NW Cape Coral/Lee County Watershed Initiative
Phase I
Summary Report

Lee County, Florida

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1.0 INTRODUCTION

1.1 PROJECT BACKGROUND

Under a consent order between the State of Florida Department of Environmental Regulation and a local developer, a freshwater retention system deemed the North Spreader Canal (NSC) was constructed between 1977 and 1984. This included canals and a barrier with a boat lift at the southern end of the system.

Following completion of the barrier in 1984, the system developed areas of significant erosion and various breaches occurred. These breaches allowed tidal water from Matlacha Pass to flow into the NSC. This created a system that mixed storm water with tidal flow from Matlacha Pass, creating a brackish estuarine environment with high levels of salinity fluctuation. In 2008, the barrier was removed and remains out today.

1.2 PROJECT OBJECTIVES

Currently, Lee County and the City of Cape Coral are undertaking a joint project called the Northwest Cape Coral/Lee County Watershed Initiative. This initiative is being overseen under a joint Project Team consisting of representatives from Lee County, the City of Cape Coral, and expert consultants. Under Phase 1 of the initiative, the project team had three primary goals:

- Provide detailed quantification of the existing hydrodynamic and transport conditions between the NSC and the adjacent waters of Matlacha Pass
- Provide detailed quantification of the existing water quality conditions within the NSC and the adjacent waters of Matlacha Pass
- Develop a hydrodynamic model of the system to allow assessment of future management alternatives
- Identify Key Ecological Indicators and Water Quality Targets for the NSC

In support of these goals, an extensive data collection, data analysis and model development program was implemented. Based on the results from this work, four reports were produced that present in detail the work performed and the results. The reports are entitled:

- Water Quality Data Characterization
- Hydrodynamic Data Characterization
- Hydrodynamic Model Development and Calibration
- Water Quality and Biological Indicators

The report presented herein summarizes the work conducted and the key findings from each report.

1.3 REPORT OUTLINE

Following this introduction, the report is broken down into four sections. Section 2 provides a description of the project area and key features driving the circulation and water quality conditions. Section 3 presents a summary of the work performed and the findings from the hydrodynamic data characterization. Section 4 presents a summary of the development and calibration of the hydrodynamic model. Section 5 presents a summary of the work performed and the findings from the water quality data characterization. Section 6 presents a summary of the water quality and biological indicators. Section 7 summarizes key findings and conclusions from the Phase I work on the Northwest Cape Coral/Lee County Watershed Initiative.

2.0 PROJECT AREA DESCRIPTION

Figure 2-1 provides an overview of the primary study area. For the purposes of this report, the study area is broken down into four key regions:

- The NSC
- The tidal canal system to the east of the NSC (designated the interior canals)
- The Key Ditch (KD) located to the west of the NSC
- The area to the west of the KD out to Matlacha Pass

Each of these regions is shown on Figure 2-1. The following sections provide a general description for each component, along with key aspects of the project area.

2.1 NSC AND BREACHES

The NSC is approximately 8.5 miles long and generally runs in a north-south direction. It is located immediately west of developed areas of Cape Coral. The NSC represents the westernmost extent of development that the Florida Department of Environmental Protection (FDEP) allowed to encroach into the mangroves bordering Matlacha Pass.

The southernmost end of the NSC was originally bounded by a barrier that was constructed to enclose the NSC and prevent tidal exchange with Matlacha Pass. A boat lift was included in the barrier design to allow boats access to the pass from the canals north of the barrier. This was referred to as the Ceitus boat lift.

Over the years following the installation of the barrier and boat lift, the western bank of the NSC developed several breaches that allow flow into and out of the NSC. In addition to the breaches along the bank of the NSC, the southern barrier was breached through erosion of the mangrove areas west of the barrier. The boat lift and barrier were removed in July 2008 by revision of the consent order approved by both the FDEP and the U.S. Army Corps of Engineers (USACE). Figures 2-2a through 2-2c show images of the boat lift in 1995 prior to the erosion into the mangroves to the west of the barrier, in 2007 just prior to the boat lift removal in 2008, and present conditions in 2014.

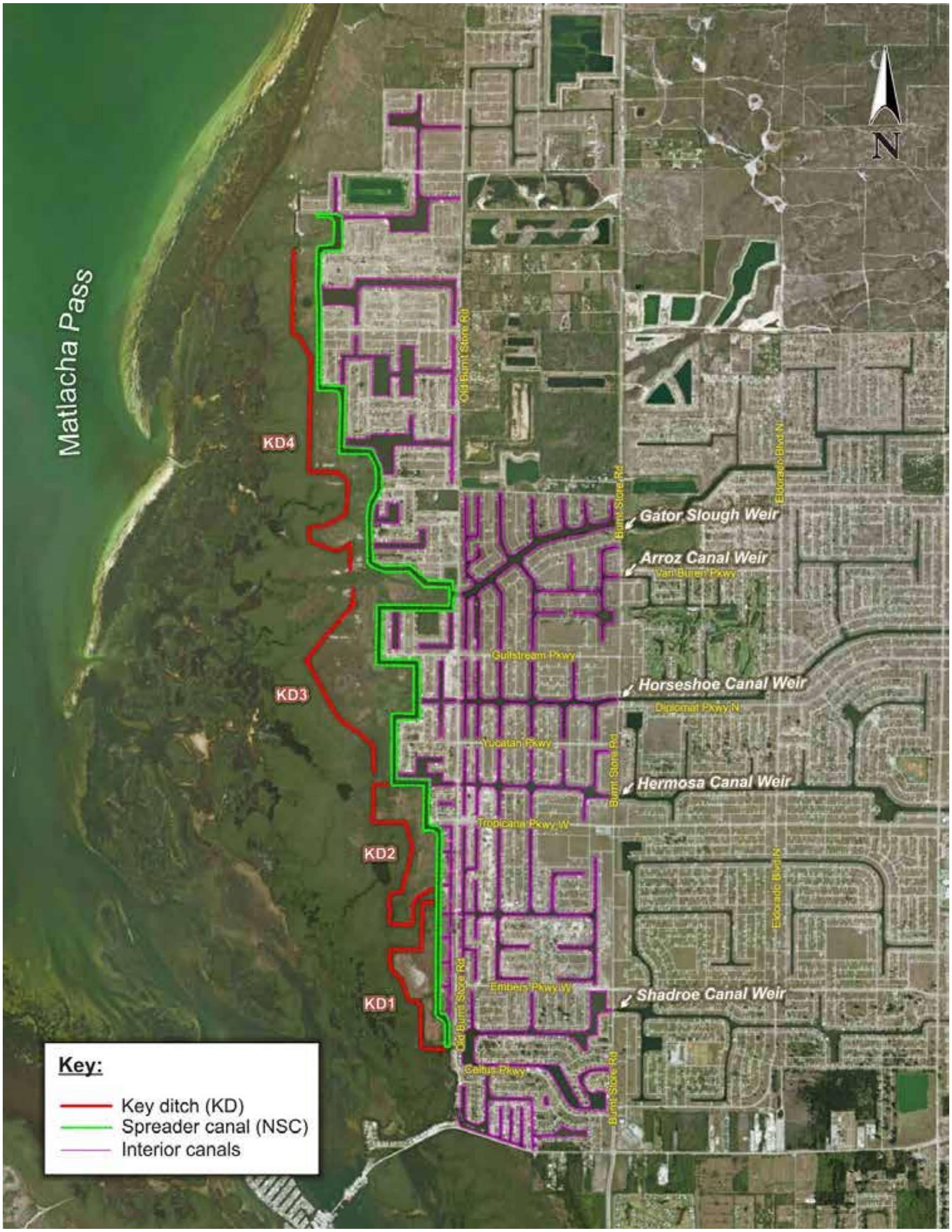

Figure 2-1. Project Area Map

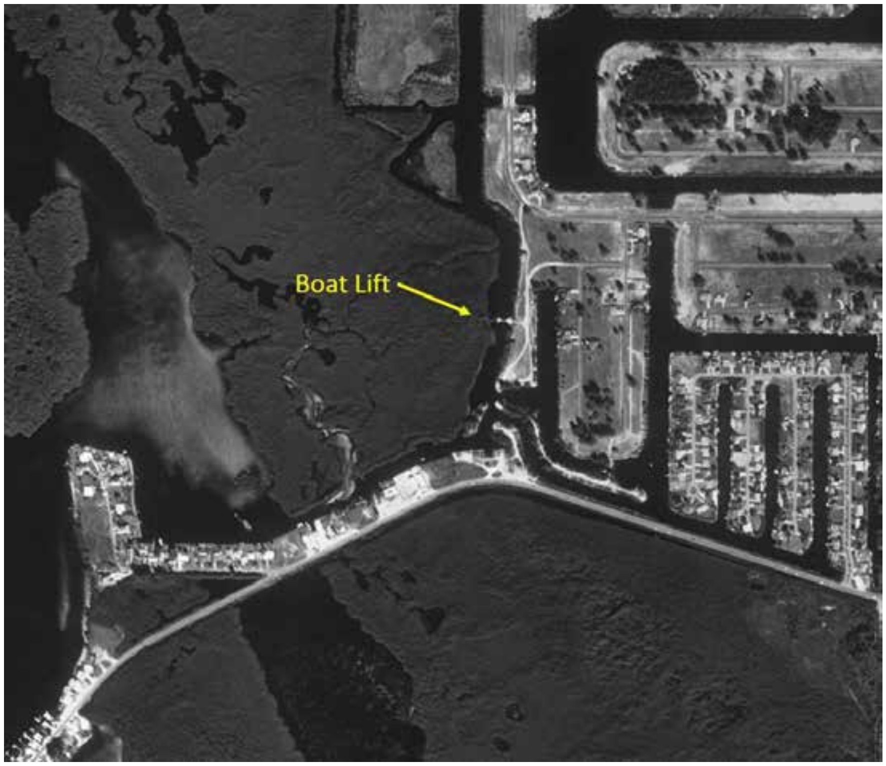

Figure 2-2a. Ceitus Boat Lift in 1995

Figure 2-2a. Ceitus Boat Lift in 2007

Figure 2-2a. Ceitus Boat Lift in 2014

Through previous studies, a total of 17 breaches (including the breach that occurred at the location of the former boat lift) were documented. Figure 2-3 shows the locations of the previously documented breaches and provides their location identifications.

Since their initial formation, and the removal of the boat lift in 2008, the breaches have adjusted and stabilized to the present conditions. Of the original 17 breaches, a total of 7 presently have significant flow passing through them from the NSC to the Key Ditch. Flows in these breaches were monitored by USGS as part of the Phase I study for a period of 6 months in 2013. Figure 2-4 shows the location of the monitored breaches. Table 2-1 provides the correspondence between the breach numbers (shown on Figure 2-2) and the USGS monitoring sites.

The first identified breach corresponds to the location of the boat lift (Breach 13). Since the removal of the boat lift this location now provides a primary flow path for tides moving into the NSC from Matlacha Pass and is referred to as the southern opening. USGS set up a flow monitoring site (USGS-00) at this location to measure the tidal flows into and out of the NSC through the opening.

USGS-01 (Breach 12), is located approximately 500 ft north of the former barrier location. This is where Ceitus Creek, a tributary that connects back into the tidal channel that runs parallel with causeway over Matlacha Pass, breached into the NSC. When this occurred, significant erosion of Ceitus Creek followed, creating some very deep holes and causing significant transport of material south into the channel. In 2002, a repair of the breach into Ceitus Creek was attempted under the direction of the FDEP. This repair failed within a few days, with blowouts on each side of the attempted repair. Subsequent to the removal of the barrier, indications are that this channel is now stable or possibly accreting.

The second breach that was monitored, USGS-02 (Breaches 11 and 12), is located approximately 1000 ft north of where Ceitus Creek enters the NSC. This breach connects to the south end of the southernmost segment of the KD (KD1 on Figure 2-1) and is located at the point where the tidal portion of Shadroe Canal intersects the NSC.

The third monitored breach USGS-03 (Breach 8) is located approximately 2 miles up the NSC from USGS-02. This breach connects to the northern end of one segment of the KD (KD2 on Figure 2-1) and is located at the point where the tidal portion of Hermosa Canal intersects the NSC.

The fourth monitored breach, USGS-04 (Breach 7), is located approximately 1.2 miles up the NSC from USGS-03. This breach connects to the middle of a segment of the KD (KD3 on Figure 2-1) and is located between the points where the tidal portions of Horseshoe Creek and Gator Slough intersect the NSC.

The fifth monitored breach USGS-06 (Breach 4) is located approximately 1.8 miles up the NSC from USGS-04. This breach connects to the southern end of the northernmost segment of the KD (KD4 on Figure 2-1) and is approximately 1.1 miles north of where the tidal portion of Gator Slough intersects the NSC.

The final monitored breach, USGS-07 (Breach 1A), is located 1.1 miles up the NSC from USGS-06. This breach also connects to the northernmost segment of the KD (KD4 on Figure 2-1) and is approximately 2.2 miles north of where the tidal portion of Gator Slough intersects the NSC.

Table 2-1. Correspondence between USGS Monitoring Locations and Breach Location Numbers from Previous Studies

USGS Station	Breach Number
USGS-00	13
USGS-01	12 (Ceitus Creek)
USGS-02	10 and 11
USGS-03	8
USGS-04	7
USGS-06	4
USGS-07	1A

Figure 2-3. Location of Previously Documented Breaches in the NSC

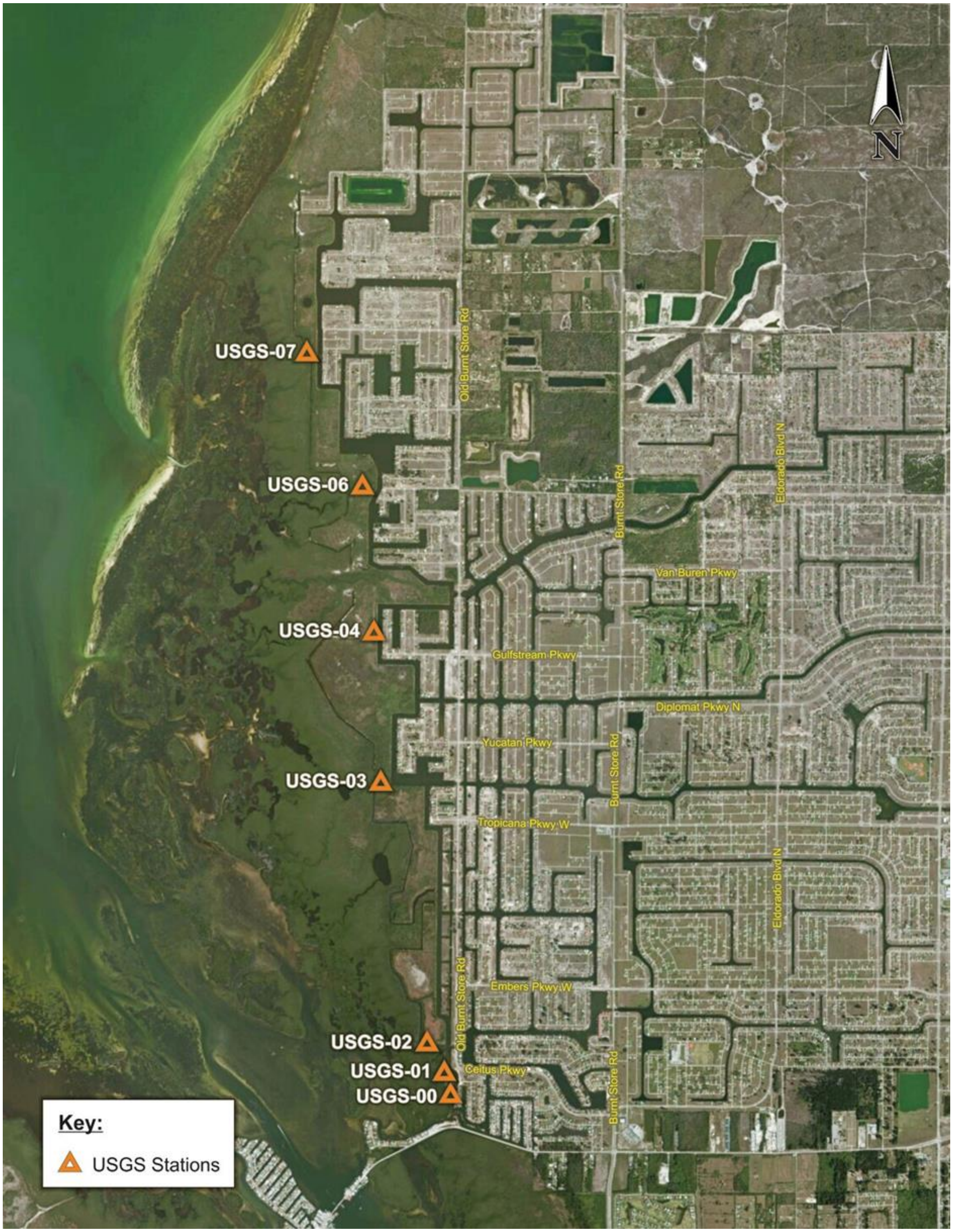

Figure 2-4. Location of USGS Monitoring Stations

2.2 INTERIOR CANALS

A complex network of interior canals are located to the east of the NSC (Figure 2-1). These canals run in both north-south and east-west directions. The interior canals range from around 75 ft wide up to 150 ft wide, with the dead-end canals generally narrower.

There are four primary canals that run east-west from the spreader canal to the weir structures on Burnt Store Road. These canals extend upstream of the weir structures and are the four primary freshwater canals that convey stormwater from the drainage areas to the east of the weir structures. Additionally, a weir structure south of the Gator Slough weir drains a small area upstream (Arroz Canal weir). The locations of the weir structures are identified on Figure 2-1. These are, from south to north:

- Shadroe Canal weir,
- Hermosa Canal weir,
- Horseshoe Canal weir,
- Arroz Canal weir, and
- Gator Slough weir

The elevations of the weir structures are above the normal tidal fluctuations in the interior canals, so the waters upstream are fresh.

2.3 KEY DITCH (KD)

The KD is located west of the NSC and was excavated originally to mark the intended waterward extent of development (see Figure 2-1). FDEP action limited the extent of development to the eastern side of the NSC, but the KD remains an important feature regulating tidal exchange between Matlacha Pass and the NSC. Field reconnaissance of the KD indicates that the sides of the KD are at an elevation that allows some level of tidal exchange in a transverse direction, with the mangrove areas to the west, going out to Matlacha Pass. Flows move through very porous soils and mangrove roots where there is no definitive side of the KD. Additionally, some direct connections between the KD and open water areas to the west exist, along with tidal creek signatures that can be seen in aerial photography.

At present, there are four distinct sections of the KD. Based upon field reconnaissance, examination of aerial photography, and analyses of hydrodynamic data, it does not appear that these segments are significantly hydraulically interconnected. Of the monitored breaches described in Section 2.2, six provide direct connections between the NSC and the KD. Breaches 10 and 11 (USGS-02) connect section KD1 (Figure 2-1) to the NSC. Breach 8 (USGS-03) connects section KD2 to the NSC. Breach 7 (USGS-04) connects section KD3 to the NSC. Finally, breaches 4 and 1A (USGS-06 and USGS-07 respectively) connect section KD4 to the NSC.

2.4 WEST OF KEY DITCH AND MATLACHA PASS

Moving west from the KD is a transition area that goes from dense mangroves, with some upland areas, to mangrove islands interspersed with open water. The mangrove islands then transition out to the open waters of Matlacha Pass. The aerial photograph in Figure 2-1 shows signatures of various tidal creeks that extend from the KD through the mangroves to the pass. Prior to development, these creeks conveyed tidal flow and stormwater runoff through the mangroves to Matlacha Pass. Although the KD and the NSC broke the connectivity of the creeks, they still function to allow tidal exchange and stormwater discharge between the KD and the pass.

Matlacha Pass runs between the mainland and Pine Island and provides a connection between Charlotte Harbor, San Carlos Bay, and the tidal portions of the Caloosahatchee River. In the area of the NSC, the width of the pass varies from more than 2 miles down to near one-half mile. The dominant tidal connection between Matlacha Pass and the NSC occurs at the southern end of the NSC and runs along the northern side of Pine Island Road. At its base, this connection is approximately 100 ft wide.

3.0 HYDRODYNAMIC DATA CHARACTERIZATION

3.1 INTRODUCTION AND OBJECTIVES

Under Phase I of the Northwest Cape Coral/Lee County Watershed Initiative, an extensive hydrodynamic data collection effort was executed. This included installation of continuous recording instruments to measure water levels, velocities, flows, and salinity. This monitoring program occurred from September of 2012 through February of 2014. The goal of the Hydrodynamic Data Characterization was to quantify the existing circulation and transport conditions which exist between the NSC and Matlacha Pass using data collected as part of this project. The full detailed analyses of the data are presented in a separate report entitled “NW Spreader Canal, Hydrodynamic Data Characterization”. The sections below provide a summary of the data collected, the data analyses performed, and the key findings from the analyses.

3.2 DATA

As part of this project, hydrodynamic data were collected between September 2012 and February 2014 at stations throughout the NSC, the interior canals, above the weirs, within the KD, and in Matlacha Pass. Hydrodynamic data included the following:

- Water level
- Velocity and Flow
- Salinity
- Temperature

Data were collected at a total of 28 fixed locations. A total of 19 stations had water level only, the remaining 9 stations had water level, salinity, and temperature. Figure 3-1 presents the locations of the water level only stations, Figure 3-2 the stations with water level, salinity, and temperature, and Figure 3-3 the stations upstream of the weir structure which collected water level. The stations recorded water level measurements every 6 minutes to provide a continuous record. The water level measurements upstream of the weir structures were collected to supplement flow gaging data collected by the U.S. Geological Survey (USGS). This was necessary since USGS flow gaging stations were taken off-line during the period of the study.

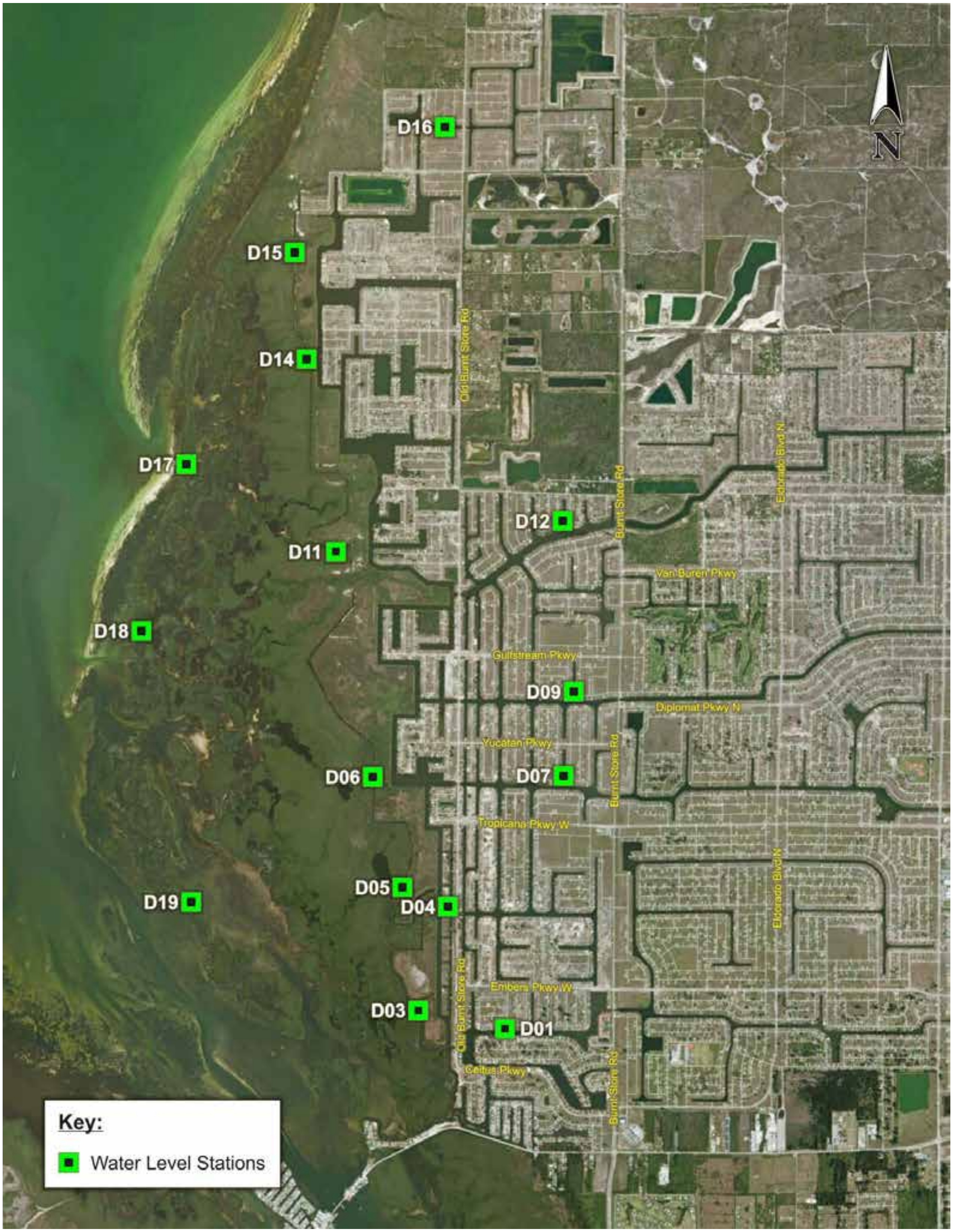

Figure 3-1. Water Level Only Station Locations

Figure 3-2. Water Level, Salinity, Temperature Station Locations

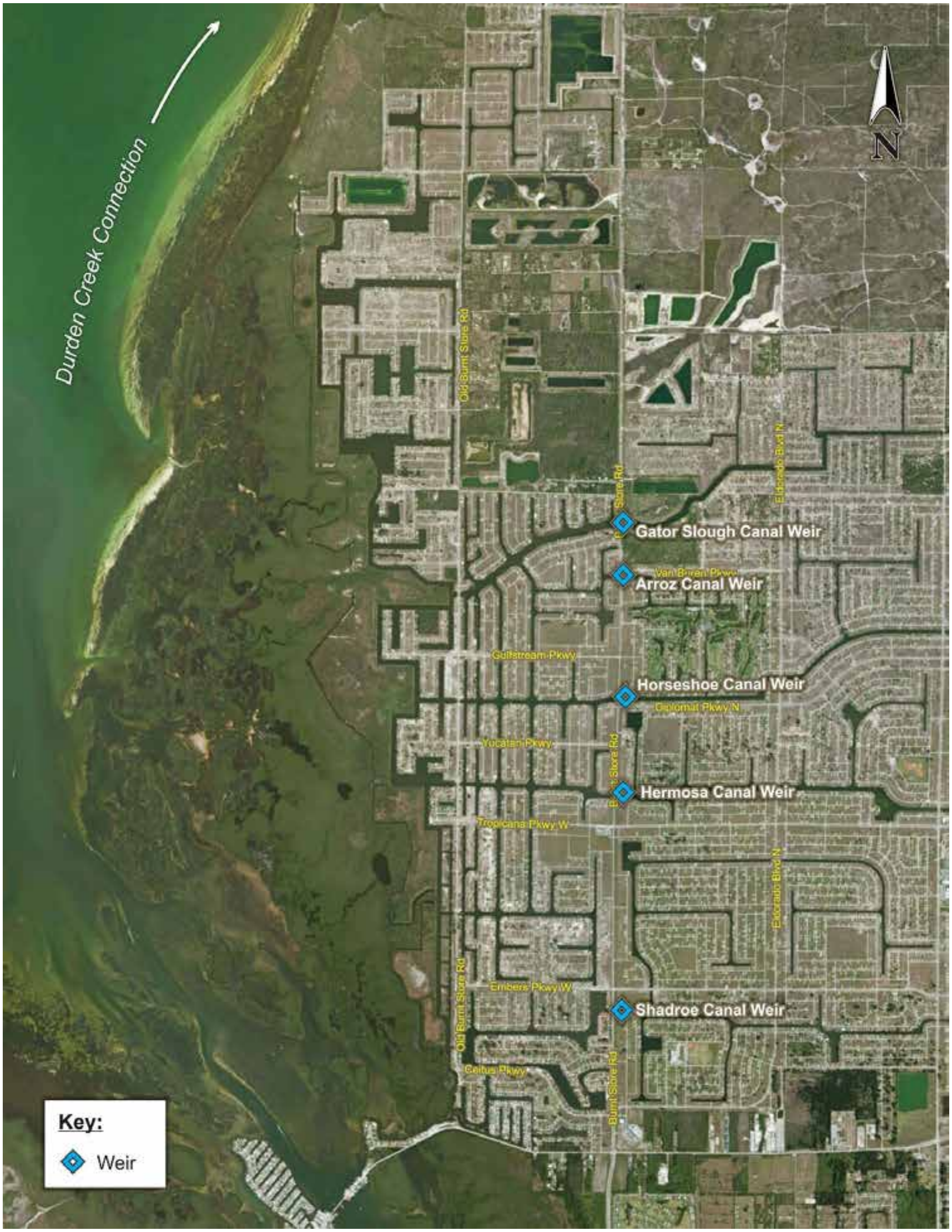

Figure 3-3. Water Level Stations Upstream of Weir Structures

The water level, salinity, and temperature stations were installed in September of 2012 and maintained until December of 2014. The stations had periodic failures through the data collection period. Appendix A presents a Gant Chart which shows the period where good data were collected for each station. A survey was performed to set the elevations at each location so that the water levels could be converted to a common datum, the North American Vertical Datum of 1988 (NAVD88).

USGS collected water level and velocity data at 6 of the breaches and at a site immediately south of the former barrier location along the main channel of the NSC. USGS serviced and maintained these instruments from August of 2013 through March of 2014. Figure 4-4 presents the locations of these stations. USGS calculated the time series of flow passing through each of the cross-sections using their Index Velocity Method. Using this method, a relationship is developed between flow and the measured index velocity and cross-sectional area. Cross sections were surveyed at the location of each instrument and the cross-sectional area as a function of water level determined. These were then multiplied by the index velocity in order to get the time series of flow. The period of record of good data from the USGS monitoring program is shown on the Gant Chart in Appendix A.

The final data set used in the analyses was the freshwater inflow over the weir structures. Historically USGS has monitored flows at 4 of the 5 weirs (Figure 4-3) including Shadroe Canal, Hermosa Canal, Horseshoe Canal, and Gator Slough. During the data collection period, from September 2012 to February 2014, the various gages were decommissioned by USGS. To address this issue, water level stations were established at each of the weirs (as described earlier). Using the water level data, along with the rating curves for the weirs, the flows for the period of the data collection (where USGS flow was unavailable) were calculated.

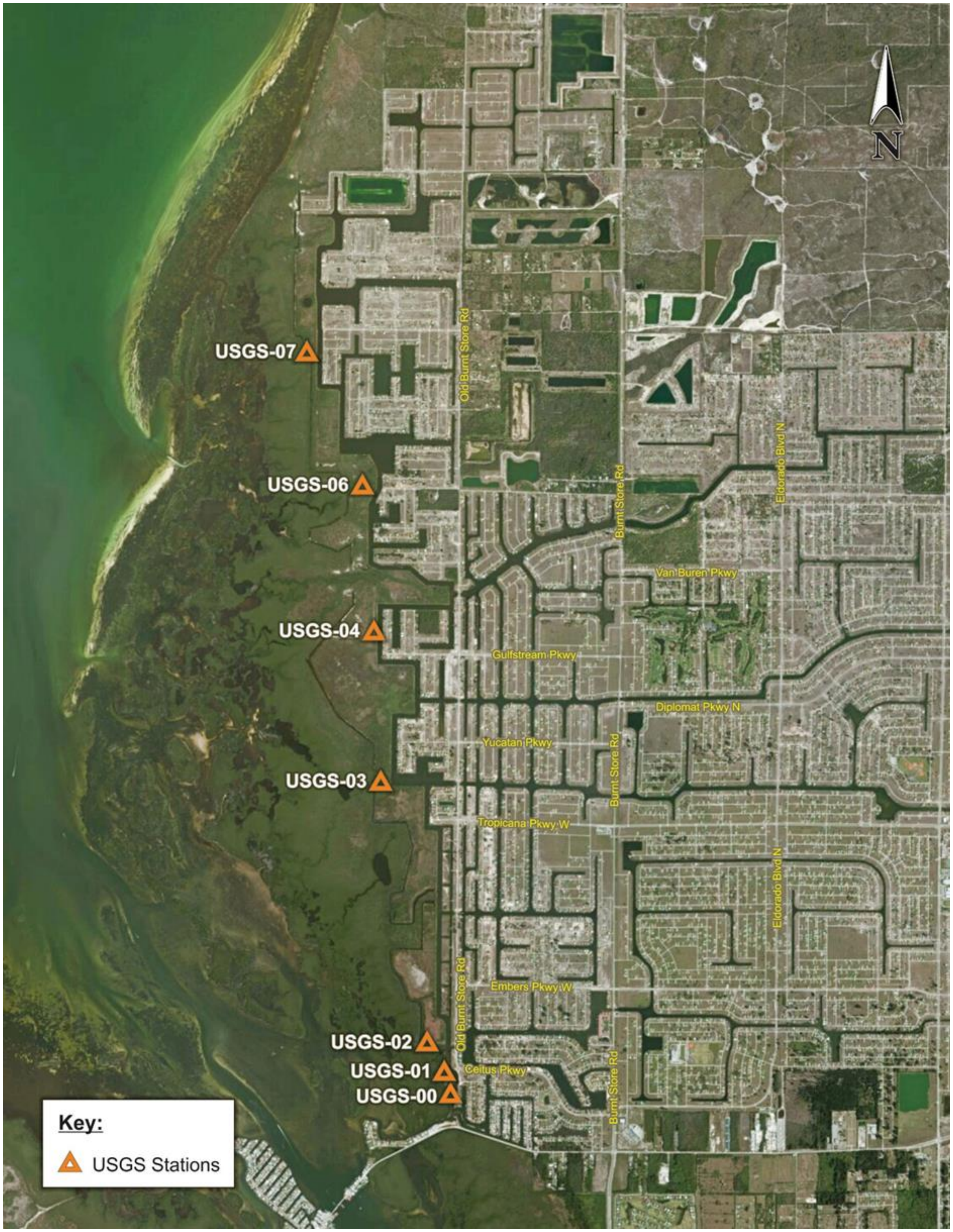

Figure 3-4. USGS Water Level, Velocity, and Flow Stations within Breaches

3.3 ANALYSES

A series of analyses were performed on the hydrodynamic data described in Section 4.2. The purpose of the analyses were to quantify the hydrodynamic conditions within, and interaction between the NSC and interior canals, the KD, and Matlacha Pass. Specific key analyses included;

- Analyses of freshwater inflows to define conditions under which hydrodynamic data analyses conducted;
- Analyses of the phasing and damping of water level fluctuations throughout the system to define the progression of tidal waves moving from the Matlacha Pass into the NSC and the relative damping of the tidal components;
- Assessment of the flow patterns into and out of the breaches relative to the flow at the former location of the Ceitus barrier;
- Analyses of the relative tidal prism/flow and temporal variations between the breaches and the former location of the Ceitus barrier under varying freshwater inflow conditions;
- Analyses of the temporal and spatial variability of salinity by location and the correlation with freshwater inflow;
- Assessment of the measured velocities at the breaches to determine the level of potential scour and if the openings are currently at equilibrium, depositional, or erosional conditions.

3.3.1 FRESHWATER INFLOW

Figure 4-5 presents the freshwater inflows over the weirs for the period of the hydrodynamic data collection. The data showed that at the start of the data collection in September of 2012 flows over the weirs were high with a large flow event at the beginning of October. Following the flow event, flows over the weirs tapered off going to near zero at most of the structures due to holding back of water for supply purposes. The small flows seen over the weirs at Shadroe and Hermosa Canals is due mostly to leaking bladders on the weirs used to hold up elevations. Flows stay near or at zero through the winter until May of 2013 when flows begin to rise. Through the summer flows generally increase with a large flow event at the end of June beginning of July of 2013. Through the end of summer into September, flows increase up to the largest flow event captured during the monitoring which occurred in the last week of September 2013. Following the event flows quickly drop with flows after

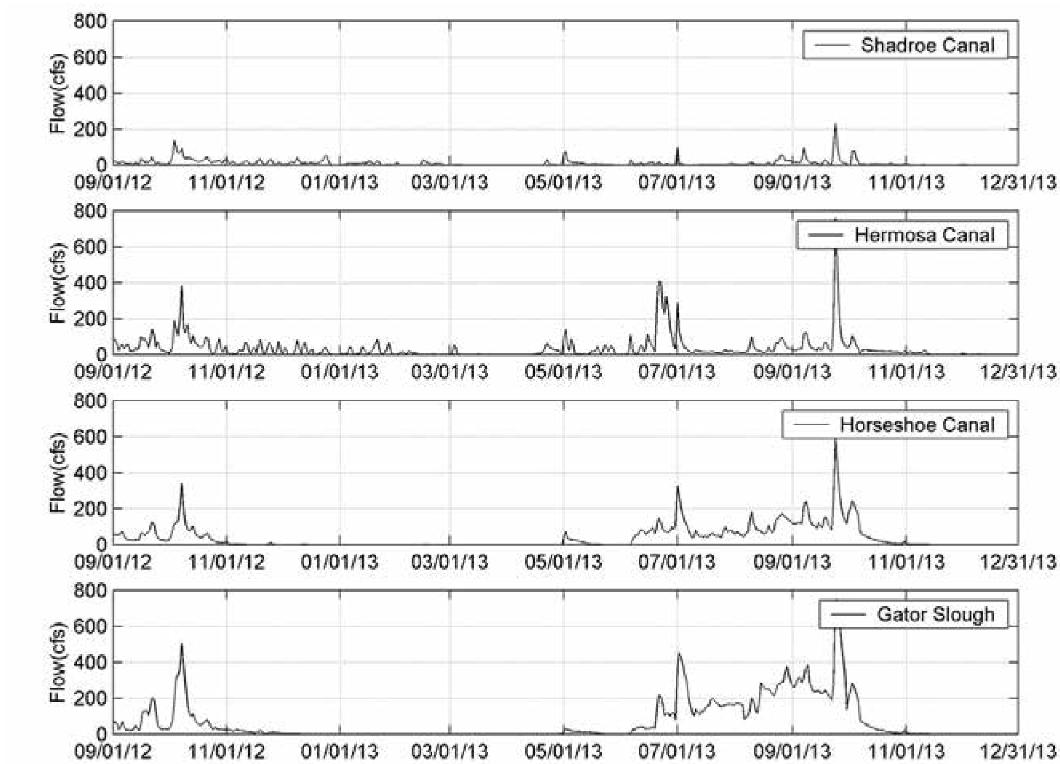

Figure 3-5. Measured Freshwater Inflow over Weirs (9/1/12 to 12/31/15)

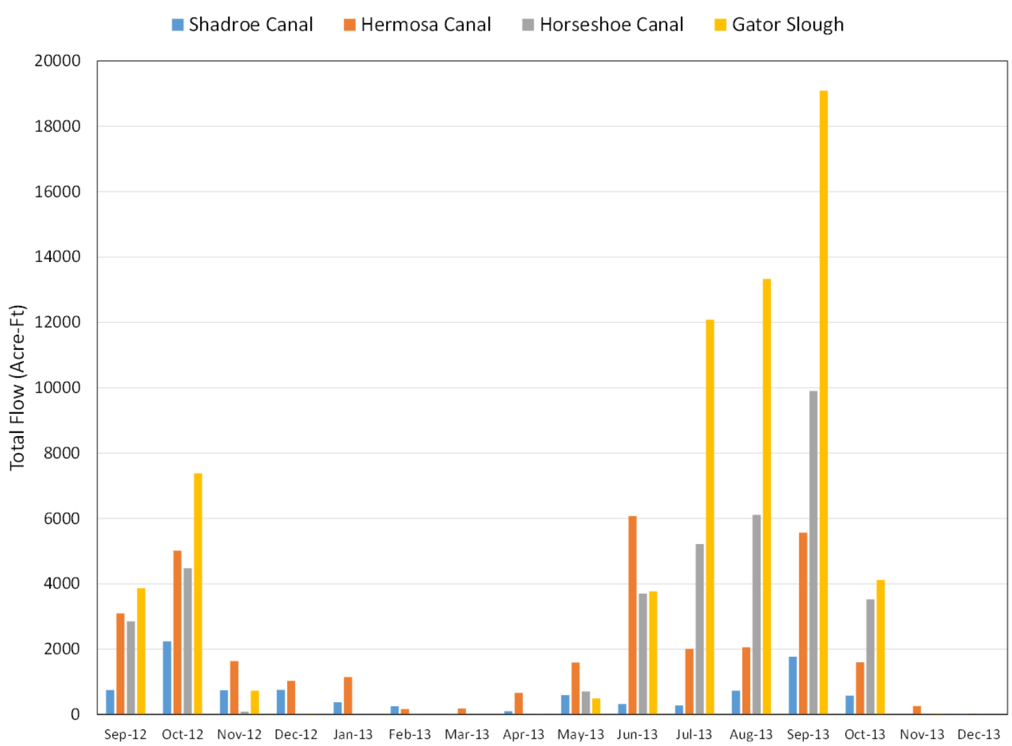

Figure 3-6. Monthly Total Flows over Weirs (September 2012 to December 2013)

October 15 down to near zero which holds through the end of the year. The water level measurements above the weir structures ended in December of 2013 so no measured flow data available after that point.

Figure 4-6 presents the monthly totals for the data collection period. The plot clearly demonstrates the seasonal pattern typical of the system. It also shows that there are a significant number of months during the data collection period where total flow during the month was near or at zero. The plot also shows that flows increase moving from south to north. When the total flow over all the weirs is high (> 10,000 acre-ft/mo) Gator Slough on average carries 50% of the flow while Horseshoe, Hermosa, and Shadroe carry 30%, 15%, and 5% respectively. When flows are near zero, this relationship if flipped with the small amount of flow coming over Hermosa and Shadroe due to the leaky nature of their bladder systems.

Examination of the flows in 2012 and 2013 versus historic flows (back to 1990) showed that 2012 was generally an average year in terms of total flow and maximum flow, while 2013 was a wet year in terms of total flow and average in terms of maximum.

3.3.2 WATER LEVELS

Figure 4-7 presents plots of the water levels at four stations, D-19, D-01, D-06, and D-16 (Figure 4-1). Station D-19 is in Matlacha Pass, D-01 is within the interior canals near the southern end of the system, D-06 is within the KD and D-16 is within the interior canals at the northern end of the system. The top plot presents measurements for a 3-week period in September of 2013 the wettest month during the data collection. The bottom plot for 3-weeks at the end of October into November of 2013, a near zero total flow period.

Examination of the plots demonstrates a key aspect of the system. That is the damping of the tidal fluctuations and elevation of the mean water level. The damping and elevation of the mean water level occurs throughout the NSC, interior canals, and KD and occurs almost immediately as the tidal wave passes through the southern opening through the southern channel. This phenomena is seen in both the high flow and near zero flow periods with the higher flow period also seeing an additional mean water level increase due to the freshwater inflow.

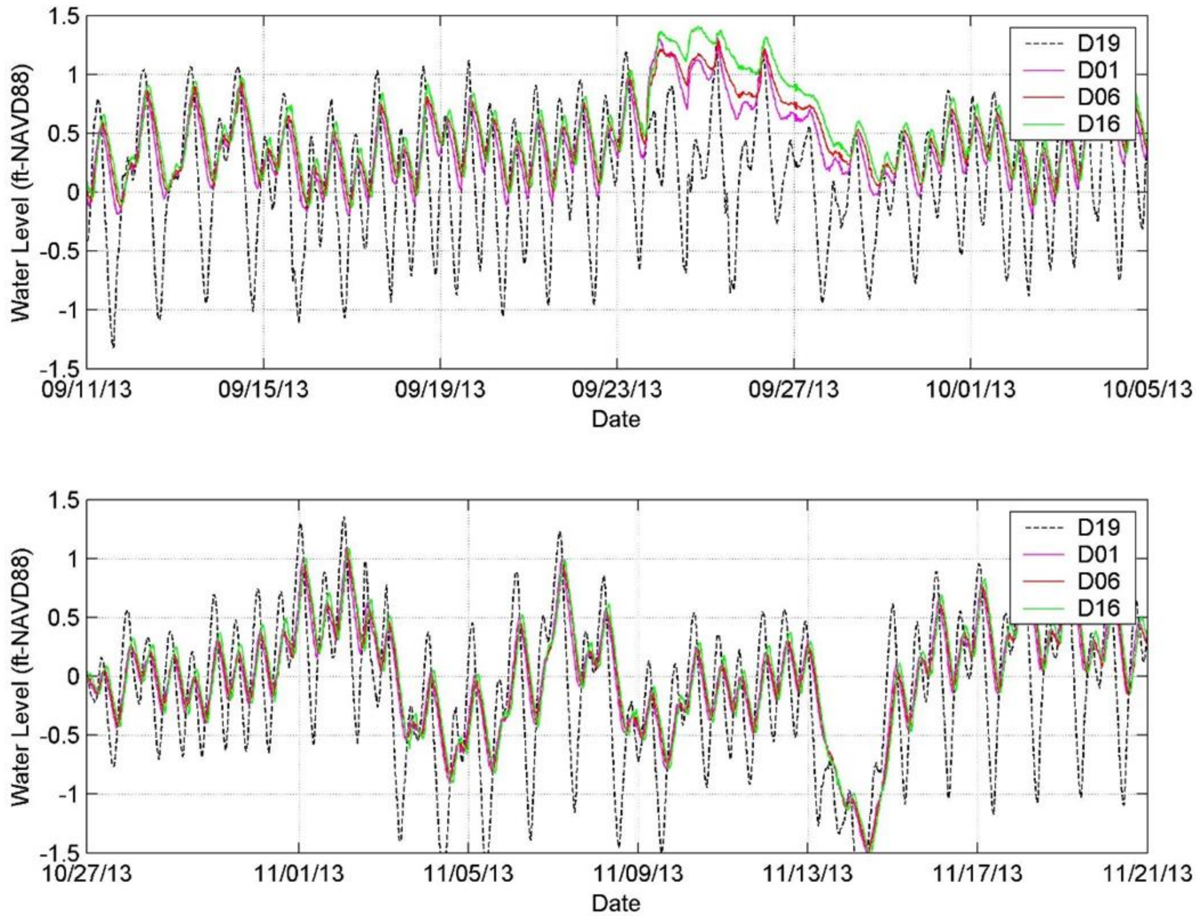

Figure 3-7. Measured Water Levels at Various Stations During Wet (Top Plot) and Dry (Bottom Plot) period.

Harmonic Analyses were performed on all of the continuous water level gages operated from September 2012 through December 2013. Harmonic Analysis extracts the tidal components from the record and allows comparison of the average tidal components between the stations to determine patterns. Figures 4-8a and 4-8b present tidal amplitudes and phase lags by station respectively. The stations are presented as Matlacha Pass stations moving from north to south and the interior stations moving south to north. The tidal amplitudes represent the magnitude of the highs and lows while the phase lags represent the time the tidal highs and lows arrive at a location in relation to the base location (D-17). The analyses highlight a number of characteristics about the system. First it supports the damping shown in the plots above and that the damping occurs immediately through the southern opening. The M2 and S1 amplitudes are damped over 50% moving from D-19 to D-01. It shows that the NSC, interior canals, and KD behave similarly. Other than Station D-11 the amplitudes are nearly identical throughout the interior. It shows that the primary progression of the tides are from north to south through Matlacha Pass and then south to north through the NSC, interior canals, and KD. Other than Station D-11 the phase lags increase moving from north to south through Matlacha Pass and then south to north through the system.

The one station which does not follow the patterns described above is D-11. It shows that the tidal wave reaches this location ahead of all of the other interior stations and that the amplitude is less damped. This is due to the fact that this station is located at a point in the KD where there is a direct and full time flowing connection between the KD and the open waters of Matlacha Pass. This connection can be clearly seen in aerials and was navigated in a small powerboat during a reconnaissance of the area. This connection and the phasing of the tidal wave through this connection is a key driver in breach flow through this northern section of the KD (KD4). This will be discussed in more detail in Section 4.3.3 where flow measurements through the breaches and through the southern opening are discussed.

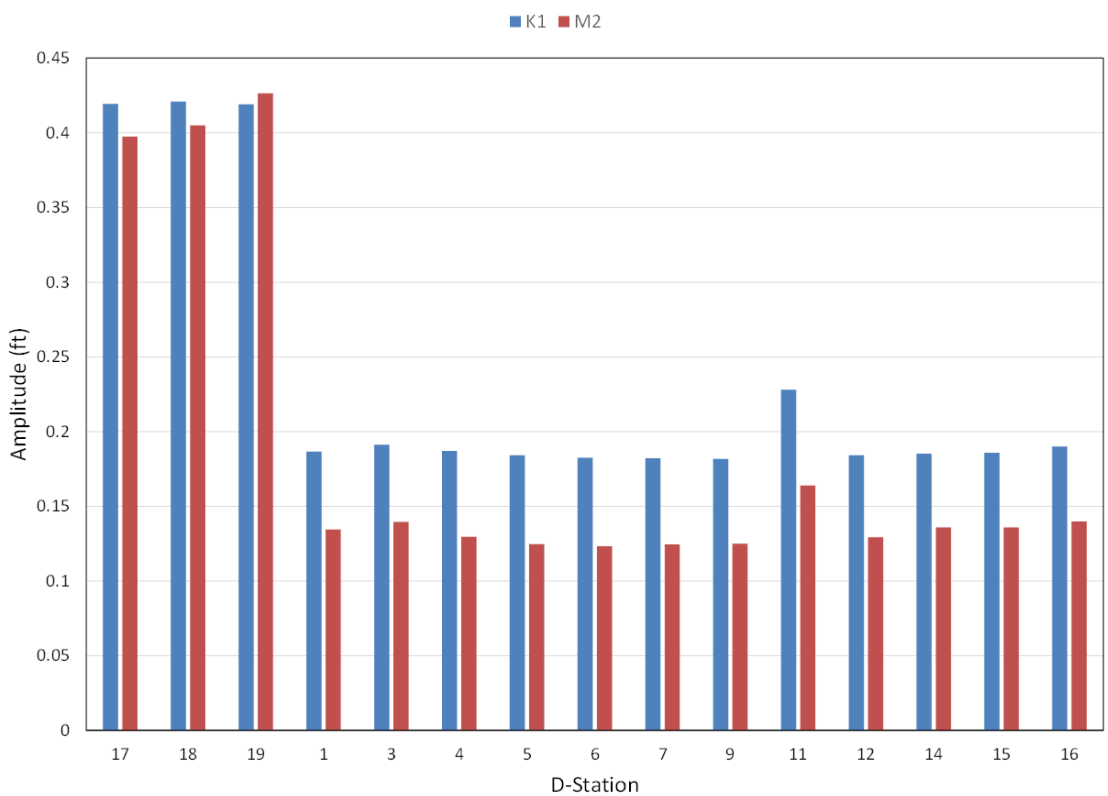

Figure 3-8a. Tidal Harmonic Amplitudes by Station

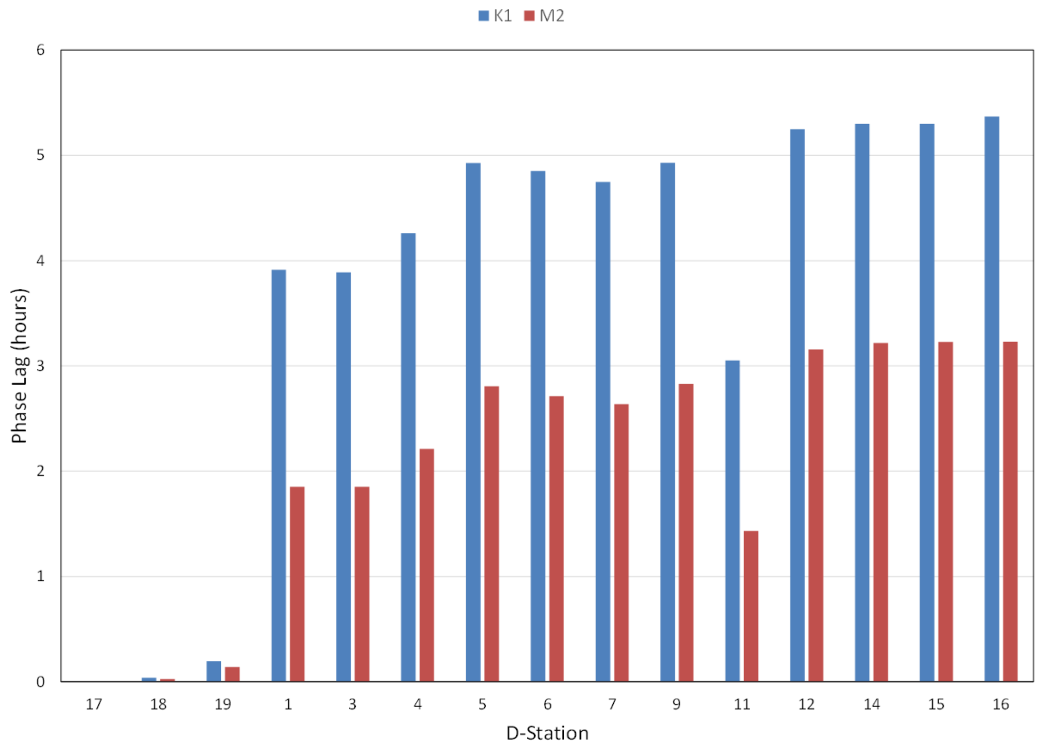

Figure 3-8b.   Tidal Harmonic Phase Lag from D-17 by Station

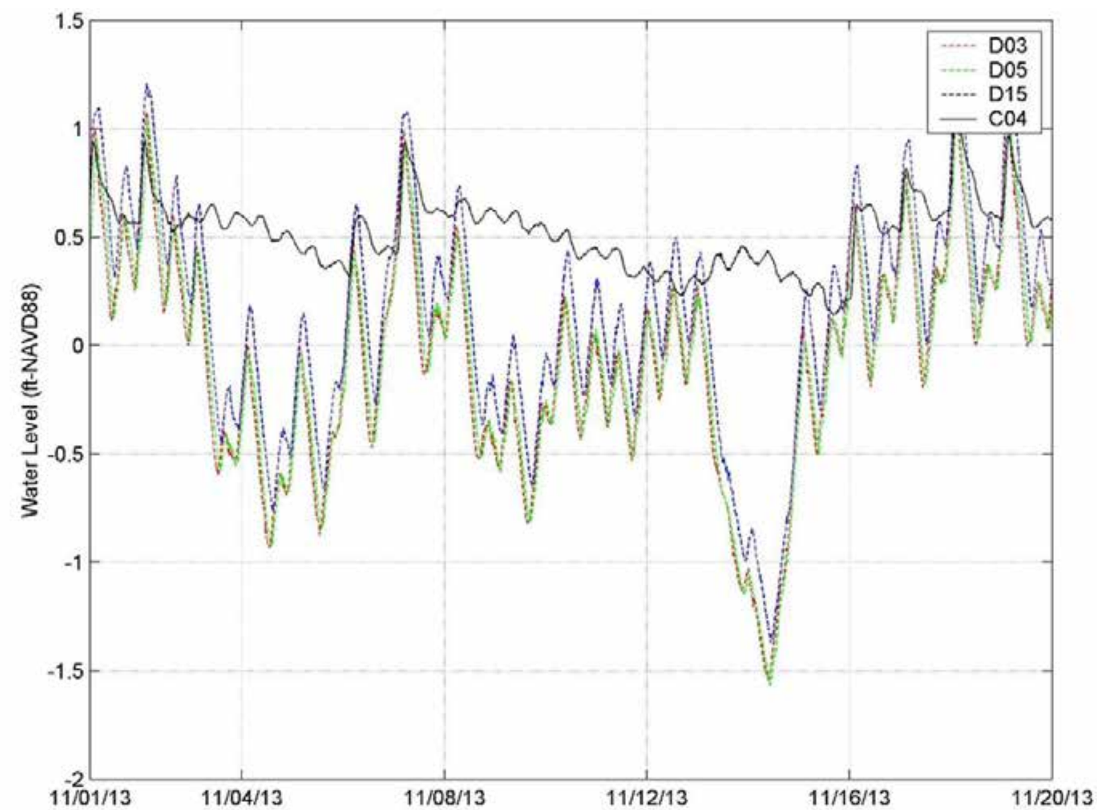

Figure 3-9.   Water Levels Measured in Sections of the KD

The final characteristic of the system derived from the water level analyses is highlighted in Figure 4-9. The plot presents the water level fluctuations measured in each of the four sections of the KD outlined in Figure 2-1 (KD1, KD2, KD3, and KD4). D-03 measured water level in KD1, D05 in KD2, C04 in KD3, and D15 in KD4. While the water levels in three of KD sections show similar tidal responses (KD1, KD2, and KD4) water levels in KD3 are significantly different. This section of the KD has only one connection to the NSC through the breach measured by USGS-04 (Breach 7). This connection is very shallow and does not flow other than when water levels are above the mean tide level in the NSC. This section of the KD is generally more disconnected from the NSC and Matlacha Pass than the remainder of the system, and clearly is not interconnected to the sections of the KD north and south of it. This is an important aspect as it is the KD sections that provide connection between the NSC and Matlacha Pass other than the southern entrance. As such, KD3 does not provide a significant flow pathway from the NSC to Matlacha Pass in comparison to the other KD sections.

3.3.3 FLOWS

As discussed earlier, USGS measured continuous flows within the primary breaches connecting the NSC with the KD from August of 2013 to February of 2014. Simultaneously measurements were made in Ceitus Creek and the southern channel connecting to Matlacha Pass which together represent the flows coming in through the southern entrance. Figure 4-4 presented the locations where measurements were made. During this period freshwater inflow over the weirs went from the highest levels during the data collection period (August and September) down to zero after October 15 through February of 2014. As data for calculating the flow over the weirs was not available after December of 2013, the data analyses of the breach and southern entrance flows are limited to August through December of 2013. The analyses conducted quantified the following characteristics of the flows through the breaches and the southern entrance (including Ceitus Creek);

- the relative magnitude and direction of the time dependent flows through the breaches and the southern entrance, and how those magnitudes and directions change based on water levels in the NSC and Matlacha Pass as well as freshwater inflows,
- the connectivity between the NSC/KD and Matlacha Pass through direct connections and remnant tidal channels,

- the magnitude of the net flows out of the NSC through the breaches and the southern entrance and how they relate to the total flow over the weirs, and
- the percent of the total flow coming in over the weirs passing out through the southern entrance versus through the breaches, and how that varies between wet and dry conditions.

Figures 4-10a and 4-10b present the measured flow through the breaches and the southern entrance during a dry period and a wet period respectively. On each figure, the top plot presents the flows through the southern entrance (USGS-00) versus the remaining stations, while the bottom plot presents comparisons of all the stations other than USGS-00. For all flow plots, positive values represent flow out of the NSC while negative flows represent flow in. Looking at the top plot in Figure 4-10a shows the significant difference in the tidally driven flow through the Southern entrance and all of the other breaches, including Ceitus Creek. The difference is on the order of 10 times. During very high flow events (Figure 4-10b top plot after September 23) the relative difference is lessened as all of the monitored breaches are flowing out, but the magnitude of the flow moving out through the southern entrance is still significantly larger than what passes out any of the breaches connecting to the KD or through Ceitus Creek.

Looking at the bottom plot on Figure 4-10a shows that, during dry periods, the breaches flow in different directions during the same time frames. On a rising tide, flows are into the NSC through the southern entrance (USGS-00), Ceitus Creek (USGS-01), Breach 4 (USGS-06), and Breach 1A (USGS-07), while flows are out of the NSC at the remaining breaches, Breach 10/11 (USGS-02), Breach 8 (USGS-03), and Breach 7 (USGS-04). During a wet period (Figure 4-10b) this same condition exists other than when the total flow over the weirs gets large enough so that the incoming tides are overwhelmed. This only occurs between 9/24 and 9/30 when total flows were over 1500 cfs.

Another characteristic of the breaches connecting the NSC with the KD, is the change in flow capacity as a function of water levels in the NSC. Figures 4-11a and 4-11b present plots of the directly measured and filtered (average) water levels against measured flows. Examination of the plots shows that the flow magnitudes through the breaches increase as the mean water levels rise and drop at times to near zero when water levels are low. This is indicative of intermittent connections coming online between Matlacha Pass and the KD as

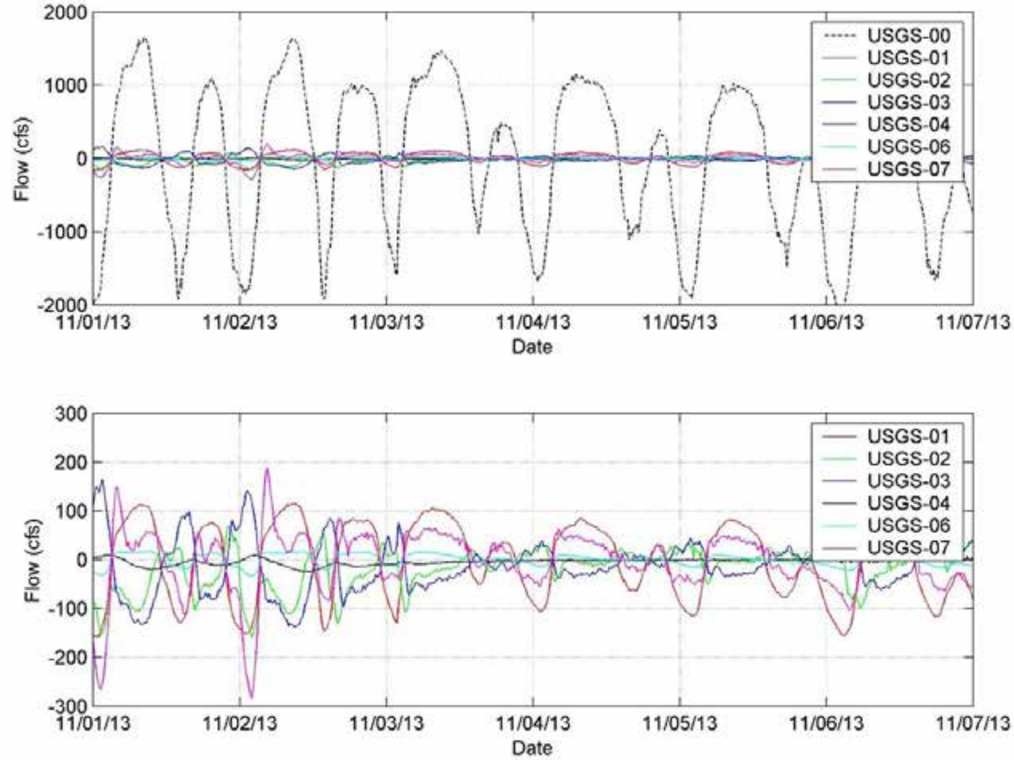

Figure 3-10a. Comparison of Measured USGS Flows during Dry Period

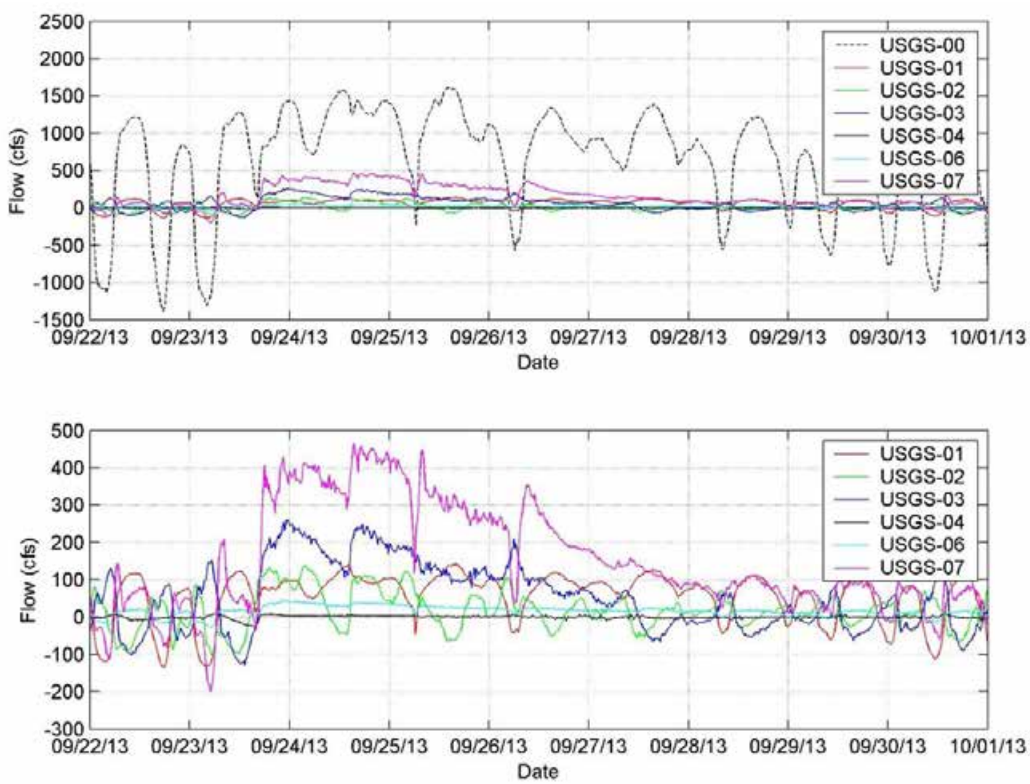

Figure 3-10b. Comparison of Measured USGS Flows during Wet Period

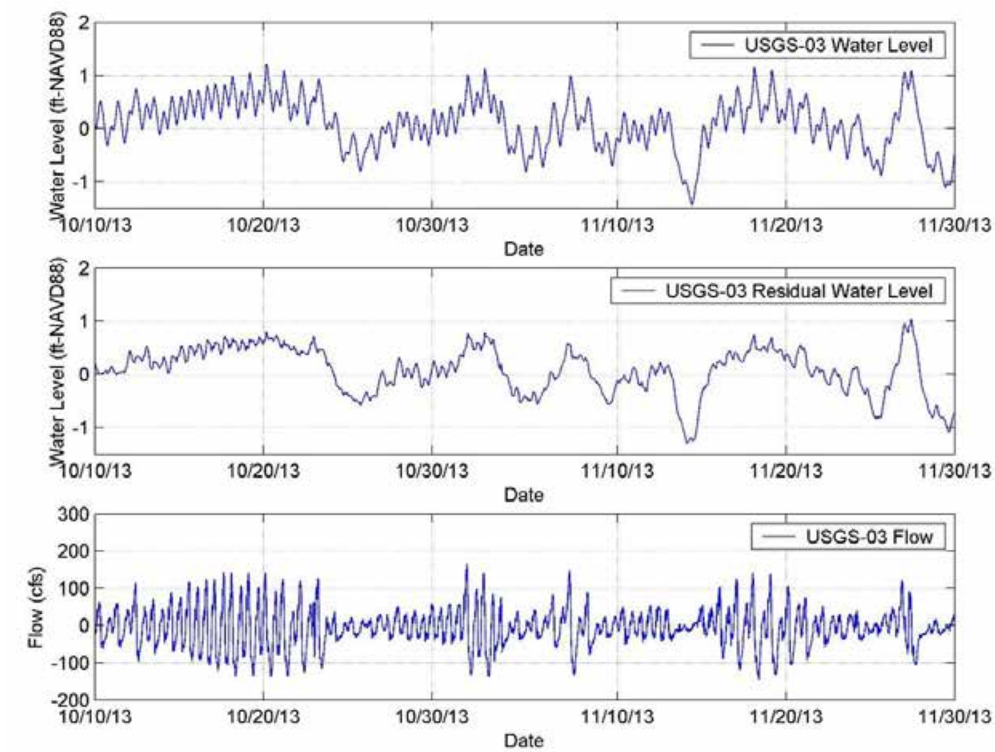

Figure 3-11a. Measured Water Level, Residual Water Level, and Flow at USGS-03, 10/10/13 to 11/30/13 (positive = out of NSC, negative = into NSC)

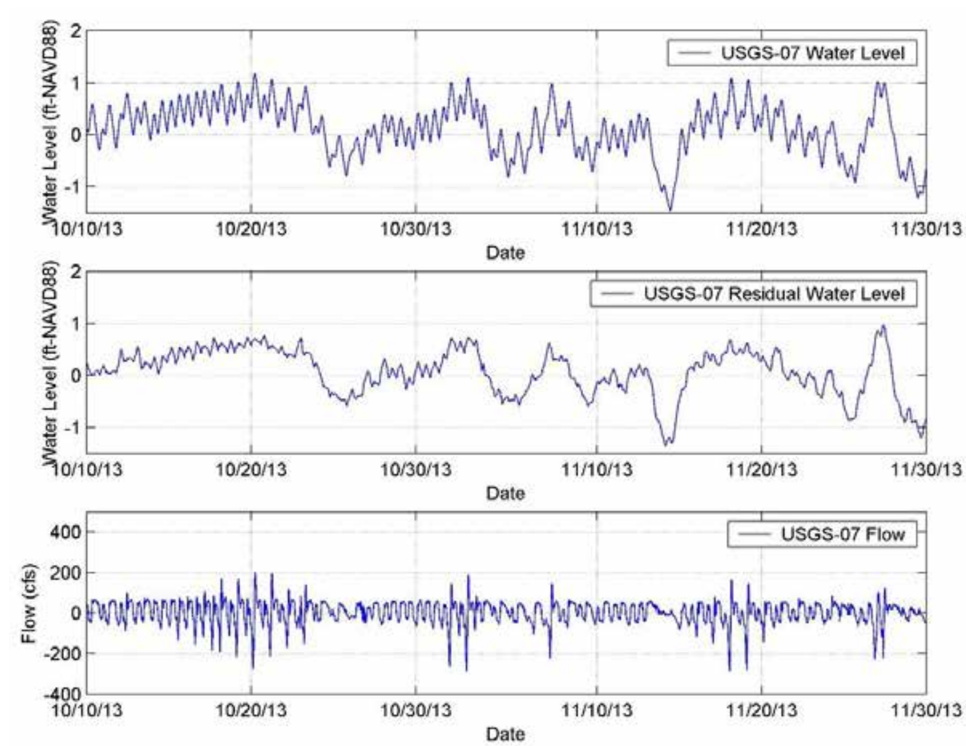

Figure 3-11b. Measured Water Level, Residual Water Level, and Flow at USGS-07, 10/10/13 to 11/30/13(positive = out of NSC, negative = into NSC)

water levels rise. Generally this seems to occur when water levels rise above 0.0 to 0.1 feet NAVD88. This phenomena occurs at all of the breaches that connect the NSC with the KD. Based on survey data and reconnaissance within the KD, the western side overtops when water levels rise. When this happens connections with the waters within the mangrove areas to the west come on line and flows through the breaches increase. The connections are most likely happening through remnant tidal channels that can be seen in aerial photography (see Figure 2-1). This is an important characteristic to understand as it governs the capacity for the breaches to pass water into and out of the NSC.

In order to define how the freshwater entering the system over the weirs moves through the system and out to Matlacha Pass, the time-series of measured flows at each of the breaches were filtered to remove the tidal components. The filtered flows then allow the net flow by monitored breach and through the southern entrance (including Ceitus Creek) to be quantified. These can then be compared over time and during specified periods.

Figures 3-12a and 3-12b present the time series of the net flows and the cumulative (summed) flows through the data collection period. In each figure, the top plot includes all of the USGS monitored stations, while the bottom plot does not have station USGS-00. This is done so that the scale of the plot allows visual comparisons of the flows through the breaches without the larger USGS-00 flows. The graphs highlight that a large portion of the net flow out of the system passes through the southern entrance. It also highlights that over this period some of the breaches showed net inflow. This is a function of the complex hydrodynamics and flows described earlier. Examination of the breaches shows that the northernmost breach 1A (USGS-07) has the largest net outflow after the southern entrance.

In order to quantify the net flows during specified periods, the filtered flows were summed by month and for the high flow event at the end of September. Table 3-1 presents the sums for each of the USGS monitored locations. Looking at the distribution of net flows passing the USGS stations shows that, during the wet period (September), the percent of the flow (which was monitored) going out past USGS-00 (southern end) and USGS-01 (Ceitus Creek – Breach 12) is between 76 to 81 percent. USGS stations 02, 03, and 06 (Breaches 10/11, 8, and 4 respectively) pass between 0 and 6 percent of the total flow. USGS-07 (Breach 1A) passes between 14 and 16 percent of the flow. USGS-04 (Breach 7) actually shows net negative flows even during this wet period.

Moving through the transition period (October) to the dry months (November and December) there is a shift from a condition of net outflow to a balance of net inflow through the breaches and net outflow passed USGS-00 (the southern end). This pattern is relatively consistent with some of the breach openings showing a greater degree of net inflow. Overall there is still a net volume of inflow per the calculations.

One aspect that should be considered in this balance is evaporation. Based on typical values for Southwest Florida a net deficit of rainfall/evaporation rates in November and December would be on the order of 2 inches per month. Based on a calculated area of the canals of 1087 acres this would equate to 181 acre-feet. While a potential contributor, this does not account for the total net inflow volumes presented in Table 3-1.

Table 3-2 presents the total flow passing over each of the weir structures and the total flow for these same periods. Comparison of the total flow over the weirs with the net flows presented in Table 3-1 shows that the variations by month and event are similar, and the total volumes are of the same general magnitude. This indicates that the monitoring program quantified the bulk of the flow moving through the system.

Table 3-1. Monthly (and Event) Net Flows at USGS Stations (positive = out of NSC, negative = into NSC)

Month	USGS-00	USGS01	USGS02	USGS03	USGS04	USGS06	USGS07	**Total**
	Total Volume (acre-ft)							
September	23276	1923	5	768	-159	580	4200	**30593**
October	6027	291	-905	-351	-112	116	751	**5816**
November	801	-155	-658	-428	-83	-6	-171	**-701**
December	573	-187	-493	-355	-3	-45	-174	**-685**
9/23 to 9/30	11956	980	318	957	-1	278	2690	**17179**

Table 3-2. Monthly (and event) Flows over Weir Structures

Start Date	End Date	Shadroe Canal (acre-ft)	Hermosa Canal (acre-ft)	Horseshoe Canal (acre-ft)	Gator Slough (acre-ft)	**Total (acre-ft)**
1-Sep-13	30-Sep-13	1773	5569	9903	19088	**36333**
1-Oct-13	31-Oct-13	578	1598	3526	4114	**9817**
1-Nov-13	30-Nov-13	13	257	31	36	**337**
1-Dec-13	31-Dec-13	4	18	0	0	**23**
23-Sep-13	30-Sep-13	970	3642	4307	7551	**16470**

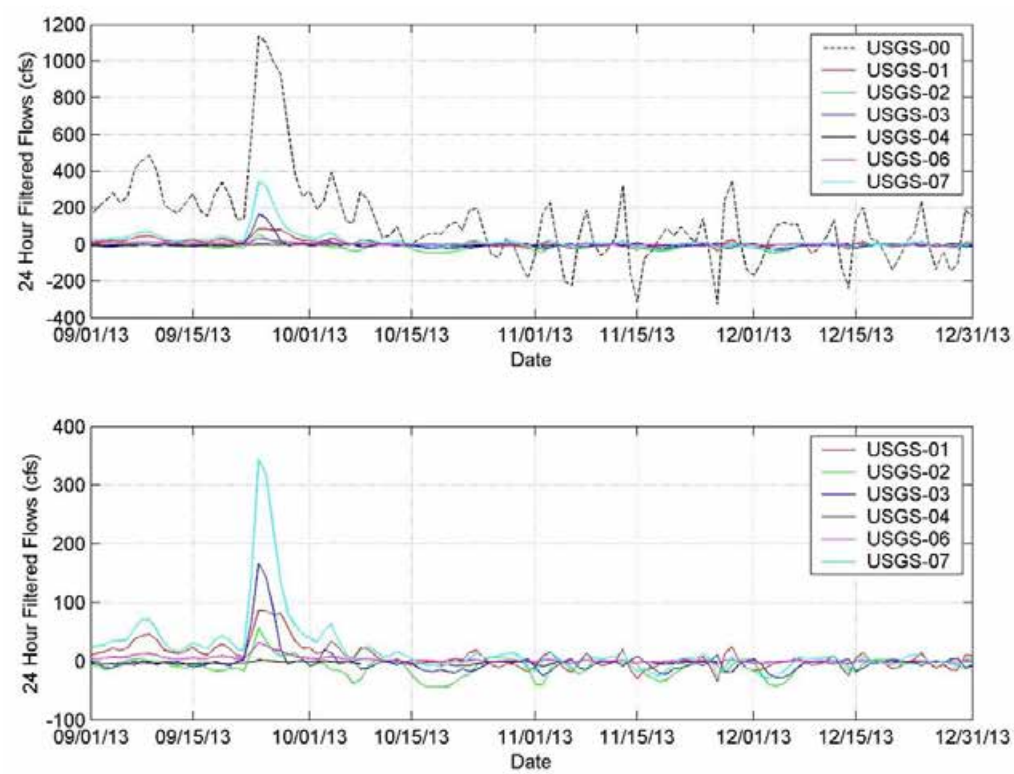

Figure 3-12a. Time Series of Filtered Flows

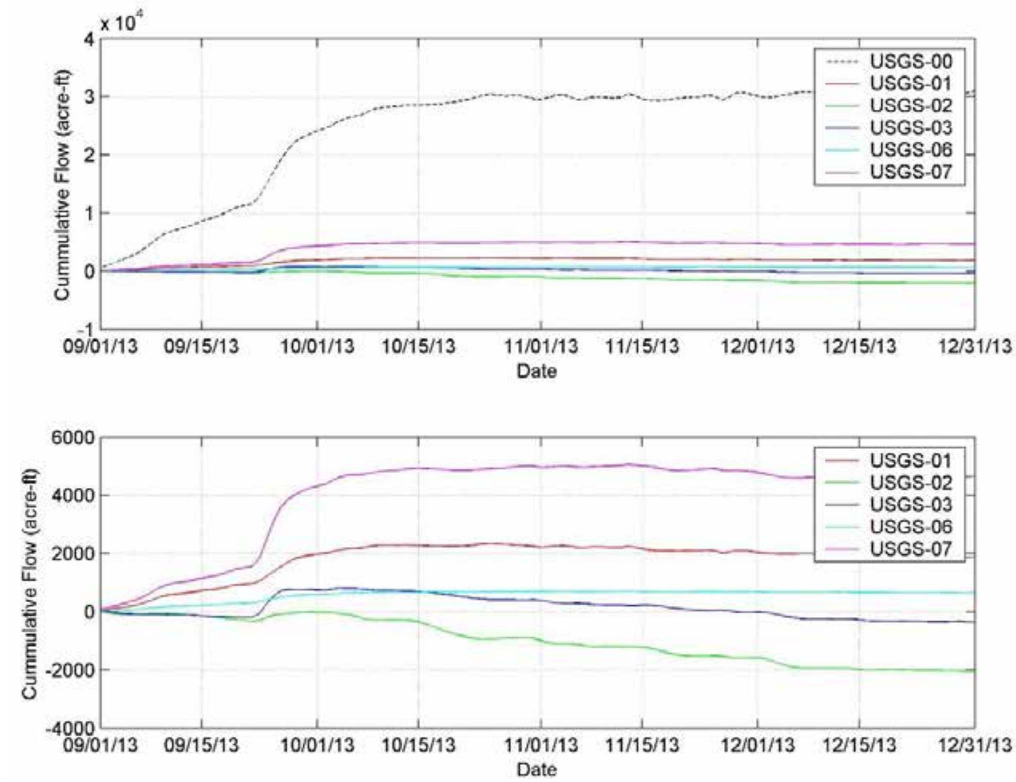

Figure 3-12b. Cummulative Flows

3.3.4 SALINITY

Figure 3-2 presented the locations where continuous salinity data were collected. Overall there were QA/QC issues with the salinity data with some stations showing significant gaps, while others had issues relative to salinity magnitudes identified in the data QA/QC process. That being said, the data can be used to highlight how the system behaves overall in terms of salinity variation and spatial distribution within the NSC and KD. Figures 3-13a and 3-13b present plots of the daily average salinity along with the total flow over the weirs and discrete salinity measurements taken by Lee County for two locations within the NSC (C-03 and C-07). These stations had the most complete data sets, are at two ends of the NSC (south end and north end respectively), and matched closest generally with the discrete samples. Figures 3-14a and 3-14b present data at two locations within the KD (C-04 within KD3 and C-06 within KD4). No discrete measurements were available for comparison at the KD stations so the magnitudes cannot be fully verified. The discrete data, where available, are presented to provide more accurate absolute salinity levels based on the QA/QC issues.

Looking at the salinity response to the freshwater inflows within the NSC and within the KD shows that overall the responses are very similar in terms of pattern, response time and magnitude. The data collection starts at a wet period and all of the stations show salinity levels near zero in the NSC and varying between 0 and 10 ppt in the KD. As the flows drop off from October to November 2012 salinities throughout the system rise, with salinity rising faster within the KD stations than in the NSC. Salinities eventually stabilize during the dry period with levels in the NSC near 20 to 25 ppt and levels in the KD between 30 and 35 ppt. It should be noted that the salinity levels in the KD may be artificially high based on findings during the QA/QC process. As flows come up mid-summer of 2013, the salinity levels in both the KD and NSC drop relatively quickly and stay near zero during the wet period, the salinities then begin to rise back up in the same manner previously described as flows go to zero in October of 2013. The data show that significant salinity drops occur with relatively small freshwater inflows. The data show that overall the system is highly sensitive to freshwater inflow, the patterns are similar throughout the NSC and KD, and generally the KD shows higher values.

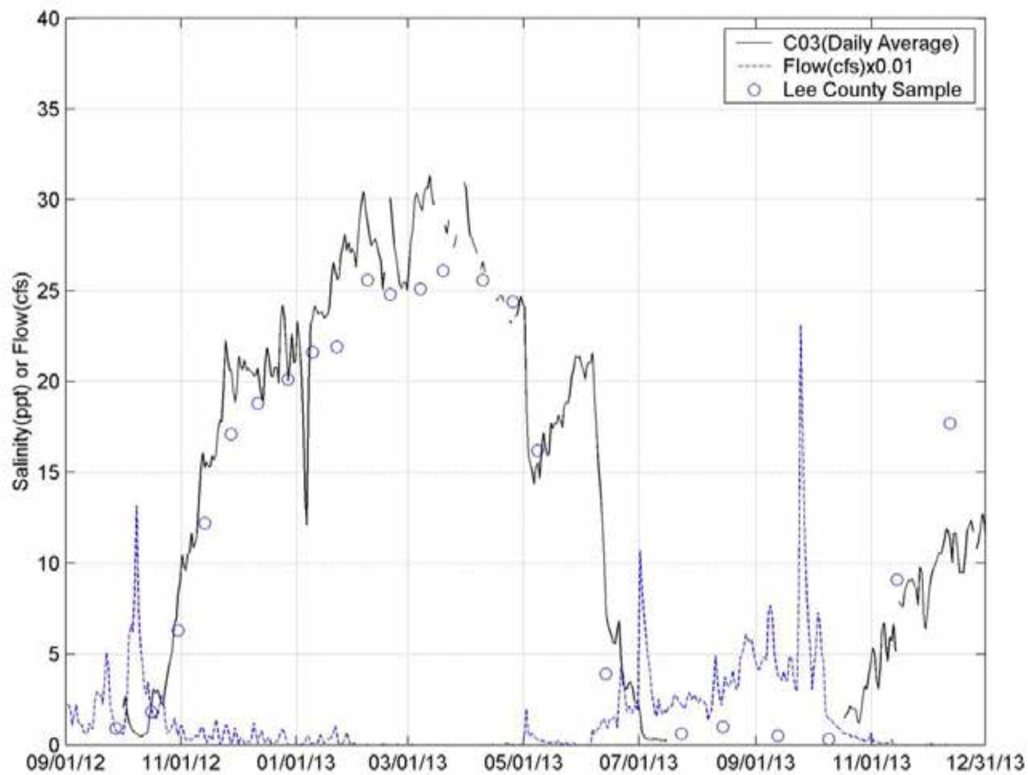

Figure 3-13a. Daily Average/Discrete Salinity versus Flow Over Weirs at C-03

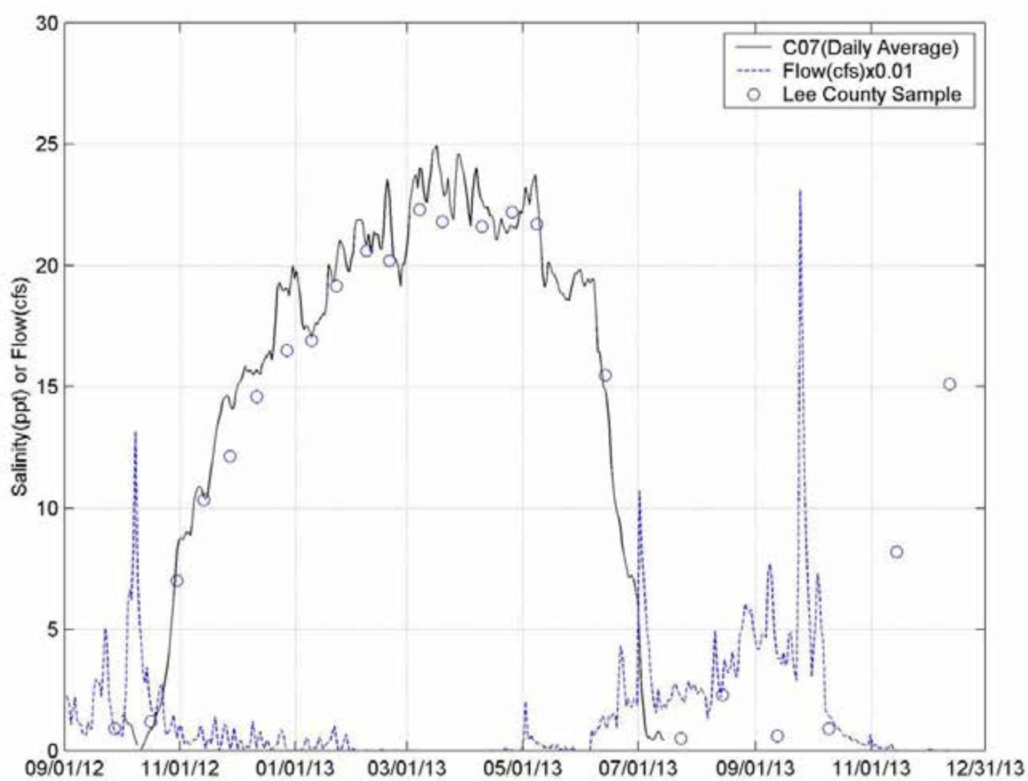

Figure 3-13b. Daily Average/Discrete Salinity versus Flow Over Weirs at C-07

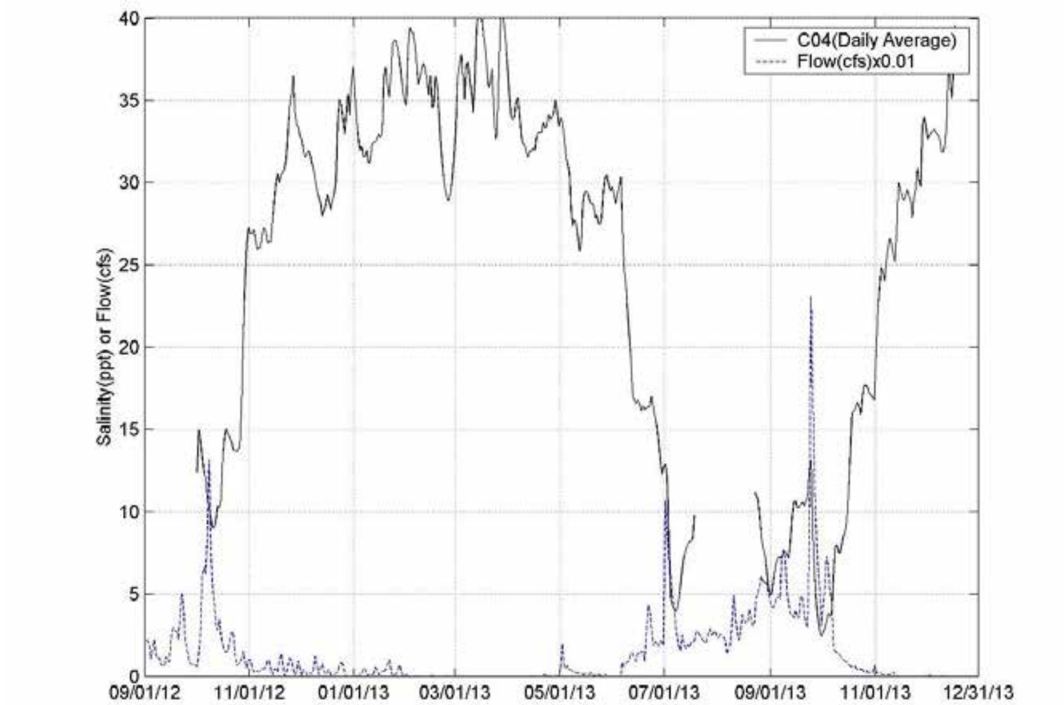

Figure 3-14a. Daily Average Salinity versus Flow Over Weirs at C-04

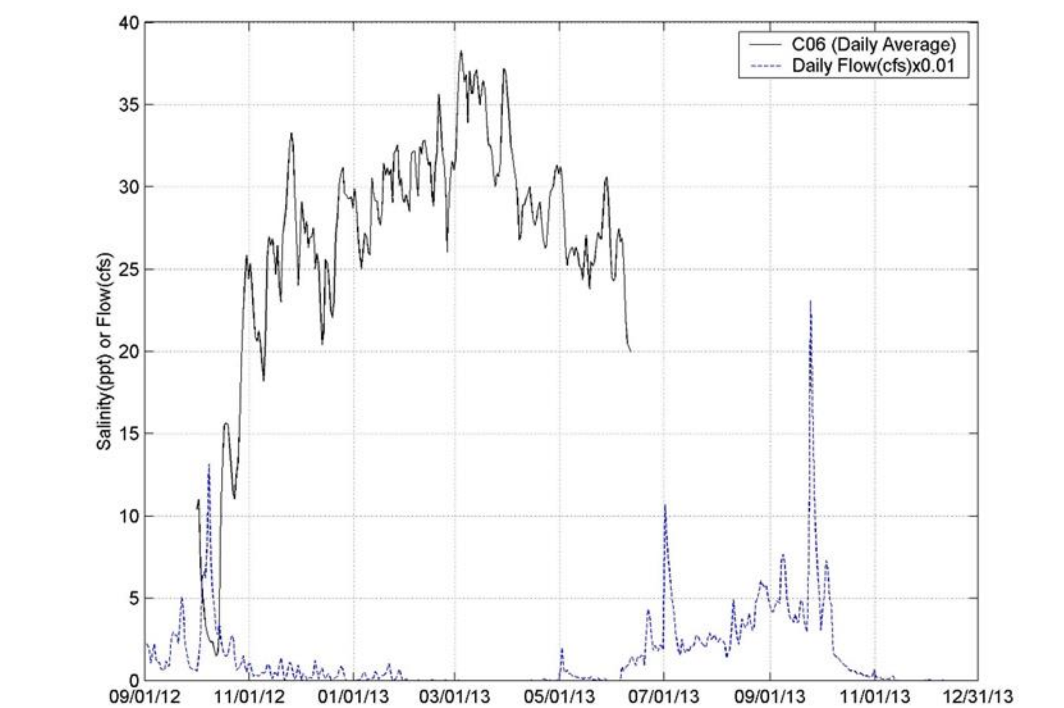

Figure 3-14b. Daily Average Salinity versus Flow Over Weirs at C-06

3.4 KEY FINDINGS

Based on the hydrodynamic data analyses summarized above, the following key findings were made from the data;

- Tidal amplitudes within the NSC and KD are damped between 61 to 64 percent in comparison to the tides in Matlacha Pass and this damping occurs almost immediately entering the NSC at the southern end.
- Analyses of the tidal phase shows that the tidal wave progresses from south to north within the NSC and there is limited tidal influence coming into the system from connections with Matlacha Pass.
- There is one full-time operating connection between Matlacha Pass and the KD and that occurs at the southern end of KD4. The tidal influence from this connection (in terms of water levels) is limited and localized.
- Under all but high flow conditions, during a rising tide, flows are into the NSC at USGS-00, USGS-01, USGS-06, and USGS-07, while flows are out at USGS-02 and USGS-03.
- The flows measured at USGS-02, USGS-03, USGS-04, USGS-06, and USGS-07 are highly dependent upon the mean water level in Matlacha Pass, with significantly higher flow magnitudes when mean water levels are higher. The flows are based upon connections to the areas west of the KD and Matlacha Pass "coming online" at higher water.
- During the monitored high flow period (September 2013) the percent of the monitored net flow going out USGS-00 (southern end) and USGS-01 (Ceitus Creek – Breach 12) is between 76 to 81 percent. USGS stations 02, 03, and 06 (Breaches 10/11, 8, and 4 respectively) pass between 0 and 6 percent of the total monitored net flow. USGS-07 (Breach 1A) passed between 14 and 16 percent of the total monitored net flow.

4.0 HYDRODYNAMIC MODEL DEVELOPMENT

4.1 INTRODUCTION AND OBJECTIVES

Under Phase I of the Northwest Cape Coral/Lee County Watershed Initiative, a complex hydrodynamic model was developed. A detailed presentation of the model development and calibration is presented in a separate report entitled “Northwest Cape Coral/Lee County Watershed Initiative, Hydrodynamic Model Development and Calibration”. The following provides a summary of the work completed.

The model extents include the interior canals up to the weir structures on Burnt Store Road; the NSC and the breach connections that were monitored; the KD; the mangrove areas between the KD and Matlacha Pass; and finally Matlacha Pass, from the connection to Charlotte Harbor down to near McCardle Island. The purpose of the model development is to provide a tool to allow testing of future management scenarios relative to flows from the upstream watershed or physical alterations of the system and the impacts upon circulation, transport, and salinity. The work under Phase I included the model development and calibration, which are summarized in the sections to follow.

4.2 MODEL DEVELOPMENT

The Environmental Fluid Dynamics Code (EFDC) model was utilized for this project. EFDC is a general purpose modeling package for simulating two- and three-dimensional flow, and transport in surface water systems including: rivers, lakes, estuaries, reservoirs, wetlands and near shore to shelf scale coastal regions. The EFDC model was originally developed by Dr. John Hamrick at the Virginia Institute of Marine Science and is considered public domain software. EFDC is currently supported by Tetra Tech for the U.S. Environmental Protection Agency (EPA) Office of Research and Development (ORD), EPA Region 4, and EPA Headquarters. The model is able to simulate the water levels, velocities, flows, and salinity throughout the system.

The first aspect of the hydrodynamic model development is the definition of the model extents or coverage. This is achieved through the development of the model grid. Figure 4-1 presents the final model grid. The grid was developed in a stepwise manner, iterating and testing the grid in order to get to the final grid presented in Figure 4-1. Key aspects of the grid include the detailed representation of the interior canals and the NSC, detailed representation of the KD and the breach connections between the NSC and the KD, and finally representation of storage areas within the mangroves between the KD and Matlacha Pass.

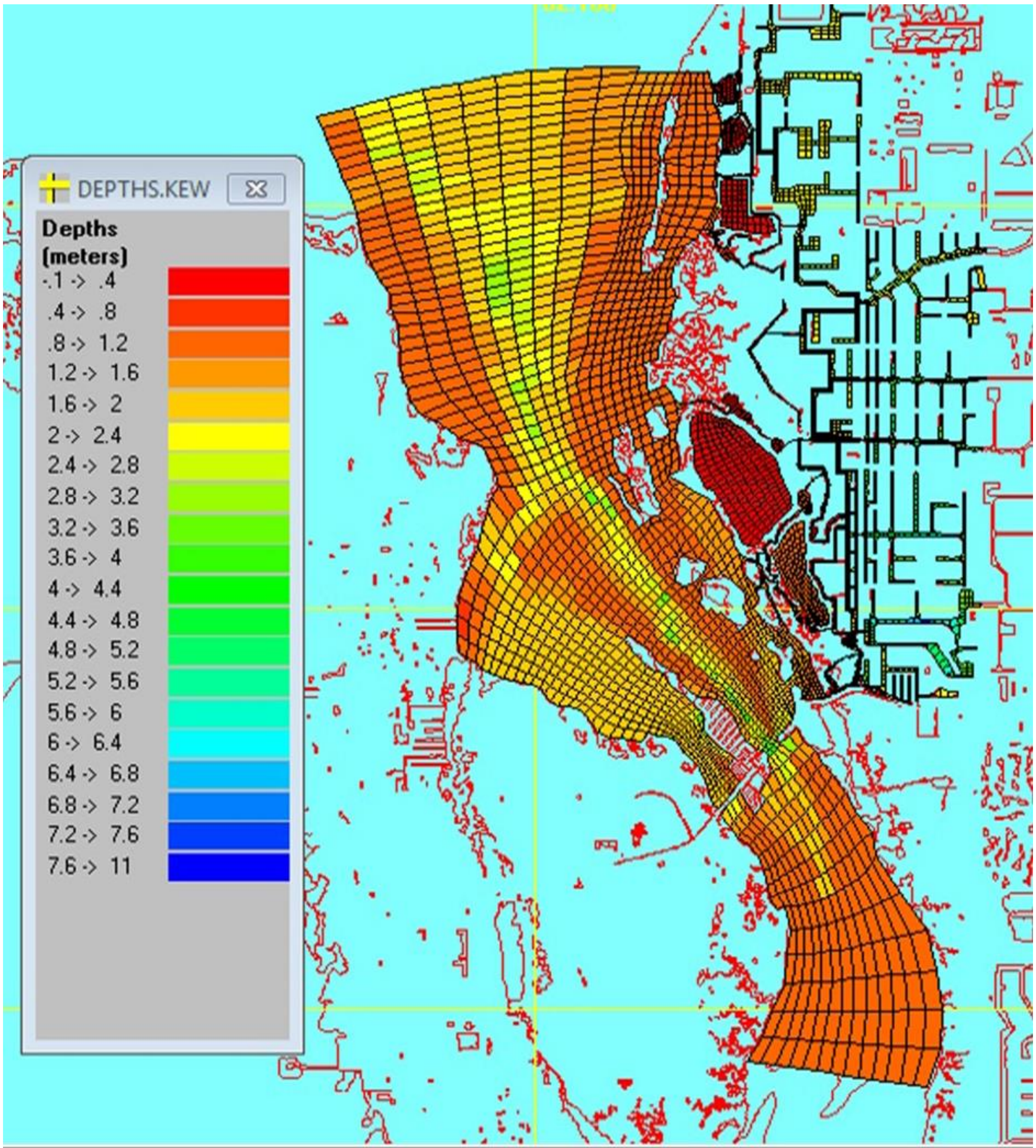

Figure 4-1. Model Grid and Bathymetry

Once the model grid has been created, the next step is the development of the model bathymetry. The datasets available for use in defining the model bathymetry included the following;

- NOAA chart data in electronic format;
- centerline data from the Regional Waterway Management System datasets; and
- centerline and transect survey data gathered as part of the NW Cape Coral/Lee County Watershed Initiative.

All bathymetric data utilized in the model grid development were converted to NAVD88. These data were then utilized to develop the average depth within each of the model grid cells by averaging all of the raw data found within each grid cell. Where data were not found within grid cells, kriging methods were used to develop appropriate average cell depths. Figure 4-1 presents the model bathymetry used for the final simulations.

The next step in the model development process is to generate the model inputs, for the hydrodynamic model this include;

- Water levels (tides) and salinity at the north and south ends of the grid in Matlacha Pass;
- Freshwater inflows over the weir structures along Burnt Store Road; and
- meteorologic conditions primarily wind stress at the water surface.

The model was run for the period of the data collection described in Section 3.2, October 2012 through December 2013. The boundary conditions for the simulations, other than the wind stress, came from the collected data.

Water levels at the north and south boundary were derived from the measured data in Matlacha Pass. Salinities at the north and south boundaries came from data collected under Lee Counties water quality sampling program within Matlacha Pass near the boundaries. Finally the freshwater inflows came from the measured flows over the weirs presented in Section 3. The wind speed and direction for the hydrodynamic model were developed using data from the Big Carlos Pass station. While data were available from stations more proximal to the study area, this location was utilized because it represented the nearest nearshore station that includes the coastal influence on wind.

4.3 MODEL CALIBRATION

Model calibration is the process of comparing the results of the model simulations (water levels, flows, and salinity) against the measured data. As described in Section 3, an extensive data set of water levels, flows, and salinity were collected, these data were used for the model calibration. A complete set of model simulation results are presented in the calibration report, the following provides example comparisons for key aspects.

4.3.1 WATER LEVELS

Figures 4-2a and 4-2b present example water level calibration plots for two stations at the south end of the NSC and two stations at the north end of the NSC respectively. The time frame selected includes a wet period August-September and a dry period November-December. The plots show that the model is capturing the mean water level elevation and the damping of the tidal wave moving into the system. Additionally, the model is capturing the water level variations seen during the high flow event in September. Table 4-1 presents model calibration statistics for all of the water level stations. The statistics include the Root Mean Square Error (RMSE) which is a measure of the difference between the model simulation and the data; the Mean Error (ME) which is a measure of how well the model captures the average conditions, and finally the Correlation Coefficient (R^2) which is a measure of how the model and data correlate. The error statistics show that the model is doing very well simulating the water levels throughout the system.

Table 4-1. Error Statistics for Water Level Simulations (01/01/13 – 12/10/13)

Station	RMSE (ft)	ME (ft)	R^2
D-17	0.1	-0.1	0.99
D-19	0.1	0.0	0.95
D-01	0.1	0.0	0.95
D-03	0.1	0.0	0.96
D-04	0.1	-0.1	0.95
D-05	0.1	0.0	0.94
D-06	0.1	0.0	0.96
D-07	0.1	0.0	0.95
D-09	0.1	0.0	0.96
D-11	0.2	0.0	0.80
D-12	0.1	-0.1	0.96
D-14	0.1	-0.1	0.96

Table 4-1. Error Statistics for Water Level Simulations (01/01/13 – 12/10/13)

Station	RMSE (ft)	ME (ft)	R^2
D-15	0.2	-0.2	0.95
D-16	0.1	-0.1	0.96
USGS-00	0.1	-0.1	0.94
USGS-01	0.2	-0.2	0.94
USGS-02	0.1	0.0	0.96
USGS-03	0.1	-0.1	0.96
USGS-06	0.2	-0.2	0.94
USGS-07	0.1	-0.1	0.96

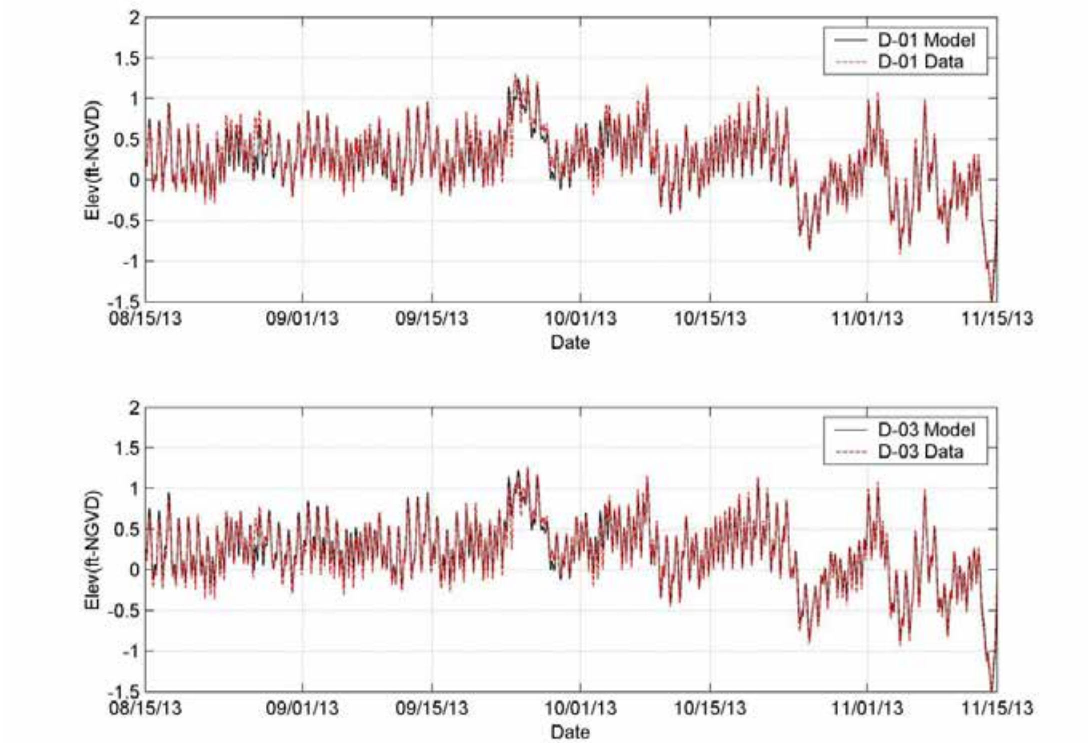

Figure 4-2a. Simulated vs Measured Water Level at Stations D-01 and D-03 (08/15/13 – 11/15/13)

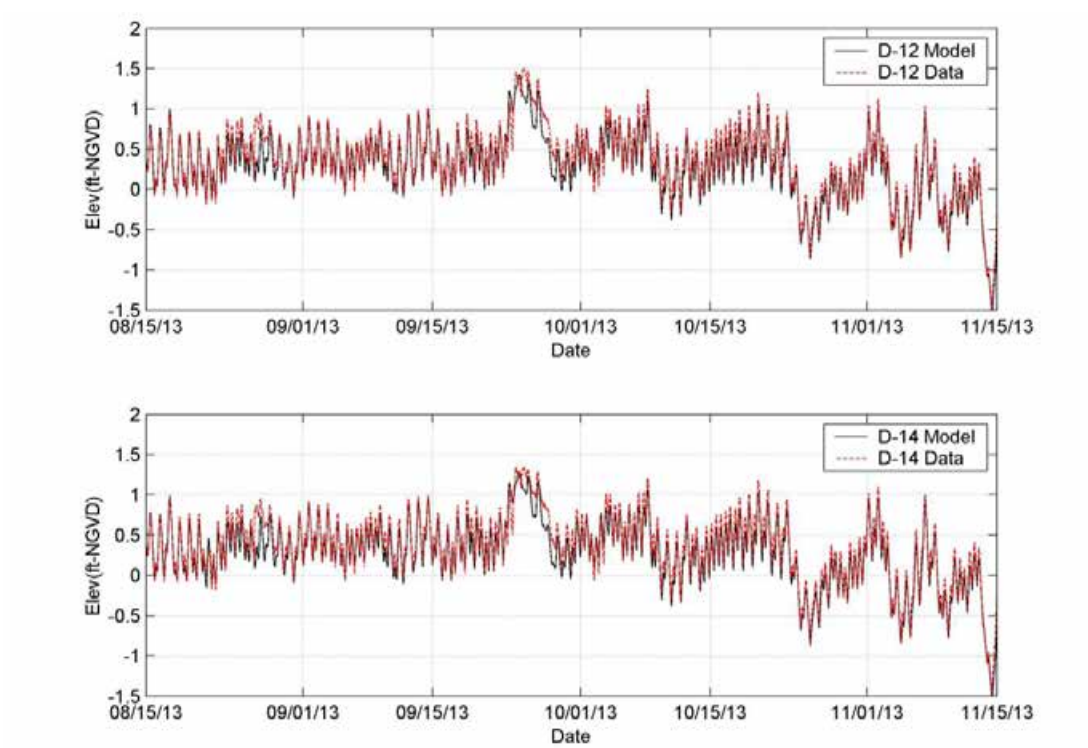

Figure 4-2b. Simulated vs Measured Water Level at Stations D-12 and D-14 (08/15/13 – 11/15/13)

4.3.2 BREACH AND SOUTH ENTRANCE FLOWS

Figures 4-3a through 4-3c present flow calibration plots for all of the USGS flow measurements within the breaches and the southern entrance. The time frame selected includes a wet period (September) moving into a dry period (October). The plots show that the model is capturing the flow magnitudes and characteristics reasonably at all of the stations. Some of the higher flows within the breaches at stations USGS-02 and USGS-03, but given the complexity of these flows, the simulations are reasonable. The model is doing very well simulating the characteristics of the flows in the northern breaches at stations USGS-06 and USGS-07.

Table 4-2 presents model calibration statistics for the flow stations. The error statistics show that the model is doing very well simulating the flows at the southern entrance and Ceitus Creek and the northern breaches. The breaches at USGS-02 and USGS-03 have lower correlation coefficients due to the complexity of the flow conditions, but the errors are reasonable.

Table 4-2. Error Statistics for USGS Station Flow Simulations (09/01/13 – 12/10/13)

Station	RMSE (cfs)	ME (cfs)	R^2
USGS-00	355.06	50.89	0.84
USGS-01	29.02	10.17	0.88
USGS-02	36.95	9.61	0.33
USGS-03	45.43	4.00	0.45
USGS-06	6.08	-0.11	0.83
USGS-07	45.61	-15.38	0.78

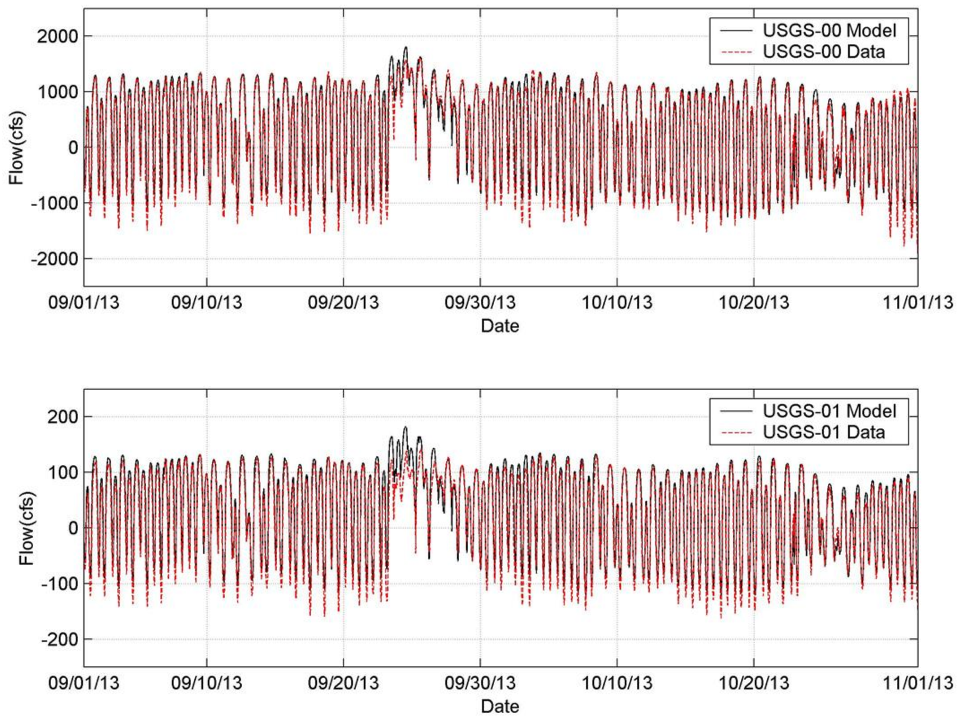

Figure 4-3a. Simulated vs Measured Flow at Stations USGS-00 and USGS-01 (09/01/13 – 11/01/13)

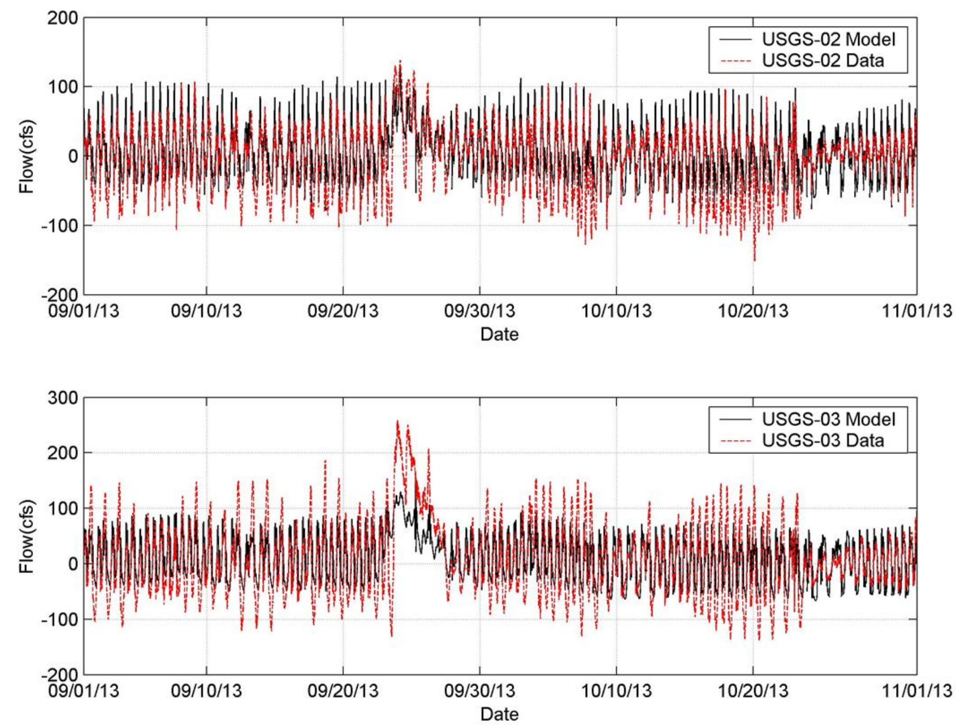

Figure 4-3b. Simulated vs Measured Flow at Stations USGS-02 and USGS-03 (09/01/13 – 11/01/13)

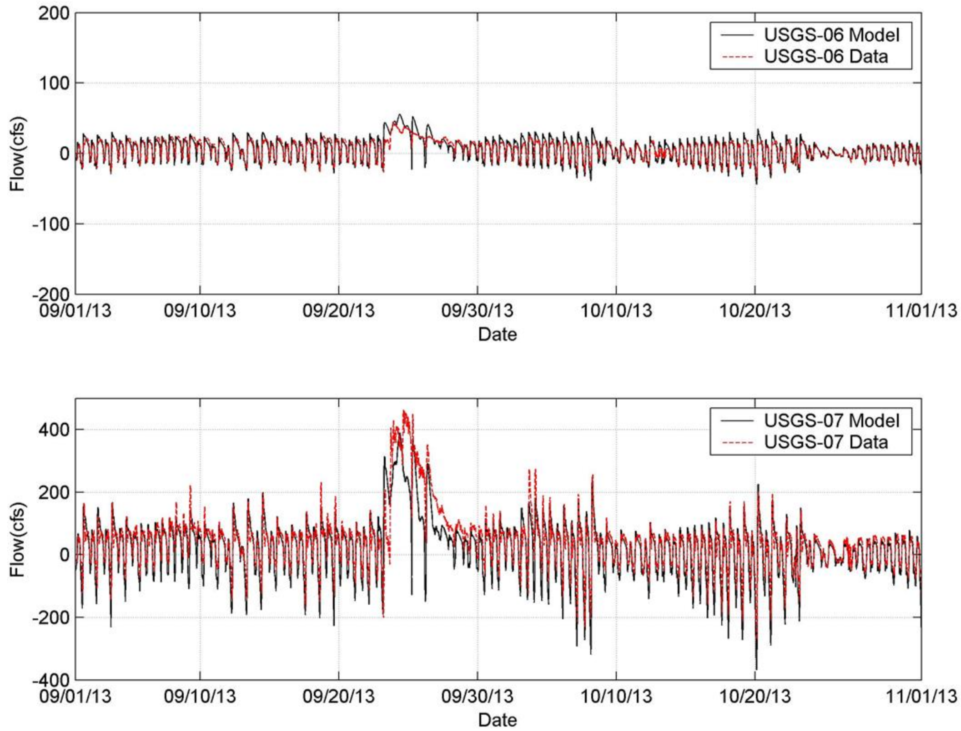

Figure 4-3c. Simulated vs Measured Flow at Stations USGS-06 and USGS-07 (09/01/13 – 11/01/13)

4.3.3 SALINITY

Figures 4-4a through 4-4b present comparisons of the simulated versus measured salinity at two locations along the NSC. One around the middle-southern end (C-03) and one at the northern end (C-07). Overall the model is capturing the magnitude and timing of the response to the freshwater inflow. Some of the differences in the beginning of the model simulation may be due to a number of potential aspects, such as:

- Limited boundary condition data, and/or
- Insufficient time for the model spin up prior to the comparison to the data starting January 1, and/or
- Errors in the freshwater inflow.

Due to the highly sensitive nature of the salinity simulations to the freshwater inflow (looking at the degree of response at some stations to the very small inflows in May), small errors in freshwater inflow may have a significant impact on the salinity simulations. Overall though, the model appears to capture the timing and magnitude of the system responses to the freshwater inflows on salinity.

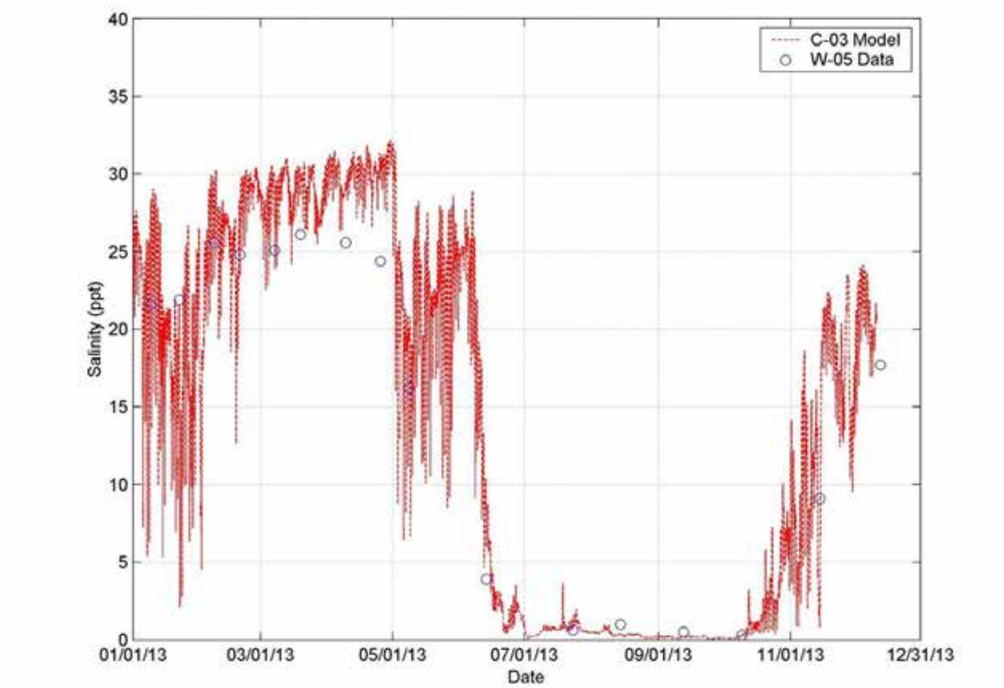

Figure 4-4a. Simulated vs Measured Salinity at Station C-03

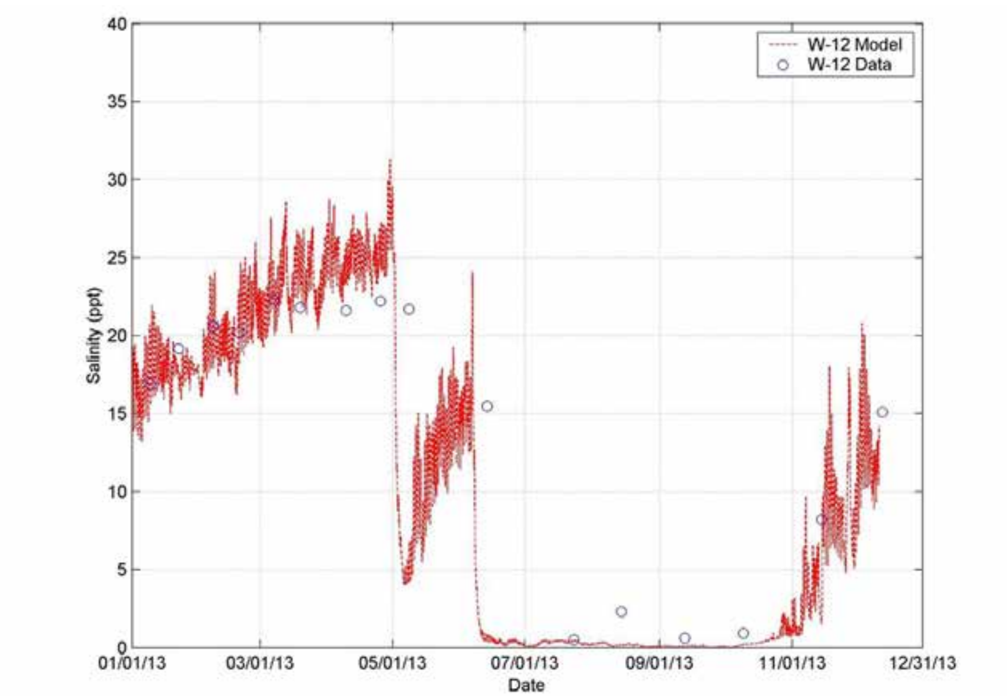

Figure 4-4a. Simulated vs Measured Salinity at Station C-07

5.0 WATER QUALITY DATA CHARACTERIZATION

5.1 INTRODUCTION AND OBJECTIVES

Under Phase I of the Northwest Cape Coral/Lee County Watershed Initiative, an extensive analysis of available water quality data was executed. This included key water quality parameters indicative of the health of the waters in the area of the NSC. This included;

- The freshwater canals above the weir structures which discharge into the NSC,
- The NSC and the interior canals, and
- Matlacha Pass which receives the discharge out of the NSC.

This goal of the water quality data characterization was to provide a detailed spatial and temporal description of existing water quality data within the waters in and upstream of the NSC as well as Matlacha Pass. The results serve as a foundation for analytical work to identify key water quality indicators describing the relationship between water quality in the NSC and in Matlacha Pass and ultimately to assess the overall water quality conditions. The complete detailed analyses of the data are presented in a separate report entitled “NW Spreader Canal, Water Quality Data Characterization”. The sections below provide a summary of the data collected, the data analyses performed, and some key findings from the analyses. Due to the volume of data and the extent of the analyses presented in the detailed report, the summary presented herein only describes a portion of the overall findings. The detailed report also provided calculated loads over the weir structures, the reader is referred to this report to see the calculated loads.

5.2 DATA

The North Spreader Canal (NSC) along with the water upstream within the drainage basins and its downstream receiving waterbody (Matlacha Pass) has been routinely sampled for water quality and includes some stations with continuous periods of record of at least 20 years. The City of Cape Coral has conducted routine (monthly) fixed-location water quality sampling throughout the watershed since 1992. Lee County has maintained an active water quality sampling effort in Matlacha Pass since 1996. The Shellfish Environmental Assessment Section (SEAS) program has sampled a series of fixed stations for in-situ physical chemistry and fecal coliforms in Matlacha Pass since 1985. Most recently, Lee County conducted a synoptic sampling effort within the NSC, Matlacha Pass, and upstream of the weir structures. Finally, the Coastal Charlotte Harbor Monitoring Network (CCHMN) has maintained a probabalistic sampling network throughout Matlacha Pass since 2002. Together these programs represent a fairly comprehensive data set from which to characterize historical water quality conditions, identify spatial differences, identify trends over time, and develop meaningful, management level indicators to guide decision making regarding best management practices for the health of the watershed and receiving waters. Figure 5-1 presents the locations where water quality data were collected by agency. The locations for the CCHMN are shown as a single point in Matlacha Pass due to the random nature of the program for the collection of data.

For the purposes of analyses there are three somewhat distinct areas for the assessment of water quality conditions, these are;

- Canals above the weir structures,
- The NSC and interior canals below the weir structures, and
- Matlacha Pass and adjacent waters.

These are the distinctions that FDEP makes when evaluating the waters in the area for compliance with water quality criteria.

For the agencies shown in Figure 5-1, the City of Cape Coral has maintained long-term monitoring stations within the NSC and interior canals and above the weir structures since 1990. Additionally, Lee County did an intensive sampling at multiple locations within the NSC, the interior canals, and above the weir structures in 2012 and 2013 (Lee Ceitus). For Matlacha Pass data came from multiple sources including, Lee County fixed station monitoring from 1996 to the present, the intensive sampling by Lee County (Lee Ceitus) done in 2012 and 2013, the SEAS program from 1980 to the present, and the CCHMN which has been implementing their random monitoring program in Matlacha Pass since 2002.

The specific parameters for the analyses included the following;

- Salinity
- Dissolved Oxygen (DO)

- Nutrients (TN, TP)
- Chl a
- Turbidity
- Total Suspended Solids (TSS)
- Secchi Disk Depth
- Fecal Coliform

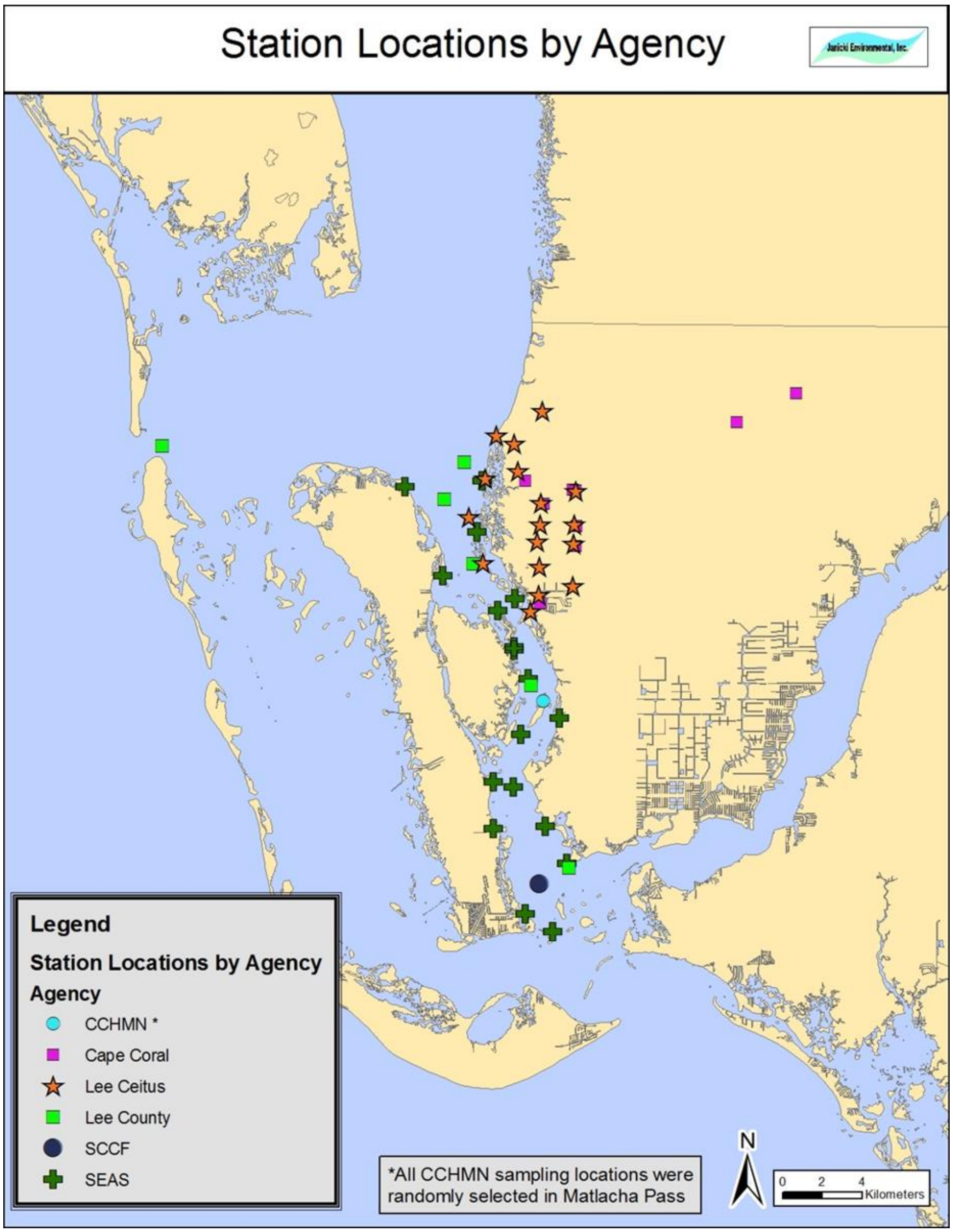

Figure 5-1. Stations Locations by Agency

5.3 ANALYSES

For each of the data sets by agency, specific analyses were conducted based on the types and frequency of data available. The specific analyses included;

- Spatial distribution of long-term averages
- Distribution of the data (box and whisker plots)
- Trend analysis, and
- Correlations between stations

The following presents examples of the data analyses performed outlining some key aspects and findings. For a full presentation of all the data and all of the detailed analyses, the reader is referred to the Water Quality Data Characterization Report discussed above. Section 1.3.1 presents results from the analyses of the data within the NSC and upstream of the weir structures. Section 1.3.2 presents results from within Matlacha Pass.

5.3.1 NSC AND CANALS ABOVE WEIR STRUCTURES

The primary long-term data gathered within the NSC and upstream of the weir structures came from the City of Cape Coral monitoring program. As discussed above, this program has been collecting data since 1992. A number of the stations maintained by the City were started in 2008, which is the time frame when the boat lift was removed, so that the data from this point forward would reflect conditions as they stand today with the boat lift removed.

Figures 5-2, 5-4, 5-6, 5-8, and 5-10 provide the average concentrations from 2008 to 2013 for TN, DO, Chl a, secchi disk, and fecal coliform. For these analyses, the period of record is truncated to 2008-2013, since all stations (except Station 150) were collecting TN data over this time period. Examination of the data shows a few aspects of the system. The nutrient concentrations (TP shows similar distribution and levels) are generally low especially in the areas upstream of the weir structures. Correspondingly the Chl a levels are also generally low in the system. The secchi disk data shows values typical of the colored systems in this area. Finally, the fecal coliform levels are universally low. If the data are compared between stations, it shows that there is a pattern of higher values in the area of

Gator Slough and the waters downstream of the Gator Slough weir. While these values are not high in an absolute sense, they are generally higher than the data in the other areas.

Figures 5-3, 5-5, 5-7, 5-9, and 5-11 provide the long-term average concentrations for TN, DO, Chl a, secchi disk, and fecal coliform. For these analyses, the period of record is the full period of available data for each of the stations. Examination of the plots gives some idea of the general trends in the water quality conditions. While variable between stations, and some stations do not show significant trends, the overall results show significant increasing trend in the TN, Chl a, and fecal coliforms. Correspondingly, there is a decreasing trend in the DO levels and the secchi disk levels.

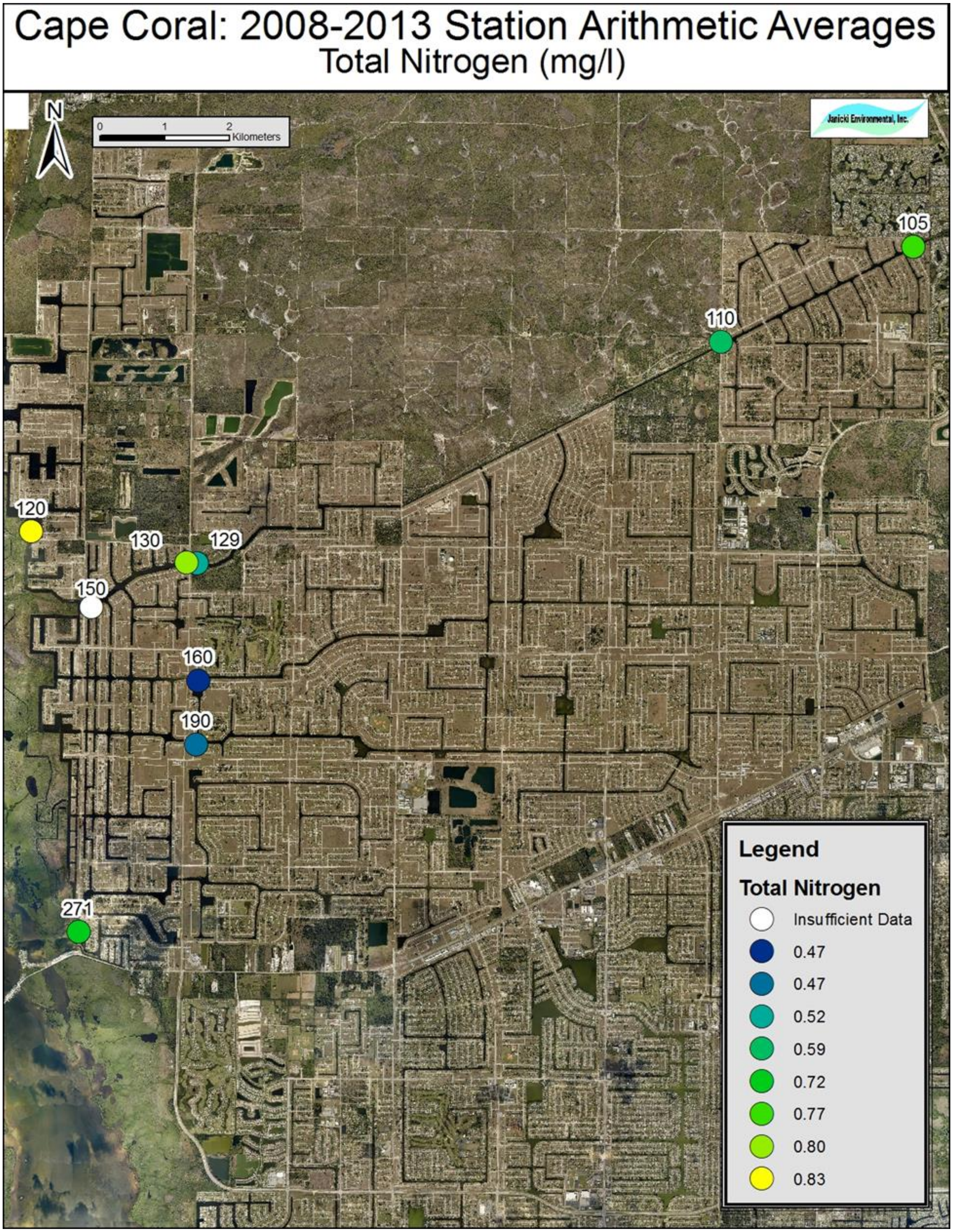

Figure 5-2. Arithmetic Average of Total Nitrogen Concentrations between 2008 and 2013 for Cape Coral Fixed Stations in the NSC

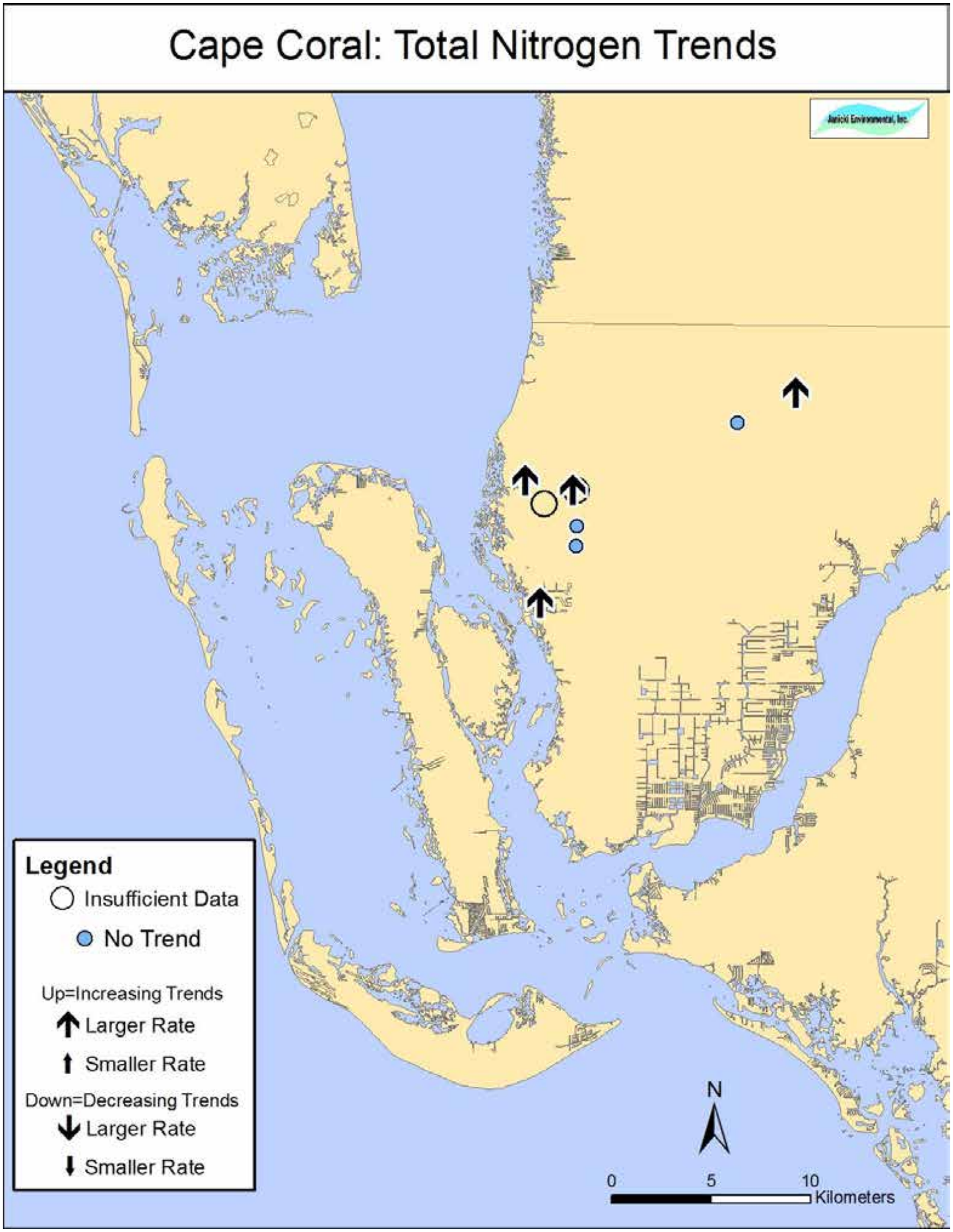

Figure 5-3. Total Nitrogen Trends for Cape Coral Fixed Stations in the NSC

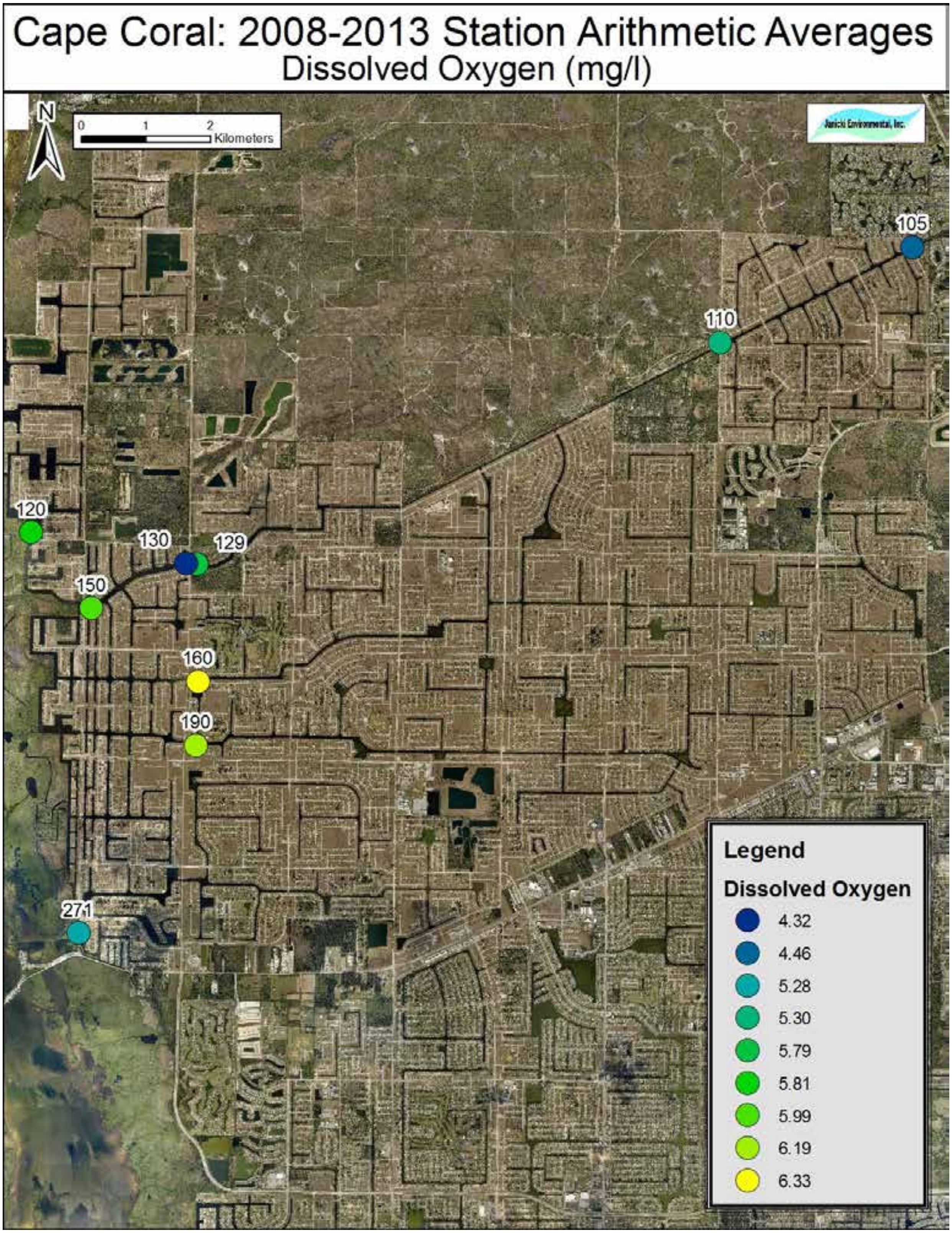

Figure 5-4. Arithmetic Average of Surface Dissolved Oxygen at Cape Coral Fixed Station Samples Collected between 2008 and 2013 in the NSC

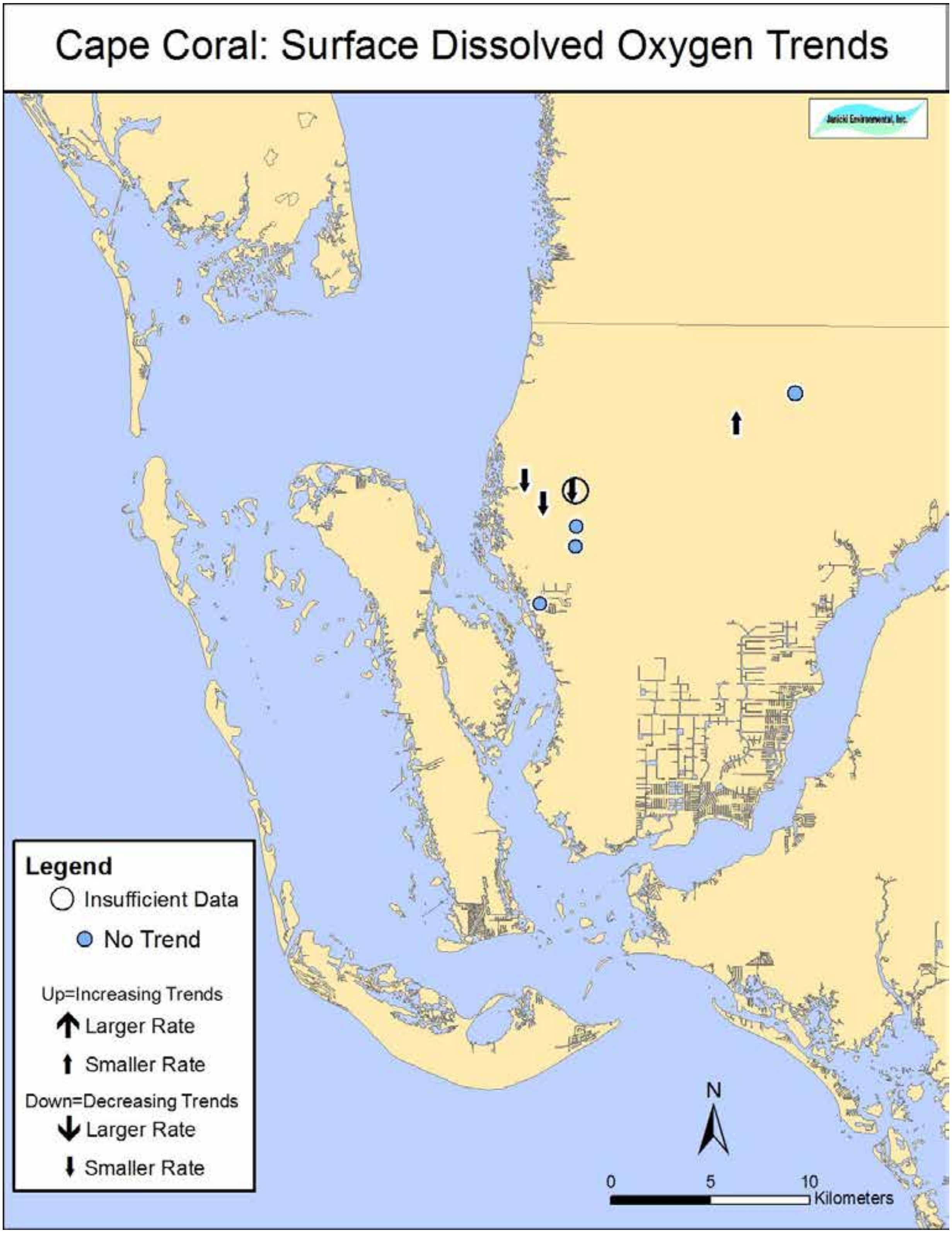

Figure 5-5. Surface Dissolved Oxygen Trends for Cape Coral Fixed Stations in the NSC

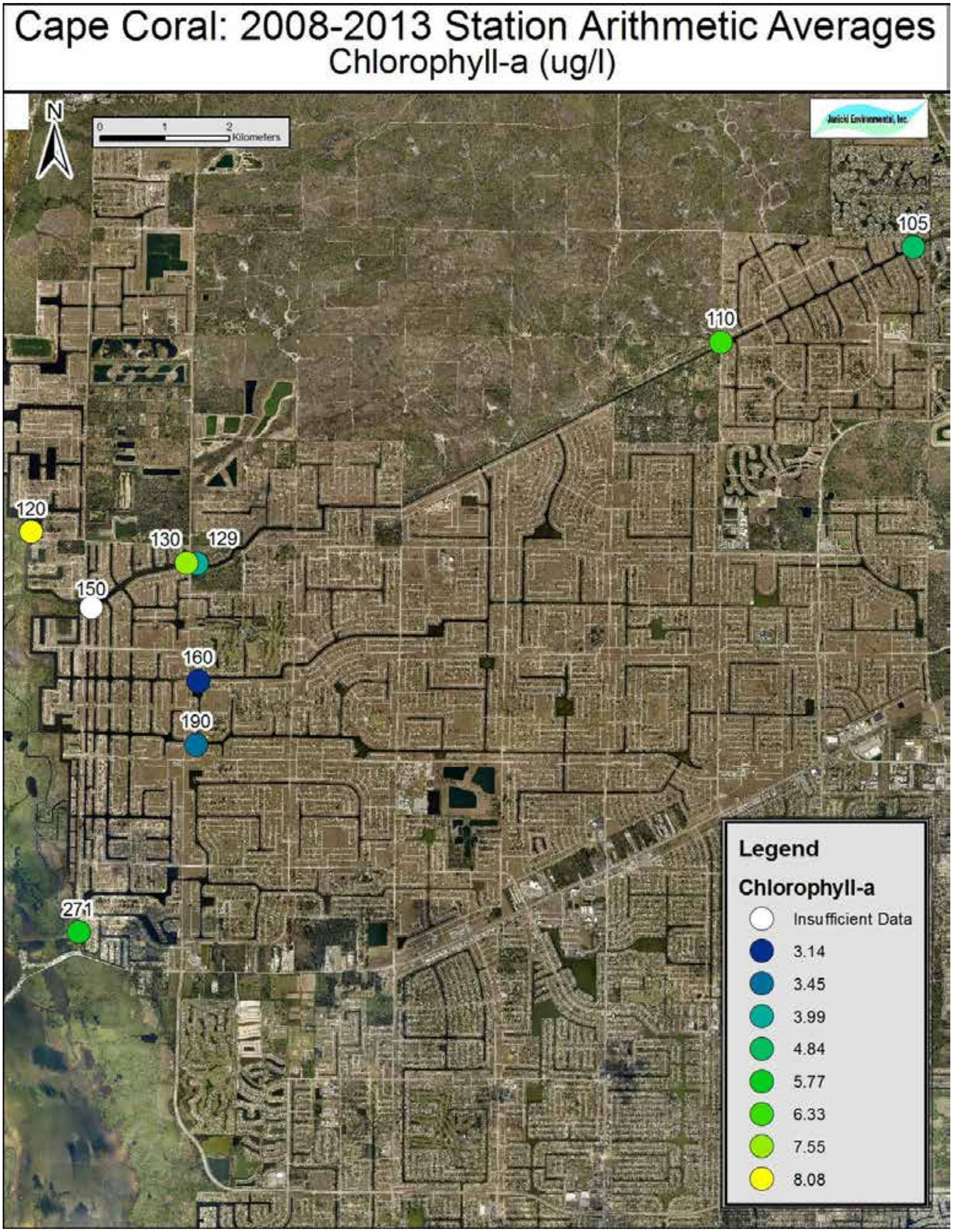

Figure 5-6. Arithmetic Average of Chlorophyll a at Cape Coral Stations for Samples Collected between 2008 and 2013

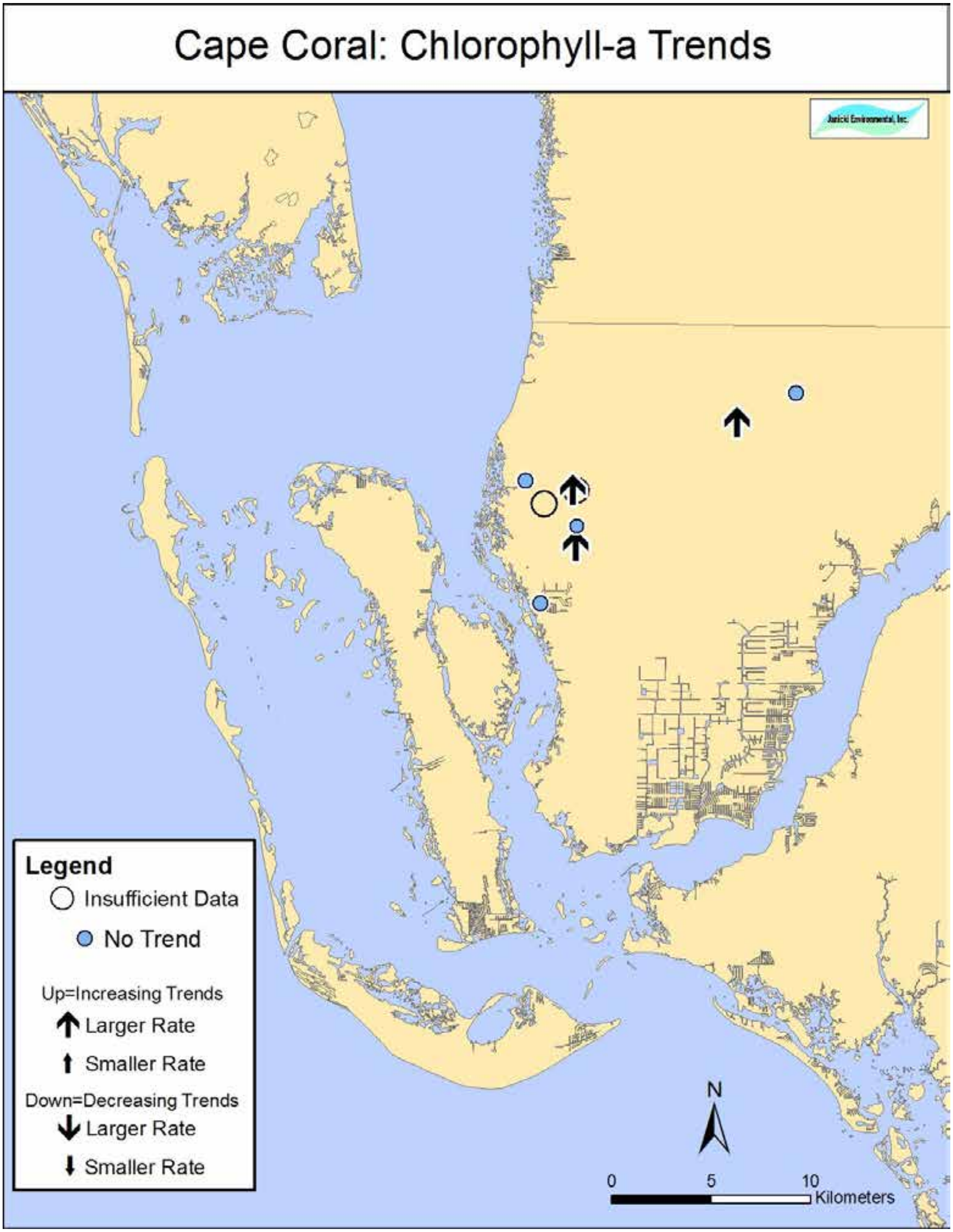

Figure 5-7. Chlorophyll a Trends for Cape Coral Fixed Stations in the NSC

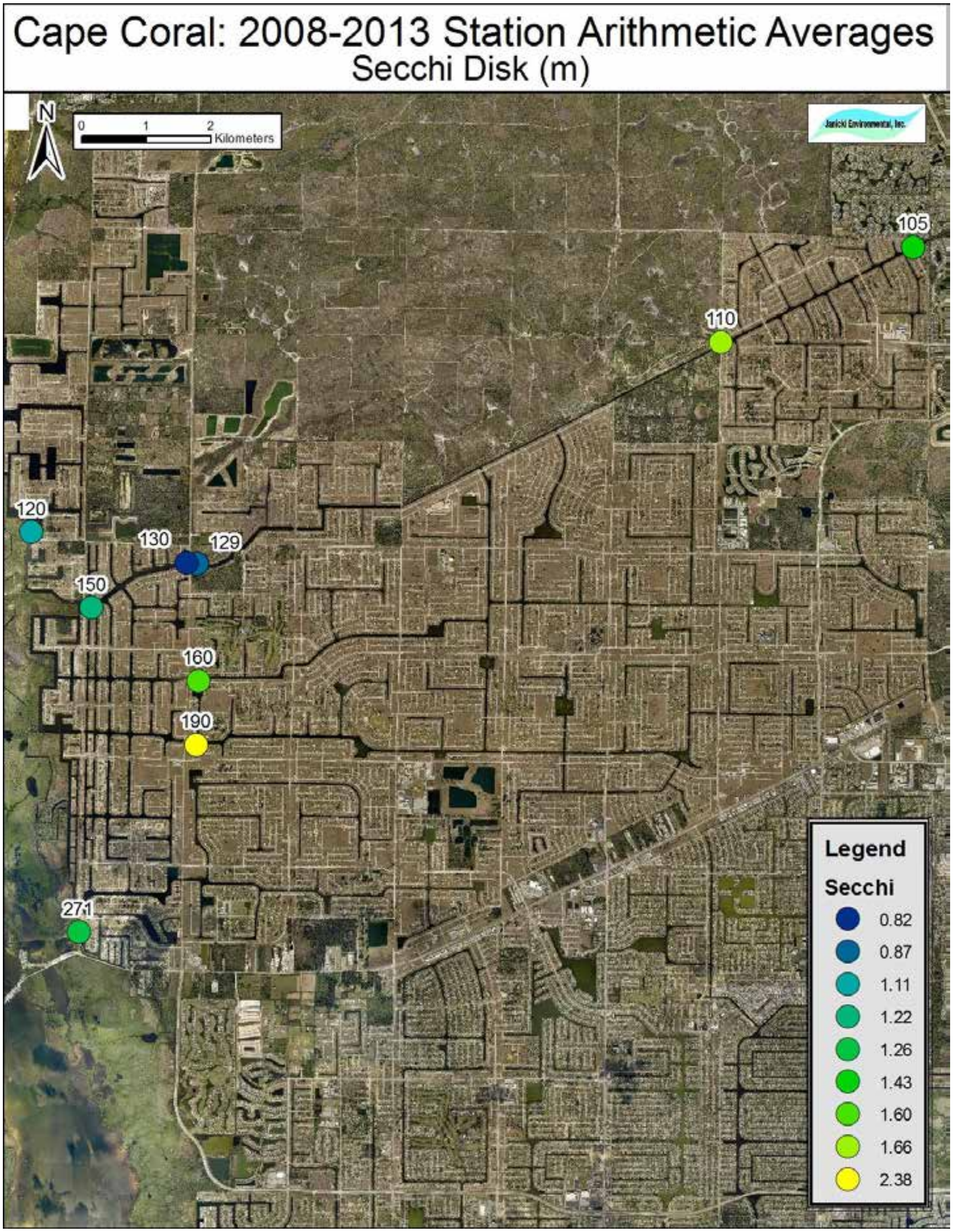

Figure 5-8. Arithmetic Average Secchi Disk Visibilities at Cape Coral Stations for Samples Collected between 2008 and 2013

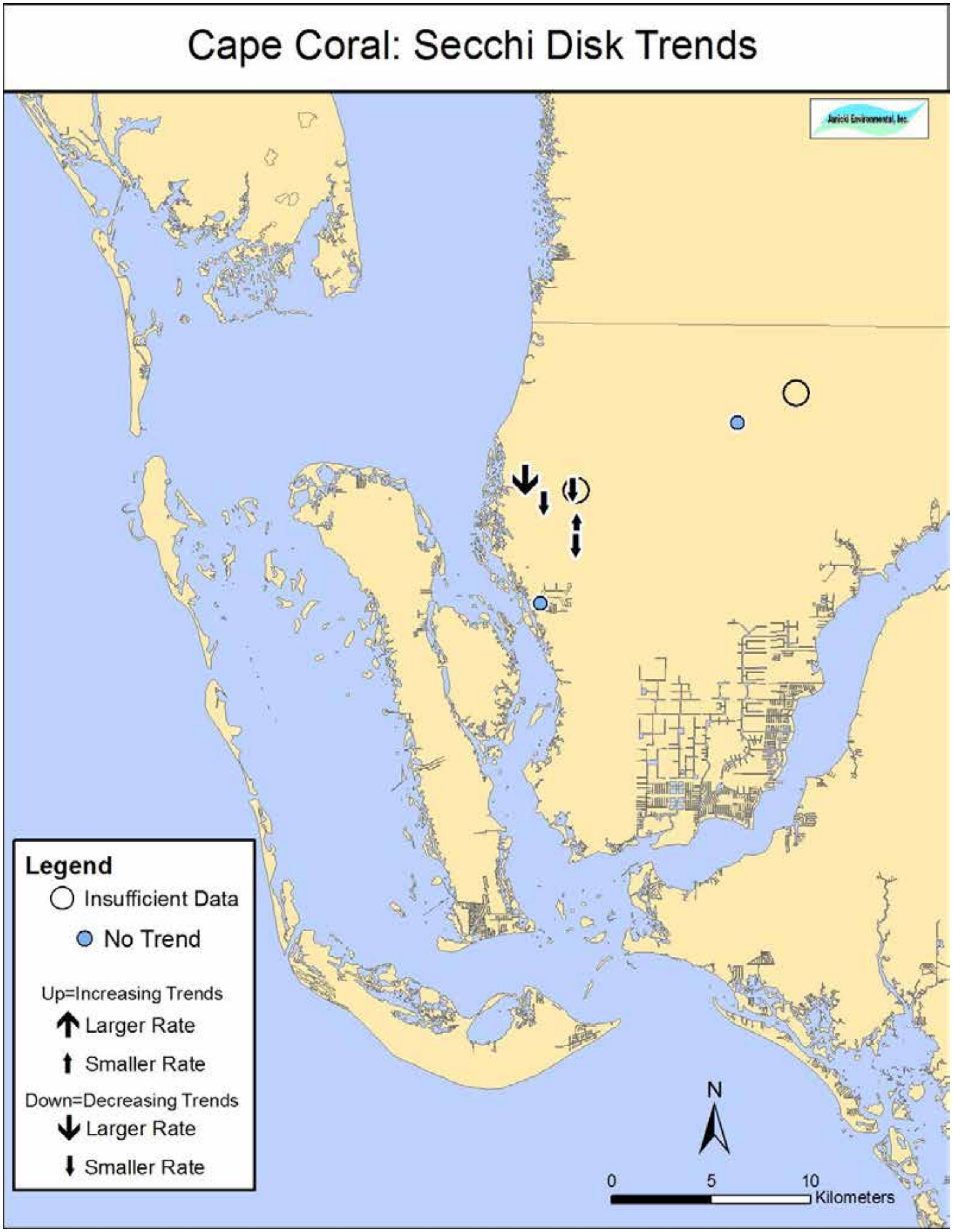

Figure 5-9. Secchi Disk Visibility Trends for Cape Coral Fixed Stations in the NSC

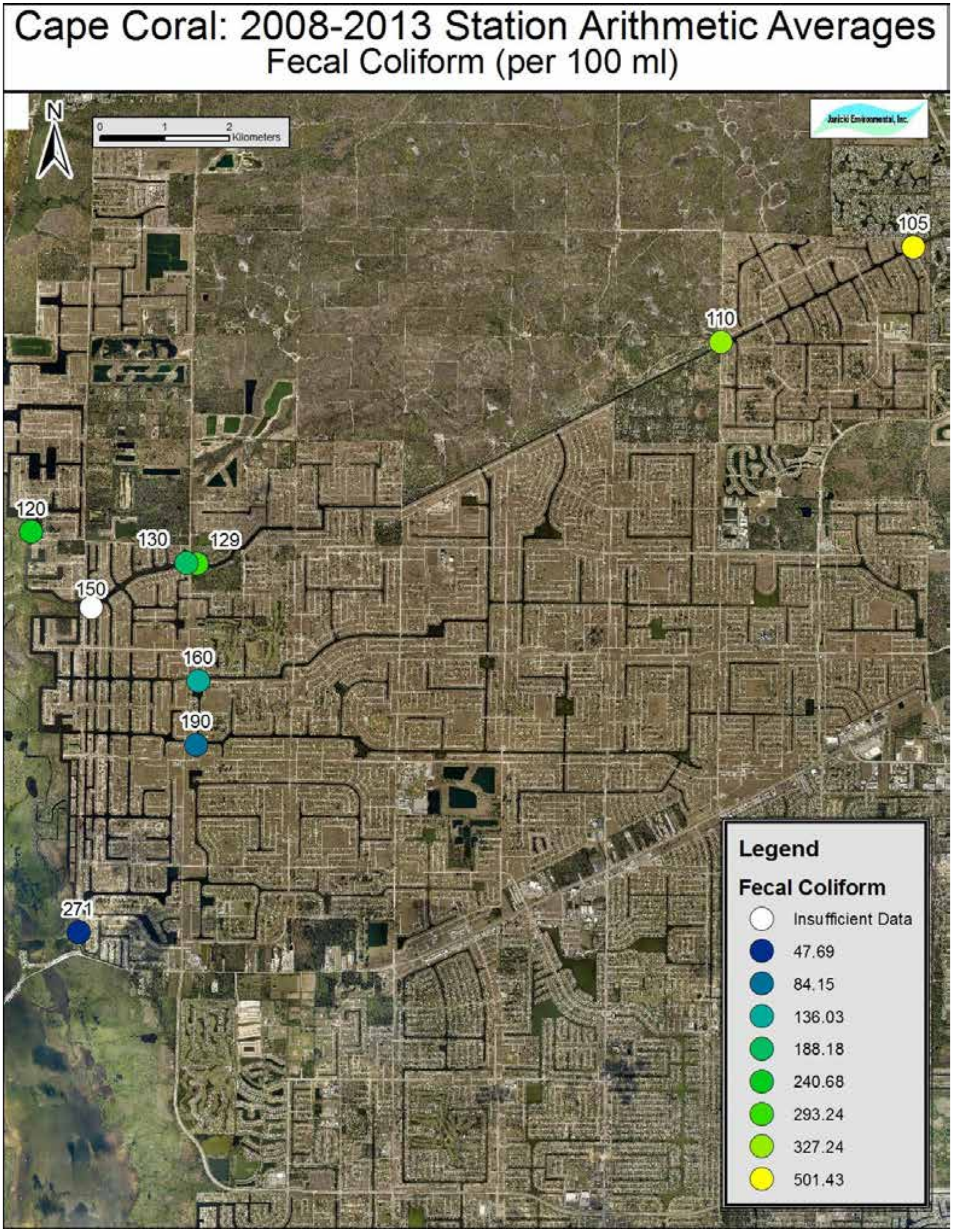

Figure 5-10. Arithmetic Average of Fecal Coliform at Cape Coral Stations for Samples Collected between 2008 and 2013 in the NSC

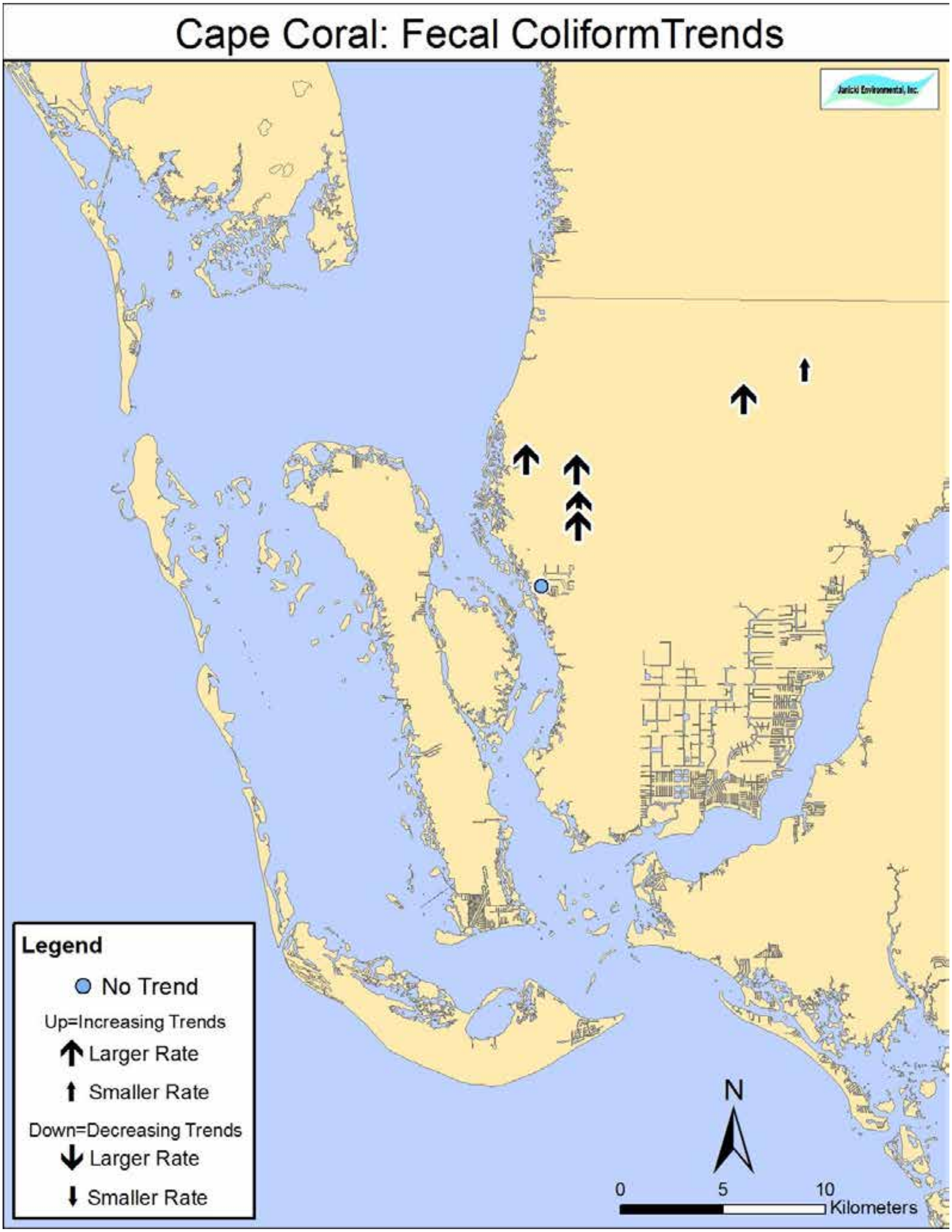

Figure 5-11. Fecal Coliform Trends for Cape Coral Samples Taken in the NSC

5.3.2 MATLACHA PASS AND SURROUNDING WATERS

One of the primary long-term data sets in Matlacha Pass come from the Lee County fixed monitoring stations. This program has been ongoing since 1996. The following presents results within Matlacha Pass similar to the results presented within the NSC in Section 1.3.1.

Figures 5-12, 5-14, 5-16, 5-18, and 5-21 provide the average concentrations from 1996 to 2013 for TN, DO, Chl a, secchi disk, and fecal coliform. Examination of the data shows a few aspects of the system. The TN concentrations are generally low with over 75% of the data below 1.0 mg/L. The distribution of DO concentrations were very similar across stations, with 75 percent of the data collected having concentrations between 5.5 and 7.5 mg/L. The Chl a levels are also generally low with at least 75 percent of the data collected were below 8 µg/L, indicating that typical chlorophyll values would not be considered bloom conditions. The secchi disk data shows good results with at least 75 percent of the data collected having a visibility greater than 1 meter (m). Finally, the fecal coliform levels are universally low. If the data are compared between stations, it shows that water quality conditions in the area of the NSC discharge are not atypical in relation to the other stations monitored within Matlacha Pass.

Figures 5-13, 5-15, 5-17, 5-19, and 5-21 provide the long-term average concentrations for TN, DO, Chl a, secchi disk, and fecal coliform. For these analyses, the period of record is the full period of available data for each of the stations. Examination of the plots gives some idea of the general trends in the water quality conditions. Overall the data do not show significant trends in the parameters shows, with only Chl a showing a significant decreasing trend at multiple stations.

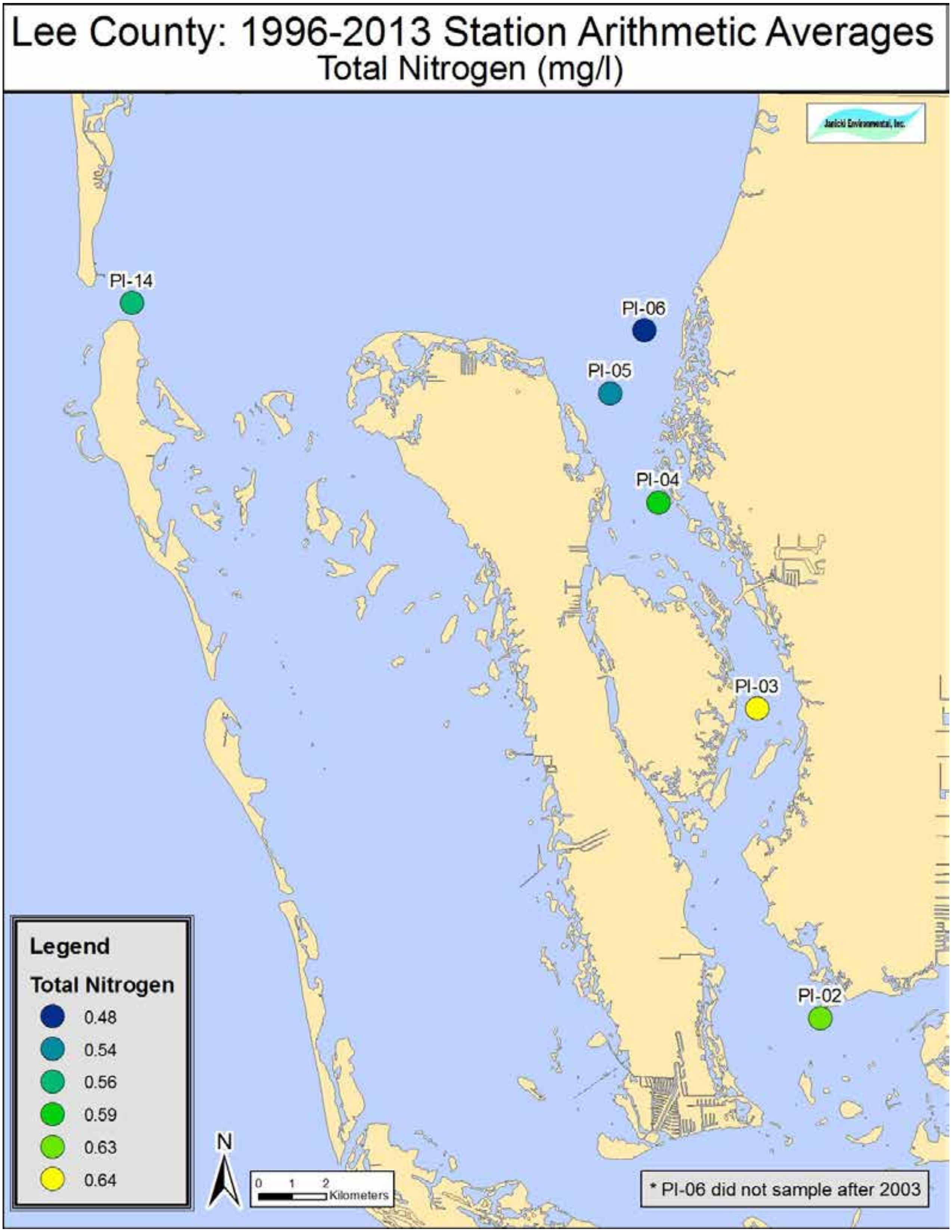

Figure 5-12. Arithmetic Averages for Total Nitrogen for Lee County Fixed Sampling Stations

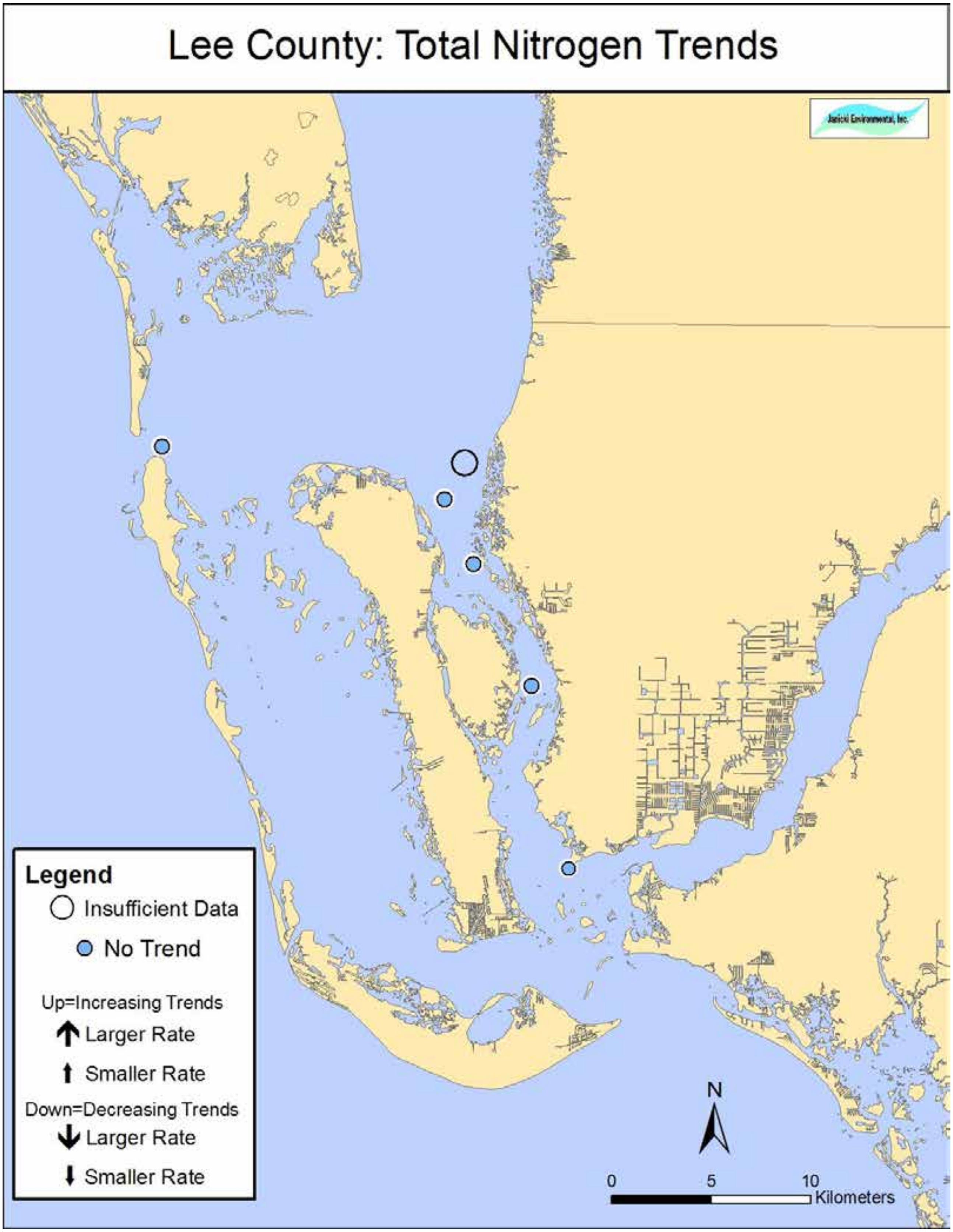

Figure 5-13. Total Nitrogen Trends for Lee County Fixed Sampling Stations

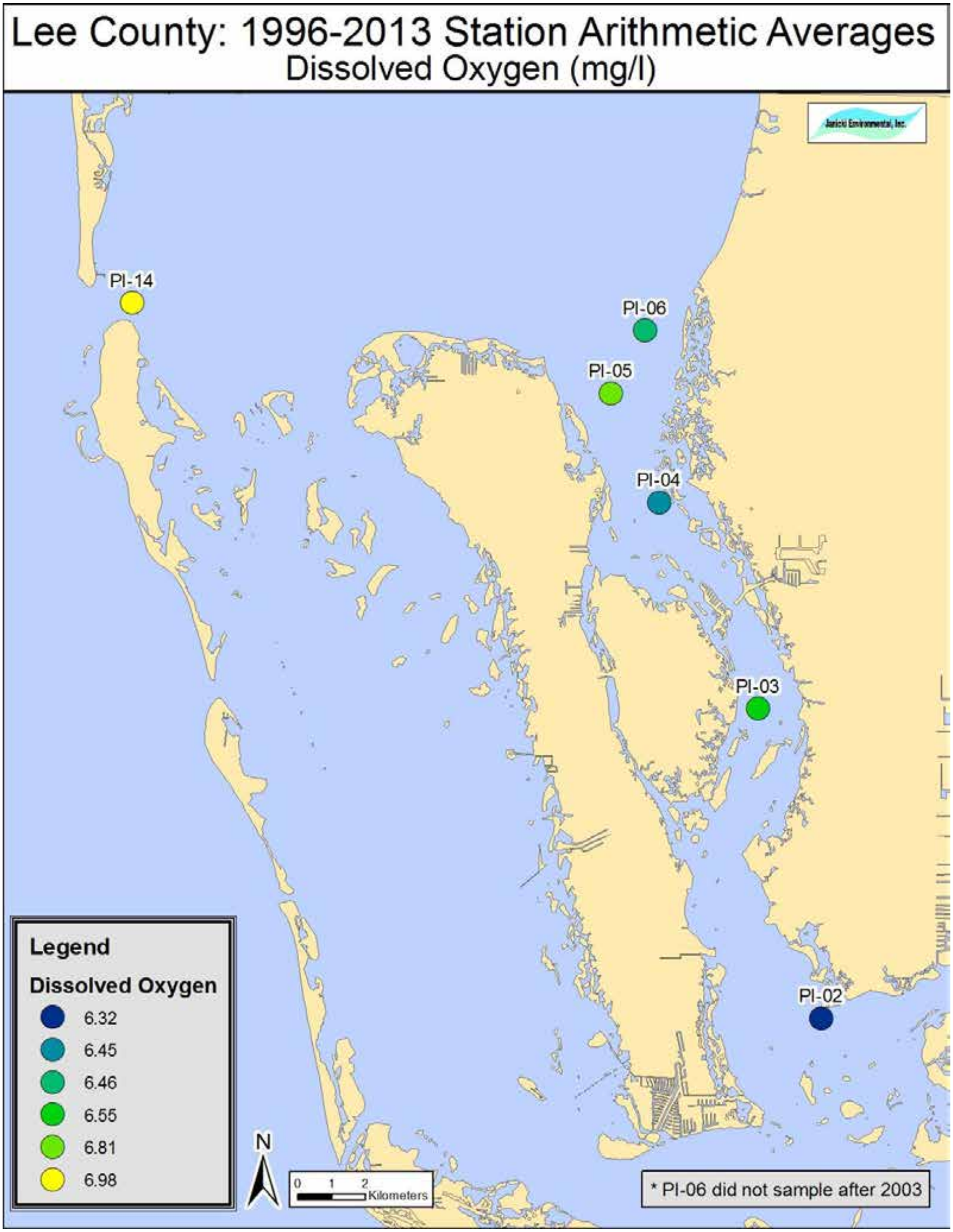

Figure 5-14. Arithmetic Average for Dissolved Oxygen for Lee County Fixed Stations

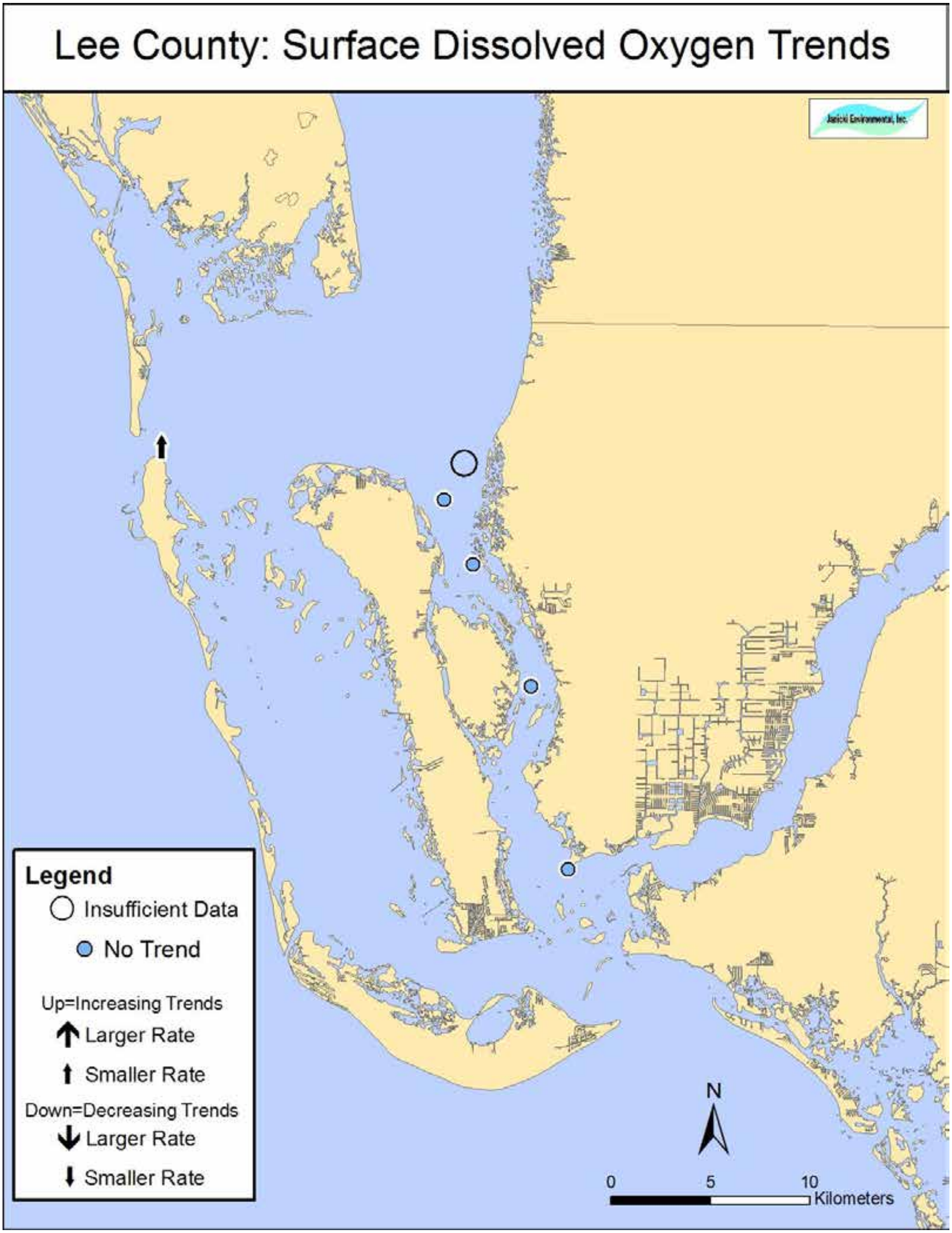

Figure 5-15. Dissolved Oxygen Trends for Lee County Fixed Stations

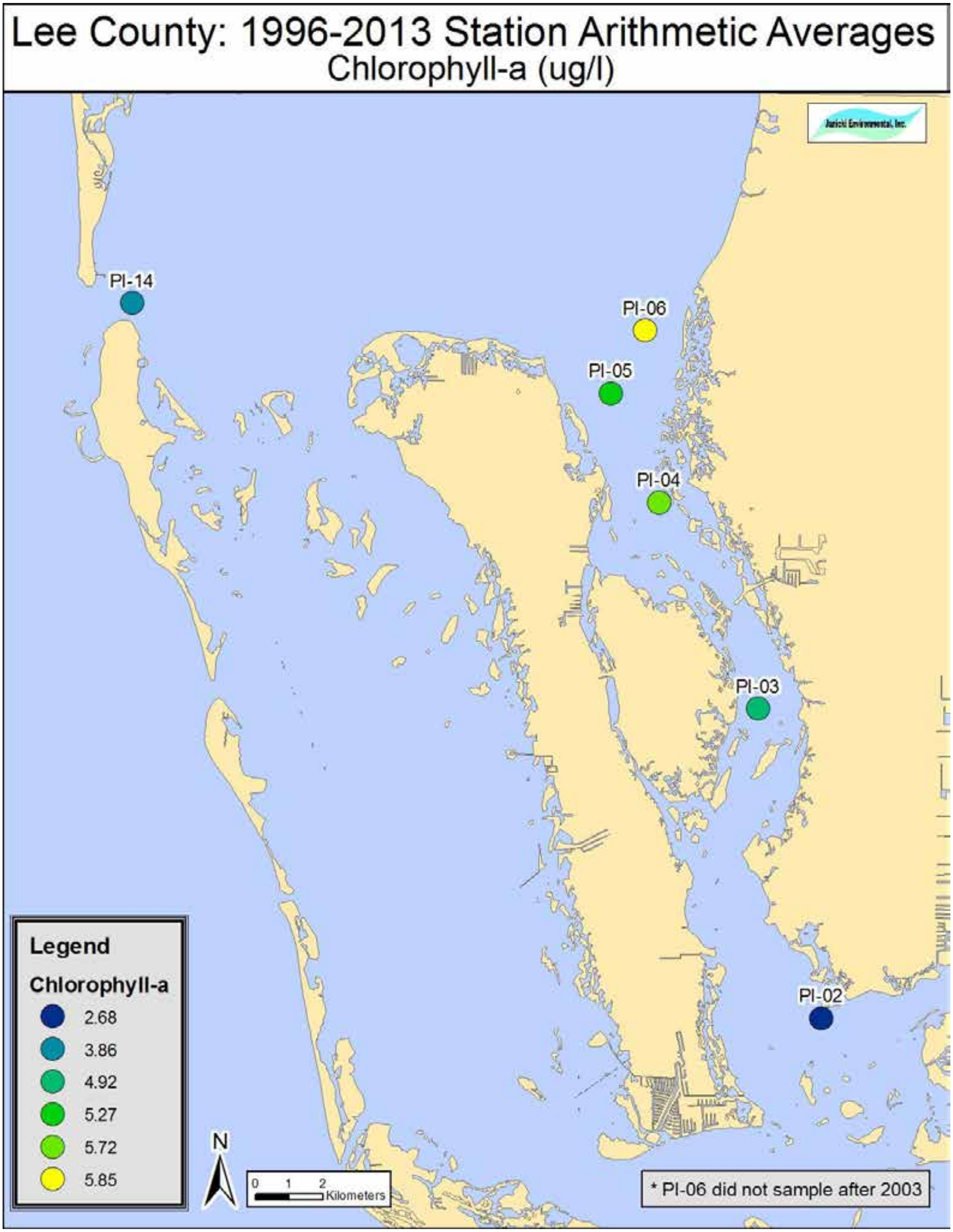

Figure 5-16. Arithmetic Average Chlorophyll a for Lee County Fixed Stations

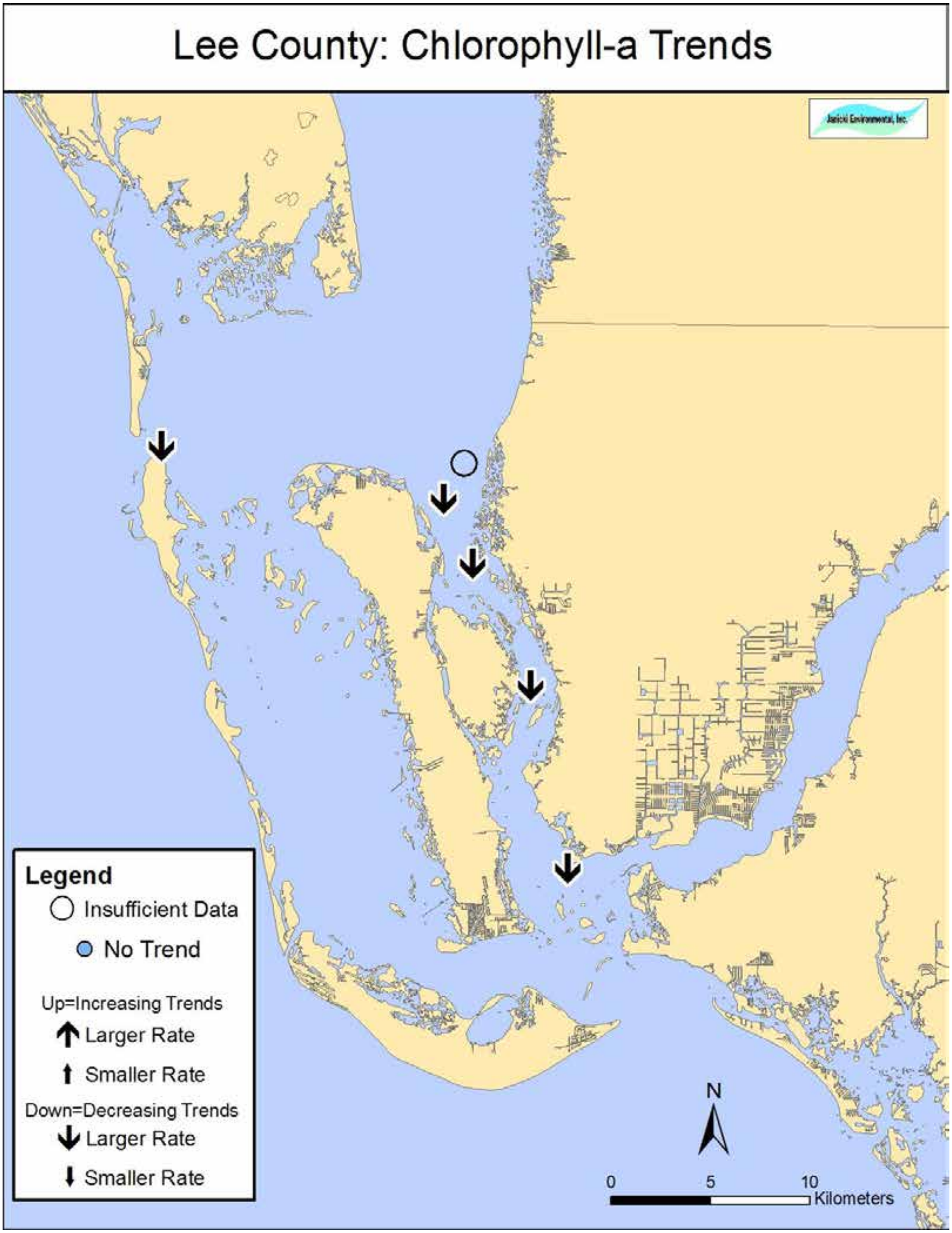

Figure 5-17. Chlorophyll a Trends for Lee County Fixed Stations

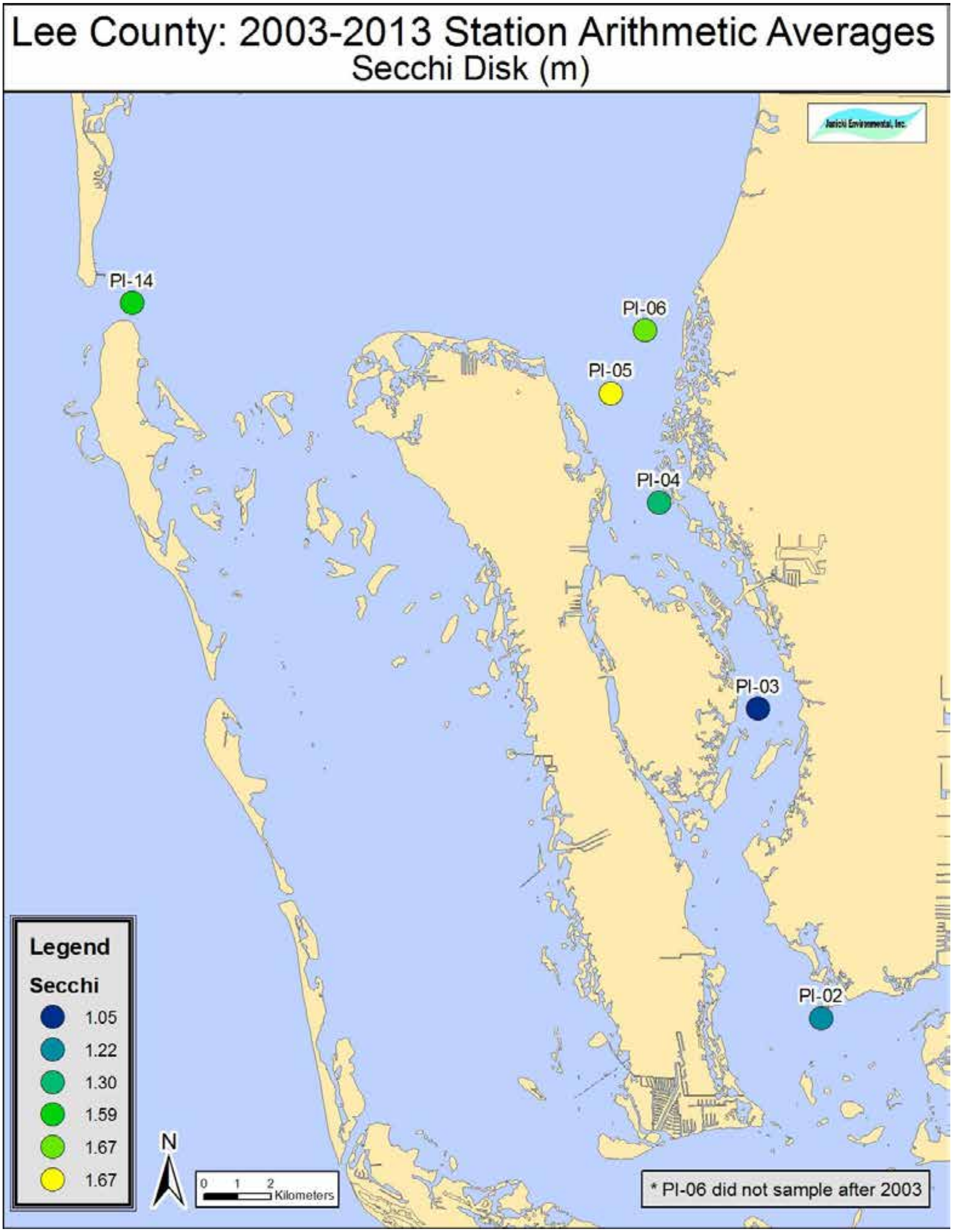

Figure 5-18. Arithmetic Average of Secchi Disk Visibility for Lee County Fixed Stations

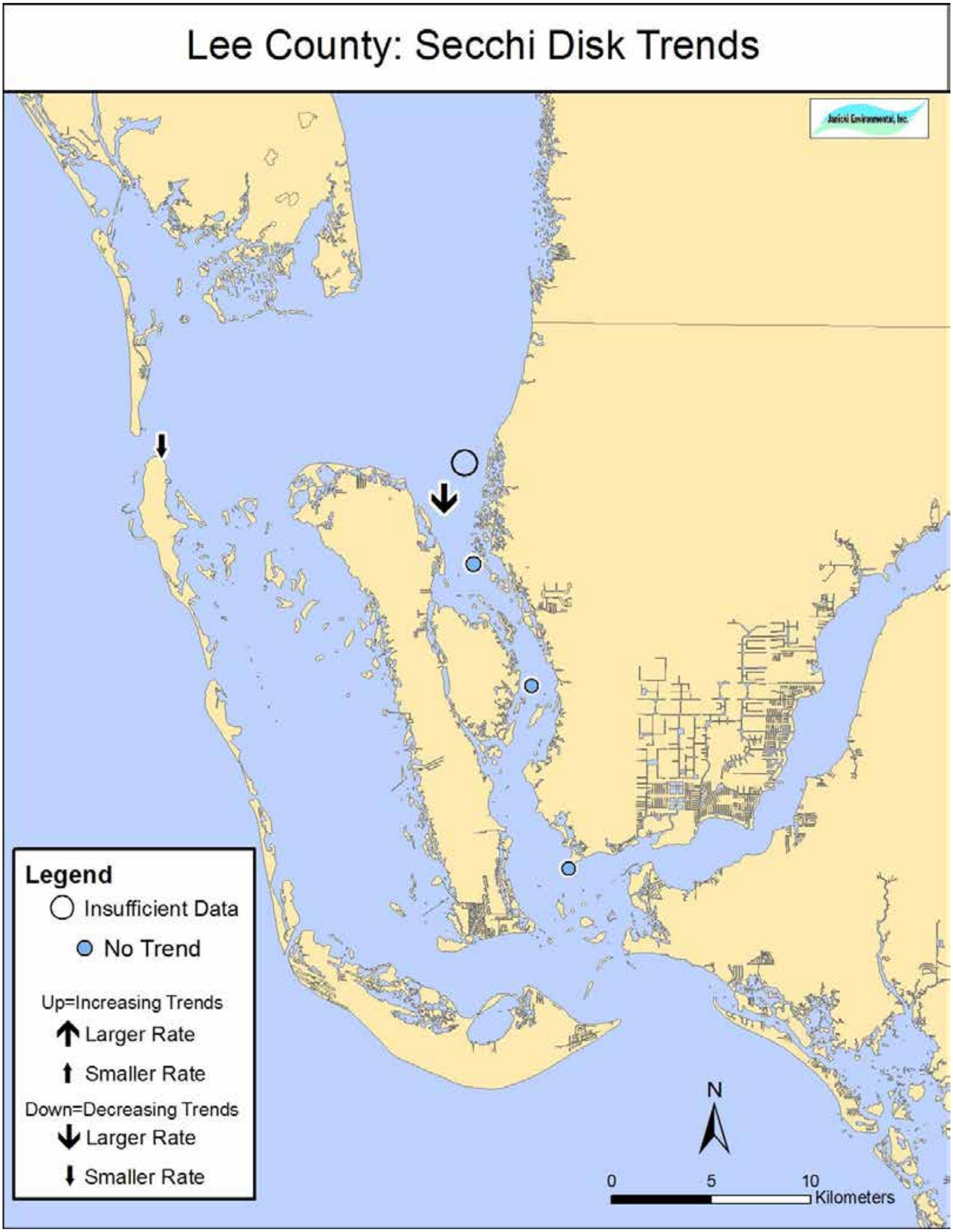

Figure 5-19. Secchi Disk Visibility Trends for Lee County Fixed Stations

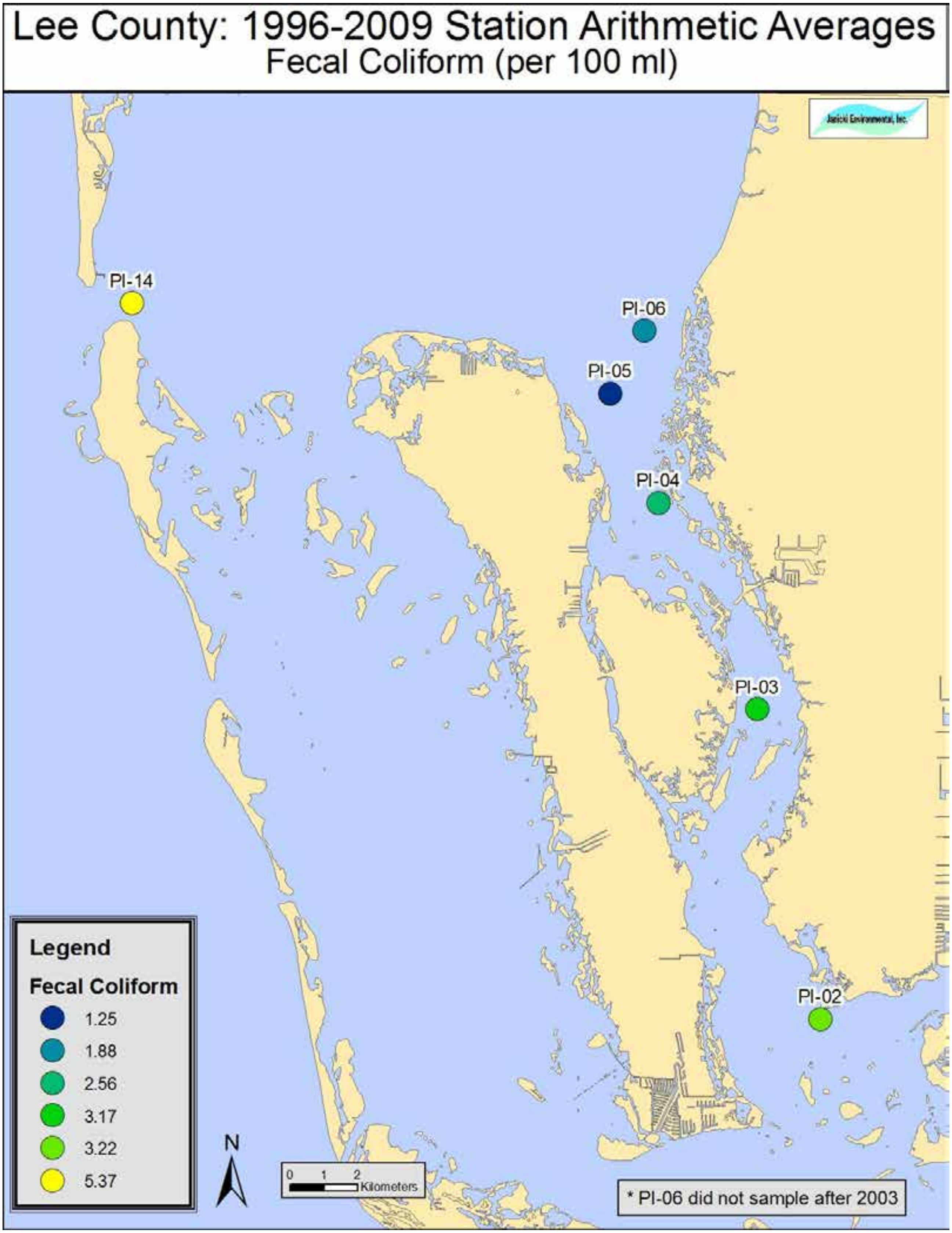

Figure 5-20. Arithmetic Average for Fecal Coliform for Lee County Fixed Stations

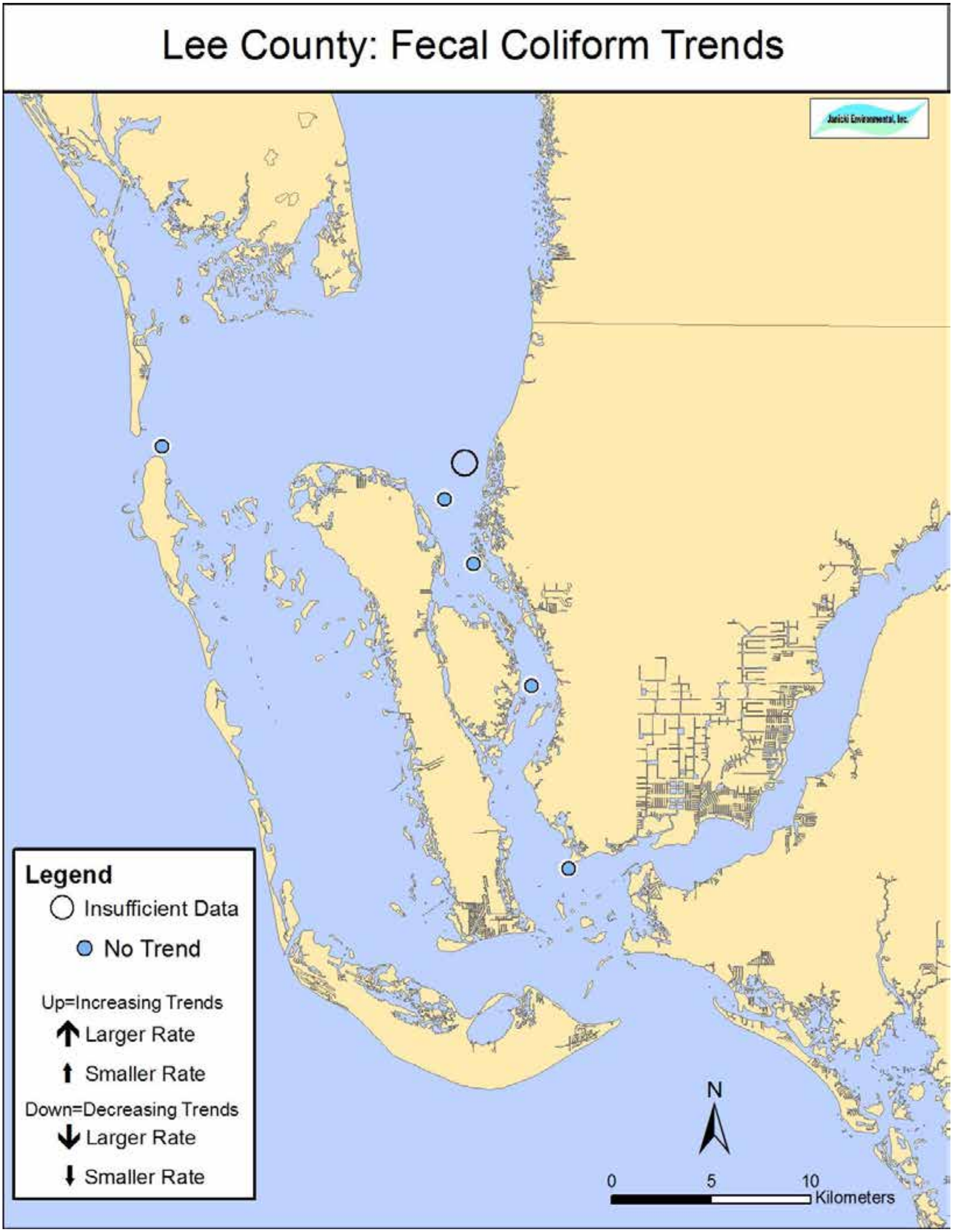

Figure 5-21. Fecal Coliform Trends for Lee County Stations

5.4 SUMMARY

The Water Quality Data Characterization was intended to establish a thorough understanding of the spatial and temporal characteristics of empirical water quality data to serve as a foundation for analytical work to identify key water quality indicators describing the relationship between water quality in the NSC and in Matlacha Pass. The data described include information on freshwater flow and loads discharging into the western portion of the NSC system, long-term water quality monitoring data at fixed stations located upstream and downstream of the discharge points, and both long-term and synoptic data collected in the receiving waters within the canal network and in Matlacha Pass. Together these data represent the current and historical water quality information known for the project area. In Section 6 below, the available water quality data are be assessed against presently adopted criteria for key parameters.

6.0 WATER QUALITY AND BIOLOGICAL INDICATORS

6.1 INTRODUCTION AND OBJECTIVES

Under Phase I of the Northwest Cape Coral/Lee County Watershed Initiative, an evaluation of the water quality data presented in Section 5 along with biological resources in the waters of the NSC and Matlacha Pass was conducted. The goals for this work were as follows;

- To identify key water quality indicators for the NSC and Matlacha Pass;
- To compare ambient water quality data from the NSC and Matlacha Pass to existing water quality standards or criteria; and
- To identify key biological indicators for the NSC and Matlacha Pass, and compare current conditions to existing targets or thresholds.

The complete results from this work are presented in a separate report entitled "NW Spreader Canal, Water Quality and Biological Indicators". The sections below provide a summary of the results and key determinations.

6.2 WATER QUALITY INDICATORS AND COMPARISON TO AVAILABLE CRITERIA

Based on the assessment of the ecological conditions within the NSC and Matlacha Pass and the potential effects of future management actions, the following water quality indicators were identified;

- Salinity
- Dissolved oxygen (DO)
- Chlorophyll *a* (Chl *a*)
- Total nitrogen (TN)
- Total phosphorus (TP)
- Water clarity

These are the water quality parameters that either have existing standards or criteria or have been identified as likely to be affected by the configuration of the NSC or the freshwater inflows from the watershed that drains to the NSC and, eventually, Matlacha Pass.

The State of Florida has established water quality standards and/or criteria for DO, chlorophyll, TN, and TP. These values are:

- Freshwater (above weir structures)
  - Chl *a* = 20 micrograms per liter (µg/L)- annual arithmetic average
  - DO %sat = 38 percent - No more than 10 percent exceedance
  - TN = 1.54 milligrams per liter (mg/L) - annual geometric average
  - TP = 0.12 mg/L - annual geometric average
- Marine (Matlacha Pass for all and NSC below weir structures for DO)
  - Chl *a* = 6.1 µg/L - annual arithmetic average
  - DO %sat = 42 percent - No more than 10 percent exceedance
  - TN = 0.58 mg/L - annual geometric average
  - TP = 0.08 mg/L - annual geometric average

Using the available data, the measured water quality was compared to the above criteria for the waters above the weir structures and within Matlacha Pass.

The brackish areas within the NSC are very similar in nature to tidal creeks that drain to the open waters of downstream estuarine waters. They are neither freshwaters nor strictly estuarine (Janicki Environmental, 2011). Therefore, applying the current numeric nutrient criteria (NNC) for freshwater creeks or open water estuaries can result in faulty assessments of water quality status. As a result, EPA is currently funding a project that is examining a series of tidal creeks in southwest Florida that provides much needed data to identify potential NNC for these waterbodies. Once tidal creek NNCs are adopted, the analyses can be compared against the appropriate criteria. The detailed report provides a comparison for informational purposes.

Table 6-1 presents the years (1991-2013) that the freshwaters within the City of Cape Coral have either passed or failed the freshwater criteria. The annual average Chl *a*, TN, and TP concentrations passed the criteria for all years for which data were collected. Generally, the water quality complied with the DO criterion, with the exception of several years in the 1990s and recently from 2010 through 2012.

Table 6-1. Average Annual Concentrations for Freshwaters within Cape Coral and Percent Pass/Fail Relative to Water Quality Criteria

Year	N	Annual Averages			Pass/Fail			
		Chlorophyll	TN	TP	Chlorophyll	TN	TP	DO %Fail
1991	11		0.11	0.02		P	P	9%
1992	36		0.22	0.02		P	P	14%
1993	36		0.35	0.01		P	P	22%
1994	36		0.32	0.01		P	P	13%
1995	36	2.23	0.51	0.01	P	P	P	6%
1996	36	1.34	0.45	0.01	P	P	P	8%
1997	36	2.94	0.46	0.01	P	P	P	20%
1998	36	3.30	0.42	0.01	P	P	P	6%
1999	36	2.11	0.30	0.03	P	P	P	6%
2000	36	1.30	0.55	0.03	P	P	P	3%
2001	36	5.09	0.50	0.03	P	P	P	3%
2002	36	2.39	0.38	0.04	P	P	P	0%
2003	37	5.77	0.46	0.06	P	P	P	0%
2004	36	4.87	0.56	0.03	P	P	P	2%
2005	36	3.27	0.35	0.04	P	P	P	0%
2006	36	1.90	0.32	0.03	P	P	P	3%
2007	36	3.96	0.34	0.03	P	P	P	8%
2008	46	5.20	0.41	0.03	P	P	P	5%
2009	55	3.15	0.45	0.03	P	P	P	9%
2010	60	2.83	0.32	0.02	P	P	P	23%
2011	60	5.77	0.52	0.02	P	P	P	13%
2012	46	4.83	0.53	0.02	P	P	P	26%
2013	60	4.28	0.49	0.02	P	P	P	0%

Table 6-2 presents the years (2002-2013) that the estuarine waters within Matlacha Pass have either passed or failed the NNC and the marine DO criteria. The TN, TP, and Chl a criteria applied in this table were established specifically for Matlacha Pass. The annual average Chl *a* concentrations exceeded this criterion in 2 years - 2008 and 2011. The DO standard was exceeded more than 10 pecent of the time from 2007 through 2012. The TN criterion was exceeded in most years during the 2002-2013 period. The TP criterion was exceeded in several years during the early portion of this period but compliance was achieved in most of the recent years.

Table 6-2. Average Annual Concentrations for Estuarine Waters within Matlacha Pass and Pass/Fail Relative to Water Quality Criteria

Year	N	Annual Averages			Pass/Fail			
		Chlorophyll	TN	TP	Chlorophyll	TN	TP	DO %Fail
2002	45	0.43	0.48	0.11	P	P	F	0%
2003	55	2.86	0.49	0.13	P	P	F	0%
2004	52	5.81	0.60	0.07	P	F	P	0%
2005	60	5.37	0.62	0.07	P	F	P	0%
2006	60	2.81	0.50	0.07	P	P	P	0%
2007	60	2.56	0.44	0.07	P	P	P	0%
2008	60	13.85	0.56	0.09	F	P	F	2%
2009	60	4.78	0.50	0.07	P	P	0	0%
2010	60	4.28	0.90	0.06	P	F	P	0%
2011	55	6.54	0.75	0.05	F	F	P	0%
2012	60	3.91	0.97	0.06	P	F	P	0%
2013	60	5.73	0.99	0.07	P	F	P	0%

6.3 Key Biological Indicators and Targets

The key biological indicators proposed for this project include seagrasses and oysters. Both of these indicators are critical components of the NSC/Matlacha Pass ecosystem. Their habitat suitability is dependent upon the key water quality indicators discussed previously.

Seagrass targets have been established for Matlacha Pass by the Charlotte Harbor National Estuary Program (CHNEP) (Janicki et al., 2009). The primary goal was to establish targets designed to maintain and/or restore seagrass acreage to its historical extent. Restoration targets were defined through an analysis of historical and recent aerial surveys of the study area.

The CHNEP seagrass targets for Matlacha Pass are:

- Protection Target – 7,582 acres
- Restoration Target – 1,733 acres
- Total Target – 9,315 acres

To achieve these targets, two key water quality indicators must be within the ranges adequate for the typical seagrasses, these are salinity and water clarity.   Based on available information on tolerances of the various seagrass types in the area, the proposed salinity target for seagrasses is an annual average salinity that ranges from 20 to 35 ppt. Based on studies performed for the Charlotte Harbor National Estuarine Program (Dixon and Wessel, 2014) K_{dPAR} (a measure of light attenuation) ranges were set identified for seagrasses in the area. Based on this work, the proposed light target to support seagrasses is based on the Dixon and Wessel Water Quality Estimating Tool for Matlacha Pass and ranges from 0.62 (30th percentile) and 0.92 (70th percentile).

Oysters compose a significant component of the estuarine ecosystem in and around the NSC. Oysters and other estuarine biota can be found in habitats that vary widely in their salinity. Their populations often benefit from the typical seasonal variation in salinity as their spatial distributions also follow these typical salinity patterns.

Oysters can be found throughout the mangrove fringe along the NSC and much of Matlacha Pass. There are no reliable areal estimates of oyster cover in the project area. Therefore, an oyster area target cannot be defined. However, salinity targets for oyster habitat suitability has been proposed. Oysters can withstand a wide range of salinity conditions, it should also be noted that oyster salinity limits can vary between populations based on site specific conditions, including salinities less than 5 ppt. This is apparent based on the presence of oysters in the lower portions of the NSC despite the effects due to the removal of the Ceitus boat lift in 2008.

The determination of the optimal salinity range for Oysters is based upon the optimal levels for growth and reproduction in addition to levels that avoid disease and the impact of prediters. Based on this, it is recommended that the target salinity range be outside of the optimal salinity range for growth and reproduction in order to lessen the negative effects of disease and high salinity predators. It is important to note that salinity conditions outside of this proposed range will not necessarily result in oyster mortality as has been seen in the oyster distribution in and around the NSC in recent years. Rather, as noted above, salinity variation can be an important factor that reduces the presence of both disease causing organisms and oyster predators (Volety et al., 2009).

7.0 SUMMARY AND KEY FINDINGS

Phase 1 of the Northwest Cape Coral/Lee County Watershed Initiative has been completed. Under Phase 1 of the initiative, the project team had four primary goals.

1. Characterize the flow and transport between the NSC and the adjacent waters of Matlacha Pass with specific emphasis on the movement of freshwater coming over the weir structures
2. Characterize the existing water quality conditions within the NSC and the adjacent waters of Matlacha Pass
3. Develop a hydrodynamic model of the system to allow assessment of future management alternatives
4. Identify water quality targets and key ecological indicators for assessment under future management scenarios

In support of these goals, an extensive data collection, data analysis and model development program was implemented. The results from this work were summarized in Sections 3 through 6 of this report. The following lists the key findings and accomplishments from Phase 1.

1. An extensive monitoring program of flows, water levels, and salinity in the NSC, upstream of the weir structures, and within Matlacha Pass was implemented from 2012 through 2013. Based on the data analyses it was determined that during freshwater inflow events, approximately 70 to 80 percent of the water that comes over the weirs into the NSC passes out the southern end of the system. Of the remaining volume, the bulk passes out through the breaches at the northern end of the NSC above where Gator Slough comes in.
2. A detailed 3-dimensional hydrodynamic model was developed for the system which included; the interior canals up to the weir structures on Burnt Store Road; the NSC and the breaches; the Key Ditch; the mangrove areas west of the NSC; and Matlacha Pass, from the connection to Charlotte Harbor down to near McCardle Island. The model provides a tool to allow testing of future management scenarios relative to flows from the upstream watershed or physical alterations of the system

and the impacts upon circulation, transport, and salinity in the NSC and Matlacha Pass.

3. A comprehensive analysis of available water quality data was completed. The analysis established a thorough understanding of the spatial and temporal characteristics of the water quality coming into the NSC over the weir structures, within the NSC, and the waters of Matlacha Pass impacted by discharges from the NSC. The analyses served as a foundation for determination of key water quality indicators which was used to assess the relationship between water quality within and coming into the NSC and in Matlacha Pass. Specific water quality indicators identified to be used in future management evaluations include, salinity, dissolved oxygen (DO), Chlorophyll a, total nitrogen (TN), total phosphorus (TP), and water clarity. For these indicators criteria, developed by FDEP, have been established for the freshwaters upstream of the weir structures, and within Matlacha Pass. Based on analyses against these criteria showed that upstream of the weir structures the waters are not impaired. Within Matlacha Pass, the results show some years where the water quality criteria are not met.
4. Key biological indicators have been established for future management scenario evaluations. The key indicators are oysters and seagrass. For these key indicators allowable ranges of salinity and water clarity targets were prescribed. For Oysters, the ranges reflect not only optimal ranges for growth and reproduction, but also for avoidance of preditors and diseases which can impact oyster communities.

Appendix A

Gantt Chart of Hydrodynamic Data

		2012																
Data Type		9/7	9/14	9/21	9/28	10/5	10/12	10/19	10/26	11/2	11/9	11/16	11/23	11/30	12/7	12/14	12/21	12/28
USGS Water Level, Flow, and Velocity	USGS-00																	
	USGS-01																	
	USGS-02																	
	USGS-03																	
	USGS-04																	
	USGS-06																	
	USGS-07																	
C-Stations (Salinity, Temperature, Water Level)	CTD-01														s	s	s	s
	CTD-02																	
	CTD-03																	
	CTD-04																	
	CTD-05																	
	CTD-06																	
	CTD-07																	
	CTD-08																	
	CTD-09																	
Water Level in Tidal Portions (D-stations)	D-01																	
	D-03																	
	D-04																	
	D-05																	
	D-06																	
	D-07																	
	D-09																	
	D-11																	
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	D-13																	
	D-14																	
	D-15																	
	D-16																	
	D-17																	
	D-18																	
	D-19																	
Water Level above Weirs (D-stations)	D-02																	
	D-08																	
	D-10																	
	D-20																	

		20																									
Data Type		1/4	1/11	1/18	1/25	2/1	2/8	2/15	2/22	3/1	3/8	3/15	3/22	3/29	4/5	4/12	4/19	4/26	5/3	5/10	5/17	5/24	5/31	6/7	6/14	6/21	6/28
USGS Water Level, Flow, and Velocity	USGS-00																										
	USGS-01																										
	USGS-02																										
	USGS-03																										
	USGS-04																										
	USGS-06																										
	USGS-07																										
C-Stations (Salinity, Temperature, Water Level)	CTD-01	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s									
	CTD-02					s	s	s	s	s	s	s	s	s	s	s	s	s	s	s							
	CTD-03																										
	CTD-04																										
	CTD-05	s	s	s	s	s													s	s	s	s	s	s	s	s	s
	CTD-06																										
	CTD-07																										
	CTD-08																										
	CTD-09																										
Water Level in Tidal Portions (D-stations)	D-01																										
	D-03																										
	D-04																										
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Water Level above Weirs (D-stations)	D-02																										
	D-08																										
	D-10																										
	D-20																										

	all parameters good data
s	all parameters good other than salinity
t	all parameters good other than temperature
st	all parameters good other than salinity and temperature
vf	all parameters good other than velocity and flow

		13																										2014								
Data Type		7/5	7/12	7/19	7/26	8/2	8/9	8/16	8/23	8/30	9/6	9/13	9/20	9/27	10/4	10/11	10/18	10/25	11/1	11/8	11/15	11/22	11/29	12/6	12/13	12/20	12/27	1/3	1/10	1/17	1/24	1/31	2/7	2/14	2/21	2/28
USGS Water Level, Flow, and Velocity	USGS-00																																			
	USGS-01																																			
	USGS-02																																			
	USGS-03																																			
	USGS-04																vf				vf					vf			vf							
	USGS-06																																			
	USGS-07																																			
C-Stations (Salinity, Temperature, Water Level)	CTD-01											t	t	t	t	st	st	st	st	st	t	t	t	t	t	t	t									
	CTD-02																																			
	CTD-03																t	t	t	t	t	t	t	t	t	t	t									
	CTD-04																																			
	CTD-05	s	s	s																																
	CTD-06																																			
	CTD-07																																			
	CTD-08																																			
	CTD-09																																			
Water Level in Tidal Portions (D-stations)	D-01																																			
	D-03																																			
	D-04																																			
	D-05																																			
	D-06																																			
	D-07																																			
	D-09																																			
	D-11																																			
	D-12																																			
	D-13																																			
	D-14																																			
	D-15																																			
	D-16																																			
	D-17																																			
	D-18																																			
	D-19																																			
Water Level above Weirs (D-stations)	D-02																																			
	D-08																																			
	D-10																																			
	D-20																																			