



# Contributions of Total Nitrogen from OSTDS to the Indian River Lagoon and the Wakulla-St. Marks River Drainage Basins, Florida

---

Technical Memorandum

April 25, 2014

**Prepared for:**

---

Brian Lapointe, Ph.D.  
Executive director of Science & Technology  
Coastal Ocean Association of Science & Technology  
9601 Oceanshore Blvd  
St. Augustine, FL 32080

**Prepared by:**

---



---

Brent A. Meyer, M.S.  
Hydrogeologic Modeler



---

Todd R. Kincaid, Ph.D.  
Principal

**TABLE OF CONTENTS**

1	Introduction	1
1.1	Overview.....	1
1.2	Purpose and Scope.....	1
1.3	Project Area .....	2
2	OSTDS NUMBER AND LOCATION ESTIMATION	2
2.1	Estimation Process.....	2
2.1.1	Volusia County .....	3
2.1.2	Brevard County .....	4
2.1.3	Indian River County .....	4
2.1.4	St. Lucie County .....	5
2.1.5	Martin County.....	6
2.1.6	Wakulla-St. Marks River Watershed .....	6
3	GROUNDWATER FLOW AND TOTAL N TRANSPORT MODEL	8
3.1	Model Design .....	8
3.1.1	Conceptual Model .....	8
3.1.2	Boundary Conditions .....	8
3.1.3	Articulation of Canal Flow .....	8
3.1.4	Total Nitrogen Inputs .....	9
3.2	Model Calibration .....	9
3.2.1	Calibration to Flows .....	9
3.2.2	Calibration to Groundwater Levels.....	9
3.3	Model Results .....	10
3.3.1	Total N Concentration.....	10
3.3.2	Travel Times .....	10
4	DISCUSSION	10
4.1.1	Active OSTDS Estimation .....	10
4.1.2	Florida Department of Health Active OSTDS Data Source .....	11
4.1.3	Potential for Increasing the Number of Active OSTDS.....	12
4.1.4	Total N Transport .....	12
5	Summary AND RECOMMENDATIONS	13
5.1	Summary .....	13
5.2	Recommendations .....	14
6	References	15
7	Tables	17
8	Figures	29

**LIST OF TABLES**

Table 1. Summary of Active OSTDS in Volusia County by service area.....	18
Table 2. Summary of Active OSTDS in Brevard County by service area.....	20
Table 3. Summary of Active OSTDS in Indian River County by service area. ....	21
Table 4. Summary of Active OSTDS in St. Lucie County by service area. ....	22
Table 5. Summary of Active OSTDS in Martin County by service area. ....	23
Table 6. Summary of Active OSTDS in the Indian River Lagoon Watershed by Sub-Basin. ....	24
Table 7. Summary of Active OSTDS in Jefferson, Leon, and Wakulla Counties.....	25
Table 8. Summary of Measured Discharge Data within the Model Domain.....	26
Table 9. Summary of Measured Groundwater Elevation Data within the Model Domain. ....	26
Table 10. Completeness Ratings for All Analyzed Sewer Service Areas.....	27

**LIST OF FIGURES**

Figure 1. Analysis of Active OSTDS in Volusia County, Florida. The left side of the figure shows a map of the extent of sanitary sewer service in Volusia County as delineated in this report. The right side of the figure shows a map of the estimated number and location of active OSTDS within Volusia County with respect to Indian River Lagoon sub-basins. Note that both maps have been rotated 30 degrees clockwise from true north.....	29
Figure 2. Analysis of Active OSTDS in Brevard County, Florida. The left side of the figure shows a map of the extent of sanitary sewer service in Brevard County as delineated in this report. The right side of the figure shows a map of the estimated number and location of active OSTDS within Brevard County with respect to Indian River Lagoon sub-basins.....	30
Figure 3. Analysis of Active OSTDS in Indian River County, Florida. The top of the figure shows a map of the extent of sanitary sewer service in Indian River County as delineated in this report. The bottom of the figure shows a map of the estimated number and location of active OSTDS within Indian River County with respect to Indian River Lagoon sub-basins.....	31
Figure 4. Analysis of Active OSTDS in St. Lucie County, Florida. The top of the figure shows a map of the extent of sanitary sewer service in St. Lucie County as delineated in this report. The bottom of the figure shows a map of the estimated number and location of active OSTDS within St. Lucie County with respect to Indian River Lagoon sub-basins. ....	32
Figure 5. Analysis of Active OSTDS in Martin County, Florida. The top of the figure shows a map of the extent of sanitary sewer service in Martin County as delineated in this report. The bottom of the figure shows a map of the estimated number and location of active OSTDS within Martin County with respect to Indian River Lagoon sub-basins. ....	33
Figure 6. Analysis of Active OSTDS in Jefferson, Leon, and Wakulla Counties, Florida. The top of the figure shows a map of the extent of sanitary sewer service in the three county area as delineated in this report. The bottom of the figure shows a map of the estimated number and location of active OSTDS within the three county area with respect to Wakulla-St. Marks River watershed. ....	34
Figure 7. Model Design Map - Locations of Discharge and OSTDS Nodal Assignments. ....	35
Figure 8. Model Result Map - Simulated Groundwater Elevations. ....	36

Figure 9. Model Result Map - Simulated Total N Concentration in Groundwater. .... 37

Figure 10. Model Result Map - Simulated Total N Concentration in Discharge. .... 38

Figure 11. Model Results Map - Time of Groundwater Travel from OSTDS to Discharge..... 39

Figure 12. Graphs of Cumulative and Yearly Steady-State OSTDS Within the Model Domain from 1970 to 2020. .... 40

Figure 13. Error Assessment Map showing the locations of data source conflicts in the City of Port Orange and the Martin County Utility North mapped sewer availability areas. .... 41

Figure 14. Map showing the location of undeveloped vacant residential parcels located outside of sewer availability areas within the model domain..... 42

## **EXECUTIVE SUMMARY**

GeoHydros, LLC was contracted by Coastal Ocean Association of Science and Technology (COAST) to evaluate the number and location of active OSTDS within the Indian River Lagoon (IRL) and the Wakulla-St. Marks River drainage basins and to construct a groundwater flow and nitrogen transport model for the region of southern Brevard County which drains to the IRL. The objectives of the project were to: 1) estimate the number of active OSTDS within the IRL and Wakulla-St. Marks River drainage basins, 2) estimate the average daily nitrogen load within these basins resulting from the OSTDS, 3) develop maps showing the count and location of OSTDS within IRL sub-basin watersheds and the estimated nitrogen load within each sub-basin, 4) develop a map showing the count, location and estimated nitrogen load within the Wakulla - St. Marks River drainage basin, 5) construct a groundwater flow and nitrogen transport model for the IRL sub-basin watersheds in southern Brevard County, Florida and 6) produce maps and tables summarizing the results of the model.

The project area covered parts of six counties adjacent to the IRL: Volusia, Brevard, Indian River, St. Lucie, Martin, and Palm Beach; and parts of three counties adjacent to the Wakulla-St. Marks River: Jefferson, Leon, and Wakulla. The analysis was completed using downloadable information from federal, state, county, and municipal sources covering the project area.

Results of our analyses reveal that there are likely 140,736 active OSTDS within the IRL basin and 37,536 active OSTDS within the Wakulla-St. Marks River basin producing a total N load of 3,846 kg/day (8,462 lbs/day) and 1,021 kg/day (2,246 lbs/day) to groundwater within the respective basins. The total N load estimates assume no biological degradation or substrate retardation. The total N load estimates do not represent the complete N load to the basins as we did not account for reuse and spray field disposal of non-OSTDS domestic wastewater treatment facility effluent or the N contribution from the agricultural and residential use of fertilizer.

The groundwater flow and total N transport model covered six IRL contributing sub-basins in southern Brevard County; Eau Gallie River, Crane Creek, Turkey Creek, Goat Creek, Kid Creek, and Trout Creek. The model was calibrated to the median of daily mean discharge measurements taken from near the confluence of the Melbourne-Tillman Canal System C-1 Canal and the head of Turkey Creek and reported by the USGS for the time period between March 1996 and September 2001.

Steady-state total N transport was simulated from 34,685 active OSTDS within the model domain. The simulation showed that nitrogen released from the OSTDS results in groundwater concentrations ranging from below detection (<0.1 mg/l) to 170 mg/l with the highest concentrations at or adjacent to OSTDS nodes. The mean groundwater concentration at OSTDS nodes was 20 mg/l and the groundwater concentration exceeded 80 mg/l at only two locations. The simulation also showed that that nitrogen released from the OSTDS results in concentrations of total N in the groundwater discharge to surficial water bodies that ranges from below 0.1 mg/l to 159 mg/l. The mean concentration among nodes with discharge concentrations of 0.1 mg/l or greater is 4 mg/l. Discharge concentrations exceed 10 mg/l at various locations along the Melbourne-Tillman, Crane Creek and Trout Creek canal systems and the IRL in the southeastern region of the model.

We also used the model to estimate the travel time from active and potential OSTDS locations to surficial water bodies. The model was seeded with the locations of 34,685 active OSTDS, which were used as start points for 3D particle tracks. These particle tracks terminate at simulated discharge nodes and give the travel time from start point to discharge. The particle track analysis yielded travel times ranging from days to 50 years with an average travel time of 5.1 years.

The travel time information allowed us to estimate the state of the aquifer with respect to total N discharge. The parcel dataset included an actual year built attribute for each of the parcels defined as having an active OSTDS and we assumed that this year equated to the year the OSTDS became active. Combining activation date and the simulated travel time data for each OSTDS, we were able to determine that 95% of

the active OSTDS within the model domain are currently in steady-state with respect to total N transport. This means that enough time has passed to allow the leading edge of the total N load from 95% of the OSTDS to reach a surficial discharge point and that these OSTDS now act as a continuous source of nitrogen discharge. We also determined that by 2020, 99% of the active OSTDS within the model domain will be discharging nitrogen either directly into the IRL or into surficial water bodies that contribute to the IRL.

The same process was used to estimate the total N load from potential OSTDS in the model domain. A potential OSTDS was defined as any undeveloped vacant residential parcel located outside of sewer service availability. Undeveloped vacant residential parcels were identified from the parcel dataset as parcels attributed as vacant residential and having a street address but no actual build date. The model was seeded with the centroids of these 26,828 parcels which were used as start points for 3D particle tracks. The particle track analysis yielded travel times ranging from days to 51 years with an average travel time of 5.7 years from start point to discharge. The travel time from start point to discharge for 99% of the potential OSTDS is 17 years or less. This means that if all of the potential OSTDS parcels are developed over the next 8 years, the total N load from the portion of Brevard County in the model domain discharging into the IRL in the next 25 years will increase by 76%, from 966 kg/day (2,125 lbs/day) to 1,698 kg/day (3,735 lbs/day).

The following recommendations were developed as consequence of the knowledge gained through the process of conducting these analyses and evaluations of the modeling results.

1. A more in depth data search should be performed for all low confidence sewer service areas. This could be performed by requesting sewer line information or a list of addresses with sewer service directly from the providers thus eliminating the dependence on FDOH dataset, which was revealed to be fraught with errors.
2. The model should be rerun using the improved estimations of OSTDS locations and the associated total N loading.
3. Additional models should be constructed for all of the remaining sub-watersheds in the IRL basin as well as for the Wakulla-St Marks River watershed. These models will provide a quantitative means to estimate existing nitrogen loading to critical water bodies (the IRL and the Wakulla River), and the probable increase in nitrogen discharge to these features associated with planned and probable future developments. The output from these models would contribute to efforts to establish and implement Total Maximum Daily Loads (TMDLs) as well as the associated Basin Action Management Plans (BMAPs) that will be designed and implemented to foster compliance with those TMDLs.

## **1 INTRODUCTION**

### **1.1 Overview**

The Indian River Lagoon (IRL) is a grouping of three lagoons: Mosquito Lagoon, Banana River, and the Indian River, on the Atlantic Coast of Florida. According to a 1989 St Johns River Water Management Report (SJRWMD, 1989), the IRL has the highest species diversity of any estuary in North America with at least 2,200 species identified, 36 of which are listed as endangered or threatened. The IRL also provides an important waterway for eastern Florida's economy. Historically, the region bordering the IRL consisted primarily of wetlands and forested land. However, population growth since the early 1900's has resulted in a demand for suitable land for agricultural and urban development. Extensive drainage projects, consisting of interconnected canal networks, were constructed to drain the region to meet these needs. Many of the canal systems were designed to drain into the IRL. These drainage projects increased the IRL watershed by diverting water that previously drained to inland waterways such as the St. Johns River, to the IRL.

Of similar ecological value is the Wakulla-St. Marks River watershed located in north-central Florida. Both the Wakulla River and the St. Marks River, which merge before discharging into the Gulf of Mexico, originate from large groundwater springs. Wakulla Springs, at the head of the Wakulla River, is one of the largest and deepest freshwater springs in the world. Both rivers provide habitat for a large number of plant, bird, and animal life and both are listed as Outstanding Florida Waters. In addition, the river system discharges into the St. Marks National Wildlife Refuge, which is an important habitat for migratory birds as well as sea turtles and manatees. While this watershed does not contain drainage projects like the IRL basin, it does contain large areas of agricultural and urban development.

The rapid urban development in these two watersheds has outpaced the expansion of public and private utilities resulting in large populations existing outside of the reach of municipal sewer systems. These non-serviced developments rely on on-site sewage treatment and disposal systems (OSTDS) for their wastewater treatment and disposal needs. These systems require unsaturated soil for the filtering, retention and degradation of biological and chemical contaminants from the liquid waste before it enters the groundwater system. The efficiency of these systems, while not 100% under optimal conditions, can be severely reduced if the systems are not regularly cleaned and repaired, if the soil is highly permeable or if the soil becomes saturated. In addition, OSTDS transform wastewater nitrogen (N) species to nitrate which is highly mobile in groundwater systems. While OSTDS are not the only human produced source of N introduced to groundwater systems, they can be a significant contributor in regions of dense urban development, poor soil type, and near surface groundwater elevations.

The location and number of OSTDS within a watershed are therefore important factors in the estimation of total N loading to groundwater and surface water. The Florida Department of Health (FDOH) is responsible for permitting OSTDS and maintaining the permit records. They maintain a database listing the location and status of all OSTDS that the FDOH has inspected. An analysis of that database relative to other published data sources, such as county maps and records, however has revealed that the FDOH database is incomplete. As a result, there is presently no immediate means of knowing the number or location of active OSTDS within Florida watersheds.

### **1.2 Purpose and Scope**

GeoHydros, LLC was contracted by Coastal Ocean Association of Science and Technology (COAST) to evaluate the number and location of active OSTDS within the IRL and the Wakulla-St. Marks River drainage basins and to construct a groundwater flow and nitrogen transport model for the region of southern Brevard County which drains to the IRL. The objectives of the project were to: 1) estimate the number of active OSTDS within the IRL and Wakulla-St. Marks River drainage basins, 2) estimate the average daily nitrogen load within these basins resulting from the OSTDS, 3) develop maps showing the count and location of OSTDS within IRL sub-basin watersheds and the estimated nitrogen load within each sub-basin, 4) develop a map showing the count, location and estimated nitrogen load within the

Wakulla - St. Marks River drainage basin, 5) construct a groundwater flow and nitrogen transport model for the IRL sub-basin watersheds in southern Brevard County, Florida and 6) produce maps and tables summarizing the results of the model.

### 1.3 Project Area

The project area for the IRL OSTDS analysis consisted of all watersheds that discharge into the IRL and covers portions of six Florida counties: Volusia, Brevard, Indian River, St. Lucie, Martin, and Palm Beach. The IRL drainage basin was sub-divided into 19 watersheds based on the 1:24,000 scale hydrologic units GIS coverage produced and distributed by the USDA/NRCS National Geospatial Management Center (USDA, 2014). The project area for the Wakulla-St. Marks River OSTDS analysis consisted of portions of three Florida counties, Leon, Jefferson, and Wakulla, which were identified as draining into the river systems using the same 1:24,000 scale hydrologic units GIS coverage. A total of 35 sub-basins from this dataset were combined to define the Wakulla-St. Marks River watershed. The grouping includes all sub-basins which drain directly into the Wakulla-St. Marks River surficial flow system as well as all sub-basins for streams and lakes which drain into swallets which are either known to discharge into the Wakulla-St. Marks River system due to dye tracing and cave mapping (i.e. Black Creek, Fisher Creek, Lost Creek, Lloyd Creek, Patty Sink, Bird Sink) or strongly suspected to discharge into the Wakulla-St. Marks River system (i.e. Jackson Lake, Lake Iamonia). While the Wakulla-St. Marks watershed does extend into south-central Georgia, only the Florida portion was analyzed for active OSTDS.

## 2 OSTDS NUMBER AND LOCATION ESTIMATION

The number and location of active OSTDS in the IRL drainage basin were determined by evaluating the available OSTDS data for the nine project area counties listed above in conjunction with maps defining the spatial boundaries of county, municipality, and private utility sewer service areas, and county parcel maps that identify the locations of non-vacant residential parcels. The results of this effort were: 1) an estimate of the total N load to the groundwater system due to OSTDS discharge, and 2) maps and GIS coverages showing the locations of the individual OSTDS within the IRL drainage basin.

### 2.1 Estimation Process

Two datasets were common in all counties: the Onsite Sewage Locations in Florida - June 2012 GIS coverage (FDOH, 2012) and the Florida Department of Revenue (FDOR) county parcel data GIS coverages (FDOR, 2010). The process for estimating the number of active OSTDS in each county differed from county to county depending on available data.

The general process was as follows.

#### Data Collection/Synthesis

1. The FDOH dataset, filtered to show only the active OSTDS, was used to identify the locations of clusters of OSTDS in each county.
2. The FDOR GIS coverage was filtered to identify all non-vacant residential parcels within the county.
3. The name and number of all domestic sewer service providers within the county were identified from the Florida Department of Environmental Protection (FLDEP) database of domestic wastewater facilities (FLDEP, 2014).
4. The boundaries for all domestic sewer utility service areas (municipal, county, state, and large private) within each county were either downloaded (when available in GIS format online) or digitized from downloaded map images.
5. All sewer connection maps developed by the utility providers and available online were downloaded and digitized into GIS.

### Data Processing

6. If a sewer connection map was available for a domestic sewer service area, that map was used exclusively to identify the non-vacant residential parcels within the service area that are connected to domestic sewer service. All other non-vacant residential parcels were assumed to be using OSTDS for wastewater treatment and disposal.
7. If no sewer map was available but a boundary polygon was available to define the sewer service area, it was assumed that all non-vacant residential parcels within the service area are connected to the provider's sewer system except for those identified as active in the FDOH dataset. In these areas therefore the number of active OSTDS was derived exclusively from the FDOH dataset.
8. If neither a sewer connection map nor a service area boundary polygon were available, the sewer service coverage area was assumed to coincide with the boundaries of the municipality. It was then assumed that all non-vacant residential parcels within that area are connected to the provider's sewer system except for those identified as active in the FDOH dataset. In these areas therefore the number of active OSTDS was derived exclusively from the FDOH dataset.
9. All non-vacant residential parcels located outside of any of the identified service areas were assumed to be using OSTDS for wastewater treatment and disposal.

One exception to this process was Indian River County for which a map was available that specifically labeled each parcel as either using domestic sewer service or OSTDS for wastewater treatment and disposal.

Once the location and number of OSTDS were identified, the total N load from each OSTDS to groundwater was calculated using an estimated 11.2 grams of nitrogen per person per day in domestic wastewater (U. S. EPA, 1992) and an estimated average number of persons per household for 2008-2012 that were obtained from the U. S. Census Bureau for each of the project counties (U.S. Census Bureau, 2014). A summary of the application of this process for each county is provided in the following sections.

#### 2.1.1 Volusia County

Eight municipal and six county sewer providers and their service areas within Volusia County were identified from the Volusia County Utility Service Areas GIS coverage (VCPW, 2008) and the FDEP database of domestic wastewater facilities (FLDEP, 2014). FDOH reports 35,913 active OSTDS in Volusia County. An additional 41,792 OSTDS were identified through our spatial analyses of sewer service areas and county parcel maps. Table 1 lists the number of reported and additionally identified OSTDS by region and section of Volusia County as well as the estimated total N load to the groundwater system associated with OSTDS discharge. Figure 1 shows the municipal and county boundaries relative to the IRL watershed boundaries and the locations of OSTDS identified in this study.

The sanitary sewer coverage for the City of Port Orange was available from two maps, Septic Tank Areas (COPO, 2010a) and Wastewater Collection and Transmission Systems (COPO, 2010b). Using these maps, we delineated 24,217 non-vacant residential parcels within the City's service area which covers the Port Orange City Limits and parts of Daytona Beach Shores, Ponce Inlet and the unincorporated county. Of these parcels, 21,856 were determined to receive municipal sewer service leaving 2,361 non-serviced non-vacant parcels, which we assumed use OSTDS for wastewater treatment.

The sanitary sewer coverage for the City of New Smyrna Beach was available from the Wastewater System Components map (UCNSB, 2006). This map shows the extent of the City's municipal sewer system from which we defined 10,735 (out of 13,677) non-vacant residential parcels as receiving municipal sewer service. We assumed that the remaining 2,942 non-serviced parcels used OSTDS for wastewater treatment.

For the remaining six municipalities, the sewer service areas were assumed to be coincident with the city limits. Sewer service in Deltona is split between a county and a municipal provider and the service area of the municipal provider was not well defined. The number of sewer connections has however been reported

by the West Volusia Beacon online newspaper as 6,000 but their locations were not identified (WVB, 2013). Therefore, in order to estimate the number of active OSTDS in Deltona, the well-defined service area for the county provider was analyzed first through the above described process, leaving 32,664 non-vacant residential parcels within the city limits. Of these, 6,000 were assumed to have sewer connection resulting in 26,664 active OSTDS. Only 11,557 active OSTDS are identified in the FDOH dataset therefore the location of the remaining 15,107 could not be determined and are not shown on the OSTDS location map (Figure 1).

For the six county sewer providers, the service areas used for spatial comparison were the ones defined in the Volusia County Public Works GIS coverage. Table 1 list the estimated number of active OSTDS within each service area and within non service areas and Figure 1 shows the extent of the sewer service areas.

In summary, we estimated 77,705 active OSTDS within Volusia County. This number is 2.2 times more than the number of active OSTDS in Volusia County reported in the FDOH June 2012 GIS coverage (35,913) and 78% of the total permitted OSTDS installations on record with the FDOH (99,257). The average N load per OSTDS was estimated at 27.66 grams per day based on 2.47 persons per household and the total N load for the county is 2,150 kg/day (4,739 lbs/day). 20,748 of the county's OSTDS are located within the IRL watershed (five sub-basins, Figure 2) for an IRL N load of 565 kg/day (1,245 lbs/day). The undefined locations for 15,107 Deltona OSTDS do not affect the IRL total N load calculation because the relevant coverage areas are well outside of the IRL drainage basin. Table 6 summarizes the OSTDS count and total N load for each sub-basin. The estimated locations for the active OSTDS are shown in Figure 1.

### 2.1.2 Brevard County

Eight municipal and six county sewer providers and their service areas within Brevard County were identified from the FDEP domestic wastewater facilities database (FLDEP, 2014) and the Water and Wastewater Service Areas for Brevard County map (BCUSD, 2013). For spatial comparison, the city limits of seven of the eight municipalities were assumed to define the boundaries of the sewer service areas. For the six County sewer providers, the service areas used were the ones defined in the County's service area map. Palm Bay does not provide sewer service throughout the city limits. However, they do provide an interactive mapping service on their website which shows the regions with sewer service (COPB, 2014). Using this map we were able to determine that approximately 13,955 parcels within the city limits receive municipal sewer service. We assumed that the remaining 26,206 non-vacant parcels use OSTDS for wastewater treatment. Table 2 lists the estimated number of active OSTDS within each service area and within the non-service areas. Figure 2 shows the extent of the sewer service areas.

In summary, we estimated 66,720 active OSTDS within Brevard County. This number is 8.7 times more than the number of active OSTDS in Brevard County in the FDOH June 2012 coverage (7,658) and 73% of the total permitted OSTDS installations on record with the FDOH (90,973). The average N load per OSTDS was estimated at 27.22 grams per day based on 2.43 persons per household and the total N load for the County is 1,816 kg/day (4,003 lbs/day). 45,485 of the County's OSTDS are located within the IRL watershed (eleven sub-basins) for an IRL N load of 1,238 kg/day (2,729 lbs/day). Table 6 summarizes the OSTDS count and total N load for each sub-basin. The estimated locations for the active OSTDS are shown in Figure 2.

### 2.1.3 Indian River County

One municipal and five county sewer providers and their service areas within Indian River County were identified from the FLDEP database of domestic wastewater facilities (FLDEP, 2014) and the Indian River County 2008 WWTF service areas map (IRC, 2013). The primary source for locating active OSTDS in Indian River County was the County's online interactive GIS map of parcels with no sewer service (IRC, 2014). This map showed parcels within the County that use OSTDS for wastewater treatment and was spatially compared to the non-vacant residential parcels coverage in order to identify the location of

residential OSTDS. Table 3 lists the estimated number of active OSTDS within each service area and within the non-service areas. Figure 3 shows the extent of the sewer service areas.

In summary, we estimated 28,889 active residential OSTDS within Indian River County. This number is 1.7 times more than the number of active OSTDS in Indian River County in the FDOH June 2012 coverage (17,457) and 78% of the total permitted OSTDS installations on record with the FDOH (36,894). The average N load per OSTDS was estimated at 26.21 grams per day based on 2.34 persons per household and the total N load for the County is 757 kg/day (1,669 lbs/day). 28,851 of the County's OSTDS are located within the IRL watershed (five sub-basins) for an IRL N load of 756 kg/day (1,667 lbs/day). Table 6 summarizes the OSTDS count and total N load for each sub-basin. The estimated locations for the active OSTDS are shown in Figure 3.

#### 2.1.4 St. Lucie County

Sewer service in St. Lucie County is primarily provided by two municipal utilities, Fort Pierce Utility Authority (FPUA) and the Port St. Lucie Utility (PSLU). Municipal utility service areas are defined in the County's Urban Service Boundary GIS coverage (SLC, 2014a). However, this coverage is for all utilities, not just sewer service. The sewer service area for the FPUA was delineated from the 2007 Fort Pierce Utilities Authority Wastewater Service Area Map available for download from the City's website. Using this map we were able to identify 17,568 non-vacant residential parcels within the FPUA service area and define 9,767 of them as having sewer connections. The remaining 7,801 parcels were assumed to use OSTDS for wastewater treatment. The PSLU sewer service area was delineated from WWTP service area maps included in the Sanitary Sewer Sub-Element document available for download on the Port St. Lucie website. Using these maps, we were able to identify 60,974 non-vacant residential parcels and 343 active OSTDS from the FDOH coverage within the PSLU sewer service area. According to the City of Port St. Lucie Water & Sewer Utility Funds Annual Budget 2012-2013 document (2013) the City provides connections to 60,543 equivalent residential connections (ERC). Therefore, we assumed that the only active OSTDS within the PSLU sewer service area were those identified in the FDOH coverage.

In addition to the two municipal sewer providers, we identified 12 County and large private wastewater treatment providers within the County from the FLDEP database of domestic wastewater facilities (FLDEP, 2014). The sewer service areas for the four County-operated sewer providers, Holiday Pines, Lakewood Park, North Hutchinson Island and South Hutchinson Island were defined from the and the St. Lucie County Utility Hydrology Placement Map (SLC, 2014b) which provided the extent of sewer lines within each service area. Using this map, we identified 7,125 non-vacant residential parcels of which 3,328 received sewer service. We assumed that the remaining 3,797 parcels use OSTDS for wastewater treatment.

The service areas for the 8 remaining private sewer providers were delineated from the Existing Wastewater Treatment Facilities Map (SLC, 2006). We assumed that all non-vacant residential parcels within the service areas, except for those identified as active in the FDOH coverage, received sewer service. All parcels located outside of a service area were assumed to use OSTDS for wastewater treatment. Figure 4 shows the extent of all service areas. Table 4 lists the estimated number of active OSTDS within each service area and within non-service areas.

In summary, we estimated a total of 16,837 active OSTDS within St. Lucie County. This number is 9.5 times more than the number of active OSTDS in St. Lucie County in the FDOH June 2012 coverage (1,776) and 38% of the total permitted OSTDS installations on record with the FDOH (44,113). The average N load per OSTDS was estimated at 29.46 grams per day based on 2.63 persons per household. The total N load for the County and for the IRL is 496 kg/day (1,093 lbs/day) since all OSTDS are located within the IRL watershed. Table 6 summarizes the OSTDS count and total N load for each IRL sub-basin and the estimated locations. The active OSTDS are shown in Figure 4.

### 2.1.5 Martin County

One private municipal, one District, one County, and two large private sewer providers were identified within Martin County from the FLDEP database of domestic wastewater facilities (FLDEP, 2014). The private municipal WWTF serves the City of Stuart and the City provides both a water and sewer service area map (COS, 2007) and a Sanitary Sewer Expansion Program map (COS, 2014). Using these maps, we were able to define the non-vacant residential parcels within the City's service area and which parcels had sewer service. Of the 3,045 non-vacant residential parcels within the service area, 1,076 receive sewer service. The remaining 1,969 parcels were assumed to use OSTDS for wastewater treatment. All parcels within the city limits but outside of the utility service area are served by Martin County Utilities North (MCUN). The MCUN service area boundary, which also includes the incorporated towns of Ocean Breeze Park and Sewall's Point, was available as a layer in an interactive map describing maintained water and sanitary sewer features (MCU, 2014). This map also identified the sewer line extents within the service area. Using those maps, we identified 32,333 non-vacant residential parcels of which 18,150 receive sewer service. The remaining 14,183 parcels were assumed to use OSTDS for wastewater treatment.

The larger of the two private sewer service providers is South Martin Regional Utilities (SMRU) with a service area covering the unincorporated community of Hobe Sound and the incorporated Town of Jupiter Island. SMRU provides an online image showing sewer lines (SMRU, 2014). Using this image we identified 9,204 non-vacant residential parcels within the SMRU service area of which 6,257 receive sewer service. The remaining 2,947 parcels were assumed to use OSTDS for wastewater treatment. No service map was available for the smaller private sewer provider, Sailfish Point, so we assumed all parcels within the service area receive sewer service.

The Loxahatchee River Environment Control District (LRECD) provides sewer service in southeastern Martin County and northeastern Palm Beach County. Maps showing LRECD service area and parcels within the service area using OSTDS for wastewater treatment are included in the *LRECD 2010 Septic System Inventory and Assessment Study* (LRECD, 2010). From these maps, we identified 2,269 non-vacant residential parcels within the LRECD service area in Martin County. 1,937 of these parcels receive sewer service leaving 332 parcels, which we assumed to be using OSTDS for wastewater treatment.

We used the LRECD maps to identify sewer service in the portion of the Loxahatchee sub-basin which extends into Palm Beach County. There are a total of 29,417 non-vacant residential parcels in the Palm Beach County portion of the Loxahatchee sub-basin of which 25,215 are within the LRECD service area and 22,476 receive sewer service. The remaining 6,941 parcels within the sub-basin were assumed to use OSTDS for wastewater treatment. All parcels located outside of a service area were also assumed to use OSTDS for wastewater treatment. Figure 5 shows the extent of all service areas. Table 5 list the estimated number of active OSTDS within each service area and within the non-service areas.

In summary, we estimated 21,949 active OSTDS within Martin County. This number is 2.3 times more than the number of active OSTDS in Martin County reported in the FDOH June 2012 coverage (9,637) and 77% of the total permitted OSTDS installations on record with the FDOH (28,375). The average N load per OSTDS was estimated at 26.88 grams per day based on 2.40 persons per household and the total N load for the county is 590 kg/day (1,301 lbs/day). A total of 28,814 (21,860 in Martin County and 6,941 in Palm Beach County) OSTDS are located within the IRL watershed (two sub-basins, St. Lucie River and Loxahatchee River) for an IRL total N load of 775 kg/day (1,708 lbs/day). Table 6 summarizes the OSTDS count and total N load for each IRL sub-basin. The estimated locations for the active OSTDS are shown in Figure 5.

### 2.1.6 Wakulla-St. Marks River Watershed

The Wakulla-St. Marks River watershed covers parts of three Florida counties: Jefferson, Leon, and Wakulla. These three counties were evaluated collectively in order to estimate the number and location of

active OSTDS. In Jefferson County, the only significant sewer provider identified from the FLDEP database of domestic wastewater facilities (FLDEP, 2014) was the municipal provider of the City of Monticello. The service area for this provider was assumed to be coincident with the city limits and all non-vacant residential parcels within the city limits except for those identified as having active OSTDS in the FDOH dataset were assumed to receive sewer service. 1,118 non-vacant residential parcels and 143 active OSTDS were identified within the Monticello service area. All other non-vacant residential parcels in the county were assumed to use OSTDS for wastewater treatment.

In Leon County, one large municipal provider, the City of Tallahassee, and five small private providers were identified from the FLDEP database of domestic wastewater facilities (FLDEP, 2014). The City of Tallahassee does not provide any form of a sewer service area map on its website, therefore we assumed a service area coincident with the city limits. All non-vacant residential parcels within the city limits except for those identified as having active OSTDS in the FDOH dataset were assumed to receive sewer service. 49,126 non-vacant residential parcels and 820 active OSTDS were identified within the Tallahassee service area. The sewer service area for the private Lake Jackson provider was assumed to cover six subdivisions; Autumn Woods, Lakeside, Lakewood Village, Rivers Landing, Russell's Pond, and Tower Oaks. Similarly, the sewer service area for the private Killearn Lakes provider was assumed to cover eight subdivisions; Deerfield Plantation, Eagles Ridge, Golden Eagle, Killearn Commons, Killearn Lakes, Pine Landing, Preservation Pointe, and Reserve at the Ridge. The sewer service areas for the remaining three private providers were assumed to be limited to the sub-divisions having the same name as the provider. All parcels within the private provider service areas were assumed to receive sewer service. All non-vacant residential parcels located outside of a service area were assumed to use OSTDS for wastewater treatment.

In Wakulla County, one municipal, one county, and two private sewer service providers were identified from the FLDEP database of domestic wastewater facilities (FLDEP, 2014). The service area for the municipal provider, The City of St. Marks, was assumed to be coincident with the city limits and all non-vacant residential parcels within the city limits except for those identified as having active OSTDS in the FDOH dataset were assumed to receive sewer service. 173 non-vacant residential parcels and one active OSTDS were identified within the St. Marks service area. The sewer service area for the county provider was delineated from the *Crawfordville Area Sewer System Map* included in the *Crawfordville Town Plan* document (WC, 2014). 784 non-vacant residential parcels within the Crawfordville region were identified as receiving sewer service. The sewer service areas for the remaining two private providers were assumed to be limited to the sub-divisions having the same name as the provider. All parcels within the private provider service areas were assumed to receive sewer service. All non-vacant residential parcels located outside of a service area were assumed to use OSTDS for wastewater treatment.

In summary, we estimated a total of 44,196 active OSTDS within the three county area. This number is 2.4 times more than the number of active OSTDS in the three counties in the FDOH June 2012 coverage (18,533) and 79% of the total permitted OSTDS installations on record with the FDOH (55,791). The average N load per OSTDS was estimated at 26.66 grams per day (Jefferson), 26.77 grams per day (Leon), and 28.67 grams per day (Wakulla) based on 2.38, 2.39, and 2.56 persons per household, respectively. The total N loads for Jefferson, Leon, and Wakulla Counties are, 836 kg/day (1,843 lbs/day), 79 kg/day (175 lbs/day), and 226 kg/day (631 lbs/day), respectively. Figure 6 shows the extent of all service areas. Table 7 lists the estimated number of active OSTDS within each service area and within the non-service areas. A total of 37,536 of the regions OSTDS are located within the Wakulla-St. Marks River watershed resulting in a total N load for the watershed of 1,019 kg/day (2,246 lbs/day). Figure 6 shows the estimated locations for the active OSTDS within the watershed.

### 3 GROUNDWATER FLOW AND TOTAL N TRANSPORT MODEL

The area of interest (AOI) for the project's groundwater flow and total N transport simulation task consisted of six IRL contributing watersheds in southern Brevard County; Eau Gallie River, Crane Creek, Turkey Creek, Goat Creek, Kid Creek, and Trout Creek. Also included was direct drainage into the IRL from the barrier islands directly east of these watersheds. The area of the AOI is 215 square miles. The AOI was conceptualized as a surficial water-table aquifer of variable thickness consisting of primarily medium to fine grained sand intermixed with silt which overlies the clays and limestones of the intermediate aquifer system (IAS). For this simulation, the IAS was assumed to be perfectly impervious, receiving no recharge from the surficial aquifer. The AOI is bounded on the west by watersheds discharging to the Upper St. Johns River and on the east by the Atlantic Ocean. The northern and southern boundaries coincide with the boundaries of other watersheds that discharge into the IRL, Horse Creek and the St Sebastian River respectively.

#### 3.1 Model Design

##### 3.1.1 *Conceptual Model*

Both the groundwater flow and N transport models were constructed in FEFLOW™ as a single layer, 3D simulation assuming steady-state flow and steady-state transport. As a result, the model simulations represent discharge and concentration values for a system in equilibrium with the assigned input conditions. The model was designed with a uniform node spacing of 28.9 m resulting in 666,662 model nodes. This allowed for the preservation of the topographic resolution defined by the 30-meter national elevation dataset (NED), which was used to define the model's surface elevation. The elevation of the bottom of the model was assigned from raster digital data defining the hydrostratigraphic surface of the IAS produced by the Florida Geological Survey as part of the Florida Aquifer Vulnerability Assessment (FAVA). The resulting aquifer thickness ranged from 65 to 154 feet. The aquifer material was assumed to be homogeneous and isotropic with a single assigned hydraulic conductivity value which was varied during the calibration process. The aquifer was assigned a porosity value of 0.1 and a storativity value of 0.2, which were intended to represent moderately porous heterogeneous sands.

##### 3.1.2 *Boundary Conditions*

Water was allowed to enter the model as diffuse surface recharge only. This recharge was assumed to be uniform over the model extent and was varied as a calibration parameter. Water was allowed to discharge from the model through internal nodes, which were used to represent canals and streams that drain the AOI and along the eastern external model boundary, which was designed to represent the coast of the Atlantic Ocean. The western, northern, and southern external boundaries were assigned as no-flow because they were assumed to represent hydrologic divides between flow into the model area and flow into other watersheds. Likewise, the bottom of the model was assigned as a no-flow boundary because the IAS was assumed to be impervious. Internal discharge was allowed at 107,432 nodes representing the traces of canals and natural waterways as well as the full extent of the IRL within the model domain (Figure 7).

##### 3.1.3 *Articulation of Canal Flow*

The connectivity of the Melbourne-Tillman Canal System and the flow direction through the canals was defined from the *Interbasin Diversion in Upper St. Johns River Basin* document (SJRWMD, 1984). The discharge nodes were assigned as constant head boundaries meaning that water was allowed to discharge from the model to the canals if the simulated groundwater elevation at the node exceeded the assigned elevation of the node. The assigned elevations at the IRL and the coastal nodes was 0 feet. The assigned elevation along canals and natural waterways was interpolated from USGS and SJRWMD stage data if available, and otherwise from the NED dataset. All discharge nodes were constrained to only allow discharge. Therefore, if the simulated groundwater elevation was below the assigned node elevation, the discharge node became inactive.

### 3.1.4 *Total Nitrogen Inputs*

Total nitrogen (N) transport was simulated from 34,685 unique point sources (contaminant nodes) representing each of the OSTDS estimated to exist within the model domain (Figure 7). The locations of the contaminant nodes were determined by snapping the estimated OSTDS locations to the closest model node. If the closest node was already occupied by an OSTDS, the location was moved to the next closest unoccupied node and no OSTDS was moved to an assigned discharge node. The contaminant nodes were set (by constraints) to deliver a constant N load of 27.216 grams per day into the groundwater flow system. The N concentration at each node varied based of the simulated flux through the model elements surrounding the node.

## 3.2 Model Calibration

The process of model calibration involves changing model parameters until the simulation best fits the hydrologic conditions the model is designed to simulate. For this project, the hydrologic conditions we intended to simulate were: 1) the average discharge into the canals and the IRL, and 2) surficial aquifer groundwater levels.

### 3.2.1 *Calibration to Flows*

The most robust dataset available from which these conditions could be defined was for discharge in the Melbourne-Tillman Canal System's (MTCS) C-1 canal that is measured near the confluence with Turkey Creek (USGS station: 02250005, USGS, 2014). These values represent the total discharge for the MTCS as all canals in this network ultimately flow into the C-1 canal up-gradient of this station. 1,313 mean daily discharge measurements, taken between March 1996 and September 2001, were available for this station. The full data record was used as the model calibration period. The median of these daily discharges was 113 cfs and that value was used as the target discharge for model calibration. Model recharge was varied until the summed discharge from all model discharge nodes above this station equaled 113 cfs. After achieving that match, the calibrated model-wide recharge value was 15.95 in/yr.

The only other discharge measurements within the model domain available for this time period were from the USGS station near the middle of the Eau Gallie River (USGS station: 02249007, USGS, 2014). The median of discharge values recorded at this station during the calibration period was 8.0 cfs. After the model was calibrated to the MTCS discharge, the summed simulated discharge for the Eau Gallie River above the Eau Gallie station was 6.0 cfs, which is below the measured median value but within the middle third of measured values. A comparison of simulated discharge to measured discharge for the other water systems within the model domain but from other time periods is shown in Table 8 (USGS, 2014). A general calibration objective was to ensure that all simulated discharges fall within the range of observed values for the respective station.

### 3.2.2 *Calibration to Groundwater Levels*

The ability to calibrate to measured groundwater elevations was limited due to a small number of measurement locations (6) and no measurements available from within the discharge time period. Due to their proximity to canals, measurements from four of the six groundwater elevation stations (SJRWMD, 2014) were used to set discharge node elevations and therefore could not be used for calibration. The mean of the measurements from the two remaining stations, each from two different time periods and both from time periods prior to the discharge time period, were used as calibration targets.

In order to calibrate the model to those groundwater levels, the hydraulic conductivity of the aquifer was varied until the minimum error between simulated and observed elevation at each station was achieved. The final hydraulic conductivity value was 39.3 feet per day. A comparison of simulated and measured groundwater elevation at the six station locations is shown in Table 9. The simulated groundwater elevations are shown in Figure 8.

### 3.3 Model Results

#### 3.3.1 *Total N Concentration*

Figure 9 shows the simulated steady-state concentration of total N in the groundwater as a consequence of loading from OSTDS. Concentrations range from below detection (<0.1 mg/l) to 170 mg/l where the highest concentrations occur at or adjacent to OSTDS nodes. The mean groundwater concentration at OSTDS nodes was 20 mg/l and the groundwater concentration exceeded 80 mg/l at two locations.

Figure 10 shows the steady-state nodal concentration of total N in discharging into the canals and stream channels as well as into the IRL, i.e. the simulated N concentration in the groundwater discharge at the respective points. Discharge concentrations range from below 0.1 mg/l to 159 mg/l with a mean concentration of 4 mg/l among nodes with discharge concentrations of 0.1 mg/l or greater (21,389 out of 108,131 discharge nodes). Discharge concentrations exceed 10 mg/l at various locations along the Melbourne-Tillman, Crane Creek and Trout Creek canal systems and into the IRL in the southeastern region of the model. The concentration at any point within the canals and streams would be defined by the sum of the simulated mass of N entering the canals at all nodes upstream of the point divided by the sum of simulated discharge at all of those same points.

#### 3.3.2 *Travel Times*

3D particle tracks were run from all assigned OSTDS nodes to their discharge points in order to estimate the time of travel for N contamination from the OSTDS point sources to the canals, streams, and the IRL due solely to advection. Figure 11 shows a map of all OSTDS nodes colored by the simulated time (in years) that it takes for water to move from the respective node to a discharge point. The fastest travel times are less than a day and occur at 3,087 OSTDS nodes that are located close to a canal, stream, or IRL discharge node. The mean travel time for all OSTDS nodes is 1,850 days or 5.1 years.

If we assume that the "year built" value contained in the FDOR parcel GIS coverage is the date at which the OSTDS became active and that the OSTDS has been in continuous use since that time, we can determine if the OSTDS is in steady-state with respect to the transport of total N. A steady-state OSTDS means that enough time has passed such that the leading edge of the N load has reached a discharge point and the OSTDS now acts as a continuous N source to the discharge feature. Using this analysis, we find that 25% of the active OSTDS in the model domain have been in steady-state since 1988, 50% since 1995, 95% are currently in steady-state and that within the next six years (2020) 99% will reach steady-state. Figure 12 shows graphs of the count of active OSTDS in steady-state by year and the number of new OSTDS reaching steady-state each year since 1970 and projected to 2020.

## 4 DISCUSSION

#### 4.1.1 *Active OSTDS Estimation*

The estimate of active OSTDS in the IRL and Wakulla-St. Marks River watersheds presented in this report is based on data and information readily available for download from federal, state, county, and municipal sources. Because of this, there are different levels of completeness in the estimations. The highest level of completeness, which we will call "high", can be assigned to the estimates for all of Indian River County, for the City of Palm Bay in Volusia County and for all parcels outside of any service area. The level of completeness is high for these regions because the estimates were made from a parcel by parcel assessment of sewer connection or for parcels which cannot receive sewer service. It is doubtful that the error associated with the number and location of active OSTDS estimation in these regions would make a significant difference in the simulated loading of total N to the IRL watersheds.

A "medium" level of completeness can be assigned to our estimations for the following regions: the Cities of New Smyrna Beach and Port Orange service areas in Volusia County, the Cities of Fort Pierce and Port St. Lucie and the St. Lucie County Utility service areas in St. Lucie County, the Martin County Utilities North, the City of Stuart, the South Martin Regional Utility, and the Loxahatchee River Environmental

Control District service areas in Martin County, and the Wakulla County service area in Wakulla County. The estimations for these regions were based on sewer line maps delineating the neighborhoods and sub-divisions which do and do not have the ability to connect to the provider's wastewater treatment facilities. In these regions, we assumed that if a neighborhood or sub-division had the possibility to connect to a sewer line then all parcels within the neighborhood or sub-division, except for those identified as active in the FDOH coverage, received sewer service. In most cases, this probably resulted in insignificant estimation errors where some number of parcels within older sub-divisions have not yet converted from OSTDS to the available sewer connection for wastewater treatment but have not been inspected by the FDOH and are thus not identified in the FDOH database.

There are, however, a few cases where we observed large inconsistencies between data sources. One example is in the City of Port Orange service area where there are several sections with a large number of active OSTDS from the FDOH coverage but where the City's sewer map shows sewer connection availability (Figure 13). In these regions, there are 2,077 non-vacant residential parcels of which 1,647 are listed as having active OSTDS in the FDOH database and which we have included in our active OSTDS estimation. A second example is in the Martin County Utility North service area where there are three regions with a large number of active OSTDS from the FDOH coverage but where the Utility's sewer map shows sewer connection availability (Figure 13). These regions contain 826 non-vacant residential parcels of which 338 are listed as having active OSTDS in the FDOH database and which we have included in our active OSTDS estimation.

With the available data, it is impossible to determine if the combined total of 1,985 active OSTDS have been converted to sewer connections and therefore should not be included in our active OSTDS estimation, or if these regions have sewer lines but no current residential connections resulting in a total under estimation of 918 active OSTDS. In these two examples, the error could be considered significant as our total N load to the IRL estimations may be high by as much as 53.6 kg/day (118 lbs/day) or low by as much as 25 kg/day (55 lbs/day).

A "low" level of completeness can be assigned to our estimations in the remaining service areas. This is because there were no available sewer connection maps from which parcels connected to sewer systems within the sewer service areas (and thus parcels with active OSTDS) could be defined. In these areas, we assumed that all parcels within the service area, except for those identified as having active OSTDS in the FDOH coverage, to be connected to the provider's wastewater treatment facility. In these regions, we estimated a total of 244,458 non-vacant residential parcels with sewer service and 63,007 parcels using OSTDS for wastewater treatment. The equivalent total N production from those parcels is 6,695 kg/day (14,728 lbs/day) and 1,745 kg/day (3,840 lbs/day) respectively. Therefore, even a 5% estimation error could result in significant total N load estimation error of hundreds of pounds per day. Table 10 list each service area with its level of completeness rating.

#### 4.1.2 Florida Department of Health Active OSTDS Data Source

The only source of information about the number and location of active OSTDS within low completeness service areas is from the FDOH Onsite Sewage Locations in Florida - June 2012 GIS coverage (FDOH, 2012). It should be noted that this data source contains a number of issues which result in error in our active OSTDS estimation. The dataset contains both closed and active inspected OSTDS and we only used the OSTDS assigned as active in our estimation process. However, we assumed all active OSTDS are residential OSTDS. Spot checks between this dataset and the parcel dataset shows that this is not always a correct assumption, but because the FDOH dataset is not annotated with type of OSTDS information, the only way to correct this error is through a time consuming parcel by parcel comparison between the FDOH dataset and the FDOR parcel maps, which was beyond the scope of this project. As a result, not all of the active OSTDS defined on the basis of the FDOH dataset can be assumed to be residential OSTDS.

A second source of error resulting from the use of the FDOH dataset is redundancy. We assumed that each active OSTDS entry in this data source represents a unique OSTDS. Again, spot checks revealed that this assumption to be invalid. The FDOH dataset can contain multiple entries for the same active OSTDS. These duplicates cannot be easily parsed out because the address entries are not exactly the same. Differences in spacing, spelling errors, and differences in abbreviations (i.e. road and rd, street and st) make a simple sort and delete process ineffective. Again, the scope of this project did not include the level of effort required to identify and delete all duplicates, which likely resulted in an overestimation of active OSTDS.

The third source of error associated with the FDOH dataset is that each active OSTDS entry does not necessarily represent a single OSTDS. Spot checking revealed that the address for some entries represents multiple parcels instead of a single residence (i.e. 440 - 560 Gopher Drive). This issue likely resulted in an underestimation of the number of active OSTDS.

Finally, many of the addresses in the FDOH dataset do not contain street numbers, just street names making it impossible to equate an entry in the FDOH dataset to a unique parcel. Furthermore, spot checking revealed that some addresses, while complete in form, did not match any of the addresses listed in the FDOR parcel dataset.

#### 4.1.3 Potential for Increasing the Number of Active OSTDS

The most immediate source for the potential increase in active OSTDS is vacant residential parcels. We performed an assessment of the location and type of vacant residential parcels in Brevard County as an example of the potential for rapidly increasing the total N load to the IRL. We chose Brevard County because we used this analysis in the groundwater flow / total N transport model and because all of the vacant residential parcels had either a full address or no address.

Comparing the parcels with no address against aerial images revealed that they represented vacant parcels within residential areas that were not designated for development (i.e. open space). Of the 66,144 vacant residential parcels in the dataset, 27,068 did not have address information. Based on the results of the aerial image assessments, these parcels were not considered to be potential future sources of N loading – i.e. as having a low probability of being developed with an OSTDS in the near future.

There are a total of 39,076 vacant residential parcels with addresses in Brevard County. Of these, 9,445 are located within sewer availability service areas as defined in this report. Of the remaining 29,631 vacant parcels, 27,932 are located within an IRL contributing sub-basin. There are two types of these vacant parcels: one which can be classified as developed, having an existing structure with a defined build date in the parcel dataset; and another that can be classified as undeveloped, having no build date in the parcel dataset. We assumed that all of these vacant parcels with no build date also have no existing structure.

This assessment revealed 27,891 vacant parcels that can be classified as undeveloped and are within the IRL watershed. We therefore consider these parcels to represent the basin's potential for near-term expansion of OSTDS and consequently the potential for increased total N load to the IRL. In Brevard County, this equates to a potential near-term increase in total N load to the IRL of 760 kg/day (1,673 lbs/day) or a 61% increase over the current estimated load.

#### 4.1.4 Total N Transport

The steady-state groundwater flow and total N transport model was designed and calibrated to simulate average hydrologic conditions. Therefore, while the transport of N may occur faster during high recharge times and slower under drought periods, these simulated travel times should equate to the average time it takes water to move from an active OSTDS to a discharge feature. Our analysis shows that currently 95% of the active OSTDS within the model domain have been active for a sufficient period of time for the total N being released at the tank to start being discharged into the region's canals and streams and into the IRL. In addition, by 2020 nitrogen from 99% of the active OSTDS in the model domain will be discharging into

these surficial water bodies. Therefore, this region is likely reaching the peak of total N discharge to the IRL with respect to currently active OSTDS (Figure 12 top).

While the total load of nitrogen to the IRL is likely reaching a peak with respect to contributions from OSTDS, the percent change in nitrogen loading is declining (Figure 12 bottom). This is because nearly all of the OSTDS in the model domain have likely reached steady-state conditions with respect to total N transport. The percent change in nitrogen discharge peaked twice with the largest peak occurring around 1990 and a second smaller peak occurring around 2007 (Figure 12 bottom). This is a function of both OSTDS location and the time when the OSTDS became active. Nitrogen from older OSTDS located large distances away from discharge features may start to discharge at the same time as nitrogen from more recent OSTDS located close to discharge features.

The potential for increasing the total N load to the IRL within the model domain comes from the 26,828 undeveloped vacant residential parcels (of the 27,891 identified for all of Brevard County) that are located outside of current sewer service areas (Figure 14). The model was used to evaluate the advective travel time from these parcels to a discharge node. We found that 10% of them will start discharging nitrogen into surficial water features in less than one year after an OSTDS becomes active, 57% after five years, 84% after ten years, and 99% after 17 years. This means that if we allow 8 years for development of these parcels, within the next 25 years the total N load to the IRL within the model domain will increase from 966 kg/day (2,125 lbs/day) to 1,698 kg/day (3,735 lbs/day). This represents a 76% increase from the current estimated total N load and will likely occur unless existing sewer service areas are expanded.

## **5 SUMMARY AND RECOMMENDATIONS**

### **5.1 Summary**

GeoHydros, LLC estimated the number of OSTDS and the associated total N loading to groundwater within the IRL basin and the Wakulla-St. Marks River basin. The project area covered parts of six IRL adjacent counties; Volusia, Brevard, Indian River, St. Lucie, Martin, and Palm Beach and parts of three Wakulla-St. Marks River adjacent counties; Jefferson, Leon, and Wakulla. The analysis was completed using downloadable information from federal, state, county, and municipal sources covering the project area.

We estimate that there are currently 140,736 active OSTDS within the IRL basin producing a total N load of 3,846 kg/day (8,462 lbs/day). We estimate that there are currently 37,536 active OSTDS within the Wakulla-St. Marks River basin producing a total N load of 1,021 kg/day (2,246 lbs/day). The total N load estimates assume no biological degradation or substrate retardation. The total N load estimates do not represent the complete N load to the basins as we did not account for reuse and spray field disposal of non-OSTDS domestic wastewater treatment facility effluent or the N contribution from the agricultural and residential use of fertilizer.

GeoHydros, LLC also constructed a steady-state groundwater flow and total N transport model covering six IRL contributing sub-basins in southern Brevard County; Eau Gallie River, Crane Creek, Turkey Creek, Goat Creek, Kid Creek, and Trout Creek. The model was calibrated to the median of daily mean discharge measurements taken from near the confluence of the Melbourne-Tillman Canal System C-1 Canal and the head of Turkey Creek and reported by the USGS for the time period between March 1996 and September 2001.

Steady-state total N transport was simulated from 34,685 active OSTDS within the model domain. The simulation showed that nitrogen released from the OSTDS results in groundwater concentrations ranging from below detection (<0.1 mg/l) to 170 mg/l with the highest concentrations at or adjacent to OSTDS nodes. The mean groundwater concentration at OSTDS nodes was 20 mg/l and the groundwater concentration exceeded 80 mg/l at only two locations. The simulation also showed that that nitrogen released from the OSTDS results in concentrations of total N in the groundwater discharge to surficial

water bodies that ranges from below 0.1 mg/l to 159 mg/l. The mean concentration among nodes with discharge concentrations of 0.1 mg/l or greater is 4 mg/l. Discharge concentrations exceed 10 mg/l at various locations along the Melbourne-Tillman, Crane Creek and Trout Creek canal systems and the IRL in the southeastern region of the model.

We also used the model to estimate the travel time from active and potential OSTDS locations to surficial water bodies. The model was seeded with the locations of 34,685 active OSTDS, which were used as start points for 3D particle tracks. These particle tracks terminate at simulated discharge nodes and give the travel time from start point to discharge. The particle track analysis yielded travel times ranging from days to 50 years with an average travel time of 5.1 years.

The travel time information allowed us to estimate the state of the aquifer with respect to total N discharge. The parcel dataset included an actual year built attribute for each of the parcels defined as having an active OSTDS and we assumed that this year equated to the year the OSTDS became active. Combining activation date and the simulated travel time data for each OSTDS, we were able to determine that 95% of the active OSTDS within the model domain are currently in steady-state with respect to total N transport. This means that enough time has passed to allow the leading edge of the total N load from 95% of the OSTDS to reach a surficial discharge point and that these OSTDS now act as a continuous source of nitrogen discharge. We also determined that by 2020, 99% of the active OSTDS within the model domain will be discharging nitrogen either directly into the IRL or into surficial water bodies that contribute to the IRL.

The same process was used to estimate the total N load from potential OSTDS in the model domain. A potential OSTDS was defined as any undeveloped vacant residential parcel located outside of sewer service availability. Undeveloped vacant residential parcels were identified from the parcel dataset as parcels attributed as vacant residential and having a street address but no actual build date. The model was seeded with the centroids of these 26,828 parcels which were used as start points for 3D particle tracks. The particle track analysis yielded travel times ranging from days to 51 years with an average travel time of 5.7 years from start point to discharge. The travel time from start point to discharge for 99% of the potential OSTDS is 17 years or less. This means that if all of the potential OSTDS parcels are developed over the next 8 years, the total N load from the portion of Brevard County in the model domain discharging into the IRL in the next 25 years will increase by 76%, from 966 kg/day (2,125 lbs/day) to 1,698 kg/day (3,735 lbs/day).

## **5.2 Recommendations**

A more in depth data search should be performed for all low confidence sewer service areas. This could be performed by requesting sewer line information or a list of addresses with sewer service directly from the providers thus eliminating the dependence on FDOH dataset, which was revealed to be fraught with errors.

The model should be rerun using the improved estimations of OSTDS locations and the associated total N loading.

Additional models should be constructed for all of the remaining sub-watersheds in the IRL basin as well as for the Wakulla-St Marks River watershed. These models will provide a quantitative means to estimate existing nitrogen loading to critical water bodies (the IRL and the Wakulla River), and the probable increase in nitrogen discharge to these features associated with planned and probable future developments. The output from these models would contribute to efforts to establish and implement Total Maximum Daily Loads (TMDLs) as well as the associated Basin Action Management Plans (BMAPs) that will be designed and implemented to foster compliance with those TMDLs.

## 6 REFERENCES

- BCUSD, 2013. Water and Wastewater Service Areas for Brevard County, Brevard County Utility Services Department, Brevard County, Florida, available from Brevard County at: <http://www.brevardcounty.us/UtilityServices>.
- COPB, 2014. Compass Interactive Maps, Water and Sewer Availability Layer, Enterprise Geographic information Systems, available from the City of Palm Bay at: <http://www.palmbayflorida.org/government/departments/utilities/services/egis>.
- COPO, 2010a. Comprehensive Plan City of Port Orange 2010-2025, Public Facilities Element, Septic Tank Areas, City of Port Orange Community Development, July 2010, available from the City of Port Orange at: [https://www.port-orange.org/community\\_development/?p=comprehensive\\_plan](https://www.port-orange.org/community_development/?p=comprehensive_plan).
- COPO, 2010b. Comprehensive Plan City of Port Orange 2010-2025, Public Facilities Element, Wastewater Collection Systems, City of Port Orange Community Development, July 2010, available from the City of Port Orange at: [https://www.port-orange.org/community\\_development/?p=comprehensive\\_plan](https://www.port-orange.org/community_development/?p=comprehensive_plan).
- COS, 2007. City of Stuart Water and Sewer Service Area, prepared for the City of Stuart Utility Division by Northstar Geomatics, Stuart, Florida, 2007, available from the City of Stuart at: <http://cityofstuart.us/index.php/utility-division>.
- COS, 2014. Sanitary Sewer Expansion Program Map, City of Stuart, Public Works Department, available from the City of Stuart at: <http://cityofstuart.us/index.php/sewer-expansion-program/sewer-expansion-maps>.
- FDOH, 2013. Onsite Sewage Treatment and Disposal Systems Installed in Florida (table), available for download at: <http://www.floridahealth.gov/healthy-environments/onsite-sewage/ostds-statistics.html>.
- FLDEP, 2014. Domestic Wastewater Facilities, Florida Department of Environment Protection, Wastewater Facility Information, available at: <http://www.dep.state.fl.us/water/wastewater/facinfo.htm>.
- FLDOH, 2012. Onsite Sewage Locations in Florida - June 2012, vector digital data, Florida Department of Health, Tallahassee, FL, available from FGDL Metadata Explorer: <ftp://ftp1.fgdl.org/pub/state/>
- FLDOR, 2010. County Parcel Data - 2010, Florida Department of Revenue, Tallahassee Florida. Available from FGDL Metadata Explorer: <ftp://ftp1.fgdl.org/pub/state/>.
- IRC, 2013. Indian River County Department of Utility Services Overall WWTF Service Areas - 2008, Indian River County 2030 Comprehensive Plan, Sanitary Sewer Sub-Element, Indian River County Community Development Department, 2013.
- IRC, 2014. Parcels with No Sewer Service in Indian River County, Indian River County Geographic Information Systems, available from Indian River County at: <http://www.ircgov.com/Departments/GIS/Index.htm>.
- LRECD, 2010. 2010 Septic System Inventory and Assessment Study, prepared for the Loxahatchee River Environmental Control District by Mathews Consulting Civil Engineers, March 2010, available from the Loxahatchee River District at: [http://loxahatcheeriver.org/septic\\_system\\_inventory.php](http://loxahatcheeriver.org/septic_system_inventory.php).
- MCU, 2014. Martin County Maintained Water and Sanitary Sewer Features Map, Technical Service, Martin County Utilities & Solid Waste Department, Martin County, Florida, available from Martin County at: [http://ap3server.martin.fl.us:7778/portal/page?\\_pageid=351,530091&\\_dad=portal&\\_schema=PORTAL](http://ap3server.martin.fl.us:7778/portal/page?_pageid=351,530091&_dad=portal&_schema=PORTAL).
- SJRWMD, 1984. Interbasin Diversion in the Upper St. Johns River Basin, Technical Publication SJ 84-10, prepared by David A. Clapp and Harold A. Wilkening for the Engineering Division of the SJRWMD Water Resources Department, Palatka, Florida, 1984, 213 pp, available from SJRWMD at: <http://www.sjrwmd.com/technicalreports/tpubs1.html>.
- SJRWMD. 1989. Surface Water Improvement and Management (SWIM) Plan for Indian River Lagoon. Submitted to Florida Department of Environmental Regulation, in Compliance with Chapter 373.451 - 373.4595, Florida Statutes and Rule 17-43.035 F.A.C. Prepared jointly by the St. Johns River Water Management District (SJRWMD) and the South Florida Water Management District (SFWMD).
- SJRWMD, 2014. St. Johns River Water Management District Hydrologic Data, Brevard County, Water Level, achieve, available from SJRWMD at: <http://webapub.sjrwmd.com/agws10/hdsnew/map.html>.

- SLC, 2006. Feasibility Study of Water Supply Integration St. Lucie County, Task 1.2 Summary Memorandum, June 2006, CN040927-WO4, Metcalf & Eddy, AECOM, available from SFWMD at: [http://www.sfwmd.gov/portal/page/portal/xrepository/sfwmd\\_repository\\_pdf/task%20201-2%20final.pdf](http://www.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/task%20201-2%20final.pdf).
- SLC, 2014a, Urban Service Boundary, St. Lucie County Online, GIS, Downloads, available from St. Lucie County at: <http://gis.stlucieco.gov/gis/Downloads.asp>.
- SLC, 2014b, St. Lucie County Hydrology Placement Map, St. Lucie County Online, Utilities Division, available from St. Lucie County at: <http://www.stlucieco.gov/utilities/index.htm>.
- SMRU, 2014. Wastewater System Coverage, Infrastructure Department, South Martin Regional Utility, available from South Martin Regional Utility at: <http://www.southmartinregionalutility.com/p/28/maps>.
- U.S. Census Bureau, 2014. State & County QuickFacts, available from U.S. Census Bureau at: <http://quickfacts.census.gov/qfd/#>.
- USDA, 2014. Watershed Boundary Dataset, HUC-12 (1:24,000 scale), available from the United States Department of Agriculture Geospatial Data Gateway at: <http://datagateway.nrcs.usda.gov/GDGOrder.aspx?order=QuickState#>.
- U.S. EPA, 1992. Water Treatment/Disposal for Small Communities, EPA/625/R-92/005 U.S. Environmental Protection Agency, Office of Research and Development, Center for Environmental Research Information, Cincinnati, OH.
- UCNSB, 2006. Wastewater & Reclaimed Water System Facility Plan, Wastewater System Components, Utilities Commission New Smyrna Beach, City of New Smyrna Beach, Volusia County, Florida, available from the Utilities Commission City of New Smyrna Beach at: <https://ucnsb.org/studies.aspx>.
- USGS, 2014. USGS Water Data for Florida, available from the USGS at: : <http://waterdata.usgs.gov/fl/nwis/>.
- VCPW, 2008. Volusia County Utility Service Areas, UtilityServiceAreas.shp, available from Volusia County at: <http://www.volusia.org/gis/download/Shapes.htm>.
- WC, 2014. Crawfordville Area Sewer System, Crawfordville Town Plan Part 1, prepared for Wakulla County by Kimley-Horn and Associates, Inc., available from Wakulla County at: [http://www.mywakulla.com/departments/planning\\_and\\_zoning/document\\_center.php#revize\\_document\\_center\\_rz1177](http://www.mywakulla.com/departments/planning_and_zoning/document_center.php#revize_document_center_rz1177).
- WVB, 2013. Deltona to finally get new sewage plant, West Volusia Beacon Online, Sep 17, 2013, available from the West Volusia Beacon at: <http://beacononlinenews.com/news/daily/6391>.

## 7 TABLES

Table 1. Summary of Active OSTDS in Volusia County by service area.

SERVICE AREA	FACILITY ID	FACILITY NAME	OWNERSHIP TYPE	SECTION	RESIDENTIAL PARCELS	FDOH ACTIVE OSTDS	ESTIMATED ACTIVE OSTDS	TOTAL N LOAD (lbs/d)
Daytona Beach	FL0025984 FLA111392 FL0025984	Daytona Beach/Bethune Point WRF Daytona Beach Westside Regional WRF Daytona Beach/Bethune Point WRF	Municipal	Daytona Beach	16,482	846	846	52
				Daytona Beach Shores	132	17	17	1
				South Daytona Beach	4,150	344	344	21
				Unincorporated	3,239	914	3,239	198
Deland	FL0020303	Deland/Wiley M. Nash WRF	Municipal	Deland	7,439	347	347	21
				Unincorporated	11,993	5,012	11,993	731
Deltona	unk	Deltona/Fisher Plant	Municipal	Deltona	32,664	11,557	26,664	1,626
				Unincorporated	2,469	1,061	2,469	151
Deltona North	FLA011121	VCUD/ Deltona North	County	Deltona	71	21	21	1
				Unincorporated	208	109	208	13
Edgewater	FL0021431	Edgewater, City of	Municipal	Edgewater	8,759	131	131	8
				Unincorporated	1,263	369	1,263	77
Halifax Plantation	FLA011131	VCUD/ Halifax Plantation WWTF	County	Halifax Plantation*	1,249	154	154	9
Holly Hill	FL0027677	Holly Hill, City of	Municipal	Holly Hill	3,925	38	38	2
				Unincorporated	155	10	155	9
Lake Helen*	na	na	na	Lake Helen	1,003	383	1,003	61
New Smyrna Beach	FL0172090	New Smyrna Beach WRF	Municipal	New Smyrna Beach	10,428	440	413	25
				Unincorporated	3,249	1,061	2,529	154
Northeast Utility	unk	VCUD/Northeast Utility	County	Flagler Beach	1	0	1	0
				Lake of Pine Run*	37	2	2	0
				Unincorporated	245	94	245	15
Orange City, Proposed	na	na	Municipal	Orange City	2,105	788	2,105	128
Ormond Beach	FL0020532	Ormond Beach WWTF	Municipal	Ormond Beach	14,693	525	525	32
				Unincorporated	5,179	1,879	5,179	316
Pierson	na	na	na	Pierson	501	165	501	31
Pine Island	FLA011207	VCUD/ Pine Island	County	Pine Island*	89	0	0	0
Port Orange	FL0020559	Port Orange WWTF	Municipal	Daytona Beach Shores	304	79	24	1
				Ponce Inlet	1,099	245	285	17
				Port Orange	19,752	1,575	569	35
				Unincorporated	3,062	965	1,483	90
Southeast Regional	FLA017413	VCUD/ Southeast Regional	County	Oak Hill	419	125	125	8
				Unincorporated	385	145	385	23

SERVICE AREA	FACILITY ID	FACILITY NAME	OWNERSHIP TYPE	SECTION	RESIDENTIAL PARCELS	FDOH ACTIVE OSTDS	ESTIMATED ACTIVE OSTDS	TOTAL N LOAD (lbs/d)
Southwest Regional	FLA011128 FLA011118	VCUD/Southwest Regional VCUD/Four Townes	County	Debary	4,353	458	458	28
				Orange City	118	10	10	1
				Unincorporated	2,399	1,633	2,399	146
Stone Island	unk	unk	County	Stone Island*	264	51	51	3
				Unincorporated	133	56	133	8
none	na	na	na	Astor Park*	307	48	307	19
				Debary	3,691	1,219	3,691	225
				Oak Hill	473	315	473	29
				Orange City	2,055	735	2,055	125
				Unincorporated	4,865	1,987	4,865	297
TOTALS					175,407	35,913	77,705	4,739

\* Unincorporated sewer service area

Table 2. Summary of Active OSTDS in Brevard County by service area.

SERVICE AREA	FACILITY ID	FACILITY NAME	OWNERSHIP TYPE	SECTION	RESIDENTIAL PARCELS	FDOH ACTIVE OSTDS	ESTIMATED ACTIVE OSTDS	TOTAL N LOAD (lbs/d)
Barefoot Bay	FL0042293	Barefoot Bay Advanced WWTF	County	Barefoot Bay*	5,133	5	5	0
Cape Canaveral	FL0020541 FL0102920	Cape Canaveral WRF CCAFS/Regional	Municipal Federal	Cape Canaveral	1,968	2	2	0
Cocoa	FL0021521	Cocoa Water Reclamation Facility	Municipal	Cocoa	4,953	69	69	4
Cocoa Beach	FL0021105	Cocoa Beach WRF	Municipal	Cocoa Beach	2,967	4	4	0
Port St. John	FLA102750	BCUD/Port St John	County	Port St John*	1,090	25	25	2
Melbourne	FL0041122 FLA010323	Melbourne/Grant Street Melbourne/DB Lee WWTP	Municipal	Melbourne	23,803	117	117	7
Merritt Island	FLA102695	BCUD/Sykes Creek	County	Merritt Island*	12,426	315	315	19
North Regional	FLA010263	BCUD/North Regional/John D Wright	County	Mims*	1,458	7	7	0
Palm Bay	FLA103357 FLA648744 FLA693782	Palm Bay #1 WRF Palm Bay#2 Palm Bay South Regional WRF	Municipal	Palm Bay	40,161	3,323	26,206	1,572
Rockledge	FL0021571	Rockledge, City of	Municipal	Rockledge	8,849	46	46	3
South Beaches	FL0040622	BCUD/South Beaches	County	Indialantic	1,151	2	86	5
				Indian Harbour Beach	2,980	9		
				Melbourne Beach	1,295	3		
				Satellite Beach	3,857	11		
				Unincorporated	5,968	61		
South Central	FL0102679	BCUD/South Central Regional	County	Palm Shores	292	14	190	11
				Viera-Suntree*	17,270	176		
Titusville	FL0103268 FLA010332	Titusville North - Osprey Titusville Blue Heron WRF	Municipal	Titusville	15,729	97	97	6
West Melbourne	FLA010332	West Melbourne/Ray Bullard	Municipal	West Melbourne	6,123	38	38	2
none	na	na	na	Grant - Valkaria	1,760	227	1,760	106
				Malabar	1,095	108	1,095	66
				Melbourne Village	307	33	307	18
				Unincorporated	36,351	2,966	36,351	2,181
TOTALS					196,986	7,658	66,720	4,003

Table 3. Summary of Active OSTDS in Indian River County by service area.

SERVICE AREA	FACILITY ID	FACILITY NAME	OWNERSHIP TYPE	SECTION	RESIDENTIAL PARCELS	FDOH ACTIVE OSTDS	ESTIMATED ACTIVE OSTDS	TOTAL N LOAD (lbs/d)
Blue Cypress	FLA010439	IRCU/Blue Cypress	County	Blue Cypress*	67	0	2	0
Central Regional	FLA010431	IRCU/Central (Gifford) WWTF	County	Unincorporated	5,301	751	1,469	85
North Regional	FLA104388	IRCU/North Regional WWTF	County	Orchid	278	5	0	0
				Sebastian	9,585	5,098	8,109	469
				Unincorporated	5,545	3,120	4,206	243
Sea Oaks	FLA104299	IRCU/Sea Oaks	County	Sea Oaks*	155	0	0	0
South Regional	FLA010435	IRCU/South Regional WWTF	County	Unincorporated	13,667	3,745	7,400	428
West Regional	FL0041637	IRCU/West Regional WWTF	County	Unincorporated	4,924	1,524	2,810	162
Vero Beach	FLA104434	Vero Beach, City Of	Municipal	Indian River Shores	1,746	76	176	10
				Vero Beach	5,472	1,120	1,389	80
				Unincorporated	2,626	741	1,275	74
none	na	na	na	Fellsmere	1,030	461	1,030	60
				Unincorporated	1,023	816	1,023	59
TOTALS					51,419	17,457	28,889	1,669

Table 4. Summary of Active OSTDS in St. Lucie County by service area.

SERVICE AREA	FACILITY ID	FACILITY NAME	OWNERSHIP TYPE	SECTION	RESIDENTIAL PARCELS	FDOH ACTIVE OSTDS	ESTIMATED ACTIVE OSTDS	TOTAL N LOAD (lbs/d)
Fort Pierce	FL0027278	Fort Pierce Utility Authority--WWTF	Authority	Fort Pierce	10,326	133	1,205	78
				Unincorporated	7,232	541	6,586	428
Harbour Ridge	FLA013986	Harbour Ridge PUD	Private	Harbour Ridge*	470	0	0	0
Holiday Pines	FLA013969	SLCU North County (Holiday Pines)	County	Holiday Pines*	1,043	1	515	0
Lakewood Park	FLA039586	SLCU Lakewood Park WWTF	Private	Lakewood Park*	2,874	254	2,786	181
North Hutchinson Island	FLA013946	SLCU North Hutchinson Island WWTF	County	North Hutchinson Island*	641	169	496	32
Panther Woods	unk	unk	unk	Panther Woods*	227	0	0	0
Port St. Lucie	FLA024929 FLA139653 unknown	Port St Lucie Utility Southport Port St Lucie Utility Westport Port St Lucie Utility Northport	Municipal Private unknown	Port St. Lucie	60,974	343	343	22
				Unincorporated	2,595	193	2,595	169
Reserve Plantation	FLA013963	Reserve Utility Corporation	Private	Port St. Lucie	2,083	15	15	1
Savanna Club	FLA013958	Savanna Club WWTF	Private	Port St. Lucie	27	0	0	0
St Lucie West	FLA013993	St Lucie West Services District	Private	St Lucie West*	6,095	16	16	1
South Hutchinson Island	FL0139475	SLCU South Hutchinson Island WRF	Private	South Hutchinson Island*	2,557	0	0	0
Spanish Lakes Fairways	FLA013998	Spanish Lakes Fairways WWTF	Private	Spanish Lakes Fairways*	408	0	0	0
Spanish Lakes Country Club	FLA013977	Spanish Lakes Country Club		Spanish Lakes Country Club*	28	0	0	0
The Grove	FLA013984	The Grove Community Assn. WWTP	Private	The Grove*	364	0	0	0
none	na	na	na	Unincorporated	2,280	111	2,280	148
TOTALS					100,234	1,776	16,837	1,093

\* Unincorporated sewer service area

Table 5. Summary of Active OSTDS in Martin County by service area.

SERVICE AREA	FACILITY ID	FACILITY NAME	OWNERSHIP TYPE	SECTION	RESIDENTIAL PARCELS	FDOH ACTIVE OSTDS	ESTIMATED ACTIVE OSTDS	TOTAL N LOAD (lbs/d)
Lakeside	FLA013853	Lakeside Village MHP	Private	Hobe Sound*	3	0	0	0
Loxahatchee Environmental Control District	FL0034649	Loxahatchee Environmental Control District WWTP	District	Unincorporated	2,269	145	332	20
Martin County Utility North	FLA043192	Martin County Utilities North WWTF	County	Ocean Breeze Park	0	6	0	0
				Sewall's Point	881	486	825	49
				Stuart	380	9	0	0
				Unincorporated	31,072	5,523	13,358	792
Sailfish Point	FLA017466	Sailfish Point WWTF	Private	Sailfish Point*	296	0	0	0
Sea Breeze	FLA013861	Sea Breeze Mobile Manor	Private	Hobe Sound*	4	0	0	0
South Martin Regional Utility	FLA013859	South Martin Regional Utility WWTF	Private	Hobe Sound*	8,699	882	2,442	145
				Jupiter Island	505	352	505	30
Stuart	FLA041459	Stuart, City of	Private	Stuart	2,358	753	1,474	87
				Unincorporated	687	288	495	29
Woodbridge	FLA013839	Woodbridge Mobile Village (WWTP)	Private	Hobe Sound*	2	0	0	0
none	na	na	na	Unincorporated	2,518	1,193	2,518	149
TOTALS					49,674	9,637	21,949	1,301

\* Unincorporated sewer service area

Table 6. Summary of Active OSTDS in the Indian River Lagoon Watershed by Sub-Basin.

IRL SUB-BASIN	COUNTY	ACTIVE OSTDS BY SOURCE			TOTAL N LOAD (lbs/d)
		PARCEL	FDOH	TOTAL	
Belcher Canal	St. Lucie	5,567	1	5,568	362
Crane Creek	Brevard	1,139	55	1,194	72
Eau Gallie River	Brevard	1,214	62	1,276	77
Goat Creek	Brevard	1,105	0	1,105	66
Indian River Lagoon	Brevard	9,383	472	9,855	591
	Indian River	1,891	0	1,891	109
	Martin	725	0	725	43
	Palm Beach	234	0	234	14
	St. Lucie	501	0	501	33
	Volusia	2	0	2	0
Loxahatchee River	Martin	3,010	0	3,010	178
	Palm Beach	6,707	0	6,707	397
Mosquito Lagoon	Brevard	0	0	0	0
	Volusia	2,932	247	3,179	194
Newfound Harbor	Brevard	1,273	94	1,367	82
North Banana river	Brevard	76	1	77	5
North Canal	Indian River	1,639	0	1,639	95
South Banana River	Brevard	919	99	1,018	61
South Canal	Indian River	8,649	0	8,649	500
Spruce Creek	Volusia	4,788	4	4,792	292
St. Lucie River	Martin	18,138	0	18,138	1,075
	St. Lucie	10,395	374	10,769	699
St. Sebastian River	Brevard	847	3	850	51
	Indian River	13,287	0	13,287	768
Tomoka River	Volusia	10,411	1,922	12,333	752
Trout & Kid Creek	Brevard	478	2	480	29
Turkey Creek	Brevard	28,252	11	28,263	1,696
Turnbull Hammock	Volusia	433	9	442	27
Vero Beach Main Canal	Indian River	3,385	0	3,385	196
<b>TOTAL</b>		<b>137,380</b>	<b>3,356</b>	<b>140,736</b>	<b>8,462</b>

Table 7. Summary of Active OSTDS in Jefferson, Leon, and Wakulla Counties.

COUNTY	SERVICE AREA	FACILITY ID	FACILITY NAME	OWNERSHIP TYPE	SECTION	RESIDENTIAL PARCELS	FDOH ACTIVE OSTDS	ESTIMATED ACTIVE OSTDS	TOTAL N LOAD (lbs/d)
Jefferson	Monticello	FL0027839	Monticello, City of - WWTP	Municipal	Monticello	1118	143	143	8
	none	na	na	na	Unincorporated	2835	2076	2835	167
Leon	Tallahassee	FLA010139	T P Smith WRF	Municipal	Tallahassee	49126	820	820	48
		FLA010140	Lake Bradford Road WWTP						
	Lake Bradford Estates	FLA010148	Lk Bradford Estates MHP WWTP	Private	Lake Bradford Estates*	18	0	0	0
	Meadows-At-Woodrun	FLA010159	Meadows-At-Woodrun WWTF	Private	Meadows-At-Woodrun*	251	0	0	0
	Sandstone Ranch	FLA010167	Sandstone Ranch WWTF	Private	Sandstone Ranch*	169	0	0	0
	Lake Jackson	FLA010171	Lake Jackson WWTP	Private	Lake Jackson*	919	0	0	0
	Killearn Lakes	FLA010173	Killearn Lakes WWTP	Private	Killearn Lakes*	2106	0	0	0
	none	na	na	na	Unincorporated	30417	13241	30417	1,795
Wakulla	Wakulla County	FLA010225	Wakulla County WWTF	County	Crawfordville*	2676	582	1892	120
	Oyster Bay Estates	FLA010237	Oyster Bay Estates WWTP	Private	Oyster Bay Estates*	57	0	0	0
	River Plantation Estates	FLA010241	River Plantation Estates WWTP	Private	River Plantation Estates*	87	0	0	0
	St Marks	FLA102318	St Marks WWTF	Municipal	St Marks	173	1	1	0
	none	na	na	na	Sopchoppy	173	17	173	11
	none	na	na	na	Unincorporated	7915	1653	7915	500
TOTALS						98,040	18,533	44,196	2,649

\* Unincorporated sewer service area

Table 8. Summary of Measured Discharge Data within the Model Domain.

USGS STATION NAME	MAPID	DATE RANGE	DATA RECORDS	DISCHARGE (cfs)				
				MEDIAN	MIN	MAX	SIMULATED	%RANK
02249007 Eau Gallie River	1	Mar-96 to Sep-01	1313	8.0	0.0	168	6.0	34%
02249500 Crane Creek	2	Feb-03 to Mar-14	4042	13.0	3.5	1190	14.9	57%
02250005 Melbourne-Tillman Canal	3	Mar-96 to Sep-01	1313	113.0	0.0	2020	113.0	50%
02250500 Goat Creek	4	Apr-89 to Sep-92	2641	5.1	0.6	373	11.8	75%
02250600 Kid Creek	5	Apr-89 to Sep-96	1249	0.2	0.1	15	0.8	90%
02250700 Trout Creek	6	Apr-89 to Sep-96	2703	3.6	0.1	173	9.0	77%

Notes:

MAPID = numeric label used to identify the station location on Figure 8.

%RANK = percentile marking the position of the simulated value in the available data where the objective was to ensure that all simulated values fall within the observed range.

Table 9. Summary of Measured Groundwater Elevation Data within the Model Domain.

STATION NAME	MAPID	DATE RANGE	DATA RECORDS	GROUNDWATER ELEVATION (ft)				
				MEAN	MIN	MAX	SIMULATED	DIFF
BR1964 Three Forks Platt Parcel	1	Sep-08 to Mar-14	1701	15.5	13.5	17.09	15.5	0.0
BR0795 Laika St Palm Bay	2	May-89 to Feb-93	6	17.4	15.3	19.5	17.9	0.5
BR0754 Columbia Elementary	3	Apr-89 to Mar-91	3	27.0	26.9	27.3	25.6	-1.5
BR1982 Erna Nixon Park	4	Feb-08 to Mar-14	2137	19.5	3.8	26.0	16.8	-2.6
BR1085 SJRWMD	5	Feb-91 to Mar-93	2	17.6	17.1	18.0	20.4	2.9
C-1 Canal @ Red Bud Circle	6	Jan-88 to Sep-92	1685	8.1	4.7	17.0	8.3	0.2

Table 10. Completeness Ratings for All Analyzed Sewer Service Areas.

COUNTY	SERVICE AREA	OWNERSHIP TYPE	COMPLETENESS RATING
Brevard	Palm Bay	Municipal	HIGH
Indian River	Blue Cypress	County	HIGH
	Central Regional	County	HIGH
	North Regional	County	HIGH
	Sea Oaks	County	HIGH
	South Regional	County	HIGH
	Vero Beach	Municipal	HIGH
	West Regional	County	HIGH
Martin	Loxhatchee Env Control Dist	District	MEDIUM
	Martin County Utility North	County	MEDIUM
	South Martin Regional Utility	Private	MEDIUM
	Stuart	Private	MEDIUM
St Lucie	Fort Pierce	Authority	MEDIUM
	Holiday Pines	County	MEDIUM
	Lakewood Park	Private	MEDIUM
	North Hutchinson Island	County	MEDIUM
	Port St. Lucie	Municipal /Private	MEDIUM
	South Hutchinson Island	Private	MEDIUM
Volusia	New Smyrna Beach	Municipal	MEDIUM
	Port Orange	Municipal	MEDIUM
Wakulla	Wakulla County	County	MEDIUM
Brevard	Barefoot Bay	County	LOW
	Cape Canaveral	Municipal / Federal	LOW
	Cocoa	Municipal	LOW
	Cocoa Beach	Municipal	LOW
	Melbourne	Municipal	LOW
	Merritt Island	County	LOW
	North Regional	County	LOW
	Port St. John	County	LOW
	Rockledge	Municipal	LOW
	South Beaches	County	LOW
	South Central	County	LOW
	Titusville	Municipal	LOW
West Melbourne	Municipal	LOW	
Jefferson	Monticello	Municipal	LOW
Leon	Killearn Lakes	Private	LOW
	Lake Bradford Estates	Private	LOW
	Lake Jackson	Private	LOW
	Meadows-At-Woodrun	Private	LOW
	Sandstone Ranch	Private	LOW
	Tallahassee	Municipal	LOW
Martin	Lakeside	Private	LOW
	Sailfish Point	Private	LOW
	Sea Breeze	Private	LOW
	Woodbridge	Private	LOW
St Lucie	Harbour Ridge	Private	LOW
	Panther Woods	unknown	LOW
	Reserve Plantation	Private	LOW
	Savanna Club	Private	LOW
	Spanish Lakes Country Club	Private	LOW
	Spanish Lakes Fairways	Private	LOW
	St Lucie West	Private	LOW
The Grove	Private	LOW	

Contributions of Total Nitrogen from OSTDS to the Indian River Lagoon...

COUNTY	SERVICE AREA	OWNERSHIP TYPE	COMPLETENESS RATING
Volusia	Daytona Beach	Municipal	LOW
	Deland	Municipal	LOW
	Deltona	Municipal	LOW
	Deltona North	County	LOW
	Edgewater	Municipal	LOW
	Halifax Plantation	County	LOW
	Holly Hill	Municipal	LOW
	Northeast Utility	County	LOW
	Ormond Beach	Municipal	LOW
	Pine Island	County	LOW
	Southeast Regional	County	LOW
	Southwest Regional	County	LOW
Wakulla	Stone Island	County	LOW
	Oyster Bay Estates	Private	LOW
	River Plantation Estates	Private	LOW
	St Marks	Municipal	LOW

8 FIGURES

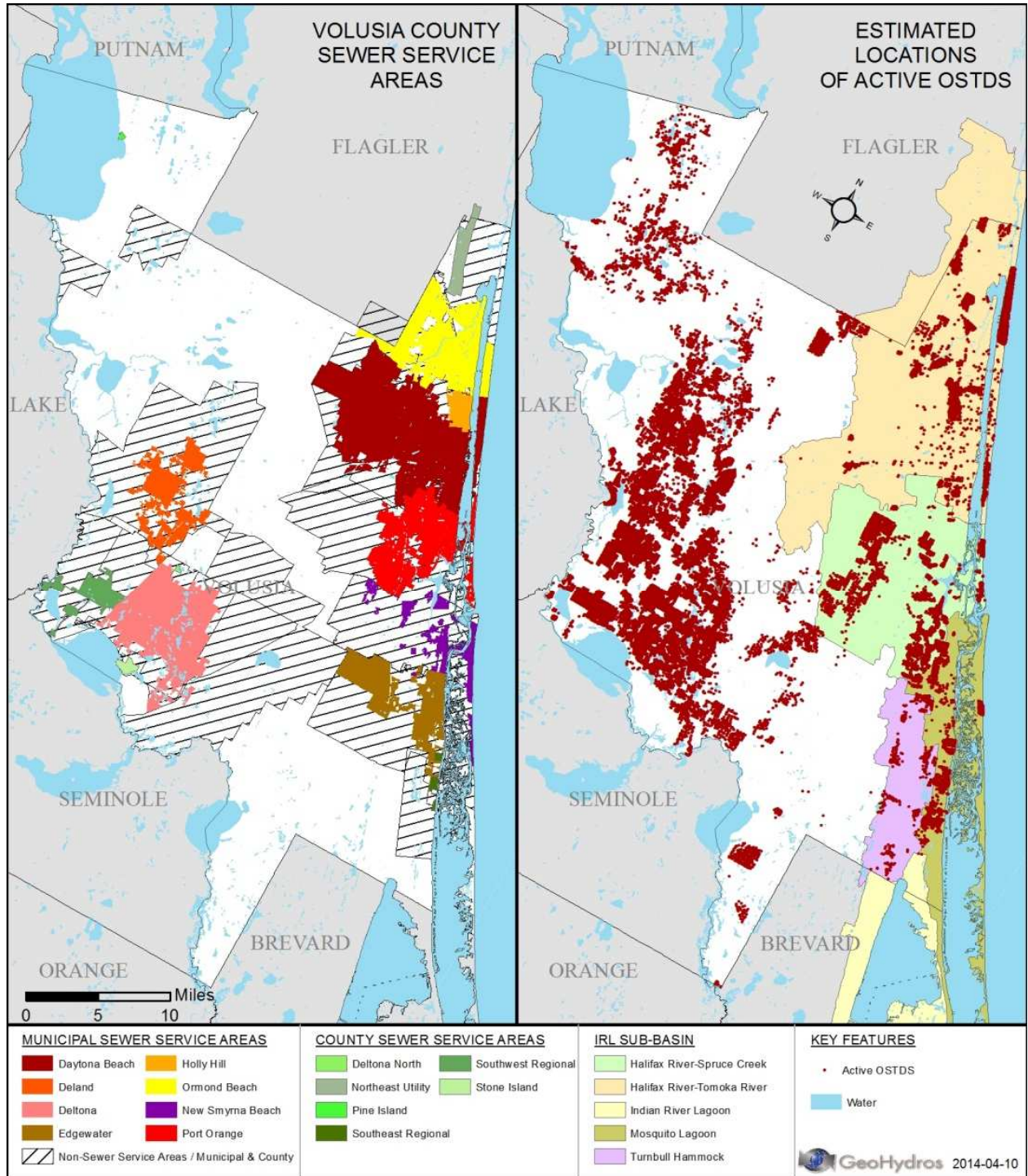


Figure 1. Analysis of Active OSTDS in Volusia County, Florida. The left side of the figure shows a map of the extent of sanitary sewer service in Volusia County as delineated in this report. The right side of the figure shows a map of the estimated number and location of active OSTDS within Volusia County with respect to Indian River Lagoon sub-basins. Note that both maps have been rotated 30 degrees clockwise from true north.

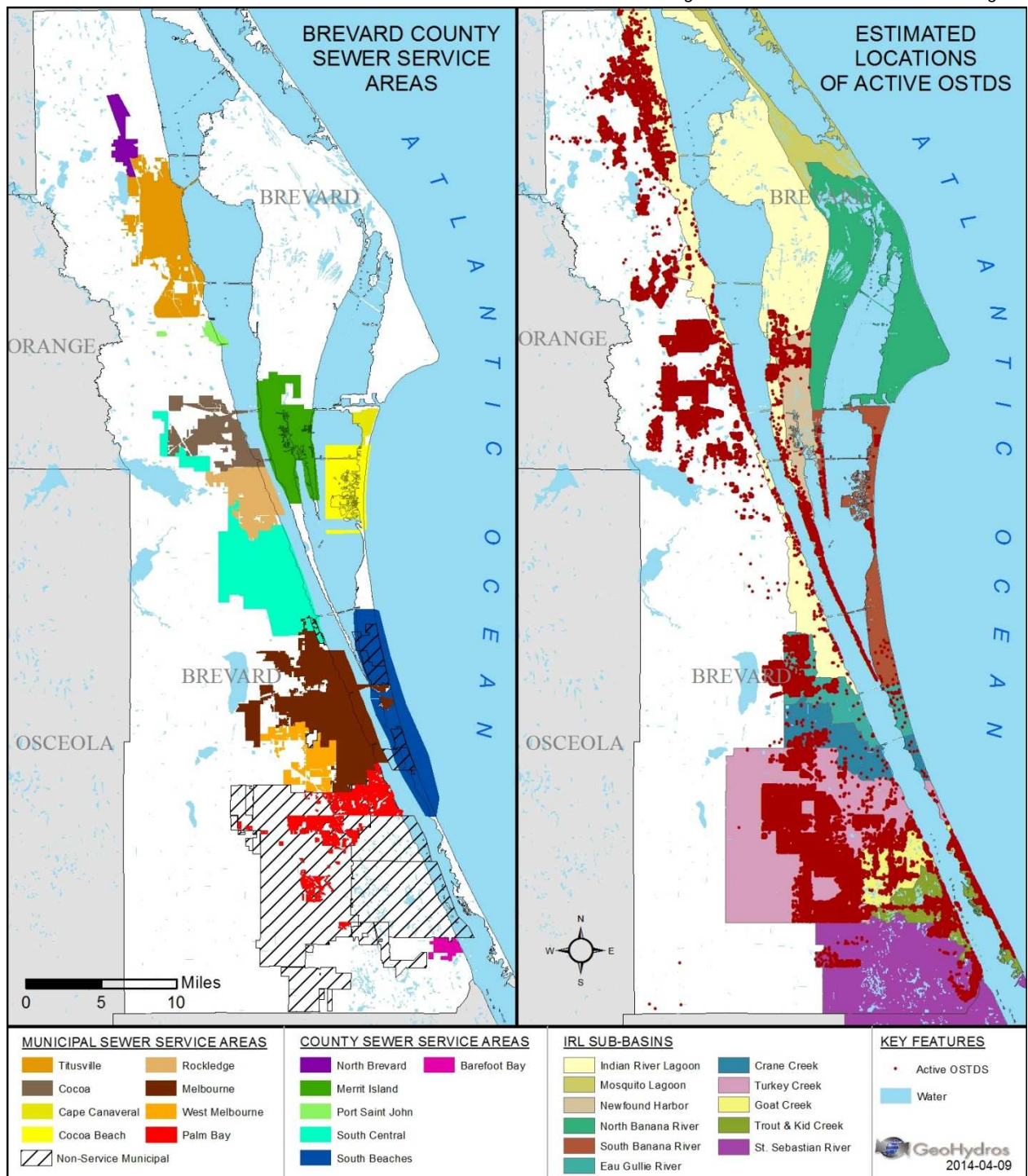


Figure 2. Analysis of Active OSTDS in Brevard County, Florida. The left side of the figure shows a map of the extent of sanitary sewer service in Brevard County as delineated in this report. The right side of the figure shows a map of the estimated number and location of active OSTDS within Brevard County with respect to Indian River Lagoon sub-basins.

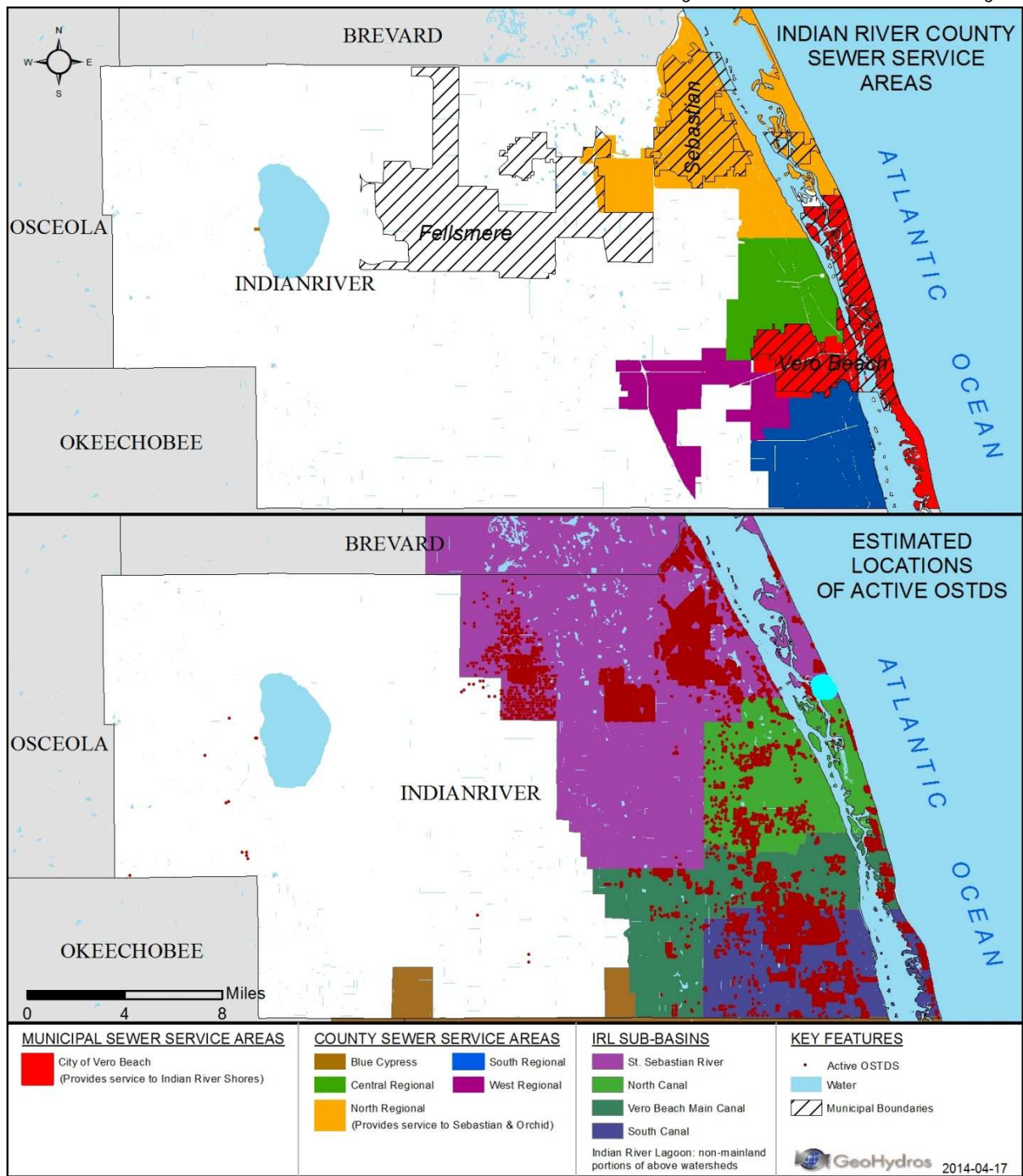


Figure 3. Analysis of Active OSTDS in Indian River County, Florida. The top of the figure shows a map of the extent of sanitary sewer service in Indian River County as delineated in this report. The bottom of the figure shows a map of the estimated number and location of active OSTDS within Indian River County with respect to Indian River Lagoon sub-basins.

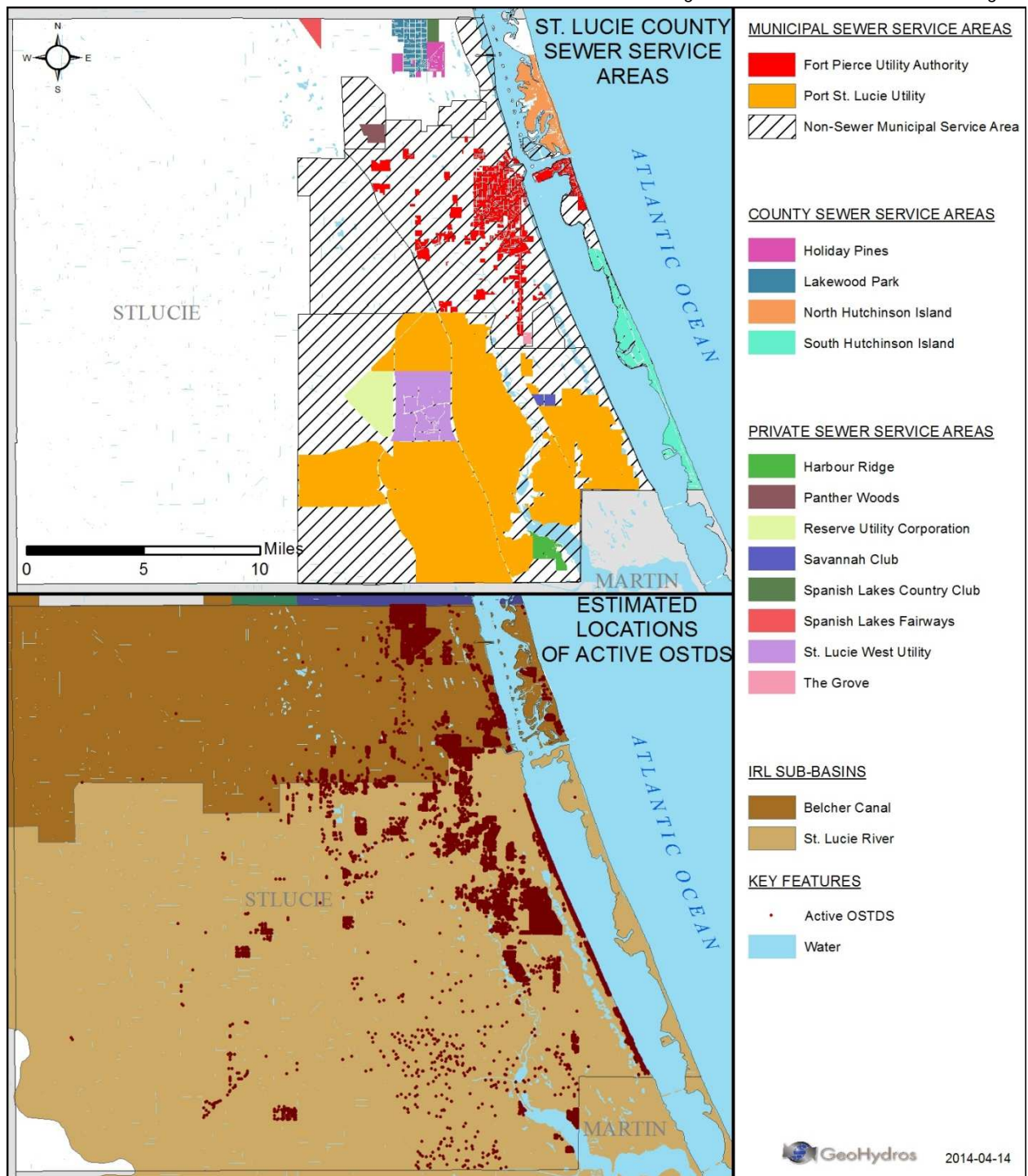


Figure 4. Analysis of Active OSTDS in St. Lucie County, Florida. The top of the figure shows a map of the extent of sanitary sewer service in St. Lucie County as delineated in this report. The bottom of the figure shows a map of the estimated number and location of active OSTDS within St. Lucie County with respect to Indian River Lagoon sub-basins.

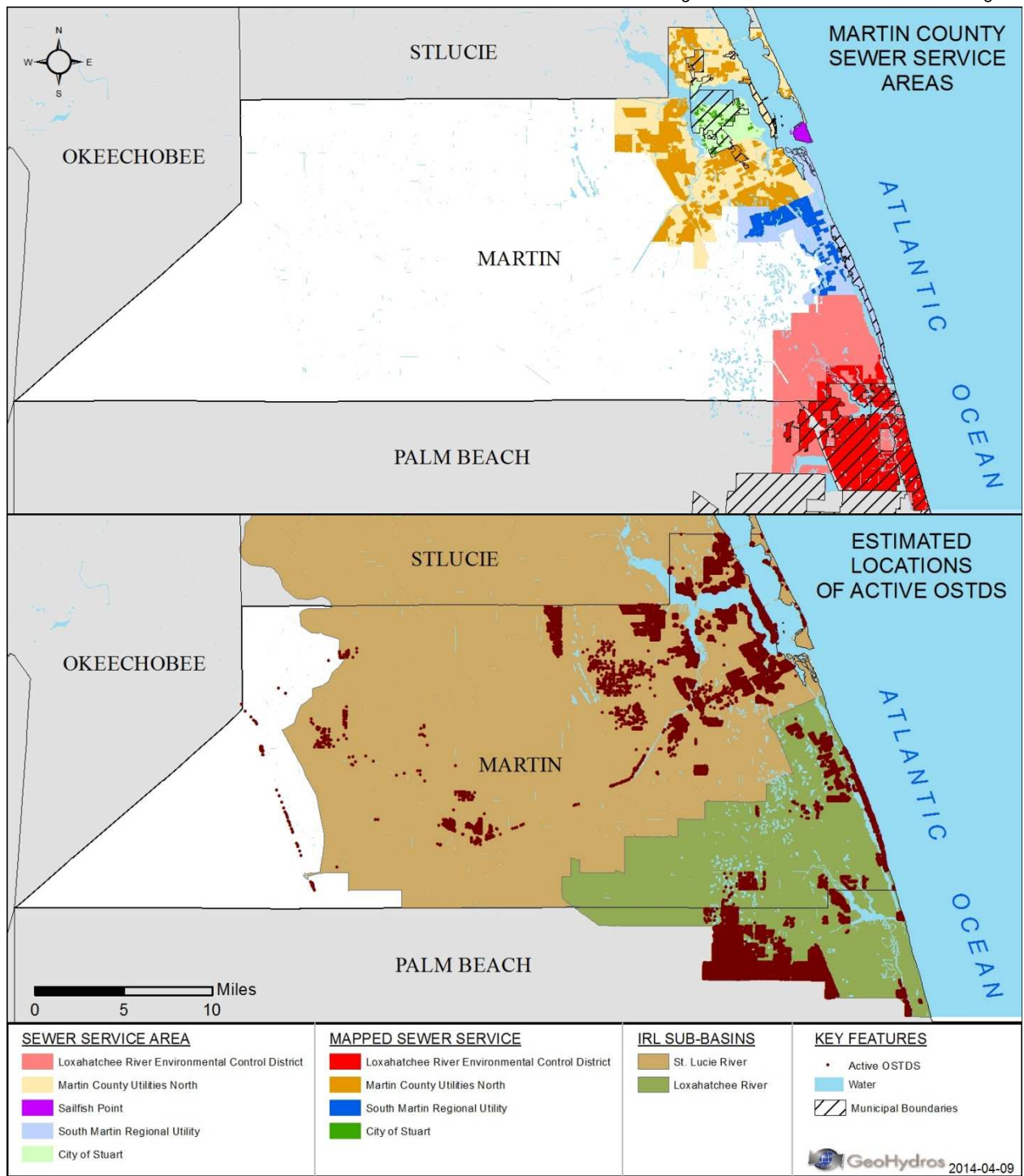


Figure 5. Analysis of Active OSTDS in Martin County, Florida. The top of the figure shows a map of the extent of sanitary sewer service in Martin County as delineated in this report. The bottom of the figure shows a map of the estimated number and location of active OSTDS within Martin County with respect to Indian River Lagoon sub-basins.

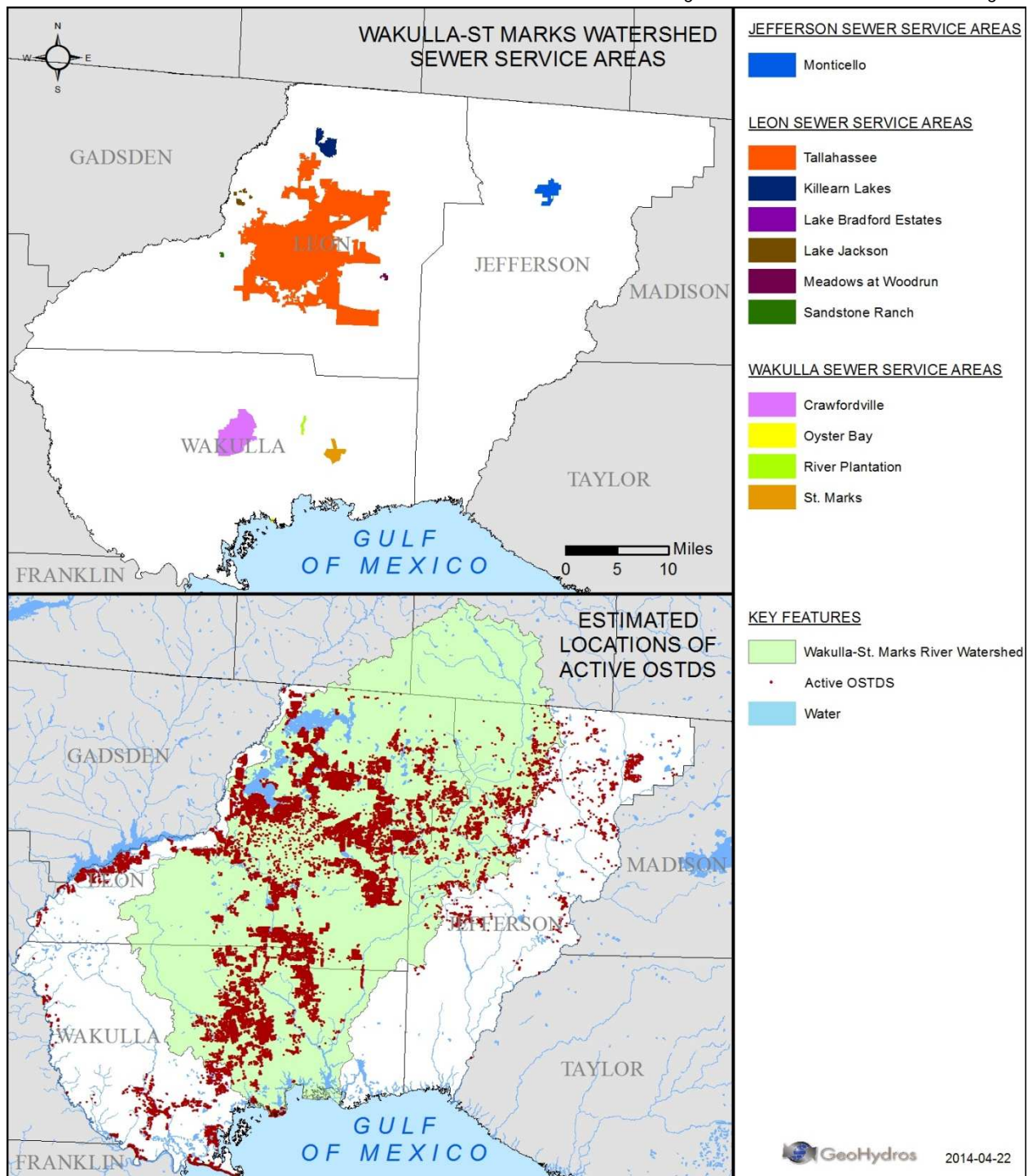


Figure 6. Analysis of Active OSTDS in Jefferson, Leon, and Wakulla Counties, Florida. The top of the figure shows a map of the extent of sanitary sewer service in the three county area as delineated in this report. The bottom of the figure shows a map of the estimated number and location of active OSTDS within the three county area with respect to Wakulla-St. Marks River watershed.

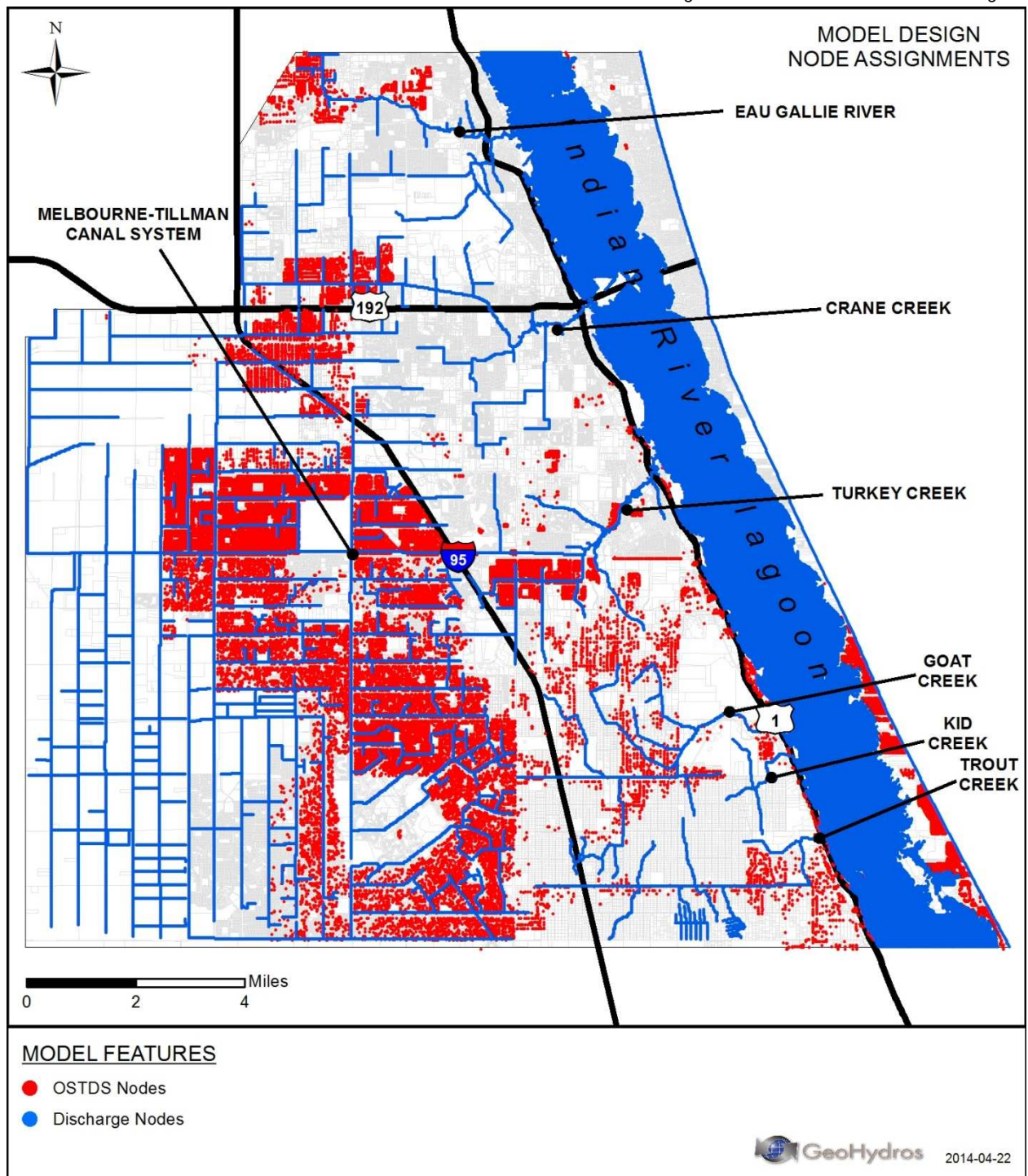


Figure 7. Model Design Map - Locations of Discharge and OSTDS Nodal Assignments.

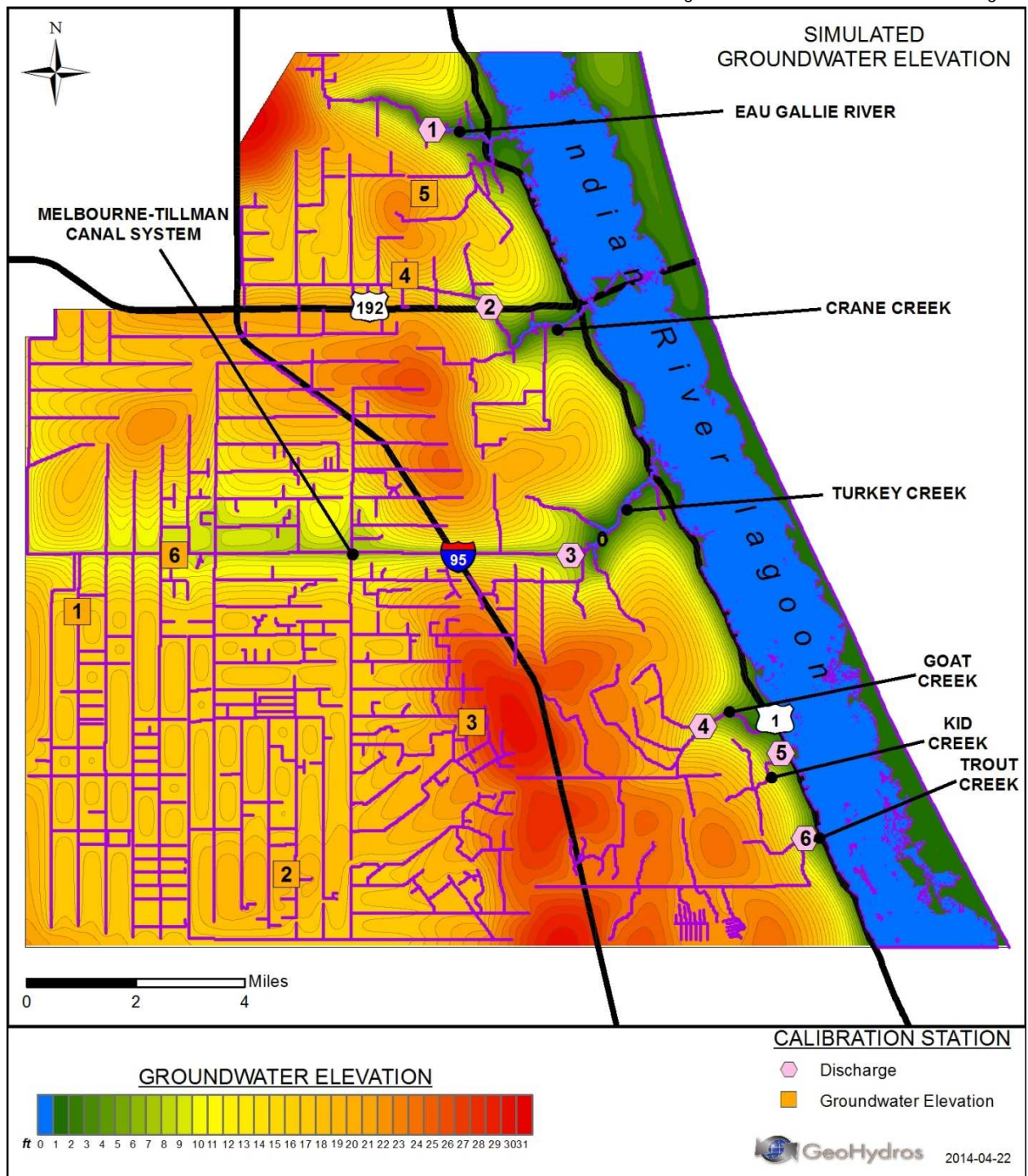


Figure 8. Model Result Map - Simulated Groundwater Elevations.

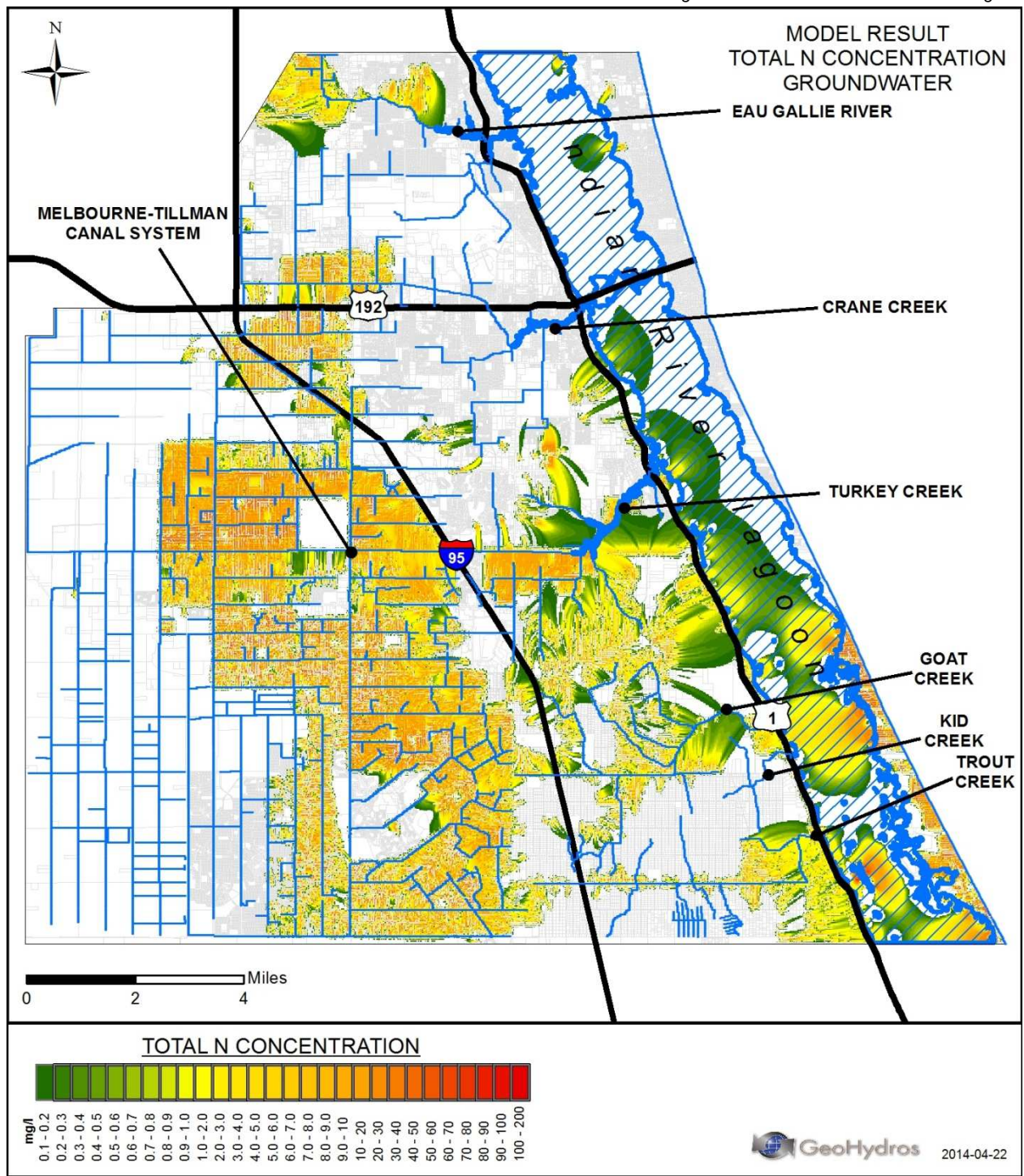


Figure 9. Model Result Map - Simulated Total N Concentration in Groundwater.

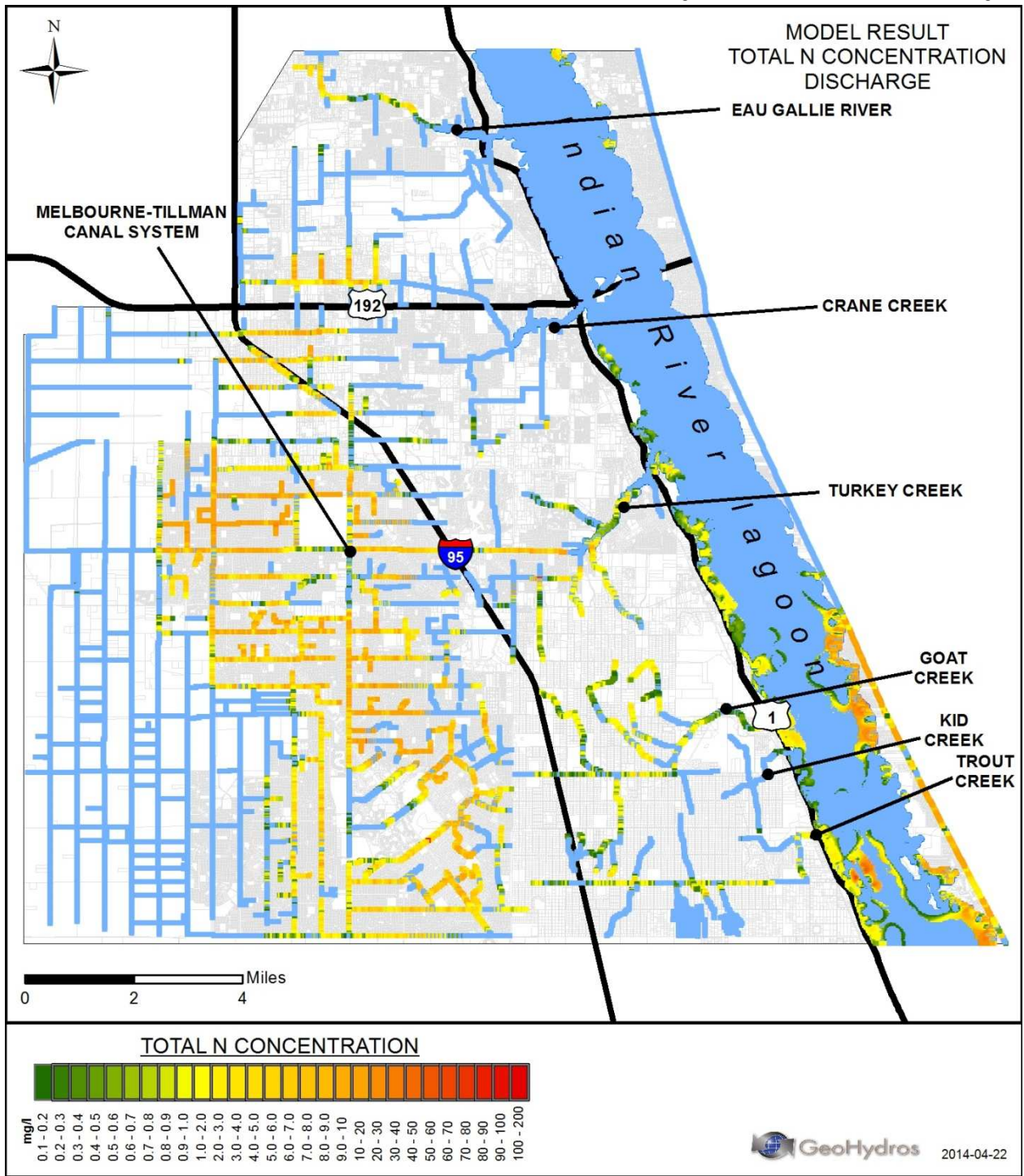


Figure 10. Model Result Map - Simulated Total N Concentration in Discharge.

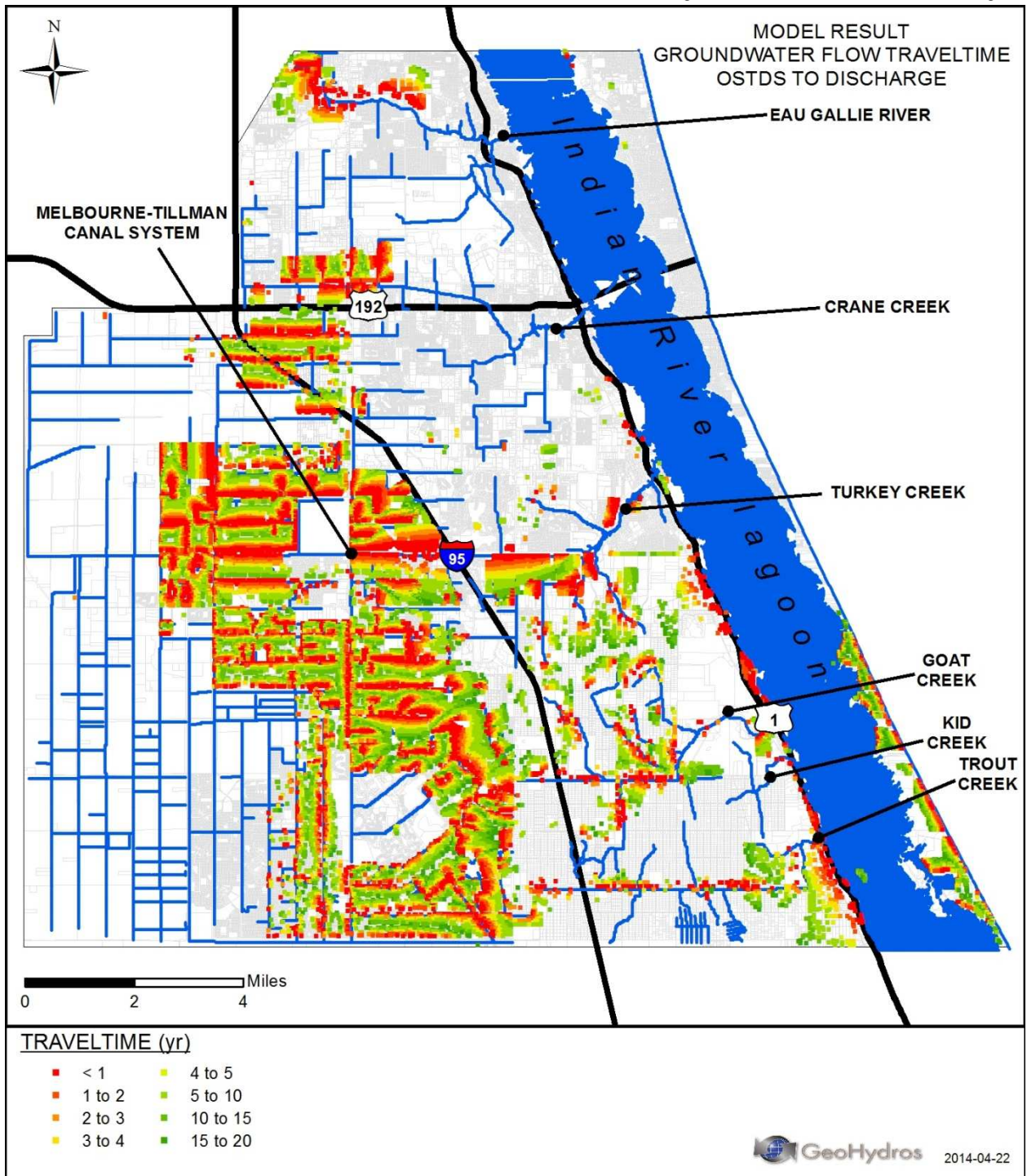


Figure 11. Model Results Map - Time of Groundwater Travel from OSTDS to Discharge.

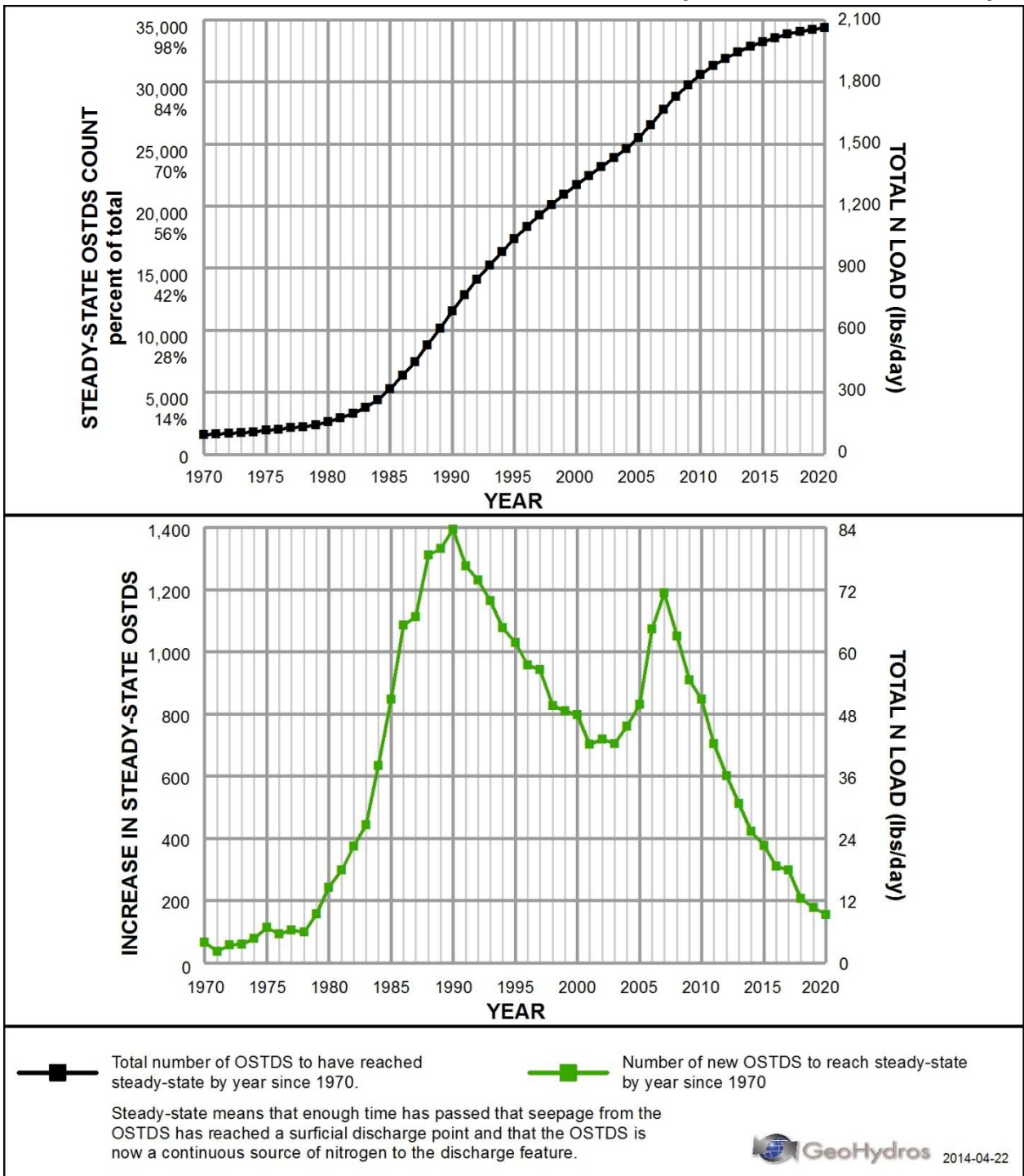


Figure 12. Graphs of Cumulative and Yearly Steady-State OSTDS Within the Model Domain from 1970 to 2020.

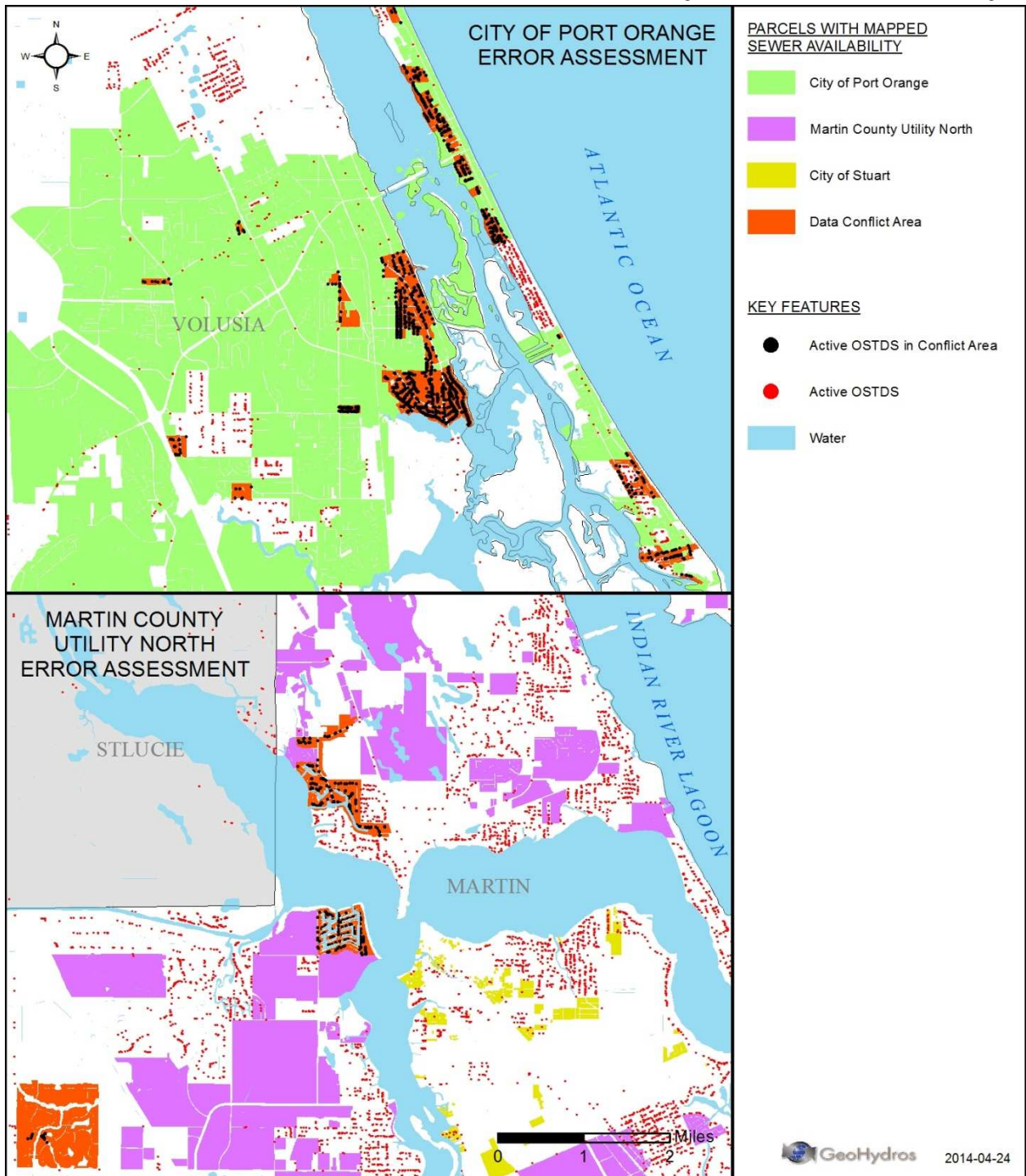


Figure 13. Error Assessment Map showing the locations of data source conflicts in the City of Port Orange and the Martin County Utility North mapped sewer availability areas.

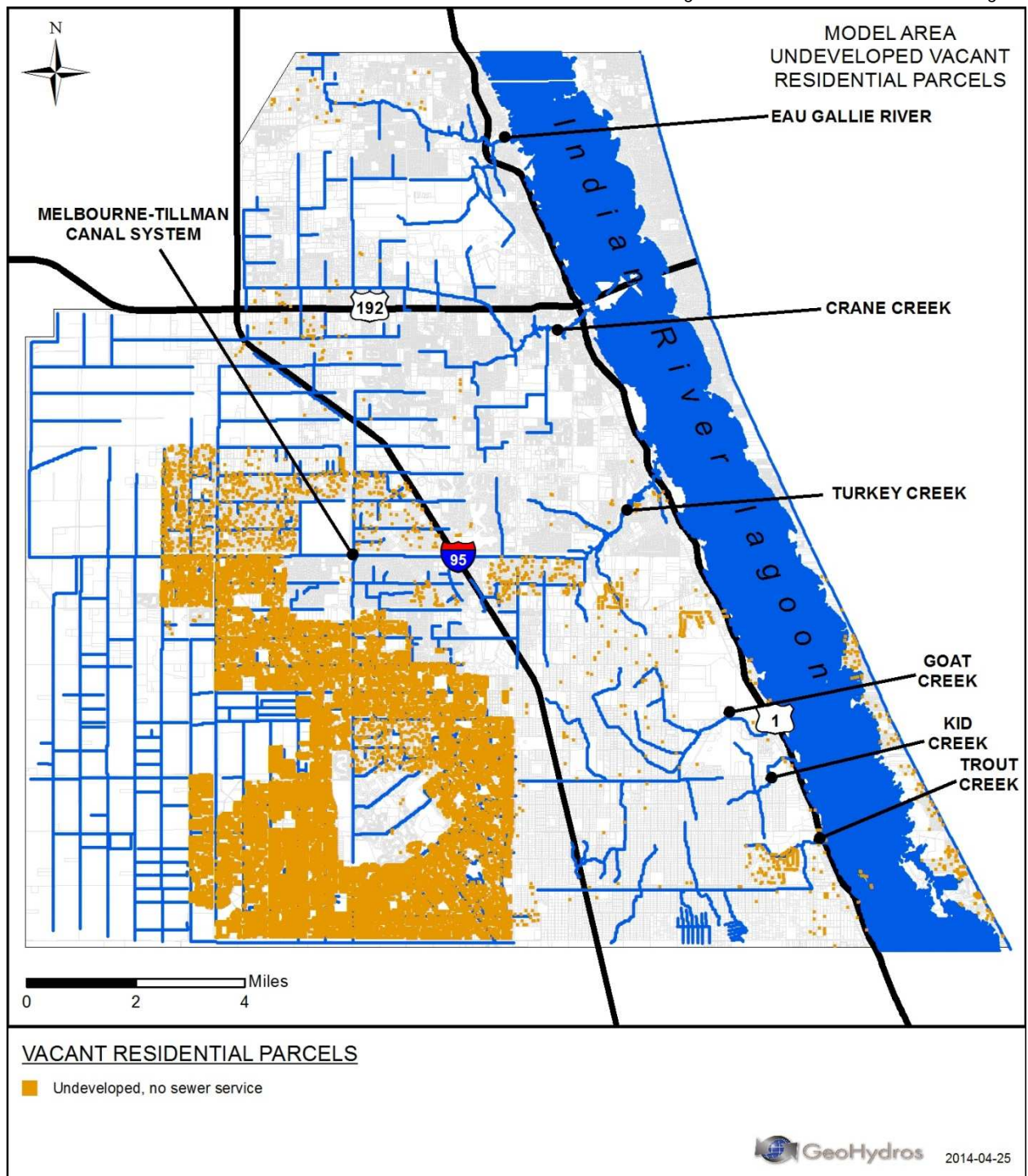


Figure 14. Map showing the location of undeveloped vacant residential parcels located outside of sewer availability areas within the model domain.

