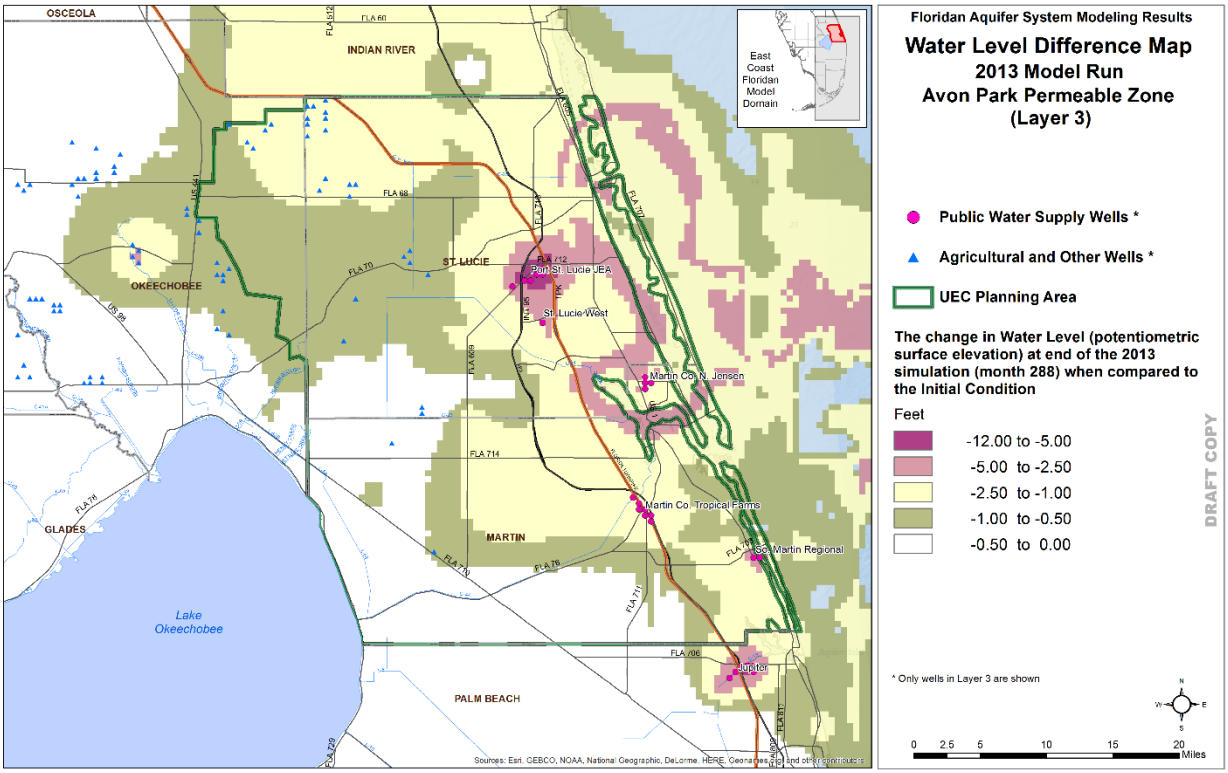
Prepared By: Resource Evaluation

# Water Level Differences



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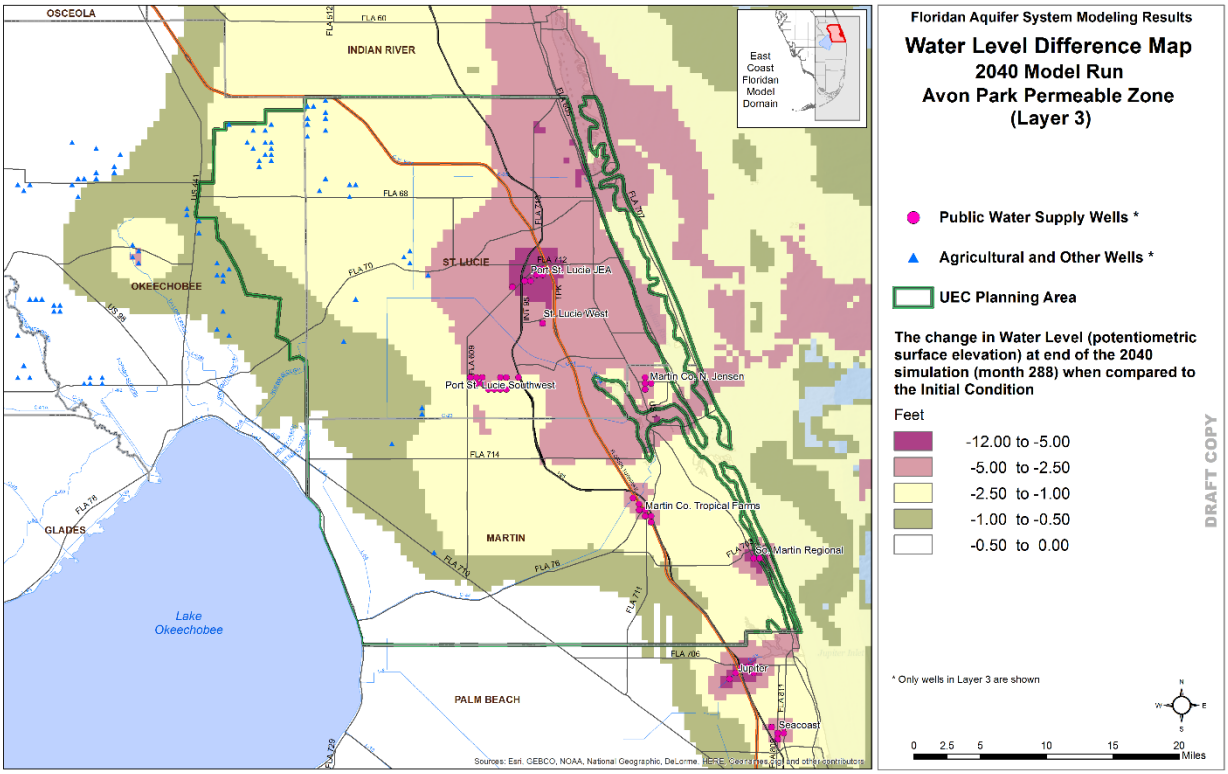


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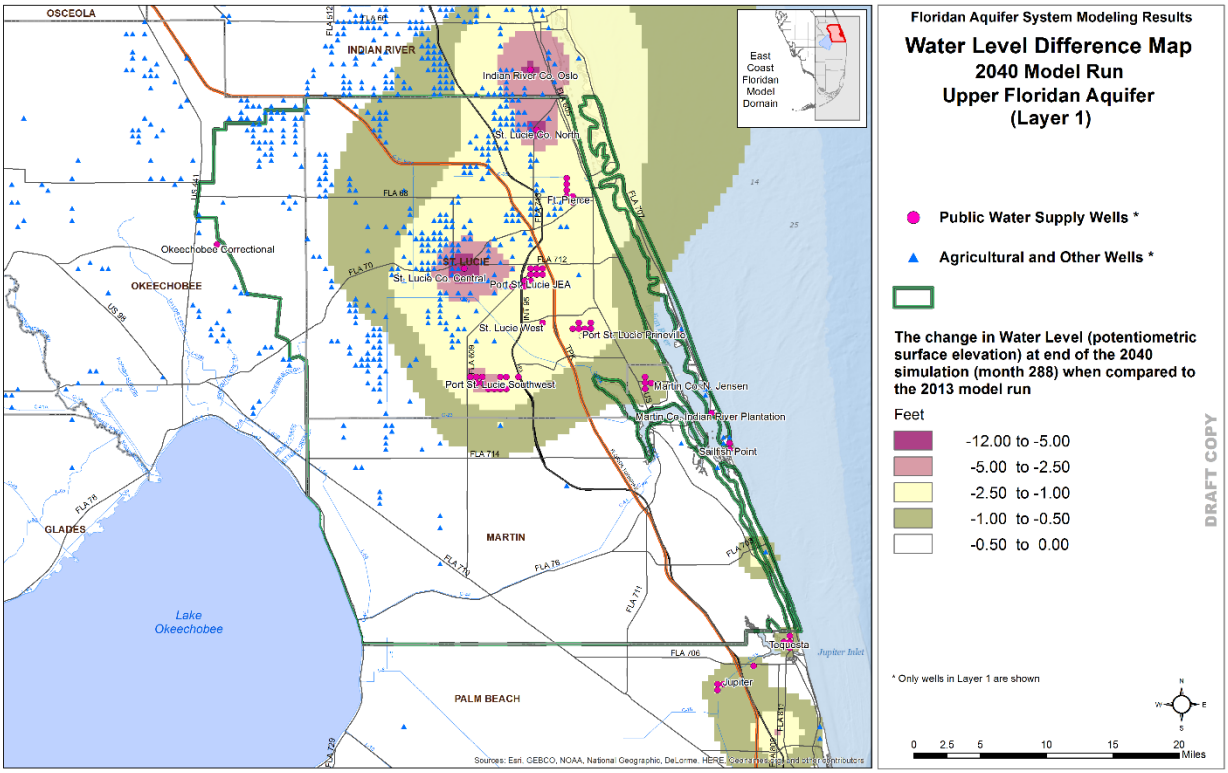


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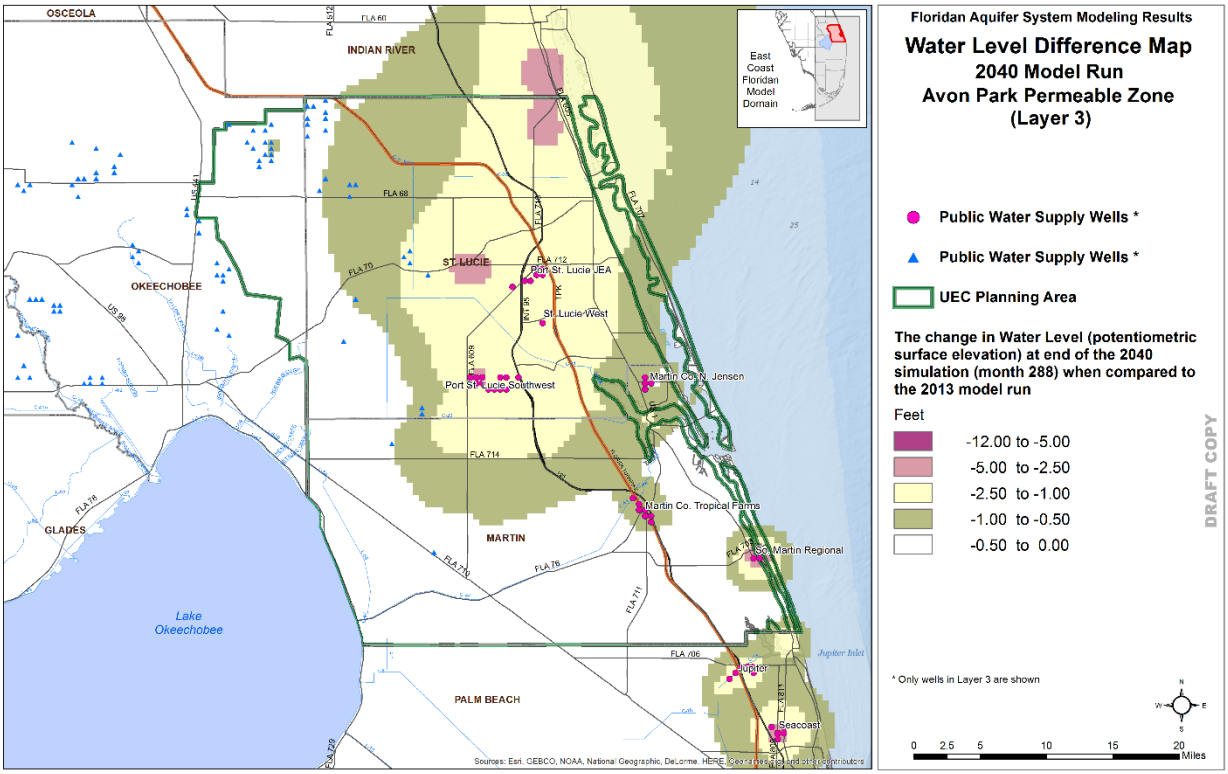


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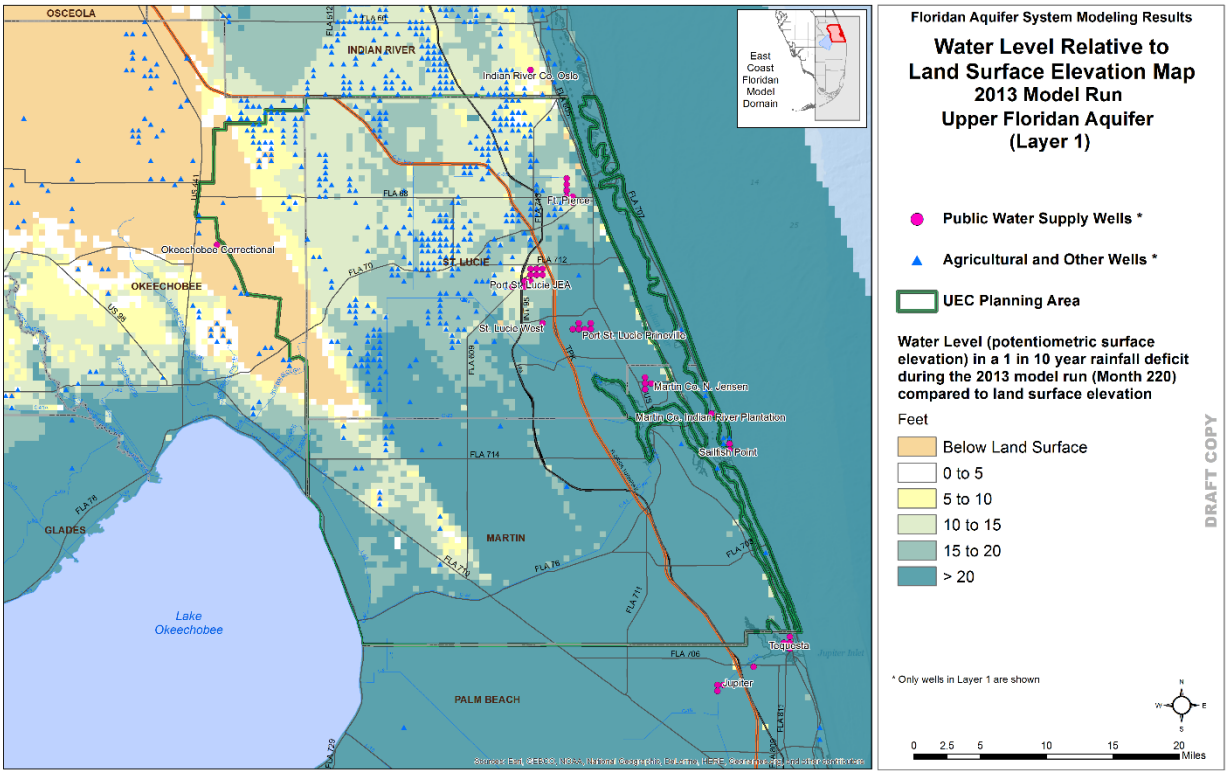
Prepared By: Resource Evaluation

# Water Level Minus Land Surface Elevation

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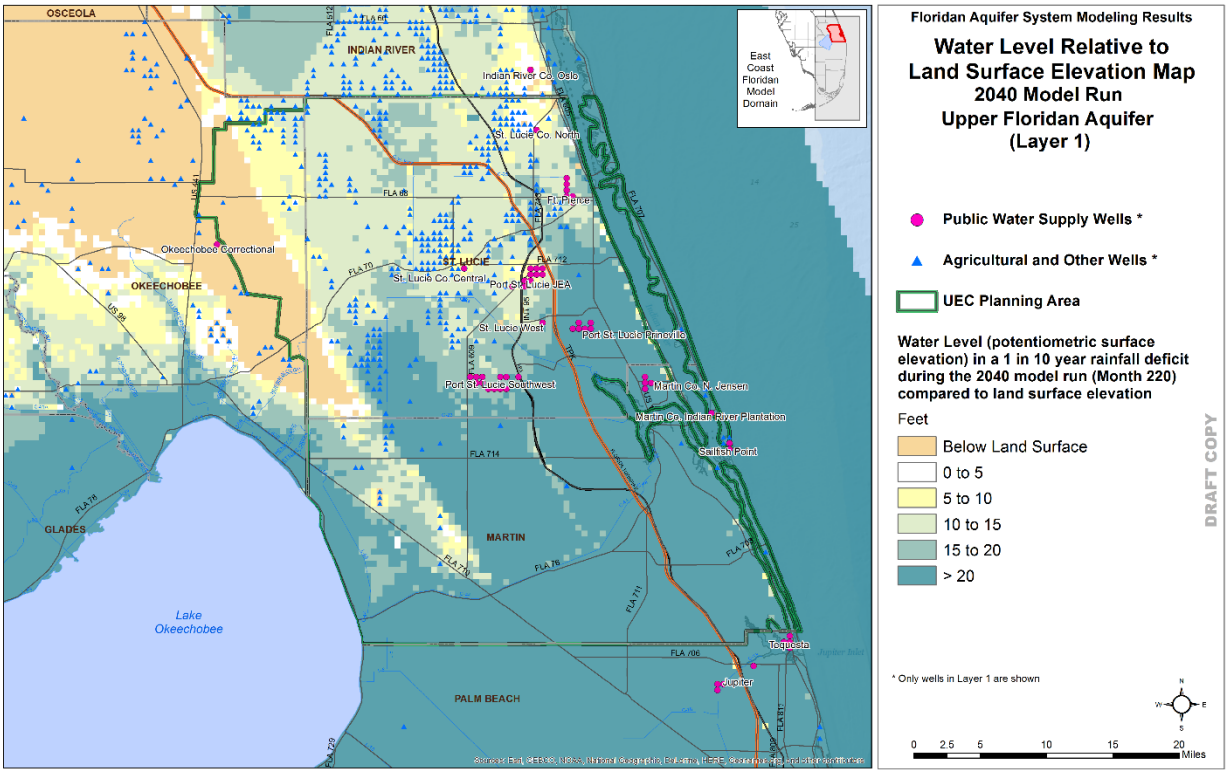


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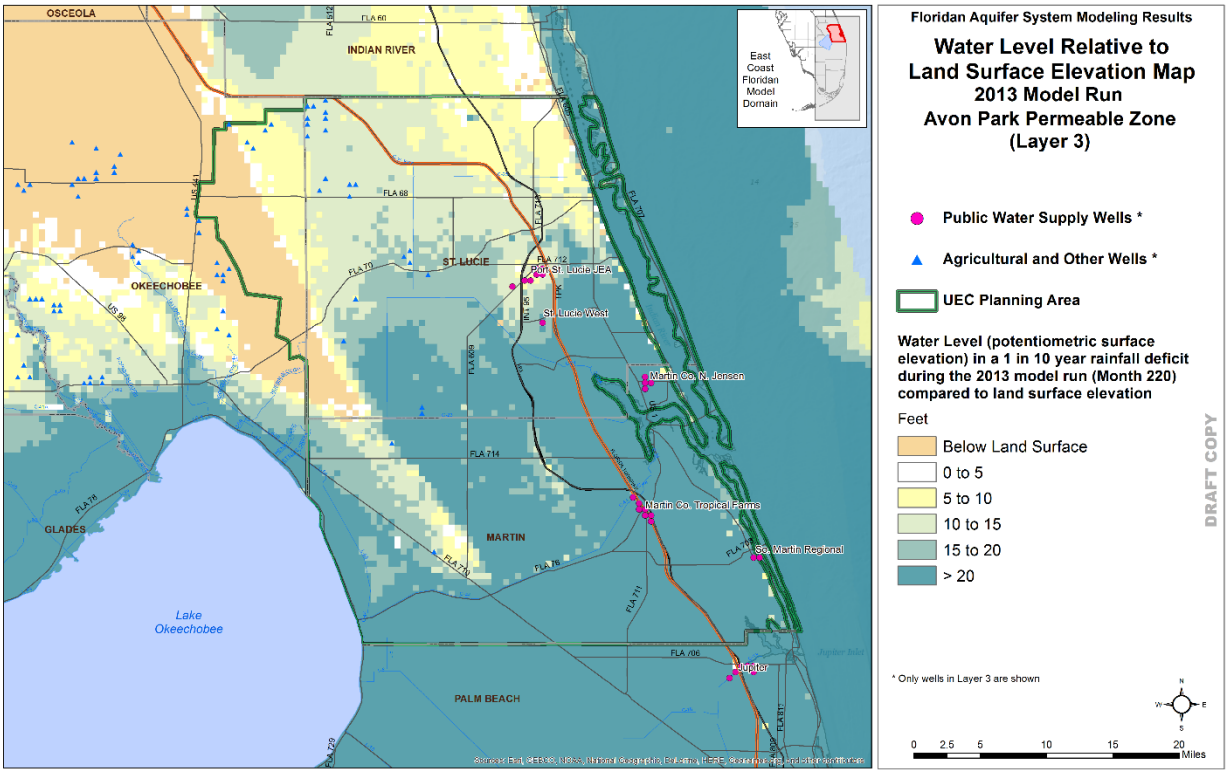


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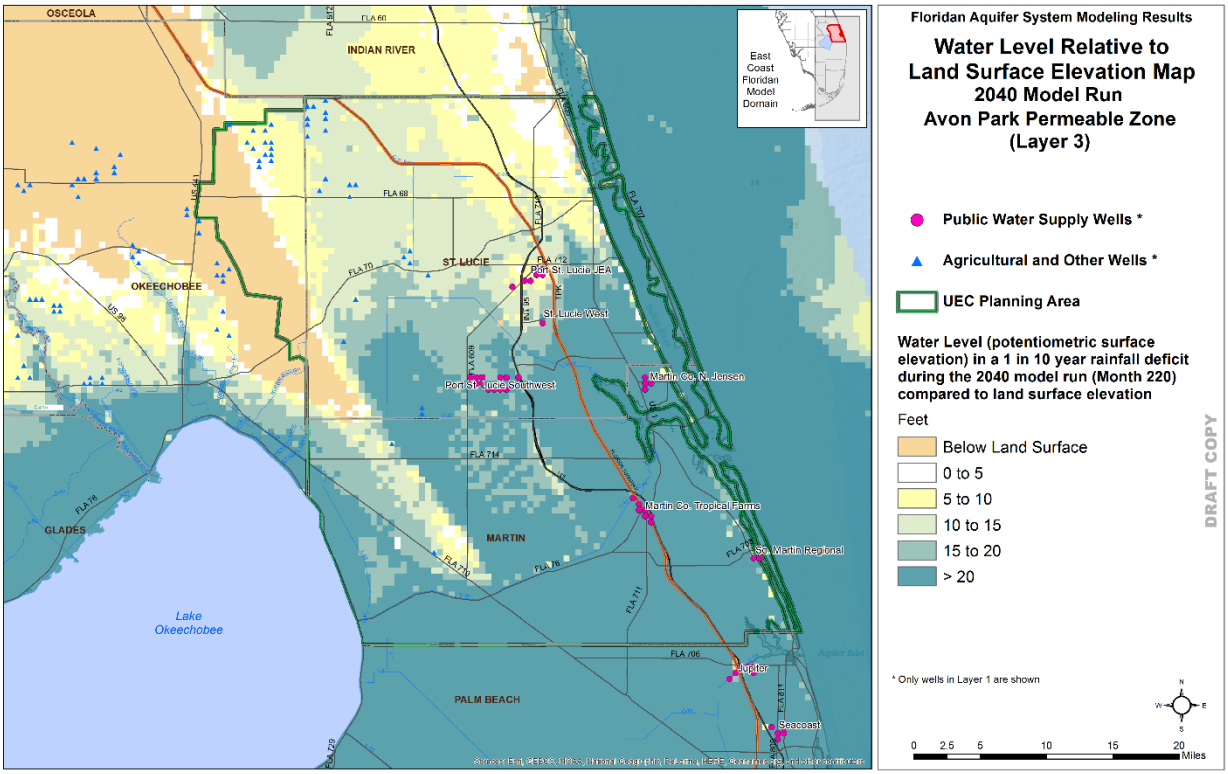


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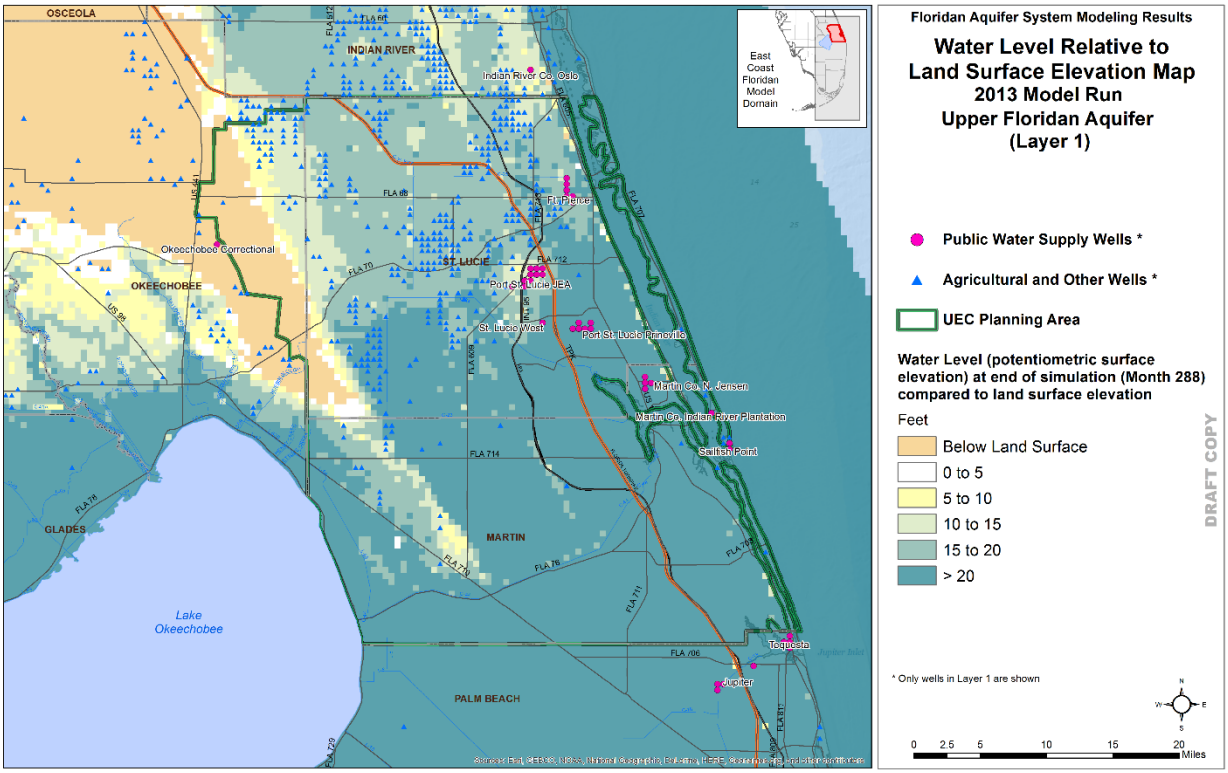


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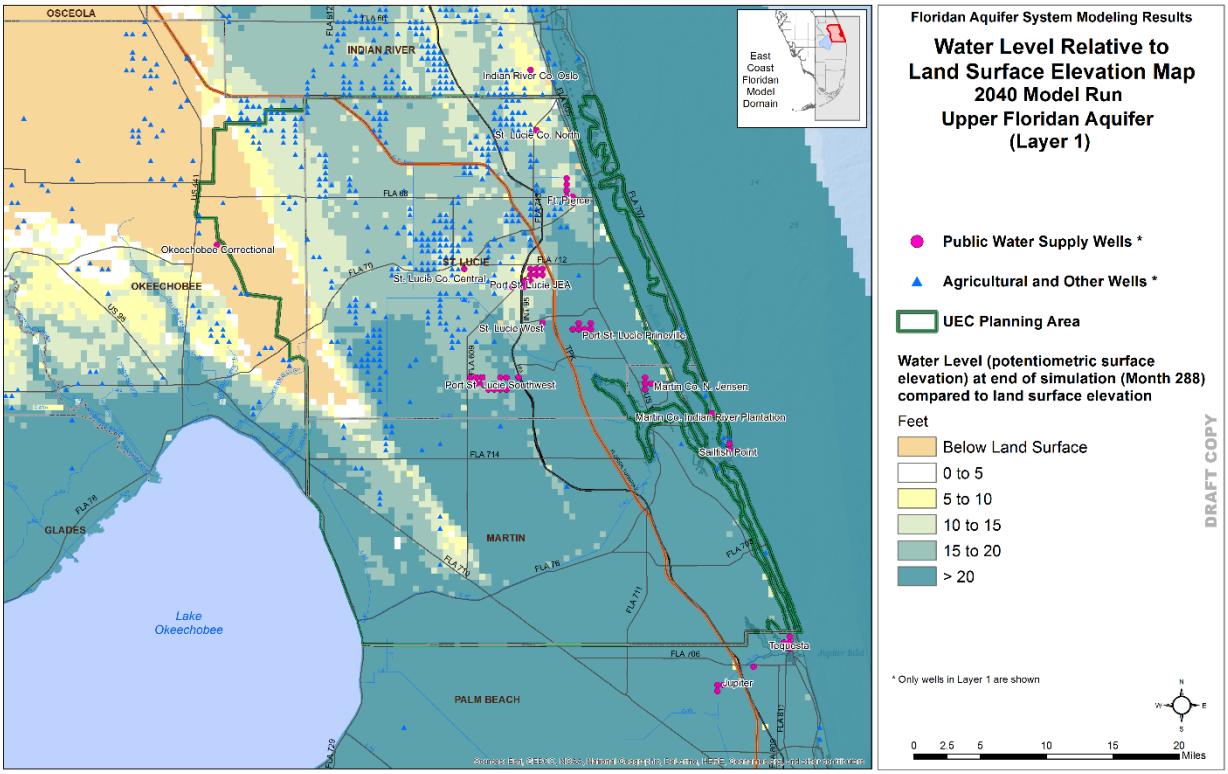


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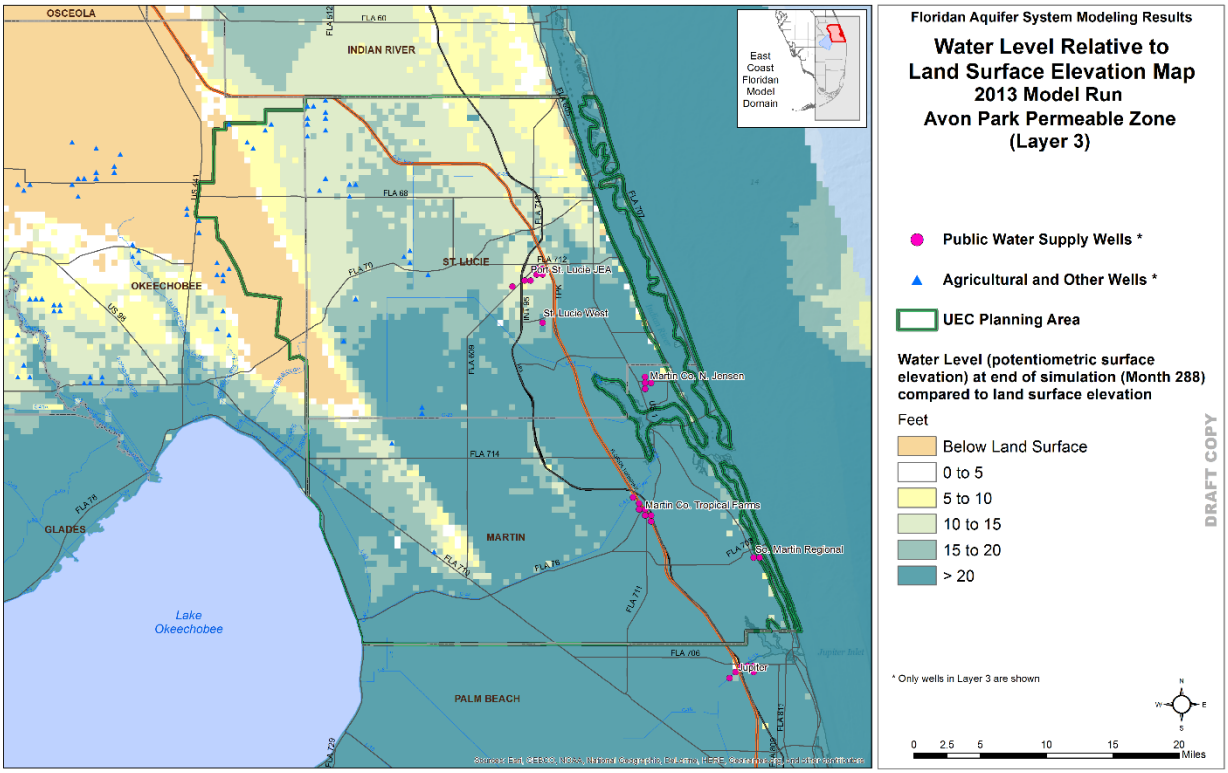


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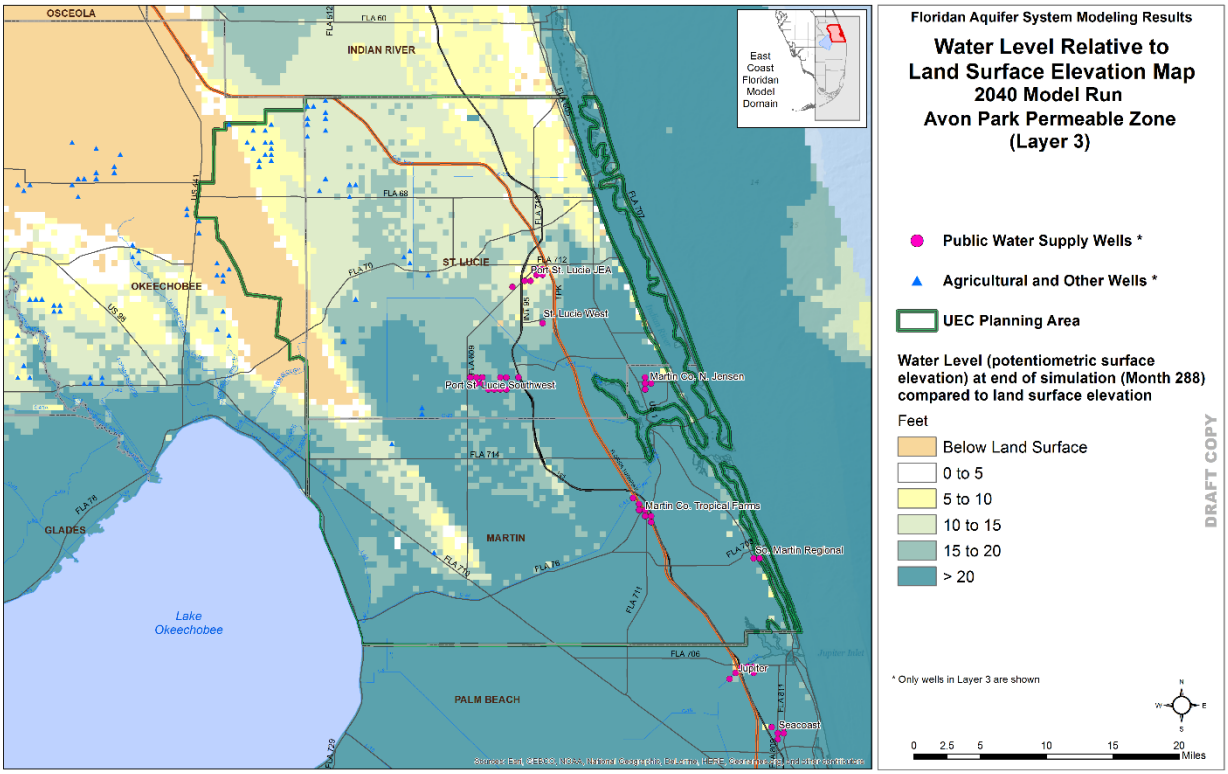


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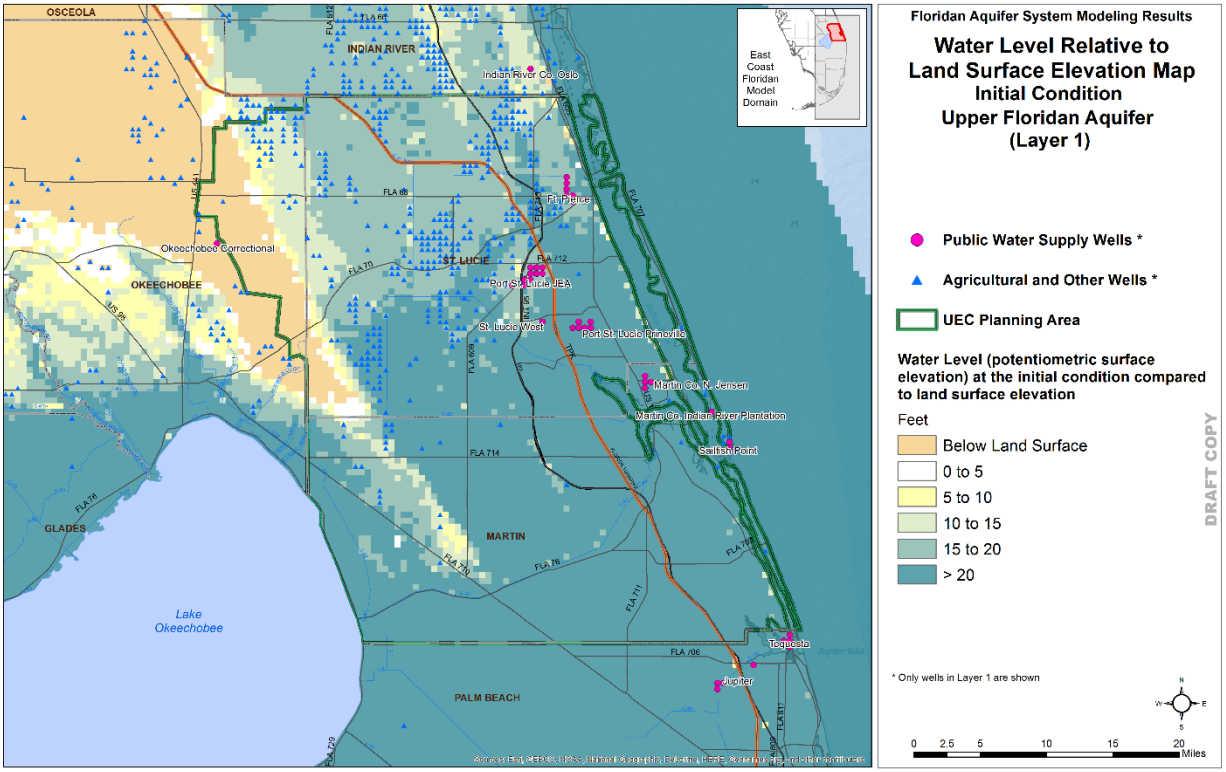


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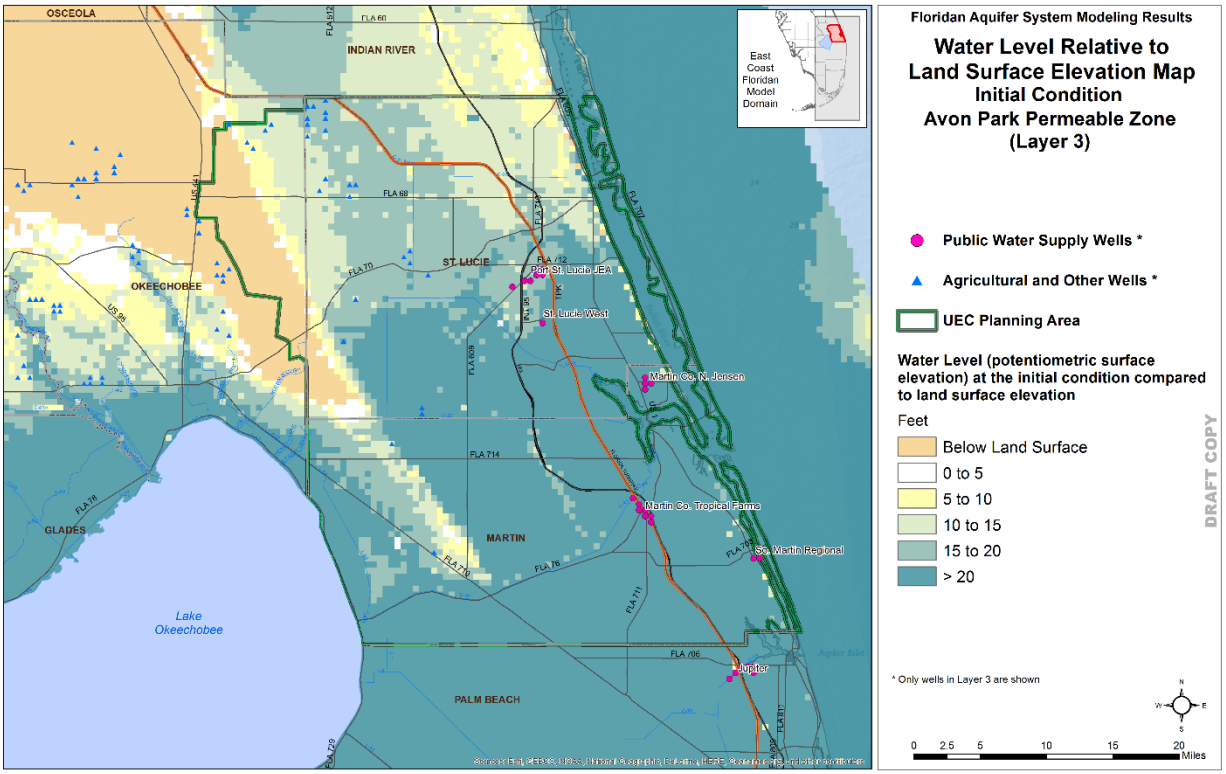


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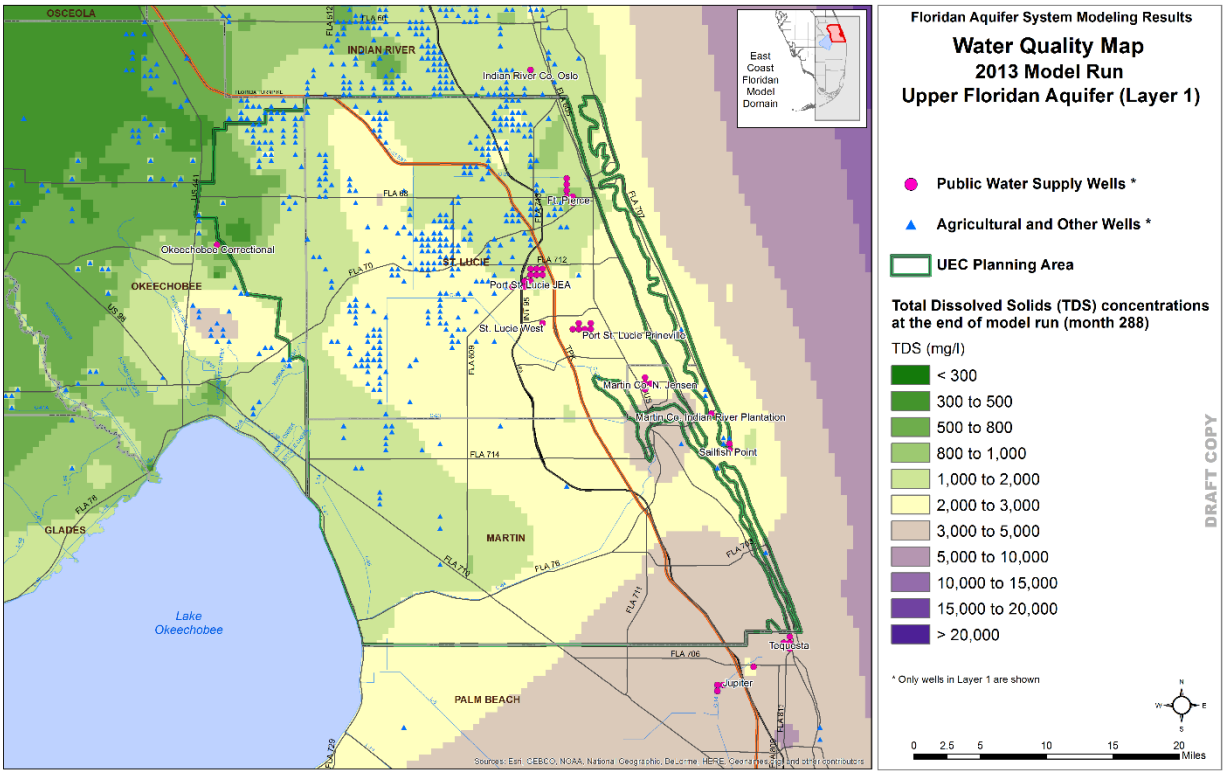
# Water Quality

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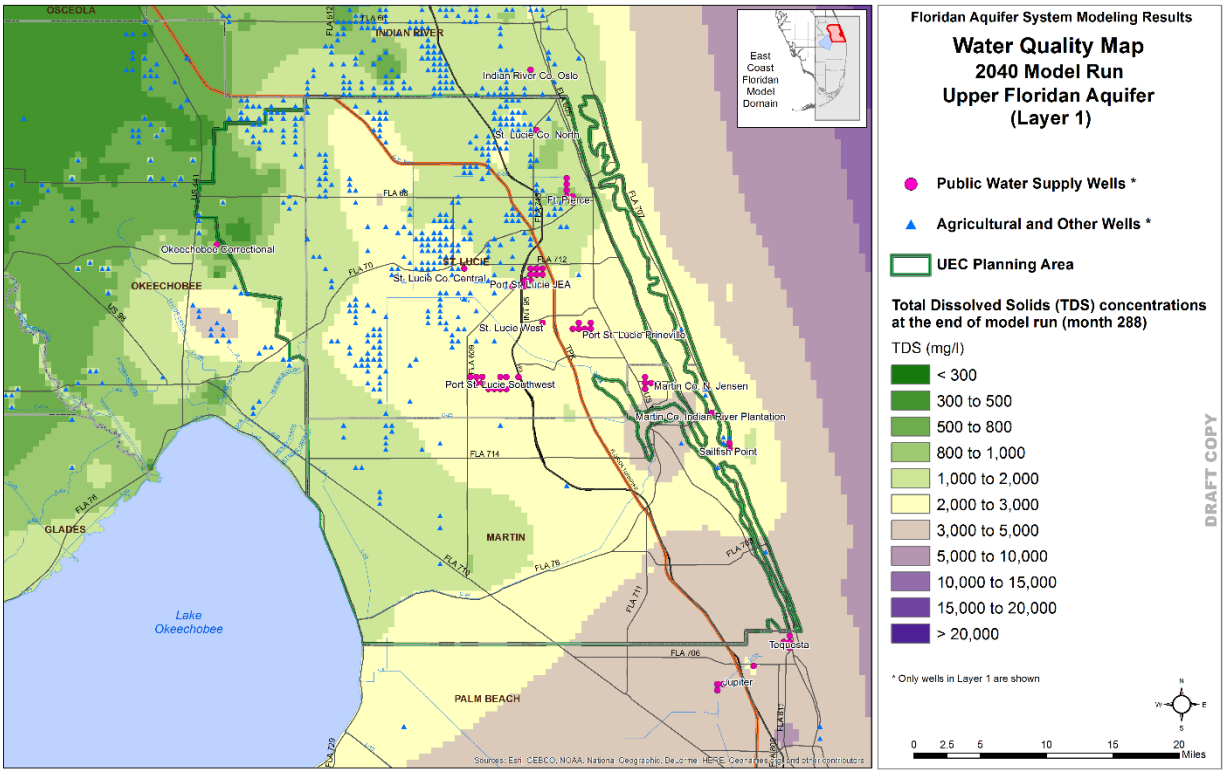


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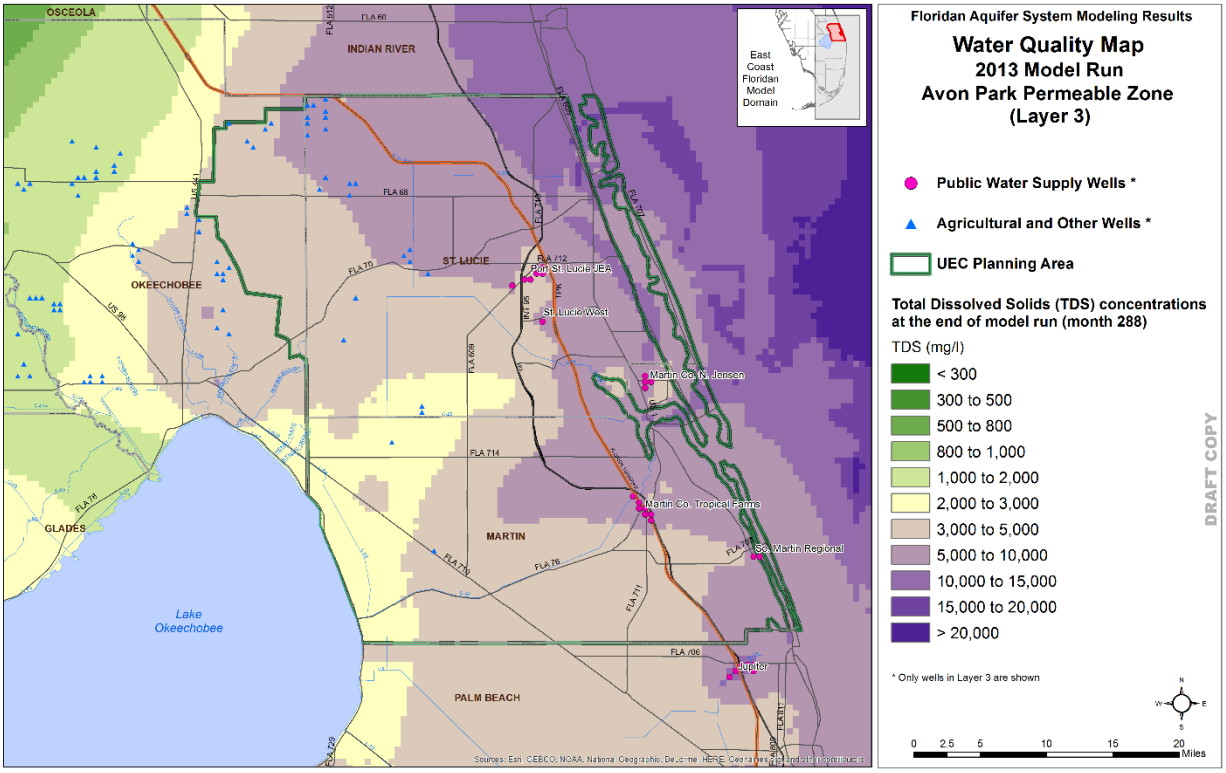


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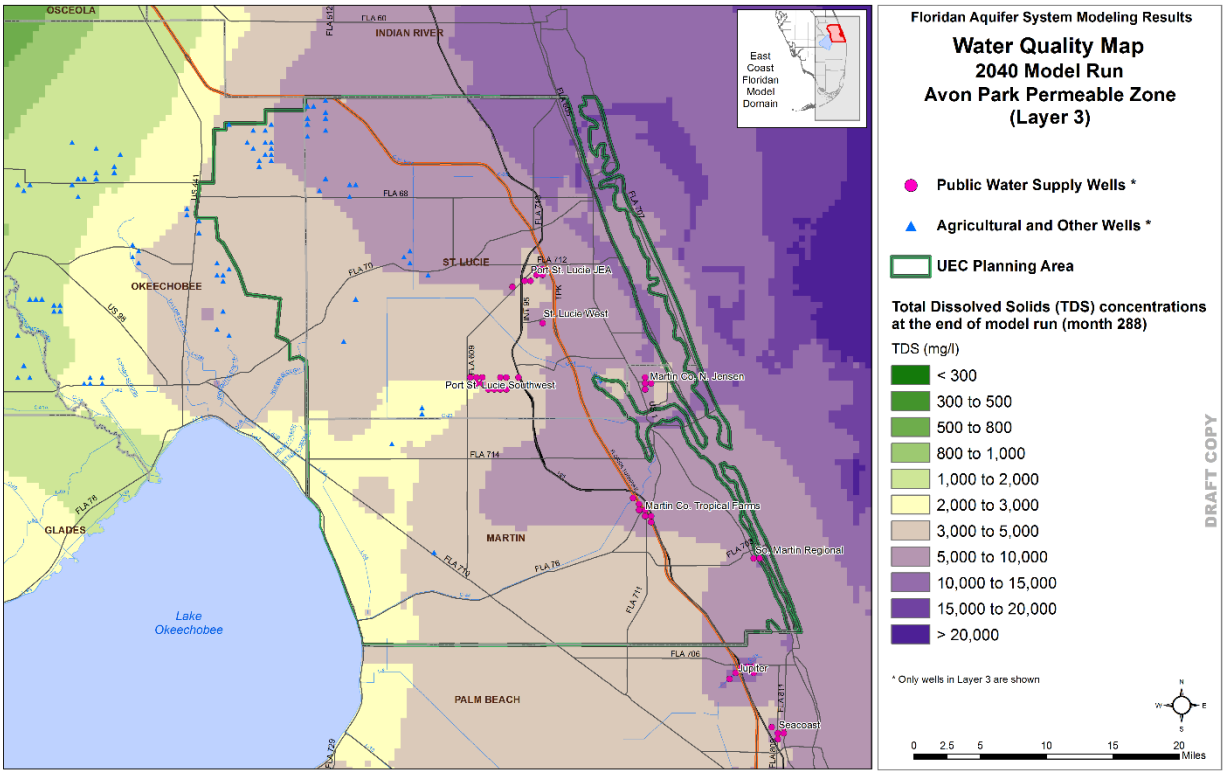


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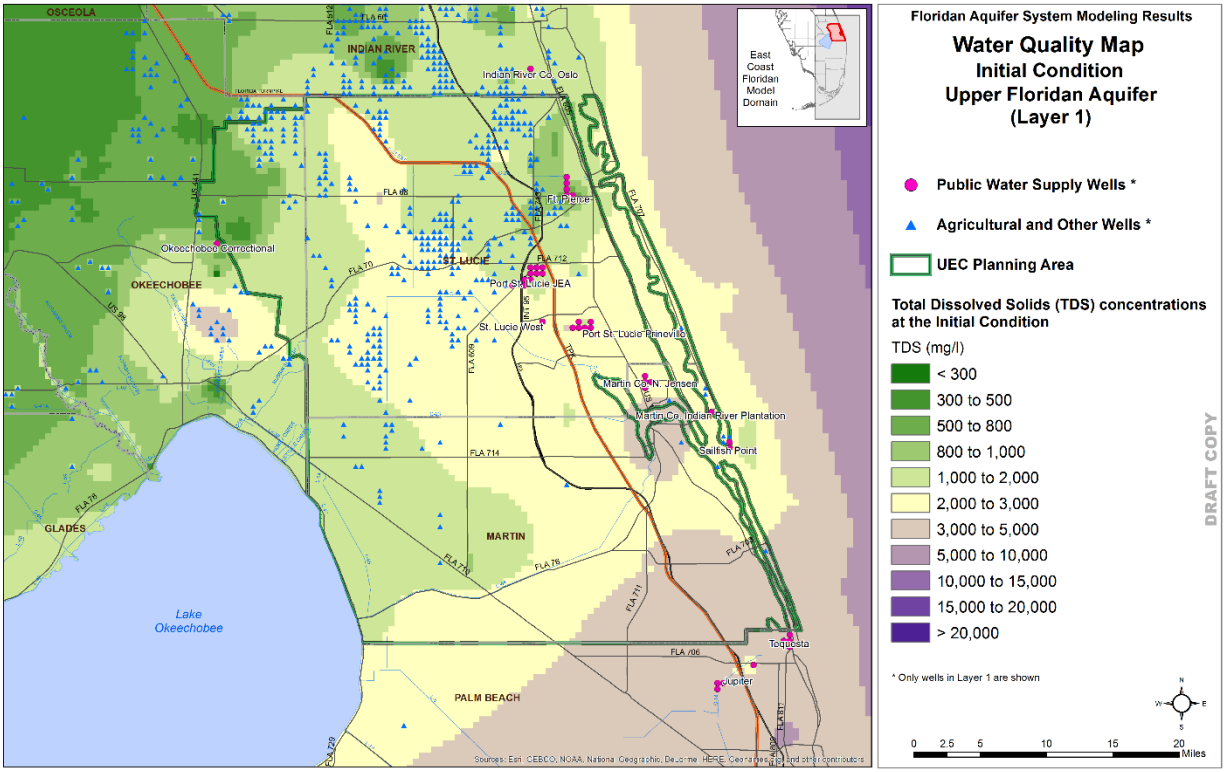


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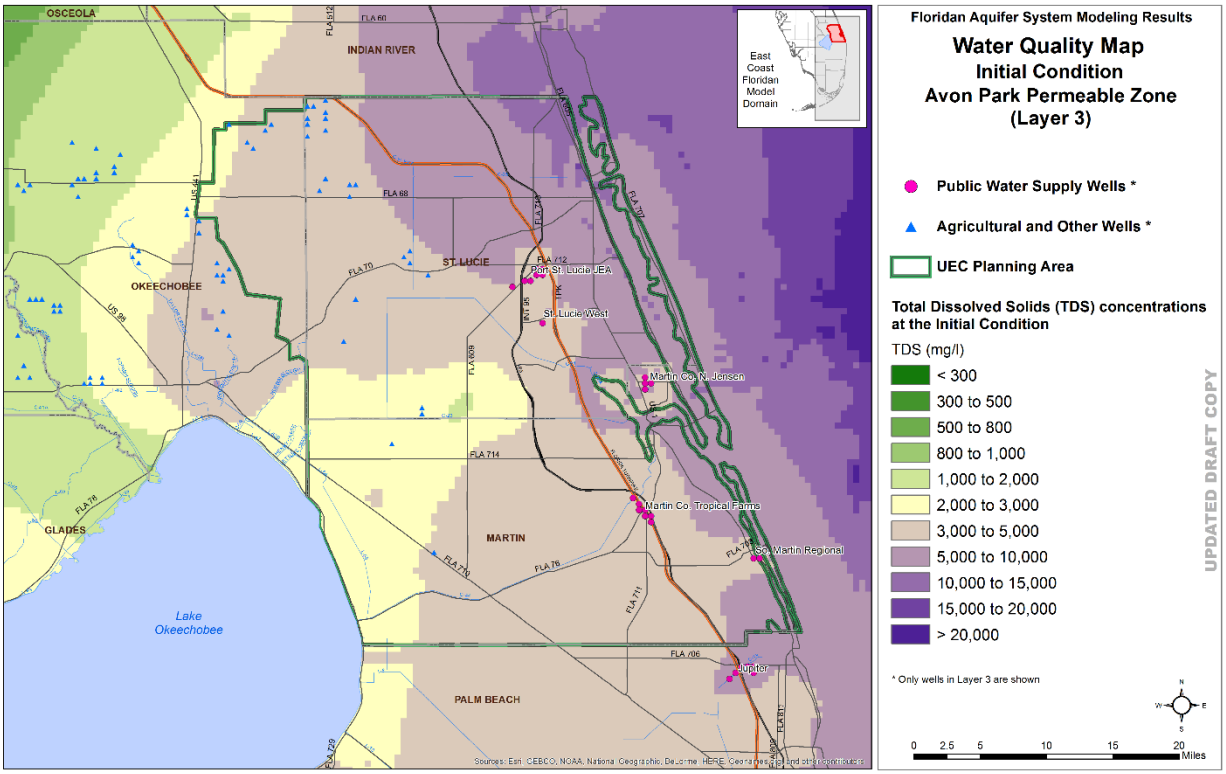


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Prepared By: Resource Evaluation

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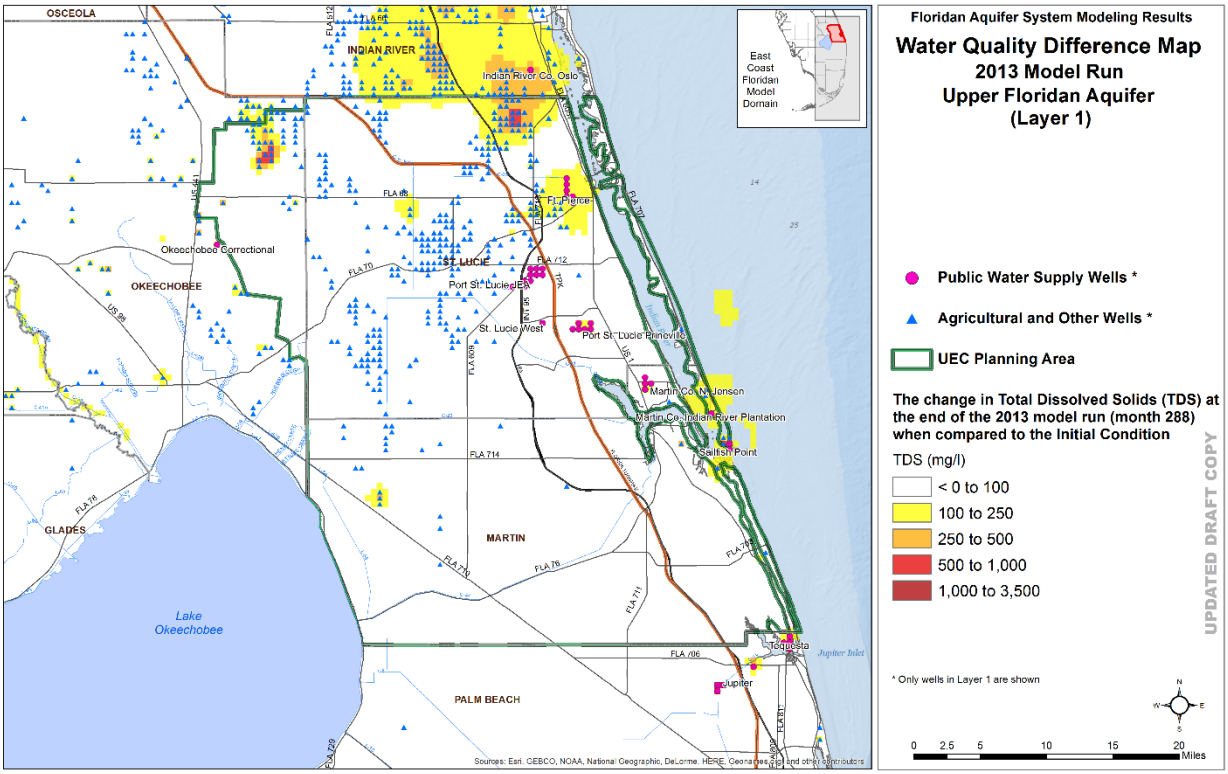


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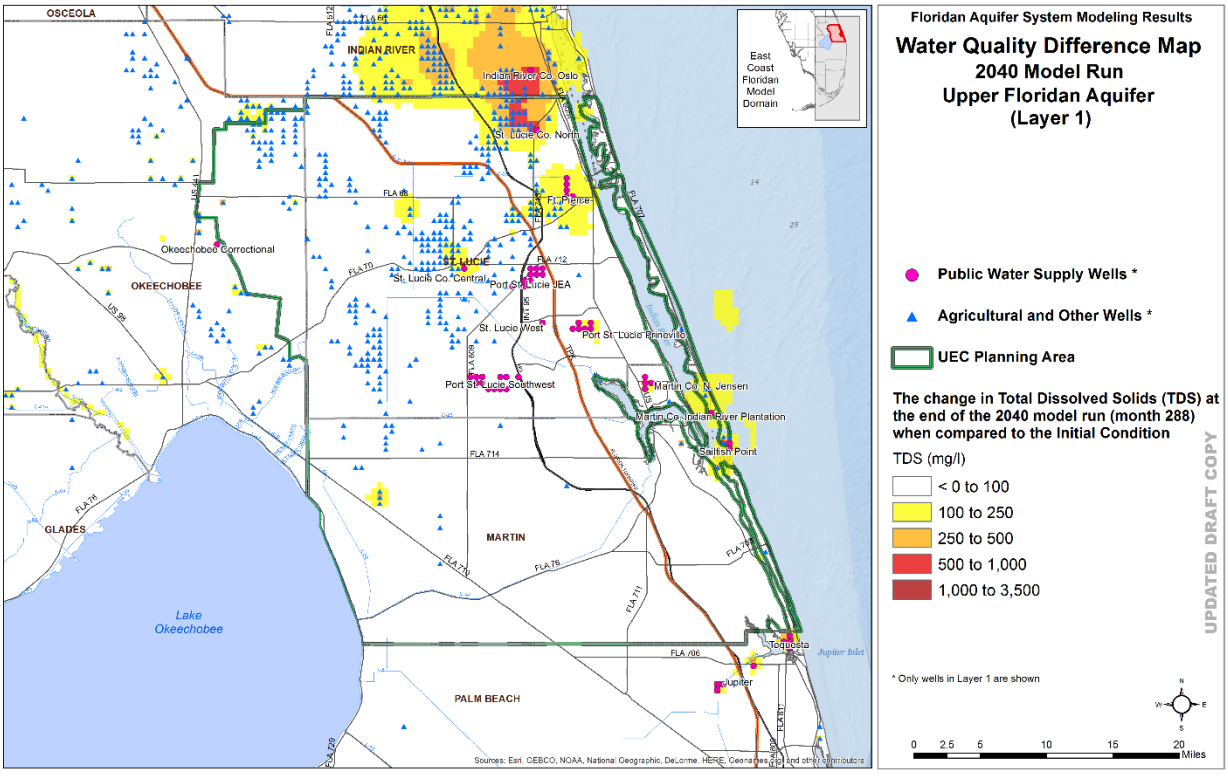


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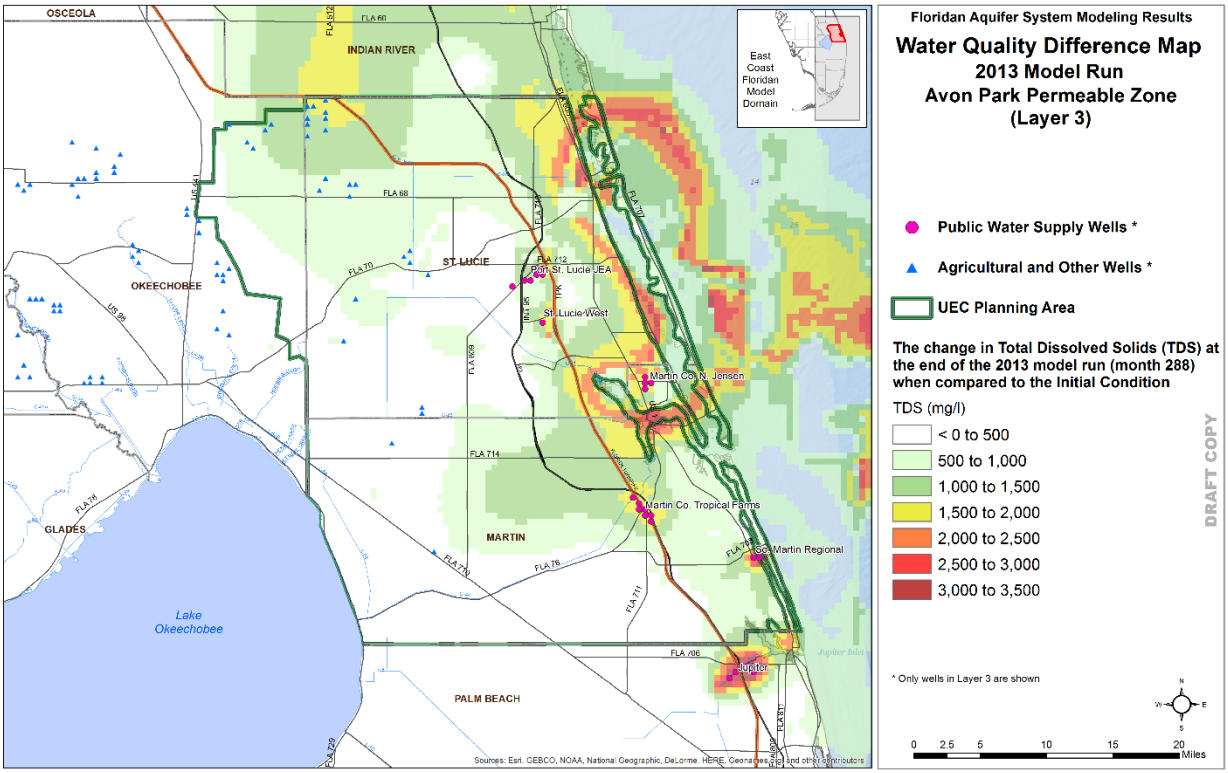


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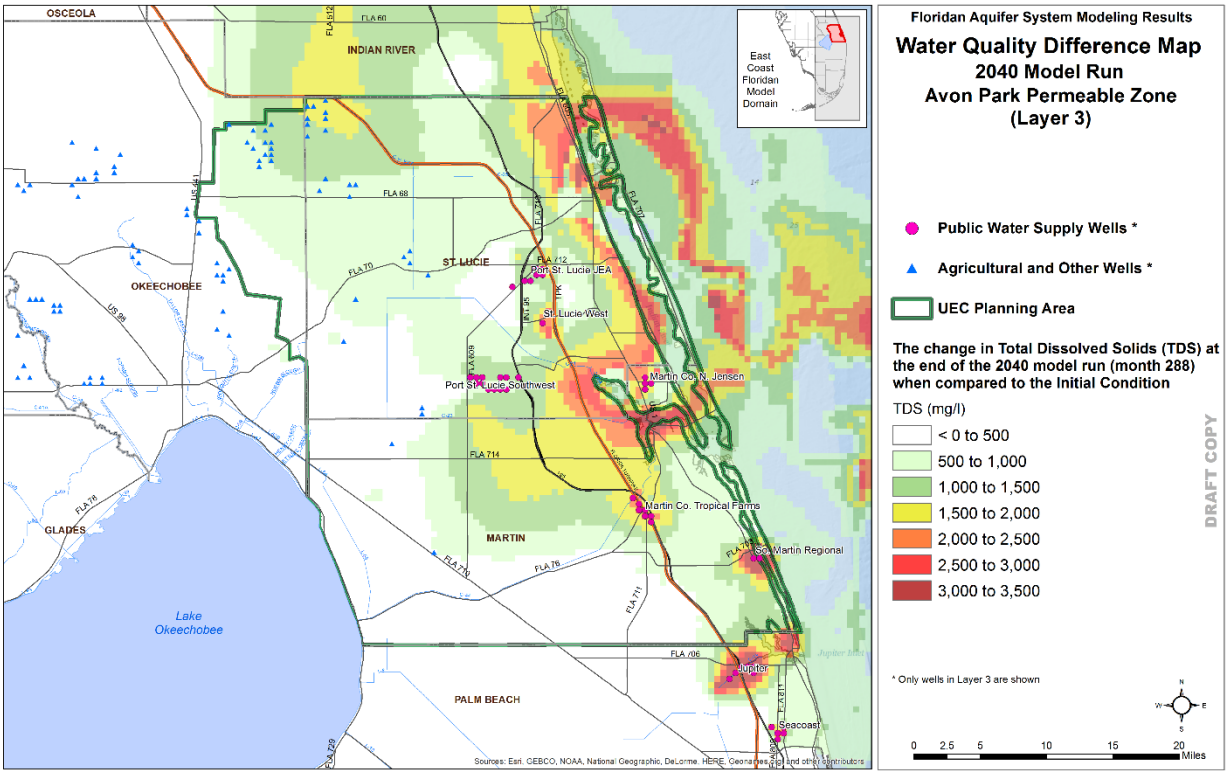


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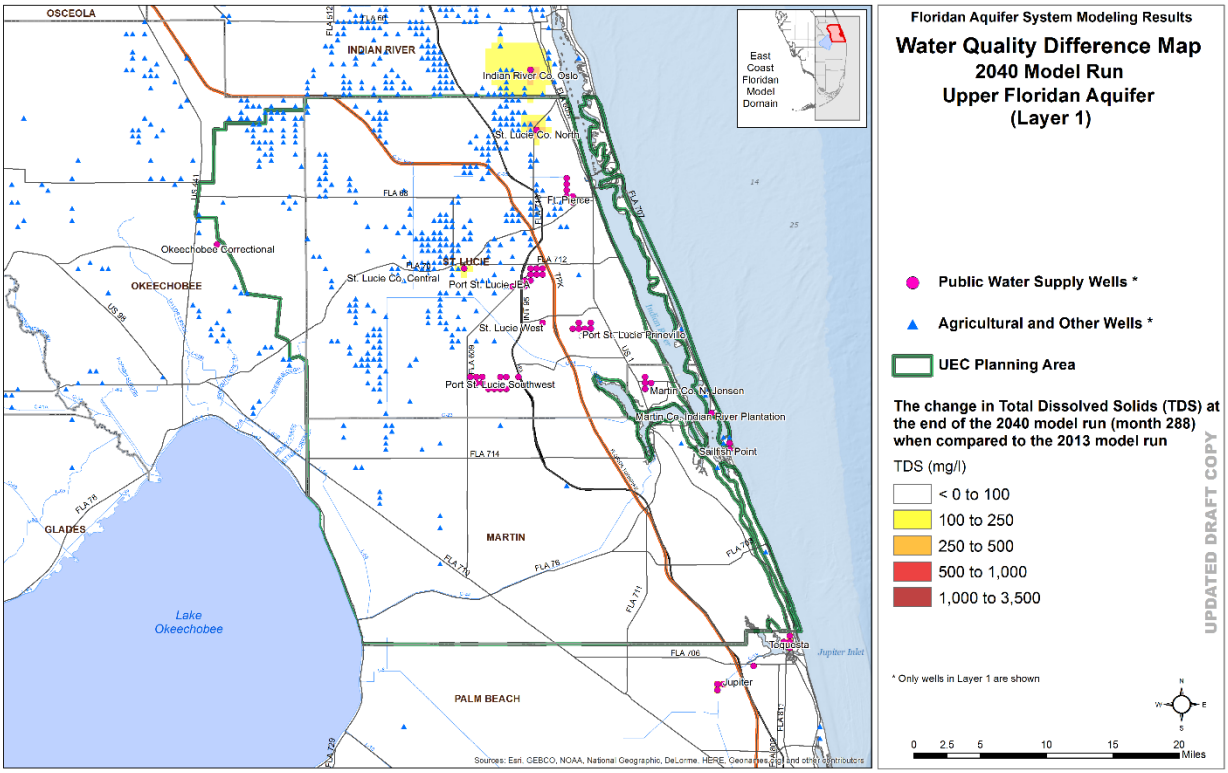


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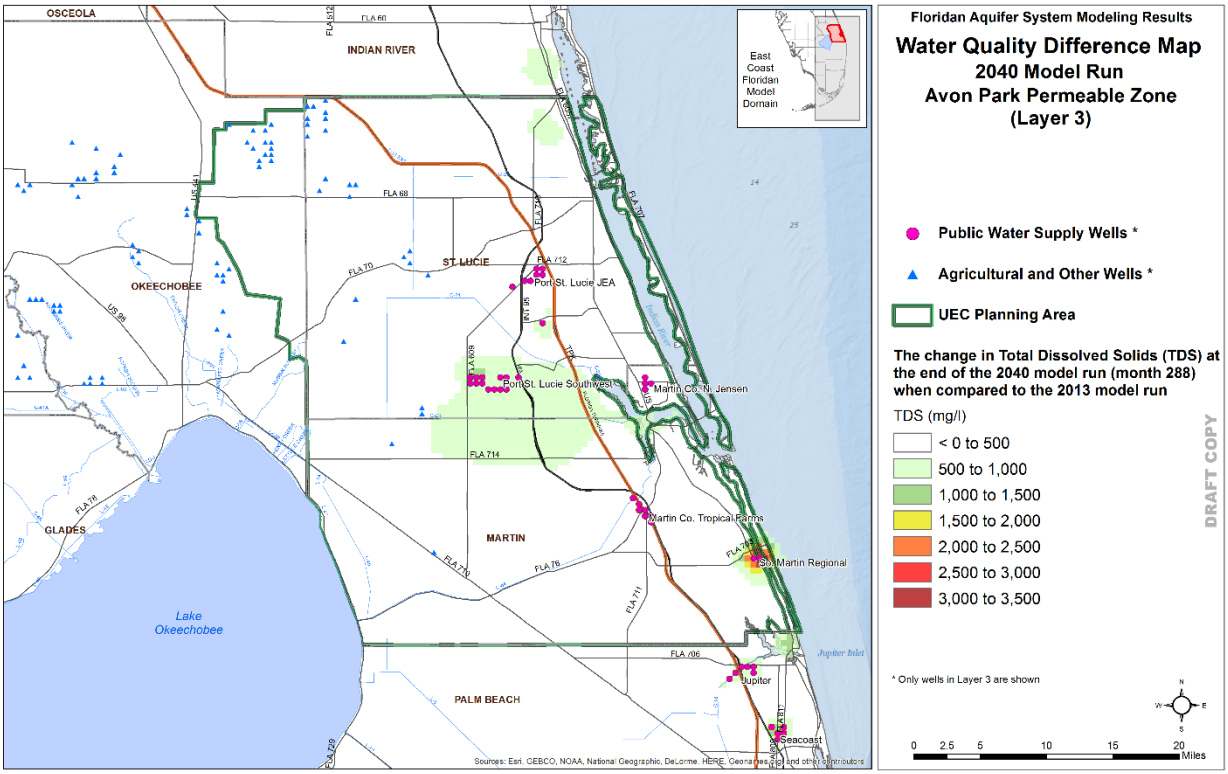


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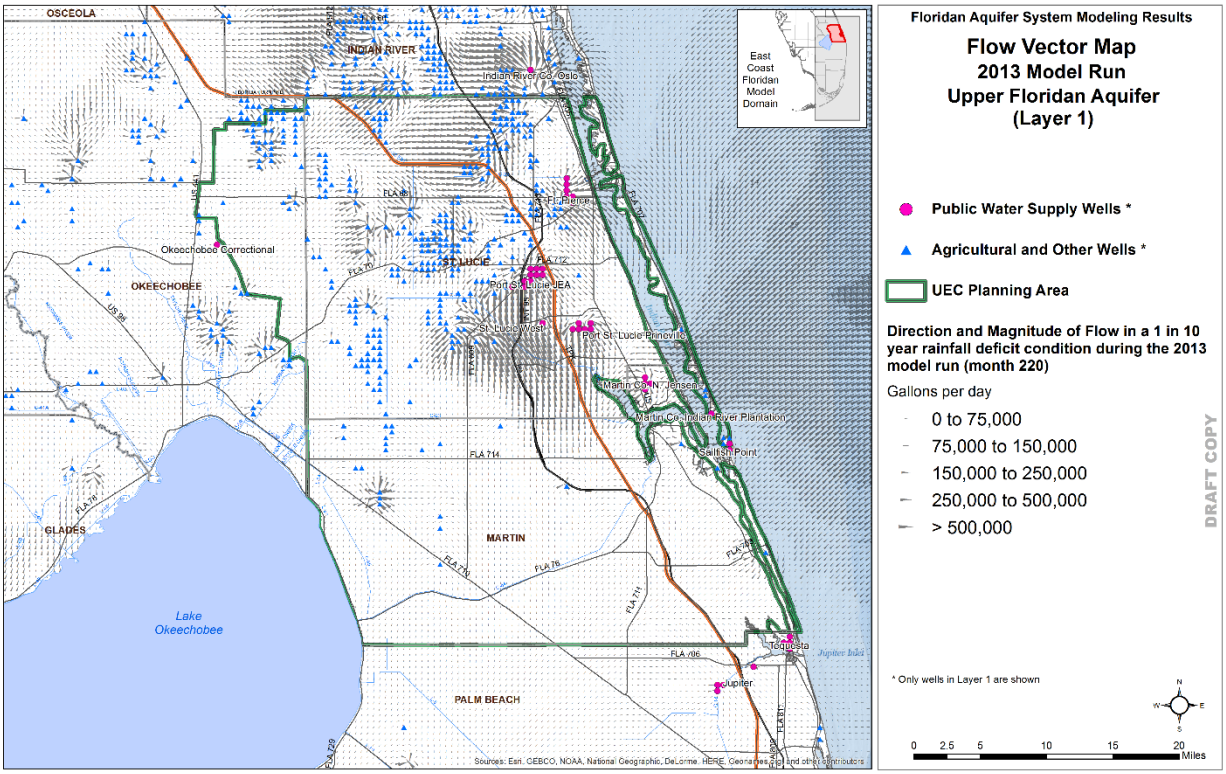
Prepared By: Resource Evaluation

# Flow Vectors

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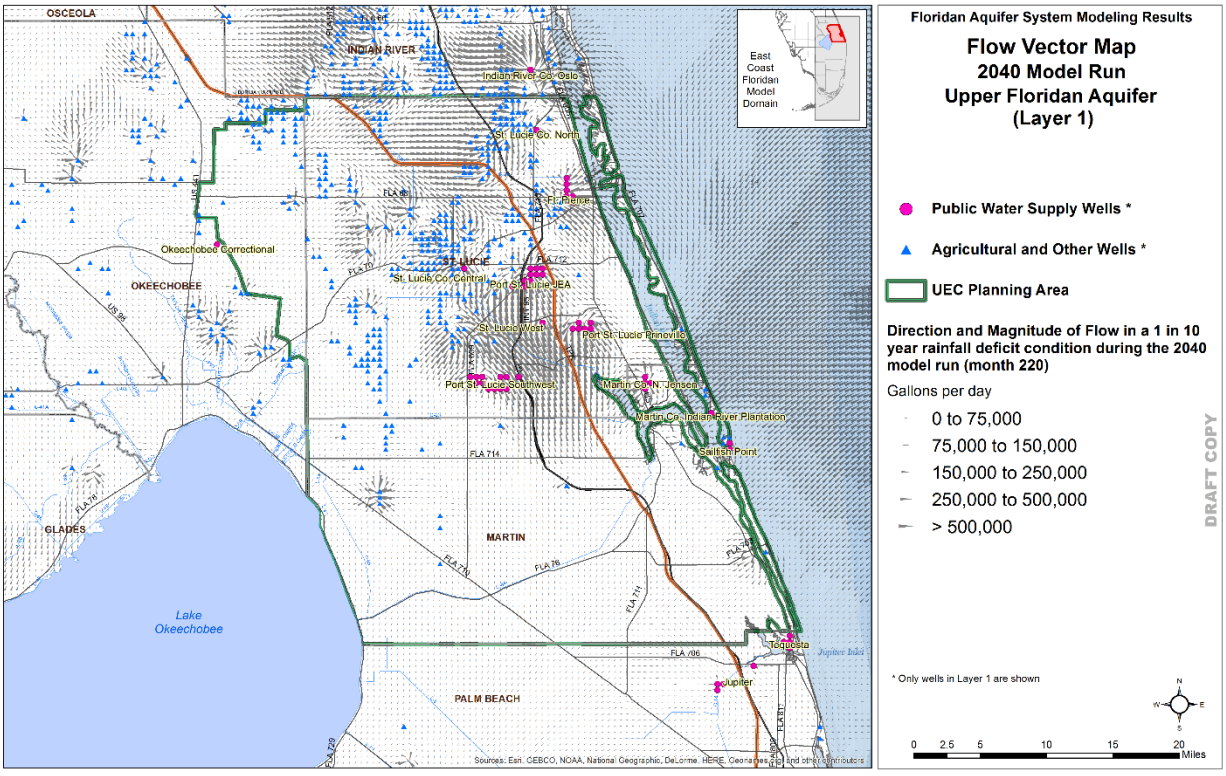


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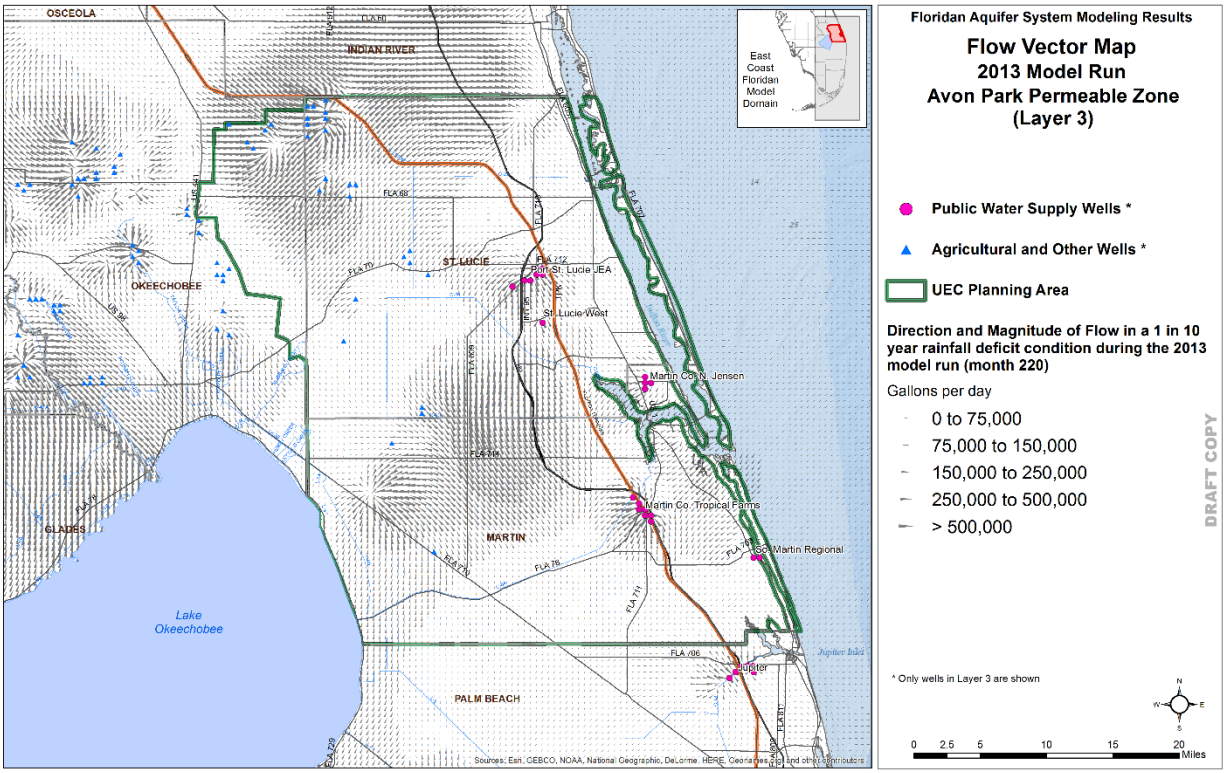


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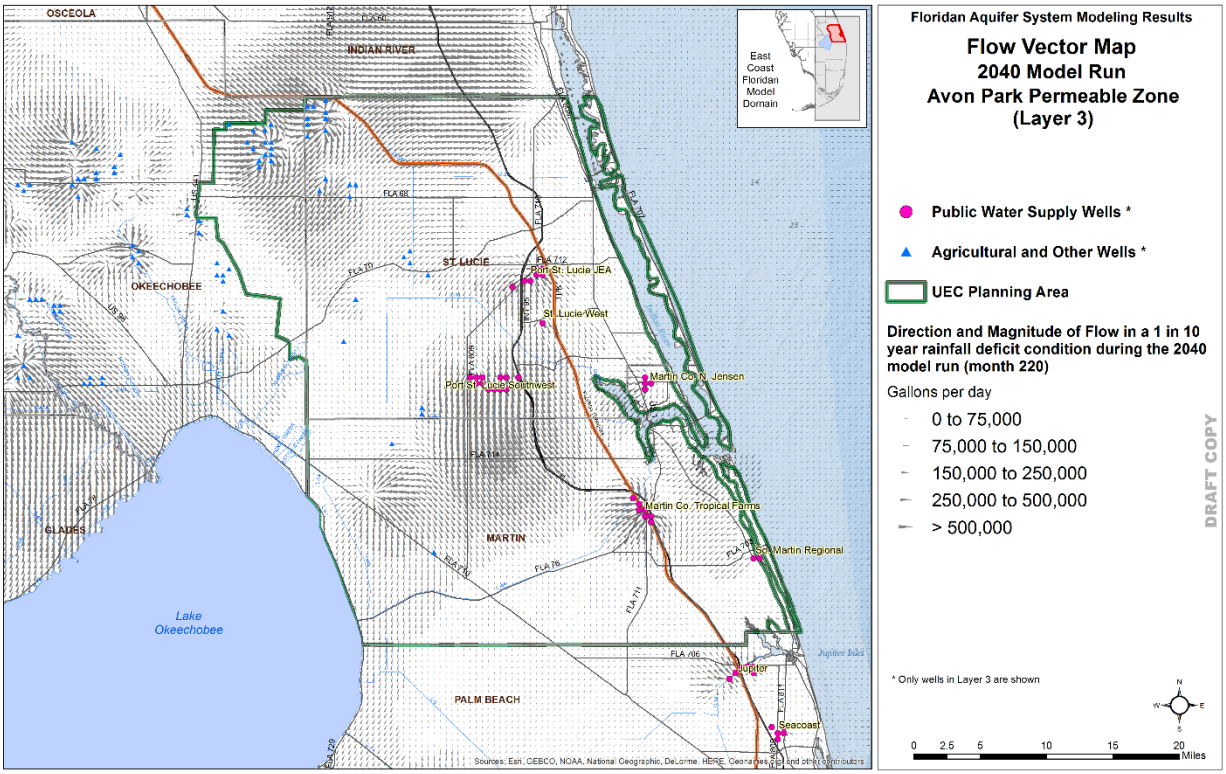


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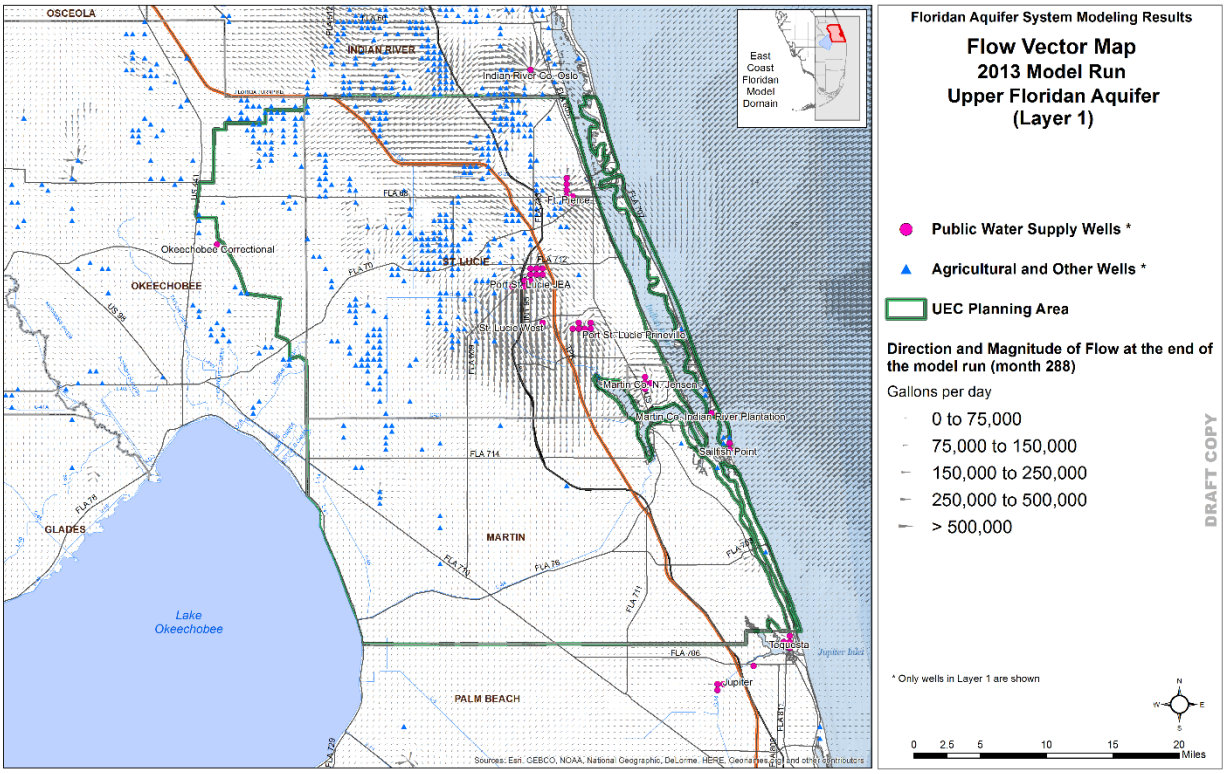


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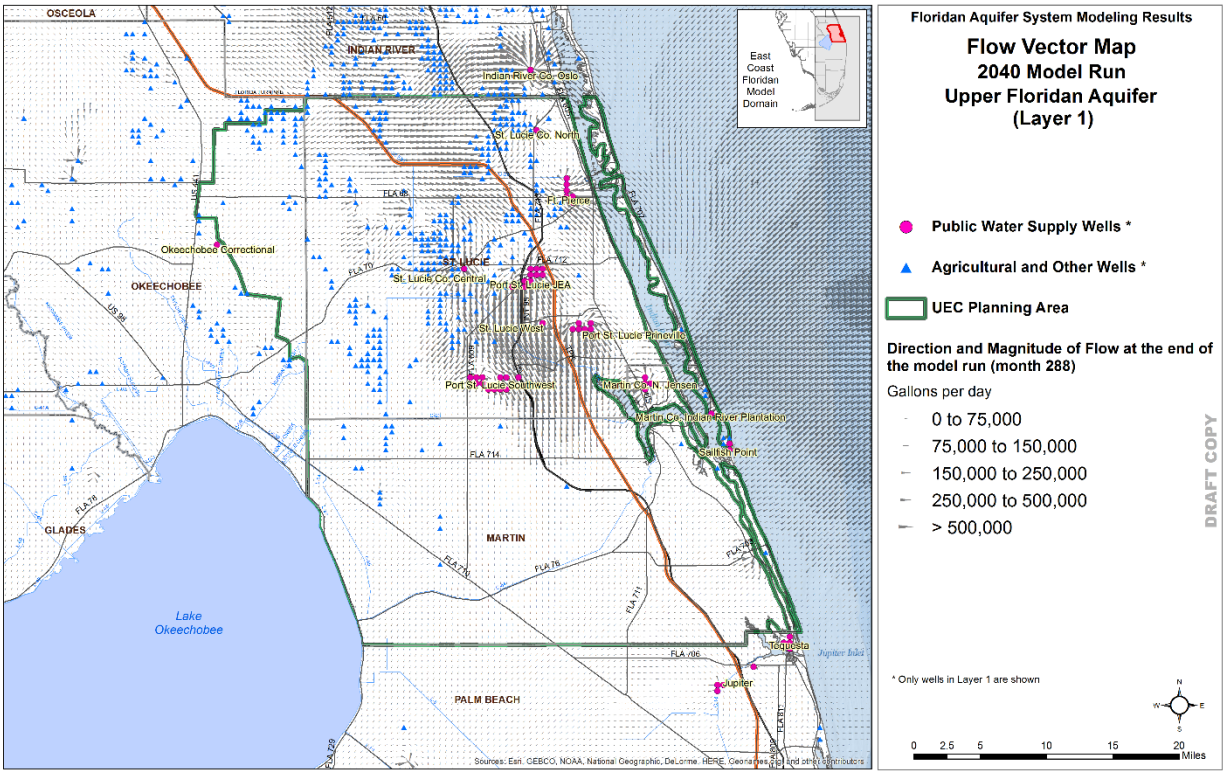


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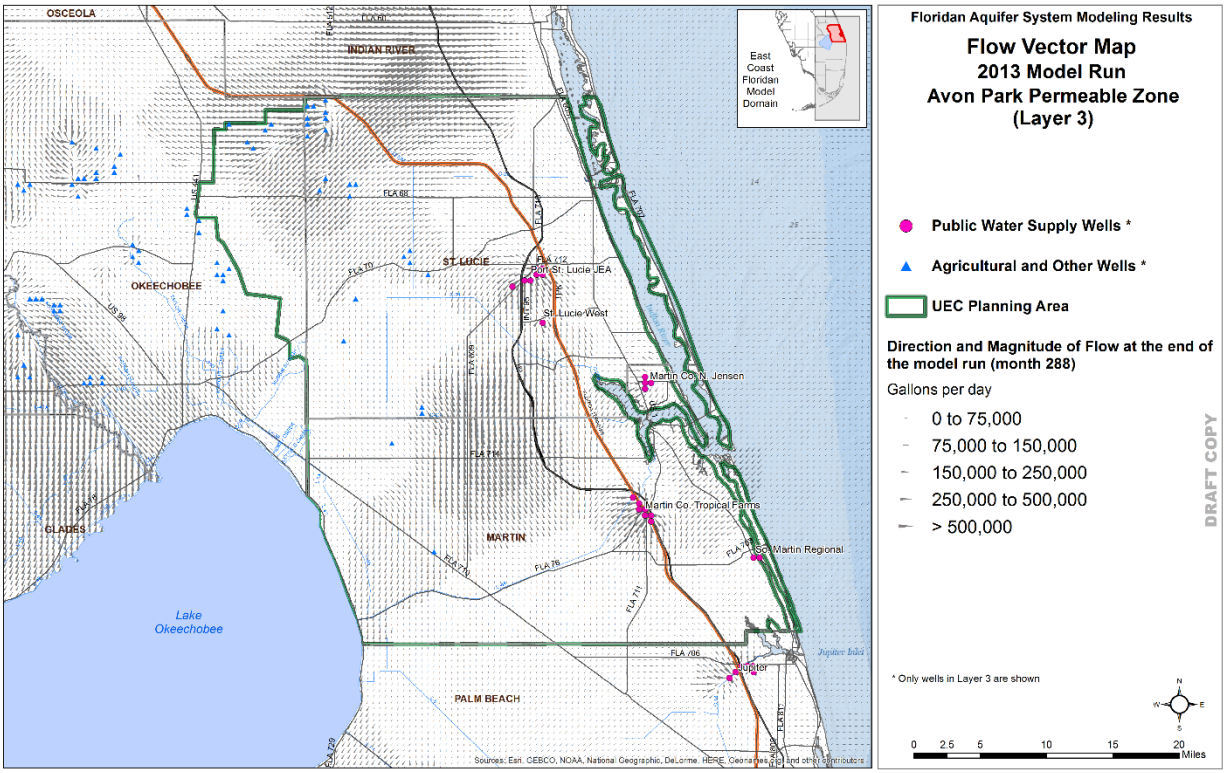


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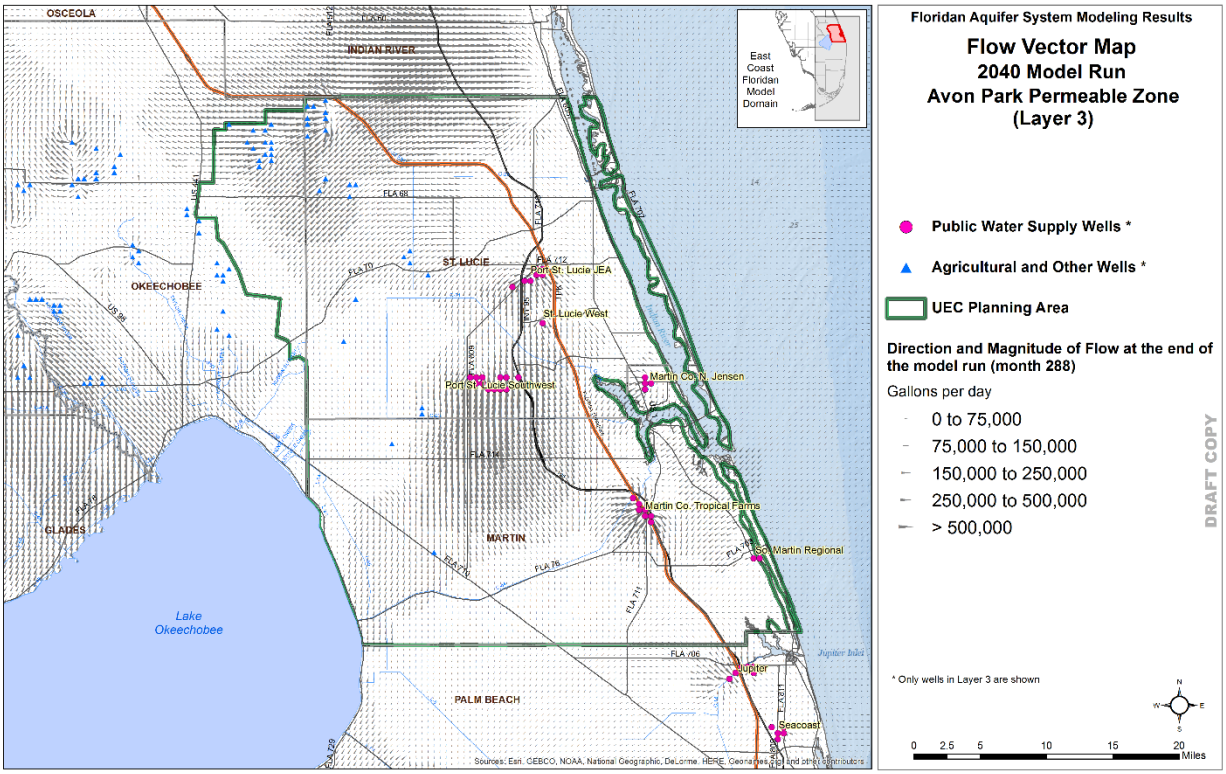


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