NW Cape Coral/Lee County Watershed Initiative
Phase I
Technical Reports:

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

Lee County, Florida

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June 2015

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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 four 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

The report presented herein provides quantification of the existing hydrodynamic and transport conditions between the NSC and Matlacha Pass using data collected as part of this project.

1.3 REPORT OUTLINE

Following this introduction, the report is broken down into four sections. Section 2 provides a description of the project area. Section 3 provides a summary of the data collected for this project. Section 4 presents detailed analyses of the hydrodynamic data to quantify the existing hydrodynamic and transport conditions between the NSC and Matlacha Pass. Section 5 summarizes the key findings from the analyses.

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 components:

- 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 system components 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 width of the canal varies but is generally around 150 feet (ft). A bathymetric survey, conducted as part of this project, showed that depths within the NSC range from 2.8 to 12.8 ft [referenced to the North American Vertical Datum of 1988 (NAVD88)] and average around 7.0 ft.

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).

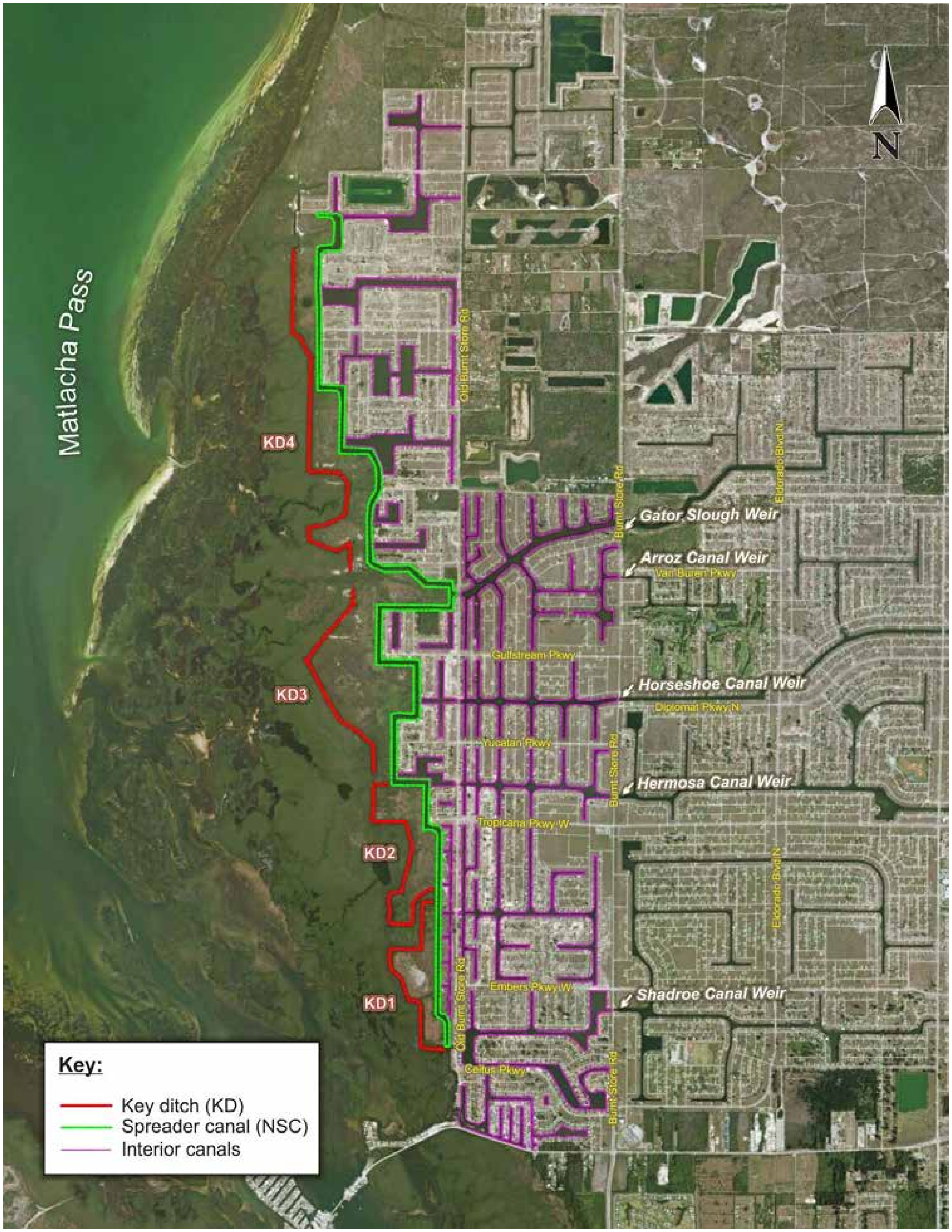


Figure 2-1. Project Area Map

Through previous studies, a total of 17 breaches (including the breach that occurred at the location of the former boat lift) were documented. Figure 2-2 shows the locations of the previously documented breaches and provides their location identifications. Appendix A presents aerial photographs showing zoomed-in views that include each of the 17 breaches as they exist today.

For the purposes of this study, eight of the breaches were monitored. These breaches were identified as the primary conduits for flow leaving the NSC and entering the KD. This includes flows entering and leaving the NSC through the opening at the south end (the former location of the barrier). Figure 2-3 shows the locations of the monitored breaches along with the southern opening. The aerial photographs (Appendix A) show zoomed-in views of the U.S. Geological Survey (USGS) monitoring sites. The location identifications used for this study reflect where USGS conducted monitoring to measure flows, water levels and velocities. Table 2-1 provides the correspondence between the breach numbers (shown on Figure 2-2) and the USGS monitoring sites.

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

Of the 17 documented breaches, as Table 2-1 shows, 8 were monitored for this project. The unmonitored breaches include (from Figure 2-2):

- Breach 1
- Breach 2
- Breach 3
- Breach 5
- Breach 6
- Breach 7B
- Breach 7A
- Breach 8A
- Breach 9

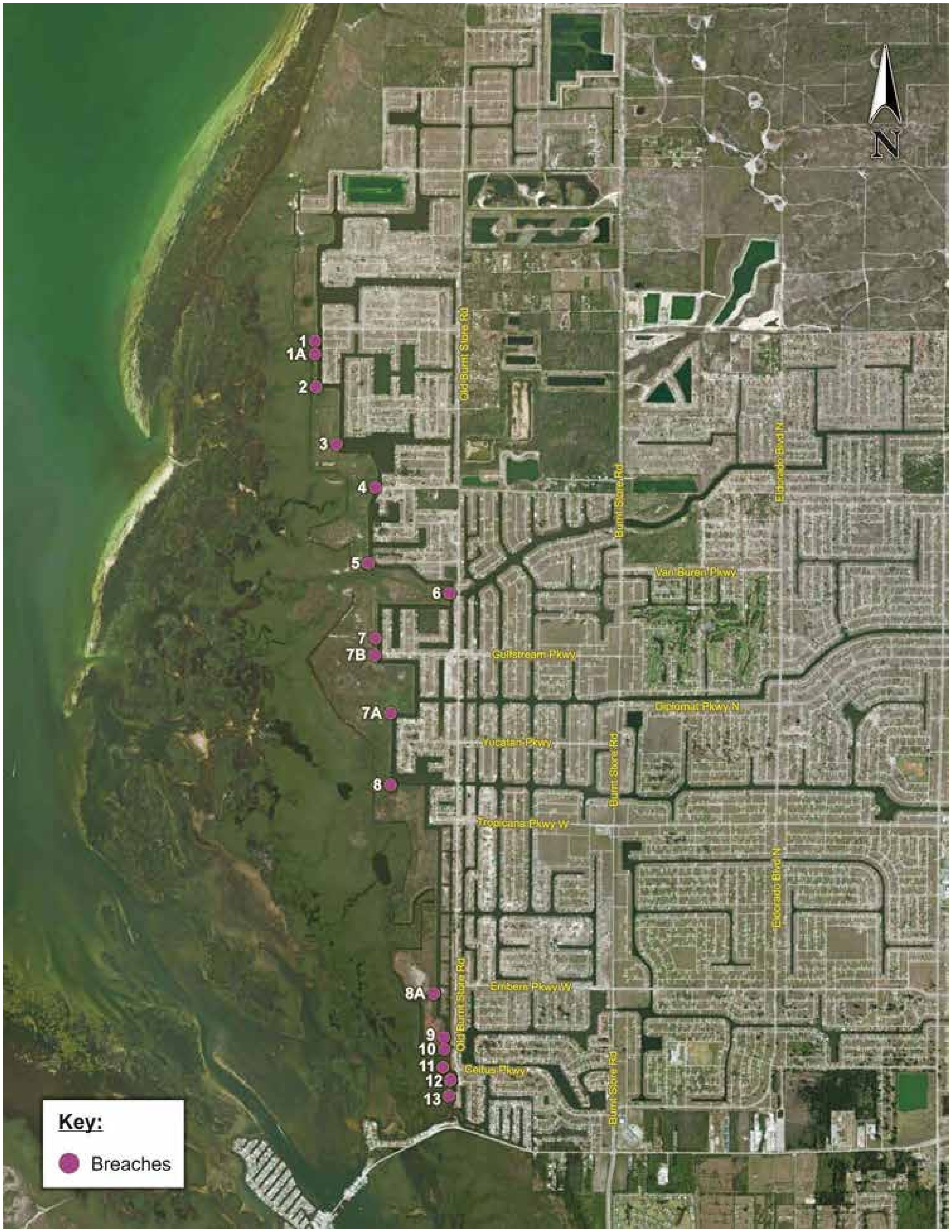


Figure 2-2. Location of Previously Documented Breaches in the NSC

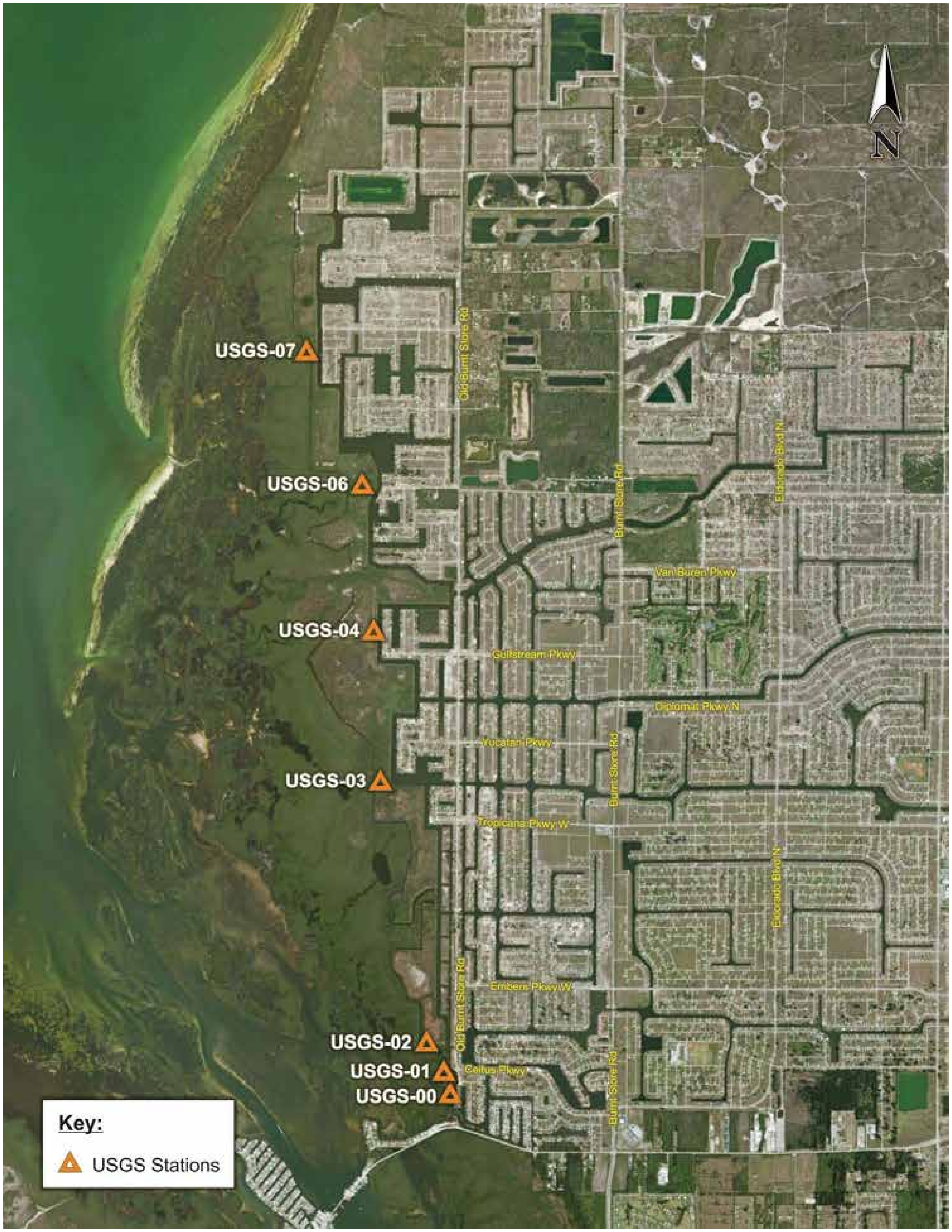


Figure 2-3. Location of USGS Monitoring Stations

The following paragraphs present descriptions of the current condition of each of these breaches (see photos in Appendix A).

Breach 1 connects to a small open water area to the west of the NSC. This open water area does not appear (based on review of aerial photography) to have a significant direct connection with the KD.

Breach 2 does not have a distinguishable direct opening along the western side of the NSC. Some vegetative signature and sediment deposition patterns in the immediate vicinity do show connection potential at times. Continuous monitoring at this location would not have been feasible.

Open water areas to the west of where Breaches 3 and 5 are located show evidence of historical connection with waters to the west of the NSC. Present vegetative signature and sediment patterns along the western side of the NSC do not indicate any appreciable level of flow occurring at either of these breaches today.

Breach 6 contains two small (10-inch) concrete pipes that pass through a seawall structure located where Gator Slough meets the NSC. These pipes are located at or above the high water level. Field observations of these pipes did not show any appreciable flow going in or coming out of the NSC.

Breach 7B does not show any signature along the western shoreline that would indicate any significant flow pathway from the NSC to the KD. Breach 7A shows some vegetative and open water indications of an intermittent connection between the NSC and the KD. The small and shallow nature of Breach 7A would have made monitoring unfeasible.

Examination of aerial photography (Appendix A) shows the historical pathways of the connections associated with Breaches 8A and 9. The conditions at the edge of the NSC do not indicate that significant flows are passing into or out of the NSC through these locations today.

In addition to the connections described in the previous paragraphs, the elevation of the west side of the NSC varies significantly, from a high of 1.7 ft in the south end to 0.8 ft at the north end, based on the 1993 Havens & Emerson / Avalon Engineering Report (Haven & Emerson, 1993). Tides within the NSC can overtop broad lengths of the western side of the NSC. Additionally, due to the porous nature of the soils and existence of mangroves, flow can be conveyed through seepage to the west from the NSC.

In order to quantify the flow entering into the NSC through the southern channel, USGS established a primary flow and water level monitoring station in the main channel to the south of the former boat lift location (USGS-00). The location of the station is shown in Figure 2-3. This station monitored flows and water levels for the same period as the breach stations described below.

Moving up through the NSC from south to north, the first monitored breach, 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 Pine Island Road, 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 that parallels Pine Island Sound Road. 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. An aerial photograph presented in Appendix A shows a zoomed-in view of the location of the USGS monitoring site.

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.

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. Based on available historical surveys, depths within the interior canals range from 2.6 to 28.9 ft (NAVD88) and average around 9.2 ft.

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.

The southernmost section (KD1) is approximately 1.3 miles long, with an average width of 50 ft. A centerline survey of this reach shows depths ranging from 2.3 to 10.0 ft, with an average depth of 4.0 ft (NAVD88). The monitored breach that connects the NSC and KD1 is located at the southern end of KD1 (Breaches 10 and 11). USGS-02 was the monitoring site within this connection (see Figures 2-2 and 2-3).

The next section, KD2, is approximately 1.7 miles long, with widths ranging from 50 to 100 ft. A centerline survey of this reach of the KD shows depths ranging from 2.6 to 11 ft, with an average depth of 4.2 ft (NAVD88). The monitored breach between the NSC and KD2 is located at the northern end of KD2 (Breach 8). USGS-03 was the monitoring site within this connection (see Figures 2-2 and 2-3).

The next section, KD3, is approximately 1.3 miles long, with widths ranging from 30 to 85 ft. A centerline survey of this reach of the KD shows depths ranging from 0.7 to 4.9 ft, with an average depth of 3.9 ft (NAVD88). The primary monitored breach between the NSC and KD3 is located near the middle of KD1 (Breach 7). USGS-04 was the monitoring site within this connection (see Figures 2-2 and 2-3). This breach is very small and shallow and frequently is dry during normal tidal conditions.

The northernmost section of the KD (KD4) is approximately 2.6 miles long, with widths ranging from 30 to 85 ft. A centerline survey of this reach of the KD shows depths ranging from 1.3 to 6.6 ft, with an average depth of 4.0 ft (NAVD88). KD4 had two monitored breaches connecting to the NSC. The first (Breach 4) connects the southern end of KD4 to the NSC approximately 1.1 miles north of where the tidal portion of Gator Slough intersects the NSC; USGS-06 was the monitoring site within this connection. The second (Breach 1A) connects the northern end of KD4 to the NSC approximately 1.1 miles north of USGS-06. USGS-07 was the monitoring site within this connection (see Figures 2-2 and 2-3). In addition to the monitored connections, a significant and navigable connection between this portion of the KD and Matlacha Pass exists at the southern end. This connection was not part of the monitoring program because it was not a connection from the NSC to the KD but rather connects KD4 directly to open waters west of the KD, which, in turn, are connected to waters within Matlacha Pass.

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 SUMMARY

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

- Water level
- Velocity and Flow
- Salinity
- Temperature

Water level, salinity, and temperature data were collected by Kevin Erwin Consulting Ecologists, Inc. (KEC) at a total of 28 locations throughout Matlacha Pass, the KD, the NSC, the interior canals, and above the weir structures on Burnt Store Road. A total of 19 stations collected water level data only, the remaining 9 stations collected water level, salinity, and temperature data. KEC maintained the instruments from August 2012 through June of 2013. After that period, the City of Cape Coral maintained the instruments. The water level measurements upstream of the weir structures were collected to supplement flow gaging data collected by USGS. This was necessary since USGS flow gaging stations were taken offline during the period of this study.

USGS collected water levels, flows, and velocities at six 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 2013 through March 2014.

The following sections present a summary of the data collected, including methodologies, station locations, period of data, and presentation of the final data.

3.1 D-STATION WATER LEVELS

Figure 3-1 presents the location of water level monitoring stations installed within Matlacha Pass, the KD, the NSC, and the interior canals. Three stations were installed within Matlacha Pass (D17, D18, D19), six within the KD (D03, D05, D06, D11, D14, D15), and six within the NSC and the interior canals (D01, D04, D07, D09, D12, D16).

Figure 3-1. *D-Station Locations*

The instruments utilized were In-Situ Rugged Troll 100s. The installation consisted of mounting pipes driven in at various locations throughout the system, and a perforated polyvinyl chloride (PVC) housing strapped to the mounting pipes below the low tide level. The instruments were installed within the PVC housings by connection to a PVC cap on the housing and a specified length of wire hanger to hold the instrument in place vertically. The PVC cap screwed to the top of the housing and a mark was made so that caps were always screwed on to the same location vertically. Figure 3-2 presents photographs of the installations.

In addition to the In-Situ Rugged Troll installations, In-Situ Rugged BaroTrolls were installed at two locations in the system. These instruments recorded local barometric pressure throughout the installation period. These data were utilized to apply barometric pressure corrections to the data prior to developing the final water levels.

The station installations occurred in late August to early September 2012, and the instruments were maintained on a monthly basis until late November and early December 2013. Appendix A presents a table showing the periods where good data were collected. Overall, the D-stations had continuous coverage for the period of record, with only short periods of bad or no data.

The data from the instruments were post-processed to provide absolute water levels referenced to the vertical datum NAVD88. Coastal Engineering Consultants (CEC) established temporary benchmarks (TBMs) at each of the instrument locations, which allowed conversion of the barometrically corrected water levels to NAVD88. The following bullets outline how the TBM elevations were established.

- Surveys were conducted using two Trimble GPS RTK receivers with GLONASS capability using a base and rover system.
- One receiver was installed on a published City of Cape Coral Benchmark (BM), and the other receiver served as a rover. A total of five published BMs were utilized for this project.
- Individual observations were collected at each instrument location. At locations with canopy cover or not suitable for GPS observations, closed conventional level loops were conducted.

Figure 3-2. Photos of D-Station Instrument Installation

- Prior to conducting observations, the rover occupied and checked into at least one other published BM.
- Orthometric heights were corrected by the latest GEOID field file (2012) in real time by the Trimble software.

CEC identified that the accuracy of the established TBMs is +/- 0.03 ft. The water level data were first processed to include corrections based upon the barometric pressure readings and then converted to NAVD88 based upon the difference between the elevation of the pressure sensor and the TBMs.

Appendix B presents plots of the water levels measured at the D-stations for the full period of record. The results are plotted on a monthly time scale, with three stations per page. The results for the Matlacha stations are presented first, followed by the stations within the KD and then within the NSC and interior canals.

3.2 USGS BREACH MEASUREMENTS

Lee County contracted USGS to collect flow, water level, and velocity data at the locations identified in Figure 2-3. A total of seven locations were monitored:

- USGS-00 – Station within the NSC that measured flows at a location immediately south of the former barrier location (Breach 13).
- USGS-01 – Station within Ceitus Creek near the point where the creek breached into the NSC (Breach 12)
- USGS-02 – Station within the breach connecting the NSC with KD1 (Breaches 10 and 11)
- USGS-03 – Station within the breach connecting the NSC with KD2 (Breach 8)
- USGS-04 – Station within the breach connecting the NSC with KD3 (Breach 7)
- USGS-06 – Station within the southern breach connecting the NSC with KD4 (Breach 4)
- USGS-07 – Station within the northern breach connecting the NSC with KD4 (Breach 1A)

USGS performed cross-sectional area measurements at each site. These were referenced to NAVD88 based upon the TBMs CEC established.

USGS installed acoustic Doppler velocity meters (ADVMs) to record velocity and water level. The instruments were located so that sufficient water remained within the cross-section at all times to allow for reliable velocity measurements. For all but one of the stations, this was not a problem. At USGS-04, zero flow occurred through the cross section at times due to water levels within the NSC and KD3 that were below the cross-sectional depth of a point to the west of where the instrument was located. This cause cessation of flow and pooling at the location of the instrument. This meant that the measurements at USGS-04 were not continuous, and there are periods with no (or unreliable) data. A similar condition occurred at times at USGS-06 but this was infrequent and simply led to conditions of near 0 flow.

Figures 3-3 through 3-9 present plots of the cross-sections at the locations where the instruments were installed, along with photos of the area. For USGS-00, an aerial view is provided showing the location of the instrument within the cross-section. TBMs (using methods described in Section 3.1) were established at each USGS monitoring location. The TBMs were utilized to adjust the water level measurements and the cross-section measurements to NAVD88.

USGS utilized the index velocity method for the computation of flows (USGS, 2012). Computing discharge using the index velocity method differs from the traditional stage-discharge method by separating velocity and area into two ratings, the index velocity rating and the stage-area rating. The outputs from each of these ratings, mean channel velocity (V) and cross-sectional area (A), are then multiplied together to compute a discharge. The stage area rating was established from the water level measurements and the flow cross-sections. The index-velocity rating was based on discrete flow measurements made at the site during the period of data collection (using an acoustic Doppler current profiler - ADCP) and correlation of that flow with the velocity readings from the ADVMs.

The station installations began on August 20, 2013 and were completed on August 30, 2013. The first set of instruments was removed on January 27, 2014, and the last set was removed on February 24, 2014. Appendix A presents a table showing the periods where good data were collected. For the period of the instrument installation, all but one of the stations had continuous data. Station USGS-04 had periods of missing water level, velocity, and flow data, based on upstream portions of the connection drying out.

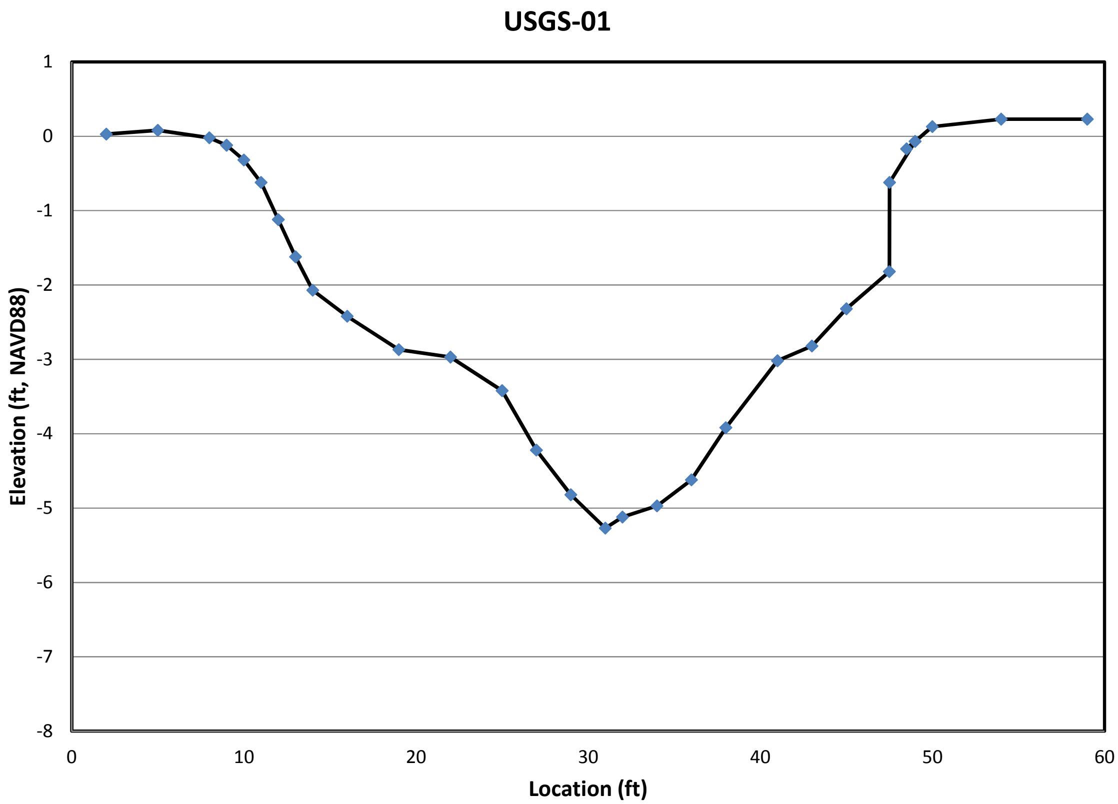


Figure 3-3. Cross-Section at USGS-01 and Photo of Connection at the NSC

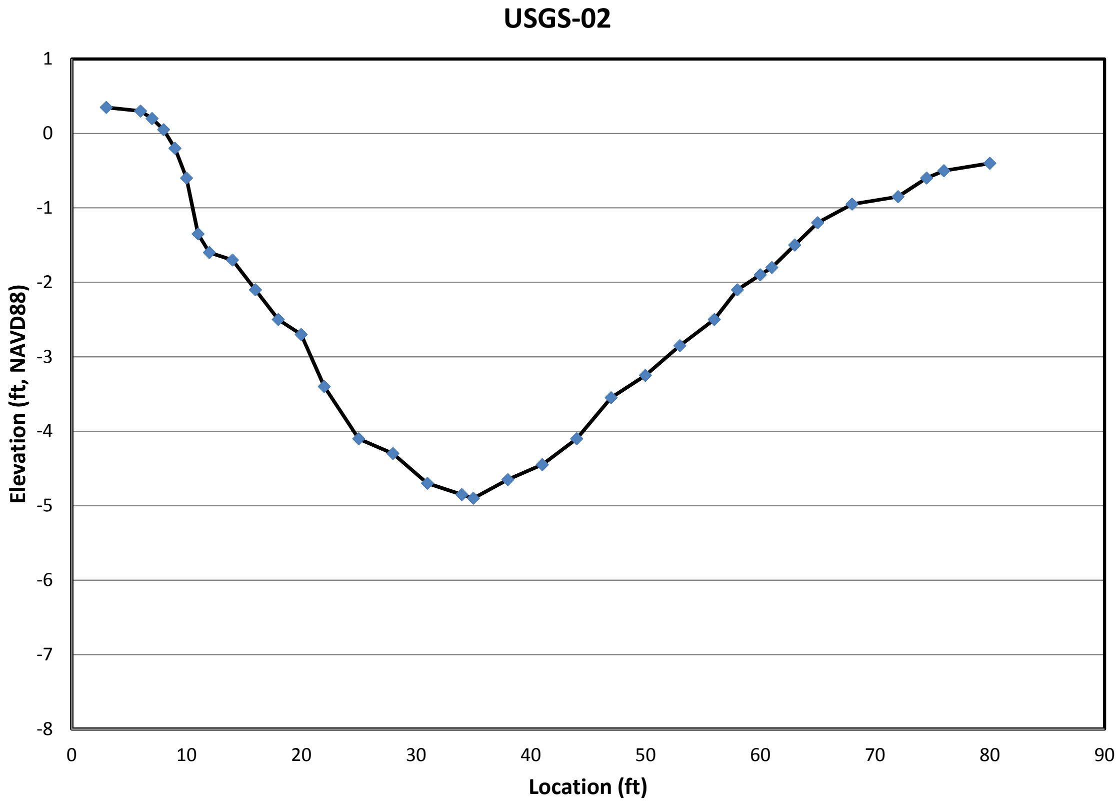


Figure 3-4. Cross-Section at USGS-02 and Photo of Opening at NSC

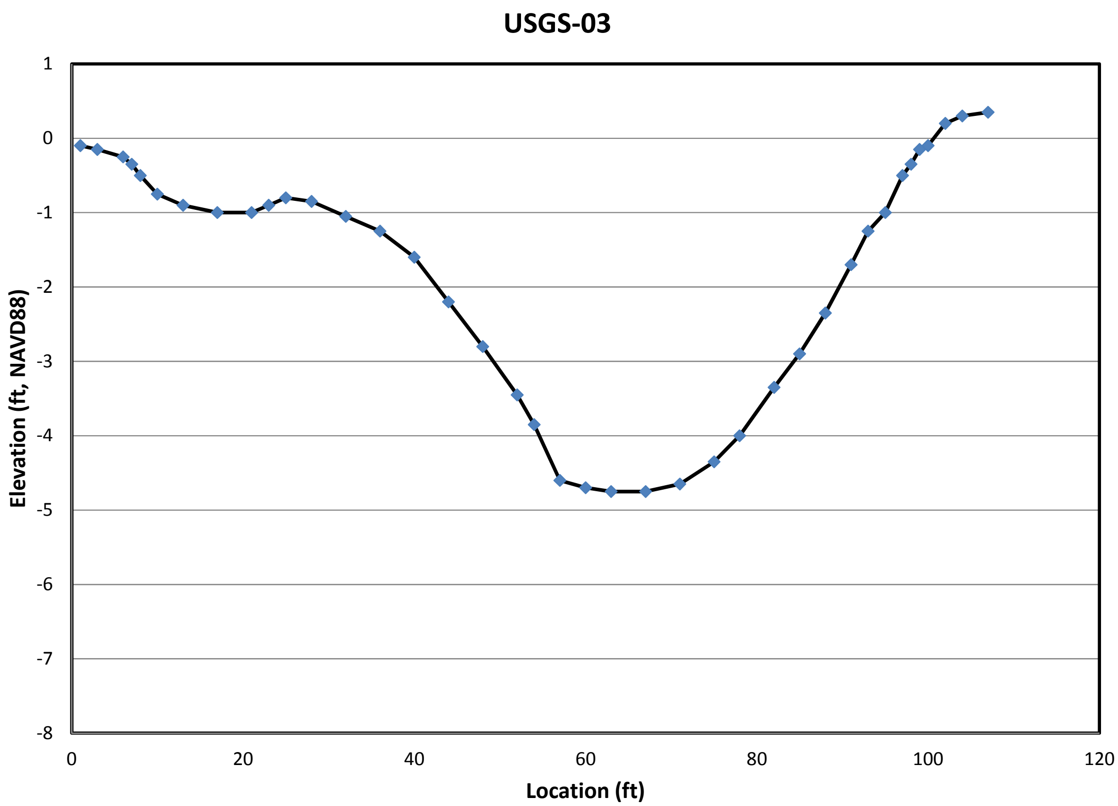


Figure 3-5. Cross-Section at USGS-03 and Photo at Connection to NSC

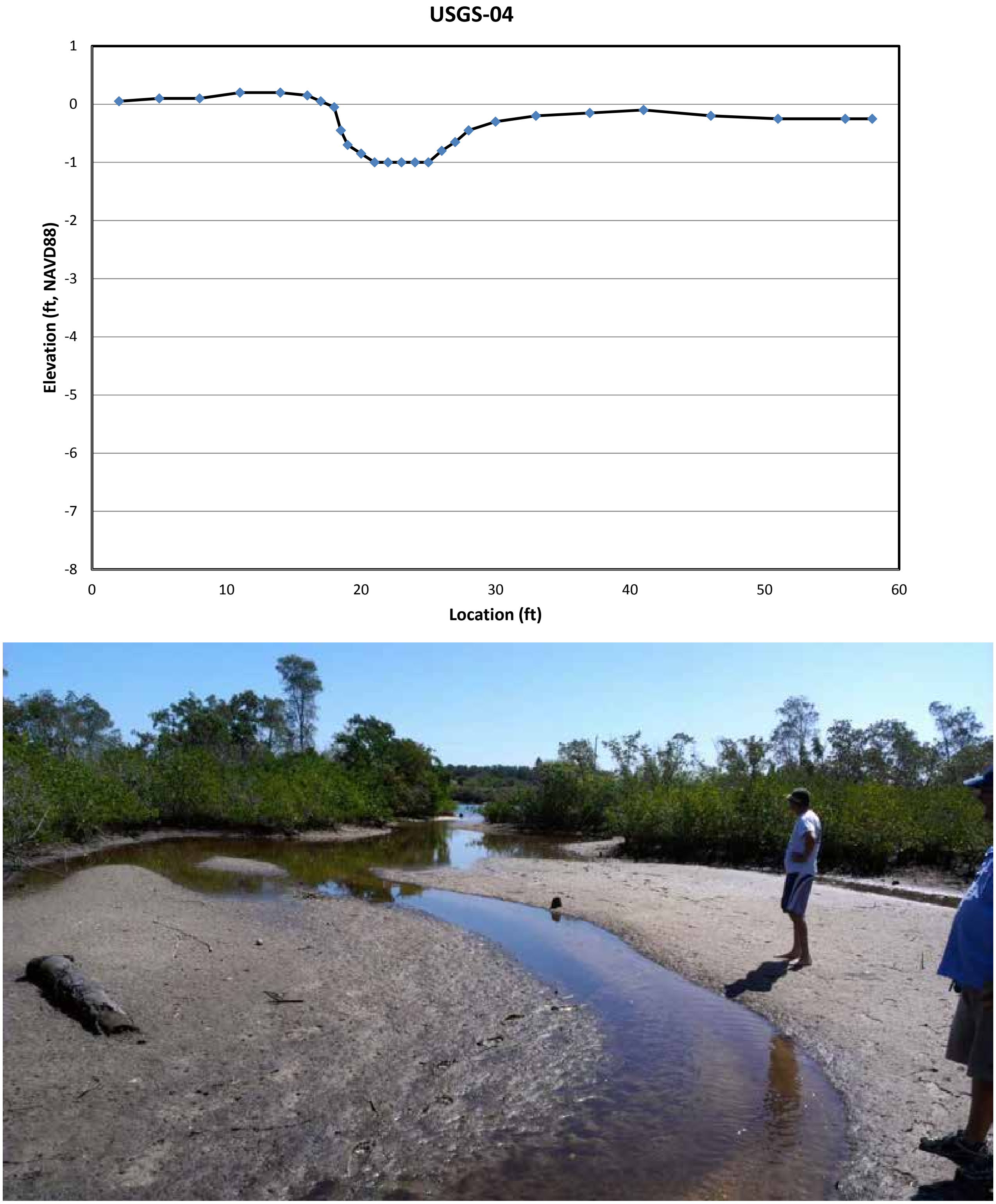


Figure 3-6. Cross-Section at USGS-04 and Photo of Interior Channel

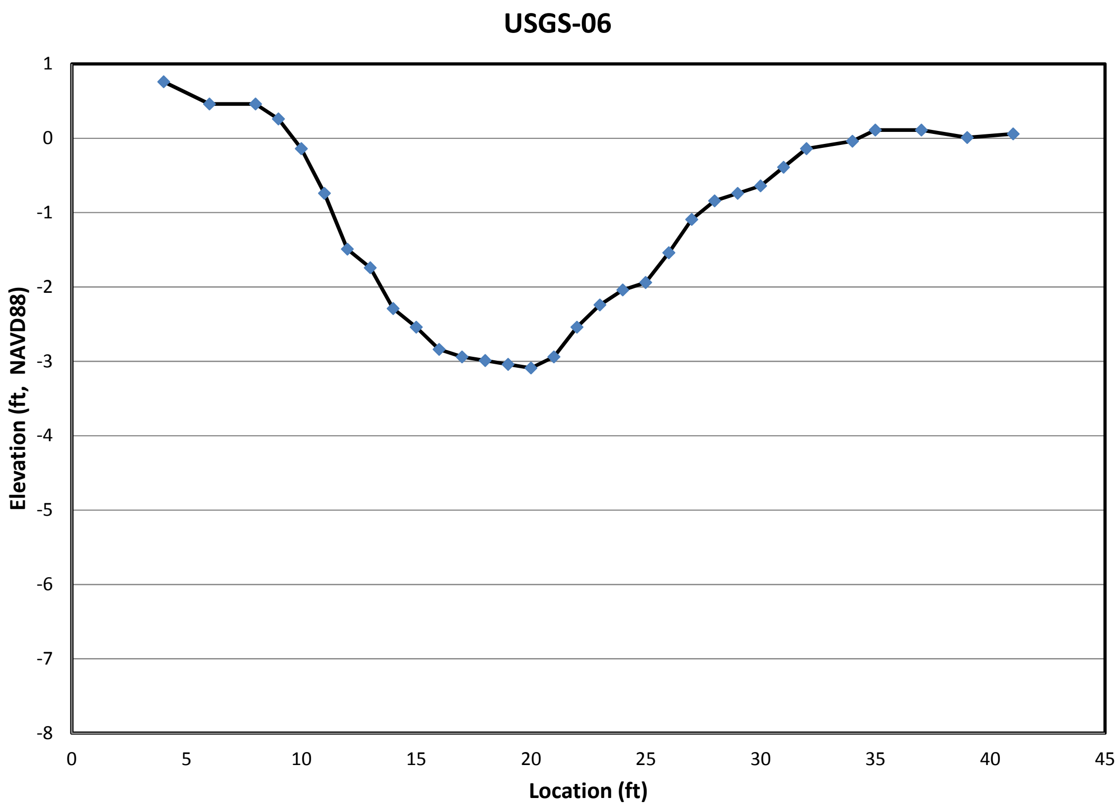


Figure 3-7. *Cross-Section at USGS-06 and photo of Interior Channel*

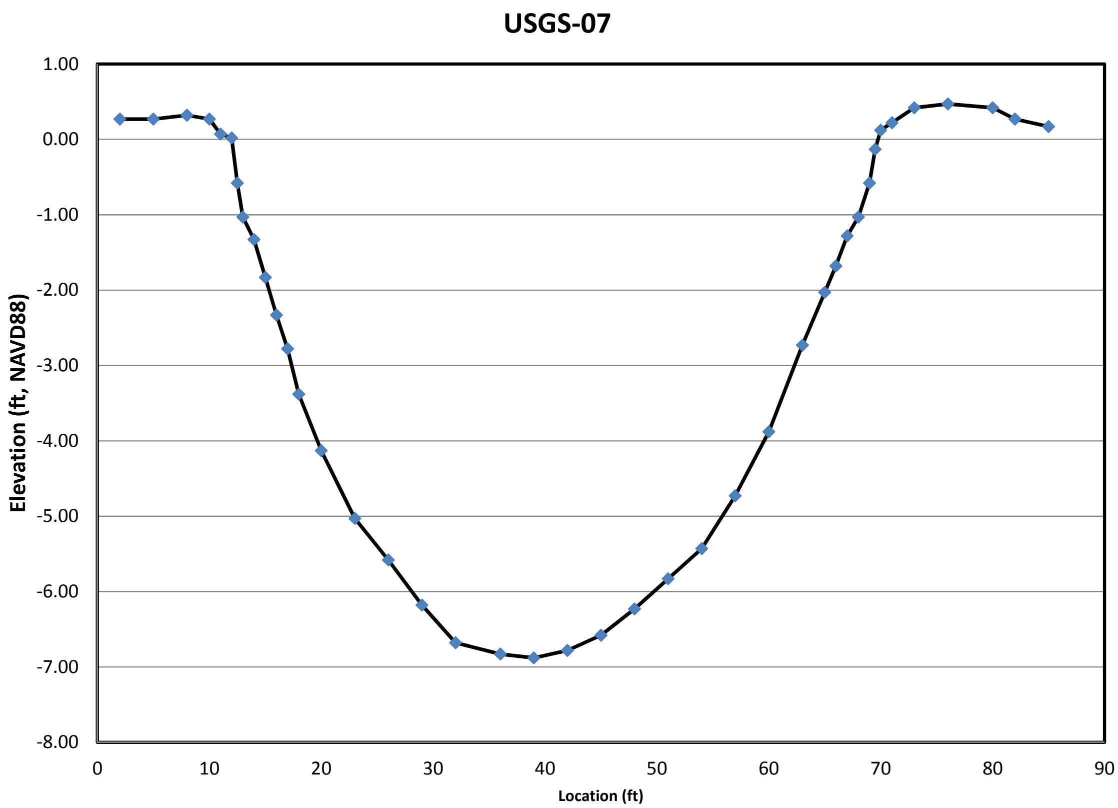


Figure 3-8. Cross-Section at USGS-07 and Photo of Connection at NSC

Figure 3-9. Aerial Photo Showing Location of USGS-00

Appendix C presents plots of the water levels, flows and velocities for each USGS monitoring station. The results are plotted monthly with three plots per page (water level, flow, velocity). The results are presented for September, October, November, December 2013 as well as January and February 2014.

3.3 FRESHWATER INFLOW TO NSC

There are currently four primary drainage basins that discharge to the NSC system. These are, along with their individual drainage areas:

- Shadroe Canal (3,865 acres)
- Hermosa Canal (5,940 acres)
- Horseshoe Canal (7,601 acres)
- Gator Slough (32,229 acres)

Additionally, north of Gator Slough, Durden Creek drains into the upper end of canals connected to the NSC. While Durden Creek has a direct outlet to Matlacha Pass through culverts at its western end, the direct connection with the northern end of the NSC provides the potential for freshwater (that does not drain to Matlacha Pass through the culverts) to enter the NSC from Durden Creek (see connection marked on Figure 3-10).

The four primary basins drain into the NSC over five weir structures located along Burnt Store Road. Figure 3-10 presents the locations of the weir structures. USGS has maintained flow monitoring equipment at four of the weir structures since 1987 (Shadroe Canal, Hermosa Canal, Horseshoe Canal, and Gator Slough). The Arroz Canal weir structure represents a relatively small amount of the overall flow to the system and has not been monitored historically. In 2013, due to budget cuts, the USGS gages were taken offline at specified times. The USGS gaging station identification numbers and the dates for discontinuing the gages are as follows:

- Shadroe Canal (USGS 02293345) – 5/23/13
- Hermosa Canal (USGS 02293347) – 7/1/13
- Horseshoe Canal (USGS 02293346) – 6/1/13
- Gator Slough (USGS 02293264) - 9/30/13

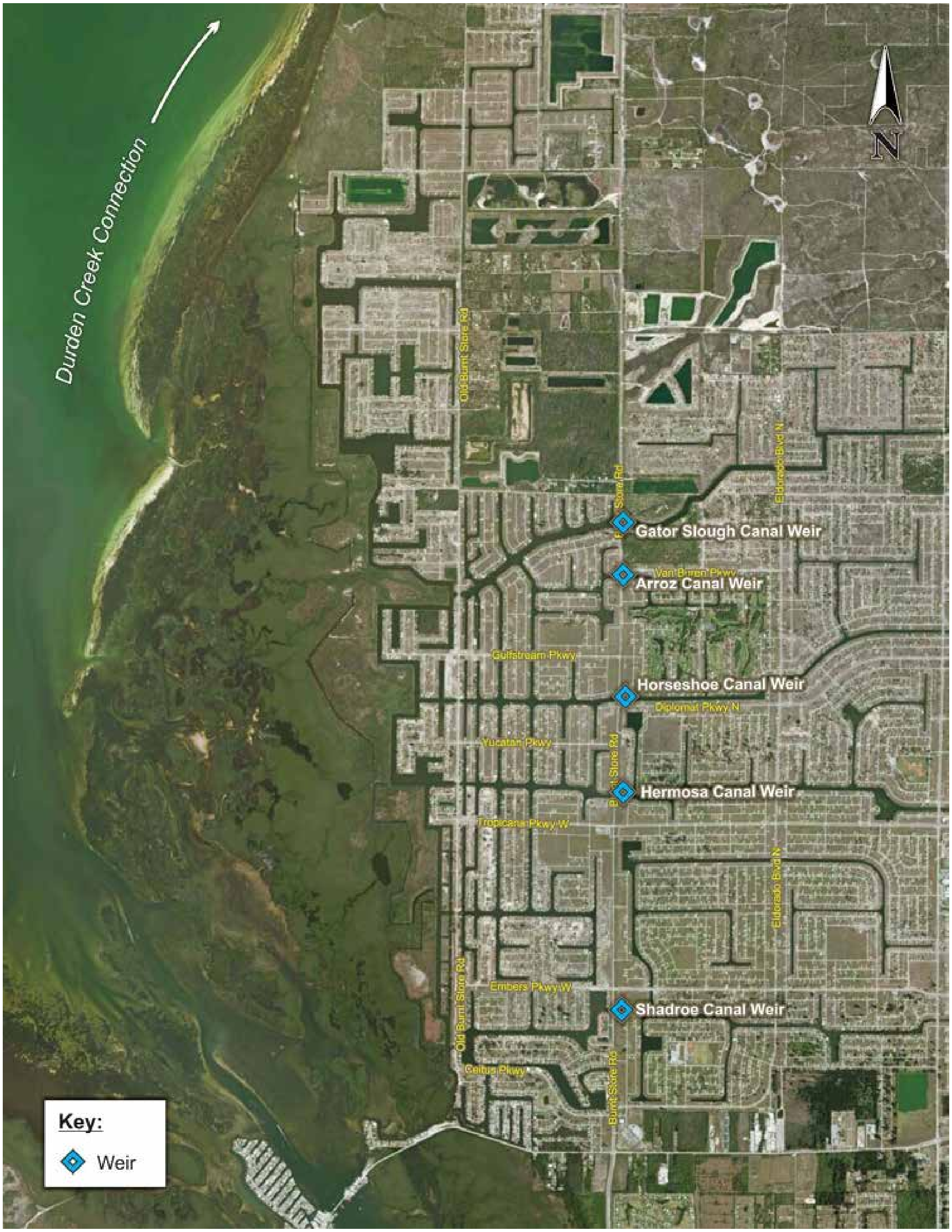


Figure 3-10. Weir Locations

The weir structures operate as water retention facilities for the City of Cape Coral. Each weir is equipped with a bladder and flap so that the level of the weir can be adjusted by inflation of the bladders. As such, the weir elevations vary over time depending upon the operations. Calculations of the flow over the weirs need to account for these variations.

At the beginning of monitoring in September 2012, it was recognized that the USGS gages would be going offline during the period of the data collection. Water level recorders, similar to those used for the tidal portions of the system (D-stations) were installed above the weir structures. As with the D-stations below the weirs, TBMs were established at each station to allow for the water levels to be corrected to NAVD88. The Gantt Chart in Appendix A shows the period where good data were collected at these stations. The chart shows that for the Gator Slough water level gage, the only good data were collected from April to June 2013. The other stations operated from September 2012 through early- to mid-December 2013.

The purpose of the instruments installed upstream of the weirs was to supplement the data USGS was gathering to allow for calculation of the freshwater inflows over the weirs through the periods after the USGS gages were discontinued. For Shadroe Canal, Hermosa Canal, and Horseshoe Canal, the D-station data filled in the gaps from the times of the USGS decommissioning through early to mid-December 2013. The USGS gage in Gator Slough was decommissioned on September 30, 2014, and the D-station did not have data to supplement for the period from September 30 to December 31. Fortunately, the operation of the weir structures was such that in mid-October, there was little to no flow going over any of the weirs (based on discussion with City of Cape Coral personnel operating the weirs). Therefore, the Gator Slough discharge was 0 into December. This only left a short gap in the Gator Slough data from September 30 through mid-October.

USGS uses a specified methodology for the calculation of flows over the weirs that is based upon stage-discharge rating curves (using water level in feet, NGVD29) and corrections of the water level elevations relative to the weir heights based on the bladder pressures recorded by the City of Cape Coral. Applied Technology and Management, Inc. (ATM) utilized this methodology to develop the flow conditions through December 2013 where USGS data did not exist. For the periods where USGS flows were available, the USGS flow calculations were utilized. Figure 3-11 presents a plot showing the USGS- and ATM-supplemented flows from September 2012 through December 2013.

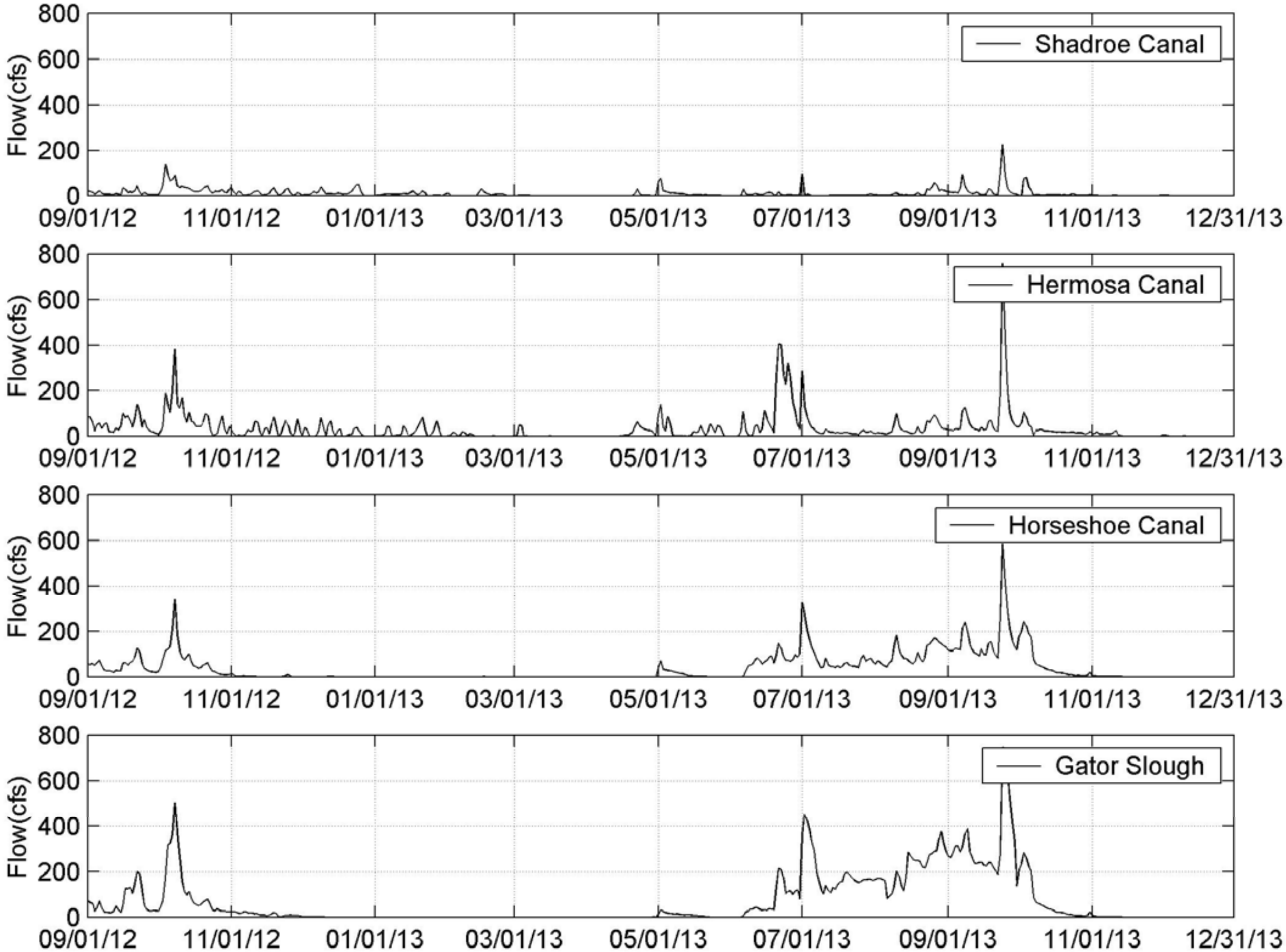


Figure 3-11. Flow Over Weirs (September 2012 to December 2013)

It should be noted that due to the existence of the bladders (some of which leak at times), as well as debris buildup on the weir structures, calculation of accurate flows over the weirs is difficult. For the period of the ATM-supplemented data, some of the USGS discrete flow measurements commonly taken to provide for correction from debris buildup were not taken. The rating curves utilized for the supplemental data were based on the last available rating curves done by USGS for each of the structures. For the gap in the USGS data following the decommissioning of the Gator Slough gage, the data from Horseshoe Canal were proportionalized based on the historical differences in the flows between the two stations.

3.4 C-STATION SALINITY AND TEMPERATURE

Figure 3-12 presents the location of stations that measured salinity, temperature, and water level within Matlacha Pass, the KD, the NSC, and the interior canals. Three stations were installed within Matlacha Pass (C01, C08, C09), two within the KD (C04, C06), and four within the NSC and the interior canals (C02, C03, C05, C07).

The instruments utilized were In-Situ Aqua Troll 200s. The installation was the same as that utilized for the D-stations. TBMs were also established for these stations and water levels converted to NAVD88. In addition to the continuous monitoring stations, discrete salinity data were collected at numerous stations throughout the study area. Many of these locations were coincident with the continuous gages. Figure 3-13 shows the locations of the discrete water quality monitoring stations.

The station installations occurred in late August to early September 2012, and the instruments were maintained on a monthly basis until late November and early December 2013. Appendix A presents a table showing the periods where good data were collected. Unlike the D-stations, these gages had some significant periods where the instruments were not working properly and, for periods where the data were clearly bad, the data were removed through the quality assurance/quality control (QA/QC) process. The remaining data were compared to the W stations to assess the accuracy of the salinity sensor calibration. While these data were not collected for the specific purpose of verifying the instrument calibration, they were taken near enough to allow comparison. Where warranted (based on inspection of the data), the W station data were used to adjust the calibration for salinity. Overall, the measured data and the W stations agree, but there are periods of time where differences exist that did not warrant adjustment of the C station results. Additionally, some levels of “noise” or “spike” data are seen in the salinity and temperature data. These occur within time series of what appear to be good data. These were left in the signals as their automated removal was not feasible. Use of the data for model calibration and the assessments presented herein must be understood in light of some of the potential errors and issues with the data as described. Overall, for the modeling work, the W station data will be defined as the more accurate. Since there were multiple sensors on each instrument, there were times where the instrument collected good data for one parameter but not another. On the Gantt Chart in Appendix A, where specific parameters had periods of bad data, these are identified by letters (s-salinity and t-temperature). During those periods, the other parameters had useable data.

Appendix D presents plots of the water levels, temperature, and salinity for the C-stations on a monthly basis for the full period. The discrete water quality sampling results that coincide with the continuous data are plotted as blue circles on the plots within the appendices. The data are presented monthly for each of the stations, starting with C01. Each plot presents the temperature, salinity, and measured water levels. Plots with data gaps are periods where data were removed through the QA/QC process.

Figure 3-12. C-Station Locations

Figure 3-13. Discrete Water Quality Monitoring Locations (W-Stations)

4.0 DATA ANALYSES

This section provides analyses of the hydrodynamic data presented in Section 3. The goal is to provide a detailed quantification of the hydrodynamics (flows, circulation, and salinity) within the NSC and adjacent waters out to Matlacha Pass using available continuous water level, flow, and salinity data described in Section 3. Specific analyses conducted include the following:

- Presentation and analyses of the flows (recent and historical) over the weirs to assess the conditions under which the detailed hydrodynamic data were collected;
- Presentation of the relative water levels measured within Matlacha Pass, the KD, the NSC, and the interior canals;
- Assessment of changes in water level conditions under dry versus wet conditions;
- Analyses of the phasing and damping of water level fluctuations (using harmonic analyses) 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;
- Presentation of the relative flows through the breaches and at the former location of the Ceitus barrier and assessment of the differences during wet and dry periods;
- Analyses of the relative tidal prism/flow and temporal variations between the breaches and at the former location of the Ceitus barrier under varying freshwater inflow conditions;
- Analyses of the salinity distribution by location and the correlation with freshwater inflow from the USGS gages;
- Correlation of salinity responses between the western canals, the NSC, the KD, and the offshore areas to assess potential sources of salinity variation; and
- 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.

The period of data analyses was from September 2012 through December 2013. This reflects the period of time where the bulk of the data overlapped. While the USGS breach measurements extend into January and February 2014, the D-station, C-station, and weir flow data ended in December 2013.

4.1 FLOW OVER WEIRS

Figures 4-1 and 4-2 present the annual average and maximum flows over each of the weir structures from 1990 through 2013. These data reflect the measurements USGS made over that period along with the supplemental flow data in 2013 ATM calculated as discussed in Section 3. Since some stations had data gaps, there are years on the plots where no annuals or maximums are presented.

Shadroe Canal weir shows annual average flows that range from less than 5 cubic feet per second (cfs) to 36 cfs. Maximum flows range from less than 50 cfs up to near 1,000 cfs. Hermosa Canal weir shows annual average flows that range from less than 5 cfs up to 43 cfs. Maximum flows range from less than 50 cfs to just above 1,000 cfs. Horseshoe Canal weir shows annual average flows that range from less than 10 cfs to 49 cfs. Maximum flows range from less than 50 cfs to just above 1,000 cfs. Gator Slough weir shows annual average flows that range from near 10 cfs to near 90 cfs. Maximum flows range from near 50 cfs to near 1,500 cfs.

Looking at the flow plots, 2012 and 2013 represent somewhat average conditions over the period of record. For 2013, using the extrapolated flows described in Section 3, the annual average flows for Shadroe Canal, Hermosa Canal, Horseshoe Canal and Gator Slough were 6 cfs, 19 cfs, 40 cfs, and 73 cfs, respectively. The maximum flows were 224 cfs, 757 cfs, 586 cfs, and 744 cfs, respectively. Based on these analyses, the period of record for the detailed hydrodynamic data collection (September 2012 through December 2013) represents overall average conditions for flows coming over the weir structures.

An important aspect of the NSC system is that the weir structures are operated for the purpose of retaining water during specified periods throughout the year. As such, there are significant days in any year where flows over the weir structures are zero. For each of the years analyzed, Figure 4-3 presents the number of zero flow days. For the purpose of the figure, a zero flow day is defined as an average daily flow of less than 0.1 cfs. The plots show that over the years, the number of zero flow days appears to be increasing. Looking at 2012 and 2013 in comparison to more recent years shows that, while there are a large number of zero flow days, there are other years with more and some with less. Overall, 2012 had more zero flow days than 2013.

Figure 4-4 presents the total flow volumes by month for the full period of the hydrodynamic data collection, for each of the weir structures. The plot shows that the detailed hydrodynamic data collection started during a wet period, with flow conditions building through October 2012 and dropping off to near zero by January/February 2013. The total flow during this period is not overly high in comparison to flows for later months. Flows remained near zero from February through April 2013 and increase steadily through the summer to the maximum flow month for the period of the data collection (September 2013). Overall, the relative flow contributions increase moving from south (Shadroe Canal) to north (Hermosa to Horseshoe to Gator). Gator Slough shows the highest level of total flow. During wet periods, flows were nearly double all of the other three locations.

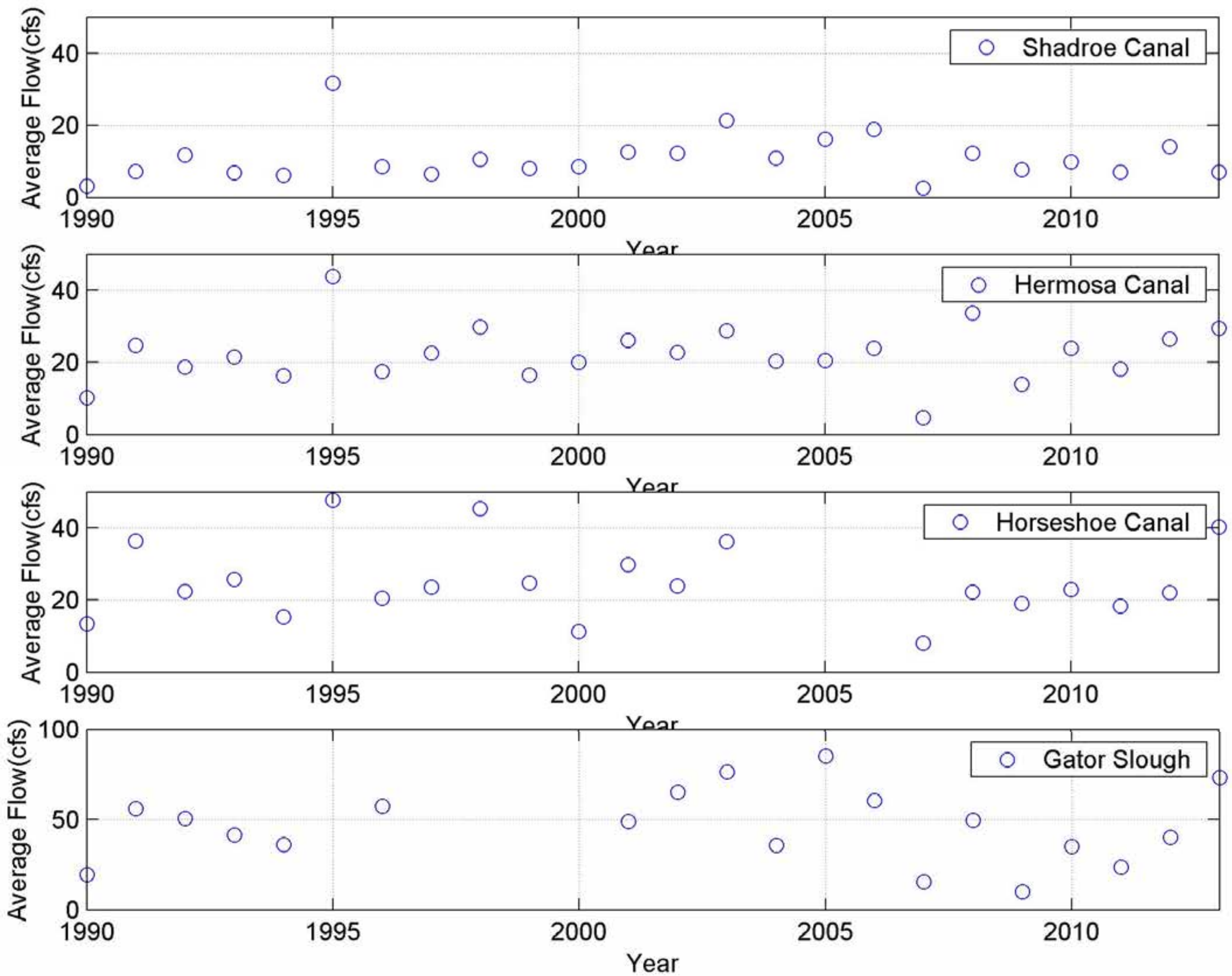


Figure 4-1. *Annual Average Measured Flows over Weirs from 1990 to 2013*

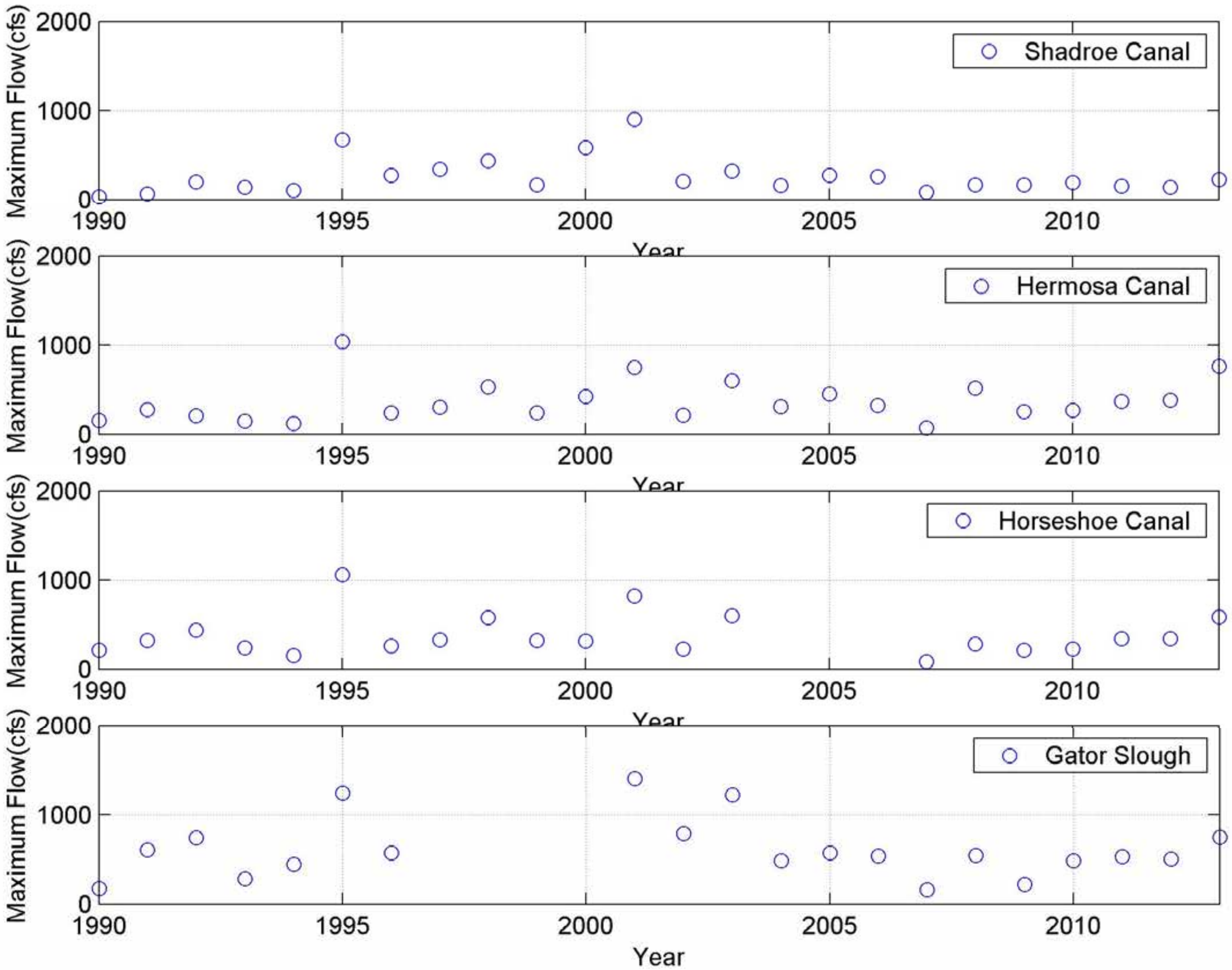


Figure 4-2. Maximum Measured Flows over Weirs from 1990 to 2013

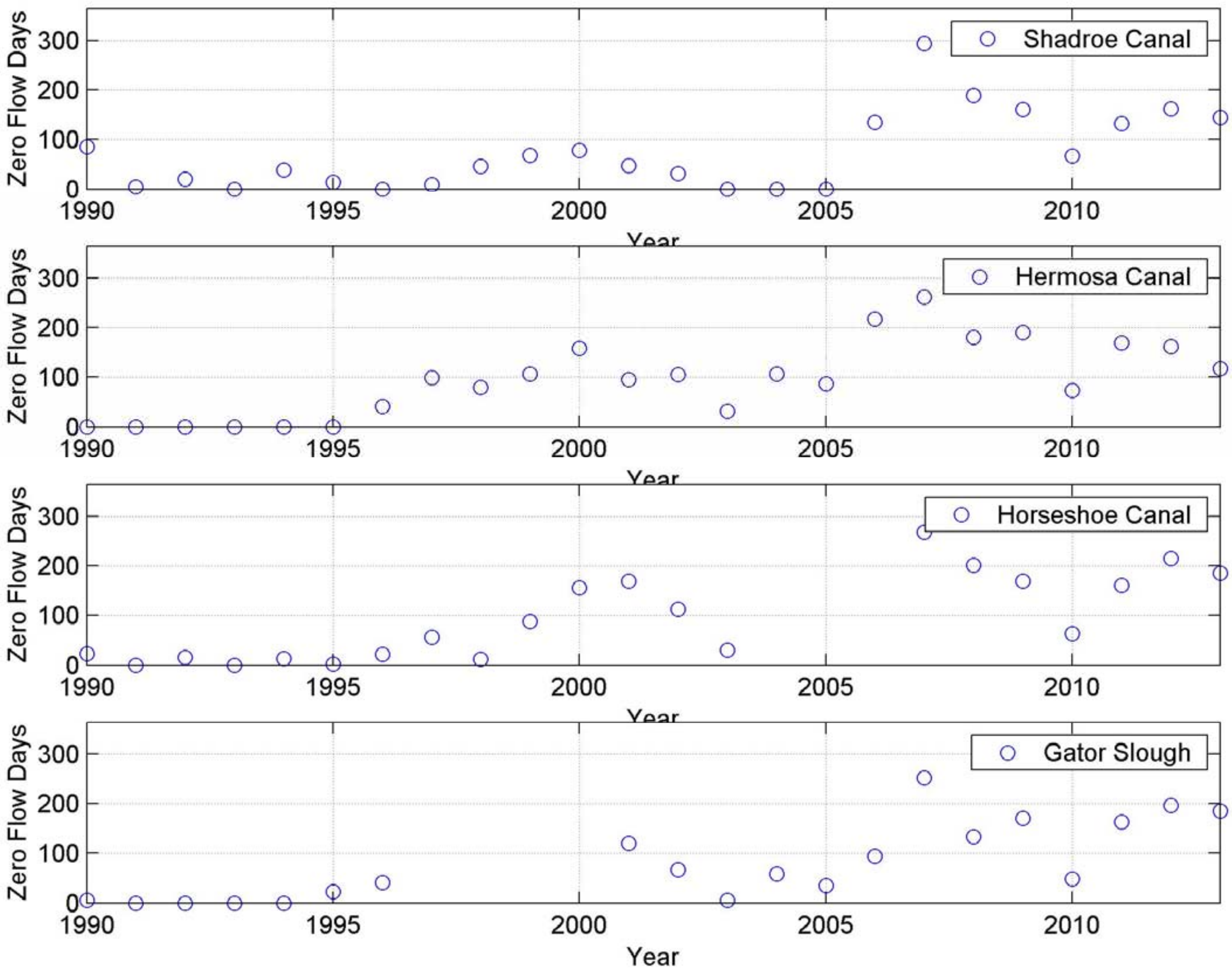


Figure 4-3. *Number of Days with Flows Less Than 0.1 cfs, 1990 to 2013*

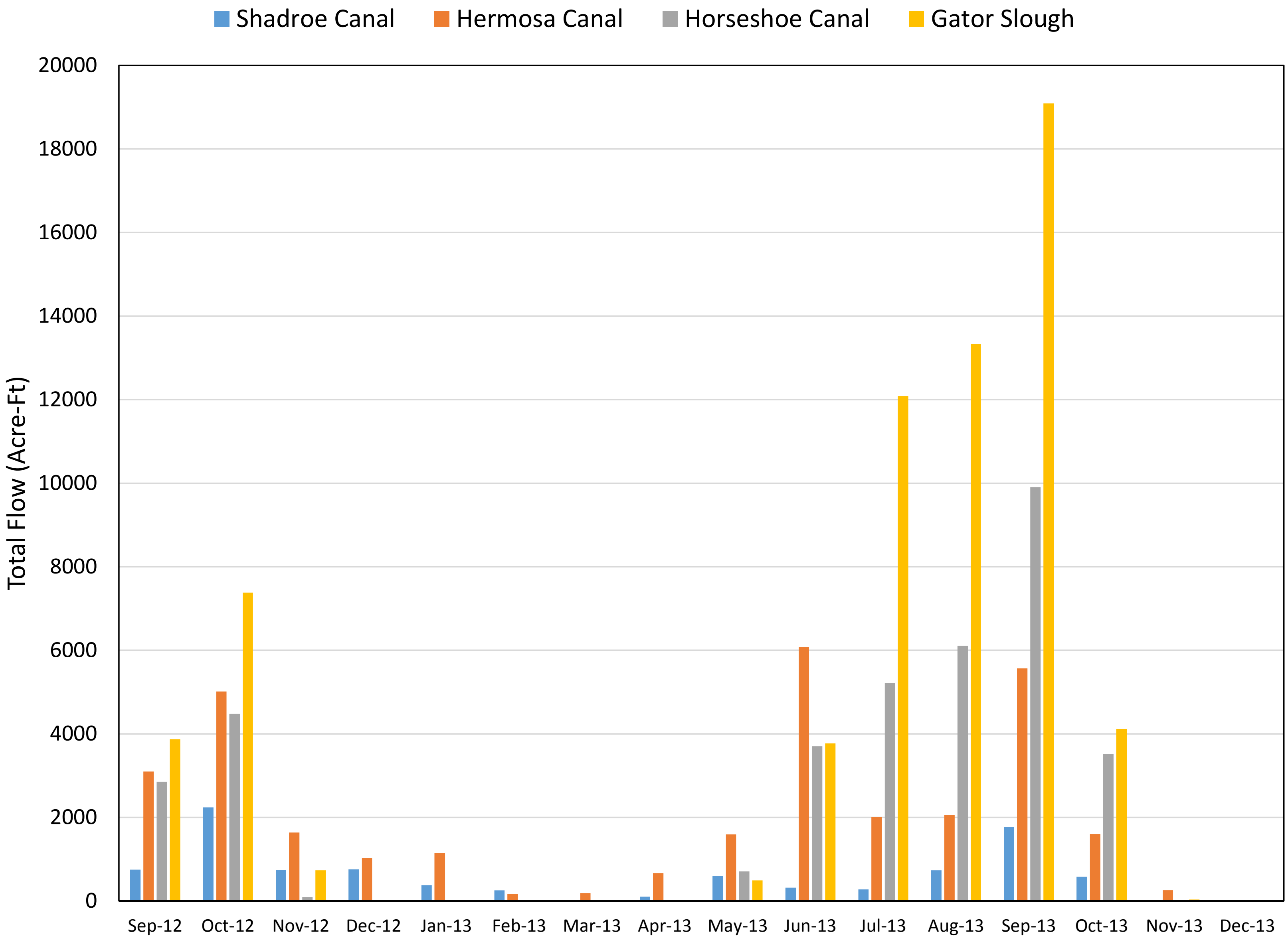


Figure 4-4. Monthly Total Flows from September 2012 through December 2013

4.2 WATER LEVELS

The following presents analyses of the D-station water level data provided in Section 3, along with some analyses of select C-station and USGS breach water level data. The water level analyses are primarily performed on the D-station data due to the relatively continuous record for these stations throughout the detailed hydrodynamic data collection period (September 2012 through December 2013) and their overall coverage, which includes all areas of the system for the most part.

Figures 4-5 through 4-7 present measured water levels at D17, D06, and D12 for 3 different months with the data plotted on individual graphs. D17 is located in Matlacha Pass, D06 is located in the second segment of the KD (KD2), D12 is located at the upper end of the interior canal that drains Gator Slough. The general hydrologic conditions for these months are:

- May 2013 – average flow month
- September 2013 – high flow month
- November 2013 – near zero flow month

Figure 4-8 presents water level plots with the graphs overlain over two 3-week periods, one representing high flow conditions (September 11, 2013 through October 5, 2013) and another a near zero flow condition (October 27, 2013 through November 21, 2013). The highest flow event measured during the period of record occurred around September 23 to 24, 2013, so the September data captures this condition.

Looking at the results from the different stations comparatively (for each of the plots) shows first the degree of damping of the tidal signal that occurs between Matlacha Pass and the interior areas (NSC, the KD, and the interior canals). The results for the interior stations are relatively similar in overall tidal magnitude and show nearly a 60 percent reduction in magnitude in comparison to the stations in Matlacha Pass. This damping occurs almost instantly as the tidal wave moves into the system (through the southern opening), as can be seen by comparison of the magnitude of the tides in the pass compared to Station D01, which is located at the southern end, near the former Ceitus barrier location. The degree of additional damping of the tidal wave as it progresses through the NSC is small in relation. This is shown by comparing the water level fluctuations at D01 (at the southern end) to D16, which is at the extreme northern end, as well as by comparison to the water level fluctuations at the other interior stations. Comparison of the results for the wet versus dry periods does not show a significant difference in the overall tidal damping relative to the hydrologic condition.

The second aspect that can be seen in the plots is the elevation of the mean water level at the interior stations versus Matlacha Pass. During some low tide events, the water levels in the pass will fall to nearly 1 ft lower than in the interior stations, while at high tide, this differential is generally less than 0.3 ft. The elevation of the mean water level varies with the hydrologic condition. As expected, during high flow events, the difference in the mean water level between the interior stations and Matlacha Pass is larger, but there is still a relatively significant difference even during zero flow period (see comparative plot for October/November in Figure 4-8).

The elevation difference (not caused by the freshwater inflow) is generated through super-elevation of the interior area (NSC and canals). This is a well-documented phenomenon that occurs in tidal inlet systems where there is a small entrance channel that fills a large embayment area (USACE, 2002). As the interior (NSC and interior canals) tidal amplitude decreases in relation to the forcing tide (tides in Matlacha Pass), the super-elevation of the system increases as seen for the interior stations. Due to the open and relatively deep nature of the NSC and interior canals, friction within this interior area is low (in relation to the friction at the southern entrance). As such, this area acts similarly to a large embayment with a narrow entrance channel (the southern end) and super-elevation occurs. The USACE Coastal Engineering Manual (USACE 2002) states:

> *Laboratory and numerical studies (Mayor-Mora 1973; Mota Oliveira 1970) have indicated that there is an increasing bay superelevation as the coefficient K decreases (Figure II-6-30) and approaches nearly 20 percent of the ocean tide range. This basic cause of setup is due to increased frictional dissipation of ebb flow in comparison to flood flow as K decreases, with peak ebb flows in the channel occurring during lower water levels for inlets with low K values. This increased tractive stress for ebb flow relative to flood flow creates the setup, or increased head, necessary to preserve continuity and drive out the same tidal prism that entered the inlet…..Model studies (Mayor-Mora 1973) show that as K decreases (and superelevation increases) the duration of ebb flow increases relative to flood flow in the inlet channel.*

For the large flow event that occurred around September 23 to 24, 2013, the results show that the overall water level at all the interior stations is elevated and remains elevated for some days as the flow event subsides. While some tidally driven fluctuations can be seen at the interior stations, they are significantly damped. The degree of elevation during this event increases moving from south to north, indicating a net increasing mean water level gradient from south to north as flows are moving out of the system. The Matlacha Pass water levels do not show a significant mean water level response to this flow event in comparison to the interior stations.

Harmonic analysis was performed on the D-station data for the full period of record to provide detailed quantification of the damping of the tidal wave and assessment of the timing (or phase) as tides moves through the system. The data are grouped by location of the stations, i.e., Matlacha Pass, the KD, or the NSC and interior canals. Harmonic analysis breaks out the various astronomical tidal constituents based on their driving function. The diurnal constituents are those that are driven primarily by the sun and represent a frequency of around 24 hours (K1 – 23.9 hours, O1 – 25.8 hours). The semi-diurnal constituents are those that are driven primarily by the moon and represent a frequency around 12 hours (M2 – 12.4 hours, S2 – 12.0 hours). Results are presented for the largest amplitude constituents, the K1 and M2 constituents.

Table 4-1 presents the results of the harmonic analyses. This includes the M2 and K1 amplitudes at each station, along with the phase lag in hours from a base station. Station D17 was chosen as the base station. Examination of the tidal data showed that the tidal wave progresses southwards through Matlacha Pass, therefore, D17 represents the first D-station that experiences the wave as it moves through the system. Figures 4-9 and 4-10 present bar charts of the tidal amplitude and the phase lag in hours for the D-stations. The results are generally ordered moving in the direction of the tidal wave progression, i.e., moving north to south through Matlacha Pass and moving south to north through the NSC, KD and the interior canals.

Examination of the results in Table 4-1 and Figures 4-9 and 4-10 shows some key aspects of the system. First, it provides a detailed quantification of the damping of the components of the tidal wave. There is little damping of the tidal wave as it moves through Matlacha Pass, but moving into the NSC system, the diurnal constituents are damped between 54 to

57 percent, while the semi-diurnal constituents are damped between 67 to 71 percent. This makes sense since damping is generally greater for higher frequency signals versus lower frequency signals. Averaging the tidal signals gave a range of damping of the overall signal from 61 to 64 percent. Based on this, the tidal signal is damped nearly 60 percent immediately moving from Matlacha Pass into the NSC system, with the remaining damping 3 to 4 percent occurring as the wave moves north through the system. This initial damping through the southern opening and limited damping through the remainder of the system is consistent with the causes of the super-elevation discussed previously and the assertion that the system acts somewhat like a large tidal embayment with a narrow entrance.

Table 4-1. Harmonic Analyses of D-Station Water Levels

	K1 Constituent		M2 Constituent	
Station	Amplitude (ft)	Phase (hours)	Amplitude (ft)	Phase (hours)
Matlacha Pass Stations				
17	0.42	0.00	0.40	0.00
18	0.42	0.04	0.40	0.03
19	0.42	0.20	0.43	0.14
KD Stations				
3	0.19	3.89	0.14	1.85
5	0.18	4.93	0.12	2.81
6	0.18	4.85	0.12	2.71
11	0.23	3.05	0.16	1.43
14	0.19	5.30	0.14	3.22
15	0.19	5.30	0.14	3.23
NSC and Interior Canal Stations				
1	0.19	3.91	0.13	1.85
4	0.19	4.26	0.13	2.21
7	0.18	4.75	0.12	2.64
9	0.18	4.93	0.13	2.83
12	0.18	5.25	0.13	3.16
16	0.19	5.37	0.14	3.23

Looking at the phase lag results in Table 4-1 and the bar chart in Figure 4-10, shows the progression of the tidal wave. The wave moves into the system, moving from south to north through the NSC. One exception to this is that D06 leads D05 in terms of the wave progression. Both of these stations are within the second segment of the KD (KD2), and the connection to the NSC is at the north end near D06. As such, the phase lag represents the progression of the wave in KD2, which passes through the breach on the north end (Breach 8, USGS-03) and moves south through KD2.

The lag of the wave (due to the damping through the southern entrance) moving from Matlacha into the NSC is on the order of 2 to 4 hours, depending upon the constituent, with the time for the wave to move through the NSC from south to north at around 1.2 hours.

Another exception in the analyses is Station D11. This station was located in the southern end of the northernmost segment of the KD (KD4). The analyses showed lower damping in the tidal signals and lower phase lags than any other station in the NSC/KD system. This appears to be isolated to this station. The reason for this anomaly is the direct connection to the open water mangrove areas of Matlacha Pass west of D11. This connection appears to operate during most if not all of the water level fluctuations and was navigable with a Jon boat. The effects of this connection, at least in terms of tidal amplitude and phasing, seem isolated to D11 and are not significantly felt further up KD4 at Station D14. The harmonic analysis did not show this direct connection influence from Matlacha Pass for any of the other KD segments (where tides were measured). This included data from KD1 and KD2.

The one section of the KD that did not have a D-station located in it was KD3. This segment of the KD did have a conductivity, temperature, and depth (CTD) station located in it. Figure 4-11 presents a plot showing the measured water levels at C04 in comparison to the measured water levels in the other three KD sections. D03 is located in KD1, D05 is located in KD2, and D15 is located in KD4. It is clear that the water level fluctuations (and, therefore, the overall hydrodynamics) are significantly different in KD3 than the other segments of the KD. While the other segments experience the full range of water level fluctuations occurring in the NSC, the water level variations are much more damped, and occur at times when the tidal conditions in the NSC are above a certain elevation. This KD segment appears to fill when tides get above around 0.5 ft NAVD88 but then remain relatively level (with minor daily fluctuations that may be wind driven) and slowly drain until water levels in the NSC are high enough to fill this segment through Breach 7 (USGS-04), which, as shown, is a very narrow, shallow breach section. Clearly, there is a sill level to this breach that is around 0.5 ft NAVD88 even though the cross-section (presented in Section 3) showed lower levels at the location of the instrument. USGS identified that the channel elevations to the west of its station were at higher elevations.

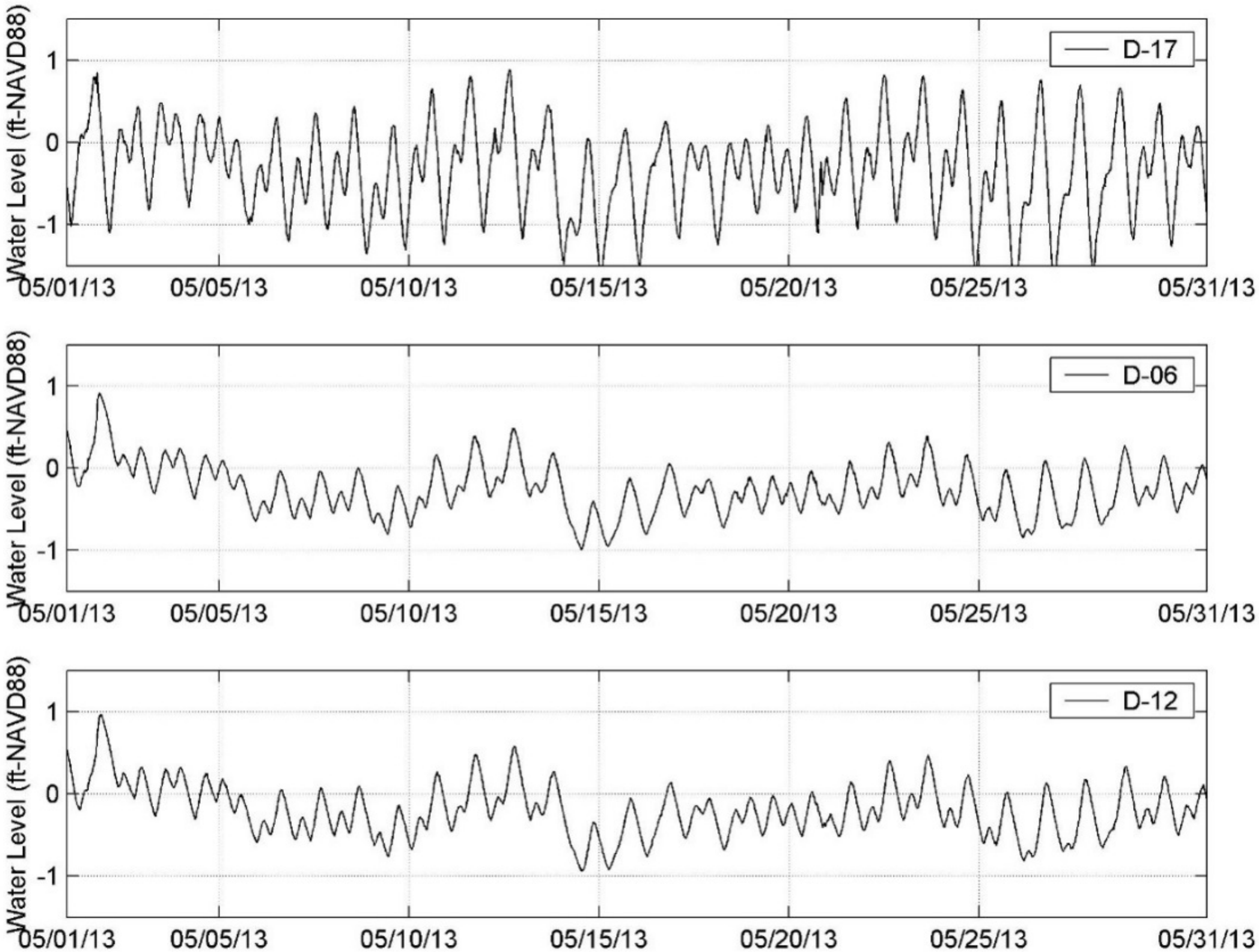


Figure 4-5. Measured Water Levels at D17, D06, and D12 (May 2013)

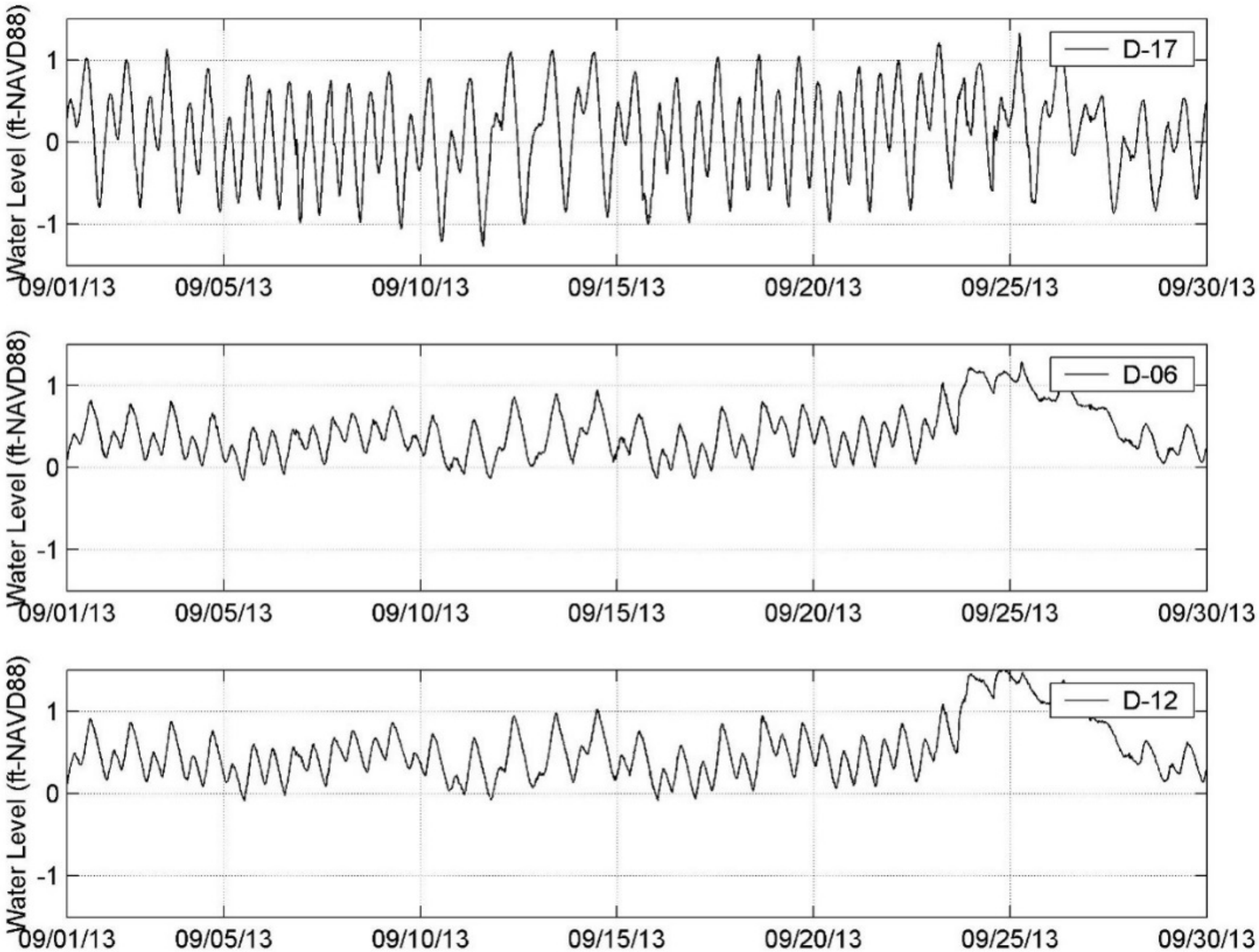


Figure 4-6. Measured Water Levels at D17, D06, and D12 (September 2013)

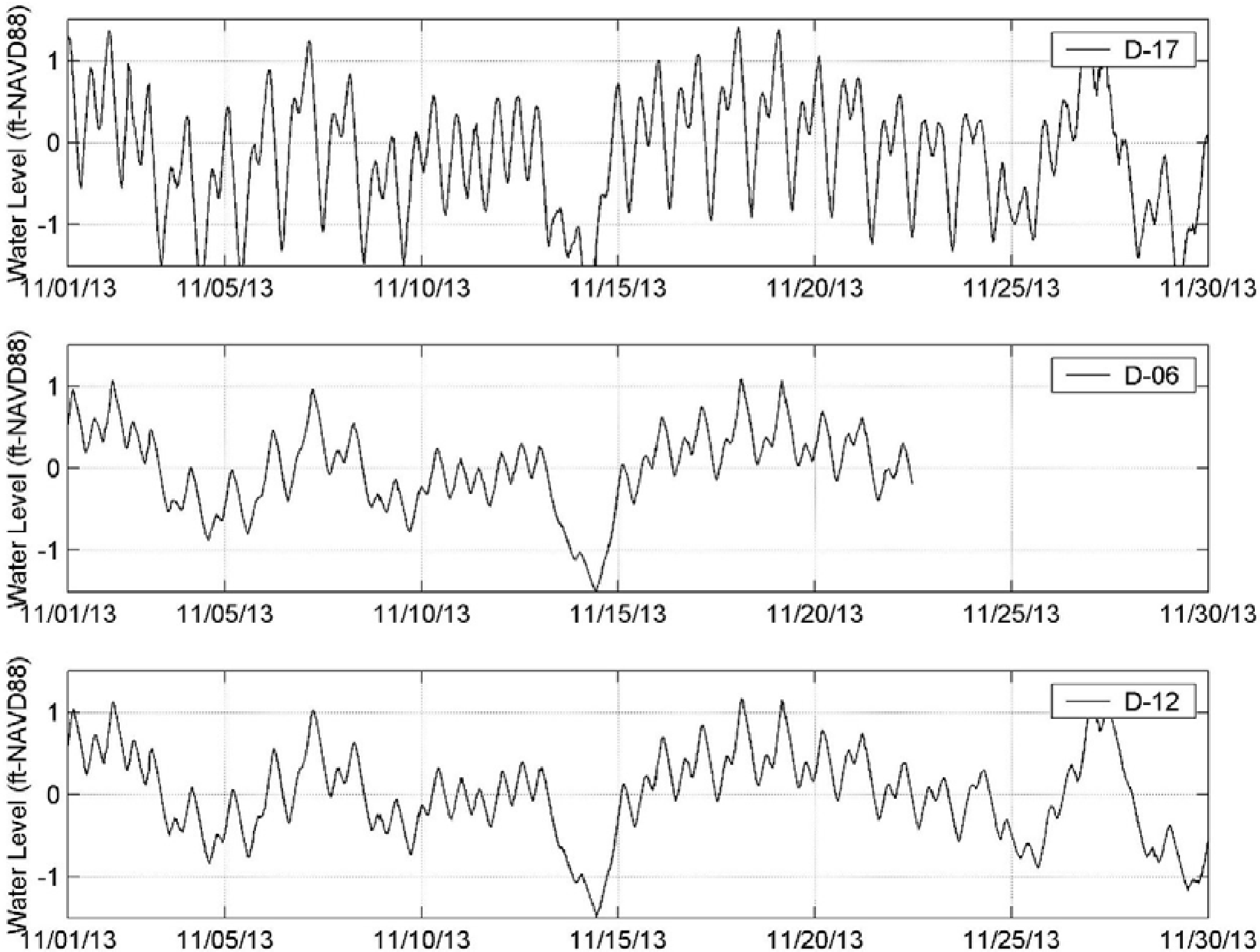
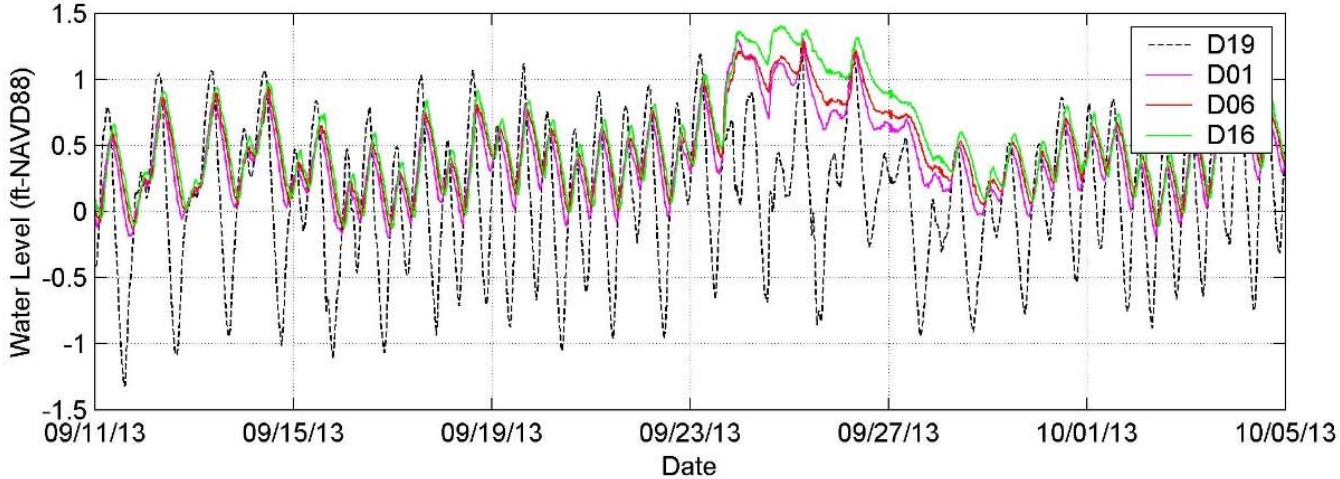


Figure 4-7. Measured Water Levels at D17, D06, and D12 (November 2013)



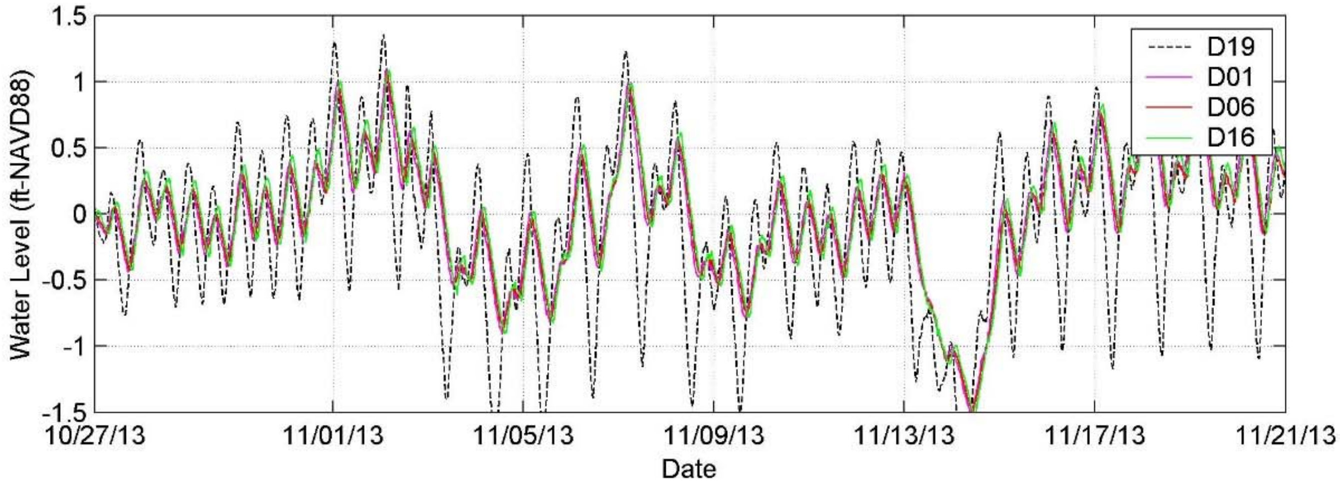


Figure 4-8. Comparison of Measured Water Levels during Wet (09/11/13 to 10/05/13) versus Dry Period (10/27/13 to 11/21/13)

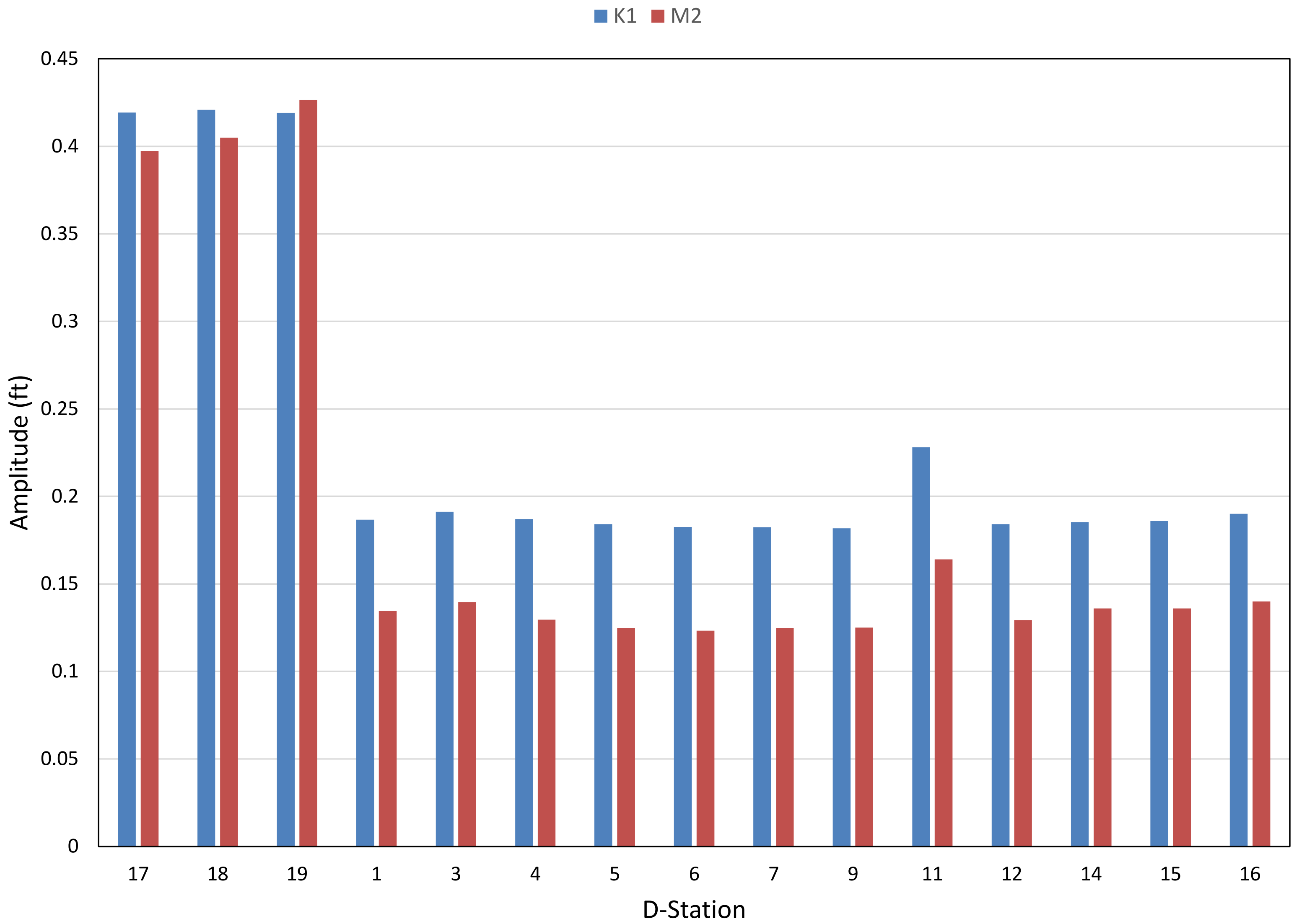


Figure 4-9. D-Station Tidal Amplitudes by Station

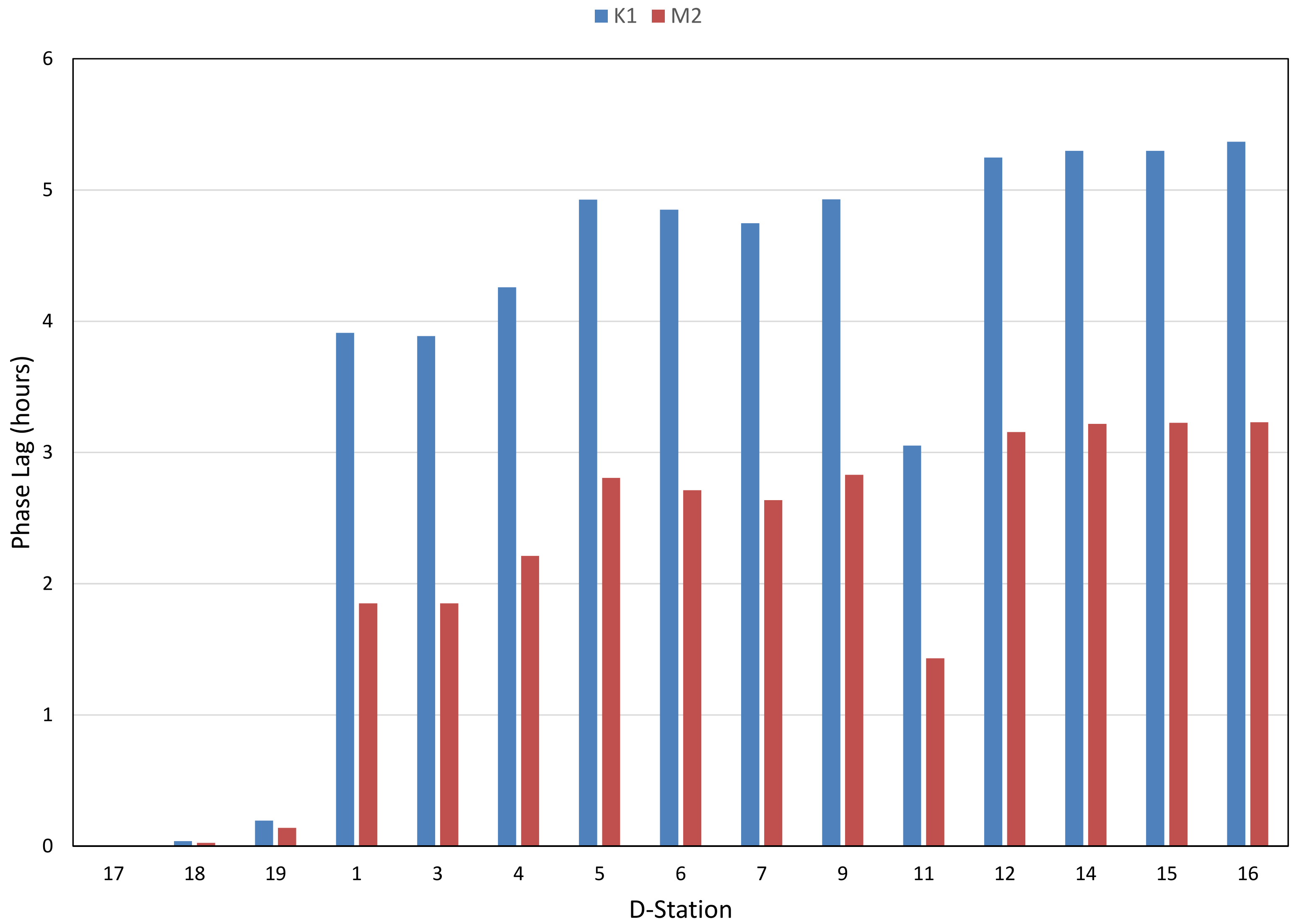


Figure 4-10. D-Station Tidal Phase Lag by Station

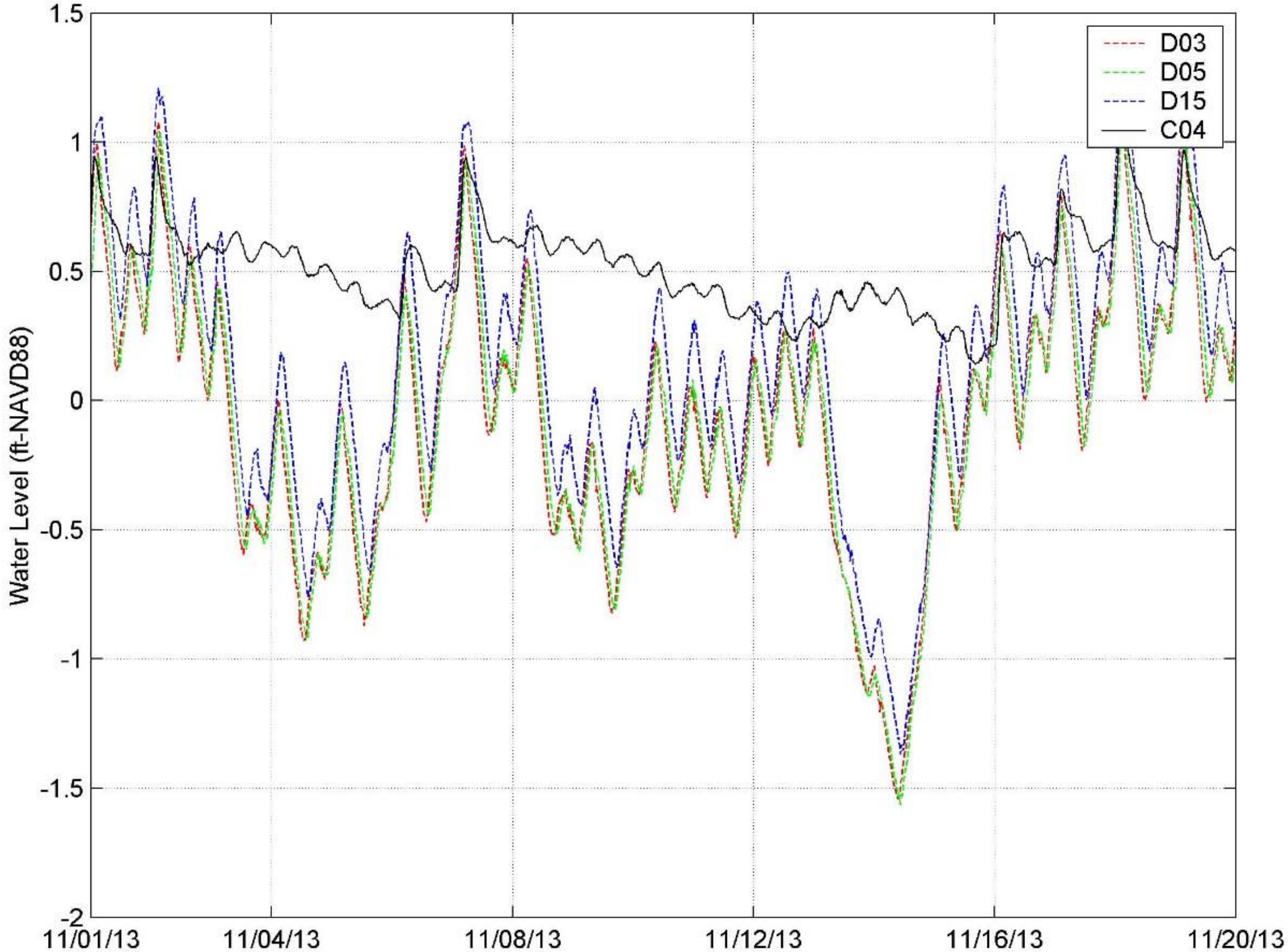


Figure 4-11. Measured Water Level at Station C04 versus D03, D05, and D15

4.3 USGS FLOW MEASUREMENTS

The following presents analyses of the USGS flow and water level data presented in Section 3. USGS collected data at six breaches and within the opening at the southern end from the end of August 2013 through the end of February 2014. The data analyses presented herein are limited to September 2013 through December 2013, since this period reflects overlap with the available D-station tide data and the measured flows over the weirs. This period contained hydrologic conditions from a wet period (September to mid-October) through a period of zero flow over the weirs (mid-October through December).

Figures 4-12 through 4-18 present measured water levels (referenced to NAVD88), measured flows, and residual water levels at each of the USGS stations for September 1, 2013 through October 10, 2013. This period was chosen as representative of wet conditions based upon the flows over the weirs presented in Section 4.1. The residual water levels were calculated by removal of the astronomical constituents discussed in Section 4.2. The remaining signal generally represents local meteorologically driven water level fluctuations or long-term (astronomical or meteorological) fluctuations within Matlacha Pass and/or the Gulf of Mexico. Figures 4-19 through 4-25 present the same data for the period from October 10, 2013 through November 30, 2013. This period represents dry or near zero freshwater discharge conditions. The flows are presented as positive and negative magnitudes of flow, with the convention being that flow into the NSC system is negative while flow out is positive.

Looking first at the flow magnitudes in Figures 4-12 through 4-18 (the wet period), the ebb flow (positive) at USGS-00 (Figure 4-12) ranges between 800 cfs to 1200 cfs during conditions outside of the highest flow event, while flood flows (negative) range between 800 cfs to 1500 cfs. The shape of the flow curves is typical of ebbing and flooding inlets, with the mixed flow durations reflective of shifts from semi-diurnal to diurnal tidal conditions typical of the Gulf of Mexico. Examination of the graphs shows that the flooding tide is shorter than the ebbing tide. This is consistent with the tidal inlet hydraulics discussion presented in Section 4.2 which stated "*Model studies (Mayor-Mora 1973) show that as K decreases (and superelevation increases) the duration of ebb flow increases relative to flood flow in the inlet channel*". During the high flow event that occurred between September 23 and September 30, flow is almost always directed out of the NSC (positive), with magnitudes reaching up near 1,500 cfs during ebb tide conditions.

Examination of the flows measured at USGS-01 (Figure 4-13) during the wet period, shows that ebb flow magnitudes range between 50 and 120 cfs, while flood flows range between 50 and 160 cfs. The overall shape of the ebb and flood curves are similar to what was seen at USGS-00, identifying that its behavior is similar. As with USGS-00, during the high flow event, discharge is almost always directed out of the NSC (positive), with magnitudes reaching up near 140 cfs.

Ebb and flood flow magnitudes at USGS-02 (Figure 4-14) during the wet period range between 50 to 100 cfs. The shape of the flow curve at USGS-02 is different than at USGS-00 and USGS-01, with a much more spikey, irregular shape. During the high flow event, while there are some periods where flows are coming in (negative), generally the flows are out of the NSC (positive).

Ebb flow magnitudes at USGS-03 (Figure 4-15), during the wet period, range between 50 to 200 cfs, while flood flows range between 50 and 120 cfs. As with USGS-02, the shape of the flow curves are different than at USGS-00 and USGS-01, with a much more spikey, irregular shape. During the high flow event, flows are always out of the NSC (positive), with magnitudes reaching near 270 cfs.

For USGS-04 (Figure 4-16), the residual water level is not presented due to the lack of data during some time periods not allowing a proper harmonic analyses and removal of the harmonic constituents. During the wet period, ebb and flood flows are small in relation to the other stations, with flows magnitudes generally less than 20 cfs. This is a function of the highly shallow nature of this connection. In the graph, there is a clear net inflow (negative) component of the signal. Even during the freshwater event, while inflow magnitudes are reduced, there is a very low net flow out of the NSC (positive), which is never much greater than around 8 cfs, even during the peak freshwater inflow period.

For USGS-06 (Figure 4-17), during the wet period, ebb and flood flow magnitudes are small, ranging between 10 to 20 cfs. The shape of the curves resembles what was seen at USGS-00 and USGS-01, suggesting a similar tidal inlet hydraulics response. This may be due to the direct connection of this portion of the KD to Matlacha Pass described previously.

During the high flow event, flows are always out of the NSC, with a peak magnitude near 40 cfs.

For USGS-07 (Figure 4-18), during the wet period, ebb and flood flow magnitudes range between 0 and 100 cfs. One key aspect of the flows measured at USGS-07 is the short period spikes that occur where flow magnitudes can double from the typical conditions. During the high flow event, there is a strong net flow out (positive) of the NSC, with magnitudes reaching up to 450 cfs. This station shows the largest impact of the freshwater flows on the overall flow magnitudes.

Looking at the measured flows and water levels during the dry period (Figures 4-19 through 4-25) identifies a key component of how tidal exchange and, ultimately, any exchange, works between the NSC and the adjacent waters (KD and Matlacha Pass). Looking at the water levels during this period, particularly the residual water level, there is a high degree of fluctuation of the mean water level over this 40-day period in comparison to the mean water levels during the wet period. There is a significant period of time when the mean water levels drop below 0 ft-NAVD88, which was not seen in the wet period. Looking at the measured flows at USGS-02 through USGS-07, there is a distinct correlation between the magnitude of flow and the mean water level. This difference in magnitude does not appear to be related to spring versus neap tides, but rather the mean water level. When water levels are down, there is a direct drop off in the overall flow magnitude that jumps up significantly when the mean water level rises. Analyses of the data, in conjunction with the areas of the KD to which the breaches connect, identified that during the low water level periods (for USGS-02 and USGS-03 which flow into KD1 and KD2, respectively), the flow magnitudes reflect the area of the KD section being filled. As the mean water levels rise, the magnitude of the flows is much larger, indicating interaction and exchange with areas other than the direct KD section, i.e., filling and draining of adjacent areas around the KD sections. In essence, the data identify that the volume of water passing any specific breach changes with the mean water level as new areas adjacent to the KD or connections with Matlacha Pass come online. This is a key component of the system to understand as the ultimate transport, movement or passage of water is highly dependent on the mean water level at that time, and the distribution of where fresh water entering the system will go also depends upon this aspect. Therefore, any model simulation of the exchange must take this phenomena into account to simulate the flow through the breaches and the ultimate exchange with Matlacha Pass.

Figures 4-26 and 4-27 present comparative plots of the flows within each of the breaches during a zero flow period (November 1, 2013 to November 7, 2013) and the freshwater event period (September 22, 2013 to October 1, 2013). Two plots are presented for each time period. One (top plot) includes USGS-00 and the other (bottom plot) does not include USGS-00. This allows an assessment of the comparative magnitude of the USGS-00 flow to the others, while also allowing for a larger scale view of only the breach flows to compare their flow magnitudes and characteristics.

Looking first at the dry period (Figure 4-26), the plot demonstrates an important aspect of the system hydrodynamics. Looking at the flow directions (negative being in and positive being out) during a rising tide (flood), USGS-00, USGS-01, USGS-06, and USGS-07 flow in, while on a falling tide, they flow out. In contrast, during a rising tide, USGS-02 and USGS-03 flow out, and on a falling tide, flow in. The explanation for this is that USGS-00 and USGS-01 respond directly to the Matlacha tides moving in through the lower end and passage is in during a rising tide. USGS-02 and USGS-03 pass flow out as they fill the volume of the KD sections (KD1 and KD2) they are connected to and, at times, fill additional area, depending upon the mean water level. This was supported by the water level measurements at D05 and D06, which showed the tide phases moving into and out of KD2. USGS-06 and USGS-07 flow in during a rising tide due to the direct connection to Matlacha Pass, identified in Section 4.2. The phasing of this direct connection leads the phasing of the tidal wave progressing up the NSC, causing the inflowing condition during a rising tide.

Another key aspect that can be seen in the plots is that when mean water levels are higher, the volumes of flow passing USGS-02 (Breaches 10/11), USGS-03 (Breach 8), USGS-06 (Breach 4) and USGS-07 (Breach 1A) are much larger. This indicates that other connections (the remnant tidal creeks seen in the aerial photos and adjacent mangrove areas) come online between the KD and Matlacha Pass and cause a greater volume of water to pass into and out of the NSC through the KD.

The general ebb/flood flow distribution between the breaches identified above (i.e., USGS-02 and USGS-03 showing differing flow directions) can also be seen during the wet period when the freshwater inflows are not too large (Figure 4-27). When the freshwater inflow then becomes big enough, it overwhelms the tidal signal for most of the stations. It is interesting to note that only for a very short period is the tidally driven flow at USGS-02 overwhelmed by the freshwater inflow. Very quickly, this signal returns to the condition where its flow is opposite the other USGS stations. As the data show, the complex nature of the ebb/flood conditions within the breaches is a critical aspect of the overall flow and exchange that must be taken into account in any model simulations to properly assess the relative distribution of flow between the NSC and Matlacha Pass.

To assess the net flows and to provide an evaluation of the relative net discharge between the breaches and the southern opening, the USGS flow data were filtered to remove the tidal components of the signal. A Godin filter was utilized for the removal of the tidal signal. This is the standard method USGS utilizes for filtering tidal discharge measurements. The filtering of the signal provides daily net discharge values. Figure 4-28 presents plots of the filtered flows. The top plot presents all of the USGS station results, including USGS-00. The bottom plot presents all of the stations except USGS-00, to allow a smaller scale view of the other station results. The plots show the time-dependent net discharge through each breach in comparison to the net discharge through the south end. The transition between the wet period to the dry period can be seen in the plots with conditions occurring during the dry period where there are extended periods of net inflow and net outflow due to set up and set down in Matlacha Pass. Looking at the bottom plot, the results show clear periods where some of the breaches show net inflow, even while others are showing a net outflow.

Figure 4-29 presents plots of the cumulative flow calculated from the daily filtered values presented in Figure 4-28. The plots present the cumulative volumes in acre-ft. The plot in Figure 4-29 can be broken down into three somewhat distinct time periods. The first period (Period 1) includes from September 1 up to the large flow event which occurred on September 24. During this time, total flow over the weirs ranged around 400 to 500 cfs and remained relatively constant. The second period (Period 2) starts on September 24, when a high rainfall event caused total flows to jump to near 2,300 cfs and then steadily drop to about 500 cfs around September 29. Following the event (after September 29th – Period 3), flows generally drop, until they reach near 0 around the end of October.

Looking at the cumulative flow plots shows that during Period 1, four of the flow stations show net outflow (positive slope). This includes USGS-00 (station at southern end on NSC near former barrier), USGS-01 (Ceitus Creek, Breach 12), USGS-06 (Breach 4), and USGS-07 (Breach 1A). During that same time period, USGS-02 (Breach 10/11) and USGS-03 (Breach 8) show net inflow. This is important because during that period, the total freshwater inflows are well above the overall averages for the system. During Period 2, all of the stations show a net outflow (positive slope). Following the large freshwater inflow event, the stations level off and, through the dry months, some of the stations show a net inflow (negative) slope, with the greatest net inflow seen for USGS-02 and USGS-03.

To compare the total net flows measured at the breaches and the southern end with the volumes passing over the weirs, the daily flow values from the USGS measurements and from the weirs were summed to produce total net volumes over specified periods. For the analyses, the summations were done for each month (September through December) and then for the high flow event (September 23 to September 30). Table 4-2 presents the summed weir flows. The results are presented as total acre-feet of discharge for the period of the analyses.

Table 4-2. 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**

Table 4-3 presents the results for the USGS stations. Looking first at the totals, the weir discharges, for the most part, are larger than the net flows calculated at the USGS stations. For September, the weir flow measurements are 19 percent higher. For October, they are 68 percent higher. For the dry months (November and December), the weir flows show net volumes flowing into the system, while the USGS stations show net inflow. The total volumes for both cases are relatively small. For the freshwater inflow event (September 23 to September 30), the weir flows are actually 4 percent lower. It should be noted here that errors in the weir flows are expected, given how the flow calculations were made and the assumptions needed (see discussion in Section 3.3). These potential errors should be taken into account when comparing the net flows. In general, the percent difference in total volume between the weir flows and the net flows calculated at the USGS stations increase as the measured flow values decrease. While the data set for comparison is limited, the smallest percent difference is seen where the largest flows are being measured (during the event) and seem to increase as the flows being measured get smaller, i.e., for September (wet period), October (transition from wet to dry), and then November and December (dry period). There are a number of potential reasons for the discrepancy between total volumes measured over the weirs and the volumes measured by the USGS stations, including:

- Error in the measured weir flows or USGS flows,
- Inflow/outflows through other minor breaches or connections,
- Overbank flow into or out of the NSC, or
- Seepage out of the NSC due to head generated by super-elevation of the interior canals and NSC.

Table 4-3. 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**

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. The distribution of the flows during the wet period is illustrated in Figures 4-30 and 4-31. These graphics provide an aerial view of the system, with scaled vectors showing the net flow volumes passing the USGS stations and flowing over the weir structures for the month of September and the event (September 23 to 30), respectively.

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. Figure 4-32 presents an illustration of the net flow patterns during a dry period (December).

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 1,087 acres, this would equate to 181 acre-ft. While a potential contributor, this does not take into account the total net inflow volumes presented in Table 4-3.

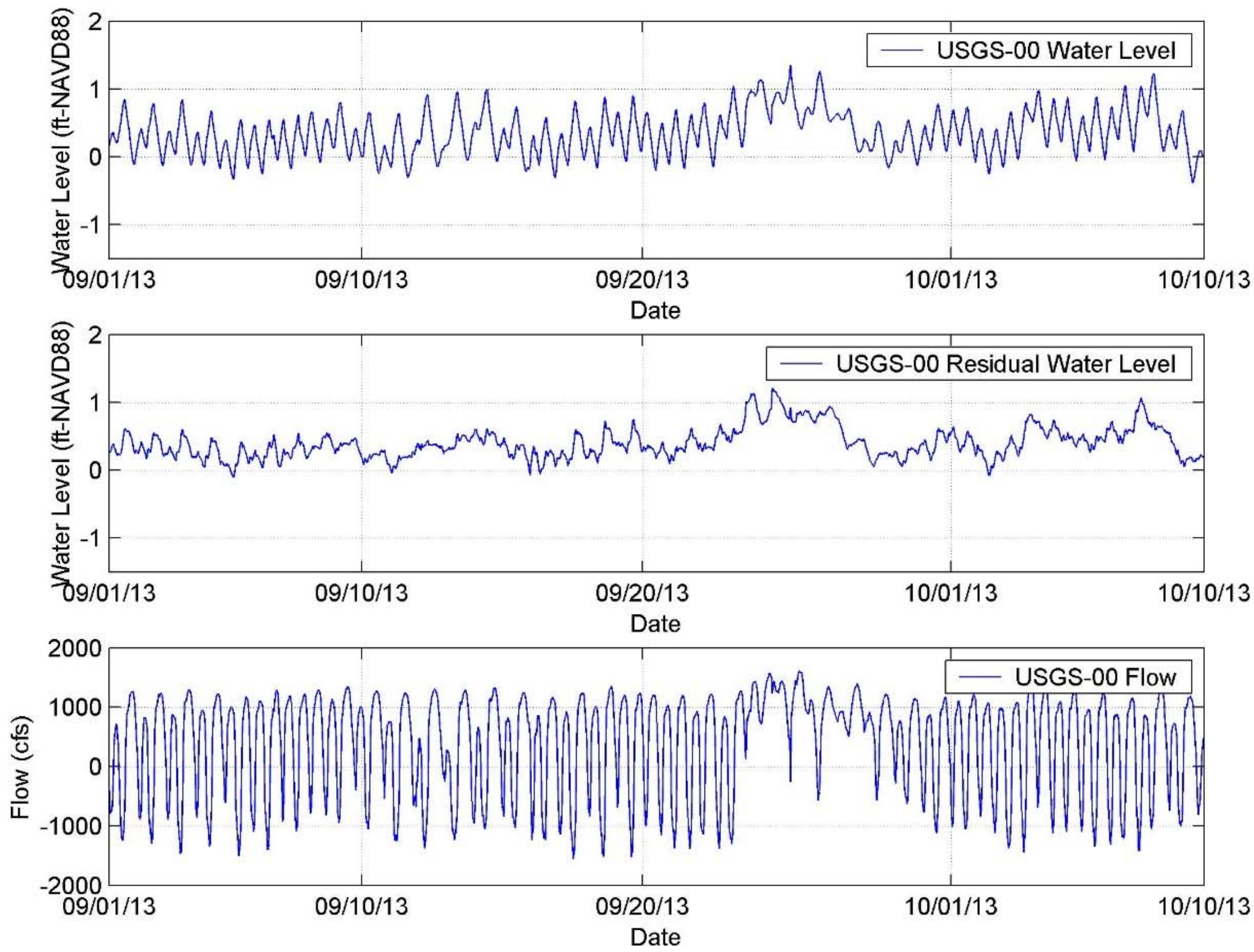


Figure 4-12. *Measured Water Level, Residual Water Level, and Flow at USGS-00, 9/1/13 to 10/10/13 (positive = out of NSC, negative = into NSC)*

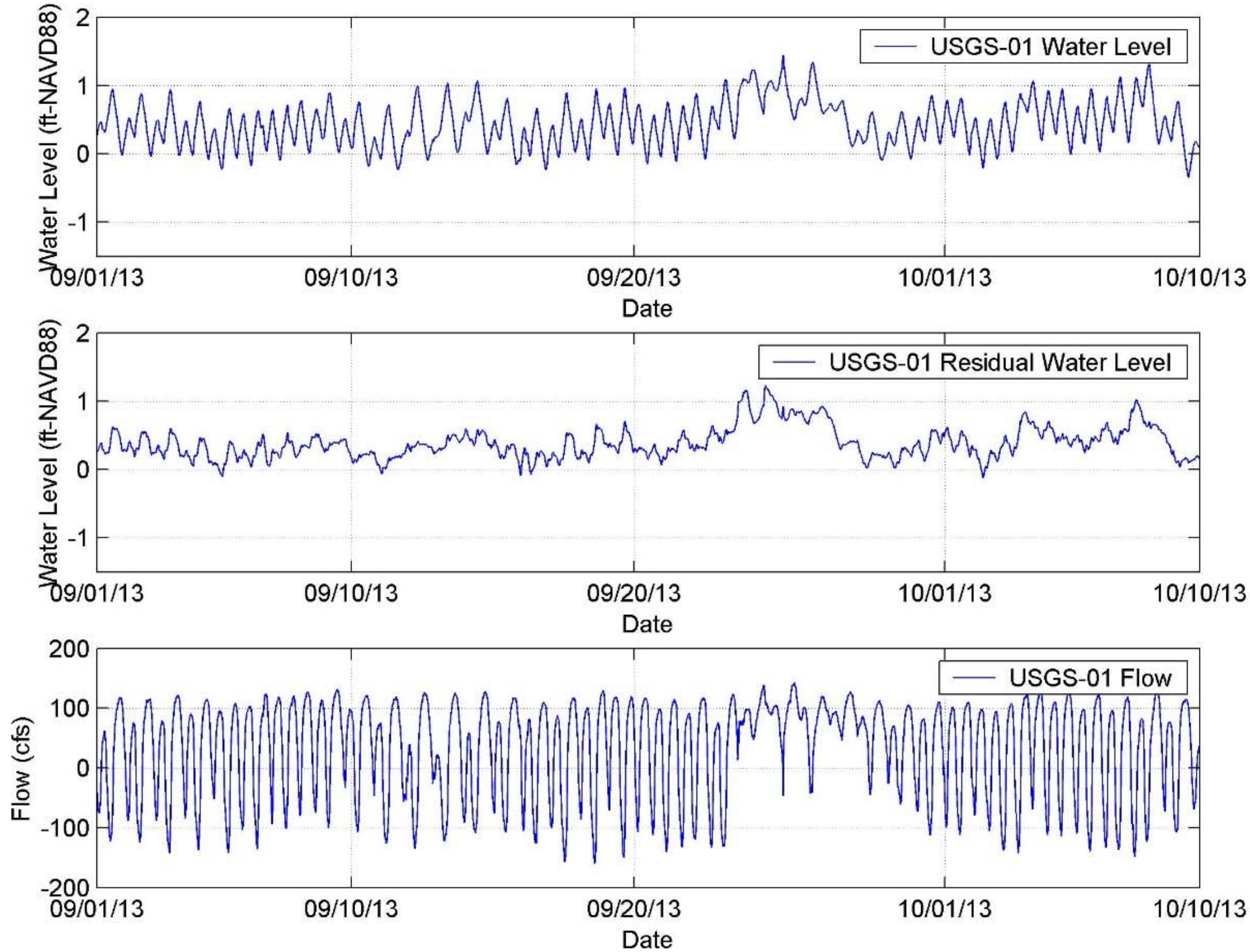


Figure 4-13. Measured Water Level, Residual Water Level, and Flow at USGS-01, 9/1/13 to 10/10/13 (positive = out of NSC, negative = into NSC)

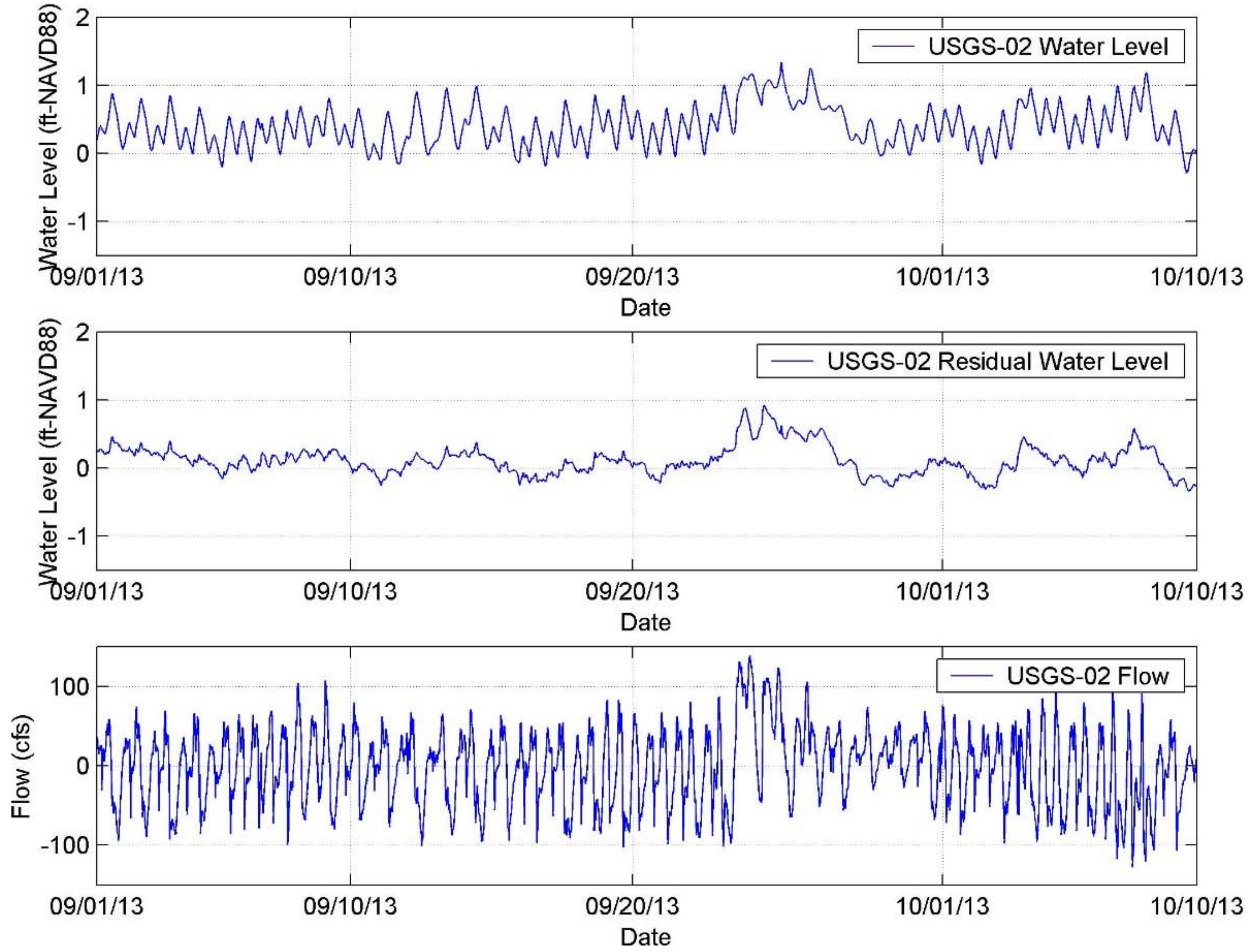


Figure 4-14. Measured Water Level, Residual Water Level, and Flow at USGS-02, 9/1/13 to 10/10/13 (positive = out of NSC, negative = into NSC)

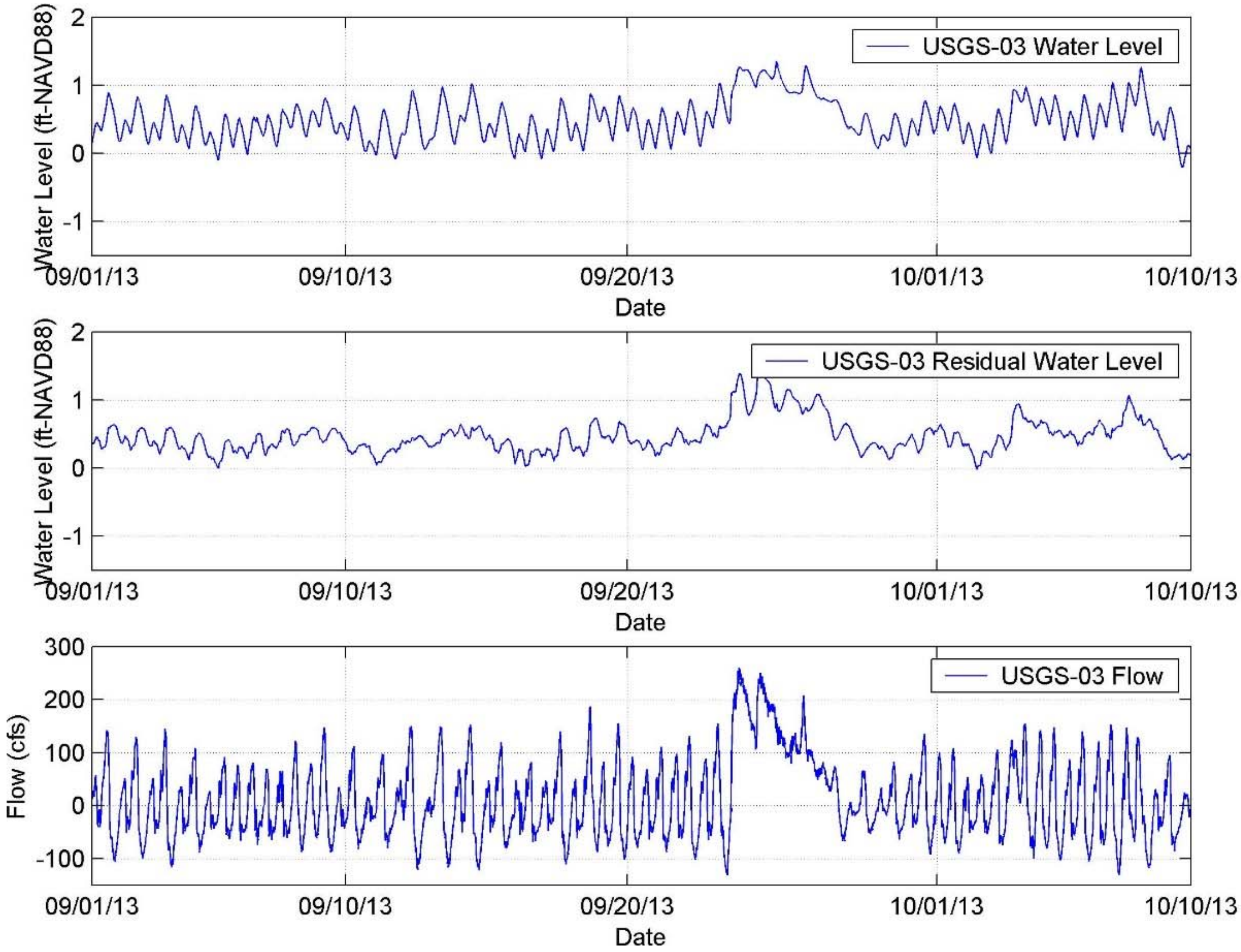


Figure 4-15. Measured Water Level, Residual Water Level, and Flow at USGS-03, 9/1/13 to 10/10/13 (positive = out of NSC, negative = into NSC)

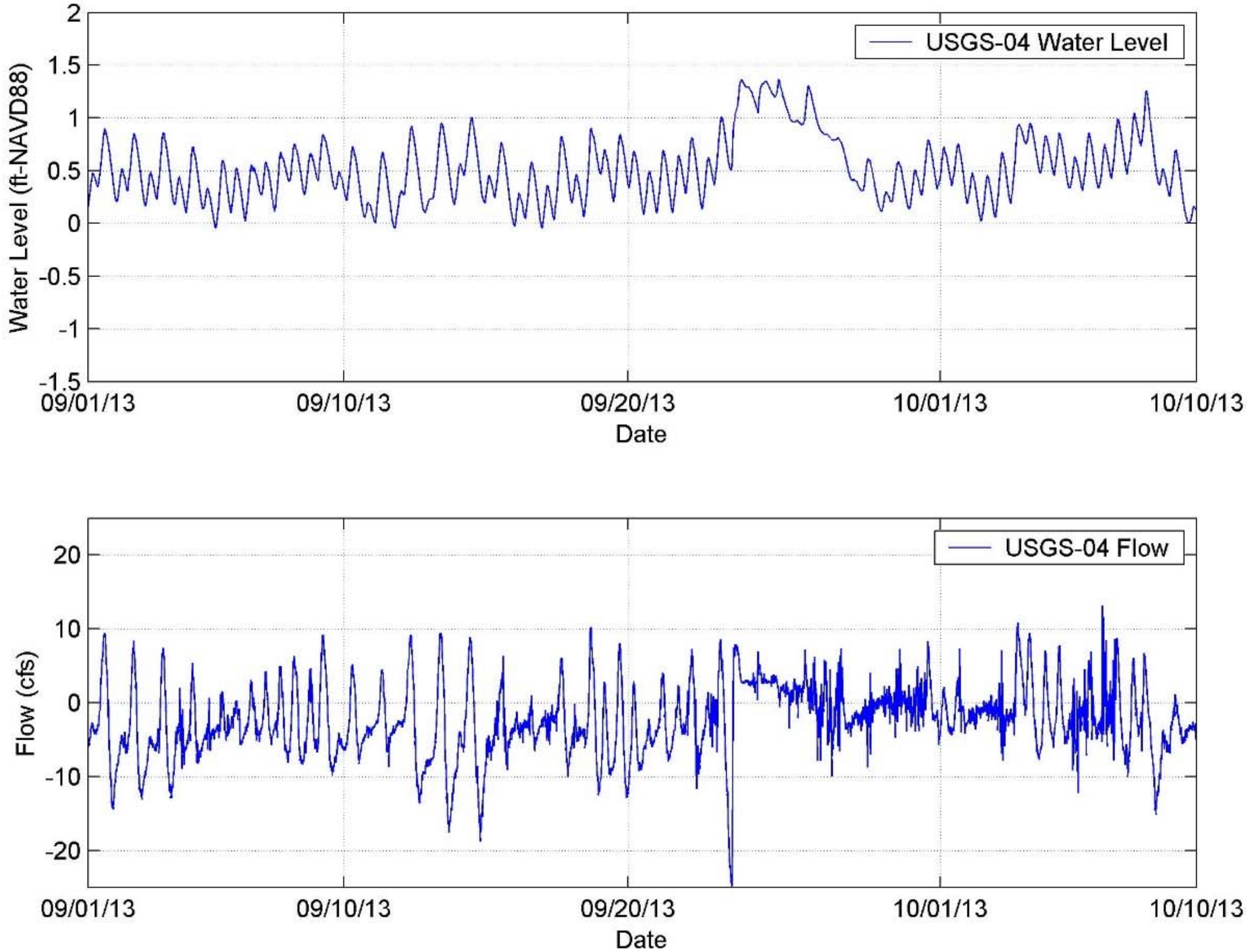


Figure 4-16. Measured Water Level and Flow at USGS-04, 9/1/13 to 10/10/13 (positive = out of NSC, negative = into NSC)

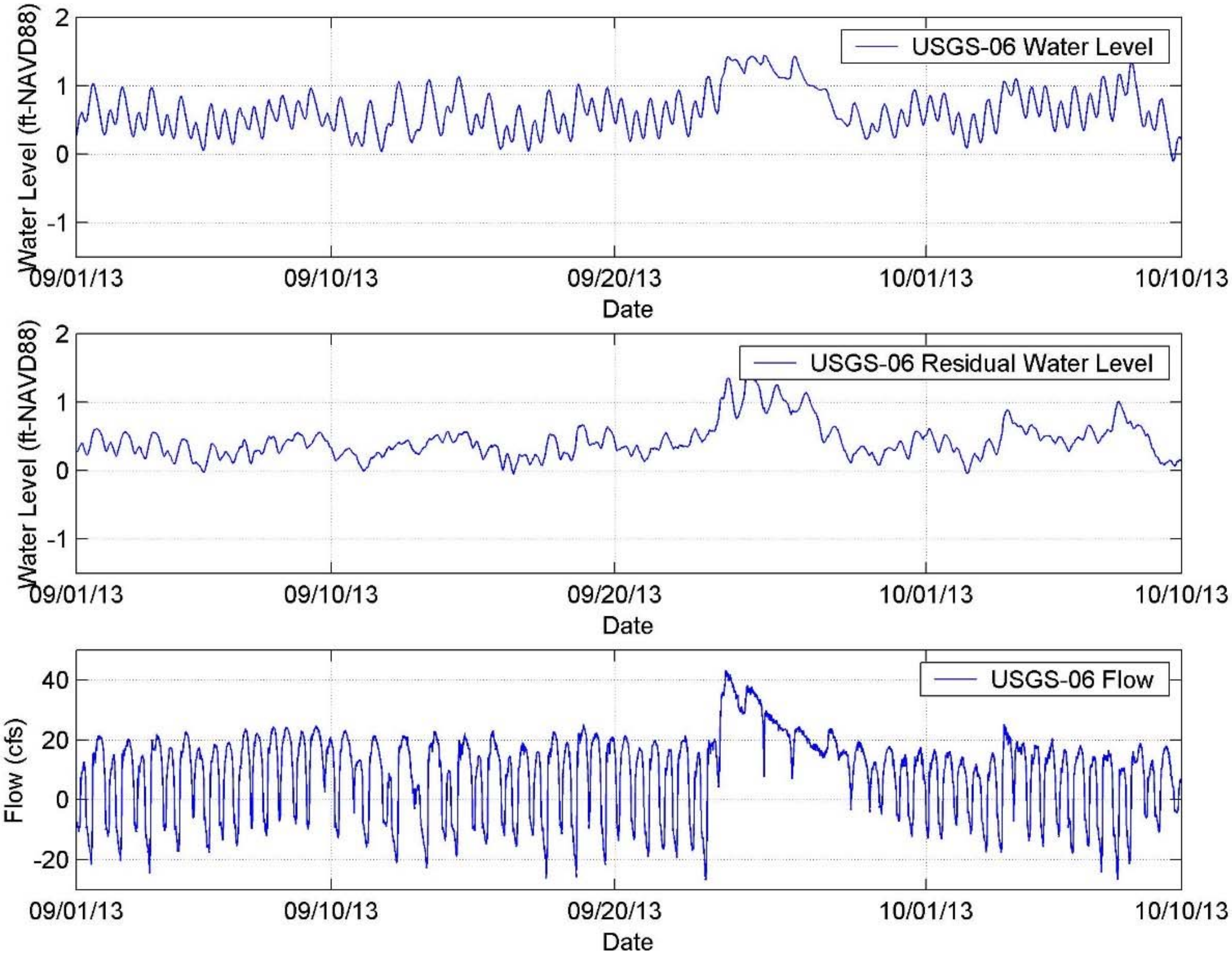


Figure 4-17. Measured Water Level, Residual Water Level, and Flow at USGS-06, 9/1/13 to 10/10/13 (positive = out of NSC, negative = into NSC)

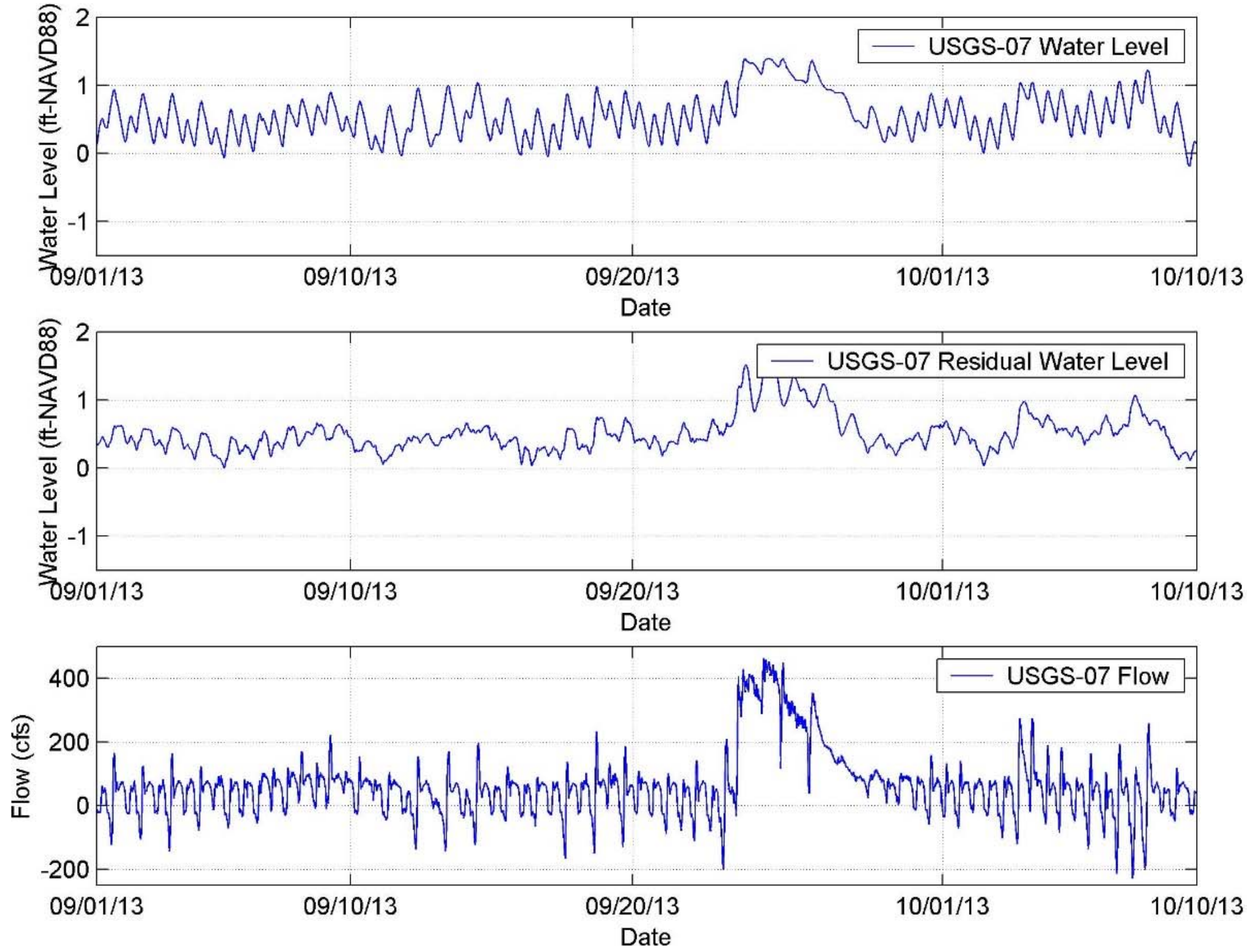


Figure 4-18. Measured Water Level, Residual Water Level, and Flow at USGS-07, 9/1/13 to 10/10/13 (positive = out of NSC, negative = into NSC)

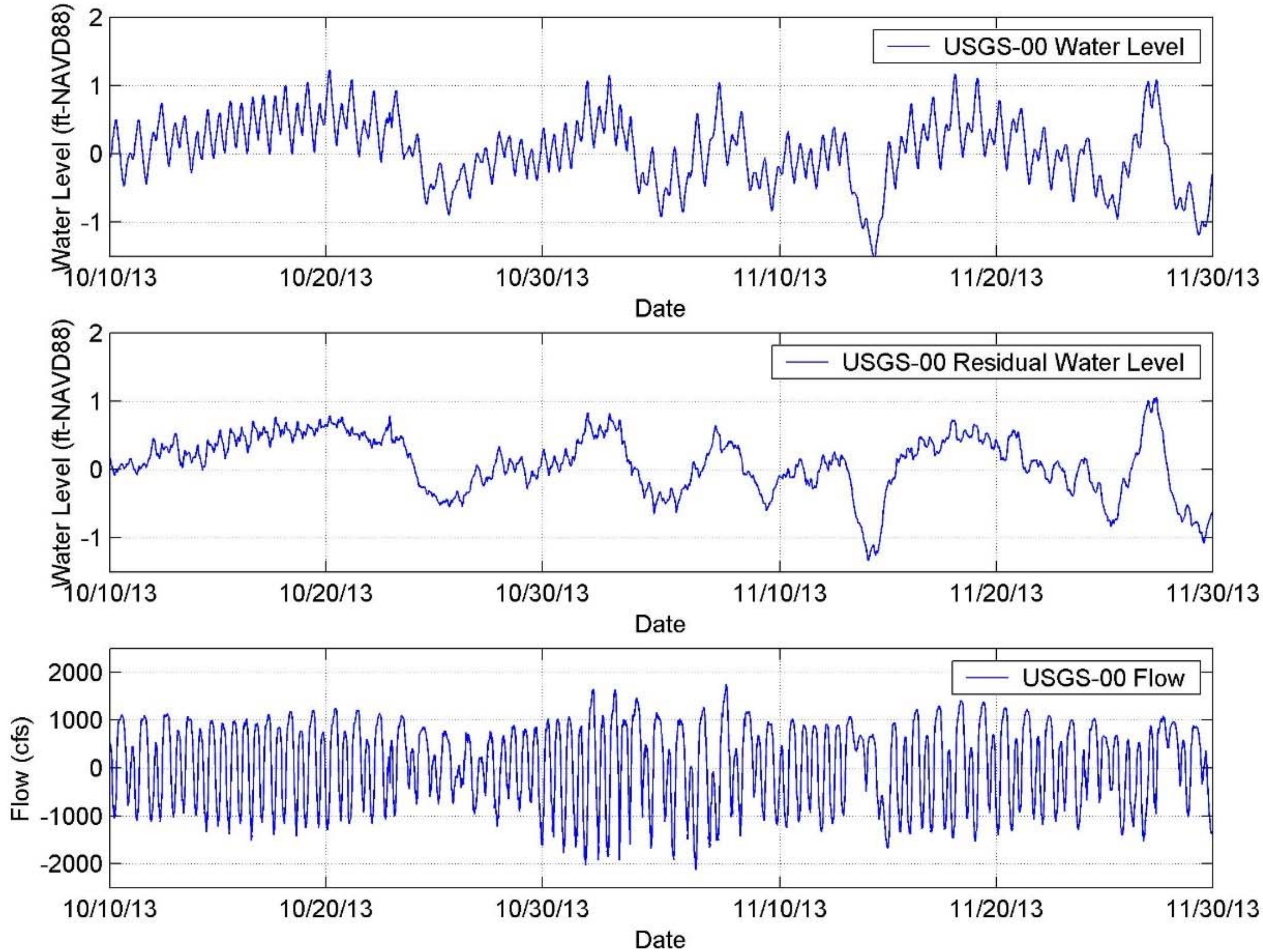


Figure 4-19. Measured Water Level, Residual Water Level, and Flow at USGS-00, 10/10/13 to 11/30/13 (positive = out of NSC, negative = into NSC)

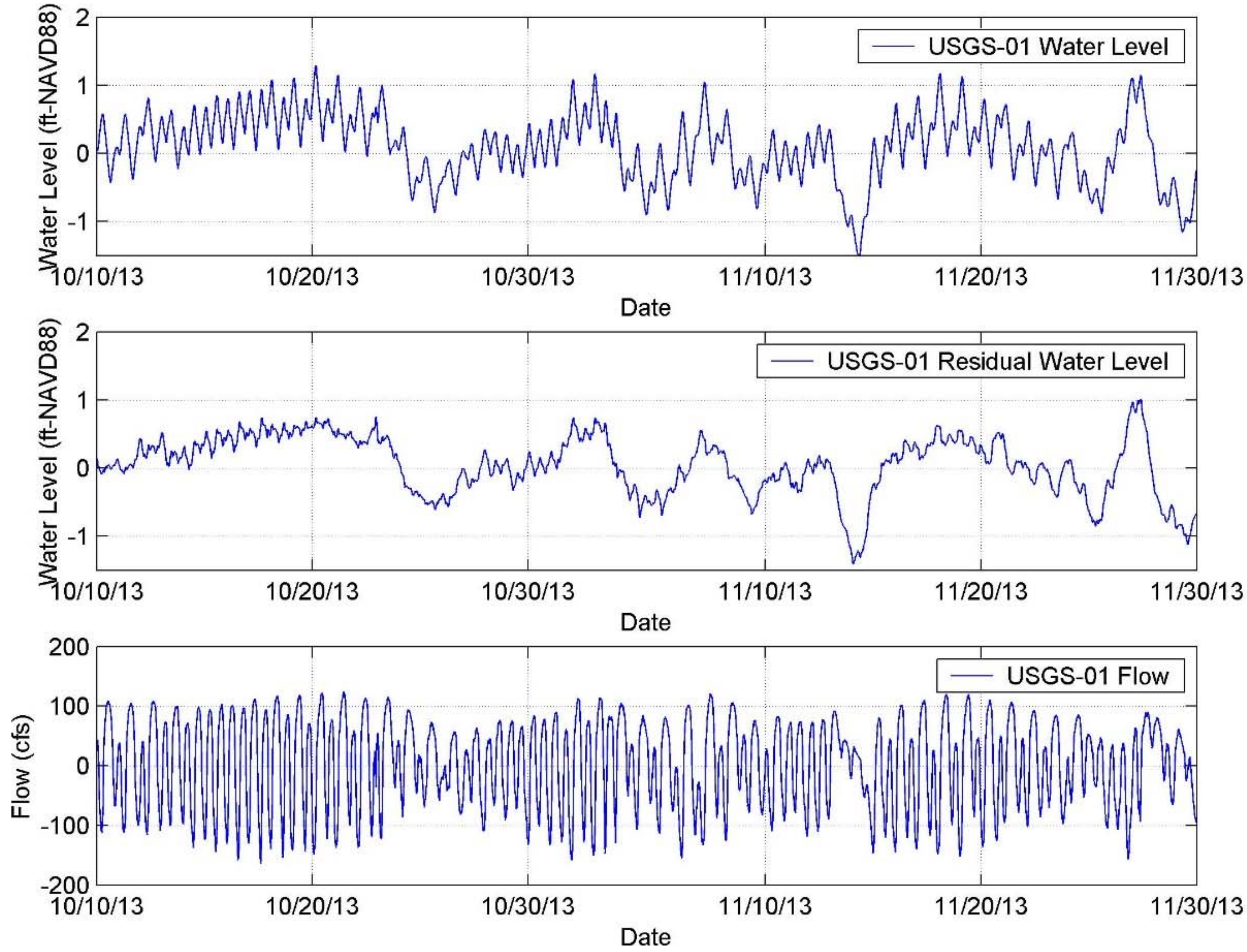


Figure 4-20. Measured Water Level, Residual Water Level, and Flow at USGS-01, 10/10/13 to 11/30/13 (positive = out of NSC, negative = into NSC)

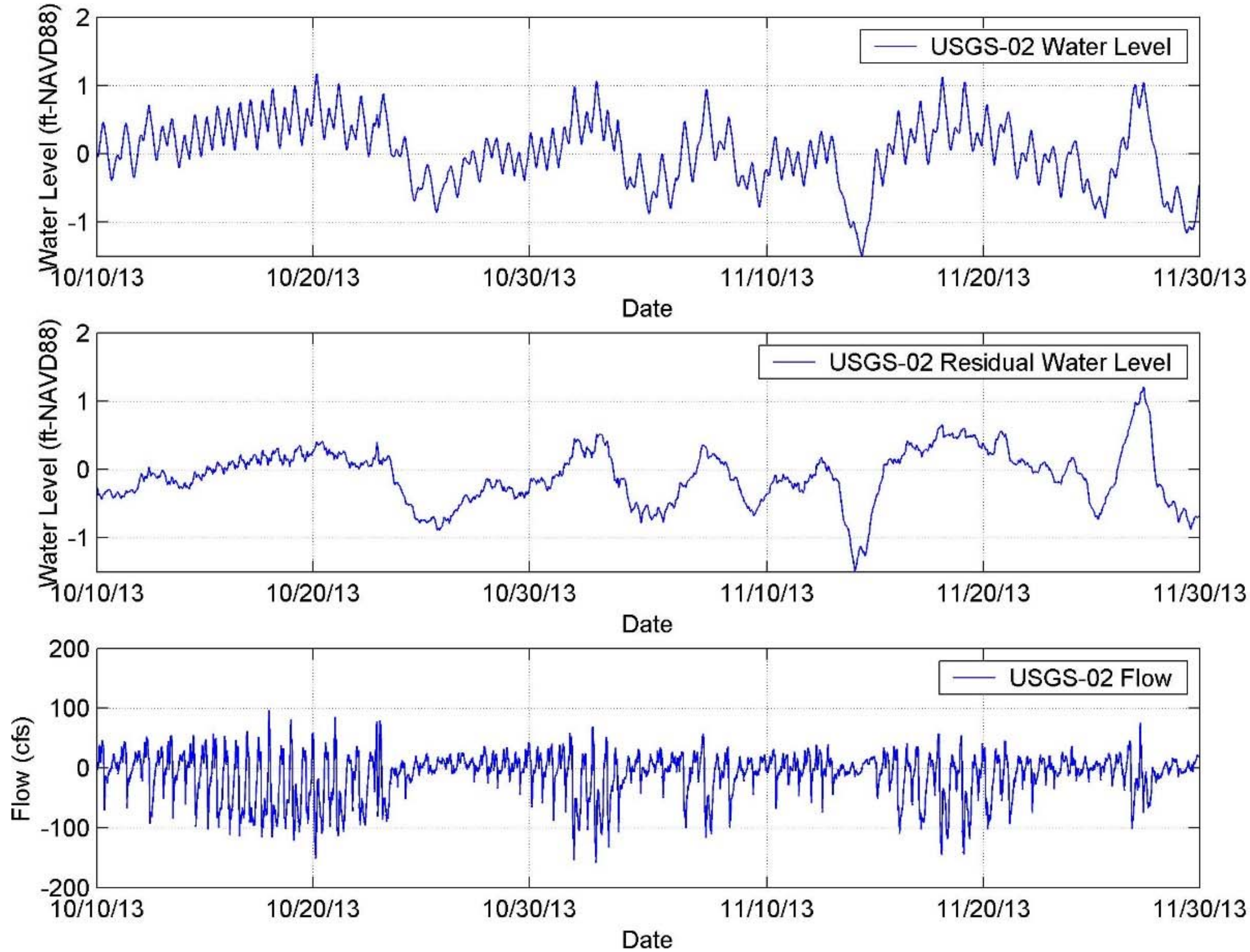


Figure 4-21. Measured Water Level, Residual Water Level, and Flow at USGS-02, 10/10/13 to 11/30/13 (positive = out of NSC, negative = into NSC)

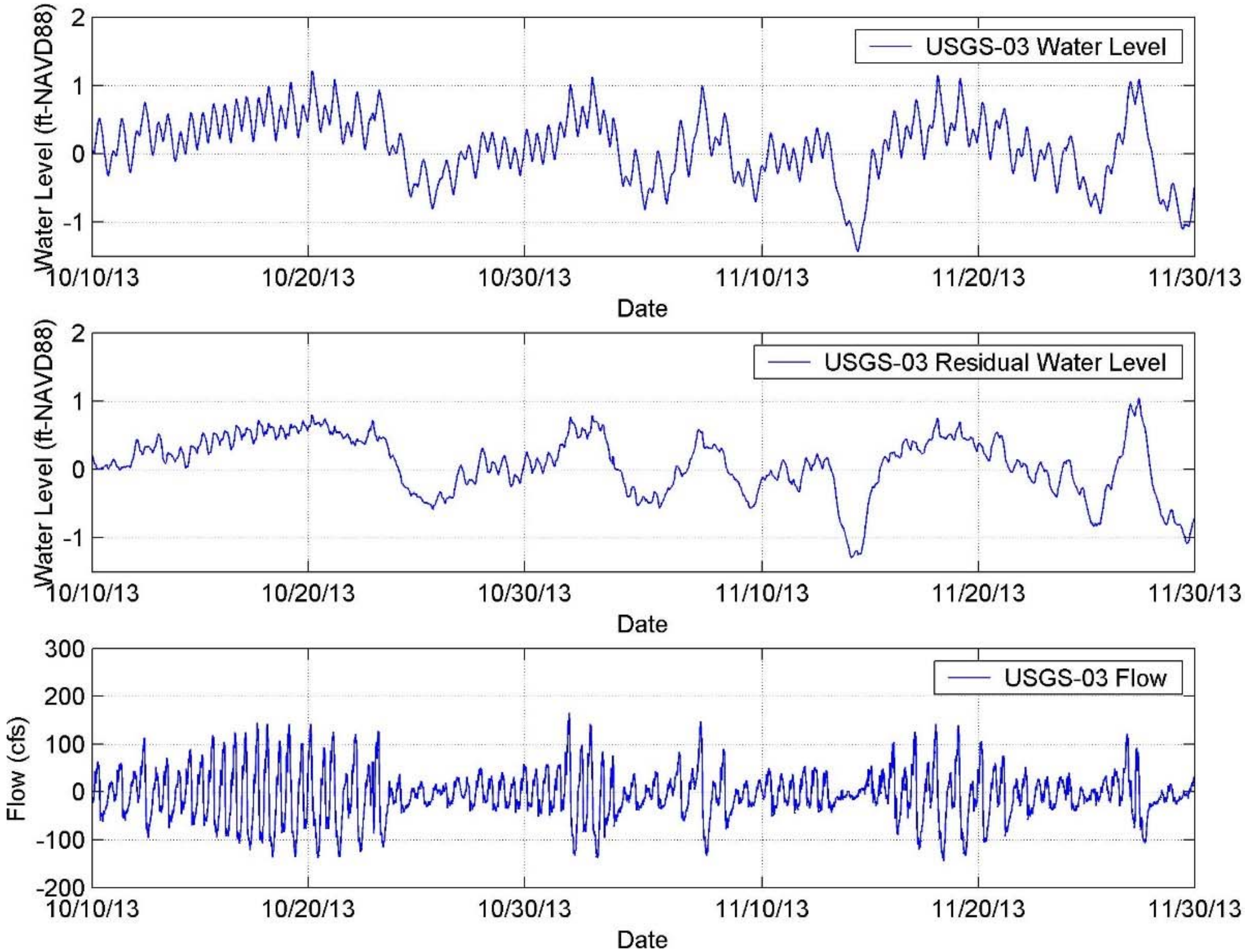


Figure 4-22. Measured Water Level, Residual Water Level, and Flow at USGS-03, 10/10/13 to 11/30/13 (positive = out of NSC, negative = into NSC)

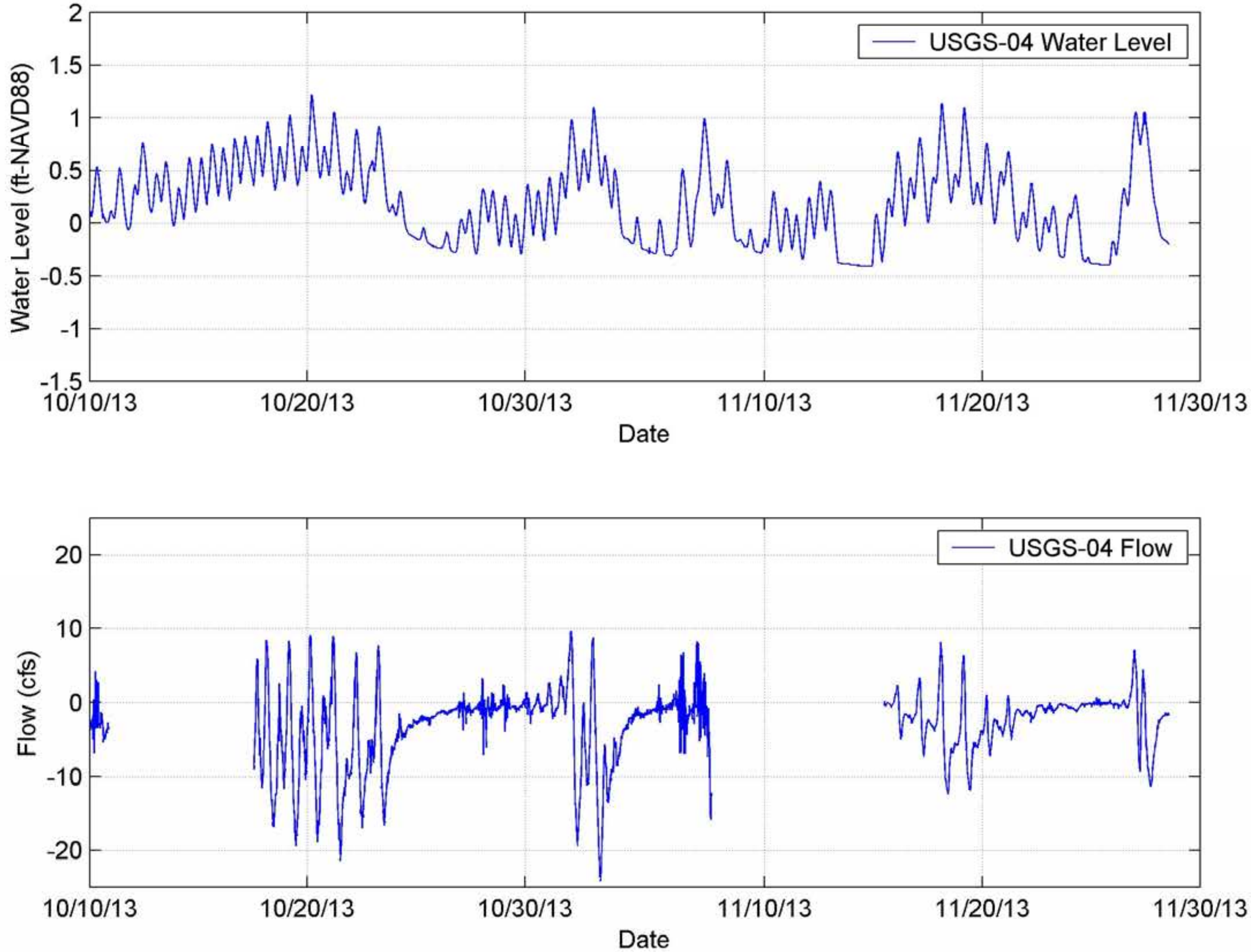


Figure 4-23. Measured Water Level and Flow at USGS-04, 10/10/13 to 11/30/13 (positive = out of NSC, negative = into NSC)

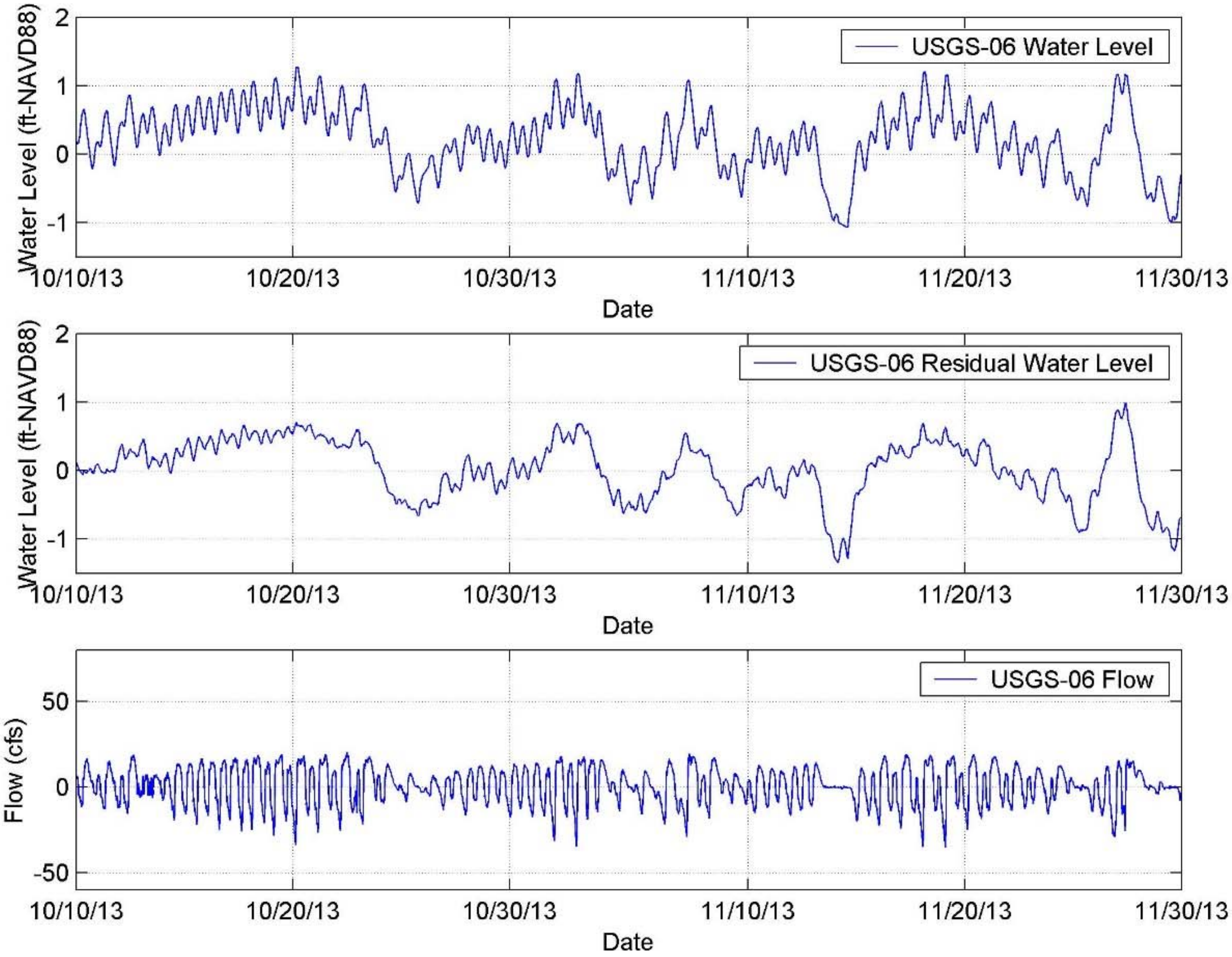


Figure 4-24. Measured Water Level, Residual Water Level, and Flow at USGS-06, 10/10/13 to 11/30/13 (positive = out of NSC, negative = into NSC)

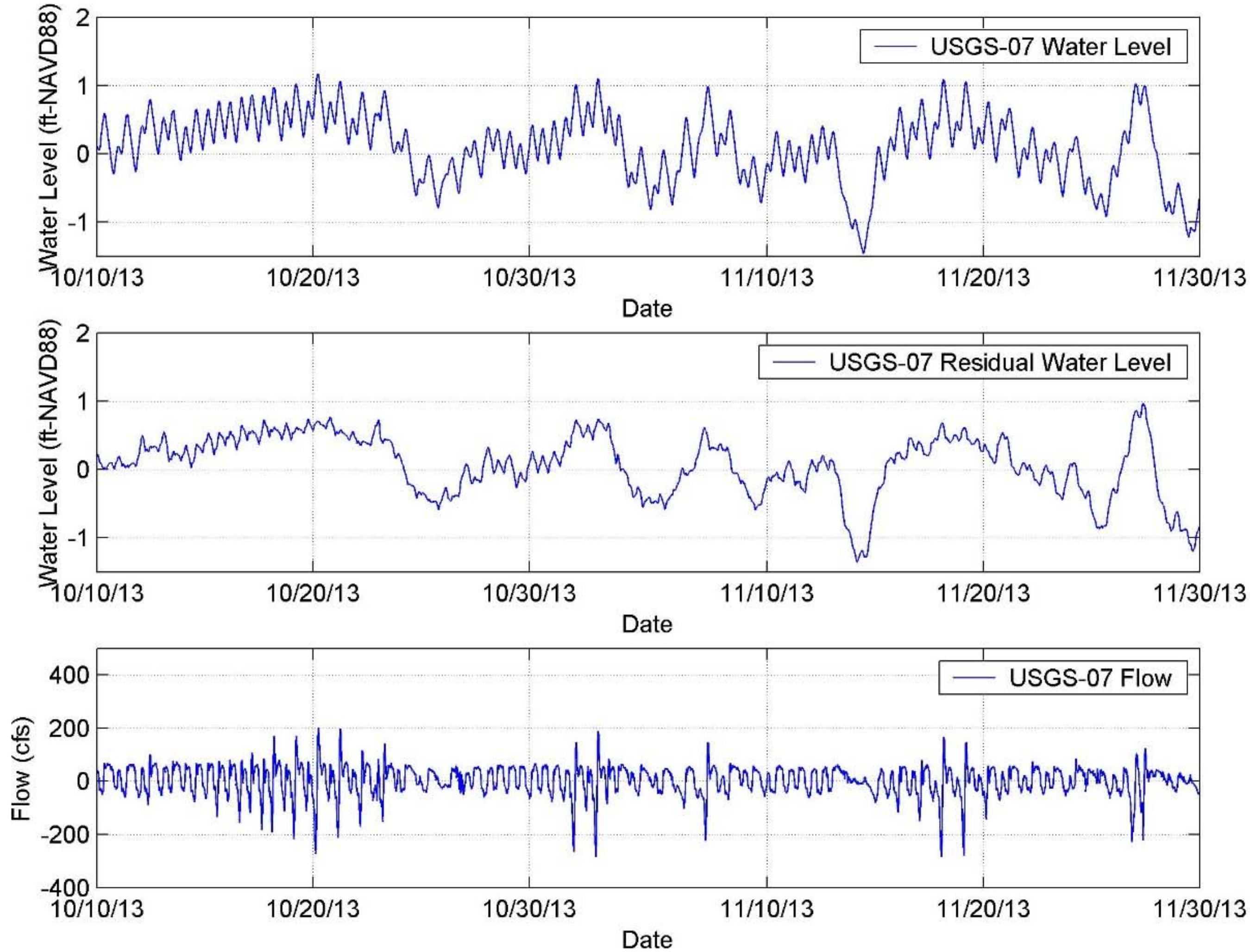


Figure 4-25. Measured Water Level, Residual Water Level, and Flow at USGS-07, 10/10/13 to 11/30/13(positive = out of NSC, negative = into NSC)

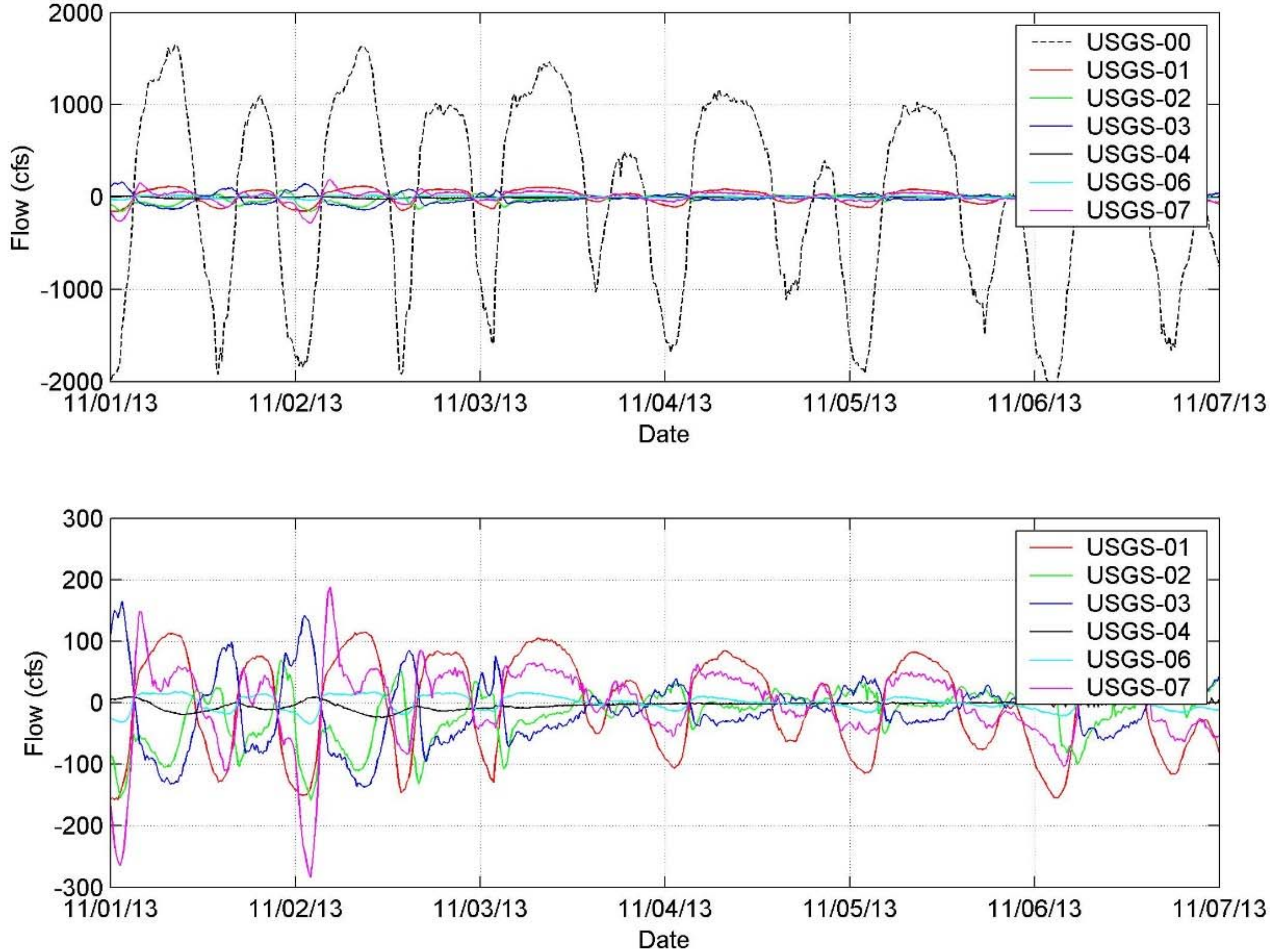


Figure 4-26. Comparison of Measured USGS Flows (Dry Period)

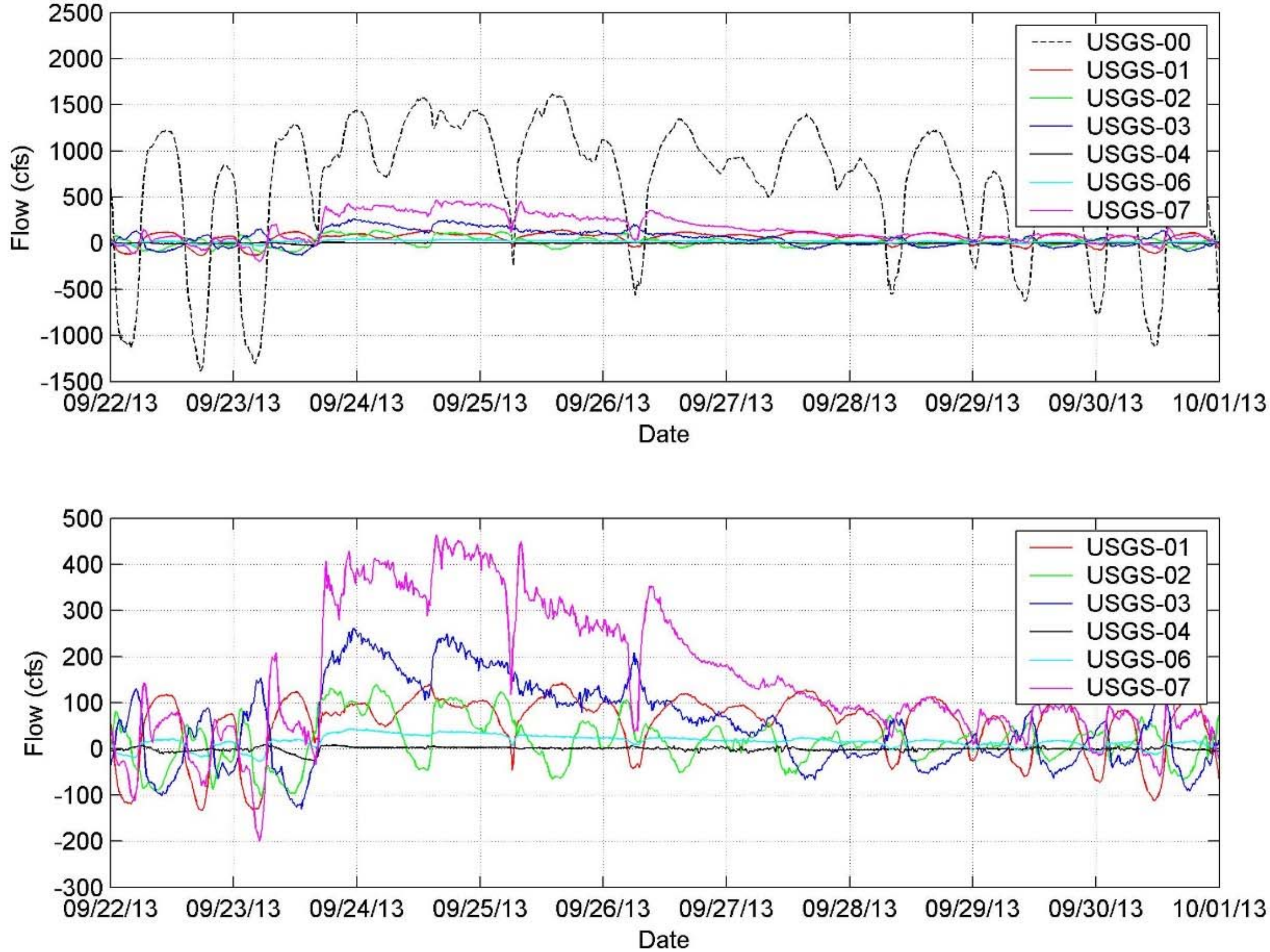


Figure 4-27. Comparison of Measured USGS Flows (Wet Period)

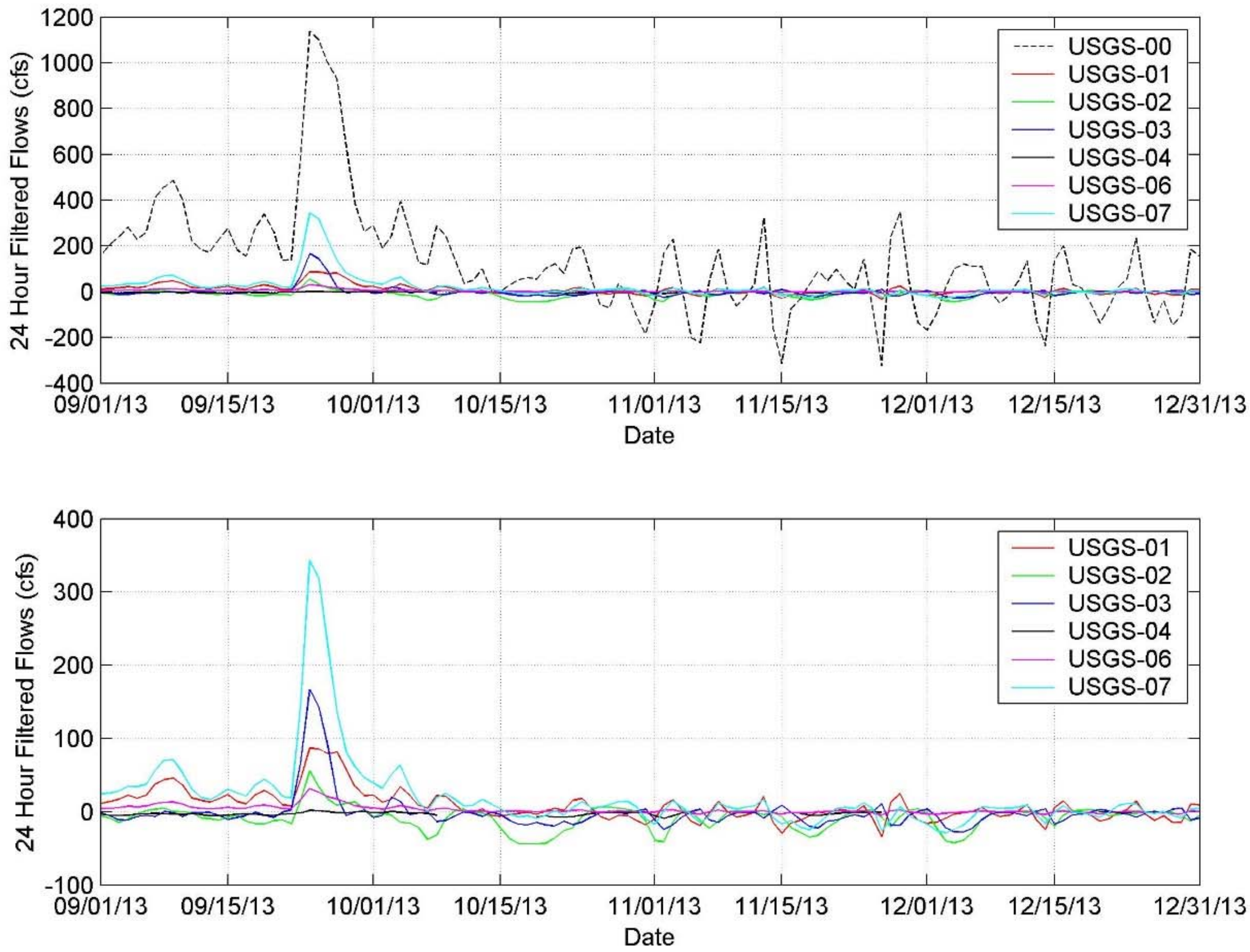


Figure 4-28. Filtered Flows

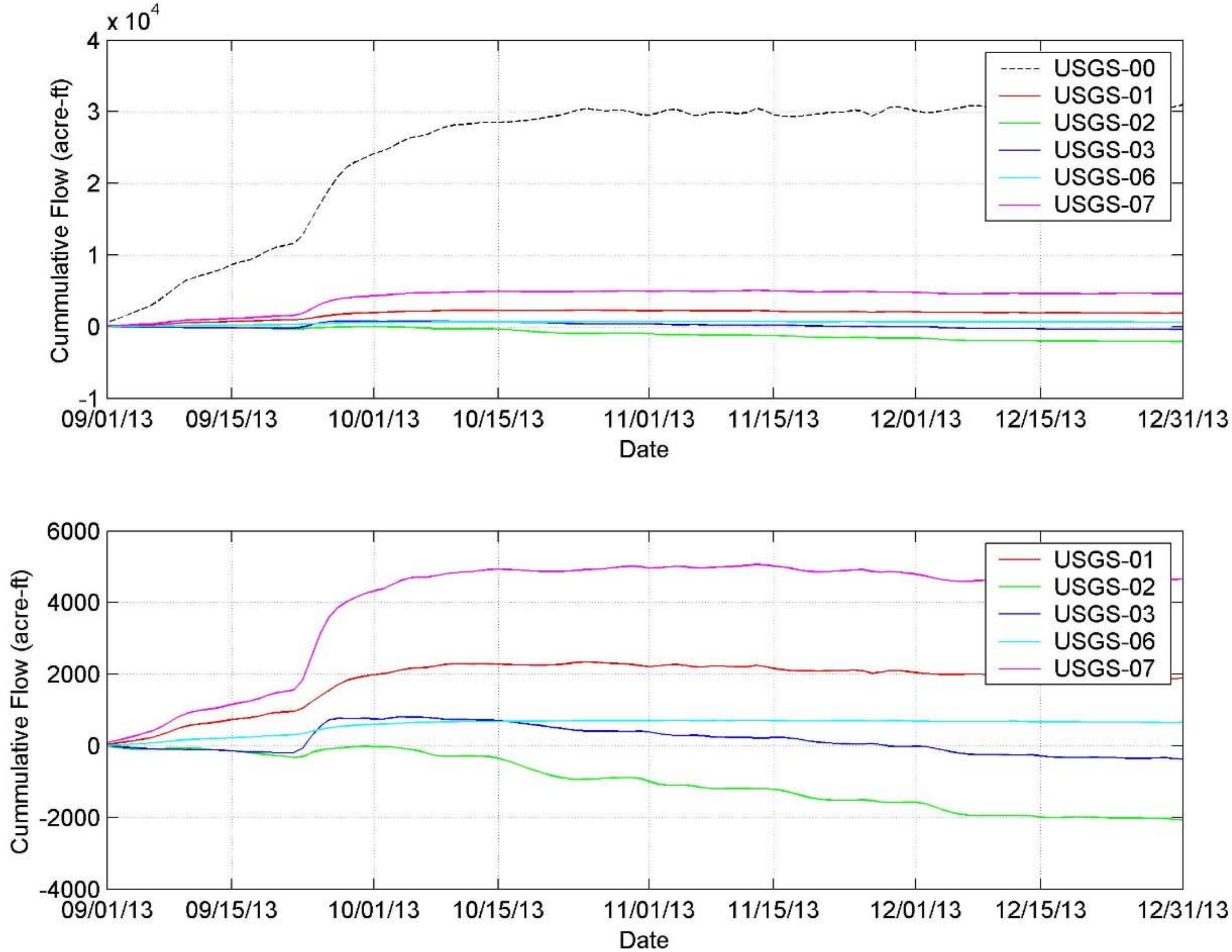


Figure 4-29. Cumulative Flows

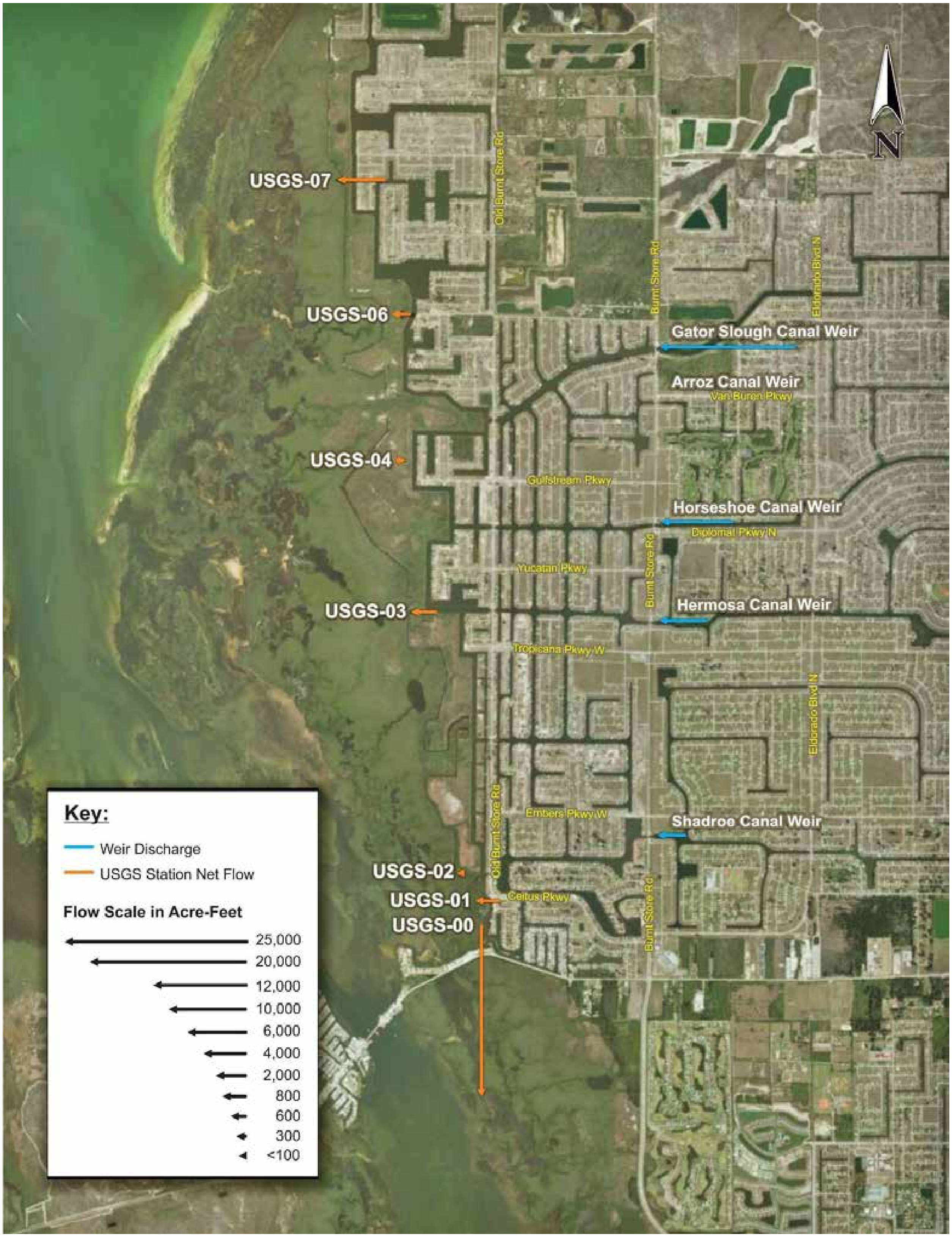


Figure 4-30. Distribution of Net Flows into and out of the NSC for September 2013

Figure 4-31. Distribution of Net Flows into and out of the NSC for Event (September 24-30, 2013)

Figure 4-32. Distribution of Net Flows into and out of the NSC for December 2013

4.4 SALINITY

The following presents analyses of the measured salinity data from the C-stations and W-stations presented in Section 3. The analyses reflect that the C-stations had periods of bad or missing data. The analyses are presented for the data within the NSC (C02, C03, C05, and C07) and the KD (C04 and C06).

Figures 4-33 through 4-38 present the measured salinities. In each figure, the top plot presents the raw measured data plotted in conjunction with the discrete W-station data. The bottom plot present the daily average salinities along with the measured total flow over the weirs.

Examination of the salinities within the NSC (Figures 4-33 through 4-36) shows that overall, the stations have a similar response to the flow conditions. The instruments were installed during a wet period, when salinity levels were near zero. As the flows dropped off through October 2012, the salinities steadily rose over a 4-month period from November 2012 through March 2013. During zero flow conditions, the system levels off. At the point where the salinities leveled off, the maximum values were highest near the southern end (C02) and decreased moving into the NSC up to the northernmost station (C07). In May, when the flows start again, there is an initial drop in salinity, with C05 seeming to show the most significant response, and then some rise back up as flows drop again following the May event. From June through July, as flows increase, the salinities throughout the system drop to near zero. At the point of the highest flows (September), only C02, the station at the southern end, still shows any appreciable salinity levels, with levels at this station dropping to zero during ebbing tides. By the time of the event in September, all the salinities measured within the NSC are near or at zero. Where data were measured, there is a net rise in salinity after flows drop off in mid-October 2013. The net rise appears similar to that seen in 2012. The degree of salinity fluctuation decreases moving up the NSC, with Station C02 showing the highest fluctuation levels on a daily basis (5 to 10 ppt), and Station C07 showing the lowest (1 to 2 ppt).

A similar response is seen in the two stations within the KD. The difference is that overall salinity levels are higher and, at times (especially at C04), are super-saturated in comparison to the salinity levels in Matlacha Pass. This is most likely a function of evaporation that would be most pronounced at station C04, due to the isolated nature of that section of the KD, as shown in Section 4-2.

Based upon the data collected, the overall salinity response in the NSC and KD are similar and follow a consistent pattern, based on the flows over the weirs. The salinity levels during dry period are between 20 to 35 ppt in the NSC, with stations further into the system showing lower levels (20 to 25 ppt) than those closer to the southern entrance (25 to 35 ppt). Within the KD during the same time frame, salinity levels are higher, between 30 to 40 ppt. As flows over the weirs increase moving into the wet period, salinity levels drop to a point during wet periods where nearly all of the NSC drops at times down to 0 ppt, while within the KD, the levels drop down to between 5 and 10 ppt. These results are based upon the hydrologic conditions seen during the period of measurement, which, based on the analyses presented in Section 4.1, represents average to wet conditions for the system.

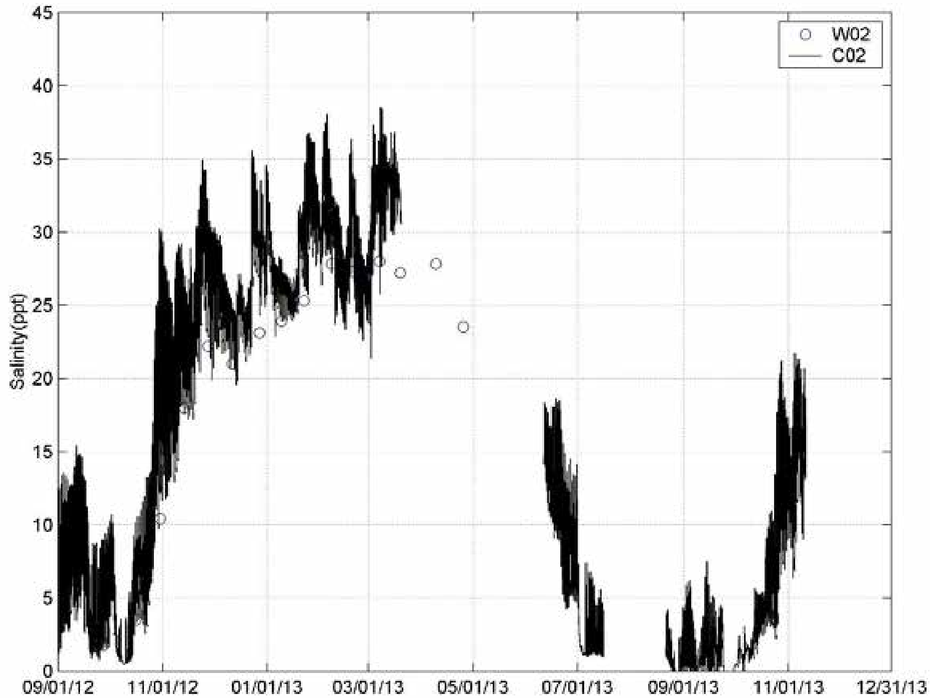


Figure 4-33a. Continuous Salinity at C02 versus Discrete Salinity at W02

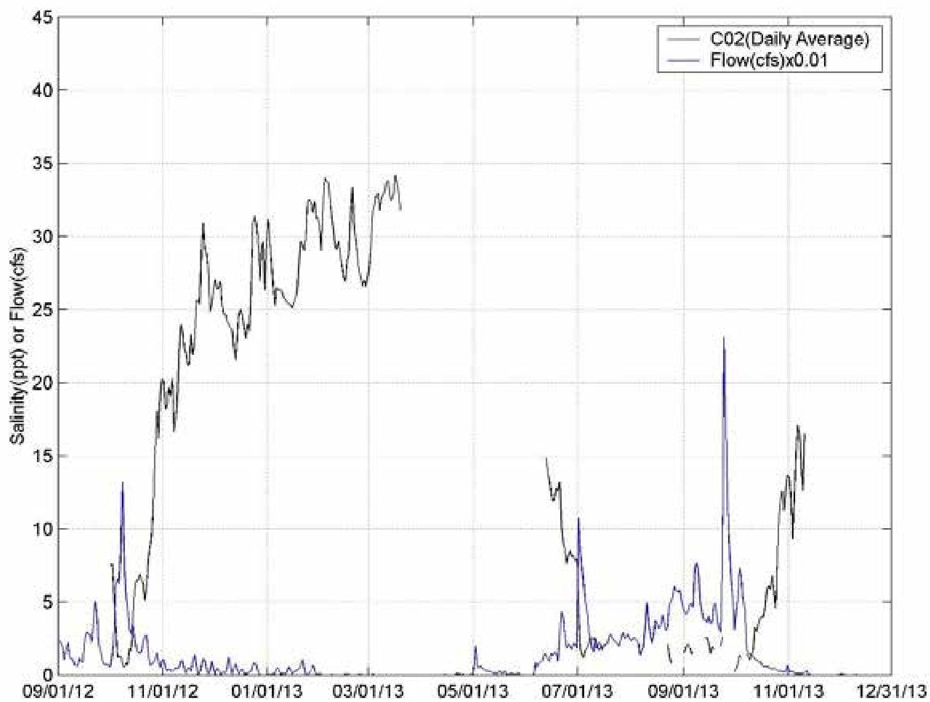


Figure 4-33b. Daily Average Salinity Measured at C02 versus Total Freshwater Inflow

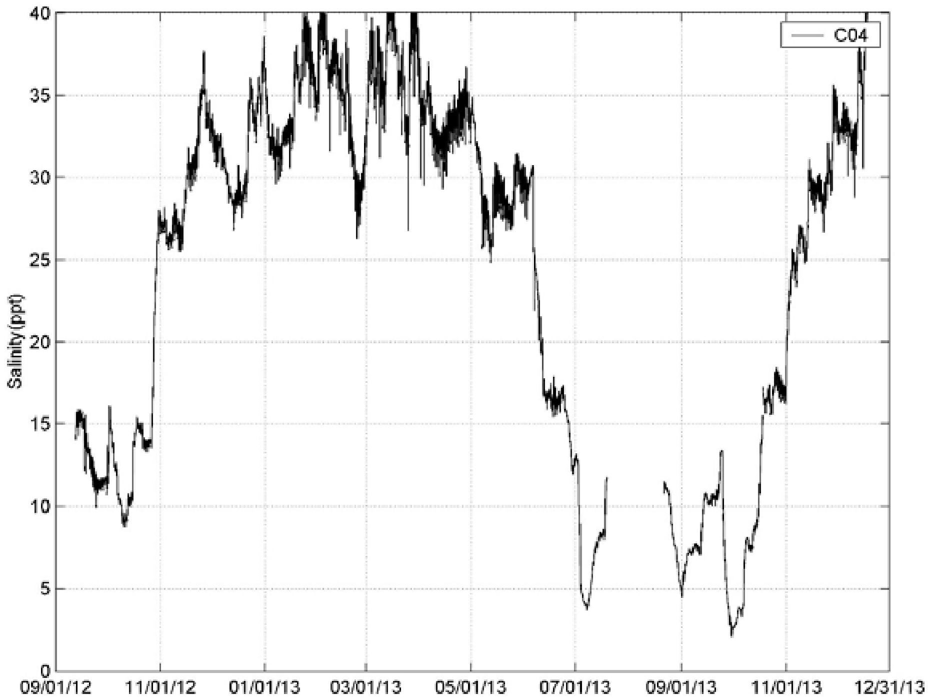


Figure 4-34a. Continuous Salinity at C04

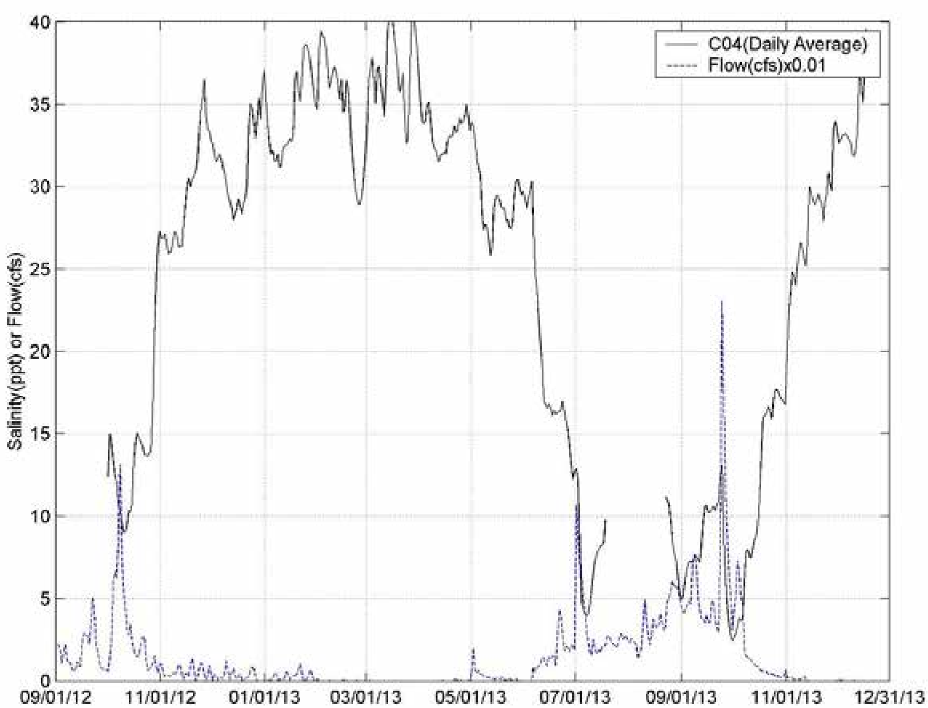


Figure 4-34b. Daily Average Salinity Measured at C04 versus Total Freshwater Inflow

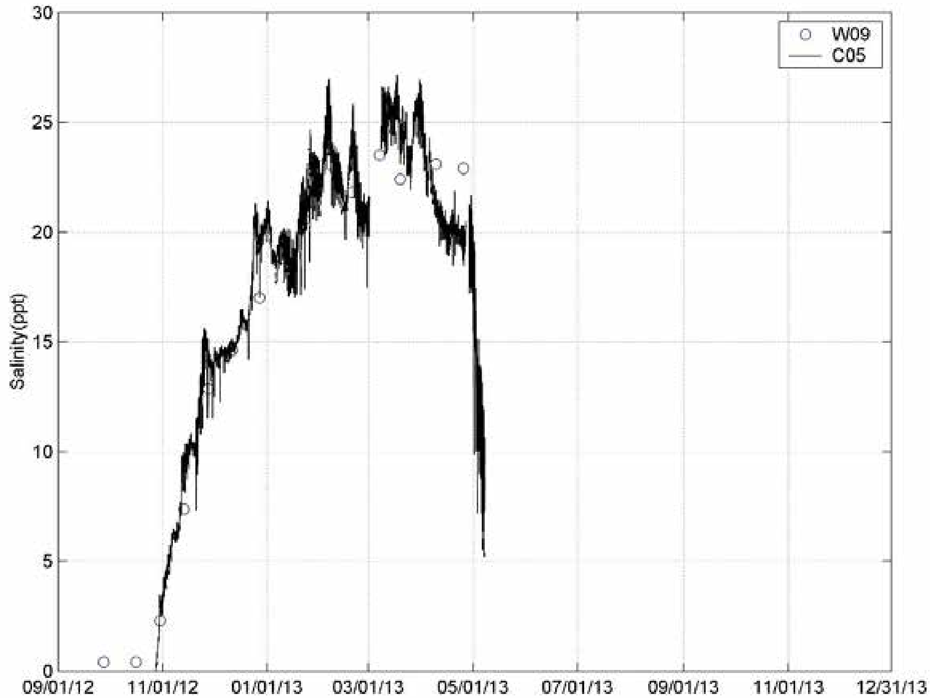


Figure 4-35a. Continuous Salinity at C05 versus Discrete Salinity at W09

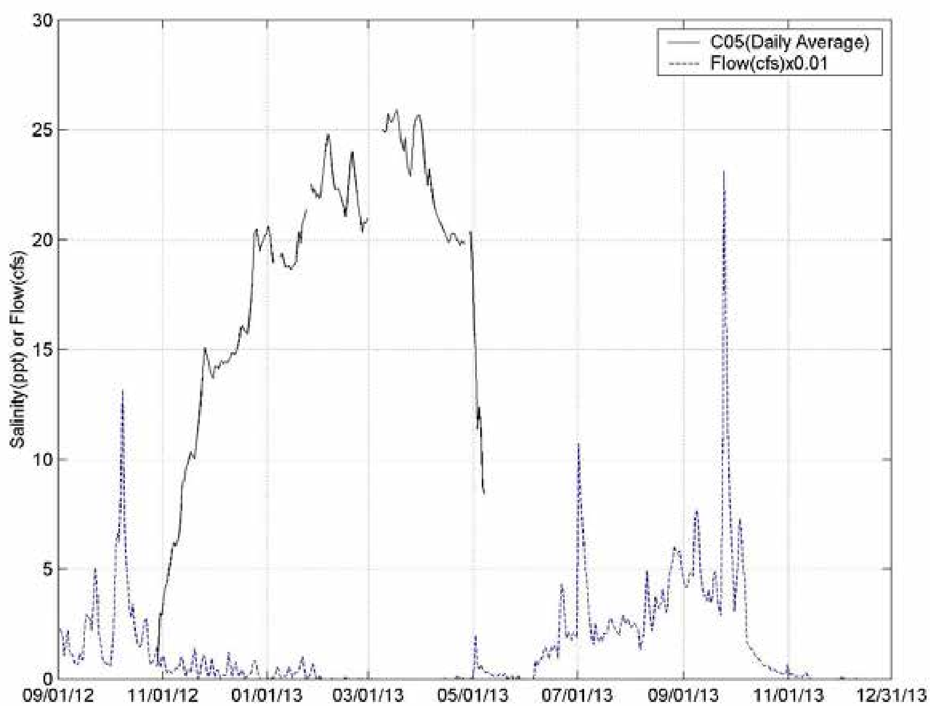


Figure 4-35b. Daily Average Salinity Measured at C05 versus Total Freshwater Inflow

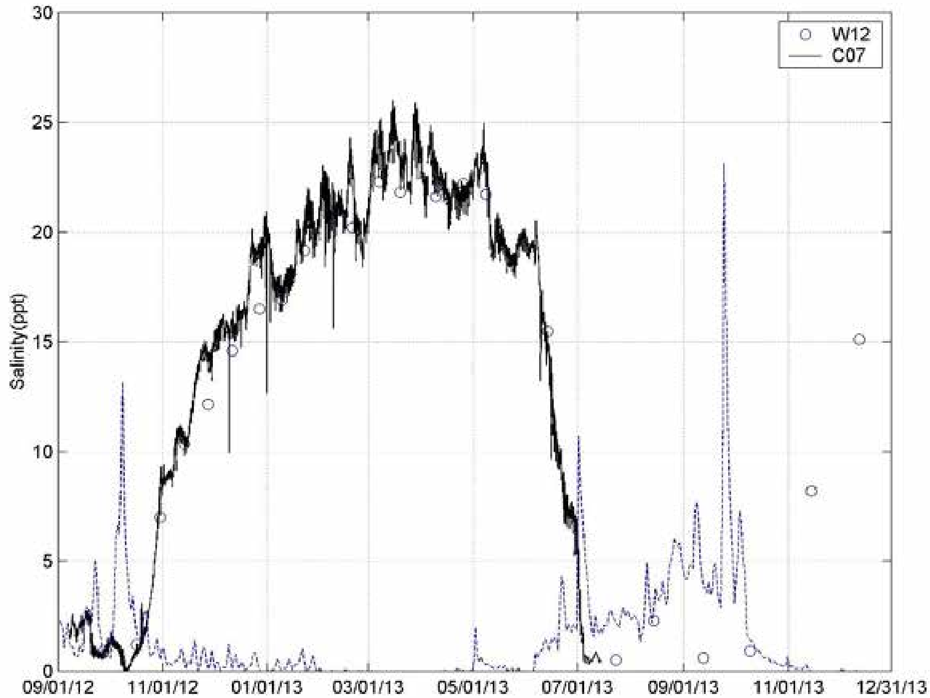


Figure 4-36a. Continuous Salinity at C07 versus Discrete Salinity at W12

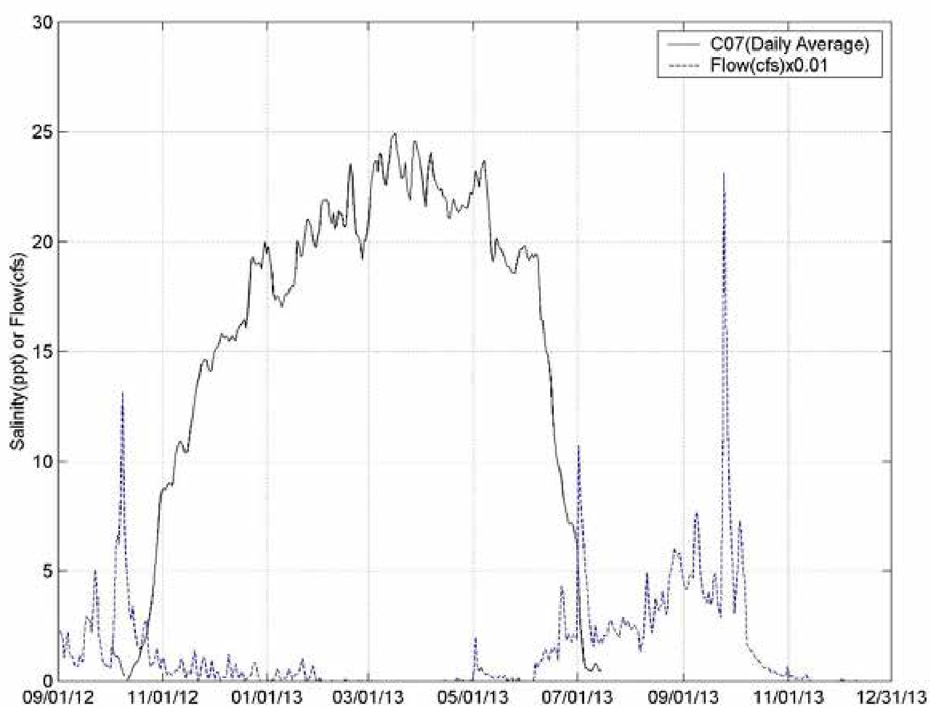


Figure 4-36b. Daily Average Salinity Measured at C07 versus Total Freshwater Inflow

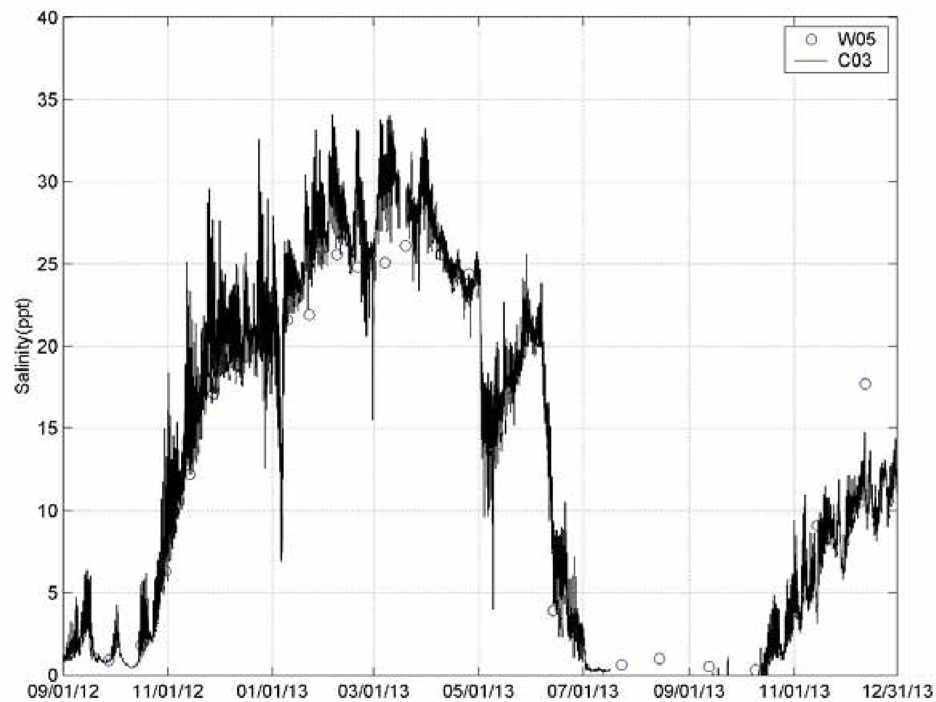


Figure 4-37a. Continuous Salinity at C03 versus Discrete Salinity at W05

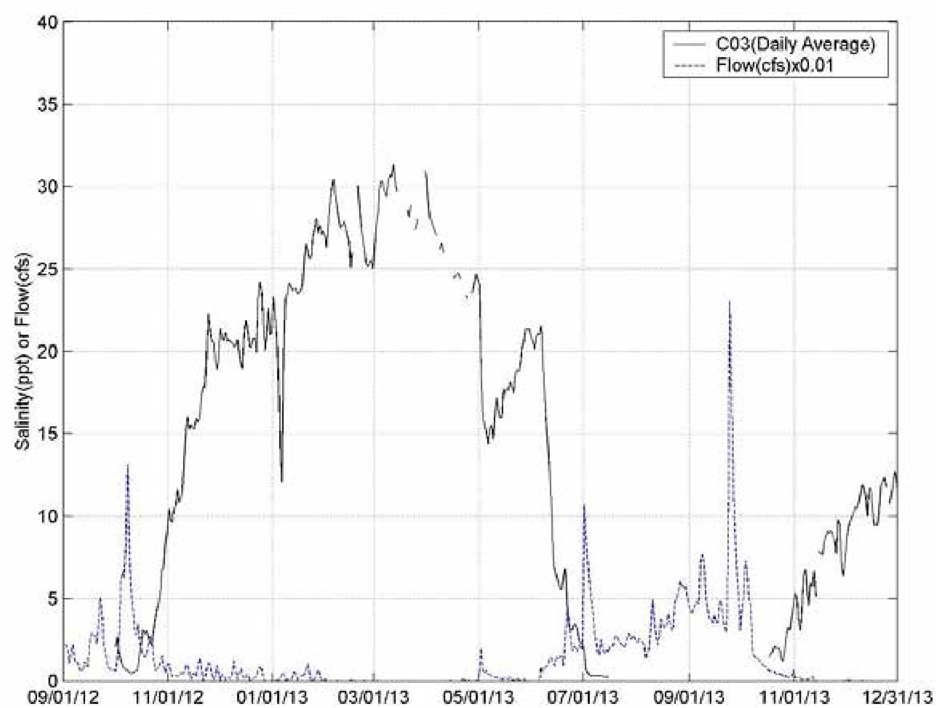


Figure 4-37b. Daily Average Salinity Measured at C03 versus Total Freshwater Inflow

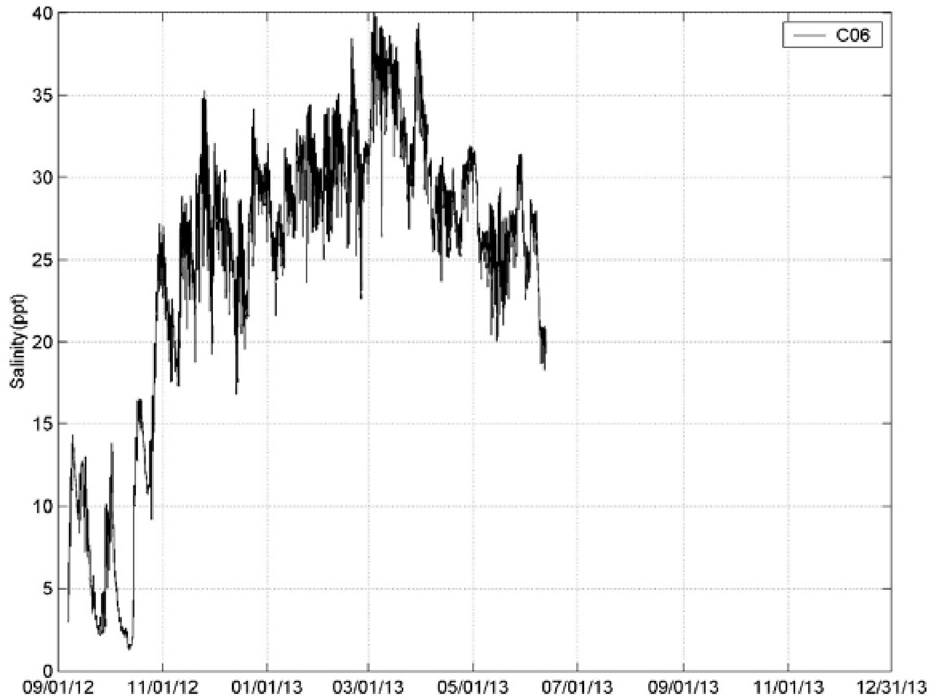


Figure 4-38a. Continuous Salinity at C06

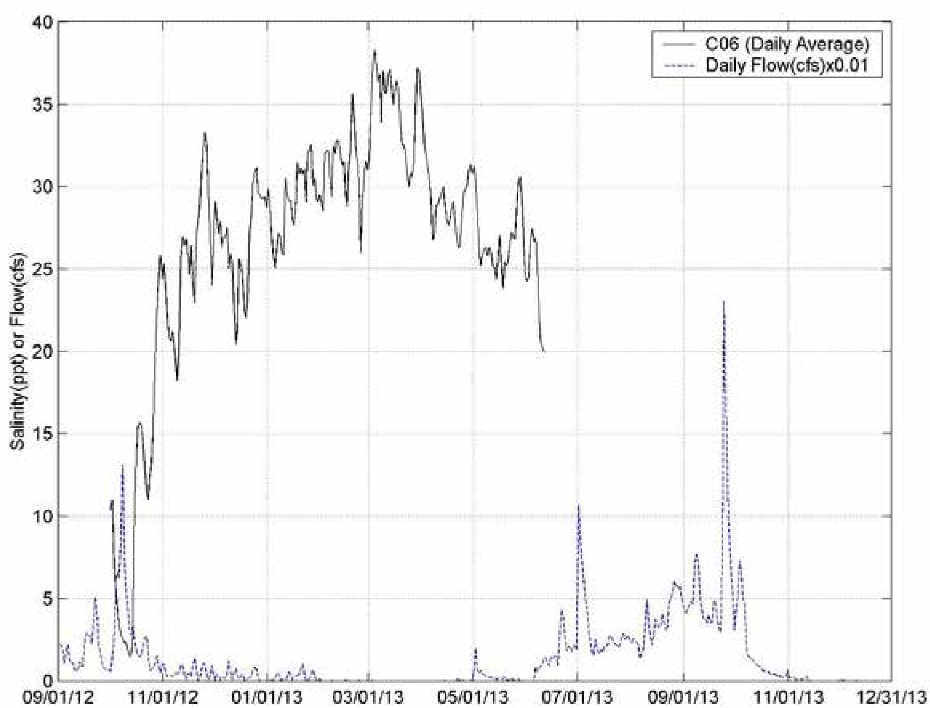


Figure 4-38b. Daily Average Salinity Measured at C06 versus Total Freshwater Inflow

4.5 BREACH VELOCITIES

The following presents analyses of the measured velocities at the breaches in relation to the potential for scour and ongoing erosion. The discussion represents a qualitative evaluation of the erosion potential given the magnitude of the measured velocities.

Figures 4-39 and 4-40 present plots showing the velocities at each of the USGS stations during a dry period (November 1, 2013 to November 7, 2013) and the period of significant freshwater inflow (September 23, 2013 to September 30, 2013). Examination of the velocity magnitudes during the dry period shows that only the USGS-00 (Breach 12) measured velocities that could be considered as erosive, with values as high as 2.5 feet per second (ft/s) at times. All of the other stations showed relatively low velocities, generally less than 1 ft/s. Examination of the velocities during the freshwater inflow event showed similar results for the breaches, with USGS-07 (Breach 1A) showing values greater than 1 ft/s, with maximum values around 1.2 ft/s. The measured velocities at USGS-00 during this period are significantly damped. The velocity measurements reflect the average cross-sectional area velocities at the location of the USGS stations. Velocity magnitudes upstream and downstream of these locations may be higher or lower depending upon the cross-sectional areas. The extrapolation of these velocities relative to erosive conditions must consider this aspect. In general, it is not expected that upstream or downstream velocities will be significantly different. Therefore, based on these data, under the present conditions, it does not appear that any of the breaches will experience additional erosion unless the overall hydrologic conditions change significantly.

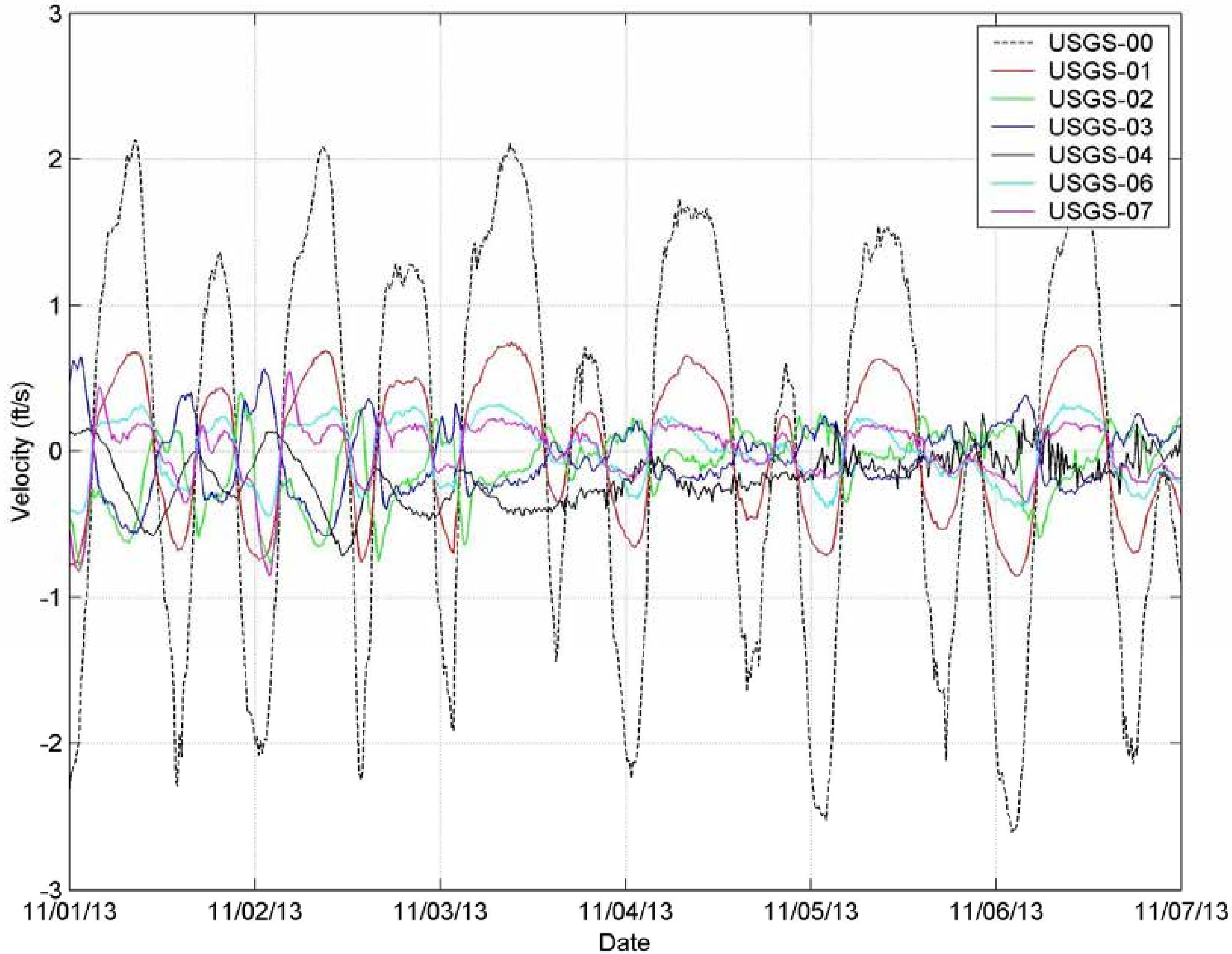


Figure 4-39. *Comparison of Measured Breach Velocities (Dry Period)*

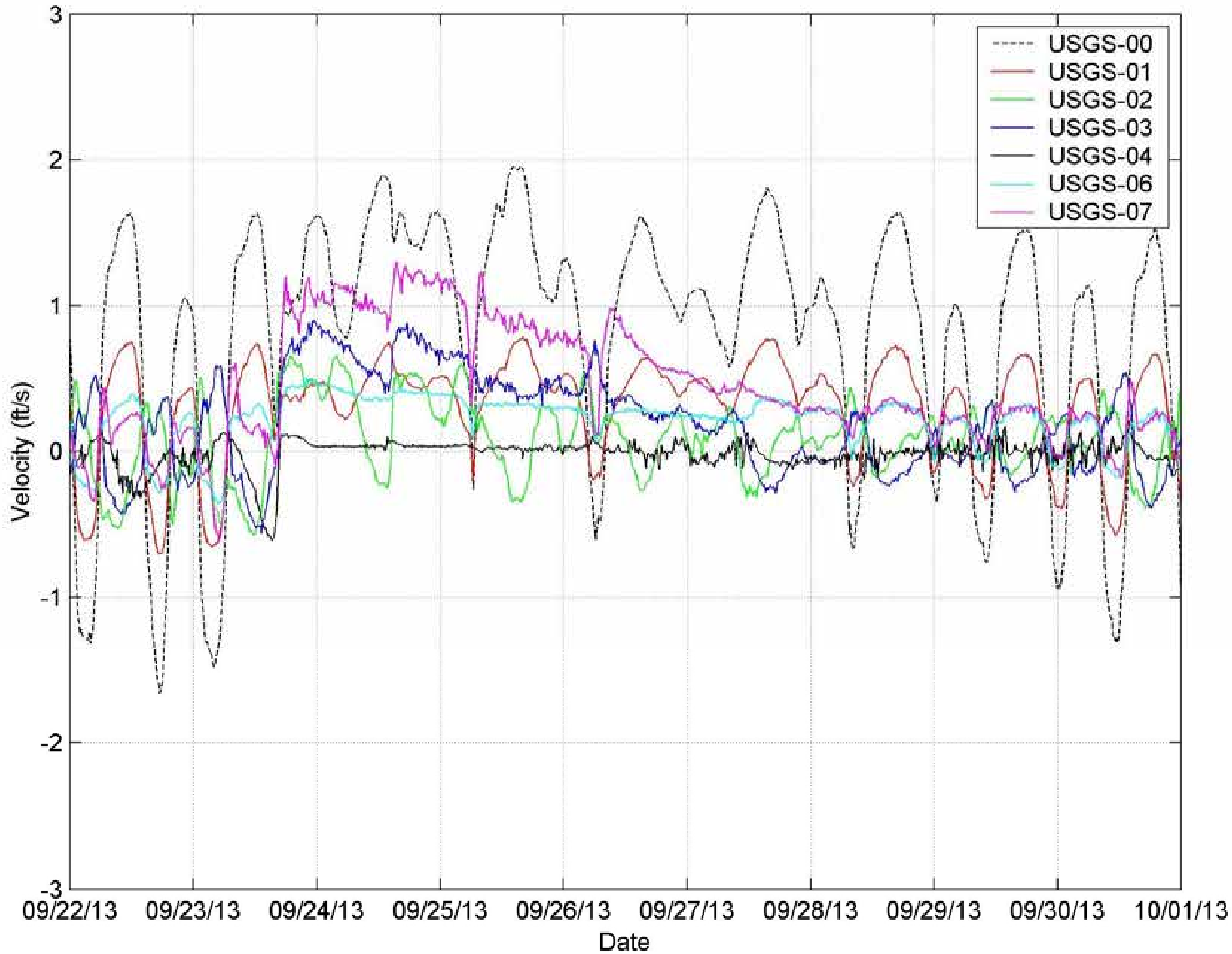


Figure 4-40. Comparison of Measured Breach Velocities (Wet Period)

5.0 SUMMARY AND CONCLUSIONS

This report provided a summary of the hydrodynamic data collected between August 2012 and February 2013. This included the following:

- Continuous water level measurements at 15 stations located within Matlacha Pass, the KD, the NSC, and the interior canals.
- Continuous salinity, temperature, and water level measurements at 9 stations located within Matlacha Pass, the KD, the NSC.
- Continuous water level, flow and velocity measurements at the 6 breaches along the NSC and near the location of the former Ceitus barrier
- Continuous water level measurements above the weir structures at Shadroe Canal, Hermosa Canal, Horseshoe Canal, and Gator Slough

The summary included the station locations, data collection methods, and the period of records for the final data.

In addition to the data summary, analyses were performed to quantify the hydrodynamic conditions within, and exchange between, the NSC, the KD, and Matlacha Pass. The following are the key findings from the hydrodynamic data analyses.

- Tidal amplitudes within the NSC and KD are damped between 61 to 64 percent in comparison to the tides in Matlacha Pass.
- 61 percent of the damping of the tidal amplitudes occurs almost immediately entering the NSC system at the southern end, while the remaining 3 percent occurs moving through the system from south to north.
- 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.

- The system behaves similarly to a large embayment with a constricted entrance and exhibits similar response characteristics such as super-elevation of the interior embayment and increased duration of ebb flow relative to flood flow.
- 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 reverse is seen on a falling tide. At USGS-06 and USGS-07, this is due to the connection to Matlacha Pass at the southern end of KD4. At USGS-02 and USGS-03, this is due to filling of the KD from the NSC through these breaches.
- Breach 4 is highly limited in its connection, and the section of the KD that it connects (KD3) is isolated from Matlacha Pass and the other segments of the KD and behaves independently.
- The flows and velocities 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 storage areas and connections to Matlacha Pass coming online when the water levels are high. When levels go back down, these connections go away.
- 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.
- During the dry months, the system showed a pattern of net inflow at the breaches (including at USGS-01, Ceitus Creek), with a net outflow at the southern end. Overall, during the dry periods, the monitored USGS stations showed a net overall inflow.
- Velocity measurements in the breaches are not sufficiently high to create erosive conditions.

This report summarized the analyses conducted on the available hydrodynamic data for the purpose of quantifying existing hydrodynamic conditions within the NSC and the interaction of the NSC with the KD and Matlacha Pass. This information will be utilized in the development and calibration of a hydrodynamic model of the system. The results of the modeling are presented within a separate report. These data, along with the results from other components of the Phase I work, quantify the existing conditions within the NSC and their interaction with the adjacent waters (KD and Matlacha Pass).

In Phase II of this project, the results presented herein, along with the hydrodynamic model and results from the other reports will be utilized to assess the impacts of potential management actions. The goal will be to assess the potential for improving the overall ecologic conditions within the NSC, KD and the waters of Matlacha Pass.

6.0 REFERENCES

Havens & Emerson. 1993. Spreader Waterway Breach Area Improvements Design Report. Havens and Emerson Consulting Engineers, Inc.

U.S. Army Corps of Engineers (USACE). 2002. Coastal Engineering Manual. Engineer Manual 1110-2-1100, U.S. Army Corps of Engineers, Washington, D.C. (in 6 volumes).

U.S. Geological Survey (USGS). 2012. Computing Discharge Using the Index Velocity Method, Techniques and Methods 3–A23. Victor A. Levesque and Kevin A. Oberg, Reston, Virginia.

Appendix A

Gantt Chart of Hydrodynamic Data

Data Type		2012																
		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																	
	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																	

Data Type		20																									
		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																										
	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																										

	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

Data Type		13																										2014								
		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																																			
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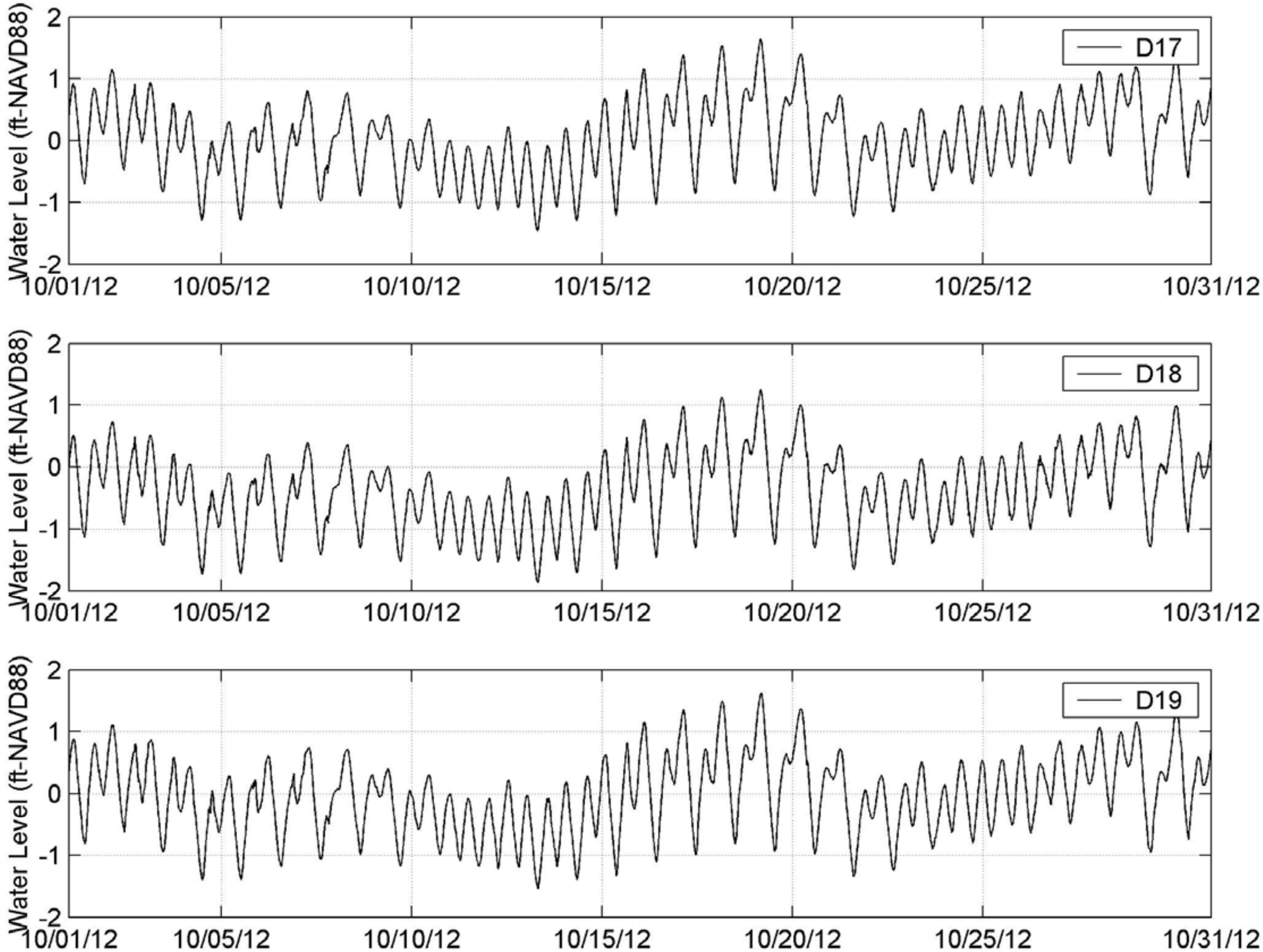
	D-13																																			
	D-14																																			
	D-15																																			
	D-16																																			
	D-17																																			
	D-18																																			
	D-19																																			
Water Level above Weirs (D-stations)	D-02																																			
	D-08																																			
	D-10																																			
	D-20																																			

Appendix B

Measured Water Levels at D-Stations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D18
D19
Water Level (ft-NAVD88)
2
1
0
-1
-2
10/01/12
10/05/12
10/10/12
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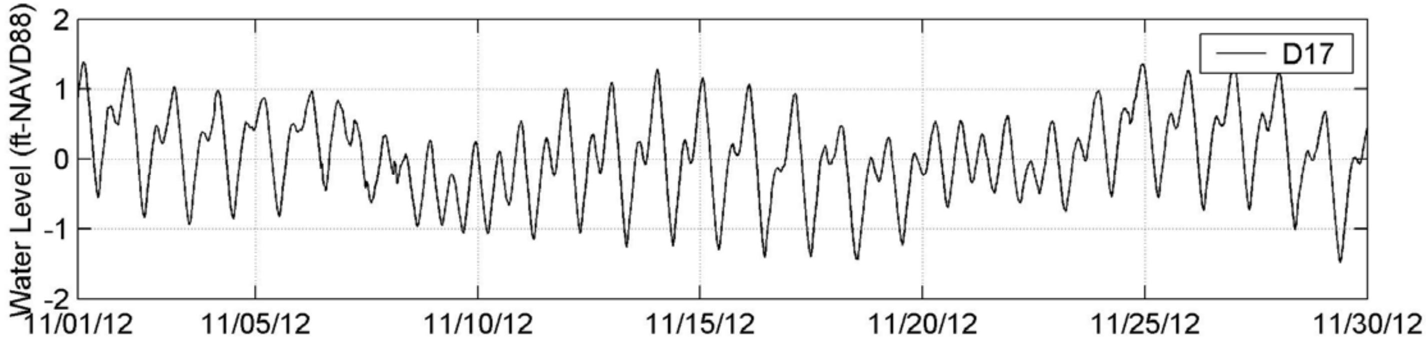
10/20/12
10/25/12
10/31/12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D17
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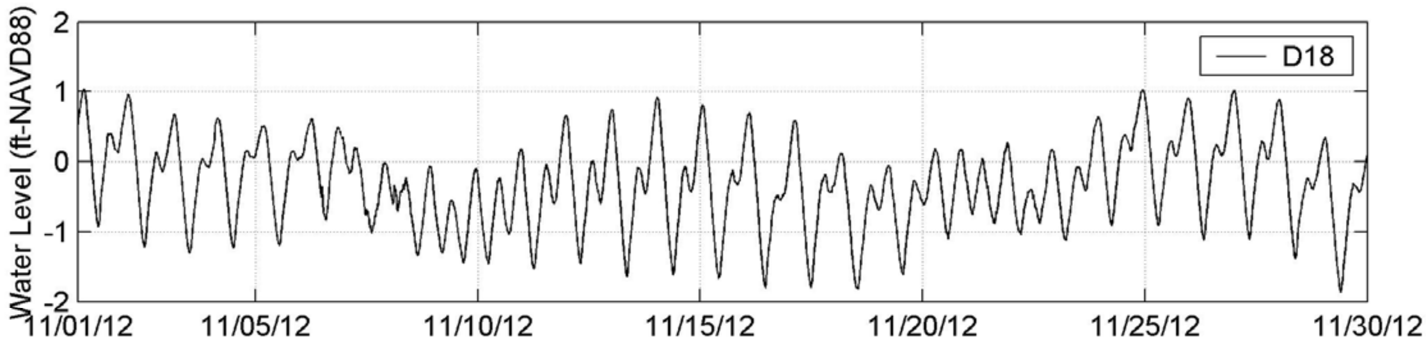
11/25/12
11/30/12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0
-1
-2
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11/10/12
11/15/12
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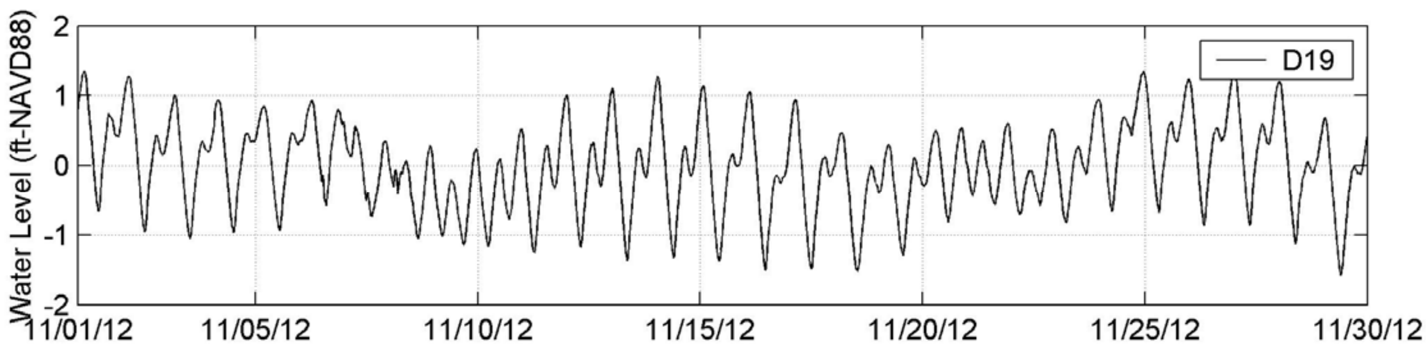
11/25/12
11/30/12


Water Level (ft-NAVD88)
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1
0
-1
-2
11/01/12
11/05/12
11/10/12
11/15/12
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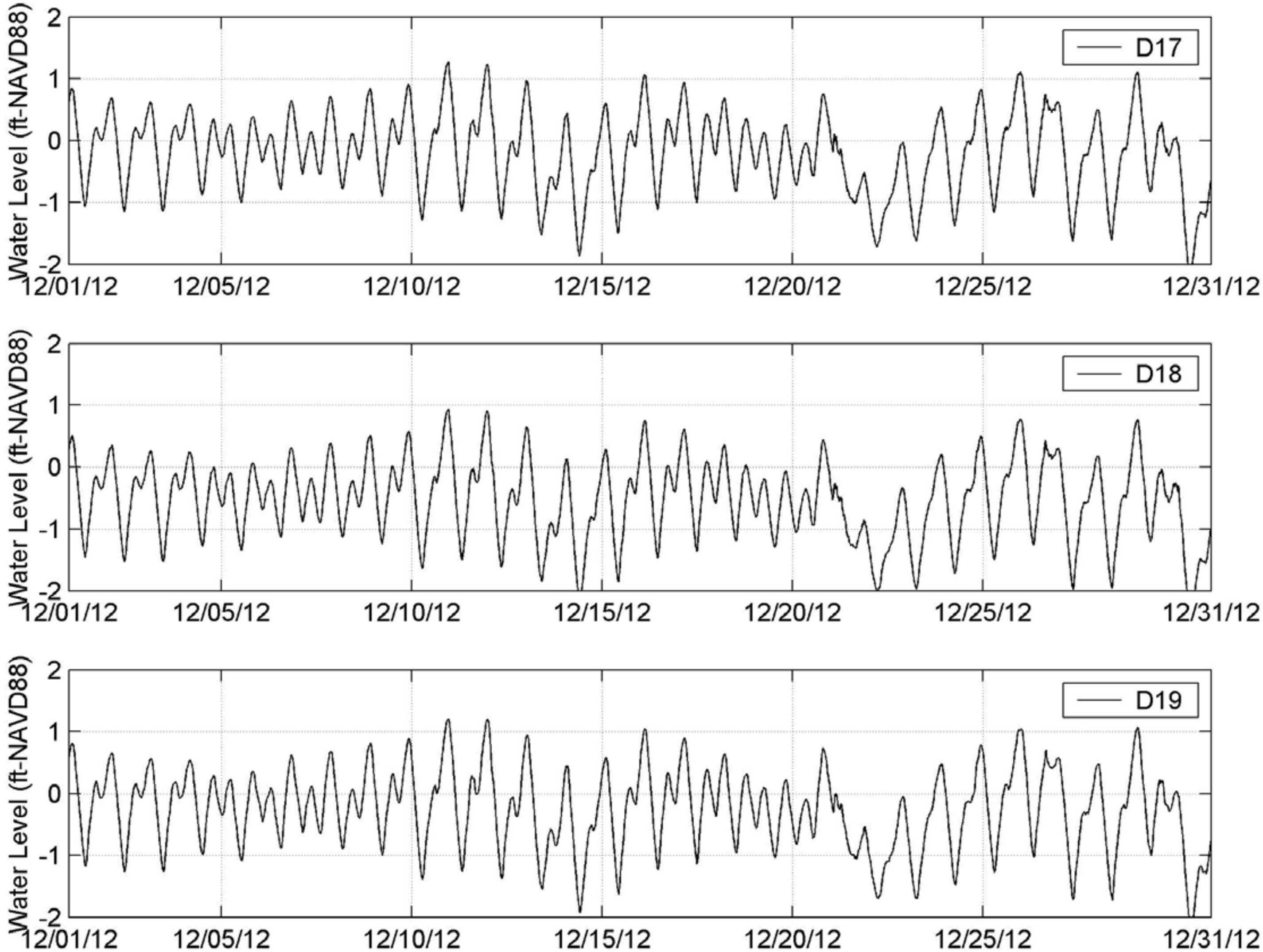
11/25/12
11/30/12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D18
D19
Water Level (ft-NAVD88)
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-2
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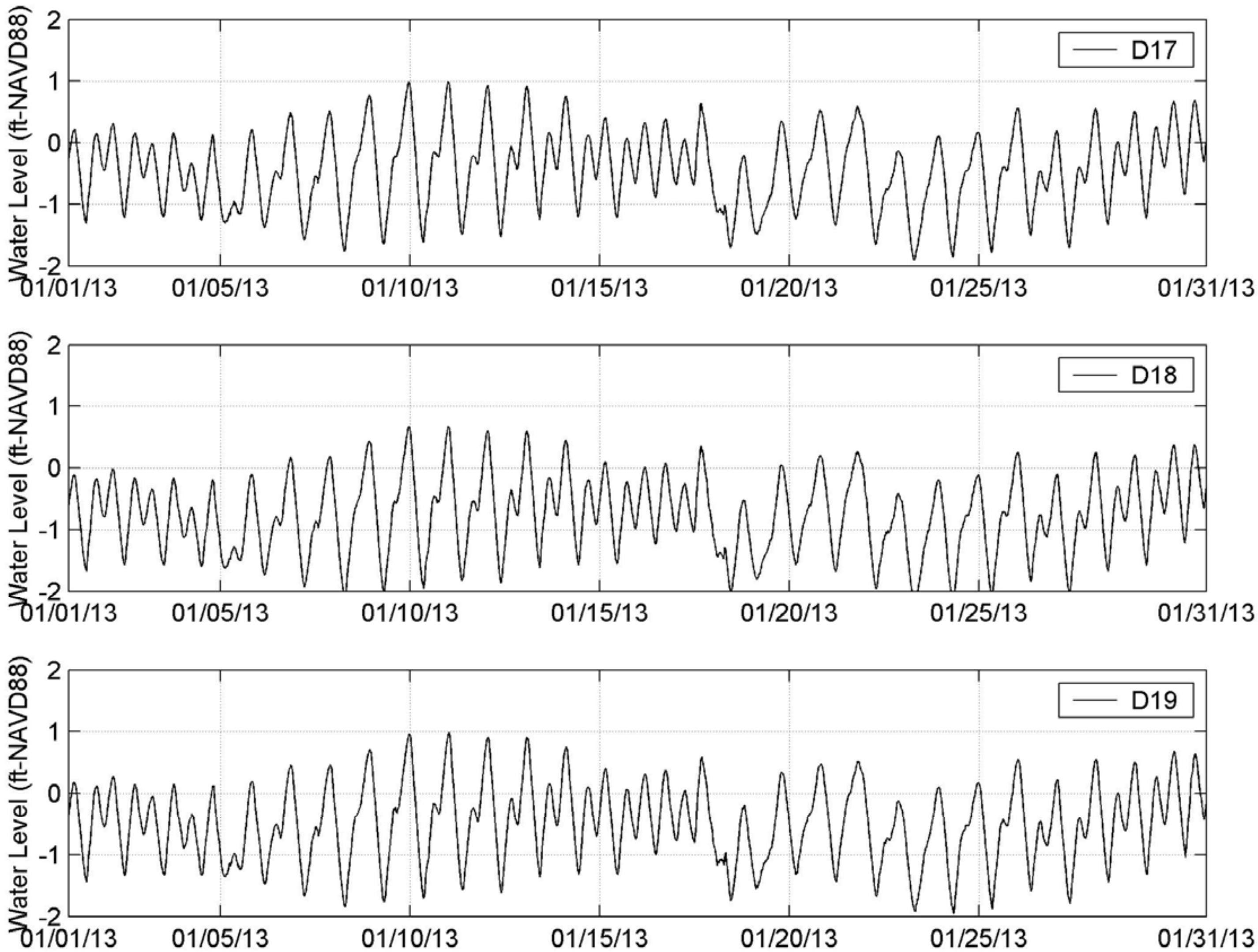
12/31/12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D18
D19
Water Level (ft-NAVD88)
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-2
01/01/13
01/05/13
01/10/13
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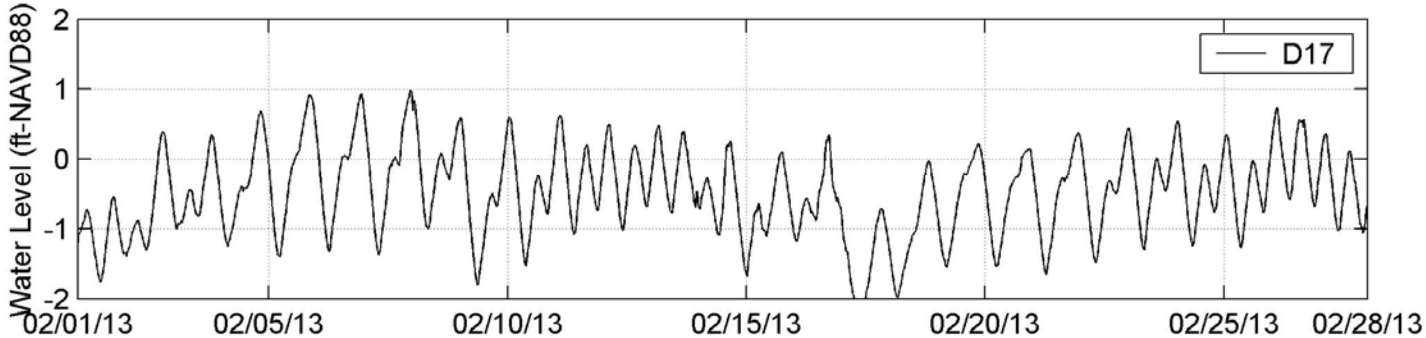
01/25/13
01/31/13



D17
Water Level (ft-NAVD88)
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1
0
-1
-2
02/01/13
02/05/13
02/10/13
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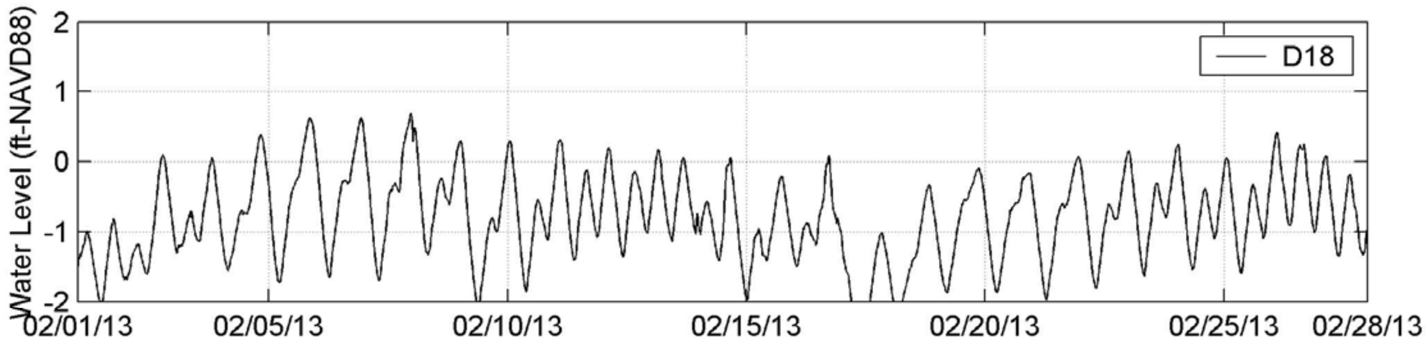
02/25/13
02/28/13



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02/01/13
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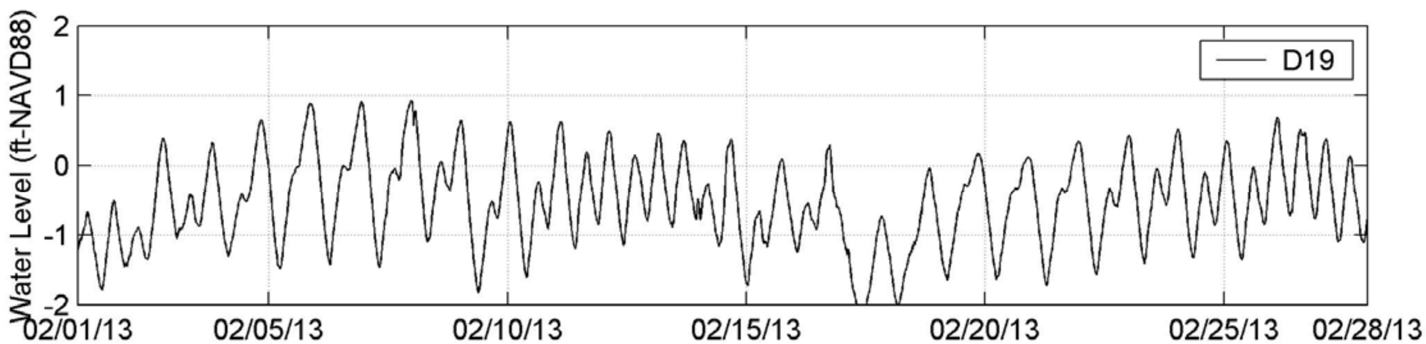
02/25/13
02/28/13



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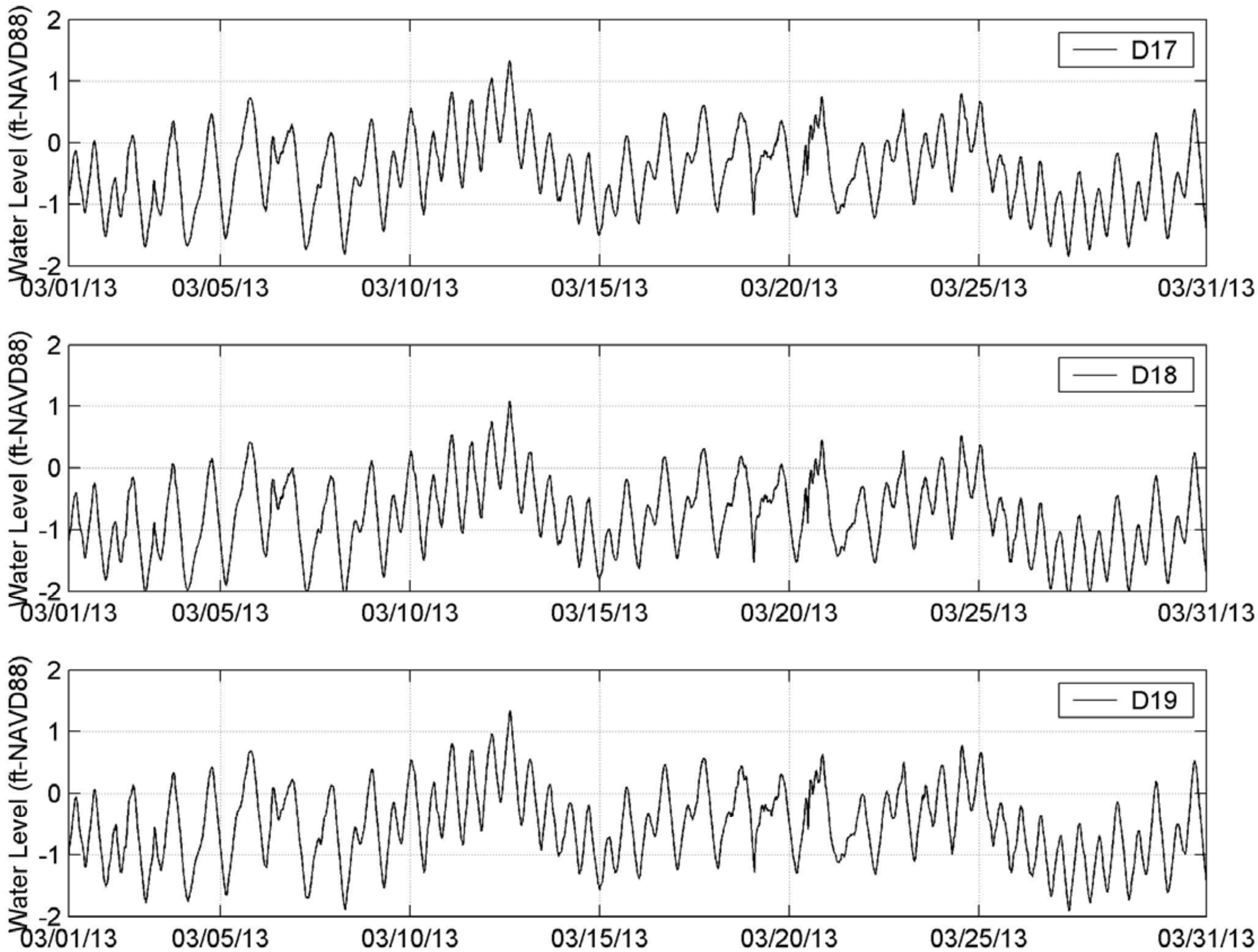
02/28/13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D18
D19
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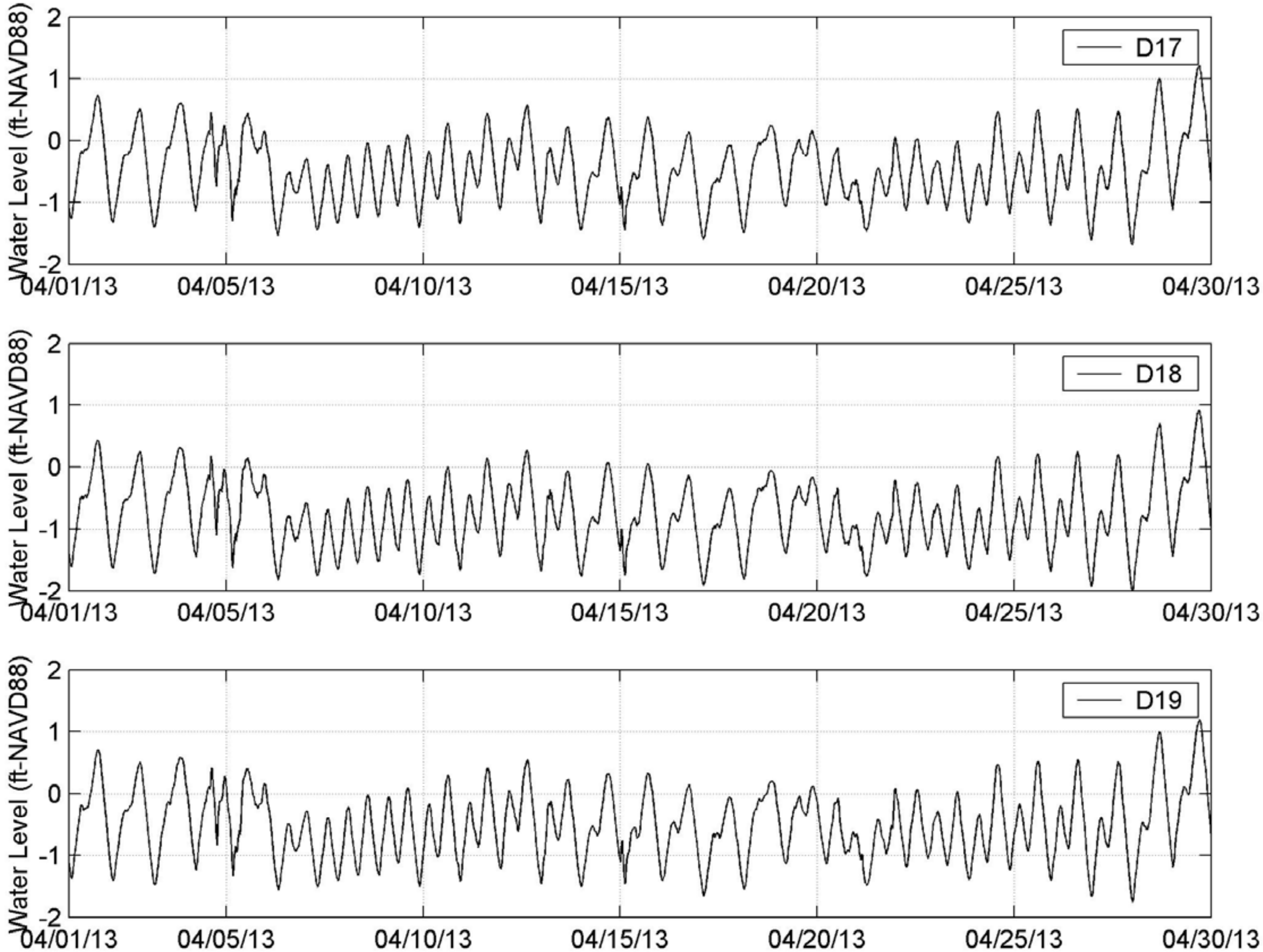
03/25/13
03/31/13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D17
04/01/13
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04/10/13
04/15/13
04/20/13
04/25/13
04/30/13
Water Level (ft-NAVD88)
2
1
0
-1
-2
D18
04/01/13
04/05/13
04/10/13
04/15/13
04/20/13
04/25/13
04/30/13
Water Level (ft-NAVD88)
2
1
0
-1
-2
D19
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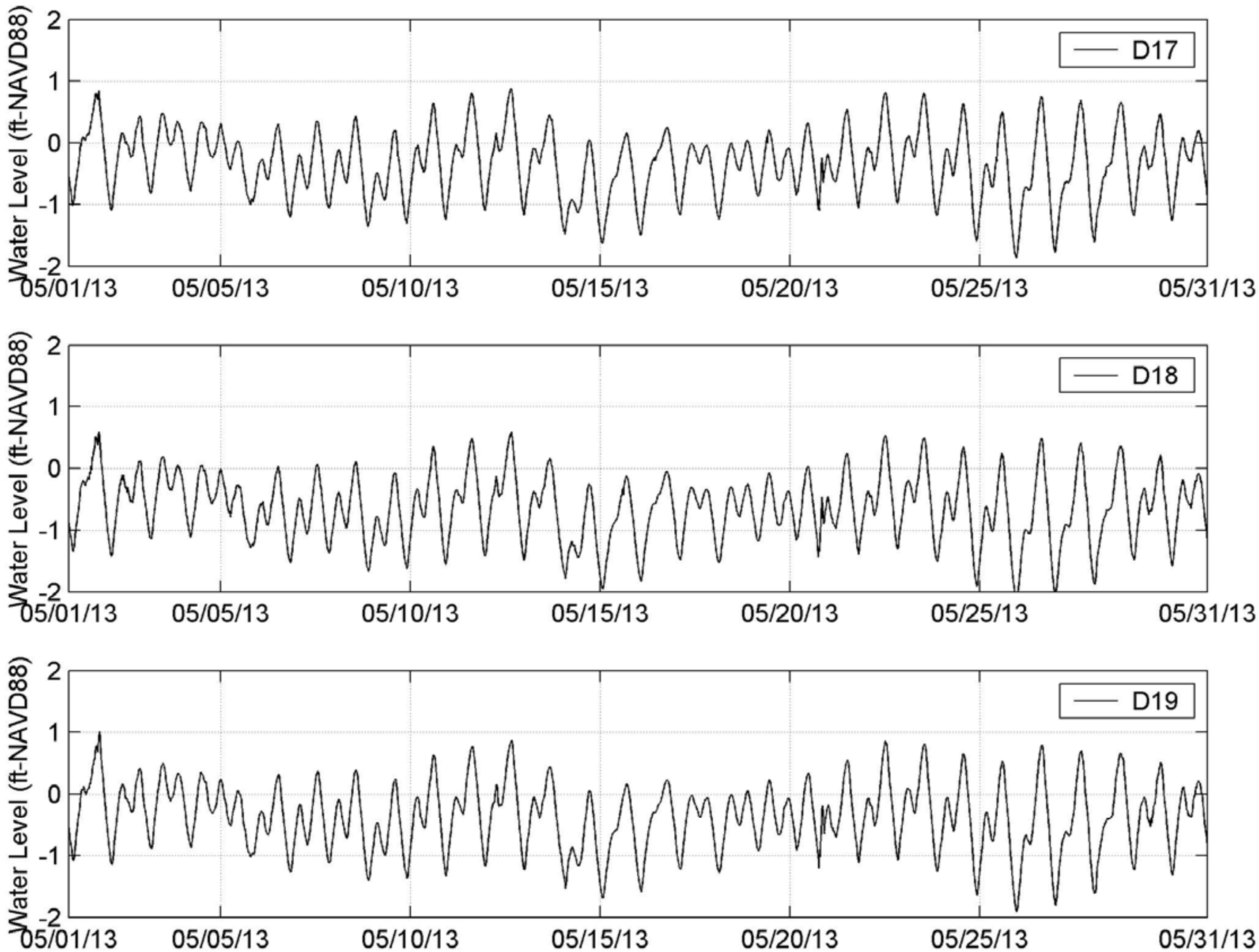
04/30/13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D18
D19
2
1
0
-1
-2
05/01/13
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05/10/13
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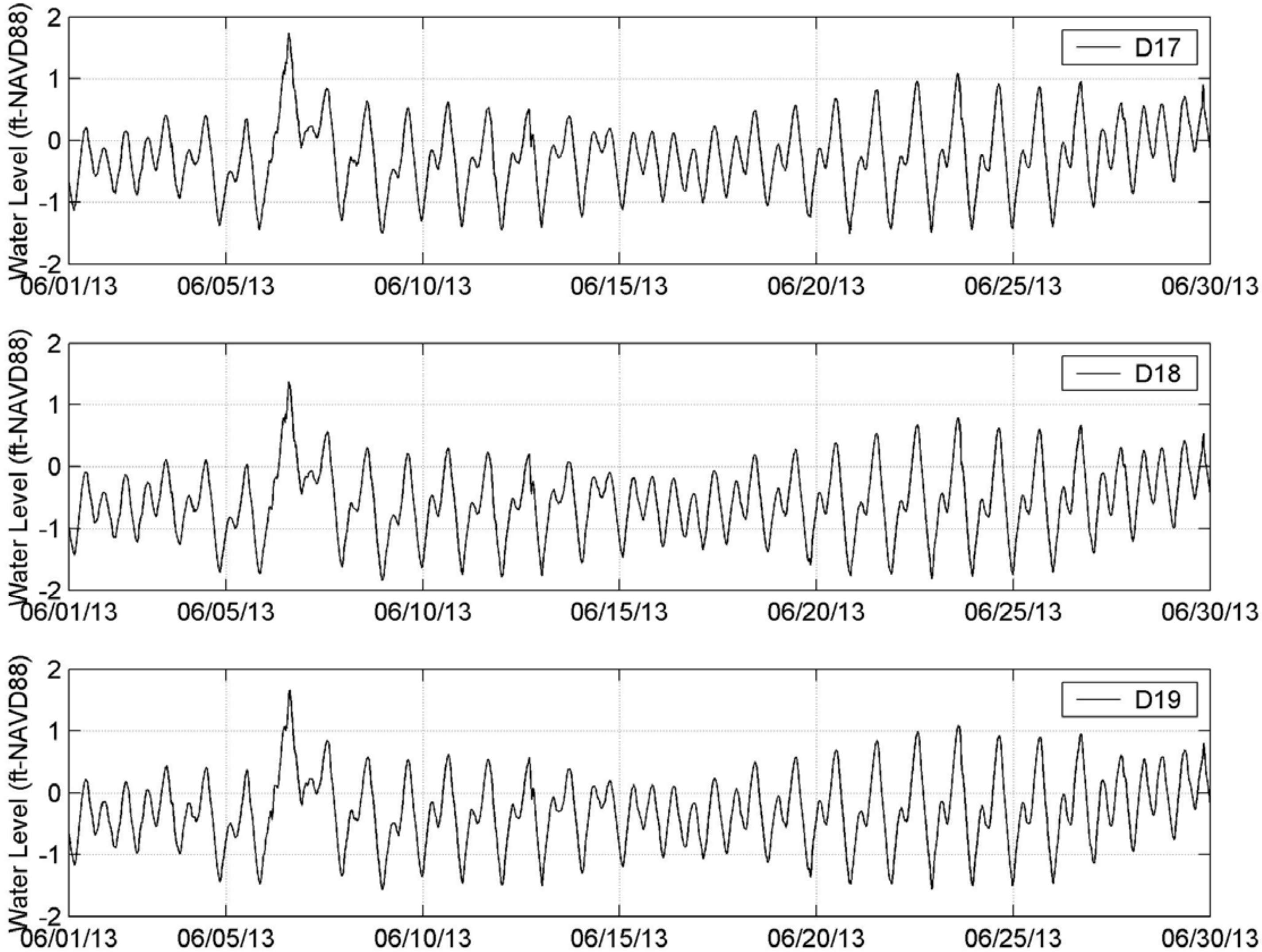
05/25/13
05/31/13


D17
D18
D19
Water Level (ft-NAVD88)
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1
0
-1
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06/01/13
06/05/13
06/10/13
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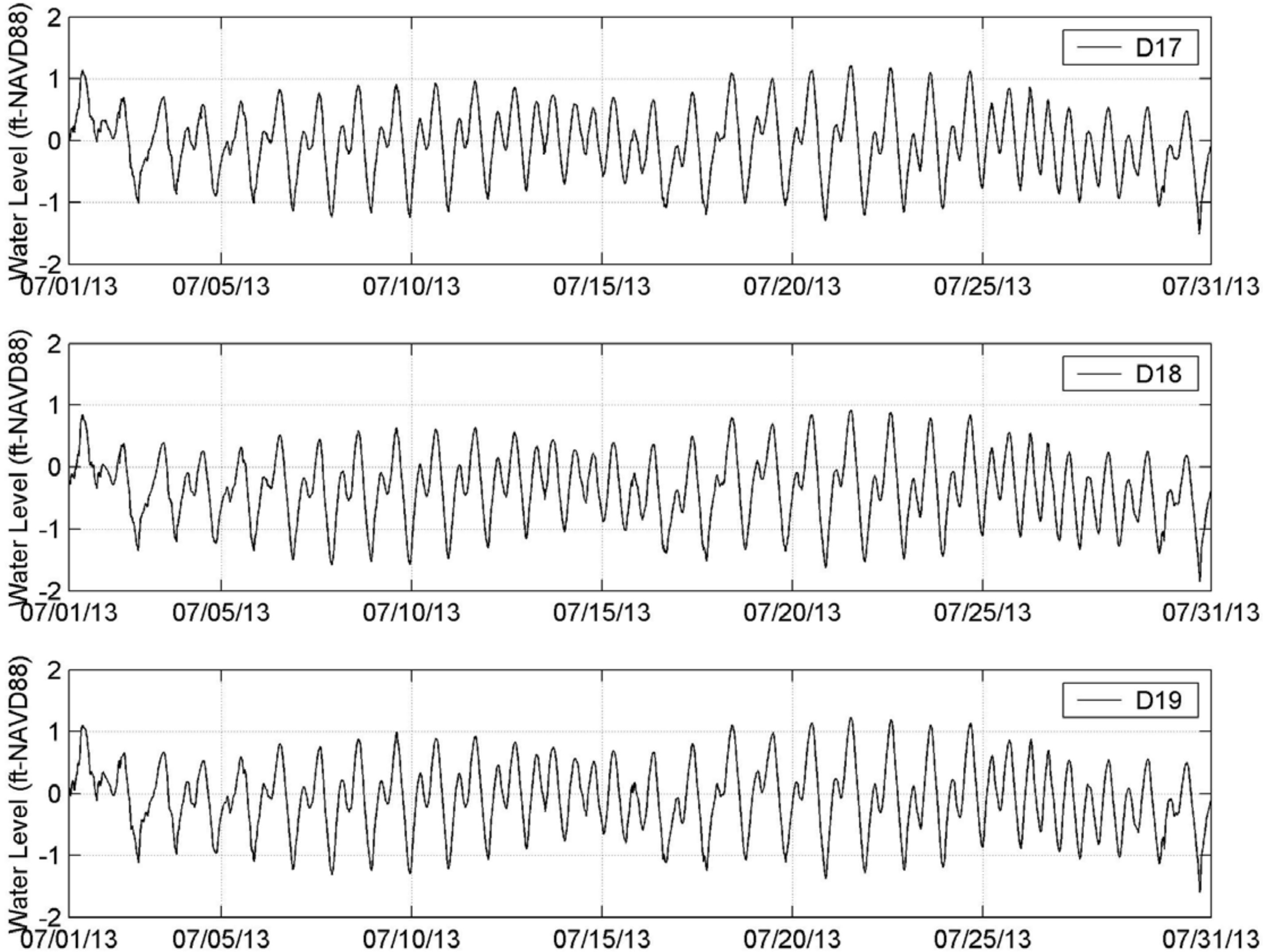
06/25/13
06/30/13



Water Level (ft-NAVD88)
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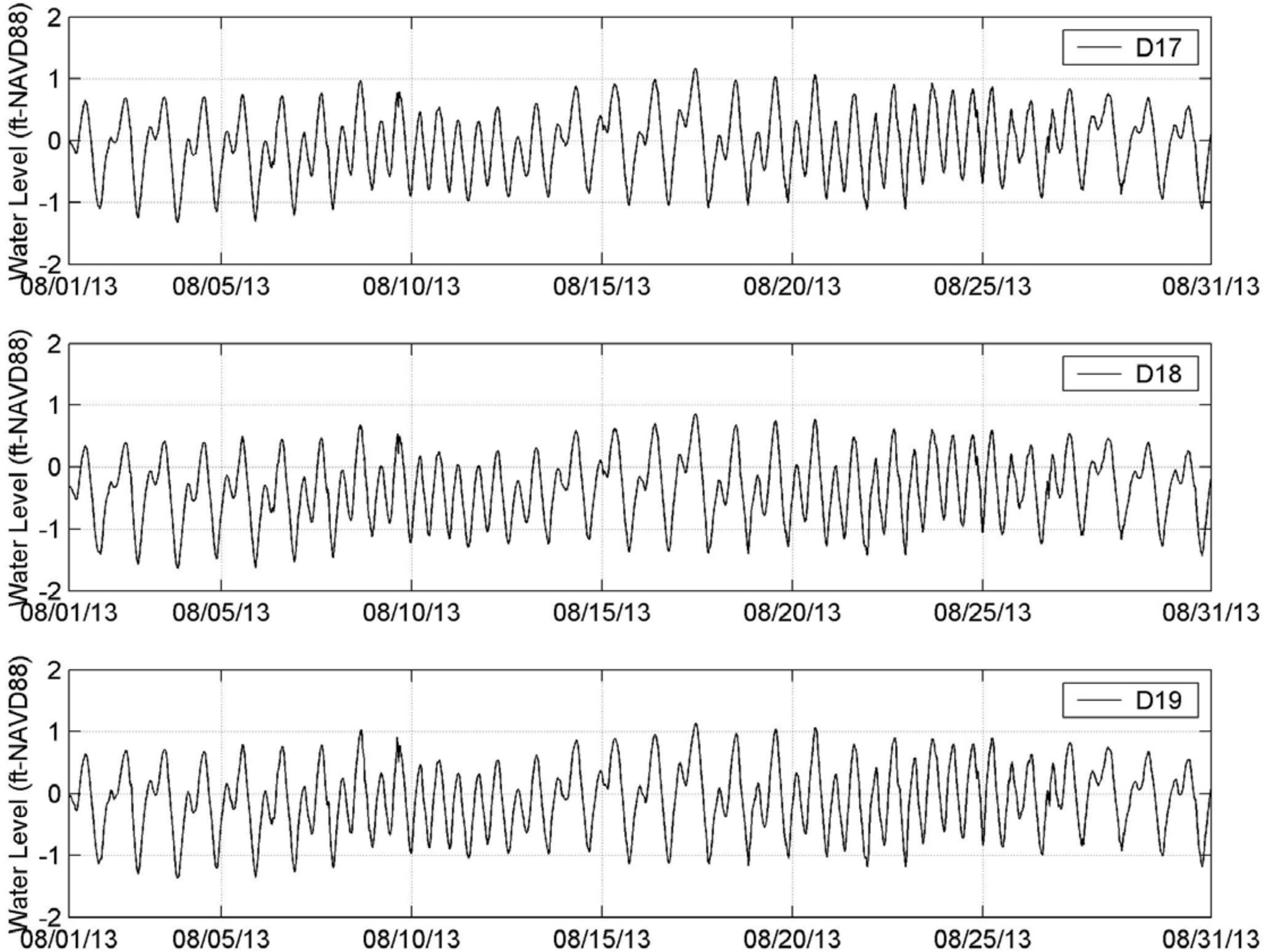
1
0
-1
-2
D17
07/01/13
07/05/13
07/10/13
07/15/13
07/20/13
07/25/13
07/31/13
Water Level (ft-NAVD88)
2
1
0
-1
-2
D18
07/01/13
07/05/13
07/10/13
07/15/13
07/20/13
07/25/13
07/31/13
Water Level (ft-NAVD88)
2
1
0
-1
-2
D19
07/01/13
07/05/13
07/10/13
07/15/13
07/20/13
07/25/13
07/31/13



D17
D18
D19
Water Level (ft-NAVD88)
2
1
0
-1
-2
08/01/13
08/05/13
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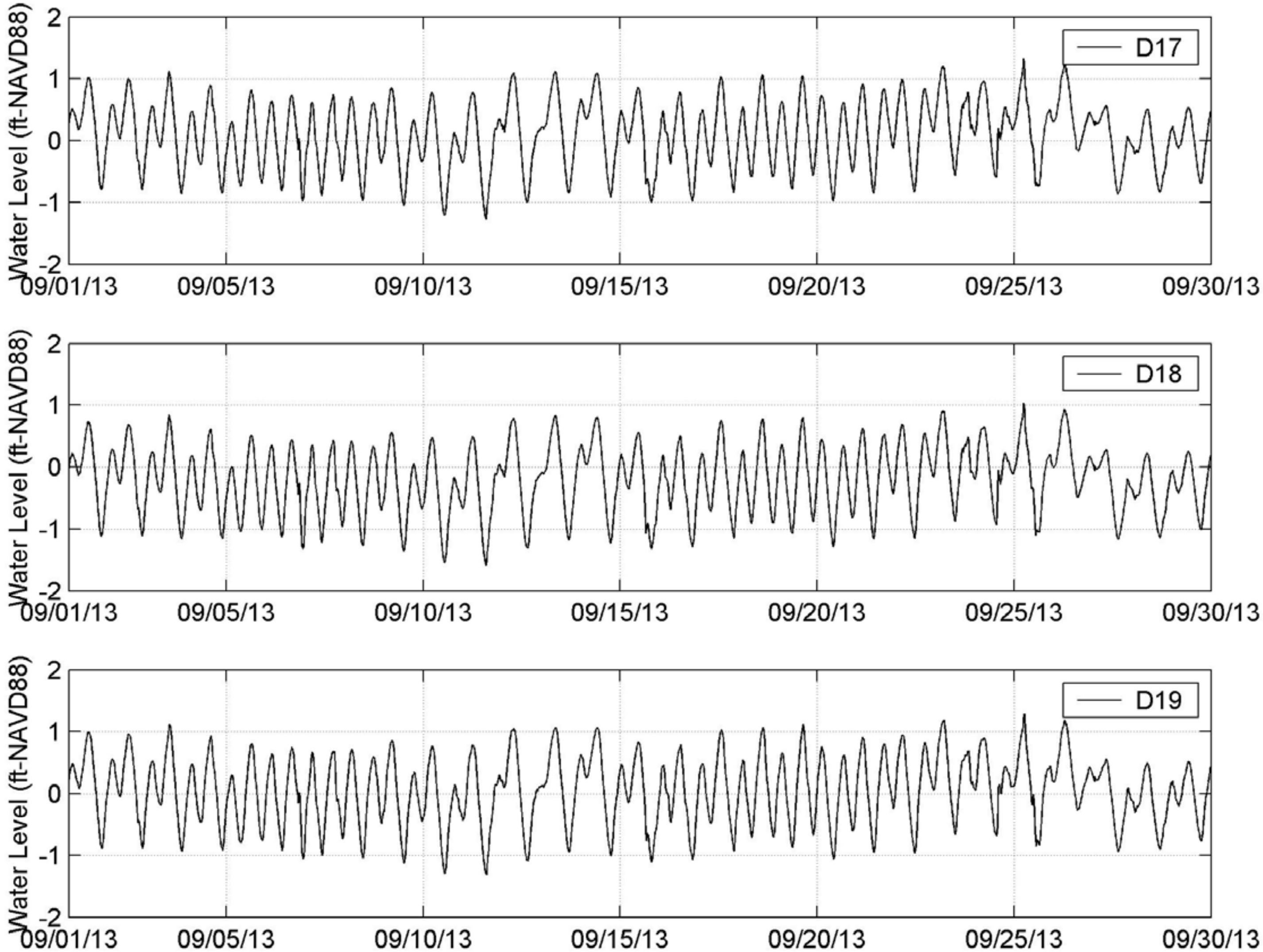
08/31/13


Water Level (ft-NAVD88)
D17
D18
D19
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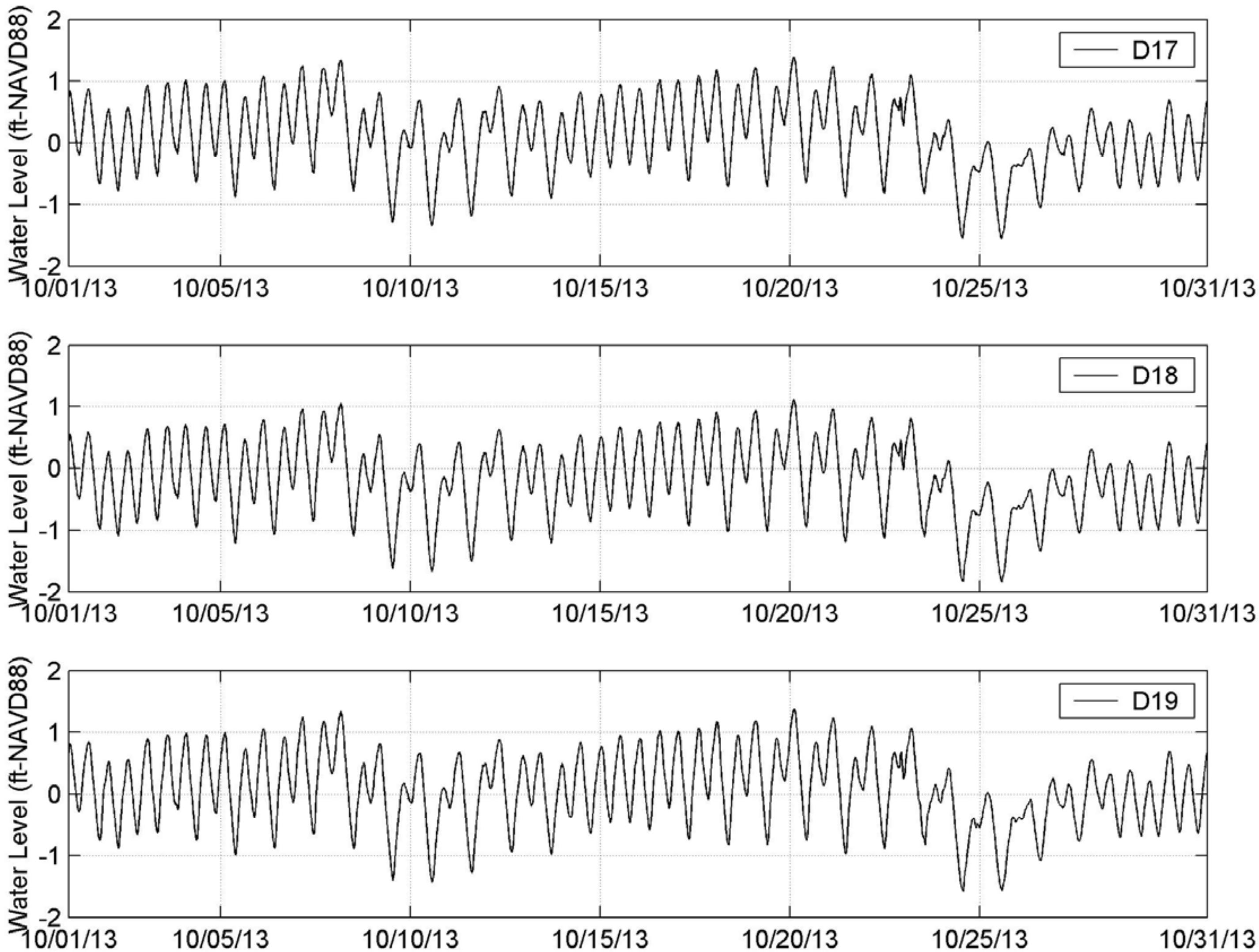
09/30/13


Water Level (ft-NAVD88)
D17
D18
D19
2
1
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-1
-2
10/01/13
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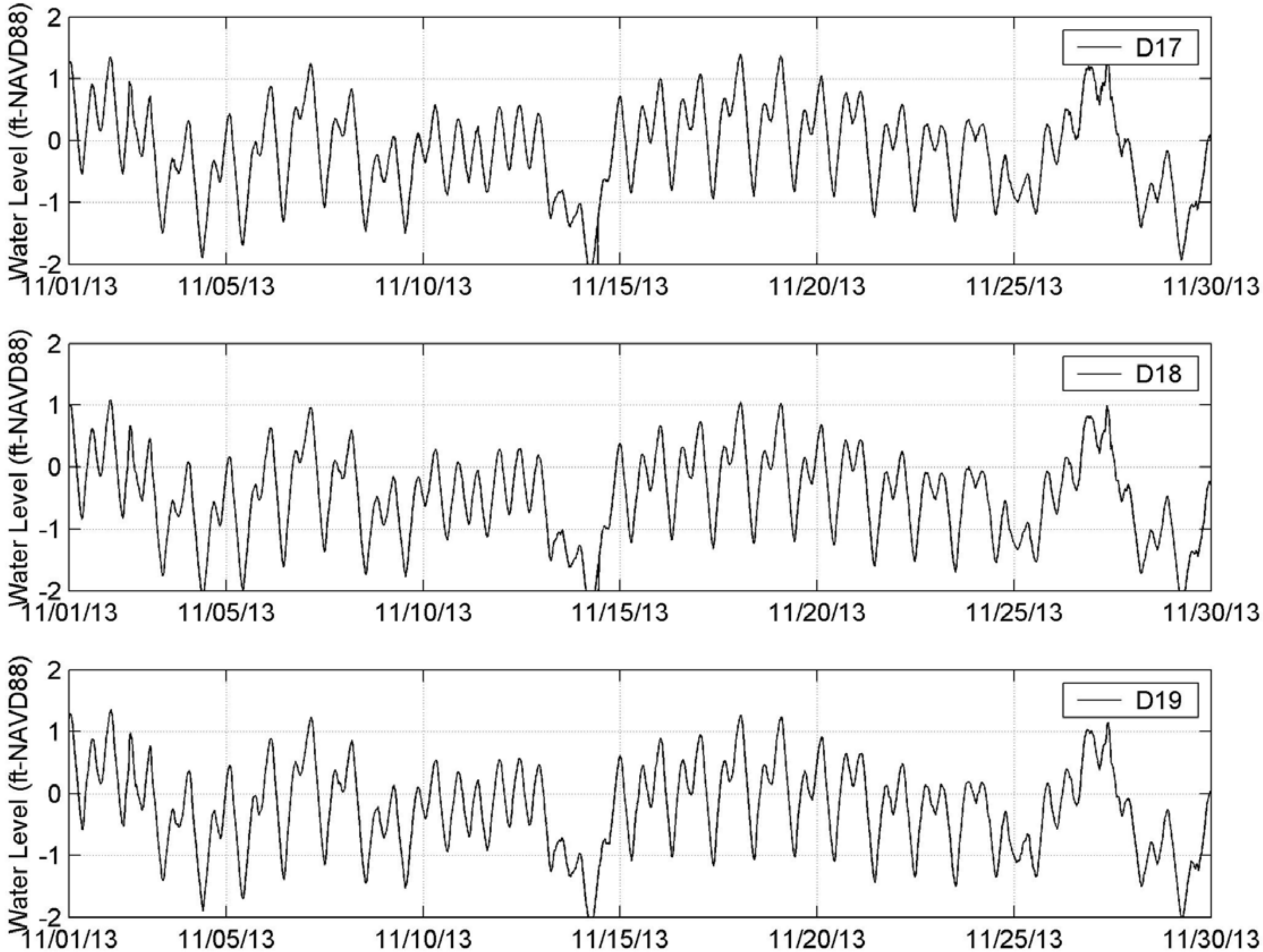
10/31/13


Water Level (ft-NAVD88)
D17
D18
D19
2
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-1
-2
11/01/13
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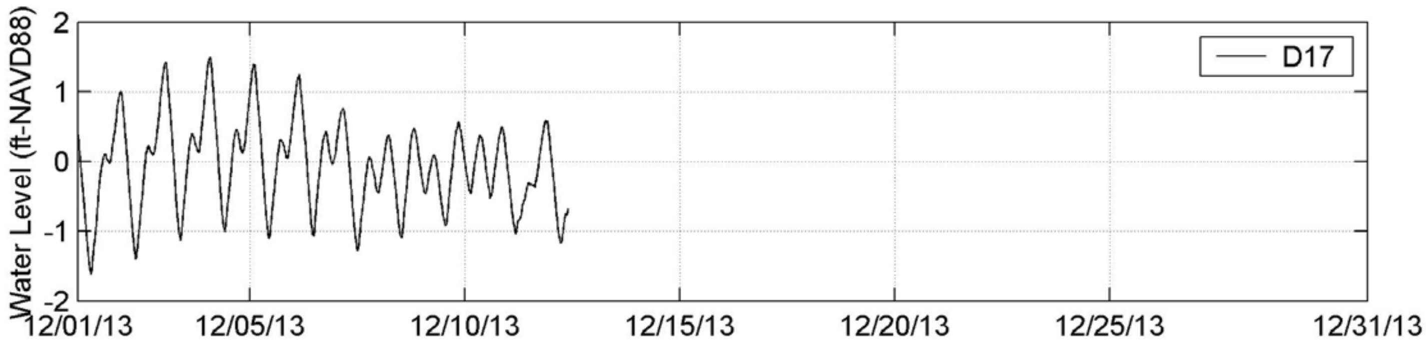
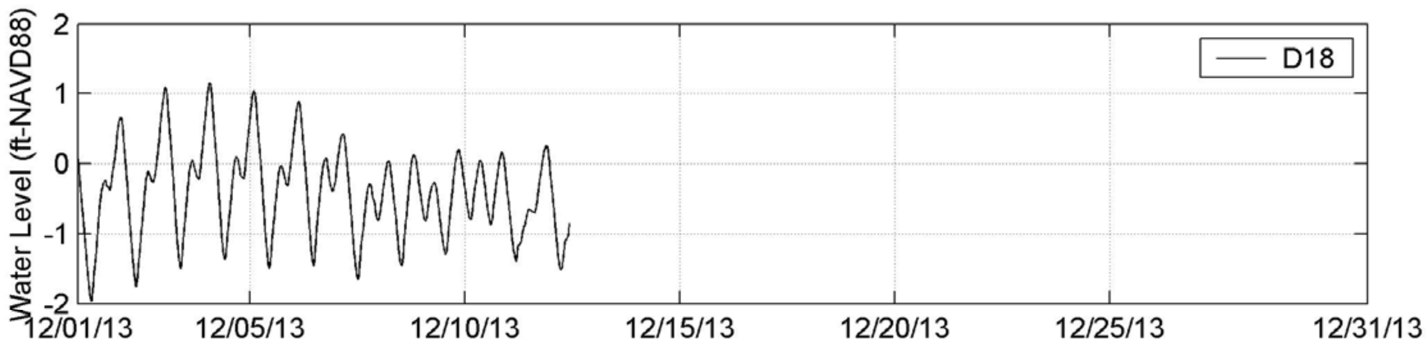
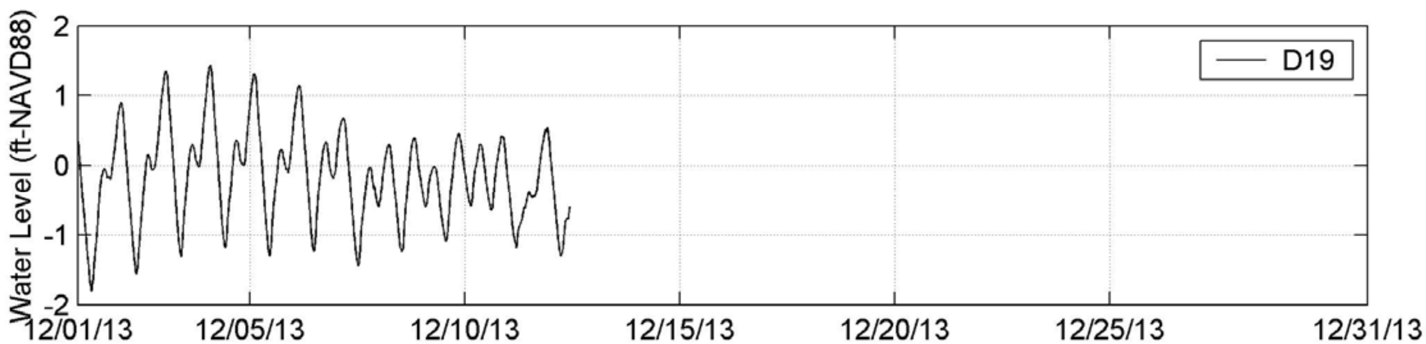
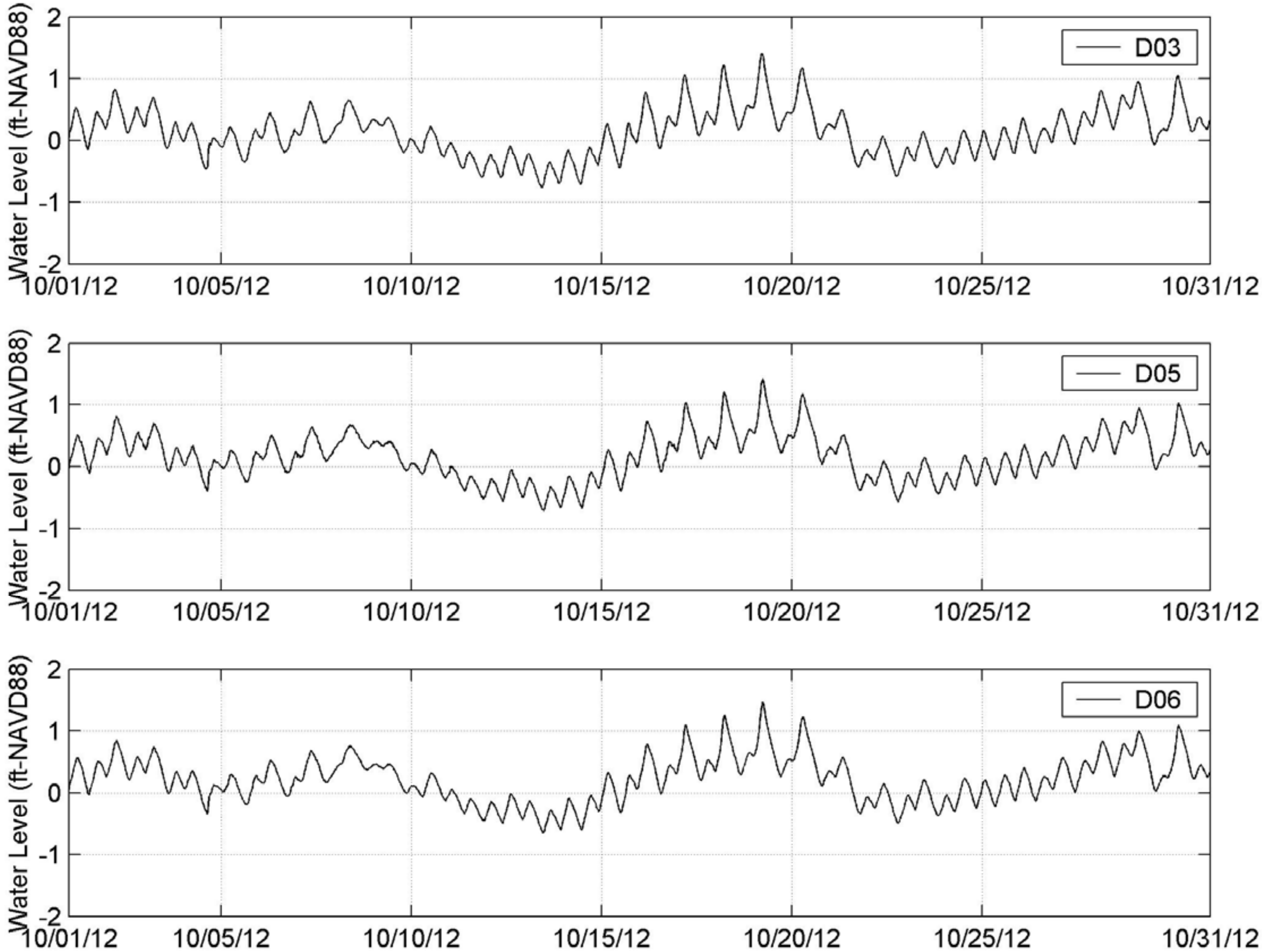
11/25/13
11/30/13


D17
Water Level (ft-NAVD88)
2
1
0
-1
-2
12/01/13
12/05/13
12/10/13
12/15/13
12/20/13
12/25/13
12/31/13


D18
Water Level (ft-NAVD88)
2
1
0
-1
-2
12/01/13
12/05/13
12/10/13
12/15/13
12/20/13
12/25/13
12/31/13


D19
Water Level (ft-NAVD88)
2
1
0
-1
-2
12/01/13
12/05/13
12/10/13
12/15/13
12/20/13
12/25/13
12/31/13


D03
D05
D06
Water Level (ft-NAVD88)
2
1
0
-1
-2
10/01/12
10/05/12
10/10/12
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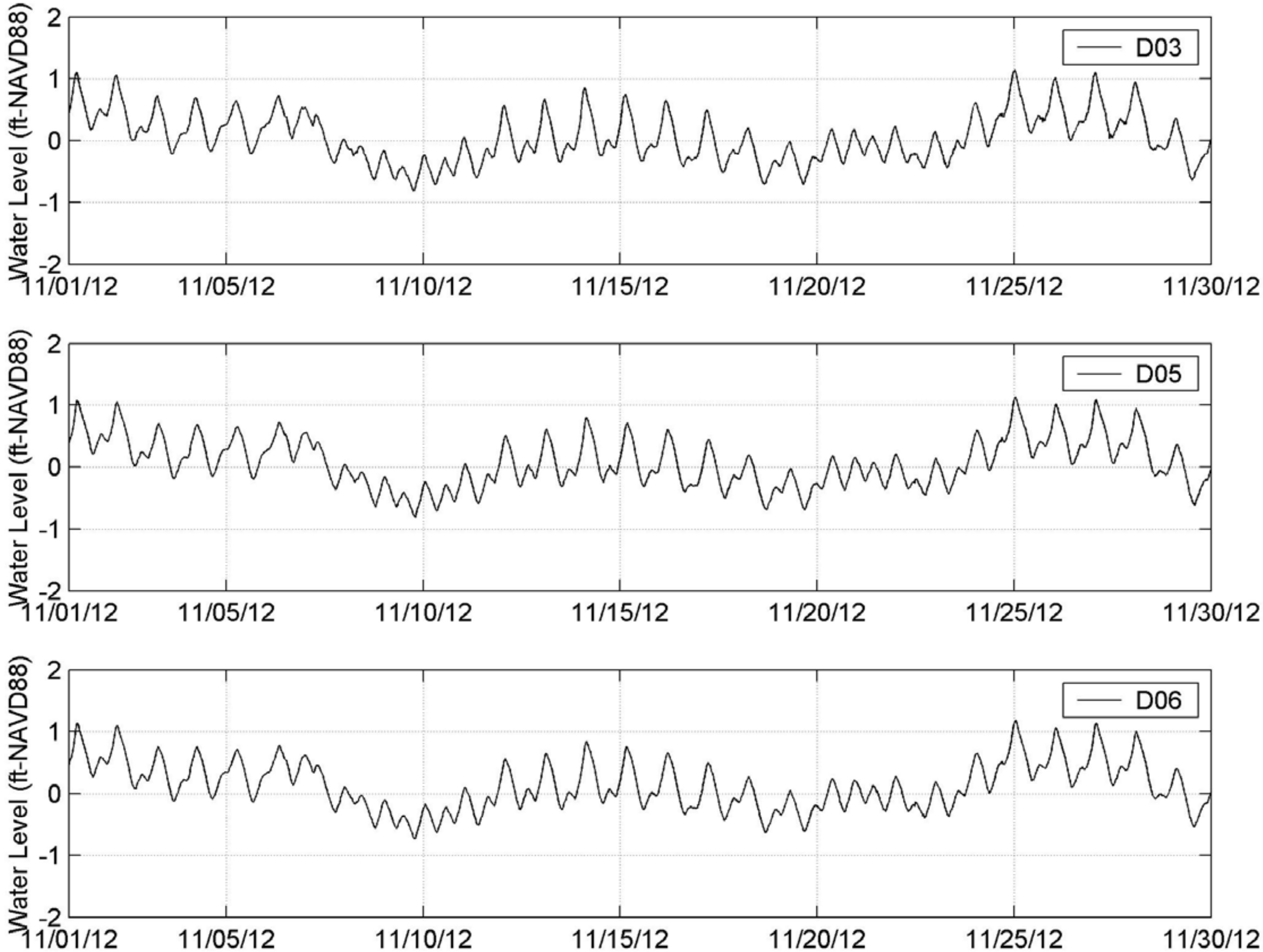
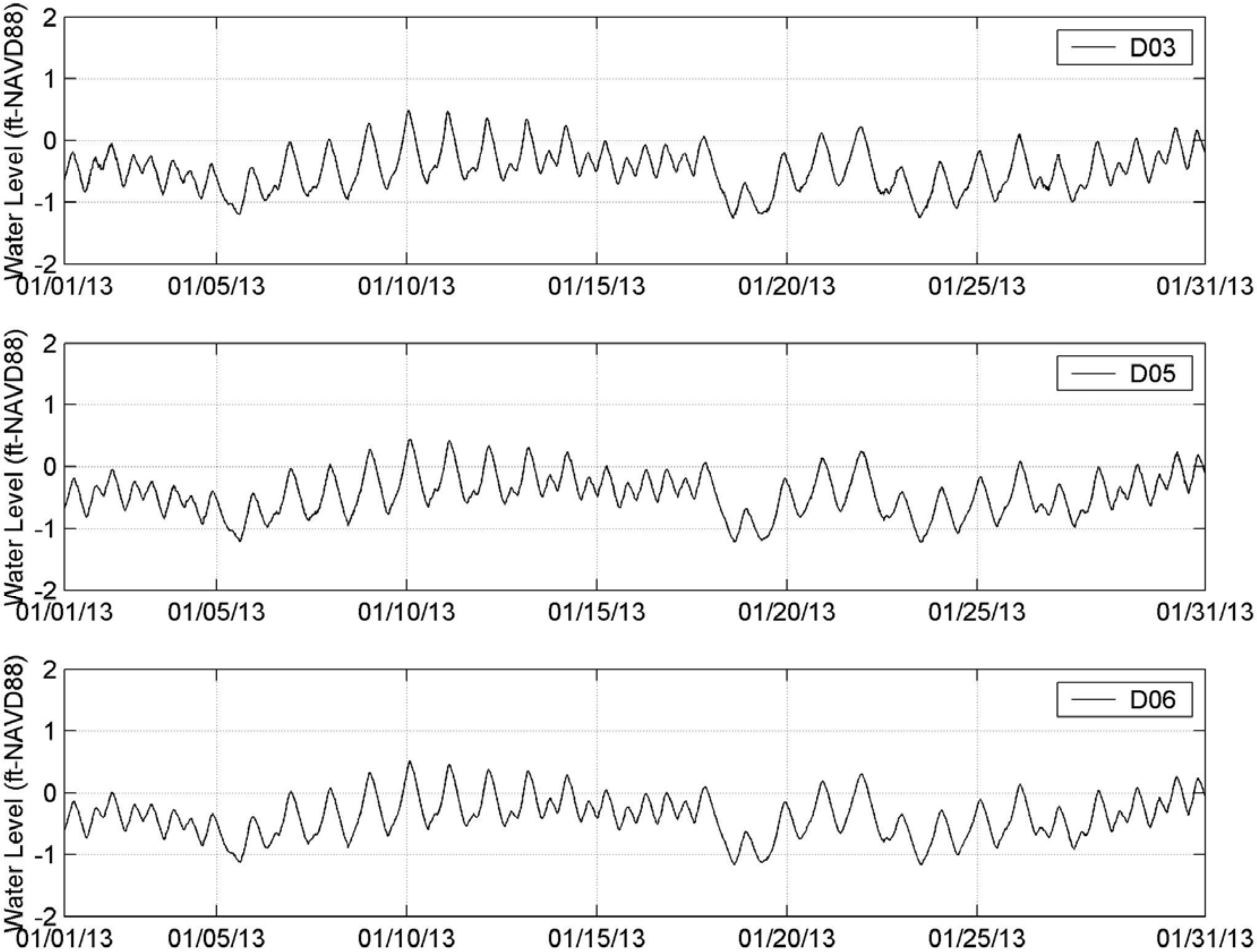
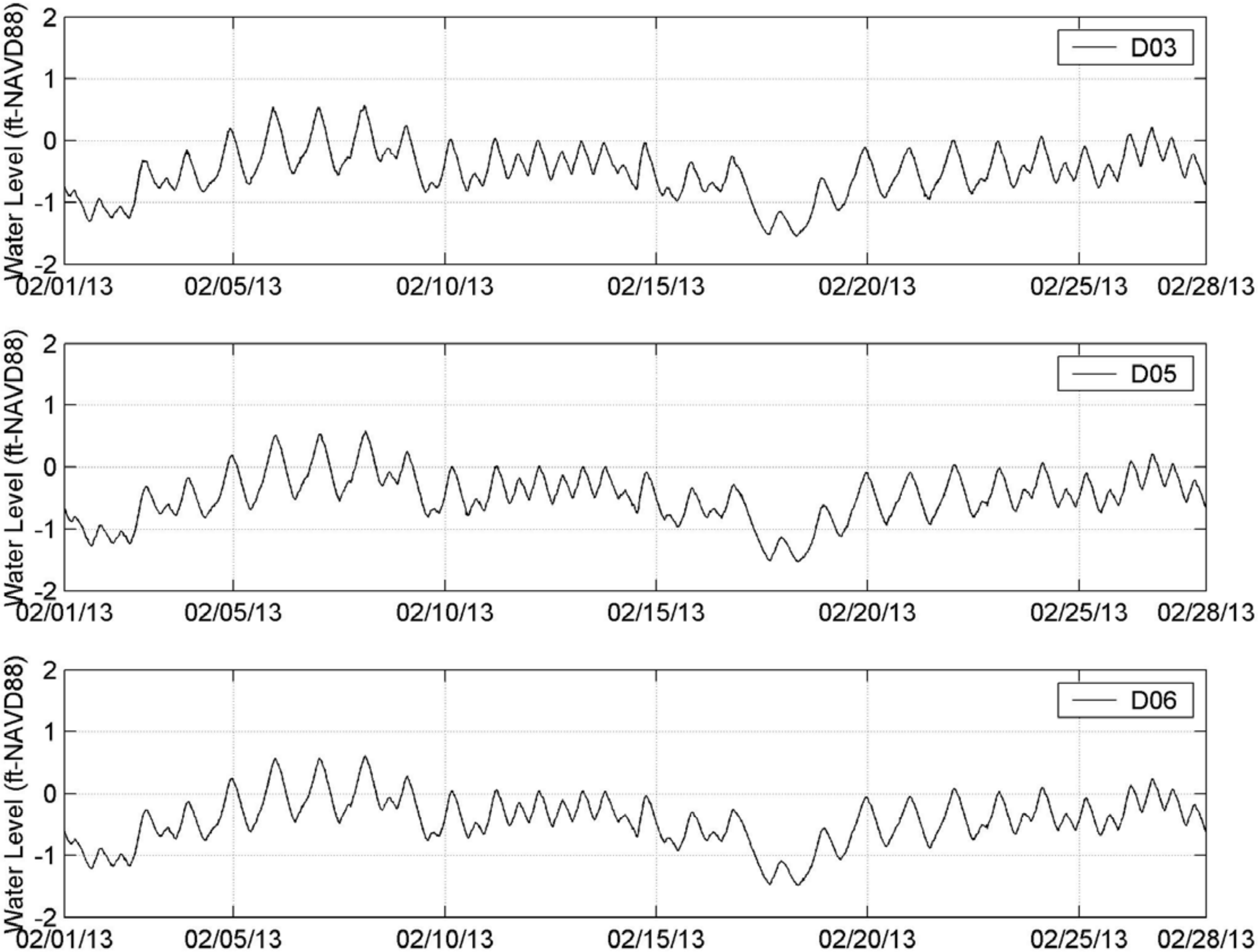
10/25/12
10/31/12


D03
D05
D06
Water Level (ft-NAVD88)
2
1
0
-1
-2
11/01/12
11/05/12
11/10/12
11/15/12
11/20/12
11/25/12
11/30/12


Water Level (ft-NAVD88)
2
1
0
-1
-2
D03
01/01/13
01/05/13
01/10/13
01/15/13
01/20/13
01/25/13
01/31/13
Water Level (ft-NAVD88)
2
1
0
-1
-2
D05
01/01/13
01/05/13
01/10/13
01/15/13
01/20/13
01/25/13
01/31/13
Water Level (ft-NAVD88)
2
1
0
-1
-2
D06
01/01/13
01/05/13
01/10/13
01/15/13
01/20/13
01/25/13
01/31/13


D03
D05
D06
Water Level (ft-NAVD88)
2
1
0
-1
-2
02/01/13
02/05/13
02/10/13
02/15/13
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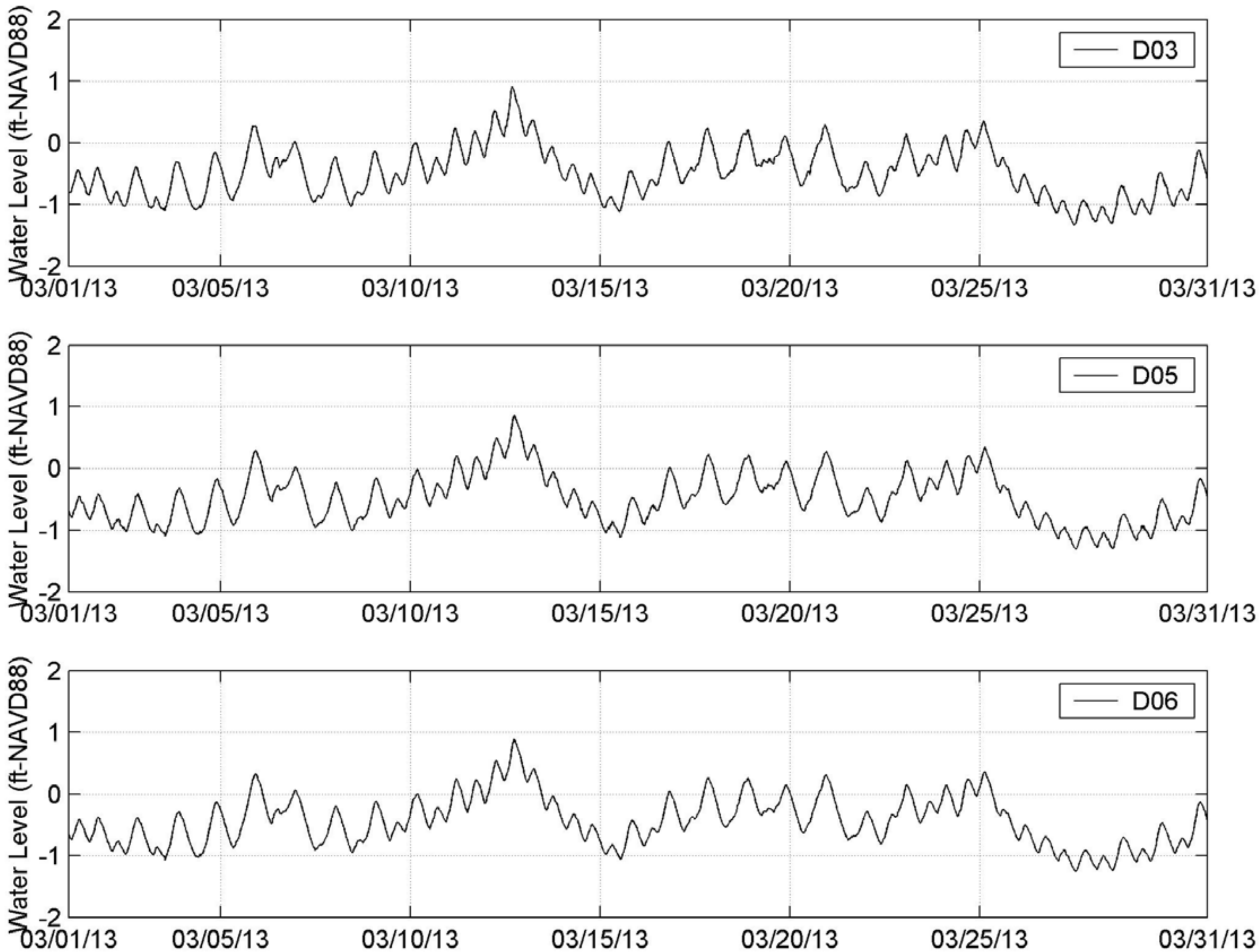
02/25/13
02/28/13


D03
D05
D06
Water Level (ft-NAVD88)
2
1
0
-1
-2
03/01/13
03/05/13
03/10/13
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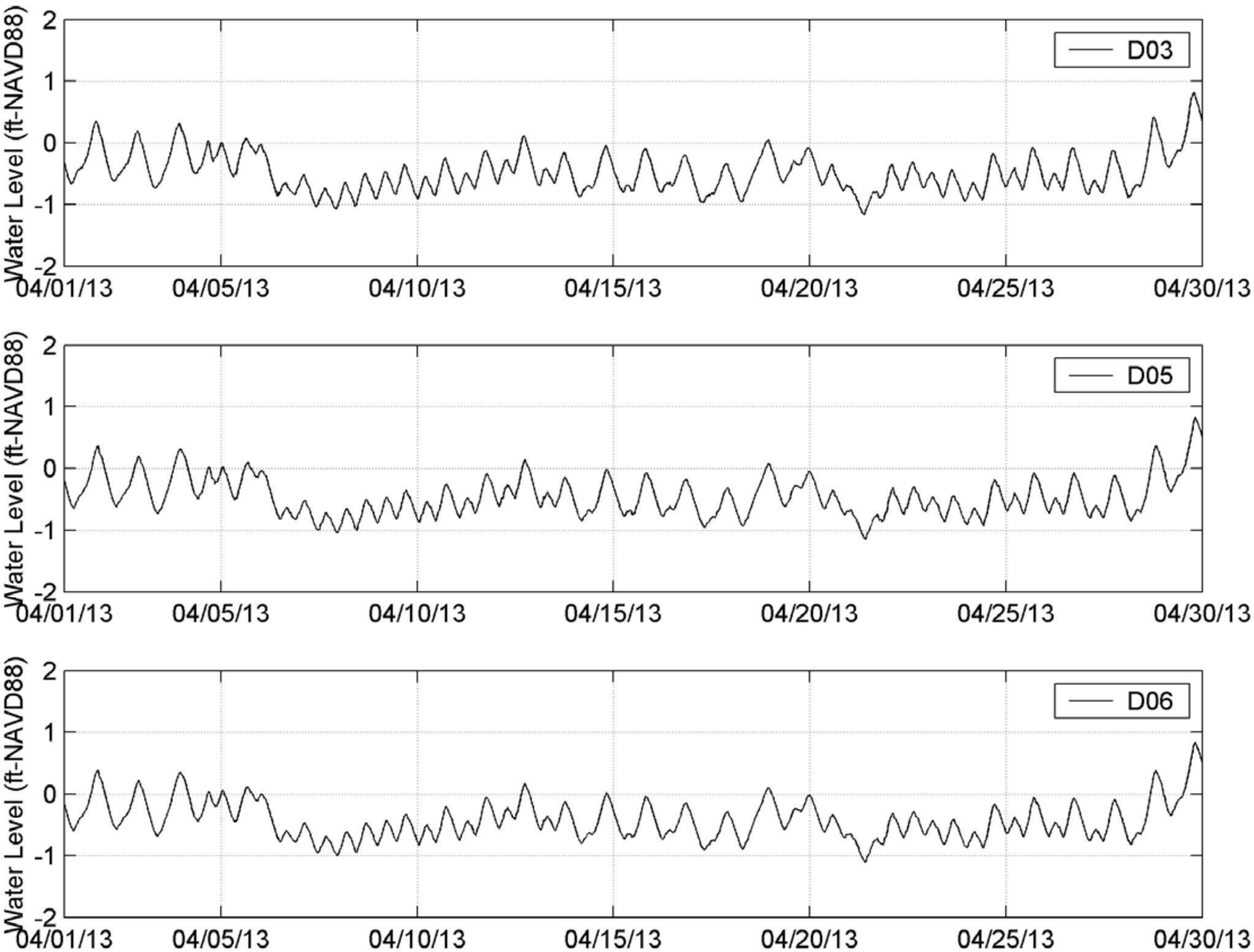
03/20/13
03/25/13
03/31/13



Water Level (ft-NAVD88)
D03
D05
D06
2
1
0
-1
-2
04/01/13
04/05/13
04/10/13
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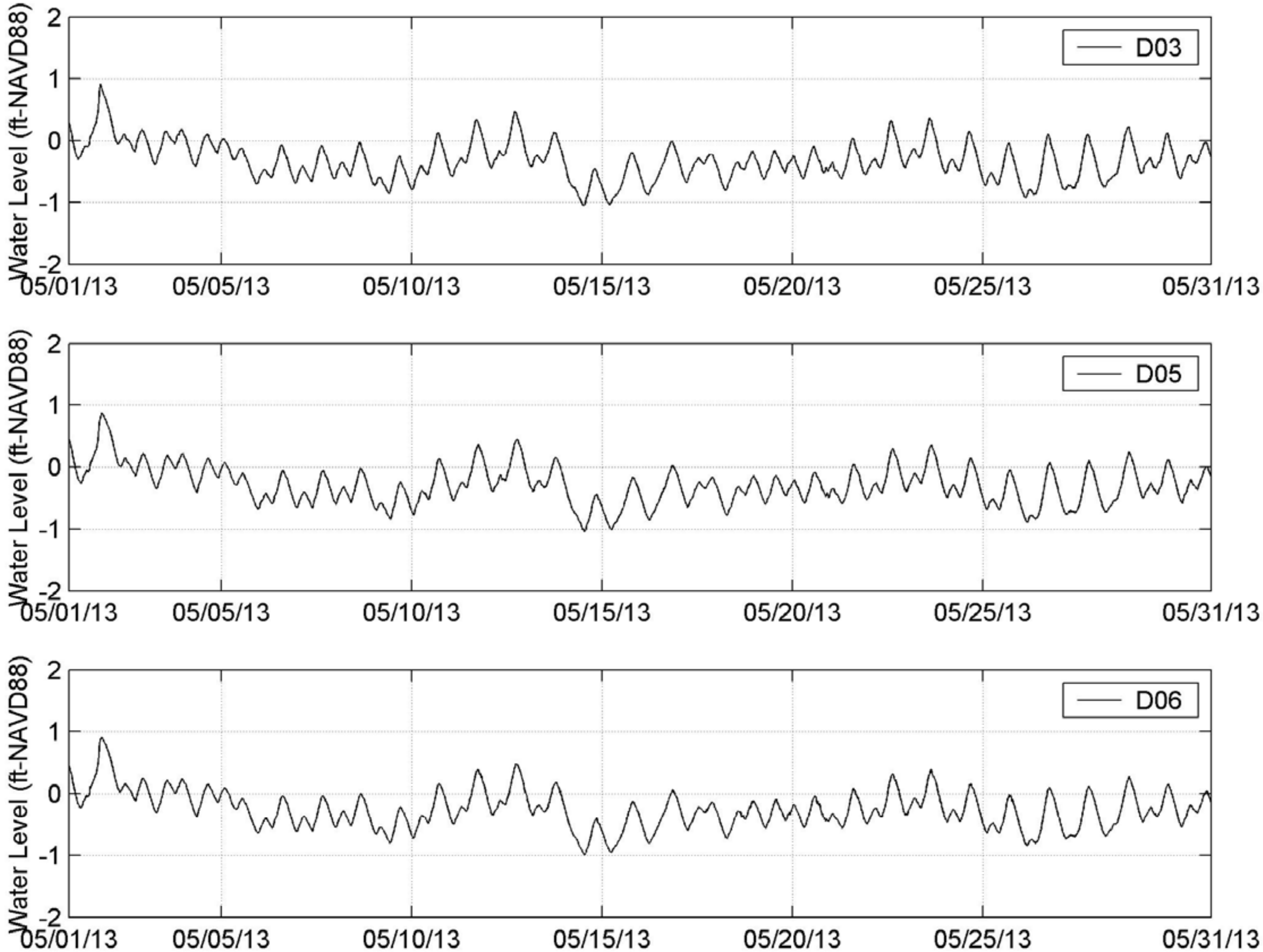
04/20/13
04/25/13
04/30/13


Water Level (ft-NAVD88)
D03
D05
D06
2
1
0
-1
-2
05/01/13
05/05/13
05/10/13
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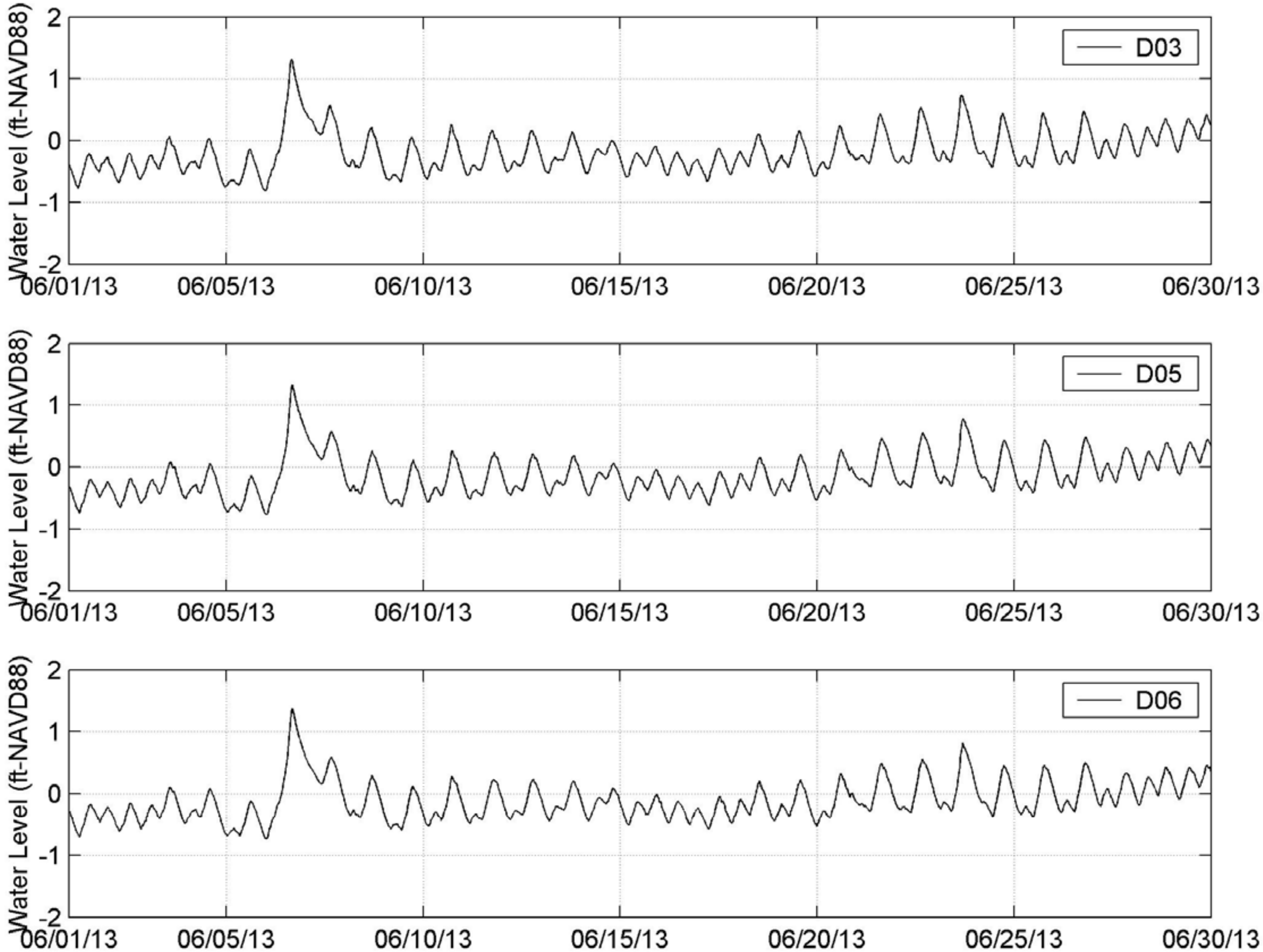
05/25/13
05/31/13



Water Level (ft-NAVD88)
D03
D05
D06
2
1
0
-1
-2
06/01/13
06/05/13
06/10/13
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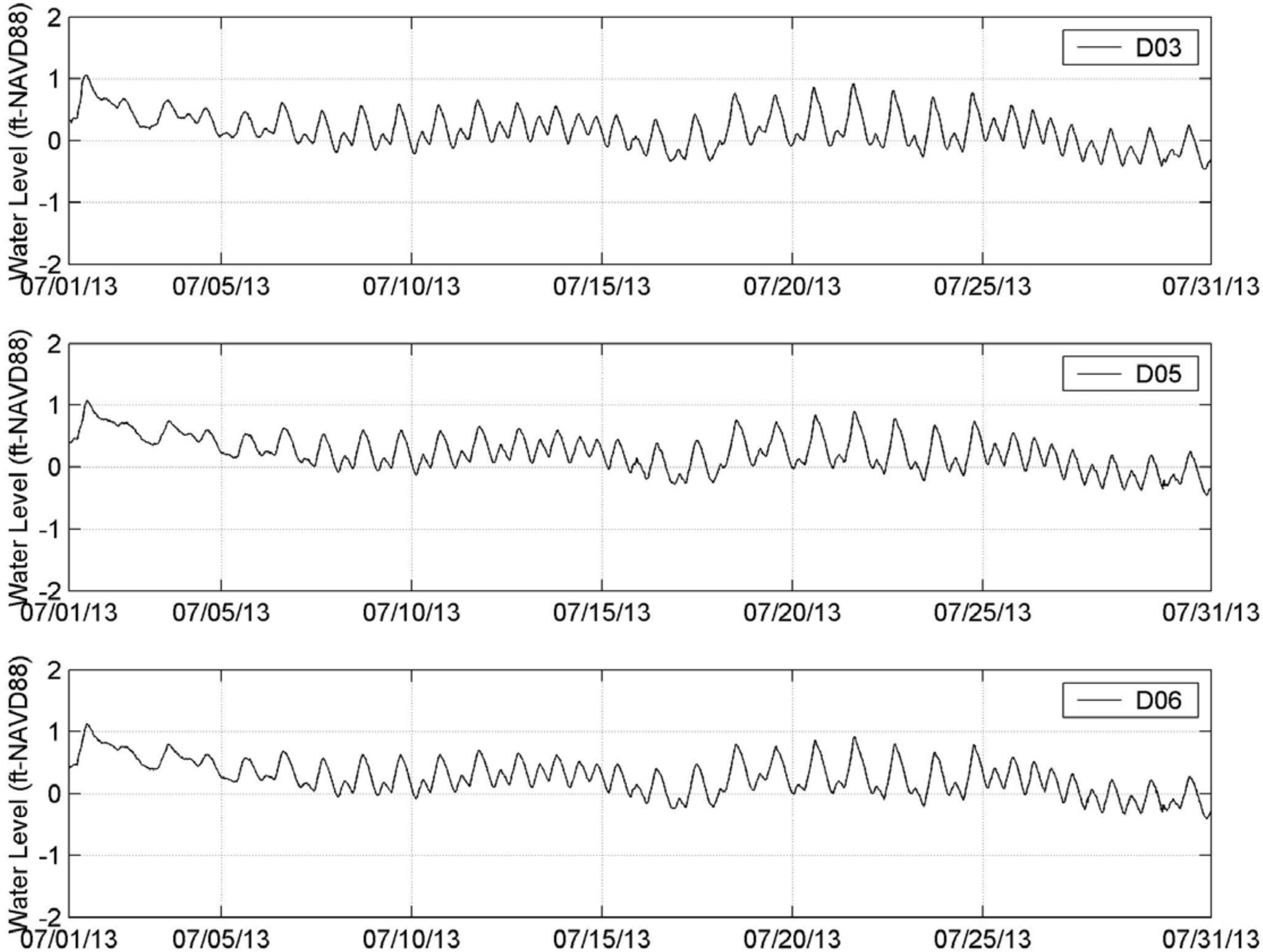
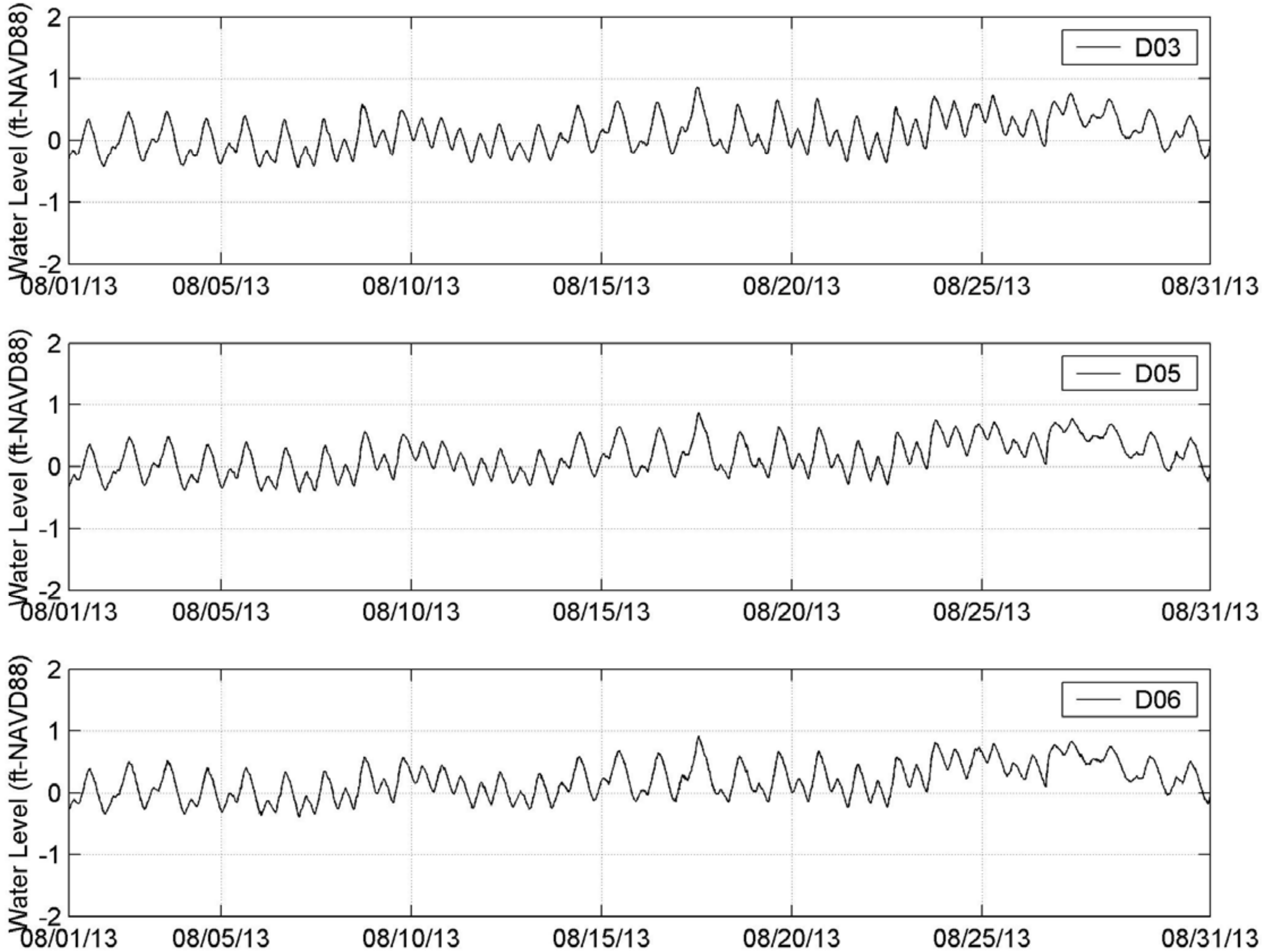
06/25/13
06/30/13



D03
D05
D06
Water Level (ft-NAVD88)
2
1
0
-1
-2
07/01/13
07/05/13
07/10/13
07/15/13
07/20/13
07/25/13
07/31/13


D03
D05
D06
Water Level (ft-NAVD88)
2
1
0
-1
-2
08/01/13
08/05/13
08/10/13
08/15/13
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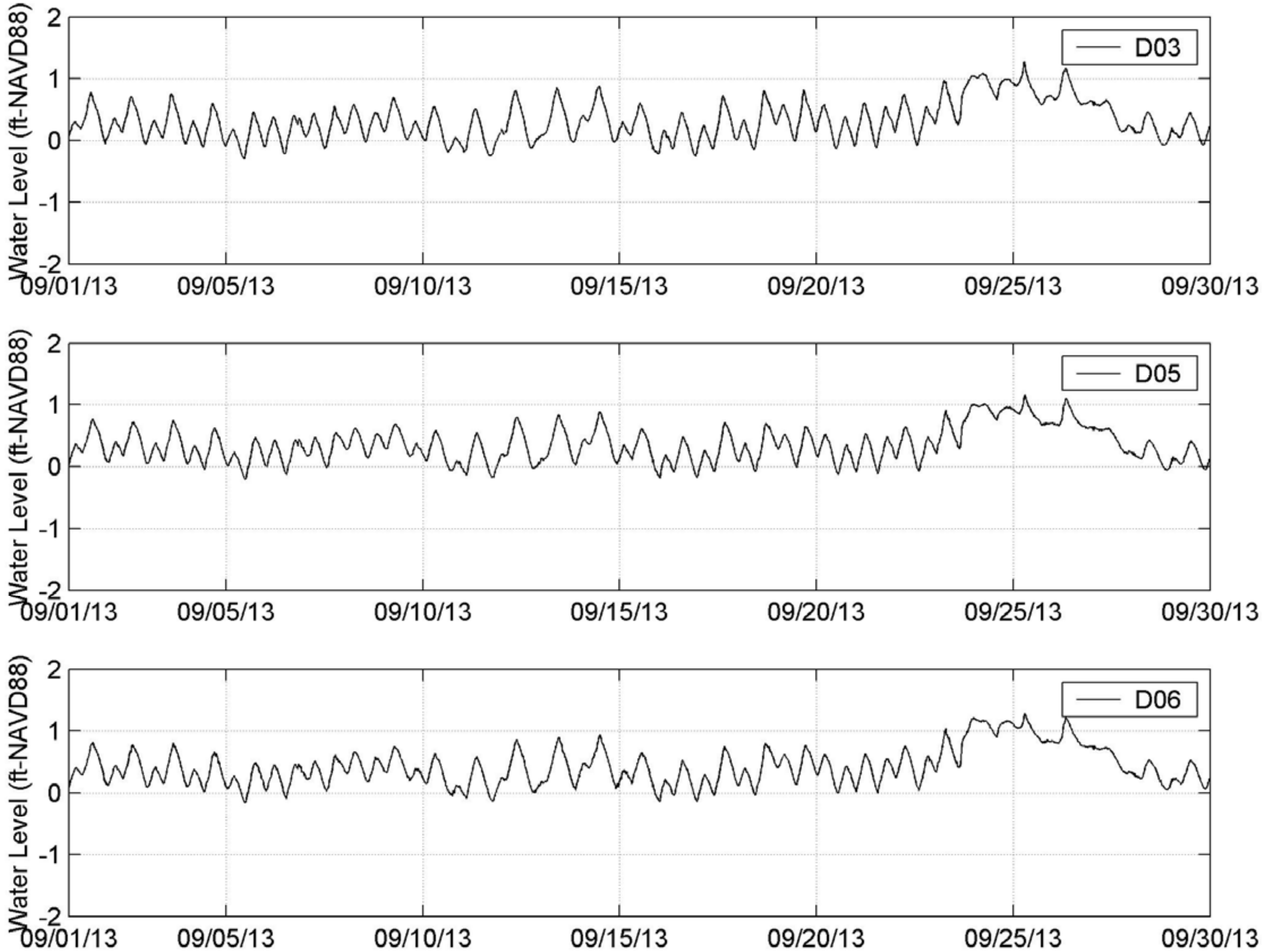
08/25/13
08/31/13


D03
D05
D06
Water Level (ft-NAVD88)
2
1
0
-1
-2
09/01/13
09/05/13
09/10/13
09/15/13
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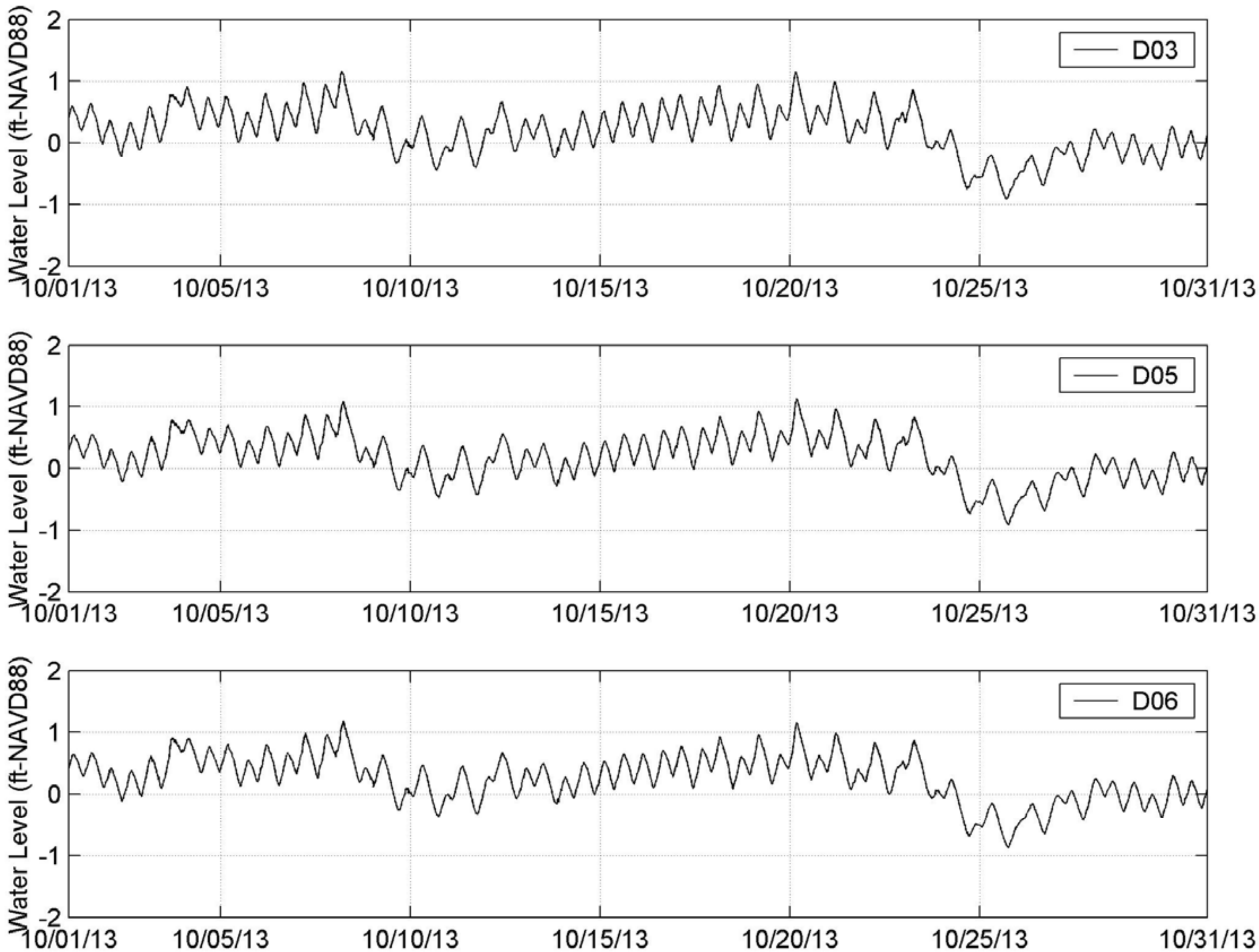
09/25/13
09/30/13


D03
D05
D06
Water Level (ft-NAVD88)
2
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0
-1
-2
10/01/13
10/05/13
10/10/13
10/15/13
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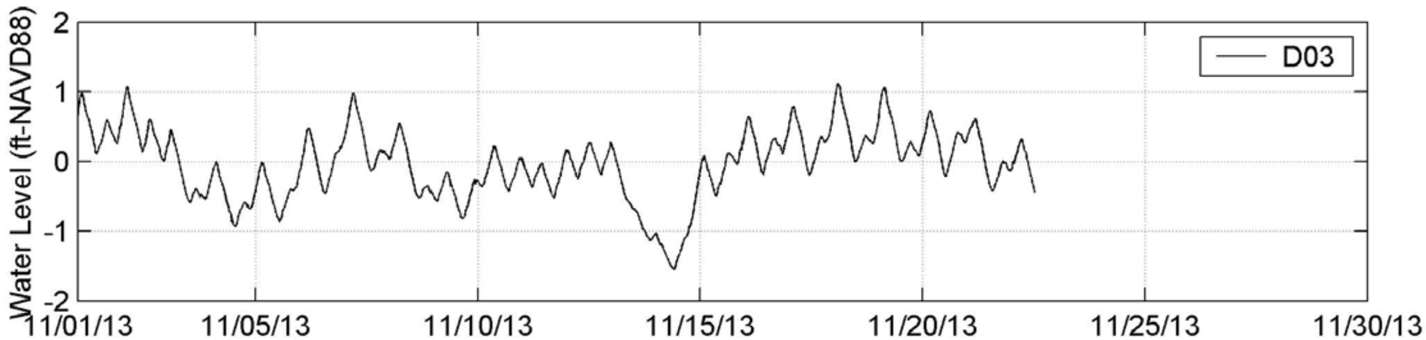
10/25/13
10/31/13


D03
Water Level (ft-NAVD88)
2
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0
-1
-2
11/01/13
11/05/13
11/10/13
11/15/13
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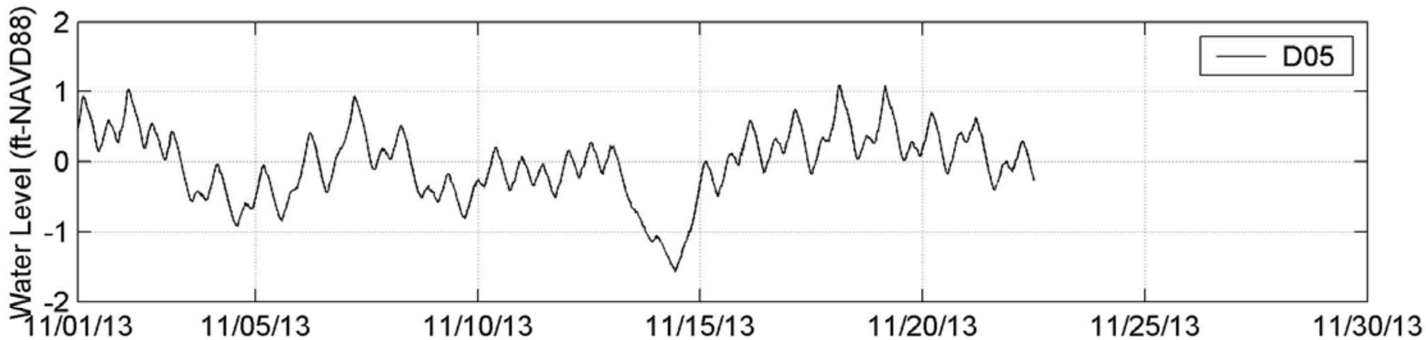
11/25/13
11/30/13


D05
Water Level (ft-NAVD88)
2
1
0
-1
-2
11/01/13
11/05/13
11/10/13
11/15/13
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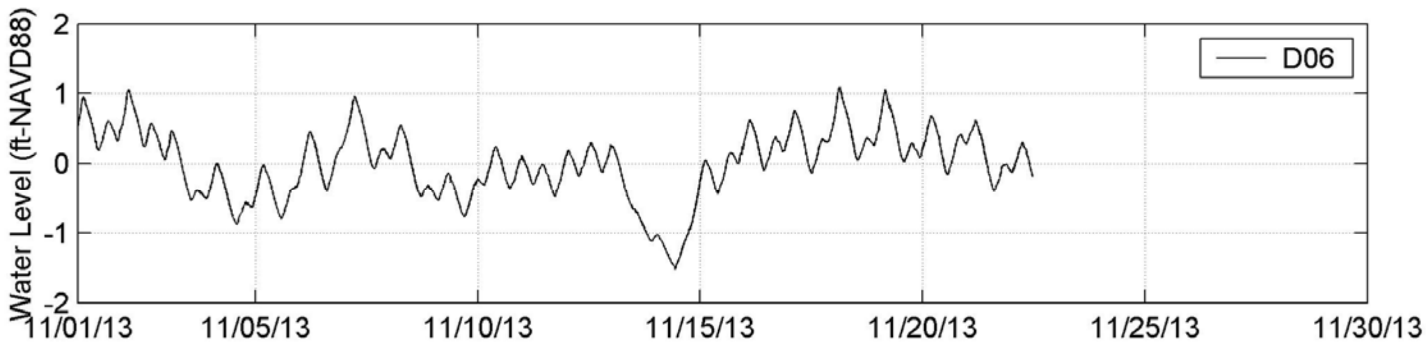
11/25/13
11/30/13


D06
Water Level (ft-NAVD88)
2
1
0
-1
-2
11/01/13
11/05/13
11/10/13
11/15/13
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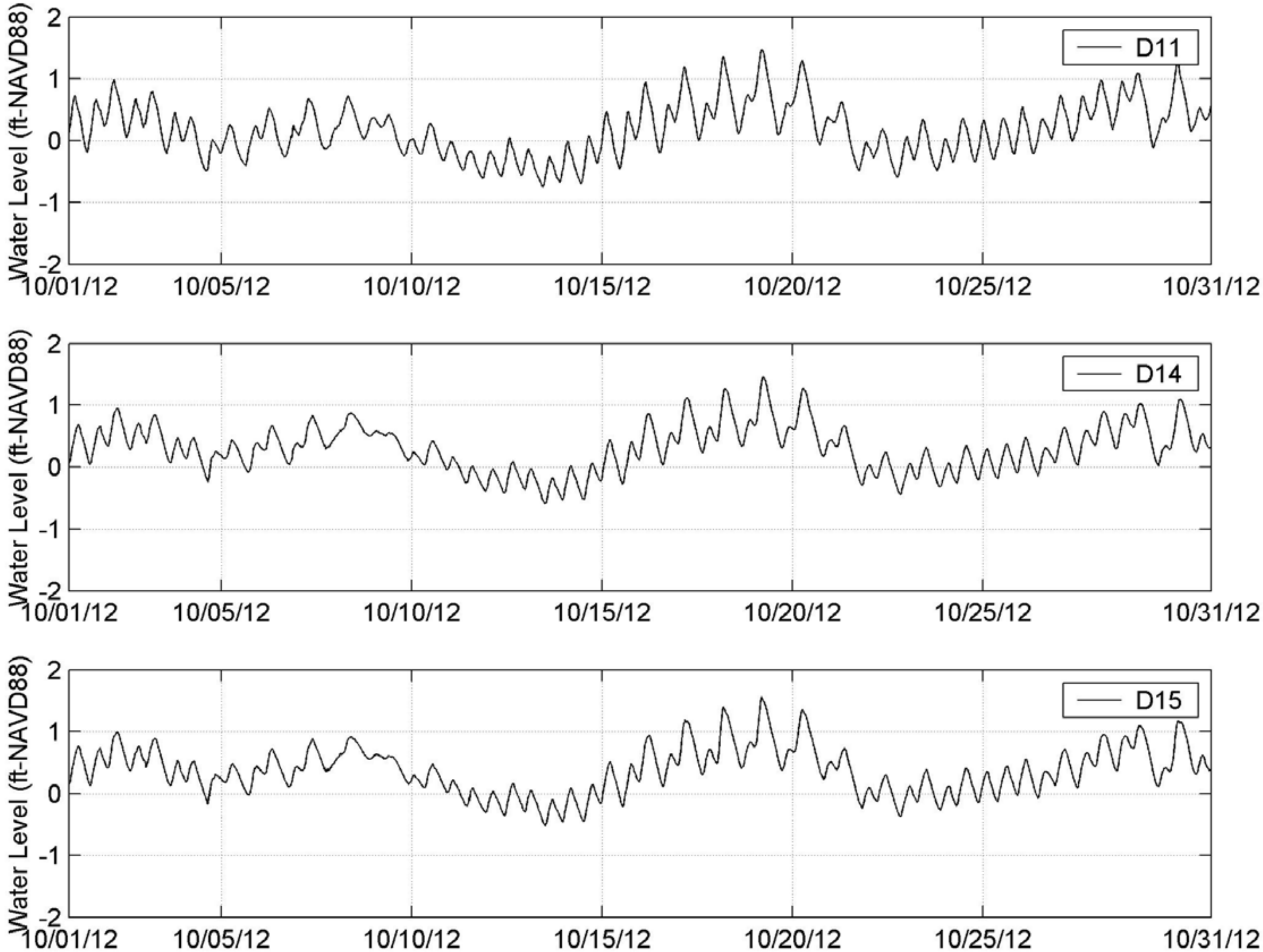
11/25/13
11/30/13


D11
D14
D15
Water Level (ft-NAVD88)
2
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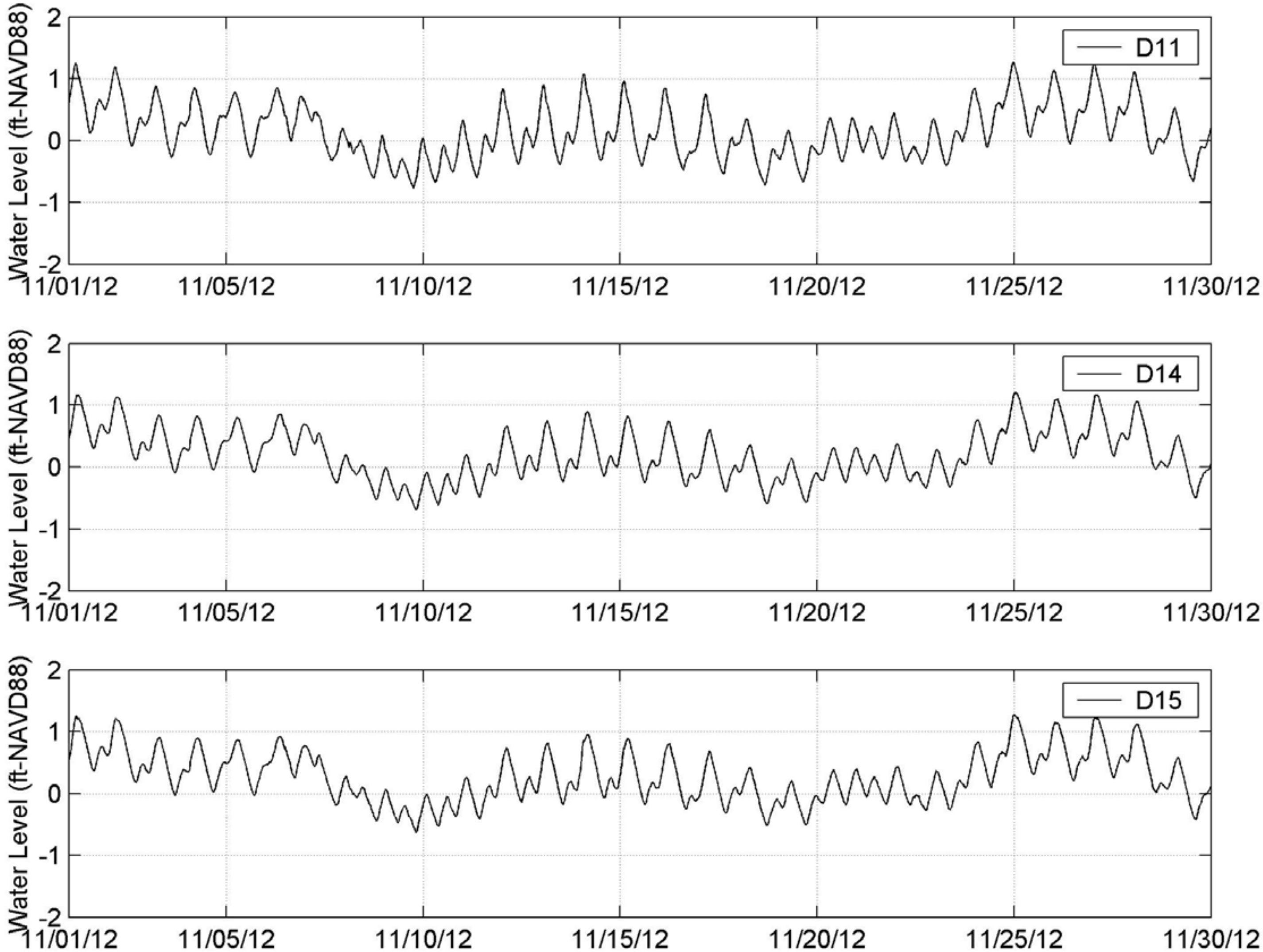
0
-1
-2
10/01/12
10/05/12
10/10/12
10/15/12
10/20/12
10/25/12
10/31/12


D11
D14
D15
Water Level (ft-NAVD88)
2
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0
-1
-2
11/01/12
11/05/12
11/10/12
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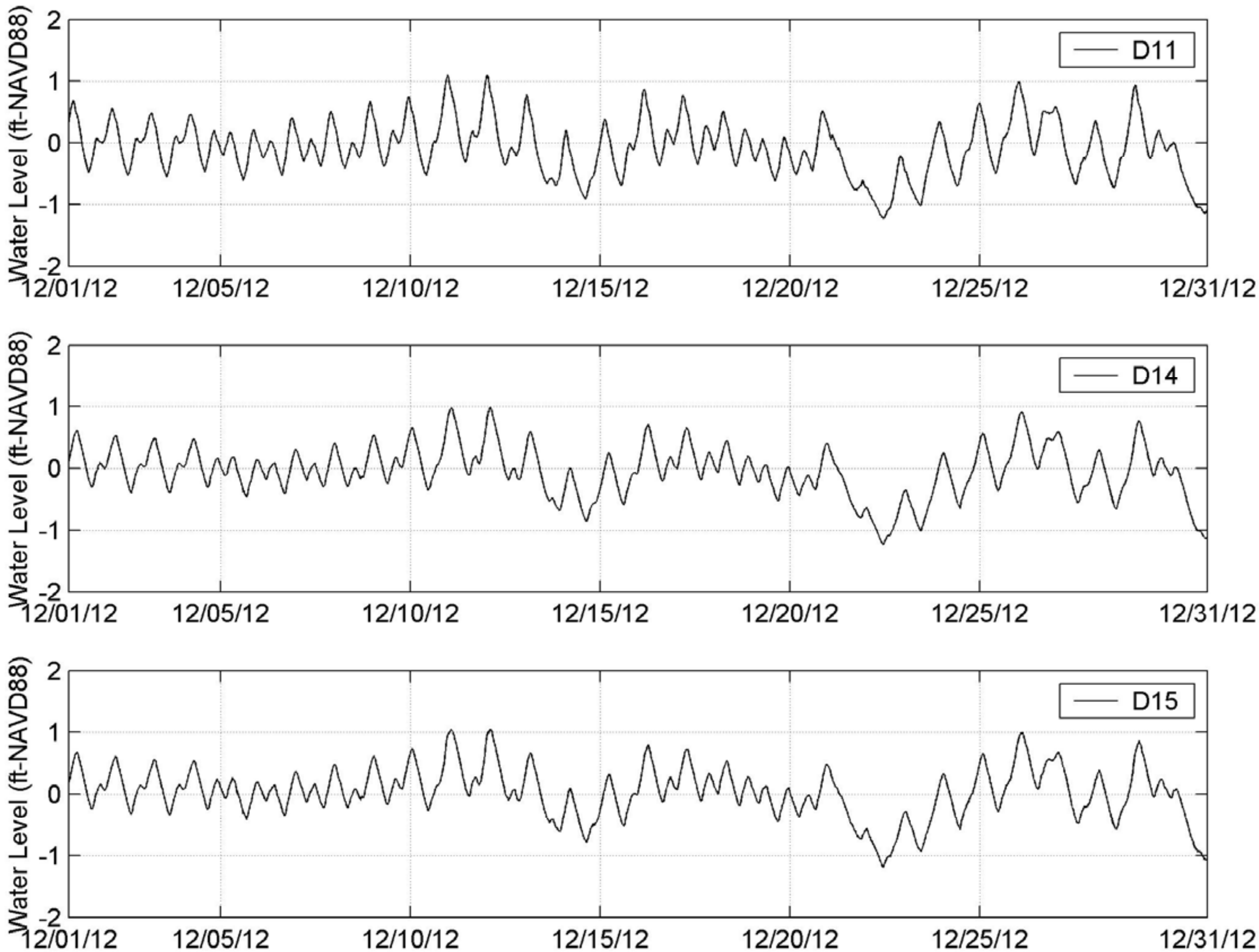
11/25/12
11/30/12



D11
D14
D15
Water Level (ft-NAVD88)
2
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0
-1
-2
12/01/12
12/05/12
12/10/12
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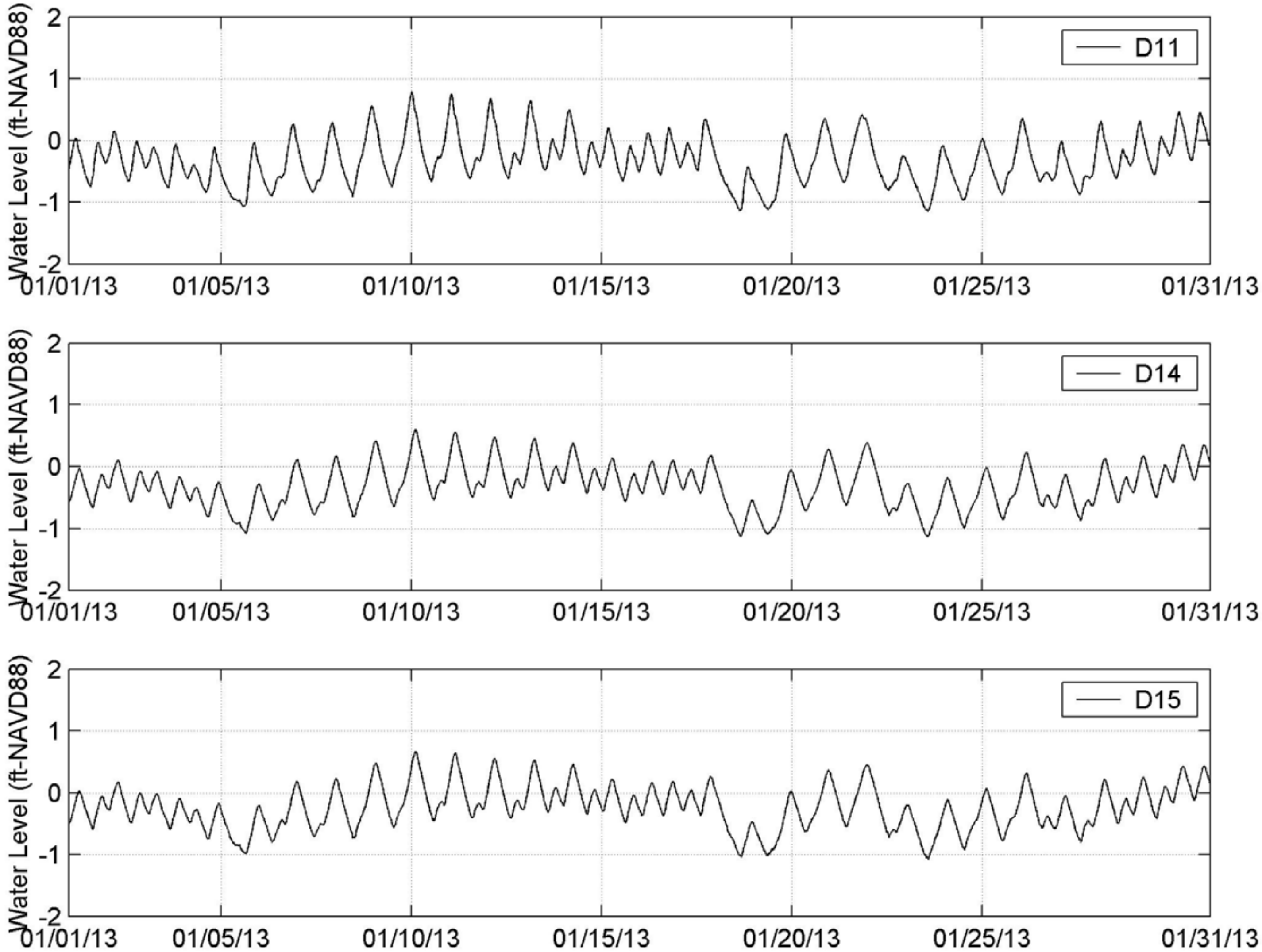
12/25/12
12/31/12



D11
D14
D15
Water Level (ft-NAVD88)
2
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0
-1
-2
01/01/13
01/05/13
01/10/13
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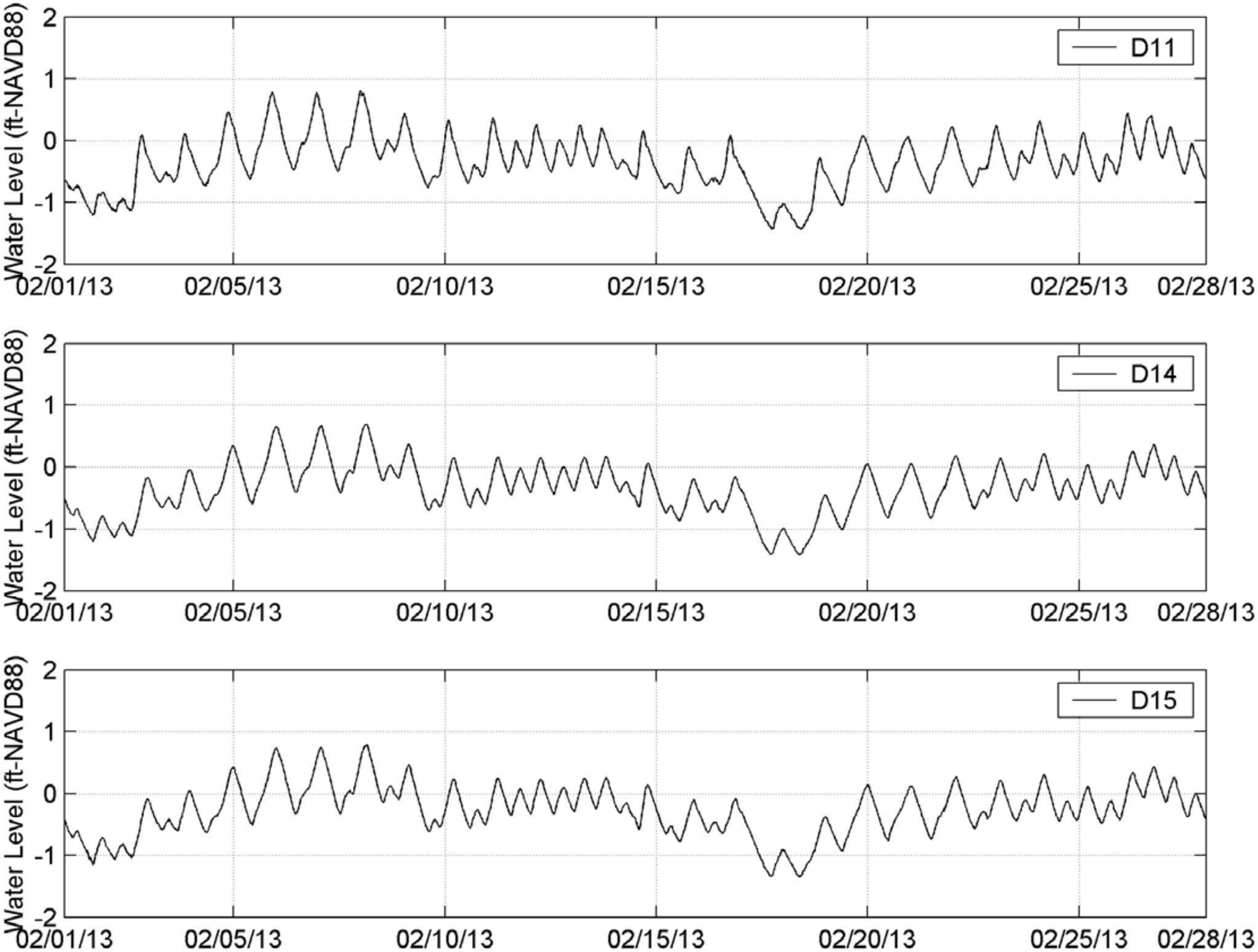
01/25/13
01/31/13


D11
D14
D15
Water Level (ft-NAVD88)
2
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0
-1
-2
02/01/13
02/05/13
02/10/13
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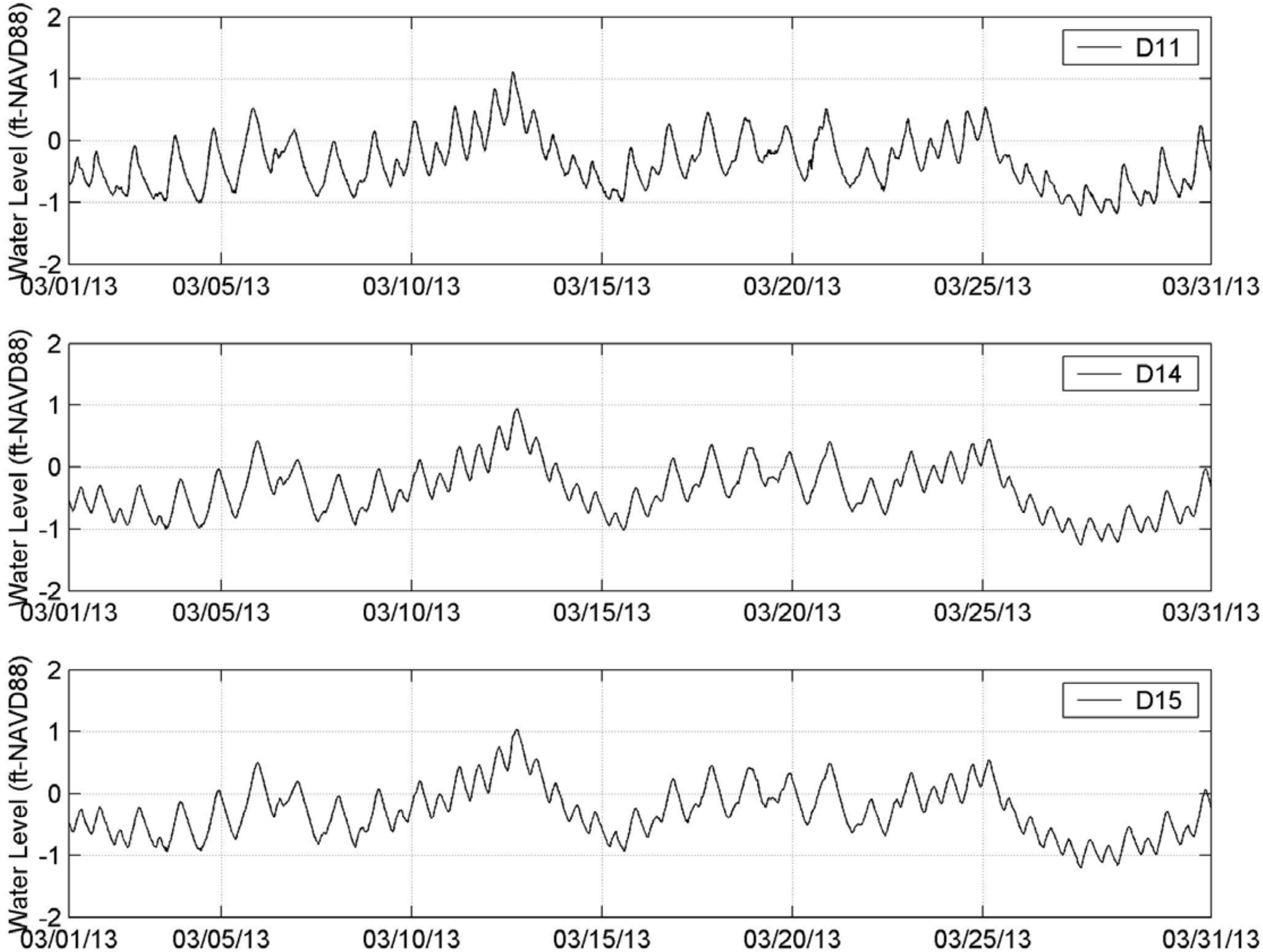
02/25/13
02/28/13


Water Level (ft-NAVD88)
D11
D14
D15
2
1
0
-1
-2
03/01/13
03/05/13
03/10/13
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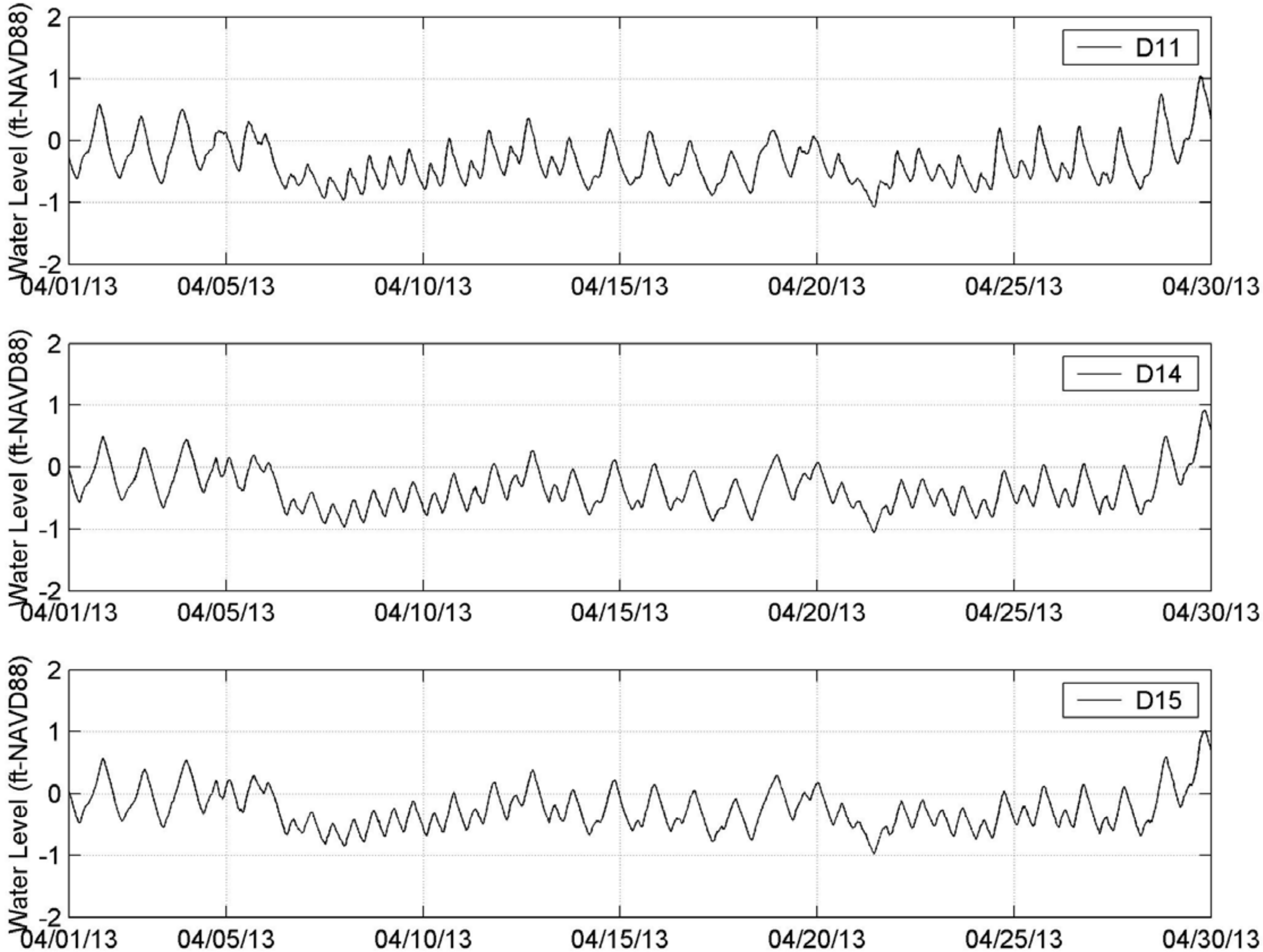
03/25/13
03/31/13



Water Level (ft-NAVD88)
D11
D14
D15
2
1
0
-1
-2
04/01/13
04/05/13
04/10/13
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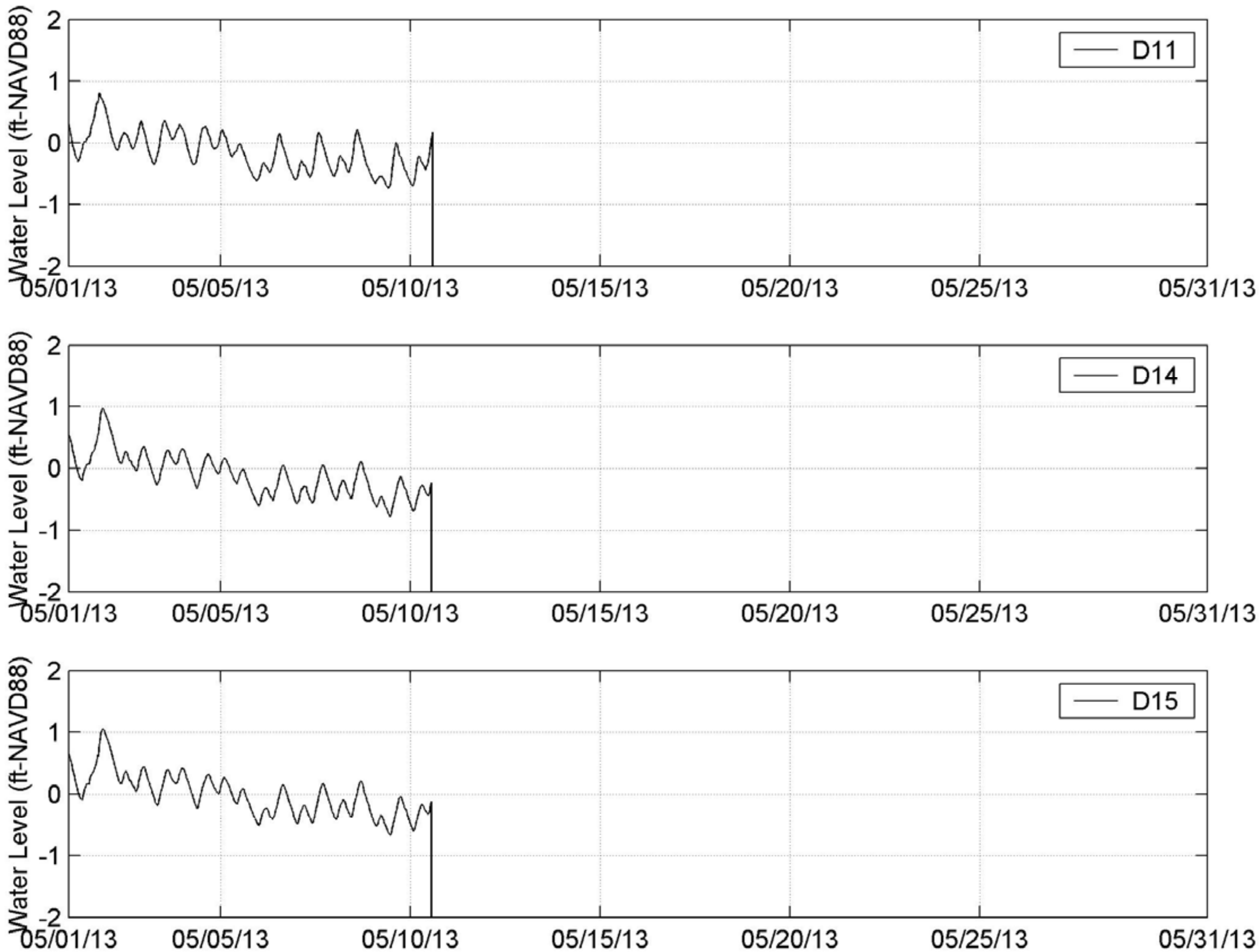
04/25/13
04/30/13


Water Level (ft-NAVD88)
D11
D14
D15
2
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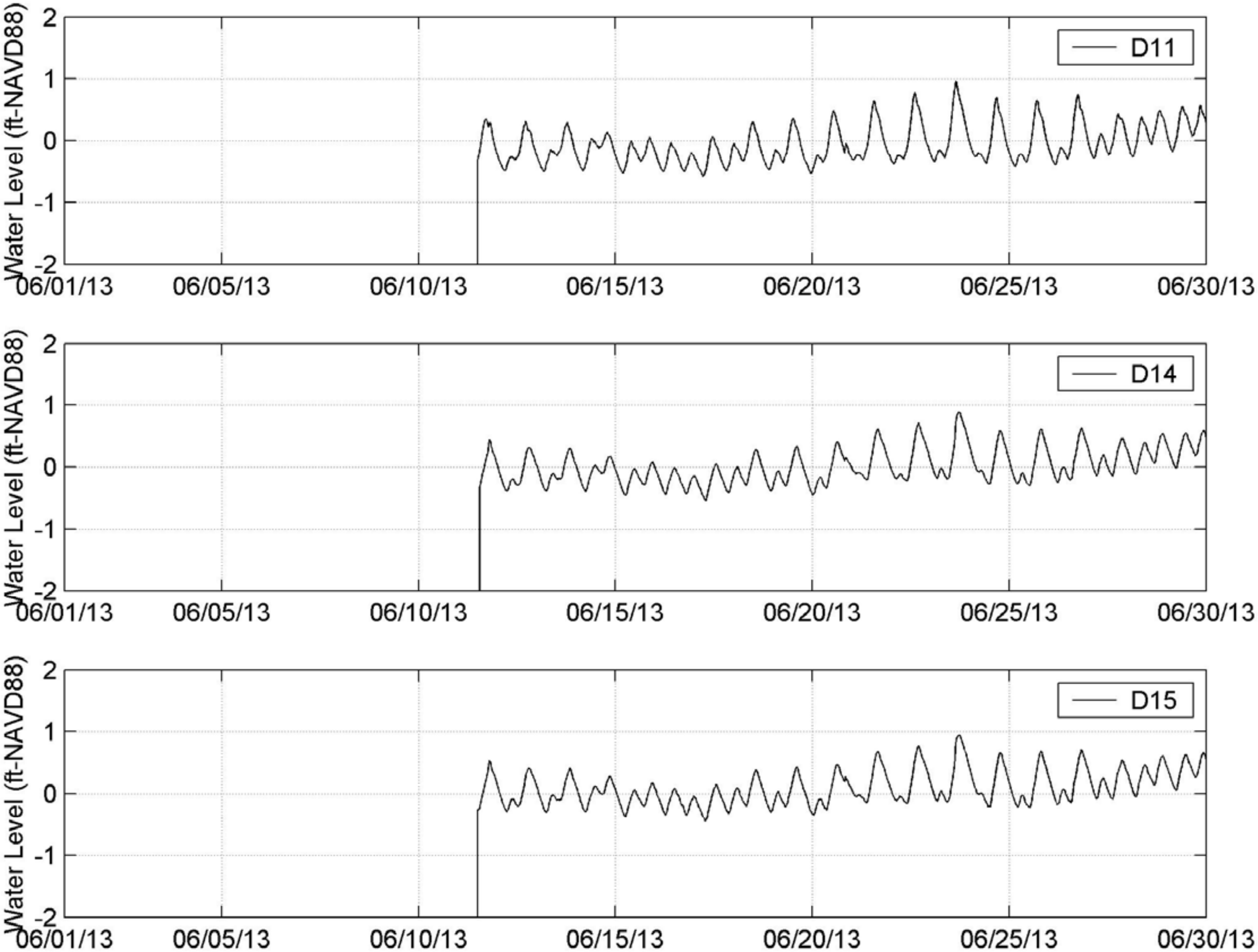
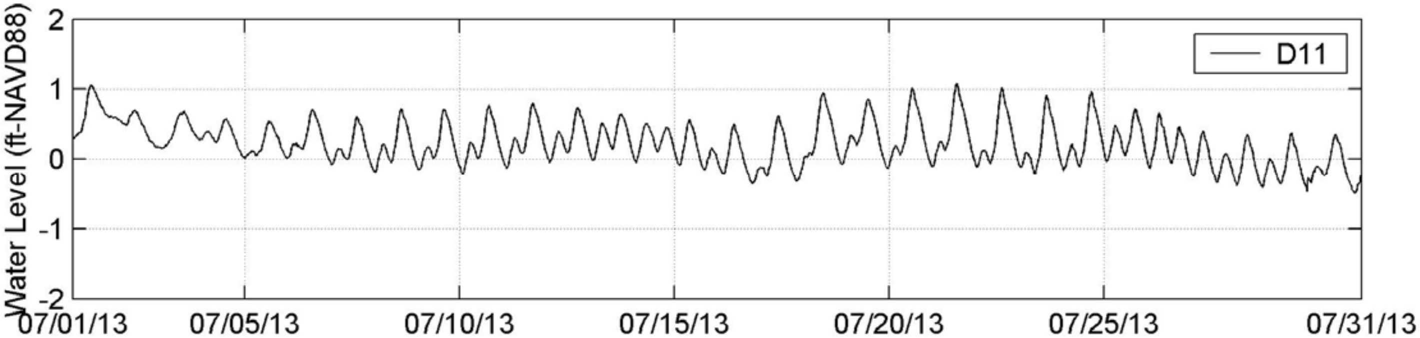
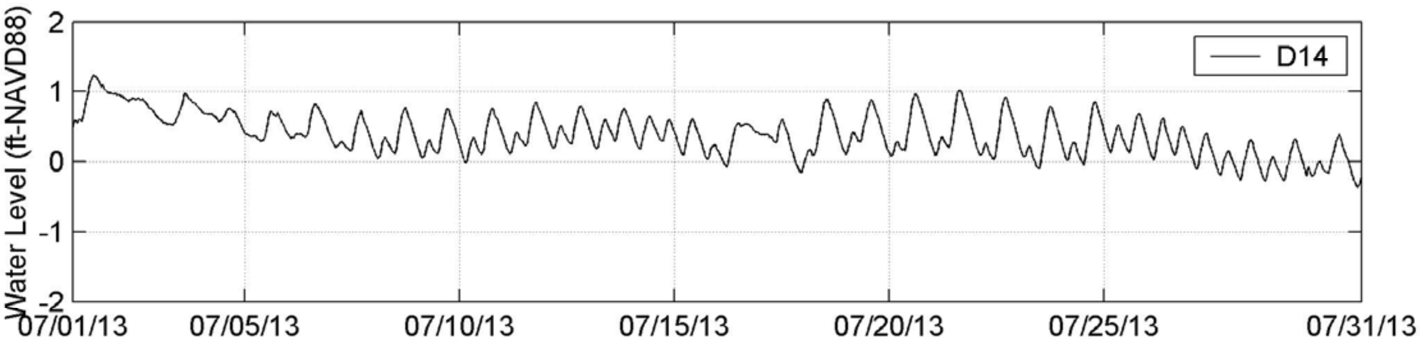
0
-1
-2
05/01/13
05/05/13
05/10/13
05/15/13
05/20/13
05/25/13
05/31/13


D11
D14
D15
Water Level (ft-NAVD88)
2
1
0
-1
-2
06/01/13
06/05/13
06/10/13
06/15/13
06/20/13
06/25/13
06/30/13


D11
Water Level (ft-NAVD88)
2
1
0
-1
-2
07/01/13
07/05/13
07/10/13
07/15/13
07/20/13
07/25/13
07/31/13


D14
Water Level (ft-NAVD88)
2
1
0
-1
-2
07/01/13
07/05/13
07/10/13
07/15/13
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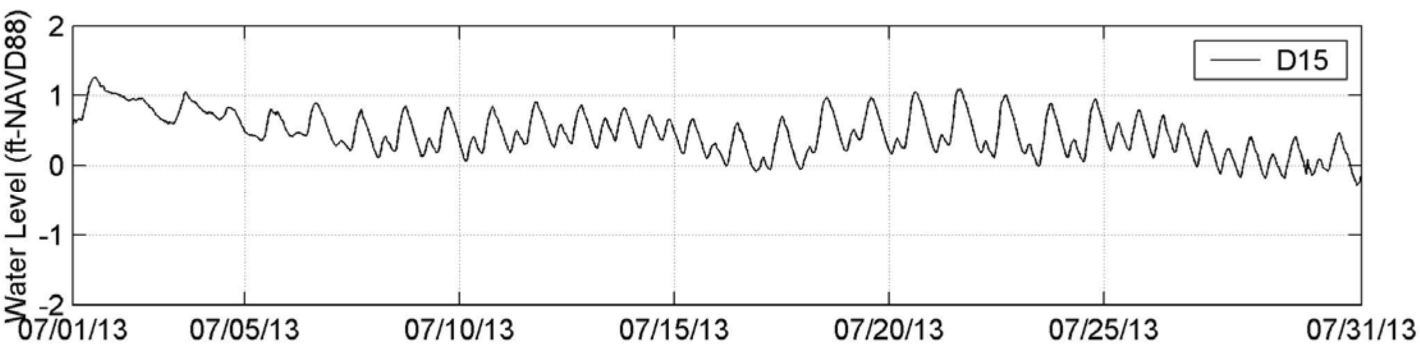
07/25/13
07/31/13


D15
Water Level (ft-NAVD88)
2
1
0
-1
-2
07/01/13
07/05/13
07/10/13
07/15/13
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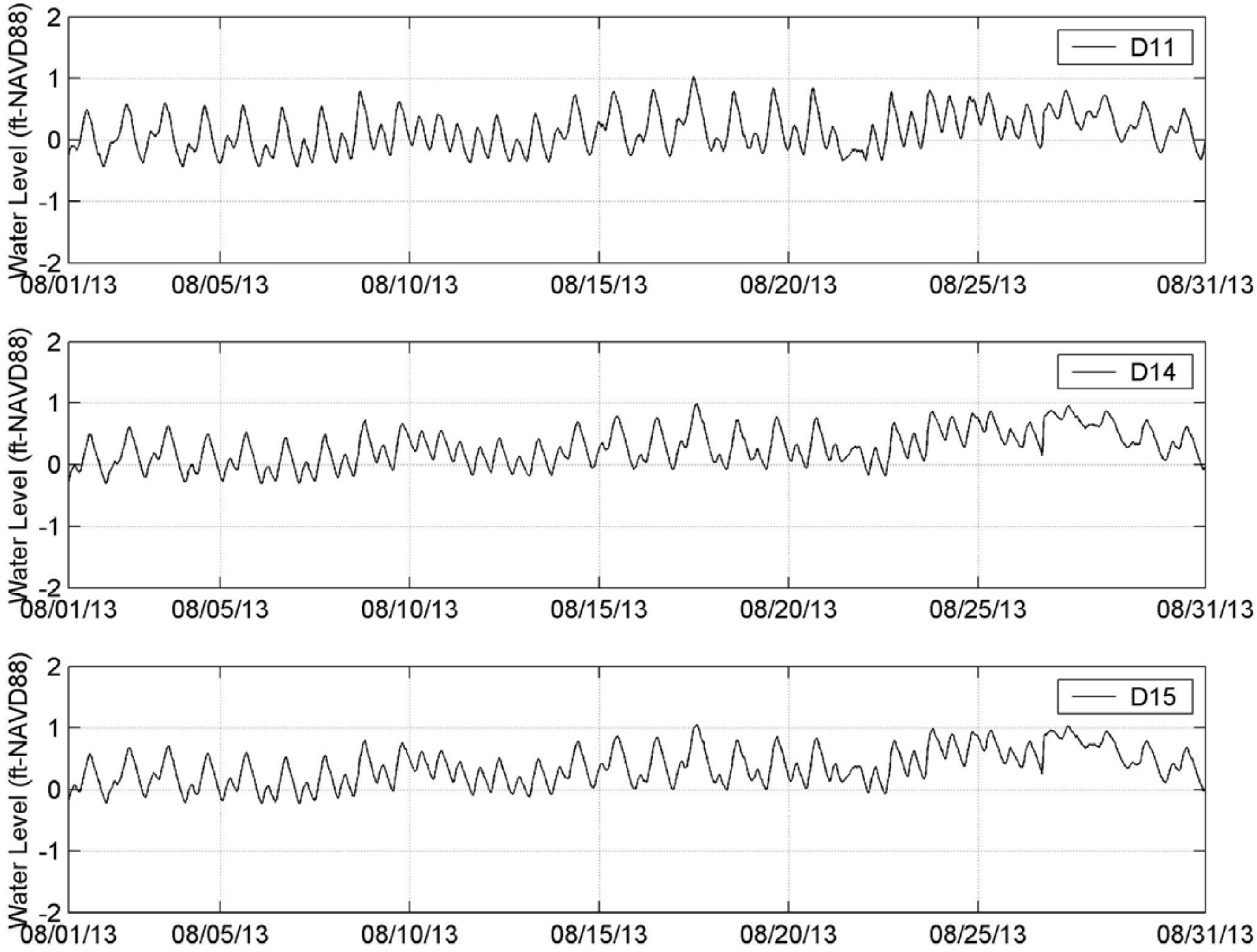
07/25/13
07/31/13


D11
D14
D15
Water Level (ft-NAVD88)
2
1
0
-1
-2
08/01/13
08/05/13
08/10/13
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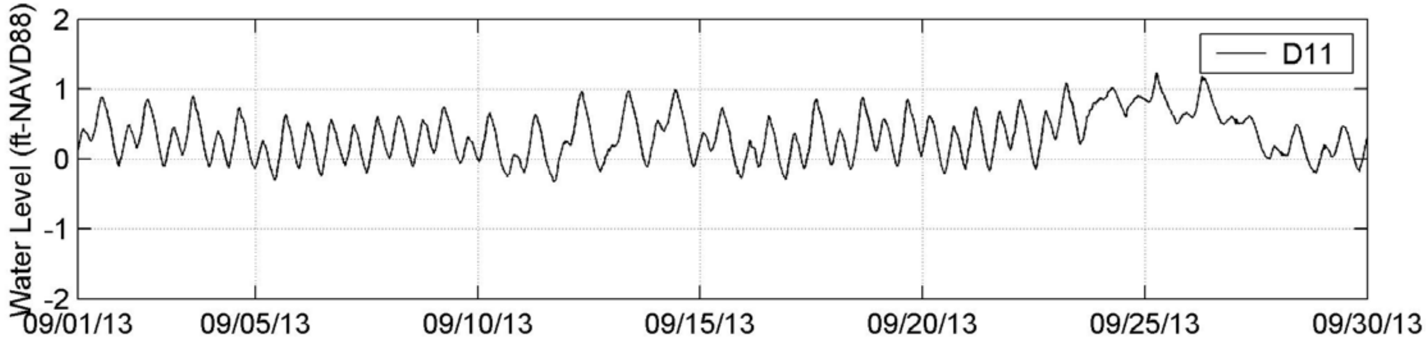
08/25/13
08/31/13


D11
Water Level (ft-NAVD88)
2
1
0
-1
-2
09/01/13
09/05/13
09/10/13
09/15/13
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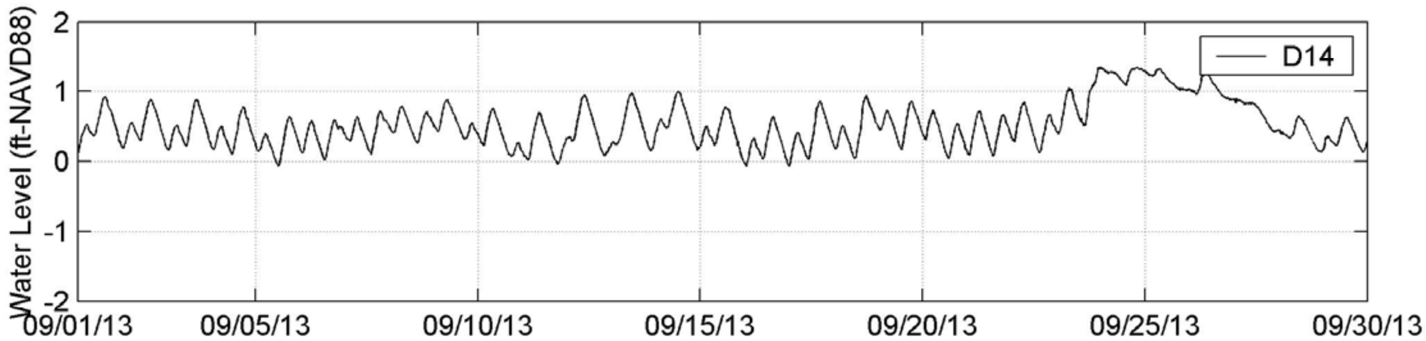
09/25/13
09/30/13


D14
Water Level (ft-NAVD88)
2
1
0
-1
-2
09/01/13
09/05/13
09/10/13
09/15/13
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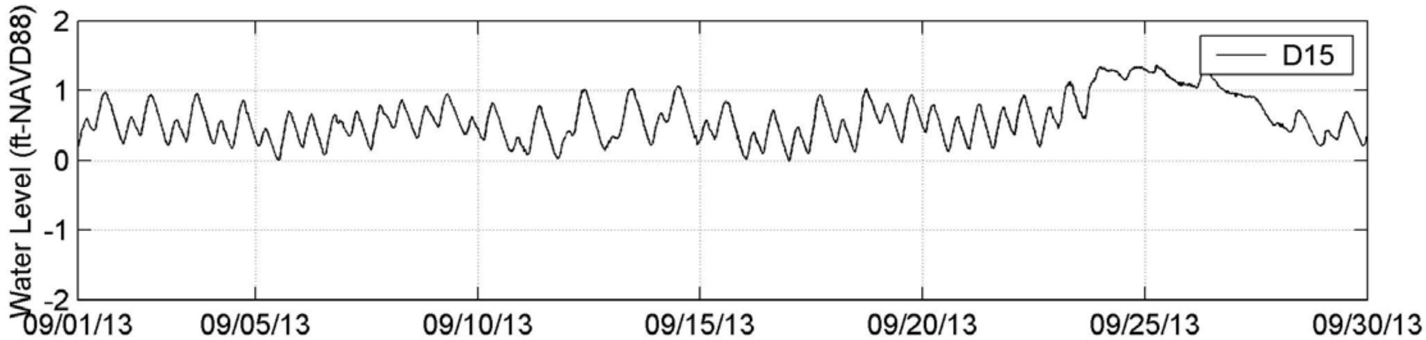
09/25/13
09/30/13


D15
Water Level (ft-NAVD88)
2
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-1
-2
09/01/13
09/05/13
09/10/13
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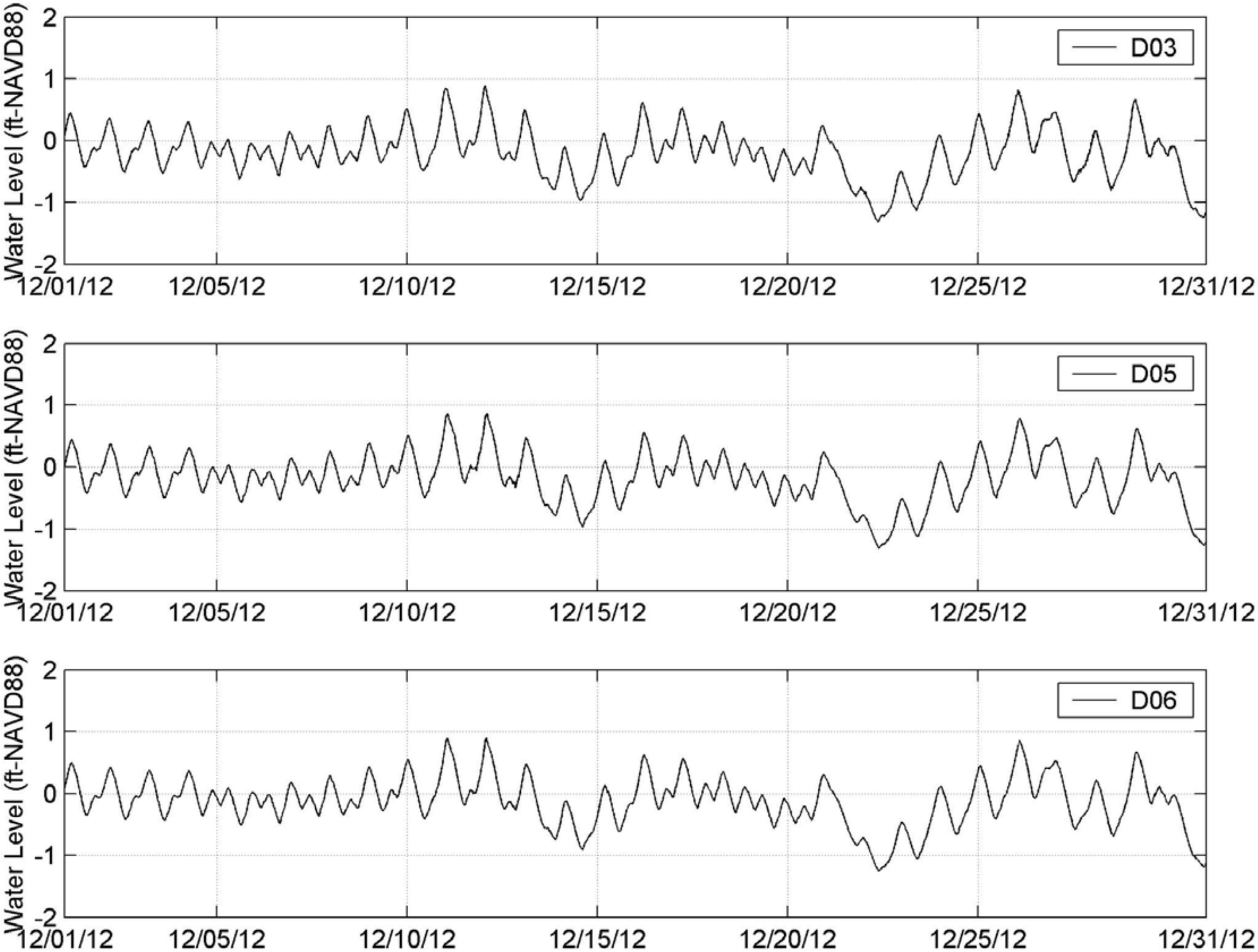
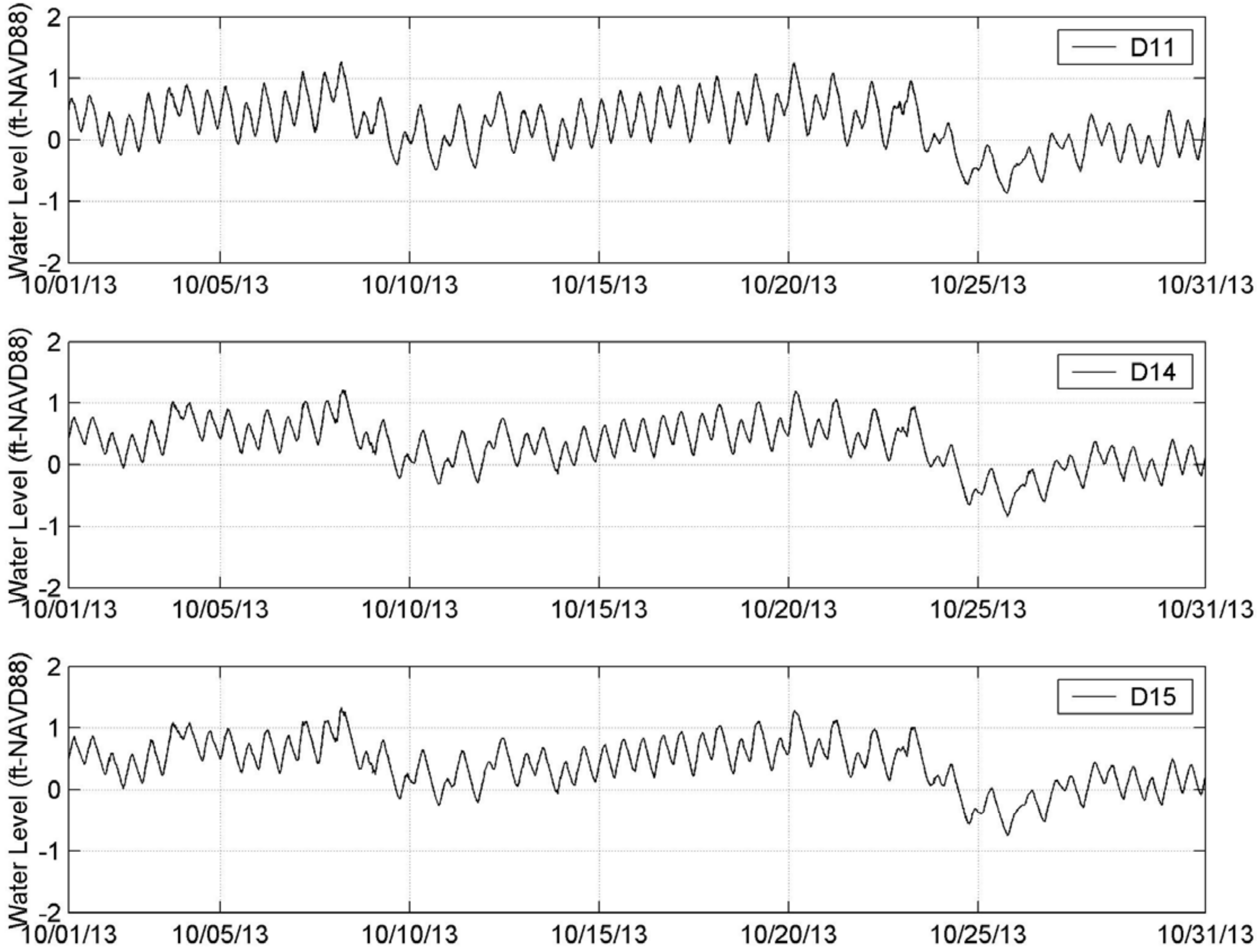
09/25/13
09/30/13


D03
Water Level (ft-NAVD88)
2
1
0
-1
-2
12/01/12
12/05/12
12/10/12
12/15/12
12/20/12
12/25/12
12/31/12
D05
Water Level (ft-NAVD88)
2
1
0
-1
-2
12/01/12
12/05/12
12/10/12
12/15/12
12/20/12
12/25/12
12/31/12
D06
Water Level (ft-NAVD88)
2
1
0
-1
-2
12/01/12
12/05/12
12/10/12
12/15/12
12/20/12
12/25/12
12/31/12


D11
D14
D15
Water Level (ft-NAVD88)
2
1
0
-1
-2
10/01/13
10/05/13
10/10/13
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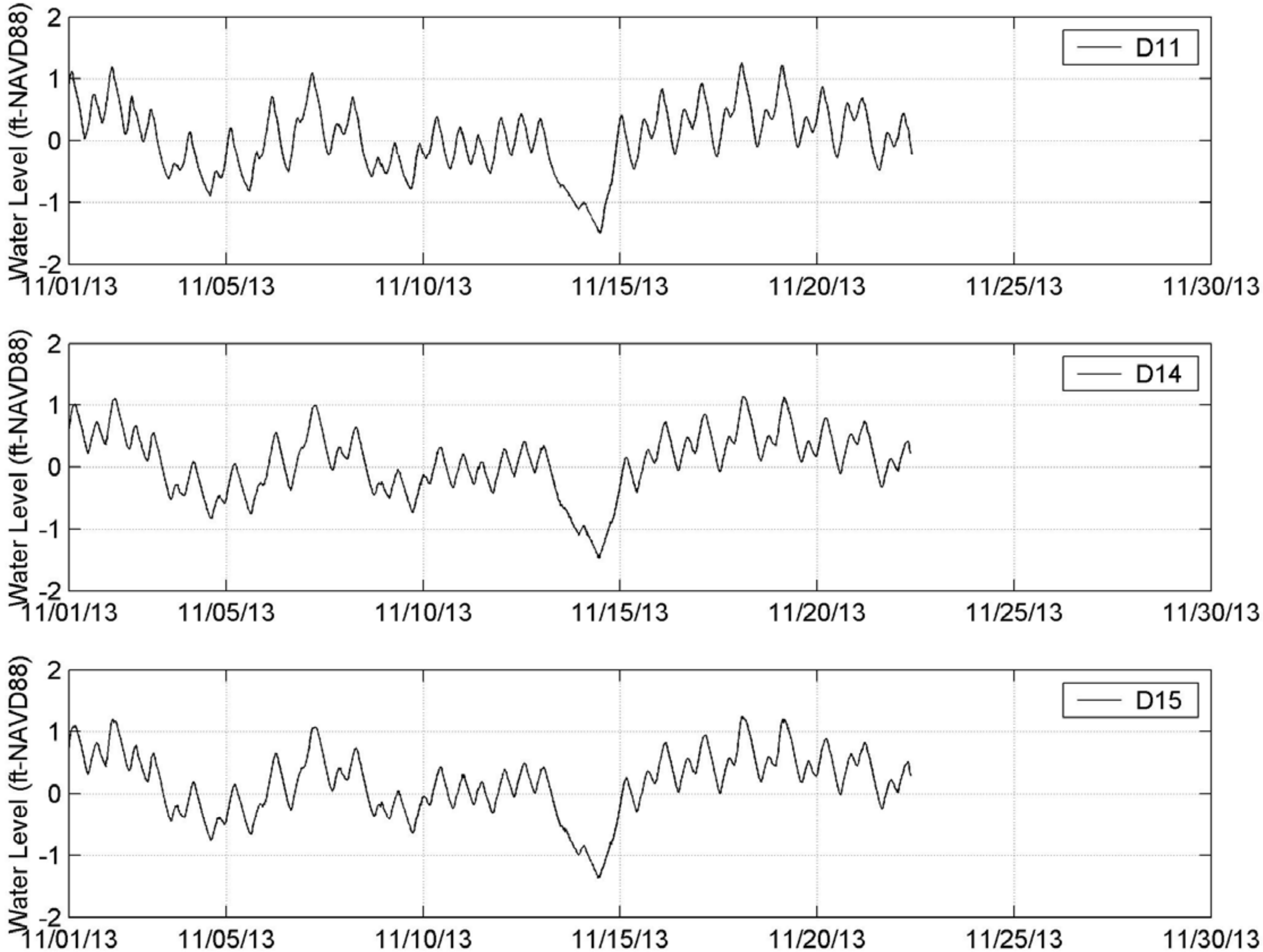
10/25/13
10/31/13


Water Level (ft-NAVD88)
D11
D14
D15
2
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0
-1
-2
11/01/13
11/05/13
11/10/13
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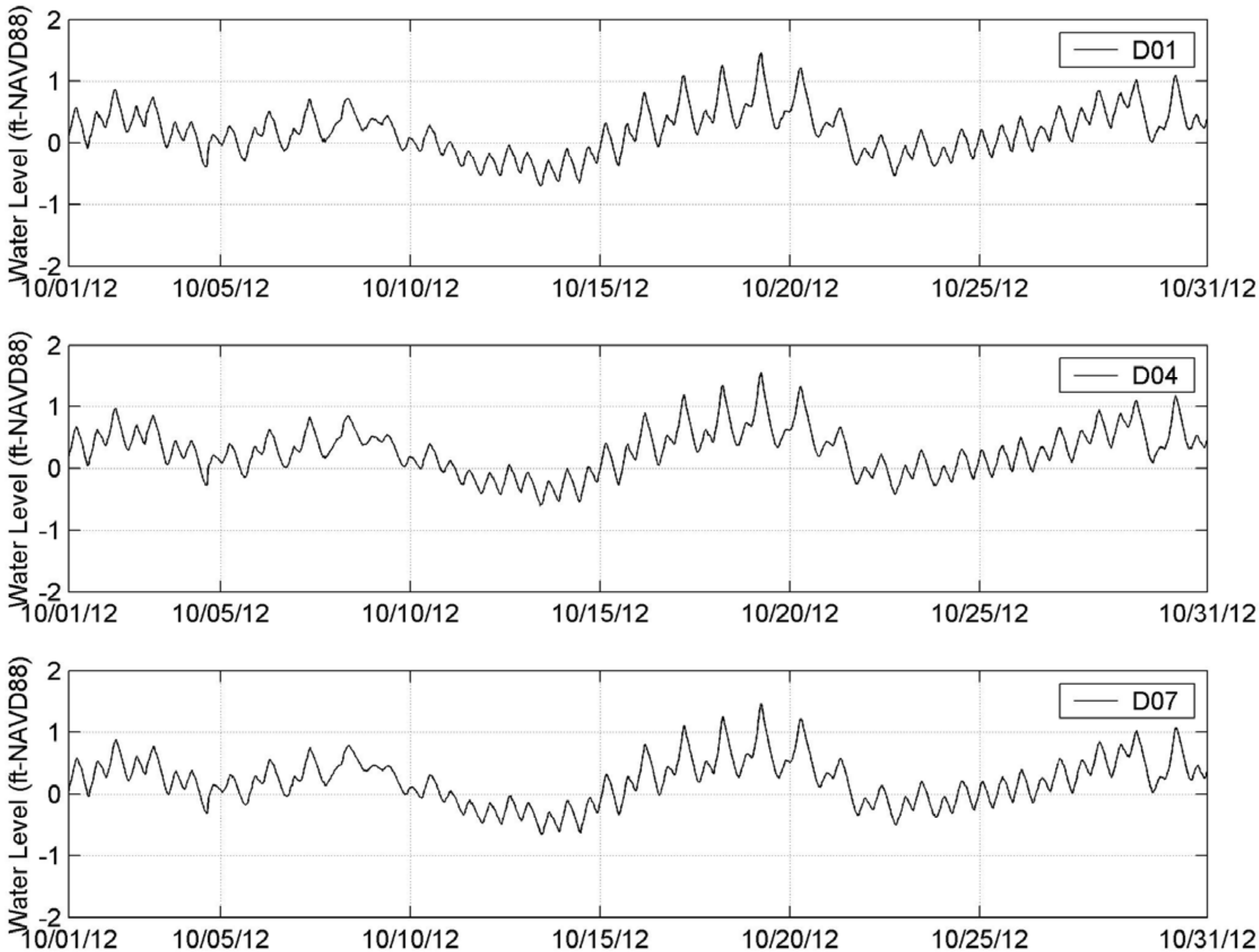
11/25/13
11/30/13


D01
D04
D07
Water Level (ft-NAVD88)
2
1
0
-1
-2
10/01/12
10/05/12
10/10/12
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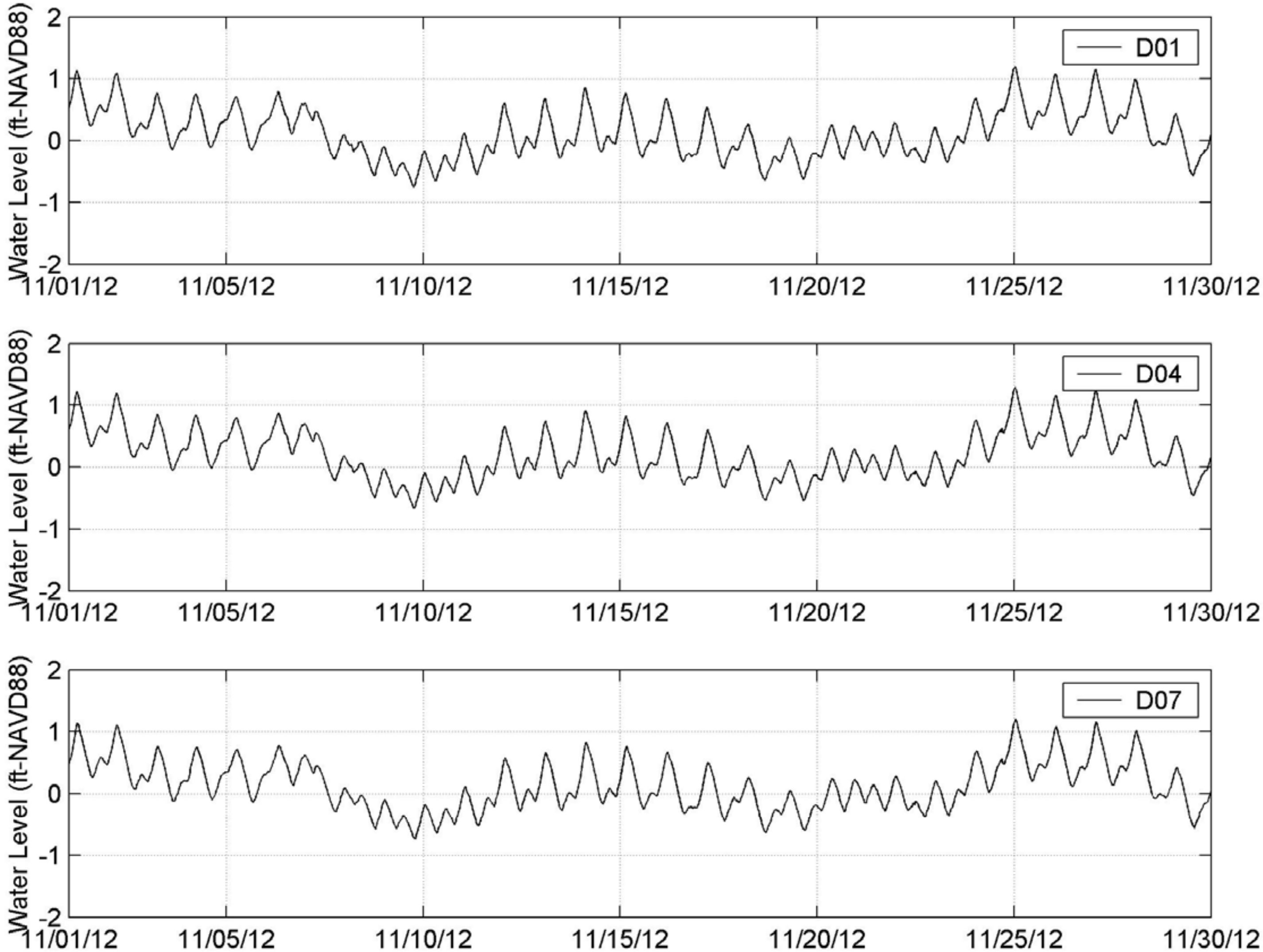
10/25/12
10/31/12


Water Level (ft-NAVD88)
D01
D04
D07
2
1
0
-1
-2
11/01/12
11/05/12
11/10/12
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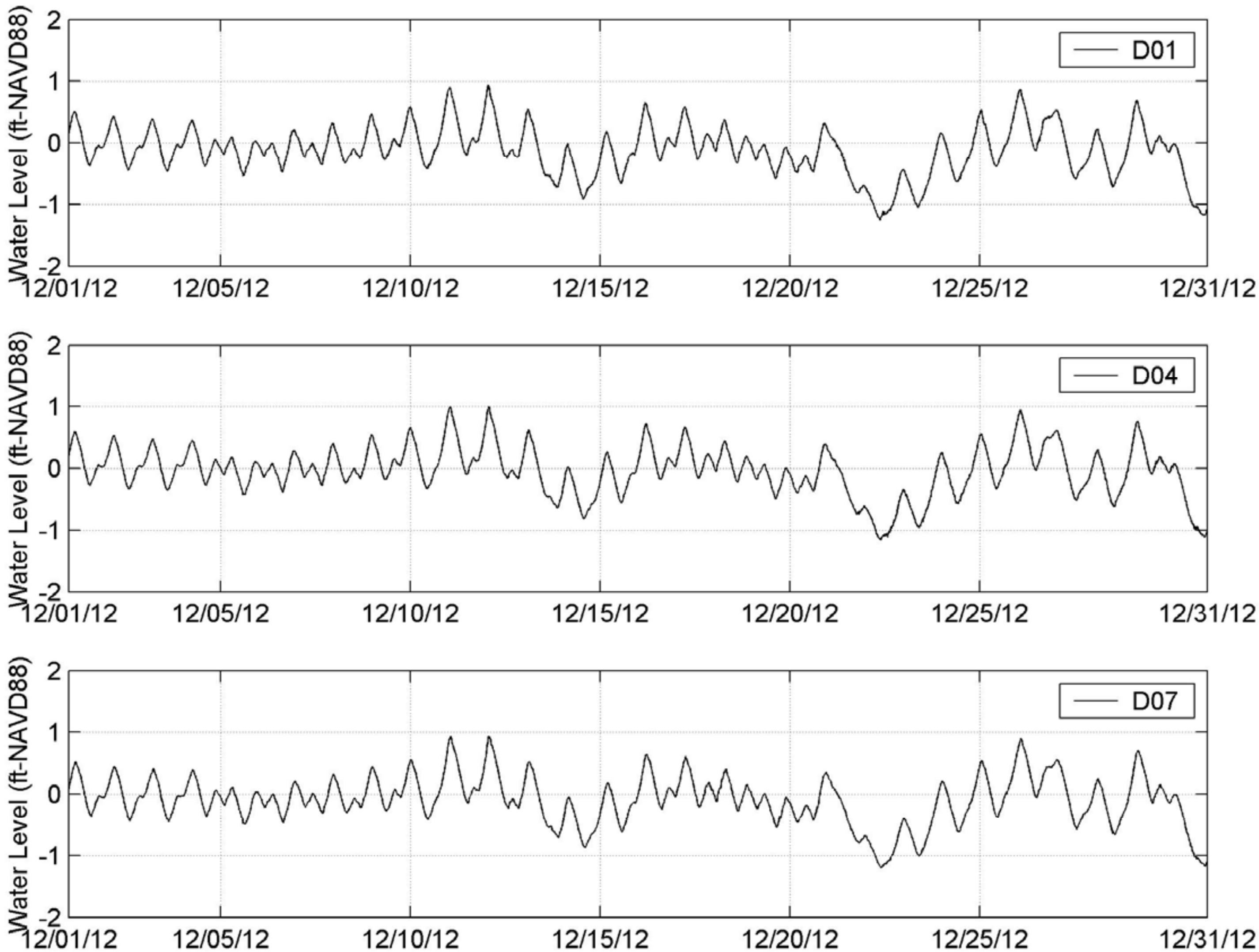
11/25/12
11/30/12


Water Level (ft-NAVD88)
D01
D04
D07
2
1
0
-1
-2
12/01/12
12/05/12
12/10/12
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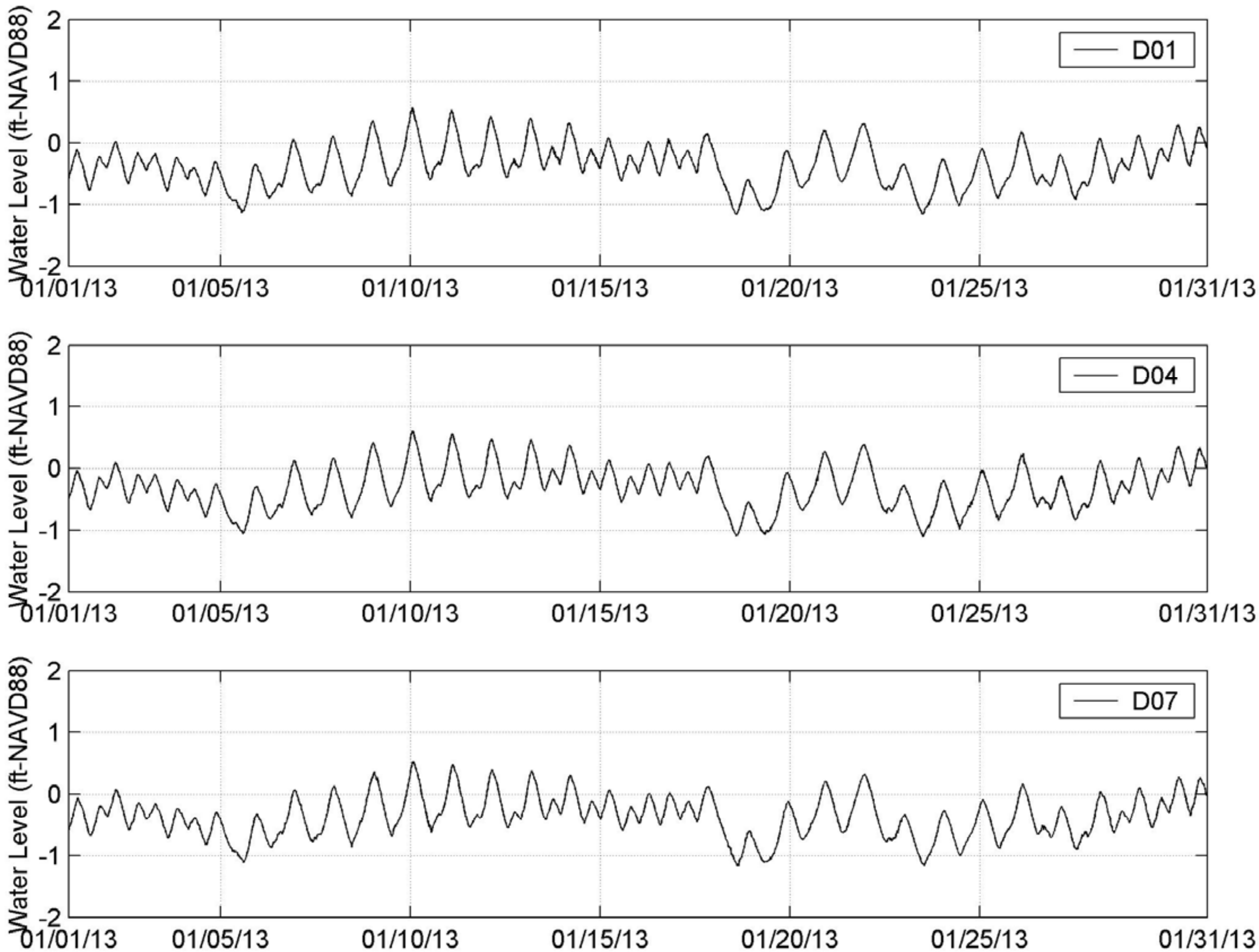
12/25/12
12/31/12


D01
D04
D07
Water Level (ft-NAVD88)
2
1
0
-1
-2
01/01/13
01/05/13
01/10/13
01/15/13
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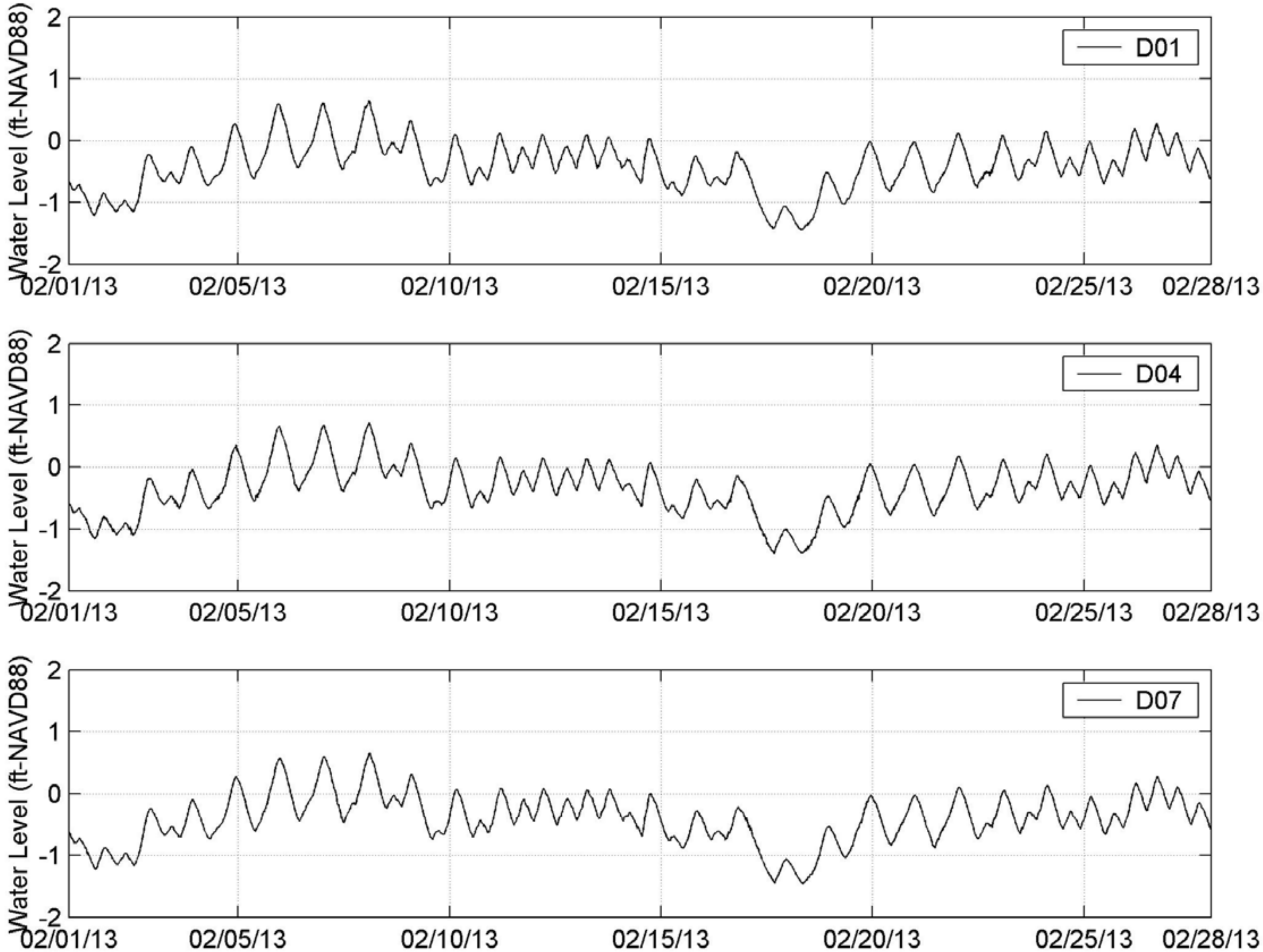
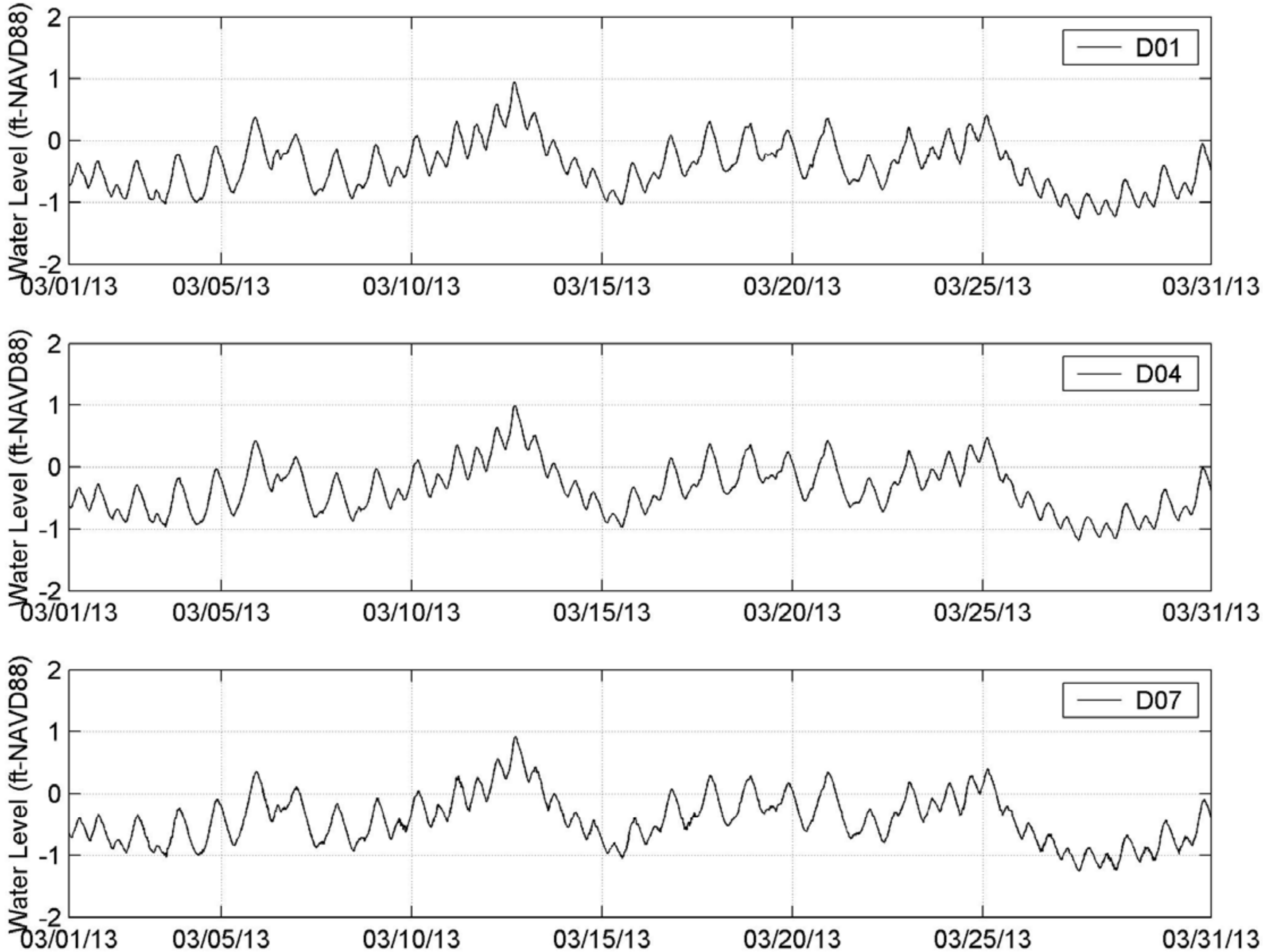
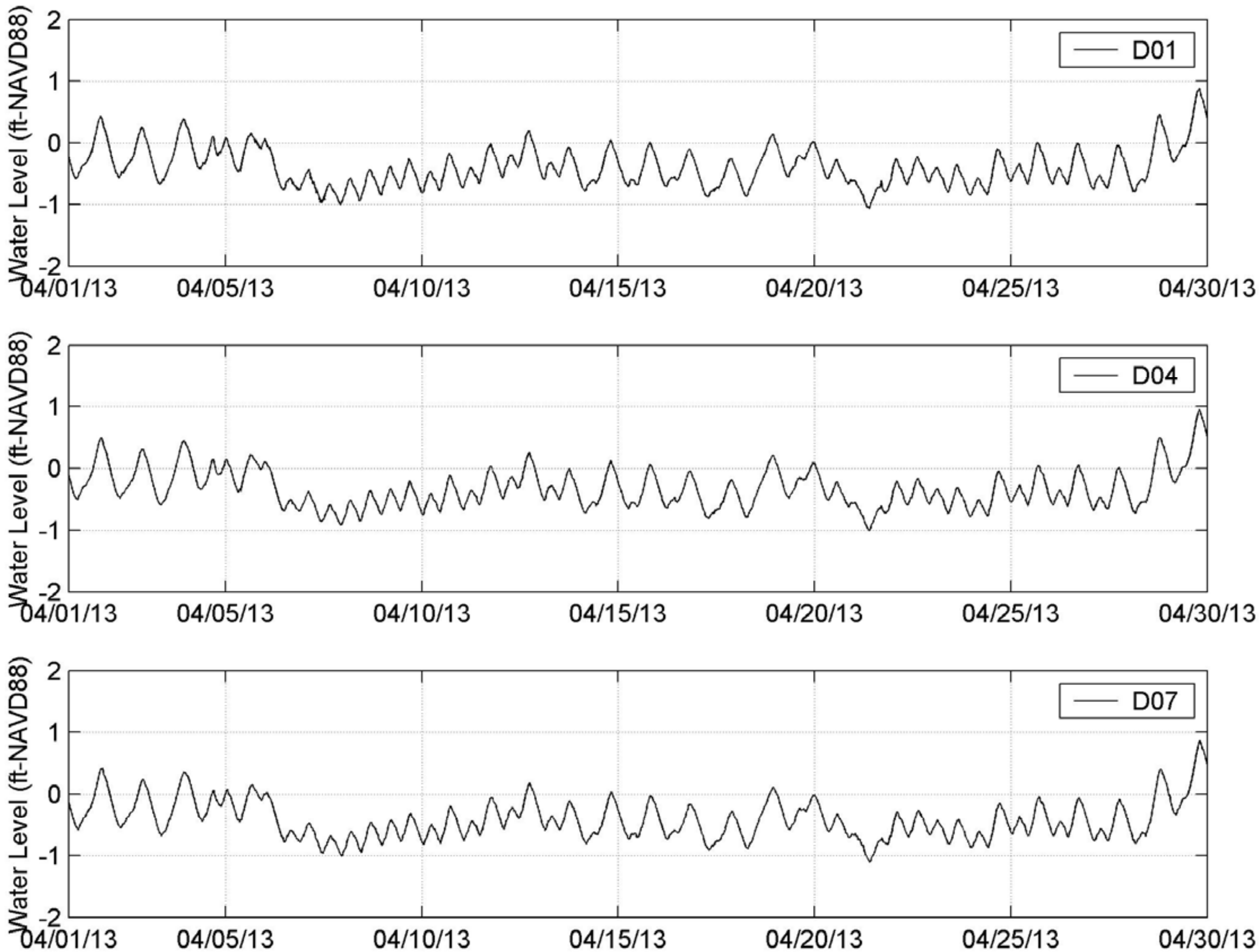
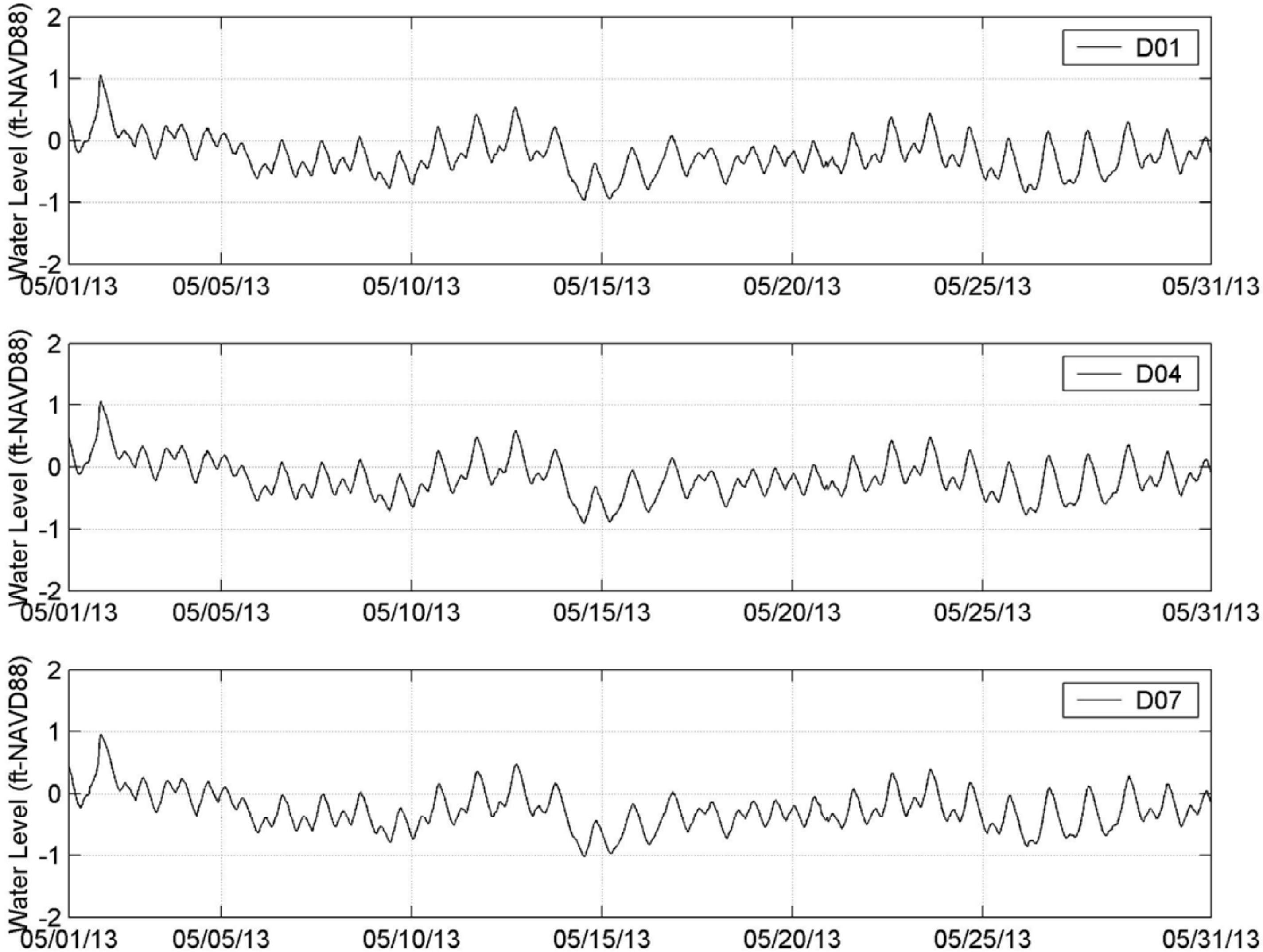
01/25/13
01/31/13

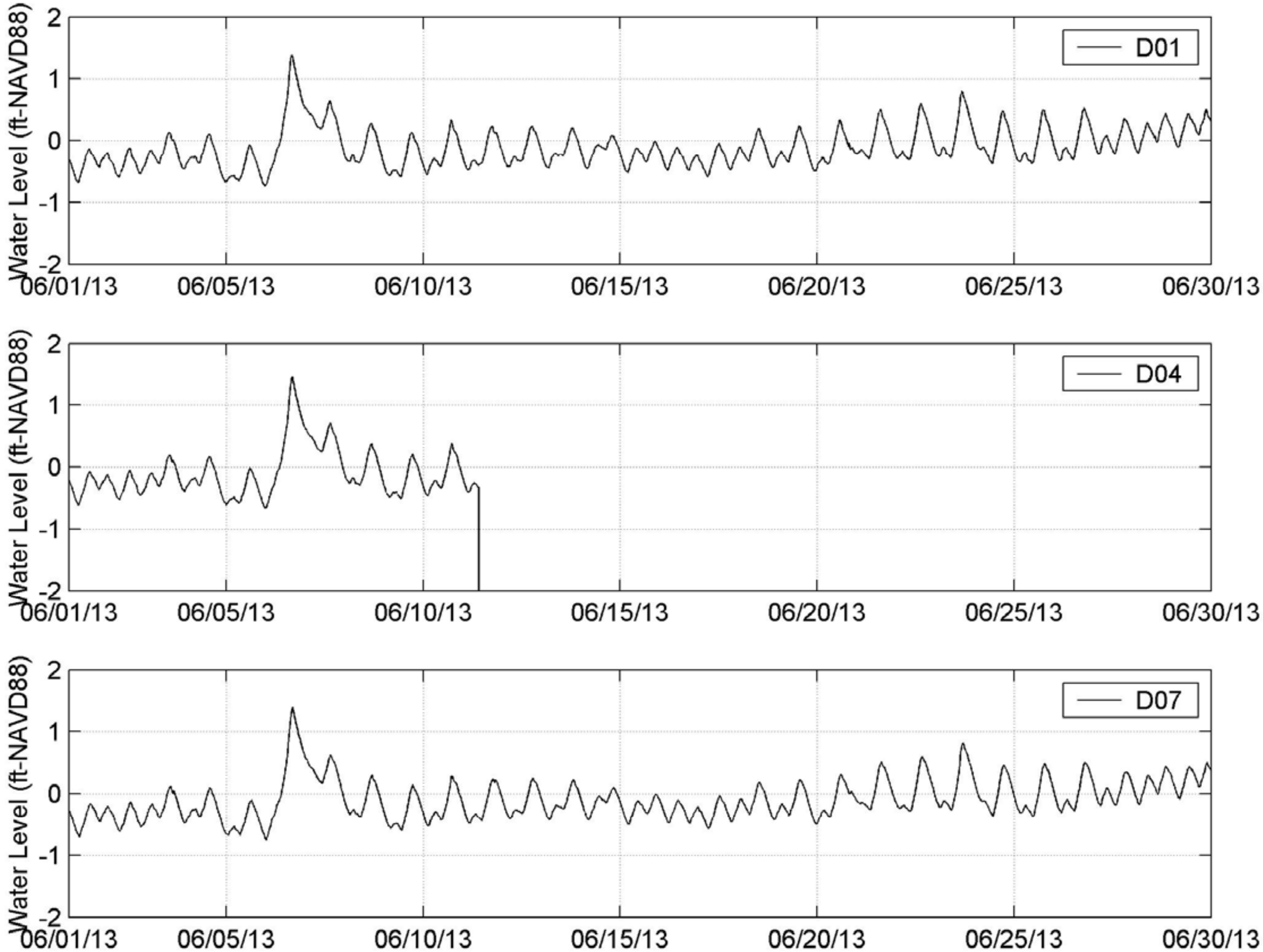

Water Level (ft-NAVD88)
2
1
0
-1
-2
02/01/13
02/05/13
02/10/13
02/15/13
02/20/13
02/25/13
02/28/13
D01
D04
D07

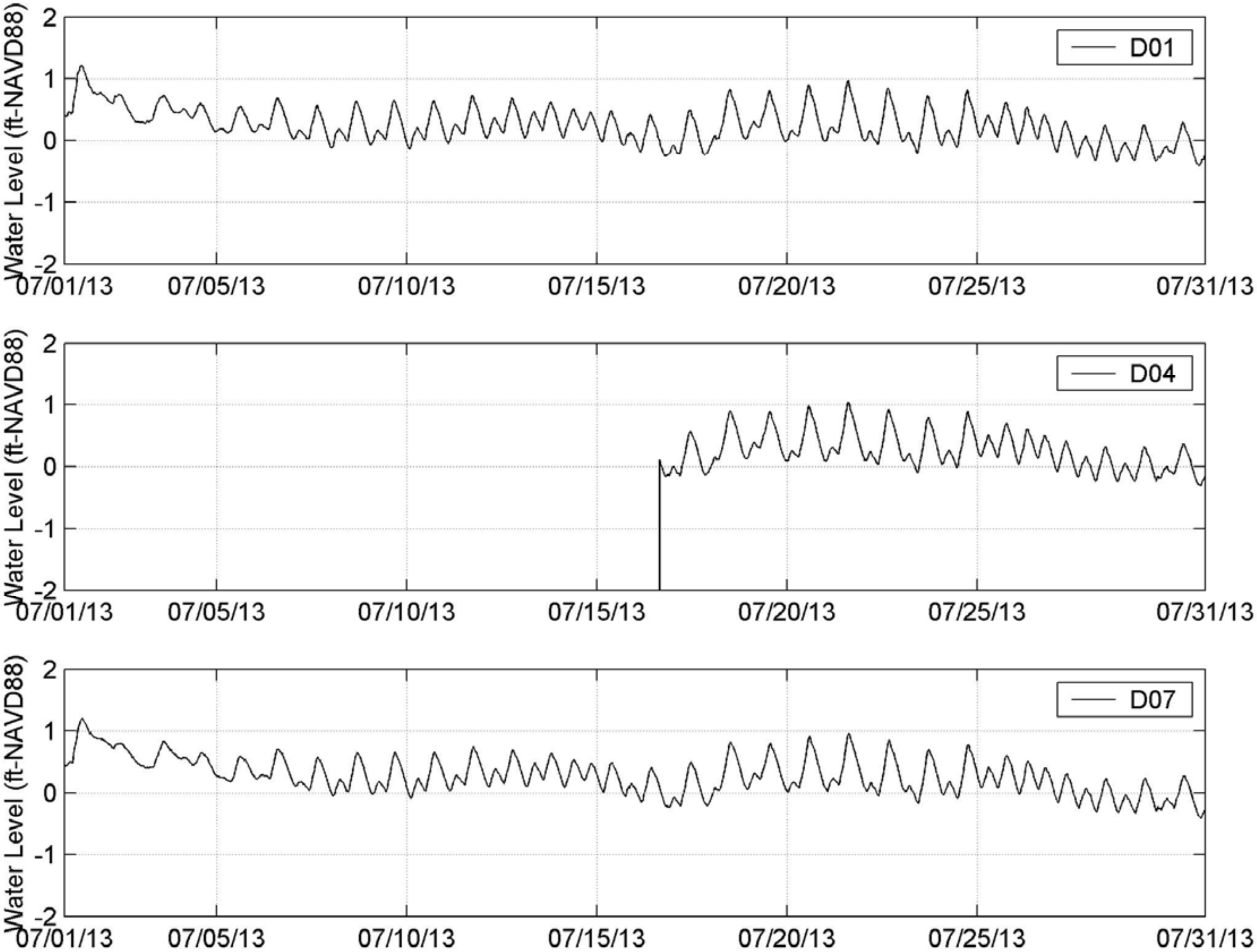


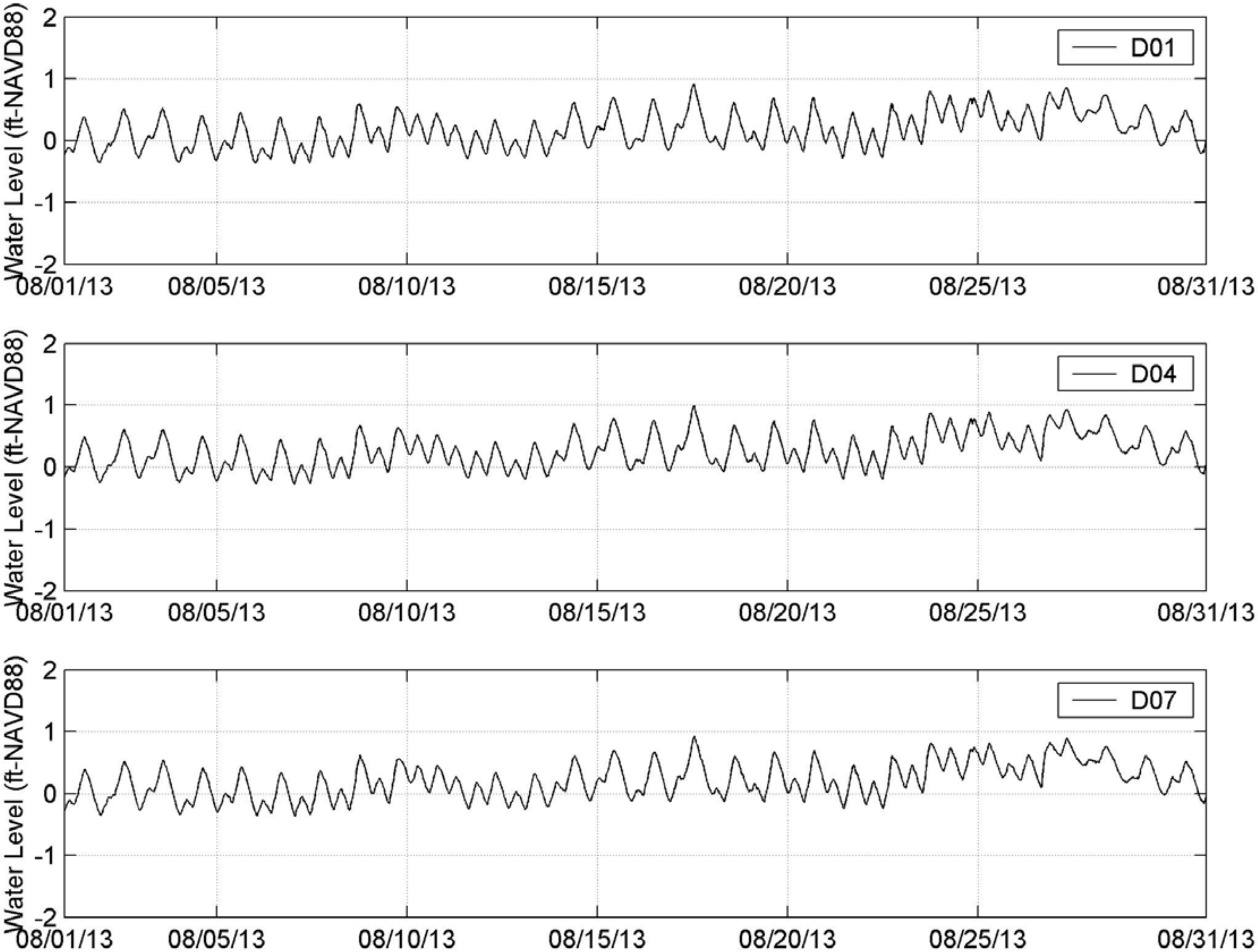
Water Level (ft-NAVD88)
D01
D04
D07
2
1
0
-1
-2
03/01/13
03/05/13
03/10/13
03/15/13
03/20/13
03/25/13
03/31/13

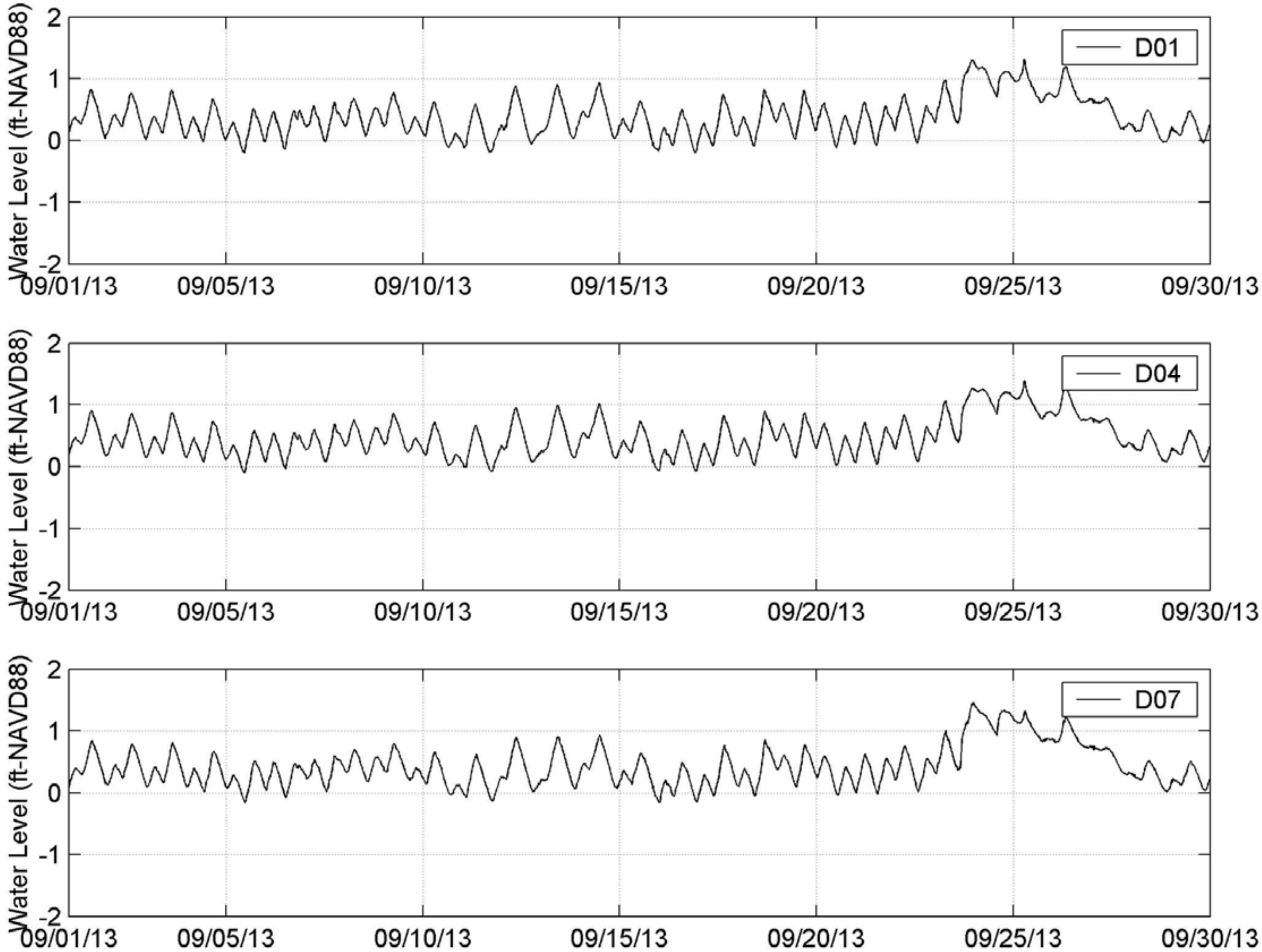

D01
D04
D07
Water Level (ft-NAVD88)
2
1
0
-1
-2
04/01/13
04/05/13
04/10/13
04/15/13
04/20/13
04/25/13
04/30/13

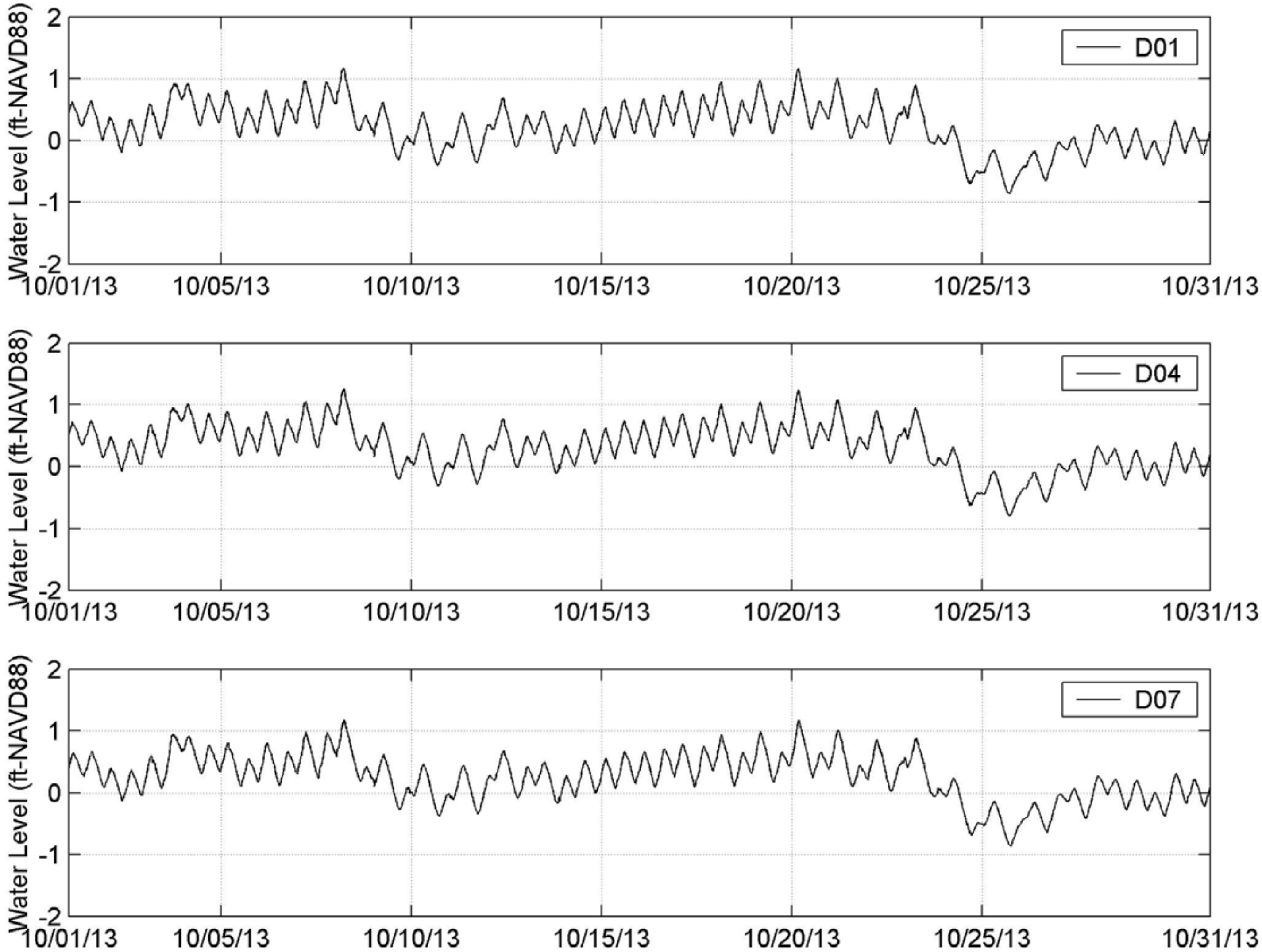

Water Level (ft-NAVD88)
D01
D04
D07
2
1
0
-1
-2
05/01/13
05/05/13
05/10/13
05/15/13
05/20/13
05/25/13
05/31/13


D01
D04
D07
Water Level (ft-NAVD88)
2
1
0
-1
-2
06/01/13
06/05/13
06/10/13
06/15/13
06/20/13
06/25/13
06/30/13

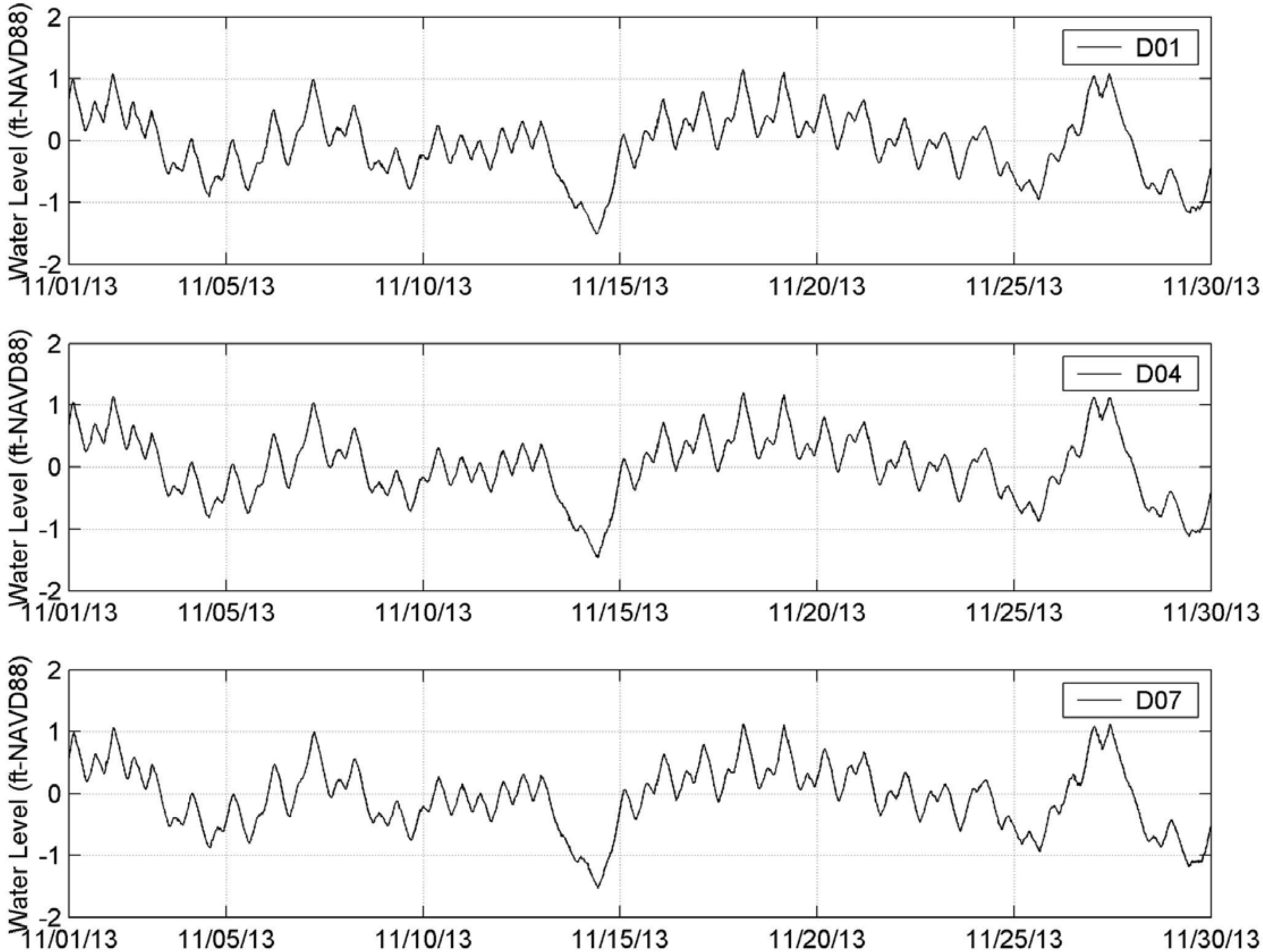

D01
D04
D07
Water Level (ft-NAVD88)
2
1
0
-1
-2
07/01/13
07/05/13
07/10/13
07/15/13
07/20/13
07/25/13
07/31/13

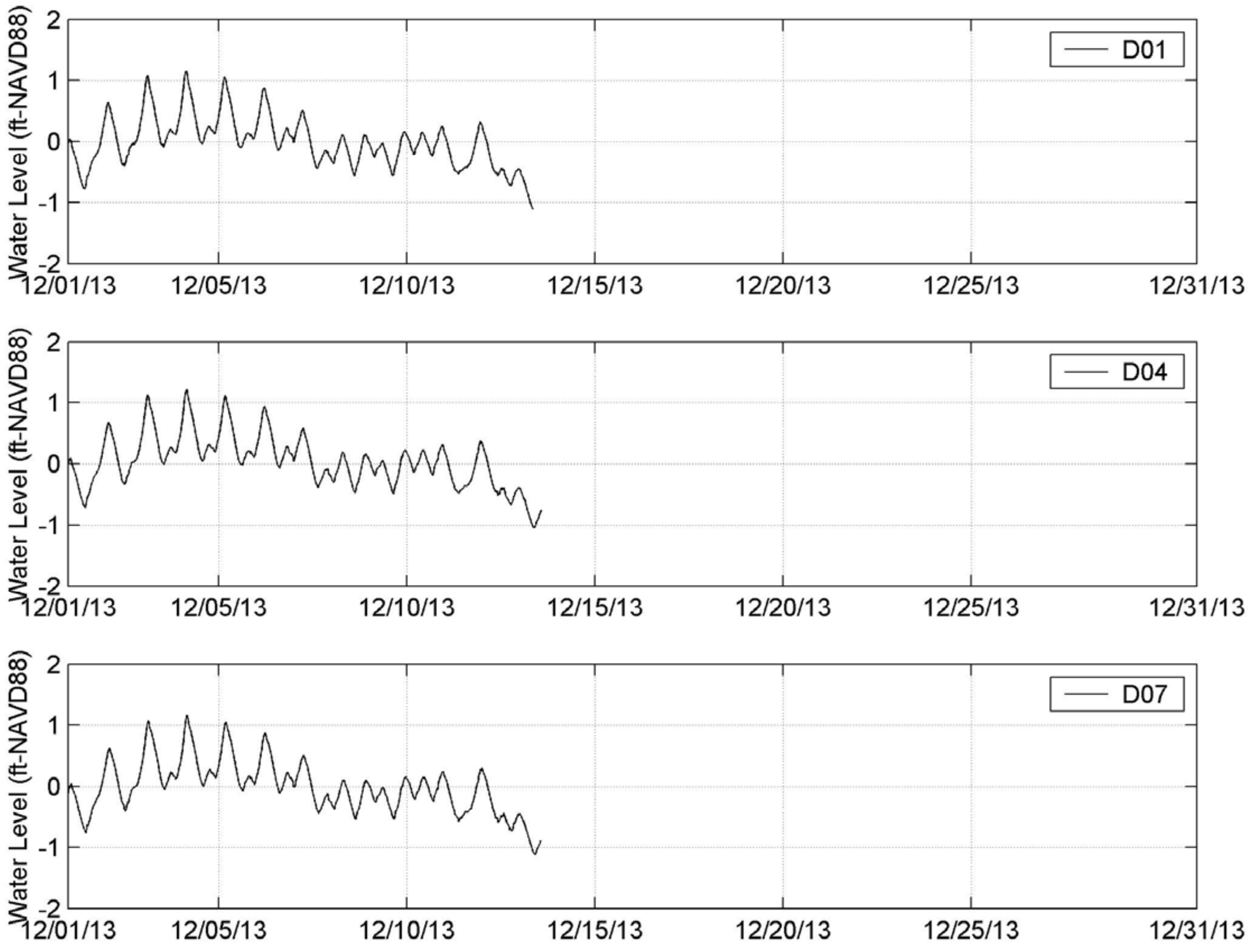

D01
D04
D07
Water Level (ft-NAVD88)
2
1
0
-1
-2
08/01/13
08/05/13
08/10/13
08/15/13
08/20/13
08/25/13
08/31/13

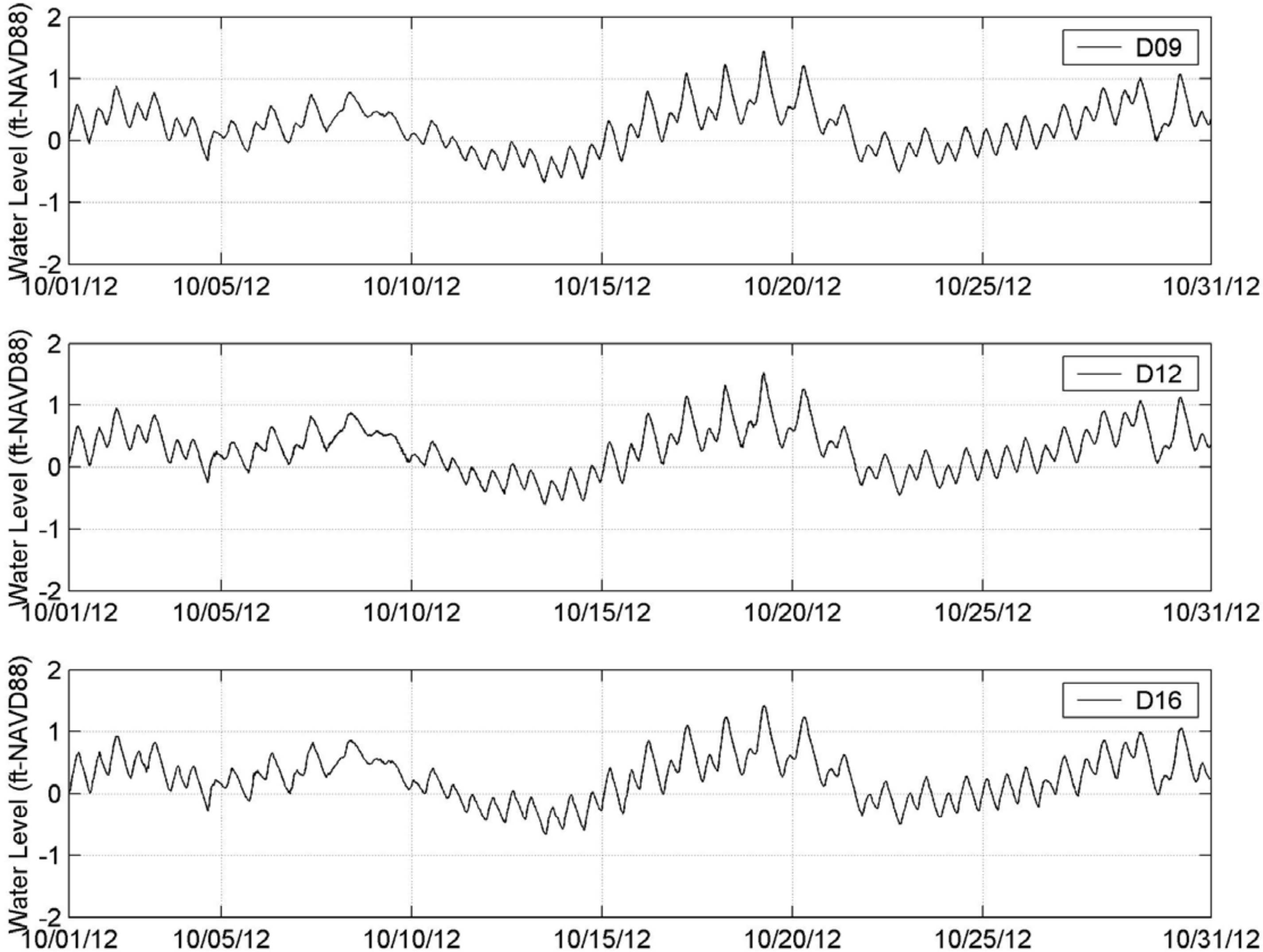

Water Level (ft-NAVD88)
D01
D04
D07
2
1
0
-1
-2
09/01/13
09/05/13
09/10/13
09/15/13
09/20/13
09/25/13
09/30/13

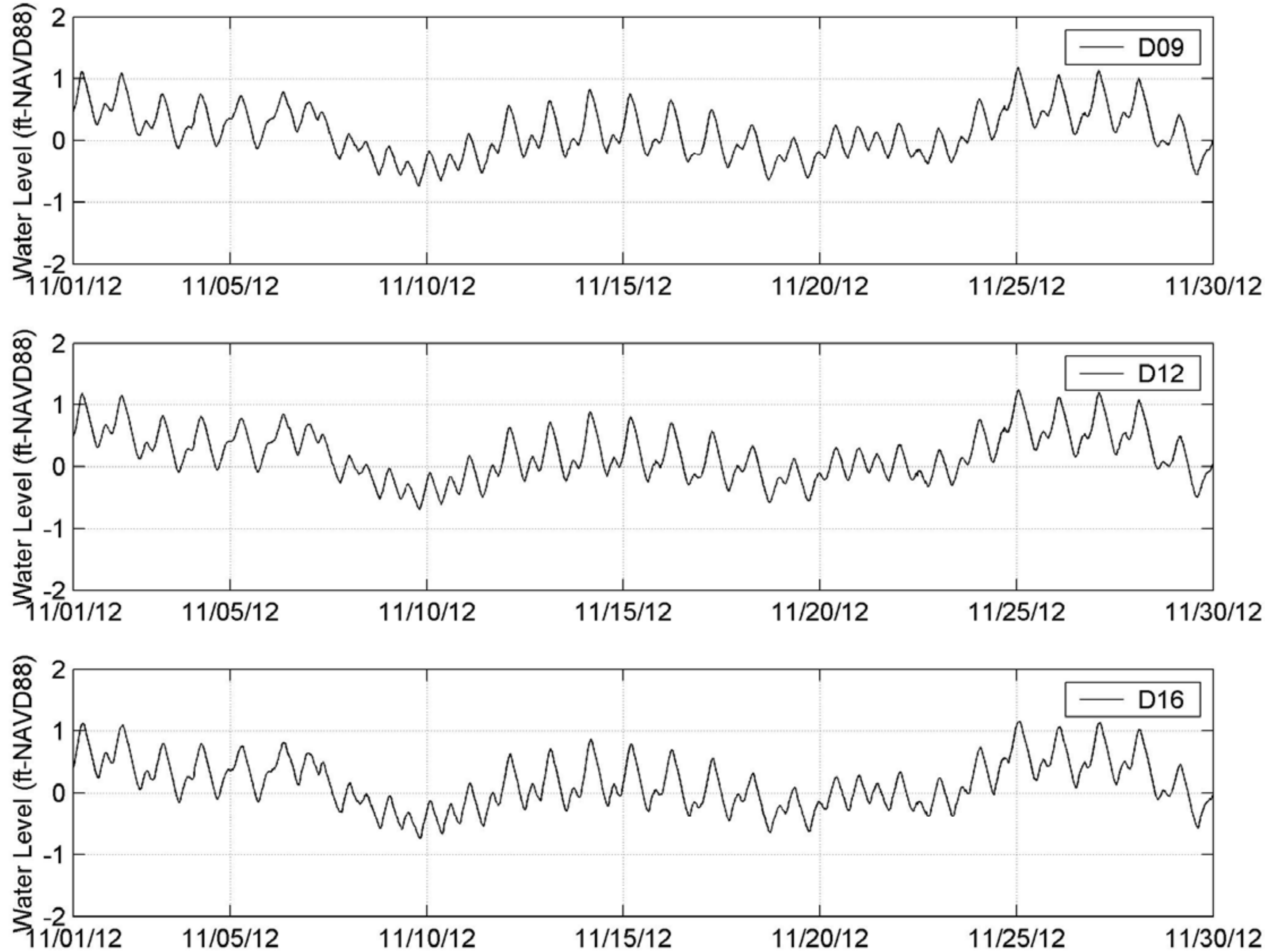


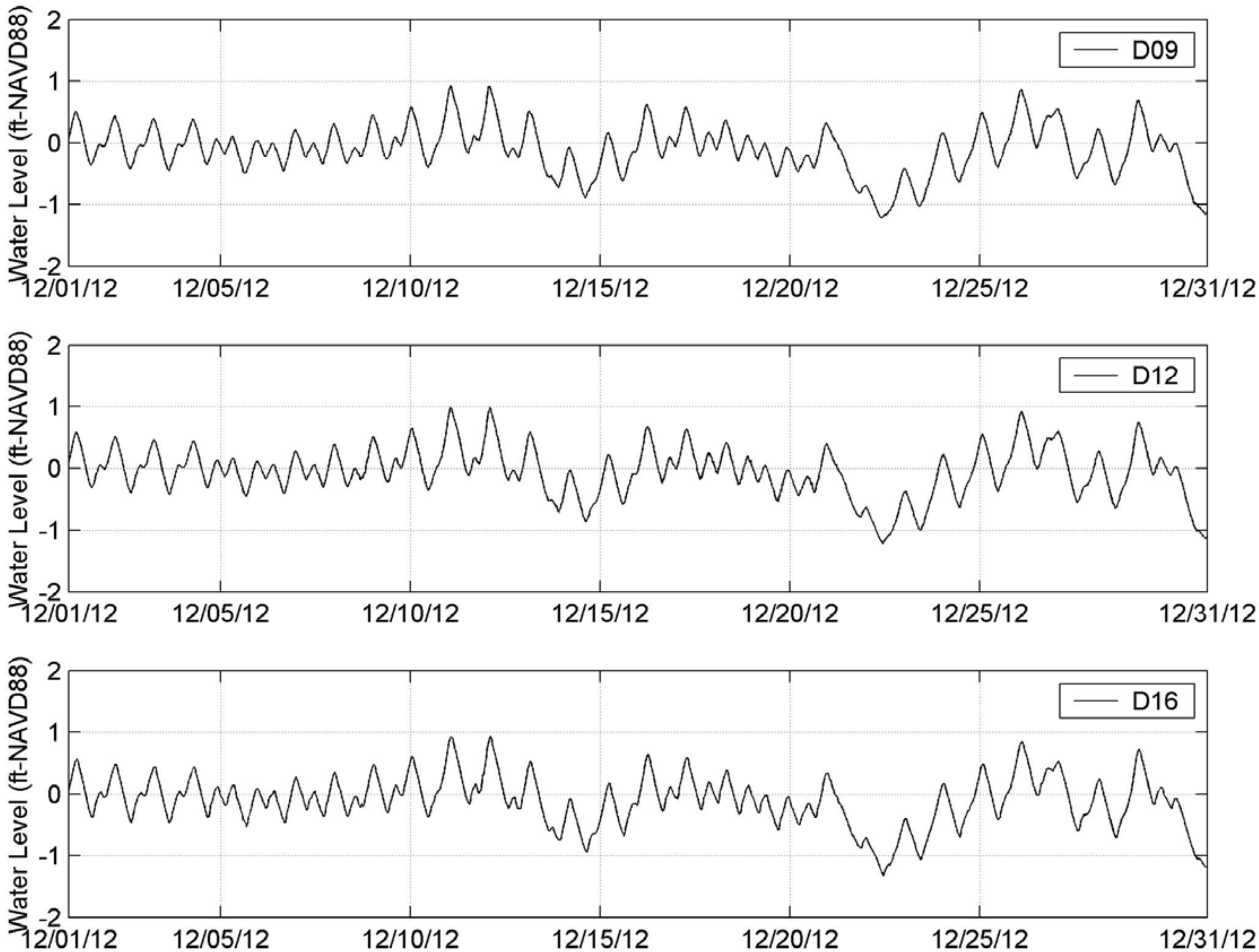
D01
D04
D07
Water Level (ft-NAVD88)
2
1
0
-1
-2
10/01/13
10/05/13
10/10/13
10/15/13
10/20/13
10/25/13
10/31/13


Water Level (ft-NAVD88)
2
1
0
-1
-2
D01
11/01/13
11/05/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13
Water Level (ft-NAVD88)
D04
Water Level (ft-NAVD88)
D07

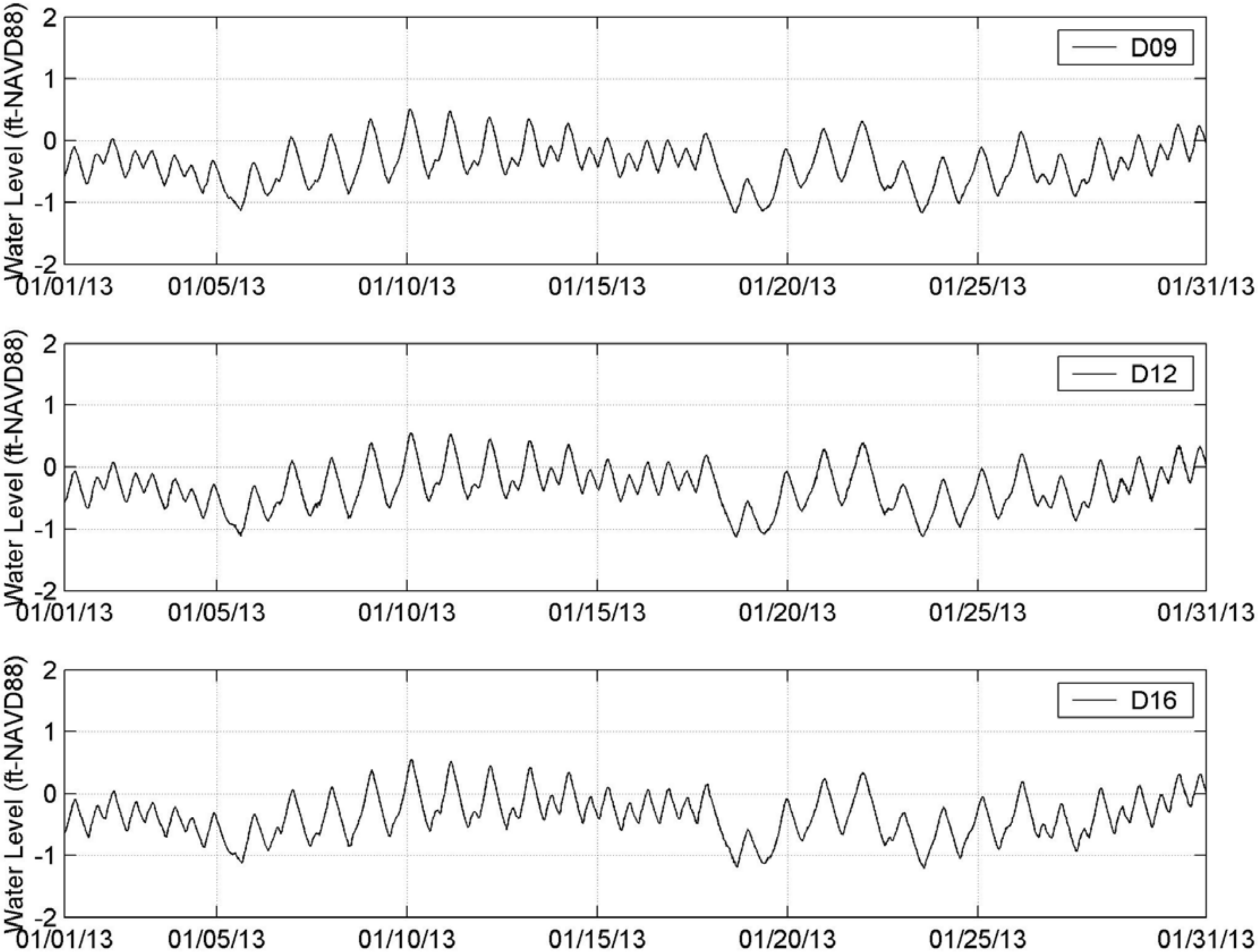

D01
D04
D07
Water Level (ft-NAVD88)
2
1
0
-1
-2
12/01/13
12/05/13
12/10/13
12/15/13
12/20/13
12/25/13
12/31/13

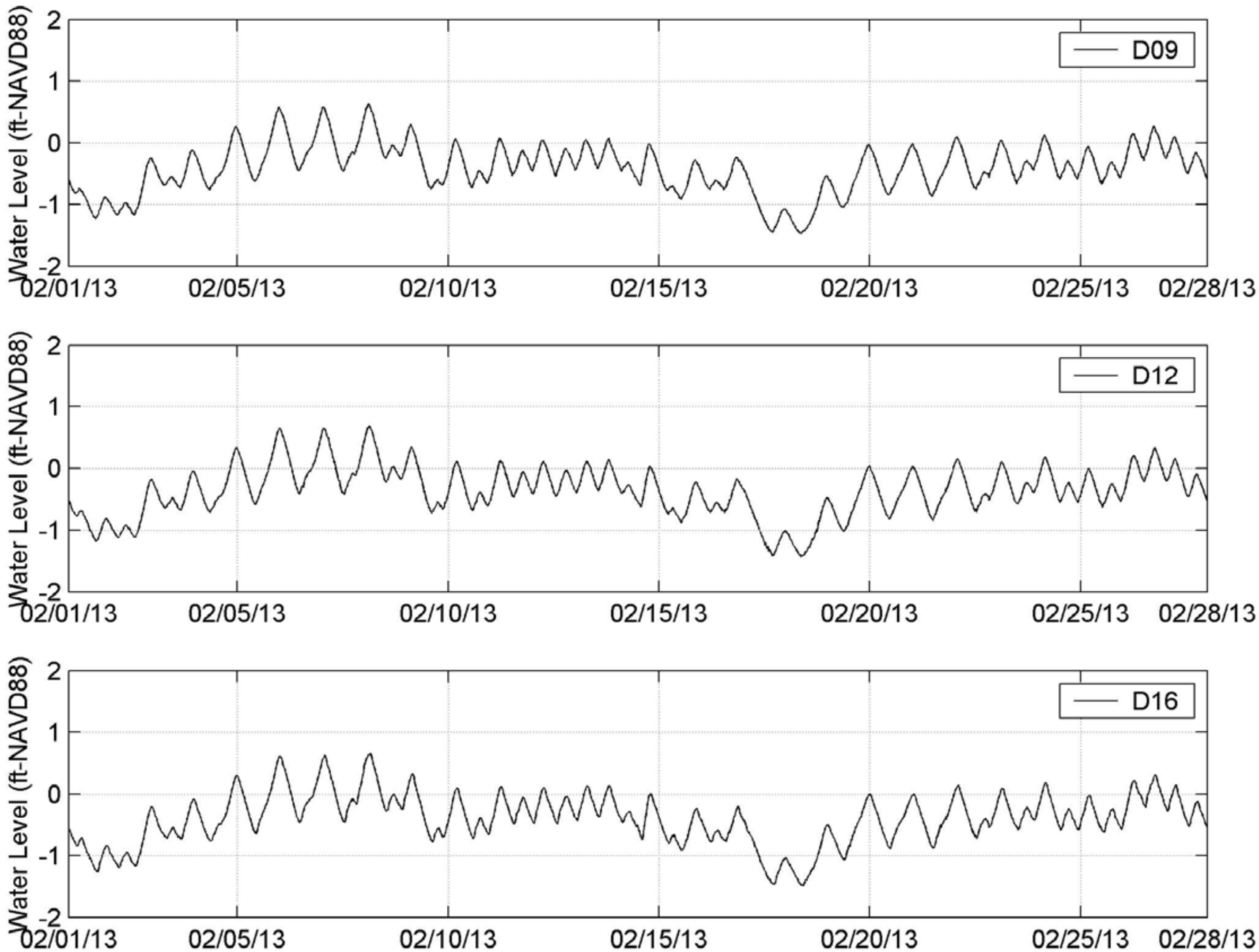

D09
D12
D16
Water Level (ft-NAVD88)
2
1
0
-1
-2
10/01/12
10/05/12
10/10/12
10/15/12
10/20/12
10/25/12
10/31/12

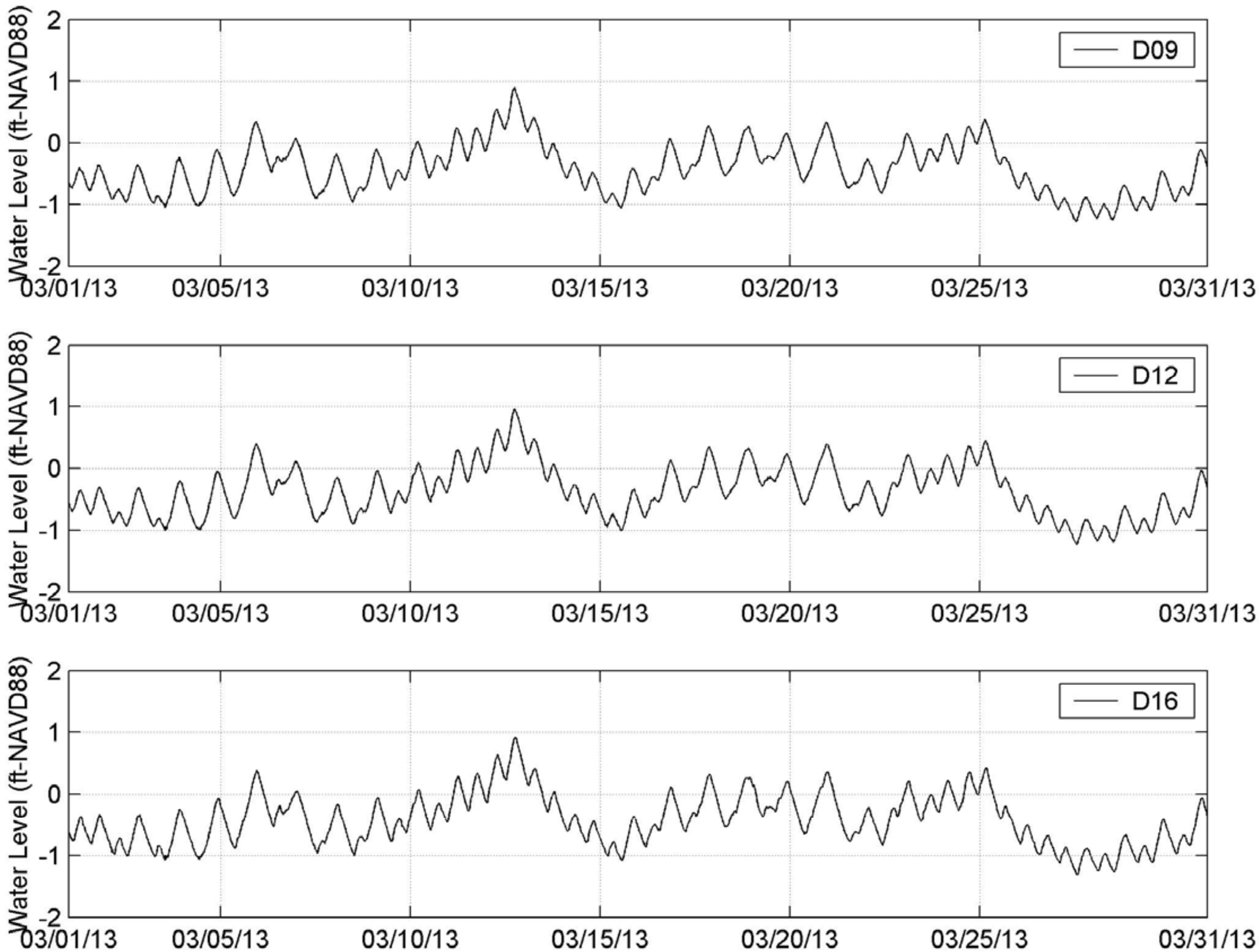

Water Level (ft-NAVD88)
D09
D12
D16
2
1
0
-1
-2
11/01/12
11/05/12
11/10/12
11/15/12
11/20/12
11/25/12
11/30/12

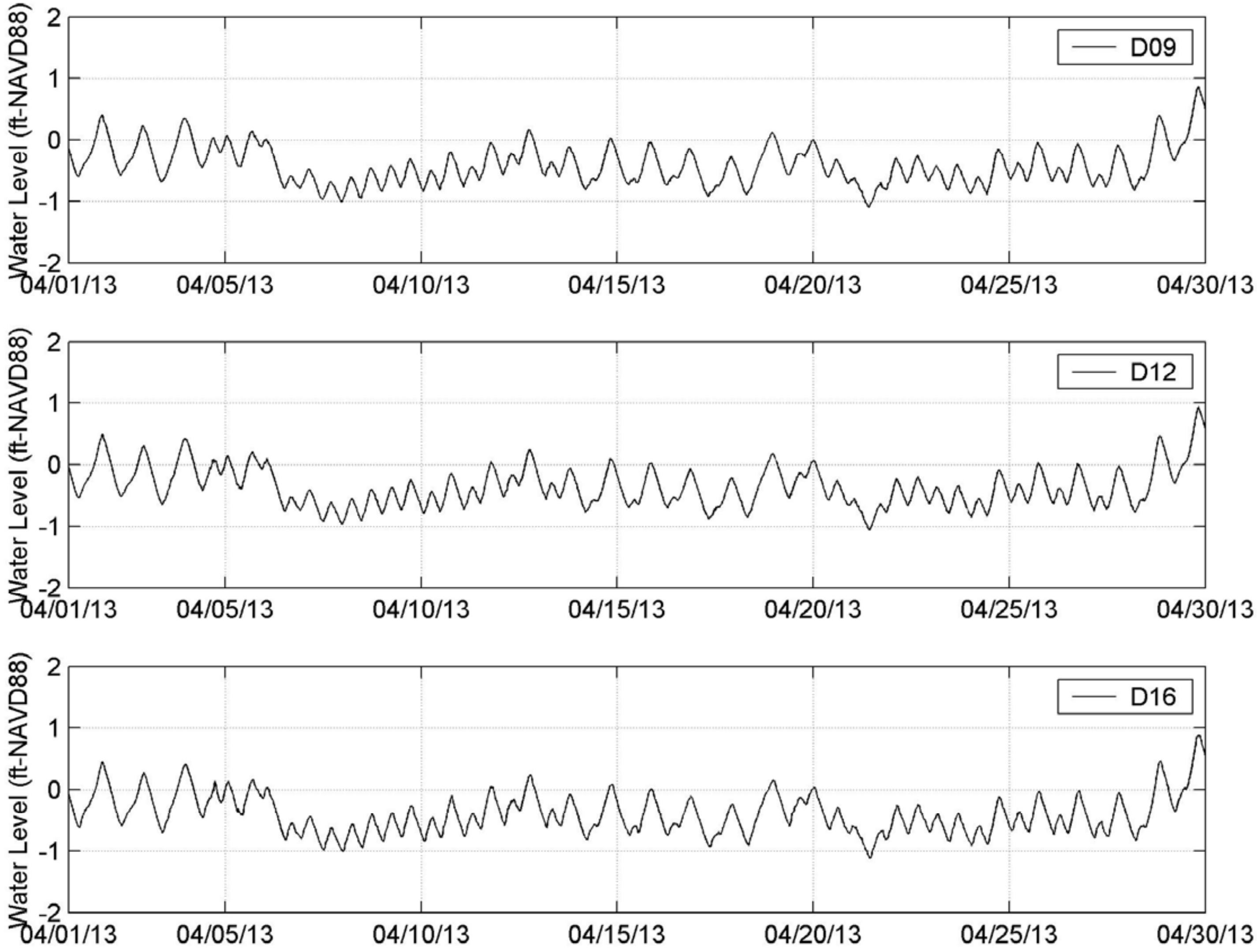


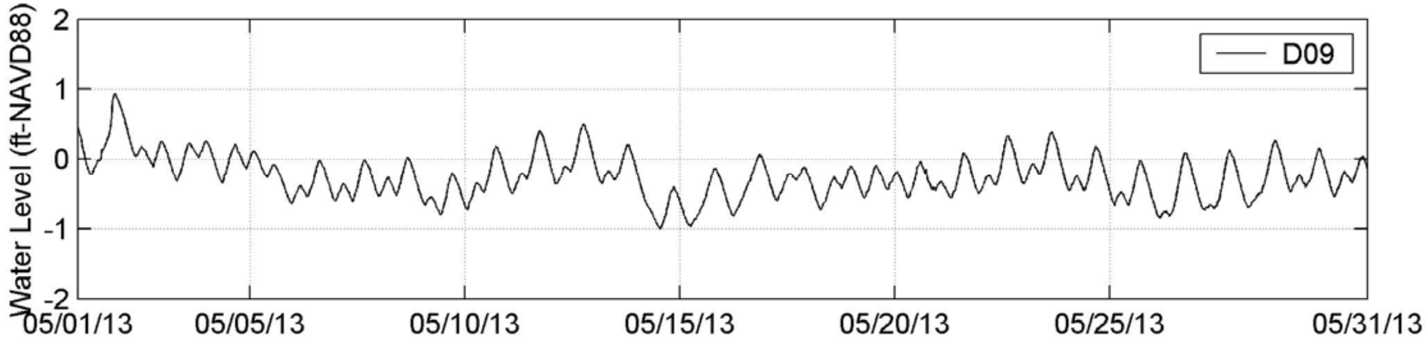
D09
D12
D16
Water Level (ft-NAVD88)
2
1
0
-1
-2
12/01/12
12/05/12
12/10/12
12/15/12
12/20/12
12/25/12
12/31/12


Water Level (ft-NAVD88)
D09
D12
D16
2
1
0
-1
-2
01/01/13
01/05/13
01/10/13
01/15/13
01/20/13
01/25/13
01/31/13

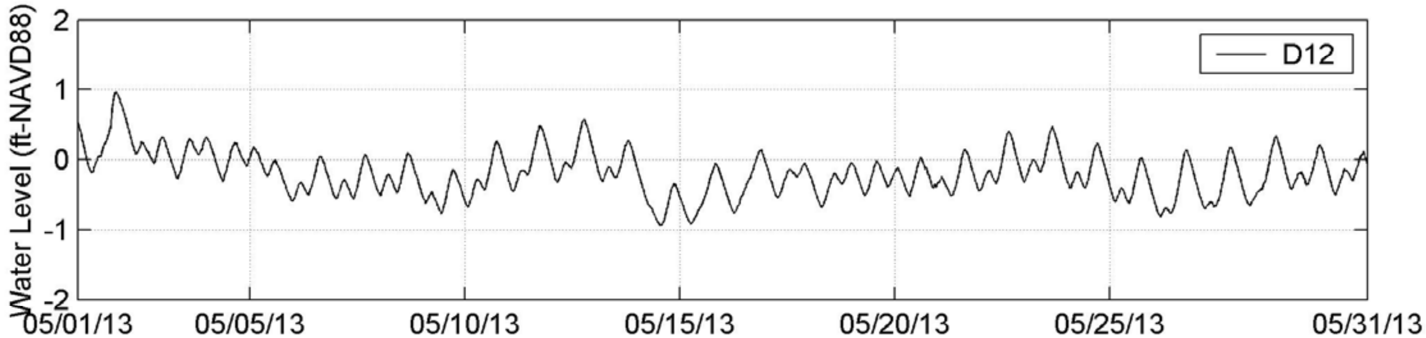

D09
D12
D16
Water Level (ft-NAVD88)
2
1
0
-1
-2
02/01/13
02/05/13
02/10/13
02/15/13
02/20/13
02/25/13
02/28/13


D09
D12
D16
Water Level (ft-NAVD88)
2
1
0
-1
-2
03/01/13
03/05/13
03/10/13
03/15/13
03/20/13
03/25/13
03/31/13

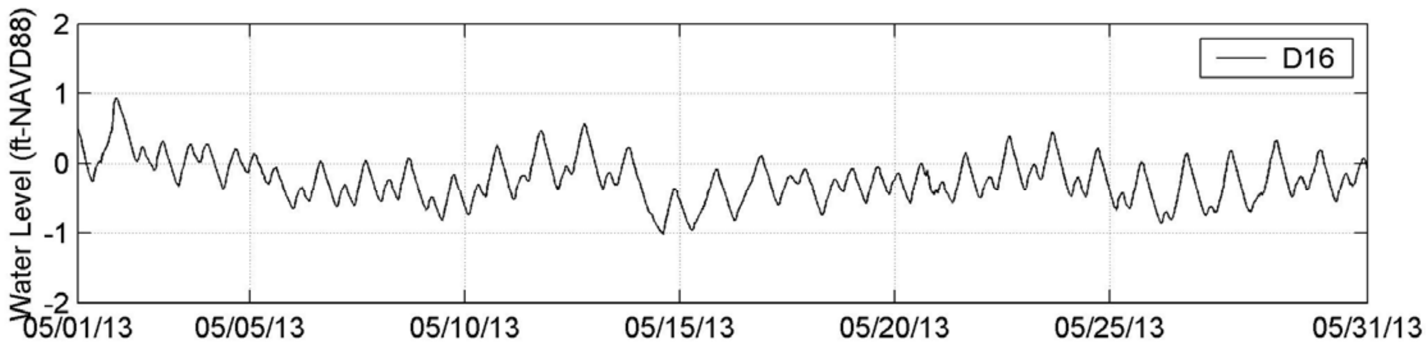

D09
D12
D16
Water Level (ft-NAVD88)
2
1
0
-1
-2
04/01/13
04/05/13
04/10/13
04/15/13
04/20/13
04/25/13
04/30/13



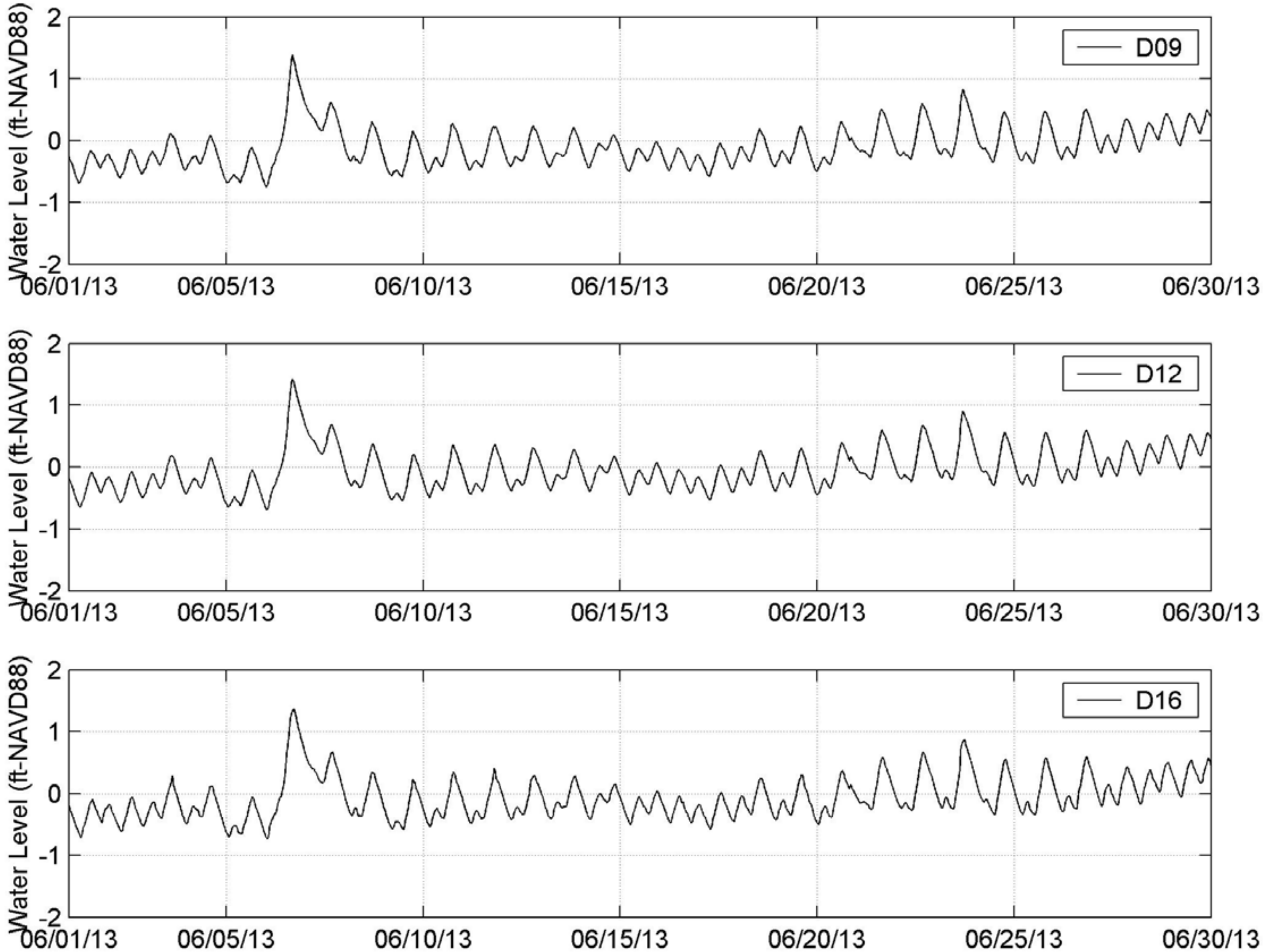
Water Level (ft-NAVD88)
2
1
0
-1
-2
D09
05/01/13
05/05/13
05/10/13
05/15/13
05/20/13
05/25/13
05/31/13

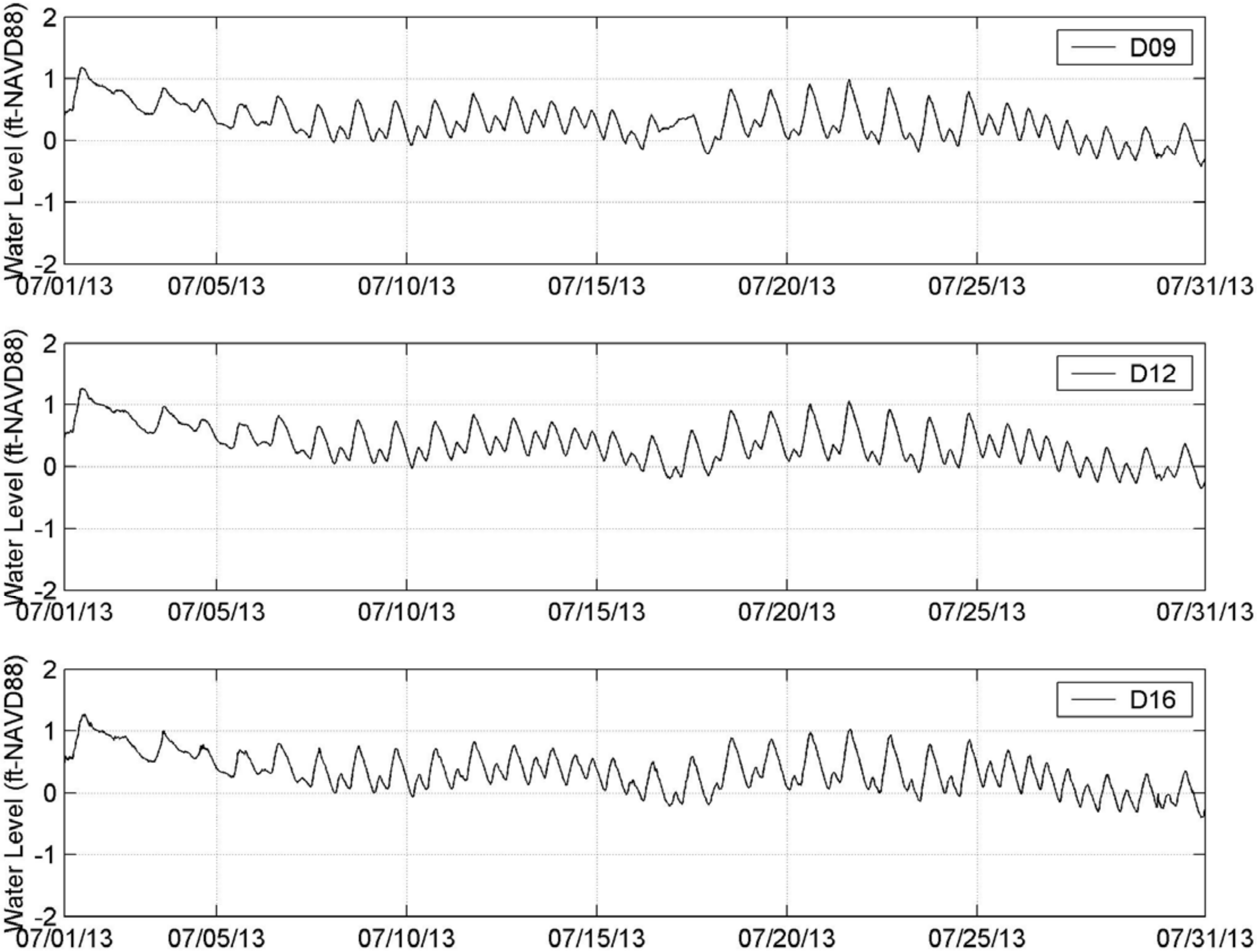


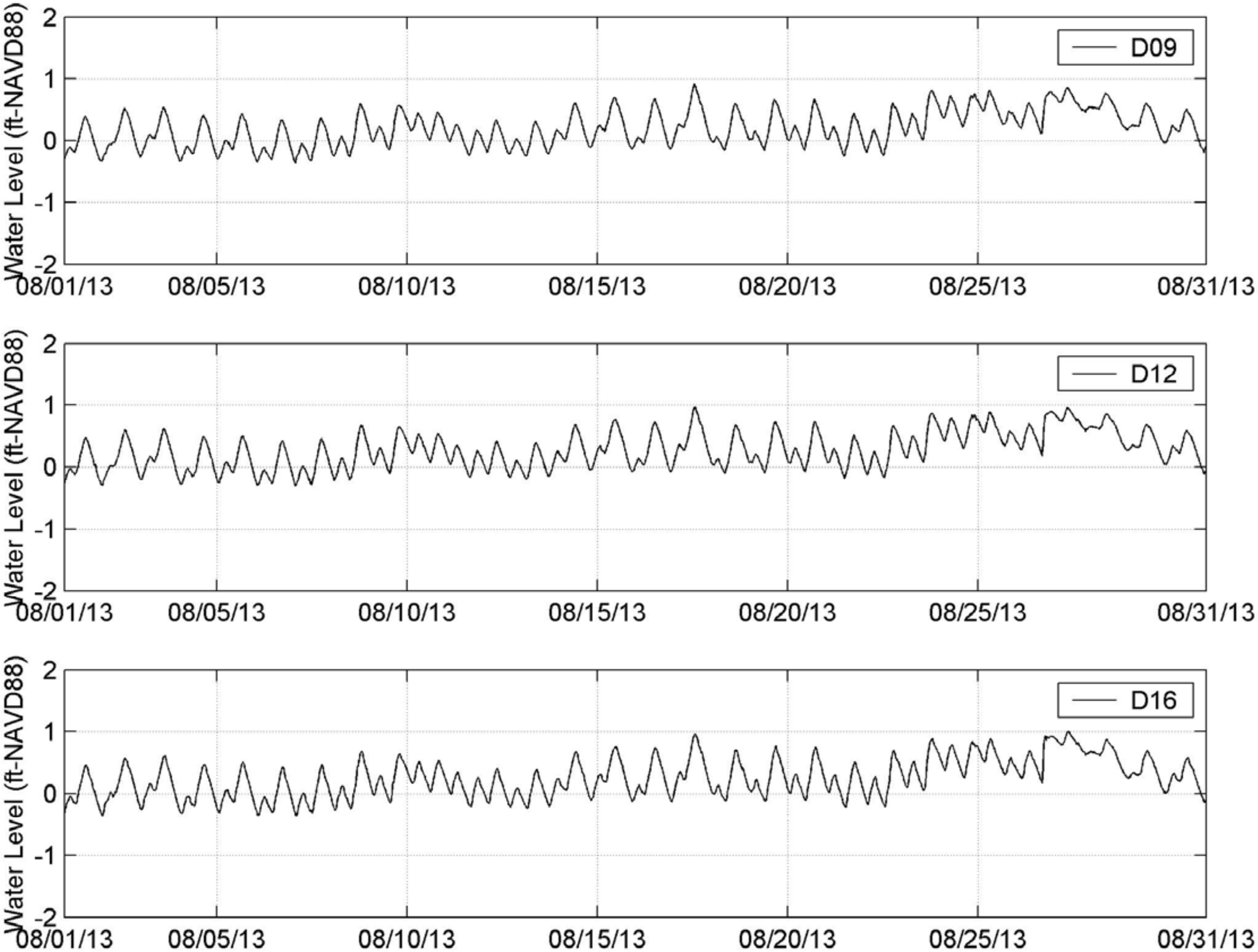
Water Level (ft-NAVD88)
2
1
0
-1
-2
D12
05/01/13
05/05/13
05/10/13
05/15/13
05/20/13
05/25/13
05/31/13

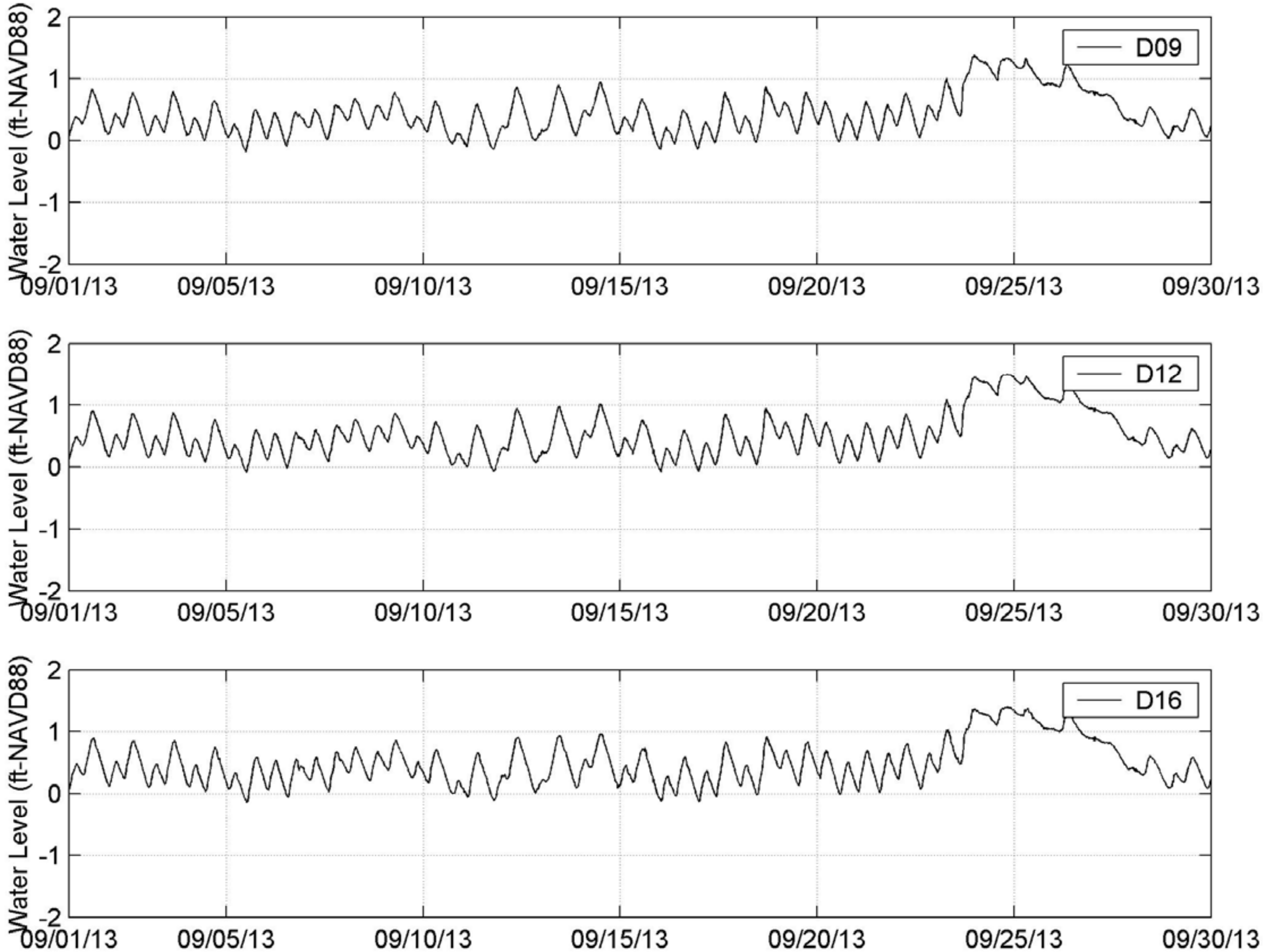


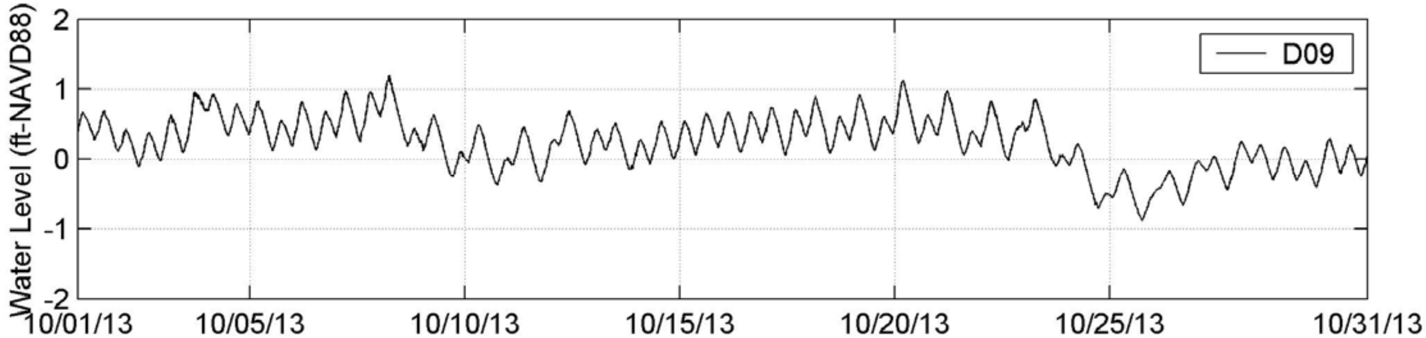
Water Level (ft-NAVD88)
2
1
0
-1
-2
D16
05/01/13
05/05/13
05/10/13
05/15/13
05/20/13
05/25/13
05/31/13

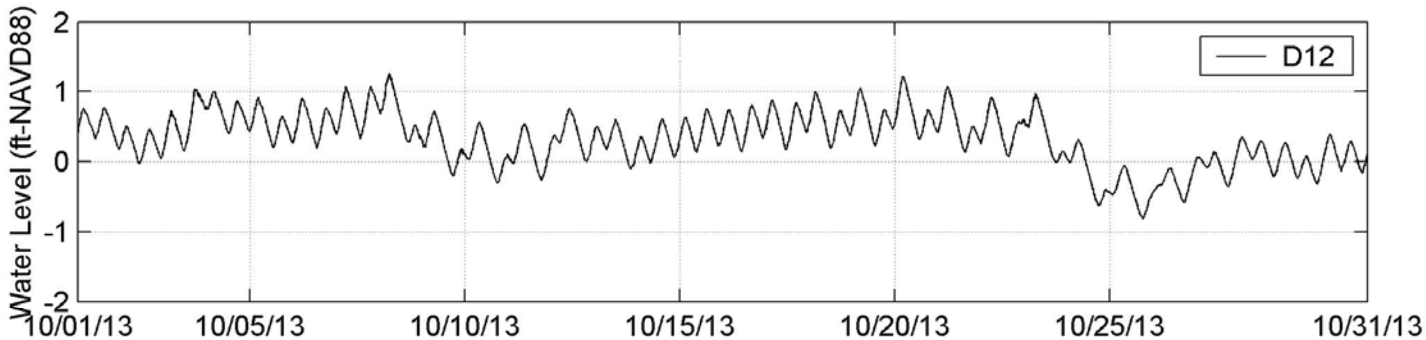

Water Level (ft-NAVD88)
D09
D12
D16
2
1
0
-1
-2
06/01/13
06/05/13
06/10/13
06/15/13
06/20/13
06/25/13
06/30/13

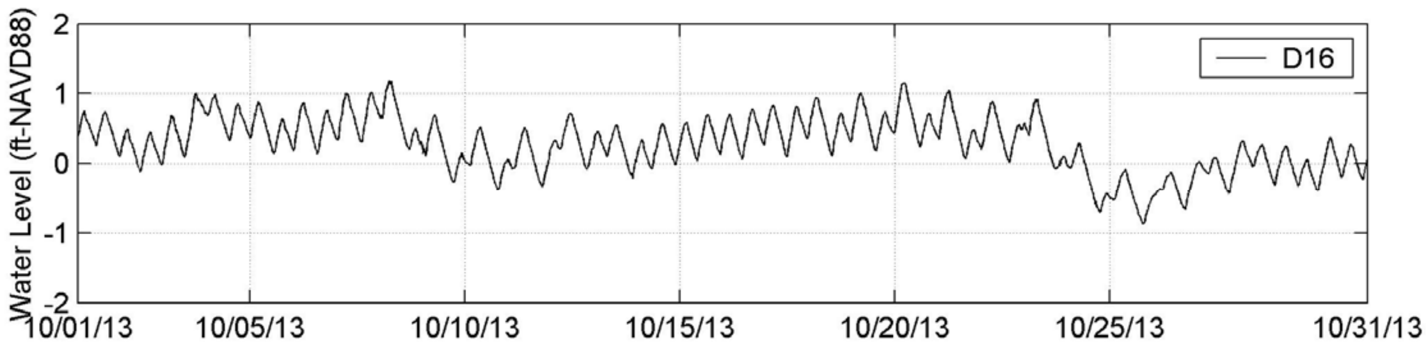

D09
D12
D16
Water Level (ft-NAVD88)
2
1
0
-1
-2
07/01/13
07/05/13
07/10/13
07/15/13
07/20/13
07/25/13
07/31/13

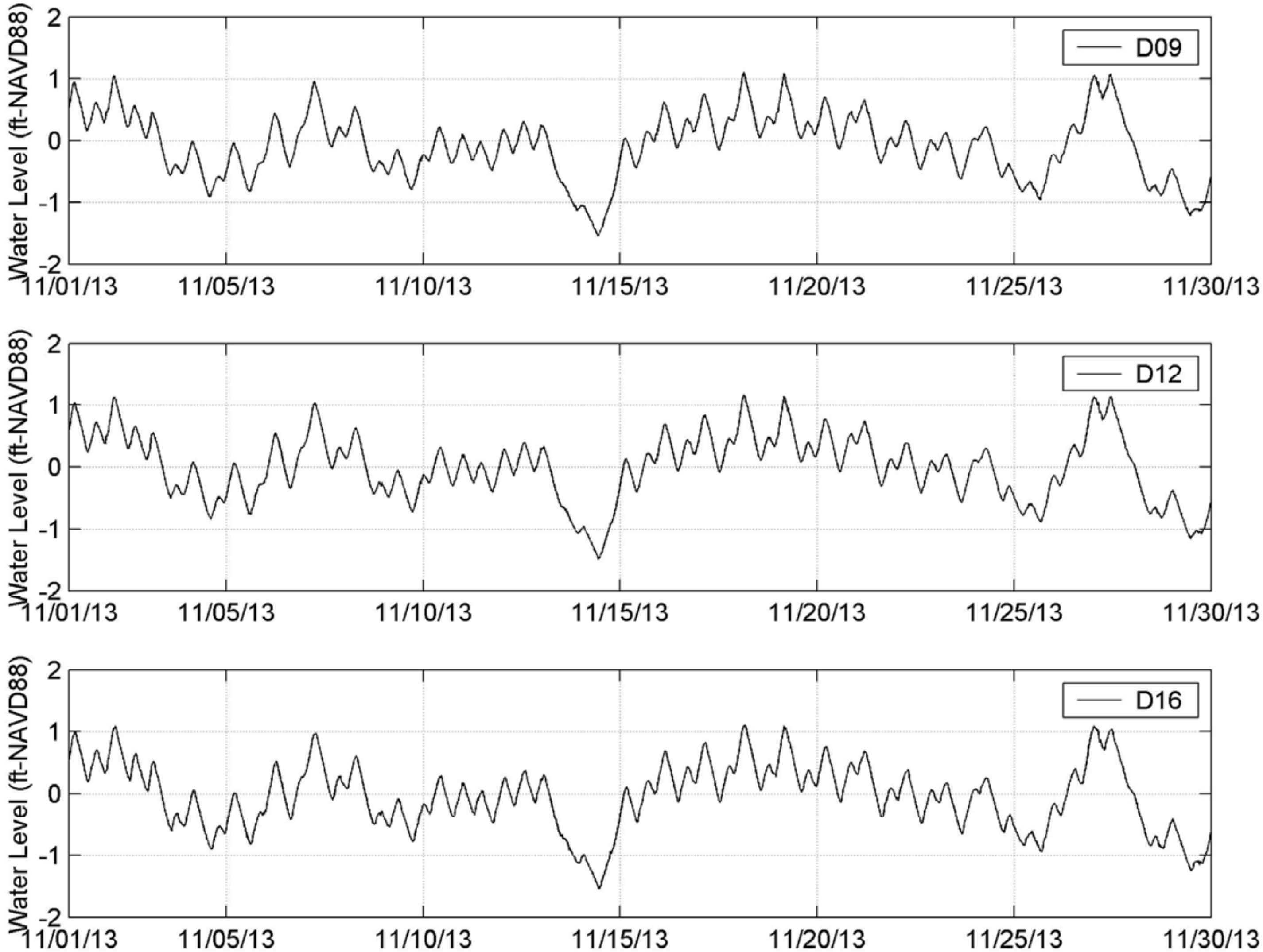

D09
D12
D16
Water Level (ft-NAVD88)
2
1
0
-1
-2
08/01/13
08/05/13
08/10/13
08/15/13
08/20/13
08/25/13
08/31/13

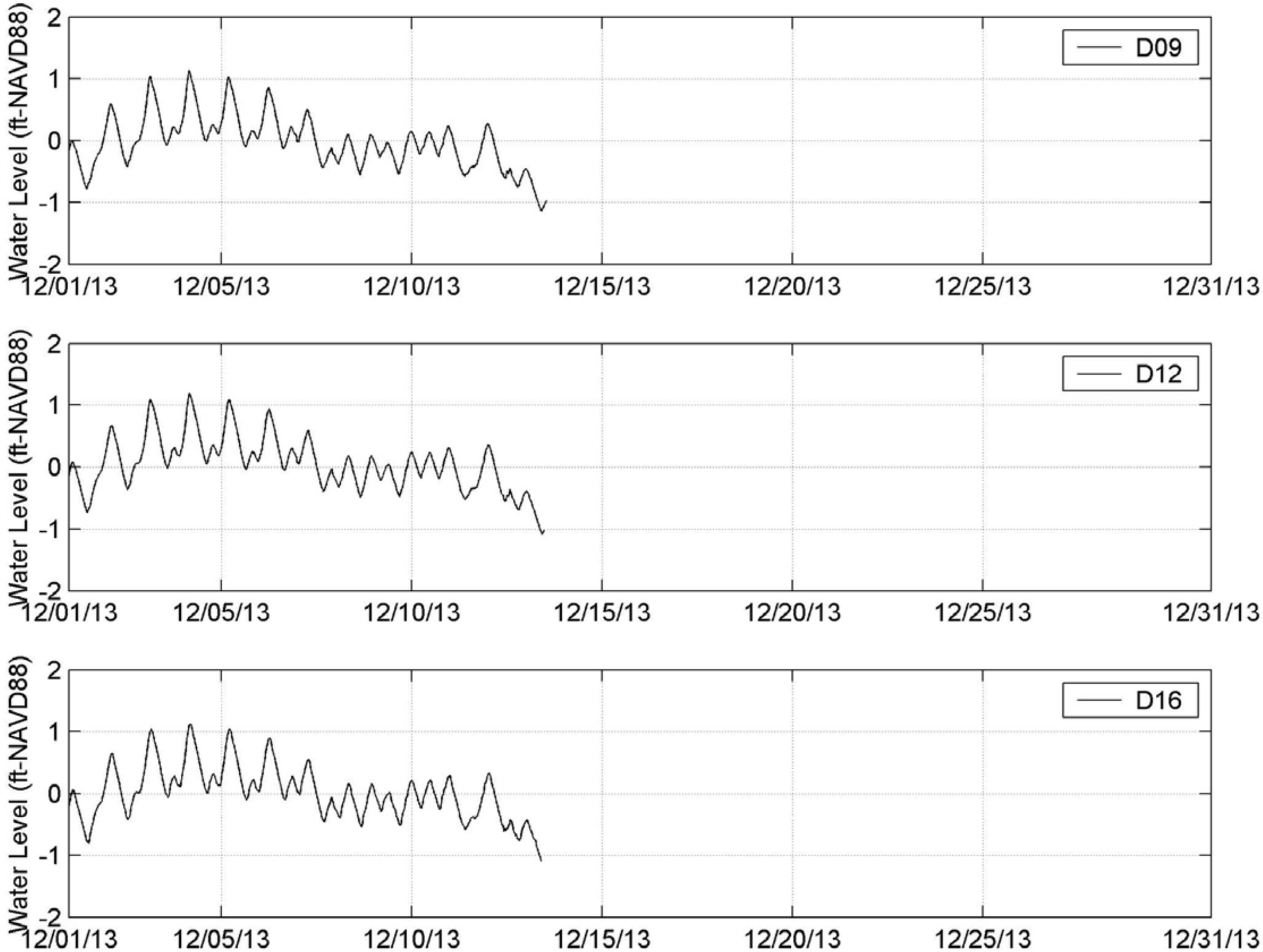

Water Level (ft-NAVD88)
D09
D12
D16
2
1
0
-1
-2
09/01/13
09/05/13
09/10/13
09/15/13
09/20/13
09/25/13
09/30/13


Water Level (ft-NAVD88)
D09
2
1
0
-1
-2
10/01/13
10/05/13
10/10/13
10/15/13
10/20/13
10/25/13
10/31/13


Water Level (ft-NAVD88)
D12
2
1
0
-1
-2
10/01/13
10/05/13
10/10/13
10/15/13
10/20/13
10/25/13
10/31/13

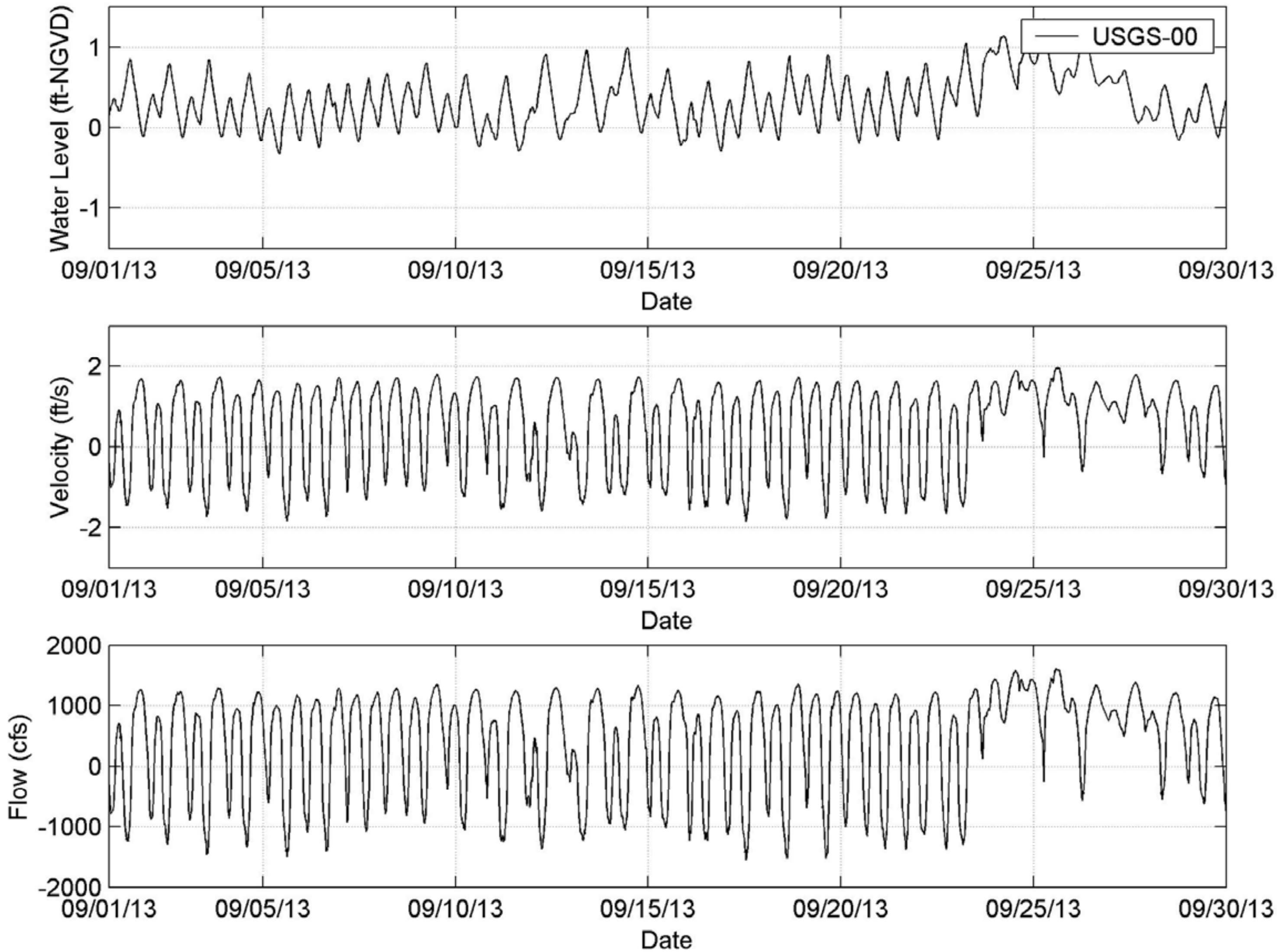

Water Level (ft-NAVD88)
D16
2
1
0
-1
-2
10/01/13
10/05/13
10/10/13
10/15/13
10/20/13
10/25/13
10/31/13


D09
D12
D16
Water Level (ft-NAVD88)
2
1
0
-1
-2
11/01/13
11/05/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13

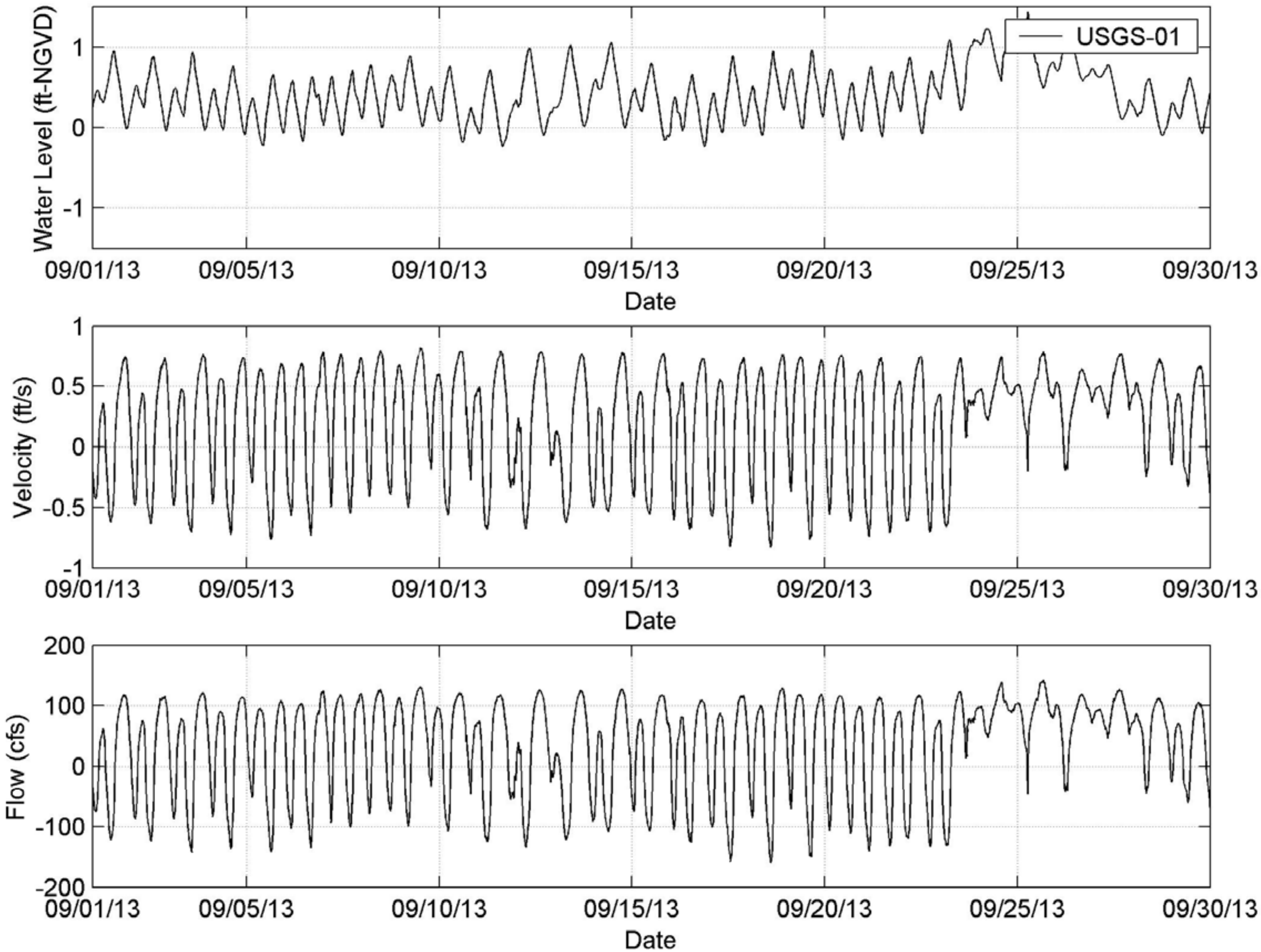

Water Level (ft-NAVD88)
2
1
0
-1
-2
D09
12/01/13
12/05/13
12/10/13
12/15/13
12/20/13
12/25/13
12/31/13
Water Level (ft-NAVD88)
2
1
0
-1
-2
D12
12/01/13
12/05/13
12/10/13
12/15/13
12/20/13
12/25/13
12/31/13
Water Level (ft-NAVD88)
2
1
0
-1
-2
D16
12/01/13
12/05/13
12/10/13
12/15/13
12/20/13
12/25/13
12/31/13

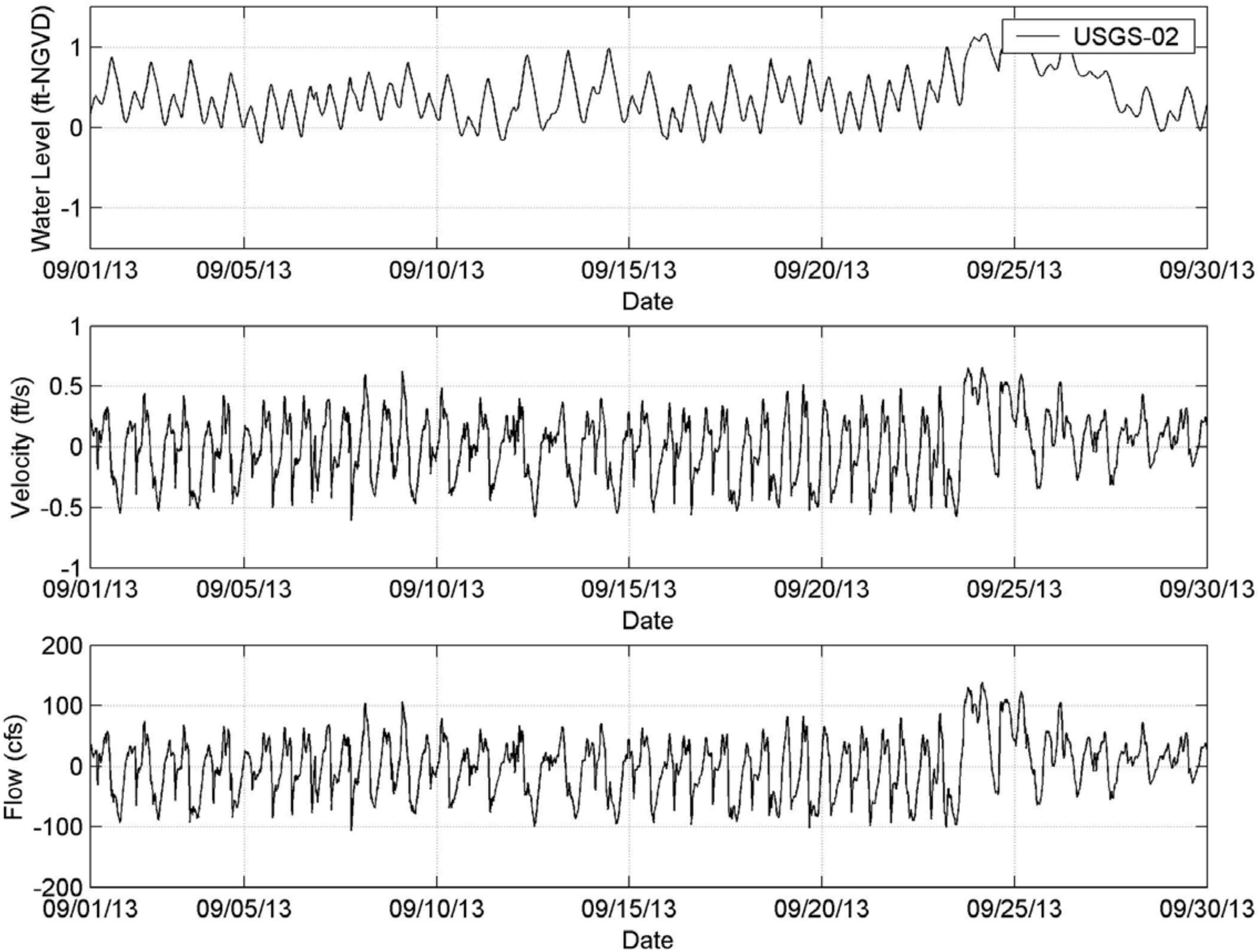
Appendix C

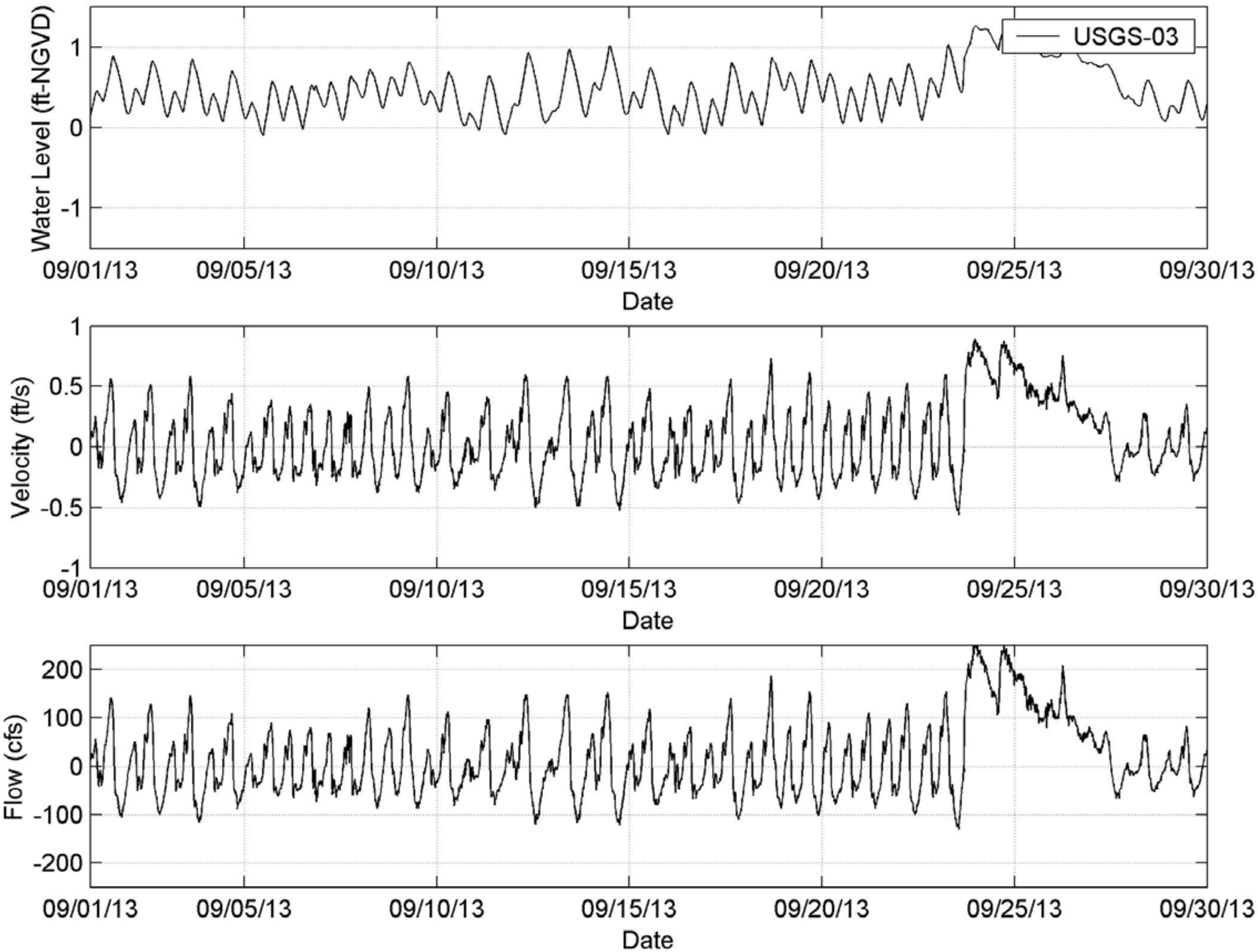
Water Levels, Velocities and Flows at USGS Stations



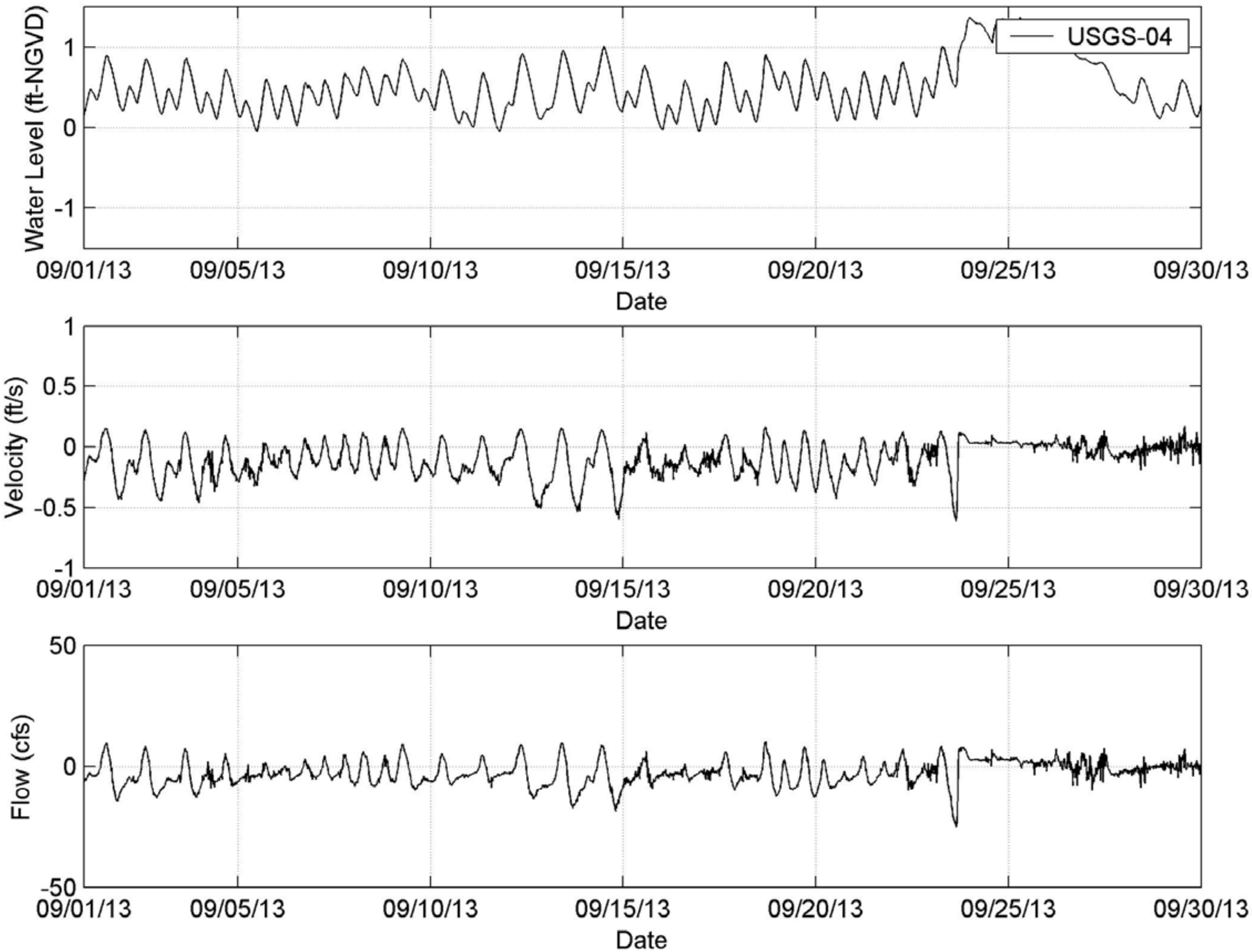
USGS-00
Water Level (ft-NGVD)
1
0
-1
Velocity (ft/s)
2
0
-2
Flow (cfs)
2000
1000
0
-1000
-2000
09/01/13
09/05/13
09/10/13
09/15/13
09/20/13
09/25/13
09/30/13
Date


USGS-01
Water Level (ft-NGVD)
1
0
-1
09/01/13
09/05/13
09/10/13
09/15/13
09/20/13
09/25/13
09/30/13
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
09/01/13
09/05/13
09/10/13
09/15/13
09/20/13
09/25/13
09/30/13
Date
Flow (cfs)
200
100
0
-100
-200
09/01/13
09/05/13
09/10/13
09/15/13
09/20/13
09/25/13
09/30/13
Date

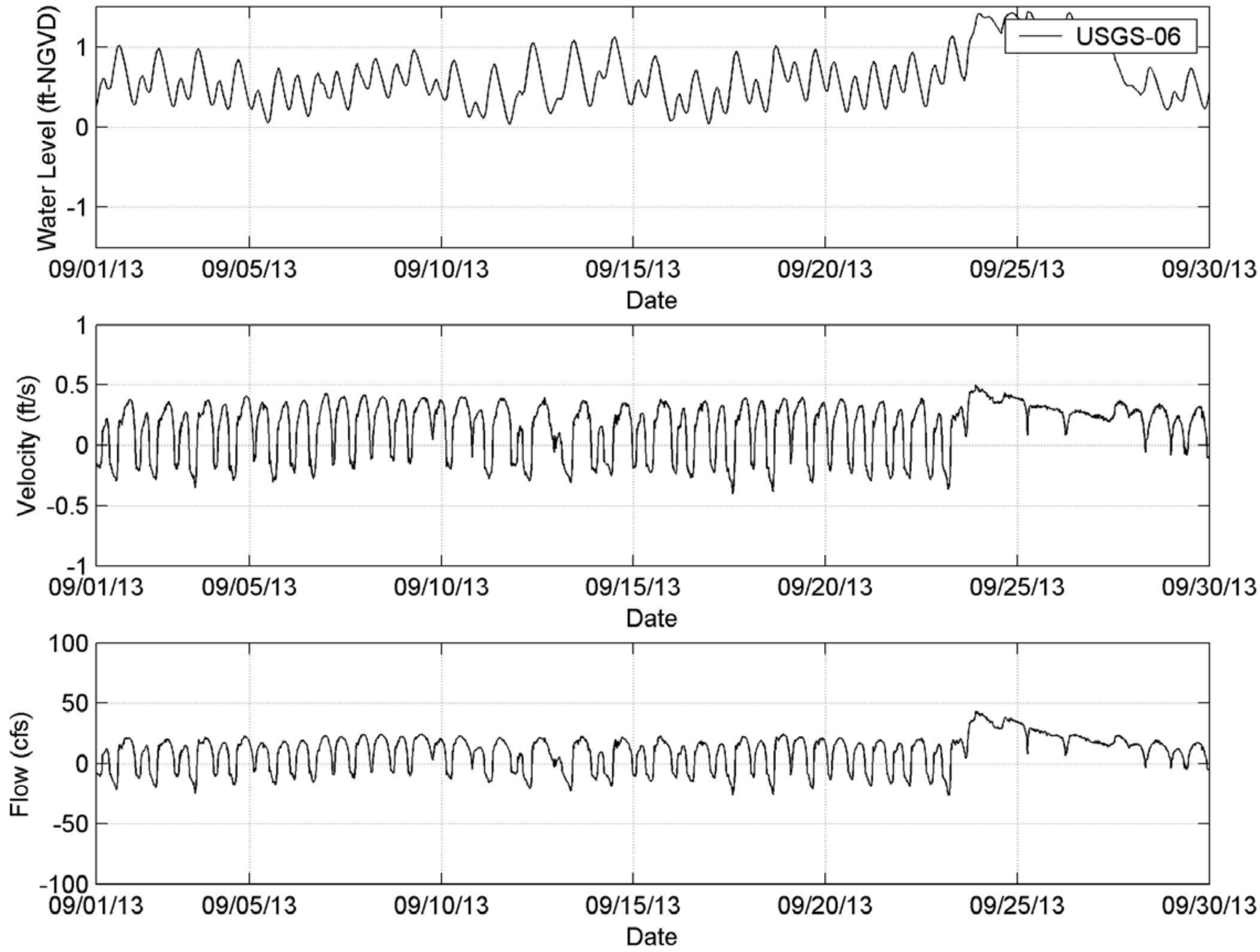

USGS-02
Water Level (ft-NGVD)
1
0
-1
09/01/13
09/05/13
09/10/13
09/15/13
09/20/13
09/25/13
09/30/13
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
Date
Flow (cfs)
200
100
0
-100
-200
Date



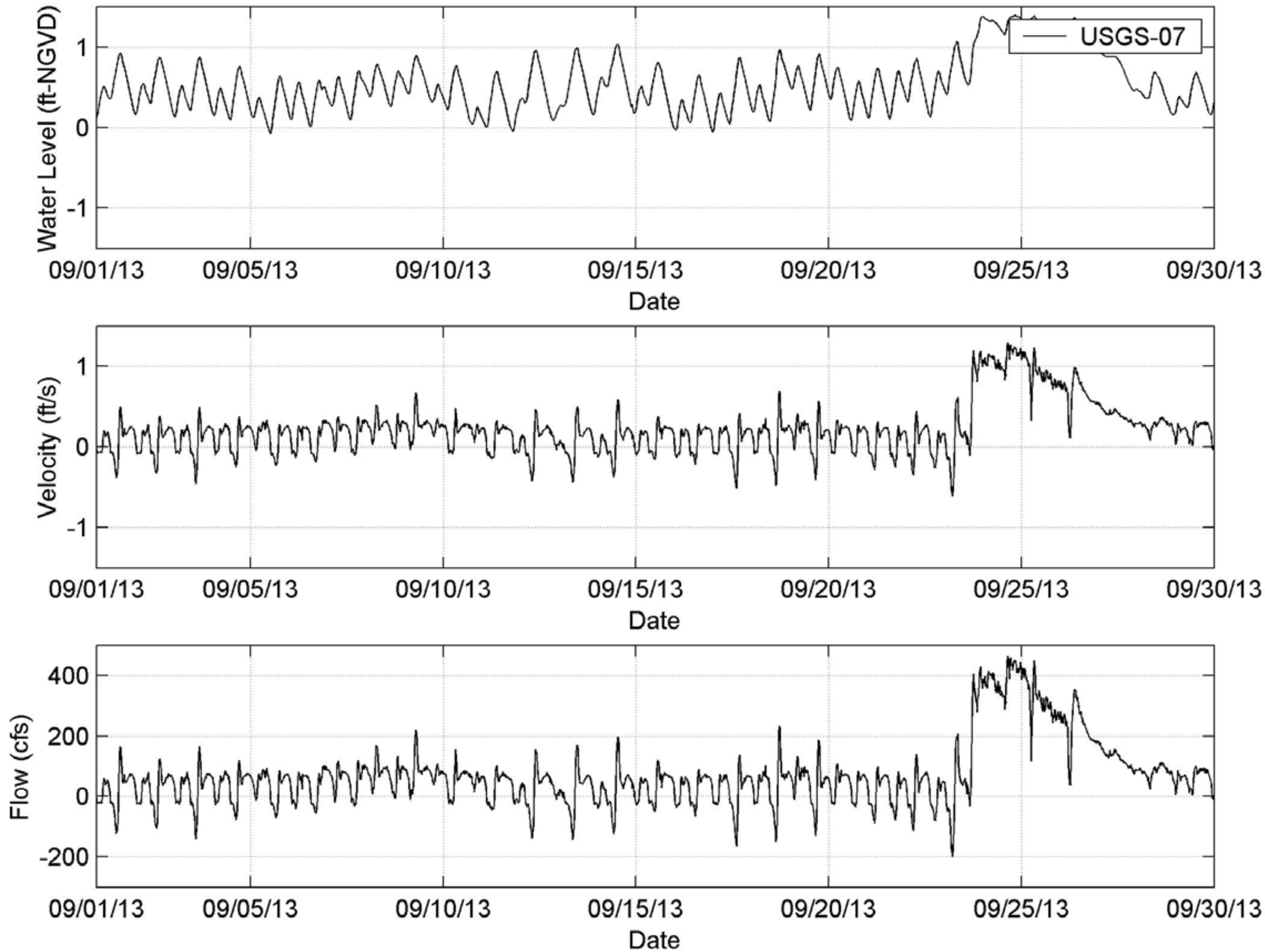
USGS-03
Water Level (ft-NGVD)
1
0
-1
09/01/13
09/05/13
09/10/13
09/15/13
09/20/13
09/25/13
09/30/13
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
Date
Flow (cfs)
200
100
0
-100
-200
Date

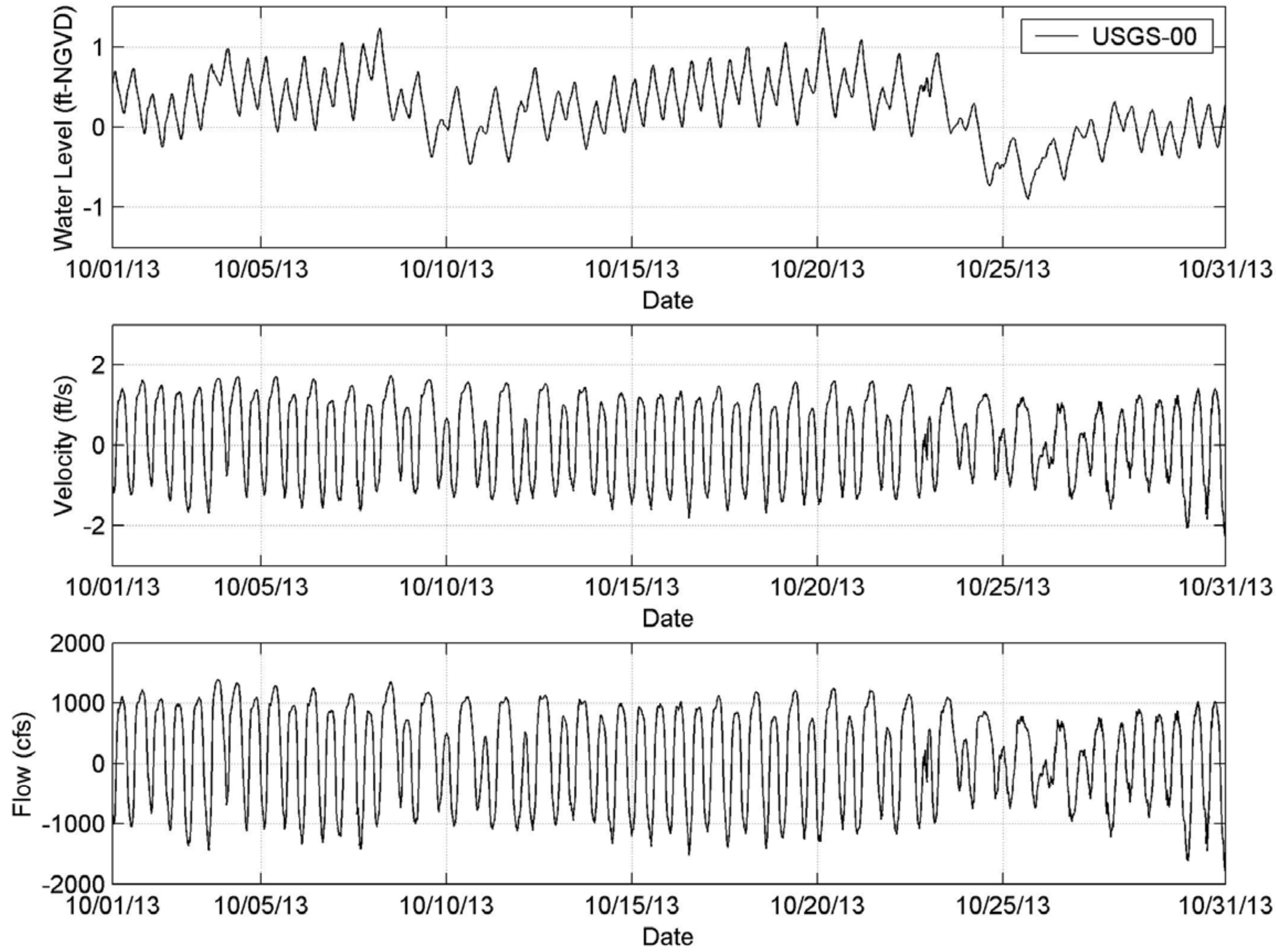


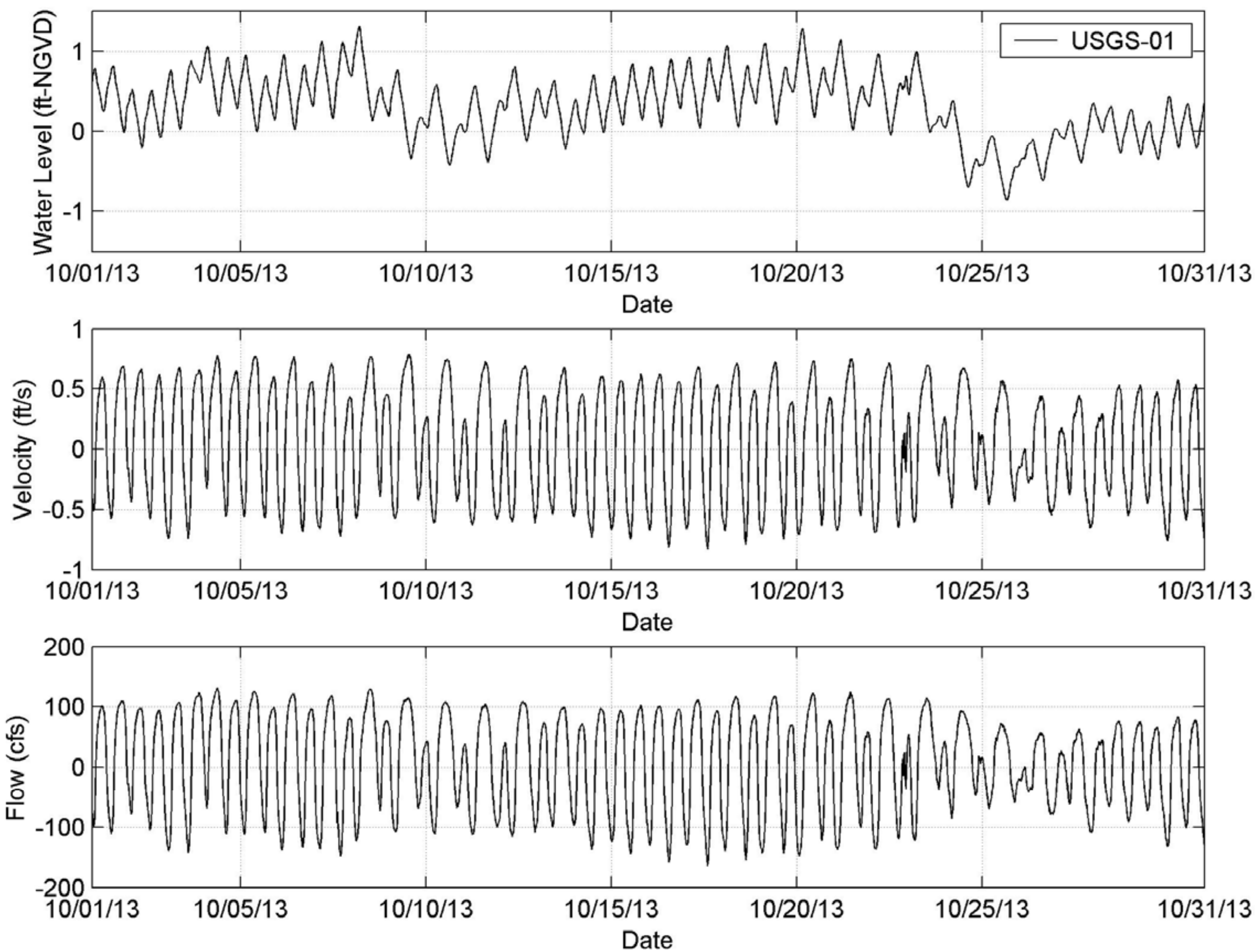
USGS-04
Water Level (ft-NGVD)
1
0
-1
09/01/13
09/05/13
09/10/13
09/15/13
09/20/13
09/25/13
09/30/13
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
09/01/13
09/05/13
09/10/13
09/15/13
09/20/13
09/25/13
09/30/13
Date
Flow (cfs)
50
0
-50
09/01/13
09/05/13
09/10/13
09/15/13
09/20/13
09/25/13
09/30/13
Date

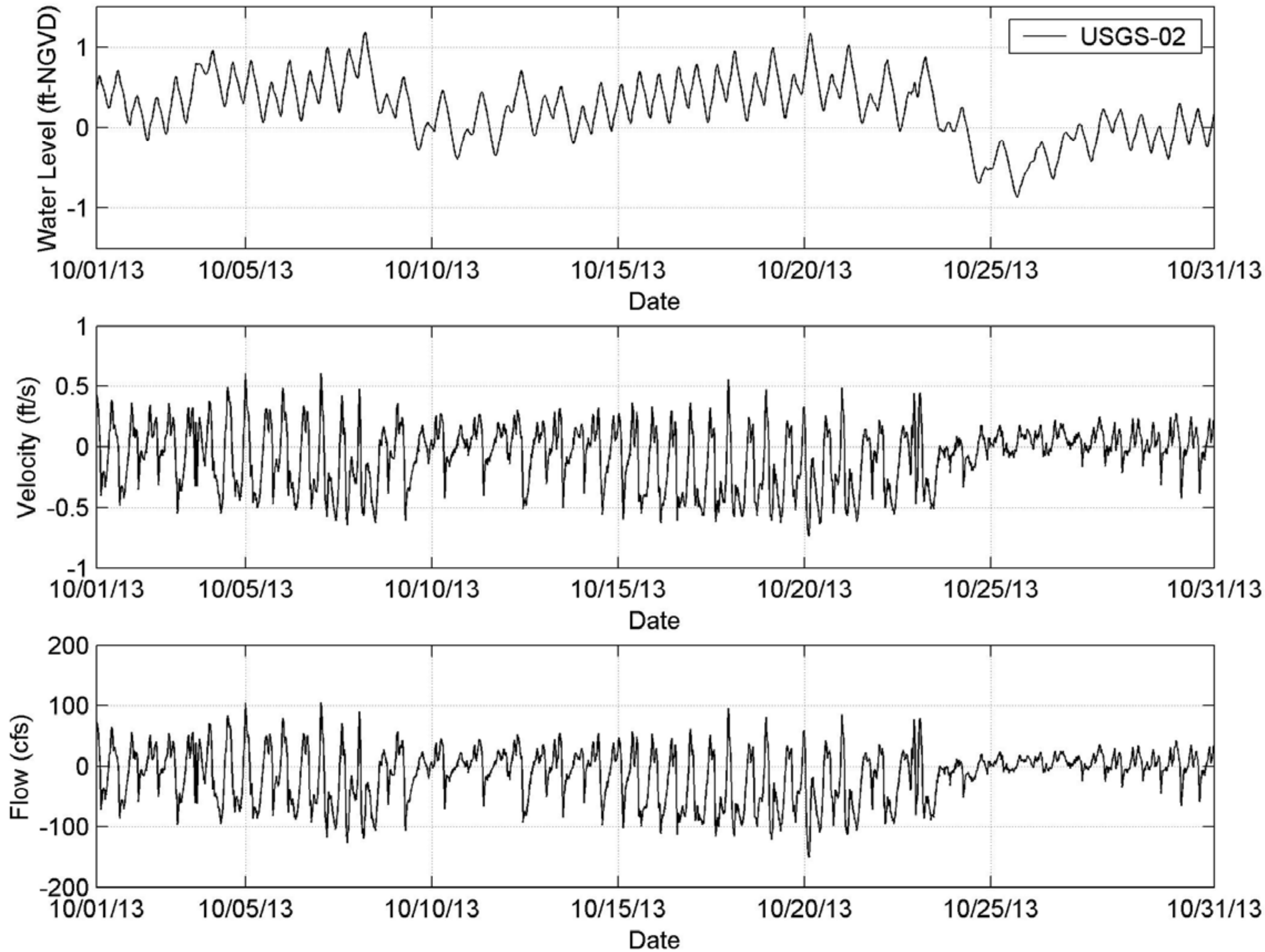


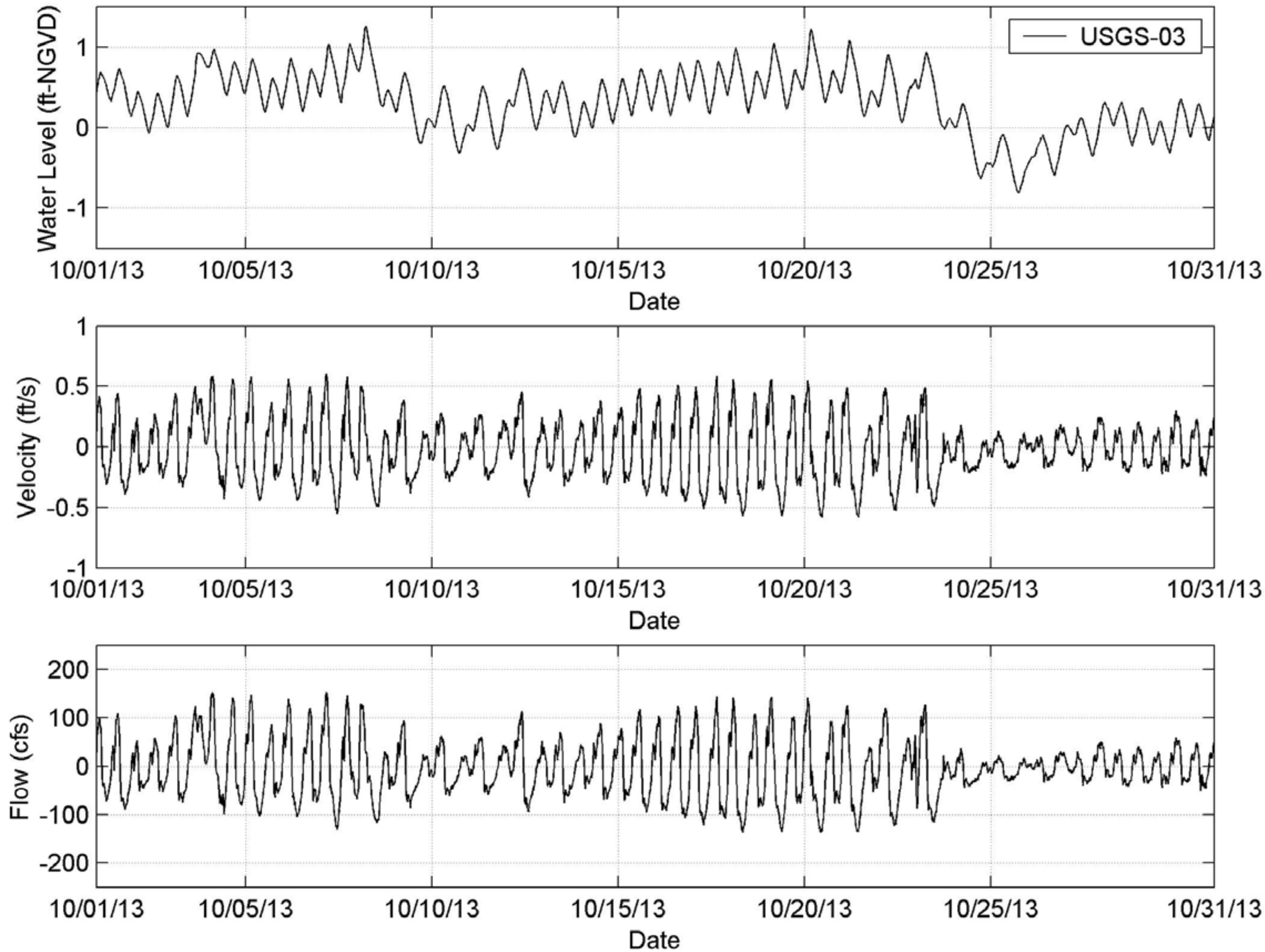
USGS-06
Water Level (ft-NGVD)
1
0
-1
09/01/13
09/05/13
09/10/13
09/15/13
09/20/13
09/25/13
09/30/13
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
Date
Flow (cfs)
100
50
0
-50
-100
Date

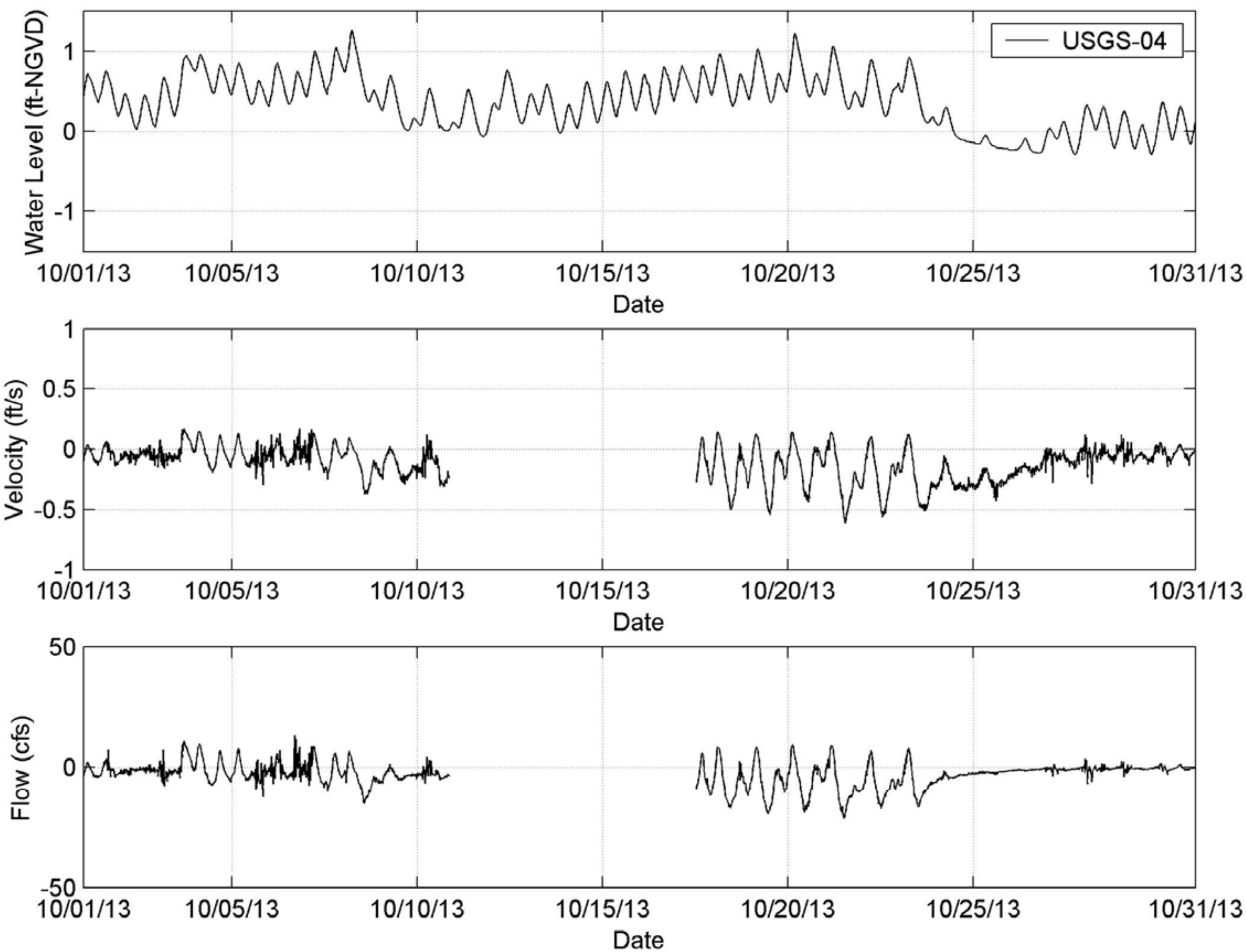

USGS-07
Water Level (ft-NGVD)
Velocity (ft/s)
Flow (cfs)
Date
09/01/13
09/05/13
09/10/13
09/15/13
09/20/13
09/25/13
09/30/13
1
0
-1
400
200
-200


USGS-00
Water Level (ft-NGVD)
1
0
-1
10/01/13
10/05/13
10/10/13
10/15/13
10/20/13
10/25/13
10/31/13
Date
Velocity (ft/s)
2
0
-2
10/01/13
10/05/13
10/10/13
10/15/13
10/20/13
10/25/13
10/31/13
Date
Flow (cfs)
2000
1000
0
-1000
-2000
10/01/13
10/05/13
10/10/13
10/15/13
10/20/13
10/25/13
10/31/13
Date

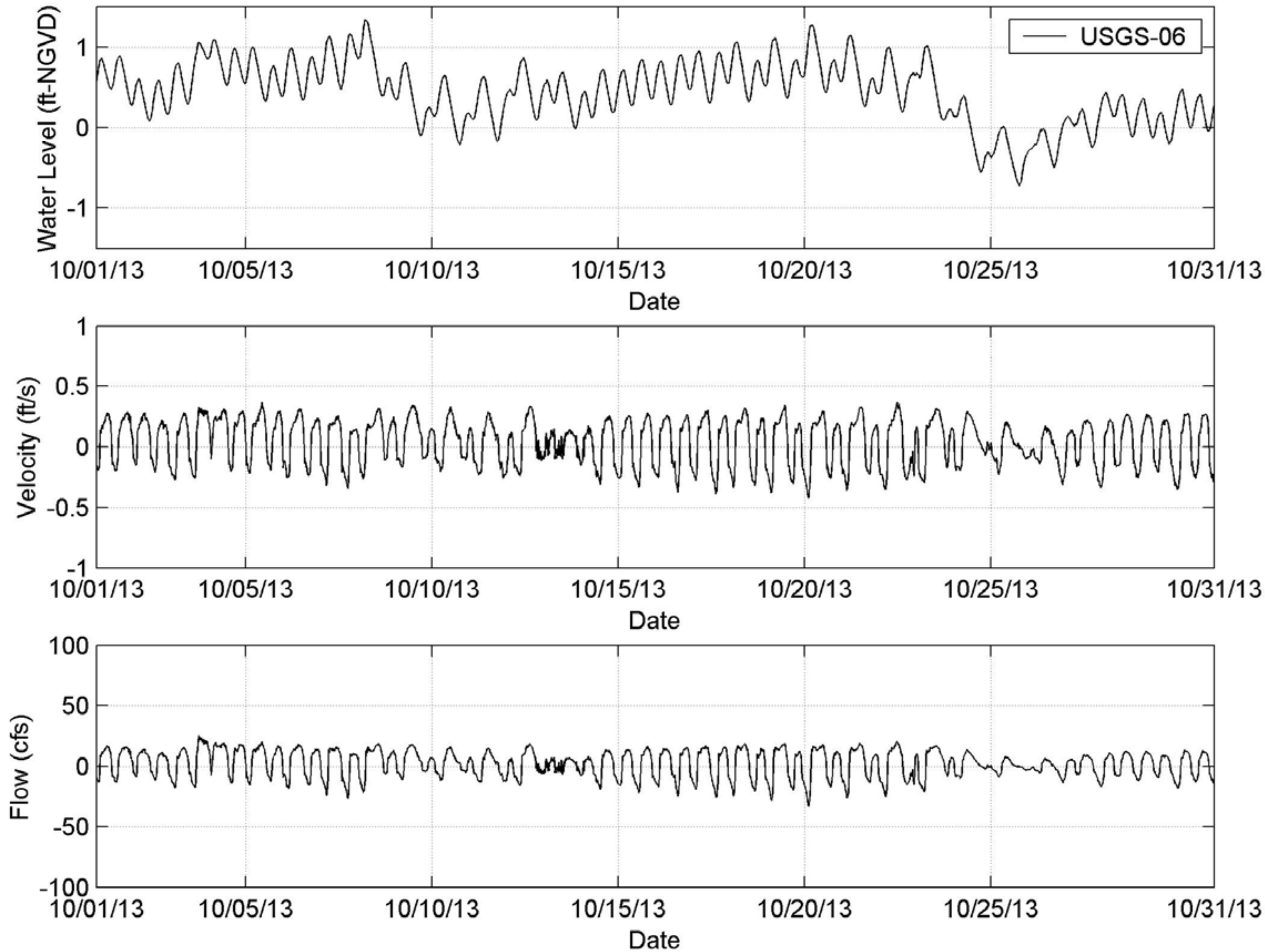

USGS-01
Water Level (ft-NGVD)
1
0
-1
10/01/13
10/05/13
10/10/13
10/15/13
10/20/13
10/25/13
10/31/13
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
Date
Flow (cfs)
200
100
0
-100
-200
Date

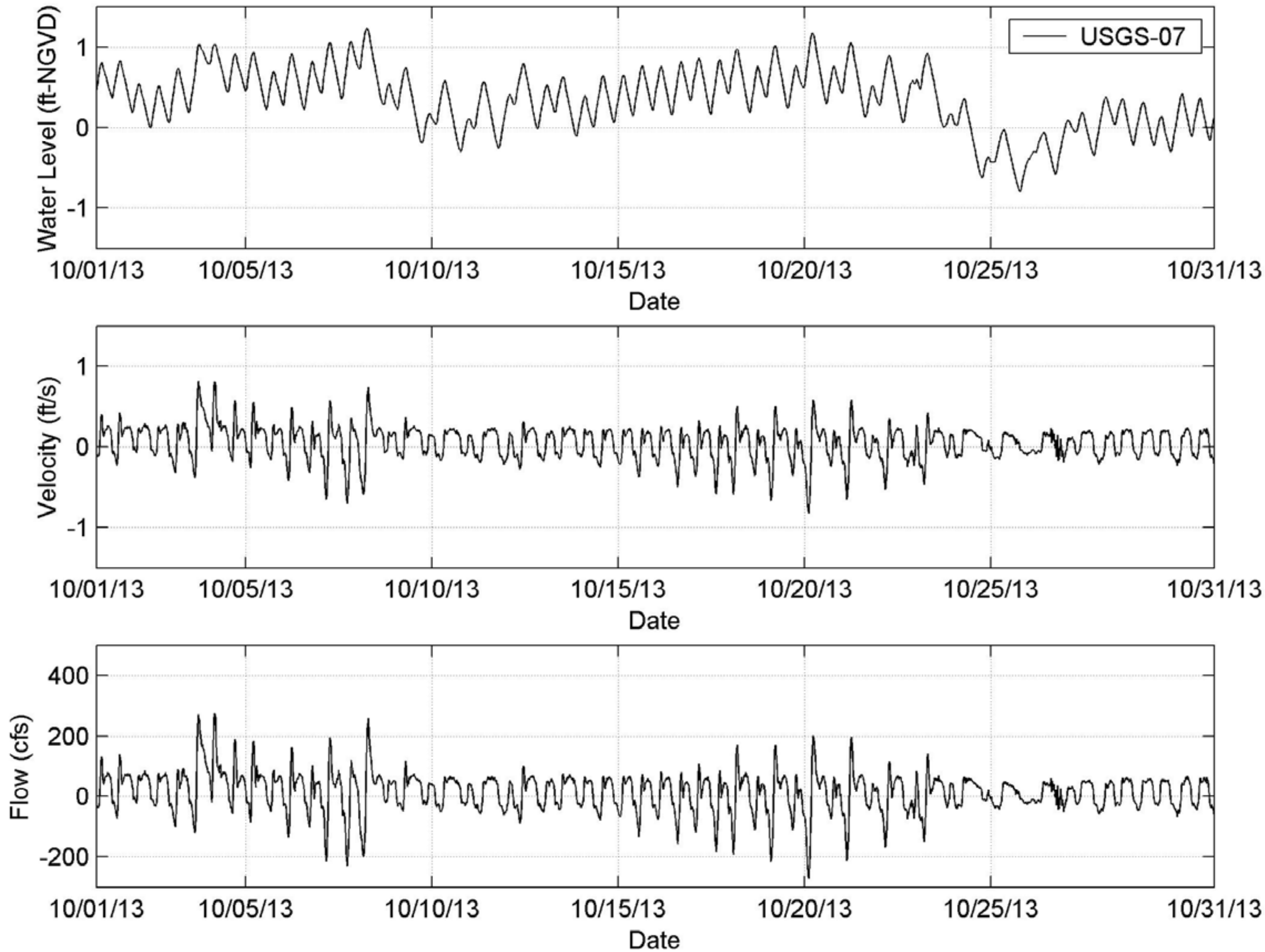

USGS-02
Water Level (ft-NGVD)
1
0
-1
10/01/13
10/05/13
10/10/13
10/15/13
10/20/13
10/25/13
10/31/13
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
Date
Flow (cfs)
200
100
0
-100
-200
Date

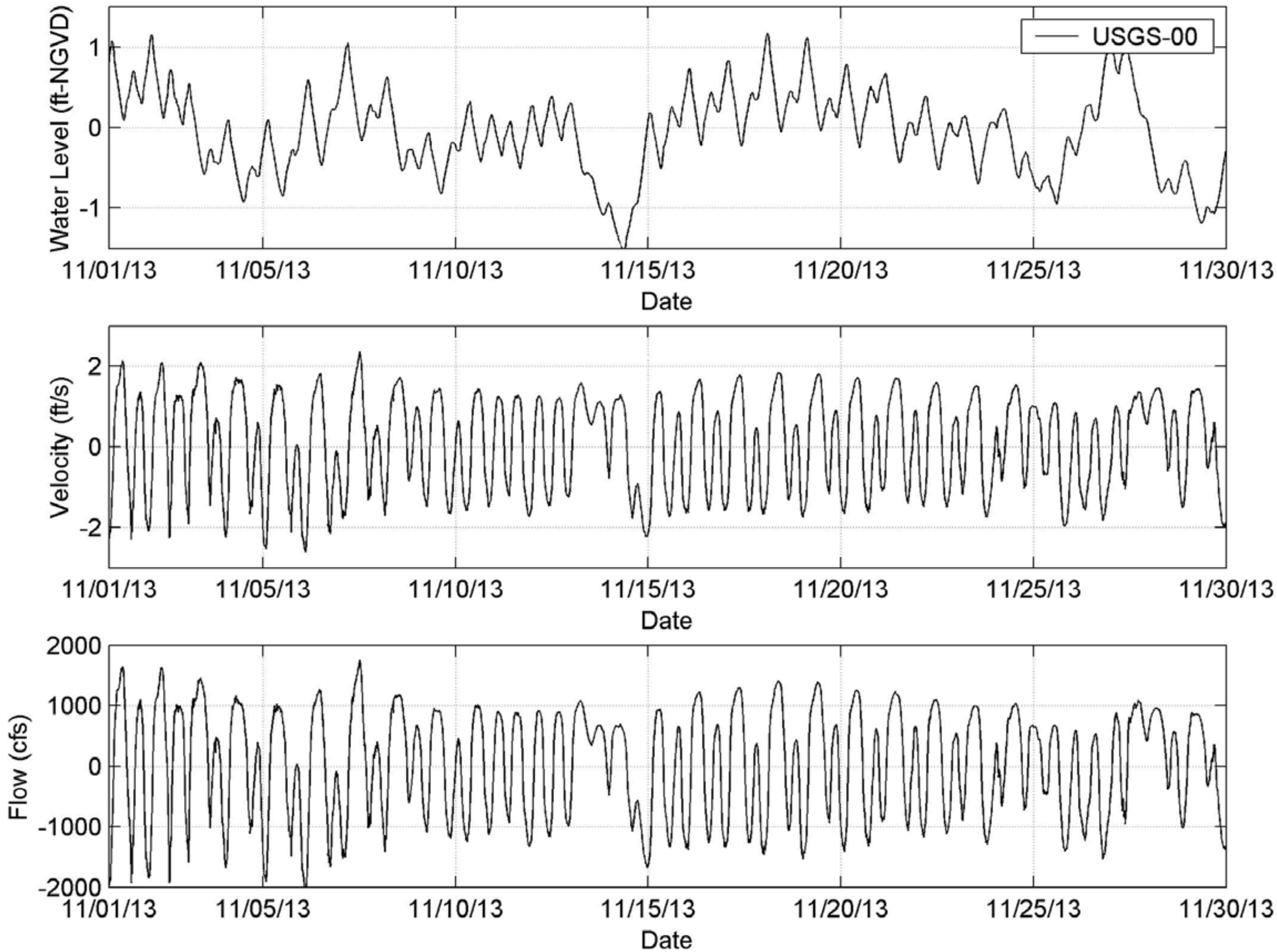

USGS-03
Water Level (ft-NGVD)
1
0
-1
10/01/13
10/05/13
10/10/13
10/15/13
10/20/13
10/25/13
10/31/13
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
Date
Flow (cfs)
200
100
0
-100
-200
Date

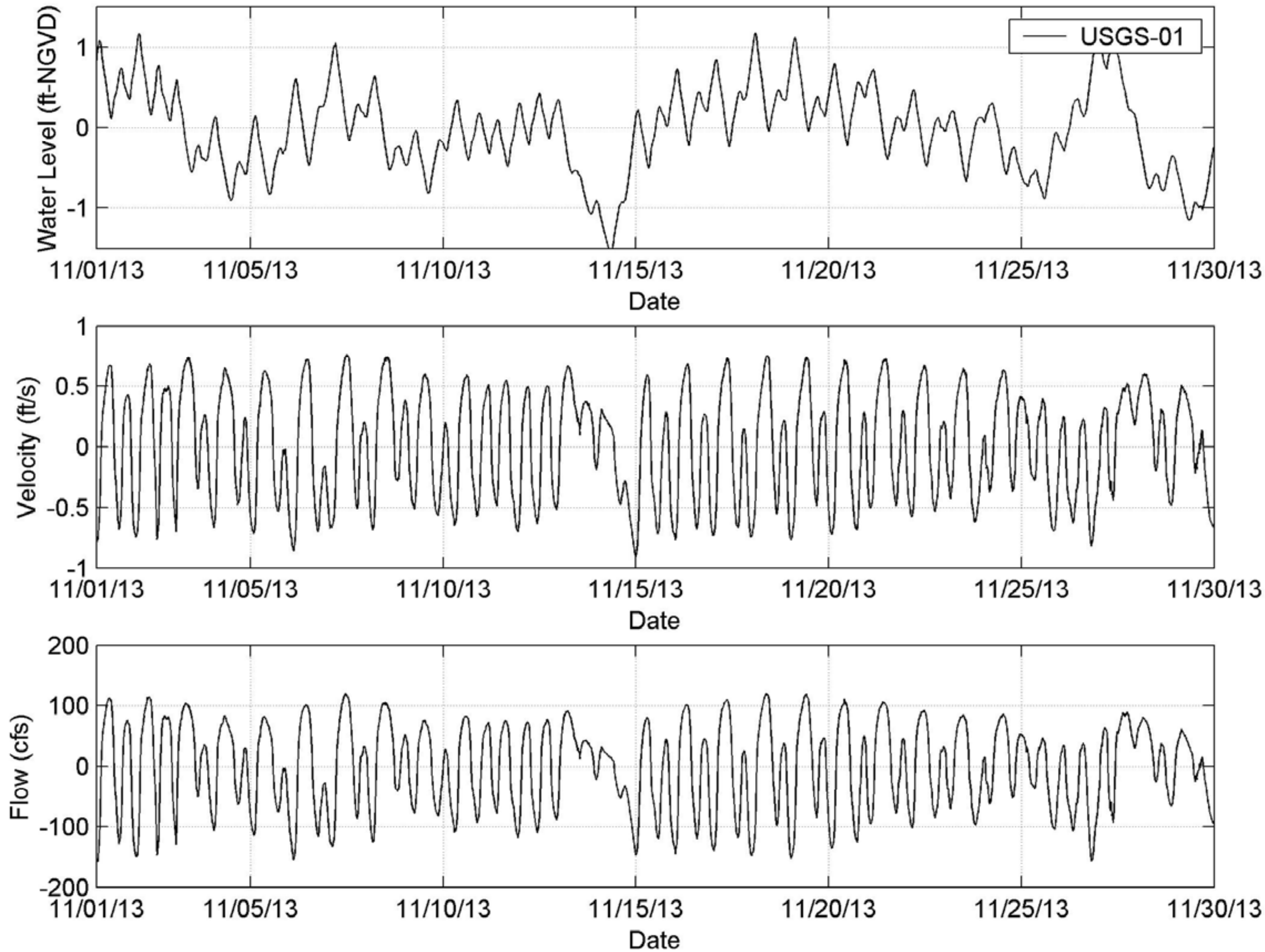


USGS-04
Water Level (ft-NGVD)
1
0
-1
10/01/13
10/05/13
10/10/13
10/15/13
10/20/13
10/25/13
10/31/13
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
Flow (cfs)
50
0
-50

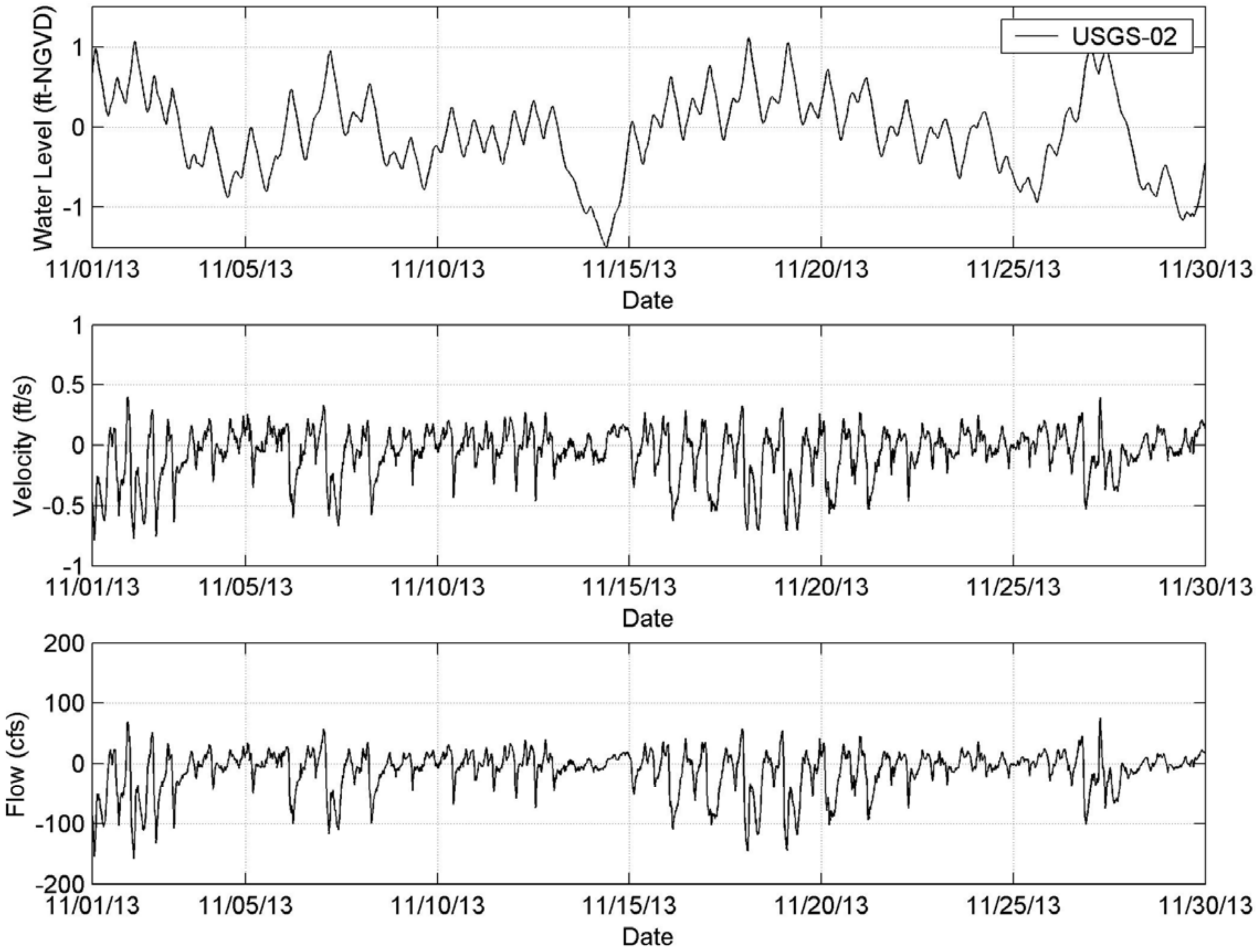

USGS-06
Water Level (ft-NGVD)
1
0
-1
10/01/13
10/05/13
10/10/13
10/15/13
10/20/13
10/25/13
10/31/13
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
10/01/13
10/05/13
10/10/13
10/15/13
10/20/13
10/25/13
10/31/13
Date
Flow (cfs)
100
50
0
-50
-100
10/01/13
10/05/13
10/10/13
10/15/13
10/20/13
10/25/13
10/31/13
Date

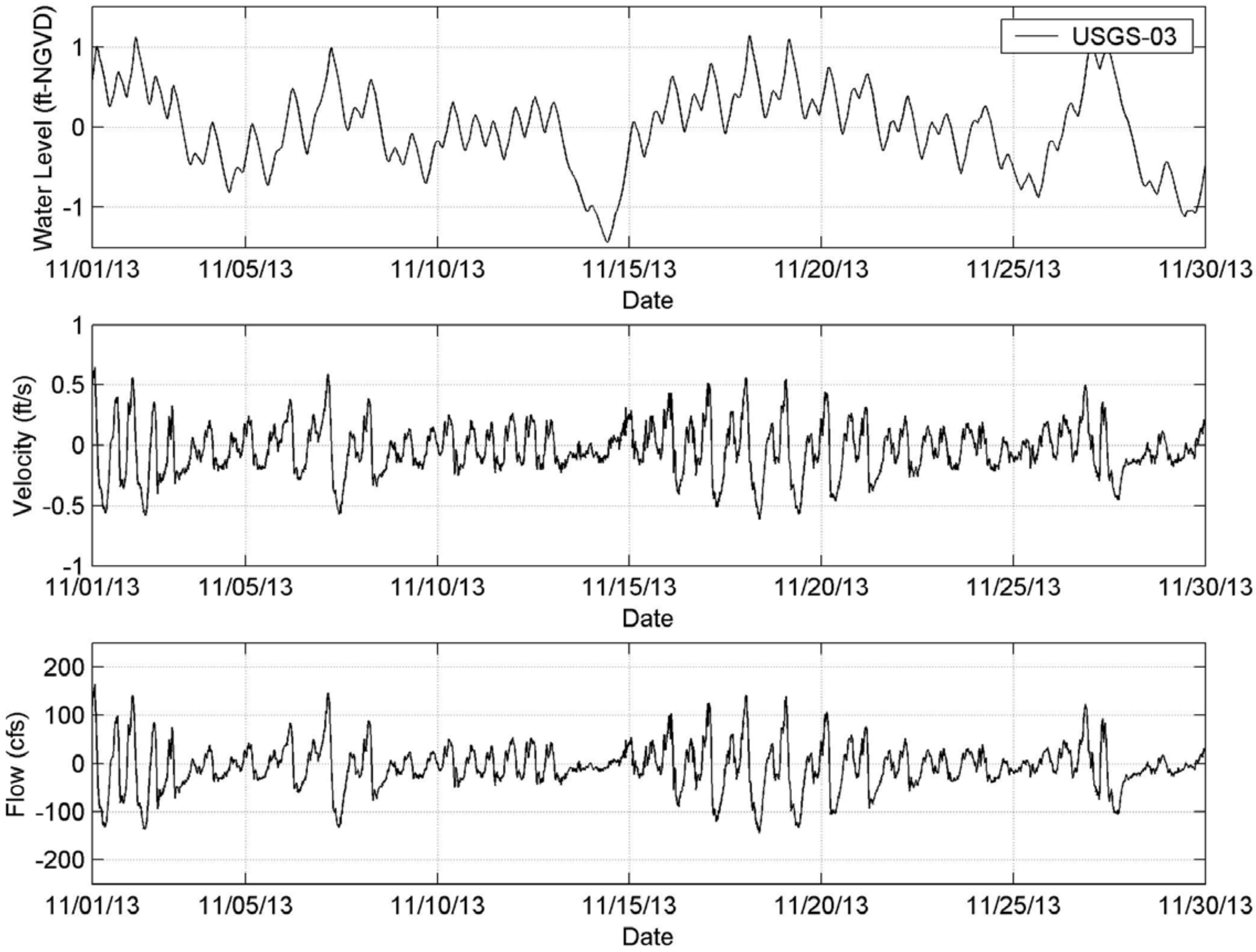

Water Level (ft-NGVD)
USGS-07
1
0
-1
10/01/13
10/05/13
10/10/13
10/15/13
10/20/13
10/25/13
10/31/13
Date
Velocity (ft/s)
1
0
-1
10/01/13
10/05/13
10/10/13
10/15/13
10/20/13
10/25/13
10/31/13
Date
Flow (cfs)
400
200
0
-200
10/01/13
10/05/13
10/10/13
10/15/13
10/20/13
10/25/13
10/31/13
Date

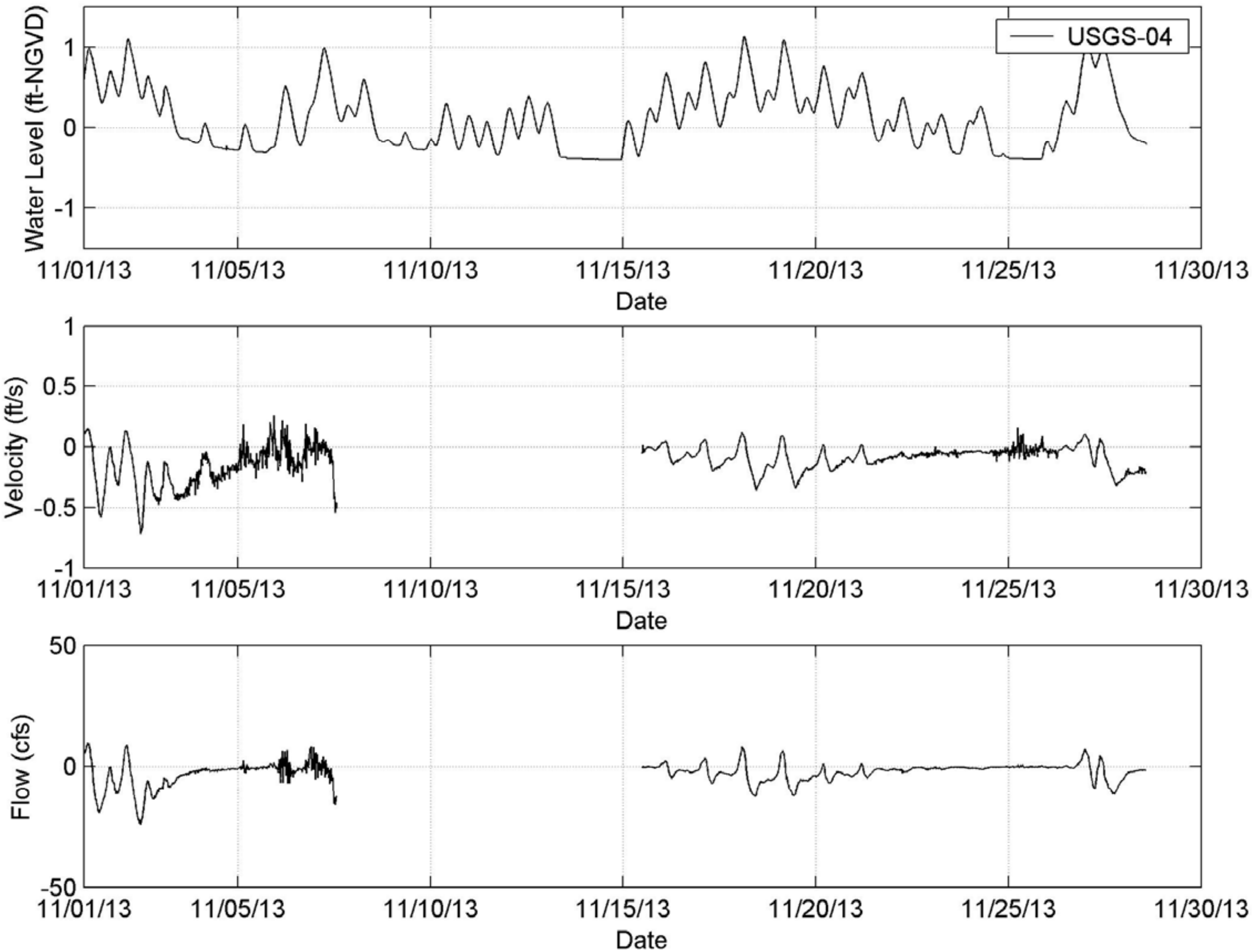

USGS-00
Water Level (ft-NGVD)
1
0
-1
11/01/13
11/05/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13
Date
Velocity (ft/s)
2
0
-2
11/01/13
11/05/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13
Date
Flow (cfs)
2000
1000
0
-1000
-2000
11/01/13
11/05/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13
Date



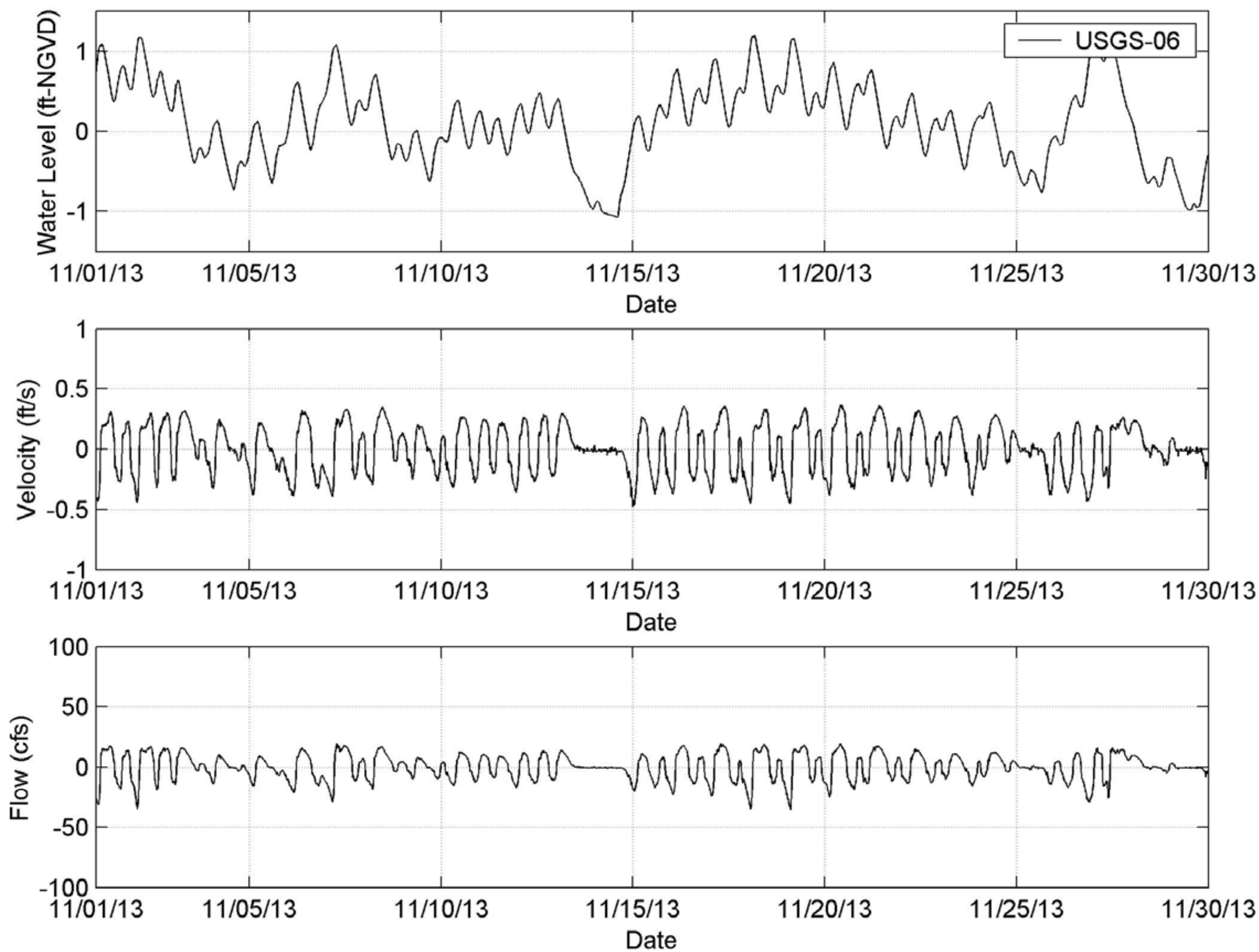
Water Level (ft-NGVD)
USGS-01
1
0
-1
11/01/13
11/05/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
11/01/13
11/05/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13
Date
Flow (cfs)
200
100
0
-100
-200
11/01/13
11/05/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13
Date

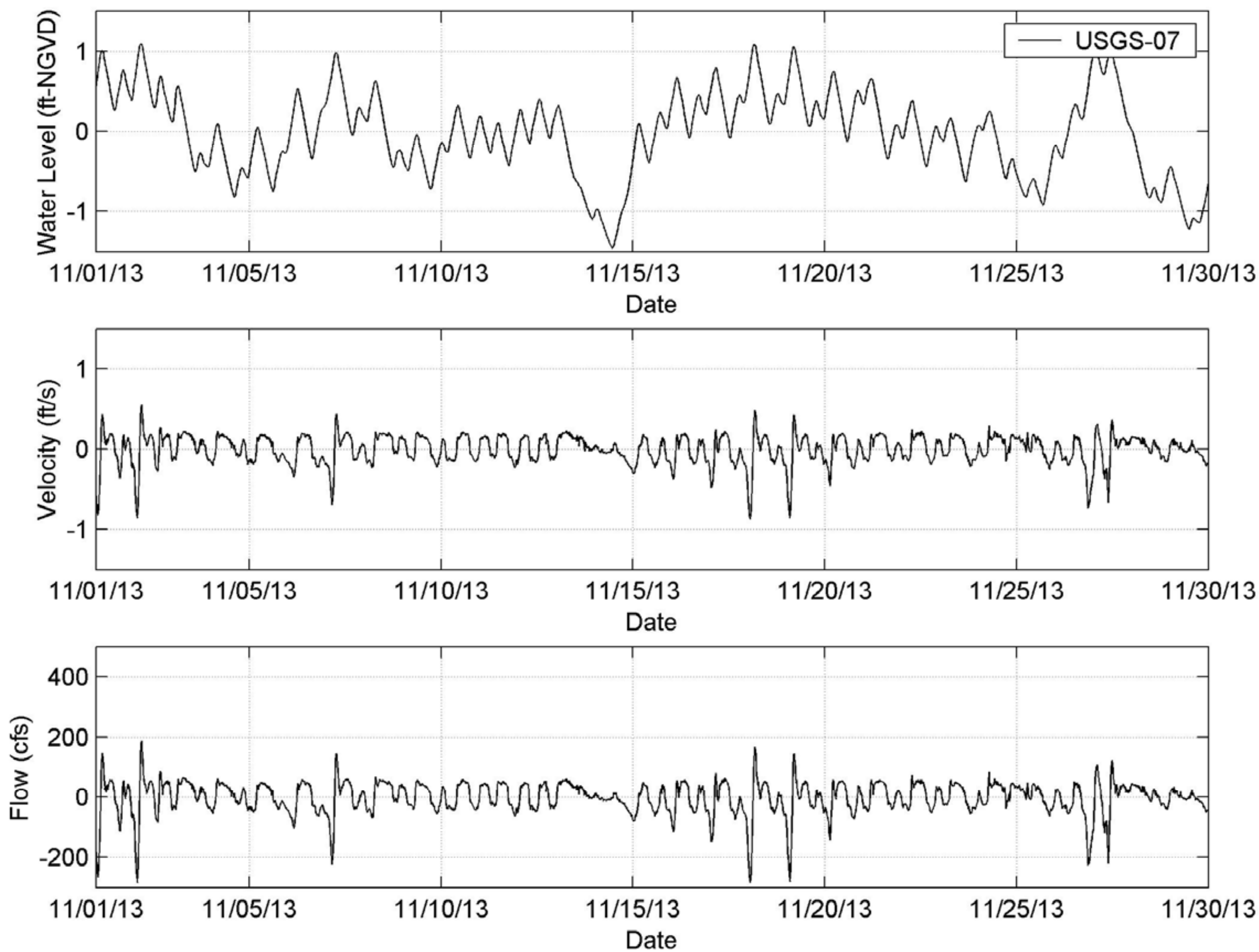

USGS-02
Water Level (ft-NGVD)
1
0
-1
11/01/13
11/05/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
11/01/13
11/05/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13
Date
Flow (cfs)
200
100
0
-100
-200
11/01/13
11/05/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13
Date

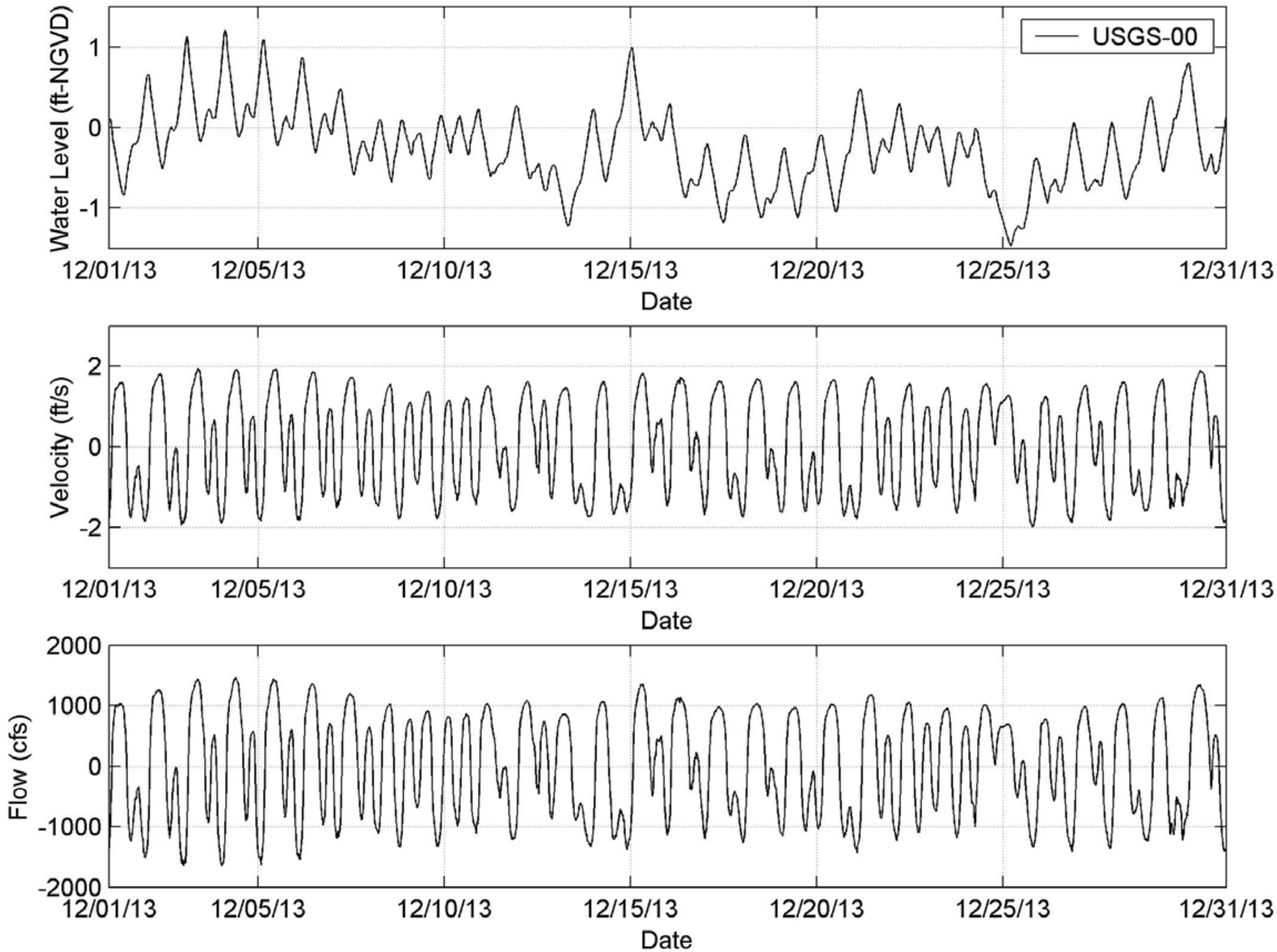

USGS-03
Water Level (ft-NGVD)
1
0
-1
11/01/13
11/05/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
11/01/13
11/05/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13
Date
Flow (cfs)
200
100
0
-100
-200
11/01/13
11/05/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13
Date

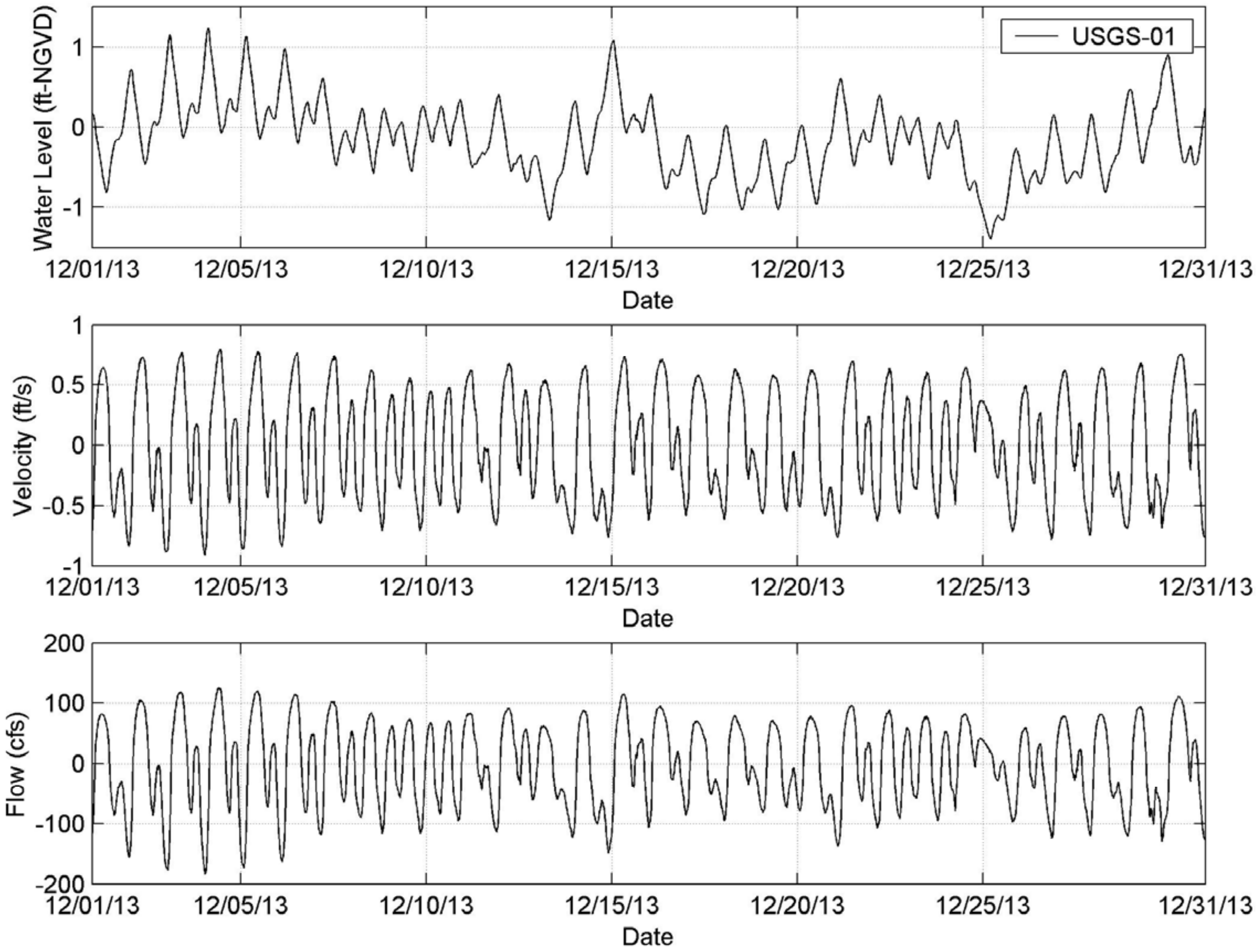


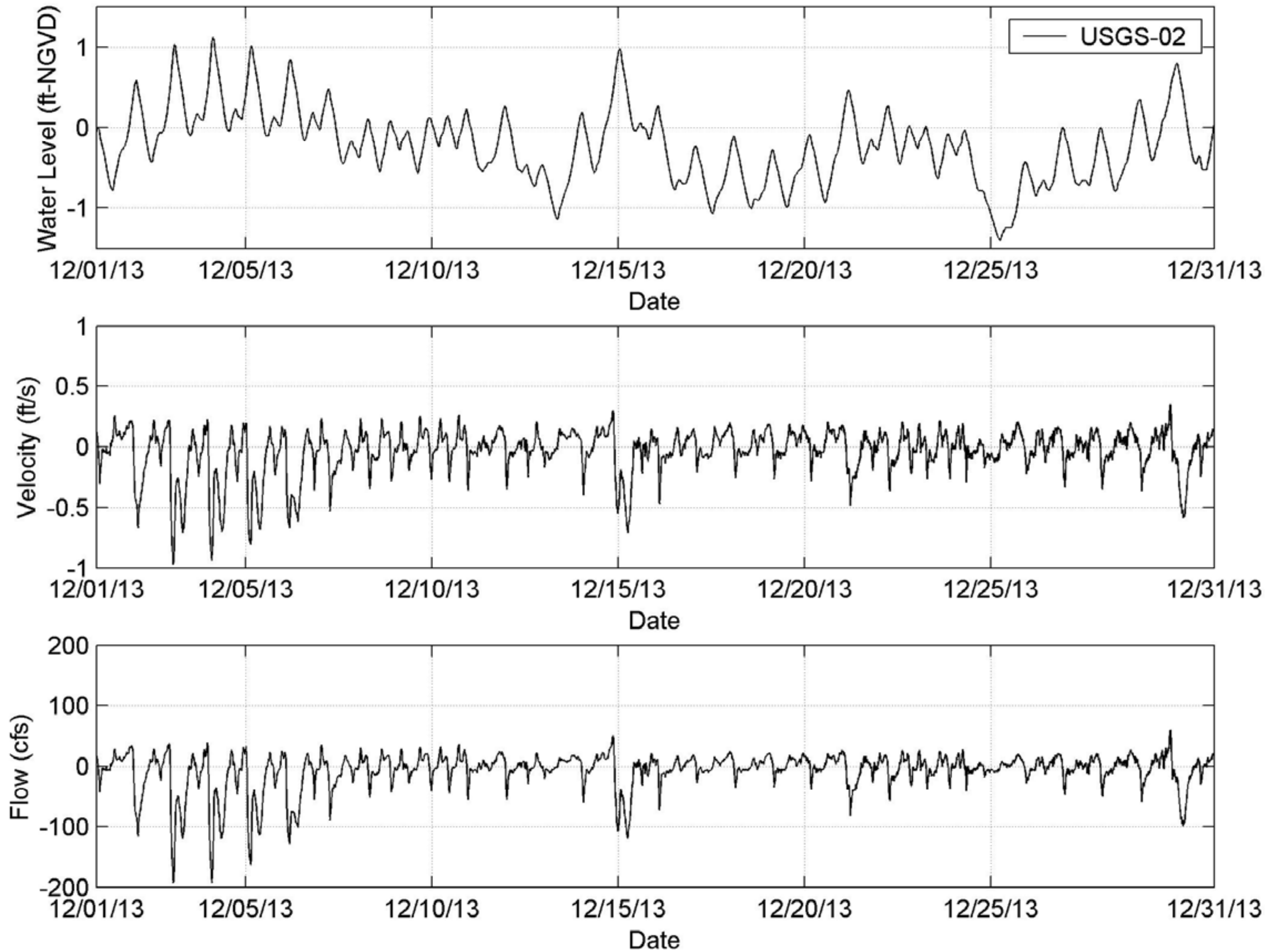
USGS-04
Water Level (ft-NGVD)
1
0
-1
11/01/13
11/05/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
11/01/13
11/05/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13
Date
Flow (cfs)
50
0
-50
11/01/13
11/05/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13
Date


USGS-06
Water Level (ft-NGVD)
1
0
-1
11/01/13
11/05/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
Flow (cfs)
100
50
0
-50
-100

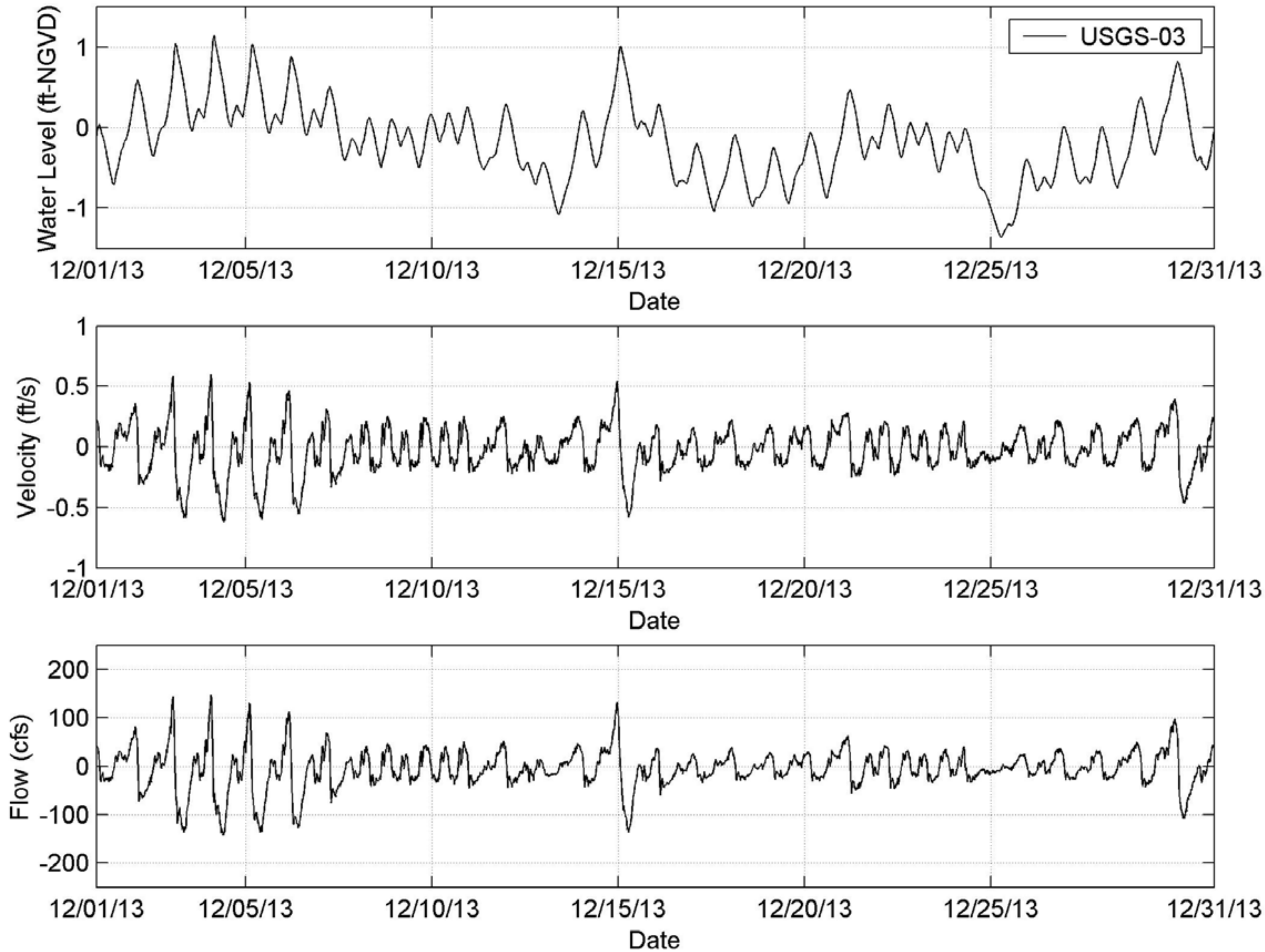

USGS-07
Water Level (ft-NGVD)
1
0
-1
Velocity (ft/s)
1
0
-1
Flow (cfs)
400
200
0
-200
11/01/13
11/05/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13
Date


USGS-00
Water Level (ft-NGVD)
1
0
-1
12/01/13
12/05/13
12/10/13
12/15/13
12/20/13
12/25/13
12/31/13
Date
Velocity (ft/s)
2
0
-2
12/01/13
12/05/13
12/10/13
12/15/13
12/20/13
12/25/13
12/31/13
Date
Flow (cfs)
2000
1000
0
-1000
-2000
12/01/13
12/05/13
12/10/13
12/15/13
12/20/13
12/25/13
12/31/13
Date

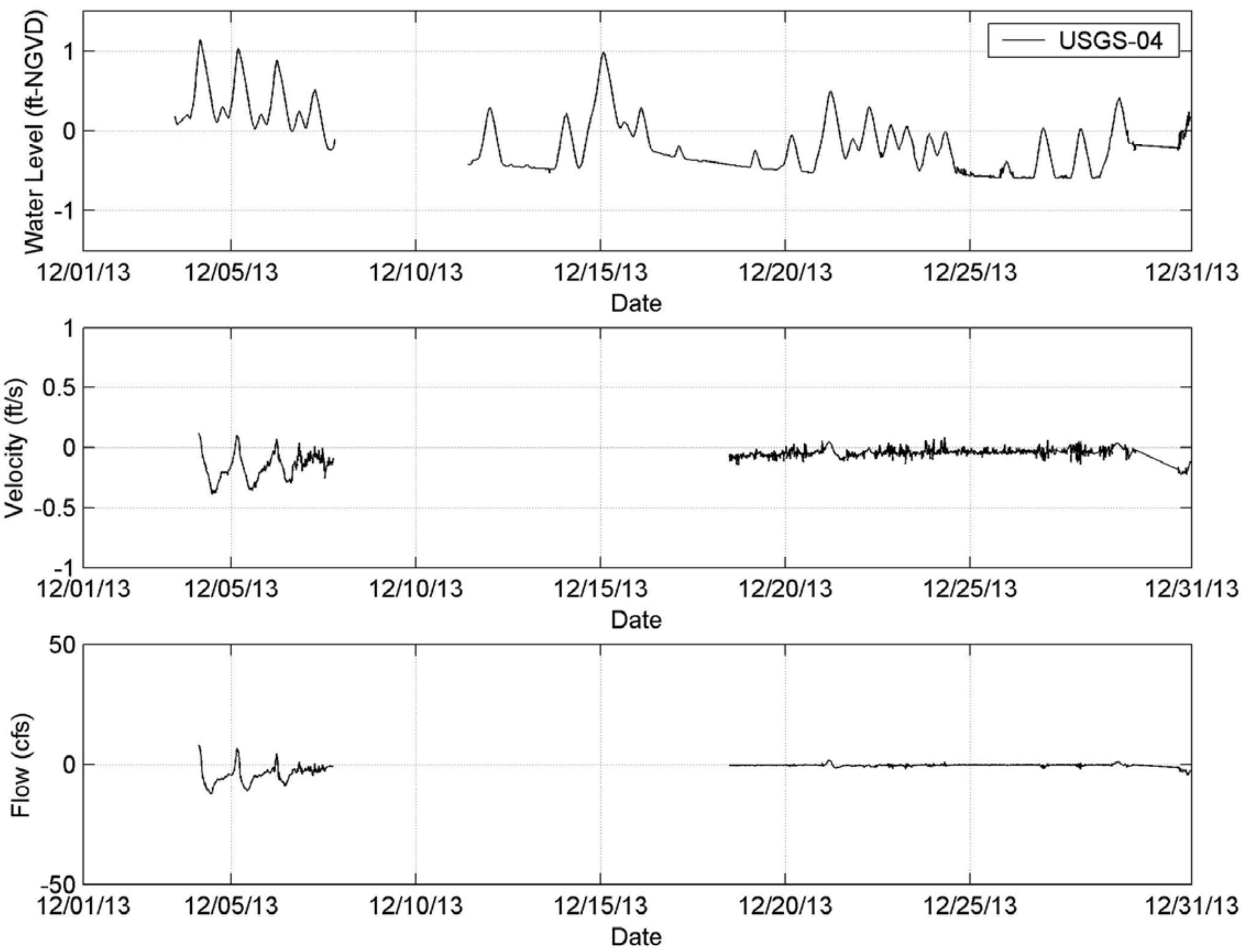

Water Level (ft-NGVD)
1
0
-1
USGS-01
12/01/13
12/05/13
12/10/13
12/15/13
12/20/13
12/25/13
12/31/13
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
Flow (cfs)
200
100
0
-100
-200

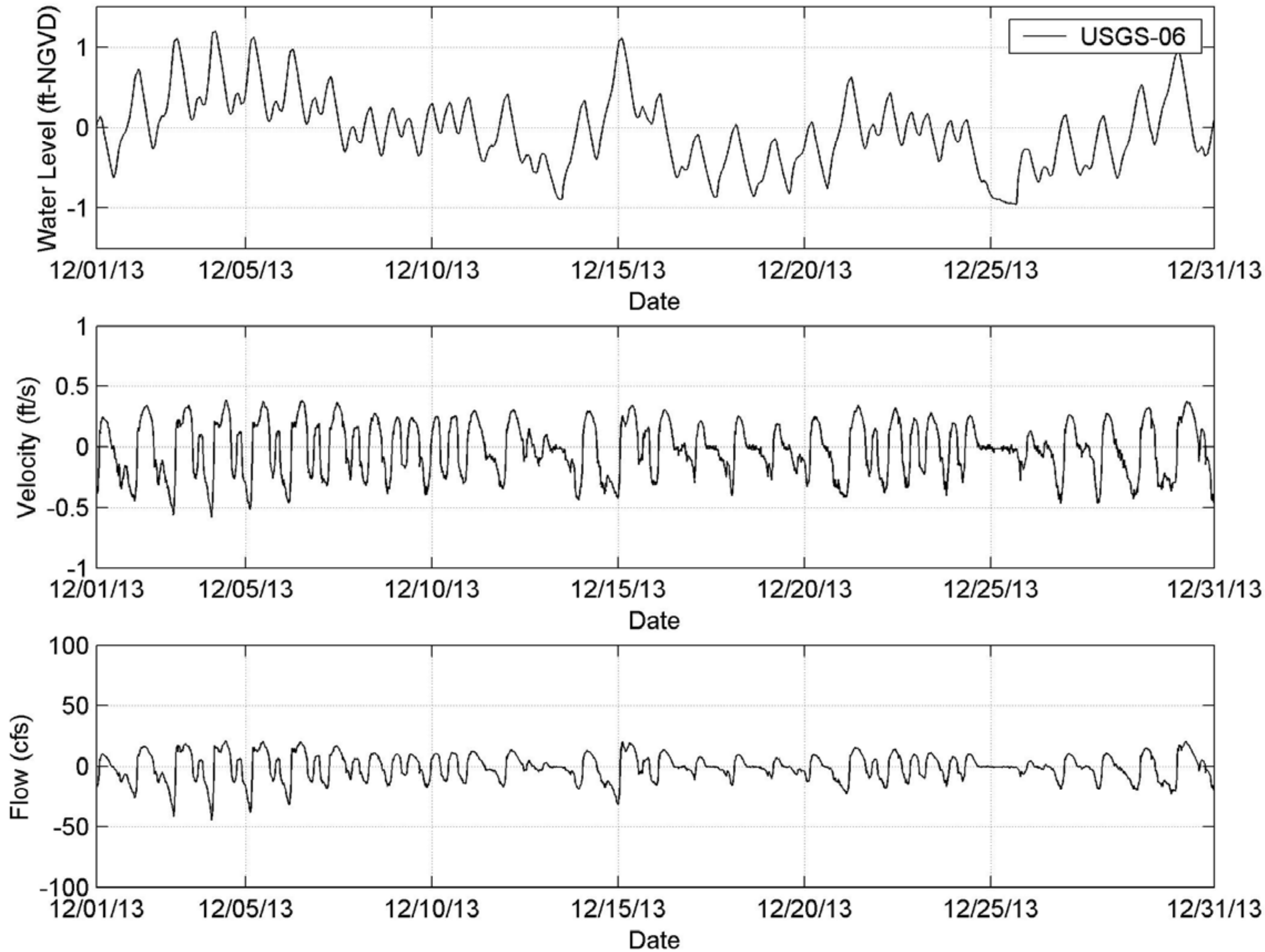


USGS-02
Water Level (ft-NGVD)
1
0
-1
12/01/13
12/05/13
12/10/13
12/15/13
12/20/13
12/25/13
12/31/13
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
Flow (cfs)
200
100
0
-100
-200

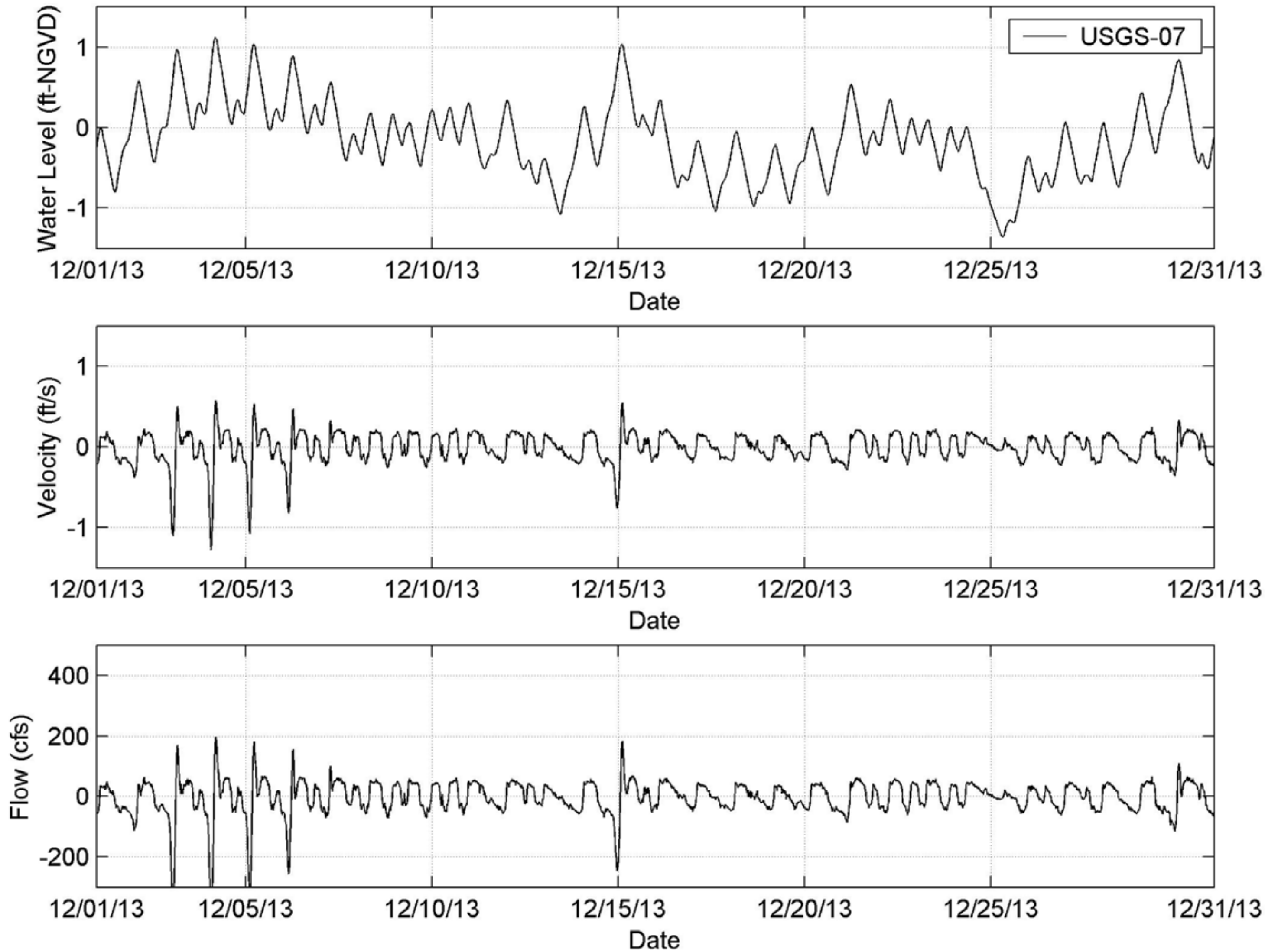


USGS-03
Water Level (ft-NGVD)
1
0
-1
12/01/13
12/05/13
12/10/13
12/15/13
12/20/13
12/25/13
12/31/13
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
Flow (cfs)
200
100
0
-100
-200

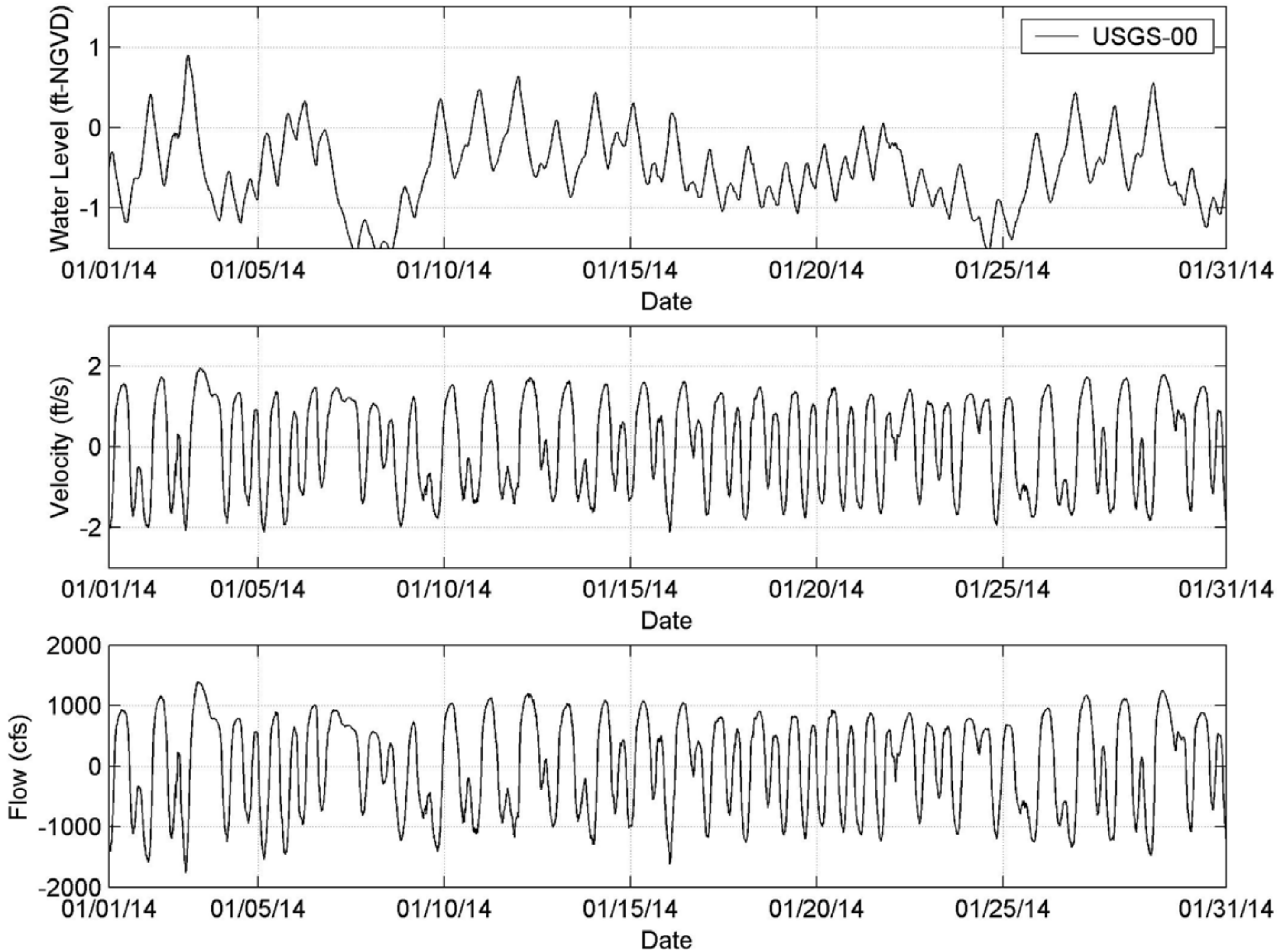

USGS-04
Water Level (ft-NGVD)
1
0
-1
12/01/13
12/05/13
12/10/13
12/15/13
12/20/13
12/25/13
12/31/13
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
Flow (cfs)
50
0
-50

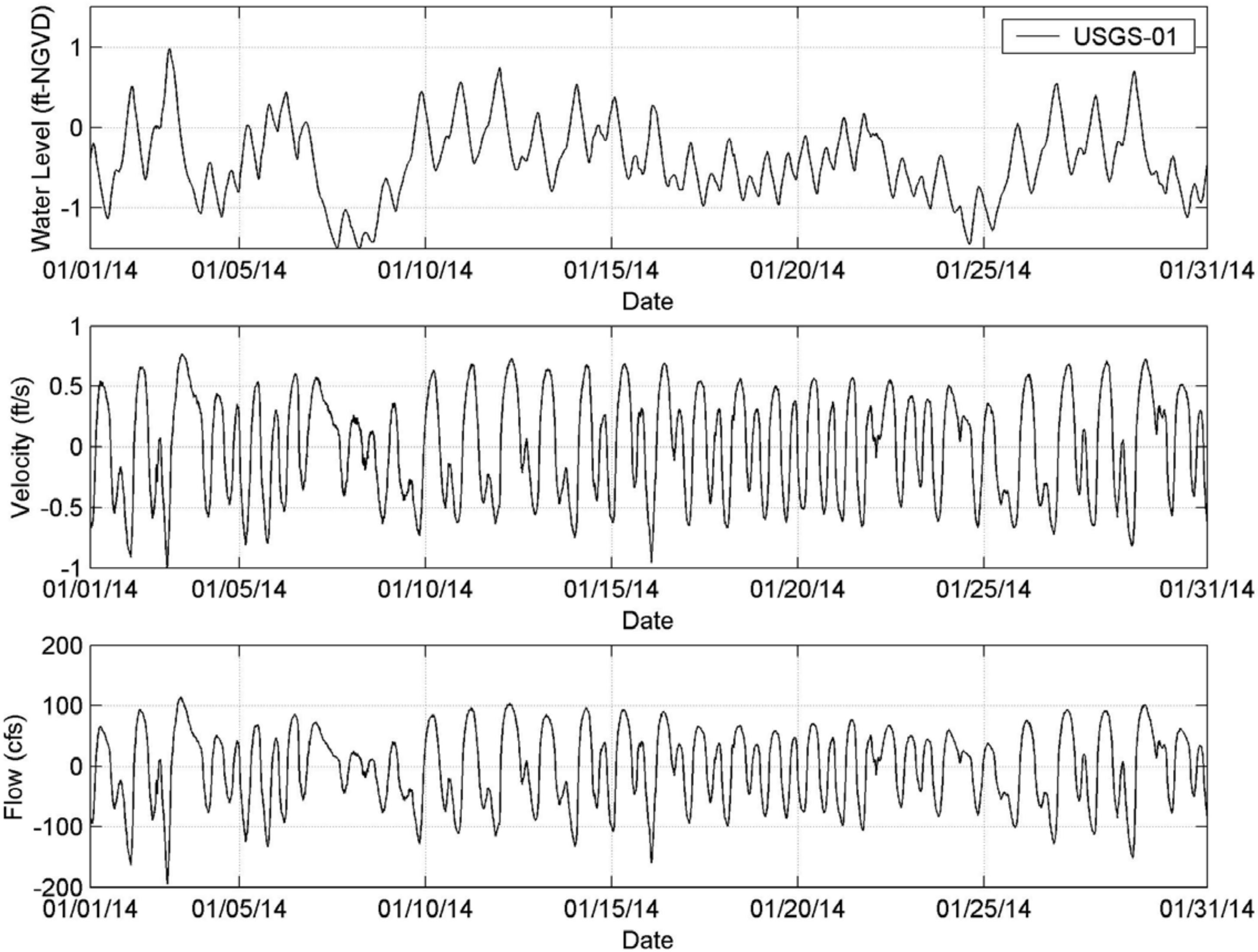


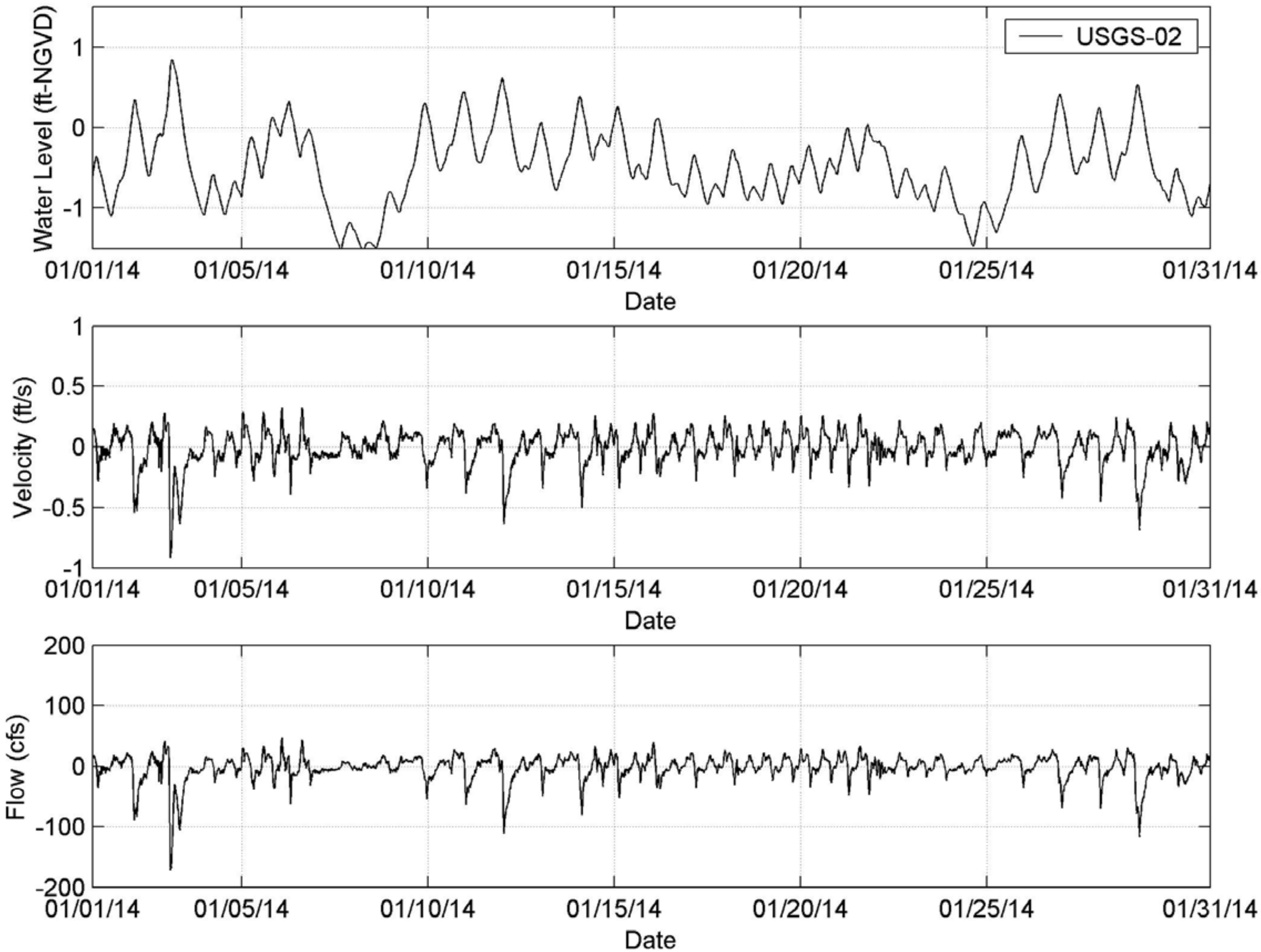
USGS-06
Water Level (ft-NGVD)
1
0
-1
12/01/13
12/05/13
12/10/13
12/15/13
12/20/13
12/25/13
12/31/13
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
Flow (cfs)
100
50
0
-50
-100



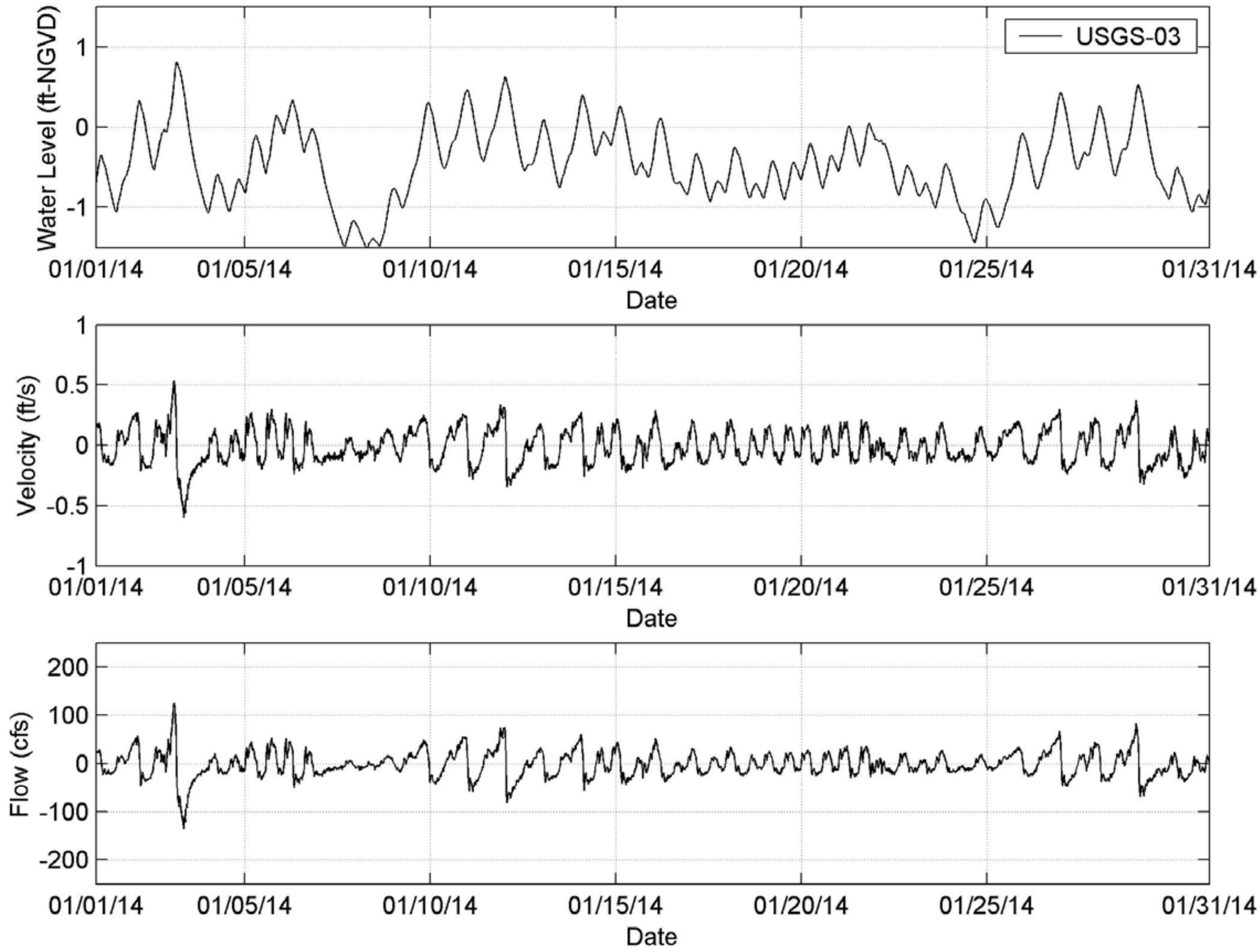
USGS-07
Water Level (ft-NGVD)
1
0
-1
12/01/13
12/05/13
12/10/13
12/15/13
12/20/13
12/25/13
12/31/13
Date
Velocity (ft/s)
1
0
-1
12/01/13
12/05/13
12/10/13
12/15/13
12/20/13
12/25/13
12/31/13
Date
Flow (cfs)
400
200
0
-200
12/01/13
12/05/13
12/10/13
12/15/13
12/20/13
12/25/13
12/31/13
Date

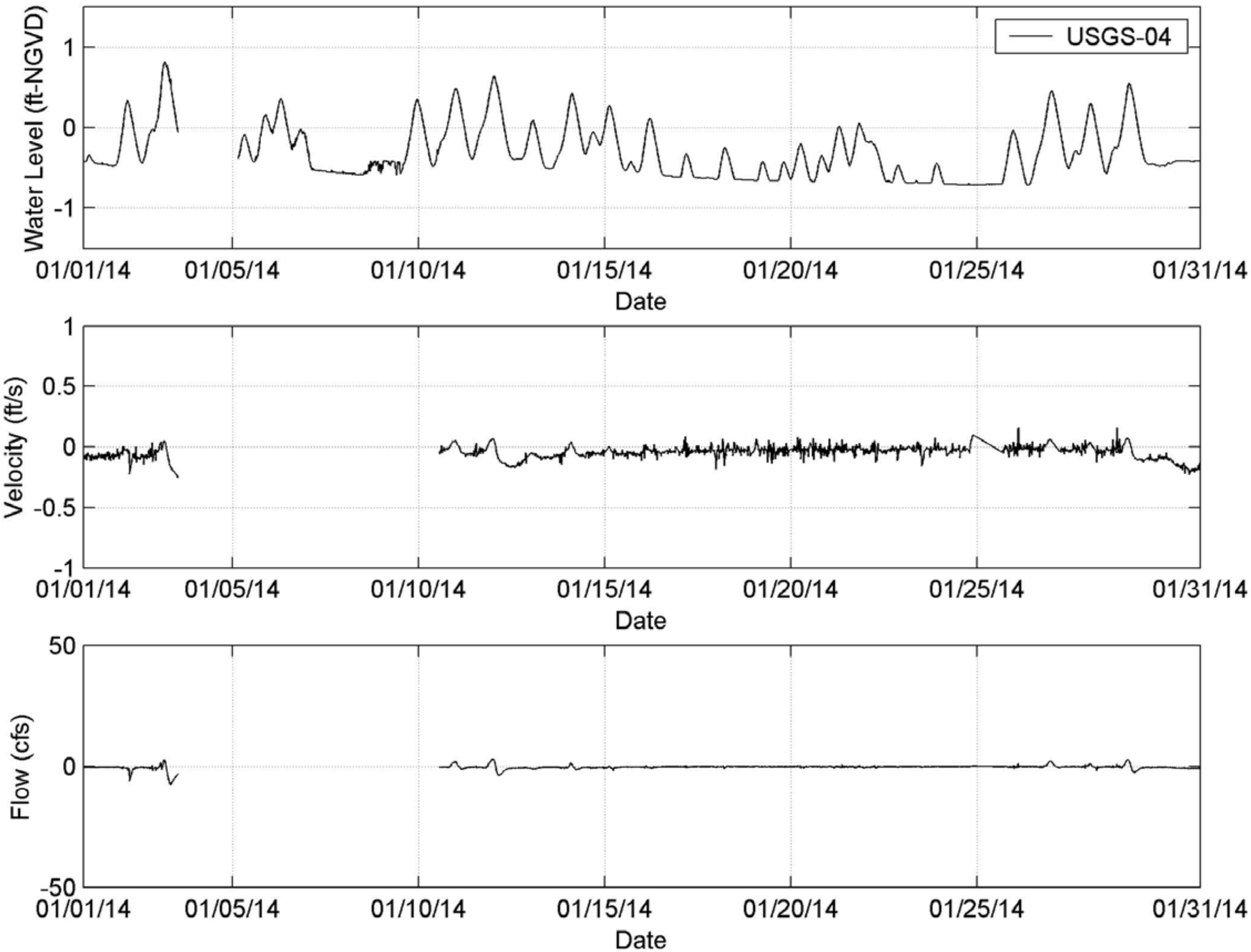

USGS-00
Water Level (ft-NGVD)
1
0
-1
01/01/14
01/05/14
01/10/14
01/15/14
01/20/14
01/25/14
01/31/14
Date
Velocity (ft/s)
2
0
-2
01/01/14
01/05/14
01/10/14
01/15/14
01/20/14
01/25/14
01/31/14
Date
Flow (cfs)
2000
1000
0
-1000
-2000
01/01/14
01/05/14
01/10/14
01/15/14
01/20/14
01/25/14
01/31/14
Date


USGS-01
Water Level (ft-NGVD)
1
0
-1
01/01/14
01/05/14
01/10/14
01/15/14
01/20/14
01/25/14
01/31/14
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
Flow (cfs)
200
100
0
-100
-200

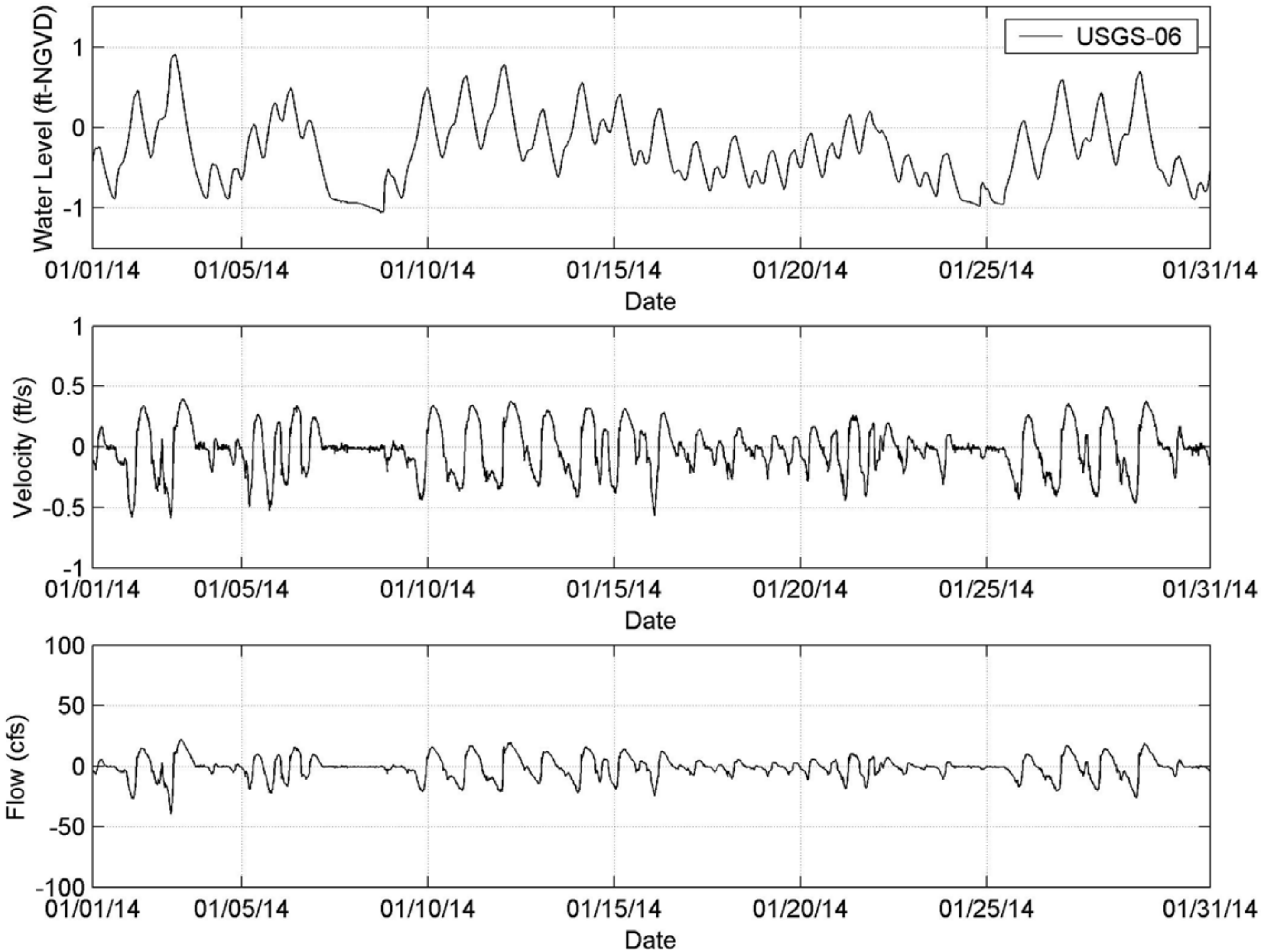


USGS-02
Water Level (ft-NGVD)
1
0
-1
Velocity (ft/s)
1
0.5
0
-0.5
-1
Flow (cfs)
200
100
0
-100
-200
01/01/14
01/05/14
01/10/14
01/15/14
01/20/14
01/25/14
01/31/14
Date

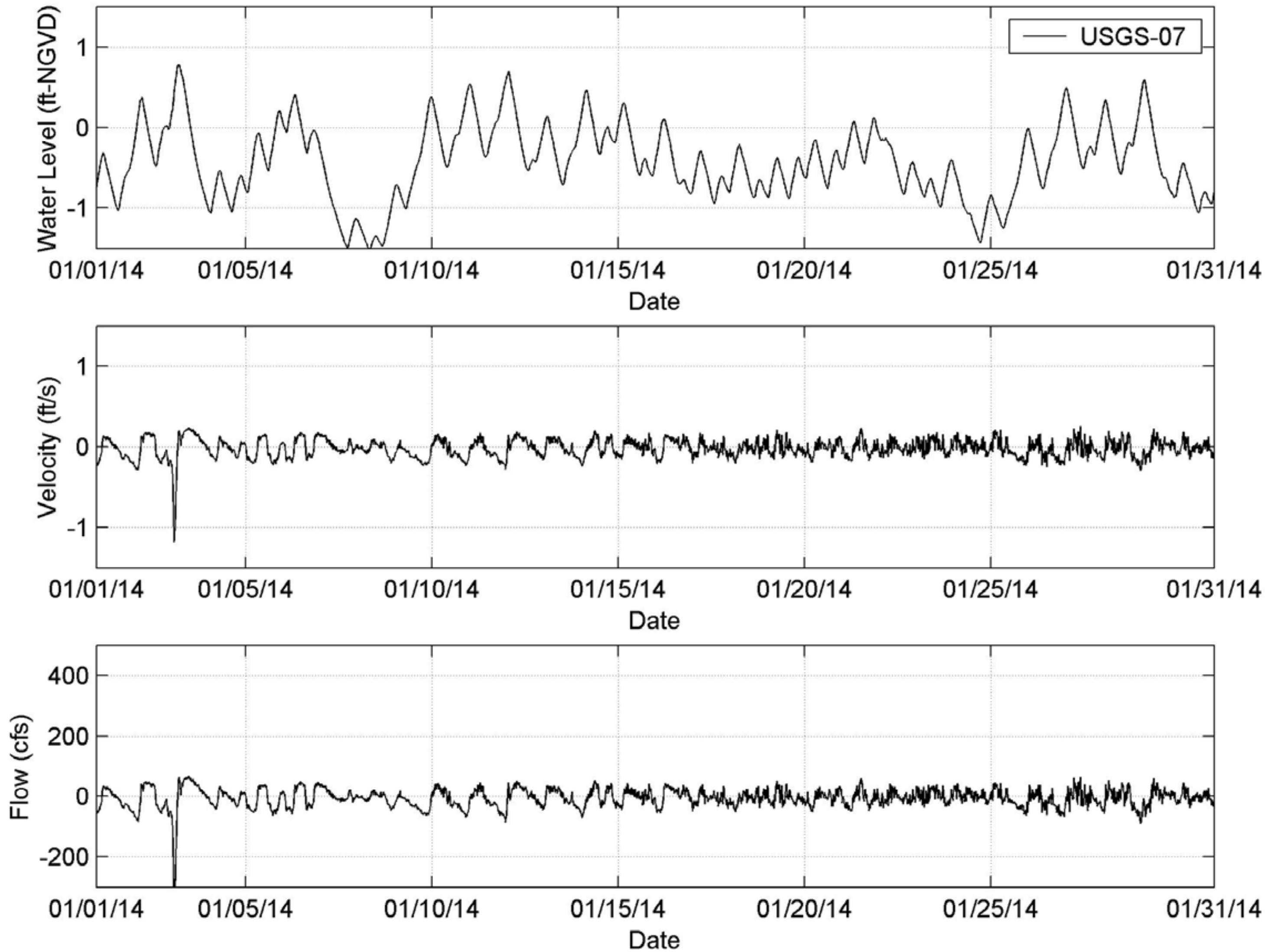

USGS-03
Water Level (ft-NGVD)
1
0
-1
01/01/14
01/05/14
01/10/14
01/15/14
01/20/14
01/25/14
01/31/14
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
01/01/14
01/05/14
01/10/14
01/15/14
01/20/14
01/25/14
01/31/14
Date
Flow (cfs)
200
100
0
-100
-200
01/01/14
01/05/14
01/10/14
01/15/14
01/20/14
01/25/14
01/31/14
Date

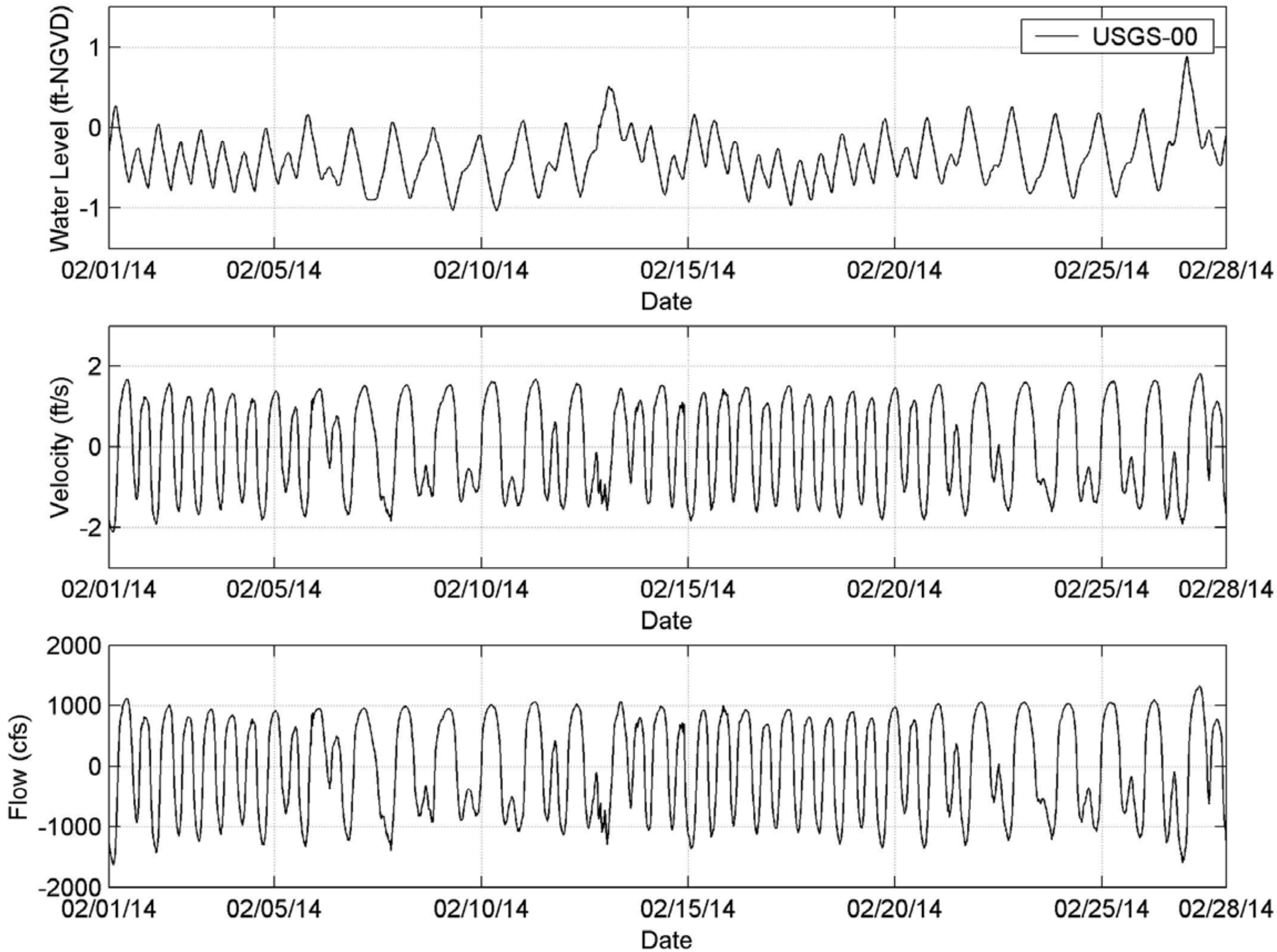


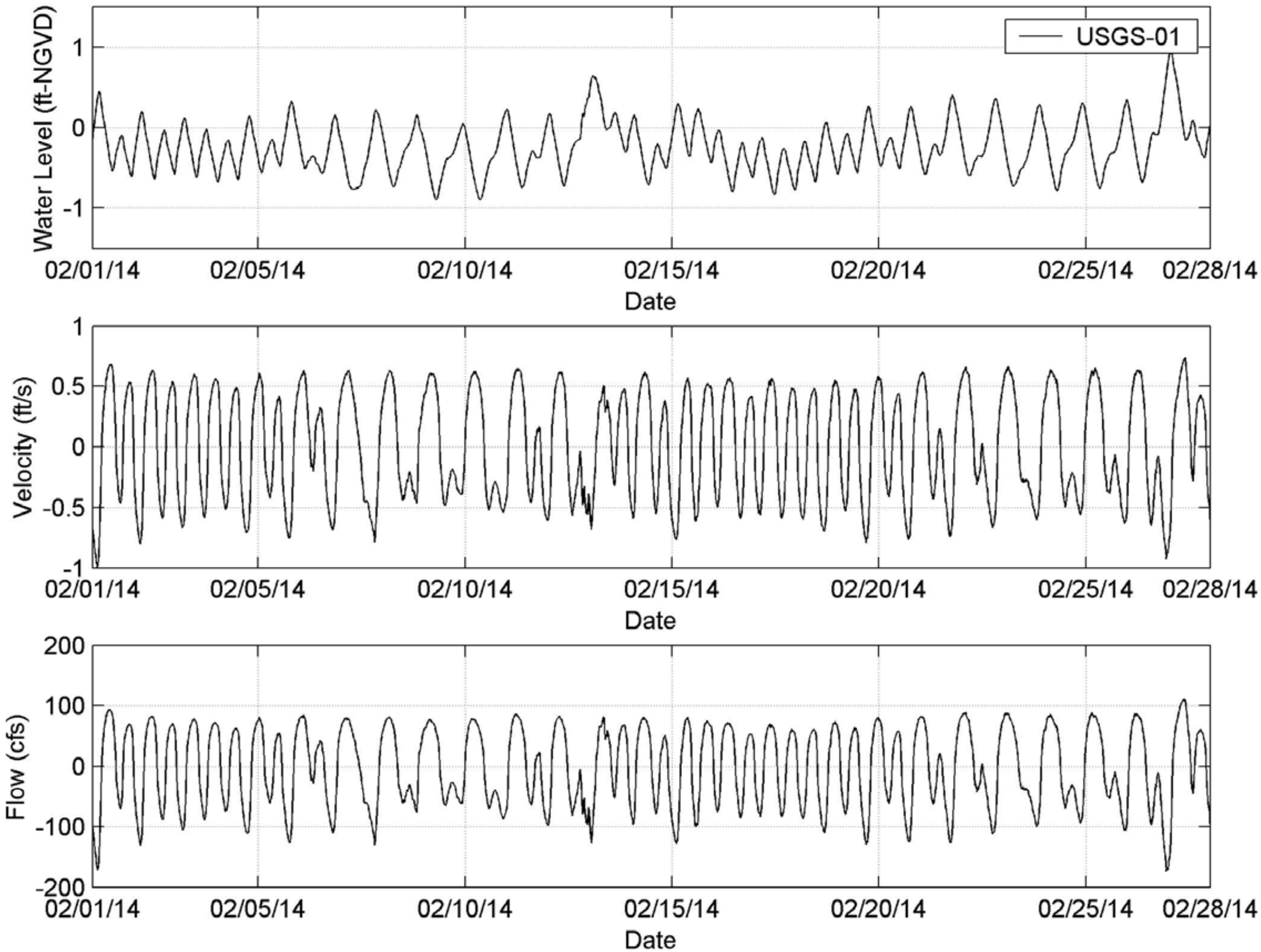
USGS-04
Water Level (ft-NGVD)
1
0
-1
01/01/14
01/05/14
01/10/14
01/15/14
01/20/14
01/25/14
01/31/14
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
Flow (cfs)
50
0
-50



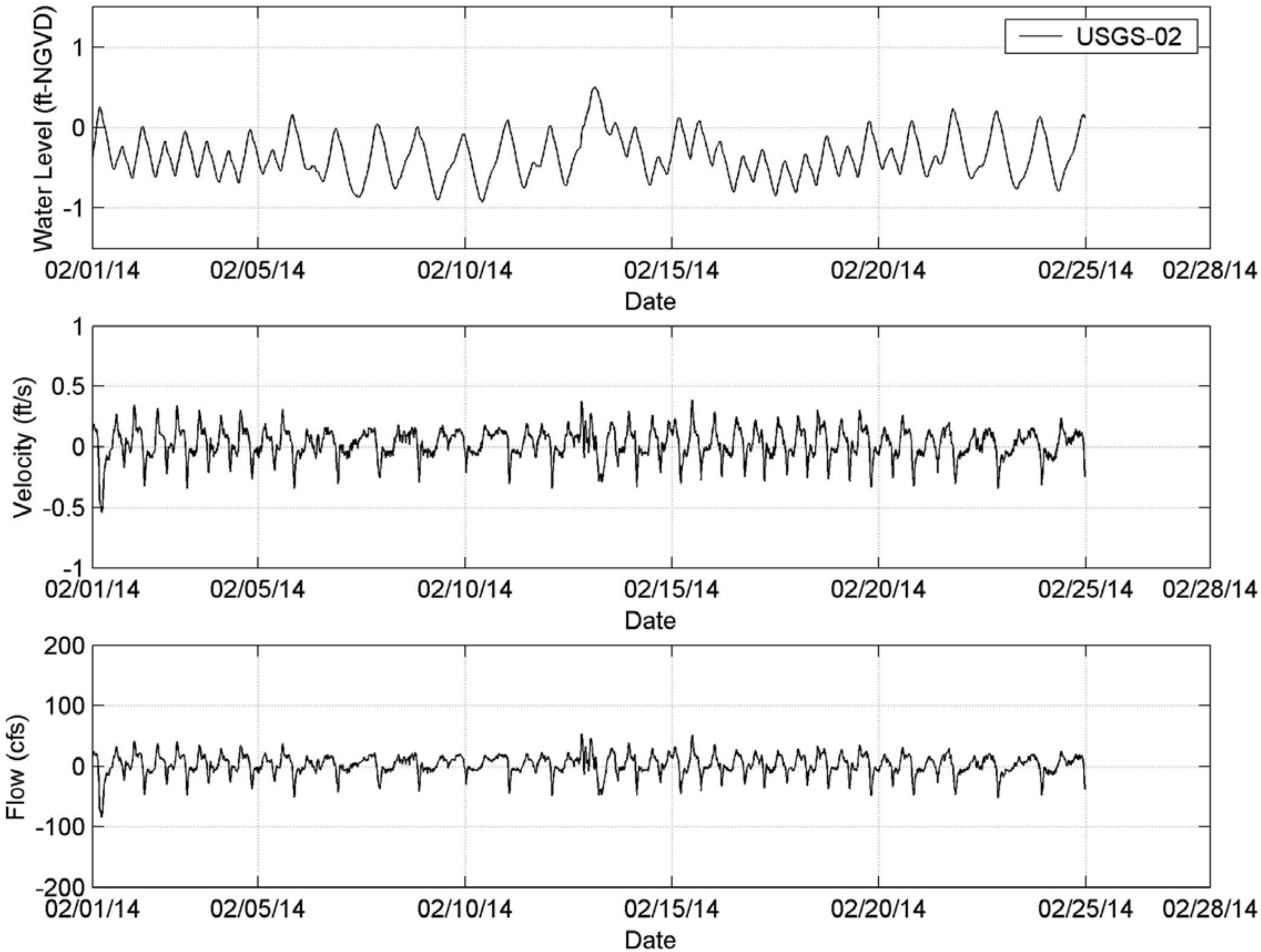
USGS-06
Water Level (ft-NGVD)
1
0
-1
01/01/14
01/05/14
01/10/14
01/15/14
01/20/14
01/25/14
01/31/14
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
Flow (cfs)
100
50
0
-50
-100

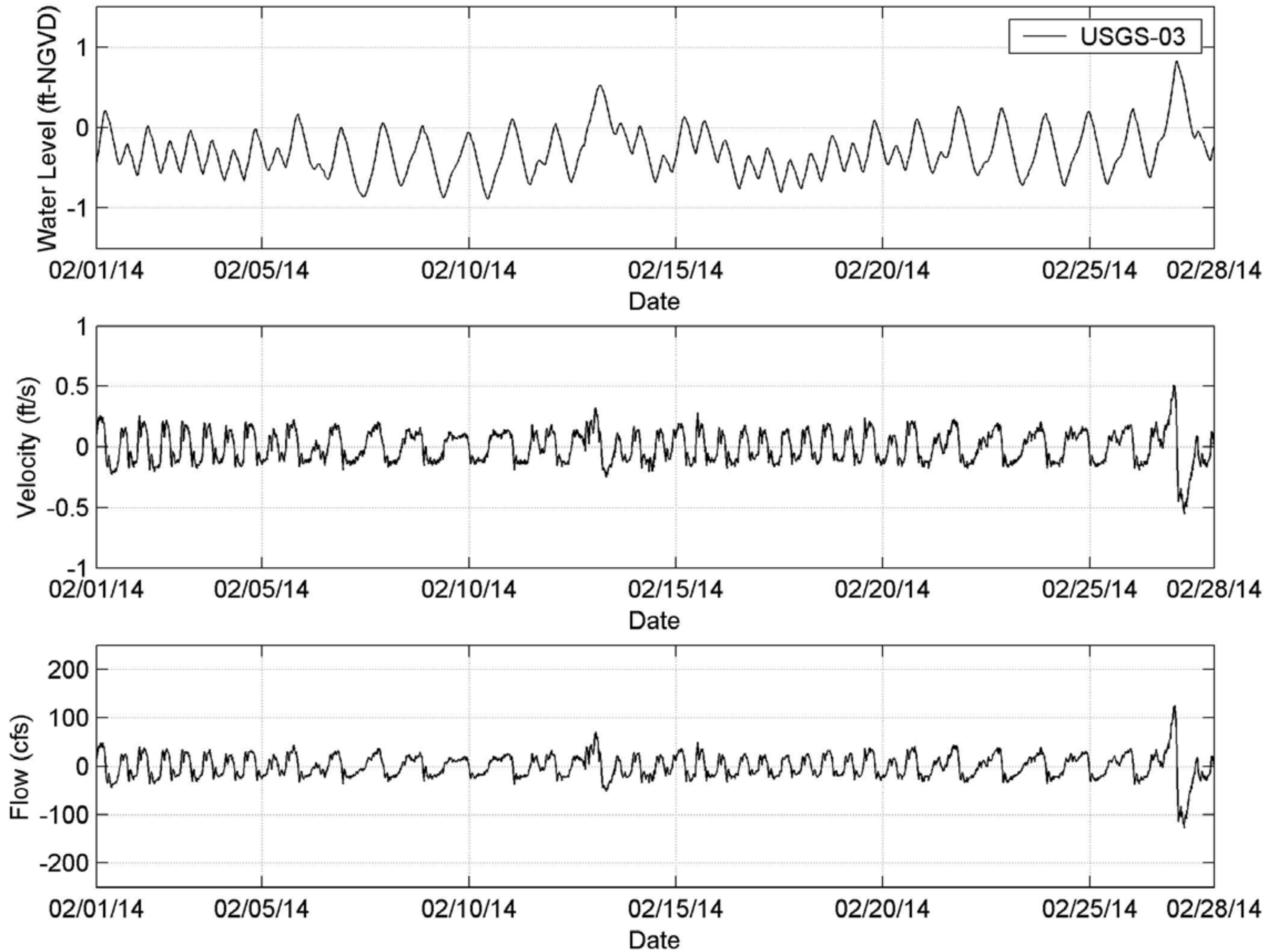

USGS-07
Water Level (ft-NGVD)
1
0
-1
01/01/14
01/05/14
01/10/14
01/15/14
01/20/14
01/25/14
01/31/14
Date
Velocity (ft/s)
1
0
-1
Flow (cfs)
400
200
0
-200

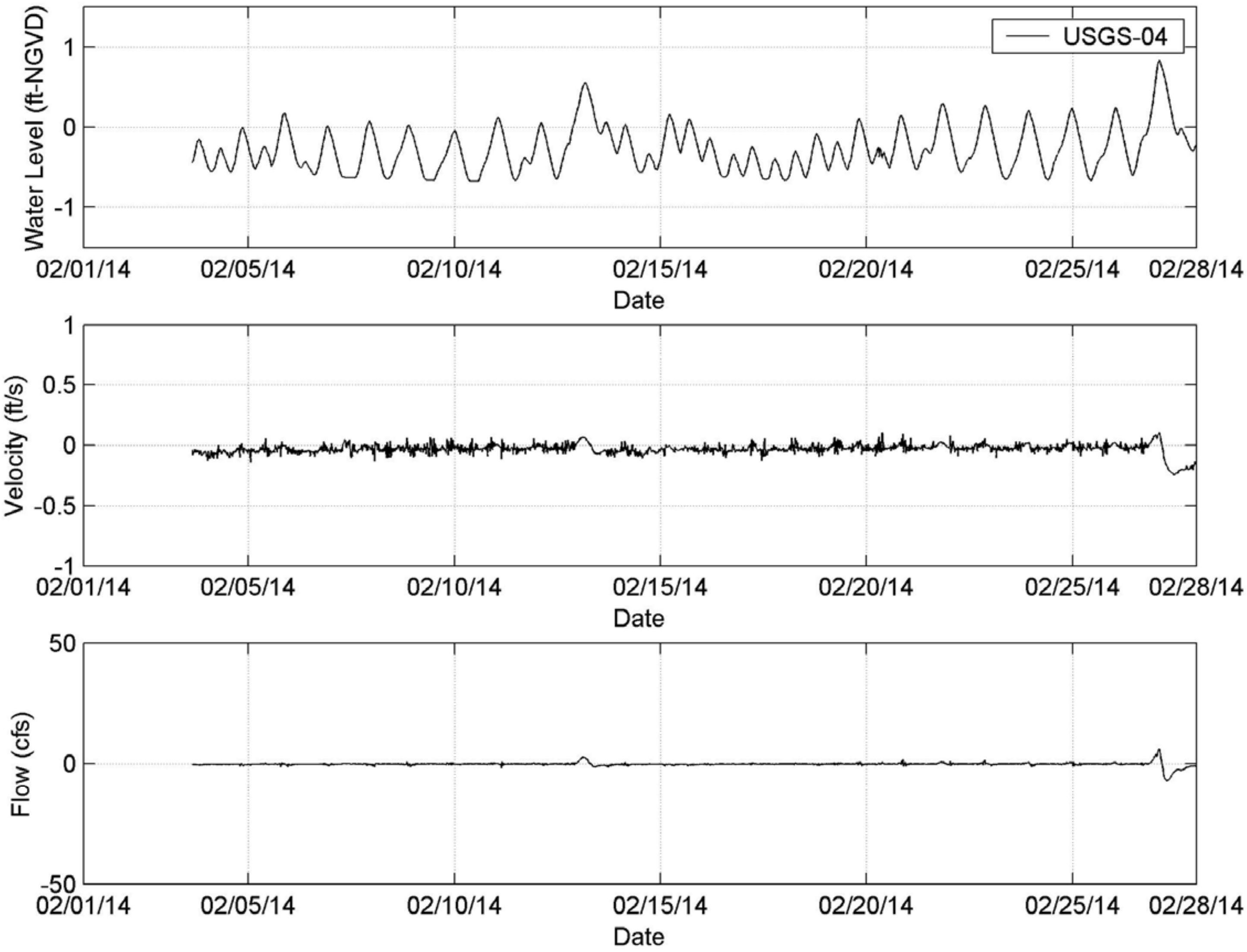

USGS-00
Water Level (ft-NGVD)
1
0
-1
Velocity (ft/s)
2
0
-2
Flow (cfs)
2000
1000
0
-1000
-2000
02/01/14
02/05/14
02/10/14
02/15/14
02/20/14
02/25/14
02/28/14
Date



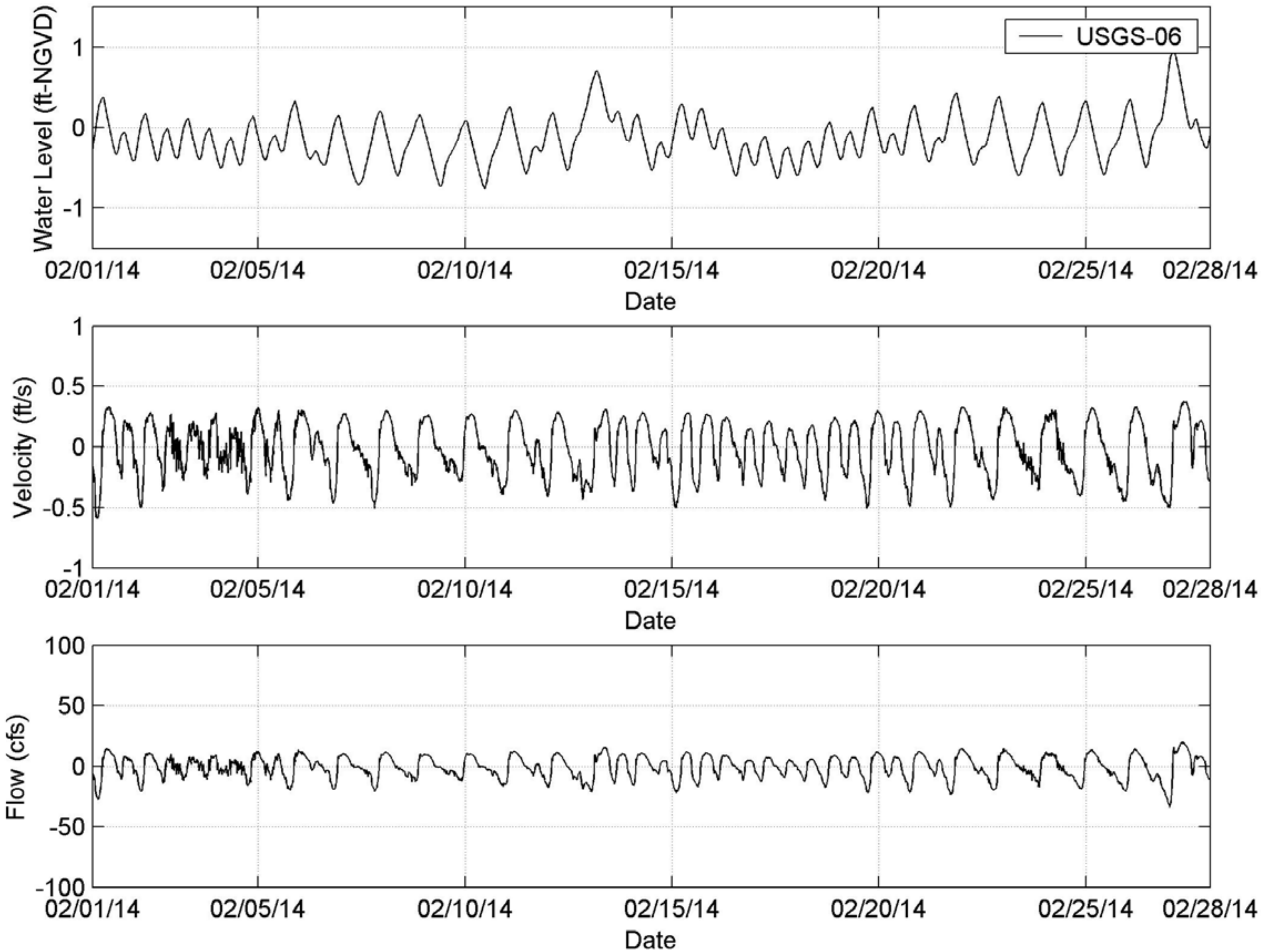
USGS-01
Water Level (ft-NGVD)
1
0
-1
02/01/14
02/05/14
02/10/14
02/15/14
02/20/14
02/25/14
02/28/14
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
Flow (cfs)
200
100
0
-100
-200

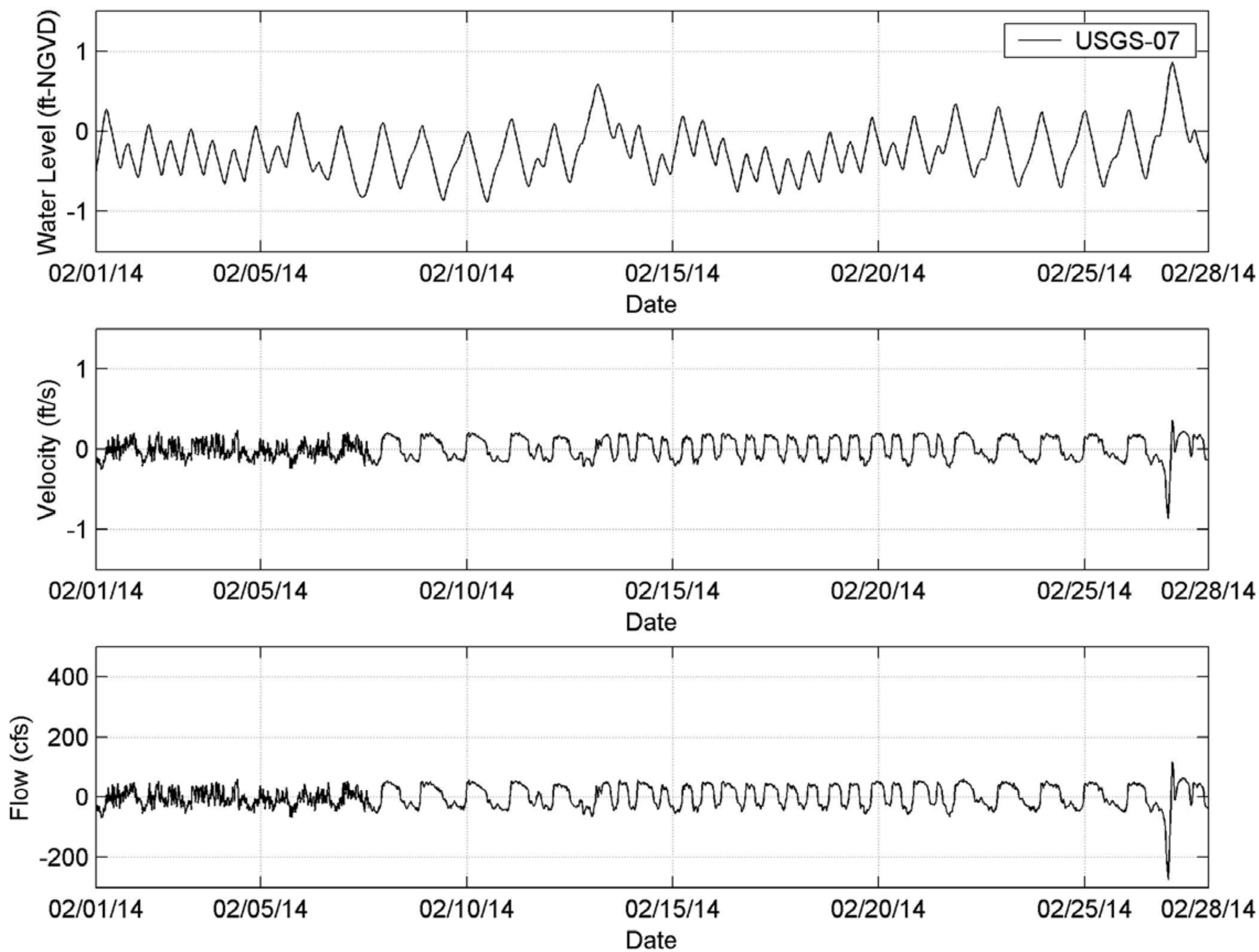

USGS-02
Water Level (ft-NGVD)
1
0
-1
02/01/14
02/05/14
02/10/14
02/15/14
02/20/14
02/25/14
02/28/14
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
02/01/14
02/05/14
02/10/14
02/15/14
02/20/14
02/25/14
02/28/14
Date
Flow (cfs)
200
100
0
-100
-200
02/01/14
02/05/14
02/10/14
02/15/14
02/20/14
02/25/14
02/28/14
Date


USGS-03
Water Level (ft-NGVD)
1
0
-1
02/01/14
02/05/14
02/10/14
02/15/14
02/20/14
02/25/14
02/28/14
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
02/01/14
02/05/14
02/10/14
02/15/14
02/20/14
02/25/14
02/28/14
Date
Flow (cfs)
200
100
0
-100
-200
02/01/14
02/05/14
02/10/14
02/15/14
02/20/14
02/25/14
02/28/14
Date



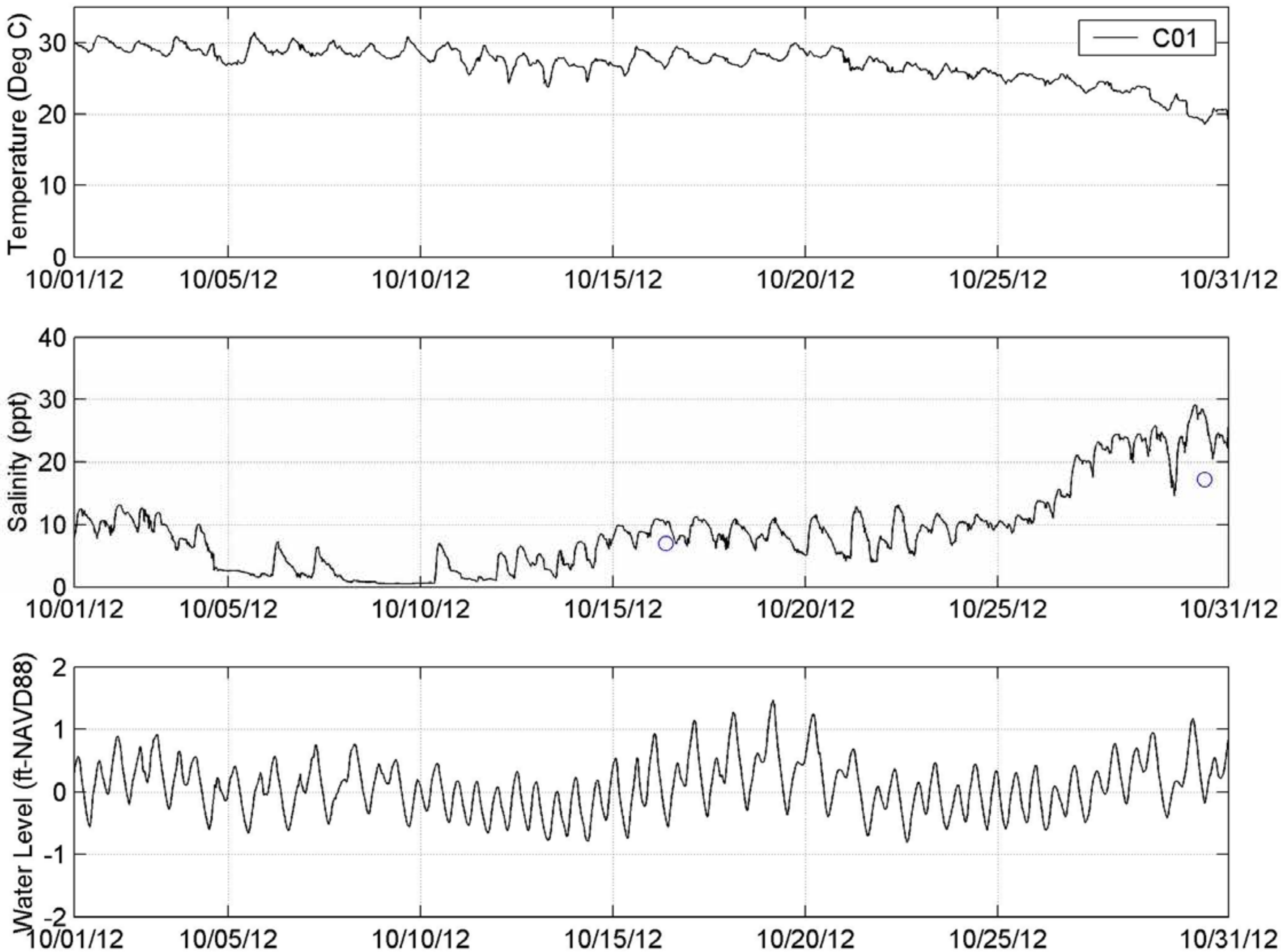
USGS-04
Water Level (ft-NGVD)
1
0
-1
02/01/14
02/05/14
02/10/14
02/15/14
02/20/14
02/25/14
02/28/14
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
02/01/14
02/05/14
02/10/14
02/15/14
02/20/14
02/25/14
02/28/14
Date
Flow (cfs)
50
0
-50
02/01/14
02/05/14
02/10/14
02/15/14
02/20/14
02/25/14
02/28/14
Date


USGS-06
Water Level (ft-NGVD)
1
0
-1
02/01/14
02/05/14
02/10/14
02/15/14
02/20/14
02/25/14
02/28/14
Date
Velocity (ft/s)
1
0.5
0
-0.5
-1
Flow (cfs)
100
50
0
-50
-100

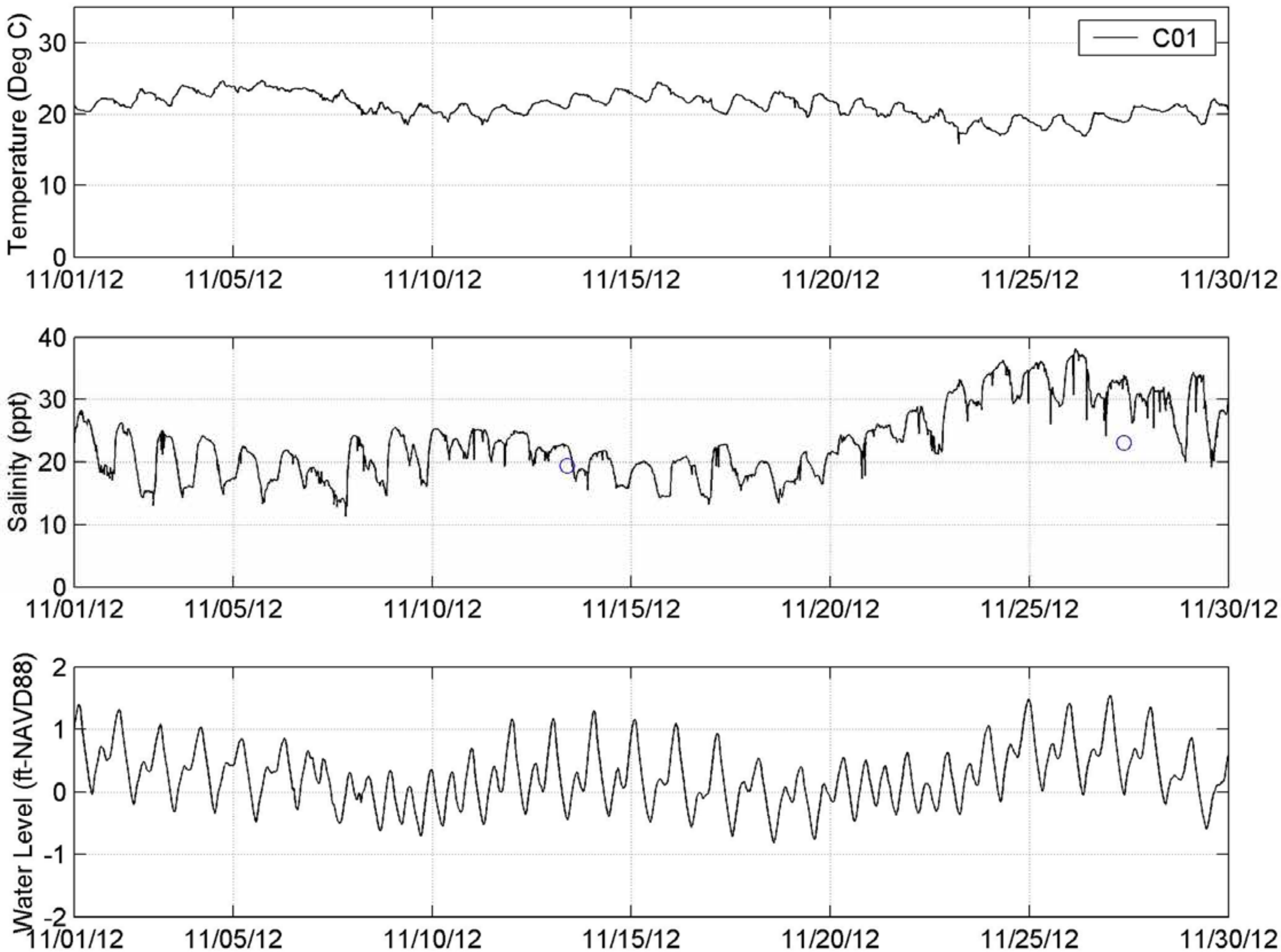

USGS-07
Water Level (ft-NGVD)
1
0
-1
02/01/14
02/05/14
02/10/14
02/15/14
02/20/14
02/25/14
02/28/14
Date
Velocity (ft/s)
1
0
-1
02/01/14
02/05/14
02/10/14
02/15/14
02/20/14
02/25/14
02/28/14
Date
Flow (cfs)
400
200
0
-200
02/01/14
02/05/14
02/10/14
02/15/14
02/20/14
02/25/14
02/28/14
Date

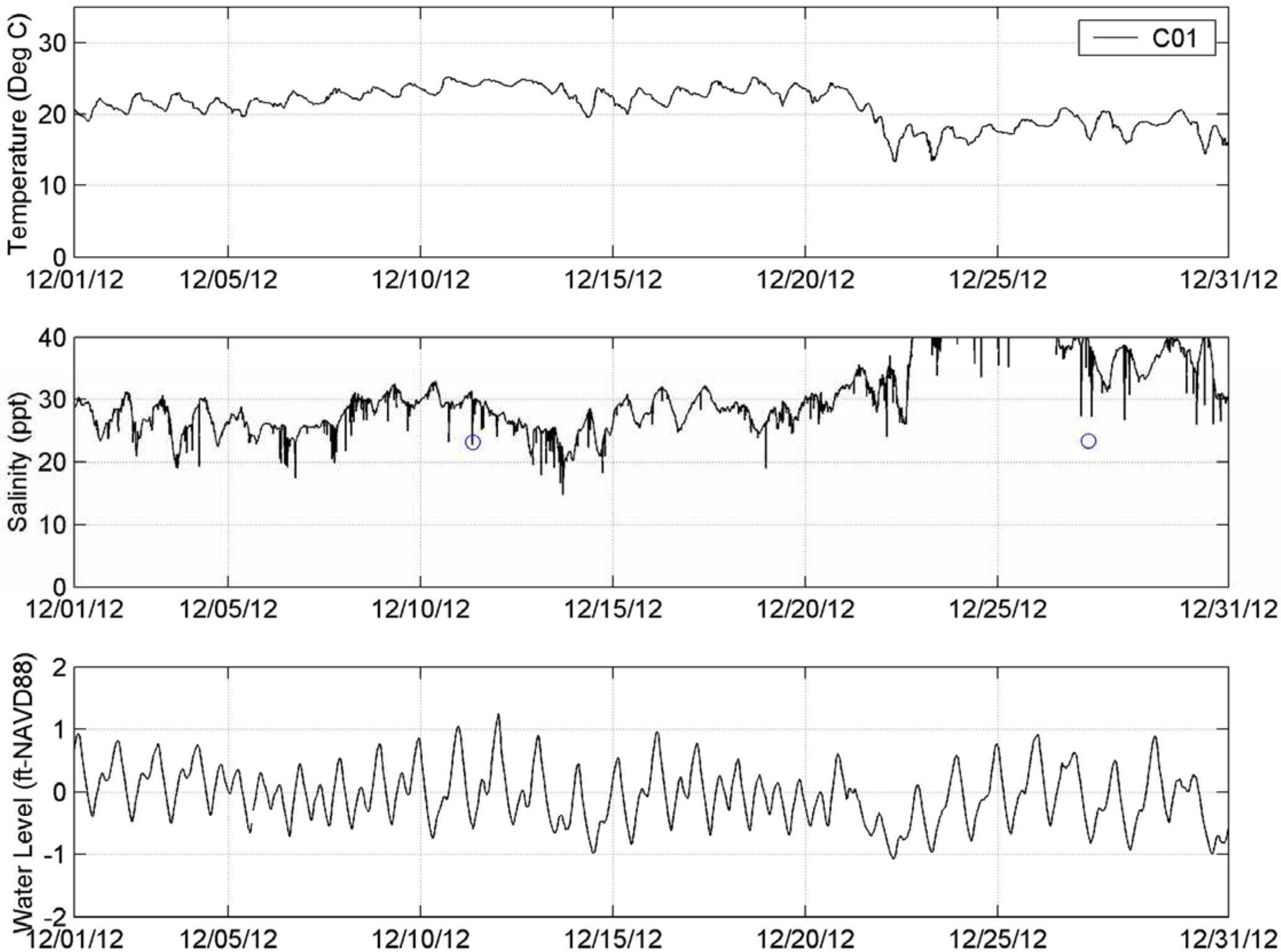
Appendix D

Measured Water Levels, Temperature and Salinity at C-Stations

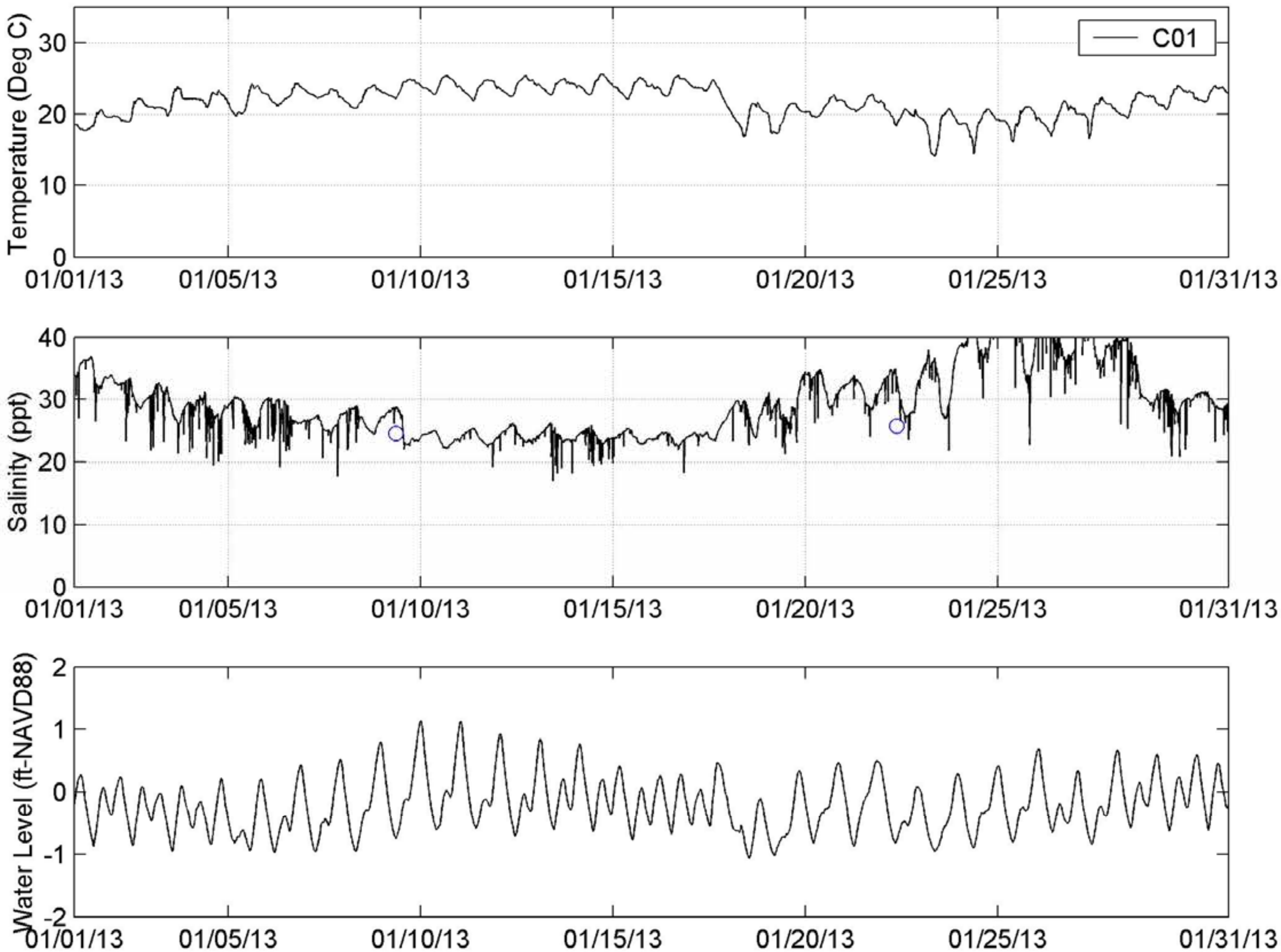


C01
Temperature (Deg C)
30
20
10
0
10/01/12
10/05/12
10/10/12
10/15/12
10/20/12
10/25/12
10/31/12
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
2
1
0
-1
-2

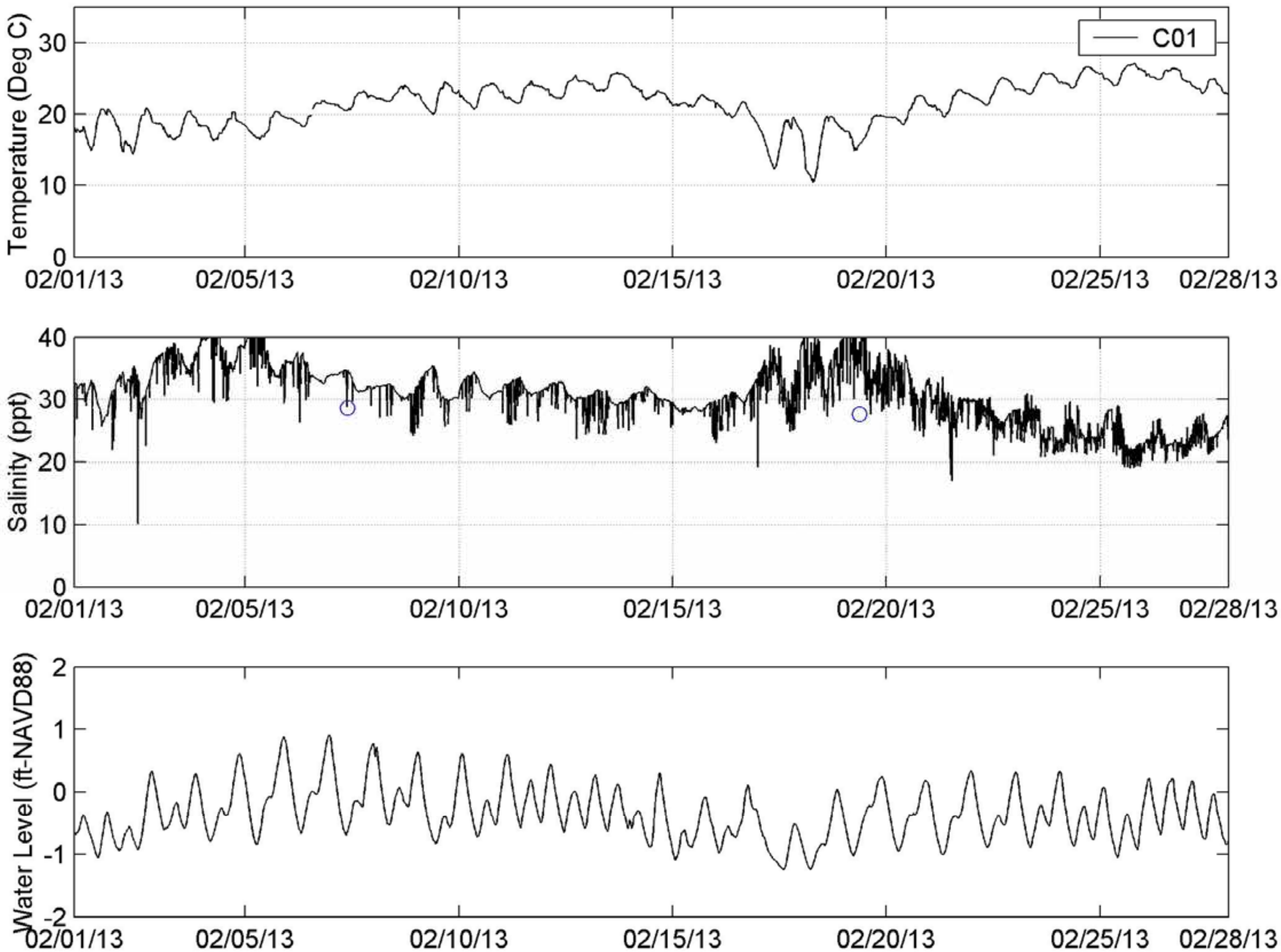

C01
Temperature (Deg C)
30
20
10
0
11/01/12
11/05/12
11/10/12
11/15/12
11/20/12
11/25/12
11/30/12
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
2
1
0
-1
-2

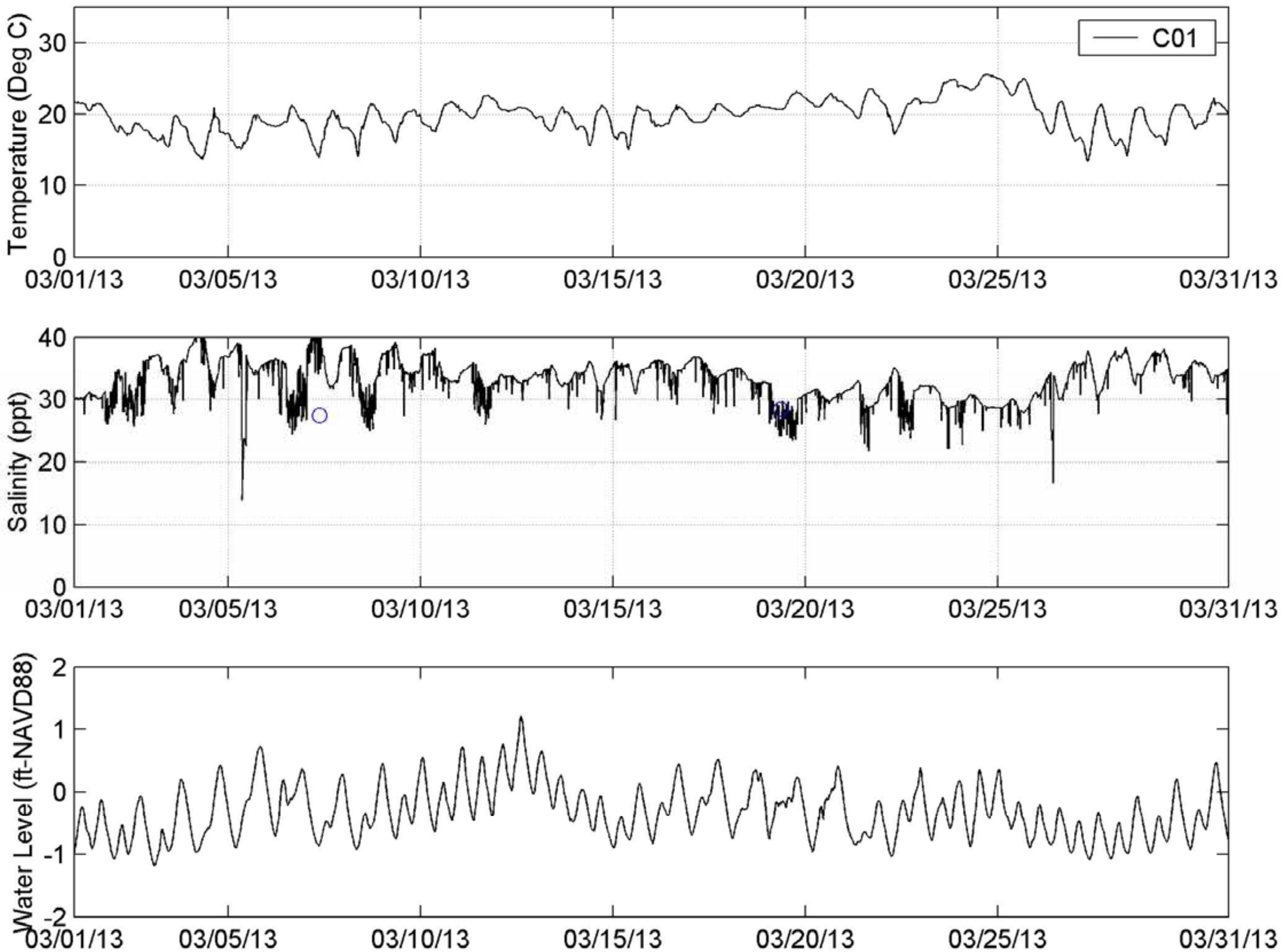


C01
Temperature (Deg C)
30
20
10
0
12/01/12
12/05/12
12/10/12
12/15/12
12/20/12
12/25/12
12/31/12
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
2
1
0
-1
-2

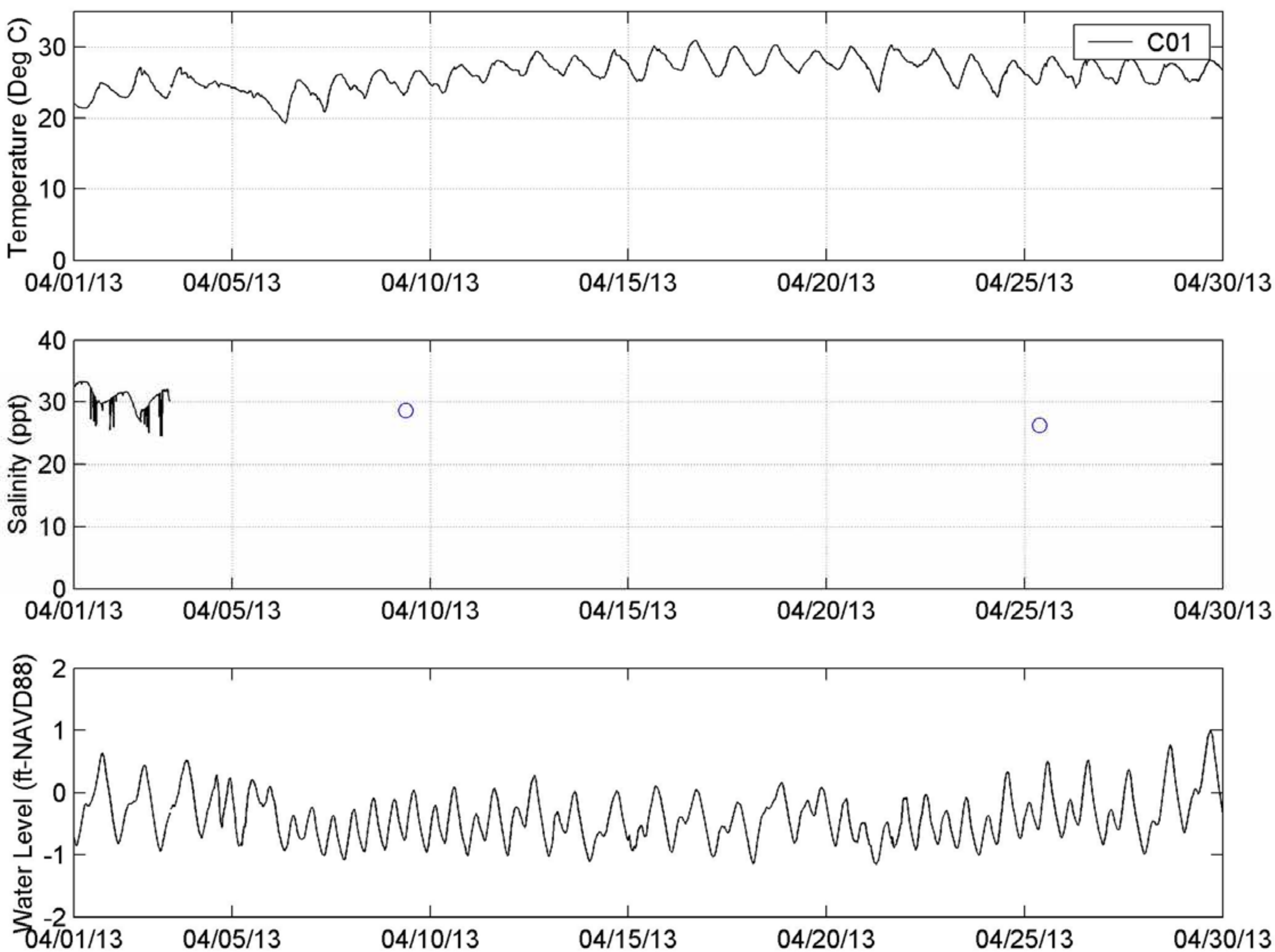


C01
Temperature (Deg C)
0
10
20
30
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
-2
-1
0
1
2
01/01/13
01/05/13
01/10/13
01/15/13
01/20/13
01/25/13
01/31/13

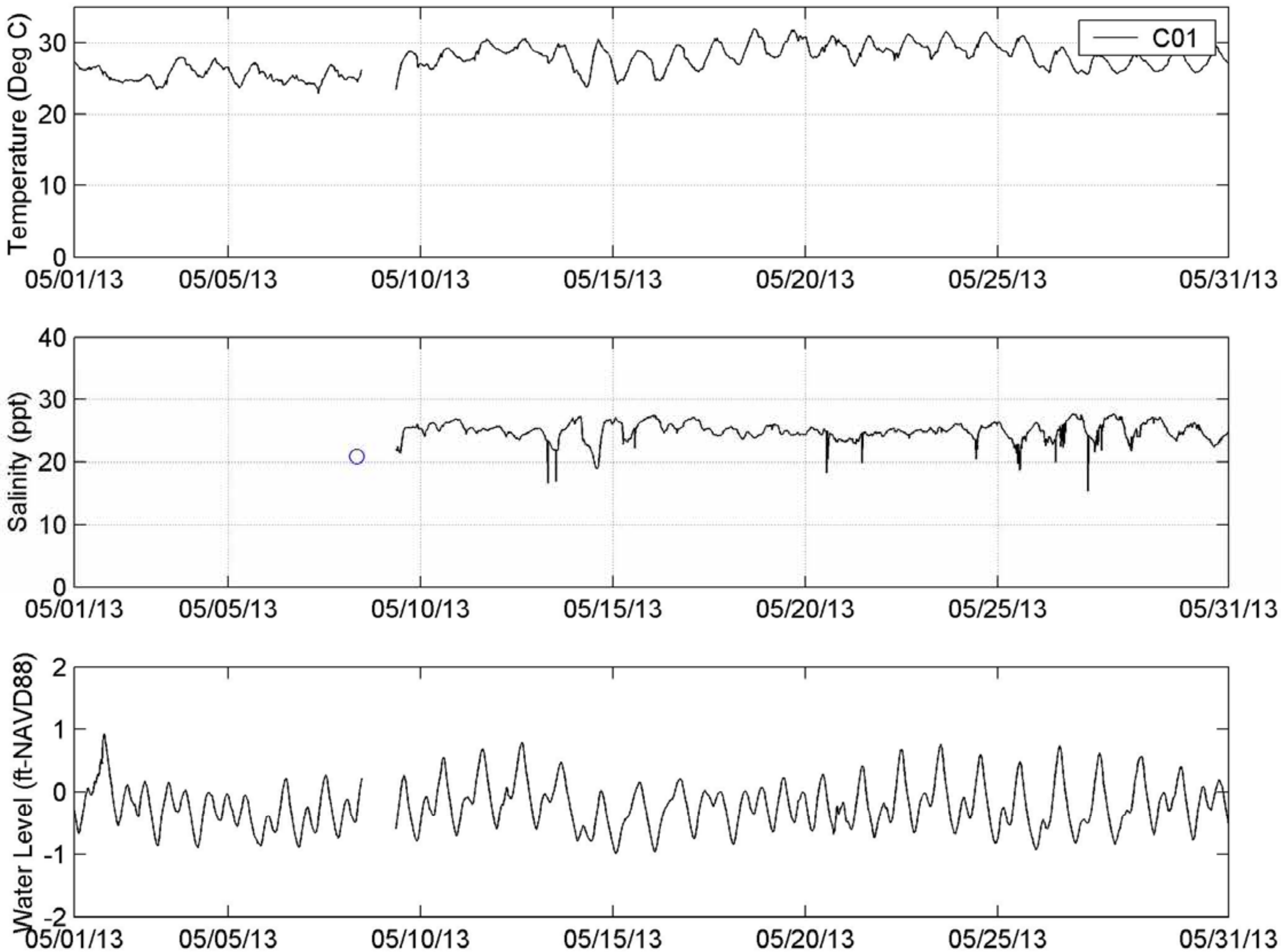

C01
Temperature (Deg C)
30
20
10
0
02/01/13
02/05/13
02/10/13
02/15/13
02/20/13
02/25/13
02/28/13
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
2
1
0
-1
-2

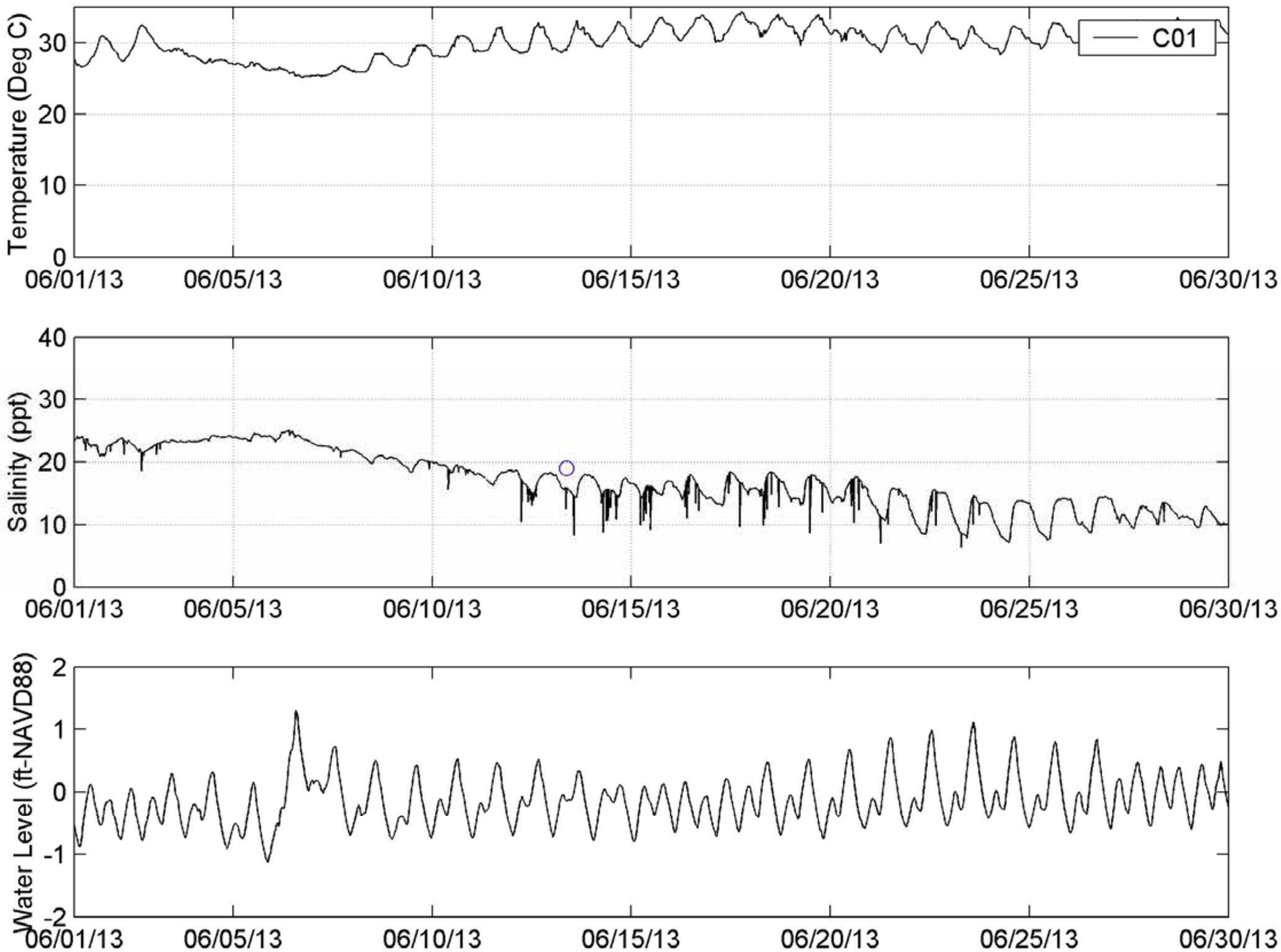


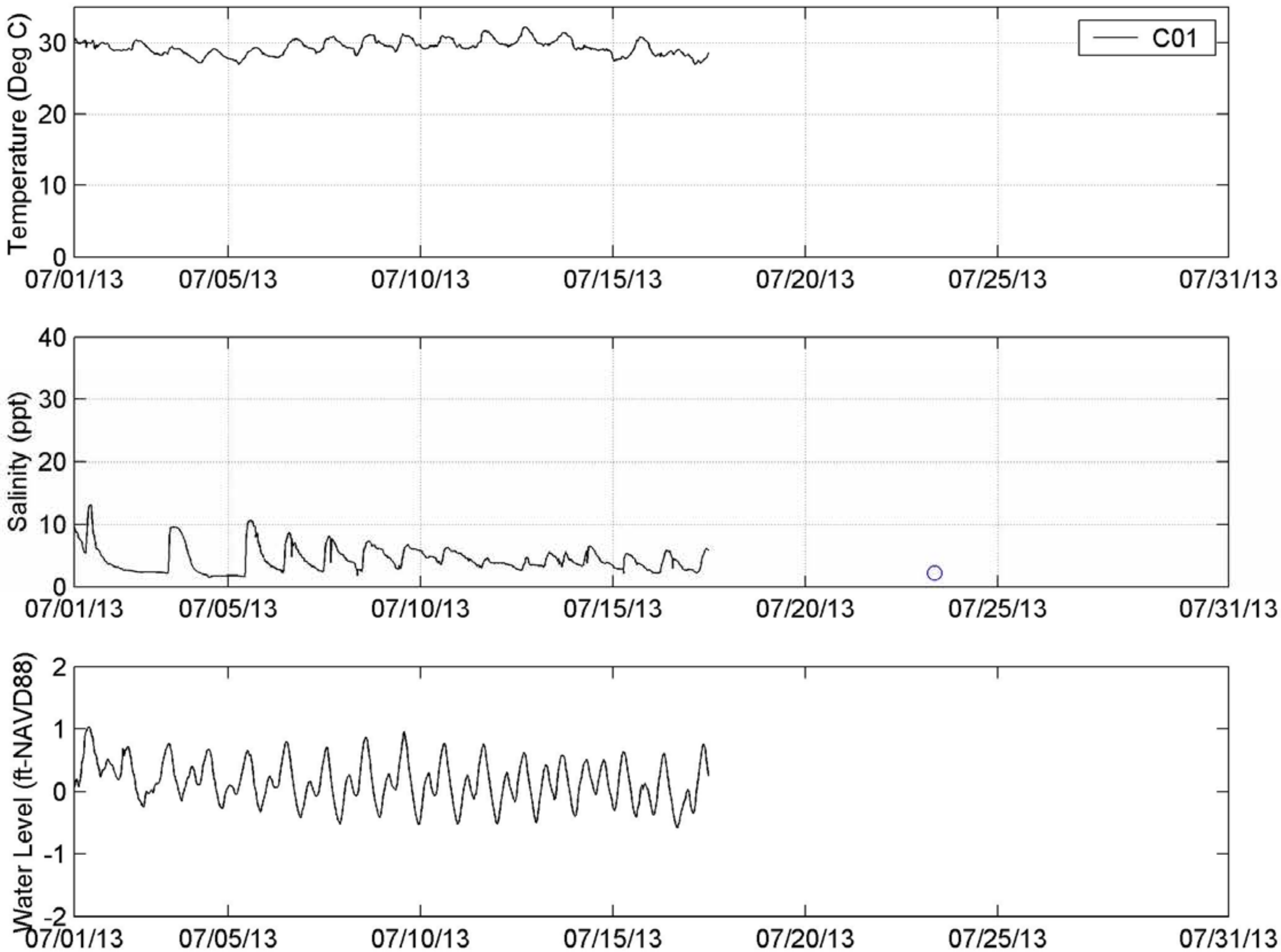
C01
Temperature (Deg C)
0
10
20
30
03/01/13
03/05/13
03/10/13
03/15/13
03/20/13
03/25/13
03/31/13
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
-2
-1
0
1
2



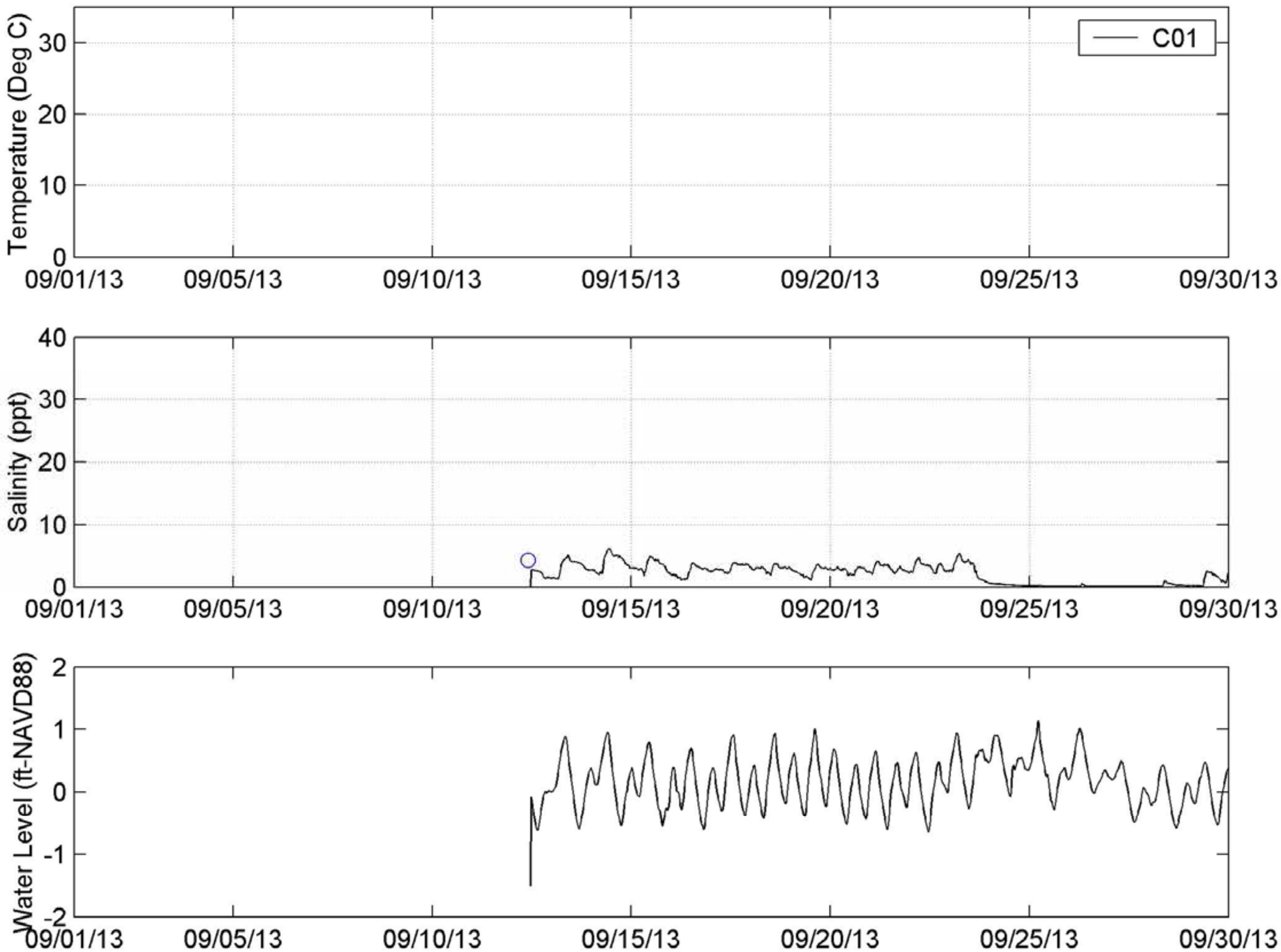
Temperature (Deg C)
C01
Salinity (ppt)
Water Level (ft-NAVD88)
04/01/13
04/05/13
04/10/13
04/15/13
04/20/13
04/25/13
04/30/13


C01
Temperature (Deg C)
30
20
10
0
05/01/13
05/05/13
05/10/13
05/15/13
05/20/13
05/25/13
05/31/13
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
2
1
0
-1
-2

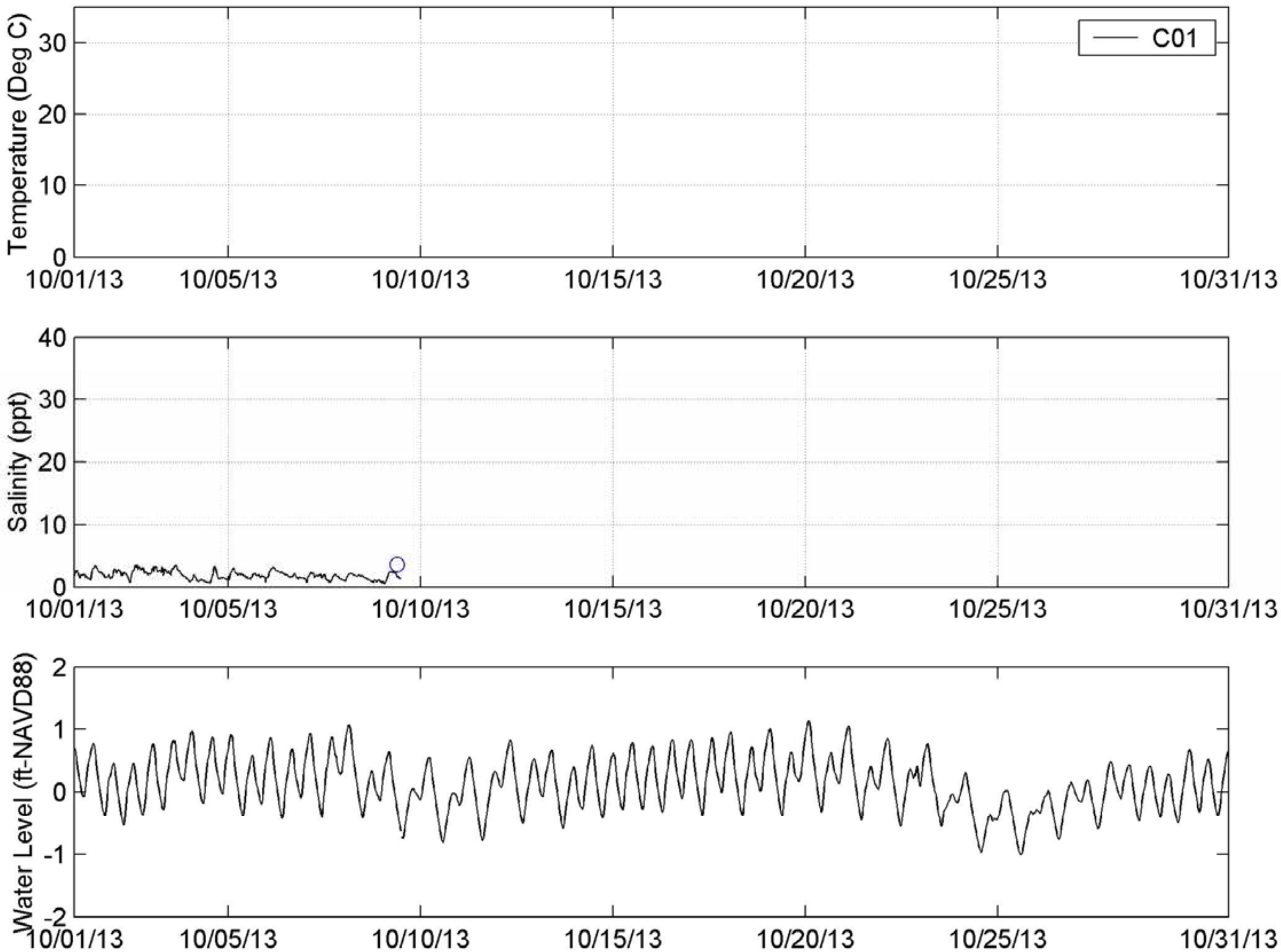

C01
Temperature (Deg C)
0
10
20
30
06/01/13
06/05/13
06/10/13
06/15/13
06/20/13
06/25/13
06/30/13
Salinity (ppt)
0
10
20
30
40
06/01/13
06/05/13
06/10/13
06/15/13
06/20/13
06/25/13
06/30/13
Water Level (ft-NAVD88)
-2
-1
0
1
2
06/01/13
06/05/13
06/10/13
06/15/13
06/20/13
06/25/13
06/30/13

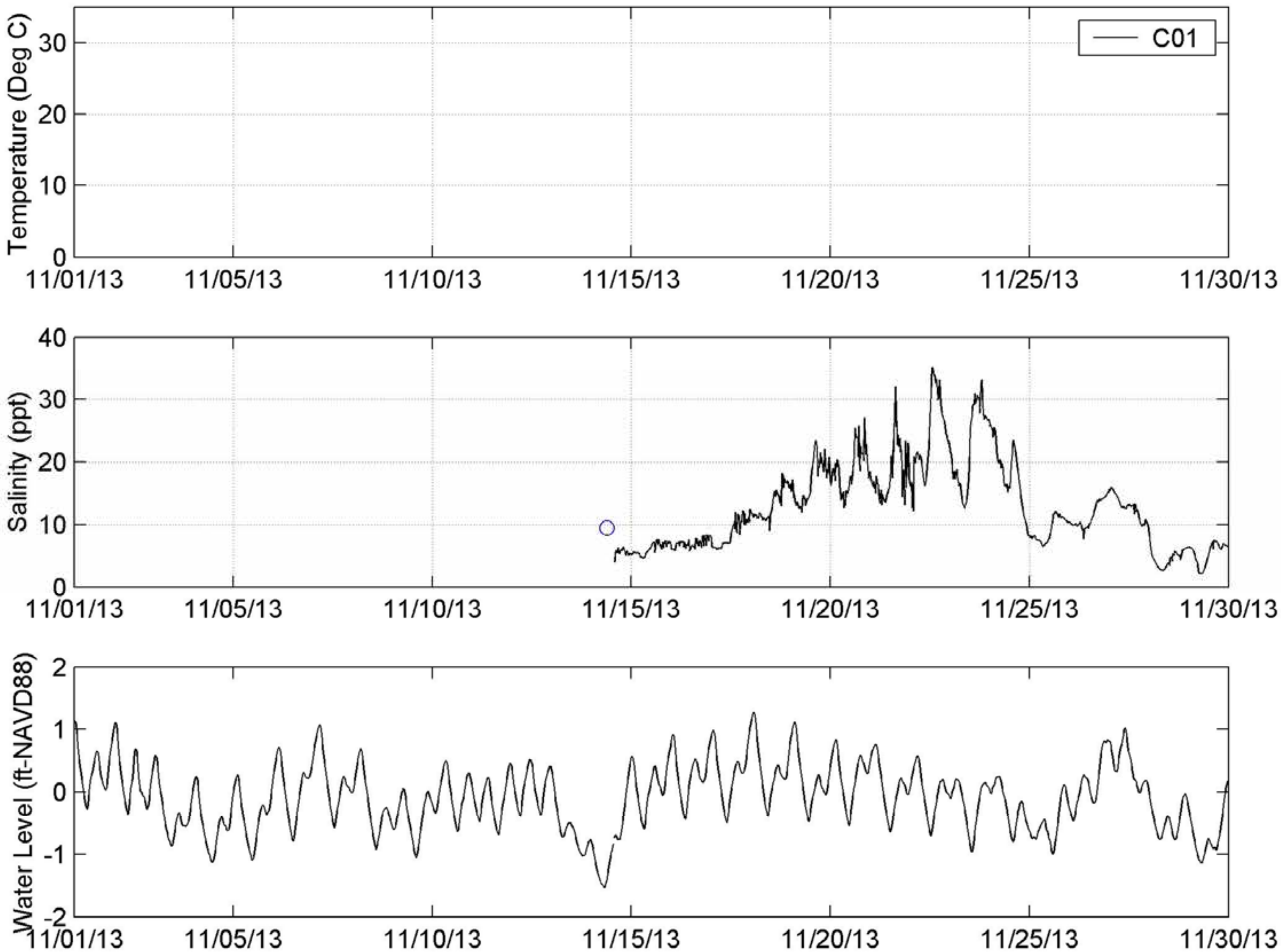


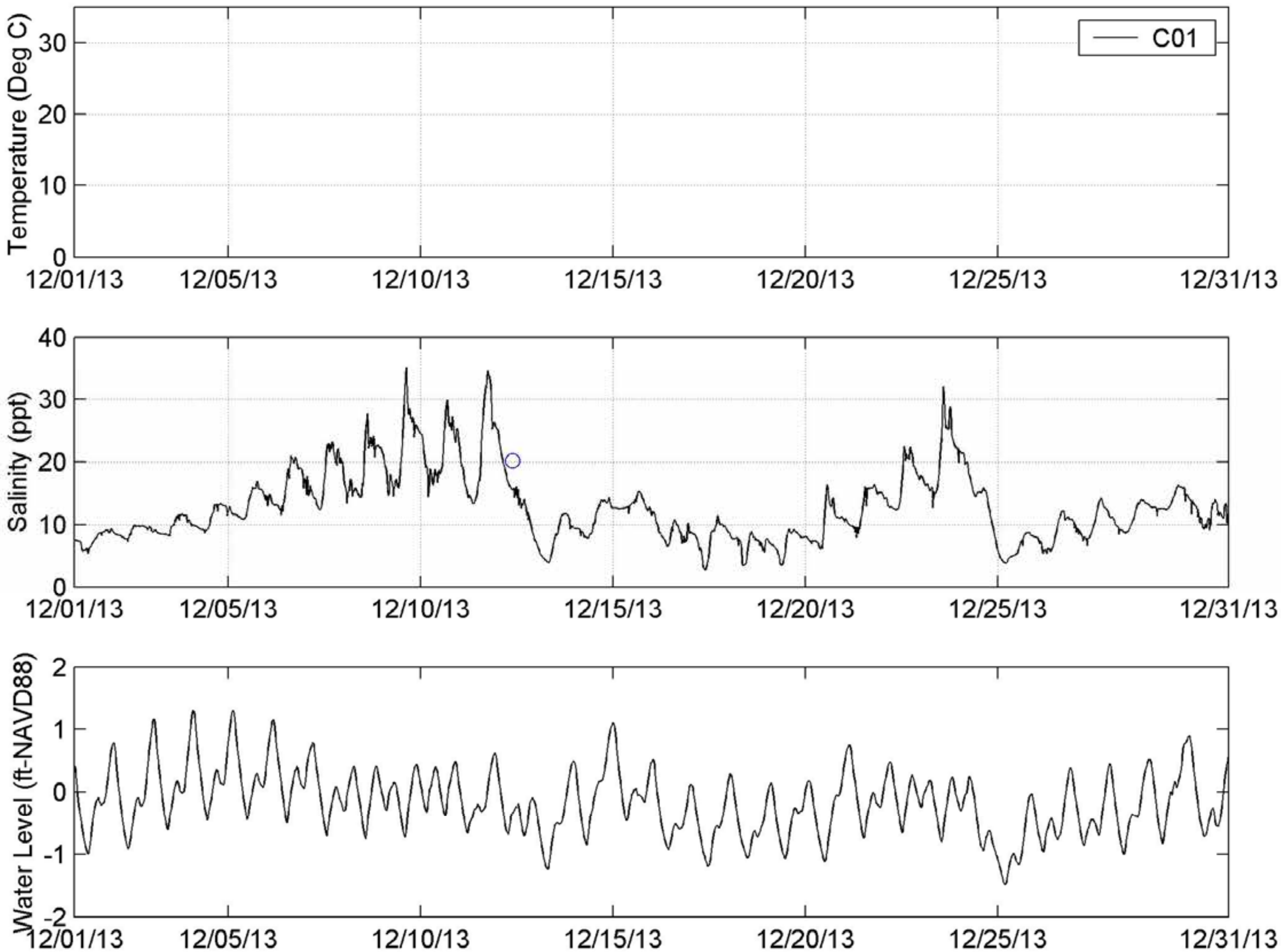
C01
Temperature (Deg C)
30
20
10
0
07/01/13
07/05/13
07/10/13
07/15/13
07/20/13
07/25/13
07/31/13
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
2
1
0
-1
-2

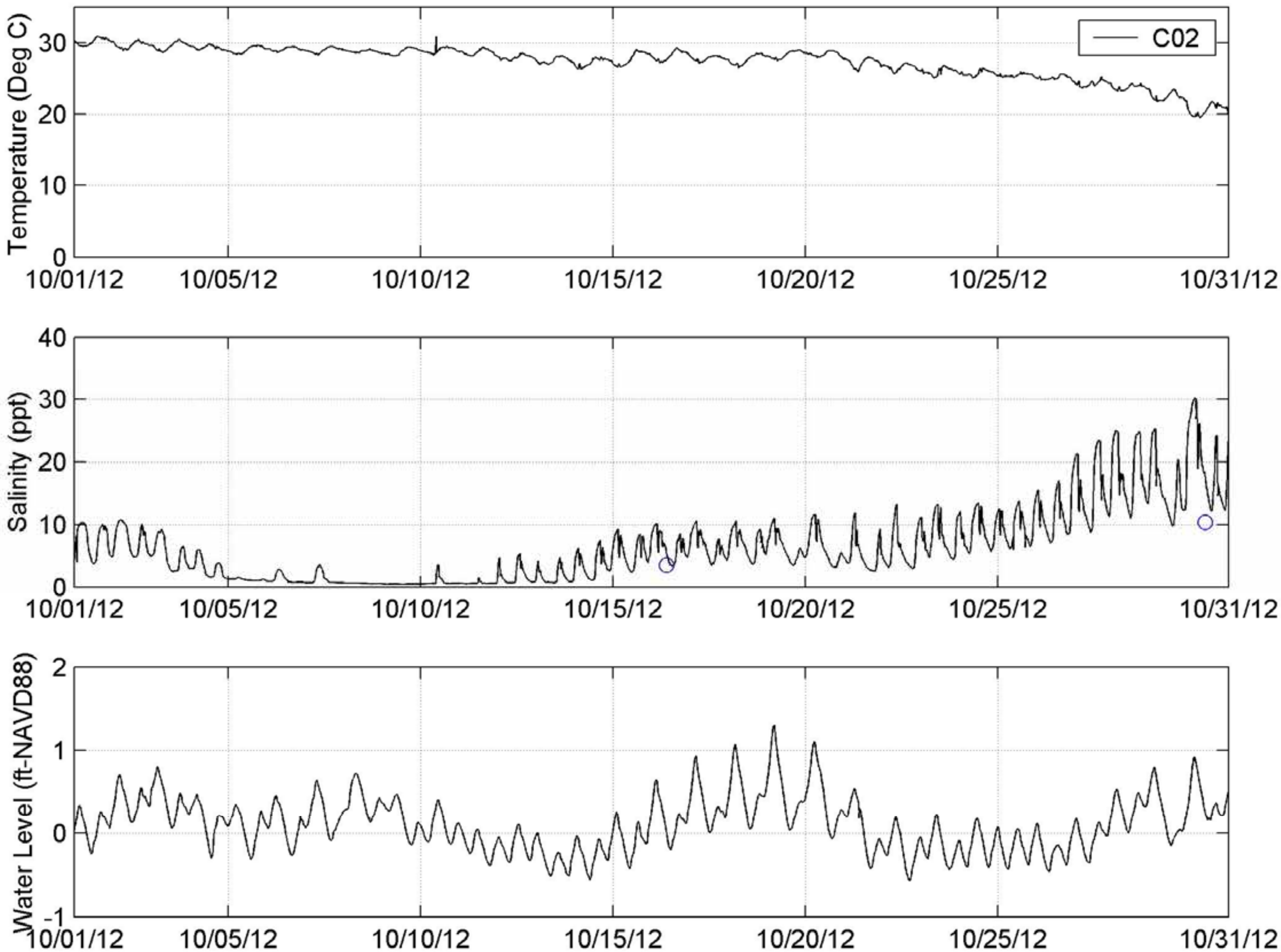


C01
Temperature (Deg C)
30
20
10
0
09/01/13
09/05/13
09/10/13
09/15/13
09/20/13
09/25/13
09/30/13
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
2
1
0
-1
-2

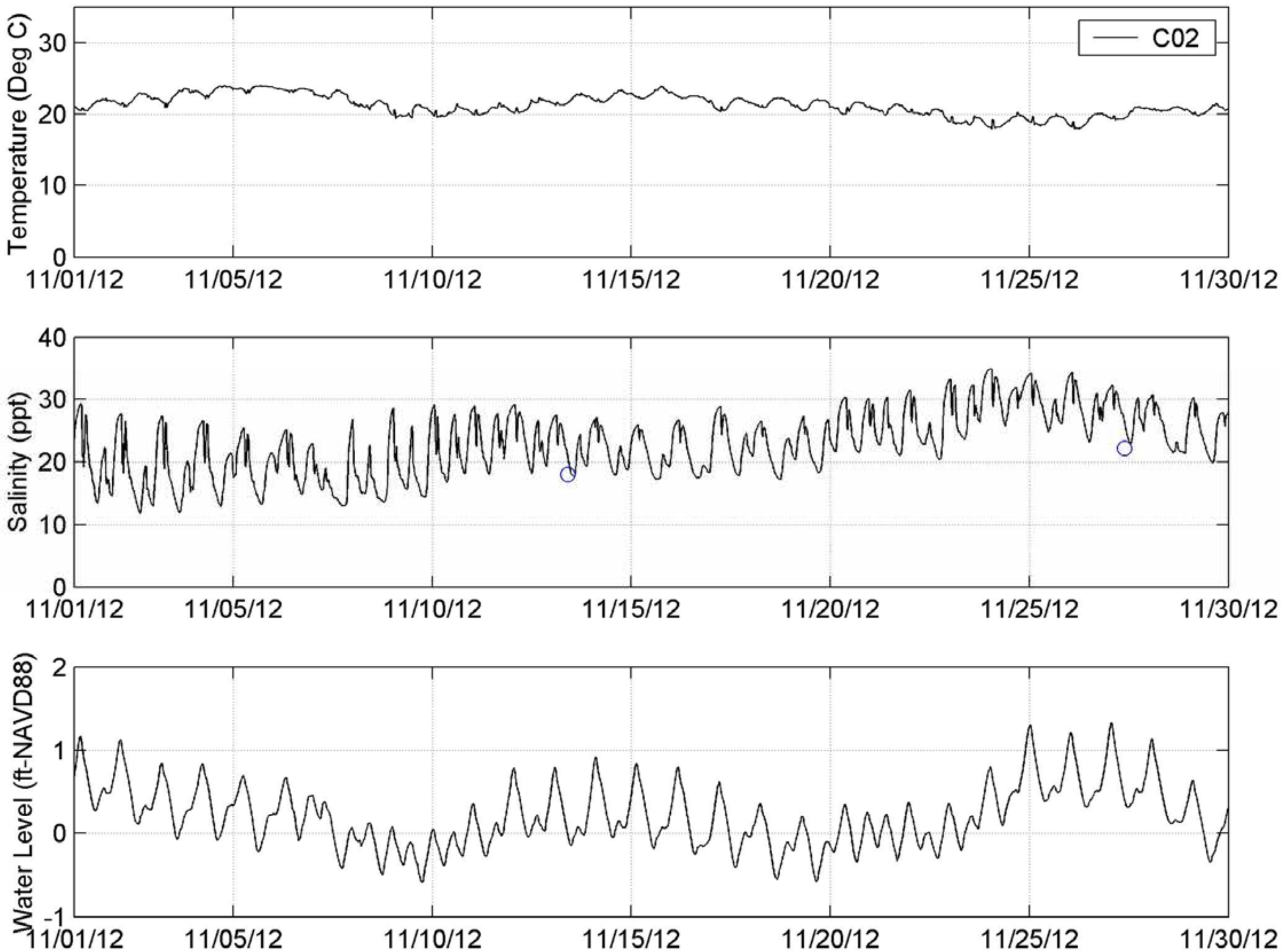

C01
Temperature (Deg C)
0
10
20
30
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
-2
-1
0
1
2
10/01/13
10/05/13
10/10/13
10/15/13
10/20/13
10/25/13
10/31/13


C01
Temperature (Deg C)
30
20
10
0
11/01/13
11/05/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
2
1
0
-1
-2

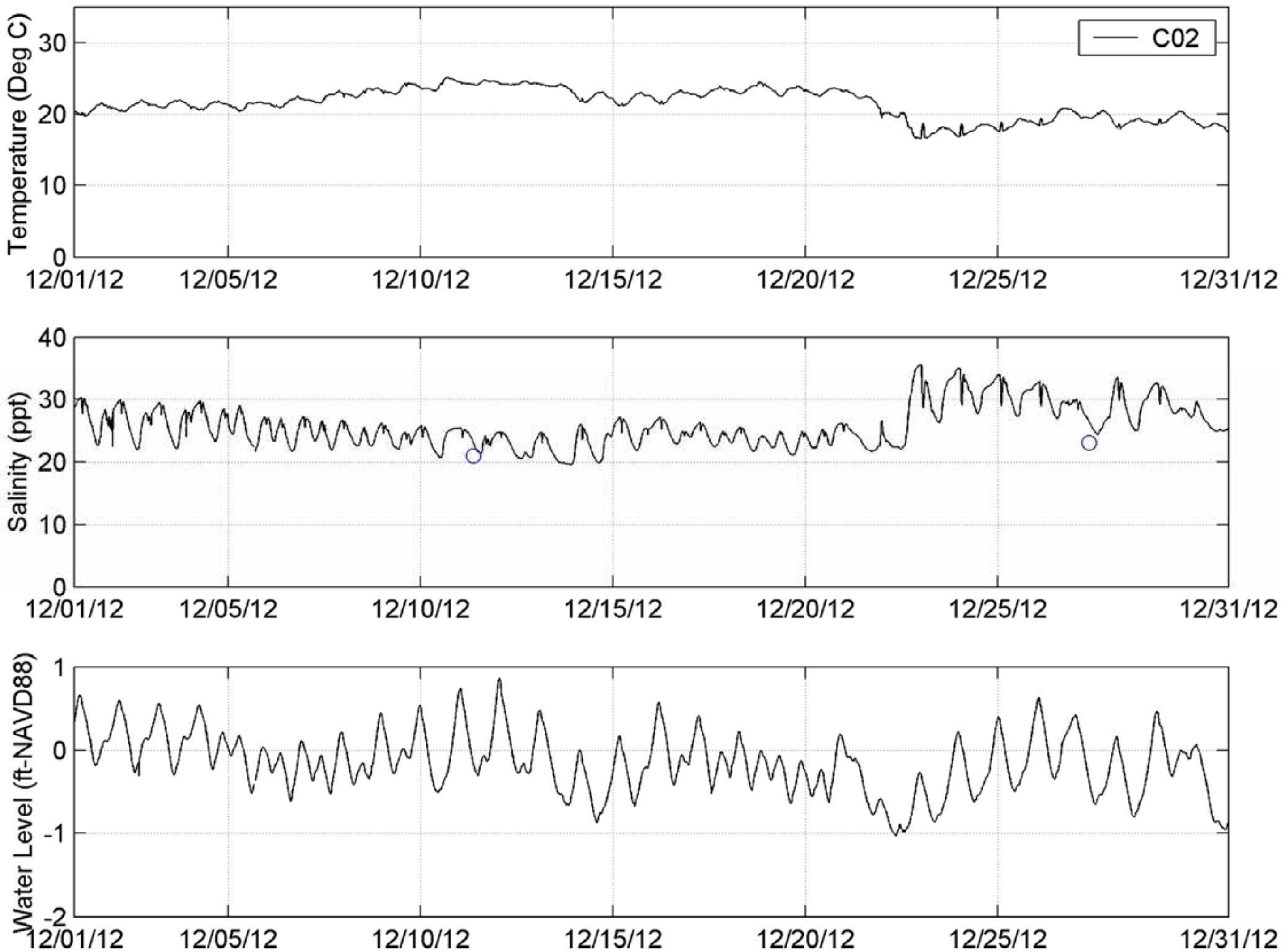

C01
Temperature (Deg C)
0
10
20
30
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
-2
-1
0
1
2
12/01/13
12/05/13
12/10/13
12/15/13
12/20/13
12/25/13
12/31/13



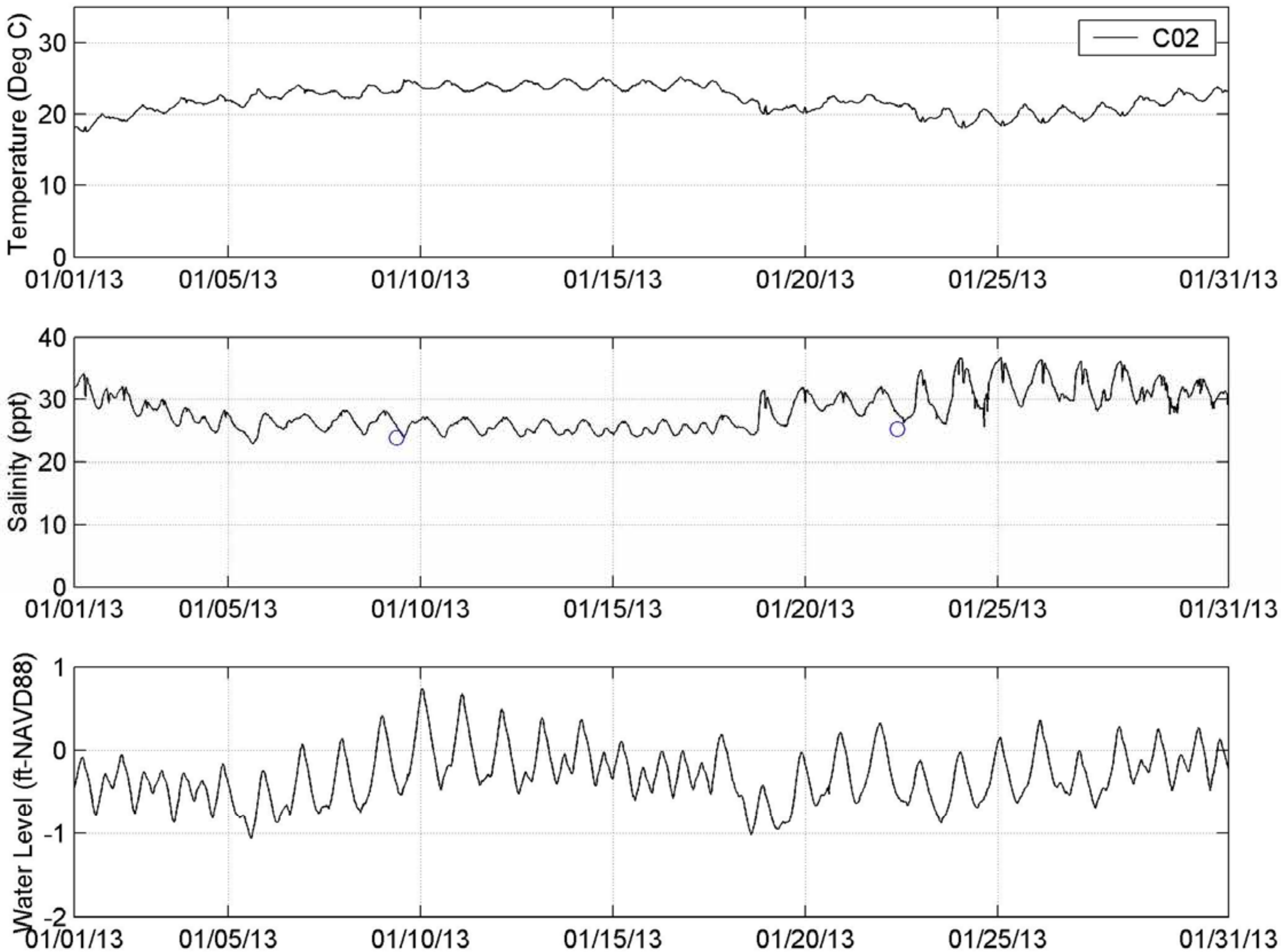
C02
Temperature (Deg C)
0
10
20
30
10/01/12
10/05/12
10/10/12
10/15/12
10/20/12
10/25/12
10/31/12
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
-1
0
1
2

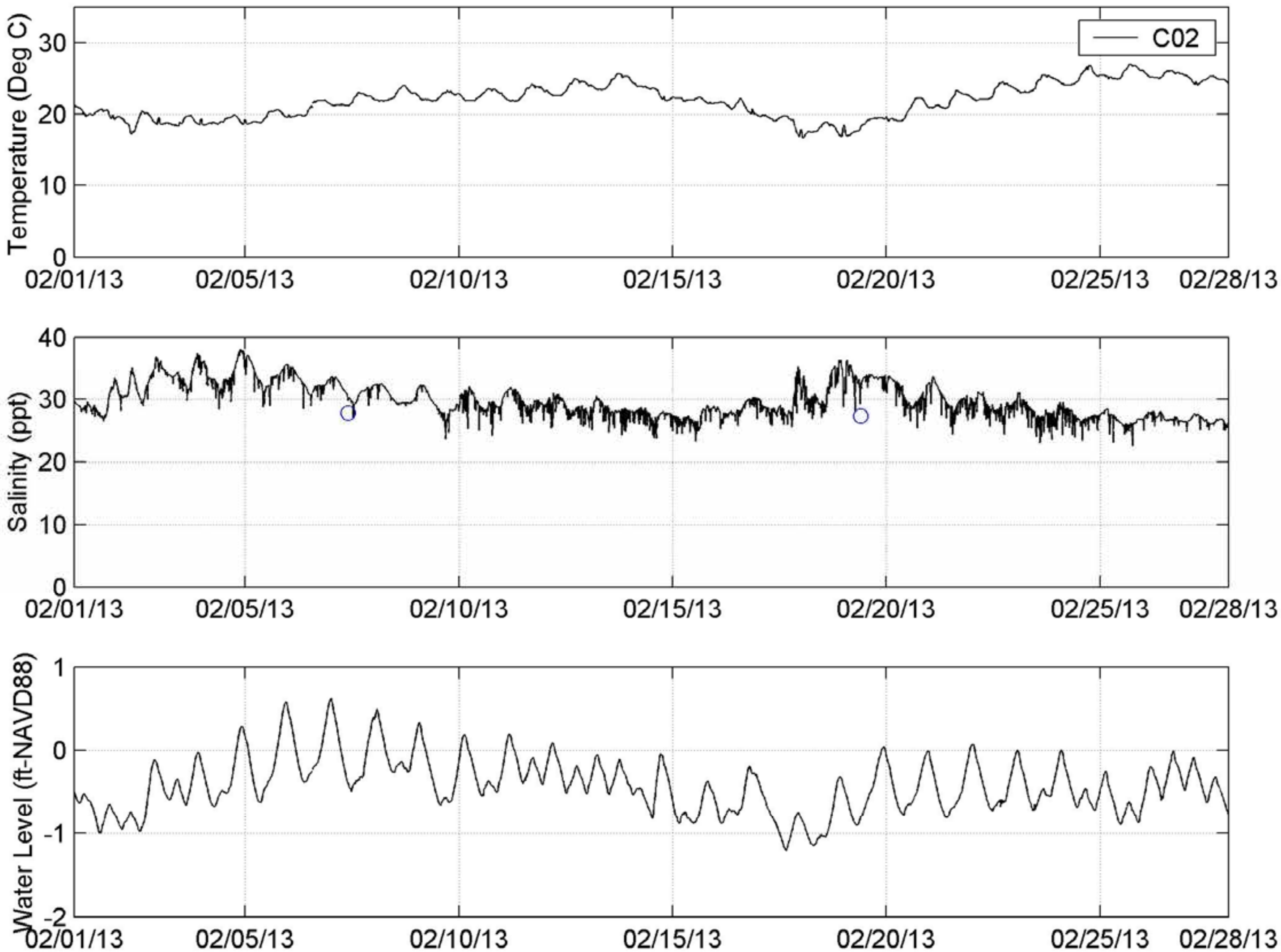


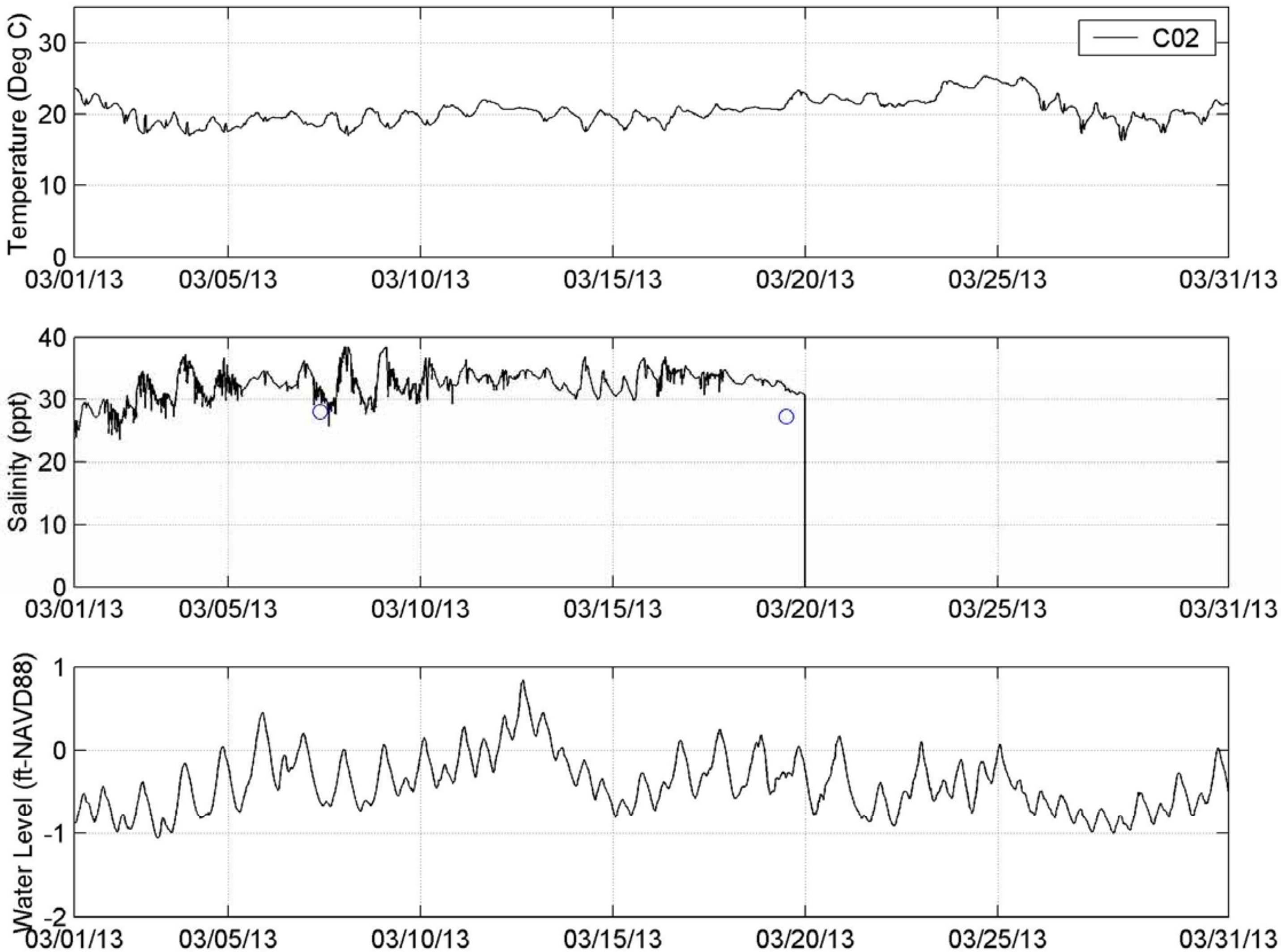
C02
Temperature (Deg C)
30
20
10
0
11/01/12
11/05/12
11/10/12
11/15/12
11/20/12
11/25/12
11/30/12
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
2
1
0
-1

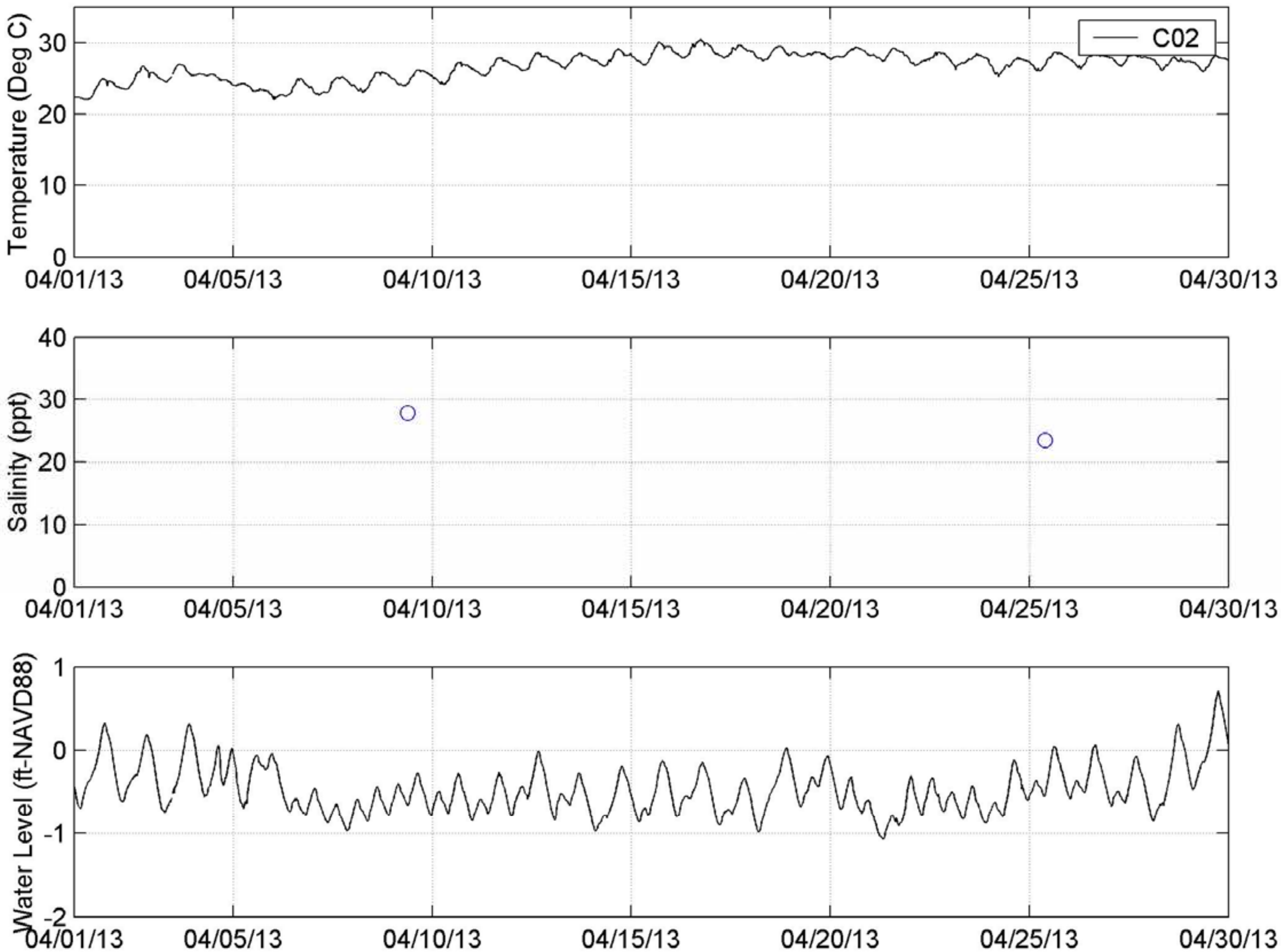


C02
Temperature (Deg C)
0
10
20
30
12/01/12
12/05/12
12/10/12
12/15/12
12/20/12
12/25/12
12/31/12
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
-2
-1
0
1

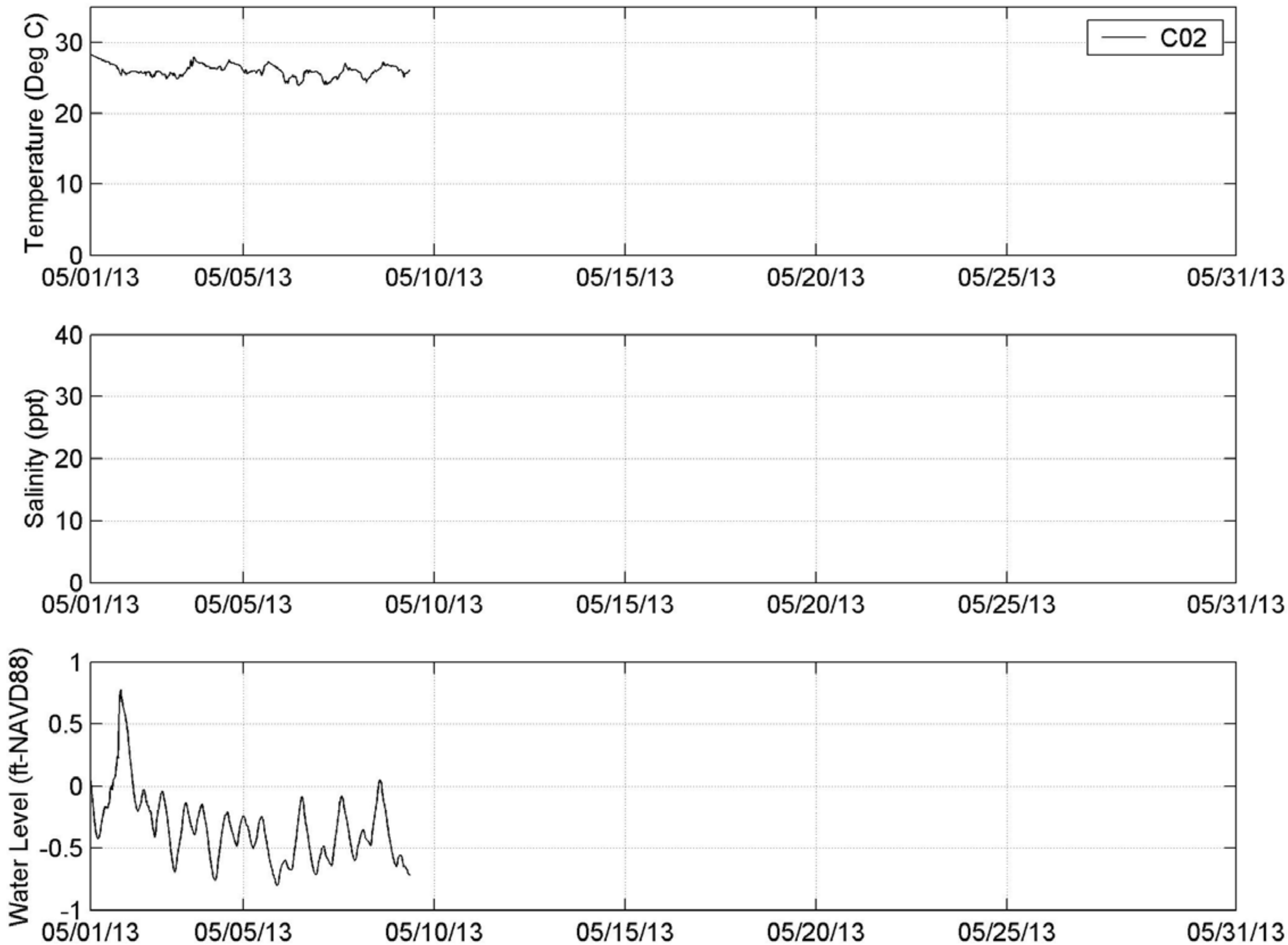

C02
Temperature (Deg C)
30
20
10
0
01/01/13
01/05/13
01/10/13
01/15/13
01/20/13
01/25/13
01/31/13
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
1
0
-1
-2

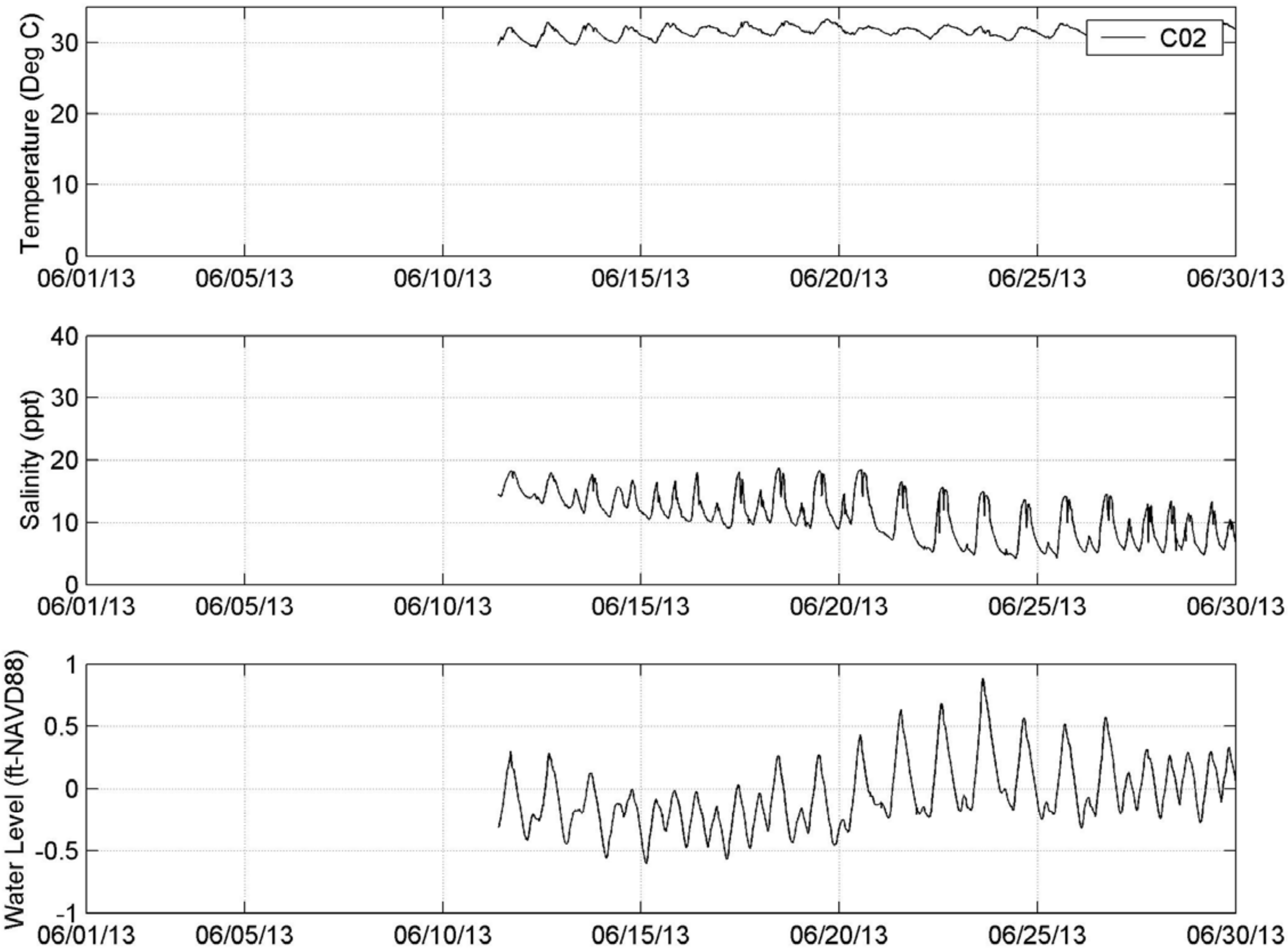

C02
Temperature (Deg C)
30
20
10
0
02/01/13
02/05/13
02/10/13
02/15/13
02/20/13
02/25/13
02/28/13
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
1
0
-1
-2

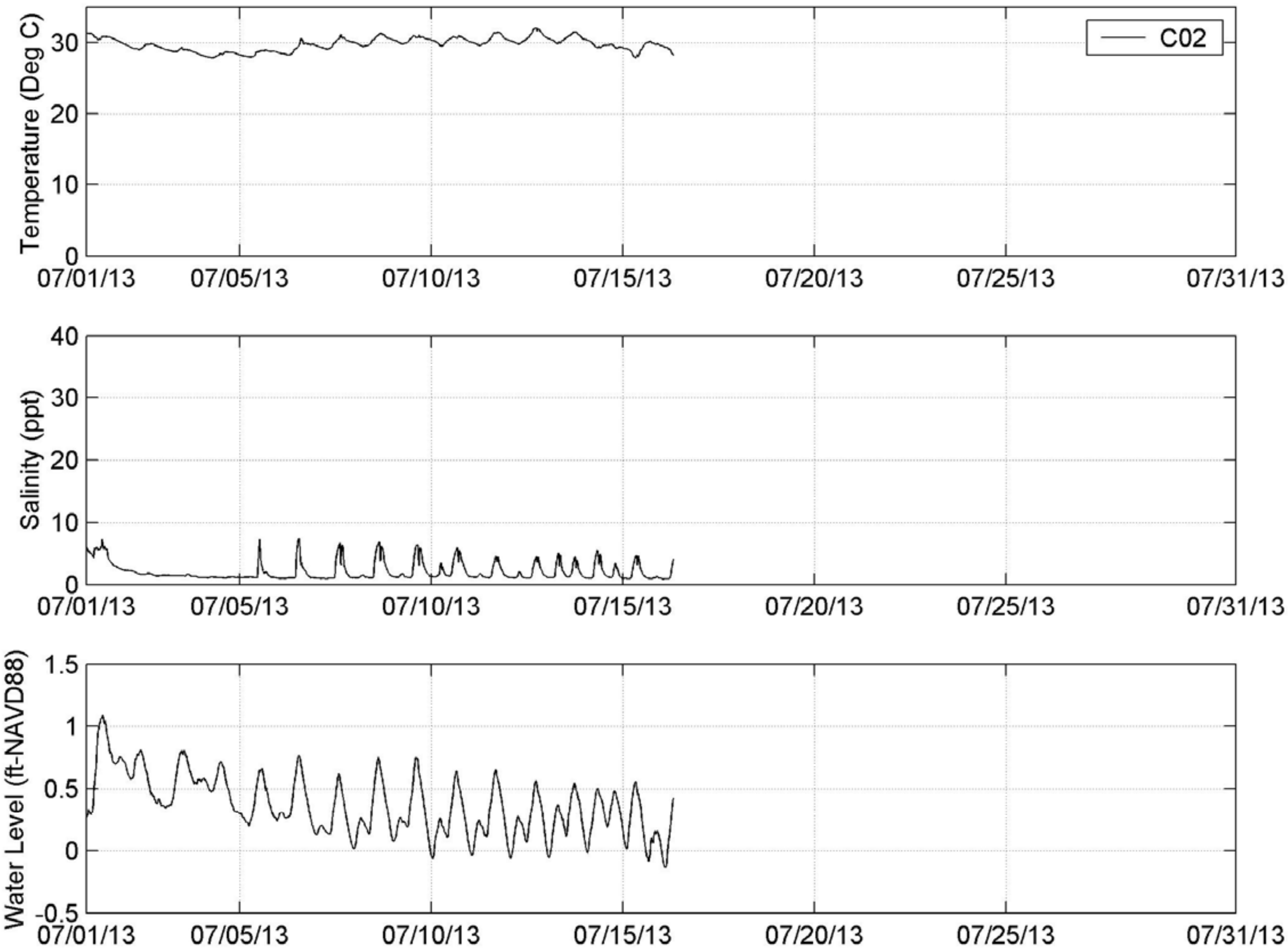

C02
Temperature (Deg C)
30
20
10
0
03/01/13
03/05/13
03/10/13
03/15/13
03/20/13
03/25/13
03/31/13
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
1
0
-1
-2



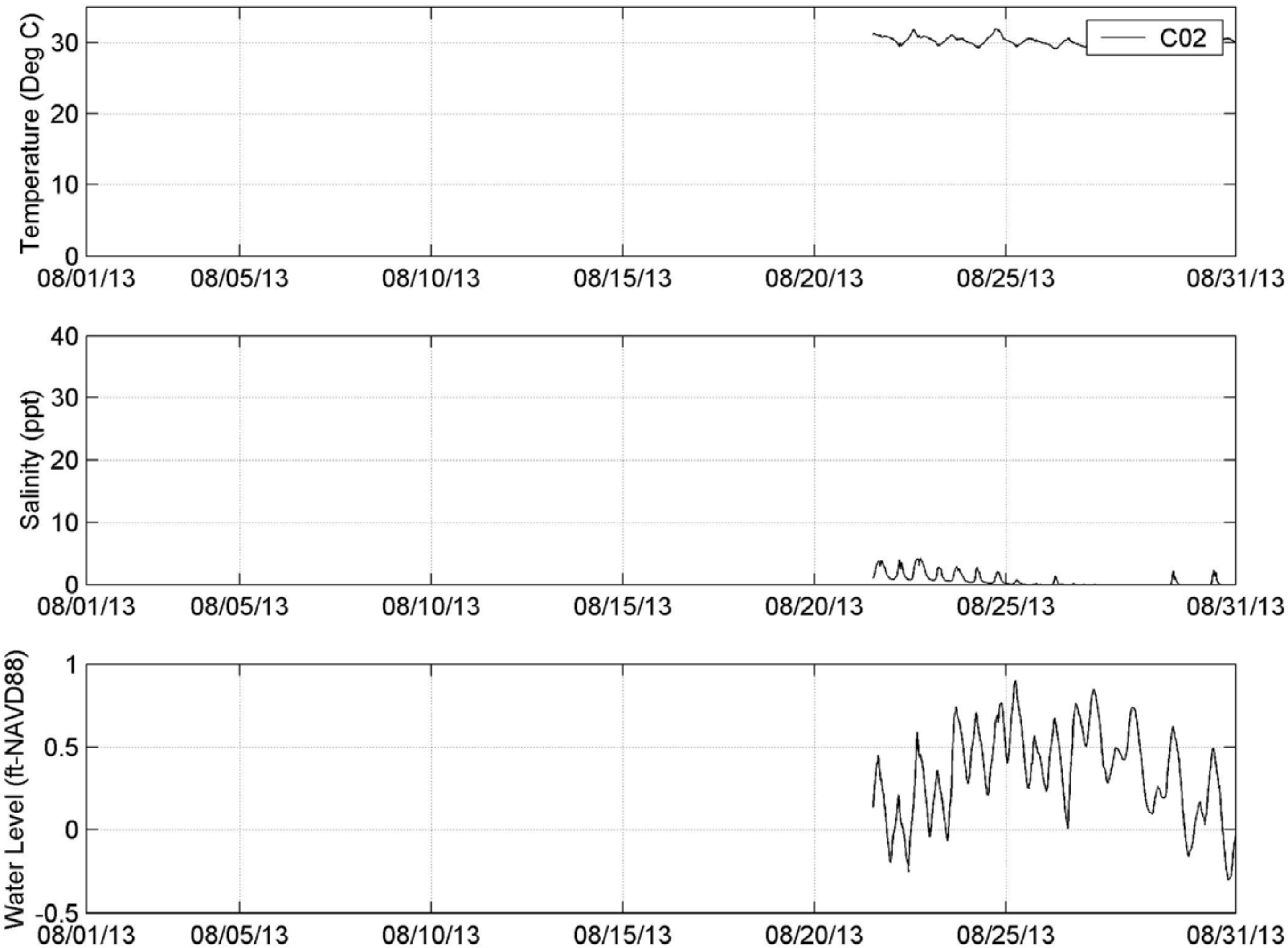
C02
Temperature (Deg C)
30
20
10
0
04/01/13
04/05/13
04/10/13
04/15/13
04/20/13
04/25/13
04/30/13
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
1
0
-1
-2


Temperature (Deg C)
0
10
20
30
C02
05/01/13
05/05/13
05/10/13
05/15/13
05/20/13
05/25/13
05/31/13
Salinity (ppt)
0
10
20
30
40
05/01/13
05/05/13
05/10/13
05/15/13
05/20/13
05/25/13
05/31/13
Water Level (ft-NAVD88)
-1
-0.5
0
0.5
1
05/01/13
05/05/13
05/10/13
05/15/13
05/20/13
05/25/13
05/31/13

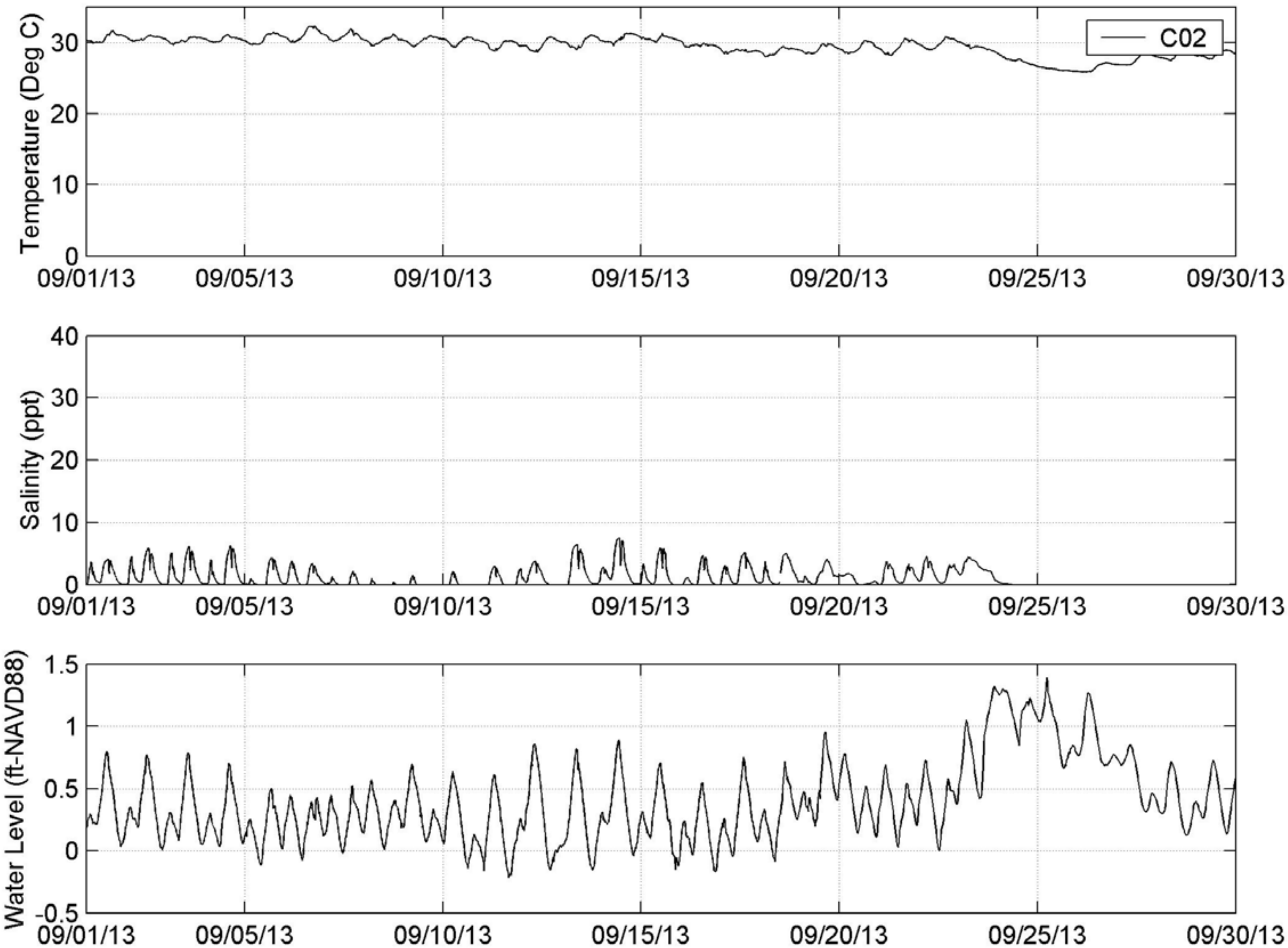

C02
Temperature (Deg C)
30
20
10
0
06/01/13
06/05/13
06/10/13
06/15/13
06/20/13
06/25/13
06/30/13
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
1
0.5
0
-0.5
-1

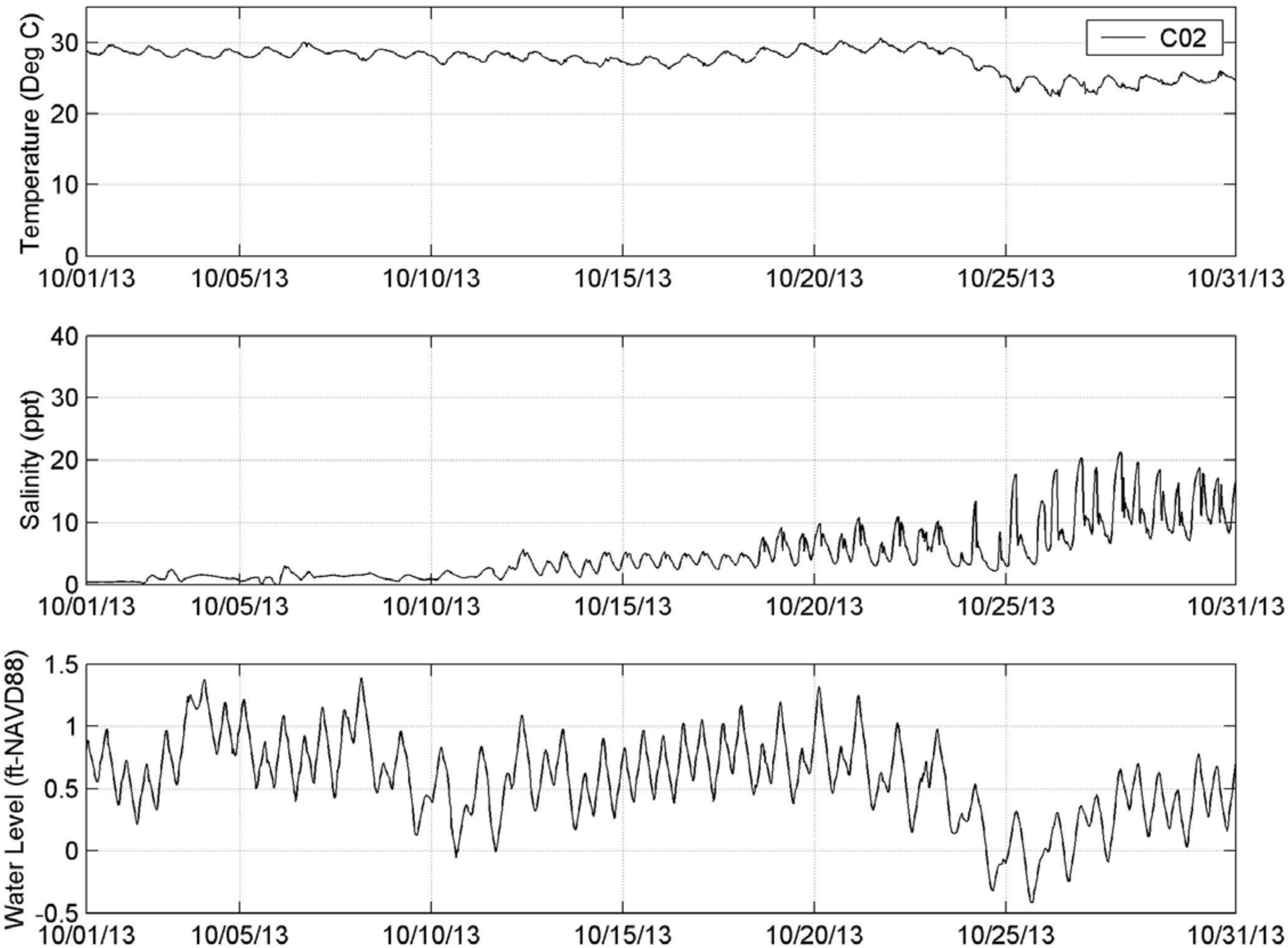


C02
Temperature (Deg C)
30
20
10
0
07/01/13
07/05/13
07/10/13
07/15/13
07/20/13
07/25/13
07/31/13
Salinity (ppt)
40
30
20
10
0
07/01/13
07/05/13
07/10/13
07/15/13
07/20/13
07/25/13
07/31/13
Water Level (ft-NAVD88)
1.5
1
0.5
0
-0.5
07/01/13
07/05/13
07/10/13
07/15/13
07/20/13
07/25/13
07/31/13

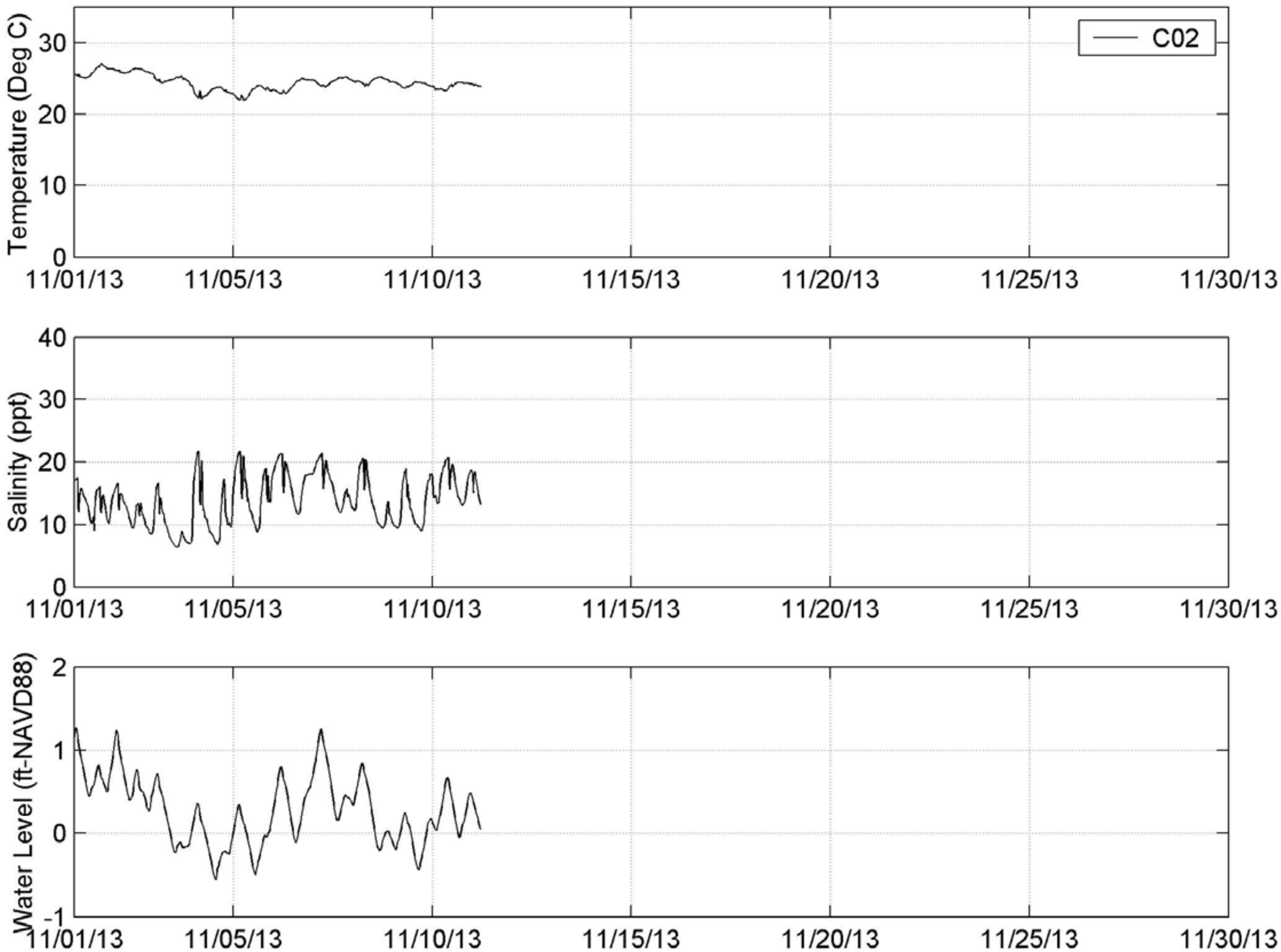


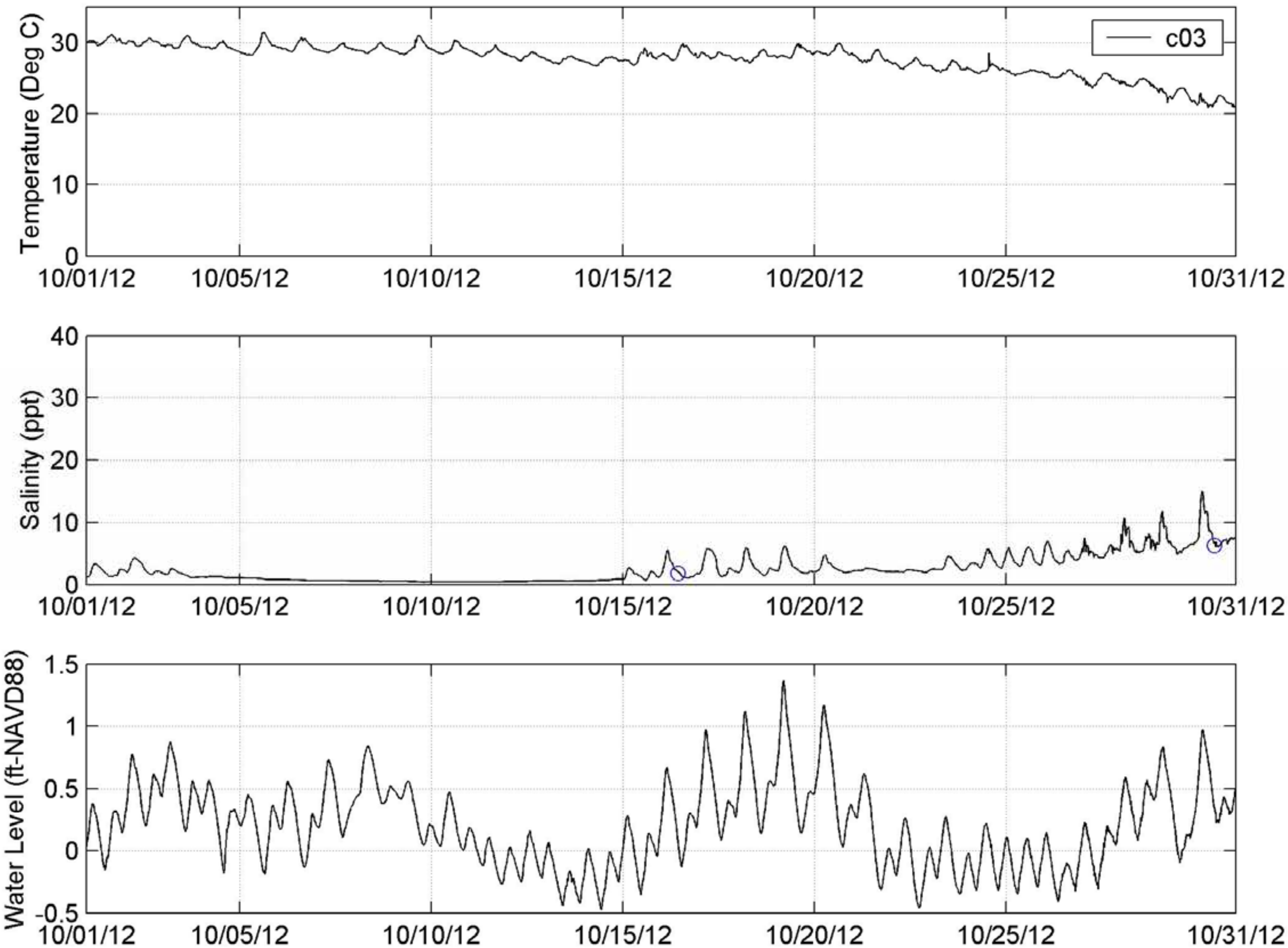
Temperature (Deg C)
30
20
10
0
C02
08/01/13
08/05/13
08/10/13
08/15/13
08/20/13
08/25/13
08/31/13
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
1
0.5
0
-0.5

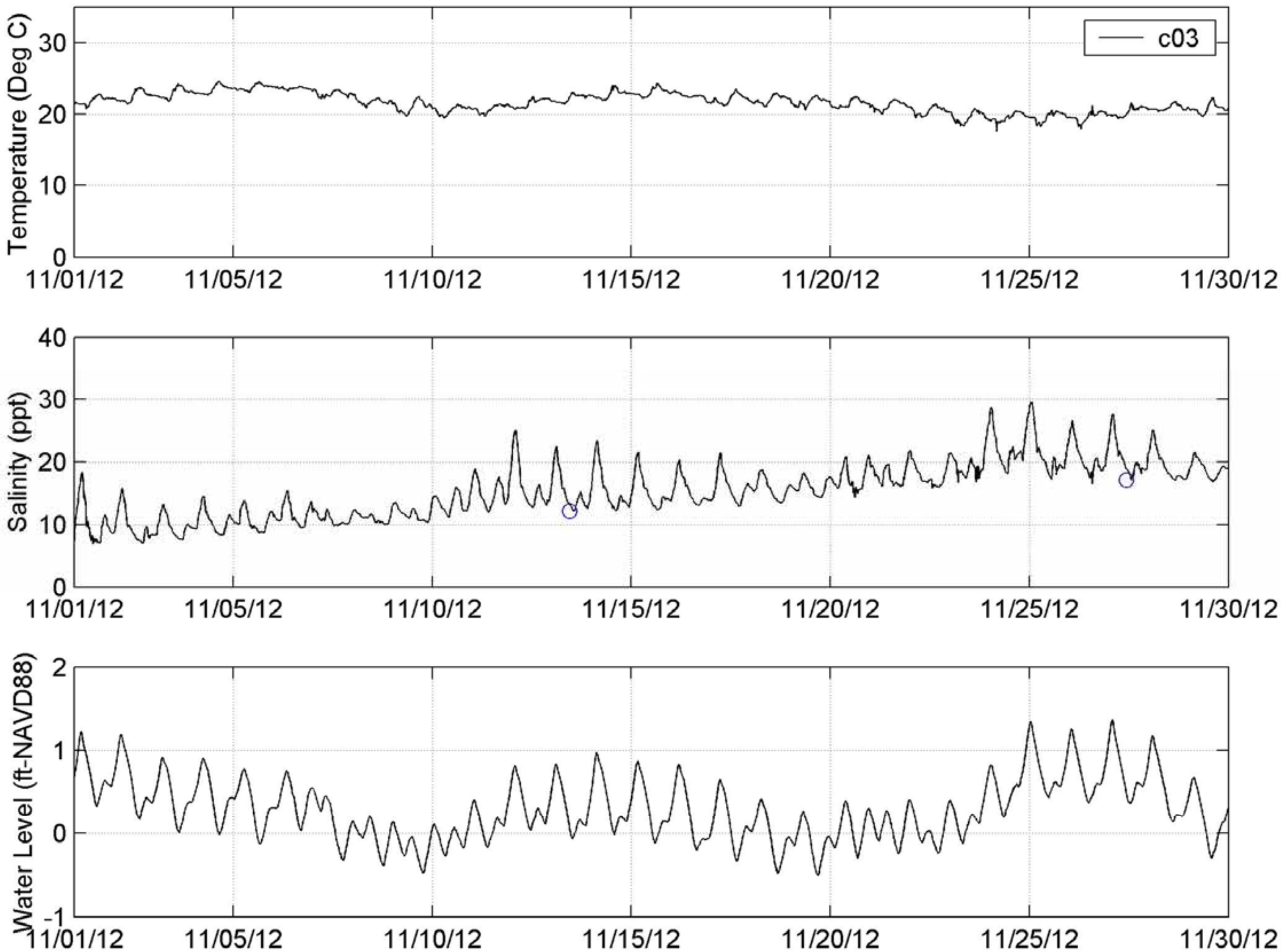

C02
Temperature (Deg C)
Salinity (ppt)
Water Level (ft-NAVD88)
09/01/13
09/05/13
09/10/13
09/15/13
09/20/13
09/25/13
09/30/13

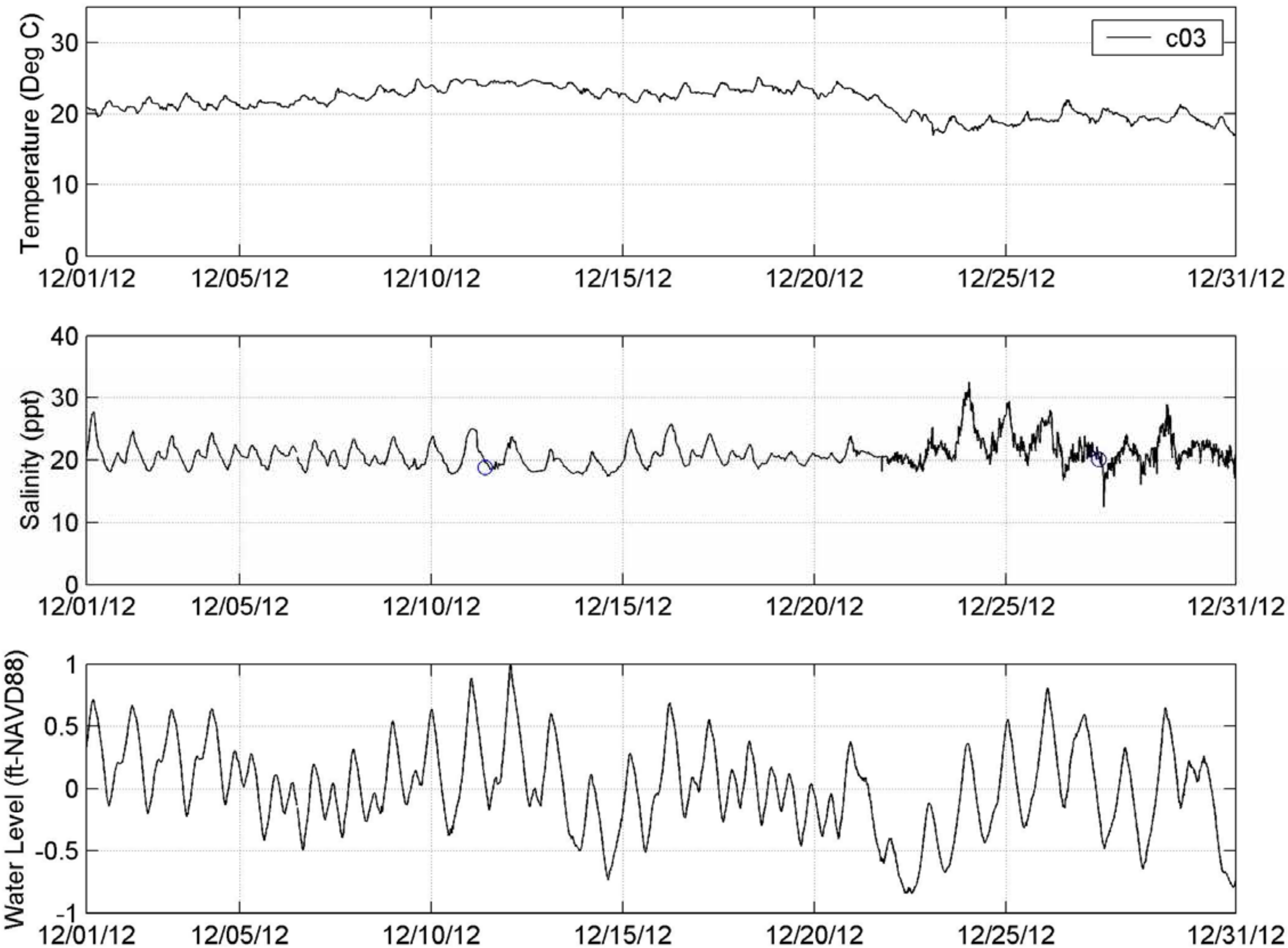


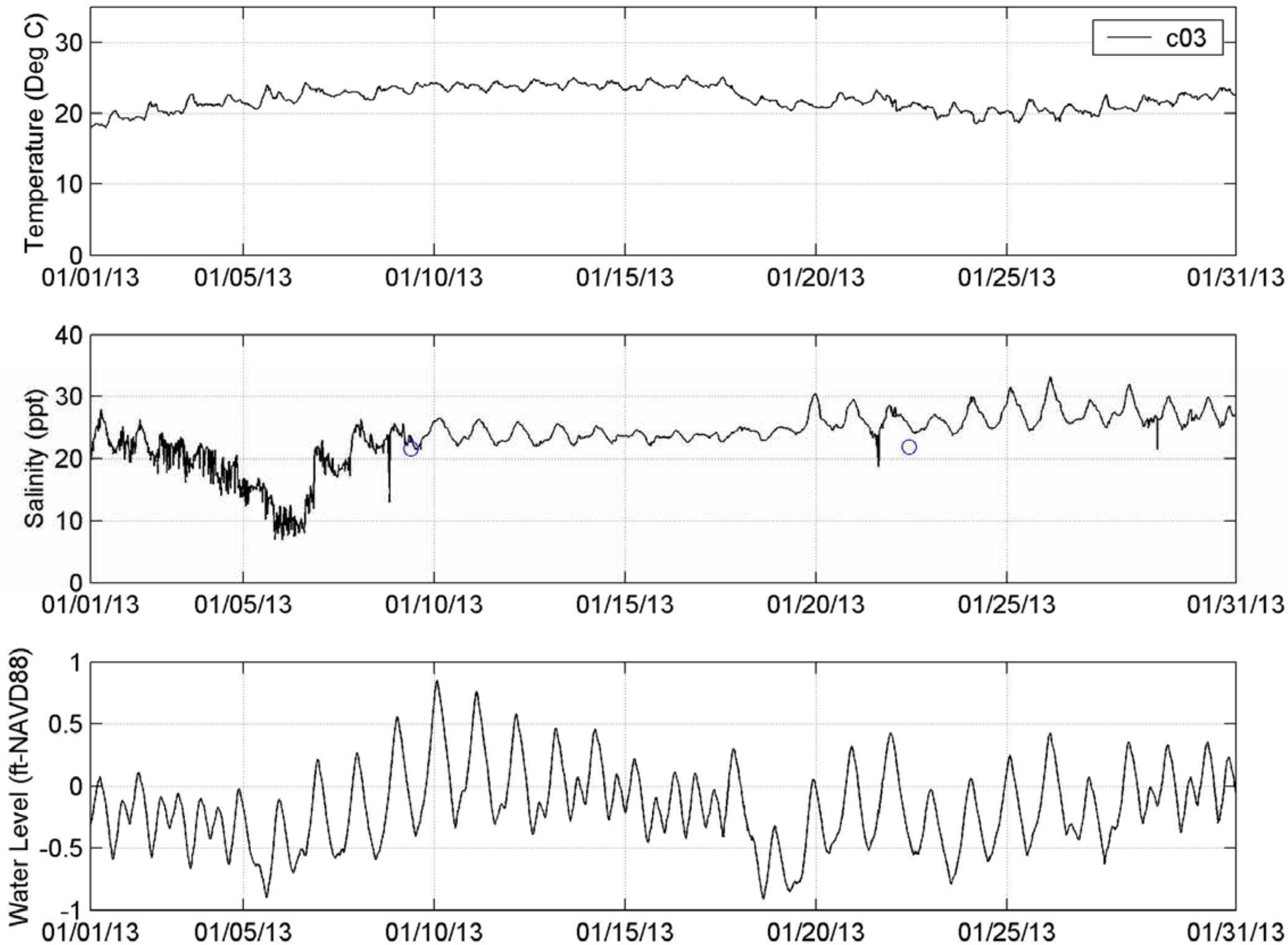
C02
Temperature (Deg C)
0
10
20
30
10/01/13
10/05/13
10/10/13
10/15/13
10/20/13
10/25/13
10/31/13
Salinity (ppt)
40
Water Level (ft-NAVD88)
-0.5
0
0.5
1
1.5


C02
Temperature (Deg C)
0
10
20
30
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
-1
0
1
2
11/01/13
11/05/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13

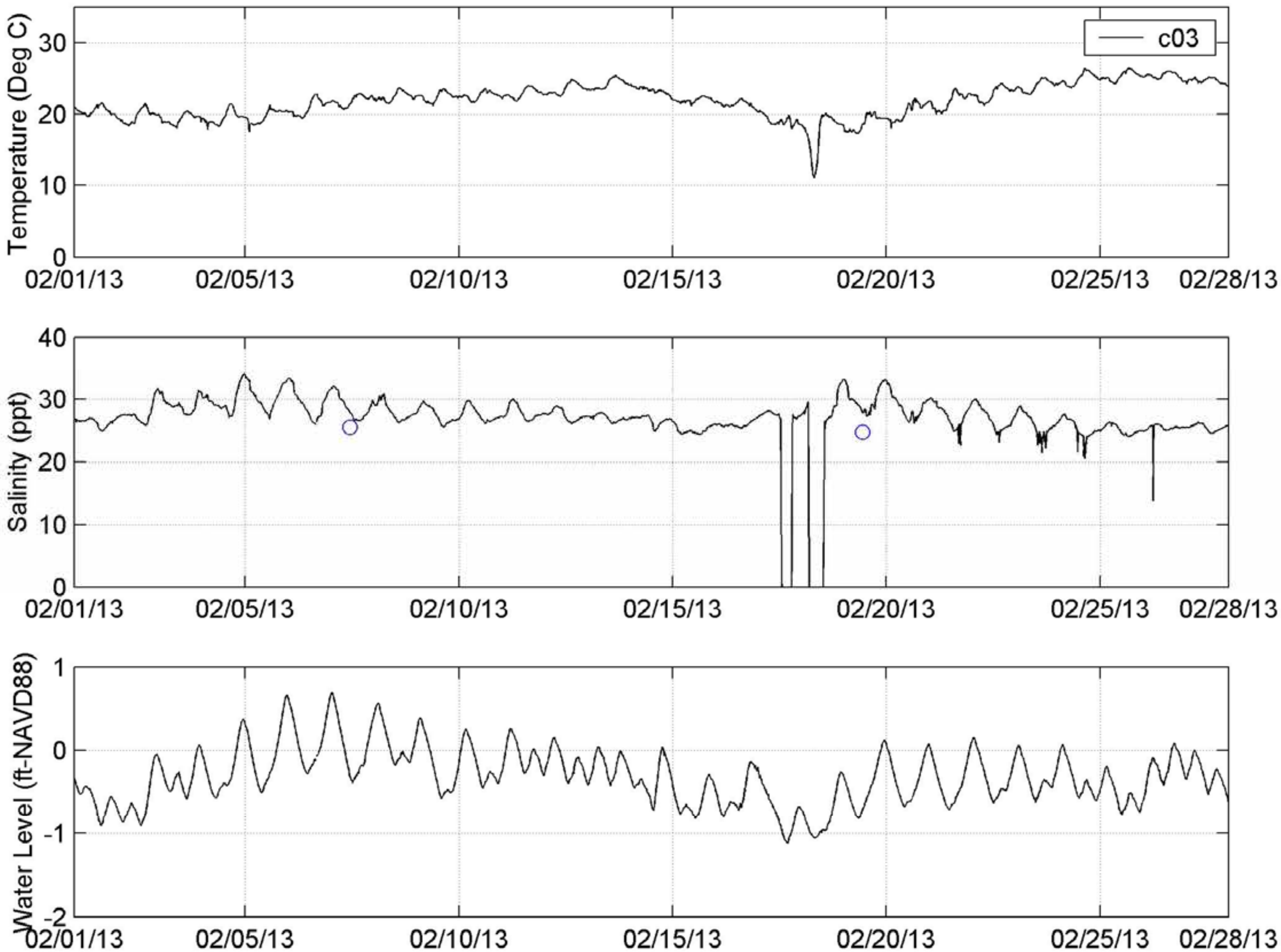

c03
Temperature (Deg C)
30
20
10
0
10/01/12
10/05/12
10/10/12
10/15/12
10/20/12
10/25/12
10/31/12
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
1.5
1
0.5
0
-0.5

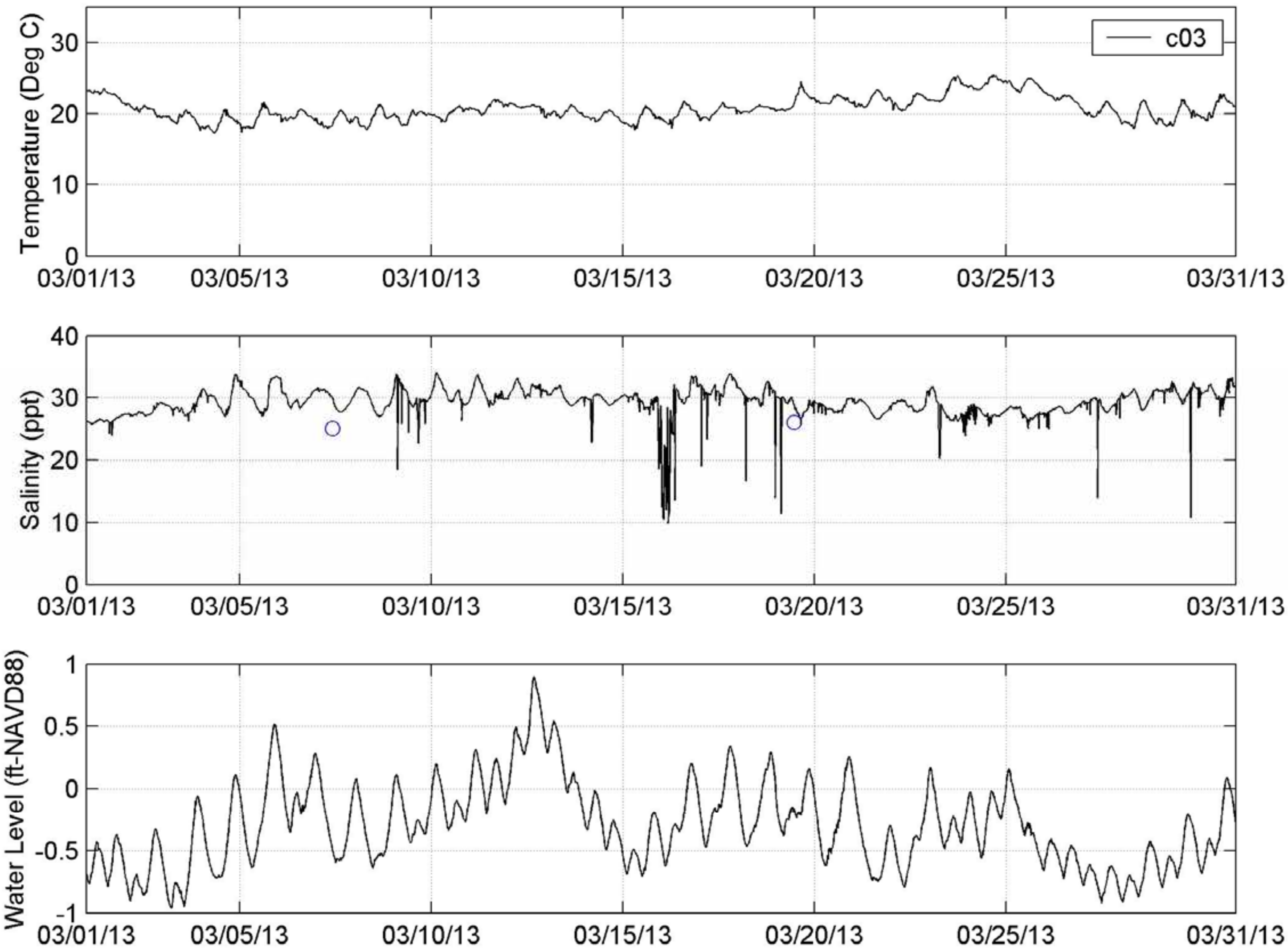

c03
Temperature (Deg C)
0
10
20
30
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
-1
0
1
2
11/01/12
11/05/12
11/10/12
11/15/12
11/20/12
11/25/12
11/30/12

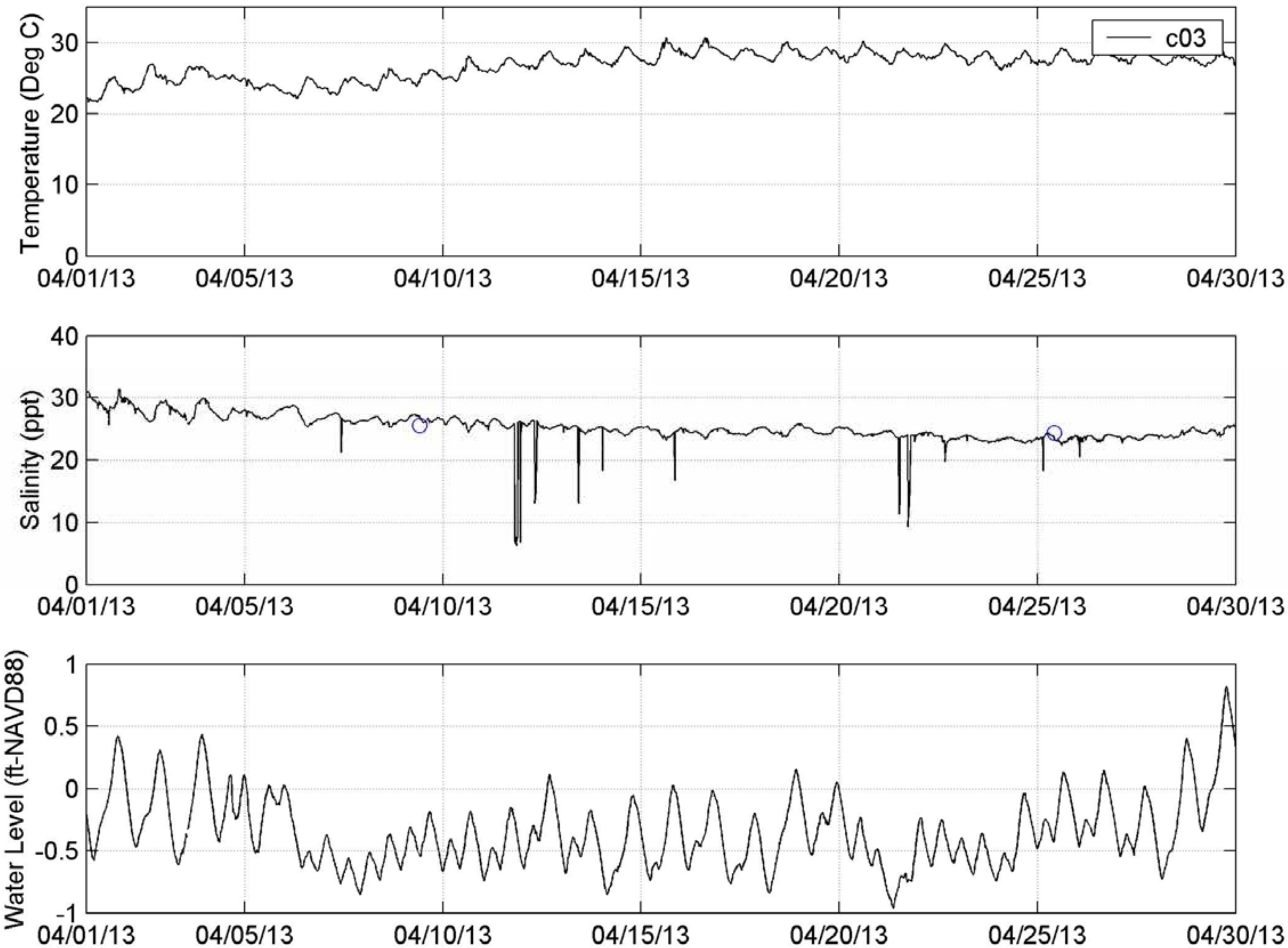

c03
Temperature (Deg C)
0
10
20
30
12/01/12
12/05/12
12/10/12
12/15/12
12/20/12
12/25/12
12/31/12
Salinity (ppt)
0
10
20
30
40
12/01/12
12/05/12
12/10/12
12/15/12
12/20/12
12/25/12
12/31/12
Water Level (ft-NAVD88)
-1
-0.5
0
0.5
1
12/01/12
12/05/12
12/10/12
12/15/12
12/20/12
12/25/12
12/31/12

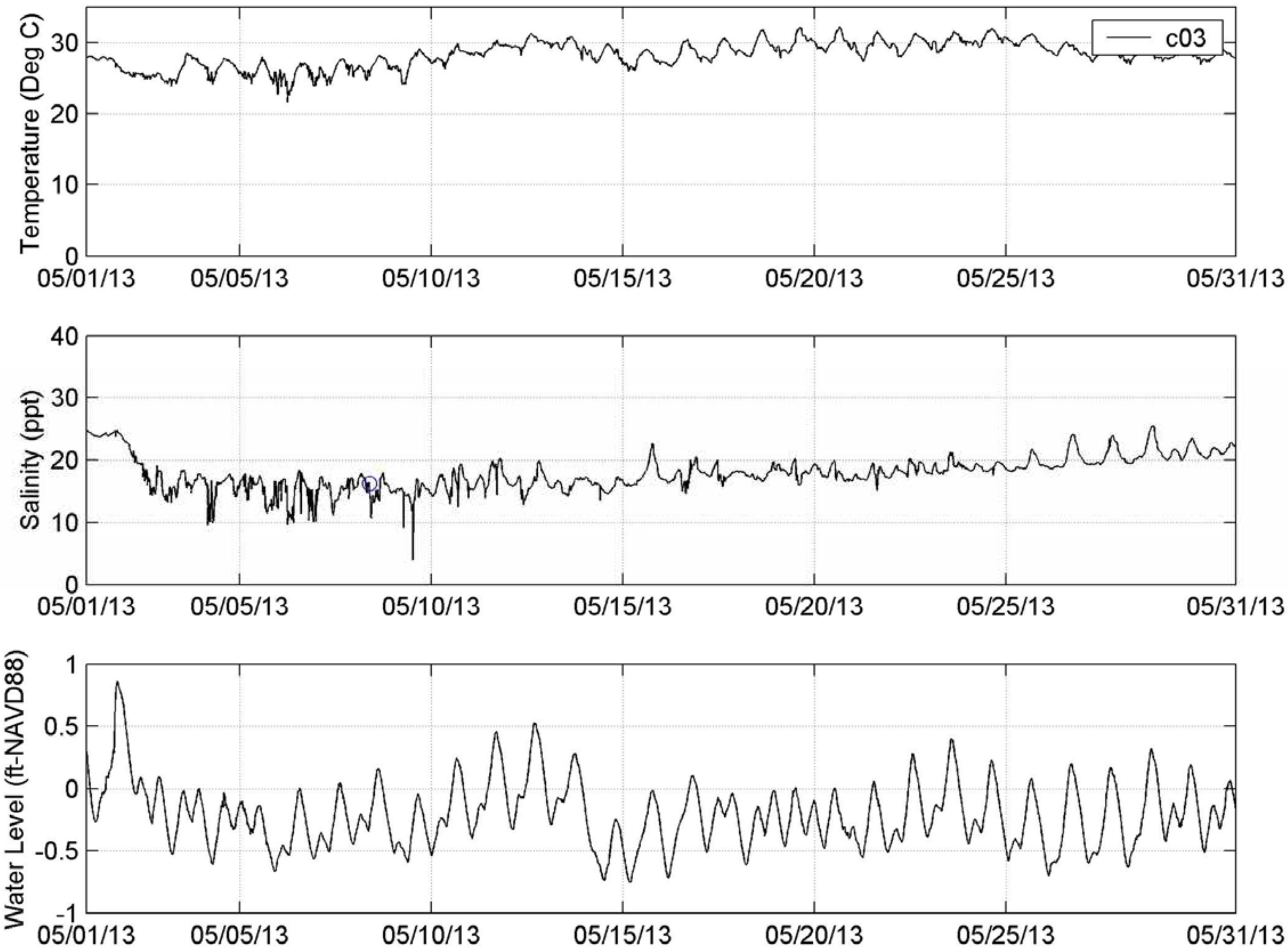


c03
Temperature (Deg C)
0
10
20
30
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
-1
-0.5
0
0.5
1
01/01/13
01/05/13
01/10/13
01/15/13
01/20/13
01/25/13
01/31/13

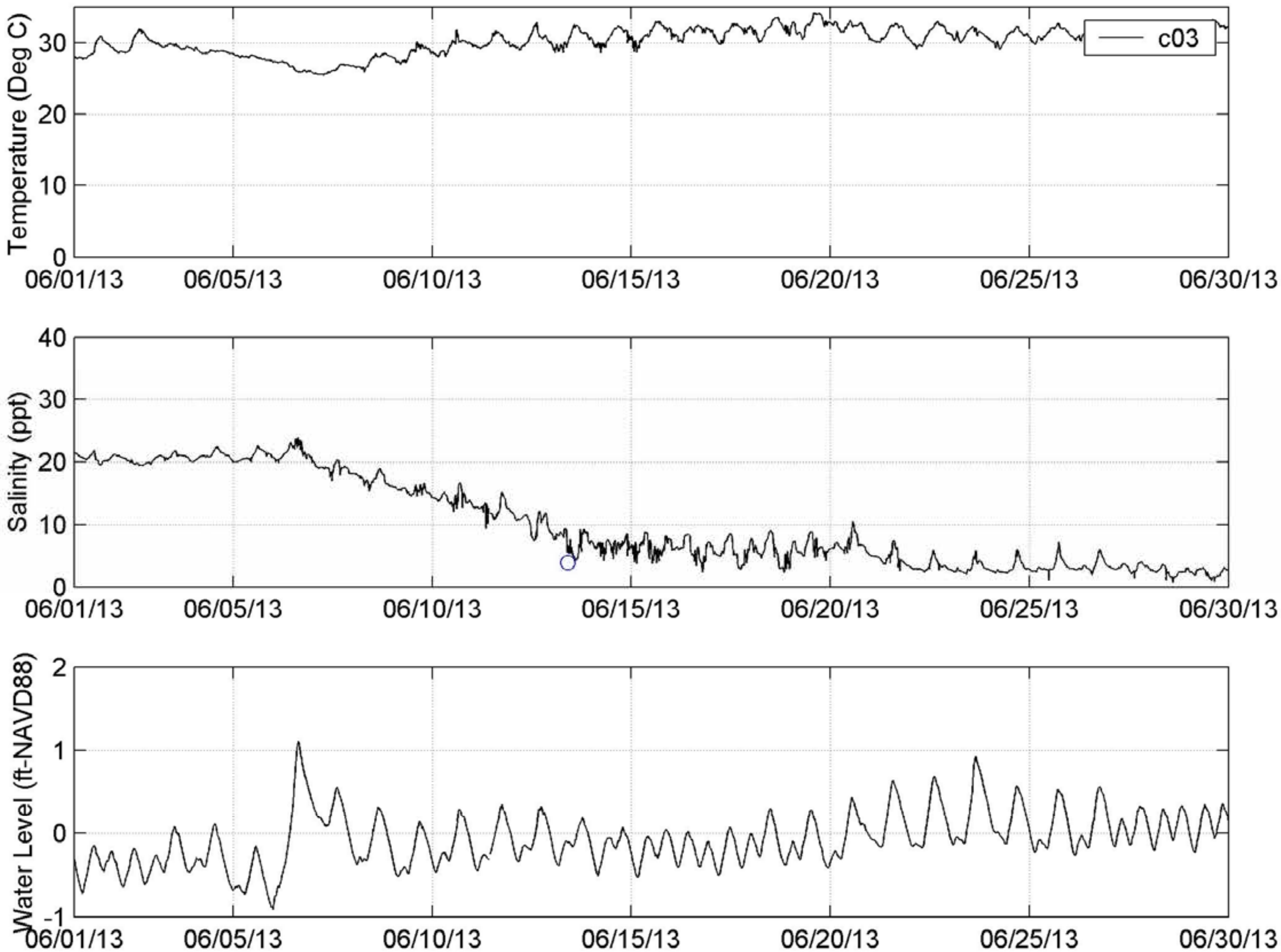

c03
Temperature (Deg C)
30
20
10
0
02/01/13
02/05/13
02/10/13
02/15/13
02/20/13
02/25/13
02/28/13
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
1
0
-1
-2


c03
Temperature (Deg C)
0
10
20
30
03/01/13
03/05/13
03/10/13
03/15/13
03/20/13
03/25/13
03/31/13
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
-1
-0.5
0
0.5
1

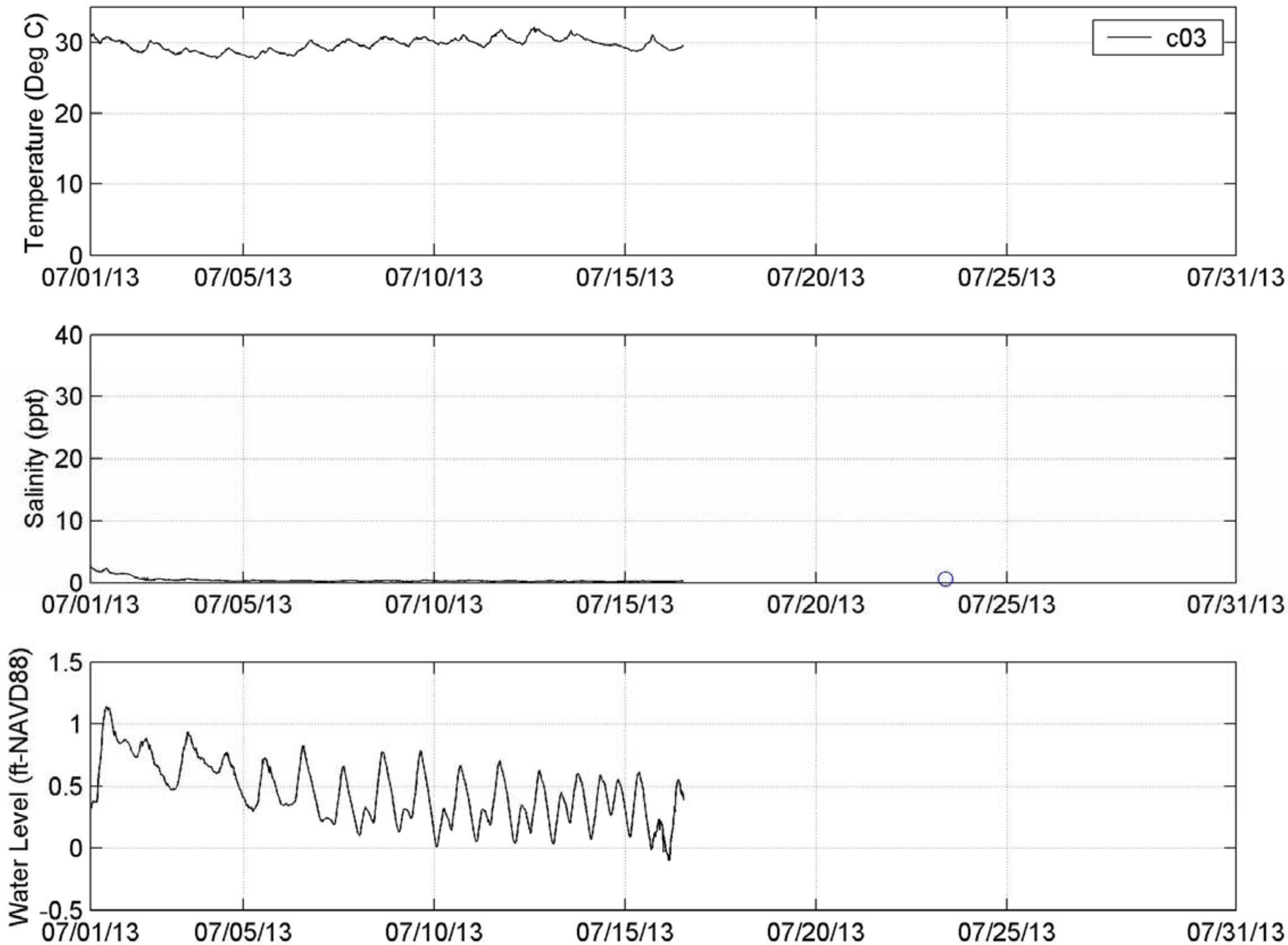

c03
Temperature (Deg C)
0
10
20
30
04/01/13
04/05/13
04/10/13
04/15/13
04/20/13
04/25/13
04/30/13
Salinity (ppt)
0
10
20
30
40
04/01/13
04/05/13
04/10/13
04/15/13
04/20/13
04/25/13
04/30/13
Water Level (ft-NAVD88)
-1
-0.5
0
0.5
1
04/01/13
04/05/13
04/10/13
04/15/13
04/20/13
04/25/13
04/30/13

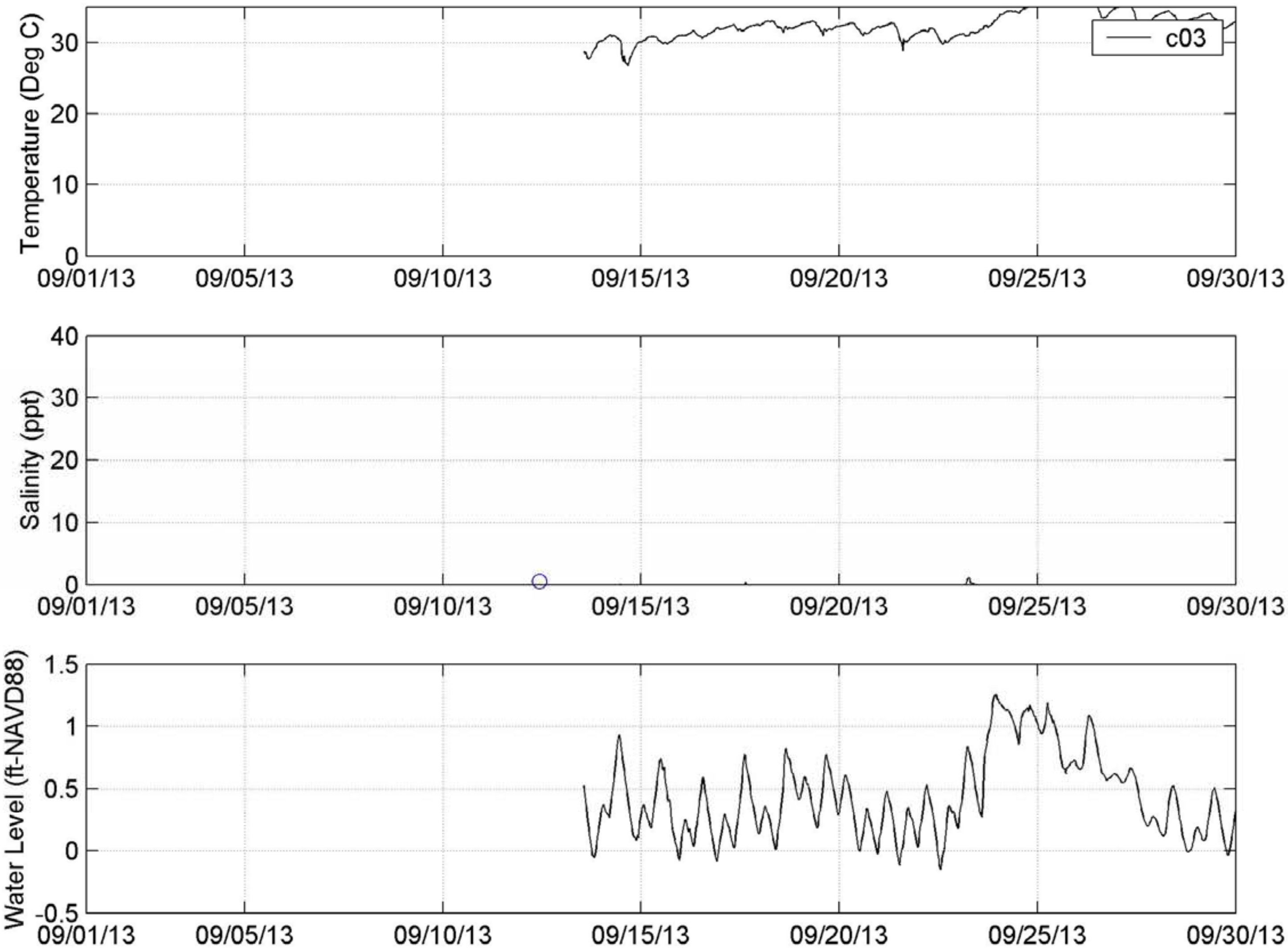


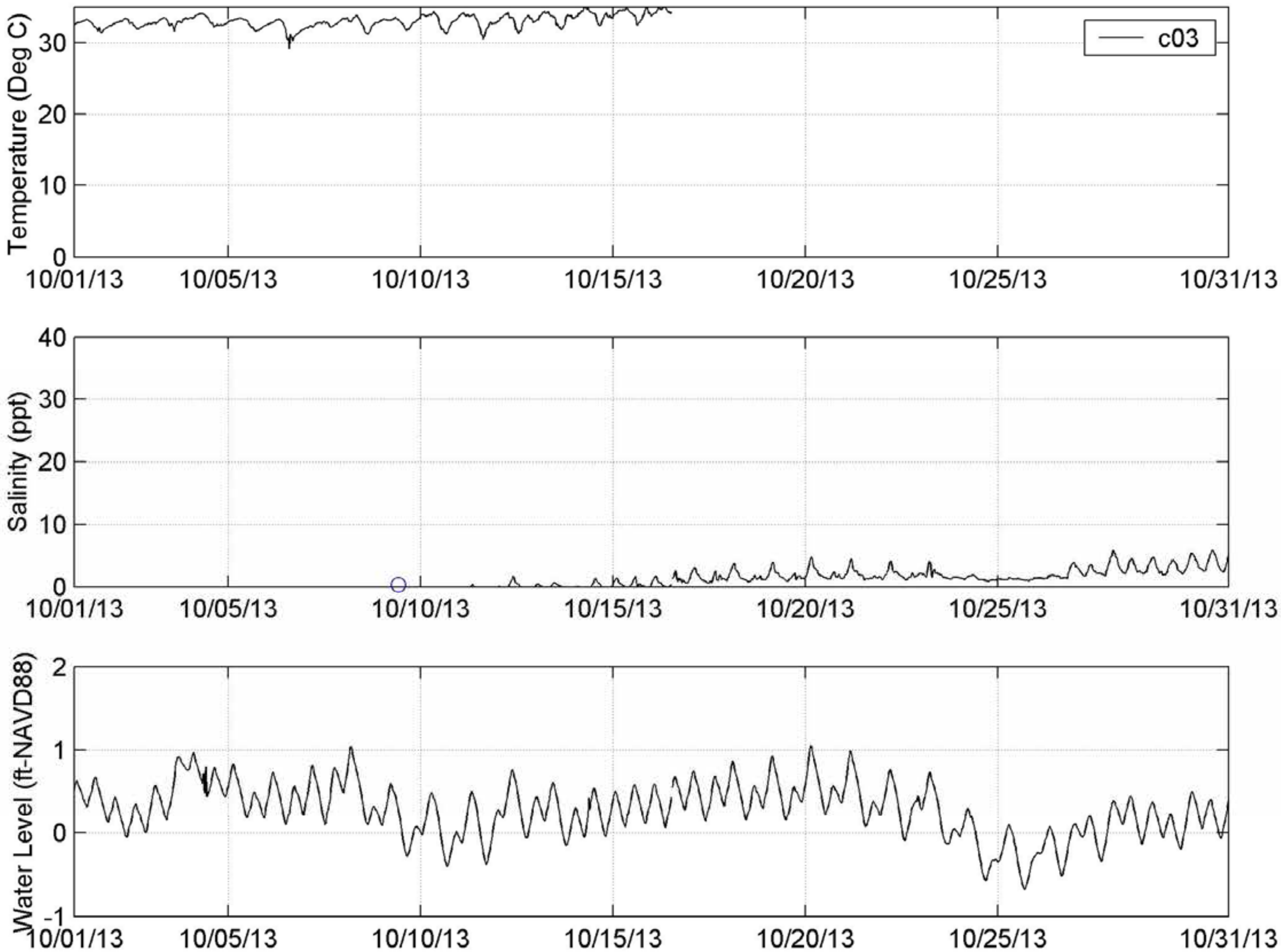
Temperature (Deg C)
c03
Salinity (ppt)
Water Level (ft-NAVD88)
05/01/13
05/05/13
05/10/13
05/15/13
05/20/13
05/25/13
05/31/13



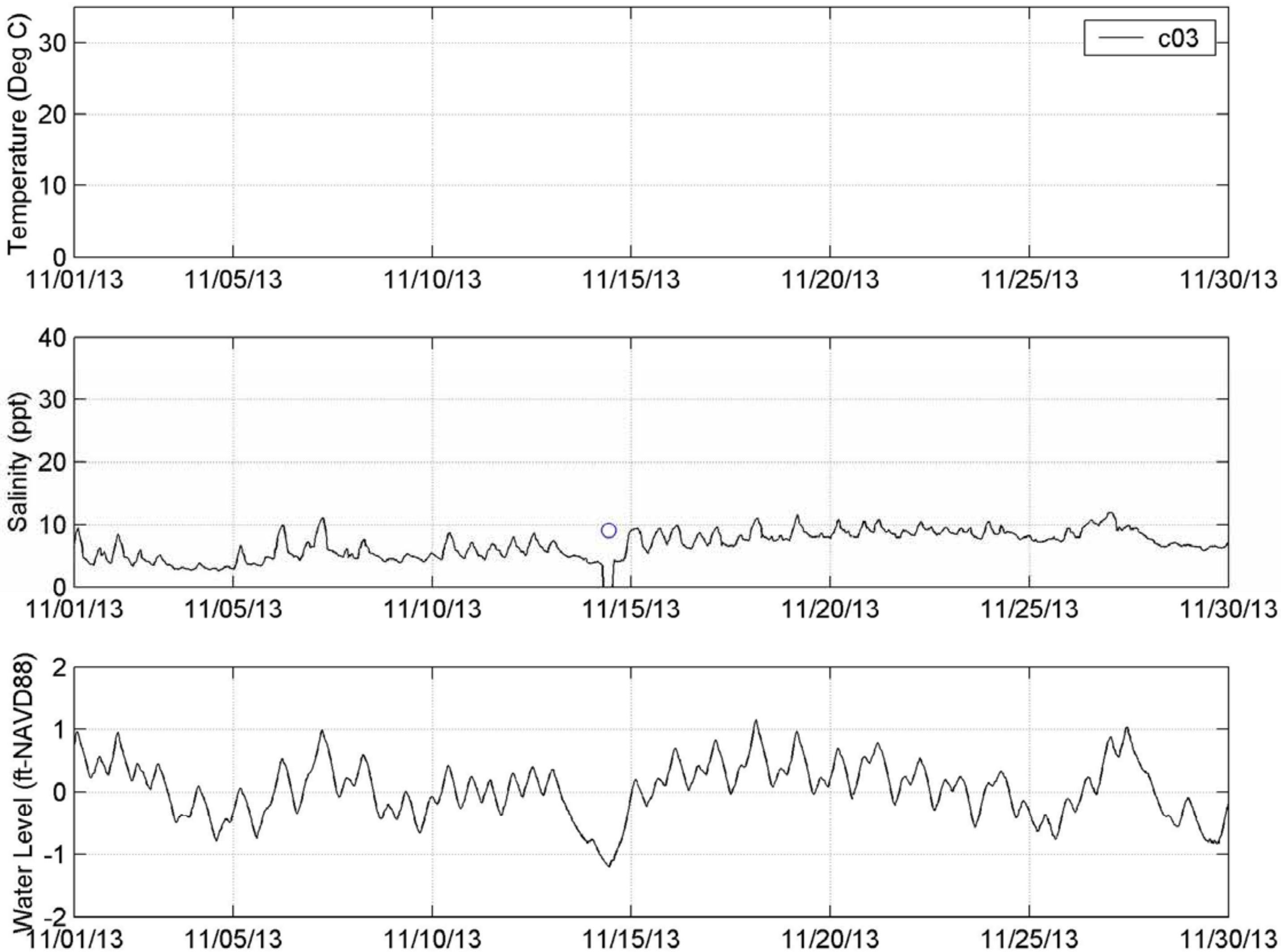
Temperature (Deg C)
c03
Salinity (ppt)
Water Level (ft-NAVD88)
06/01/13
06/05/13
06/10/13
06/15/13
06/20/13
06/25/13
06/30/13

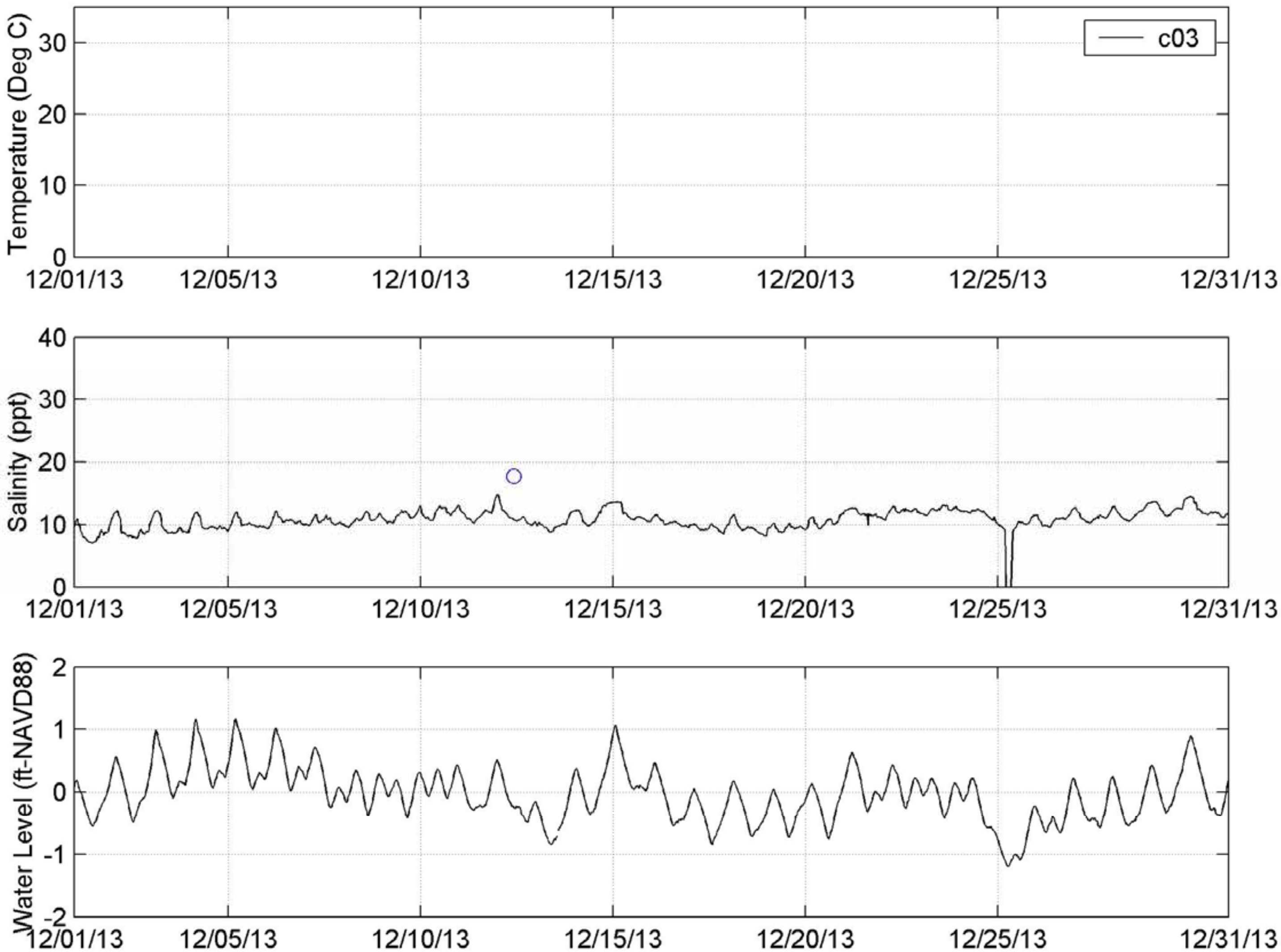

Temperature (Deg C)
30
20
10
0
07/01/13
07/05/13
07/10/13
07/15/13
07/20/13
07/25/13
07/31/13
c03
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
1.5
1
0.5
0
-0.5

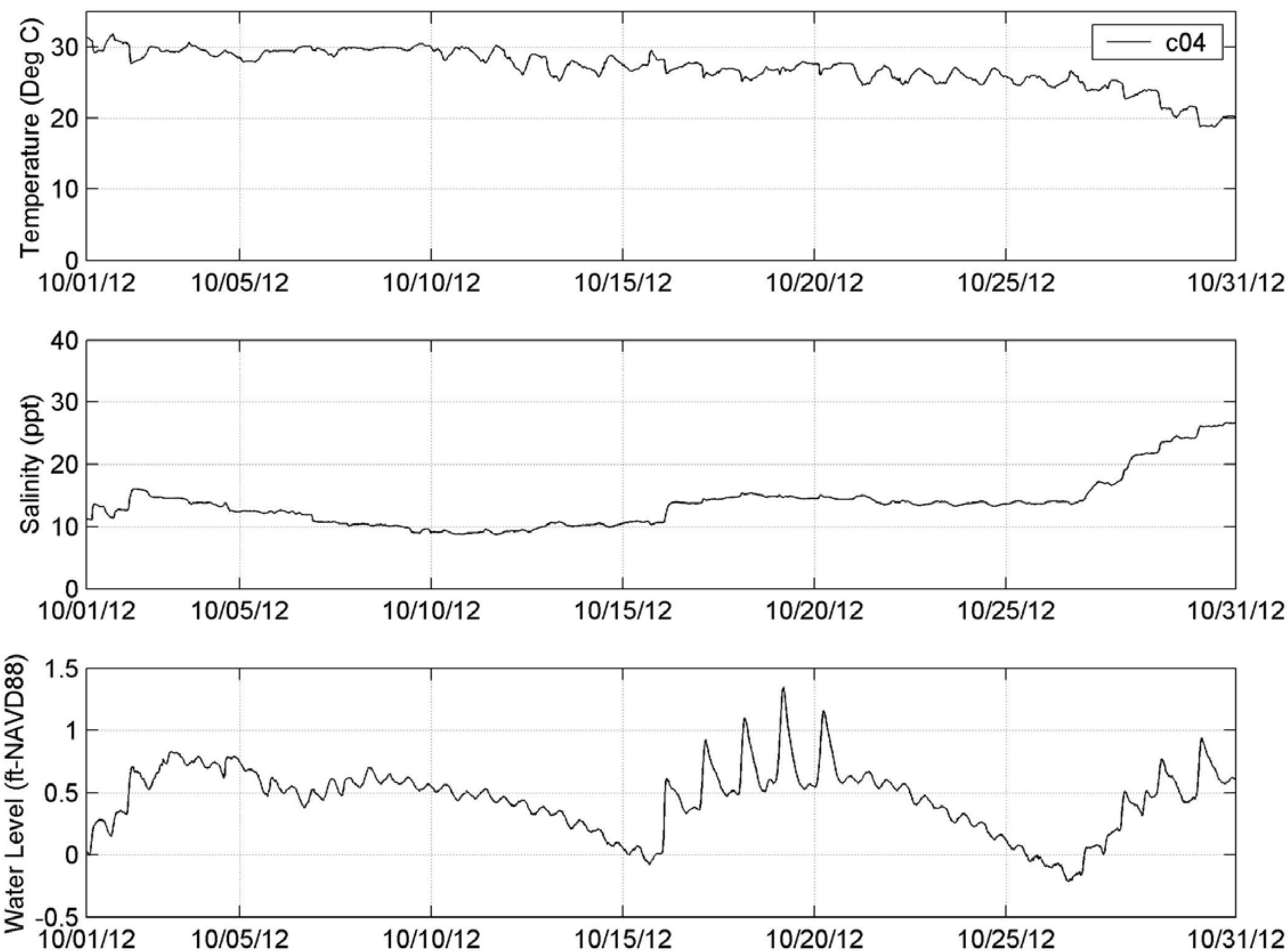

Temperature (Deg C)
c03
Salinity (ppt)
Water Level (ft-NAVD88)
09/01/13
09/05/13
09/10/13
09/15/13
09/20/13
09/25/13
09/30/13



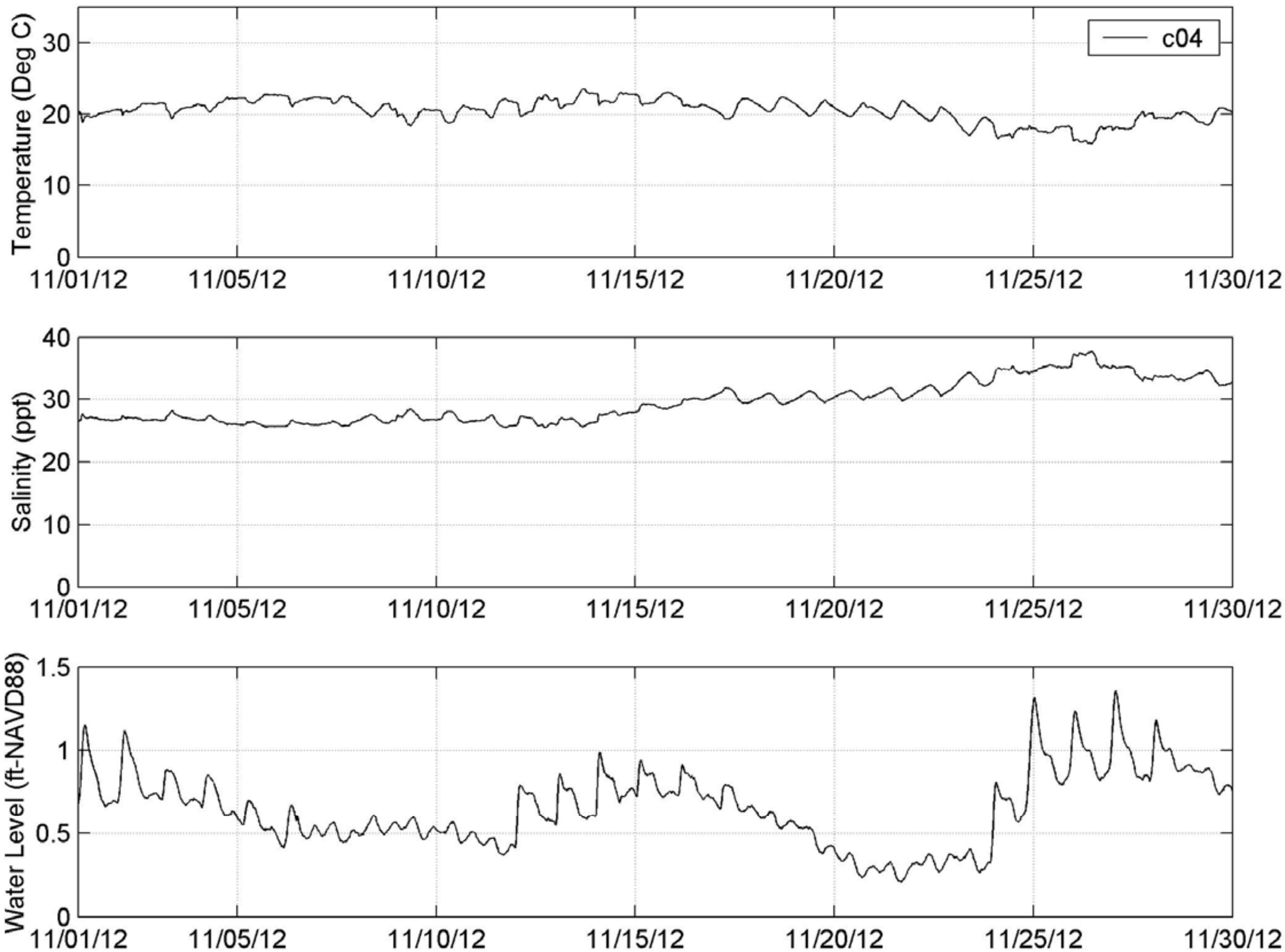
Temperature (Deg C)
0
10
20
30
c03
10/01/13
10/05/13
10/10/13
10/15/13
10/20/13
10/25/13
10/31/13
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
-1
0
1
2


c03
Temperature (Deg C)
0
10
20
30
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
-2
-1
0
1
2
11/01/13
11/05/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13

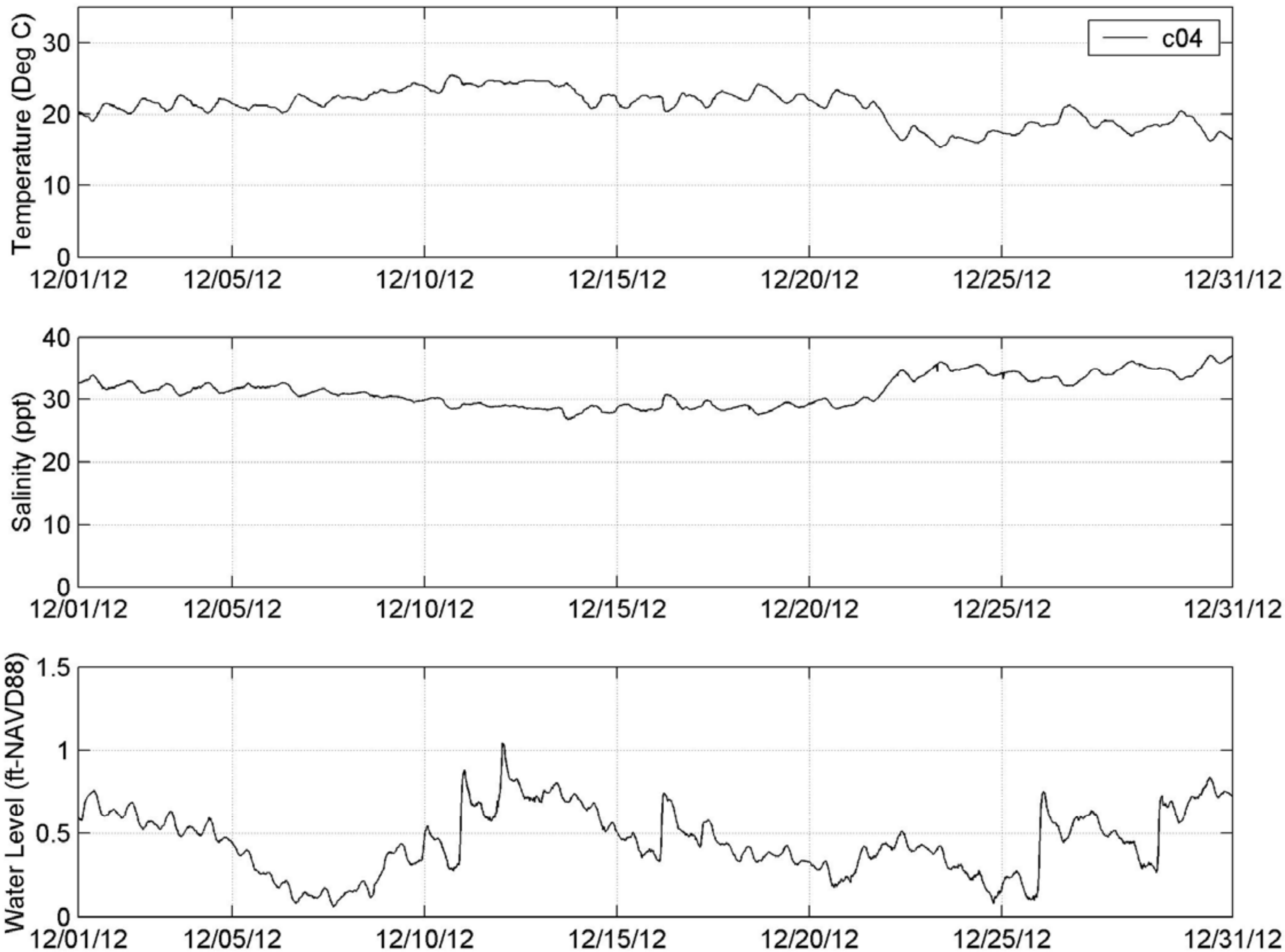

c03
Temperature (Deg C)
Salinity (ppt)
Water Level (ft-NAVD88)
12/01/13
12/05/13
12/10/13
12/15/13
12/20/13
12/25/13
12/31/13

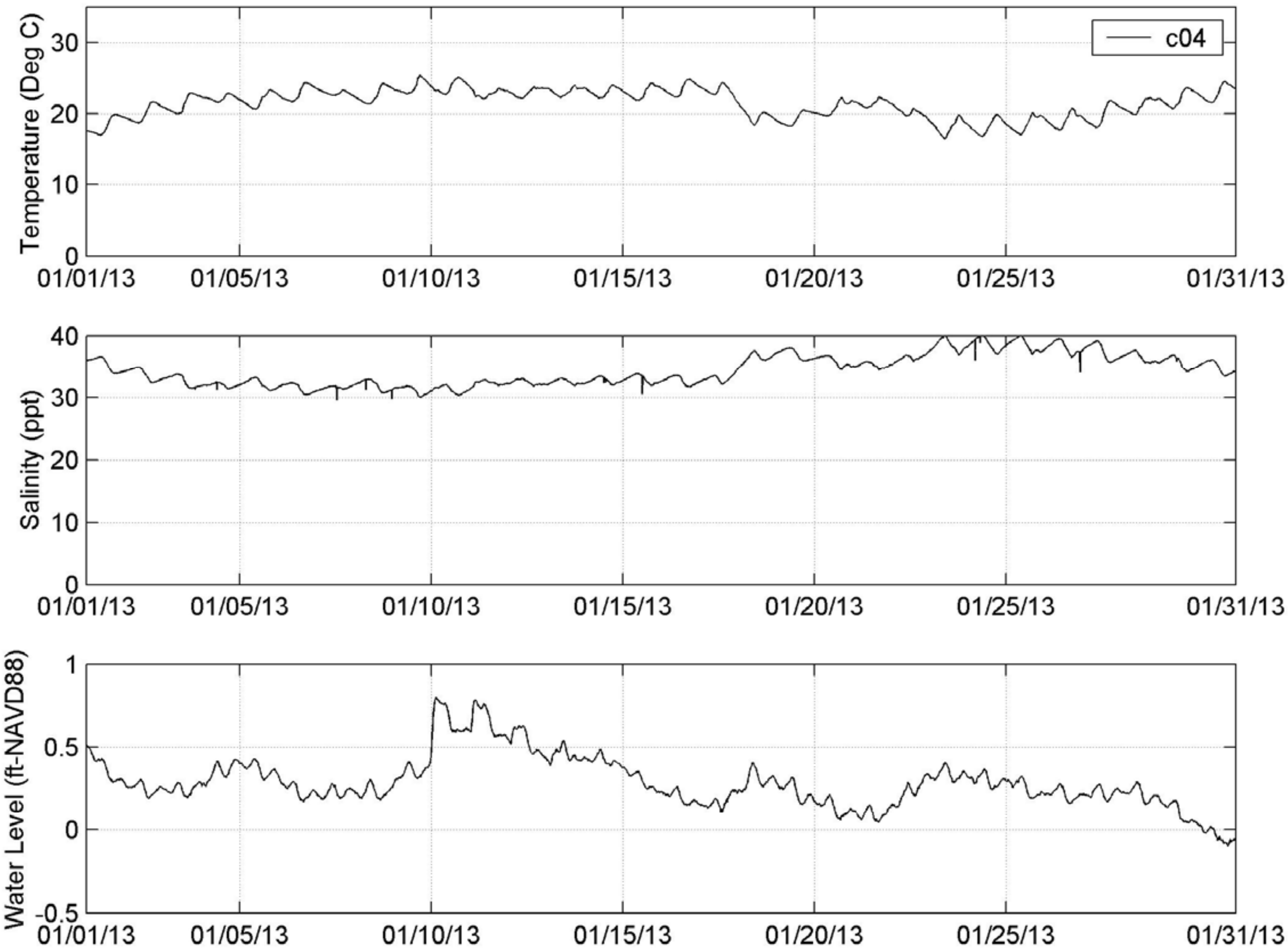


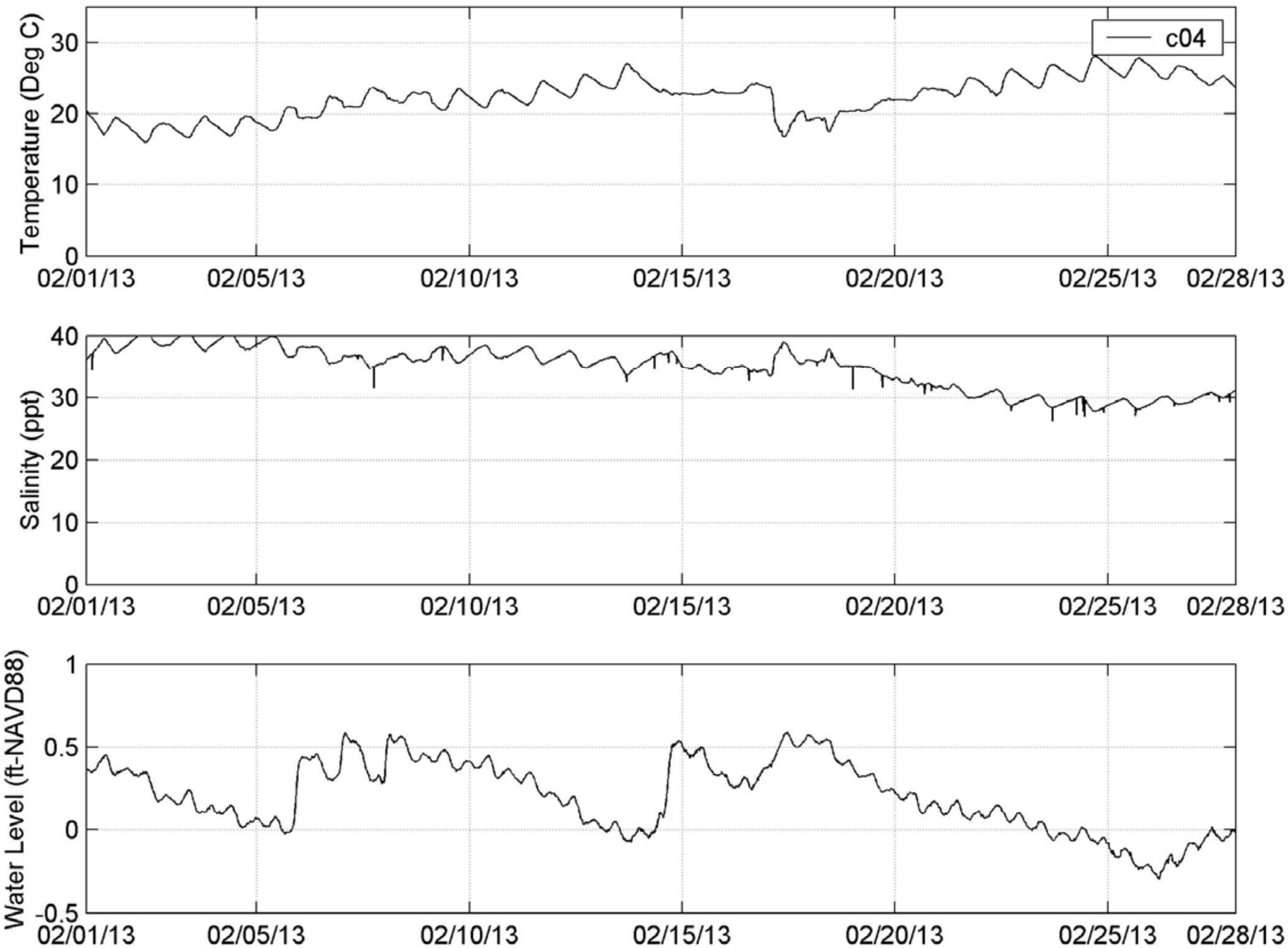
c04
Temperature (Deg C)
0
10
20
30
10/01/12
10/05/12
10/10/12
10/15/12
10/20/12
10/25/12
10/31/12
Salinity (ppt)
0
10
20
30
40
10/01/12
10/05/12
10/10/12
10/15/12
10/20/12
10/25/12
10/31/12
Water Level (ft-NAVD88)
-0.5
0
0.5
1
1.5
10/01/12
10/05/12
10/10/12
10/15/12
10/20/12
10/25/12
10/31/12

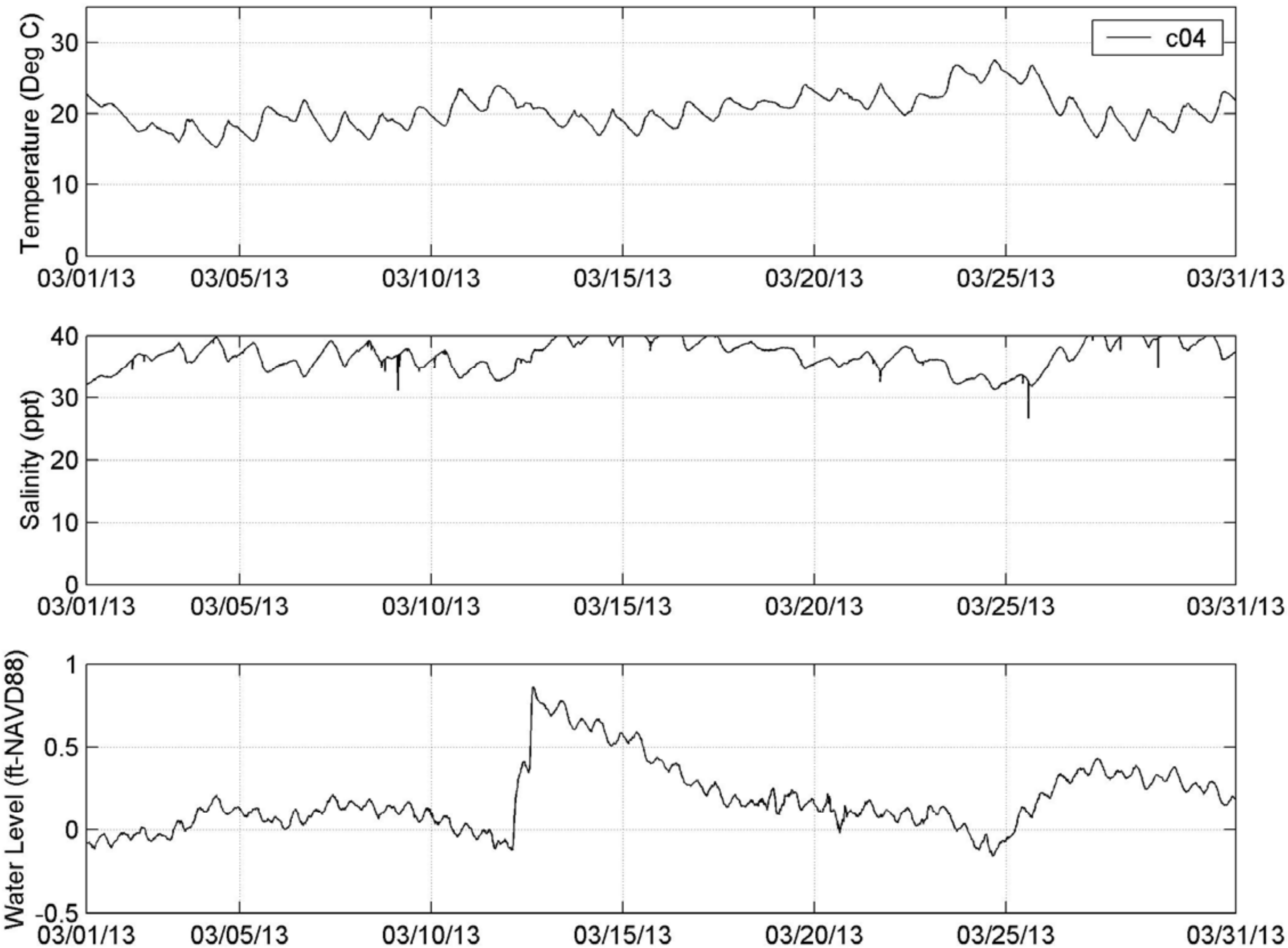


Temperature (Deg C)
c04
Salinity (ppt)
Water Level (ft-NAVD88)
11/01/12
11/05/12
11/10/12
11/15/12
11/20/12
11/25/12
11/30/12

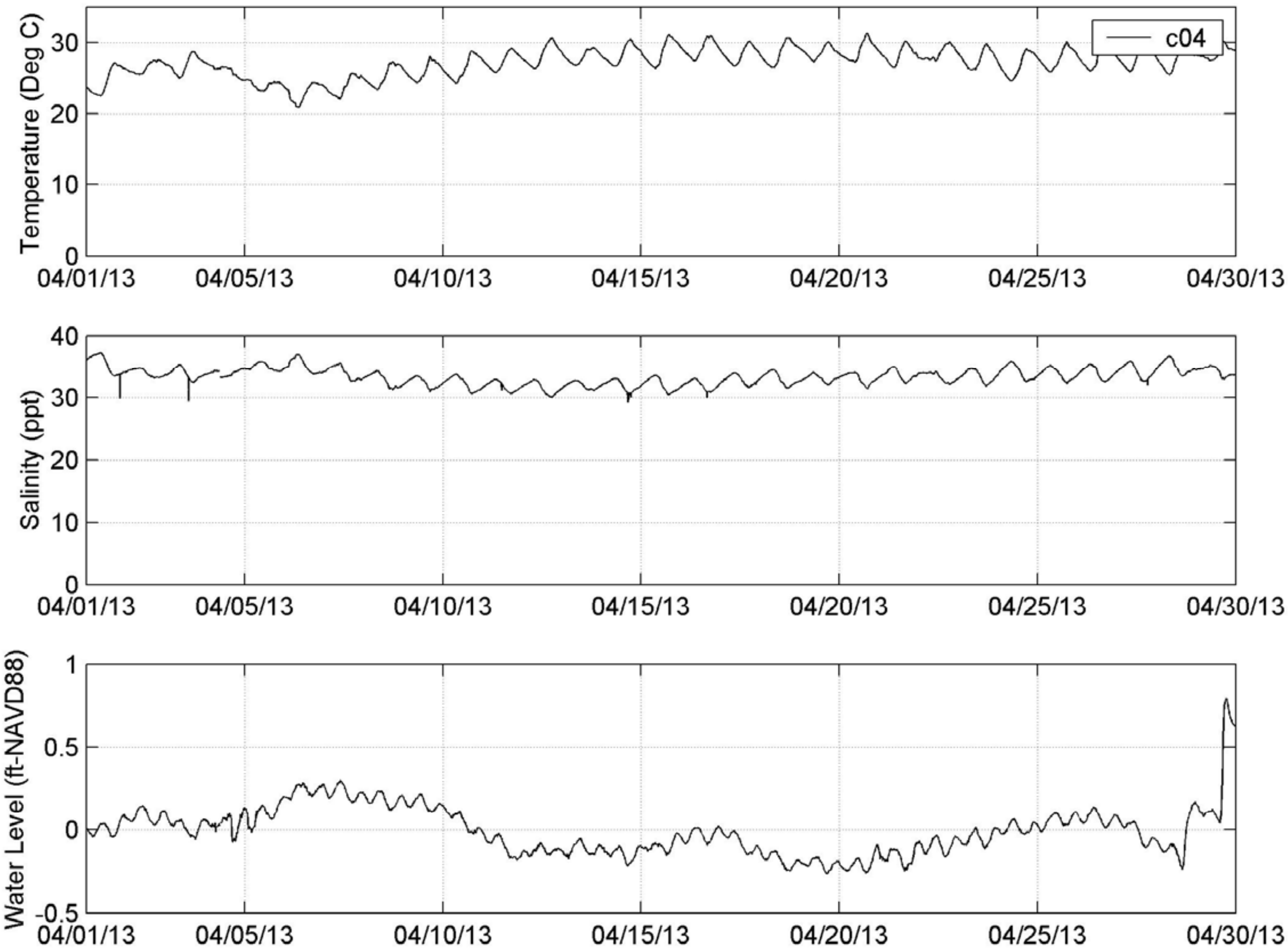

c04
Temperature (Deg C)
0
10
20
30
12/01/12
12/05/12
12/10/12
12/15/12
12/20/12
12/25/12
12/31/12
Salinity (ppt)
0
10
20
30
40
12/01/12
12/05/12
12/10/12
12/15/12
12/20/12
12/25/12
12/31/12
Water Level (ft-NAVD88)
0
0.5
1
1.5
12/01/12
12/05/12
12/10/12
12/15/12
12/20/12
12/25/12
12/31/12

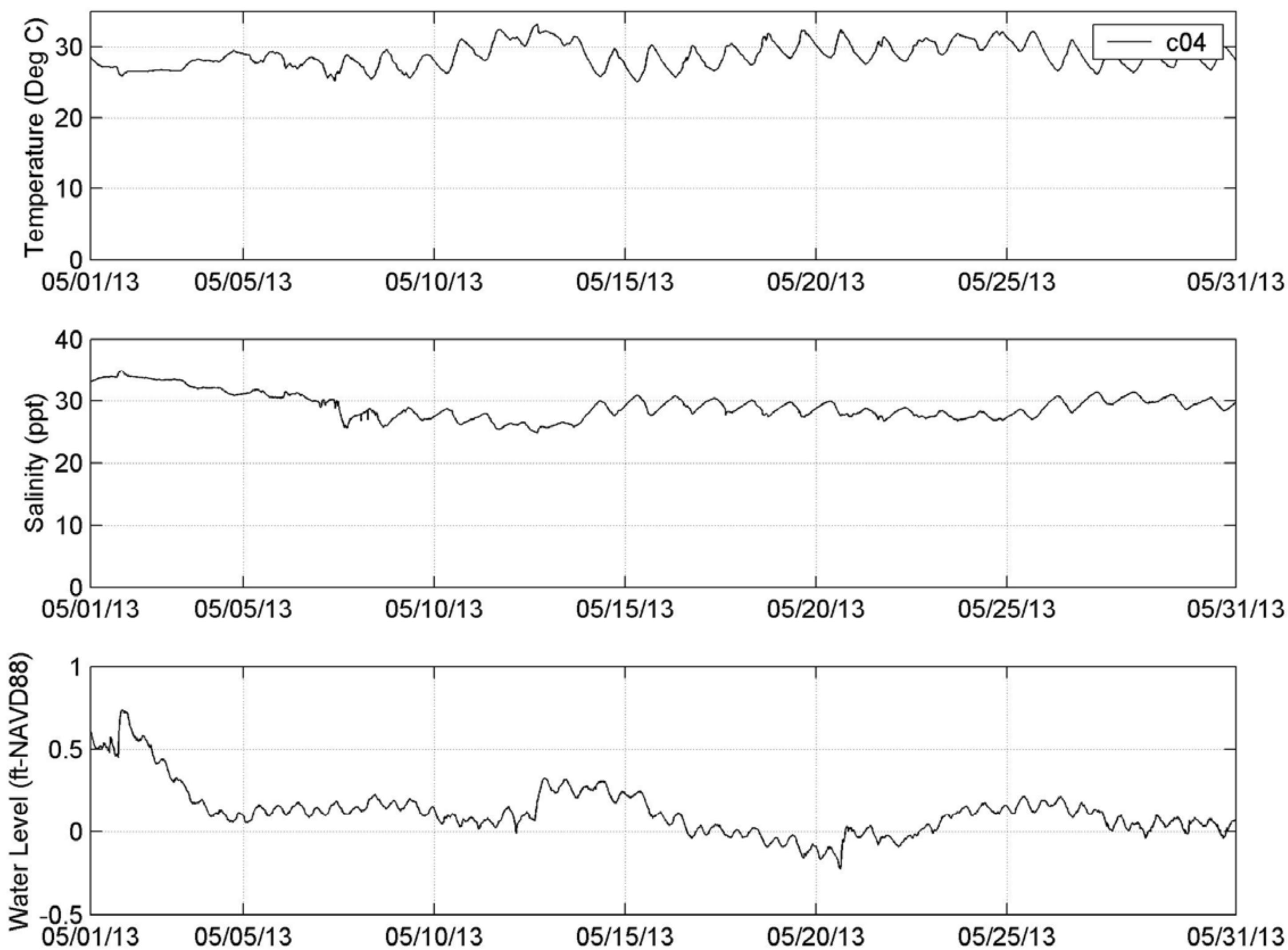

c04
Temperature (Deg C)
0
10
20
30
01/01/13
01/05/13
01/10/13
01/15/13
01/20/13
01/25/13
01/31/13
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
-0.5
0
0.5
1


c04
Temperature (Deg C)
0
10
20
30
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
-0.5
0
0.5
1
02/01/13
02/05/13
02/10/13
02/15/13
02/20/13
02/25/13
02/28/13

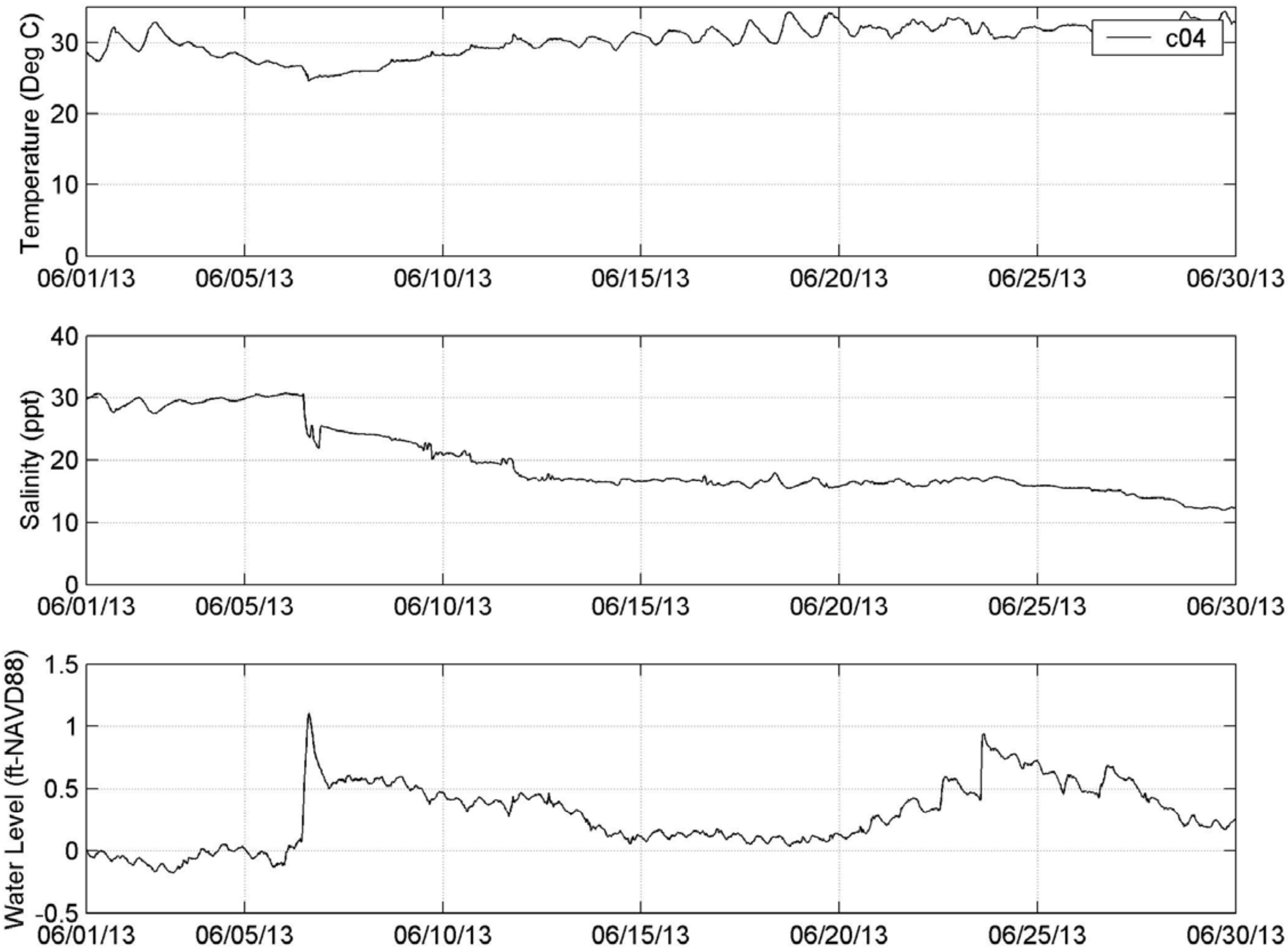


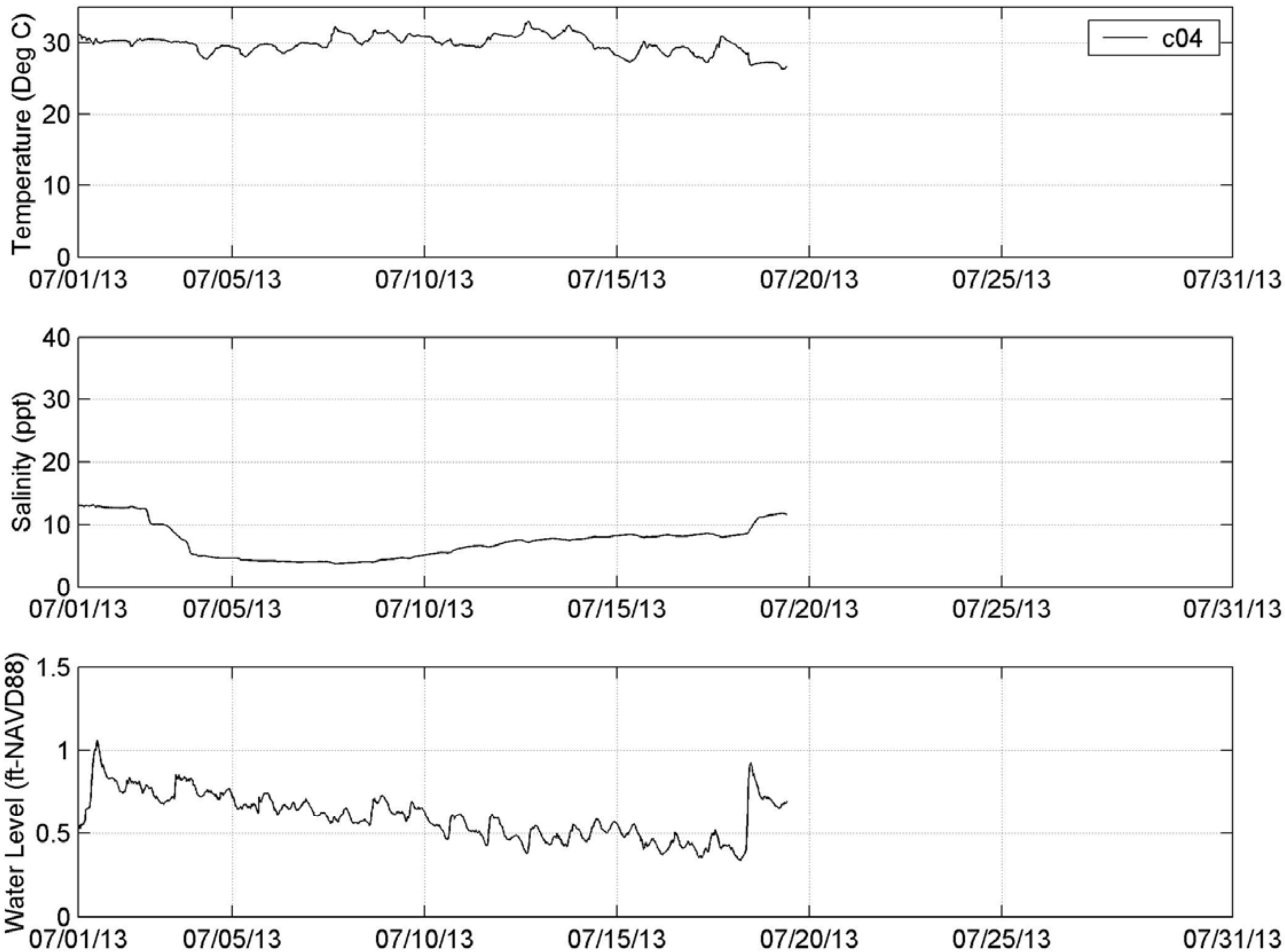
c04
Temperature (Deg C)
0
10
20
30
03/01/13
03/05/13
03/10/13
03/15/13
03/20/13
03/25/13
03/31/13
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
-0.5
0
0.5
1

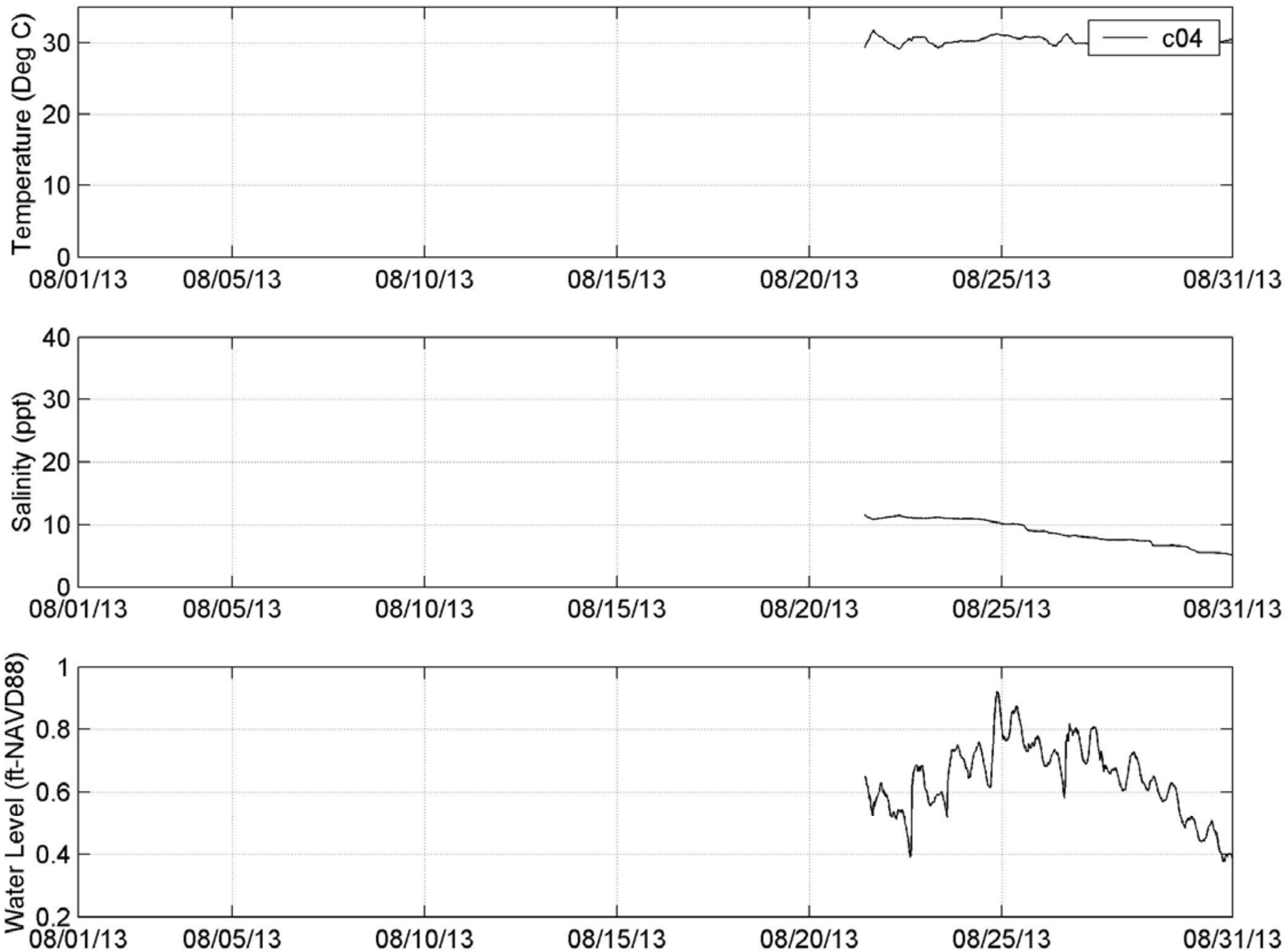

Temperature (Deg C)
c04
0
10
20
30
04/01/13
04/05/13
04/10/13
04/15/13
04/20/13
04/25/13
04/30/13
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
-0.5
0
0.5
1



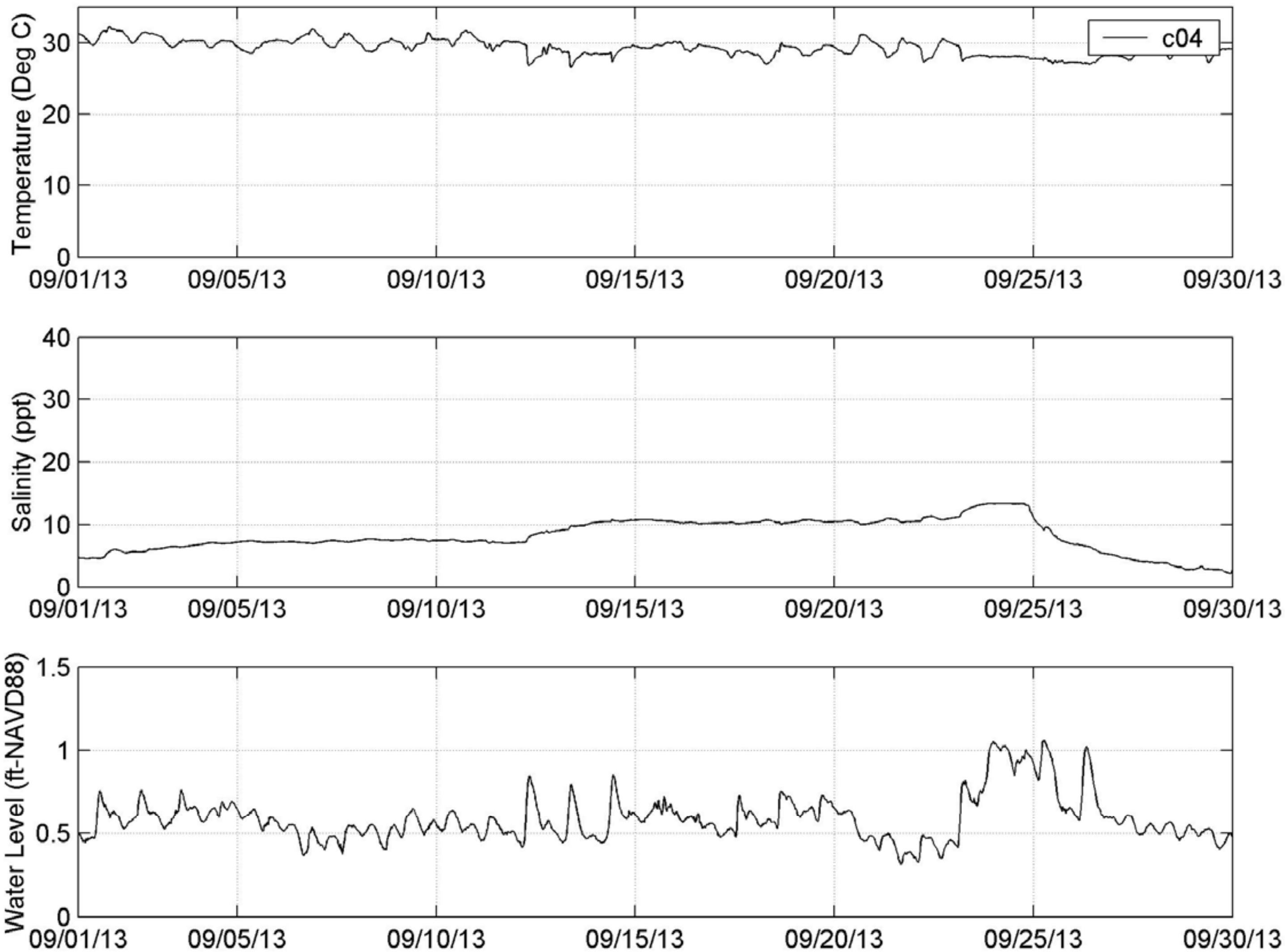
Temperature (Deg C)
0
10
20
30
c04
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
-0.5
0
0.5
1
05/01/13
05/05/13
05/10/13
05/15/13
05/20/13
05/25/13
05/31/13

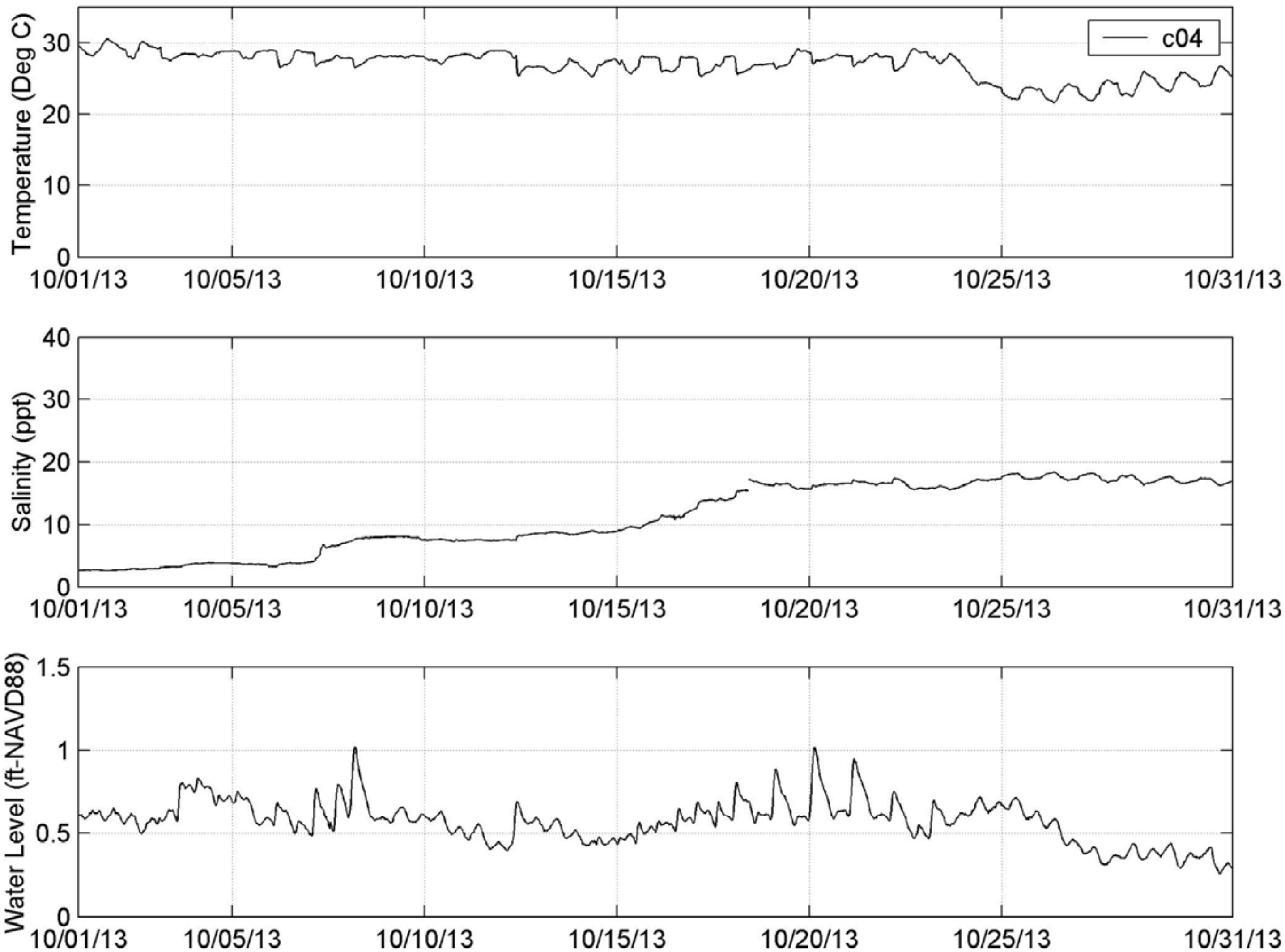

Temperature (Deg C)
c04
Salinity (ppt)
Water Level (ft-NAVD88)
06/01/13
06/05/13
06/10/13
06/15/13
06/20/13
06/25/13
06/30/13


c04
Temperature (Deg C)
0
10
20
30
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
0
0.5
1
1.5
07/01/13
07/05/13
07/10/13
07/15/13
07/20/13
07/25/13
07/31/13

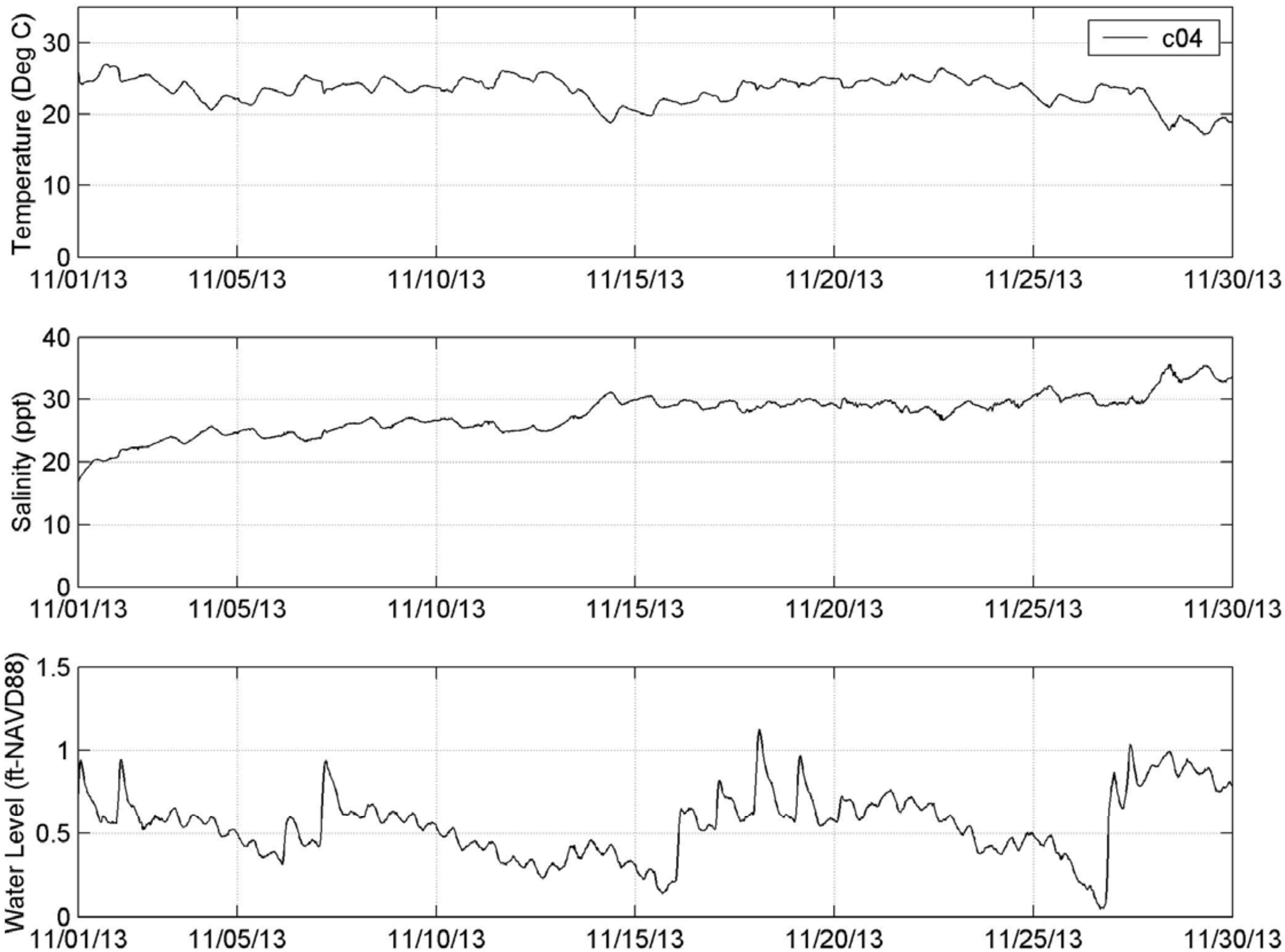


Temperature (Deg C)
30
20
10
0
c04
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
1
0.8
0.6
0.4
0.2
08/01/13
08/05/13
08/10/13
08/15/13
08/20/13
08/25/13
08/31/13

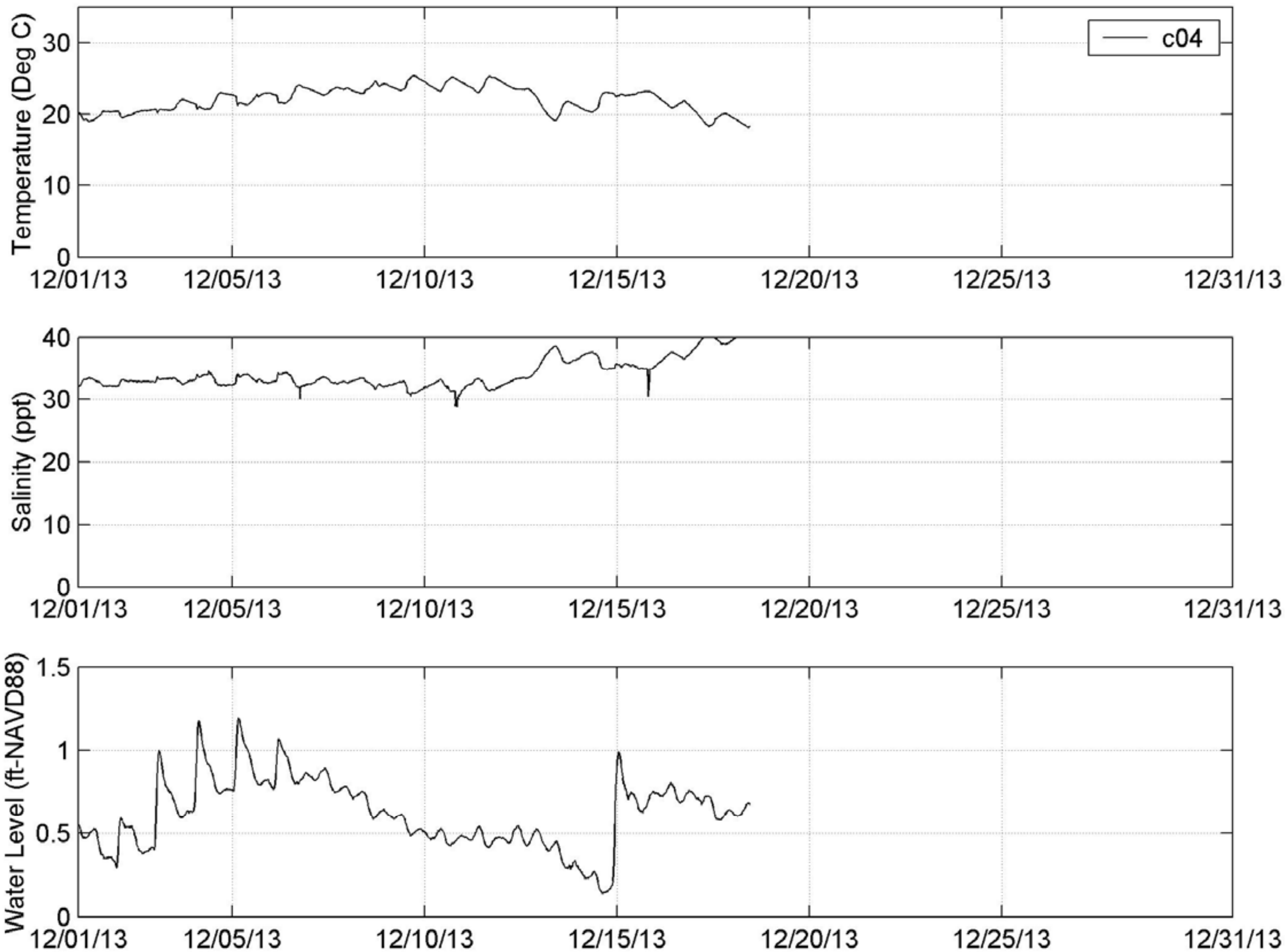

Temperature (Deg C)
30
20
10
0
c04
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
1.5
1
0.5
0
09/01/13
09/05/13
09/10/13
09/15/13
09/20/13
09/25/13
09/30/13



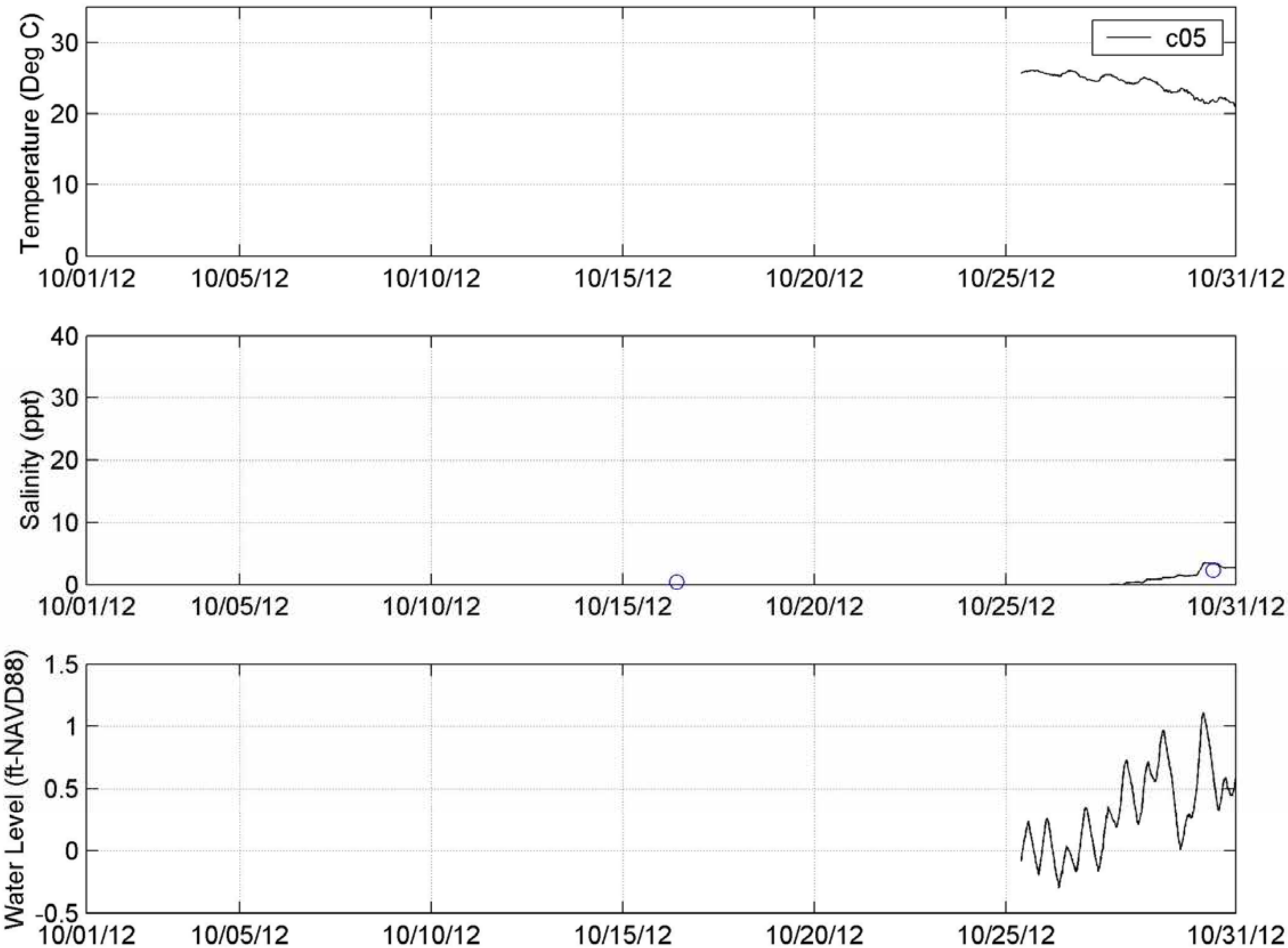
c04
Temperature (Deg C)
0
10
20
30
10/01/13
10/05/13
10/10/13
10/15/13
10/20/13
10/25/13
10/31/13
Salinity (ppt)
0
10
20
30
40
10/01/13
10/05/13
10/10/13
10/15/13
10/20/13
10/25/13
10/31/13
Water Level (ft-NAVD88)
0
0.5
1
1.5
10/01/13
10/05/13
10/10/13
10/15/13
10/20/13
10/25/13
10/31/13



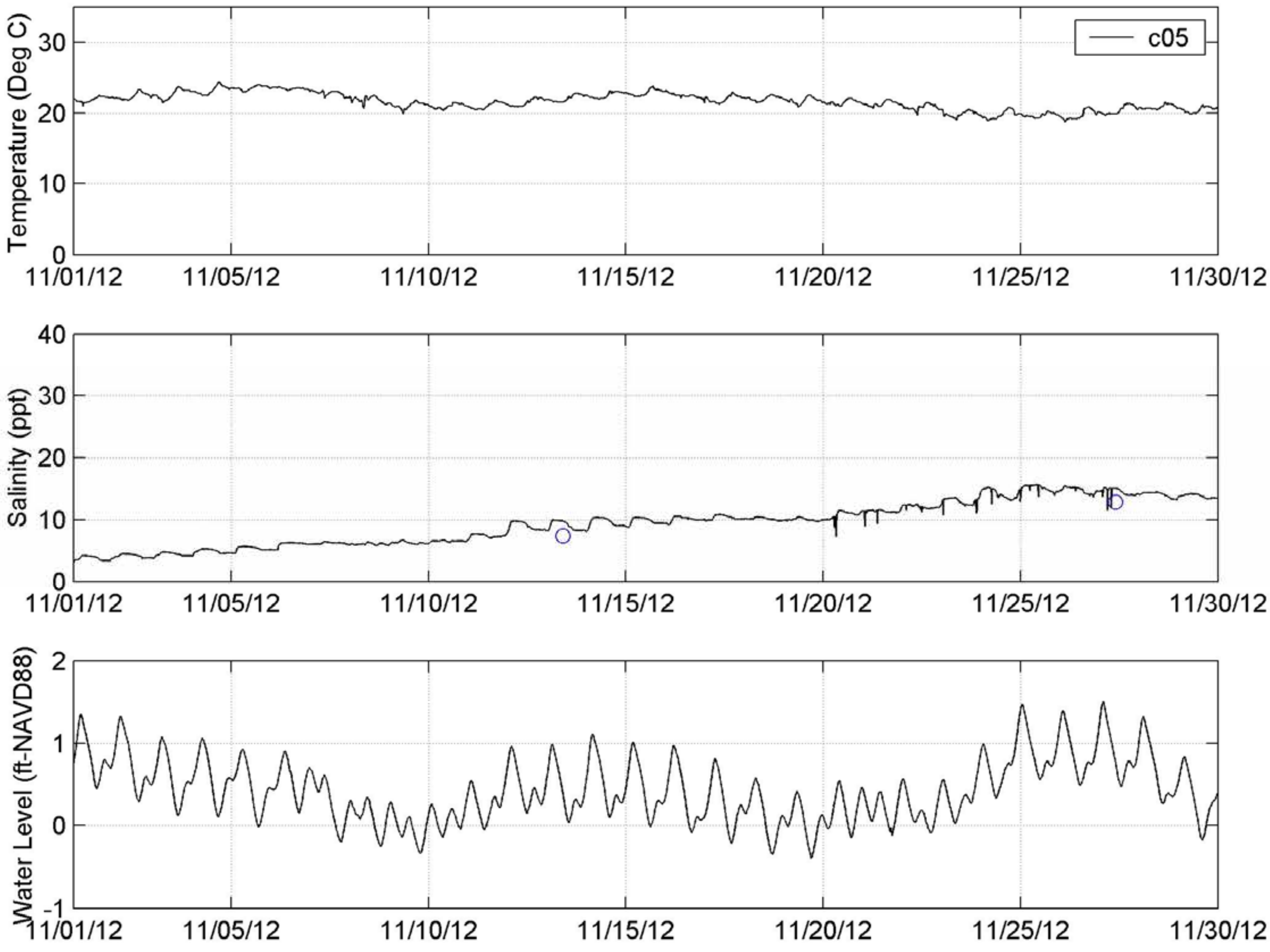
c04
Temperature (Deg C)
0
10
20
30
11/01/13
11/05/13
11/10/13
11/15/13
11/20/13
11/25/13
11/30/13
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
0
0.5
1
1.5



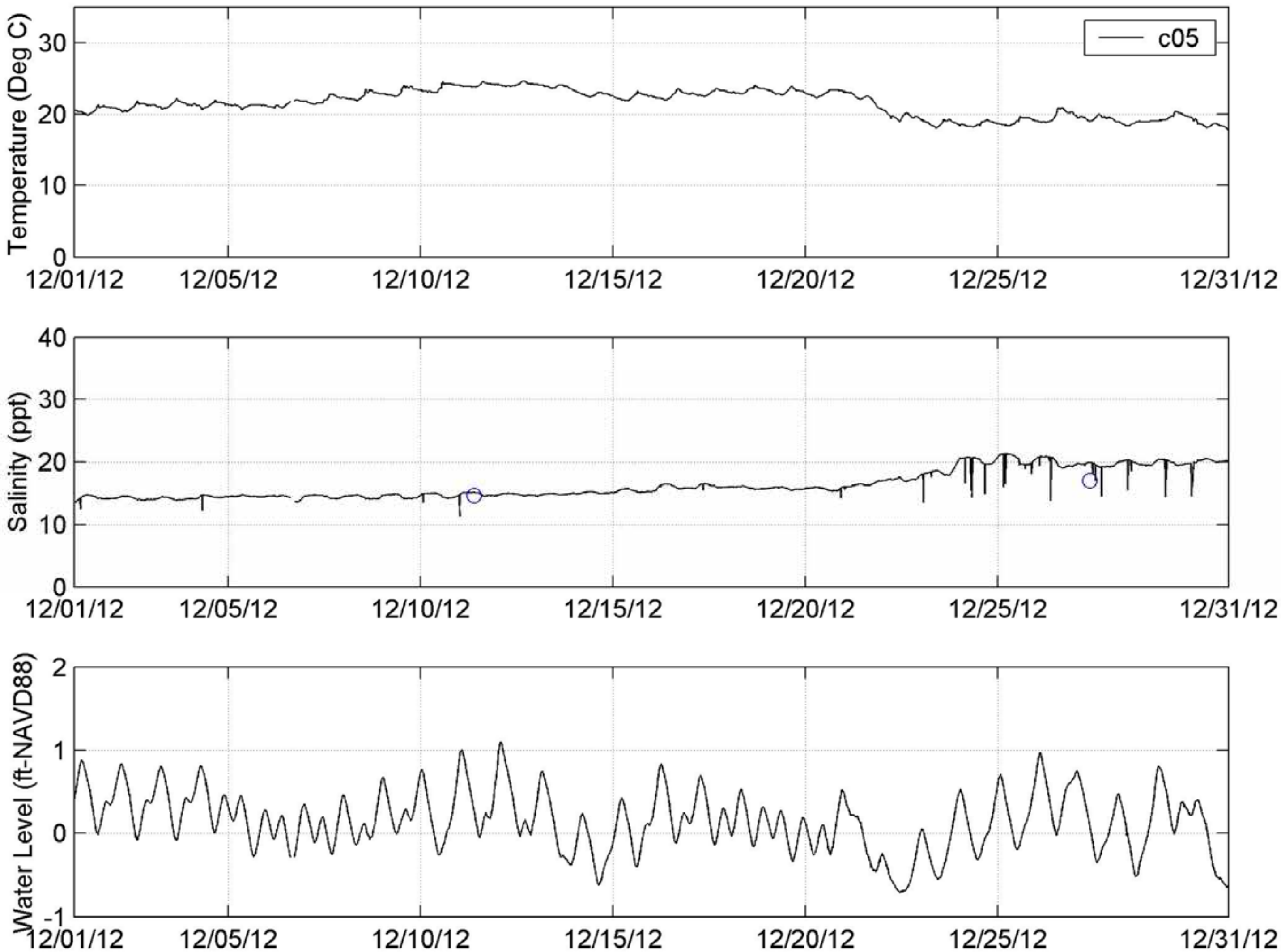
c04
Temperature (Deg C)
30
20
10
0
12/01/13
12/05/13
12/10/13
12/15/13
12/20/13
12/25/13
12/31/13
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
1.5
1
0.5
0

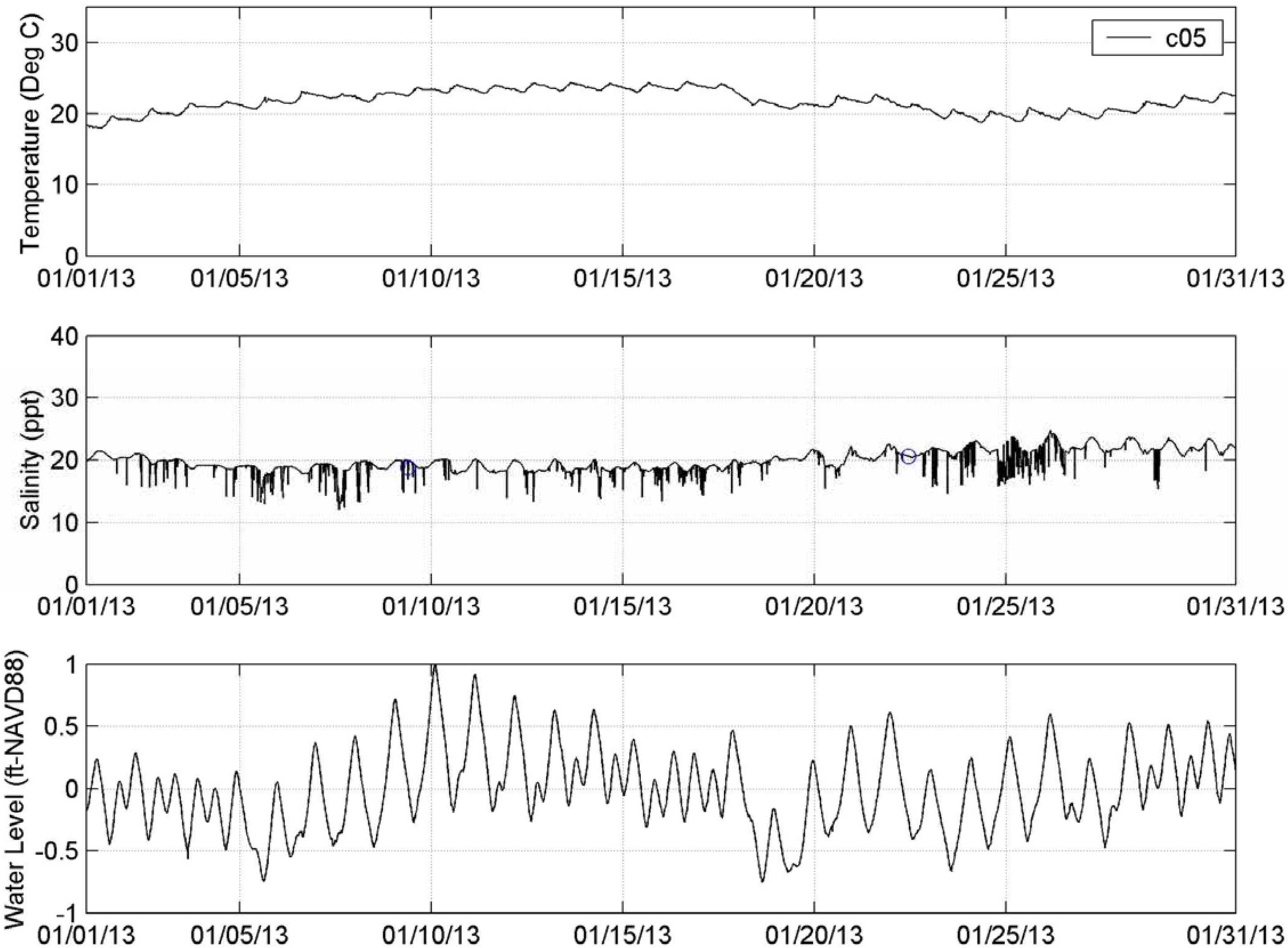


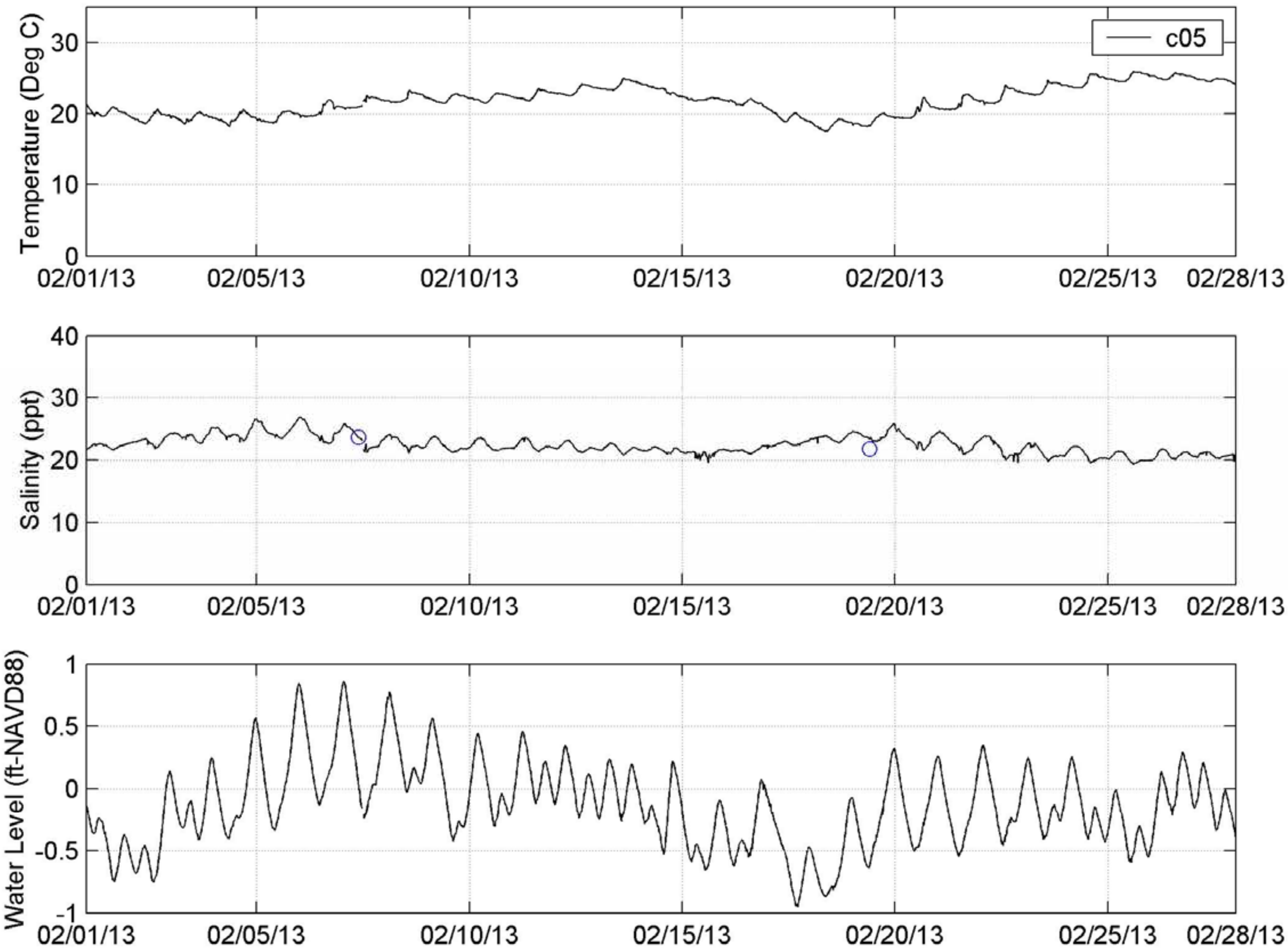
c05
Temperature (Deg C)
30
20
10
0
10/01/12
10/05/12
10/10/12
10/15/12
10/20/12
10/25/12
10/31/12
Salinity (ppt)
40
30
20
10
0
10/01/12
10/05/12
10/10/12
10/15/12
10/20/12
10/25/12
10/31/12
Water Level (ft-NAVD88)
1.5
1
0.5
0
-0.5
10/01/12
10/05/12
10/10/12
10/15/12
10/20/12
10/25/12
10/31/12

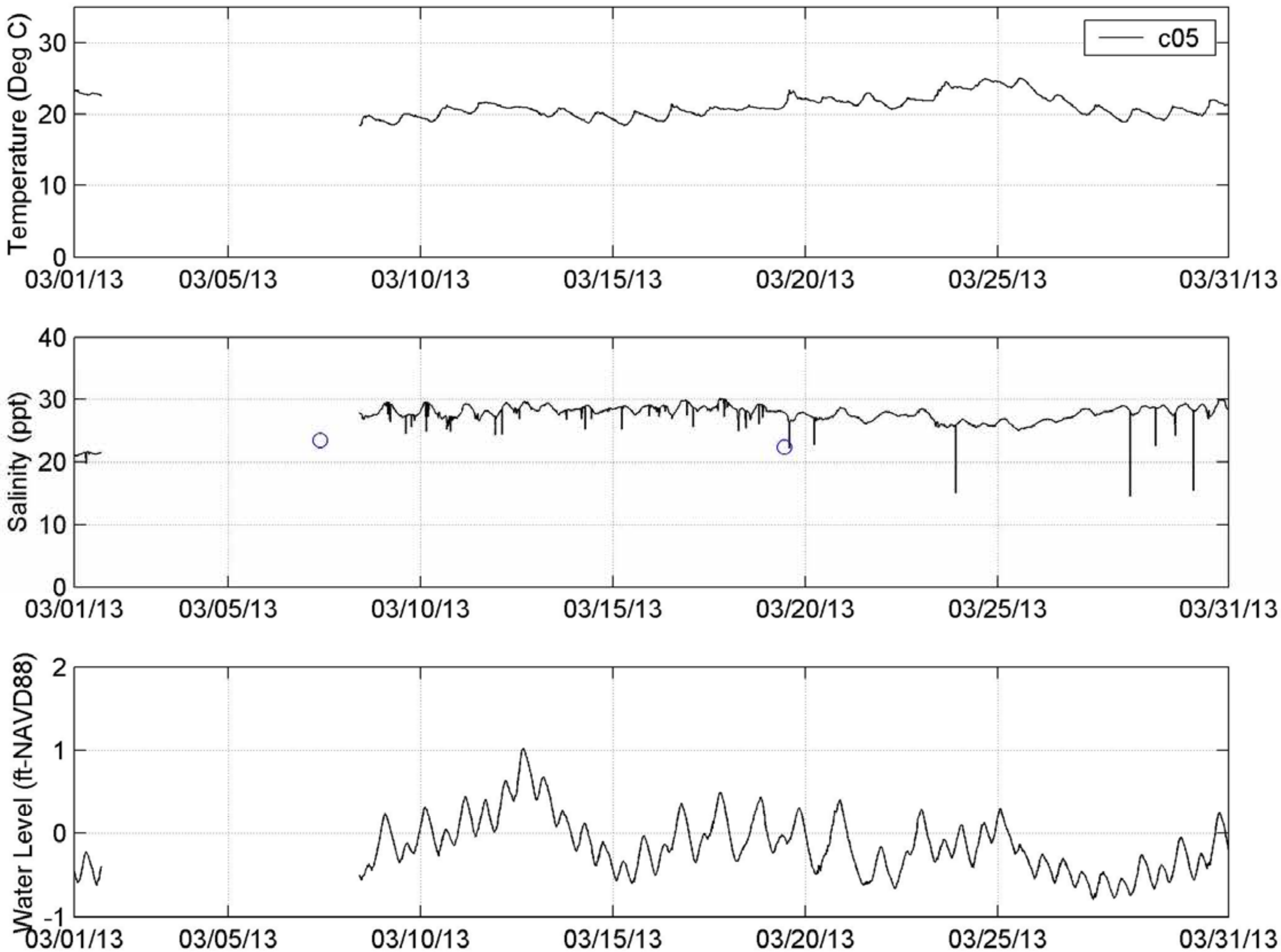


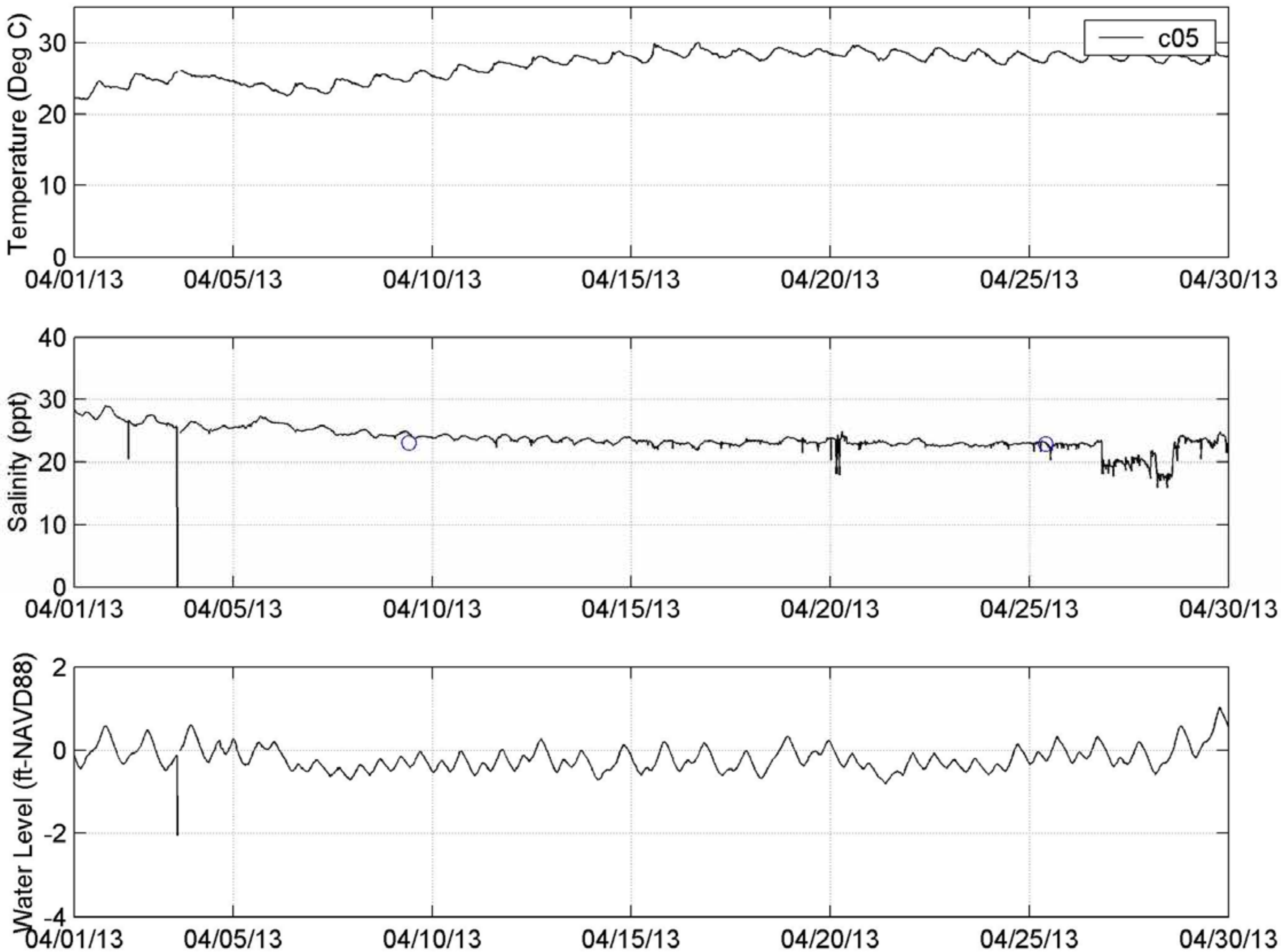
Measured Water Levels, Temperature and Salinity at C-Stations


c05
Temperature (Deg C)
0
10
20
30
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
-1
0
1
2
12/01/12
12/05/12
12/10/12
12/15/12
12/20/12
12/25/12
12/31/12

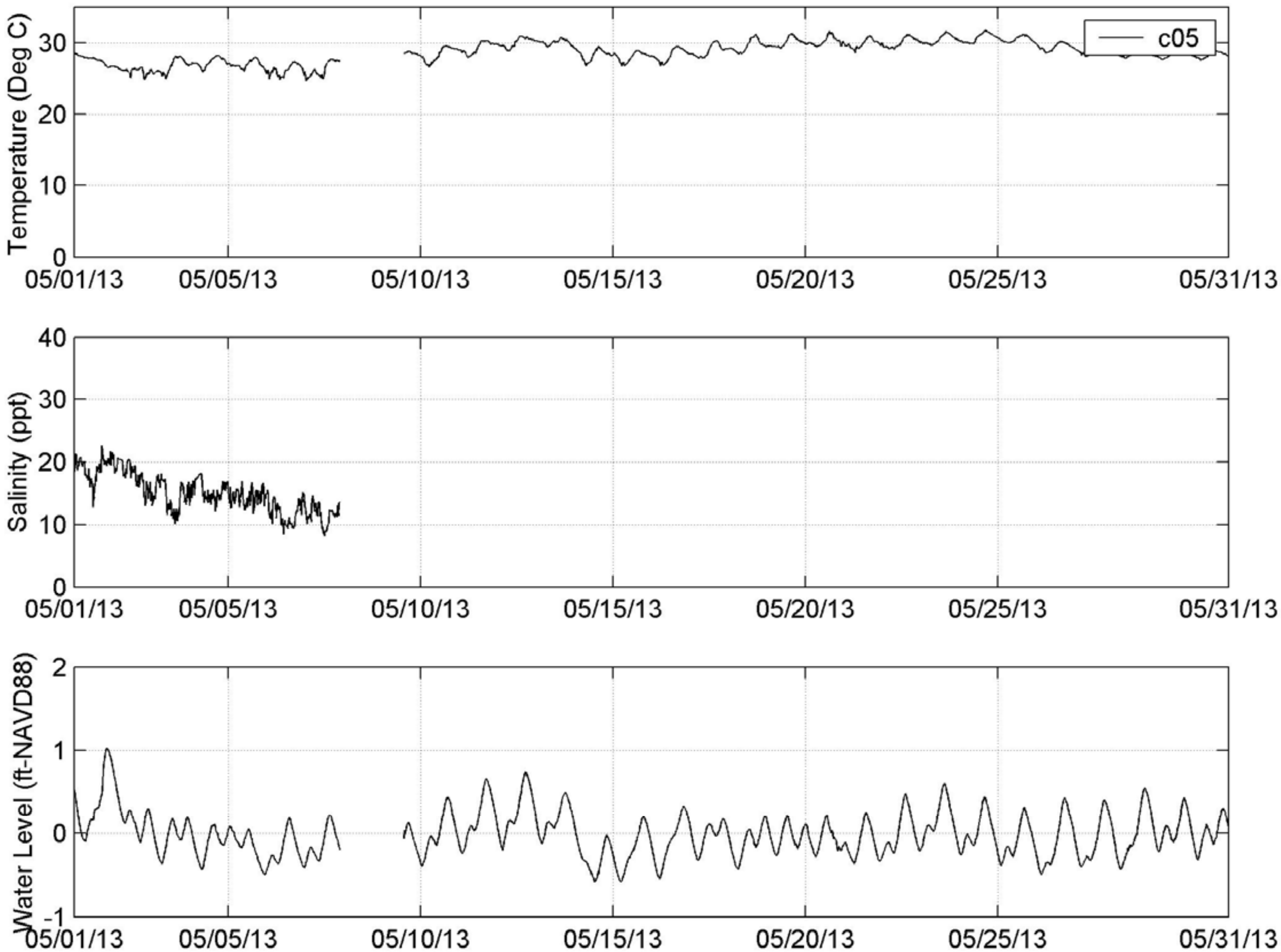

c05
Temperature (Deg C)
30
20
10
0
01/01/13
01/05/13
01/10/13
01/15/13
01/20/13
01/25/13
01/31/13
Salinity (ppt)
40
30
20
10
0
01/01/13
01/05/13
01/10/13
01/15/13
01/20/13
01/25/13
01/31/13
Water Level (ft-NAVD88)
1
0.5
0
-0.5
-1
01/01/13
01/05/13
01/10/13
01/15/13
01/20/13
01/25/13
01/31/13

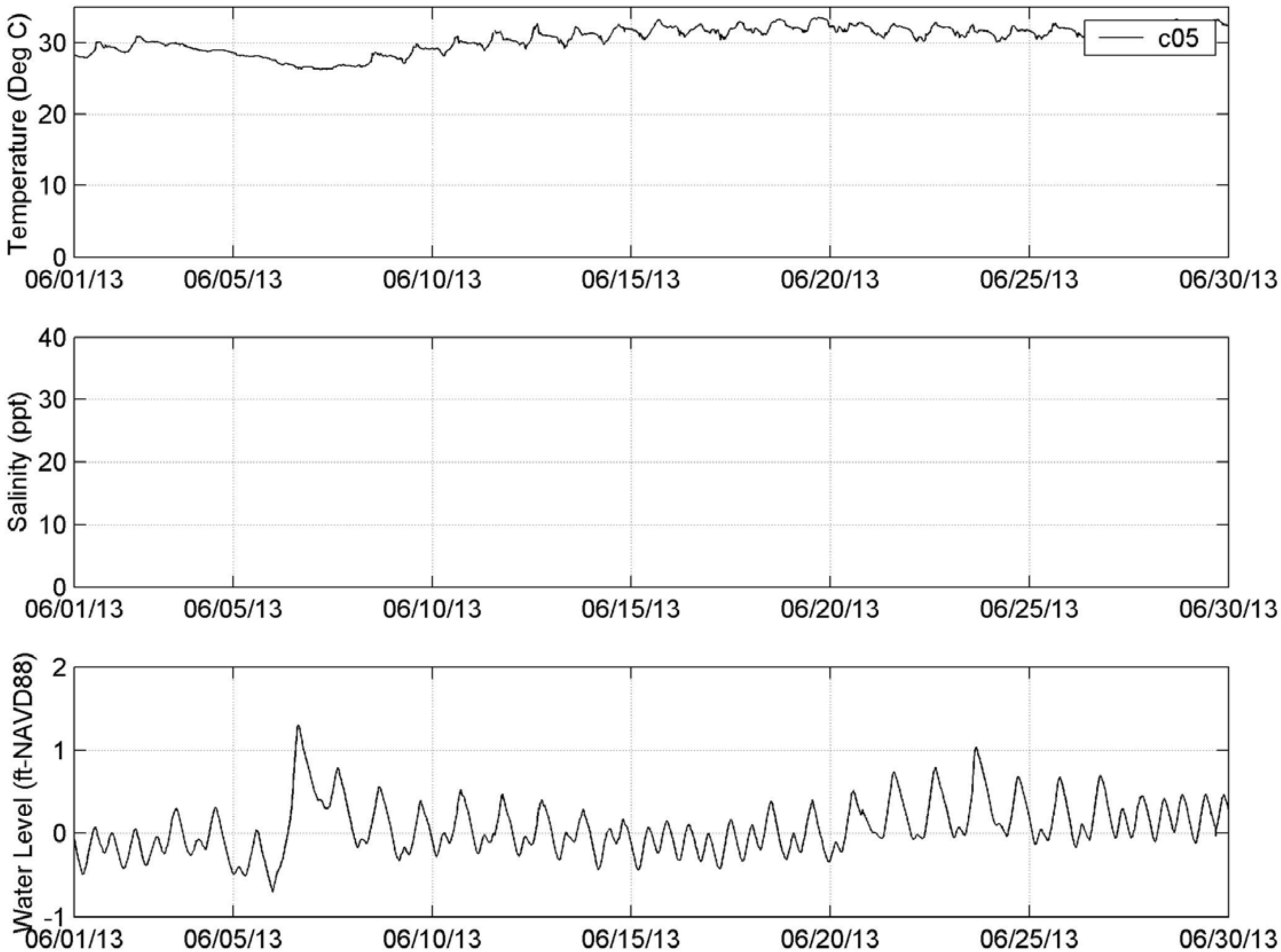

Temperature (Deg C)
30
20
10
0
c05
02/01/13
02/05/13
02/10/13
02/15/13
02/20/13
02/25/13
02/28/13
Salinity (ppt)
40
30
20
10
0
02/01/13
02/05/13
02/10/13
02/15/13
02/20/13
02/25/13
02/28/13
Water Level (ft-NAVD88)
1
0.5
0
-0.5
-1
02/01/13
02/05/13
02/10/13
02/15/13
02/20/13
02/25/13
02/28/13

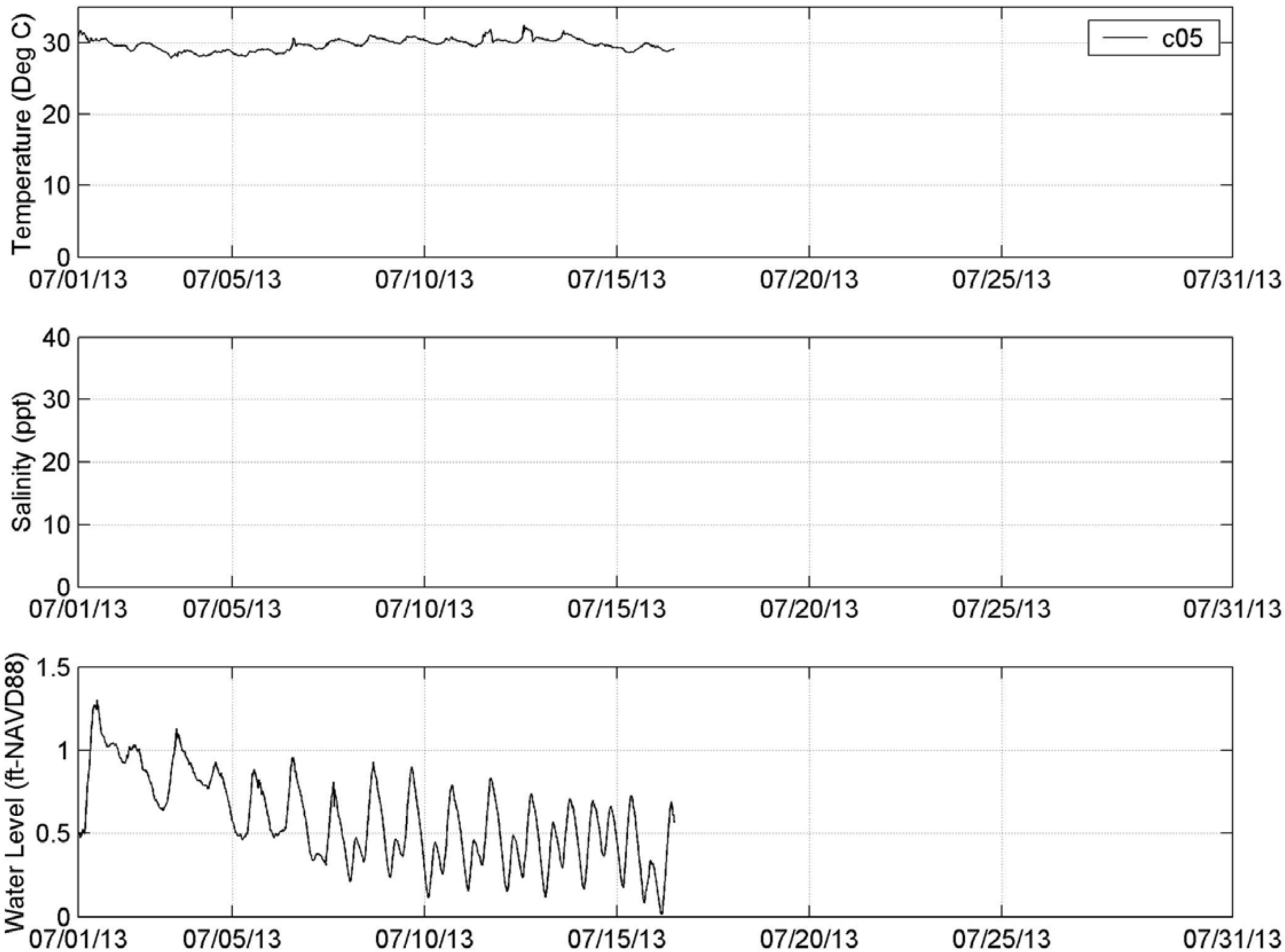

c05
Temperature (Deg C)
30
20
10
0
03/01/13
03/05/13
03/10/13
03/15/13
03/20/13
03/25/13
03/31/13
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
2
1
0
-1



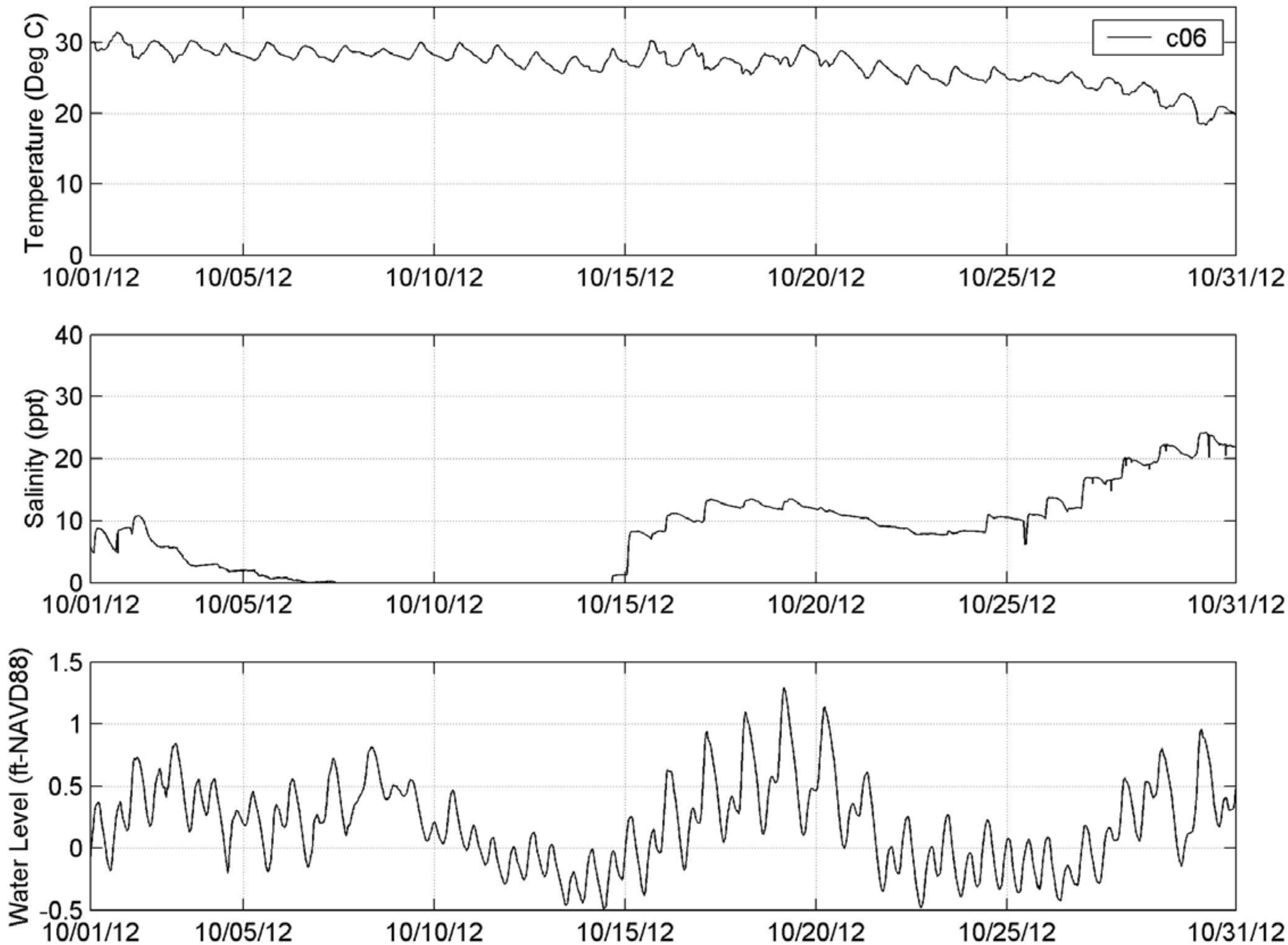
c05
Temperature (Deg C)
30
20
10
0
04/01/13
04/05/13
04/10/13
04/15/13
04/20/13
04/25/13
04/30/13
Salinity (ppt)
40
30
20
10
0
04/01/13
04/05/13
04/10/13
04/15/13
04/20/13
04/25/13
04/30/13
Water Level (ft-NAVD88)
2
0
-2
-4
04/01/13
04/05/13
04/10/13
04/15/13
04/20/13
04/25/13
04/30/13


Temperature (Deg C)
c05
Salinity (ppt)
Water Level (ft-NAVD88)
05/01/13
05/05/13
05/10/13
05/15/13
05/20/13
05/25/13
05/31/13

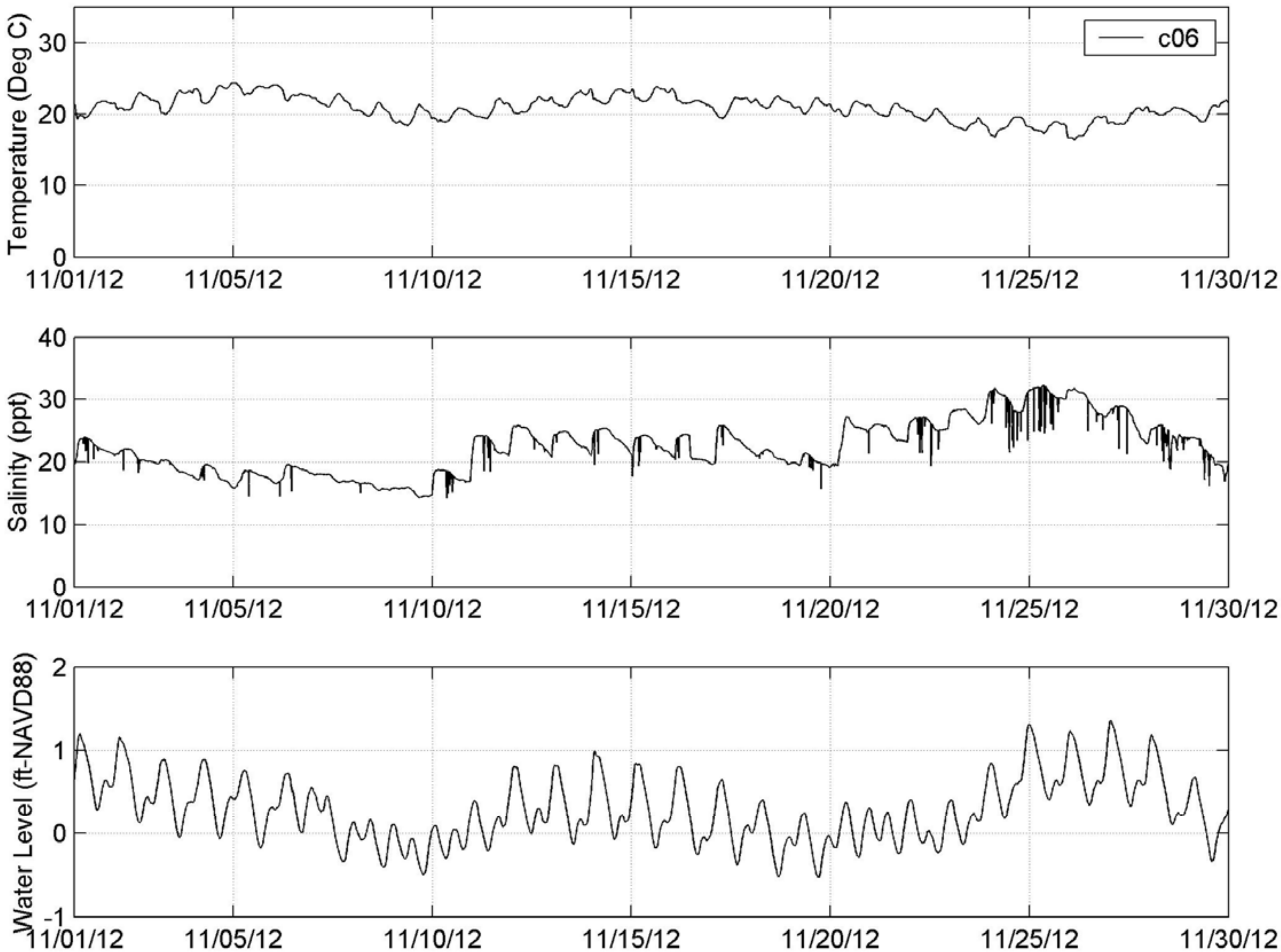

Temperature (Deg C)
30
20
10
0
c05
06/01/13
06/05/13
06/10/13
06/15/13
06/20/13
06/25/13
06/30/13
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
2
1
0
-1

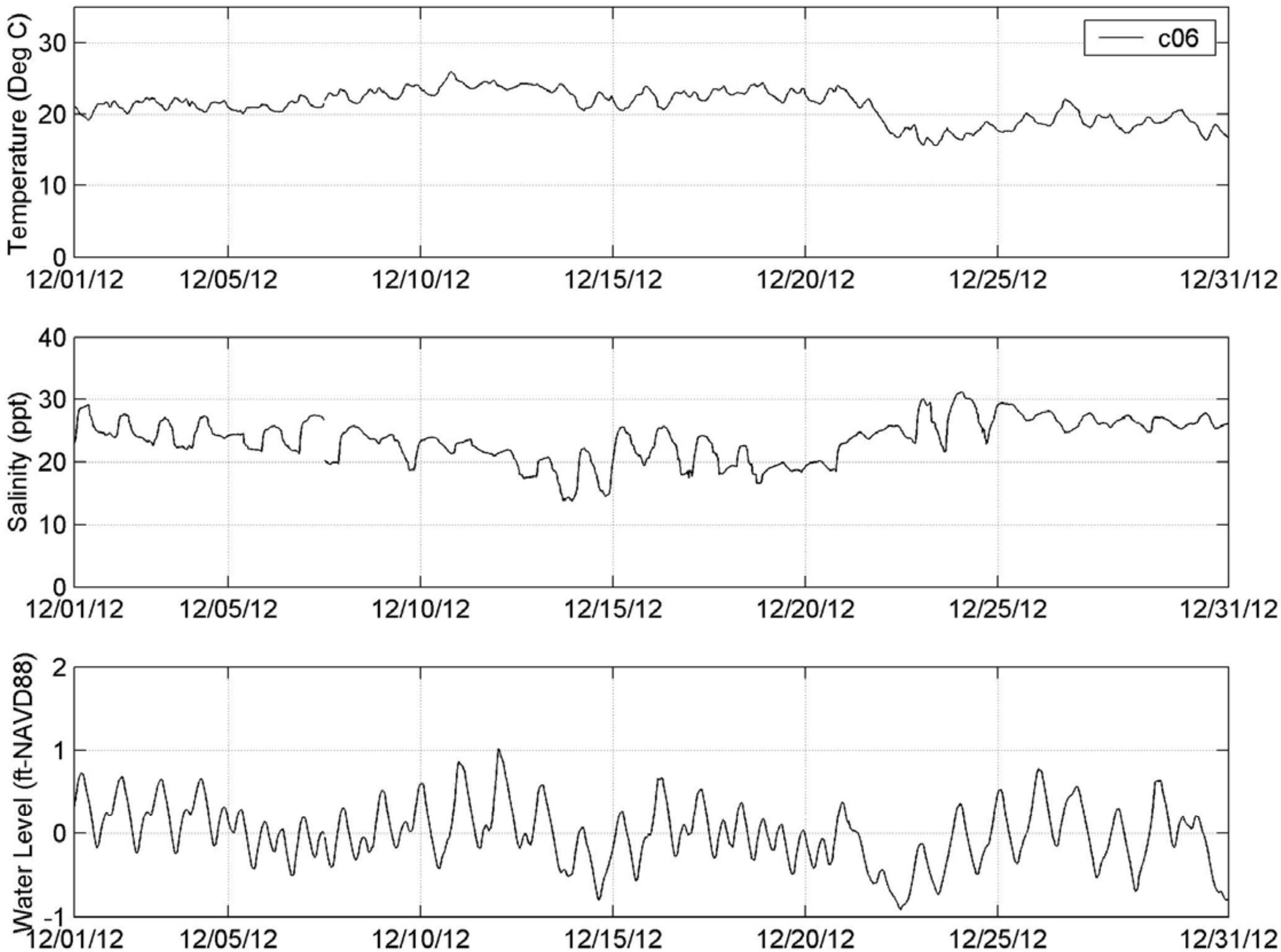


c05
Temperature (Deg C)
0
10
20
30
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
0
0.5
1
1.5
07/01/13
07/05/13
07/10/13
07/15/13
07/20/13
07/25/13
07/31/13

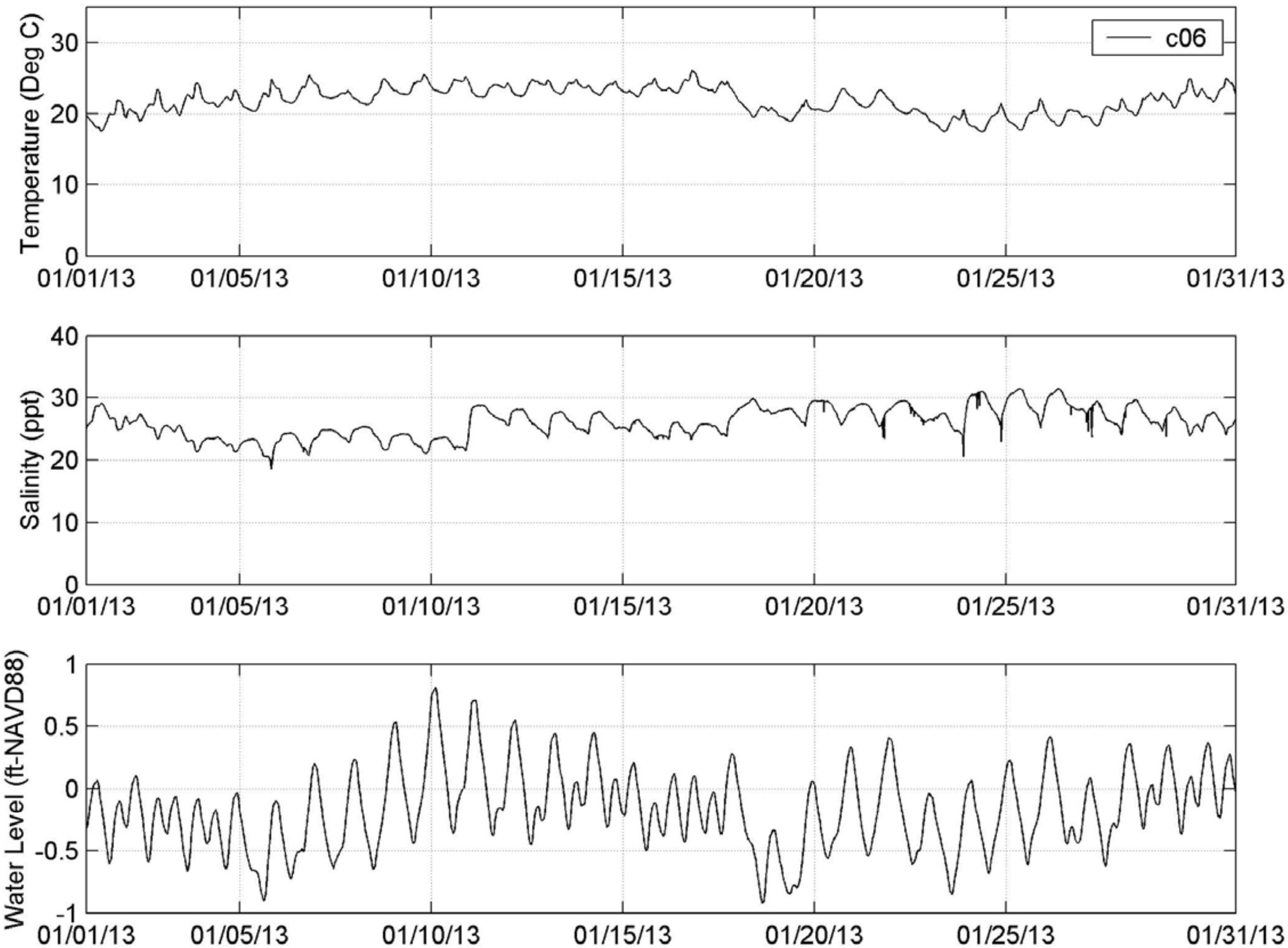


c06
Temperature (Deg C)
30
20
10
0
10/01/12
10/05/12
10/10/12
10/15/12
10/20/12
10/25/12
10/31/12
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
1.5
1
0.5
0
-0.5

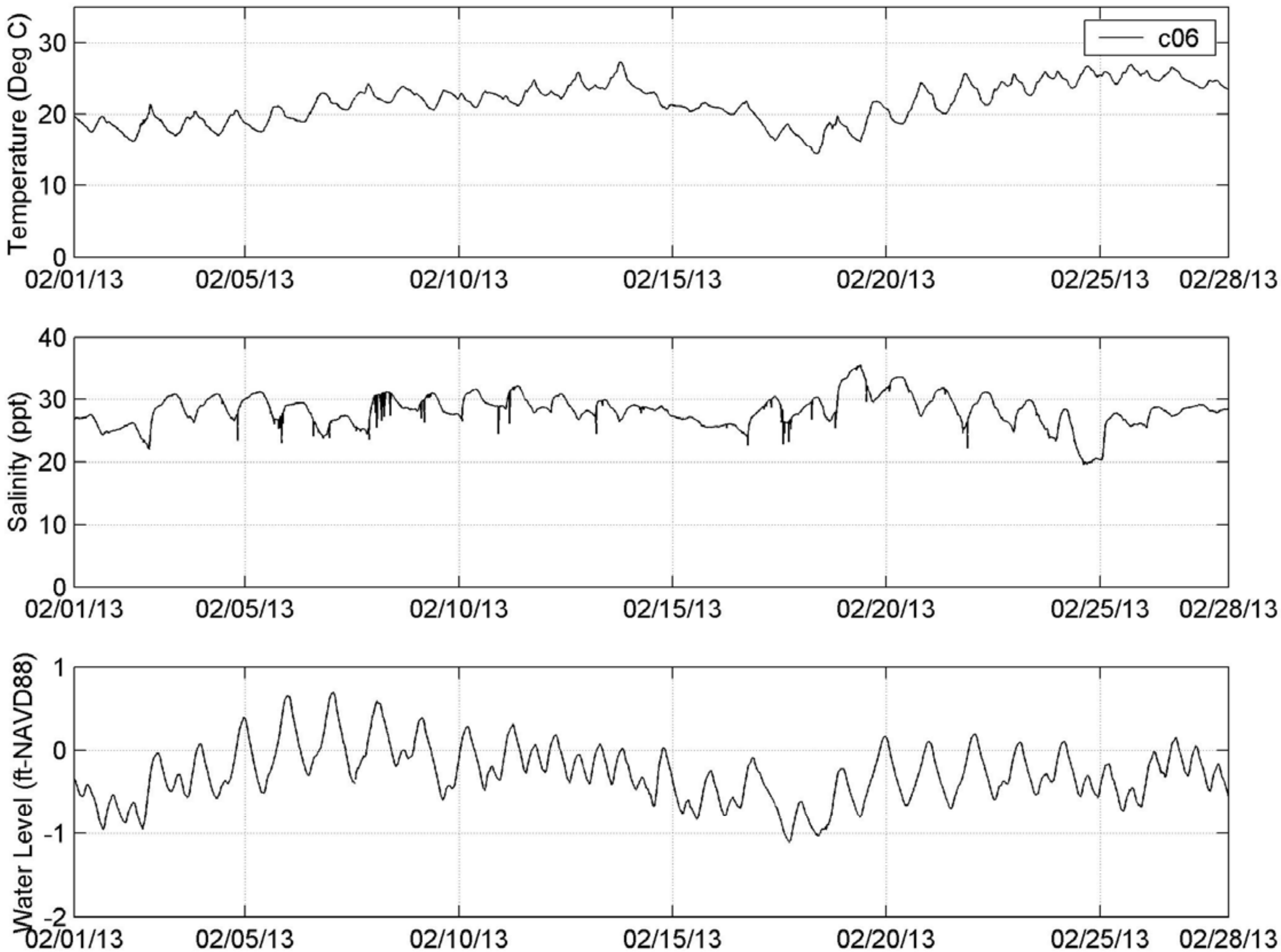

c06
Temperature (Deg C)
30
20
10
0
11/01/12
11/05/12
11/10/12
11/15/12
11/20/12
11/25/12
11/30/12
Salinity (ppt)
40
30
20
10
0
11/01/12
11/05/12
11/10/12
11/15/12
11/20/12
11/25/12
11/30/12
Water Level (ft-NAVD88)
2
1
0
-1
11/01/12
11/05/12
11/10/12
11/15/12
11/20/12
11/25/12
11/30/12



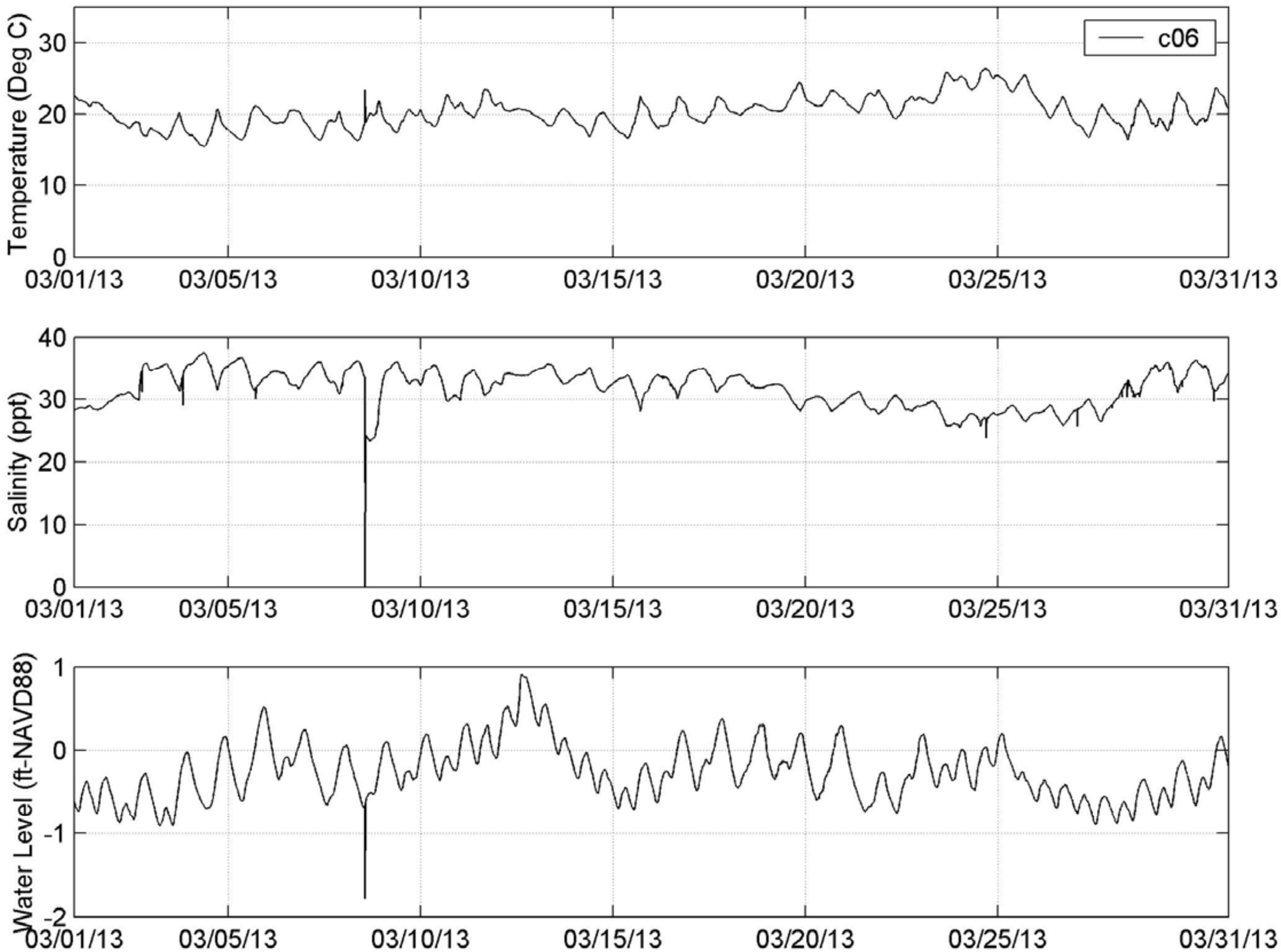
c06
Temperature (Deg C)
0
10
20
30
12/01/12
12/05/12
12/10/12
12/15/12
12/20/12
12/25/12
12/31/12
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
-1
0
1
2

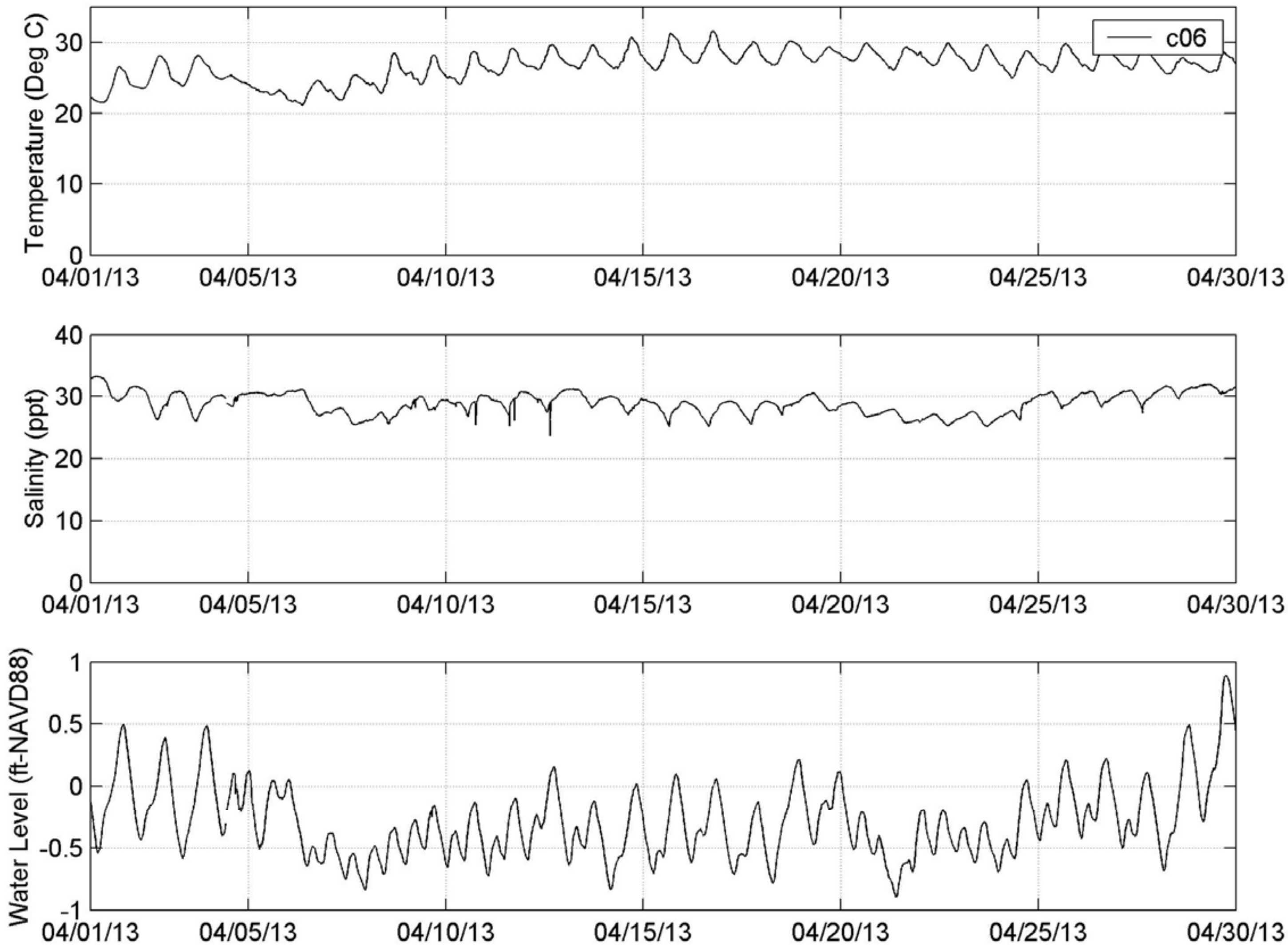


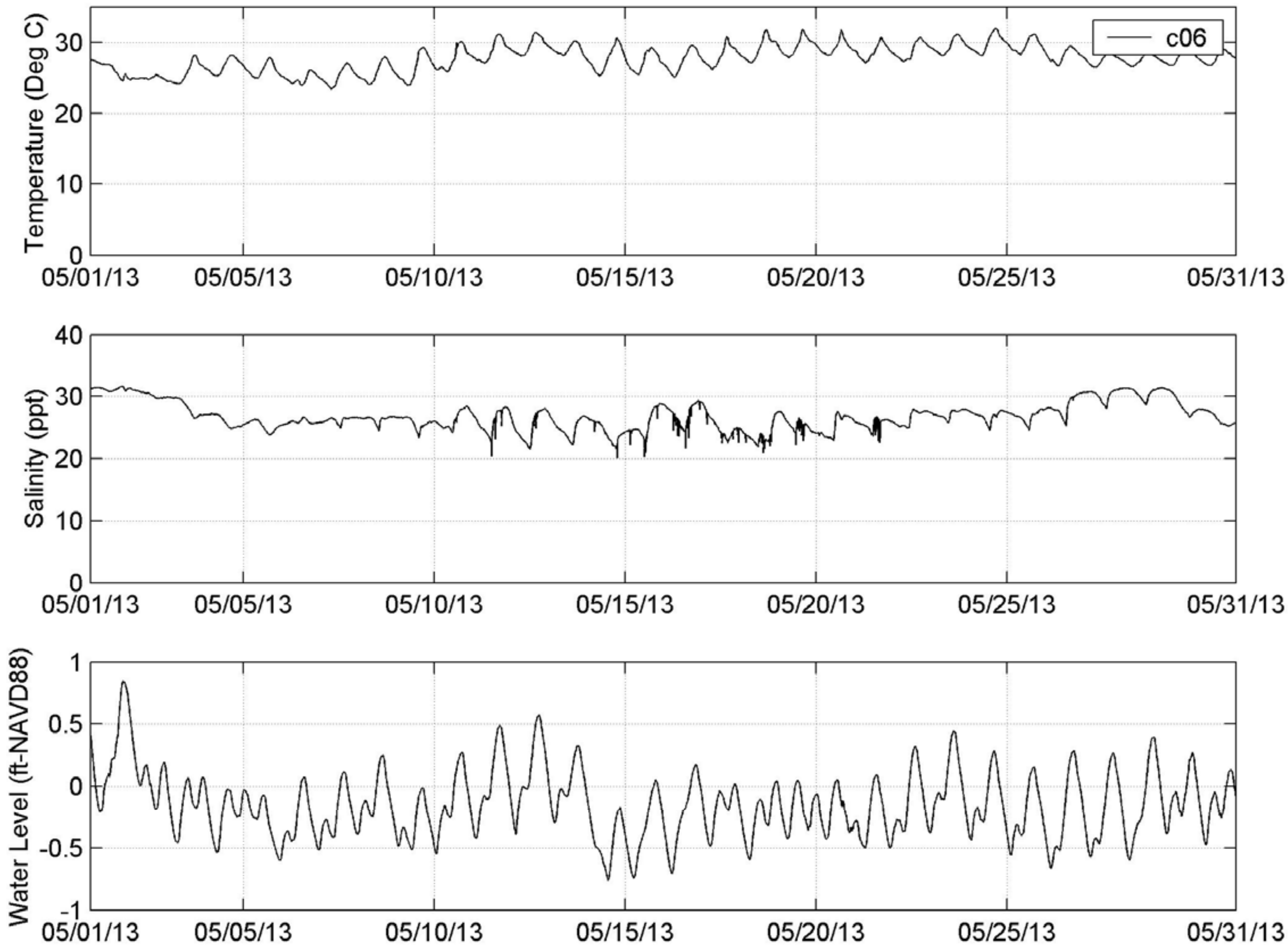
c06
Temperature (Deg C)
30
20
10
0
01/01/13
01/05/13
01/10/13
01/15/13
01/20/13
01/25/13
01/31/13
Salinity (ppt)
40
30
20
10
0
01/01/13
01/05/13
01/10/13
01/15/13
01/20/13
01/25/13
01/31/13
Water Level (ft-NAVD88)
1
0.5
0
-0.5
-1
01/01/13
01/05/13
01/10/13
01/15/13
01/20/13
01/25/13
01/31/13

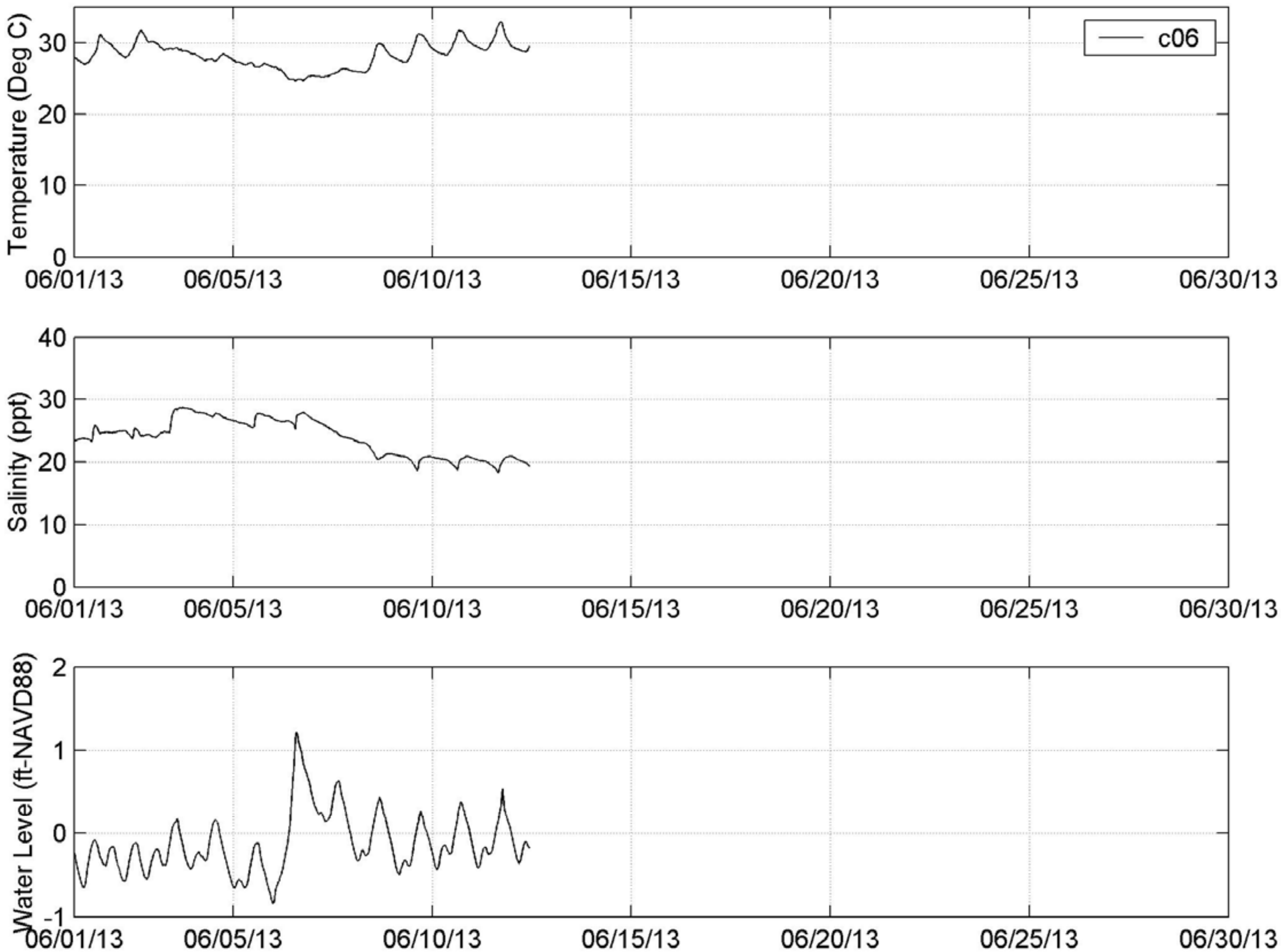


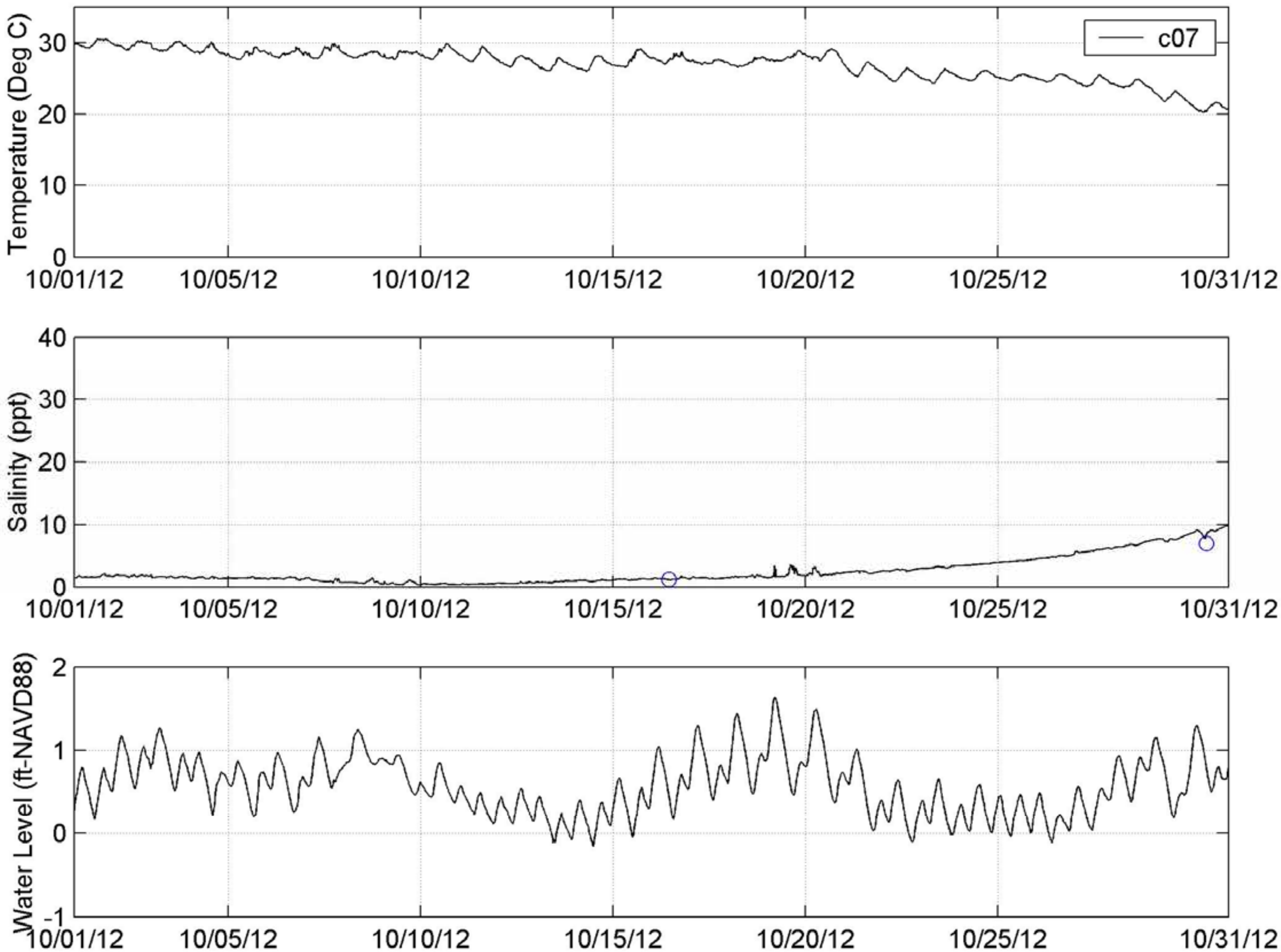
Measured Water Levels, Temperature and Salinity at C-Stations

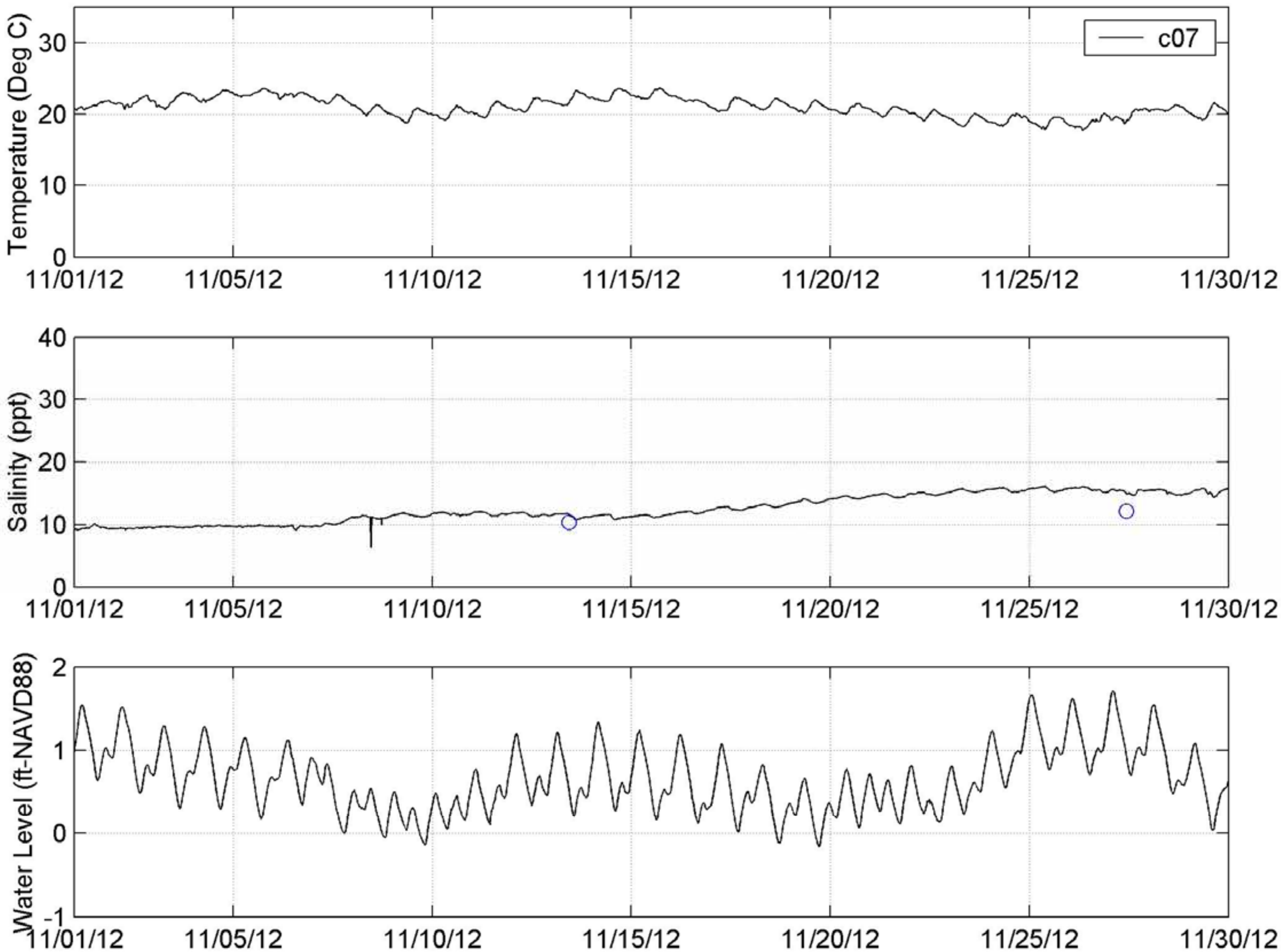

c06
Temperature (Deg C)
30
20
10
0
03/01/13
03/05/13
03/10/13
03/15/13
03/20/13
03/25/13
03/31/13
Salinity (ppt)
40
30
20
10
0
03/01/13
03/05/13
03/10/13
03/15/13
03/20/13
03/25/13
03/31/13
Water Level (ft-NAVD88)
1
0
-1
-2
03/01/13
03/05/13
03/10/13
03/15/13
03/20/13
03/25/13
03/31/13

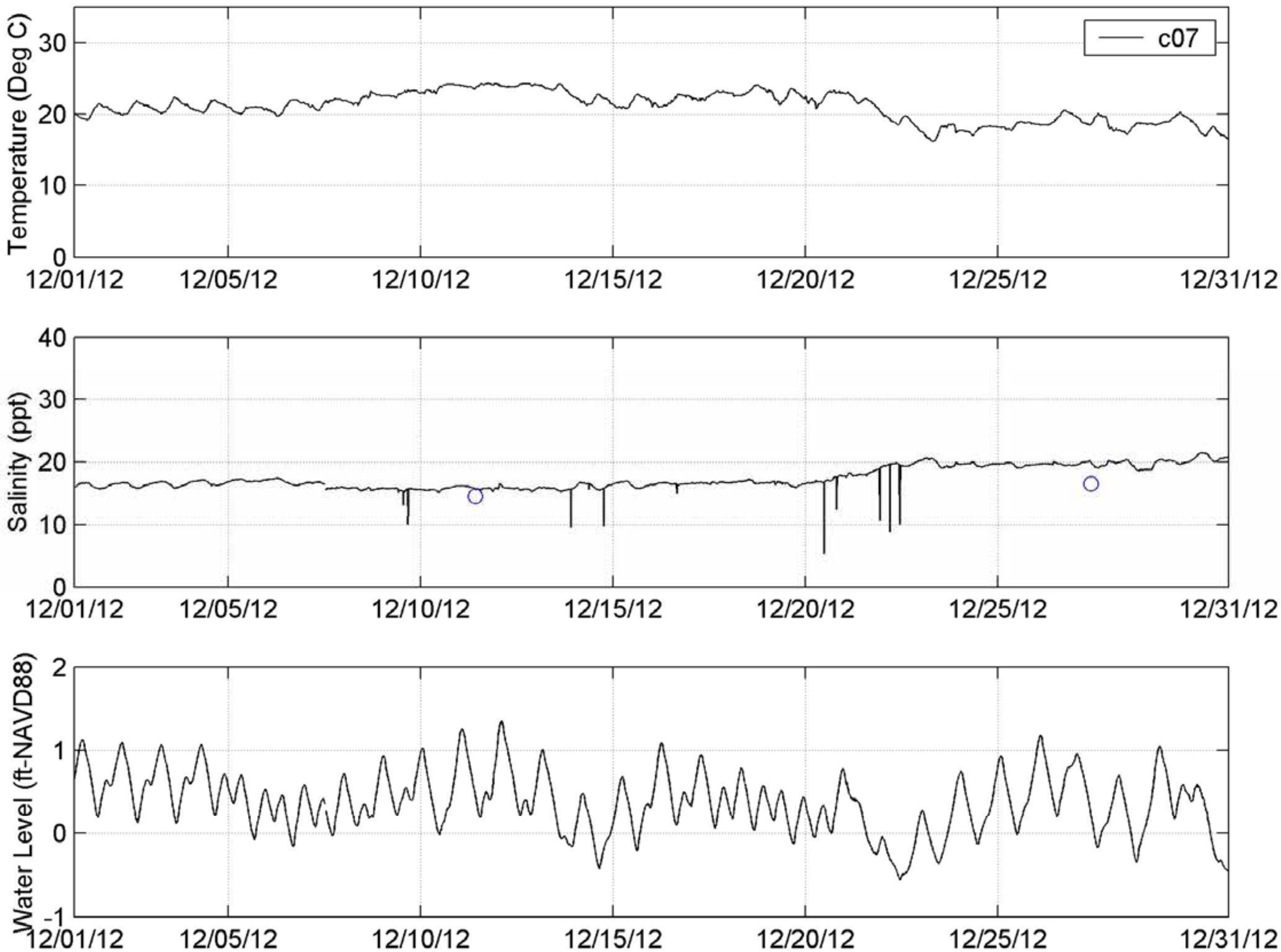

c06
Temperature (Deg C)
0
10
20
30
04/01/13
04/05/13
04/10/13
04/15/13
04/20/13
04/25/13
04/30/13
Salinity (ppt)
0
10
20
30
40
04/01/13
04/05/13
04/10/13
04/15/13
04/20/13
04/25/13
04/30/13
Water Level (ft-NAVD88)
-1
-0.5
0
0.5
1
04/01/13
04/05/13
04/10/13
04/15/13
04/20/13
04/25/13
04/30/13


c06
Temperature (Deg C)
0
10
20
30
05/01/13
05/05/13
05/10/13
05/15/13
05/20/13
05/25/13
05/31/13
Salinity (ppt)
0
10
20
30
40
05/01/13
05/05/13
05/10/13
05/15/13
05/20/13
05/25/13
05/31/13
Water Level (ft-NAVD88)
-1
-0.5
0
0.5
1
05/01/13
05/05/13
05/10/13
05/15/13
05/20/13
05/25/13
05/31/13

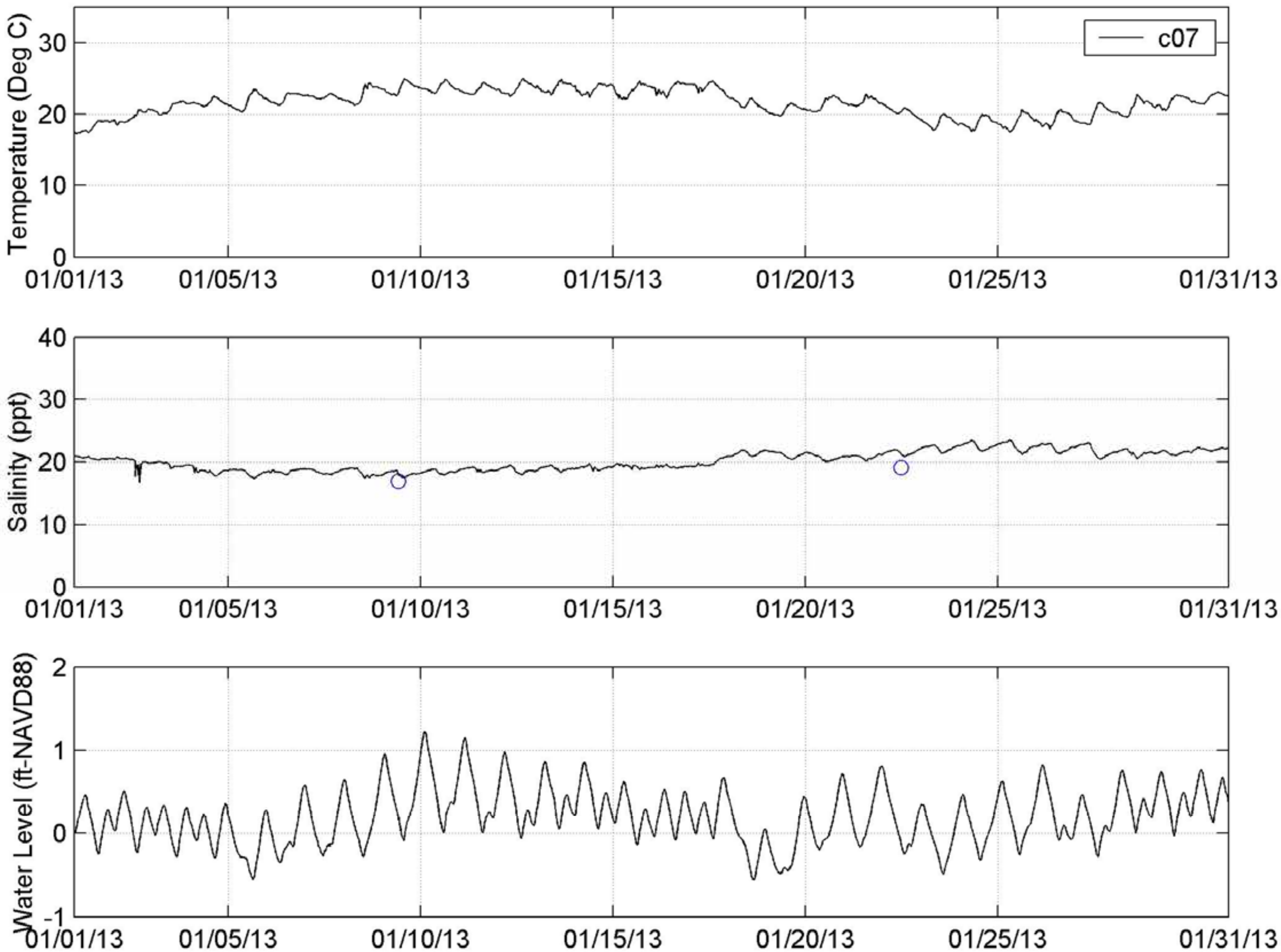

c06
Temperature (Deg C)
30
20
10
0
06/01/13
06/05/13
06/10/13
06/15/13
06/20/13
06/25/13
06/30/13
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
2
1
0
-1


c07
Temperature (Deg C)
0
10
20
30
10/01/12
10/05/12
10/10/12
10/15/12
10/20/12
10/25/12
10/31/12
Salinity (ppt)
0
10
20
30
40
10/01/12
10/05/12
10/10/12
10/15/12
10/20/12
10/25/12
10/31/12
Water Level (ft-NAVD88)
-1
0
1
2
10/01/12
10/05/12
10/10/12
10/15/12
10/20/12
10/25/12
10/31/12

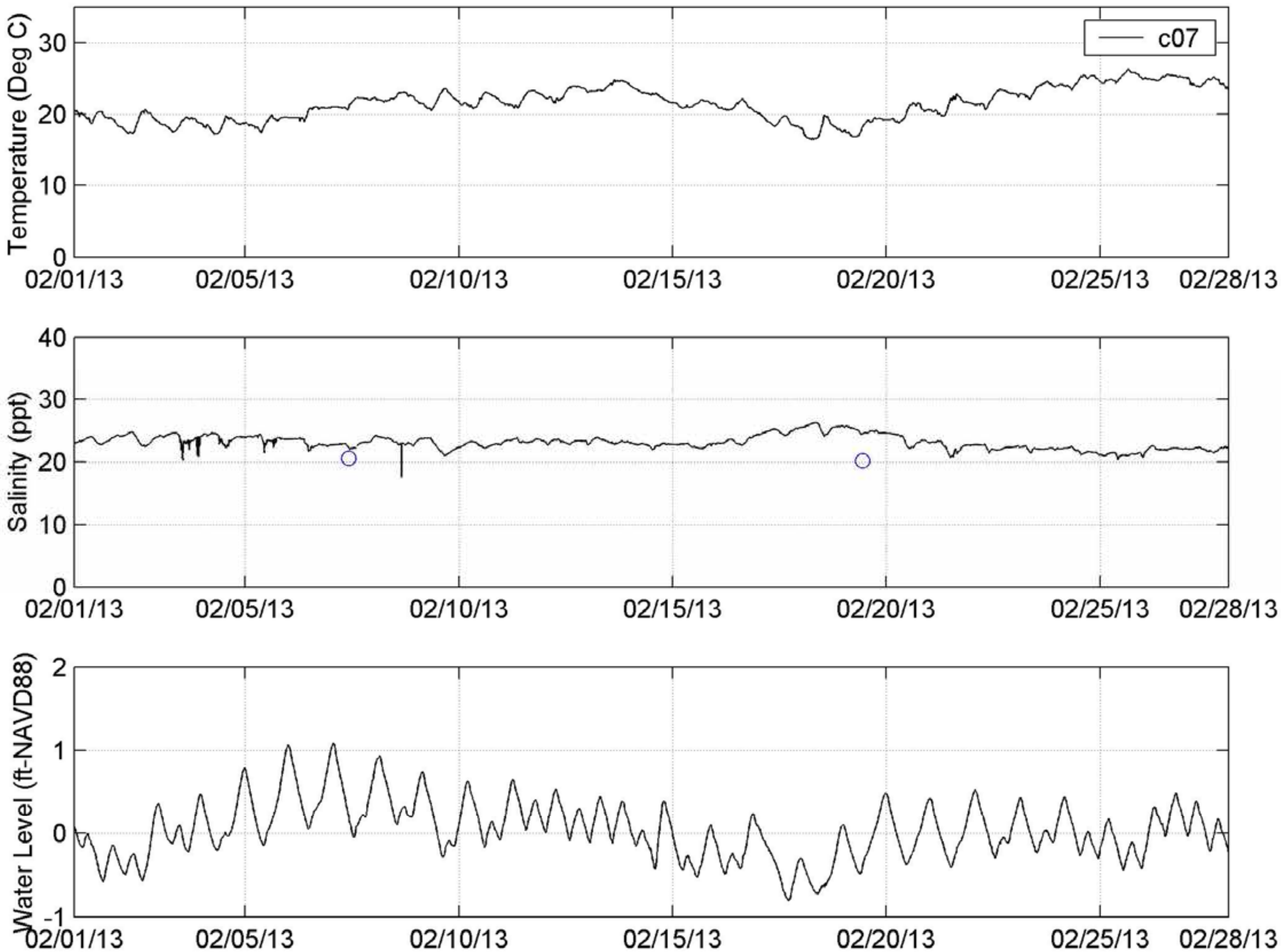

c07
Temperature (Deg C)
30
20
10
0
11/01/12
11/05/12
11/10/12
11/15/12
11/20/12
11/25/12
11/30/12
Salinity (ppt)
40
30
20
10
0
11/01/12
11/05/12
11/10/12
11/15/12
11/20/12
11/25/12
11/30/12
Water Level (ft-NAVD88)
2
1
0
-1
11/01/12
11/05/12
11/10/12
11/15/12
11/20/12
11/25/12
11/30/12

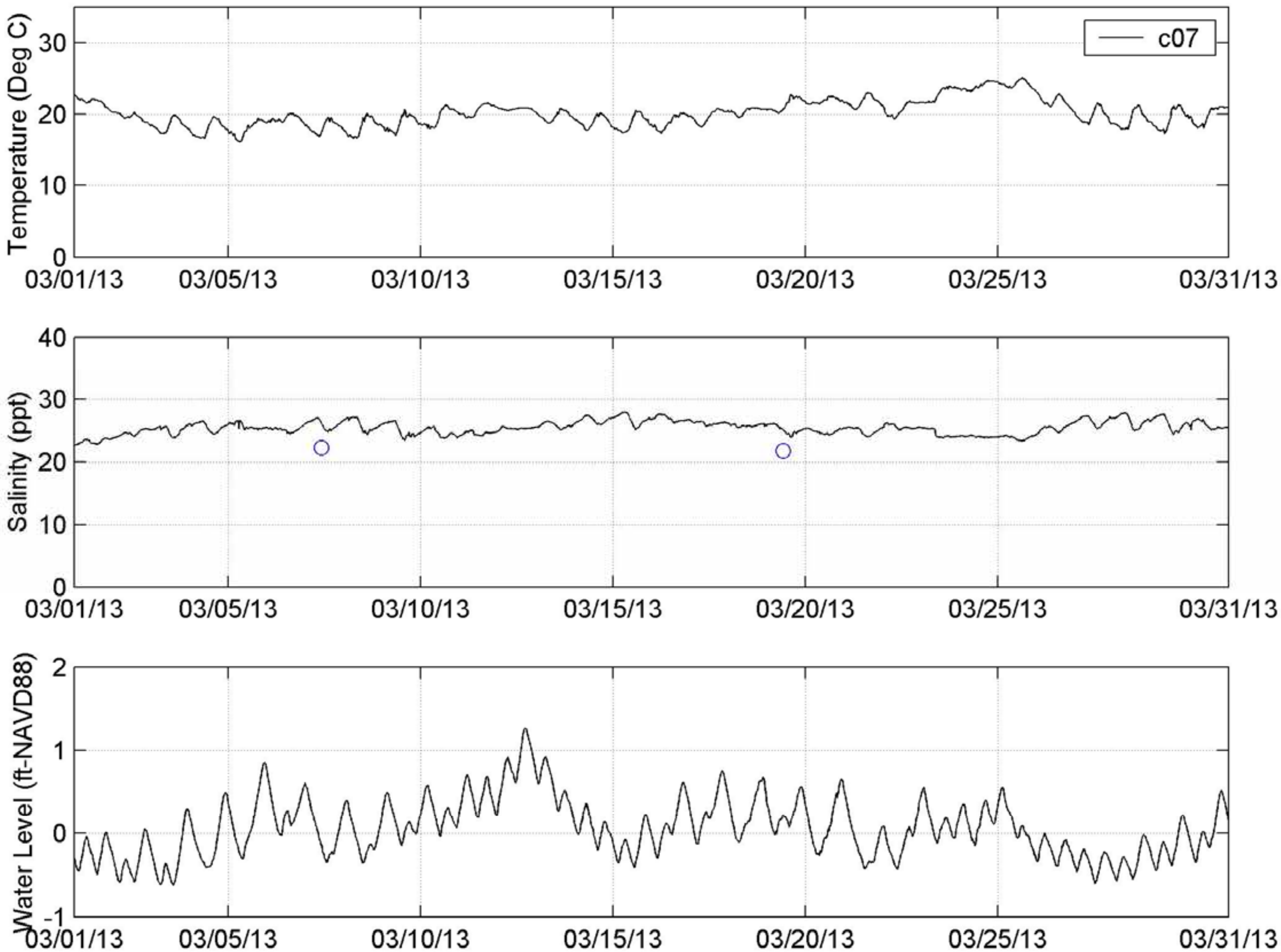


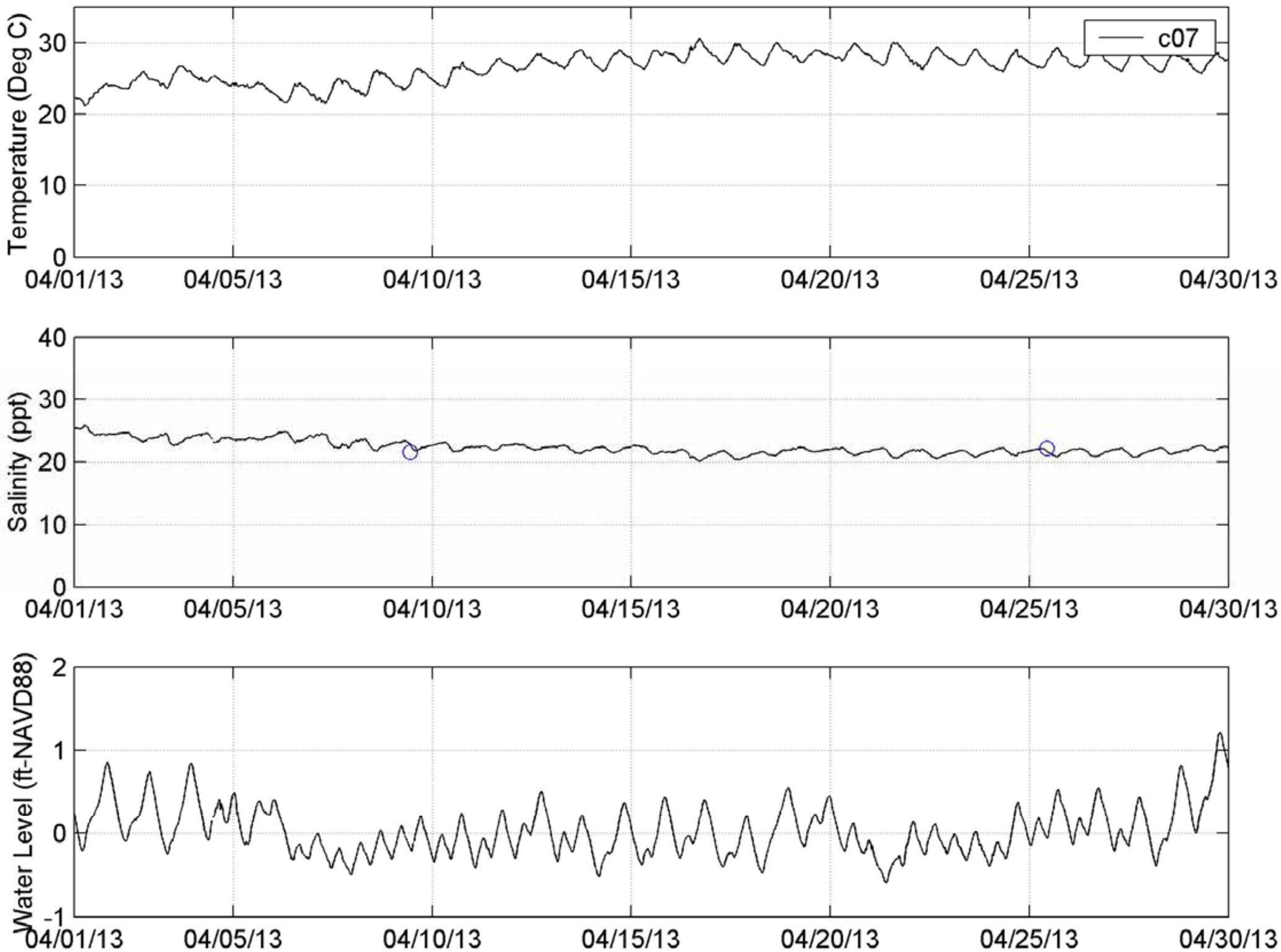
c07
Temperature (Deg C)
0
10
20
30
12/01/12
12/05/12
12/10/12
12/15/12
12/20/12
12/25/12
12/31/12
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
-1
0
1
2

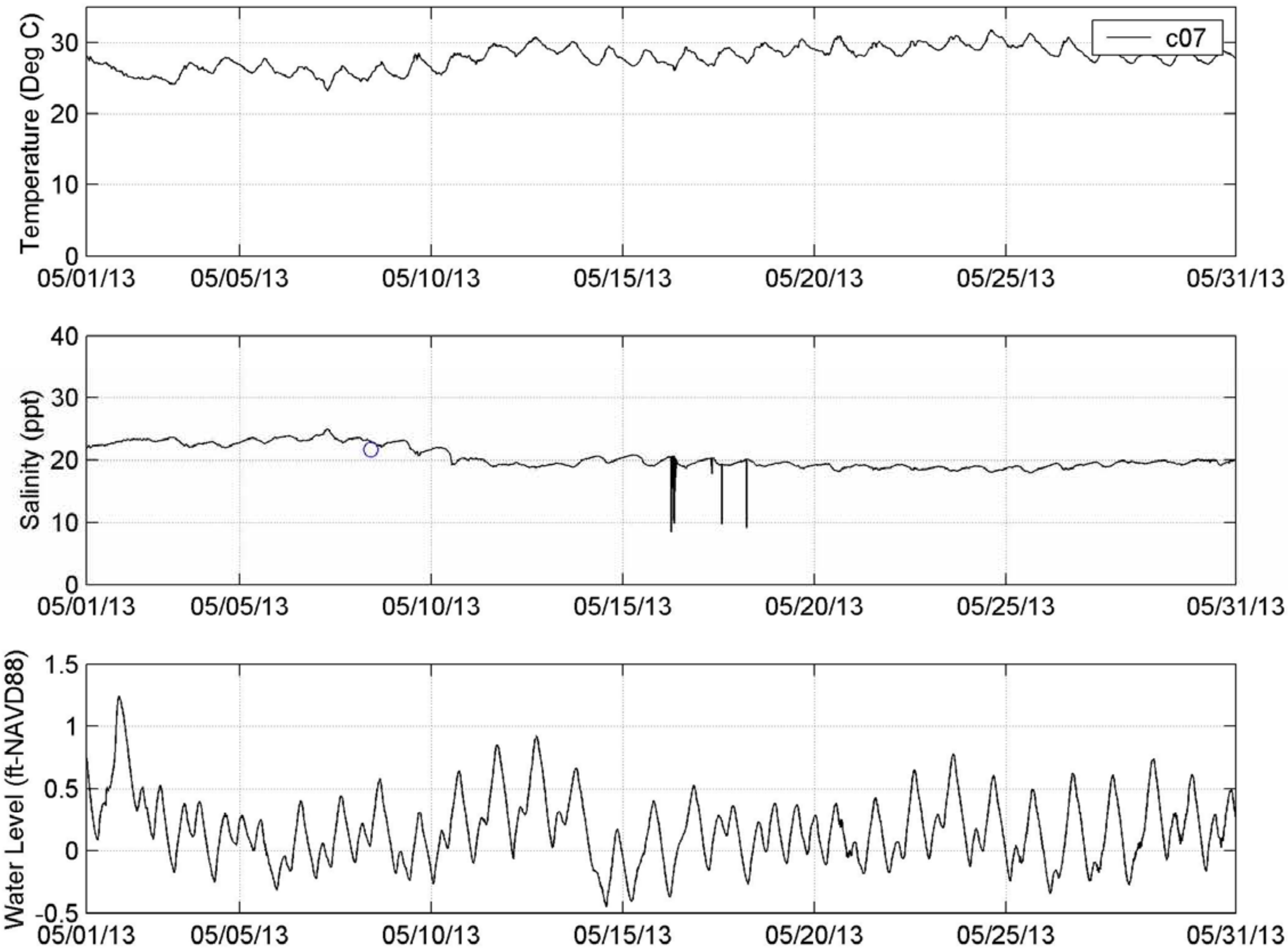


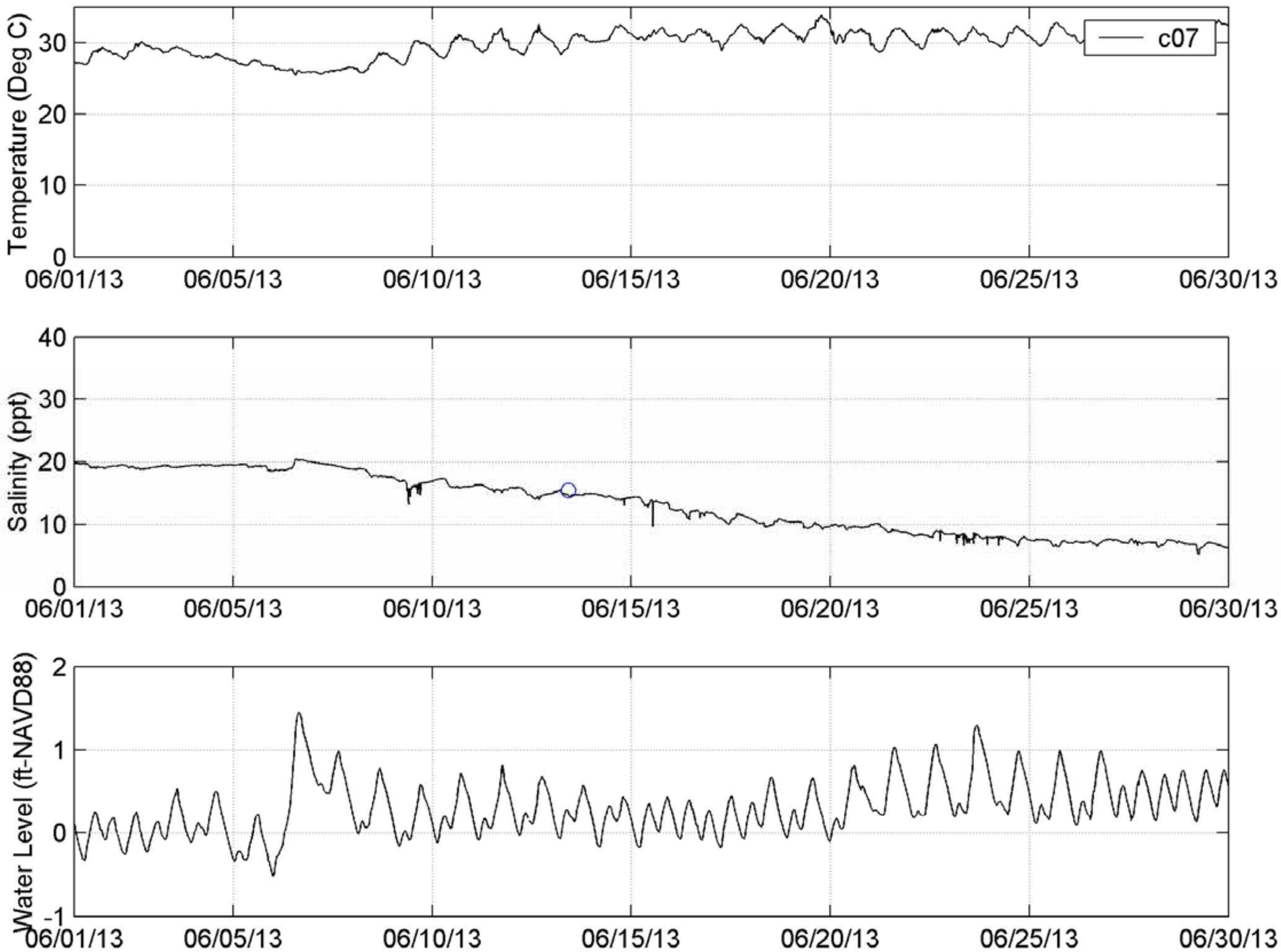
c07
Temperature (Deg C)
30
20
10
0
01/01/13
01/05/13
01/10/13
01/15/13
01/20/13
01/25/13
01/31/13
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
2
1
0
-1

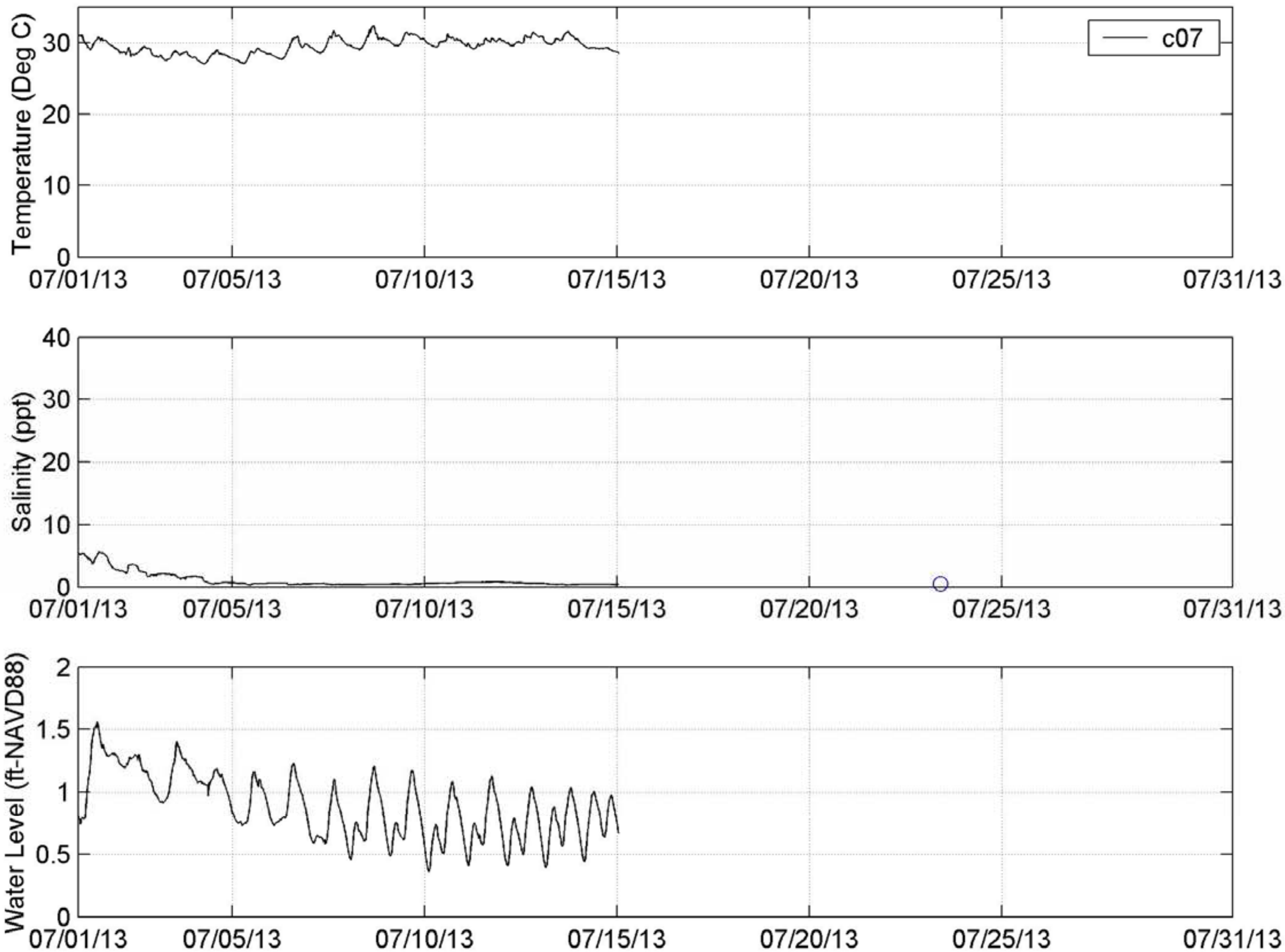

c07
Temperature (Deg C)
30
20
10
0
02/01/13
02/05/13
02/10/13
02/15/13
02/20/13
02/25/13
02/28/13
Salinity (ppt)
40
30
20
10
0
02/01/13
02/05/13
02/10/13
02/15/13
02/20/13
02/25/13
02/28/13
Water Level (ft-NAVD88)
2
1
0
-1
02/01/13
02/05/13
02/10/13
02/15/13
02/20/13
02/25/13
02/28/13

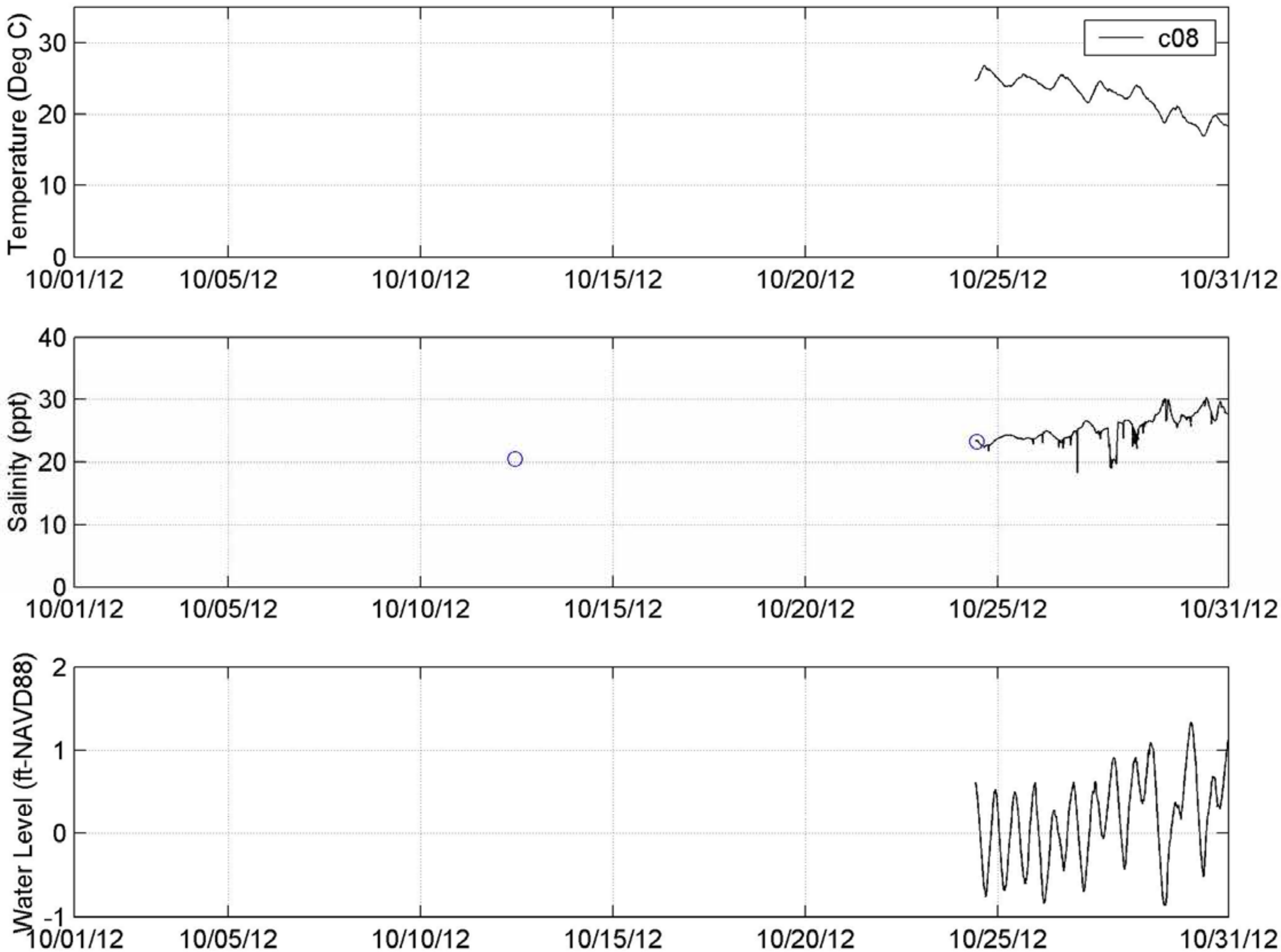

Temperature (Deg C)
c07
30
20
10
0
03/01/13
03/05/13
03/10/13
03/15/13
03/20/13
03/25/13
03/31/13
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
2
1
0
-1


c07
Temperature (Deg C)
30
20
10
0
04/01/13
04/05/13
04/10/13
04/15/13
04/20/13
04/25/13
04/30/13
Salinity (ppt)
40
30
20
10
0
04/01/13
04/05/13
04/10/13
04/15/13
04/20/13
04/25/13
04/30/13
Water Level (ft-NAVD88)
2
1
0
-1
04/01/13
04/05/13
04/10/13
04/15/13
04/20/13
04/25/13
04/30/13

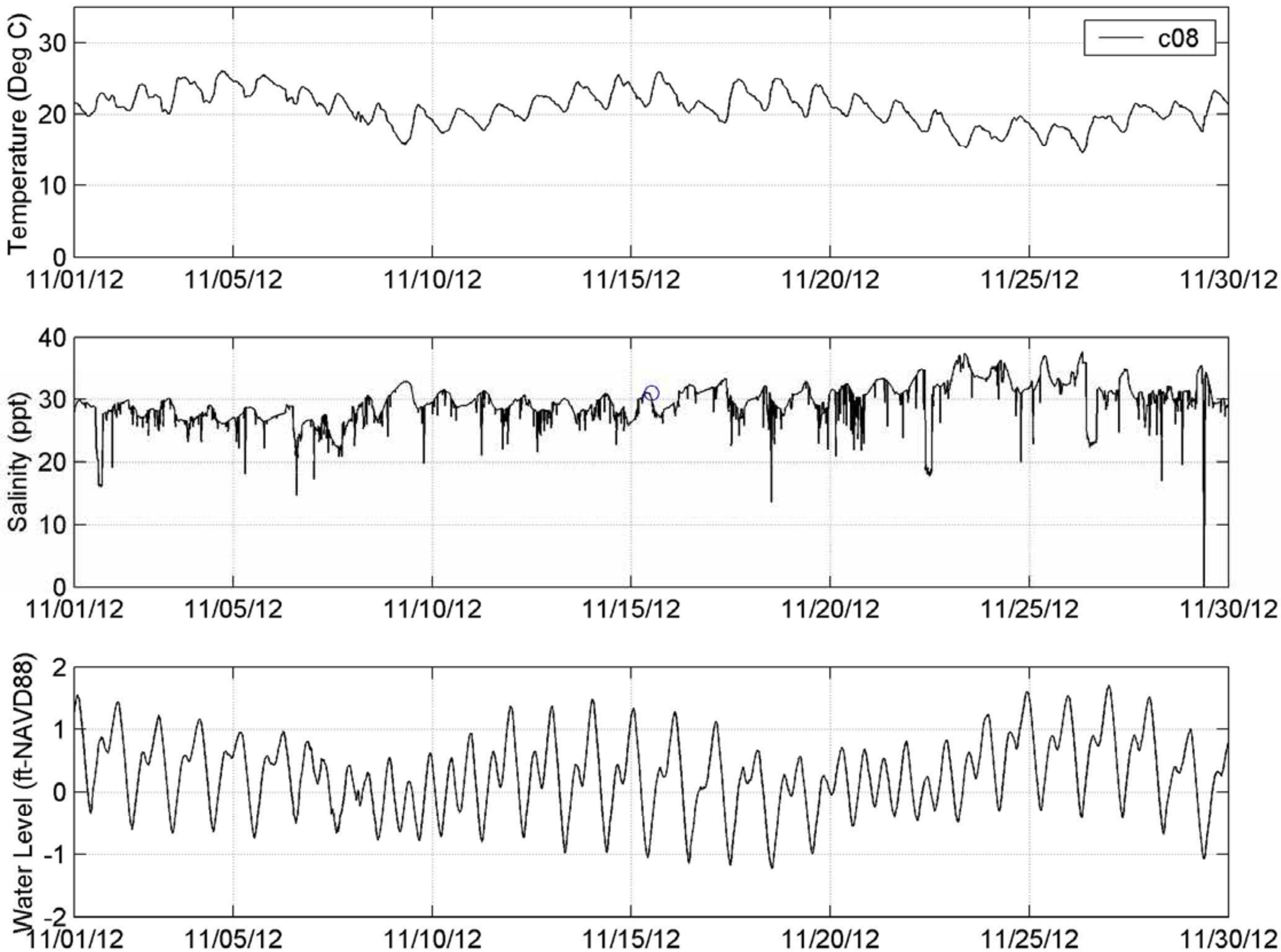

c07
Temperature (Deg C)
30
20
10
0
05/01/13
05/05/13
05/10/13
05/15/13
05/20/13
05/25/13
05/31/13
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
1.5
1
0.5
0
-0.5

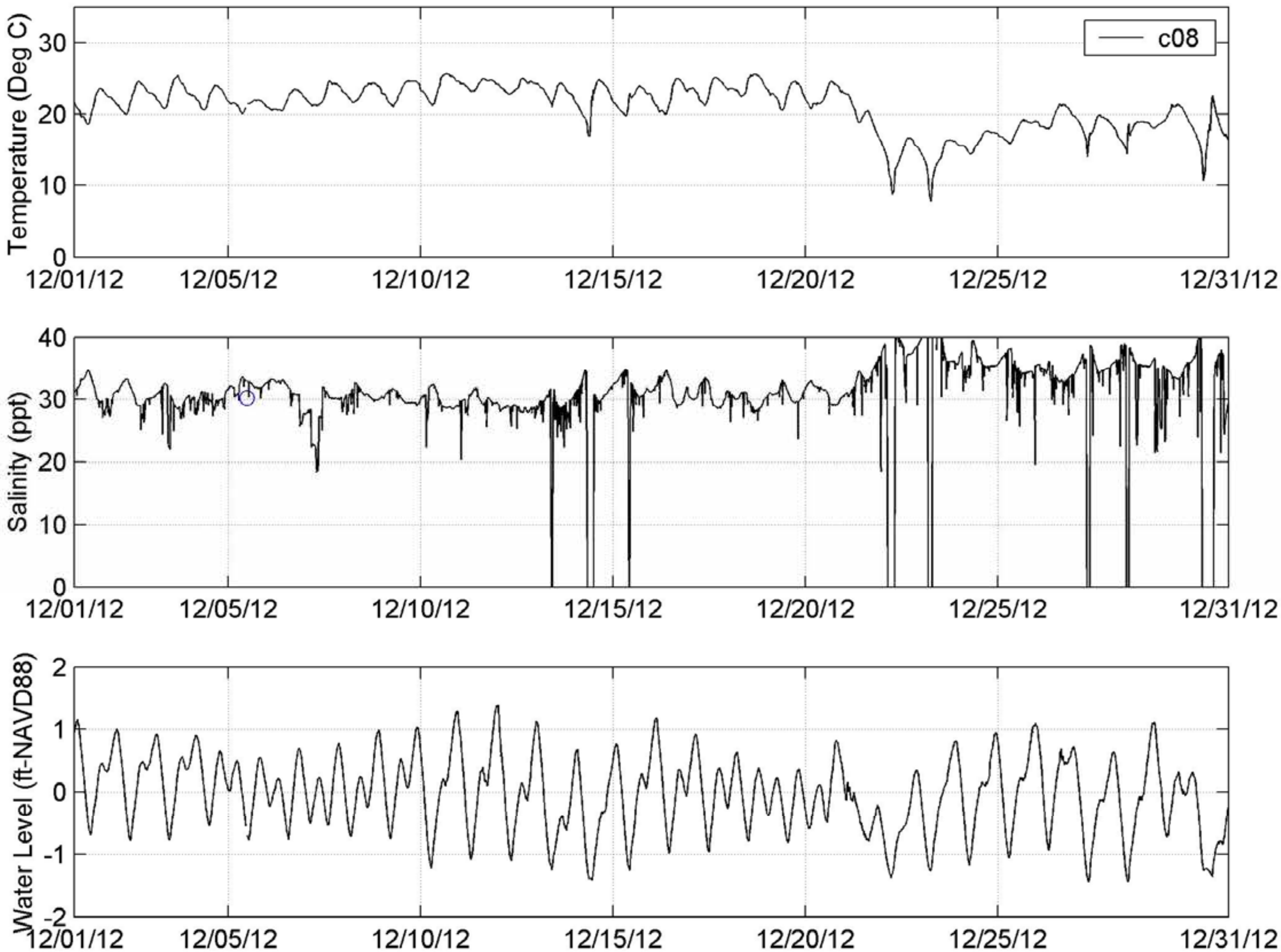

Temperature (Deg C)
c07
Salinity (ppt)
Water Level (ft-NAVD88)
06/01/13
06/05/13
06/10/13
06/15/13
06/20/13
06/25/13
06/30/13

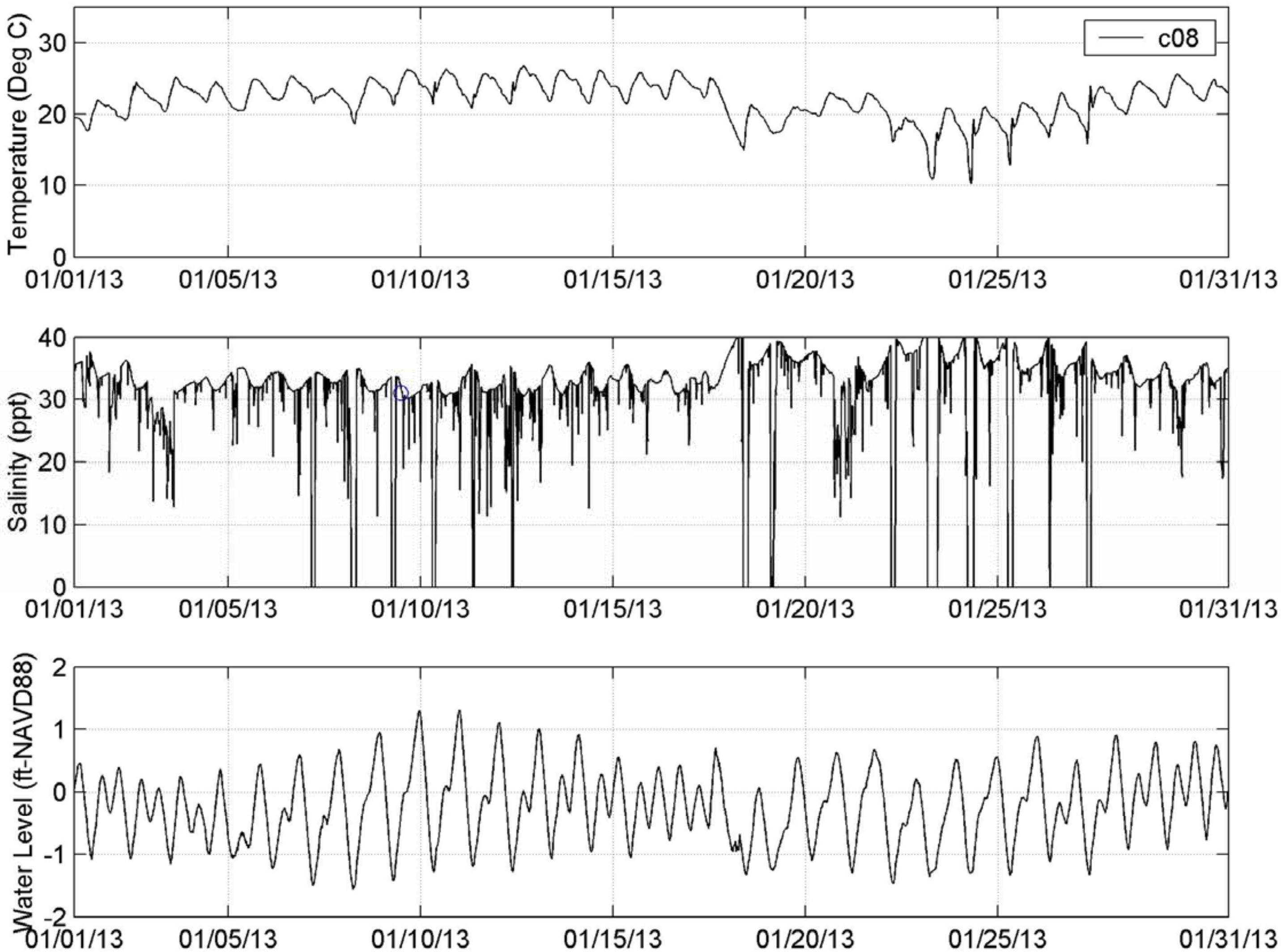

c07
Temperature (Deg C)
0
10
20
30
07/01/13
07/05/13
07/10/13
07/15/13
07/20/13
07/25/13
07/31/13
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
0
0.5
1
1.5
2

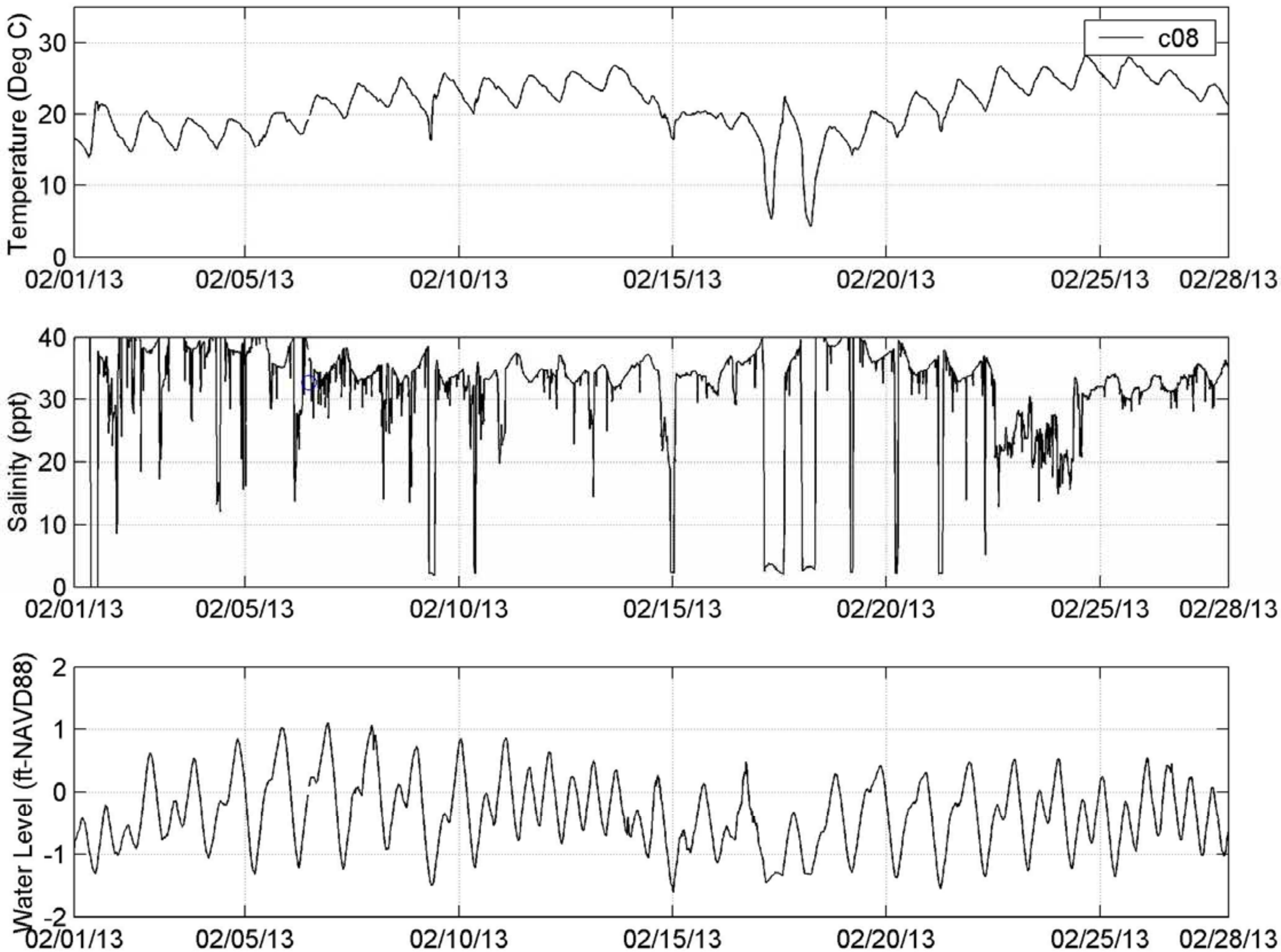


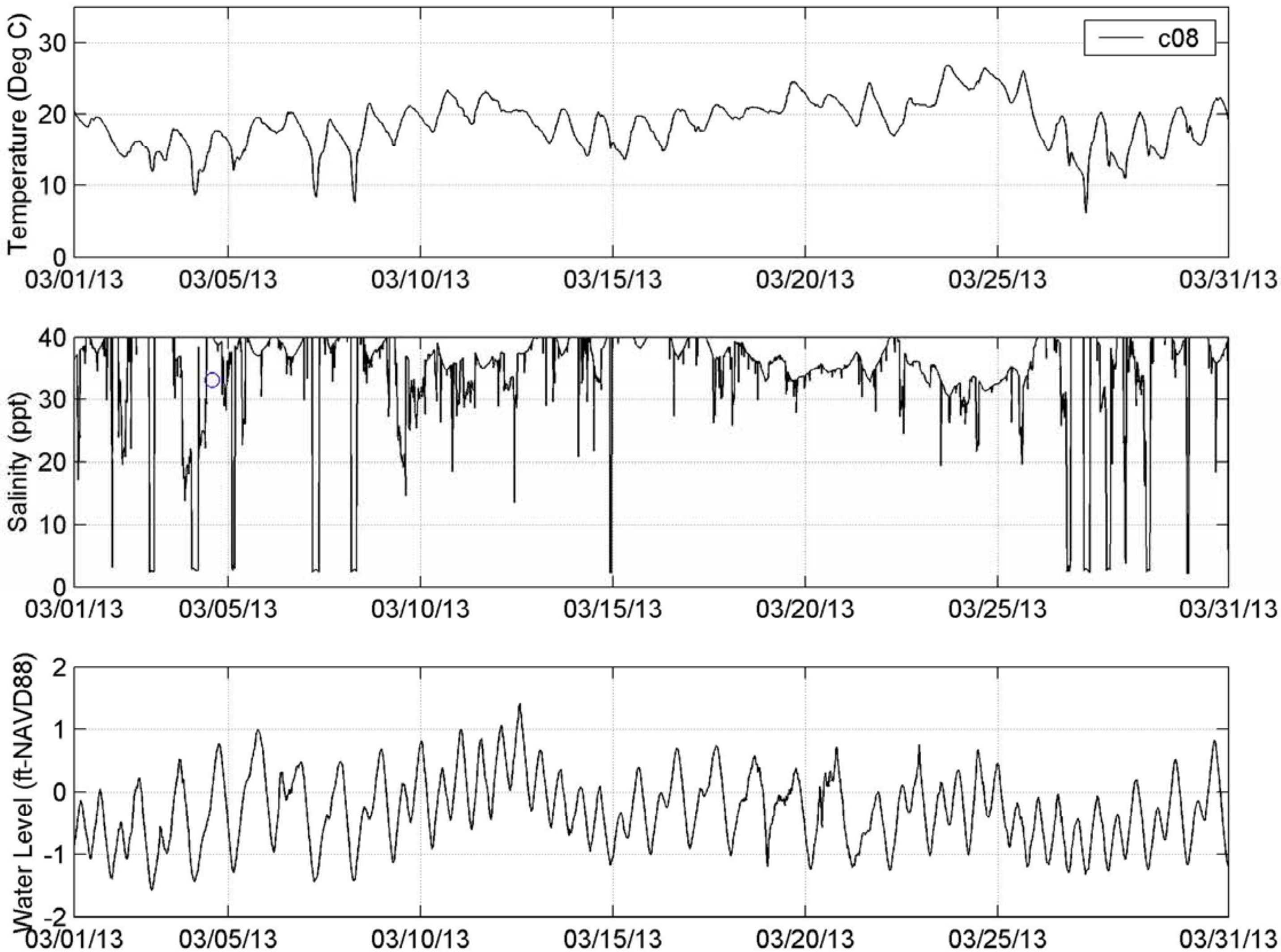
c08
Temperature (Deg C)
0
10
20
30
10/01/12
10/05/12
10/10/12
10/15/12
10/20/12
10/25/12
10/31/12
Salinity (ppt)
0
10
20
30
40
10/01/12
10/05/12
10/10/12
10/15/12
10/20/12
10/25/12
10/31/12
Water Level (ft-NAVD88)
-1
0
1
2
10/01/12
10/05/12
10/10/12
10/15/12
10/20/12
10/25/12
10/31/12

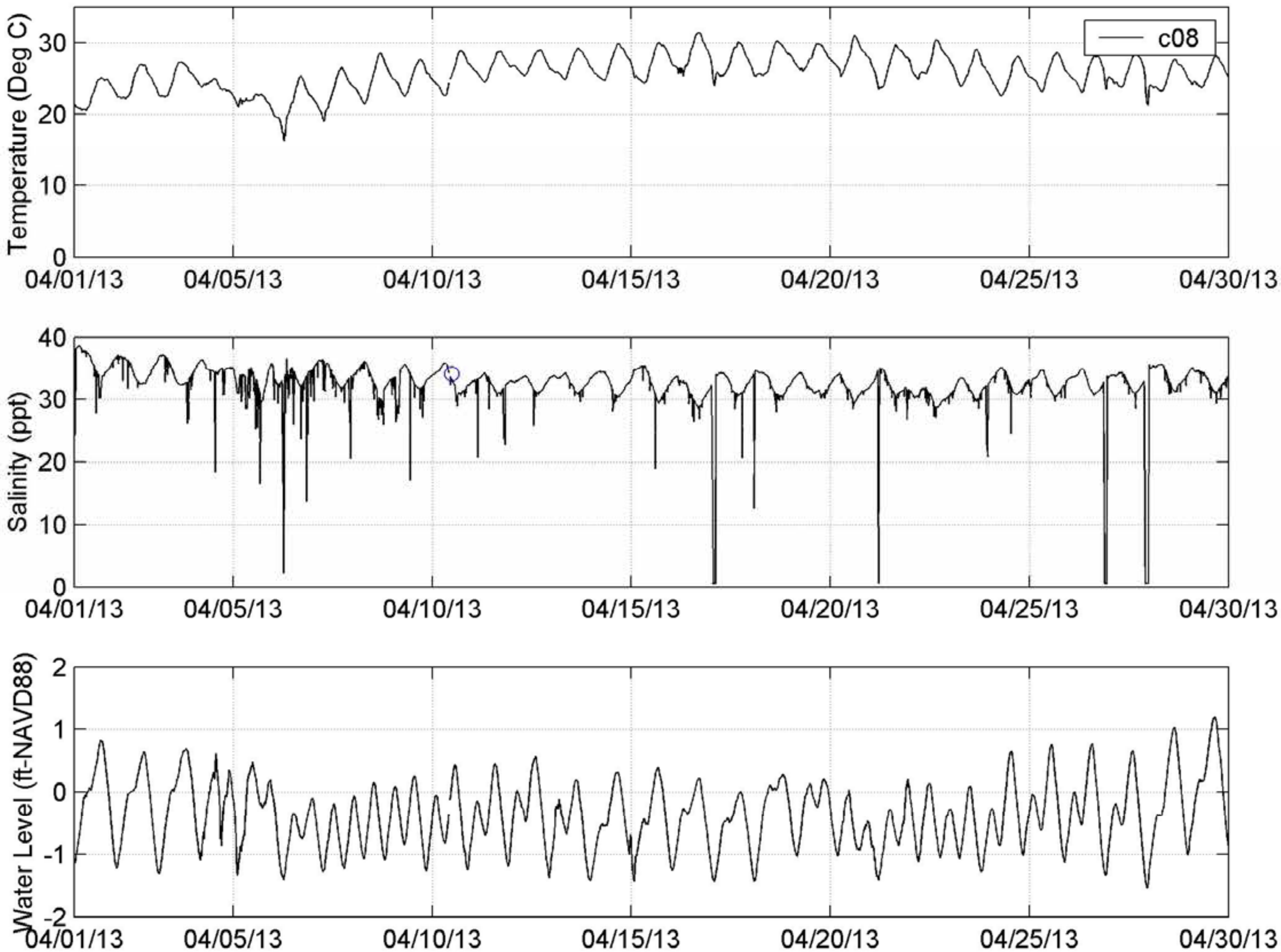

c08
Temperature (Deg C)
30
20
10
0
11/01/12
11/05/12
11/10/12
11/15/12
11/20/12
11/25/12
11/30/12
Salinity (ppt)
40
30
20
10
0
11/01/12
11/05/12
11/10/12
11/15/12
11/20/12
11/25/12
11/30/12
Water Level (ft-NAVD88)
2
1
0
-1
-2
11/01/12
11/05/12
11/10/12
11/15/12
11/20/12
11/25/12
11/30/12

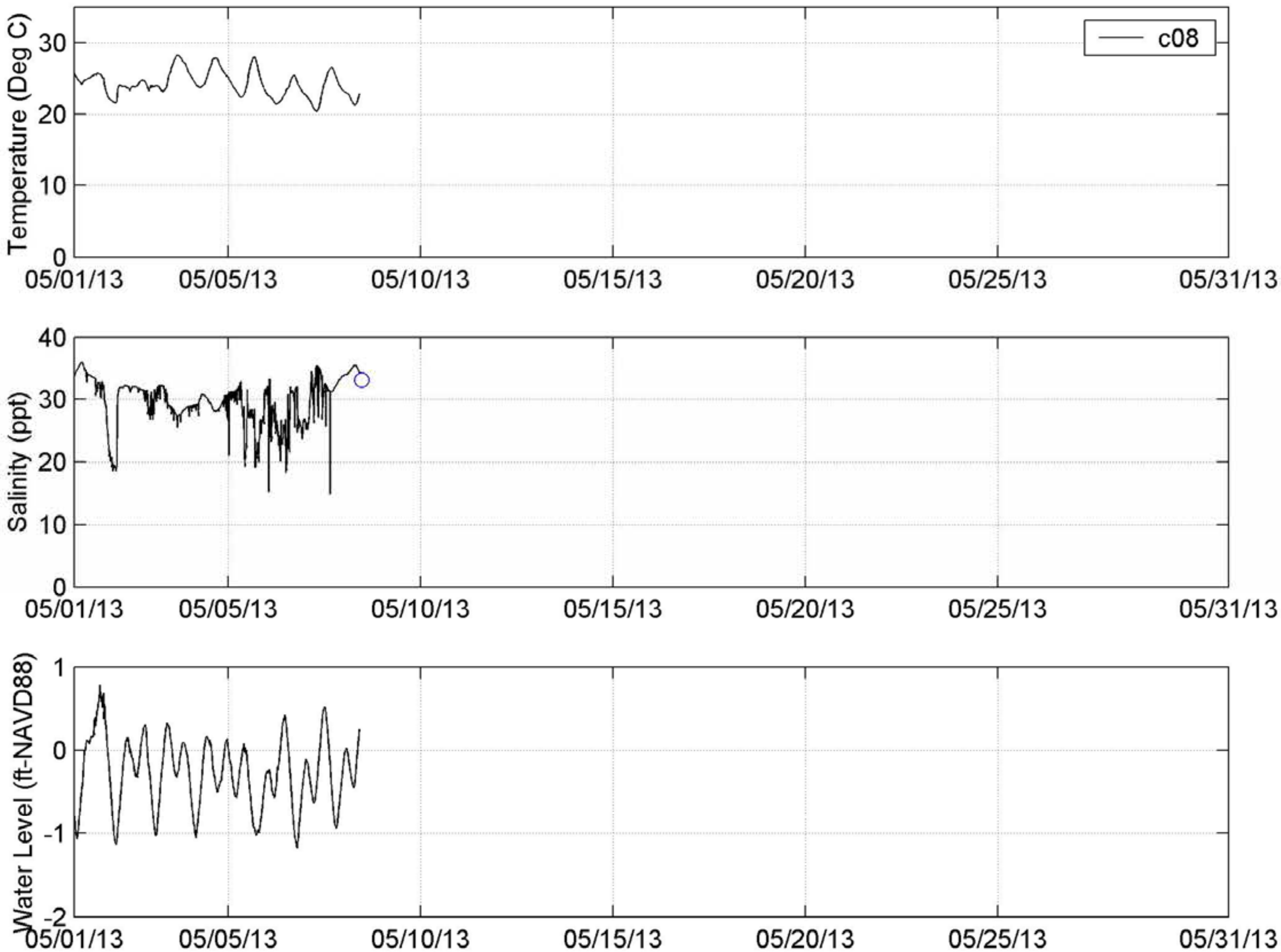

c08
Temperature (Deg C)
0
10
20
30
12/01/12
12/05/12
12/10/12
12/15/12
12/20/12
12/25/12
12/31/12
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
-2
-1
0
1
2

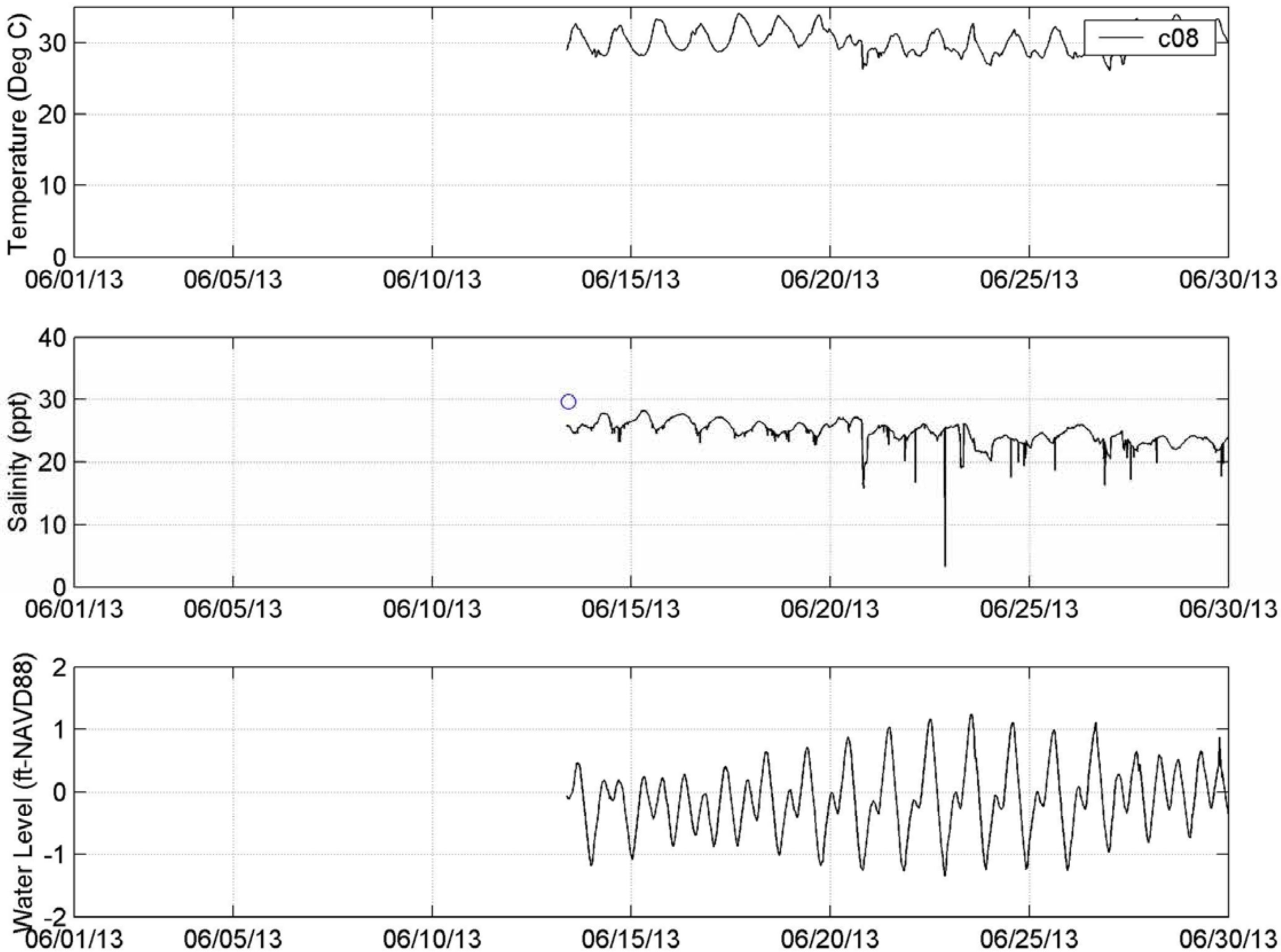

c08
Temperature (Deg C)
30
20
10
0
01/01/13
01/05/13
01/10/13
01/15/13
01/20/13
01/25/13
01/31/13
Salinity (ppt)
40
30
20
10
0
Water Level (ft-NAVD88)
2
1
0
-1
-2


c08
Temperature (Deg C)
Salinity (ppt)
Water Level (ft-NAVD88)
02/01/13
02/05/13
02/10/13
02/15/13
02/20/13
02/25/13
02/28/13

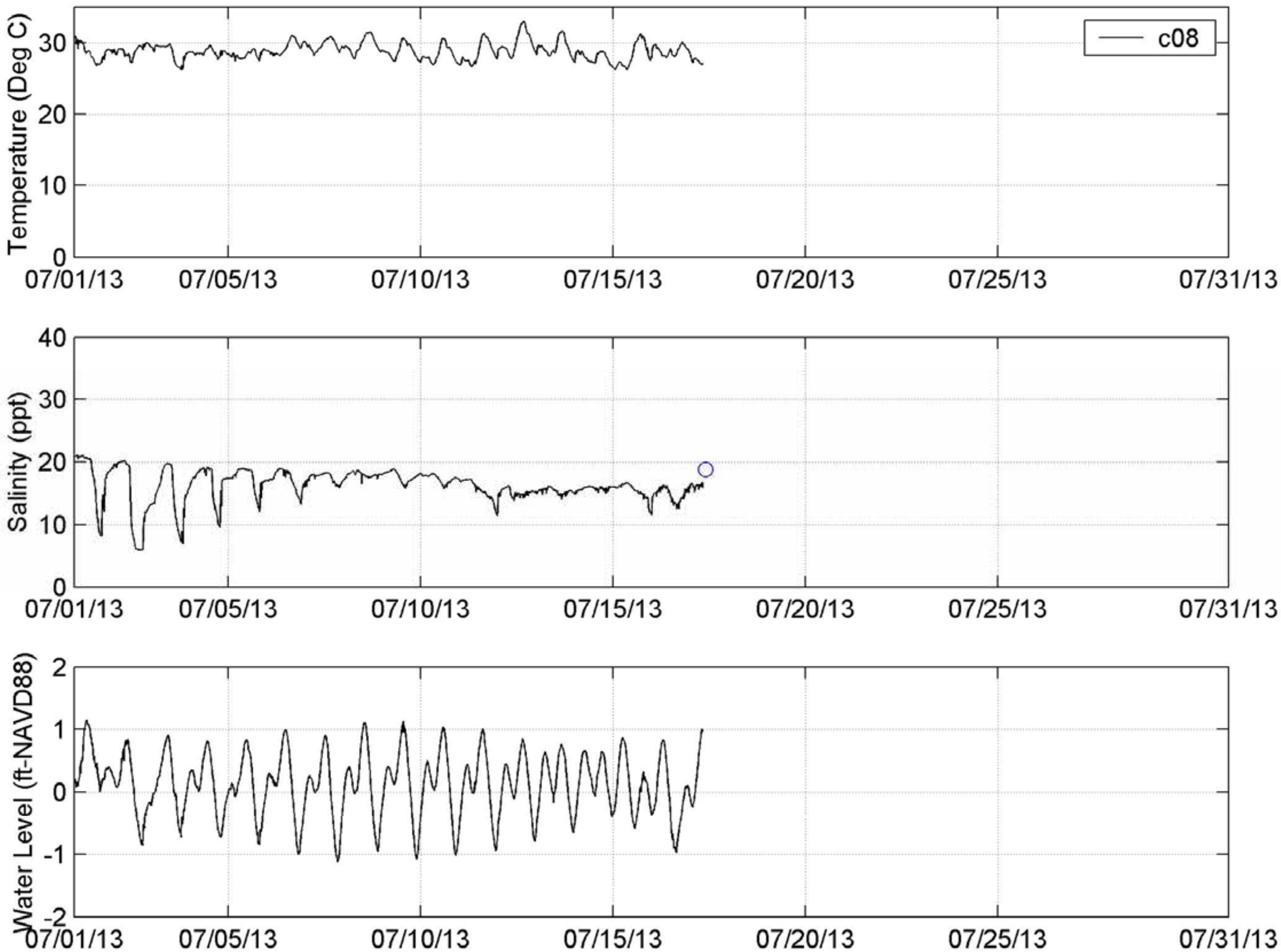

c08
Temperature (Deg C)
30
20
10
0
03/01/13
03/05/13
03/10/13
03/15/13
03/20/13
03/25/13
03/31/13
Salinity (ppt)
40
30
20
10
0
03/01/13
03/05/13
03/10/13
03/15/13
03/20/13
03/25/13
03/31/13
Water Level (ft-NAVD88)
2
1
0
-1
-2
03/01/13
03/05/13
03/10/13
03/15/13
03/20/13
03/25/13
03/31/13


c08
Temperature (Deg C)
0
10
20
30
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
-2
-1
0
1
2
04/01/13
04/05/13
04/10/13
04/15/13
04/20/13
04/25/13
04/30/13


c08
Temperature (Deg C)
30
20
10
0
05/01/13
05/05/13
05/10/13
05/15/13
05/20/13
05/25/13
05/31/13
Salinity (ppt)
40
30
20
10
0
05/01/13
05/05/13
05/10/13
05/15/13
05/20/13
05/25/13
05/31/13
Water Level (ft-NAVD88)
1
0
-1
-2
05/01/13
05/05/13
05/10/13
05/15/13
05/20/13
05/25/13
05/31/13



Temperature (Deg C)
0
10
20
30
c08
Salinity (ppt)
0
10
20
30
40
Water Level (ft-NAVD88)
-2
-1
0
1
2
06/01/13
06/05/13
06/10/13
06/15/13
06/20/13
06/25/13
06/30/13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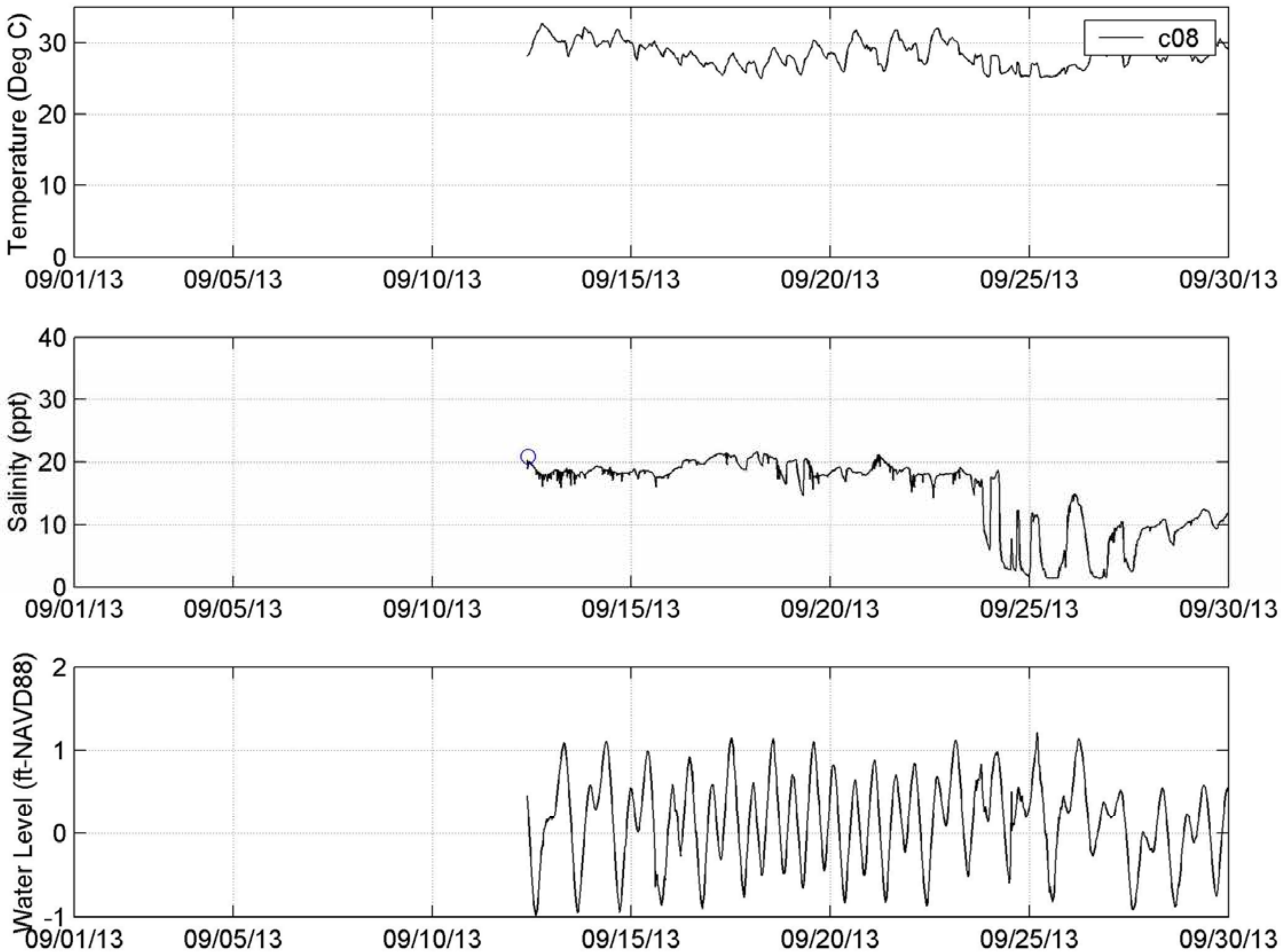
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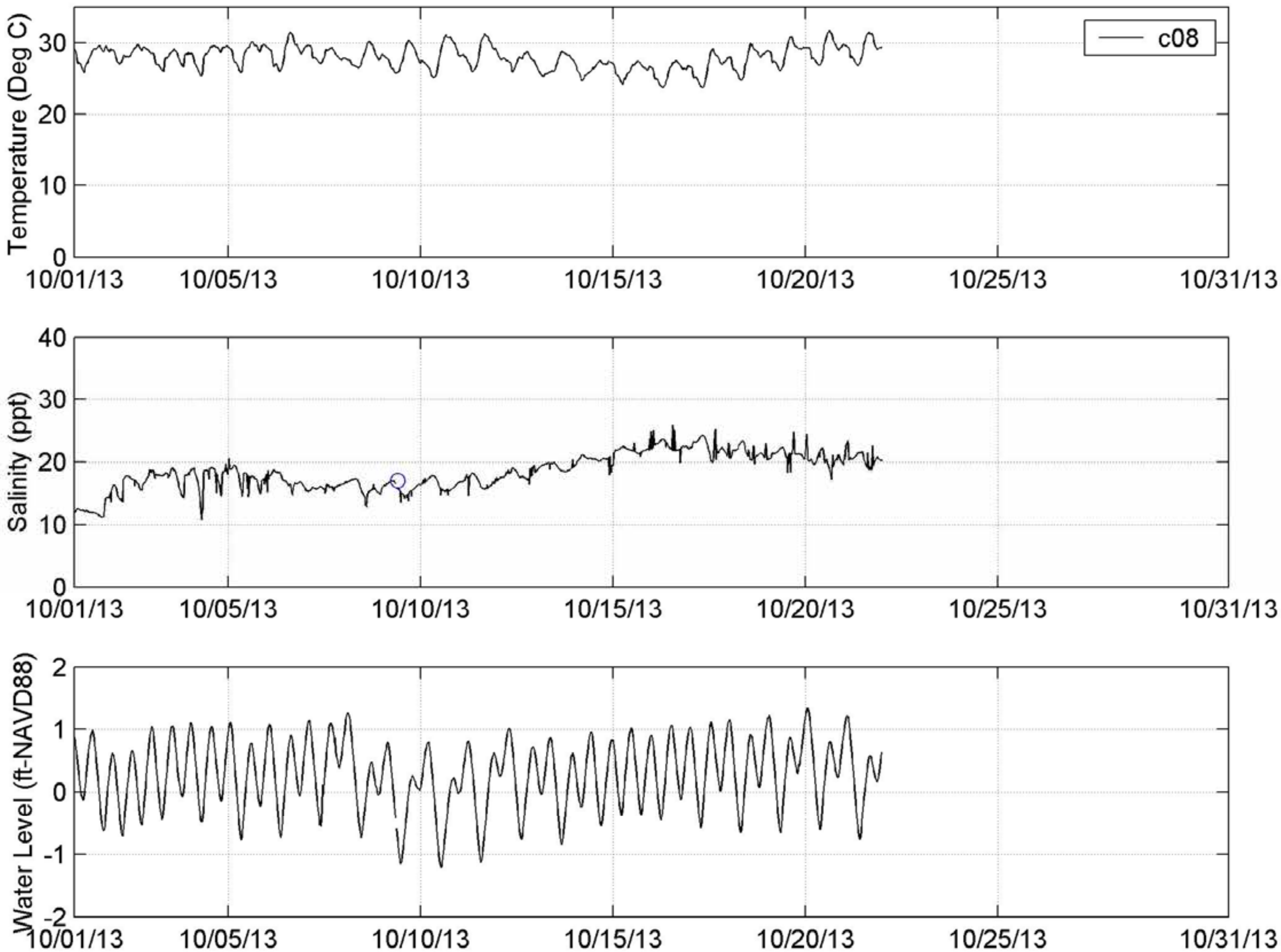
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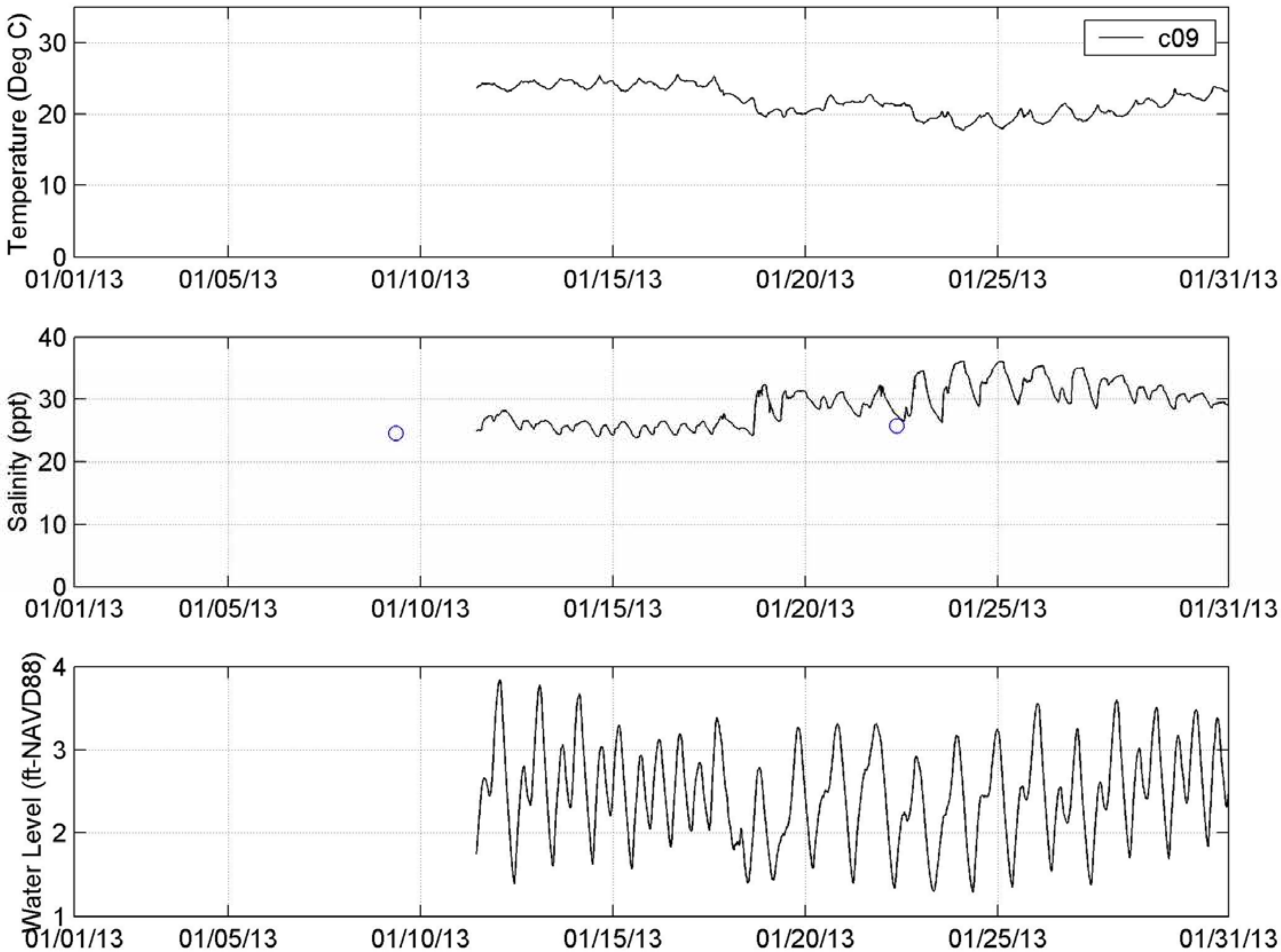
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01/20/13
01/25/13
01/31/13
Water Level (ft-NAVD88)
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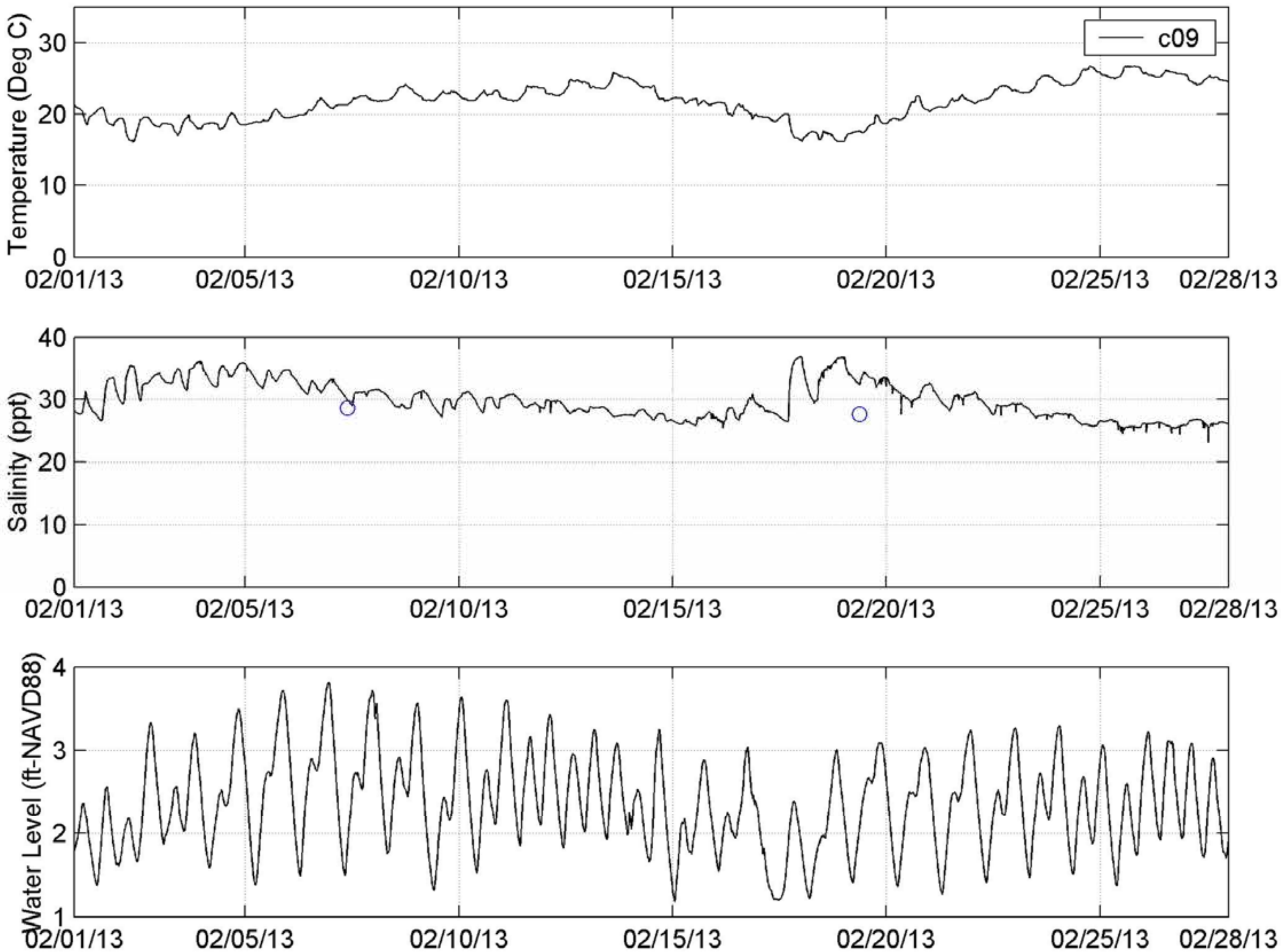
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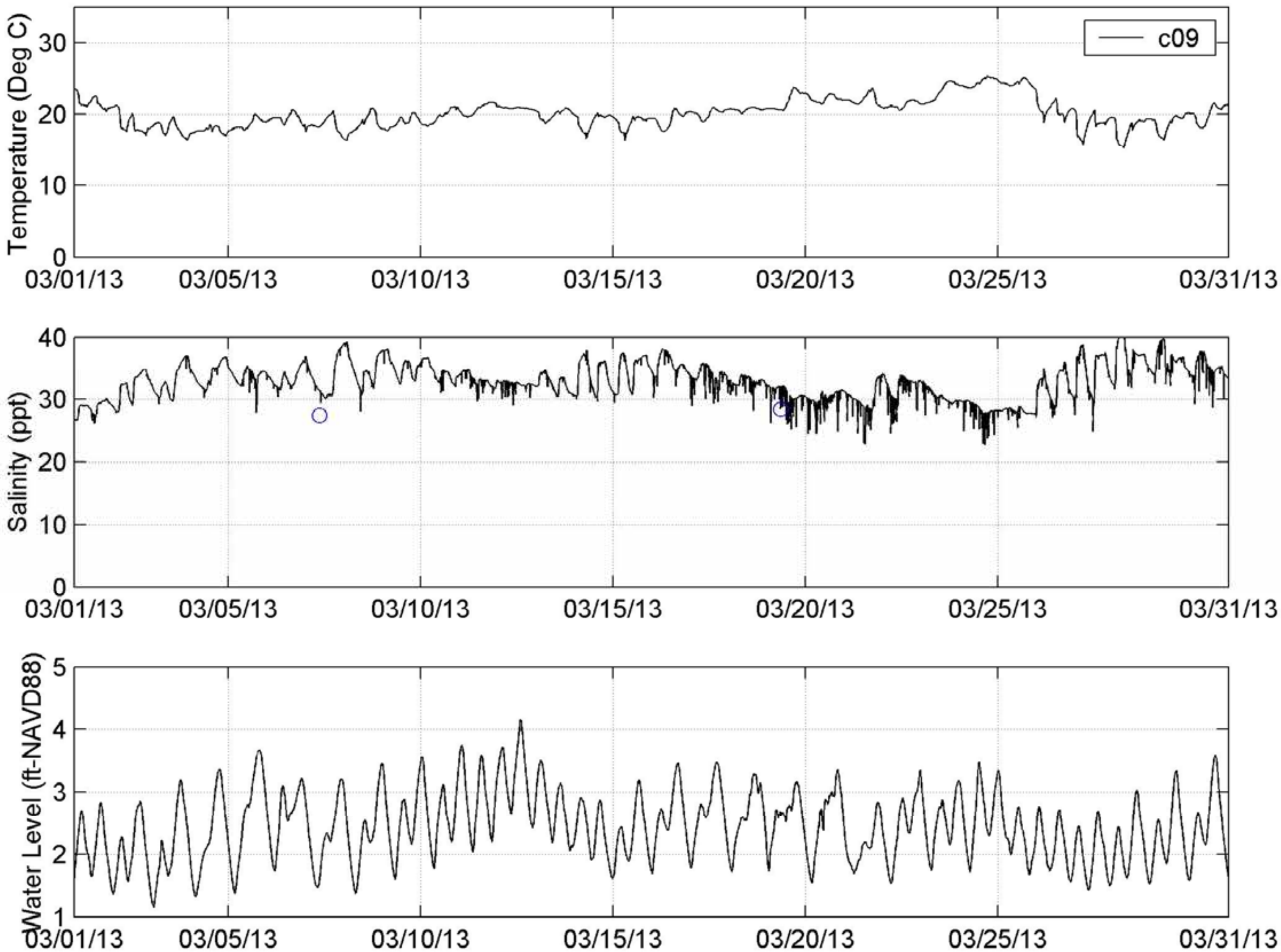

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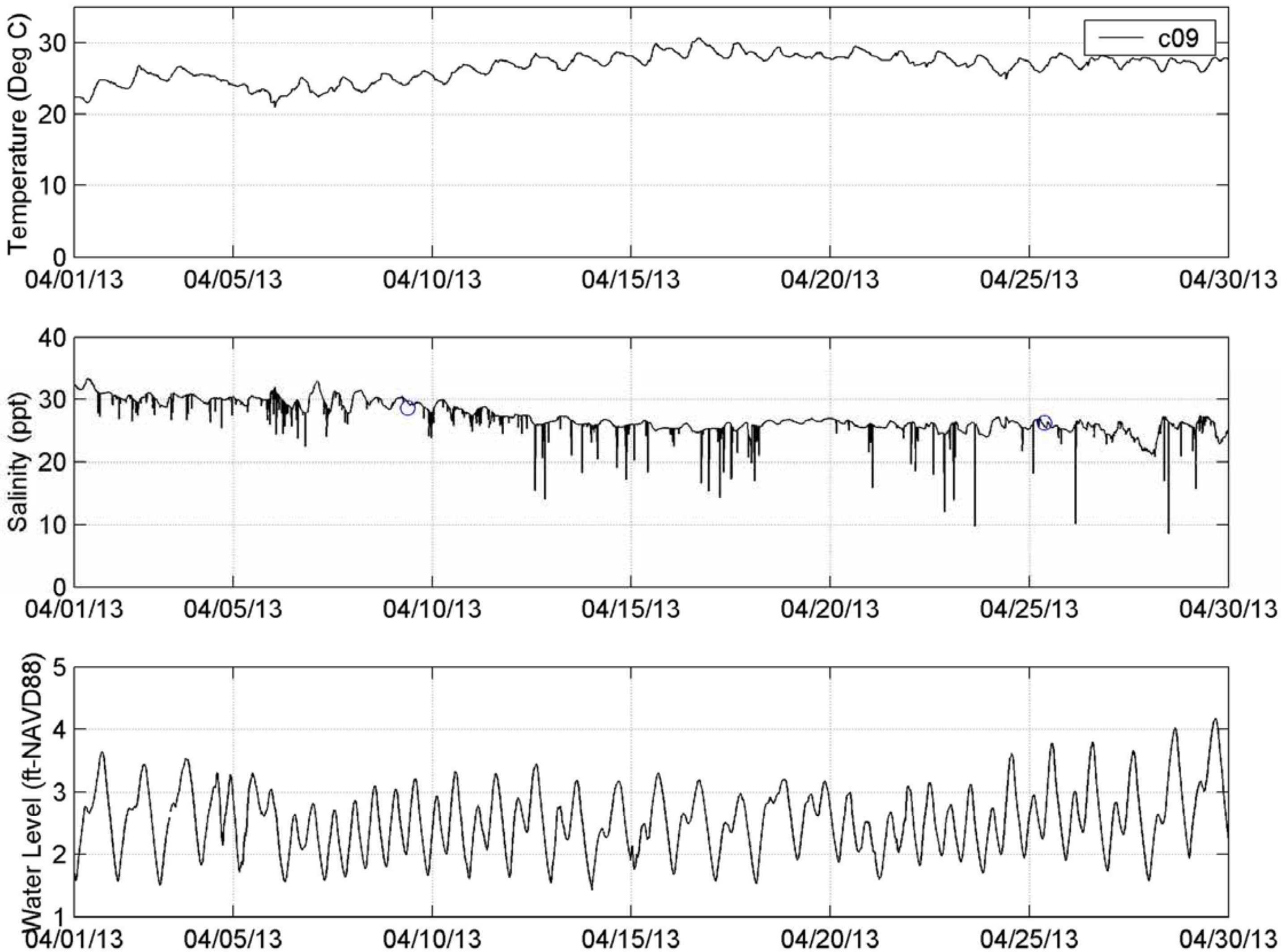

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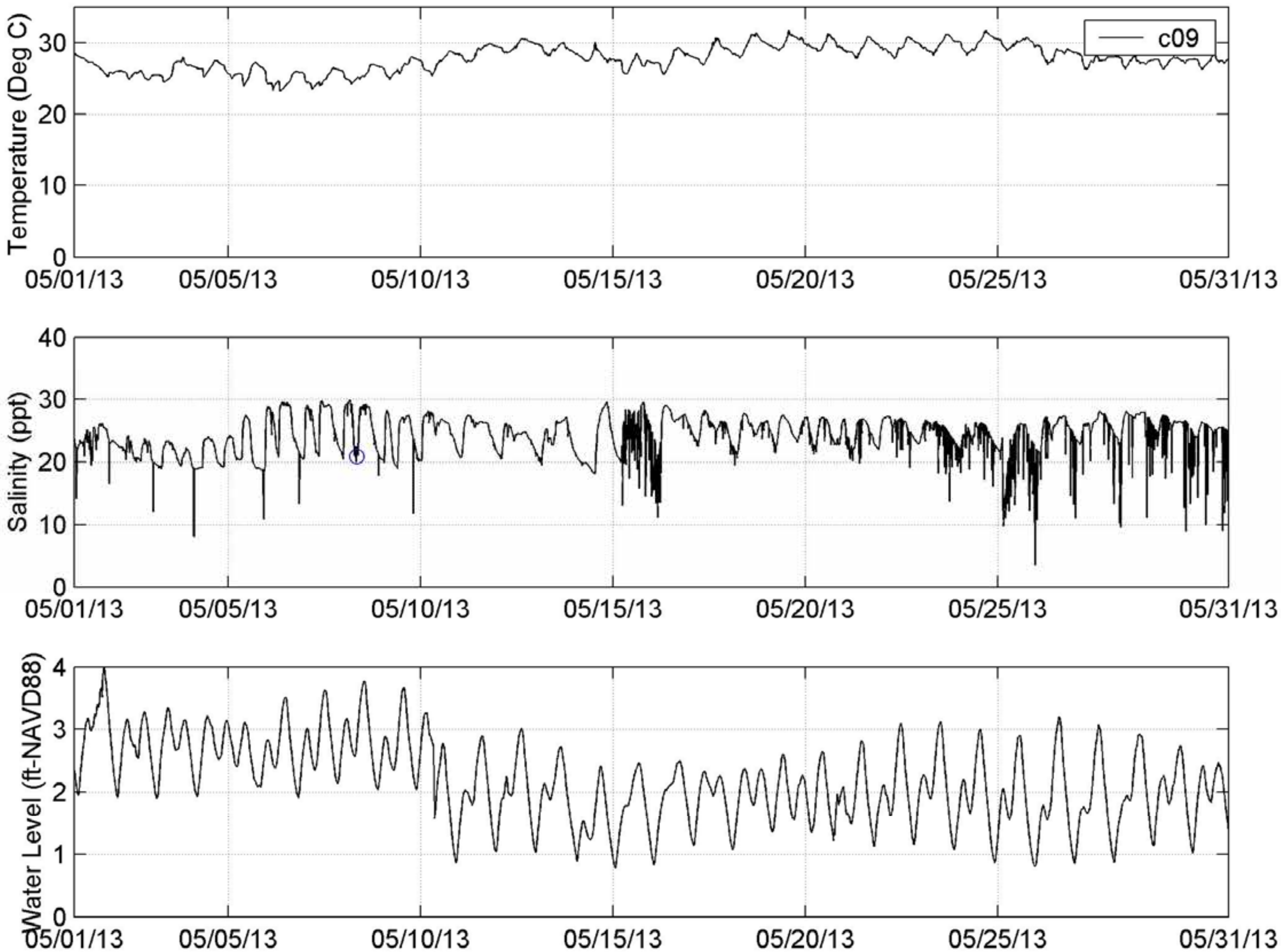
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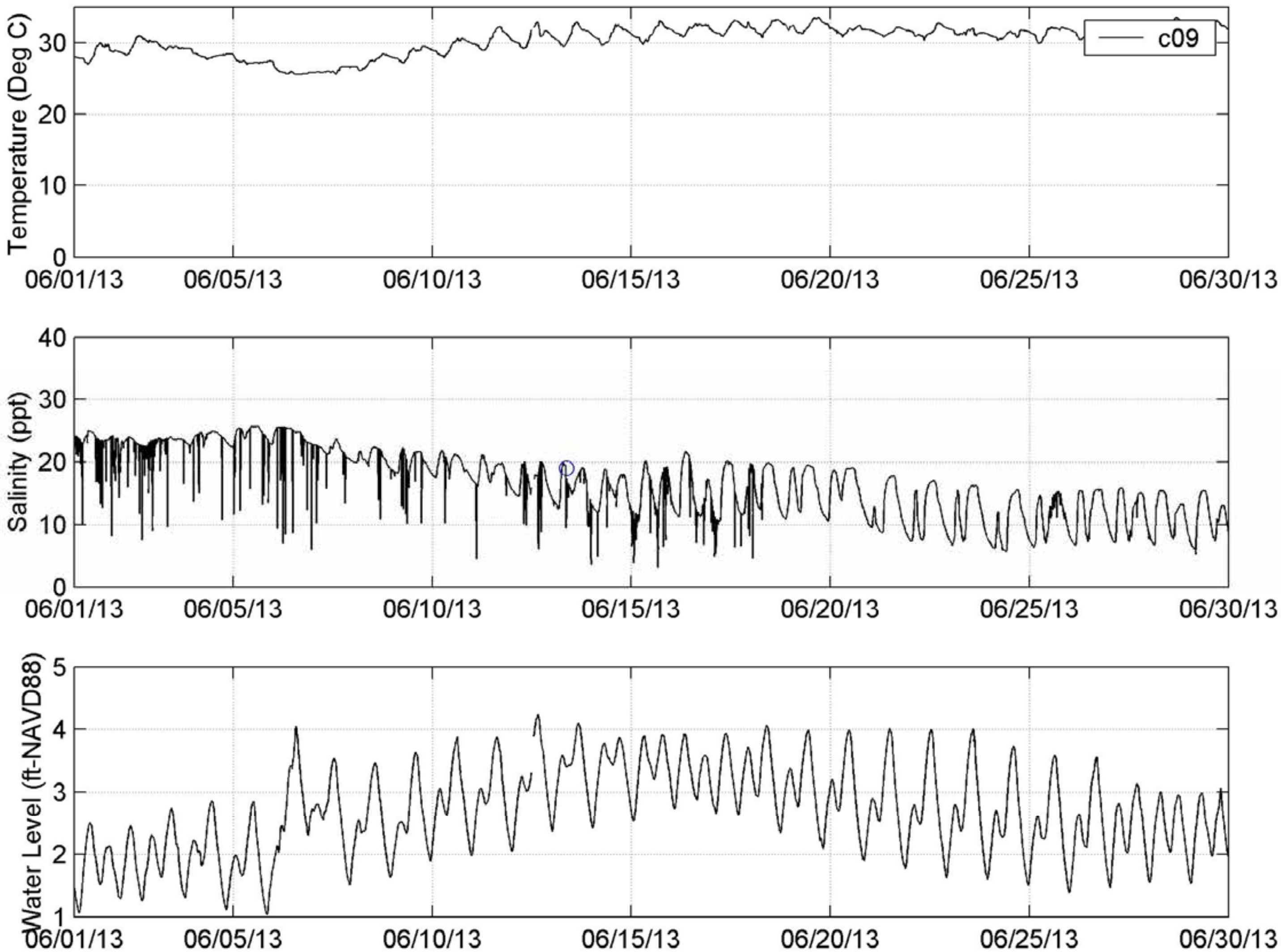
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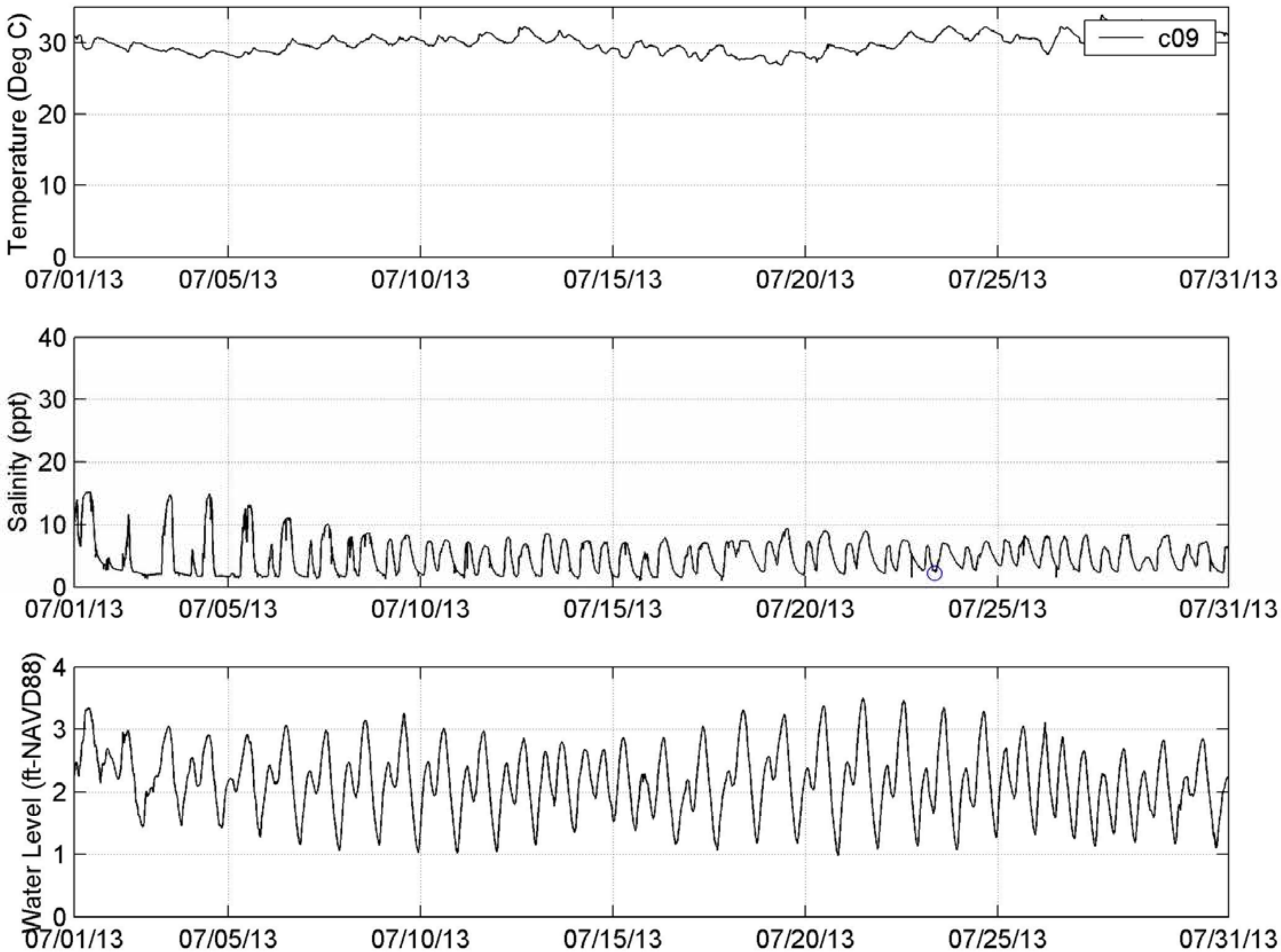
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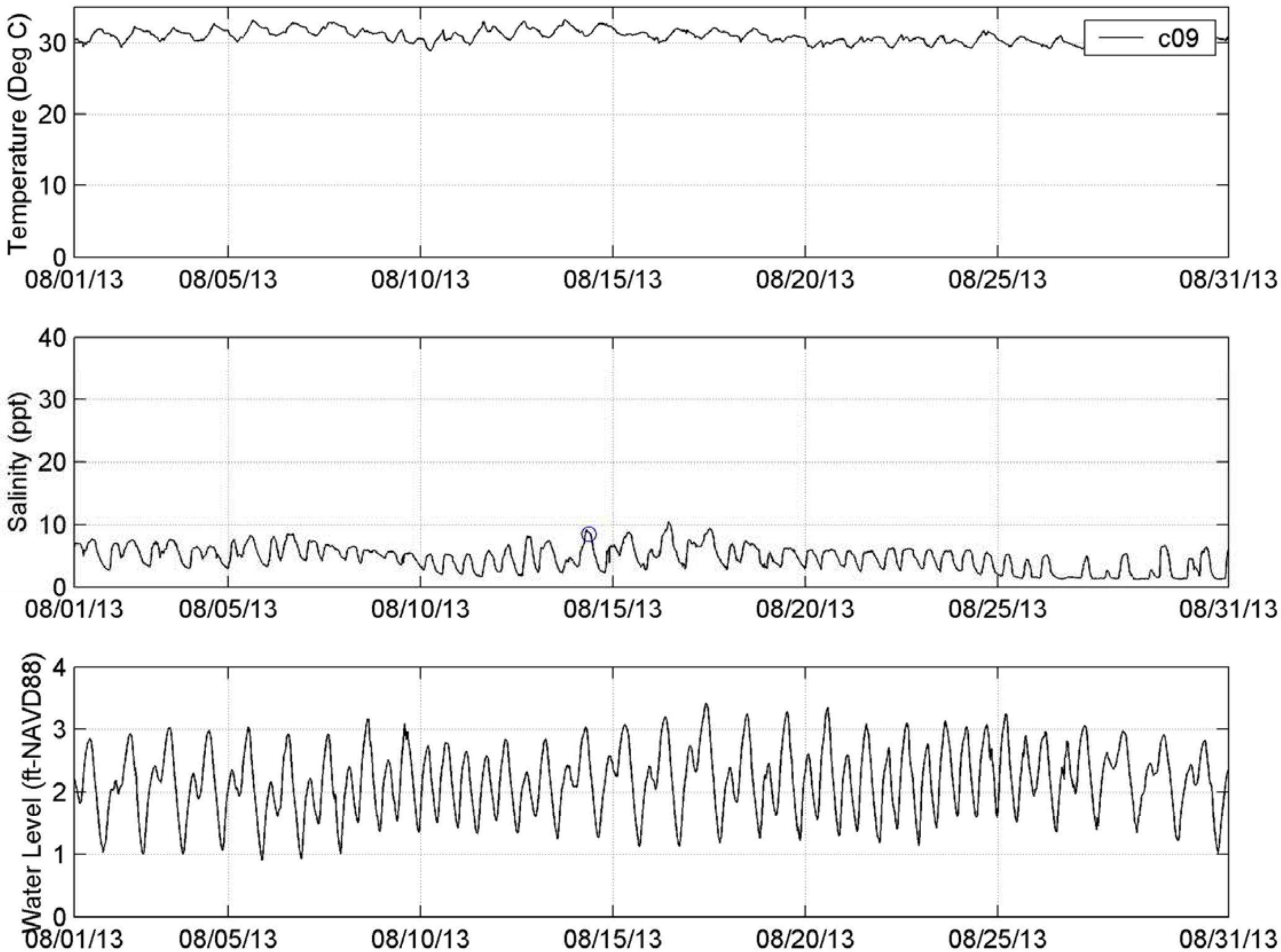
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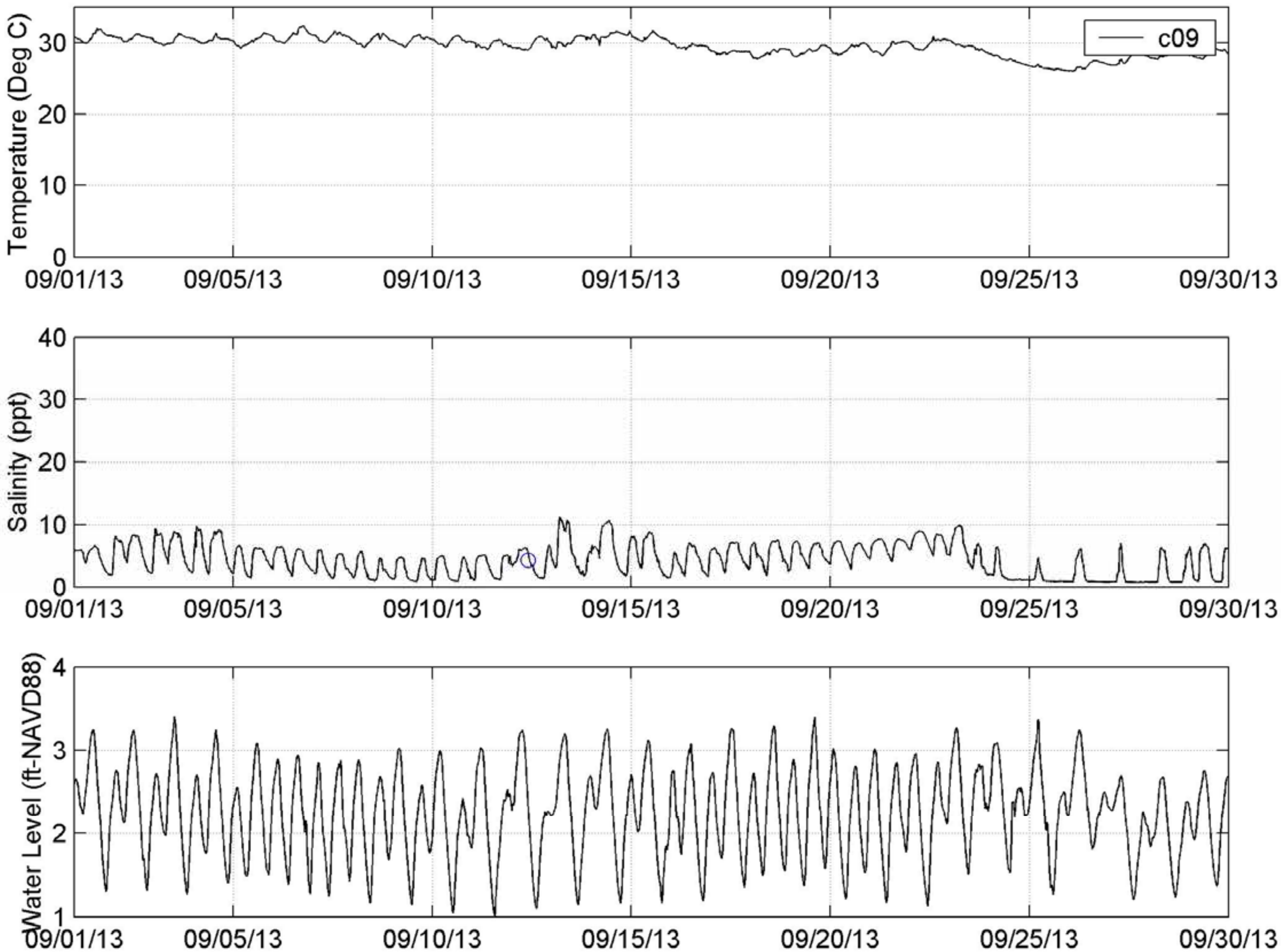
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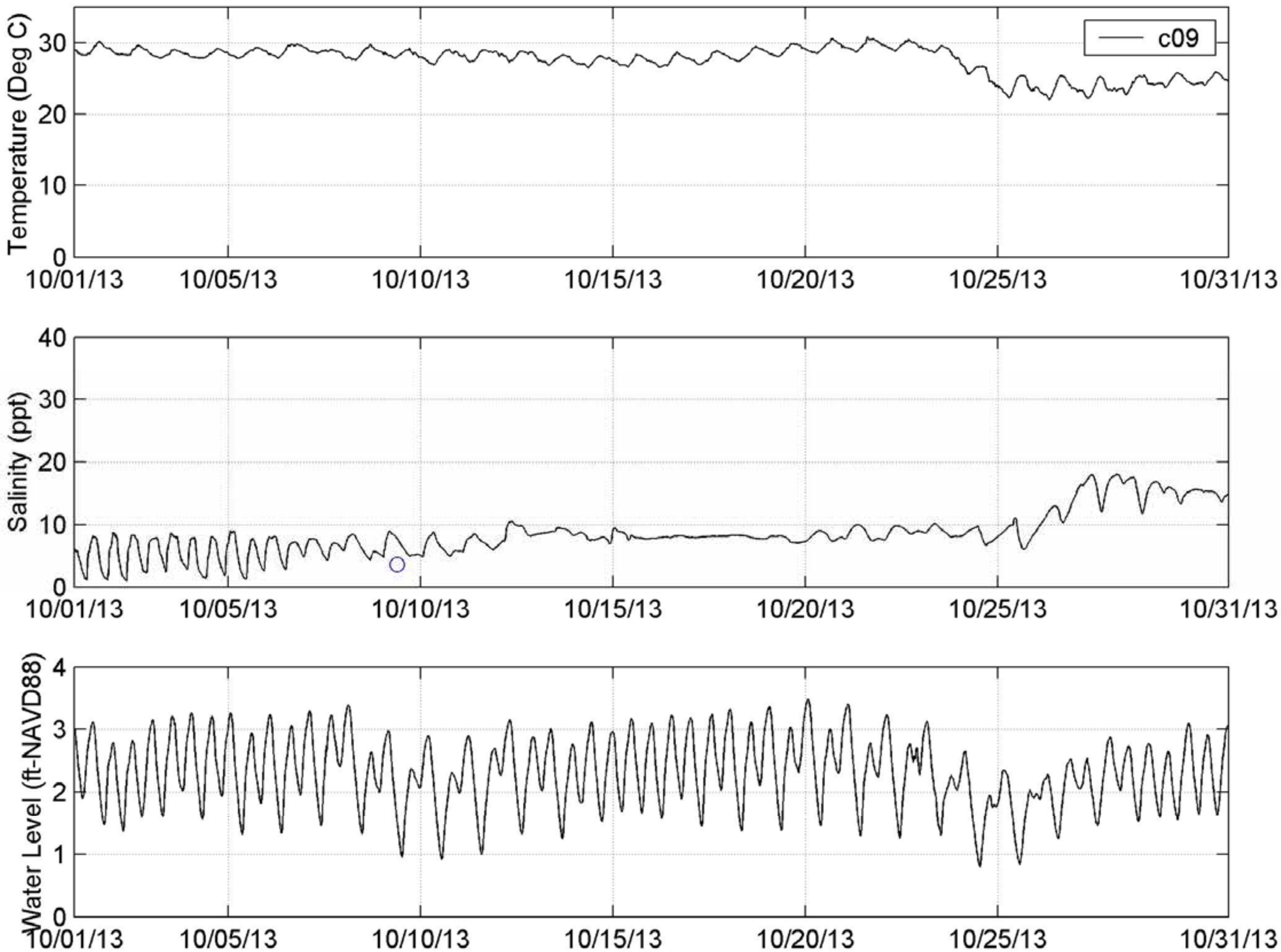
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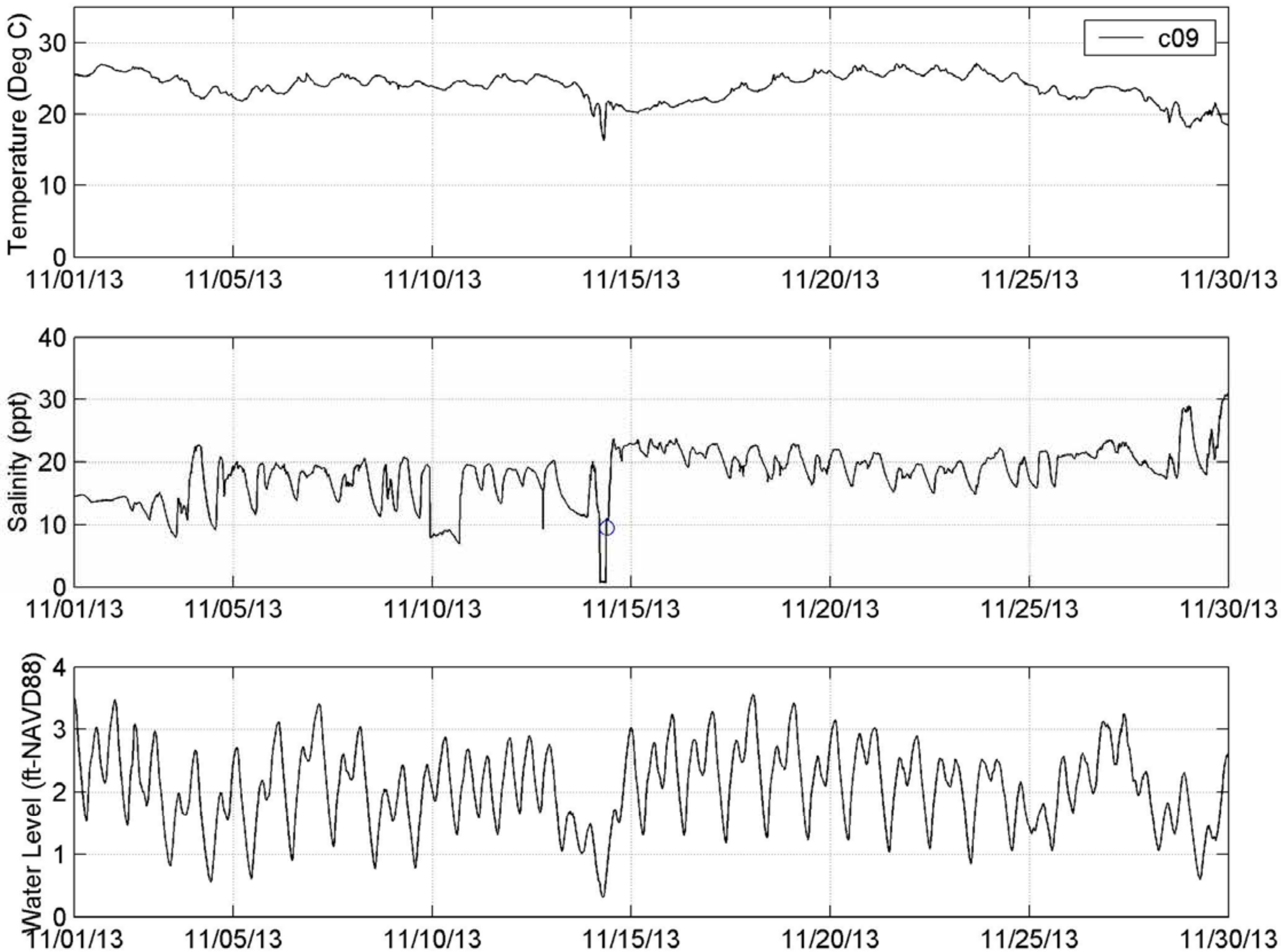

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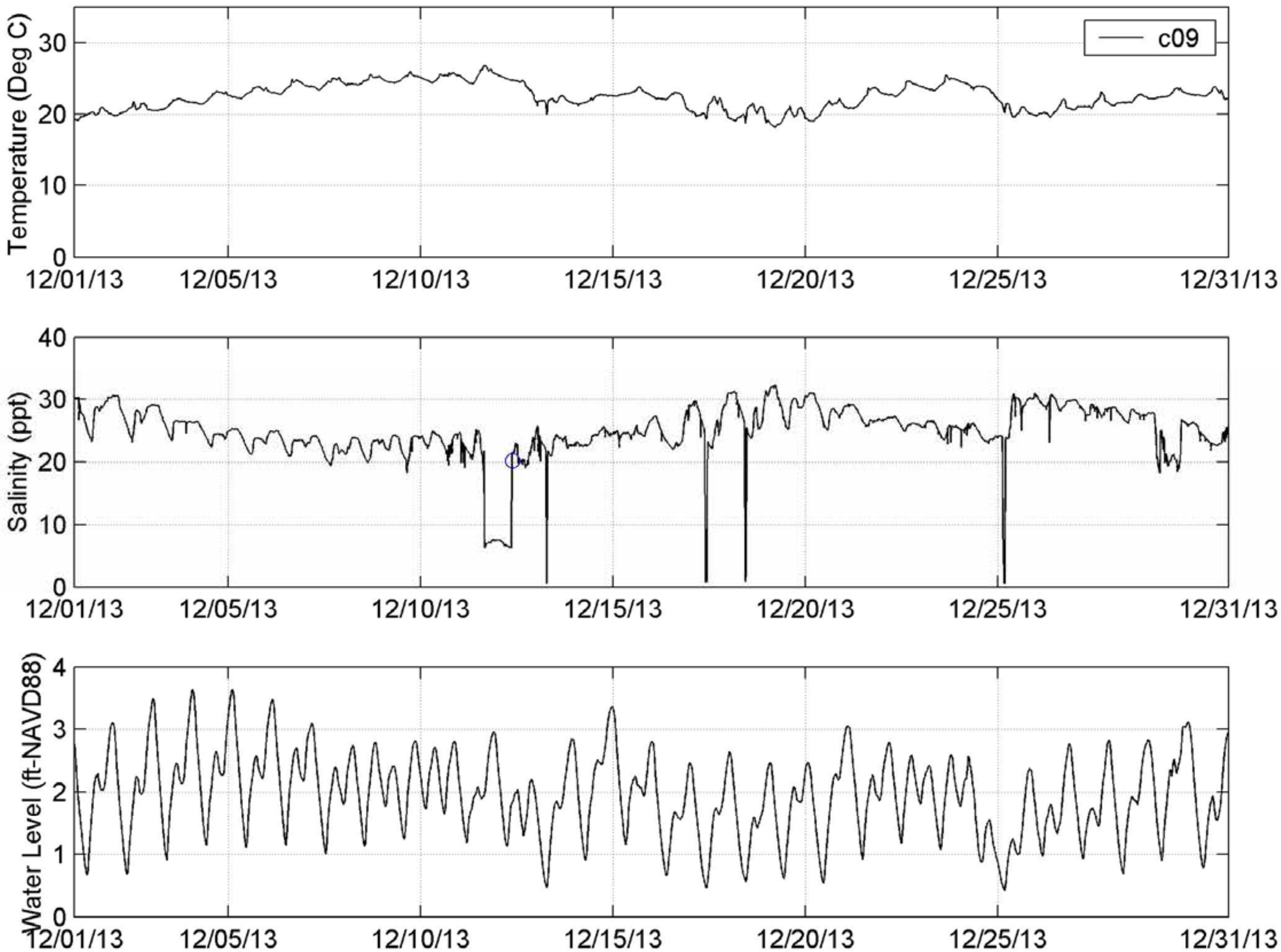
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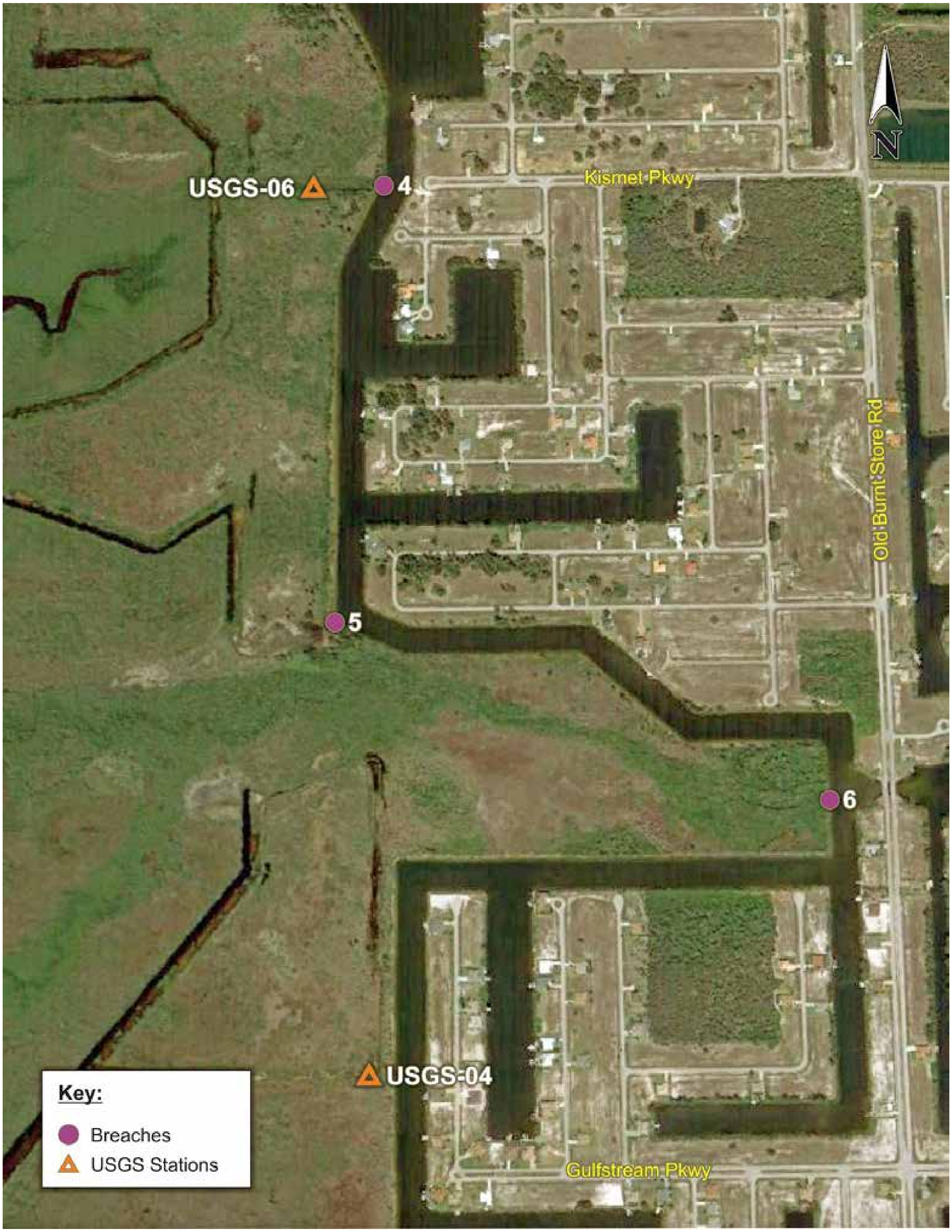
12/10/13
12/15/13
12/20/13
12/25/13
12/31/13

Appendix E

Aerial Photos of Breaches and USGS Monitoring Site Locations


N
Jacaranda Pkwy
1
USGS-07
1A
2
3
Key:
Breaches
USGS Stations


USGS-06
4
Kismet Pkwy
Old Burnt Store Rd
5
6
USGS-04
Gulfstream Pkwy
N
Key:
Breaches
USGS Stations

USGS-04
7
7B
7A
8
USGS-03
Gulfstream Pkwy
Old Burnt Store Rd
Yucatan Pkwy
Tropicana Pkwy W
N
Key:
Breaches
USGS Stations

Aerial Photos of Breaches and USGS Monitoring Site Locations

NW Cape Coral/Lee County Watershed Initiative
Phase I
Hydrodynamic Model Development and Calibration

Lee County, Florida

Lee County
P.O. Box 398
Fort Myers, FL 33902-0398

June 2015

Applied Technology and Management, Inc.
2201 NW 40 Terrace.
Gainesville, Florida 32605
386-256-1477

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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 four 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

The report presented herein presents the development and calibration of a 3-dimensional hydrodynamic model of the spreader canal system out to Matlacha Pass.

1.3 REPORT OUTLINE

Following this introduction, the report is broken down into four sections. Section 2 provides a description of the project area. Section 3 presents a general description of the Environmental Fluid Dynamics Code (EFDC) hydrodynamic model utilized for this project, the model inputs, the data sources for the model inputs, and the period of the calibration simulation. Section 4 presents the data used in the model calibration along with graphical and statistical comparisons of the model versus measured data. Section 5 summarizes the model development and calibration.

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 components:

- 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 system components 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 width of the canal varies but is generally around 150 feet (ft). A bathymetric survey, conducted as part of this project, showed that depths within the NSC range from 2.8 to 12.8 ft [referenced to the North American Vertical Datum of 1988 (NAVD88)] and average around 7.0 ft.

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).

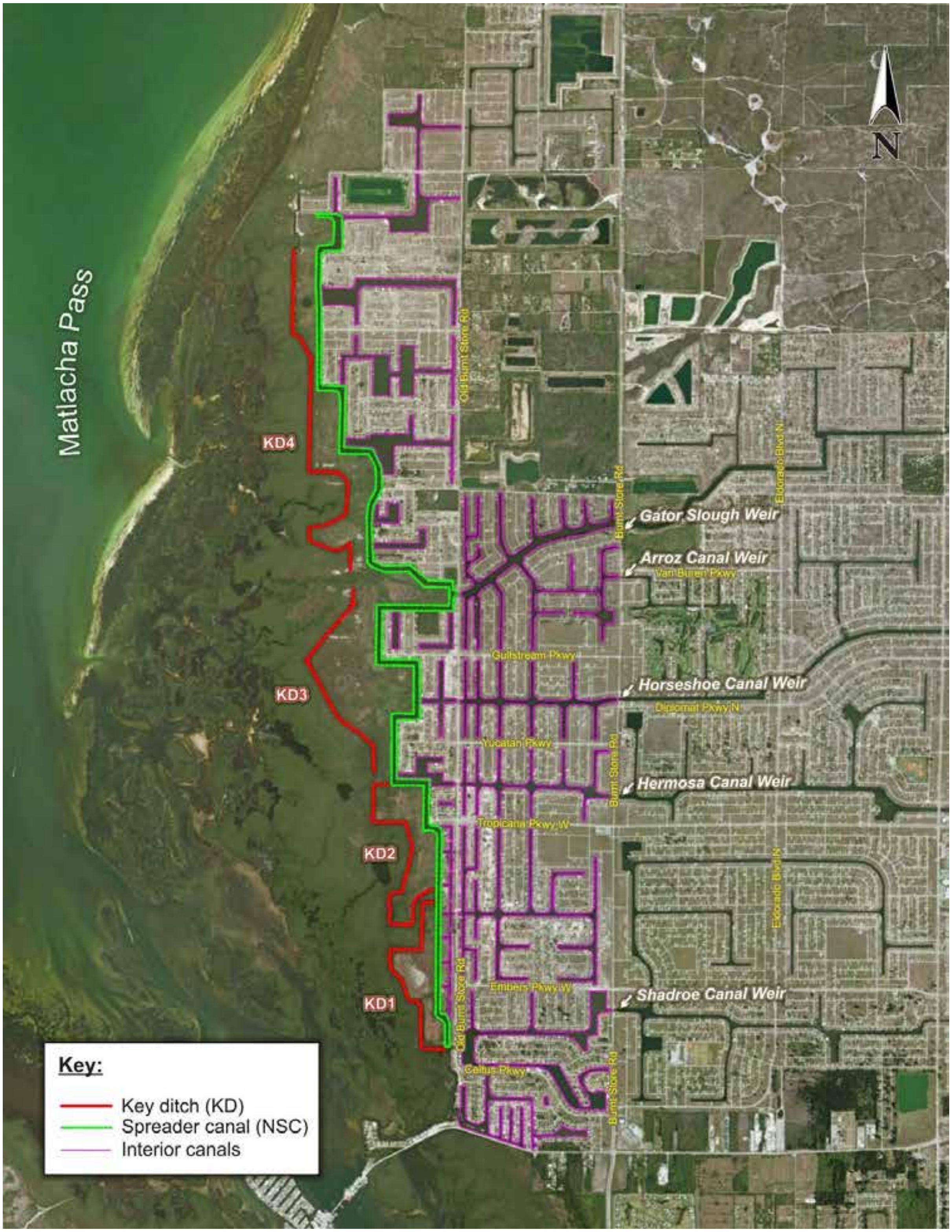


Figure 2-1. Project Area Map

Through previous studies, a total of 17 breaches (including the breach that occurred at the location of the former boat lift) were documented. Figure 2-2 shows the locations of the previously documented breaches and provides their location identifications. Appendix A presents aerial photographs showing zoomed-in views that include each of the 17 breaches as they exist today.

For the purposes of this study, eight of the breaches were monitored. These breaches were identified as the primary conduits for flow leaving the NSC and entering the KD. This includes flows entering and leaving the NSC through the opening at the south end (the former location of the barrier). Figure 2-3 shows the locations of the monitored breaches along with the southern opening. The aerial photographs (Appendix A) show zoomed-in views of the U.S. Geological Survey (USGS) monitoring sites. The location identifications used for this study reflect where USGS conducted monitoring to measure flows, water levels and velocities. Table 2-1 provides the correspondence between the breach numbers (shown on Figure 2-2) and the USGS monitoring sites.

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

Of the 17 documented breaches, as Table 2-1 shows, 8 were monitored for this project. The unmonitored breaches include (from Figure 2-2):

- Breach 1
- Breach 2
- Breach 3
- Breach 5
- Breach 6
- Breach 7B
- Breach 7A
- Breach 8A
- Breach 9

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

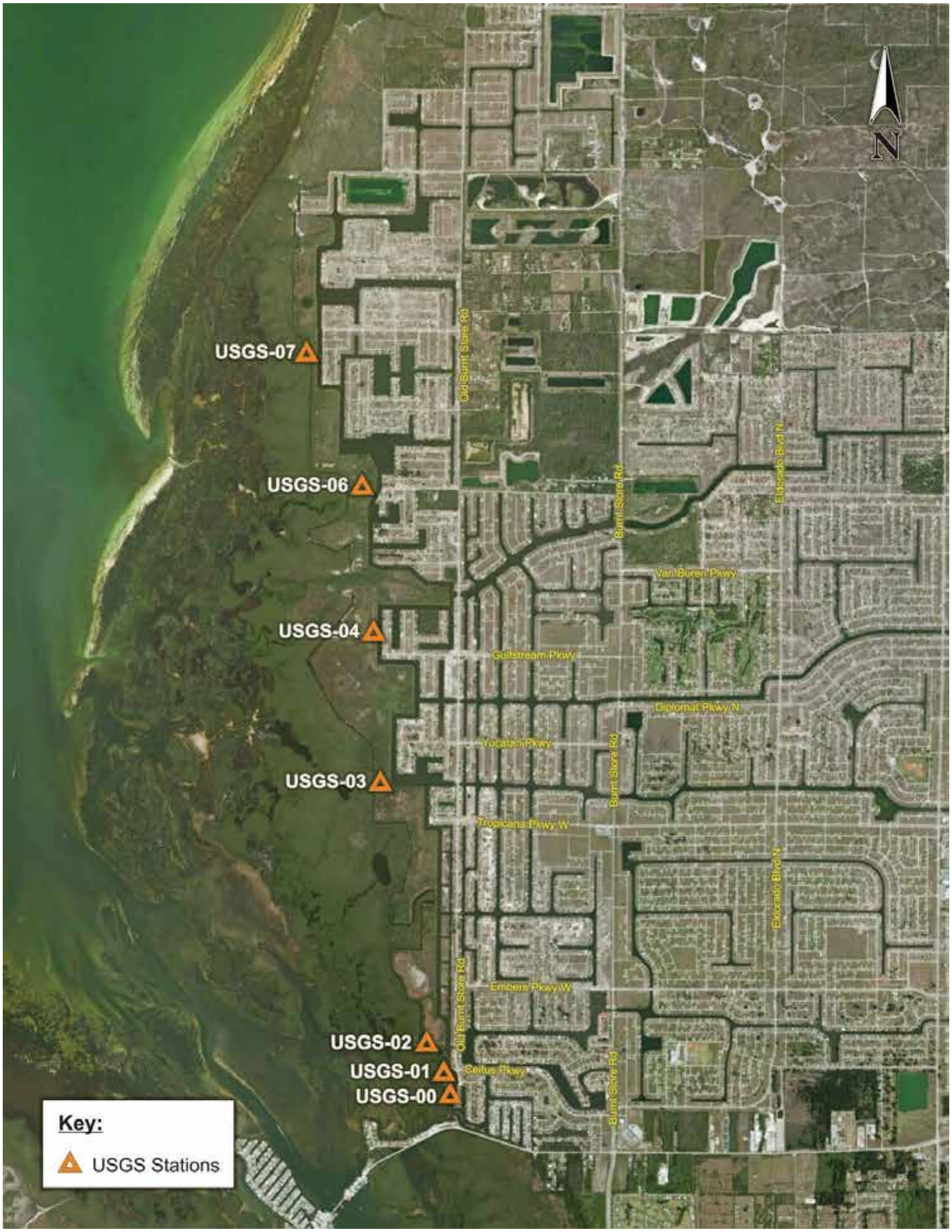


Figure 2-3. Location of USGS Monitoring Stations

The following paragraphs present descriptions of the current condition of each of these breaches (see photos in Appendix A).

Breach 1 connects to a small open water area to the west of the NSC. This open water area does not appear (based on review of aerial photography) to have a significant direct connection with the KD.

Breach 2 does not have a distinguishable direct opening along the western side of the NSC. Some vegetative signature and sediment deposition patterns in the immediate vicinity do show connection potential at times. Continuous monitoring at this location would not have been feasible.

Open water areas to the west of where Breaches 3 and 5 are located show evidence of historical connection with waters to the west of the NSC. Present vegetative signature and sediment patterns along the western side of the NSC do not indicate any appreciable level of flow occurring at either of these breaches today.

Breach 6 contains two small (10-inch) concrete pipes that pass through a seawall structure located where Gator Slough meets the NSC. These pipes are located at or above the high water level. Field observations of these pipes did not show any appreciable flow going in or coming out of the NSC.

Breach 7B does not show any signature along the western shoreline that would indicate any significant flow pathway from the NSC to the KD. Breach 7A shows some vegetative and open water indications of an intermittent connection between the NSC and the KD. The small and shallow nature of Breach 7A would have made monitoring unfeasible.

Examination of aerial photography (Appendix A) shows the historical pathways of the connections associated with Breaches 8A and 9. The conditions at the edge of the NSC do not indicate that significant flows are passing into or out of the NSC through these locations today.

In addition to the connections described in the previous paragraphs, the elevation of the west side of the NSC varies significantly, from a high of 1.7 ft in the south end to 0.8 ft at the north end, based on the 1993 Havens & Emerson / Avalon Engineering Report (Haven & Emerson, 1993). Tides within the NSC can overtop broad lengths of the western side of the NSC. Additionally, due to the porous nature of the soils and existence of mangroves, flow can be conveyed through seepage to the west from the NSC.

In order to quantify the flow entering into the NSC through the southern channel, USGS established a primary flow and water level monitoring station in the main channel to the south of the former boat lift location (USGS-00). The location of the station is shown in Figure 2-3. This station monitored flows and water levels for the same period as the breach stations described below.

Moving up through the NSC from south to north, the first monitored breach, 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 Pine Island Road, 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 that parallels Pine Island Sound Road. 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. An aerial photograph presented in Appendix A shows a zoomed-in view of the location of the USGS monitoring site.

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.

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. Based on available historical surveys, depths within the interior canals range from 2.6 to 28.9 ft (NAVD88) and average around 9.2 ft.

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.

The southernmost section (KD1) is approximately 1.3 miles long, with an average width of 50 ft. A centerline survey of this reach shows depths ranging from 2.3 to 10.0 ft, with an average depth of 4.0 ft (NAVD88). The monitored breach that connects the NSC and KD1 is located at the southern end of KD1 (Breaches 10 and 11). USGS-02 was the monitoring site within this connection (see Figures 2-2 and 2-3).

The next section, KD2, is approximately 1.7 miles long, with widths ranging from 50 to 100 ft. A centerline survey of this reach of the KD shows depths ranging from 2.6 to 11 ft, with an average depth of 4.2 ft (NAVD88). The monitored breach between the NSC and KD2 is located at the northern end of KD2 (Breach 8). USGS-03 was the monitoring site within this connection (see Figures 2-2 and 2-3).

The next section, KD3, is approximately 1.3 miles long, with widths ranging from 30 to 85 ft. A centerline survey of this reach of the KD shows depths ranging from 0.7 to 4.9 ft, with an average depth of 3.9 ft (NAVD88). The primary monitored breach between the NSC and KD3 is located near the middle of KD1 (Breach 7). USGS-04 was the monitoring site within this connection (see Figures 2-2 and 2-3). This breach is very small and shallow and frequently is dry during normal tidal conditions.

The northernmost section of the KD (KD4) is approximately 2.6 miles long, with widths ranging from 30 to 85 ft. A centerline survey of this reach of the KD shows depths ranging from 1.3 to 6.6 ft, with an average depth of 4.0 ft (NAVD88). KD4 had two monitored breaches connecting to the NSC. The first (Breach 4) connects the southern end of KD4 to the NSC approximately 1.1 miles north of where the tidal portion of Gator Slough intersects the NSC; USGS-06 was the monitoring site within this connection. The second (Breach 1A) connects the northern end of KD4 to the NSC approximately 1.1 miles north of USGS-06. USGS-07 was the monitoring site within this connection (see Figures 2-2 and 2-3). In addition to the monitored connections, a significant and navigable connection between this portion of the KD and Matlacha Pass exists at the southern end. This connection was not part of the monitoring program because it was not a connection from the NSC to the KD but rather connects KD4 directly to open waters west of the KD, which, in turn, are connected to waters within Matlacha Pass.

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 MODEL DEVELOPMENT

The following provides a detailed description of the development of the hydrodynamic model of the system described in Section 2.0. 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.

3.1 MODEL DESCRIPTION

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, transport and biogeochemical processes 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. Additionally this model has been used extensively by FDEP and the Water Management Districts (WMD) throughout the state. Specific examples of applications of EFDC within Florida by FDEP and the WMD include, Indian River Lagoon (SJRWMD), tidal portions of the St. John’s River (SJRWMD), Florida Bay (SFWMD), tidal Caloosahatchee River (FDEP), and Pensacola and Escambia Bay (FDEP).

The physics of the EFDC model, and many aspects of the computational scheme, are equivalent to the widely used Blumberg-Mellor model. The EFDC model solves the three-dimensional, vertically hydrostatic, free surface, turbulent averaged equations of motions for a variable density fluid. Dynamically coupled transport equations for turbulent kinetic energy, turbulent length scale, salinity and temperature are also solved. The two turbulence parameter transport equations implement the Mellor-Yamada level 2.5 turbulence closure scheme. The EFDC model uses a stretched or sigma vertical coordinate and curvilinear orthogonal horizontal coordinates.

The numerical scheme employed in EFDC to solve the equations of motion uses second-order accurate spatial finite differencing on a staggered or C grid. The model's time integration employs a second-order accurate three-time level, finite difference scheme with an internal-external mode splitting procedure to separate the internal shear or baroclinic mode from the external free surface gravity wave or barotropic mode. The external mode solution is semi-implicit and simultaneously computes the two-dimensional surface elevation field by a preconditioned conjugate gradient procedure. The external solution is completed by the calculation of the depth-average barotropic velocities using the new surface elevation field. The model's semi-implicit external solution allows large time steps that are constrained only by the stability criteria of the explicit central difference or higher order upwind advection scheme used for the nonlinear accelerations. Horizontal boundary conditions for the external mode solution include options for simultaneously specifying the surface elevation only, the characteristic of an incoming wave, free radiation of an outgoing wave or the normal volumetric flux on arbitrary portions of the boundary.

3.2 MODEL GRID AND BATHYMETRY

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 3-1 presents the final model grid utilized for the simulations presented herein. The grid was developed in a stepwise manner, iterating to get to the final grid presented in Figure 3-1.

The first step was development of a grid to represent the NSC and the interior canals up to the weir structures. Upon completion of the testing of the initial grid of the interior areas, a second grid area representing Matlacha Pass was developed and linked to the interior grid through the opening at the southern end. The linked grids were tested. The final step was the development of the linkages between the NSC and Matlacha Pass by simulation of the breach connections to the KD and development of connections between the KD and Matlacha Pass. Through the model calibration process, it was determined that the extents of the grid within Matlacha Pass needed to be extended further south than the bridge over Matlacha Pass to Pine Island. Based on this, the model grid was extended down to near McCardle Island. The final changes to the model grid were the addition of storage areas within the mangroves between the KD and Matlacha Pass to represent water that floods into these areas during high tide conditions. The grid presented in Figure 3-1 represents the final iteration of the grid development.

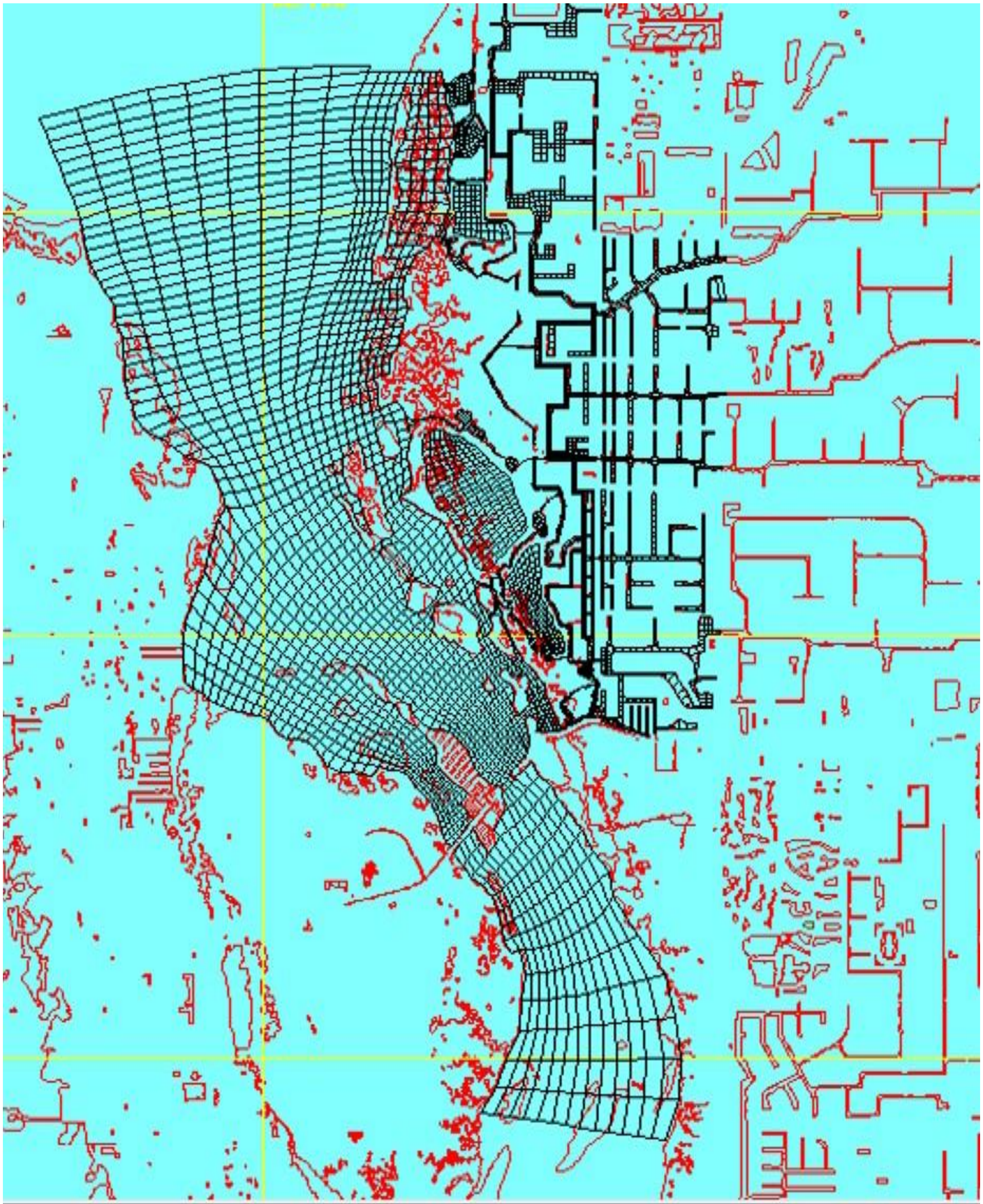


Figure 3-1. Model Grid

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 include 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 Spreader Canal Project.

These datasets provide the bathymetric conditions within the NSC and the interior canals, the breaches, the KD, and the open water areas within Matlacha Pass. At present, no data are available within the mangrove areas between the KD and Matlacha Pass. For these areas, the depths were based on the storage needs identified through the model calibration process presented in Section 4.

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 3-2 presents the model bathymetry used for the final simulations.

3.3 MODEL BOUNDARY FORCINGS AND SIMULATION PERIOD

The following boundary forcing conditions were prescribed for the model simulations;

- water levels at the tidal open boundaries in Matlacha Pass at the north and south ends;
- salinity at the tidal open boundaries in Matlacha Pass at the north and south ends;
- freshwater inflows over the weir structures along Burnt Store Road; and
- wind stress at the water surface.

Based upon the data presented within the Hydrodynamic Data Characterization Report, measured water levels are available within Matlacha Pass from October 2012 through December 2013. These data defined the period of simulation of the hydrodynamic model for calibration. For the model calibration, the months of October through December are used as the model spin-up period, while the data from January 1, 2013 through December 10, 2013 are used for model to data comparisons.

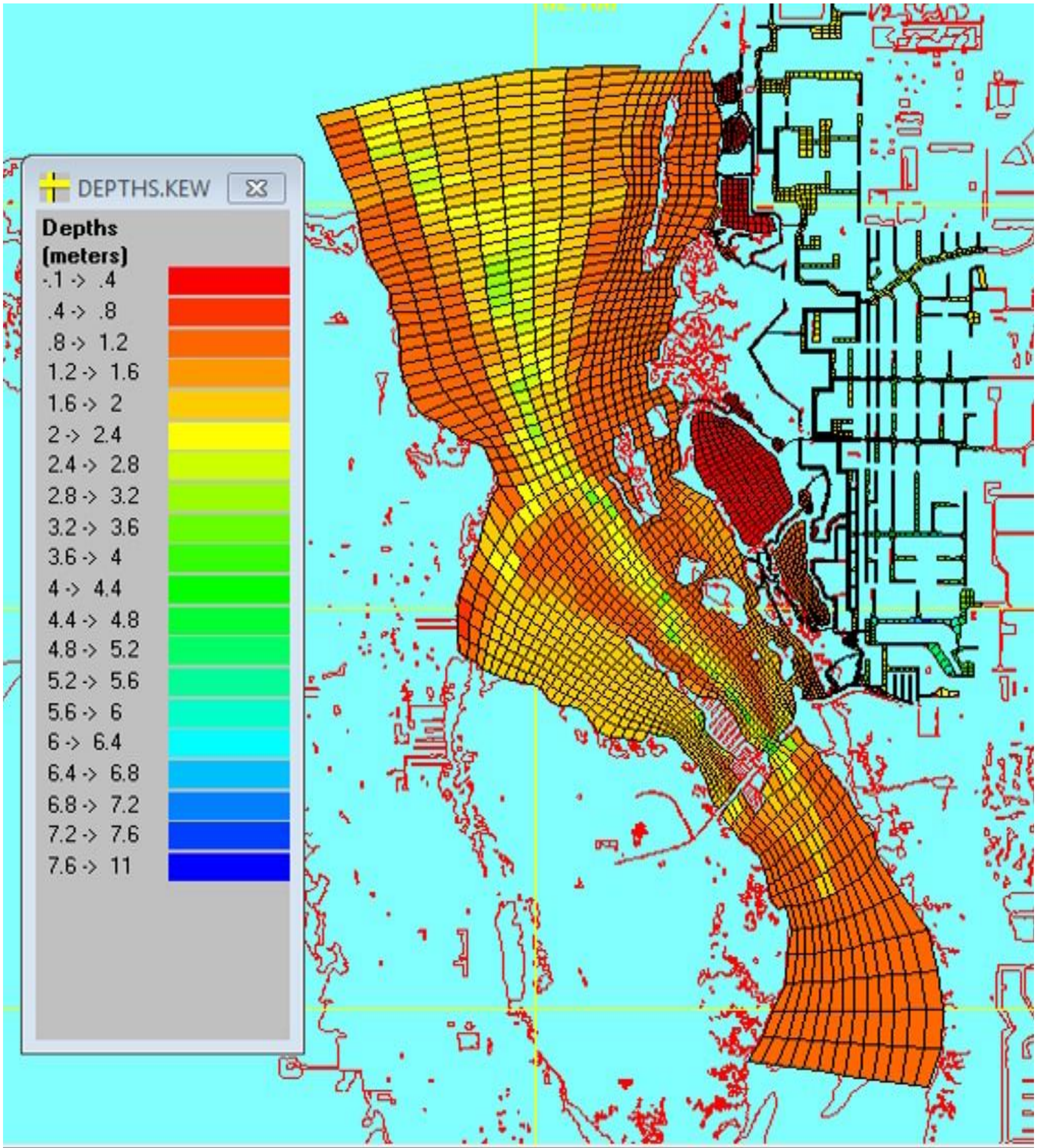


Figure 3-2. Model Bathymetry

The following sections present the time series used for each of the boundary forcing for the model simulation period.

3.3.1 WATER LEVELS AT NORTH AND SOUTH OPEN BOUNDARIES

Figure 3-3 presents the locations where water levels were measured within the system. Three stations, D-17, D-18, and D-19, were located within Matlacha Pass. To develop the northern and southern boundary water level conditions, the data from Station D-17 was used to create a time series that was phase lagged (time shifted) to reflect the time of the wave passing the northern and southern boundaries. The time shift was based upon the lag between D-17 and D-19 extrapolated to the north and to the south. The results were compared at the measurement locations during the model calibration (Section 4). Figure 3-4 presents plots of the northern and southern boundary water levels used to force the hydrodynamic model. The plot presents data from a 2-month period during the model simulations.

3.3.2 SALINITY AT NORTH AND SOUTH OPEN BOUNDARIES

To develop the salinity boundary conditions at the north and south boundaries for the full period of the model simulations, discrete salinity measurements made by Lee County were utilized. While continuous measurements were available at a station at the northern end of Matlacha Pass (C-08) near the open boundary, there were multiple times during the period of the model simulations when the data from this station were bad. Comparisons of the continuous salinity measurements with the discrete data showed that the discrete measurements provided a reasonable representation of the salinity at the boundary along the northern end. For the northern boundary, a discrete time series was generated using the data from Stations W-14 and PI-05 that represents the incoming salinity across the northern boundary. For the southern boundary only, one station, PI-03, had data near the boundary. The discrete data from this station were utilized for the southern boundary. Figure 3-5 presents plots of the discrete data utilized for the northern and southern boundaries, between these data points the model interpolates to define the inflowing salinity levels.

3.3.3 FLOWS OVER WEIR STRUCTURES

The Hydrodynamic Data Characterization Report presented the development of the flow data for the period of the model calibration. Figure 3-6 presents plots of the flows used for the model input. These data are daily average flow values flowing over the weir structures. These are the only freshwater inflows to the model.

Figure 3-3. Location of D-Stations

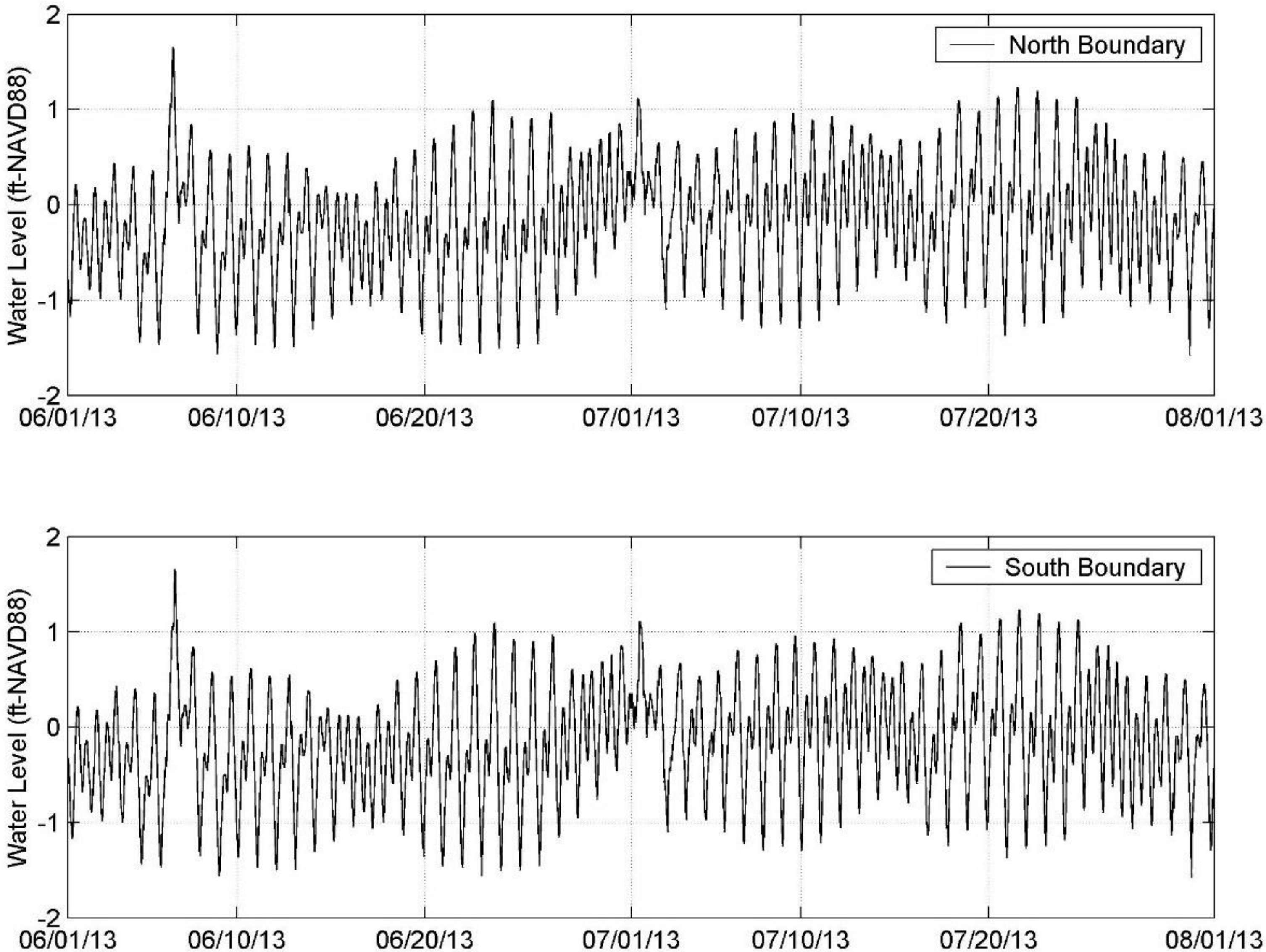


Figure 3-4. Plots of North and South Tidal Boundary Forcings

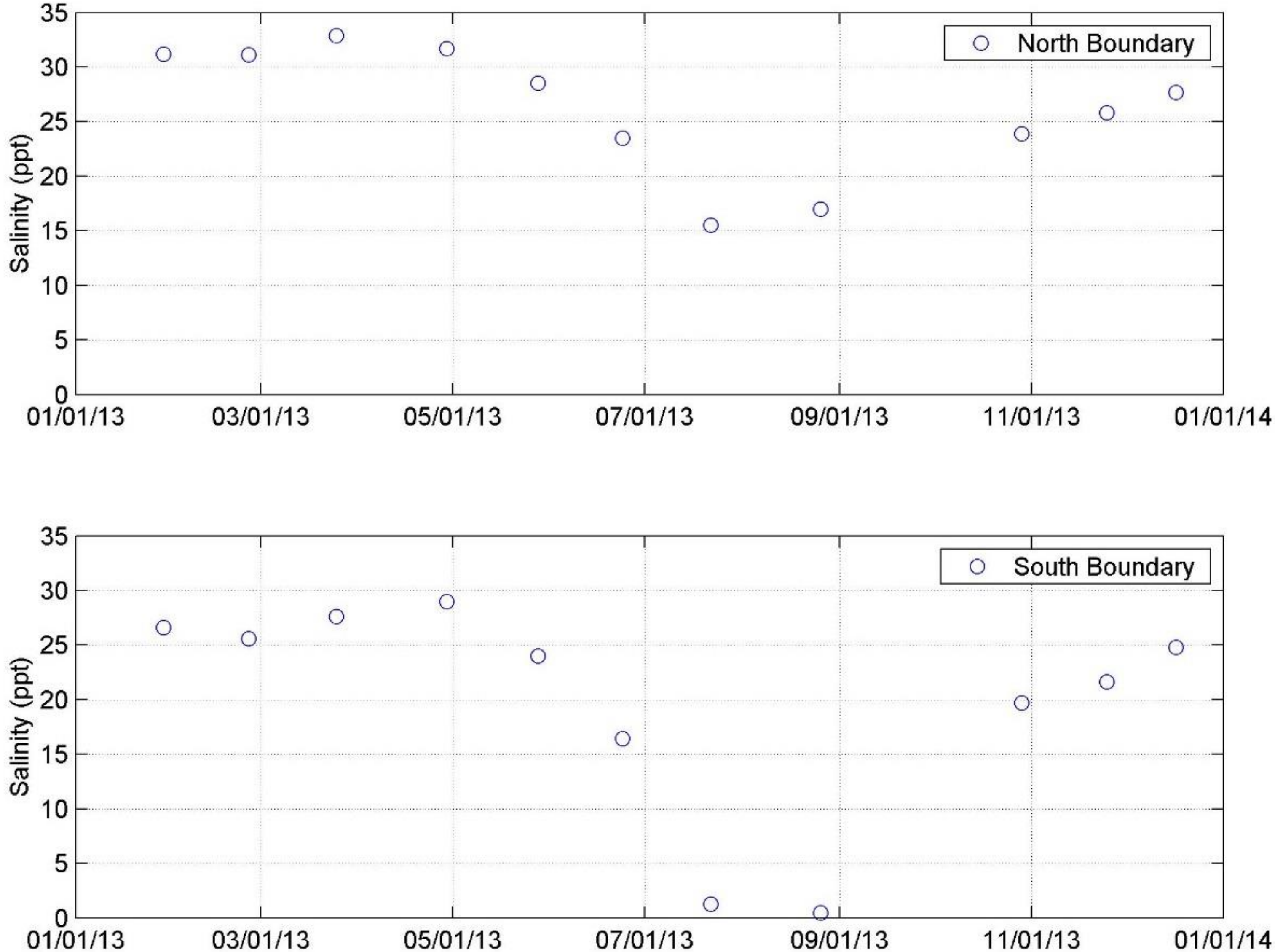


Figure 3-5. *Plots of North and South Salinity Forcings*

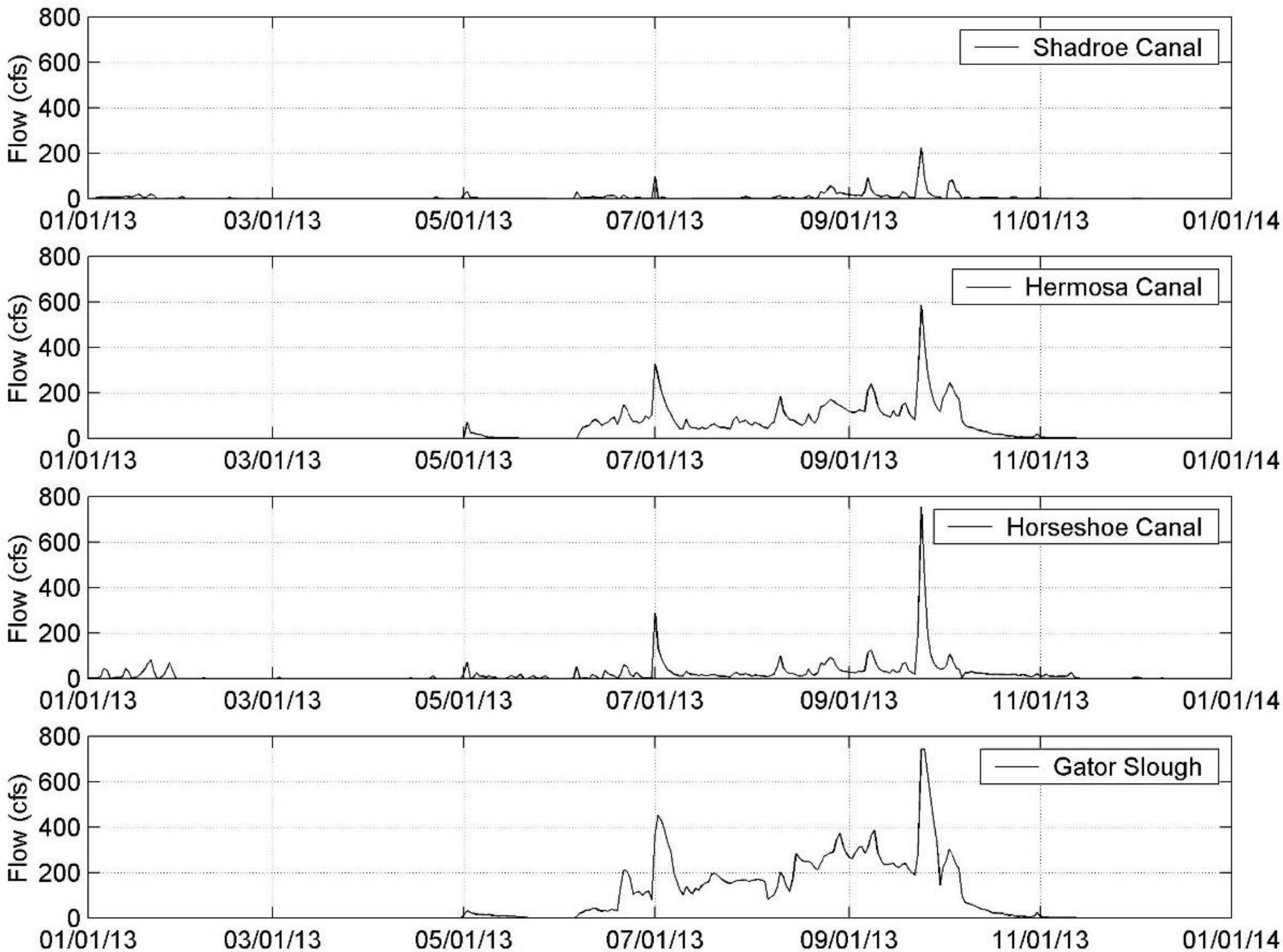


Figure 3-6. Plots of Freshwater Inflow over Weir Structures

3.3.4 WIND STRESS AT THE SURFACE

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.

4.0 HYDRODYNAMIC MODEL CALIBRATION

The following provides a detailed description of the calibration of the hydrodynamic model. This section presents the data used in the model calibration, a discussion of the calibration process used for this model, and presentation of the comparison of the model simulations to measured data for the water levels, flows, and salinity.

4.1 DATA USED IN MODEL CALIBRATION

The Hydrodynamic Data Characterization Report provided a detailed discussion of the data collected for this project. For the purposes of model calibration, the data from that report that was utilized included the continuous water level measurements at the D-stations and at the USGS breach monitoring locations, the flows measured at the USGS breach monitoring stations, and the discrete salinity data from the Lee County water quality monitoring.

Figure 4-1 presents the locations of the D-stations used for the model-to-data comparisons. These stations had time series water level data for the full model simulation period (January to December 2013). The data are referenced to NAVD88.

Figure 4-2 presents the locations of the USGS stations used for the model-to-data comparisons. These stations had time series of flow through the specified breach for a 5-month period of the model simulation (August to September 2013). In addition to the measured flows, the USGS stations also had water levels measured for the same period as the flows. The water level data are referenced to NAVD88.

Figure 4-3 presents the locations of the discrete water quality monitoring stations used for the model-to-data comparisons for salinity. These stations had monthly measurements for the full model simulation period (January to December 2013).

4.2 MODEL CALIBRATION PROCESS

Hydrodynamic model calibration is an iterative process. The following describes the overall process followed, difficulties encountered, and how those difficulties were addressed.

Figure 4-1. *Location of D-Stations*

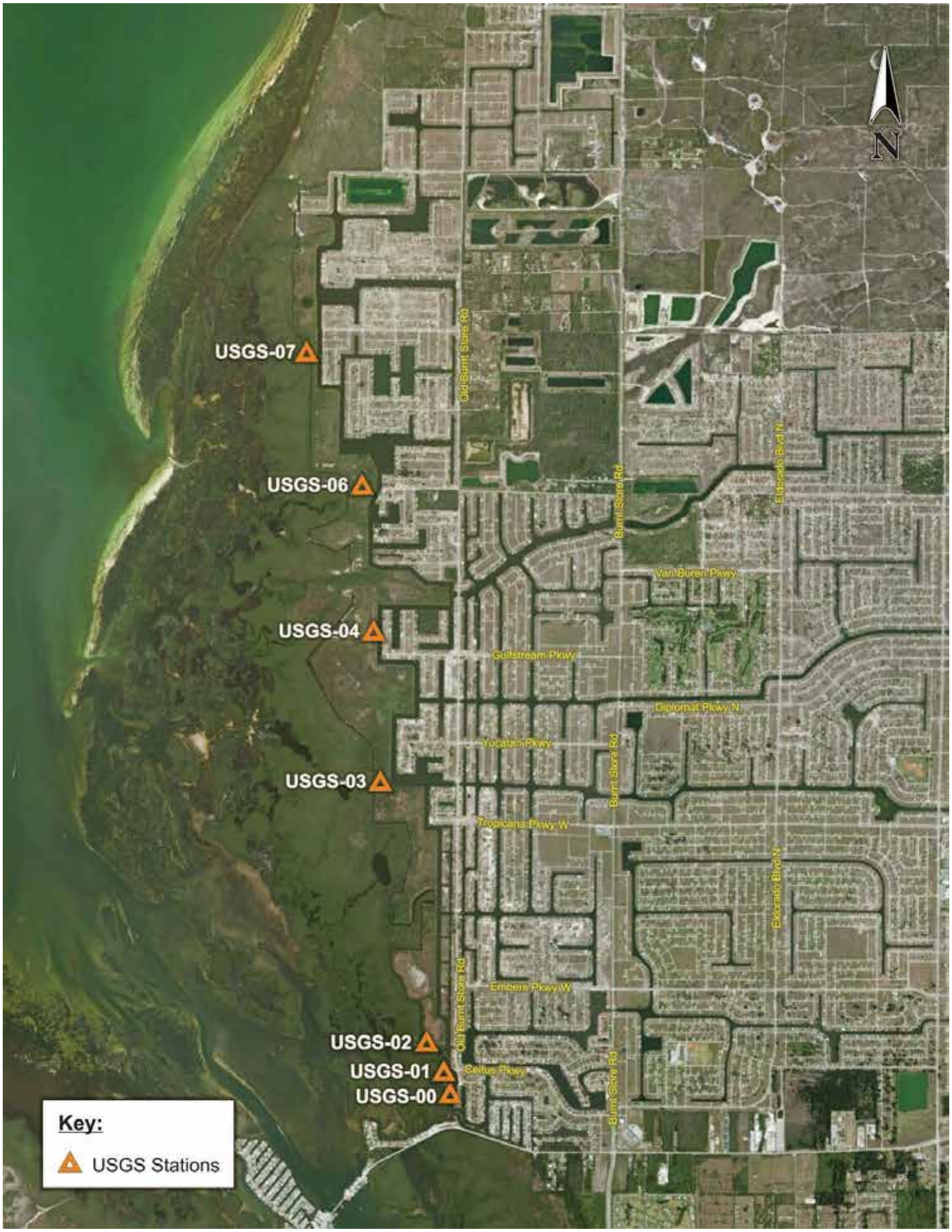


Figure 4-2. Location of USGS Flow Monitoring Stations

Figure 4-3. Location of Lee County Discrete Water Quality Monitoring Stations used for the Comparison of Salinity

As described in Section 3.2 the first step in the model development process was building a grid of the interior canal areas. This sub-model extended into Matlacha Pass at the southern opening to the canals north of Pine Island Causeway. This grid was forced using the measured data in Matlacha Pass. The purpose was to test that the interior canal grid was stable and to determine if the damping of the water level, seen in the measured data moving from the pass into the interior canals, could be replicated. The level of damping and general phase lag was seen in this sub-model.

The next step was to develop a grid of Matlacha Pass to connect to the interior grid. The original grid extended from the north end of Pine Island Sound, down to the Pine Island Causeway and was forced with data at both ends using phasing differences seen in the measured water level data in Matlacha Pass. For the first iterations, the only connection between the grid within Matlacha Pass and the interior canals was through the southern opening. The simulations showed the general water level damping, but there were certain phasing differences at the northern end of the interior canals that were not represented.

The next step was to expand the interior grid to include the breach connections between the NSC and the KD, including gridding the KD. At this point, it was possible to compare the model simulated flows through the breaches with the measured data. The comparisons showed that at lower water levels, the flows passing through the breaches were reasonably simulated, indicating that at certain water level conditions (within the NSC), the flow passing through the breaches represents a filling and draining of the area of the KD. Over certain water level elevations (generally around 0.0 ft NAVD88), additional areas or connections were occurring. In the northernmost KD segment (KD4 in Figure 2-1), the data indicate a continuous connection between Matlacha Pass and this section of the KD. Based on review of aerial photography of the area, a direct connection at the southern end of KD4 was identified, and the grid was modified to reflect this connection.

The next phases of the model calibration consisted of modification of the model grid to develop elevation dependent connections between Matlacha Pass and the KD. The connections in the model were focused on areas identified in aerial photography as remnant tidal creeks and areas where sediment erosion and deposition signatures identified primary flow pathways that were occurring connecting Matlacha Pass with the KD. The phenomena, which was identified in the Hydrodynamic Data Characterization Report, was the significant stepwise increase in flows through the breaches when tidal fluctuations and mean water levels in the pass exceeded specified elevations. This was an indication that water level dependent flow pathways existed and needed to be represented in the model. In general, it was observed that the elevation where this occurred was above 0.0 to 0.5 ft NAVD88. To represent the intermittent nature of the connections, grid cells within the connections were set to the cutoff elevation and allowed to flood and dry. When these cells flood, the connections exist, but when they dry, the connections are severed. When a sufficient number of connections were made within each of the KD sections and the flooding and drying elevations adjusted, the flows through the breaches were reasonably simulated. The final calibration presented in the following section is driven by the final cutoff elevation and connections developed.

While the flows were reasonably represented by the direct connections, review of aerial photography, as well as reconnaissance conducted using helicopter flyovers, indicated a significant area between the KD and eastern side of the Matlacha Pass grid that floods at higher tide levels. Presently, no elevation data exists to allow quantification of these flooding areas. As such, storage areas were developed within the model grid that are linked to the primary connections between the KD and Matlacha Pass. These areas flood at varied elevations, generally above 0.5 ft NAVD88.

Finally, upon completion of the breach flow calibration, the model was run to simulate salinity conditions and allow comparison within the NSC between measured data and simulated salinity. The simulations (using the salinity boundary conditions at the north and south boundaries as outlined in Section 3) generally performed well without significant adjustment of vertical stratification coefficients and transport. Generally, the salinity conditions are driven by advective transport rather than density driven impacts. This can be seen in the limited levels of stratification generally observed in the system.

4.3 SIMULATED VERSUS MEASURED WATER LEVELS

Figures 4-4 through 4-37 present plots of the simulated versus measured water levels at all the stations throughout the system. This includes the D-stations shown on Figure 4-1, as well as the USGS stations shown on Figure 4-2. For each of the D-stations, the data are presented by quarter, starting on January 1, 2013, through where the data end in December 2013. Presenting the results by quarter allows better visualization of the model-to-data comparisons. For the USGS stations, the results are presented for the 3rd and 4th quarters of 2013, i.e., from September through December 2013.

Table 4-1 presents model-to-data comparison statistics calculated for the full period of the data presented in the figures (January through December 2013 for the D-stations and September through December for the USGS stations). The statistics include the root mean square error (RMS), the mean error (ME), and the coefficient of determination (R^2). The following presents how each of these error statistics are calculated.

- Root Mean Squared Error (RMS):

$$\sqrt{\frac{\sum_{i=1}^{n}(O_i - m_i)^2}{N}}$$

- Mean Error (ME):

$$\frac{\sum_{i=1}^{n}(O_i - m_i)}{N}$$

- Coefficient of determination (R^2):

$$\left(Corrcoef\ (O_i, m_i)\right)^2$$

where: O_i = observation
M_i = model output
N = number of observations
Note: Corrcoef is a MATLAB function for correlation coefficient

The data from the model were extracted to match times of available measured data for the analyses. The statistics were then calculated from the matched data sets for the period identified.

The RMS represents the deviation of each of the individual measured-versus-simulated matched data pairs and is the most direct measurement of model-to-simulation error or difference between the results. As this measure does not have a sign (i.e., negative or positive), it does not identify if this is an underprediction or overprediction, simply what the overall differences are. The ME represents whether or not there is a bias in the results. For example if the ME is less than zero, it means that overall, the model is under predicting in an absolute sense. For both the RMS and the ME, the results are presented as values in the units of measure (feet for water level and cfs for flows). The coefficient of determination (R^2) is a measure of how the model and data line up or correlate. If the model and data lined up perfectly, the R^2 value would be 1.

The comparisons presented within the figures show that the model is doing very well simulating the magnitudes of the water level fluctuations and, specifically, the distribution of the damping and super-elevation of the water levels moving through the system. Based on the examination of the figures, there does not seem to be a significant trend in the errors, i.e., a significant increase or pattern as the tidal wave propagates into the system. The error statistics bear this out, with the errors generally being less than 0.1 to 0.2 ft and generally less than a 10 percent error. Reviewing the stations from top to bottom in Table 4-1 shows that for the RMS, the error statistics do not show a significant increase in the error moving from Matlacha Pass up into the system from the south (the primary direction of the tidal wave propagation). Looking at the mean error, there appears to be some level of increase in the error statistics moving into the system (which would reflect an error in the simulation of the mean water level). The error increase appears to be negative, which would indicate underprediction of the mean water level, but this increase is very small (generally less than 0.1 ft) and may be as much due to survey error as true error in the model. The one station that shows the most significant error is D-11, which was shown in the Hydrodynamic Data Characterization Report to be the one station where significant influence was seen from tidal wave propagation directly from Matlacha Pass to the west. While larger than the others, this error is still relatively small. Looking at the coefficients of determination, the correlations between the simulations and model are very high, all above 0.93, other than at station D-11, which is at 0.8.

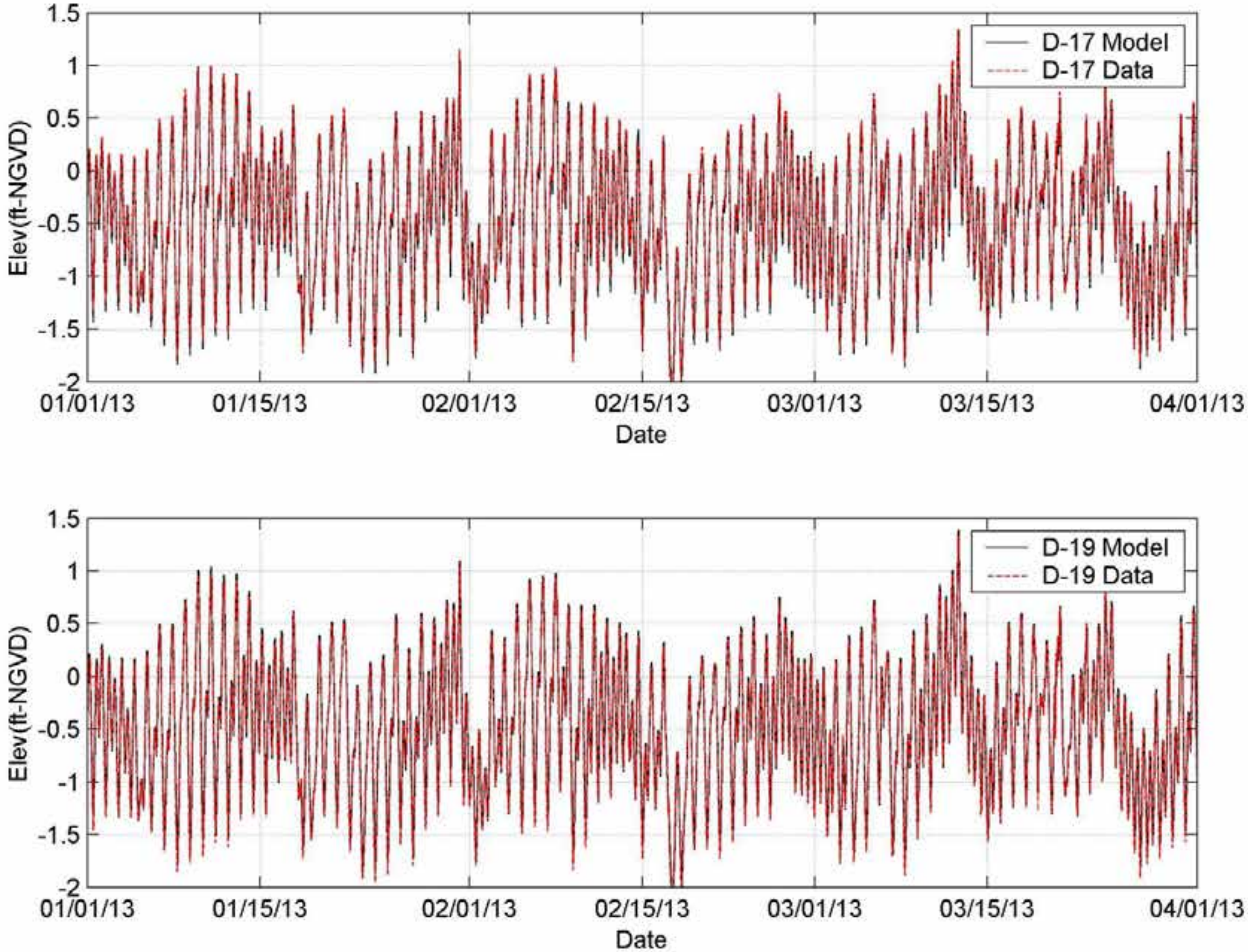


Figure 4-4. Simulated vs Measured Water Level at Stations D-17 and D-19 (01/01/13 – 04/01/13)

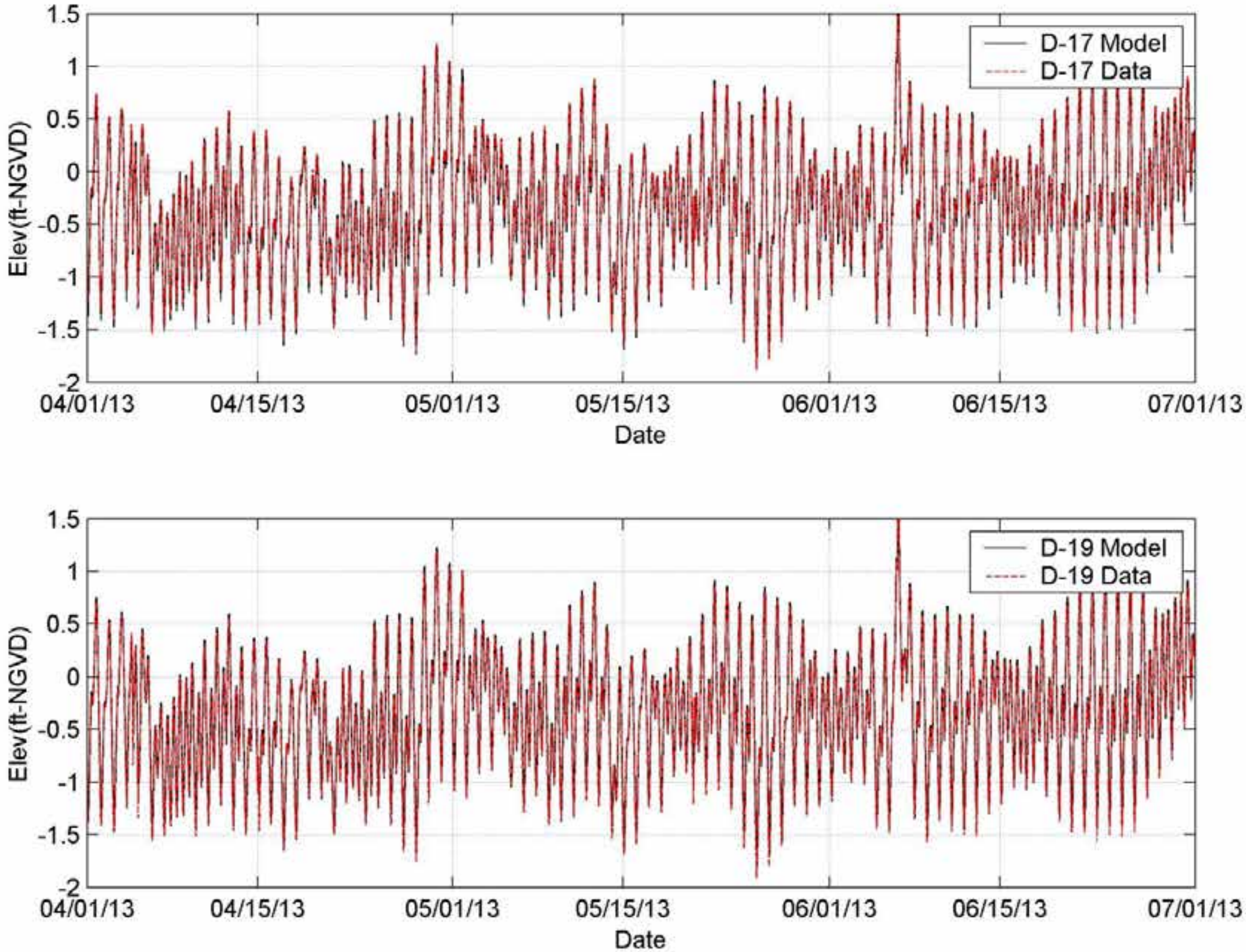


Figure 4-5. Simulated vs Measured Water Level at Stations D-17 and D-19 (04/01/13 – 07/01/13)

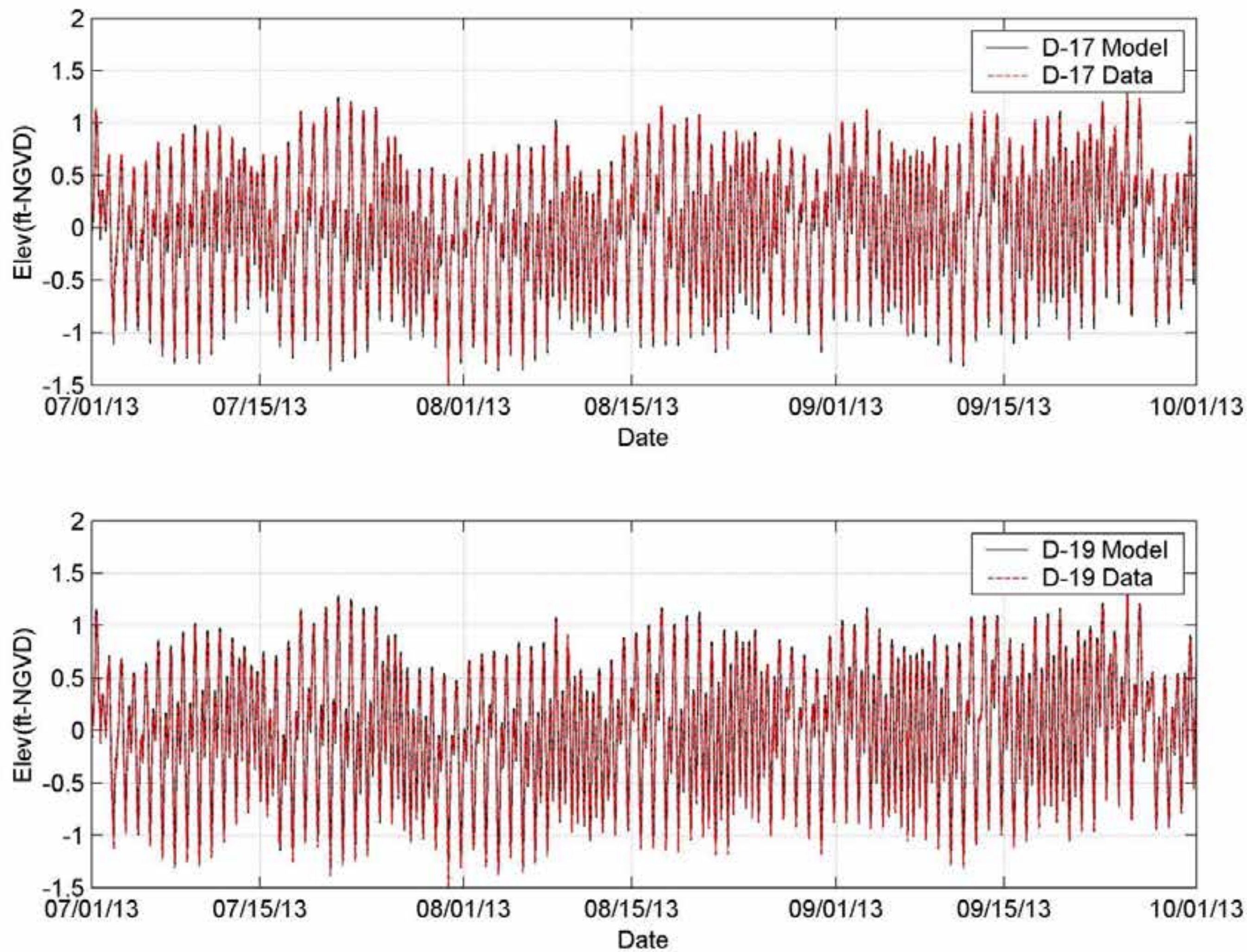


Figure 4-6. Simulated vs Measured Water Level at Stations D-17 and D-19 (07/01/13 – 10/01/13)

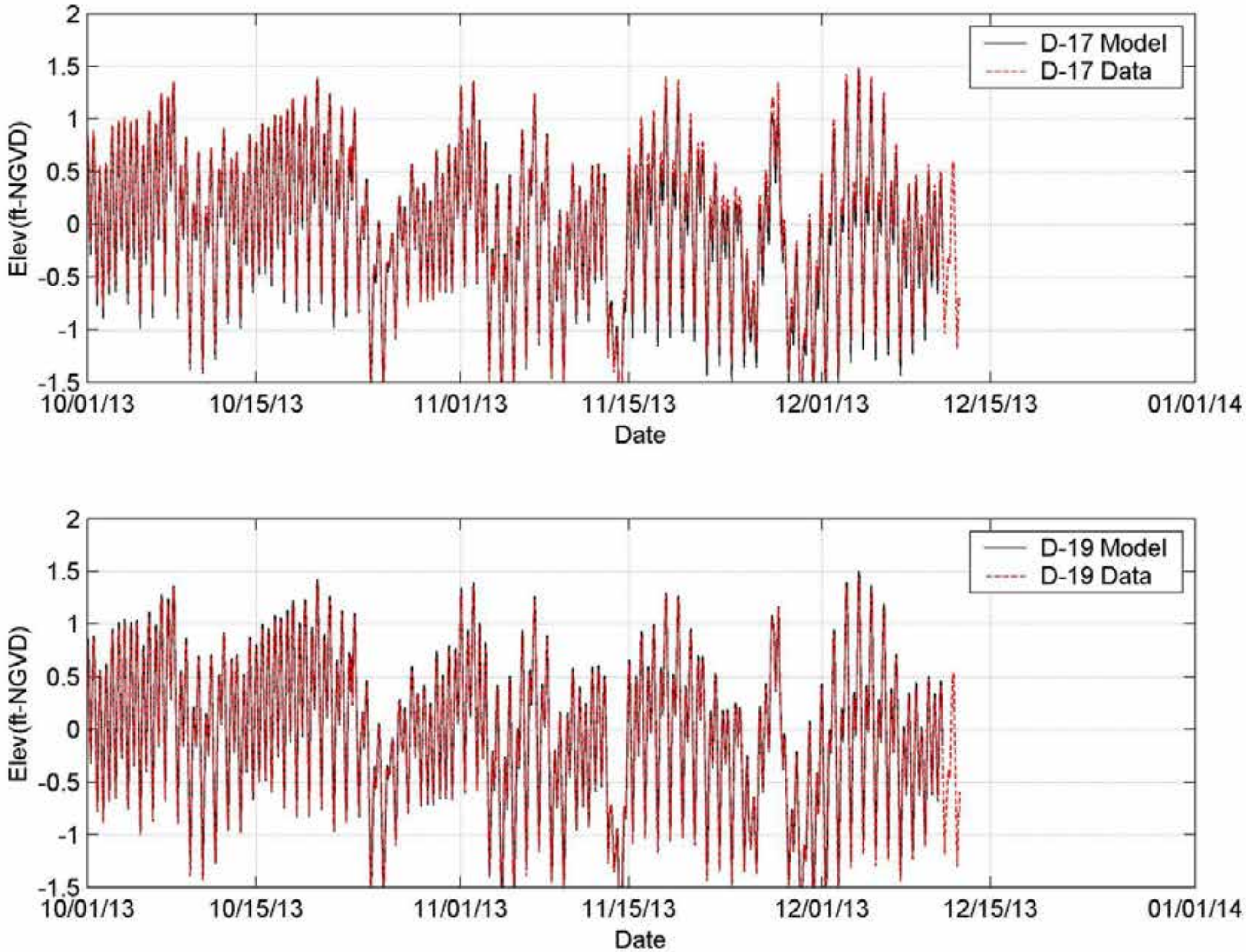


Figure 4-7. *Simulated vs Measured Water Level at Stations D-17 and D-19 (10/01/13 – 01/01/14)*

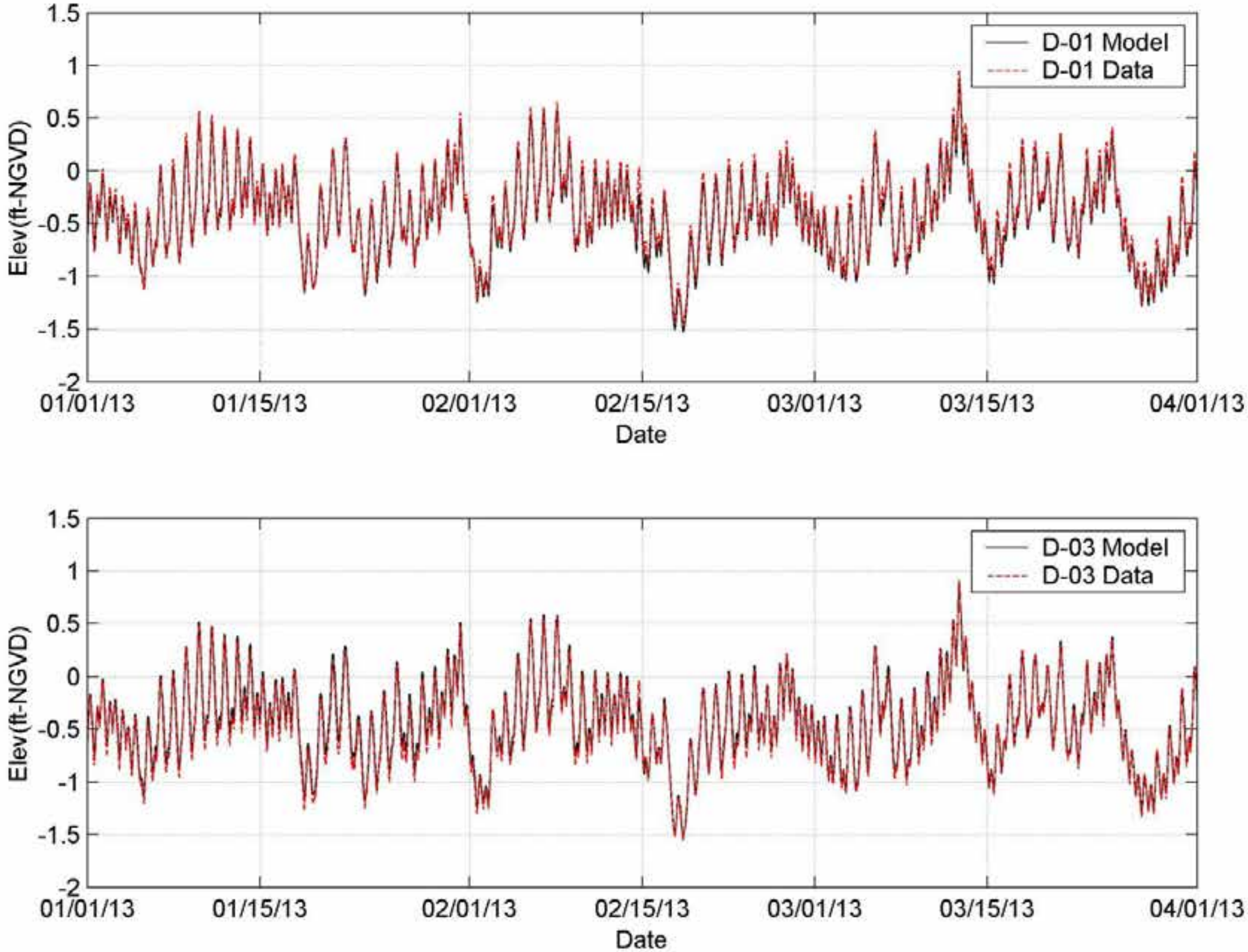


Figure 4-8. Simulated vs Measured Water Level at Stations D-01 and D-03 (01/01/13 – 04/01/13)

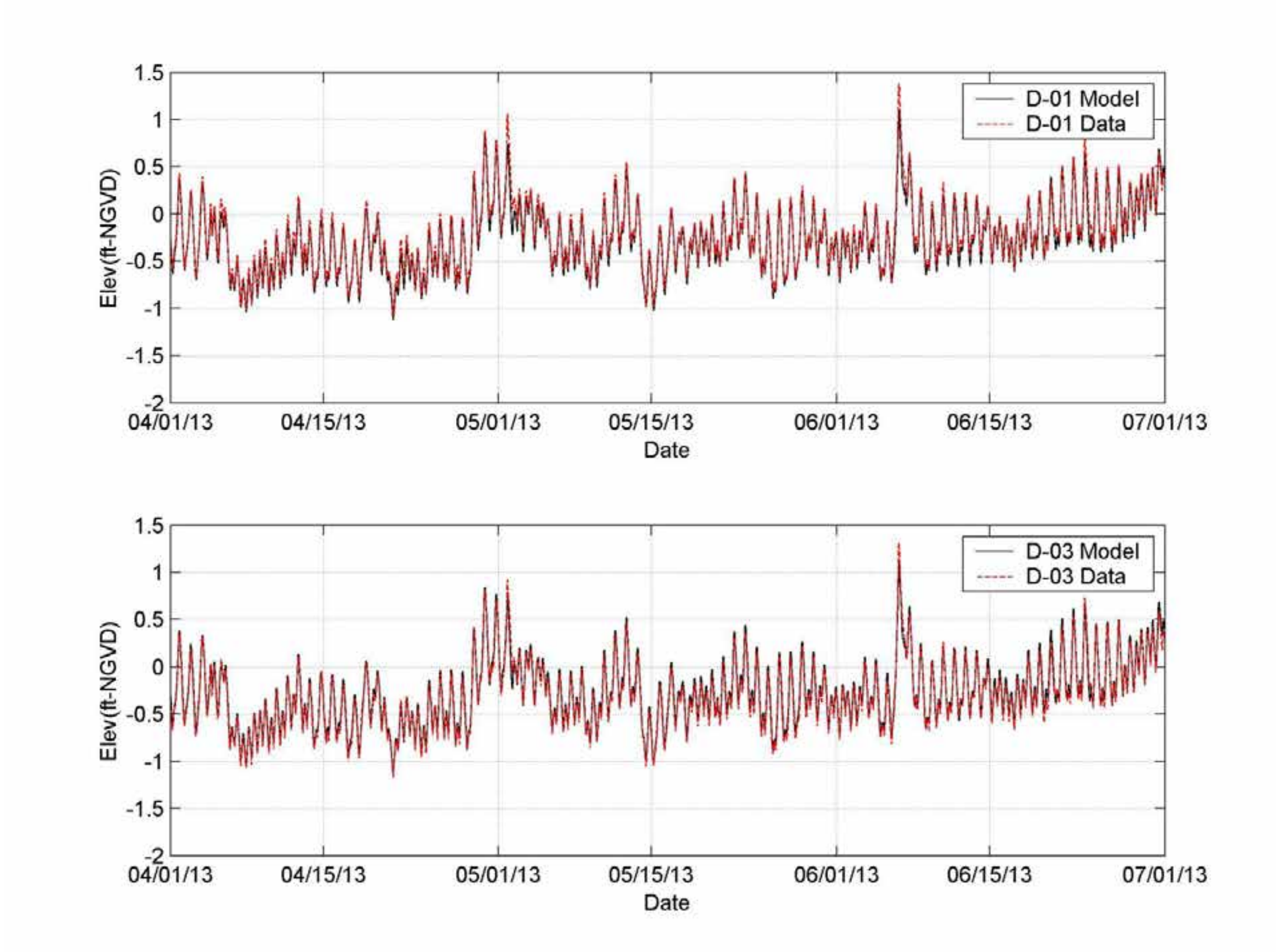


Figure 4-9. *Simulated vs Measured Water Level at Stations D-01 and D-03 (04/01/13 – 07/01/13)*

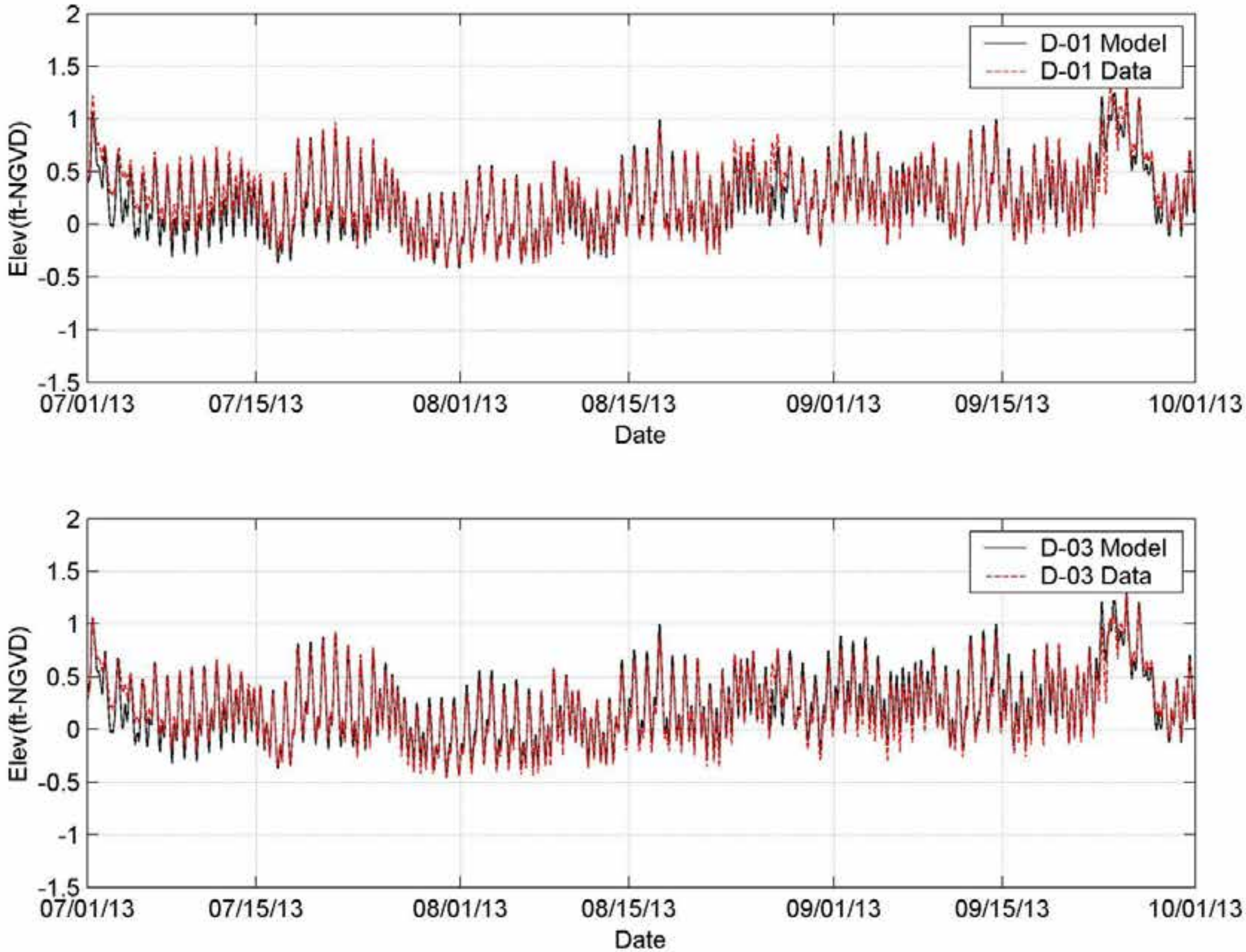


Figure 4-10. Simulated vs Measured Water Level at Stations D-01 and D-03 (07/01/13 – 10/01/13)

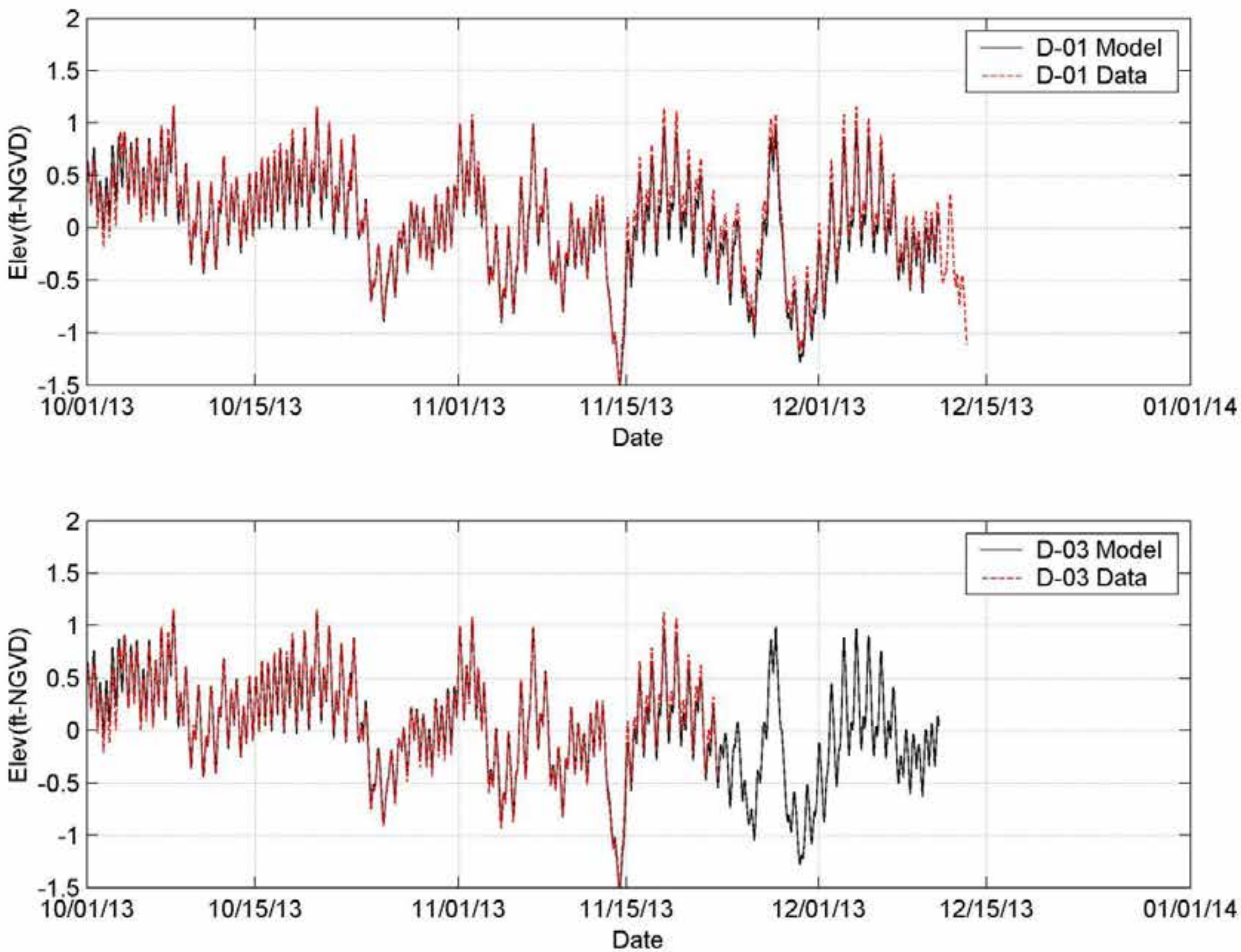


Figure 4-11. *Simulated vs Measured Water Level at Stations D-01 and D-03 (10/01/13 – 01/01/14)*

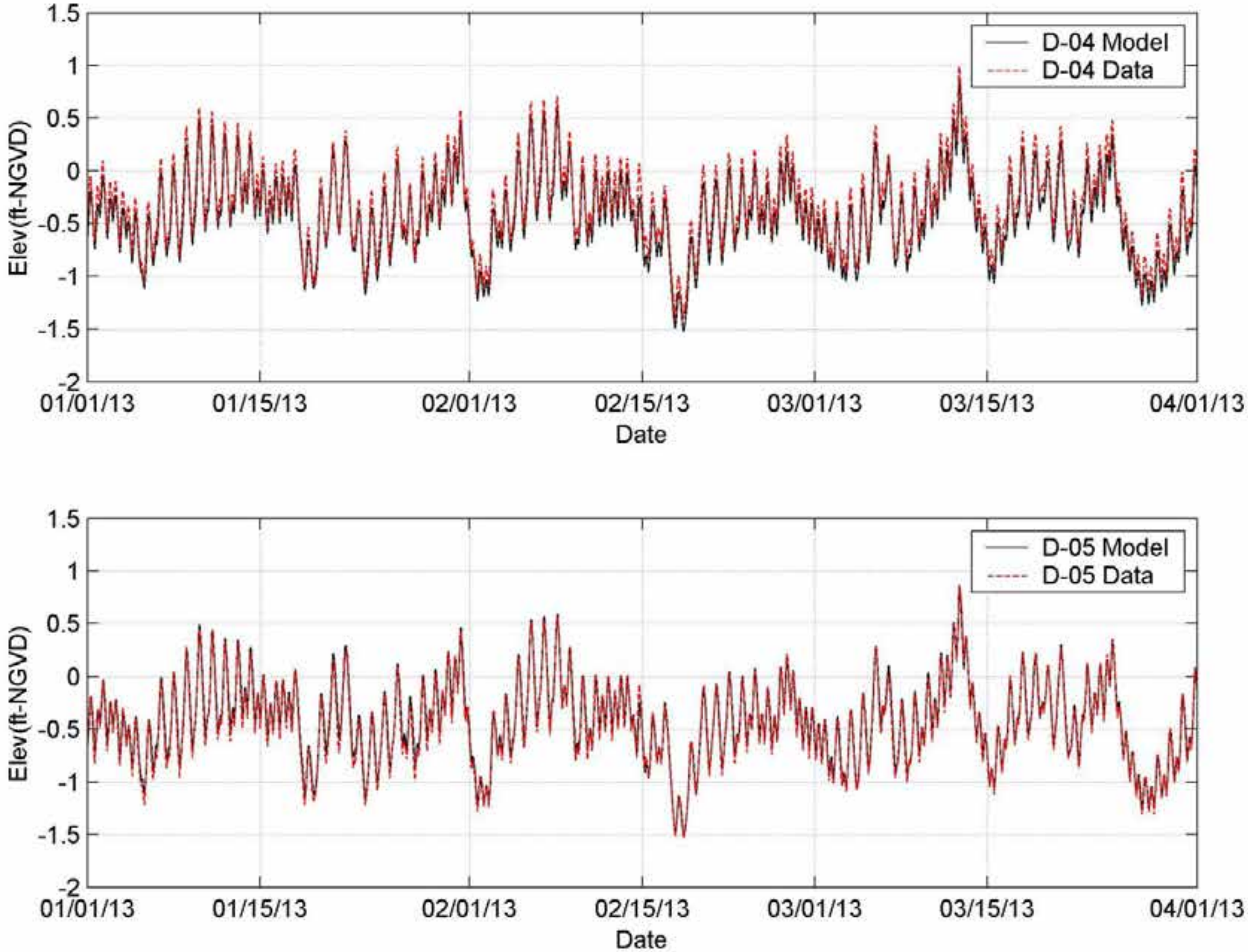


Figure 4-12. Simulated vs Measured Water Level at Stations D-04 and D-05 (01/01/13 – 04/01/13)

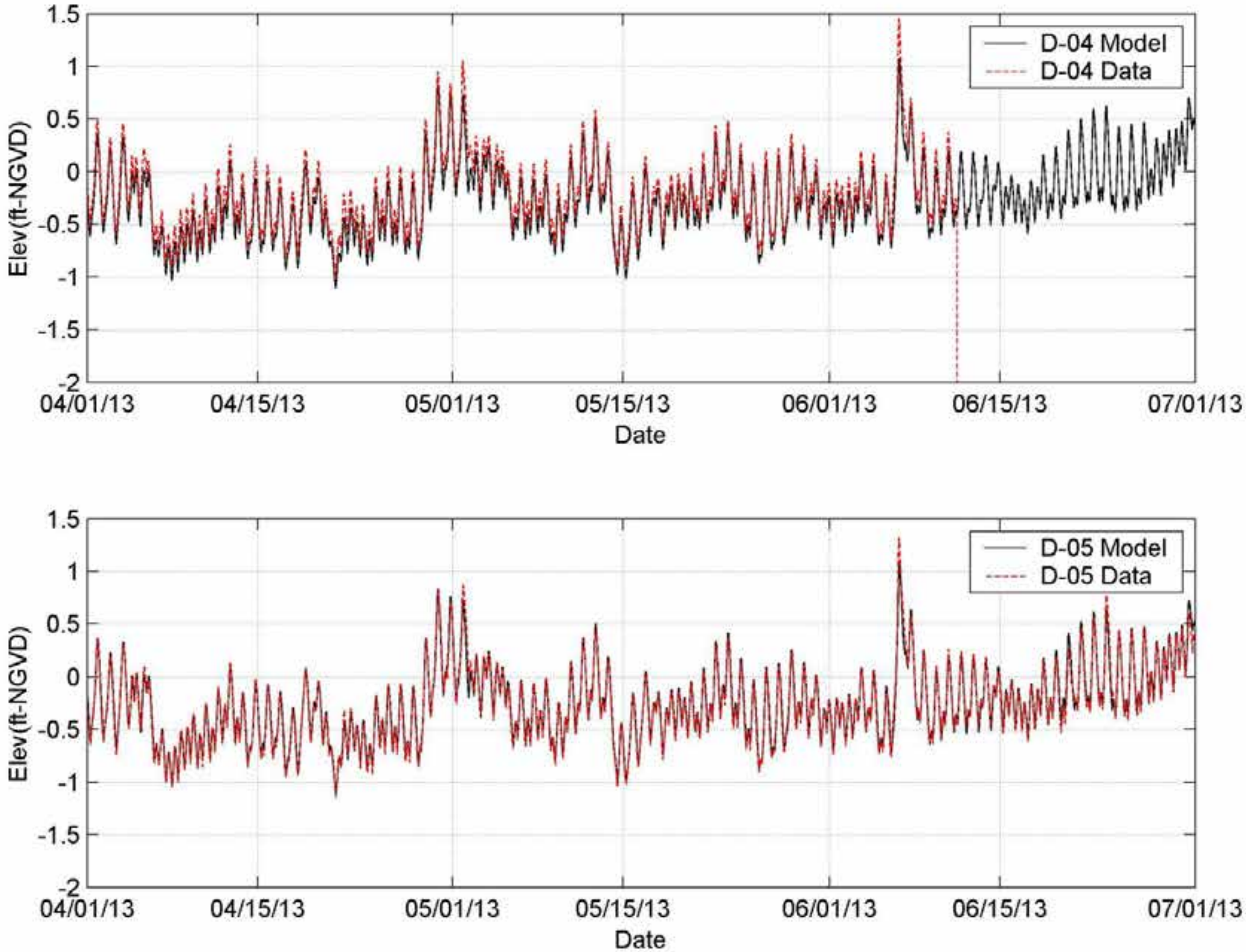


Figure 4-13. Simulated vs Measured Water Level at Stations D-04 and D-05 (04/01/13 – 07/01/13)

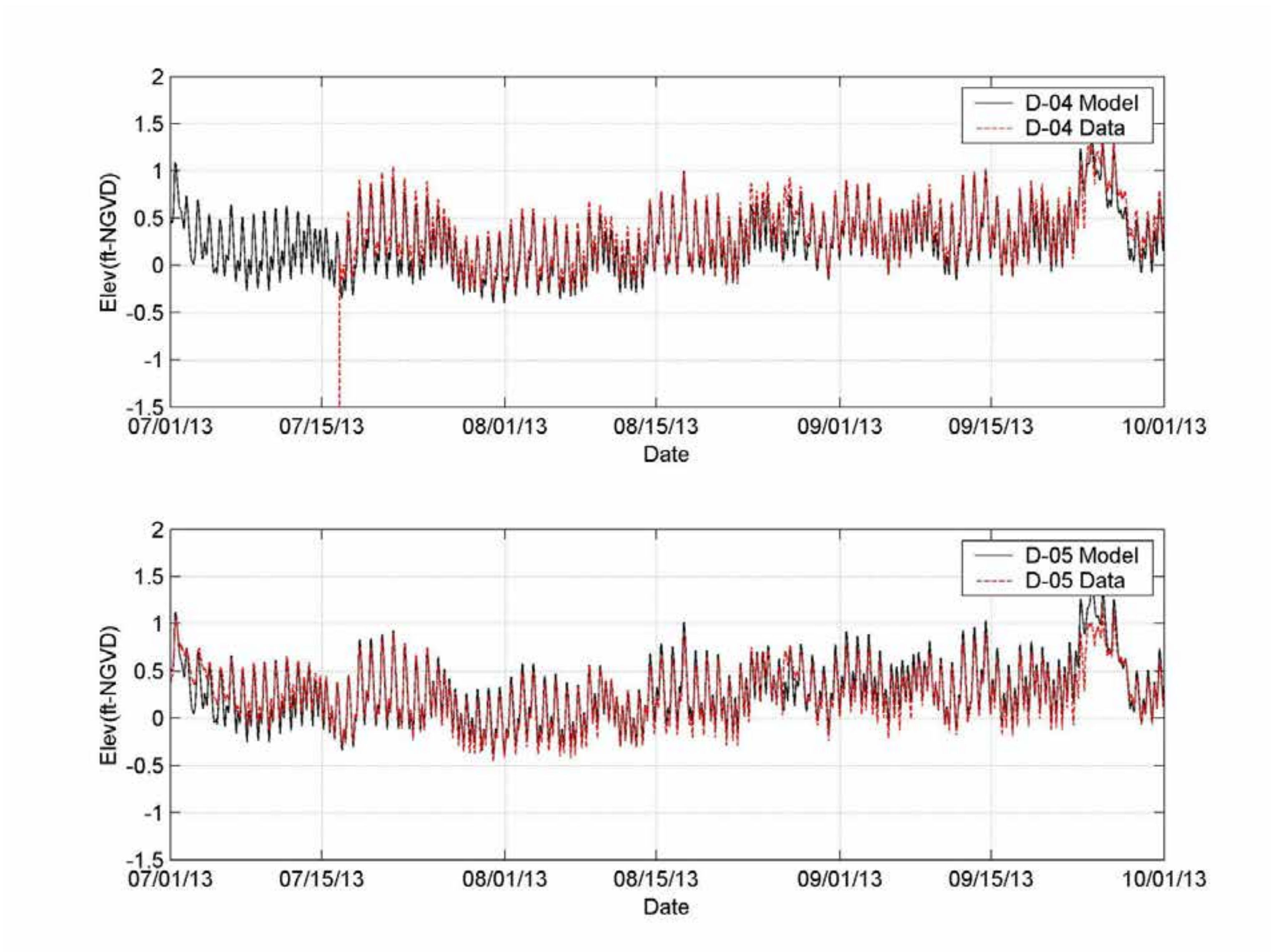


Figure 4-14. *Simulated vs Measured Water Level at Stations D-04 and D-05 (07/01/13 – 10/01/13)*

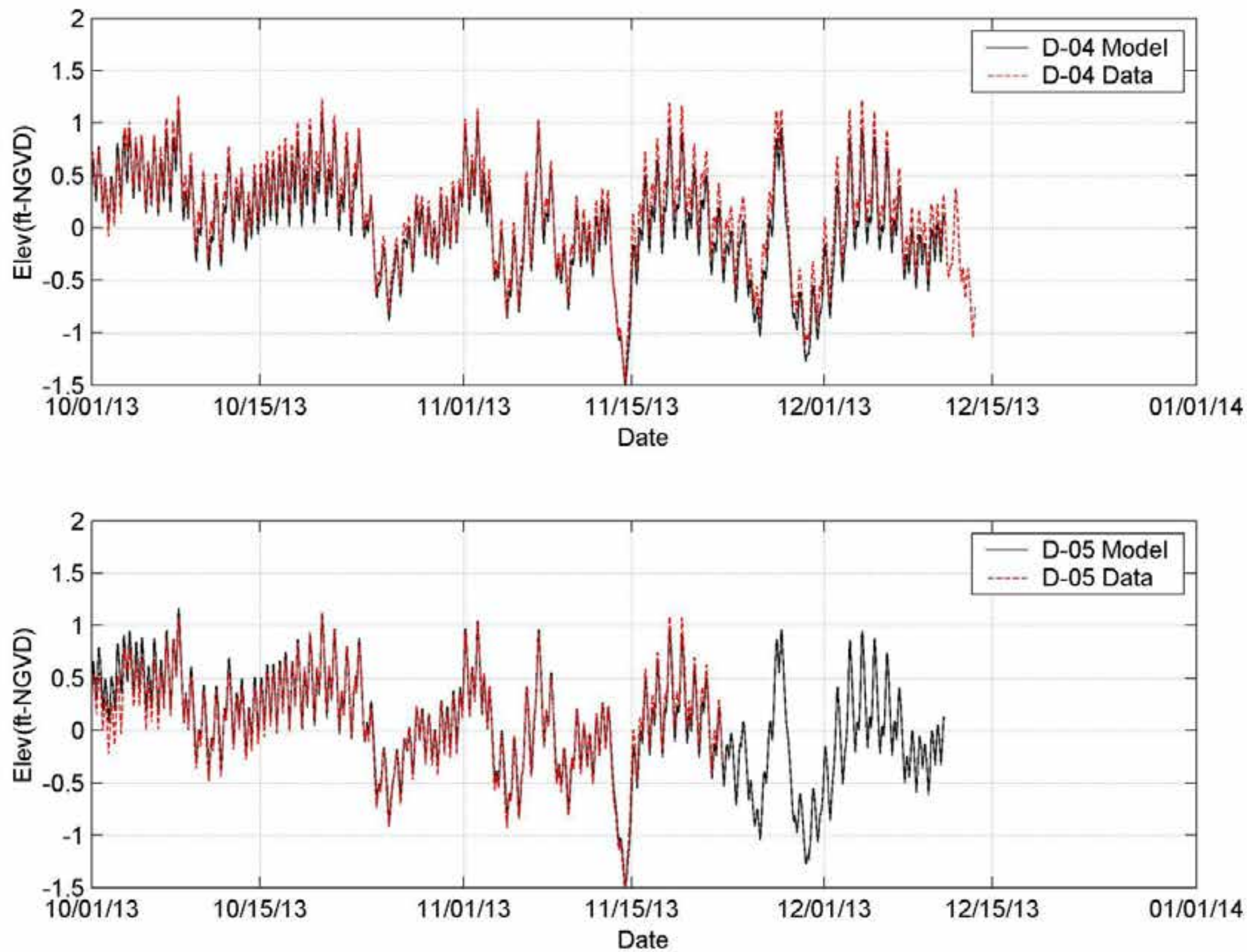


Figure 4-15. Simulated vs Measured Water Level at Stations D-04 and D-05 (10/01/13 – 01/01/14)

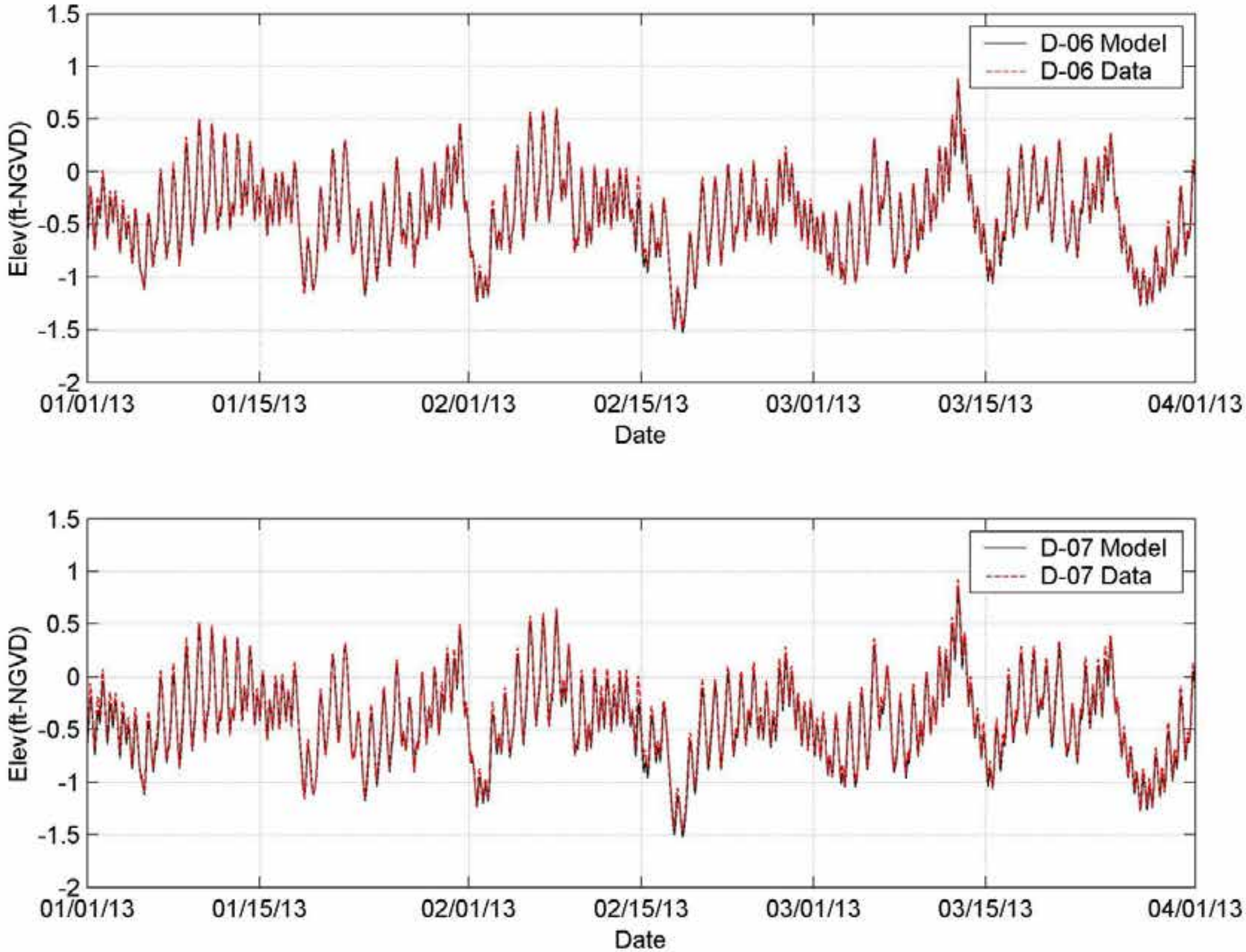


Figure 4-16. Simulated vs Measured Water Level at Stations D-06 and D-07 (01/01/13 – 04/01/13)

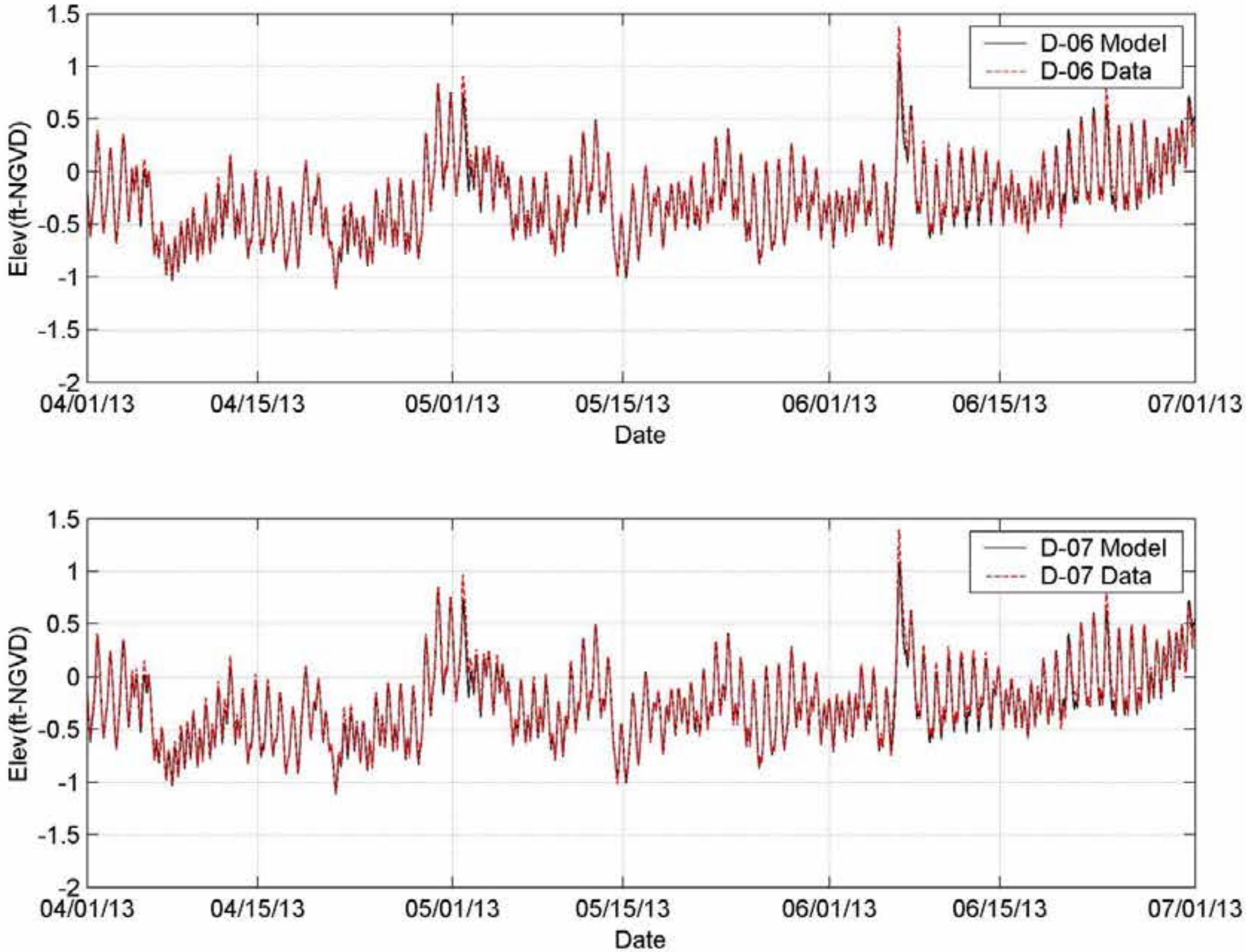


Figure 4-17. Simulated vs Measured Water Level at Stations D-06 and D-07 (04/01/13 – 07/01/13)

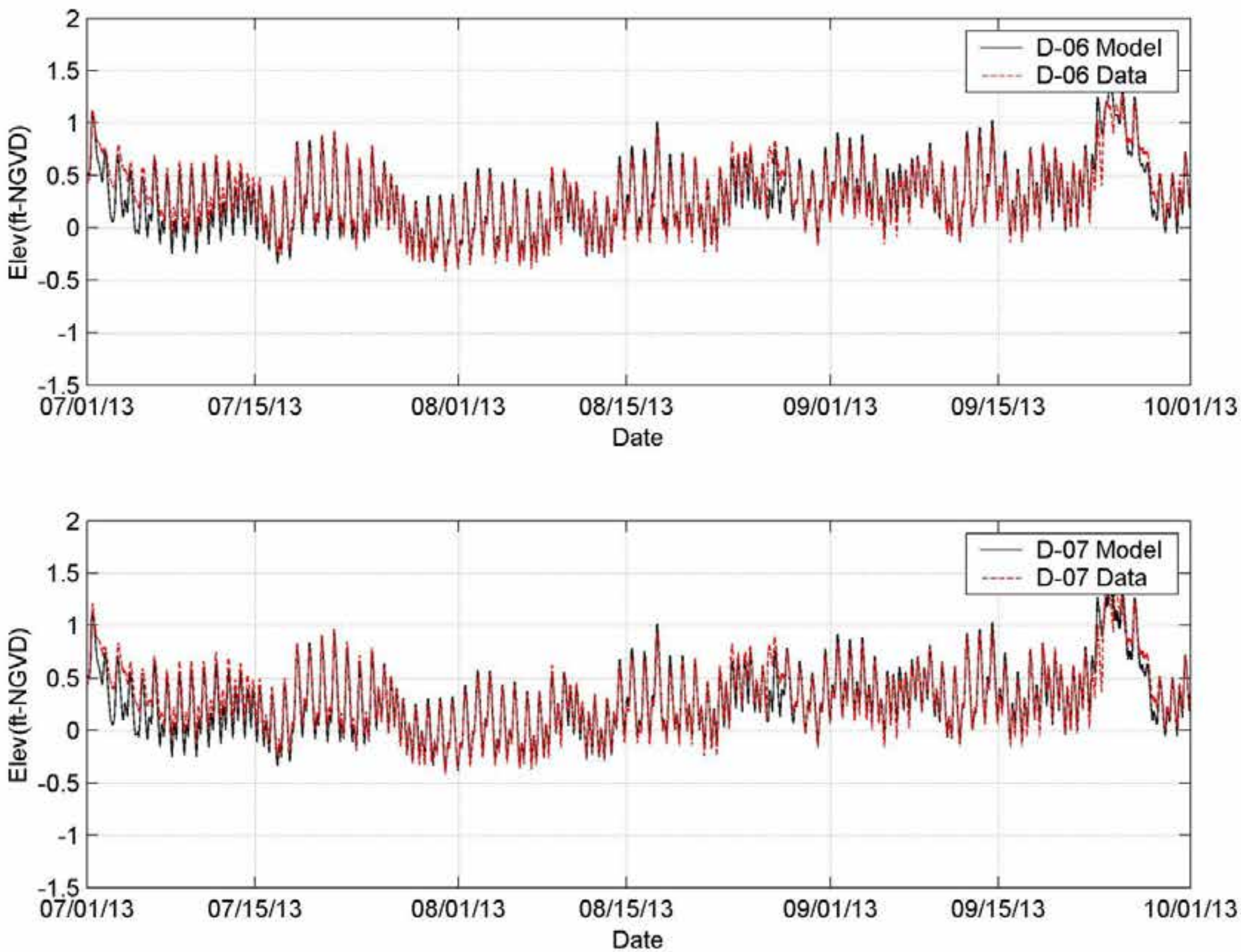


Figure 4-18. Simulated vs Measured Water Level at Stations D-06 and D-07 (07/01/13 – 10/01/13)

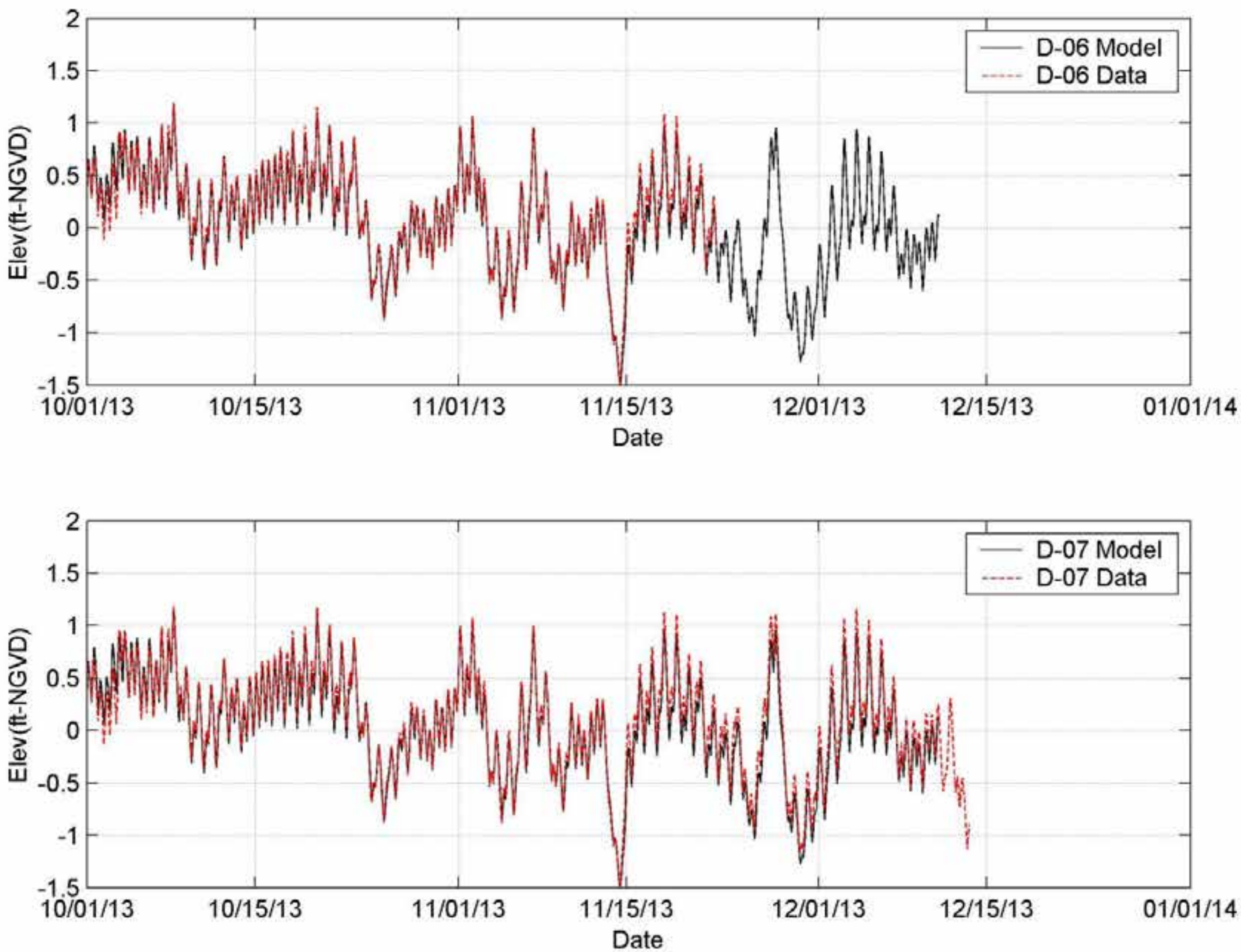


Figure 4-19. Simulated vs Measured Water Level at Stations D-06 and D-07 (10/01/13 – 01/01/14)

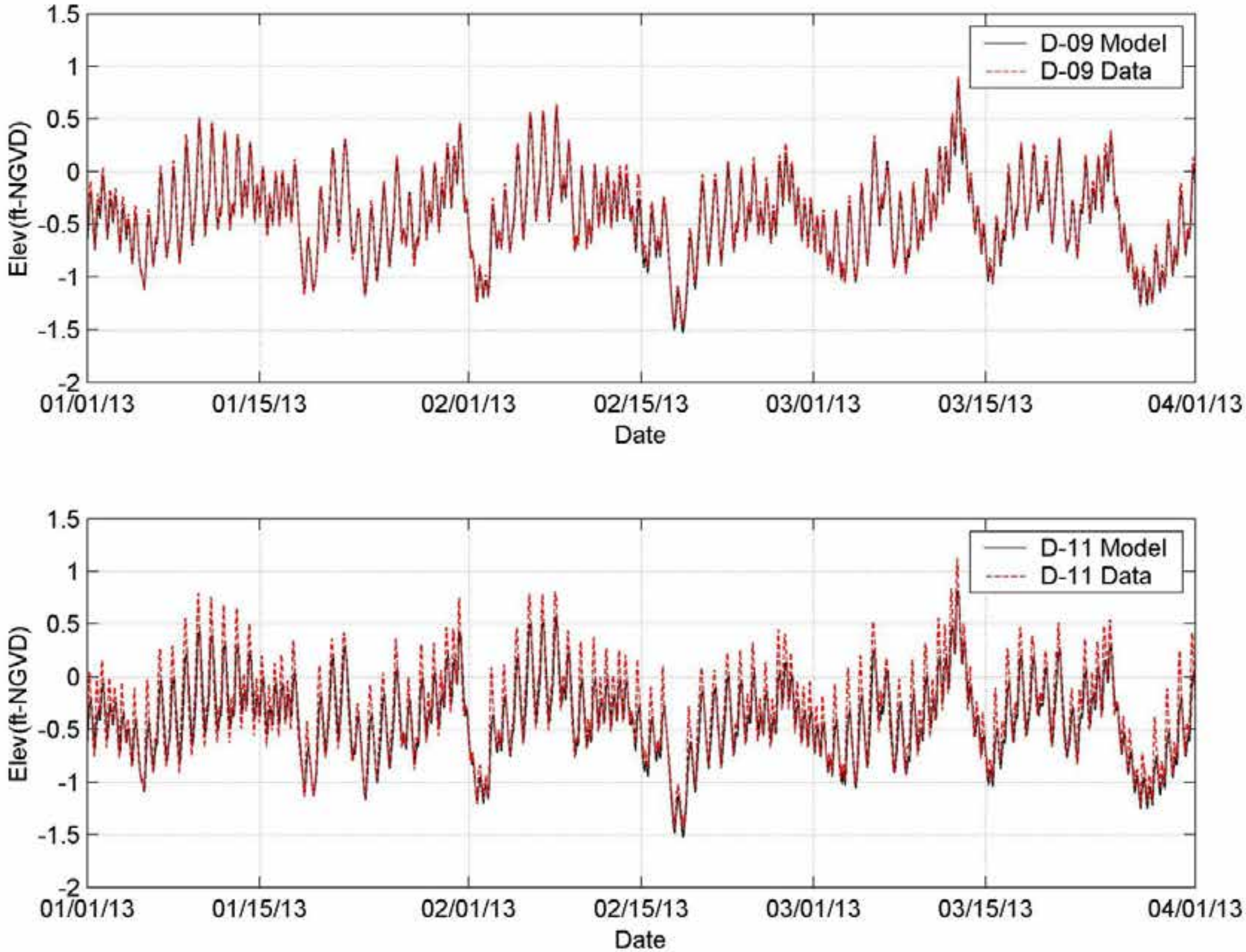


Figure 4-20. Simulated vs Measured Water Level at Stations D-09 and D-11 (01/01/13 – 04/01/13)

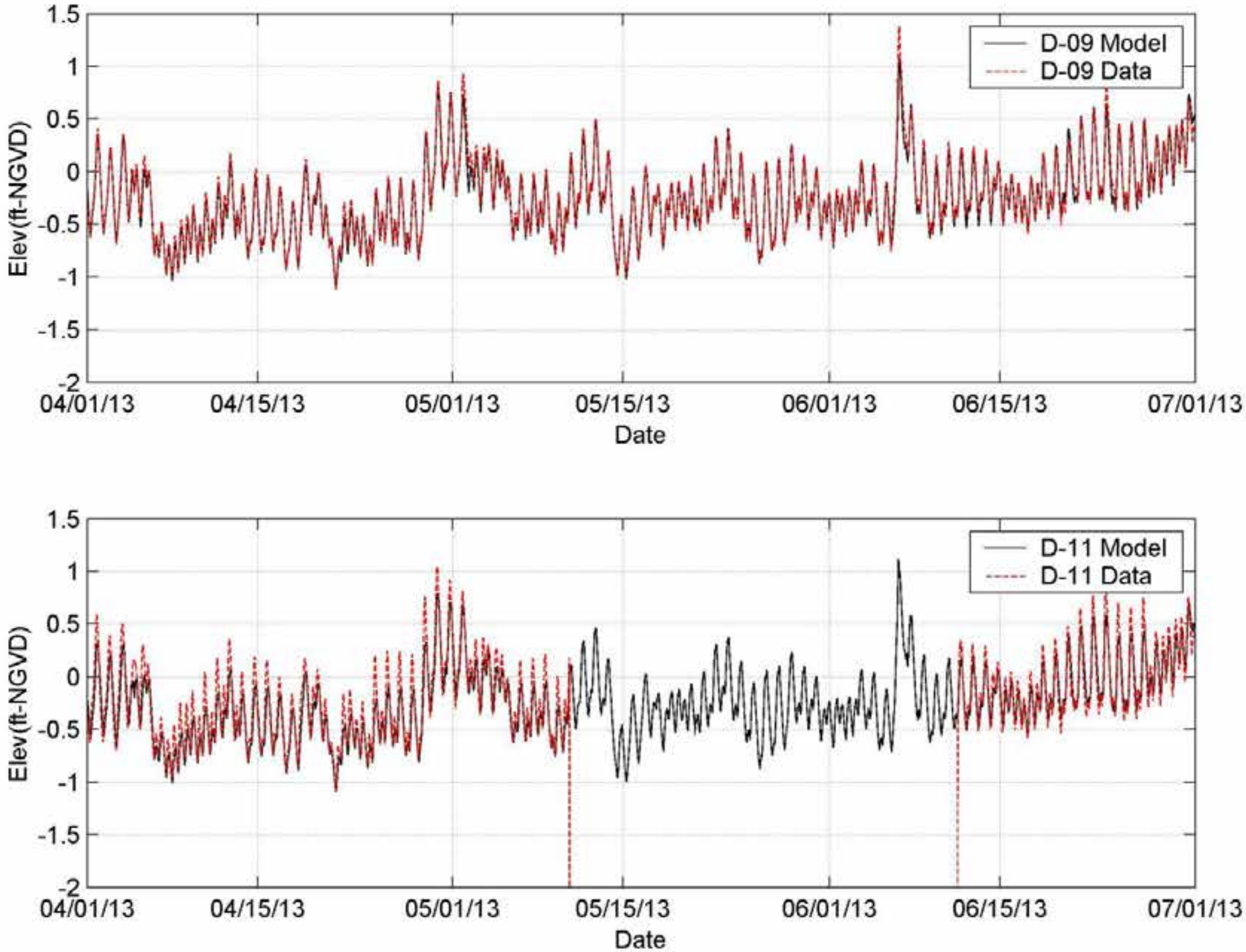


Figure 4-21. Simulated vs Measured Water Level at Stations D-09 and D-11 (04/01/13 – 07/01/13)

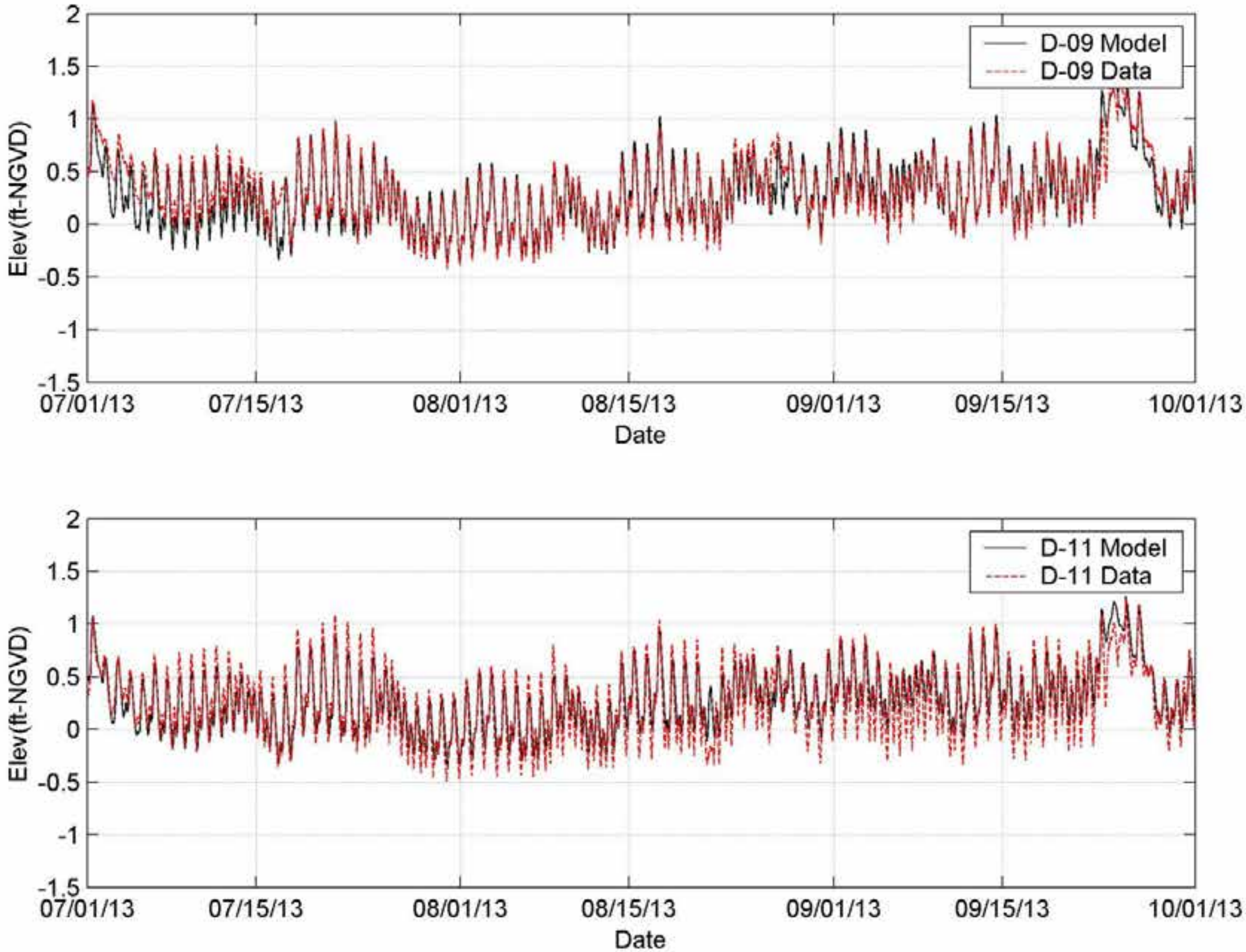


Figure 4-22. Simulated vs Measured Water Level at Stations D-09 and D-11 (07/01/13 – 10/01/13)

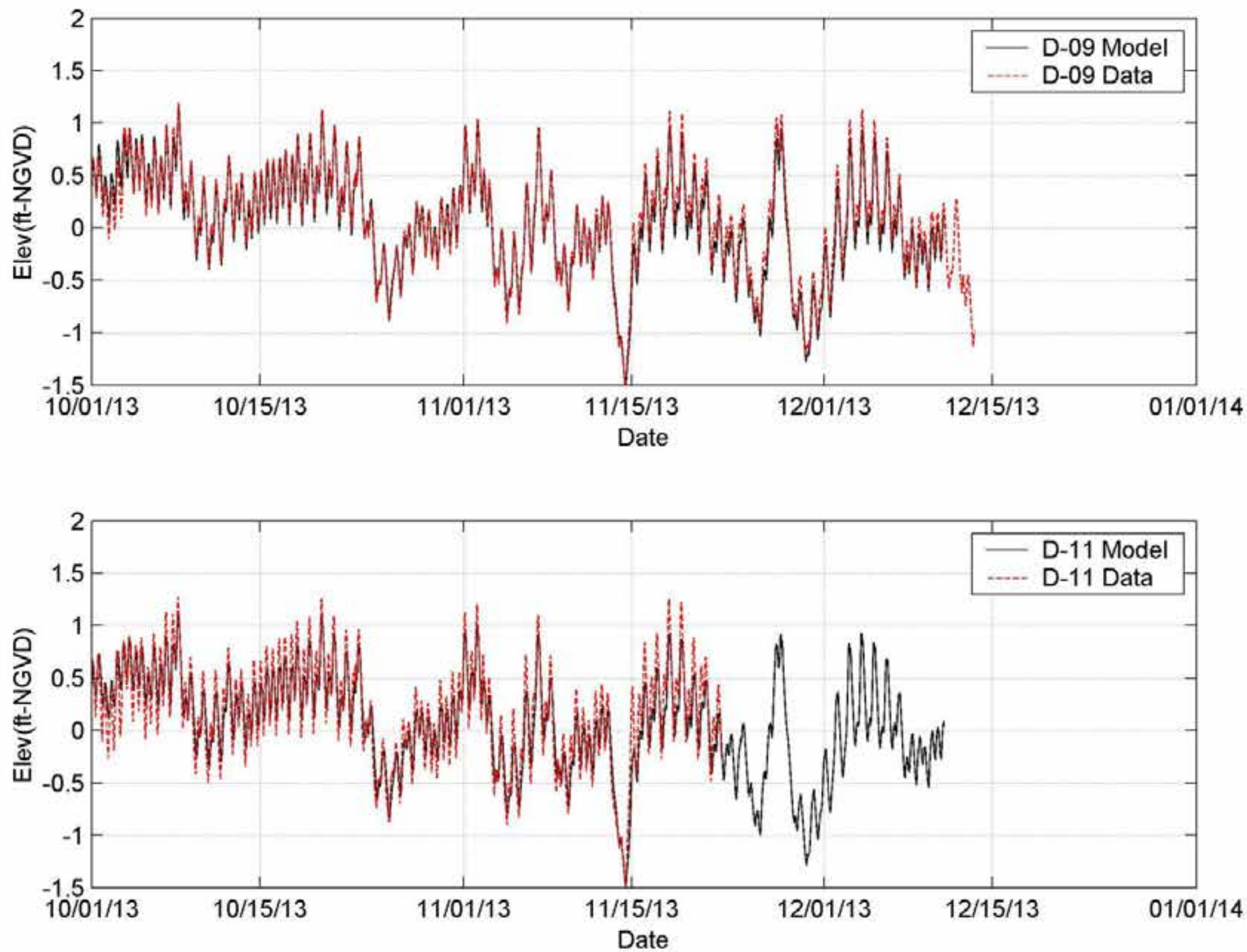


Figure 4-23. Simulated vs Measured Water Level at Stations D-09 and D-11 (10/01/13 – 01/01/14)

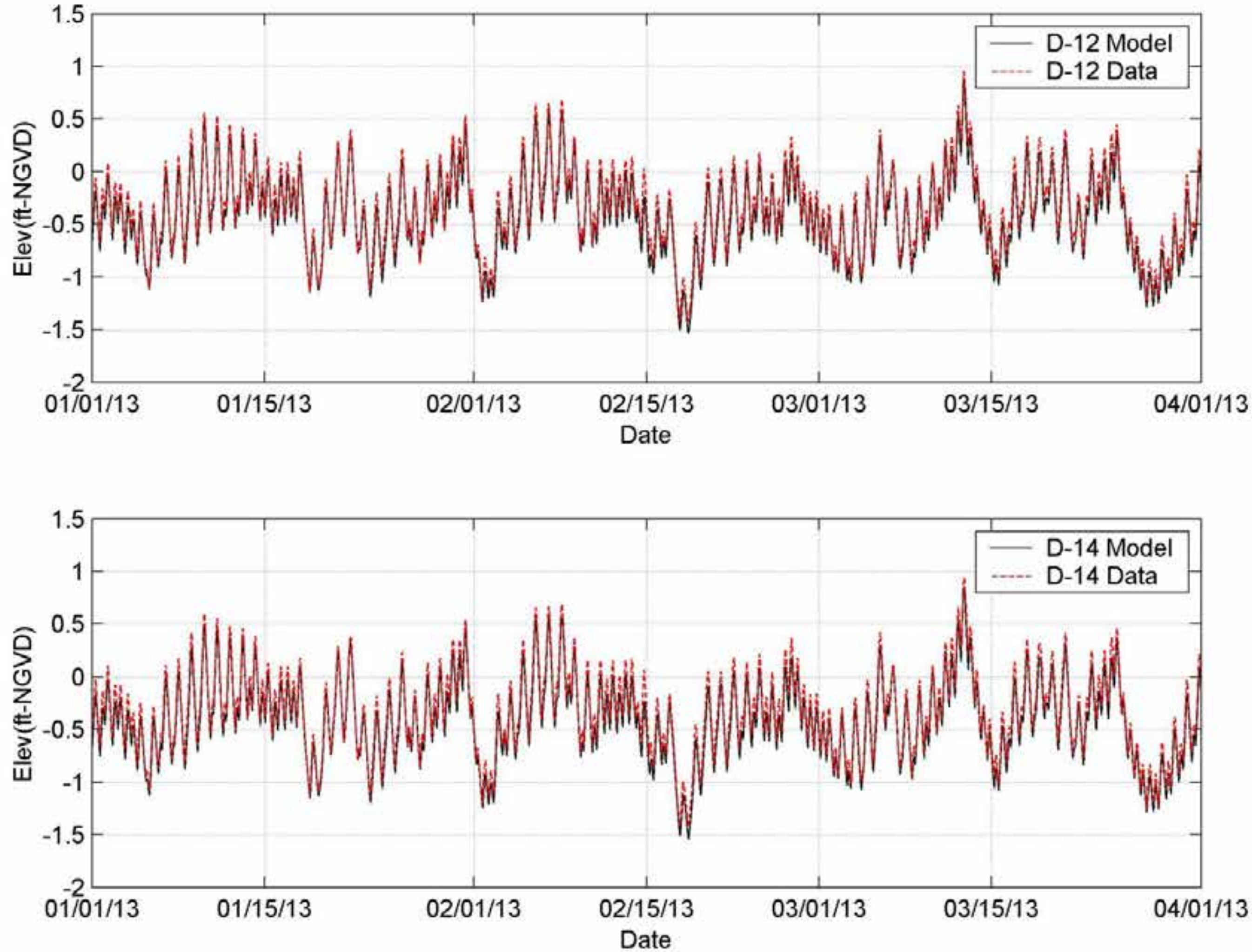


Figure 4-24. Simulated vs Measured Water Level at Stations D-12 and D-14 (01/01/13 – 04/01/13)

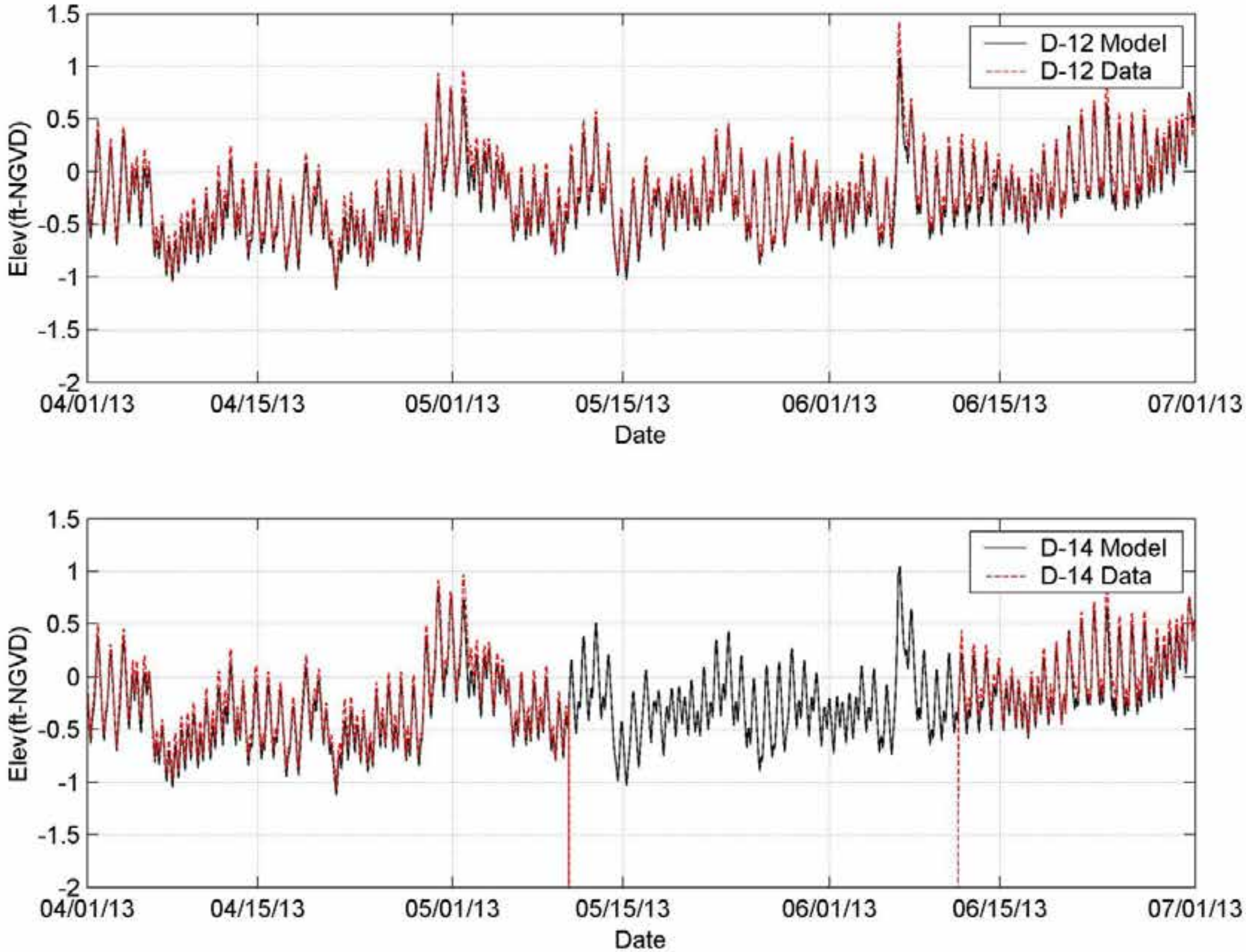


Figure 4-25. Simulated vs Measured Water Level at Stations D-12 and D-14 (04/01/13 – 07/01/13)

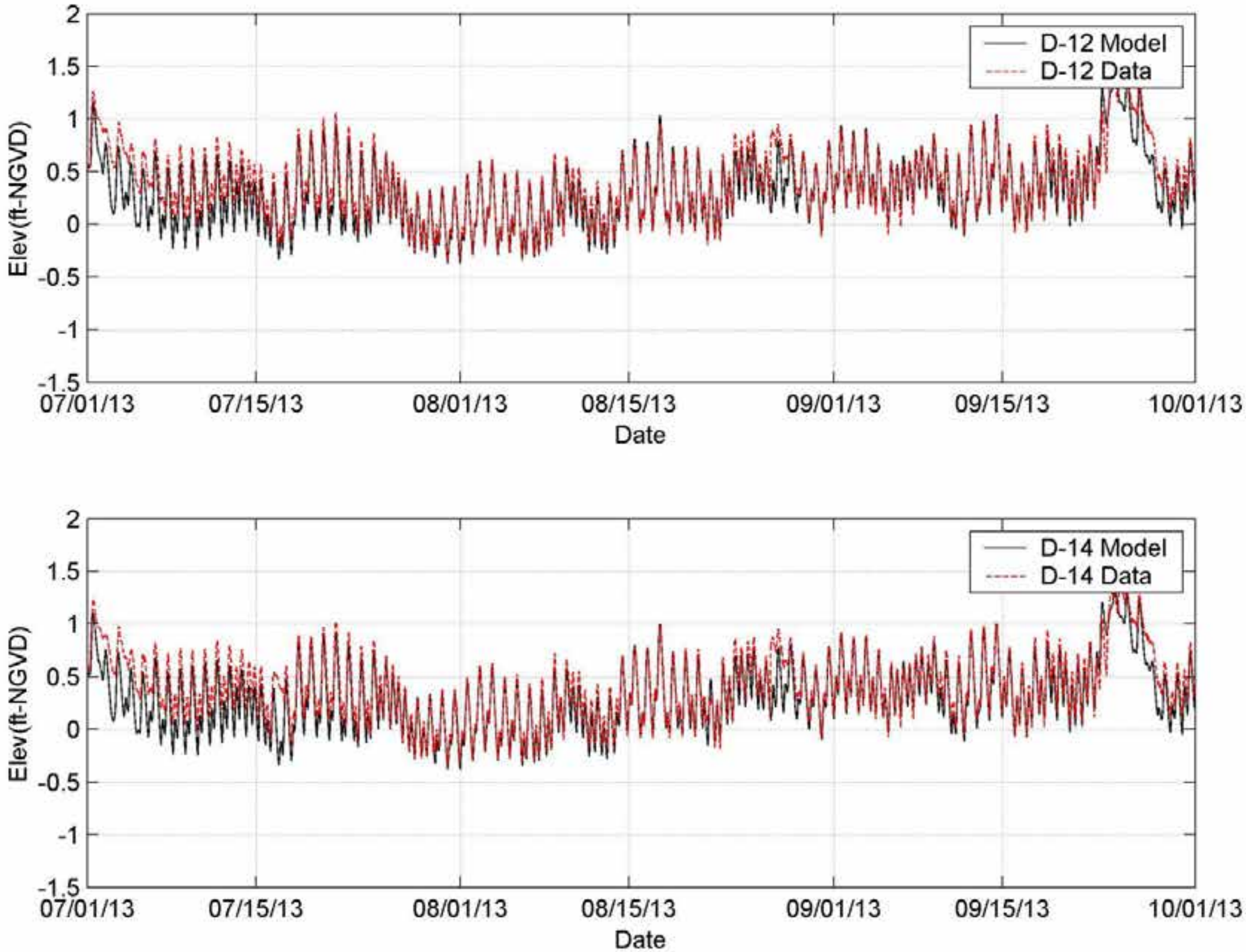


Figure 4-26. Simulated vs Measured Water Level at Stations D-12 and D-14 (07/01/13 – 10/01/13)

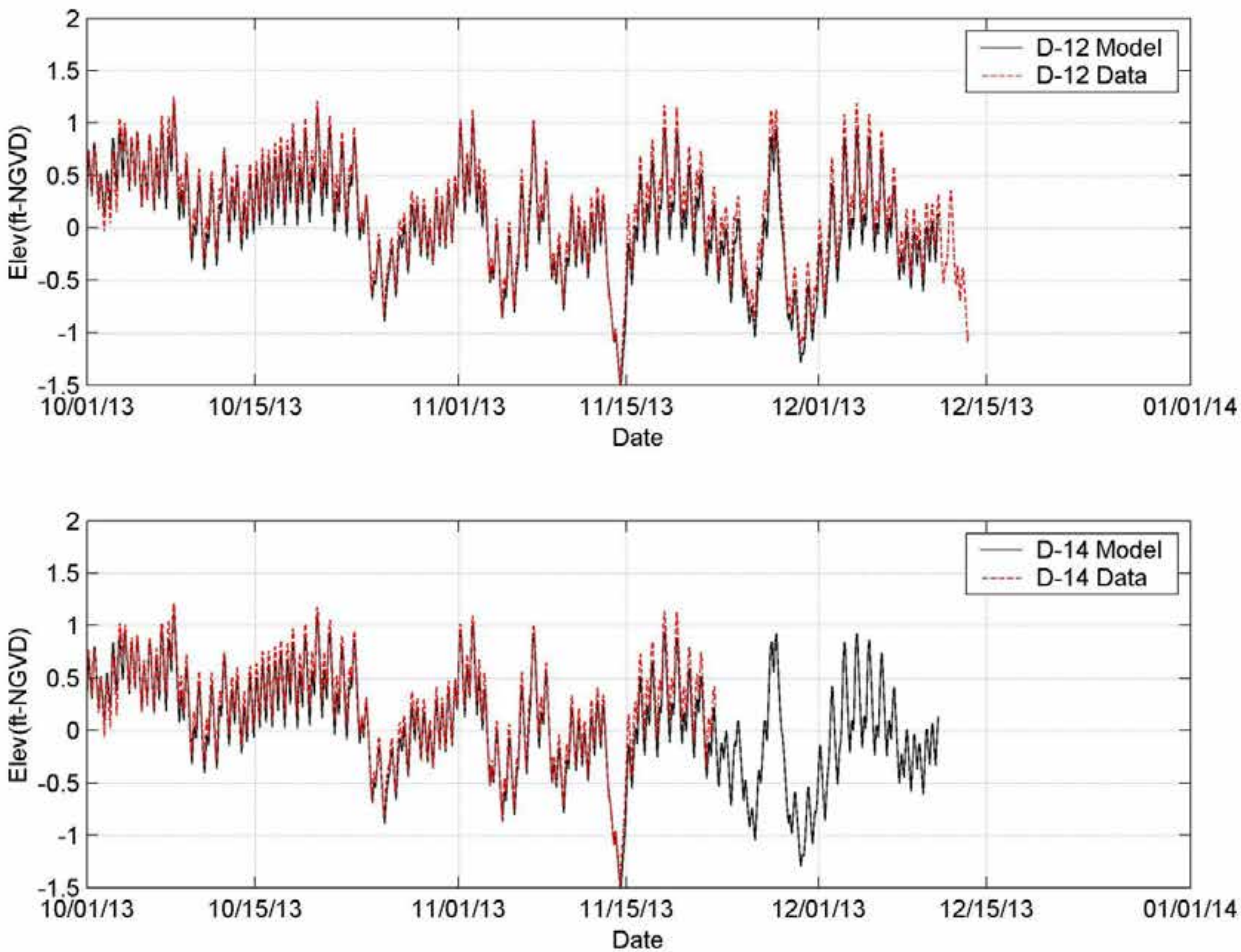


Figure 4-27. Simulated vs Measured Water Level at Stations D-12 and D-14 (10/01/13 – 01/01/14)

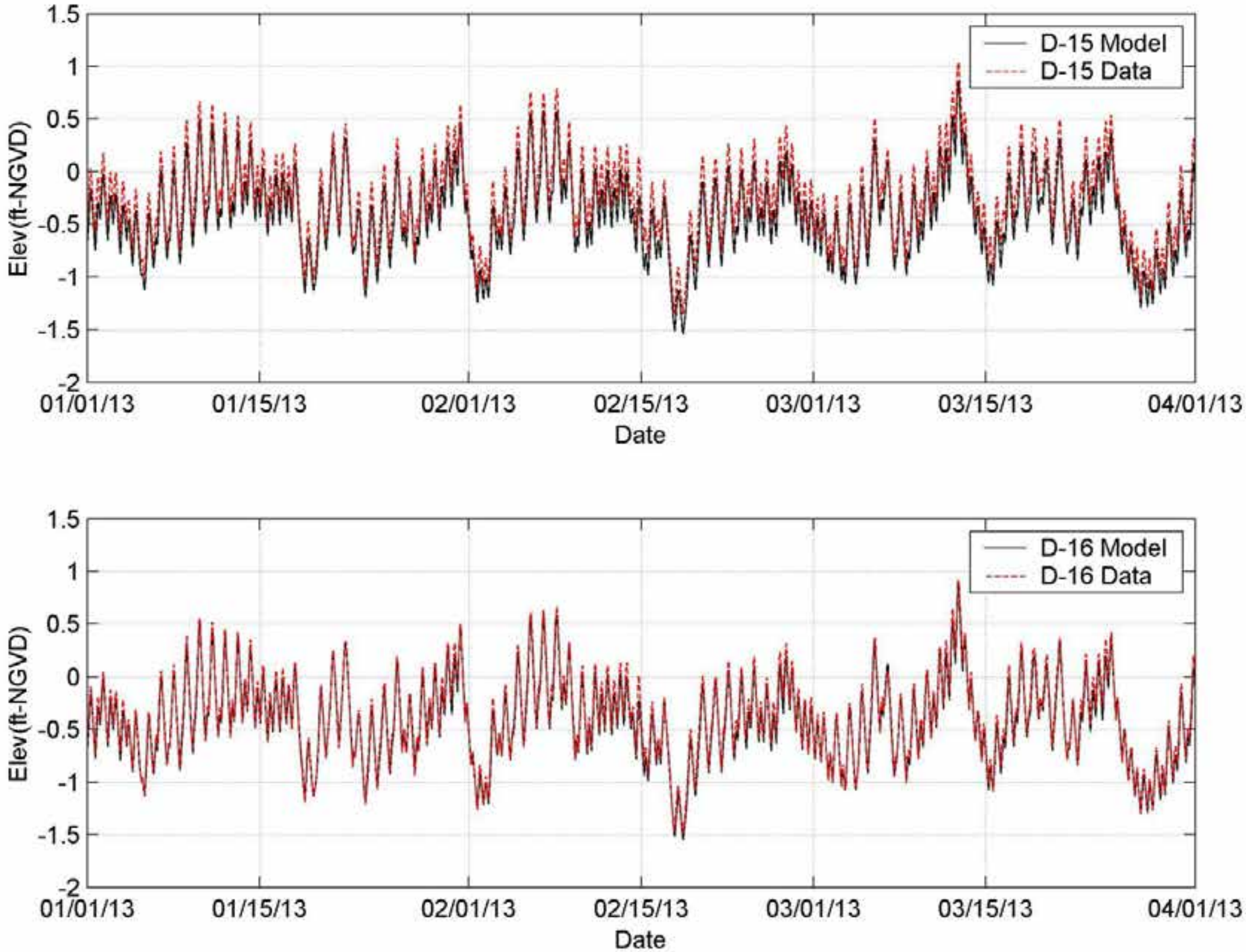


Figure 4-28. Simulated vs Measured Water Level at Stations D-15 and D-16 (01/01/13 – 04/01/13)

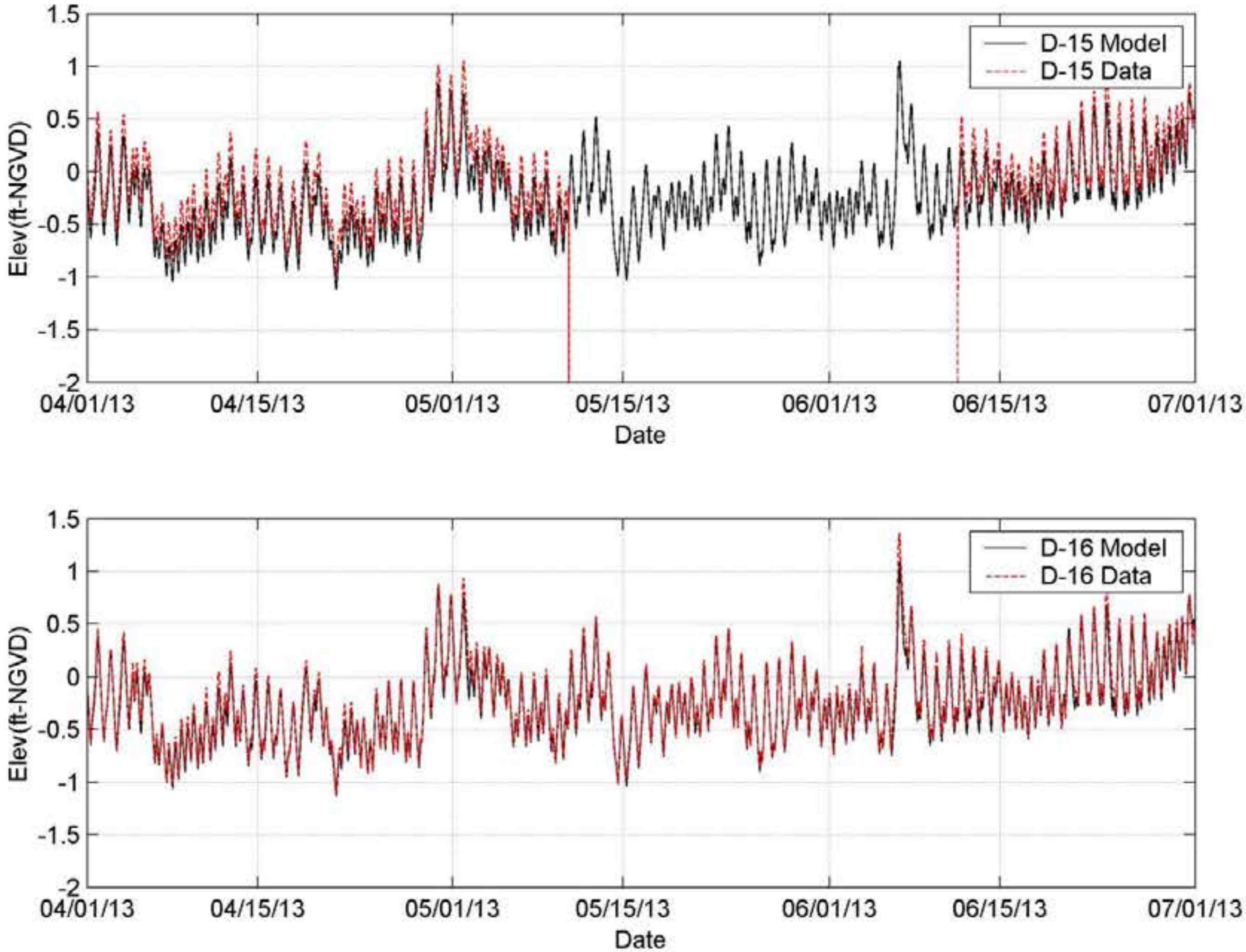


Figure 4-29. Simulated vs Measured Water Level at Stations D-15 and D-16 (04/01/13 – 07/01/13)

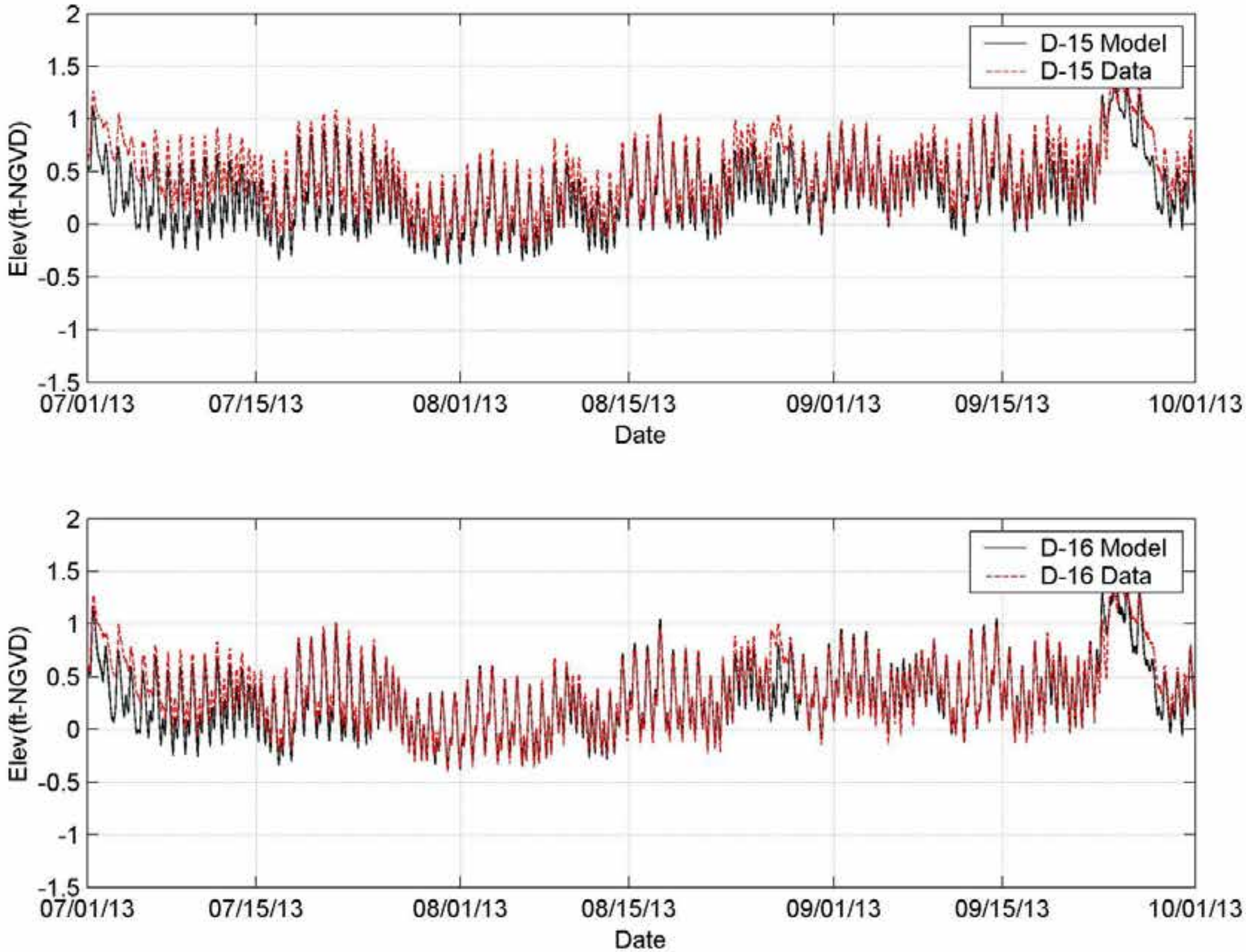


Figure 4-30. Simulated vs Measured Water Level at Stations D-15 and D-16 (07/01/13 – 10/01/13)

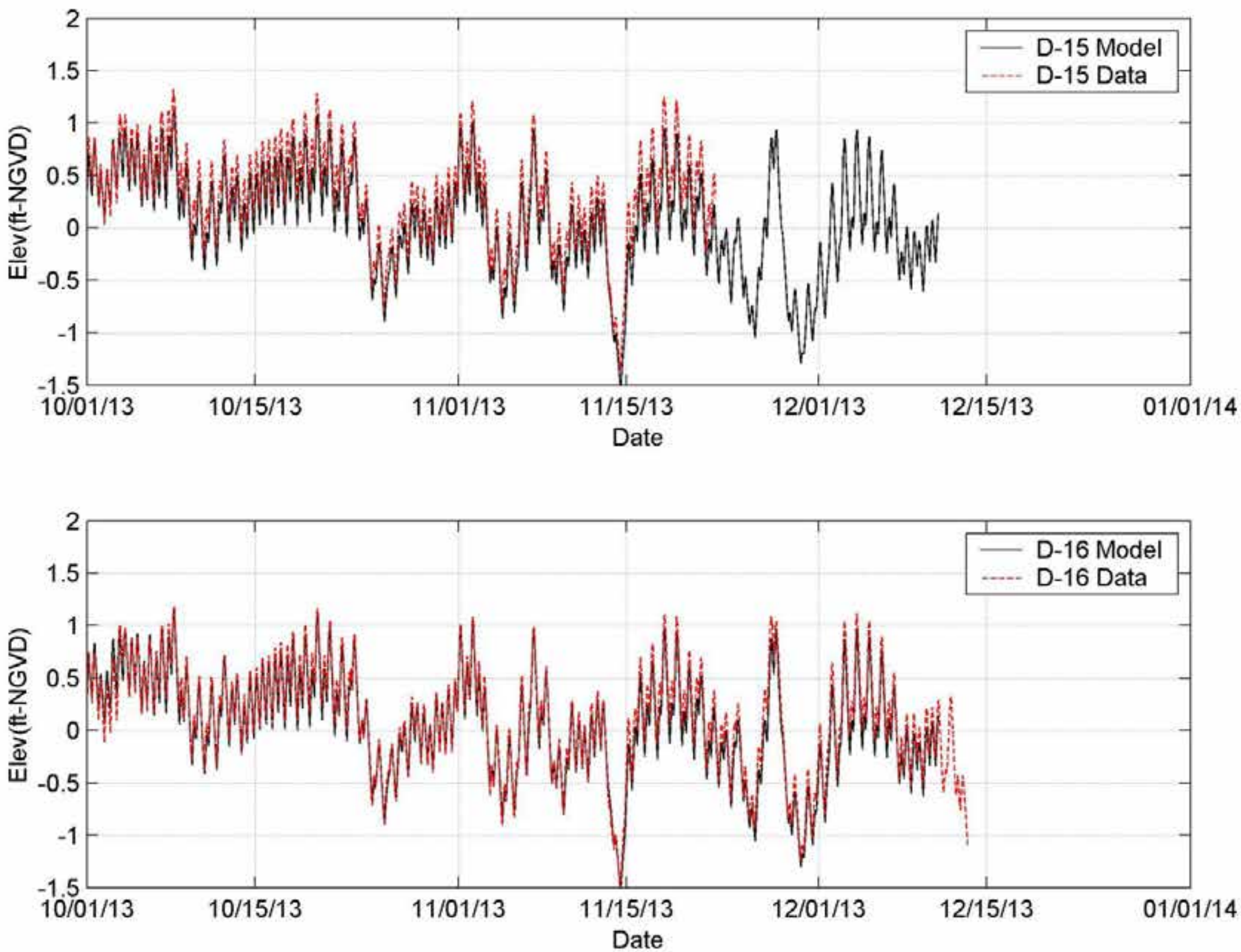


Figure 4-31. Simulated vs Measured Water Level at Stations D-15 and D-16 (10/01/13 – 01/01/14)

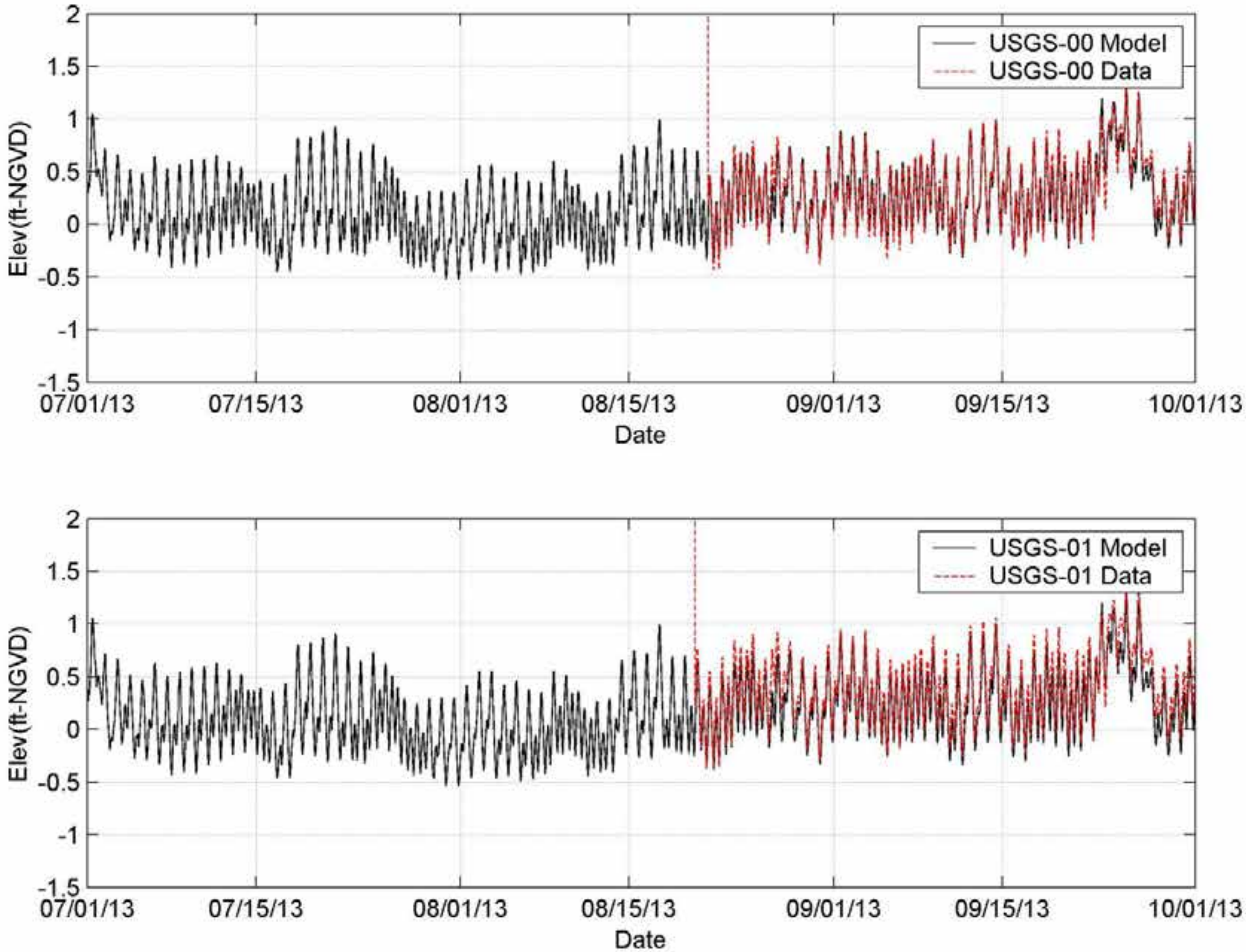


Figure 4-32. Simulated vs Measured Water Level at Stations USGS-00 and USGS-01 (07/01/13 – 10/01/13)

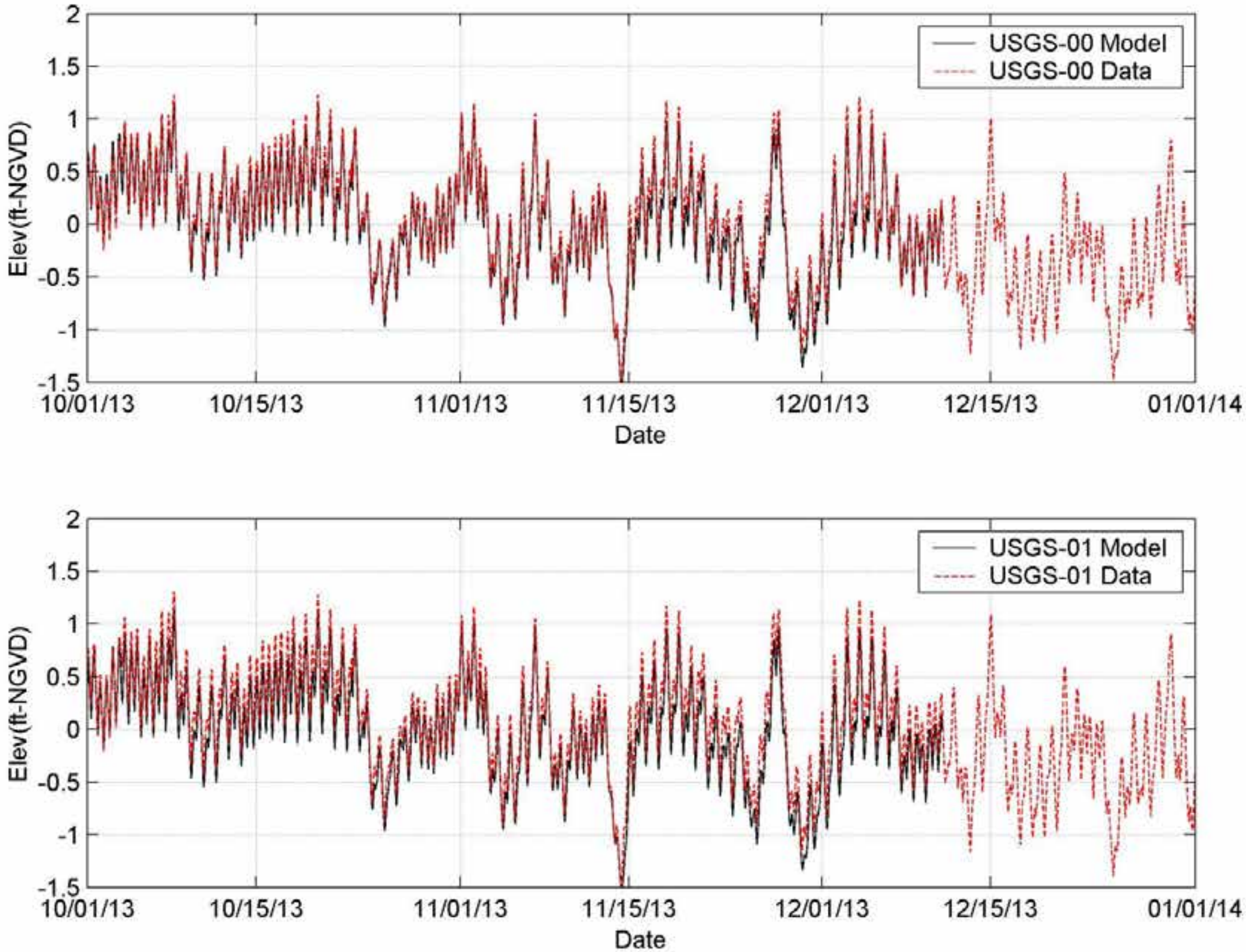


Figure 4-33. Simulated vs Measured Water Level at Stations USGS-00 and USGS-01 (10/01/13 – 01/01/14)

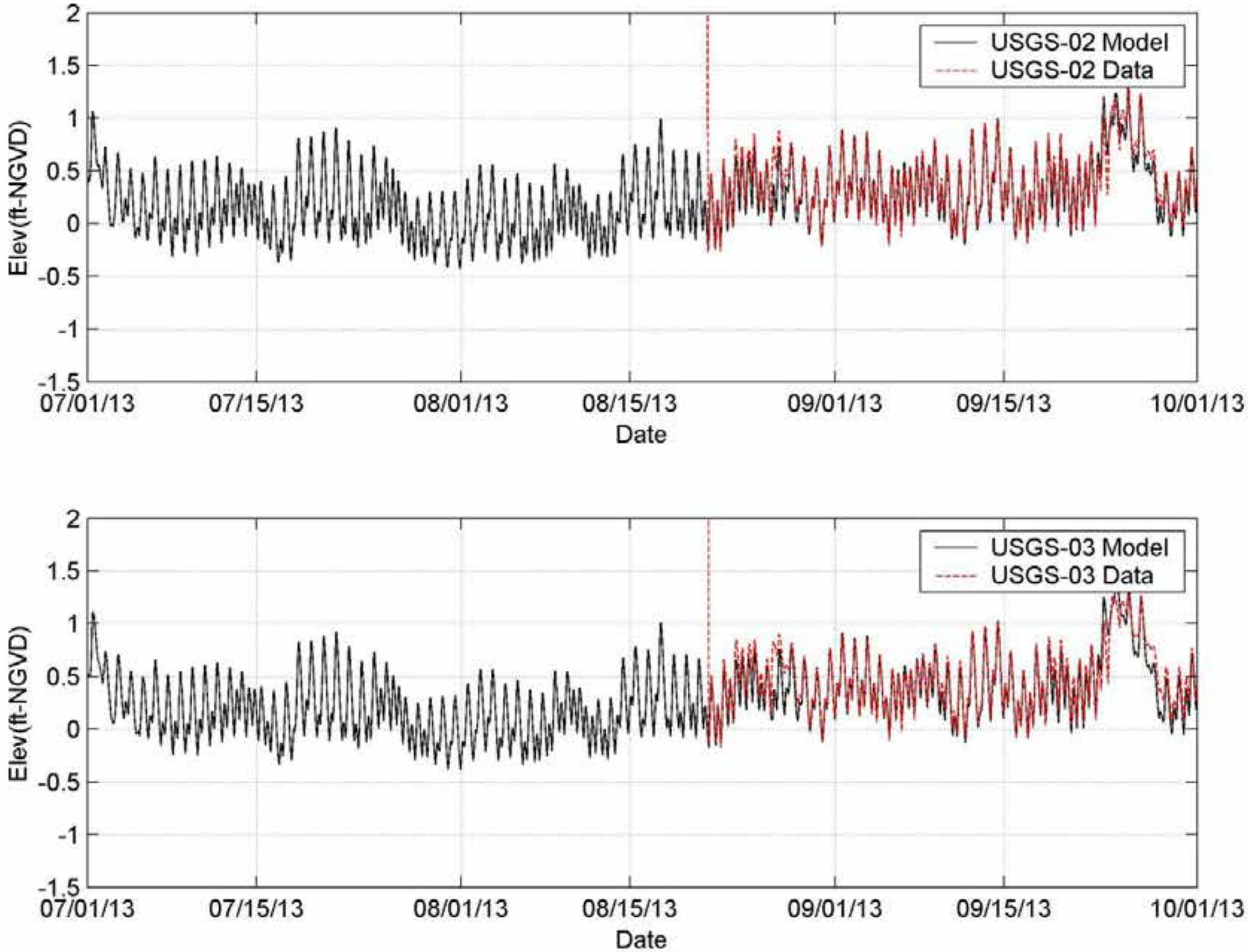


Figure 4-34. Simulated vs Measured Water Level at Stations USGS-02 and USGS-03 (07/01/13 – 10/01/13)

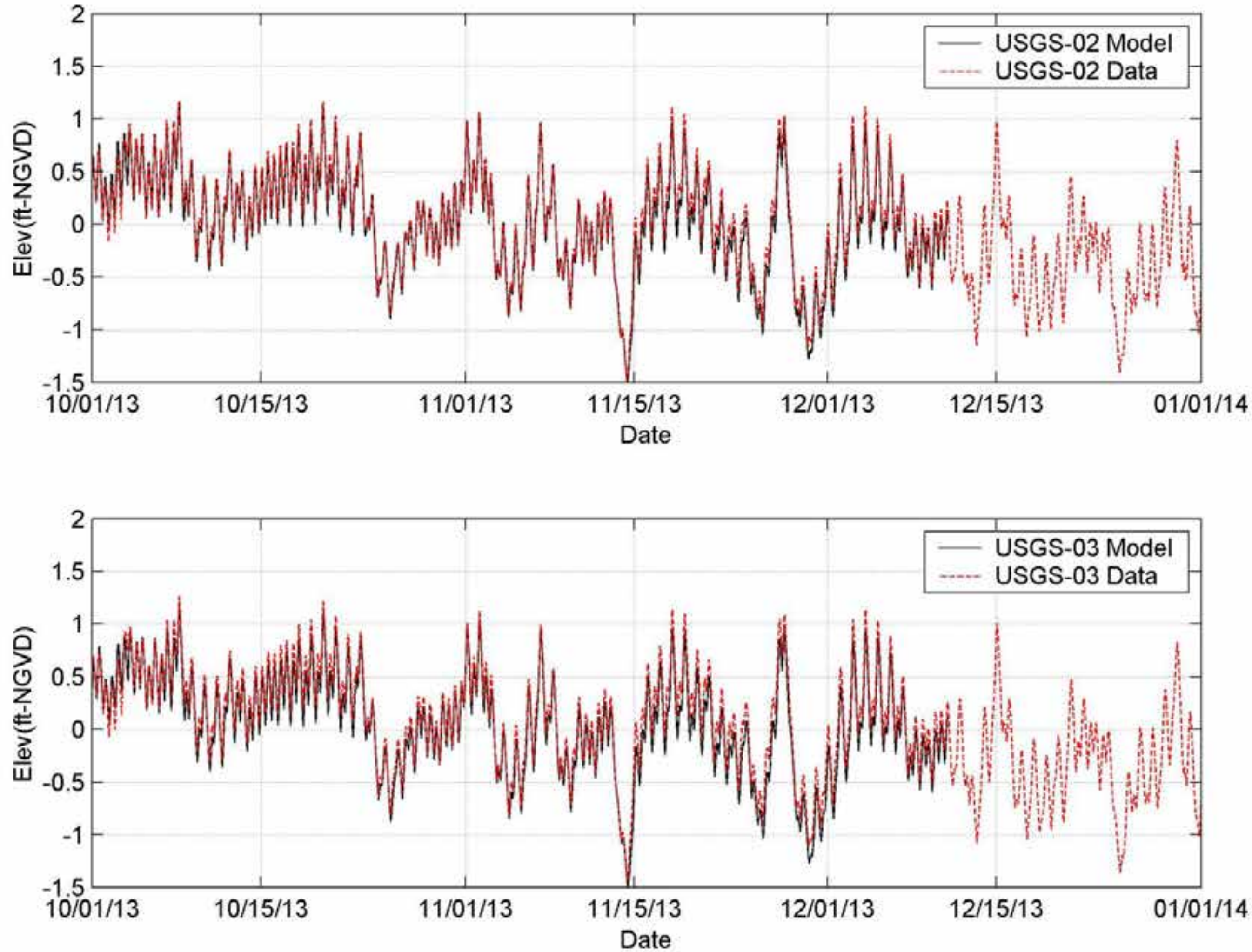


Figure 4-35. Simulated vs Measured Water Level at Stations USGS-02 and USGS-03 (10/01/13 – 01/01/14)

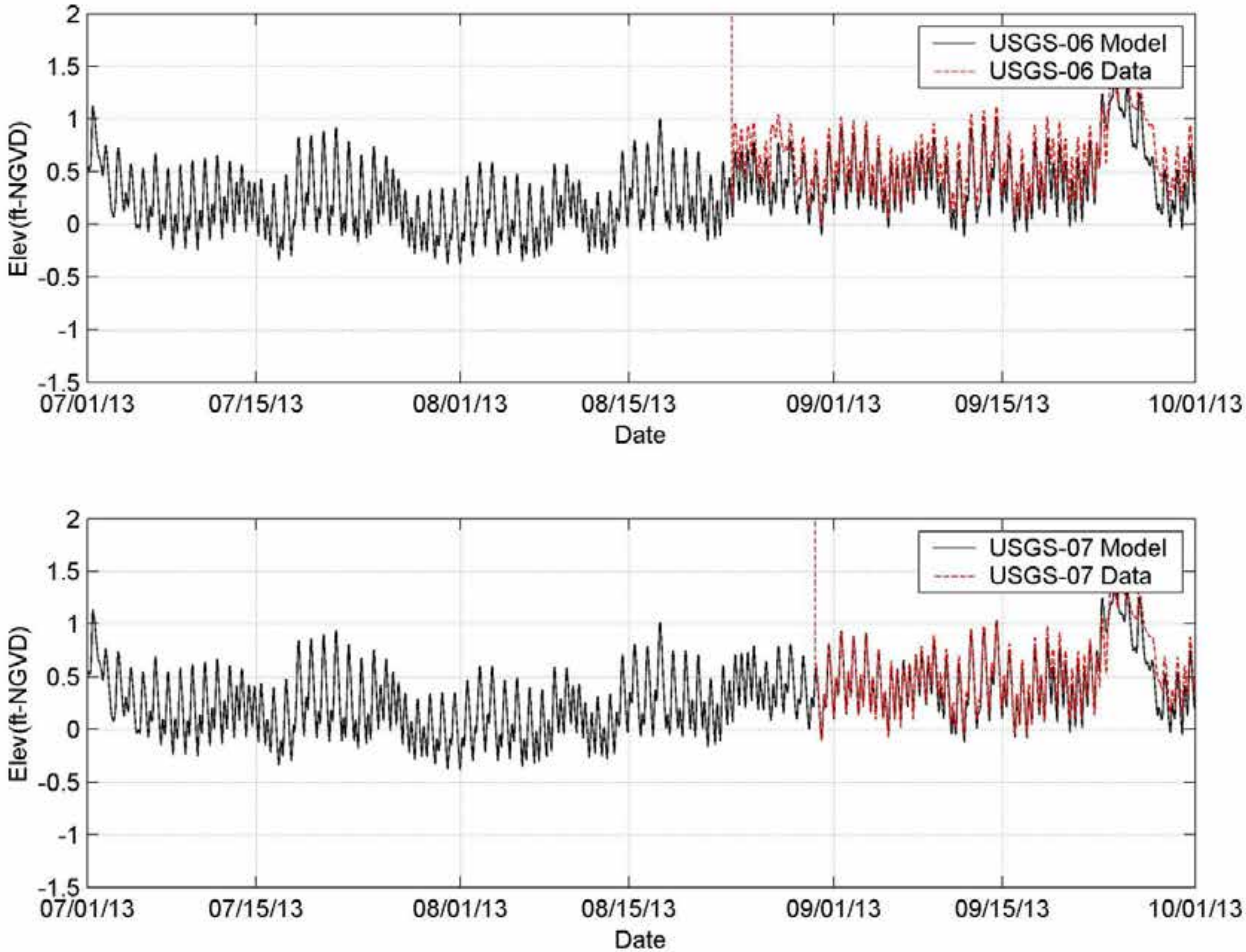


Figure 4-36. Simulated vs Measured Water Level at Stations USGS-06 and USGS-07 (07/01/13 – 10/01/13)

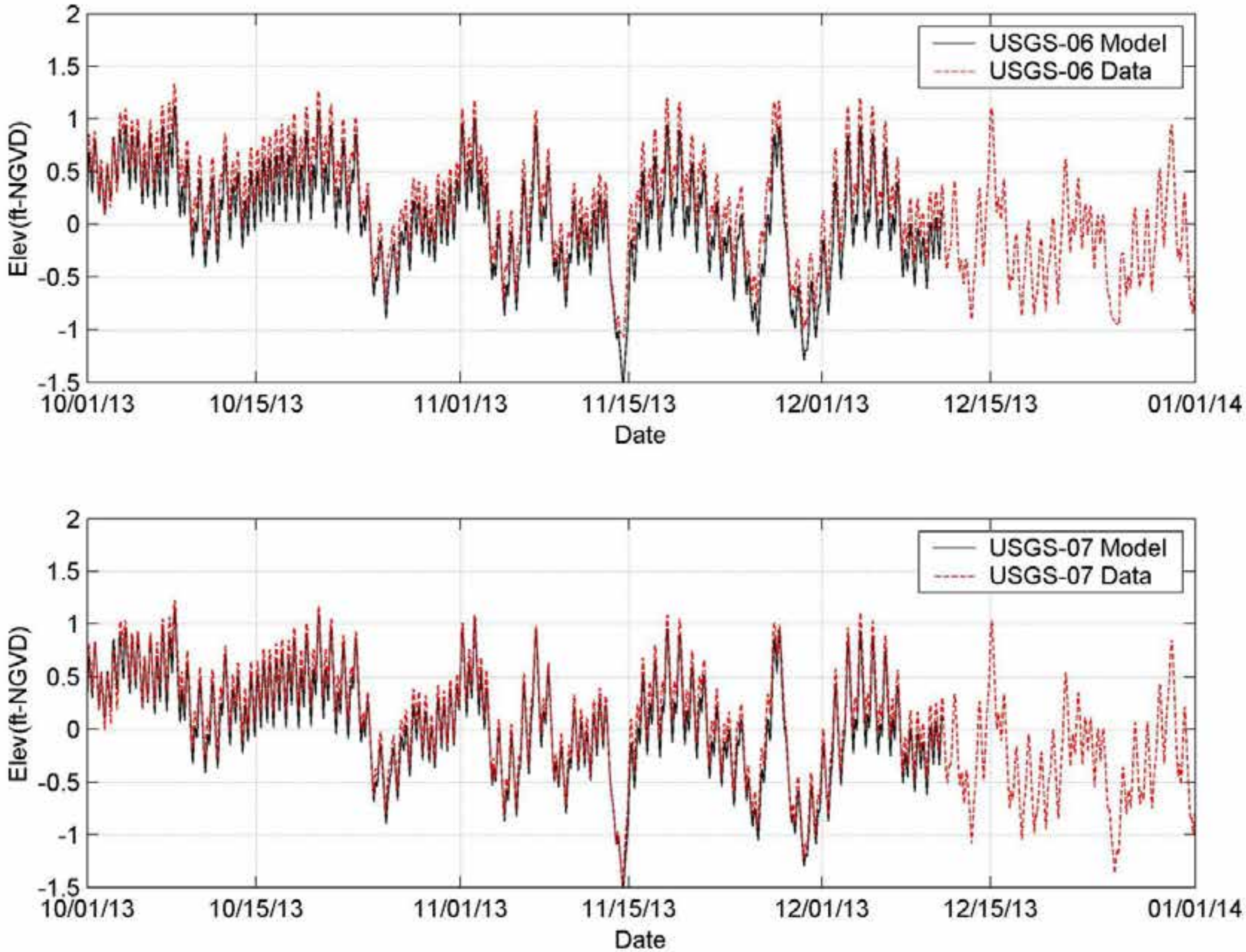


Figure 4-37. Simulated vs Measured Water Level at Stations USGS-06 and USGS-07 (10/01/13 – 01/01/14)

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
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

4.4 SIMULATED VERSUS MEASURED BREACH FLOWS

Figures 4-38 through 4-43 present plots of the simulated versus measured flows at the USGS stations. For each of the USGS stations, the data are presented over 2-month periods, starting on September 1, 2013 through December of 2013. This reflects the period of available data from the USGS stations that overlap with the model simulation period.

Table 4-2 presents model-to-data comparison statistics calculated for the full period of the data presented in the figures (September through December 2013). The statistics include the RMS, the ME, and the R^2. The equations for these error statistics are presented in Section 4.3.

As with the water level data, the data from the model were extracted to match times of available measured data for the analyses. The statistics were then calculated from the matched data sets for the period identified.

Examination of the results at the primary station (USGS-00) (Figures 4-38 and 4-39) shows that the model is slightly underpredicting the magnitude of the flows. This station passes around 70 to 80 percent of the tidal prism that enters and leaves the system. The ME shows that the model slightly overpredicts the net flow out of the system, while the RMS error shows the overall net difference in the simulated-versus-modeled flows. The R^2 for this station, 0.84, is very good relative to the prediction of flows in such a complicated system. For this station, the figures show that the model captures the shape and characteristics of the inflowing and outflowing tides, i.e., the longer duration of the outflow versus the inflow, and the peaked nature of the inflow. This is characteristic of the tidal inlet conditions of super-elevation through narrow inlets described in detail in the Hydrodynamic Data Characterization Report. The model captures this phenomenon very well. Looking at the large freshwater flow event that occurred in late September, the model is capturing the response in terms of the levels of flow reversal and the general overall magnitude, although it does appear that the model overpredicts the overall net outflow.

The flow through Ceitus Creek (USGS-01) in Figures 4-38 and 4-39 shows that it has similar characteristics to the primary station (USGS-00) in terms of shape and timing. As with the primary station, the model is doing a very good job of replicating this shape. The R^2 is very good at 0.88, as shown in Table 4-2. The RMS error and the ME are of a similar level of magnitude in relation to the overall magnitude of the flow, as was seen for USGS-00. This station also shows that the model is slightly overpredicting the net outflow.

Stations USGS-02 and USGS-03 have similar types of flow responses, which were discussed in detail in the Hydrodynamic Data Characterization Report. The KD sections to which these breaches connect do not have a continuous connection to the areas west to Matlacha Pass. Rather, based upon the water level elevations in the NSC and Matlacha Pass, direct connections (generally aligned with remnant tidal channels) come online and offline. Therefore, when the water levels are low, these two breaches pass flow sufficient to fill the KD. As water levels rise, additional connected areas, and potentially direct connections to the waters west toward Matlacha Pass, become active. A characteristic of these two breaches is that they generally flow in an opposite manner compared to the other monitored openings (USGS-00, USGS-01, USGS-06, and USGS-07). During a rising tide, these breaches flow out, and during a falling tide, they generally flow in. The model-to-data comparisons (Figures 4-40 and 4-41) show that the model is capturing the general flow direction characteristics. Additionally, the model is showing response to the water levels, i.e., with very small flows when water levels are low, transitioning to larger fluxes as water levels are higher. For both USGS-02 and USGS-03 though, there are times where the magnitudes of these flows are not simulated by the model. The statistics in Table 4-2 show the RMS and ME are larger (in relation to the flow magnitudes) than at the other stations. Additionally, these stations have lower coefficients of determination, with values of 0.33 and 0.45. While the model is capturing the general flow characteristics, there are times where the magnitudes are not well simulated. For the large freshwater inflow event, the breach measured by Station USGS-02 shows that the model is doing a reasonable job of simulating the net outflow, although the model does not quite replicate some of the reversing flow. For USGS-03, the model shows the general characteristics of the outflow, but does not capture the full magnitude flowing out through the breach.

Stations USGS-06 and USGS-07 are connected to a section of the KD that has a full-time connection to the waters of Matlacha Pass to the west. Based on this connection, and the timing of the tidal wave propagating from the south opening to the north along the NSC, the flow characteristics of these breaches are such that, generally, during a rising tide, the flow is in, and during a falling tide, the flow is out. The model-to-data comparisons in Figures 4-42 and 4-43 show that the model is doing a very good job of simulating all aspects of the tidally driven flows. This includes the magnitudes passing through both USGS-06 and USGS-07 as well as the flow curve shape and characteristics, which are especially complicated for USGS-07. One aspect that the model is doing very well at for these stations is the timing and magnitude of the additional flow pathways that come online and introduce much higher flows when water levels are high. This is the case for the entire period of the available data. For the high freshwater inflow event in September, the model does a good job of passing the magnitude of flows out of USGS-06 and does a reasonable job out of USGS-07, although the model somewhat underpredicts the total magnitude of flow out for USGS-07. The model statistics presented in Table 4-2 demonstrate that the model is performing well for these stations with high coefficients of determination and relatively low

RMS and ME. The negative values in the ME identify the overall underprediction of the model in simulating the net flow out.

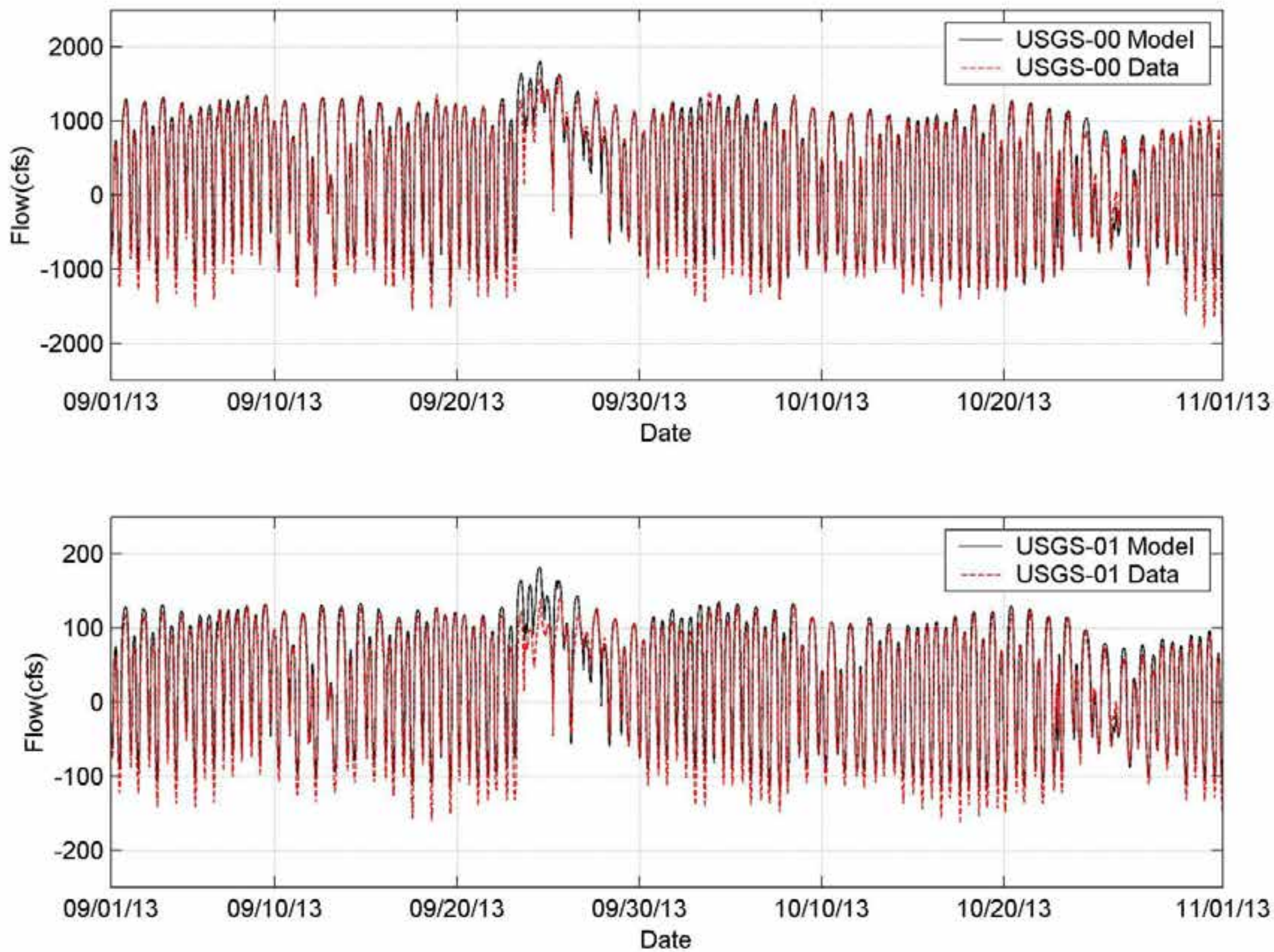


Figure 4-38. Simulated vs Measured Flow at USGS-00 and USGS-01 (09/01/13 – 11/01/13)

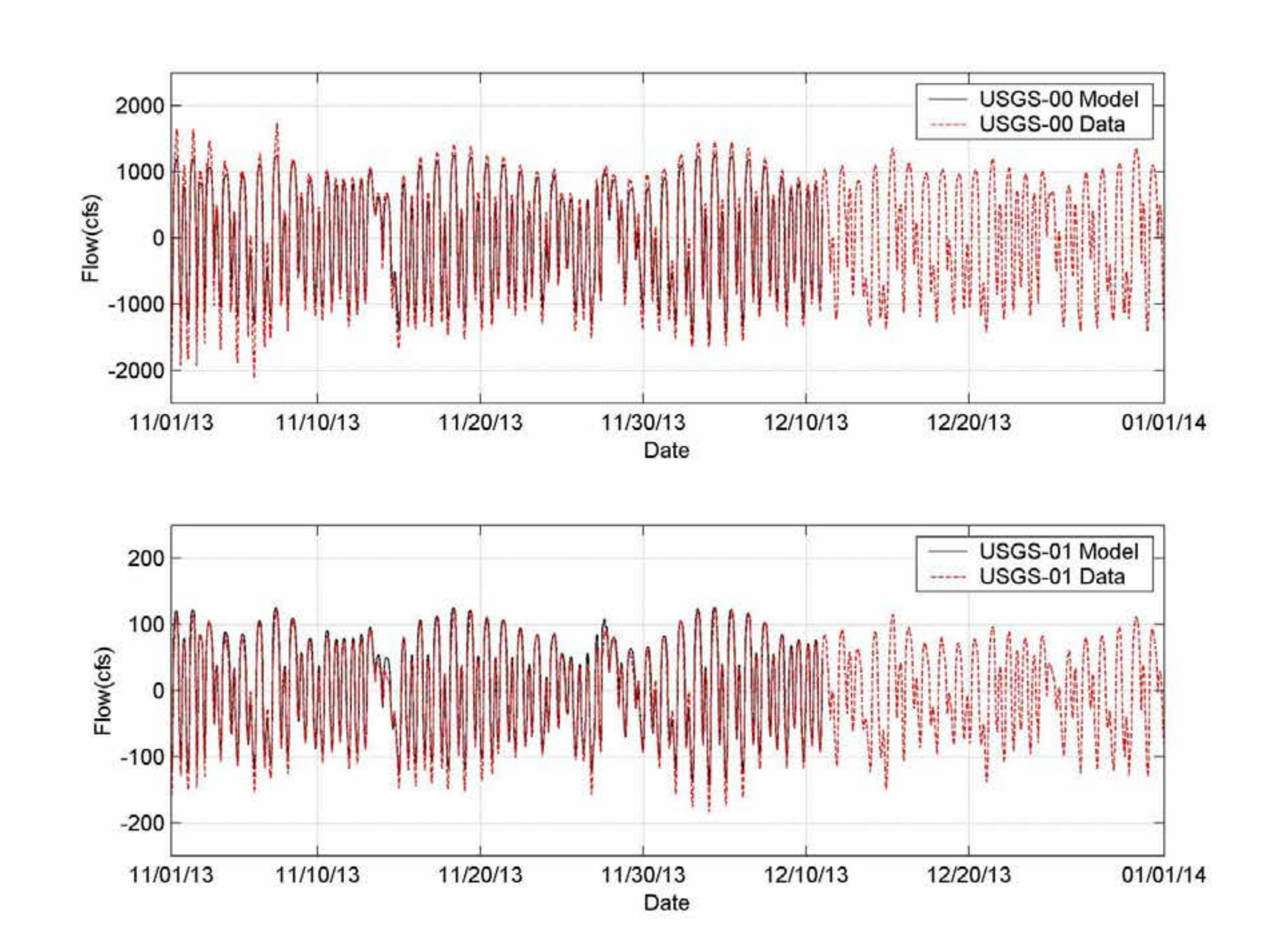


Figure 4-39. *Simulated vs Measured Flow at USGS-00 and USGS-01 (11/01/13 – 01/01/14)*

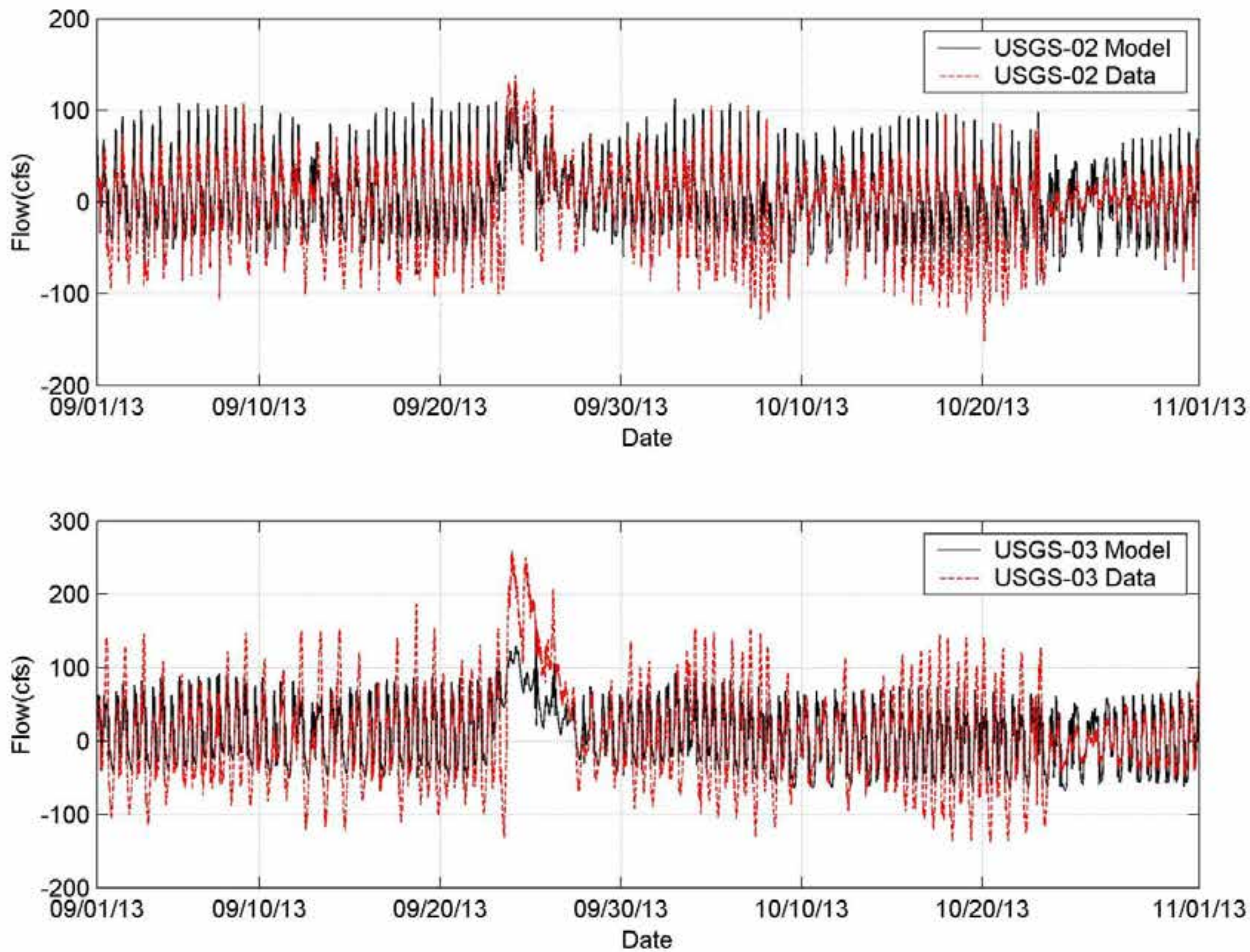


Figure 4-40. Simulated vs Measured Flow at USGS-02 and USGS-03 (09/01/13 – 11/01/13)

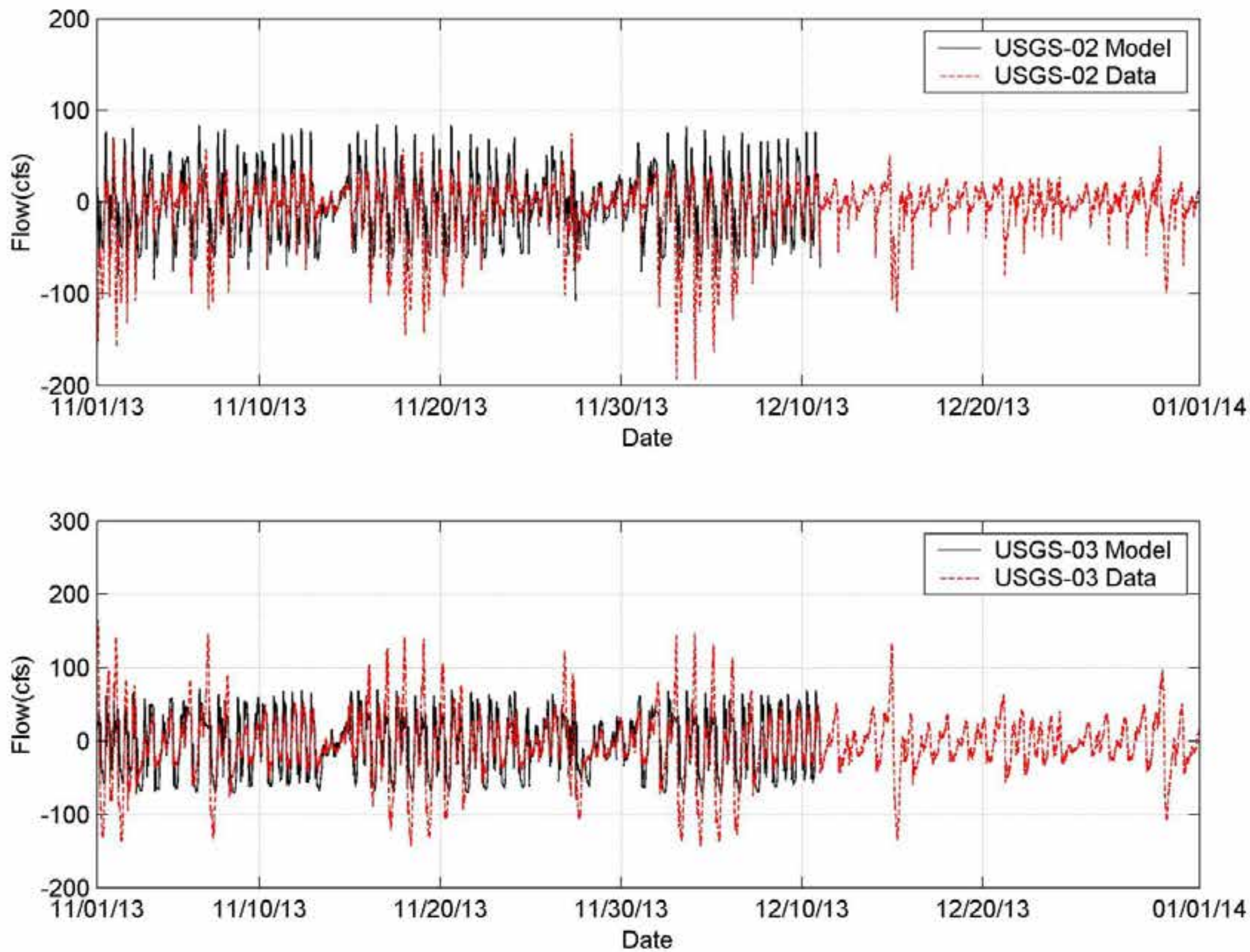


Figure 4-41. Simulated vs Measured Flow at USGS-02 and USGS-03 (11/01/13 – 01/01/14)

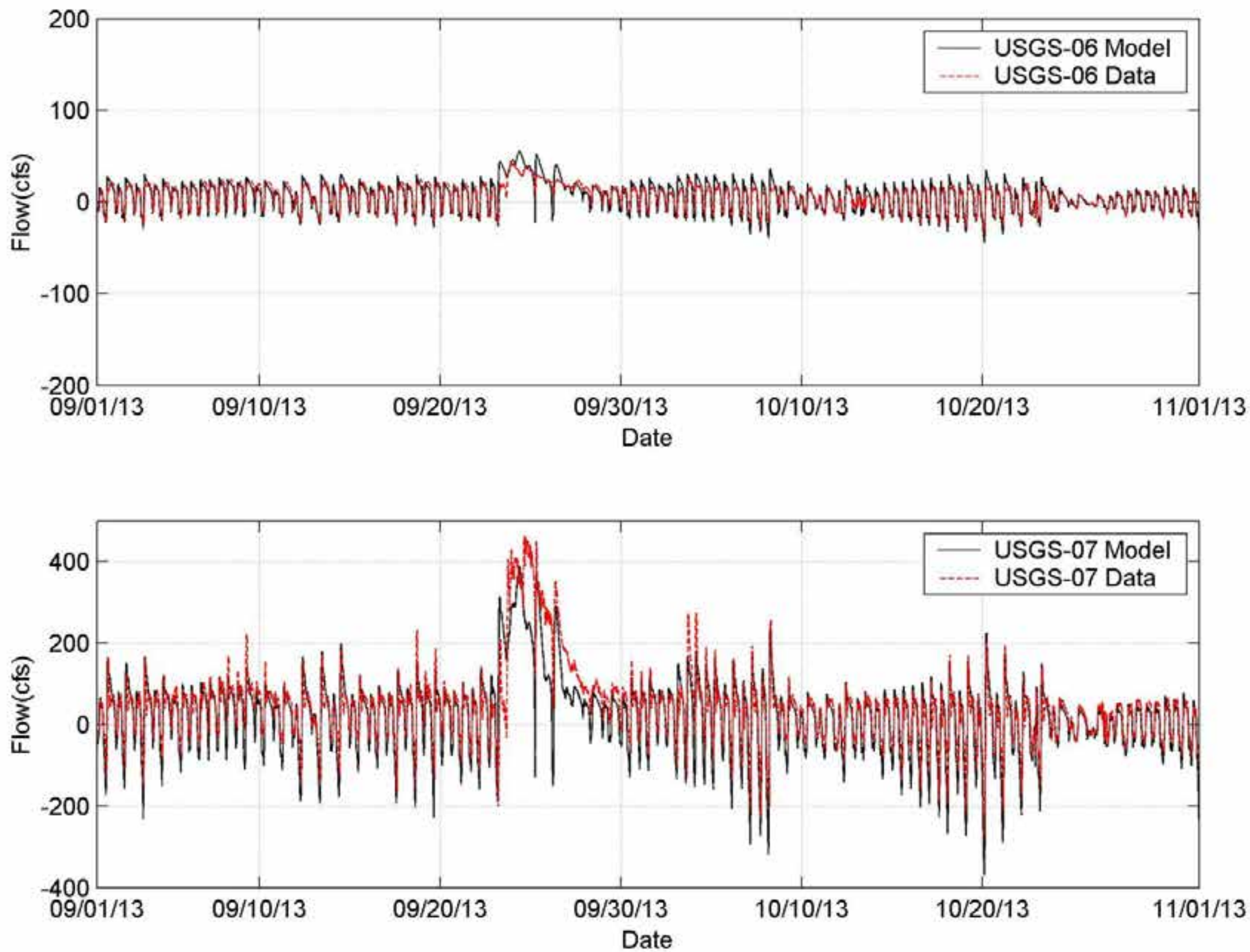


Figure 4-42. Simulated vs Measured Flow at USGS-06 and USGS-07 (09/01/13 – 11/01/13)

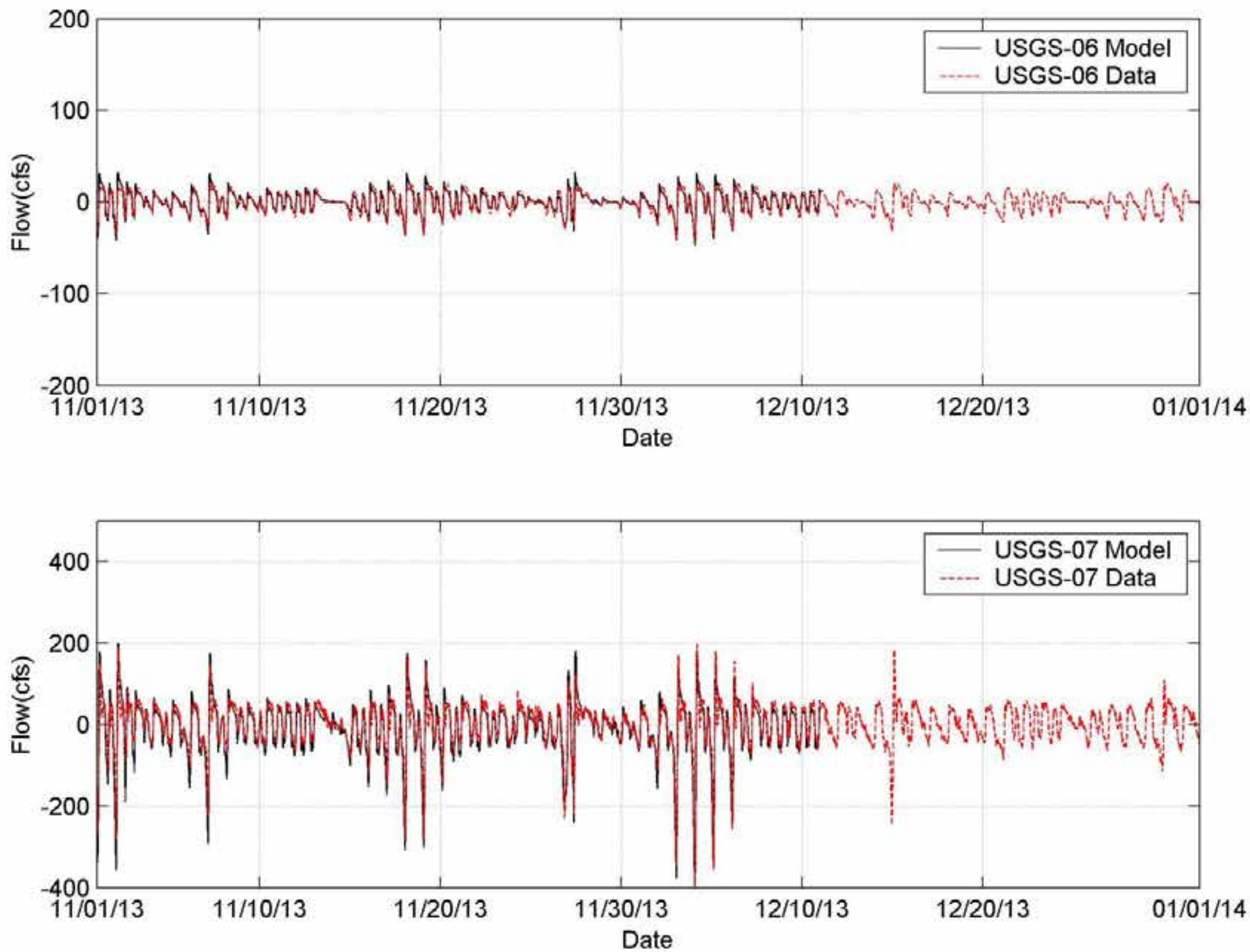


Figure 4-43. Simulated vs Measured Flow at USGS-06 and USGS-07 (11/01/13 – 01/01/14)

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

4.5 SIMULATED VERSUS MEASURED SALINITY

Figures 4-44 through 4-48 present comparisons of the simulated salinity at stations along the NSC for the full period of the model simulations (following spin-up). Based on discrepancies seen between the discrete and continuous salinity data, the model results are compared against the more reliable discrete measurements.

The period of the model simulations reflects a dry period, with low flows at the beginning, followed by a wet period, which begins around May of 2013 and extends through October 2013. The highest flow periods occur from late June through October.

Examination of the figures shows that at the beginning of the simulation, following spin up, the model somewhat over predicts the salinity levels along the spreader canal for the more southern stations. Where the results show relatively stable salinity levels in the NSC through the drier period, the model shows a net increase, which is reflective of the conditions seen in the salinity forcing shown in Figure 3-4. The model shows a response to the relatively small freshwater inflows that come into the system starting around May 1 and then shows the full response as the larger flows begin to come in around June.

The system shows the nearly complete transformation of the NSC to a freshwater condition starting in mid-June and running through mid-October. Following the cessation of flows over the weir structures around mid-October, the system shows steady salinity increases, which the model does a reasonable job of simulating, although at the lower end of the NSC, the salinities appear to recover more quickly than the data show.

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.

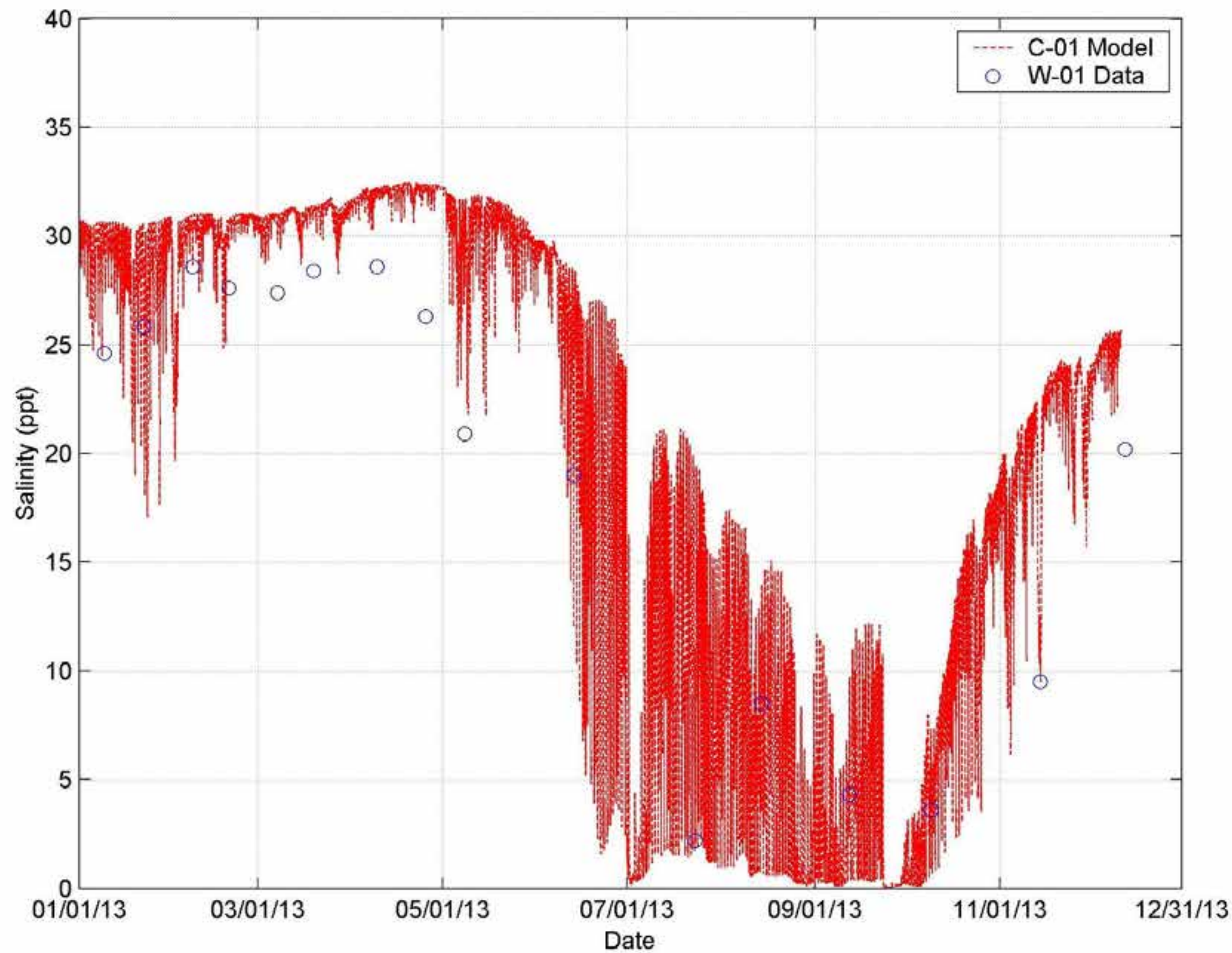


Figure 4-44. Simulated vs Measured Salinity at W-01 (01/01/13 – 12/31/13)

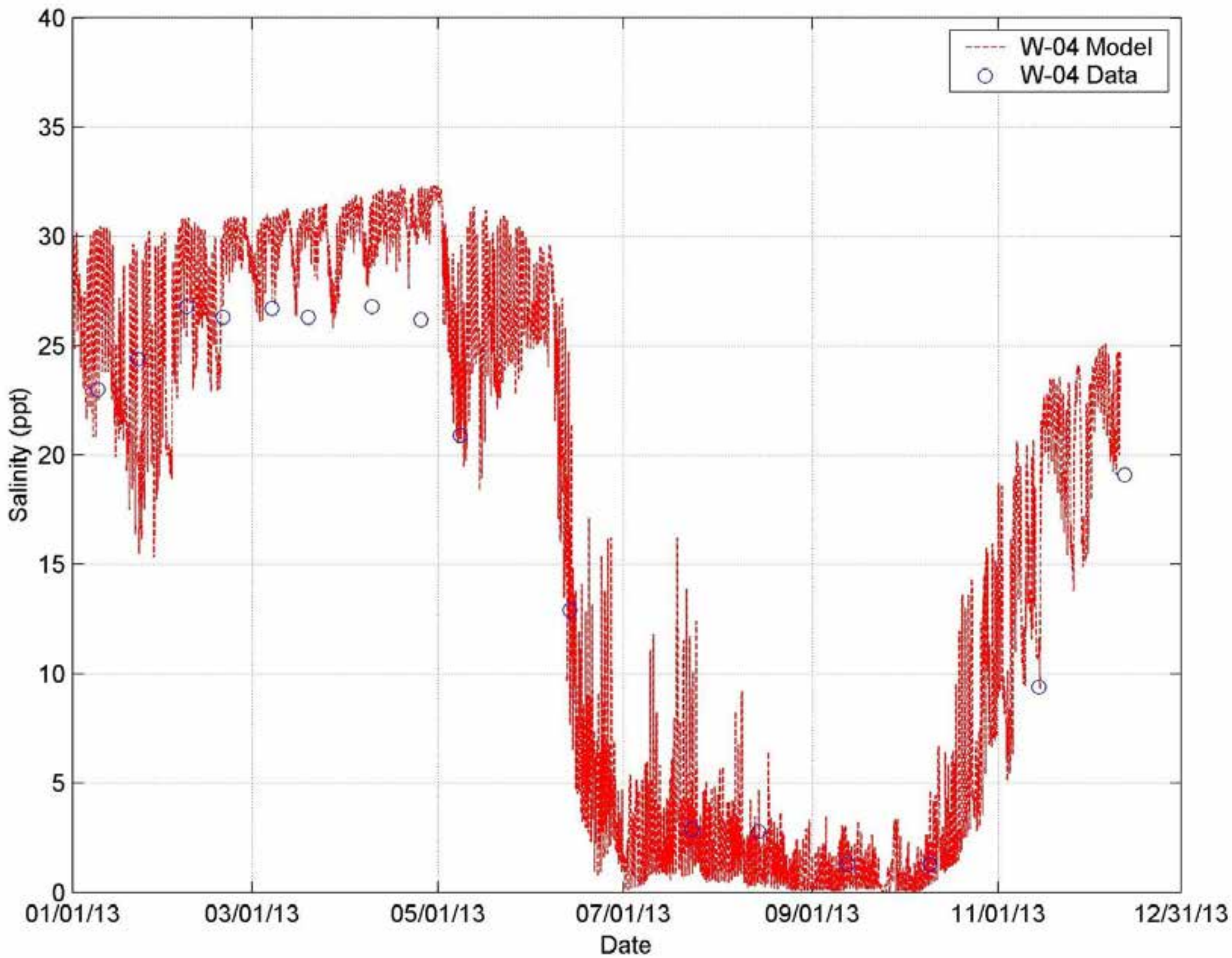


Figure 4-45. Simulated vs Measured Salinity at W-04 (01/01/13 – 12/31/13)

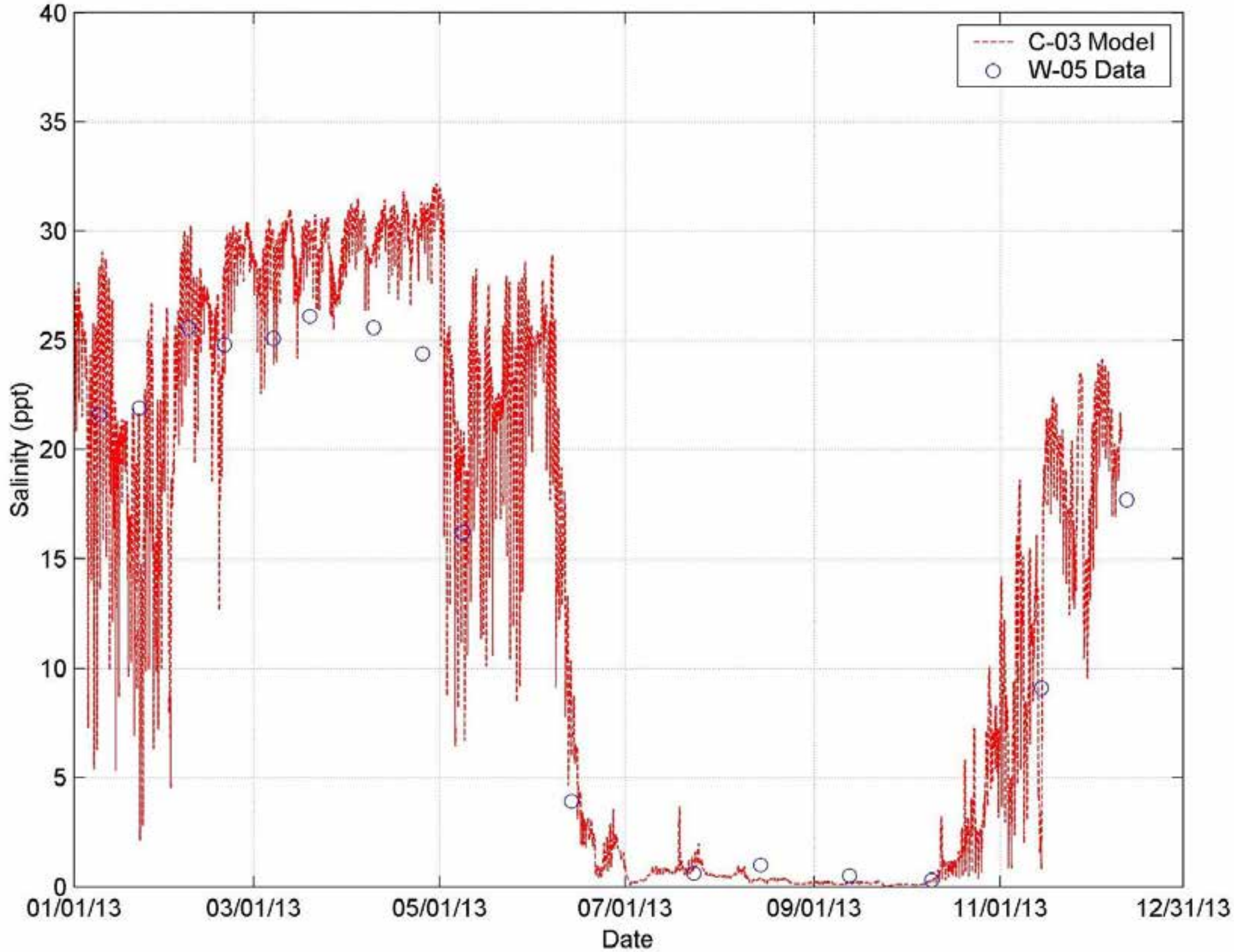


Figure 4-46. Simulated vs Measured Salinity at W-05 (01/01/13 – 12/31/13)

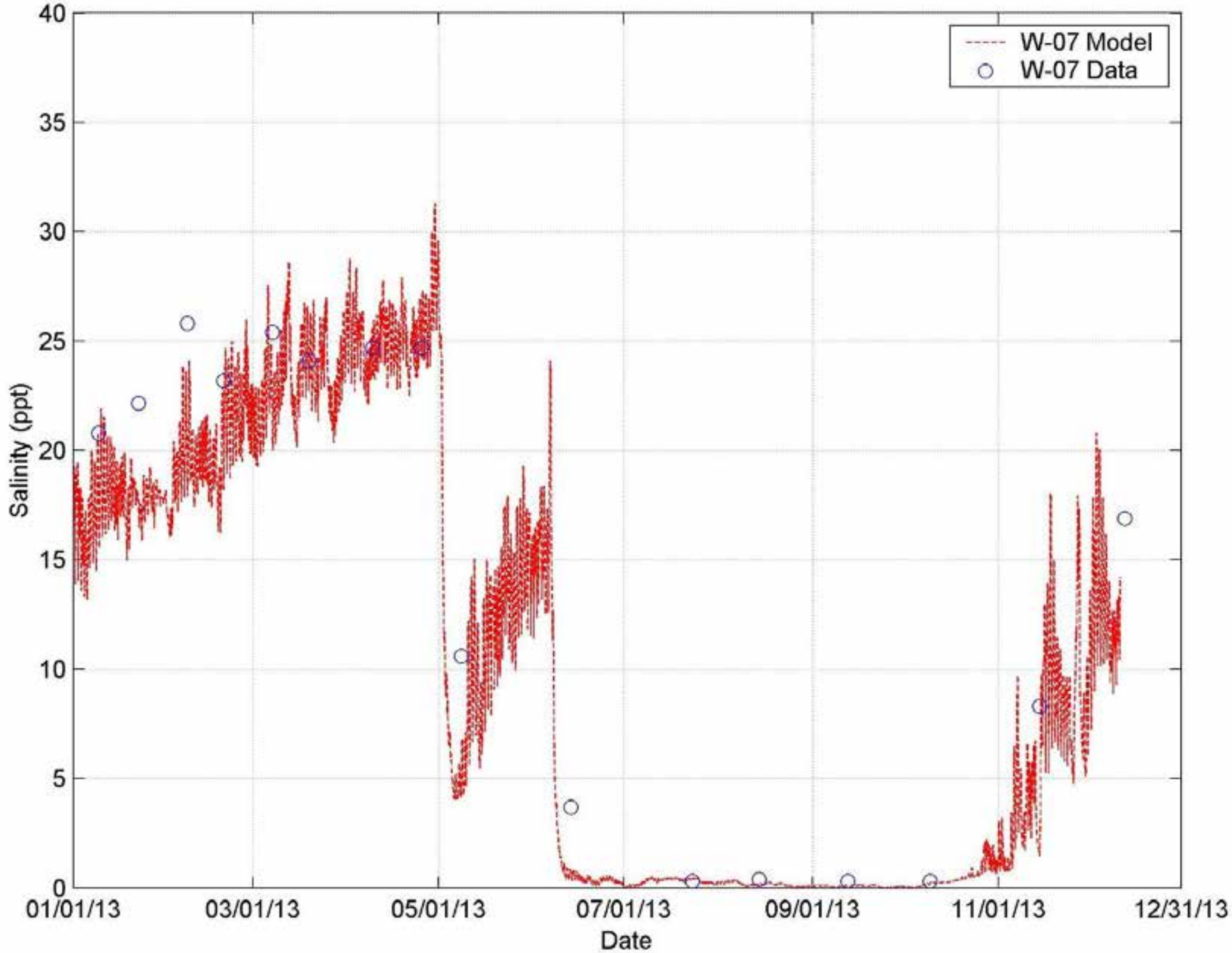


Figure 4-47. Simulated vs Measured Salinity at W-07 (01/01/13 – 12/31/13)

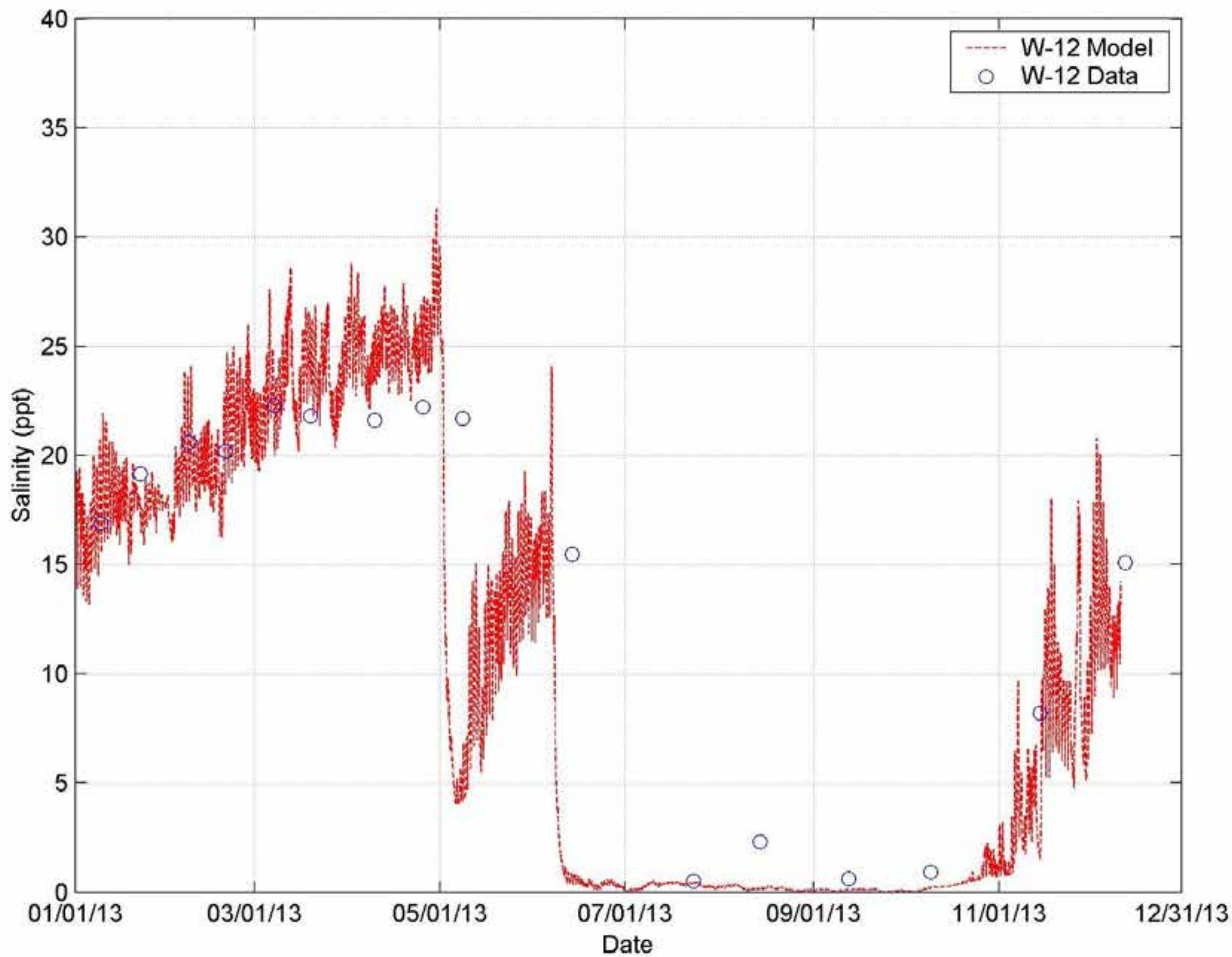


Figure 4-48. Simulated vs Measured Salinity at W-12 (01/01/13 – 12/31/13)

5.0 SUMMARY AND CONCLUSIONS

This report provided a summary of the development and calibration of the hydrodynamic model. This included the following:

- Development of the model grid and bathymetry
- Development of the model input conditions
- Model calibration approach
- Graphical and statistical comparison of the simulations versus data

The model extents included Matlacha Pass from its connection to Charlotte Harbor at the north end of Pine Island, down to near McCardle Island, the NSC and the interior canals up to the weir structures on Burnt Store Road, the KD, and the area west of the KD to Matlacha Pass.

The EFDC model was used to simulate the hydrodynamics, including the water levels, currents, flows, and salinity. The model simulations extended from October 1, 2012, through December 2013, with a 3-month spin-up period from October 1 through the end of December 2012.

The model had two open boundary conditions, one at the northern end of Matlacha Pass and one at the southern end of the grid in Matlacha Pass near McCardle Island. The water level boundary conditions were developed from measured water levels at stations in Matlacha Pass with the phase lag between the northern and southern boundaries based on measured phase lags moving through the pass. The salinity boundary conditions were derived from discrete measurements at locations near the boundaries.

Graphical and statistical comparisons of the simulated versus measured water levels were presented at 20 locations through the system. This included data within Matlacha Pass, the KD and the interior canals. The results showed very good agreement both graphically and statistically to the measured data.

Graphical and statistical comparisons of the simulated versus measured flows through the primary breaches and through the southern entrance were presented at the USGS monitoring stations. The results showed good agreement between the measured and simulated flow magnitudes, phasing and characteristics at the stations within the southern entrance and Ceitus Creek (USGS-00 and USGS-01). The same was seen for the flows within the monitored connections between the NSC and KD4 (USGS-06 and USGS-07). The model was able to simulate the general characteristics and phasing of the flows through the two primary breaches at USGS-02 and USGS-03, but at times the model was unable to capture the magnitudes of the flows, especially during periods of high water levels.

Graphical comparisons of the monthly discrete salinity collected at the water quality stations along the NSC showed that the model generally captured the timing and magnitude of the responses to the freshwater inflow on salinity within the NSC.

In Phase II of this project, the results presented herein, along with the findings from the Hydrodynamic Data Characterization Report and results from the other reports, will be utilized to assess the impacts of potential management actions. The goal will be to assess the potential for improving the overall ecologic conditions within the NSC, KD and the waters of Matlacha Pass.

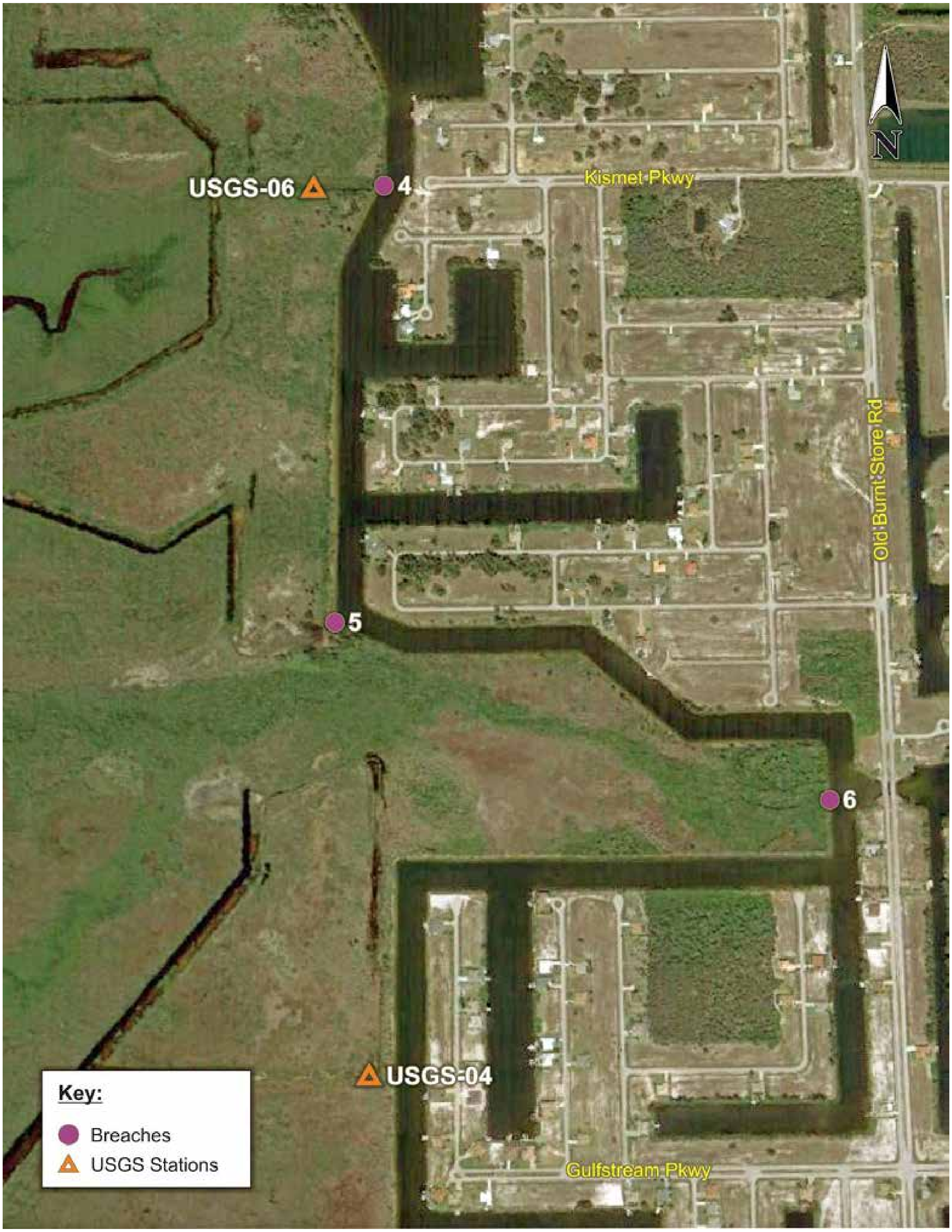
6.0 REFERENCES

Havens & Emerson, Inc. 1993. Spreader Waterway Breach Area Improvements Design Report. Cape Coral, FL

Appendix A

Aerial Photos of Breaches and USGS Monitoring Site Locations


N
Jacaranda Pkwy
1
USGS-07
1A
2
3
Key:
Breaches
USGS Stations



Kismet Pkwy
Old Burnt Store Rd
Gulfstream Pkwy
USGS-06
4
5
6
USGS-04
N
Key:
Breaches
USGS Stations


N
USGS-04
7
7B
Gulfstream Pkwy
7A
Old Burnt Store Rd
Yucatan Pkwy
8
USGS-03
Tropicana Pkwy W
Key:
Breaches
USGS Stations

Embers Pkwy W
N
8A
9
USGS-02
10
Old Burnt Store Rd
11
Ceitus Pkwy
USGS-01
12
13
USGS-00
Key:
Breaches
USGS Stations

NW CAPE CORAL/LEE COUNTY WATERSHED INITIATIVE
PHASE I
WATER QUALITY DATA CHARACTERIZATION

LEE COUNTY, FLORIDA

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JUNE 2015

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List of Commonly Used Acronyms	
BOD	Biological Oxygen Demand
CHLA	Chlorophyll *a*
COND	Conductivity
DO	Dissolved Oxygen
Kd	Light Attenuation
FCOLI	Fecal Coliform
mg/L	milligrams per liter
1/m	Per Meter
MPN	Most Probable Number
NH3	Nitrogen, ammonia
NO2	Nitrogen, nitrite
NO3	Nitrogen, nitrate
NTU	Nephelometric Turbidity Units
PO4	Orthophosphate
POR	Period of Record
ppt	Parts per thousand
PSU	Practical Salinity Units
SEAS	Shellfish Environmental Assessment Section
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TOC	Total Organic Carbon
TP	Total Phosphorus
TPO4	Total Orthophosphate
TSS	Total Suspended Solids
TURB	Turbidity
μg/L	Micrograms per liter

1.0 INTRODUCTION AND PROJECT BACKGROUND

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 four 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

This report provides detailed quantification of the existing water quality conditions within the NSC, waters upstream of the weir structures along Burnt Store Road, and the adjacent waters of Matlacha Pass using available data. Additionally, calculations of loads over the weir structures along Burnt Store road are provided for nutrients and suspended solids based on available flow and concentration data.

1.3 REPORT OUTLINE

Following this introduction, the report is broken down into three sections. Section 2 provides the water quality data characterization. Section 3 presents the calculated loads over the weir structures. Section 4 summarizes the work performed.

2.0 WATER QUALITY DATA CHARACTERIZATION

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, from which it bases shellfish closure guidance for the area. Most recently, Lee County conducted a synoptic sampling effort within the NSC in an effort to understand better the water quality dynamics within the canal. Together these programs represent a fairly comprehensive effort to collect information 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. These efforts acknowledge the effects of physical modifications that have occurred both within the watershed and in the receiving waterbody.

This technical report describes existing water quality conditions using available empirical data collected within the basin and investigates the utility of these data to establish management level indicators of water quality, including the relationship between potential watershed stressors related to nutrient pollution and water quality responses in the receiving waterbody. This report characterizes the data by the collecting agency and sampling program as separate sections of the report. For each section, there are detailed descriptions of the sampling locations, tables defining the period of record for each parameter of interest, and the sampling frequency. The parameters of interest include salinity, dissolved oxygen (DO) , total nitrogen (TN) , total phosphorus (TP) , chlorophyll *a* (Chl *a*) concentrations as an indicator of phytoplankton biomass; turbidity and total suspended solids (TSS) as indicators of water clarity; and fecal coliform concentrations as outlined in the scope of work for this project. The report sections are organized with a subsection for each of these parameters. Detailed descriptions of the data are provided within each subsection, including box plots describing the distribution of values within and across stations within each agency and time series plots describing the temporal signal for each station and parameter. Statistical tests of significance of the temporal trends and

Spearman's rank correlations describing the covariance among stations for each parameter of interest are presented. This report describes existing water quality conditions and provides the context and necessary information for a subsequent task deliverable for this project that will compare present determinations of key water quality indicators indicative of stressor-response relationships between water quality in the basin and its receiving waters within and outside the basin.

The following sections presents a data characterization for each of the agencies collecting water quality information in the NSC and adjacent waters. Station locations by agency are displayed in Figure 2-1.

2.1 CAPE CORAL FIXED STATIONS IN THE NSC

The City of Cape Coral maintains fixed water quality sampling locations throughout its jurisdiction, including several stations in the NSC. The location of the fixed-station water quality sites in the NSC and the adjacent waters are provided in Figure 2-2. Stations 105, 110, 129, and 130 are located in Gator Slough. Station 160 is located just above the weir in Horseshoe Canal, and Station 190 is located just above the weir in Hermosa Canal. Stations 120, 130, 150, and 271 are located below the weirs in the tidal portion of the NSC network.

Stations 110, 120,130,160, and 190 have been sampled routinely since 1991 (Table 2-1). Stations 105, 129 and 271 were added in 2008, with a continuous record through 2013. Station 150 has a broken period of record, with many of the laboratory data records ending in 1993 but physical water chemistry parameters (e.g., salinity, DO) continuing through 2013.

Table 2-1. Cape Coral Station Period of Record

Station	Period of Record
105	2008-2013
110	1991-2013
120	1991-2013
129	2008-2013
130	1991-2013
150	1991-2013
160	1991-2013
190	1991-2013
271	2008-2013

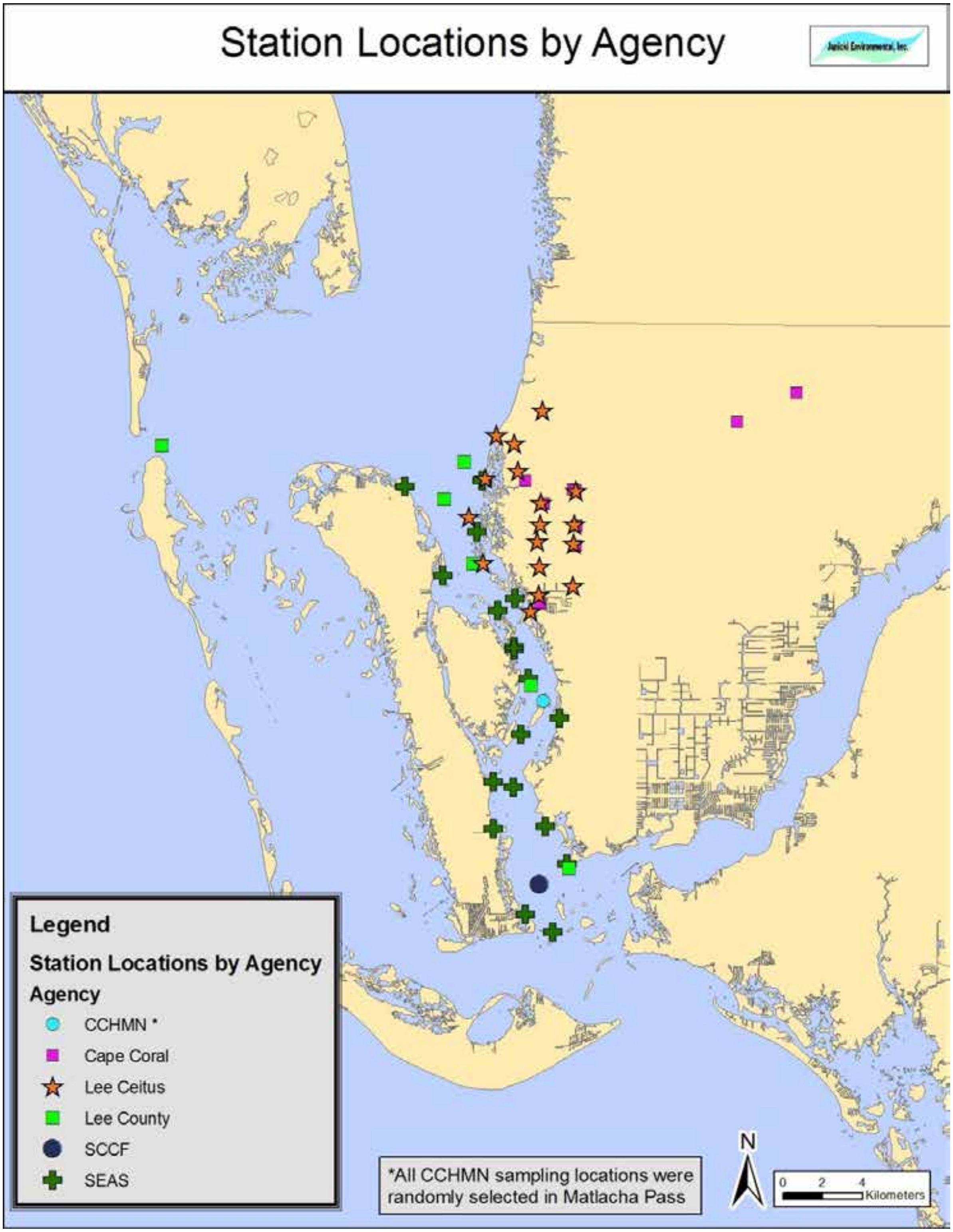


Figure 2-1. Stations Locations by Agency

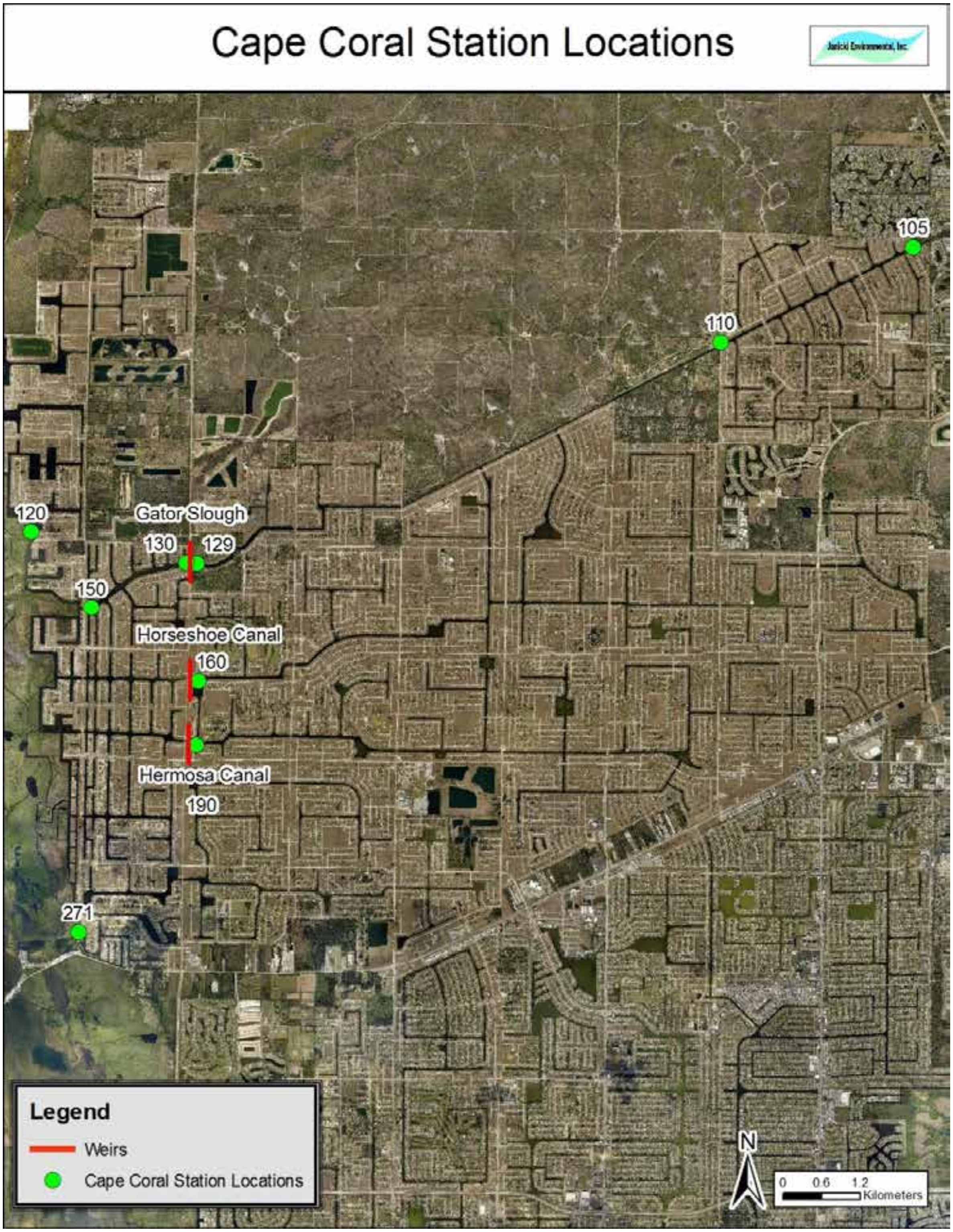


Figure 2-2. Cape Coral Sampling Locations in the NSC

Table 2-2 provides a list of the periods of record for each parameter measured at each station. True zero values existed in the dataset for some older data. These zero values were converted to the method detection limit (MDL) after conversation with the data manager at the City of Cape Coral. However, this procedure may affect the results presented for the Kendall tau trend test and the Spearman rank correlations presented in the following subsections. The following subsections characterize the data collected by Cape Coral at these stations for the principal constituents of interest.

2.1.1 SALINITY

Salinity has been sampled consistently on a monthly basis since 1992 at Stations 110, 120, 130, 150, 160, and 190, and since 2008 at Stations 105, 129, 271 (Table 2-3). The numbers in Table 2-3 represent the sampling frequency at the surface level. Generally, samples are taken at near surface, mid water column and near bottom depths for salinity. Comparisons of salinity concentrations among sample levels suggest little variation as a function of depth for most parameters sampled. Surface values are used for this data characterization.

The long-term average salinity concentrations are presented in Figure 2-3. For Cape Coral, the period of record is truncated to 2008-2013 since all stations were collecting salinity data over this time period. Stations 129 and 160 had the lowest average concentrations, while Station 271 had the highest average concentration.

Between-station variability in surface salinity is quite evident among stations, not only based on the averages, but also in the distribution of values as portrayed in the box and whisker plots (Figure 2-4). These plots represent the entire period of record for each station and are trimmed such that extremely high values are not displayed in the plots. Stations 120,130,150, and 271 are influenced by tidal exchange, while Stations 105,110, 129 (in Gator Slough) and 160 (Horseshoe Canal) and 190 (Hermosa Canal) are located above the salinity barriers in the NSC. While the period of record varies among stations, it is clear that the stations closer to Matlacha Pass (e.g., 271, 120) are more tidally influenced and experience salinity fluctuations, while those stations above the weirs show little to no salinity levels concentration.

Table 2-2. Cape Coral Constituents Sampled and Period of Record

	Station								
Parameter	105	110	120	129	130	150	160	190	271
Chlorophyll *a* (CHLA_ugl)	2008-2013	1995-2013	1995, 2008-2013	2008-2013	1995-2013	1995-1996	1995-2013	1995-2013	2008-2013
Dissolved Oxygen (DO_mgl)	2008-2013	1991-2013	1991-2013	2008-2013	1991-2013	1991-2013	1991-2013	1991-2013	2008-2013
Fecal Coliform (FECCOLI_num/100ml)	2008-2013	1991-2013	1991-1993, 1995, 2008-2013	2008-2013	1991-2013	1991-1993, 1995	1991-2013	1991-2013	2008-2013
Salinity (SAL_ppt)	2008-2013	1991-2013	1991-2013	2008-2013	1991-2013	1991-2013	1991-2013	1991-2013	2008-2013
Secchi Disk Depth (SECCHI_m)	2008-2013	1991-2013	1991-2013	2008-2013	1991-2013	1991-2013	1991-2013	1991-2013	2008-2013
Total Nitrogen (TN_mgl)	2008-2013	1991-2013	1991-1993, 2008-2013	2008-2013	1991-2013	1991-1993	1991-2013	1991-2013	2008-2013
Total Phosphorus (TP_mgl)	2008-2013	1991-2013	1991-1993, 2008-2013	2008-2013	1991-2013	1991-1993	1991-2013	1991-2013	2008-2013
Total Suspended Solids (TSS_mgl)	2008-2013	1991-2013	1991-1993, 2008-2013	2008-2013	1991-2013	1991-1993	1991-2013	1991-2013	2008-2013
Turbidity (TURB_NTU)	2008-2013	1991-2013	1991-2013	2008-2013	1991-2013	1991-2003, 2012	1991-2013	1991-2013	2008-2013

Table 2-3. Salinity Sampling Frequency by Station for Cape Coral Fixed Stations in the NSC

Year	Station									
	105	110	120	129	130	150	160	190	271	Total
1991	-	4	3	-	4	3	4	3	-	21
1992	-	12	12	-	12	12	12	12	-	72
1993	-	12	11	-	12	11	12	12	-	70
1994	-	10	11	-	12	11	11	11	-	66
1995	-	12	12	-	12	12	12	12	-	72
1996	-	12	11	-	12	12	12	12	-	71
1997	-	11	12	-	12	12	12	12	-	71
1998	-	12	12	-	12	12	12	12	-	72
1999	-	12	12	-	12	12	12	12	-	72
2000	-	10	11	-	11	11	11	11	-	65
2001	-	11	12	-	11	12	12	12	-	70
2002	-	11	12	-	11	12	11	12	-	69
2003	-	13	12	-	11	12	12	12	-	72
2004	-	12	12	-	11	12	12	12	-	71
2005	-	12	12	-	12	12	12	12	-	72
2006	-	12	12	-	12	12	11	12	-	71
2007	-	11	12	-	11	12	12	12	-	70
2008	6	12	12	3	12	12	12	12	3	84
2009	11	11	11	11	10	11	11	11	11	98
2010	12	12	12	12	12	12	12	12	12	108
2011	12	12	12	12	12	12	12	12	12	108
2012	9	9	12	9	12	12	9	9	11	92
2013	12	12	12	12	12	12	12	12	11	107
Total	62	257	262	59	260	263	260	261	60	1744

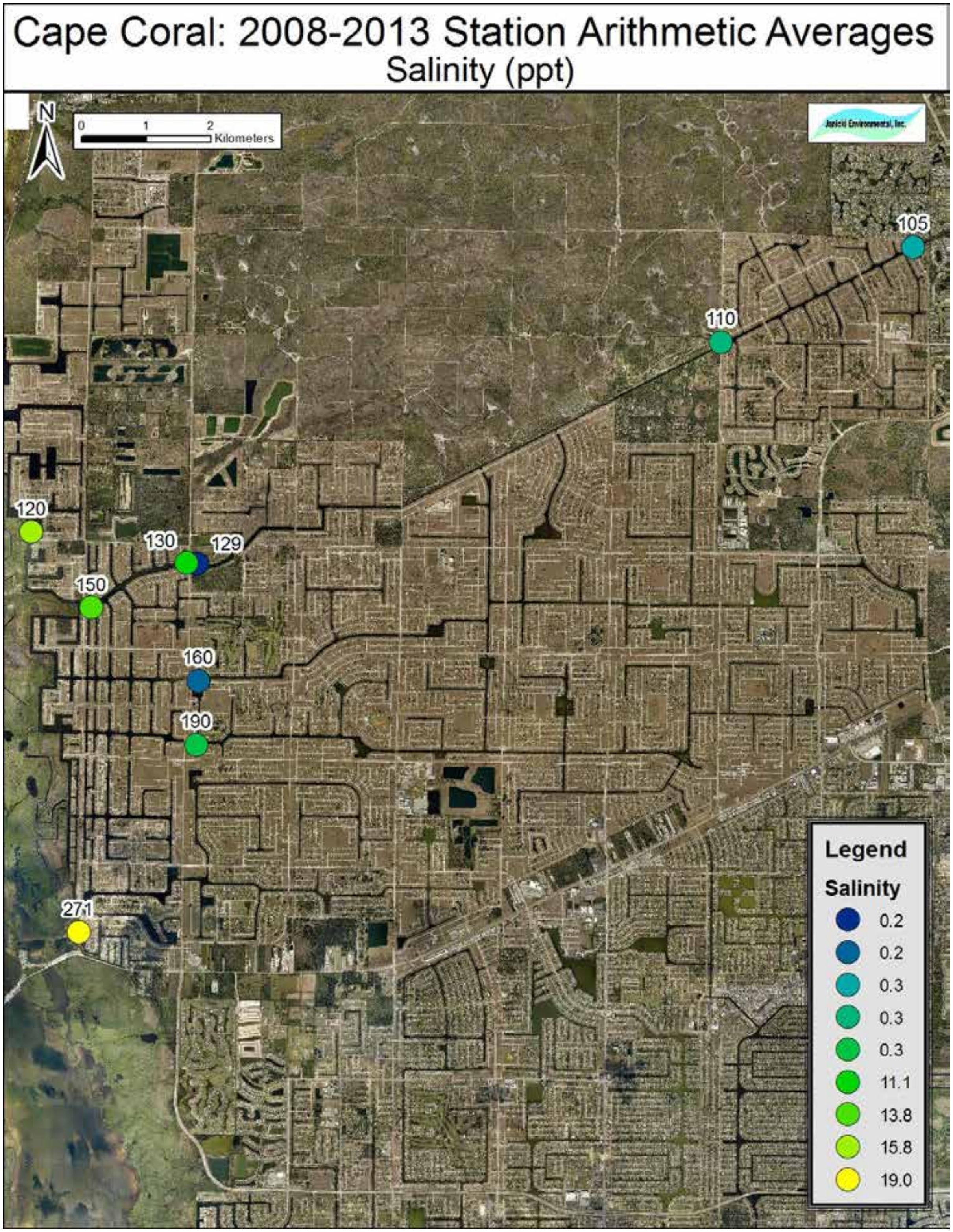
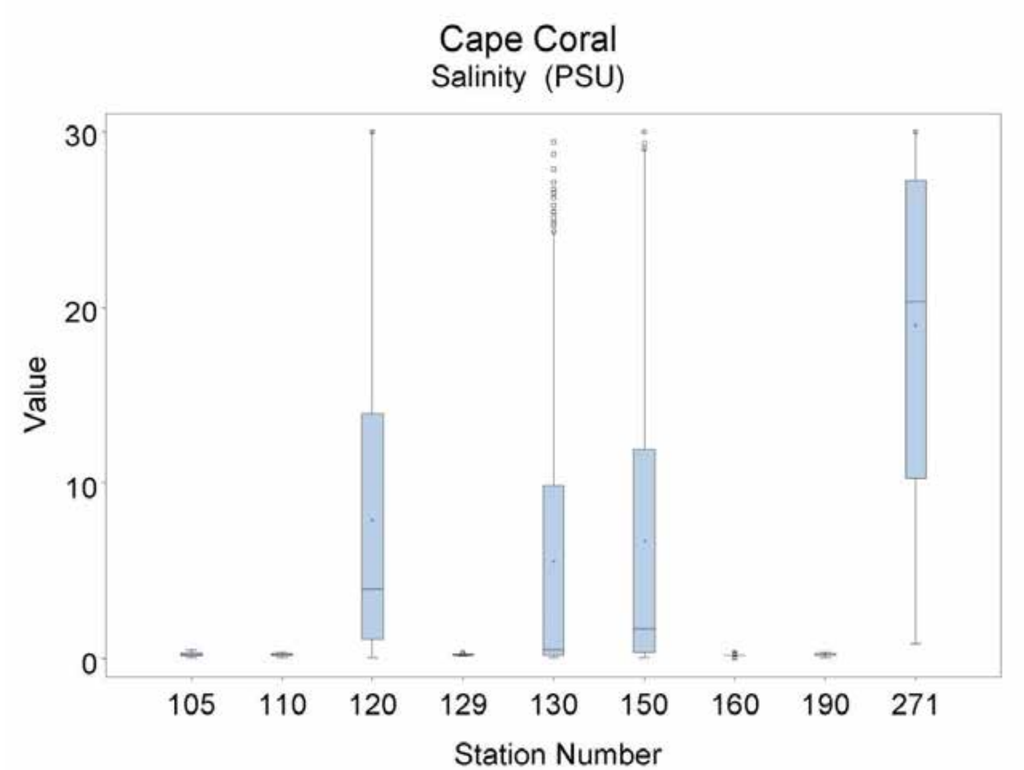


Figure 2-3. Arithmetic Averages of Surface Salinities at Cape Coral Fixed Station Samples Collected between 2008 and 2013



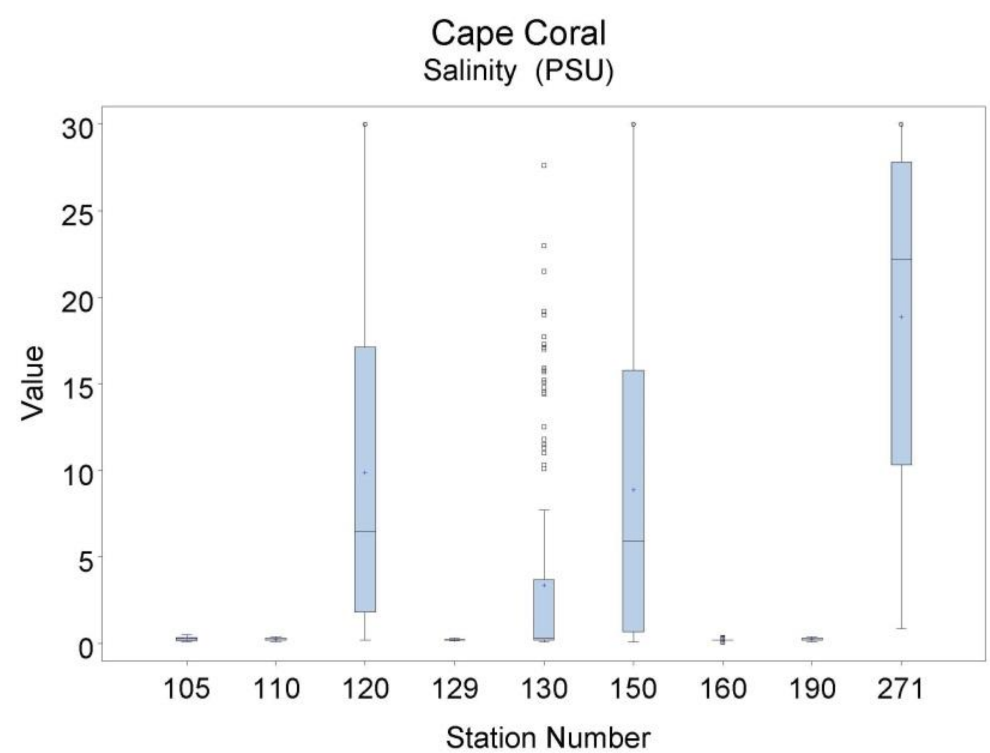


Figure 2-4. Box and Whisker Plots Displaying the Distribution of Surface Salinity (Top) and Bottom Salinity (Bottom) Concentrations among Cape Coral Fixed Water Quality Stations Located within the NSC

Time series plots (Figure 2-5) indicate that there is a high degree of temporal correlation among stations below the salinity barrier and there is a step function increase in salinity at these stations after 2005, presumably associated with the breach of the Ceitus boat lift and the associated breaches along the western berm of the NSC.

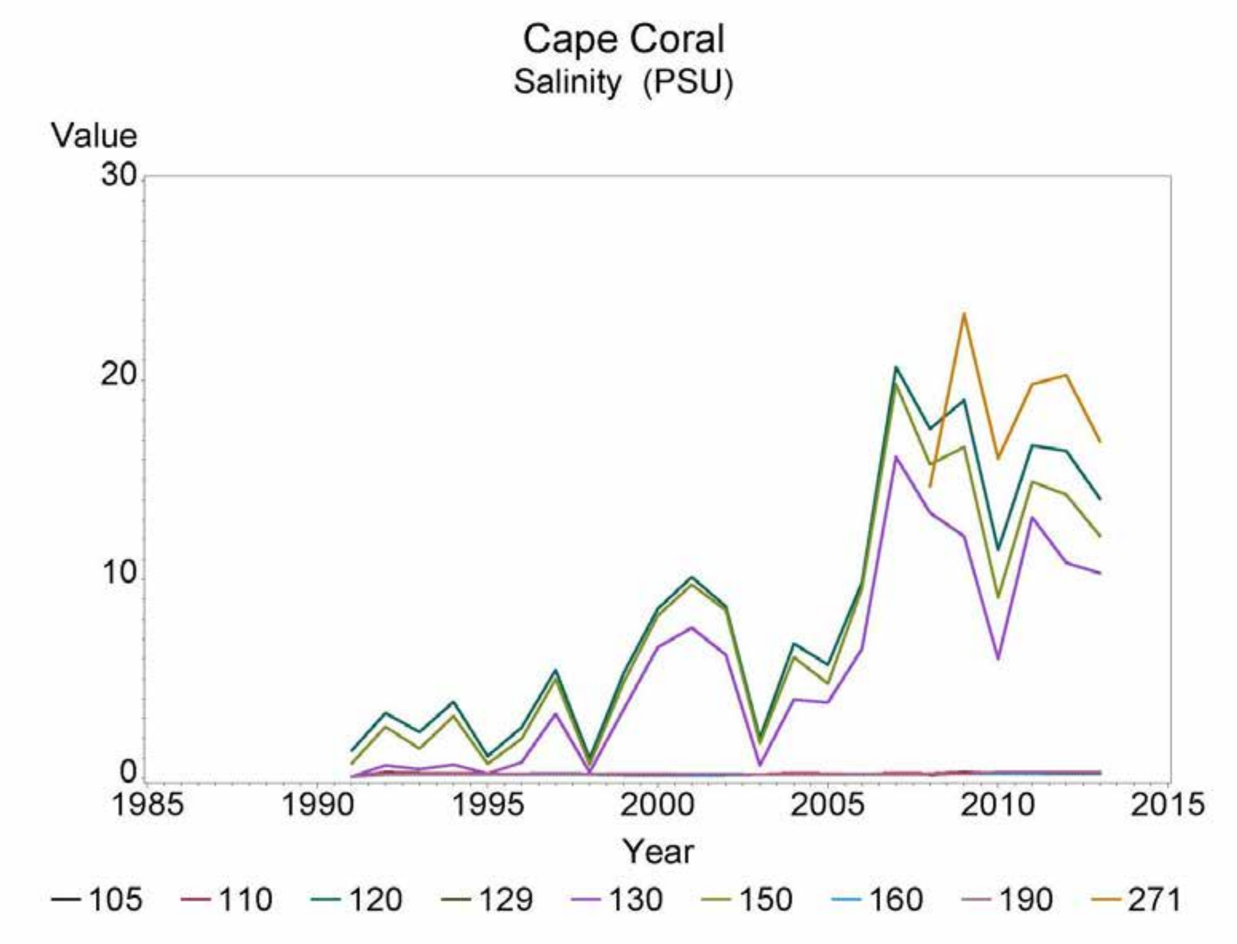


Figure 2-5. Time Series Plot of Surface Salinity for Cape Coral Water Quality Stations in the NSC

Trends for surface salinity measurements for Cape Coral stations are presented in Figure 2-6, and trends for bottom salinity measurements are provided in Figure 2-7. Salinity at Stations 120, 130 and 150 increased in both surface and bottom salinity observations. No surface or bottom trends were examined on Station 129 due to insufficient data (n <60 for surface and bottom salinity observations). No bottom trends were examined on Station 105 due to insufficient data (n <60 for bottom salinity observations).

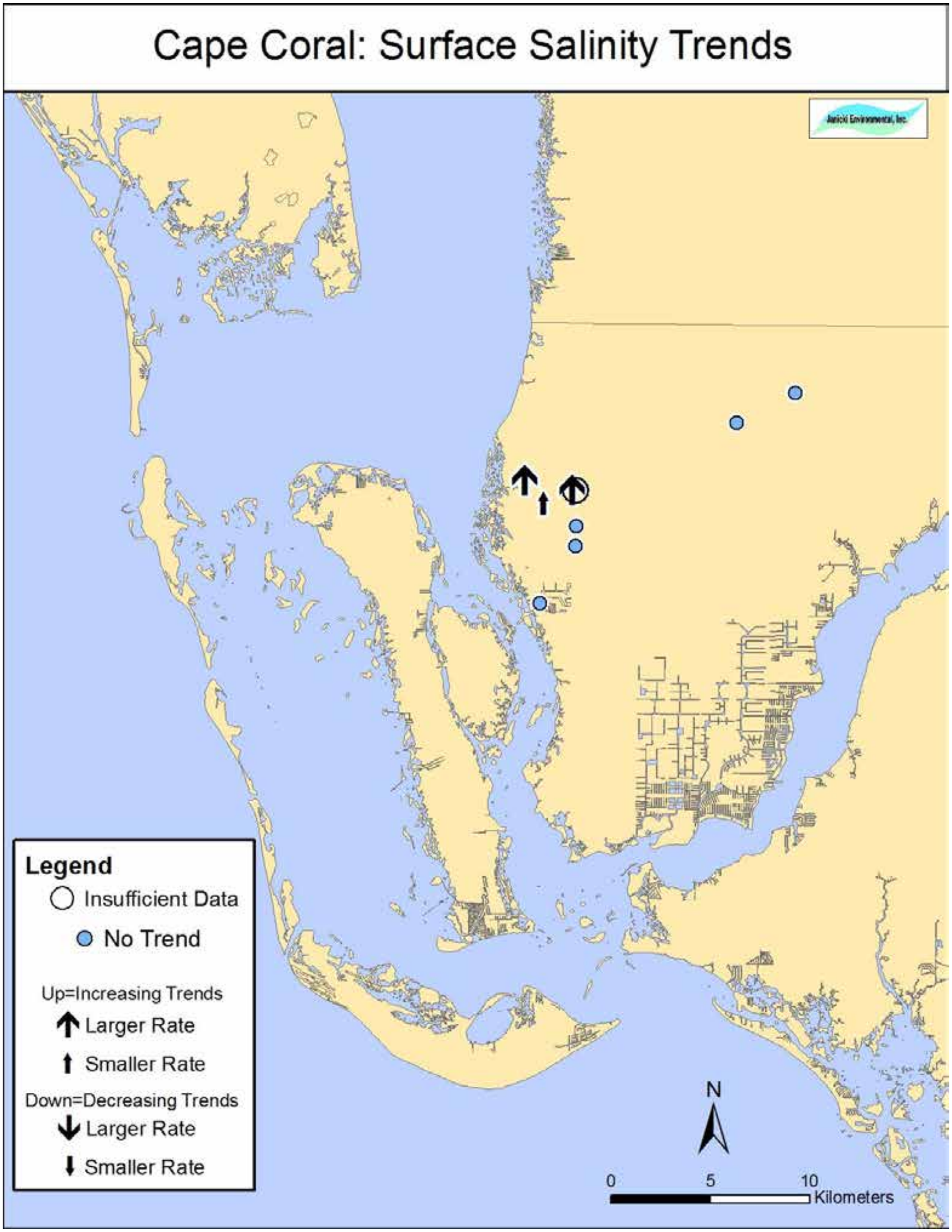


Figure 2-6. Surface Salinity Trends for Cape Coral Fixed Stations in the NSC

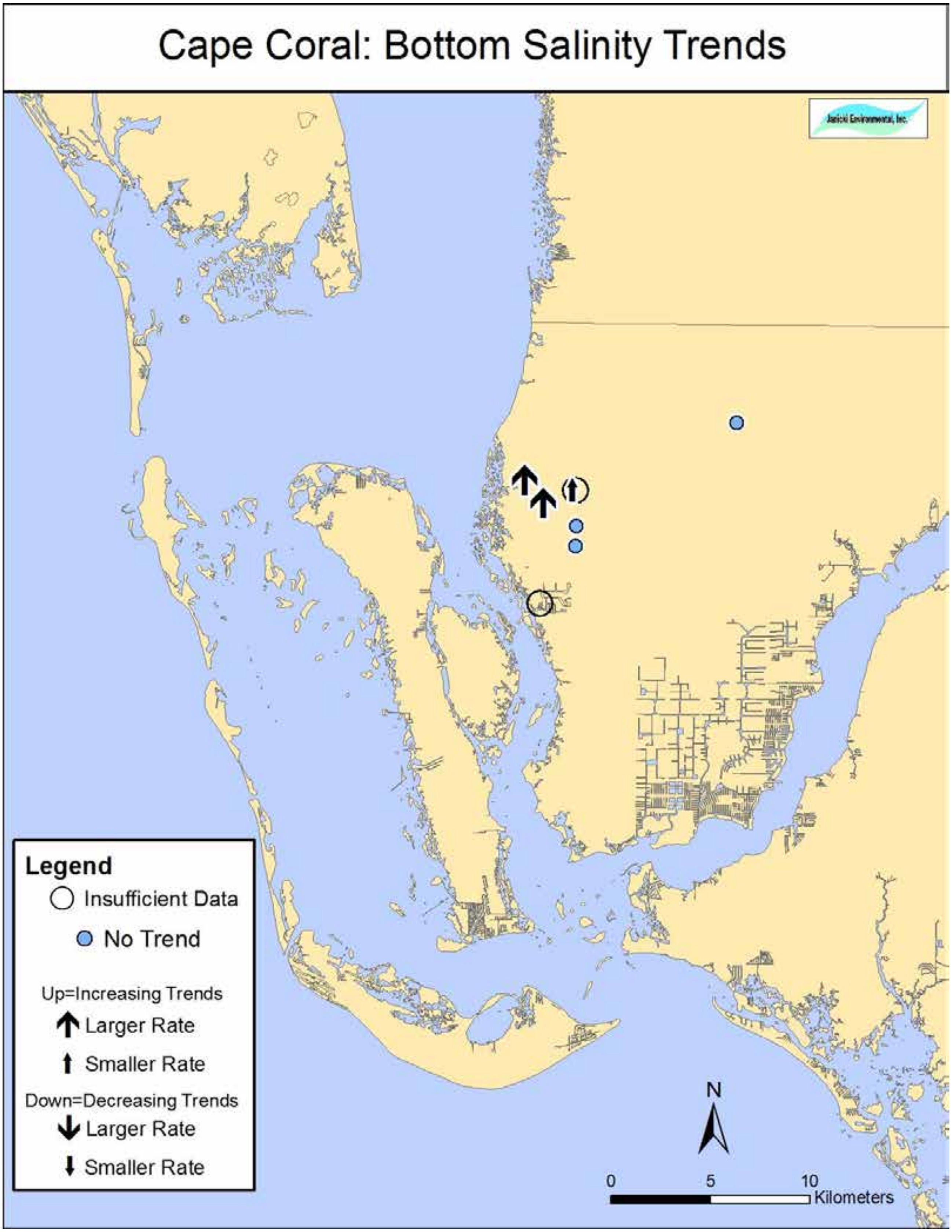


Figure 2-7. Bottom Salinity Trends for Cape Coral Fixed Stations in the NSC

To examine the similarities in surface salinities among stations, Spearman rank correlation analysis was performed to evaluate the covariance between all possible pairs of stations. The results of the correlation analysis are presented in Table 2-4. In this figure, the correlation statistic is presented in the top row, the p value associated with the statistical test of significance is presented in the second row, and the number of observations is presented in the third row. P values less than 0.05 indicate a statistically significant correlation between the two stations, indicating that they co-vary with respect to their salinity measurements over time. This means that as salinity at one station increases, salinity as the co-varying station also tends to increase. For example, salinity at Station 105 (in Gator Slough) was highly correlated with salinity at Station 110 (Table 2-4). Stations below the weirs (i.e., 120, 130, 150, and 271) were also highly correlated with one another. However, a somewhat perplexing finding is that Station 105, the most upstream site in Gator Slough and disassociated from stations below the salinity barriers, was surprisingly well correlated with several stations west of the salinity barriers. Linear regression plots of salinity between Station 105 and 271 confirm a remarkably linear relationship between salinity (and conductivity) at these stations despite the difference in magnitude (Figure 2-8a and b) (note the difference in axis scales between Station 271 and 105). Other observations of interest are that Station 129 in Gator Slough does not appear to be at all correlated with Station 130 (presumably just downstream and on the west side of the Gator Slough weir) and is only moderately correlated with Stations 110 and 105, which are upstream in Gator Slough. Station 129 had the highest correlation with Station 160, east of Horseshoe Canal.

Table 2-4. Spearman Rank Correlation for Surface Salinity for Cape Coral Fixed Stations in the NSC

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	_110	_120	_130	_150	_160	_190	_105	_129	_271
_110	1.00000 254	0.48449 <.0001 249	0.54265 <.0001 246	0.50427 <.0001 250	0.14800 0.0192 250	0.32345 <.0001 252	0.89125 <.0001 61	0.37860 0.0034 58	0.70443 <.0001 56
_120	0.48449 <.0001 249	1.00000 260	0.89289 <.0001 253	0.95819 <.0001 260	0.11569 0.0656 254	0.32540 <.0001 257	0.79124 <.0001 60	0.14274 0.2851 58	0.94814 <.0001 58
_130	0.54265 <.0001 246	0.89289 <.0001 253	1.00000 256	0.92393 <.0001 254	0.13734 0.0293 252	0.35102 <.0001 253	0.73699 <.0001 59	0.19564 0.1447 57	0.93546 <.0001 57
_150	0.50427 <.0001 250	0.95819 <.0001 260	0.92393 <.0001 254	1.00000 261	0.09785 0.1191 255	0.30841 <.0001 258	0.77425 <.0001 60	0.17006 0.2018 58	0.96279 <.0001 58
_160	0.14800 0.0192 250	0.11569 0.0656 254	0.13734 0.0293 252	0.09785 0.1191 255	1.00000 257	0.60826 <.0001 257	0.24639 0.0577 60	0.75795 <.0001 58	-0.02999 0.8263 56
_190	0.32345 <.0001 252	0.32540 <.0001 257	0.35102 <.0001 253	0.30841 <.0001 258	0.60826 <.0001 257	1.00000 260	0.41720 0.0009 60	0.47598 0.0002 58	0.42281 0.0012 56
_105	0.89125 <.0001 61	0.79124 <.0001 60	0.73699 <.0001 59	0.77425 <.0001 60	0.24639 0.0577 60	0.41720 0.0009 60	1.00000 61	0.32935 0.0116 58	0.75061 <.0001 56
_129	0.37860 0.0034 58	0.14274 0.2851 58	0.19564 0.1447 57	0.17006 0.2018 58	0.75795 <.0001 58	0.47598 0.0002 58	0.32935 0.0116 58	1.00000 58	0.15027 0.2690 56
_271	0.70443 <.0001 56	0.94814 <.0001 58	0.93546 <.0001 57	0.96279 <.0001 58	-0.02999 0.8263 56	0.42281 0.0012 56	0.75061 <.0001 56	0.15027 0.2690 56	1.00000 58

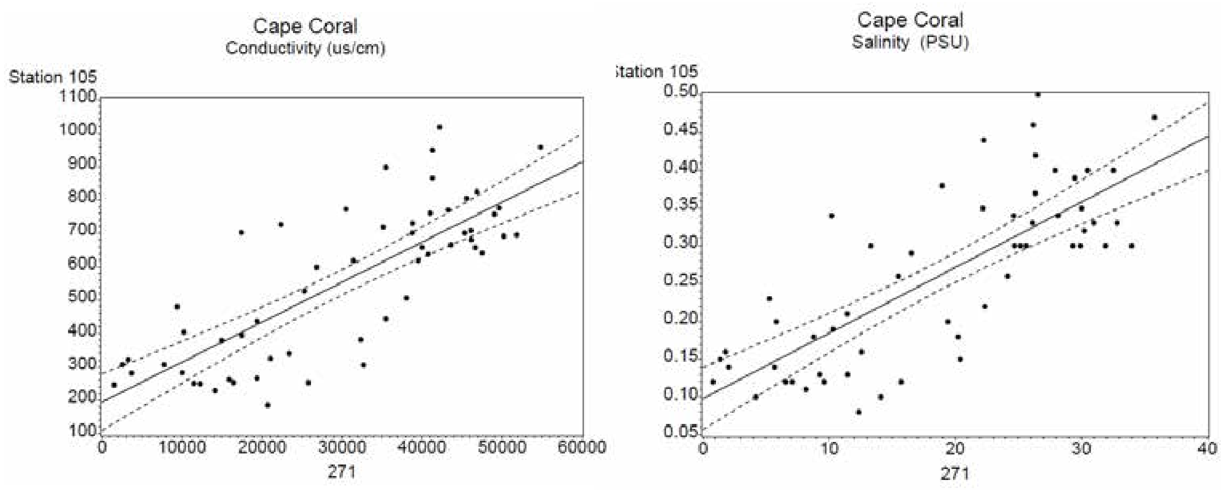


Figure 2-8. Linear Relationship between Stations 271 (X axis) and 105 (Y axis) for Surface Conductivity (left) and Salinity (right)

2.1.2 TOTAL NITROGEN (TN)

TN concentrations are the sum of Kjeldahl nitrogen, nitrate, and nitrite concentrations. These constituents have been routinely sampled since 1991 at Stations 110, 130, 160, and 190 (Table 2-5). In 2008, nitrogen concentration sampling began at Stations 105,120,129, and 271.

Table 2-5. Total Nitrogen Sampling Frequency by Station

	Station									
Year	105	110	120	129	130	150	160	190	271	Total
1991	-	4	3	-	4	3	4	3	-	21
1992	-	12	12	-	12	12	12	12	-	72
1993	-	12	8	-	12	8	12	12	-	64
1994	-	11	-	-	11	-	11	11	-	44
1995	-	12	-	-	12	-	12	12	-	48
1996	-	12	-	-	12	-	12	12	-	48
1997	-	12	-	-	12	-	12	12	-	48
1998	-	12	-	-	9	-	9	9	-	39
1999	-	12	-	-	12	-	12	12	-	48
2000	-	11	-	-	11	-	11	11	-	44
2001	-	12	-	-	11	-	11	11	-	45
2002	-	12	-	-	11	-	11	11	-	45
2003	-	13	-	-	11	-	12	12	-	48
2004	-	12	-	-	12	-	12	12	-	48
2005	-	12	-	-	12	-	12	12	-	48
2006	-	12	-	-	12	-	11	12	-	47
2007	-	12	-	-	12	-	12	12	-	48

Table 2-5. Total Nitrogen Sampling Frequency by Station

Year	Station									
	105	110	120	129	130	150	160	190	271	Total
2008	5	12	3	3	12	-	12	12	3	62
2009	10	10	11	11	11	-	11	11	11	86
2010	12	12	12	12	12	-	12	12	12	96
2011	12	12	12	12	12	-	12	12	12	96
2012	9	9	12	9	12	-	9	9	12	81
2013	12	11	12	12	12	-	12	12	12	95
Total	60	261	85	59	259	23	256	256	62	1321

The long-term average TN concentrations are provided in Figure 2-9. For Cape Coral, the period of record is truncated to 2008-2013, since all stations (except Station 150) were collecting TN data over this time period. Stations 160 and 190 had the lowest average concentrations, while Station 120 had the highest average concentration.

Between-station variability in TN concentrations is portrayed in box and whisker plots (Figure 2-10). These plots represent the entire period of record for each station, which varies among stations. Note that no TN measurements were taken at Station 150 after 1993. While there are differences among stations, more than 75 percent of the values in all stations were below 1.0 milligrams per liter (mg/L), indicating that nitrogen concentrations are not unusually elevated at any location Cape Coral sampled. However, spikes in nitrogen concentrations did occur. These plots are trimmed such that extremely high values are not displayed in the plots.

Time series plots of annual average TN concentrations suggest fairly good agreement among stations with a long-term period of record (i.e., 1991-2013), with Station 130 displaying occasional spikes in annual average concentrations approaching 1.0 mg/L. The additional stations sampled since 2008 result in generally higher TN concentrations during that time period, however, the long-term trend at Stations 160 and 190 remain stable over the long-term period of record (Figure 2-11).

Long-term trends for TN measurements for Cape Coral stations are displayed in Figure 2-12. No trends were examined on Station 129 and 150 due to insufficient data (n <60 for TN observations).

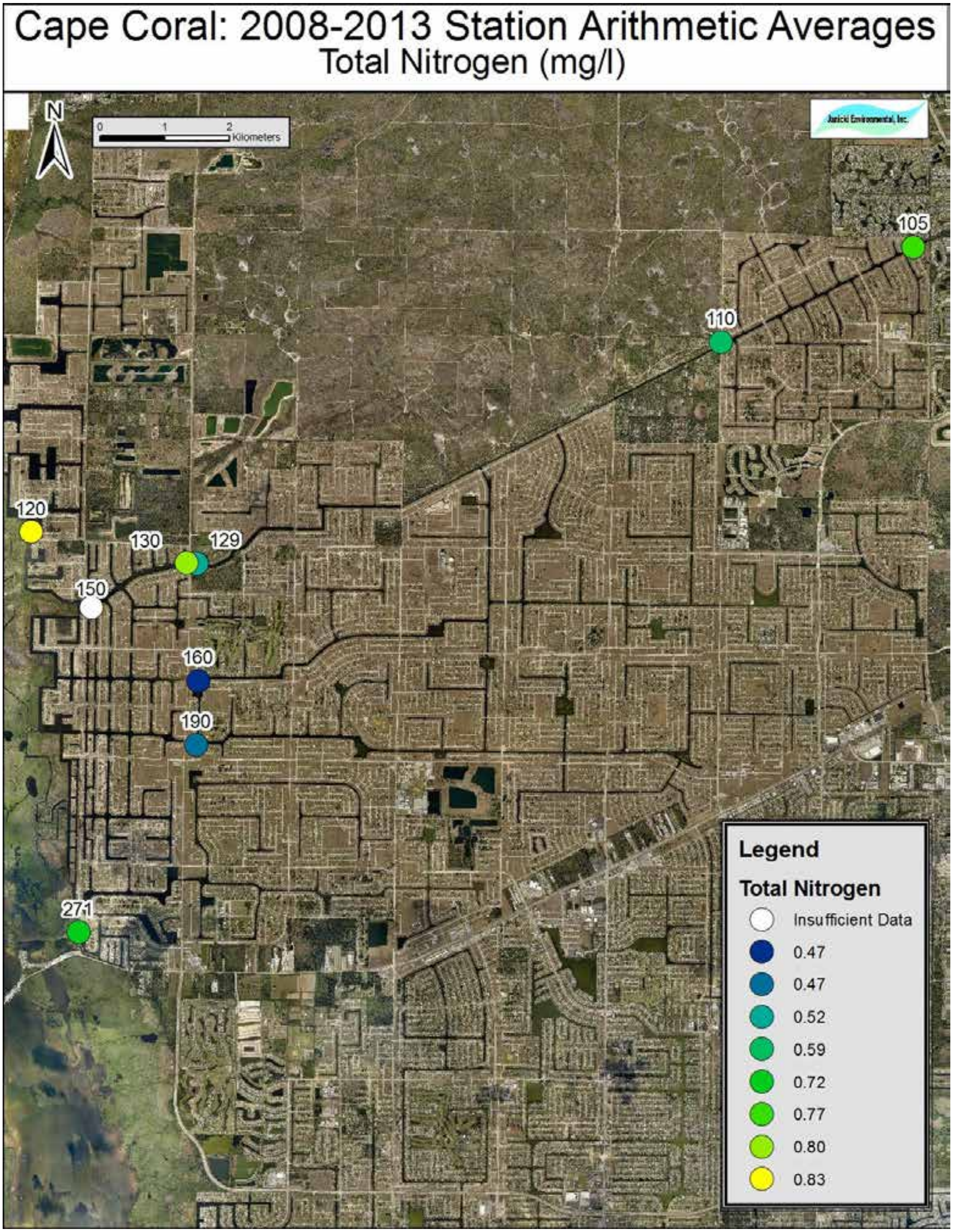


Figure 2-9. Arithmetic Average of Total Nitrogen Concentrations between 2008 and 2013 for Cape Coral Fixed Stations in the NSC

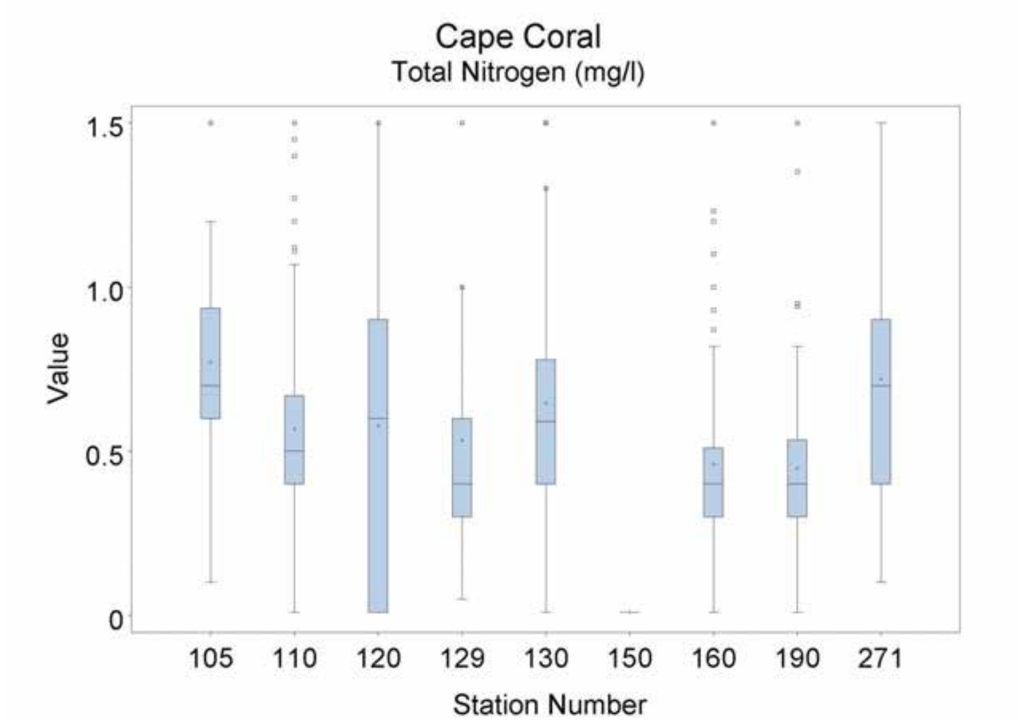


Figure 2-10. Box and Whisker Plots Displaying the Distribution of Total Nitrogen Concentrations among Cape Coral Fixed Water Quality Stations Located within the NSC

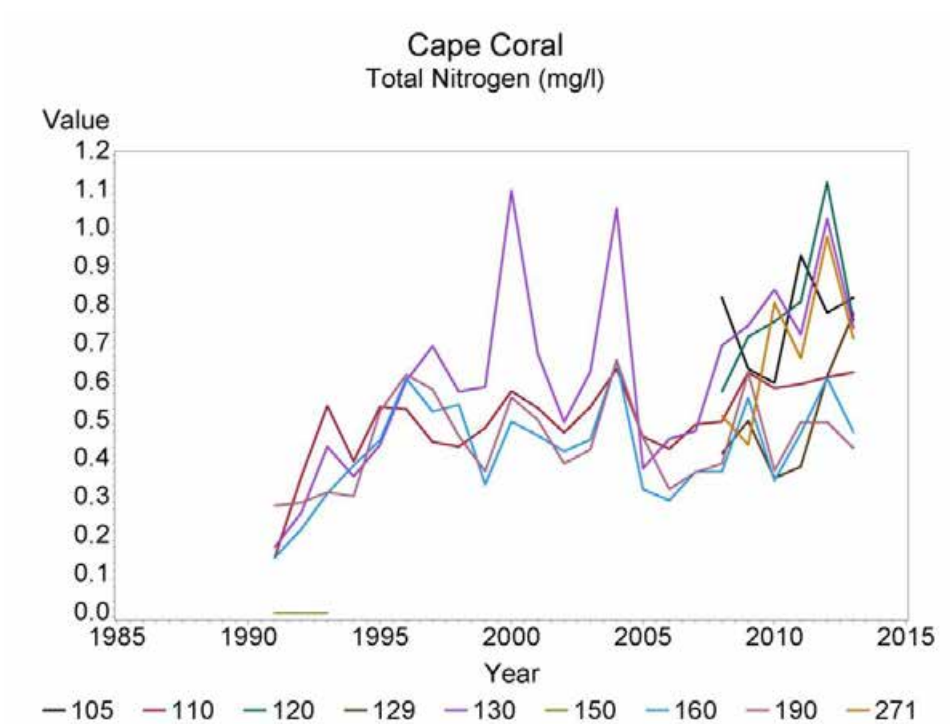


Figure 2-11. Time Series Plots of Total Nitrogen Concentrations for Each Station Sampled by Cape Coral in the NSC

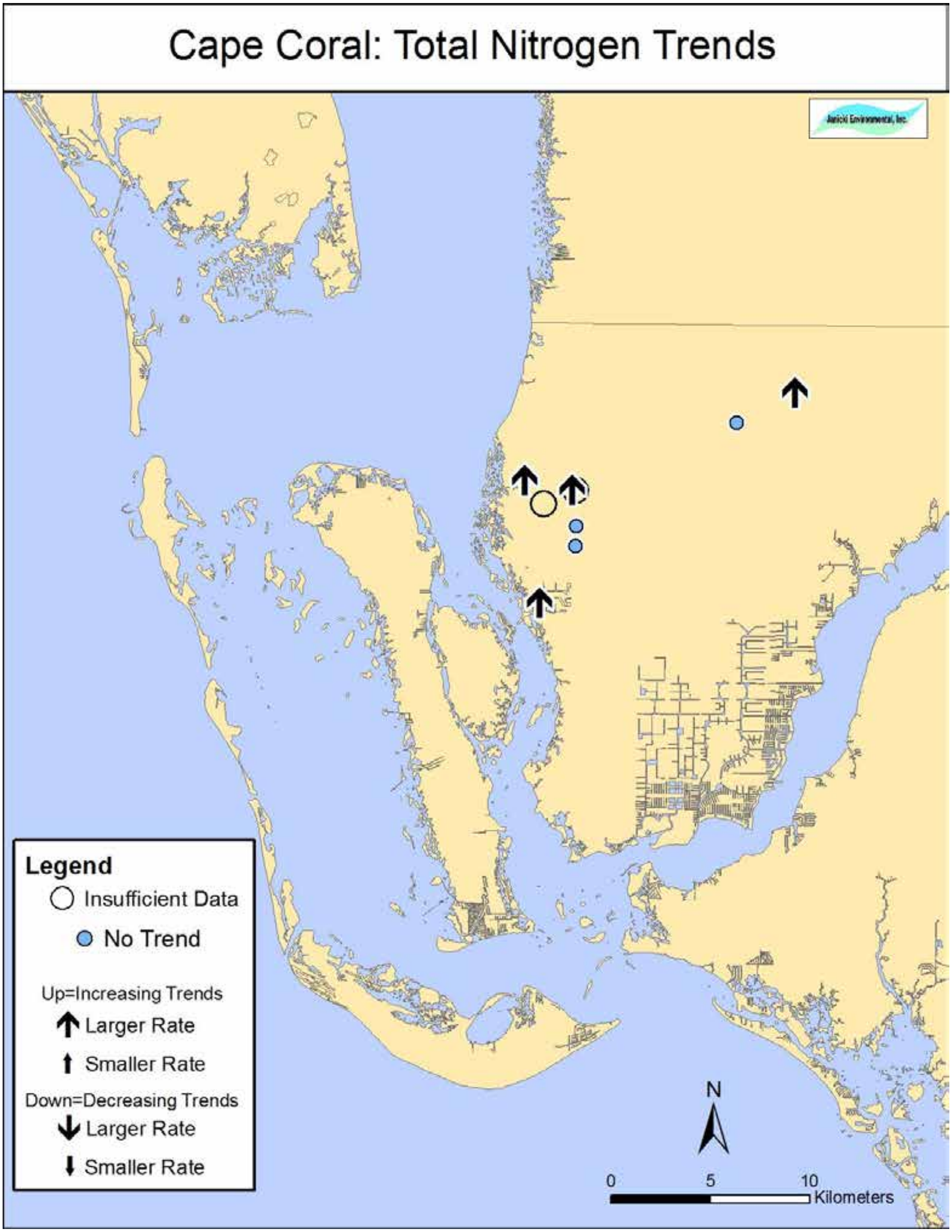


Figure 2-12. Total Nitrogen Trends for Cape Coral Fixed Stations in the NSC

Cross correlation analysis suggested that TN concentrations among stations with long-term data sets were greatest between Stations 160 and 190 (Table 2-6). For the short-term correlation among stations with observations since 2008, Stations 120 and 130 and 120 and 271 were most highly correlated.

Table 2-6. Spearman's Rank Correlation Coefficients for Total Nitrogen for Cape Coral Fixed Stations in the NSC

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	_110	_120	_130	_150	_160	_190	_105	_129	_271
_110	1.00000 258	0.15316 0.1806 78	0.09046 0.1530 251	. . 22	0.17308 0.0060 251	0.21952 0.0004 252	0.50564 <.0001 59	0.20127 0.1369 56	-0.16354 0.2284 56
_120	0.15316 0.1806 78	1.00000 83	0.71355 <.0001 82	. . 23	0.16037 0.1553 80	0.13508 0.2292 81	0.06524 0.6297 57	0.09117 0.4961 58	0.66254 <.0001 60
_130	0.09046 0.1530 251	0.71355 <.0001 82	1.00000 255	. . 22	0.25415 <.0001 252	0.33042 <.0001 253	0.15305 0.2471 59	-0.00185 0.9890 58	0.33412 0.0091 60
_150	. . 22	. . 23	. . 22	. . 23	. . 22	. . 23	. . 0	. . 0	. . 0
_160	0.17308 0.0060 251	0.16037 0.1553 80	0.25415 <.0001 252	. . 22	1.00000 253	0.52465 <.0001 253	0.31207 0.0161 59	0.36451 0.0049 58	-0.08185 0.5413 58
_190	0.21952 0.0004 252	0.13508 0.2292 81	0.33042 <.0001 253	. . 23	0.52465 <.0001 253	1.00000 255	0.24453 0.0620 59	0.44276 0.0005 58	-0.26216 0.0468 58
_105	0.50564 <.0001 59	0.06524 0.6297 57	0.15305 0.2471 59	. . 0	0.31207 0.0161 59	0.24453 0.0620 59	1.00000 60	0.30665 0.0203 57	0.02577 0.8491 57
_129	0.20127 0.1369 56	0.09117 0.4961 58	-0.00185 0.9890 58	. . 0	0.36451 0.0049 58	0.44276 0.0005 58	0.30665 0.0203 57	1.00000 58	-0.15977 0.2309 58
_271	-0.16354 0.2284 56	0.66254 <.0001 60	0.33412 0.0091 60	. . 0	-0.08185 0.5413 58	-0.26216 0.0468 58	0.02577 0.8491 57	-0.15977 0.2309 58	1.00000 60

2.1.3 TOTAL PHOSPHORUS (TP)

TP was sampled at the same frequency across stations as TN. The sampling frequency by station is presented in Table 2-7.

Table 2-7. Total Phosphorus Sampling Frequency by Station for Cape Coral Fixed Stations in the NSC

Year	Station									
	105	110	120	129	130	150	160	190	271	Total
1991	-	4	3	-	4	3	4	3	-	21
1992	-	12	12	-	12	12	12	12	-	72
1993	-	12	8	-	12	8	12	12	-	64
1994	-	11	-	-	11	-	11	11	-	44
1995	-	12	-	-	12	-	12	12	-	48
1996	-	11	-	-	11	-	11	11	-	44
1997	-	12	-	-	12	-	12	12	-	48
1998	-	12	-	-	9	-	9	9	-	39
1999	-	12	-	-	12	-	12	12	-	48
2000	-	8	-	-	9	-	9	9	-	35
2001	-	12	-	-	11	-	11	11	-	45
2002	-	12	-	-	11	-	11	11	-	45
2003	-	13	-	-	11	-	12	12	-	48
2004	-	10	-	-	12	-	10	10	-	42
2005	-	12	-	-	12	-	12	12	-	48
2006	-	12	-	-	12	-	11	12	-	47
2007	-	12	-	-	12	-	12	12	-	48
2008	5	12	3	3	12	-	12	12	3	62
2009	10	10	11	11	11	-	11	11	11	86
2010	12	12	12	12	12	-	12	12	12	96
2011	12	12	12	12	12	-	12	12	12	96
2012	9	9	12	9	12	-	9	9	12	81
2013	12	11	12	12	12	-	12	12	12	95
Total	60	255	85	59	256	23	251	251	62	1302

Long-term arithmetic averages of TP concentrations are provided in Figure 2-13. For Cape Coral, the period of record is truncated to 2008-2013 since all stations (except Station 150) were collecting TP data over this time period. Stations 190 and 160 had the lowest average concentrations, while Station 130 had the highest average concentration.

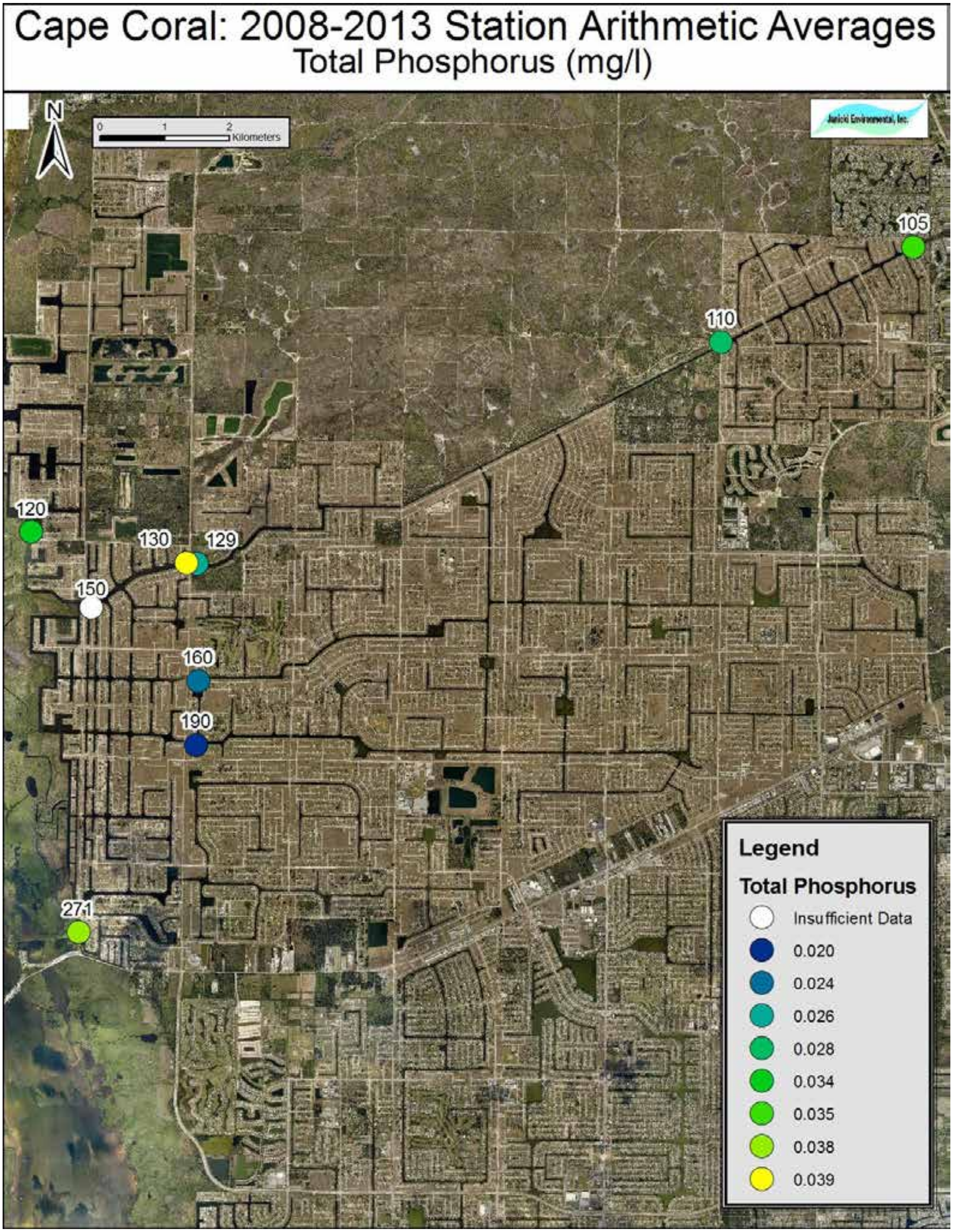


Figure 2-13. Arithmetic Averages for Total Phosphorus 2008-2013 for Cape Coral Fixed Stations in the NSC

Box and whisker plots of the TP distributions (Figure 2-14) suggest that 75 percent of the data collected across all stations had TP concentrations less than 0.05 mg/L. Stations 105 and 271 tended to have higher distribution values than other stations. The arithmetic average TP at Station 130 may be leveraged by an extreme value outlier, resulting in a higher mean value but a lower distribution of values. For most stations, at least 25 percent of the observations were at the detection limit (0.01 mg/L). These plots are trimmed so that extremely high values are not displayed in the plots.

Time series plots of annual average TP concentrations show strong agreement in the time series trends for stations with a long-term record with a concentration spike in 2002 and 2003, followed by a decline in concentrations and a trend towards detection limit values after 2005 (Figure 2-15).

Trends for TP measurements for Cape Coral stations are displayed in Figure 2-16. No trends were examined on Station 129 and 150 due to insufficient data (n <60 for TP observations).

Cross correlation analysis generated results similar to TN, where Stations 160 and 190 were highly correlated, but only moderate correlation existed among other stations. Interestingly, Stations 105 and 110 were not well correlated for TP nor was Station 105 well correlated with any other station (Table 2-8).

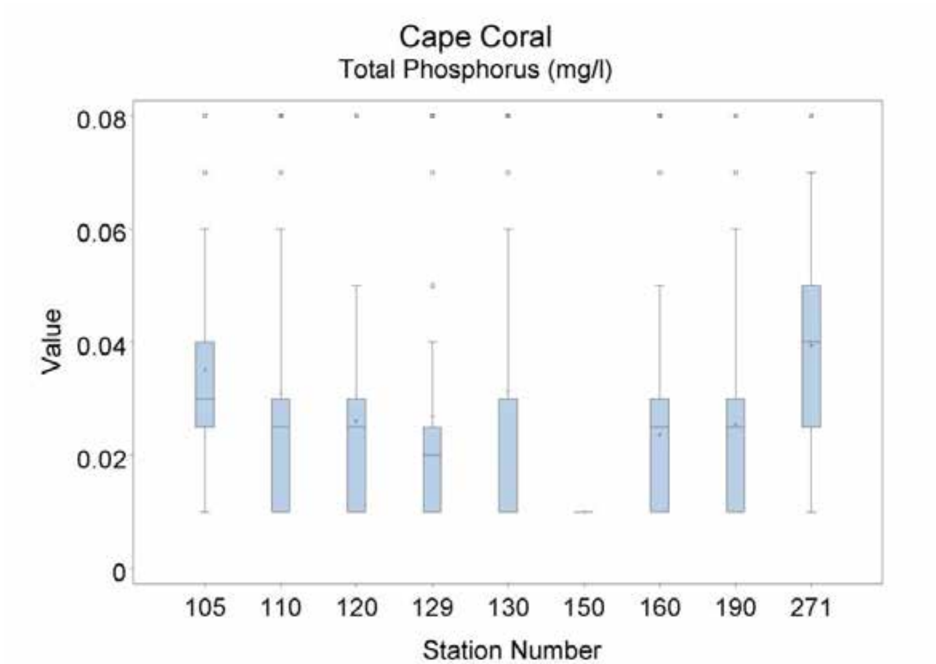


Figure 2-14. Box and Whisker Plots Displaying the Distribution of Total Phosphorus Concentrations among Cape Coral Fixed Water Quality Stations Located within the NSC

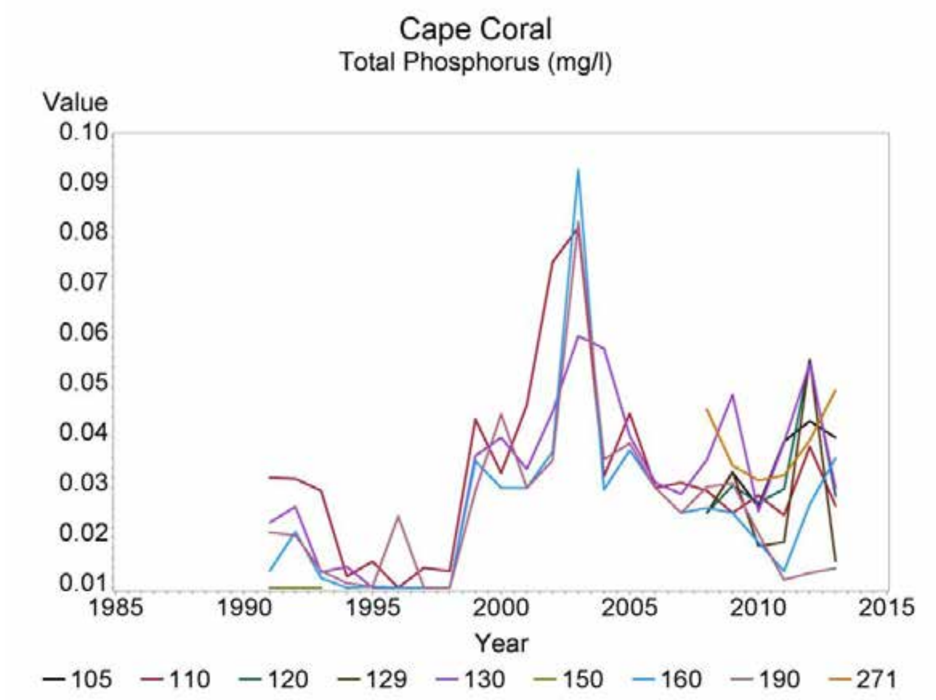


Figure 2-15. Time Series Plot of Surface Total Phosphorus for Cape Coral Water Quality Stations in the NSC

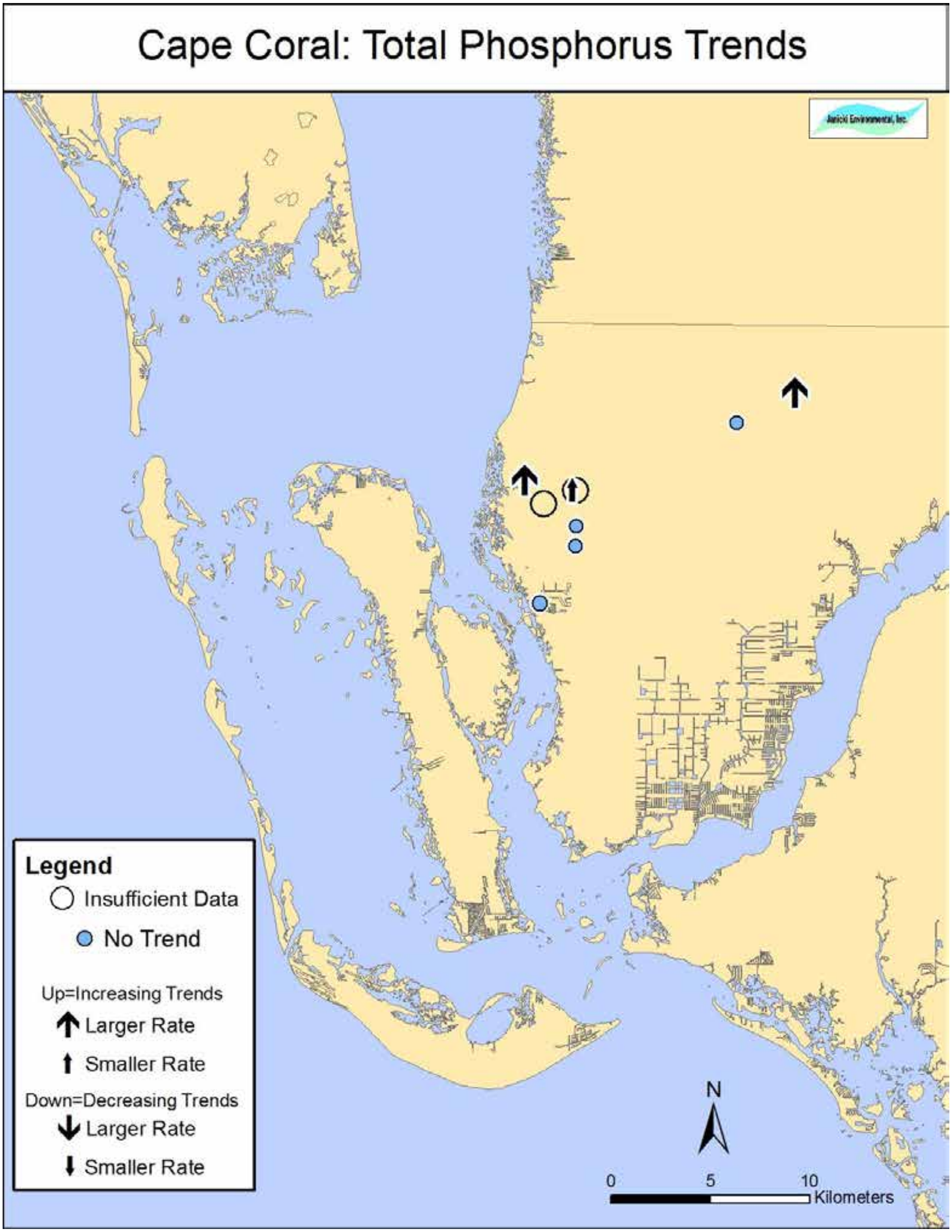


Figure 2-16. Total Phosphorus Trends for Cape Coral Fixed Stations in the NSC

Table 2-8. Spearman Rank Correlation Coefficients for Total Phosphorus for Cape Coral Fixed Stations in the NSC

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	_110	_120	_130	_150	_160	_190	_105	_129	_271
_110	1.00000 252	-0.05103 0.6573 78	0.54502 <.0001 245	. . 22	0.71025 <.0001 245	0.67839 <.0001 246	0.20479 0.1197 59	0.32961 0.0131 56	-0.14140 0.2986 56
_120	-0.05103 0.6573 78	1.00000 83	0.53762 <.0001 82	. . 23	0.10858 0.3377 80	0.12946 0.2494 81	0.08715 0.5192 57	-0.09132 0.4954 58	0.26293 0.0424 60
_130	0.54502 <.0001 245	0.53762 <.0001 82	1.00000 252	. . 22	0.64743 <.0001 247	0.61332 <.0001 248	0.13357 0.3132 59	-0.02390 0.8587 58	0.14683 0.2629 60
_150	. . 22	. . 23	. . 22	. . 23	. . 22	. . 23	. . 0	. . 0	. . 0
_160	0.71025 <.0001 245	0.10858 0.3377 80	0.64743 <.0001 247	. . 22	1.00000 248	0.88859 <.0001 248	-0.26363 0.0436 59	0.54073 <.0001 58	-0.01345 0.9202 58
_190	0.67839 <.0001 246	0.12946 0.2494 81	0.61332 <.0001 248	. . 23	0.88859 <.0001 248	1.00000 250	-0.33211 0.0102 59	0.58158 <.0001 58	-0.08395 0.5309 58
_105	0.20479 0.1197 59	0.08715 0.5192 57	0.13357 0.3132 59	. . 0	-0.26363 0.0436 59	-0.33211 0.0102 59	1.00000 60	-0.07033 0.6032 57	0.13136 0.3300 57
_129	0.32961 0.0131 56	-0.09132 0.4954 58	-0.02390 0.8587 58	. . 0	0.54073 <.0001 58	0.58158 <.0001 58	-0.07033 0.6032 57	1.00000 58	-0.23760 0.0725 58
_271	-0.14140 0.2986 56	0.26293 0.0424 60	0.14683 0.2629 60	. . 0	-0.01345 0.9202 58	-0.08395 0.5309 58	0.13136 0.3300 57	-0.23760 0.0725 58	1.00000 60

2.1.4 DISSOLVED OXYGEN

DO measurements have been routinely collected at the majority of stations in the NSC since 1991. Sampling at Stations 105,129, and 271 began in 2008. The sampling frequency for each station is provided in Table 2-9.

Table 2-9. Dissolved Oxygen Sampling Frequency by Station for Cape Coral Fixed Stations in the NSC

Year	Station									
	105	110	120	129	130	150	160	190	271	Total
1991	-	4	3	-	4	3	4	3	-	21
1992	-	12	12	-	12	12	12	12	-	72
1993	-	12	11	-	12	11	12	12	-	70
1994	-	11	11	-	12	11	12	12	-	69
1995	-	12	12	-	12	12	12	12	-	72
1996	-	12	11	-	12	12	12	12	-	71
1997	-	11	12	-	12	12	12	12	-	71
1998	-	12	12	-	12	12	12	12	-	72
1999	-	12	12	-	12	12	12	12	-	72
2000	-	10	11	-	11	11	11	11	-	65
2001	-	11	12	-	11	12	12	12	-	70
2002	-	11	12	-	11	12	11	12	-	69
2003	-	13	12	-	11	12	12	12	-	72
2004	-	12	12	-	11	12	12	12	-	71
2005	-	12	12	-	12	12	12	12	-	72
2006	-	12	12	-	12	12	11	12	-	71
2007	-	11	12	-	11	12	12	12	-	70
2008	6	12	12	3	12	12	12	12	3	84
2009	10	11	11	11	10	11	11	11	11	97
2010	12	12	12	12	12	12	12	12	12	108
2011	12	12	12	12	12	12	12	12	12	108
2012	9	9	12	9	12	12	9	9	11	92
2013	12	12	12	12	12	12	12	12	11	107
Total	61	258	262	59	260	263	261	262	60	1746

Long-term arithmetic averages of surface DO concentration for the period of record when all stations were collecting information (i.e., 2008-2013) are mapped in Figure 2-17. Stations 130 and 105 had the lowest average concentrations, while Station 160 had the highest average concentration.

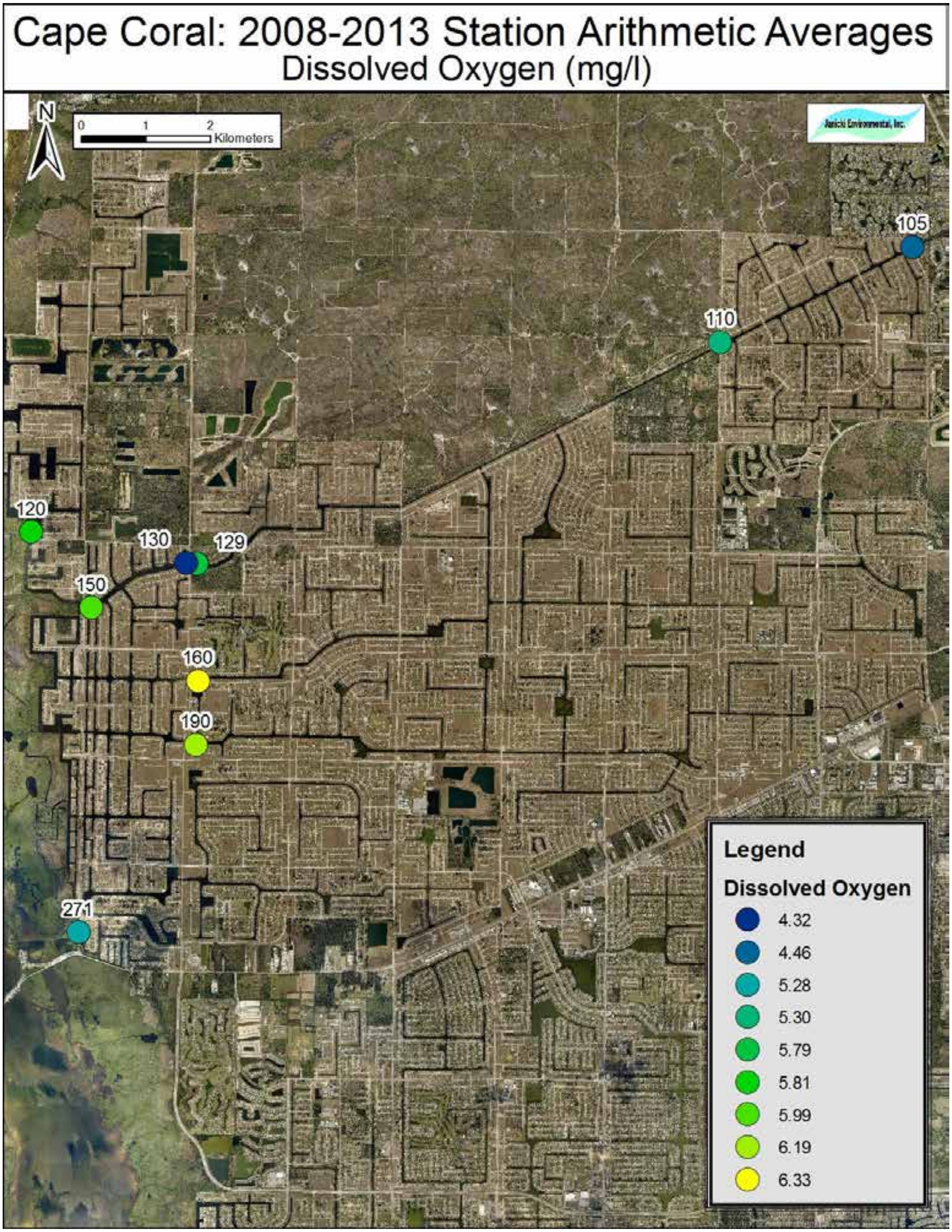


Figure 2-17. Arithmetic Average of Surface Dissolved Oxygen at Cape Coral Fixed Station Samples Collected between 2008 and 2013 in the NSC

The distribution of DO for each station at both surface and bottom levels are displayed in Figure 2-18. The median values at each station are near or above 5 mg/L for both surface and bottom values. There appears to be little difference between surface and bottom concentrations at all stations. Station 105 had the lowest distribution of values in both surface and bottom samples. The surface plot (top) is trimmed so that extremely high values are not displayed.

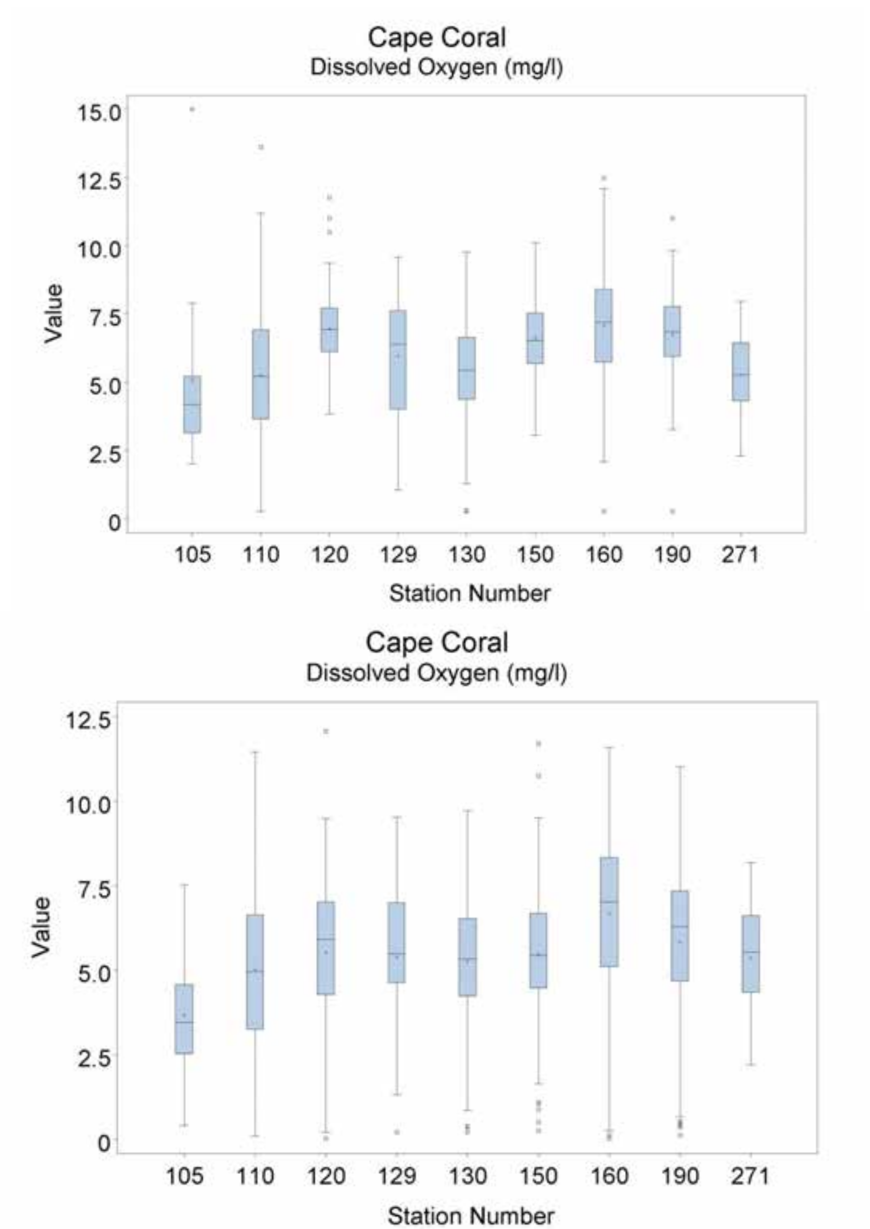


Figure 2-18. Box and Whisker Plots of Dissolved Oxygen Distributions across Stations in Surface Samples (Top) and Bottom Samples (Bottom) for Cape Coral Fixed Stations in the NSC

Time series plots indicate that Station 160 tended to have the highest annual average concentrations (Figure 2-19). DO concentrations at Station 110 were much lower than other stations prior to 2000 when they became more like the other stations and Station 130 seemed to decline. Station 105 had the lowest annual average concentrations in 2010-2013.

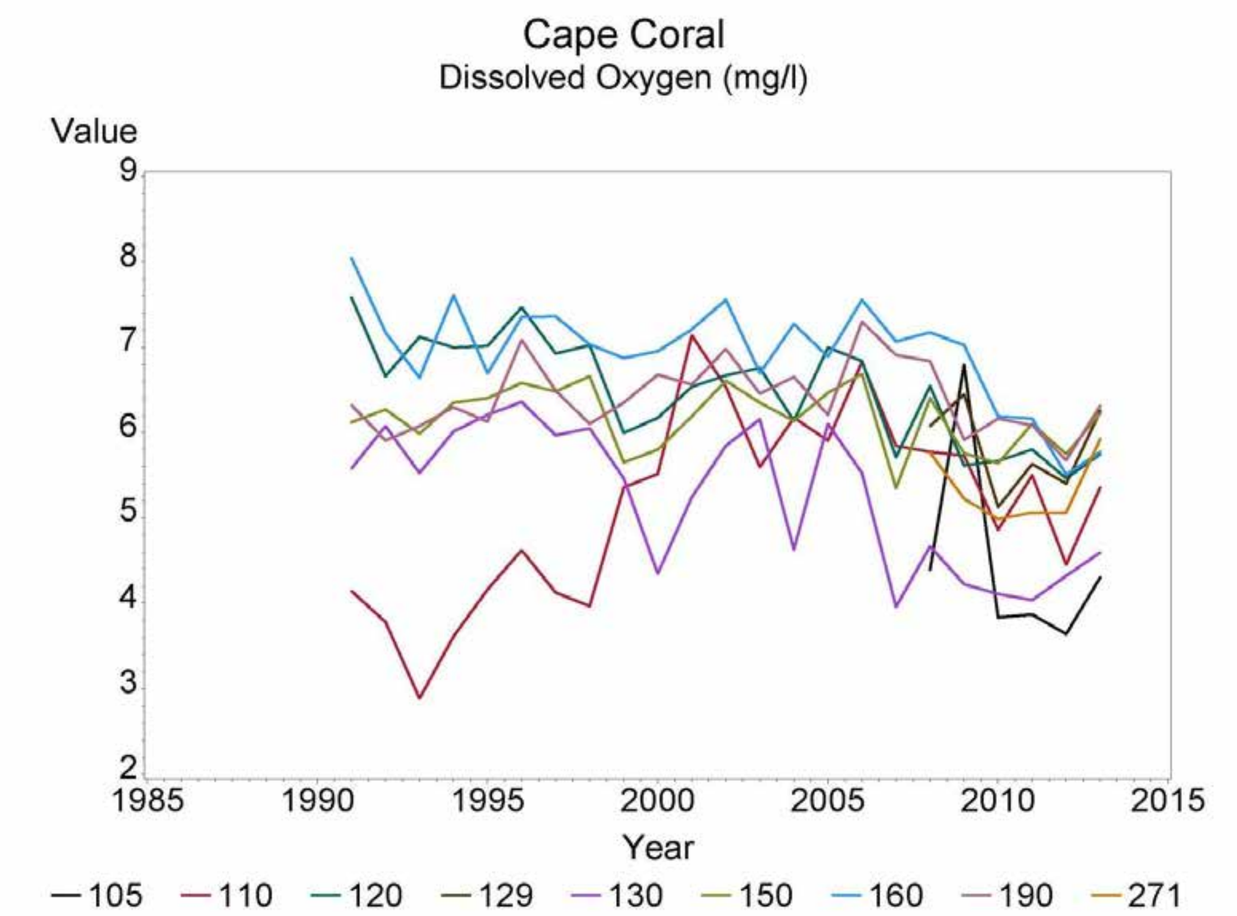


Figure 2-19. Time Series Plot of Dissolved Oxygen for Cape Coral Water Quality Stations in the NSC

Trends for surface DO measurements for Cape Coral stations are displayed in Figure 2-20 and bottom DO trends are shown in Figure 2-21. Differences in trends between surface and bottom measurements were found in Stations 130, 150 and 160. No surface or bottom trends were examined for Station 129 and no bottom trends were examined for Station 271 due to insufficient data (n <60 for surface and/or bottom DO observations).

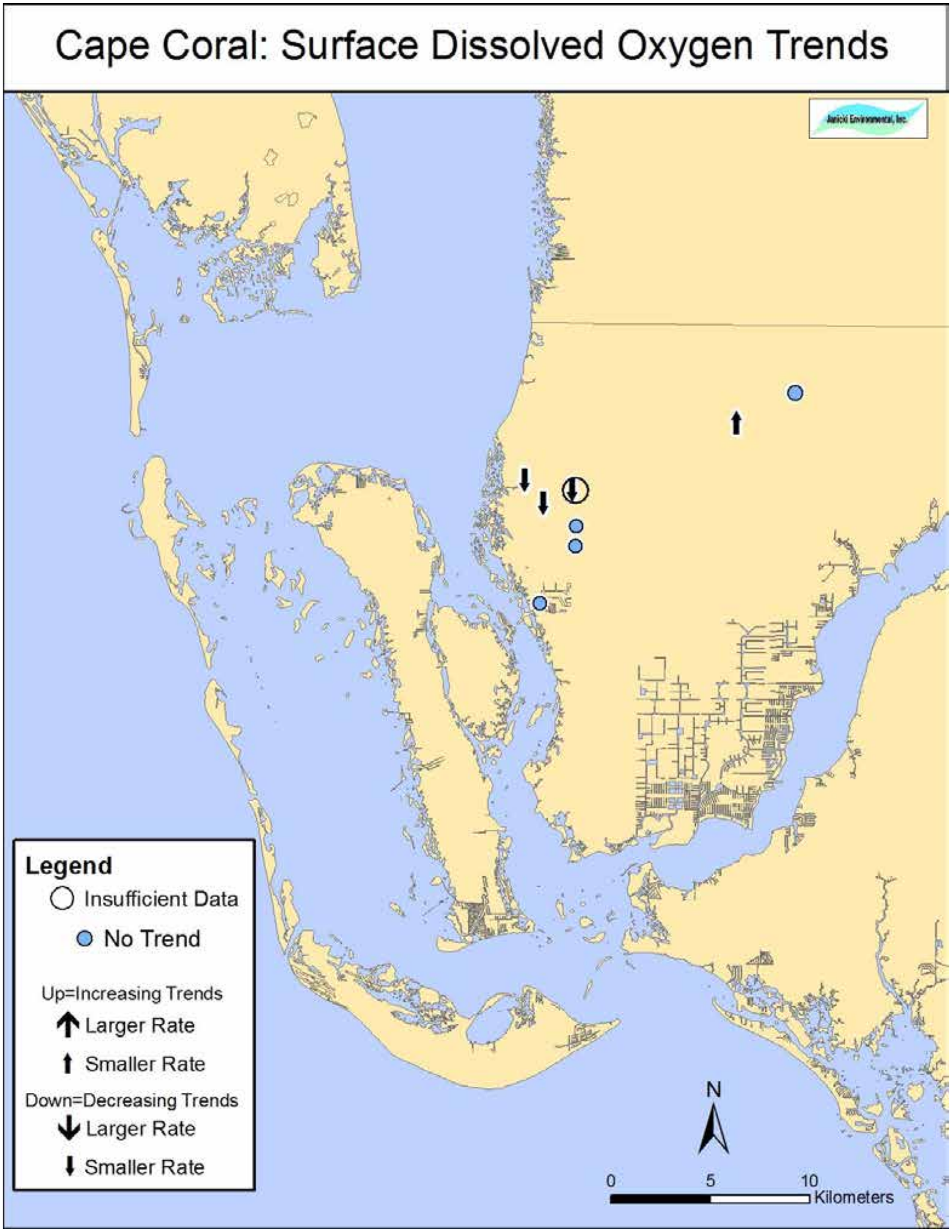


Figure 2-20. Surface Dissolved Oxygen Trends for Cape Coral Fixed Stations in the NSC

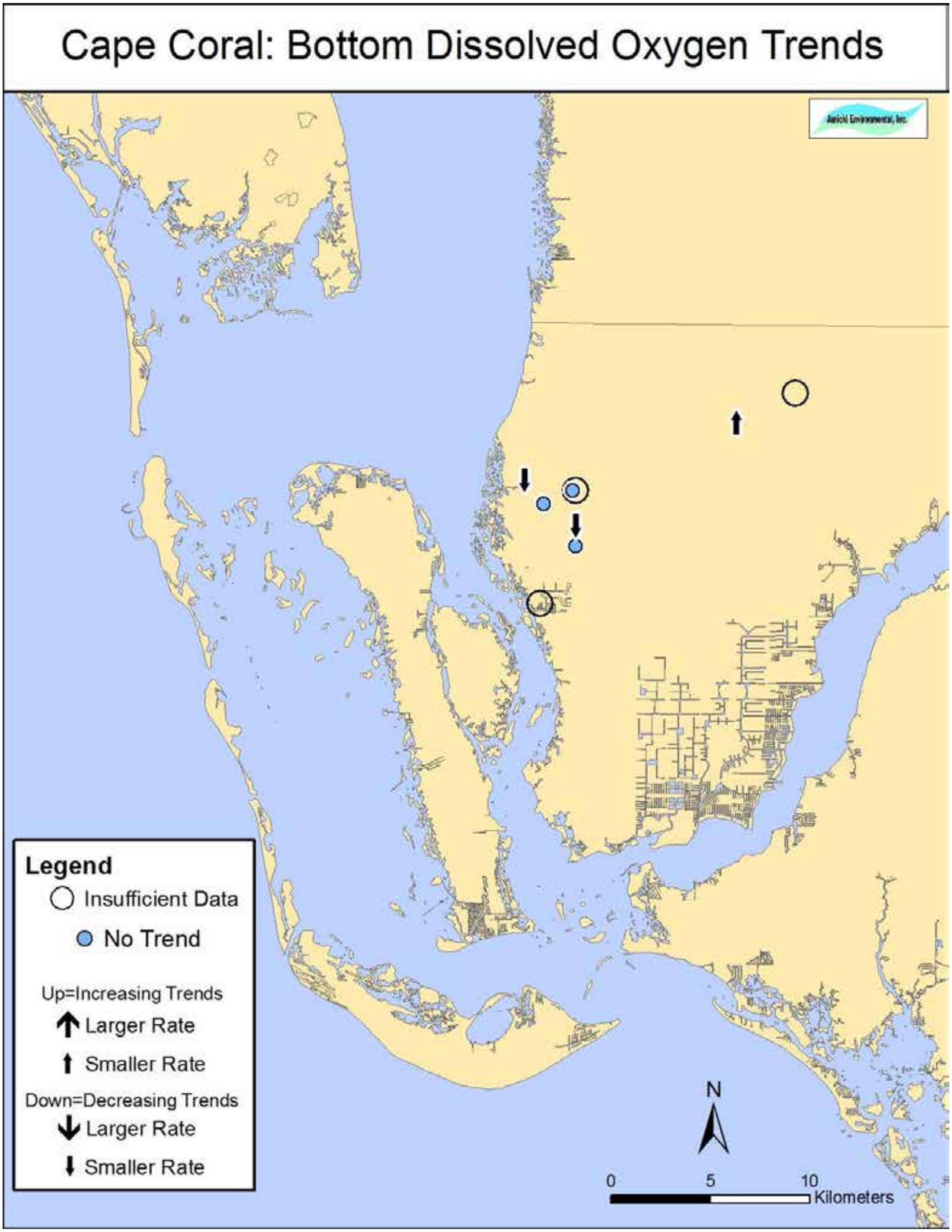


Figure 2-21. Bottom Dissolved Oxygen Trends for Cape Coral Fixed Stations in the NSC

Cross correlation analysis suggested moderate correlation among most stations, with highest correlation for the long-term stations between Stations 120 and 150, and 160 and 190 (Table 2-10). Over the shorter term period of record, considering all stations, the highest correlation was between 129 and 160.

Table 2-10. Spearman's Rank Correlation for Surface Dissolved Oxygen for Cape Coral Fixed Stations in the NSC

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	_110	_120	_130	_150	_160	_190	_105	_129	_271
_110	1.00000 255	0.29637 <.0001 250	0.10526 0.0989 247	0.44094 <.0001 251	0.59368 <.0001 251	0.62497 <.0001 253	0.70037 <.0001 61	0.73070 <.0001 58	0.40774 0.0018 56
_120	0.29637 <.0001 250	1.00000 260	0.67380 <.0001 253	0.86261 <.0001 260	0.52149 <.0001 255	0.48704 <.0001 258	0.27139 0.0360 60	0.42503 0.0009 58	0.75134 <.0001 58
_130	0.10526 0.0989 247	0.67380 <.0001 253	1.00000 256	0.67358 <.0001 254	0.33278 <.0001 253	0.34789 <.0001 254	0.06505 0.6245 59	0.12805 0.3425 57	0.54206 <.0001 57
_150	0.44094 <.0001 251	0.86261 <.0001 260	0.67358 <.0001 254	1.00000 261	0.61396 <.0001 256	0.57980 <.0001 259	0.42409 0.0007 60	0.57308 <.0001 58	0.73437 <.0001 58
_160	0.59368 <.0001 251	0.52149 <.0001 255	0.33278 <.0001 253	0.61396 <.0001 256	1.00000 258	0.79383 <.0001 258	0.51118 <.0001 60	0.88928 <.0001 58	0.52915 <.0001 56
_190	0.62497 <.0001 253	0.48704 <.0001 258	0.34789 <.0001 254	0.57980 <.0001 259	0.79383 <.0001 258	1.00000 261	0.50194 <.0001 60	0.74918 <.0001 58	0.62759 <.0001 56
_105	0.70037 <.0001 61	0.27139 0.0360 60	0.06505 0.6245 59	0.42409 0.0007 60	0.51118 <.0001 60	0.50194 <.0001 60	1.00000 61	0.63659 <.0001 58	0.55287 <.0001 56
_129	0.73070 <.0001 58	0.42503 0.0009 58	0.12805 0.3425 57	0.57308 <.0001 58	0.88928 <.0001 58	0.74918 <.0001 58	0.63659 <.0001 58	1.00000 58	0.56301 <.0001 56
_271	0.40774 0.0018 56	0.75134 <.0001 58	0.54206 <.0001 57	0.73437 <.0001 58	0.52915 <.0001 56	0.62759 <.0001 56	0.55287 <.0001 56	0.56301 <.0001 56	1.00000 58

2.1.5 CHLOROPHYLL *A*

Chl *a* has been routinely sampled at four stations in the NSC network since 1995. Four stations added chlorophyll sampling in 2008 (Table 2-11).

Table 2-11. Chlorophyll *a* Sampling Frequency by Station for Cape Coral Fixed Stations in the NSC

	Station									
Year	105	110	120	129	130	150	160	190	271	Total
1995	-	11	1	-	11	5	11	12	-	51
1996	-	10	-	-	11	2	11	11	-	45
1997	-	9	-	-	8	-	10	10	-	37
1998	-	8	-	-	8	-	8	8	-	32
1999	-	10	-	-	11	-	11	11	-	43
2000	-	8	-	-	10	-	10	9	-	37
2001	-	10	-	-	11	-	10	12	-	43
2002	-	12	-	-	11	-	11	12	-	46
2003	-	11	-	-	10	-	11	11	-	43
2004	-	10	-	-	9	-	10	10	-	39
2005	-	12	-	-	12	-	12	11	-	47
2006	-	11	-	-	11	-	10	11	-	43
2007	-	12	-	-	11	-	12	12	-	47
2008	5	12	3	3	12	-	12	12	3	62
2009	10	10	11	10	10	-	11	11	11	84
2010	12	12	12	12	12	-	12	12	12	96
2011	12	12	12	12	12	-	12	12	12	96
2012	9	9	12	9	12	-	9	9	11	80
2013	12	11	12	12	12	-	12	12	11	94
Total	60	200	63	58	204	7	205	208	60	1065

The overall arithmetic average Chl *a* concentration between 2008-2013 for each station is displayed in Figure 2-22. Stations 160 and 190 had the lowest average concentrations, while Station 120 had the highest average concentration. For Cape Coral, the period of record is truncated to 2008-2013 since all stations (except Station 150) were collecting Chl *a* data during this time period.

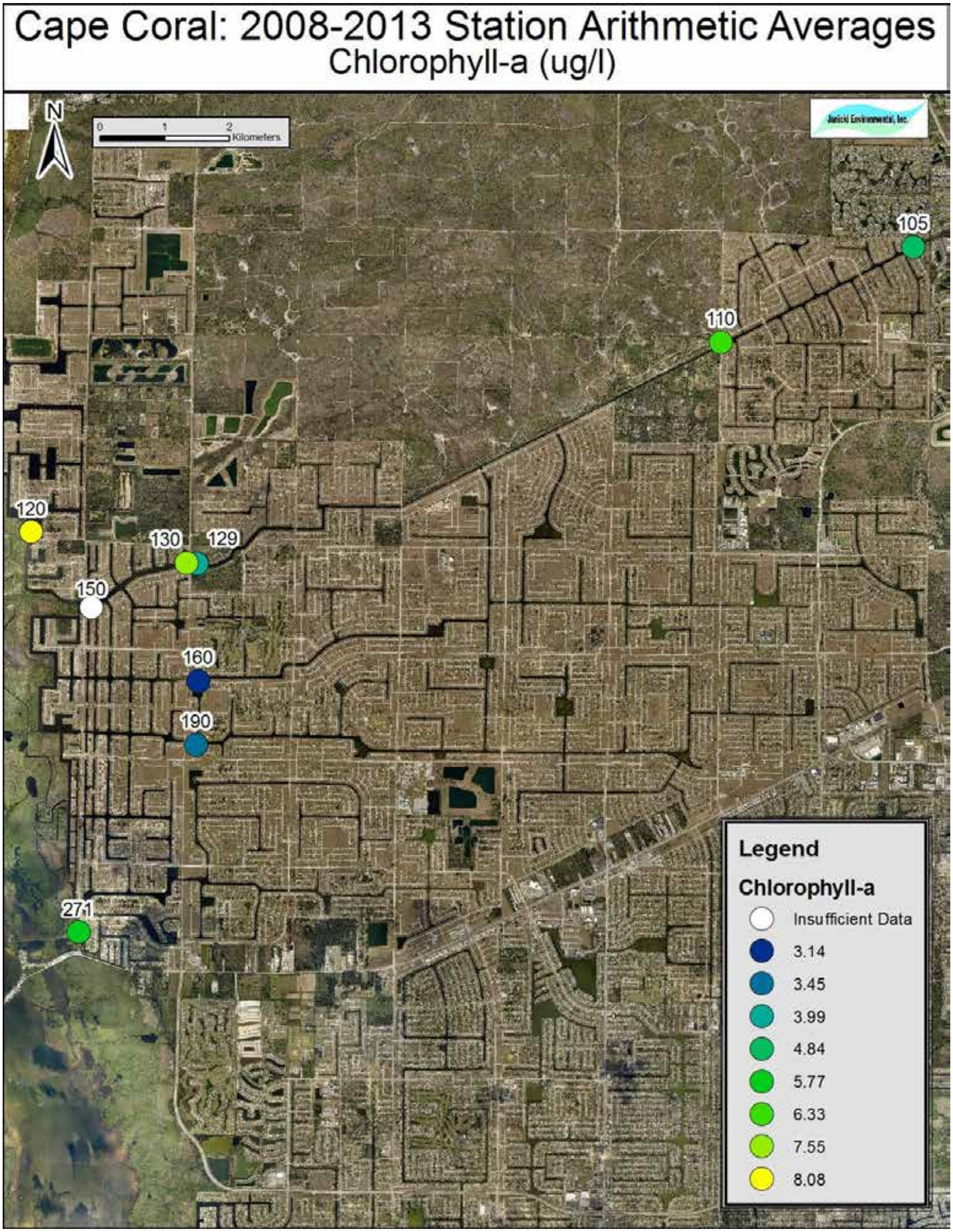


Figure 2-22. Arithmetic Average of Chlorophyll a *at Cape Coral Stations for Samples Collected between 2008 and 2013*

The distribution of Chl *a* values for each station is plotted in Figure 2-23. At least 75 percent of the values in each station were below 10 micrograms per liter (μg/L), indicating that typical chlorophyll values would not be considered bloom conditions. These plots are trimmed so that extremely high values are not displayed in the plots.

Time series plots of Chl *a* concentrations (Figure 2-24) suggest that annual average chlorophyll concentrations can vary by at least 100 percent between years but generally were under 10 μg/L in all years and all stations.

Trends for Chl *a* measurements for Cape Coral stations are displayed in Figure 2-25. No trends were examined on Station 129 and 150 due to insufficient data (n <60 for chlorophyll *a* observations).

Cross correlation analysis (Table 2-12) suggested modest correlations among stations, with the long-term stations having higher correlation coefficients than the short-term stations. The highest correlations were between Station 160 and 190, in Horseshoe and Hermosa Canals, respectively.

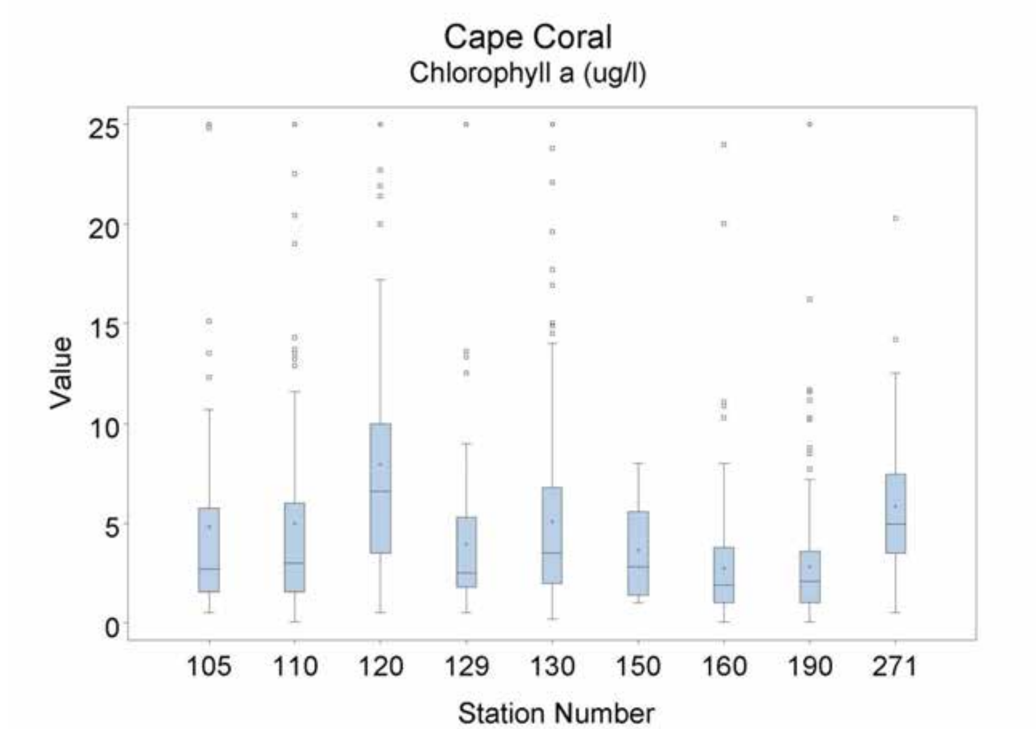


Figure 2-23. Box and Whisker Plots Displaying the Distribution of Chlorophyll a Concentrations among Cape Coral Fixed Water Quality Stations Located within the NSC

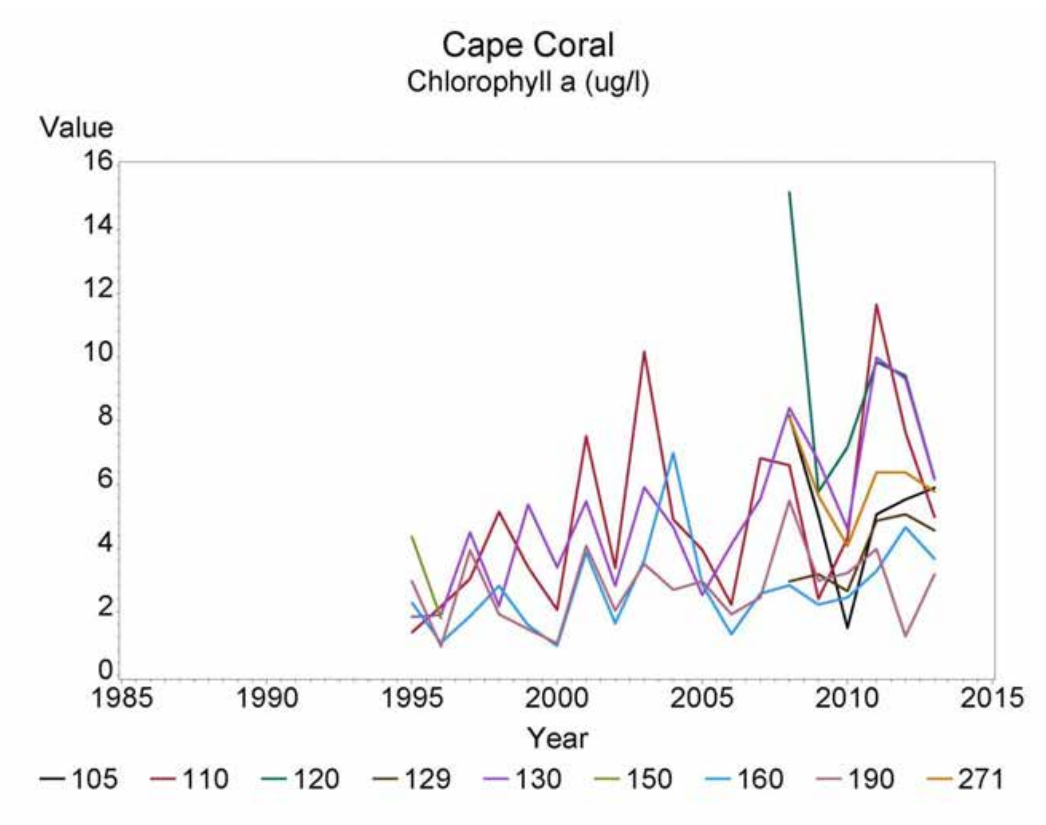


Figure 2-24. Time Series Plot of Chlorophyll a for Cape Coral Water Quality Stations in the NSC

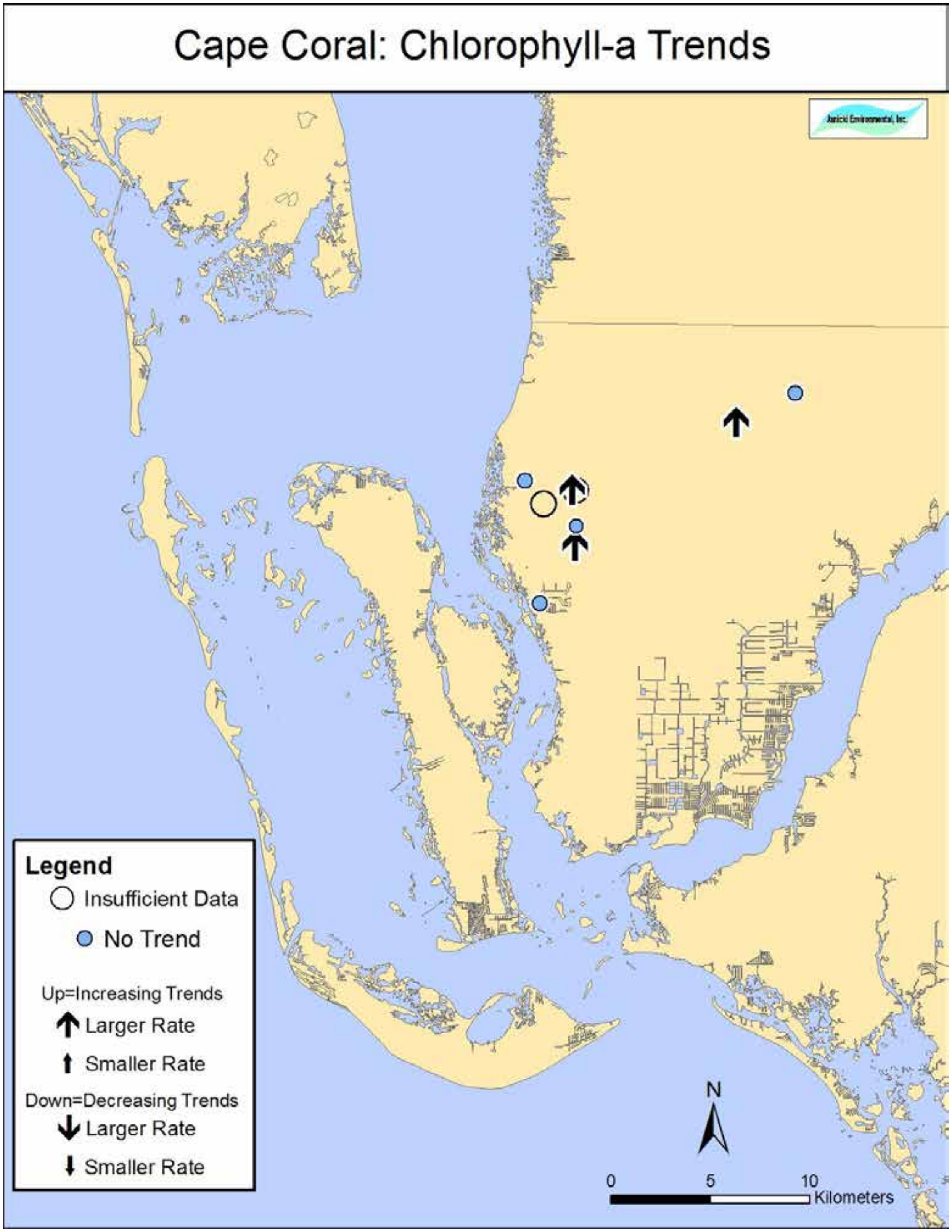


Figure 2-25. Chlorophyll a Trends for Cape Coral Fixed Stations in the NSC

Table 2-12. Spearman's Rank Correlation Coefficients for Chlorophyll *a* for Cape Coral Fixed Stations in the NSC

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	_110	_120	_130	_150	_160	_190	_105	_129	_271
_110	1.00000 200	0.25712 0.0535 57	0.33287 <.0001 186	-0.25944 0.5742 7	0.47927 <.0001 190	0.44312 <.0001 193	0.20736 0.1151 59	0.24574 0.0705 55	0.30431 0.0253 54
_120	0.25712 0.0535 57	1.00000 61	0.31961 0.0136 59	. . 1	0.28975 0.0260 59	0.46956 0.0002 59	-0.12229 0.3648 57	0.19770 0.1404 57	0.58089 <.0001 58
_130	0.33287 <.0001 186	0.31961 0.0136 59	1.00000 202	-0.57682 0.2307 6	0.25661 0.0003 196	0.32875 <.0001 198	0.11737 0.3803 58	0.11683 0.3912 56	0.44894 0.0005 57
_150	-0.25944 0.5742 7	. . 1	-0.57682 0.2307 6	1.00000 7	-0.02857 0.9572 6	0.88292 0.0085 7	. . 0	. . 0	. . 0
_160	0.47927 <.0001 190	0.28975 0.0260 59	0.25661 0.0003 196	-0.02857 0.9572 6	1.00000 204	0.62814 <.0001 202	-0.03895 0.7696 59	0.49887 <.0001 57	0.30535 0.0221 56
_190	0.44312 <.0001 193	0.46956 0.0002 59	0.32875 <.0001 198	0.88292 0.0085 7	0.62814 <.0001 202	1.00000 207	-0.04148 0.7551 59	0.11525 0.3933 57	0.32926 0.0132 56
_105	0.20736 0.1151 59	-0.12229 0.3648 57	0.11737 0.3803 58	. . 0	-0.03895 0.7696 59	-0.04148 0.7551 59	1.00000 60	-0.06990 0.6087 56	0.10313 0.4537 55
_129	0.24574 0.0705 55	0.19770 0.1404 57	0.11683 0.3912 56	. . 0	0.49887 <.0001 57	0.11525 0.3933 57	-0.06990 0.6087 56	1.00000 57	0.28341 0.0360 55
_271	0.30431 0.0253 54	0.58089 <.0001 58	0.44894 0.0005 57	. . 0	0.30535 0.0221 56	0.32926 0.0132 56	0.10313 0.4537 55	0.28341 0.0360 55	1.00000 58

2.1.6 TURBIDITY

Turbidity measures the cloudiness or haziness of the water sample and, therefore, is a measure of water clarity. Turbidity is measured by passing light through the sample and evaluating the amount of that light scattered by the particles. Turbidity samples have been routinely collected at the long-term Cape Coral stations since 1991 and at Station 105,129 and 271 since 2008 (Table 2-13). No turbidity data are available at Station 150 after 2003.

Table 2-13. Turbidity Sampling Frequency by Station for Cape Coral Fixed Stations in the NSC

	Station									
Year	105	110	120	129	130	150	160	190	271	Total
1991	-	4	3	-	4	3	4	3	-	21
1992	-	12	12	-	12	12	12	12	-	72
1993	-	12	11	-	12	11	12	12	-	70
1994	-	12	11	-	12	11	12	12	-	70
1995	-	12	12	-	12	12	12	12	-	72
1996	-	12	11	-	12	12	12	12	-	71
1997	-	11	12	-	12	12	12	12	-	71
1998	-	12	12	-	12	12	12	12	-	72
1999	-	12	12	-	12	12	12	12	-	72
2000	-	10	11	-	11	11	11	11	-	65
2001	-	11	12	-	11	12	12	12	-	70
2002	-	11	12	-	11	12	11	12	-	69
2003	-	12	11	-	10	11	11	11	-	66
2004	-	12	-	-	11	-	12	12	-	47
2005	-	12	-	-	12	-	12	12	-	48
2006	-	12	-	-	12	-	11	12	-	47
2007	-	12	-	-	11	-	11	11	-	45
2008	5	12	3	3	12	-	12	12	3	62
2009	9	9	11	11	11	-	11	11	11	84
2010	11	11	12	12	12	-	12	12	12	94
2011	12	12	12	12	12	-	12	12	12	96
2012	9	9	12	9	12	3	9	9	12	84
2013	12	11	12	12	12	-	12	12	12	95
Total	58	255	204	59	260	146	259	260	62	1563

The overall arithmetic average turbidity between 2008-2013 for each station is displayed in Figure 2-26. Turbidity values were generally low, with long-term averages between 1 and 5.18 nephelometric turbidity units (NTU). Stations in the west end of Gator Slough had the highest average turbidity samples, while Stations 160 and 190 had the lowest average values; However, these values do not generally represent deleterious water clarity conditions and are typical of southwest Florida estuaries.

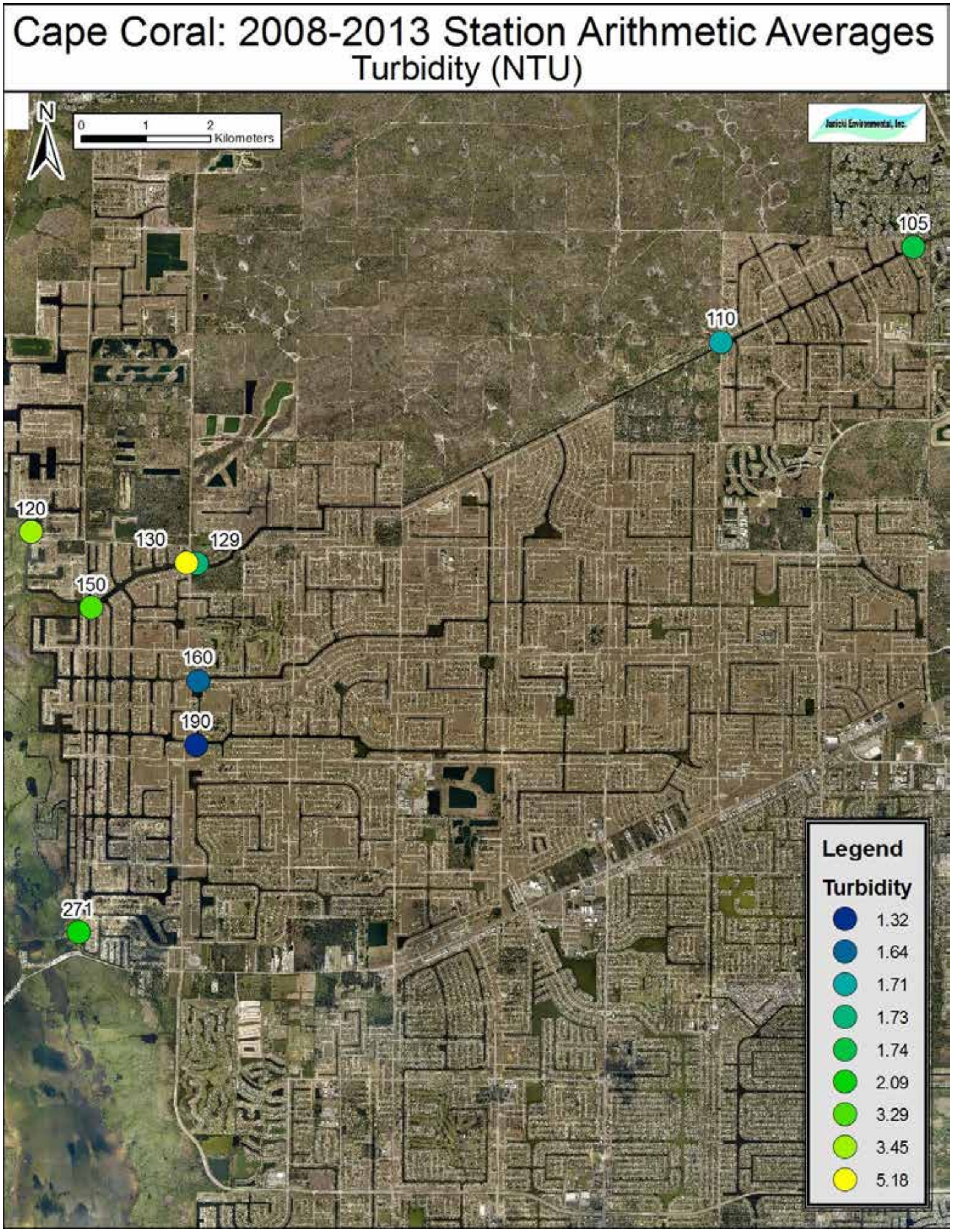


Figure 2-26. Arithmetic Averages of Turbidity at Cape Coral Fixed Stations for Samples Collected between 2008 and 2013 in the NSC

Interannual boxplots for each station confirm that the distribution of values at Stations 120, 130, and 150 tended to be higher than the other stations sampled in Cape Coral and are more likely to have values above 7.5 NTU (Figure 2-27).

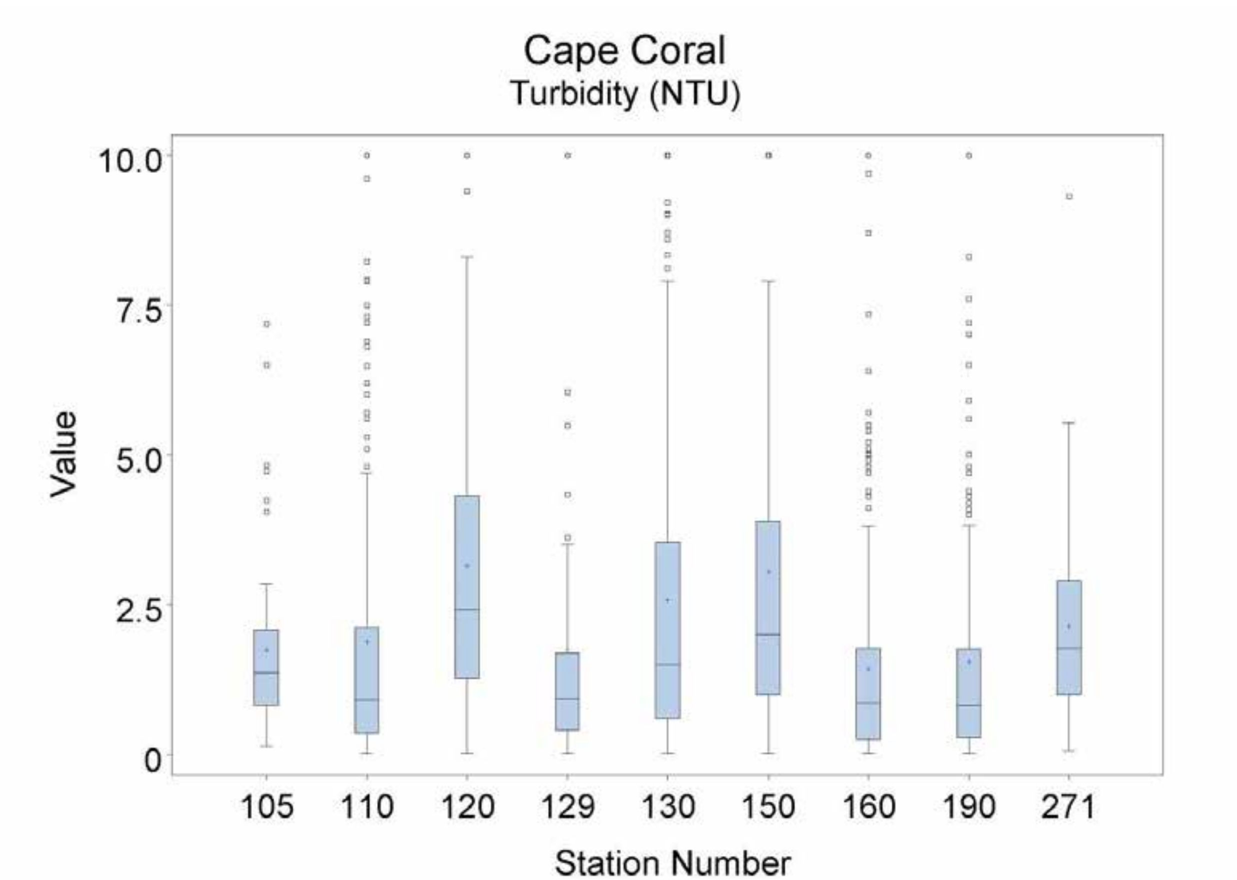


Figure 2-27. Box and Whisker Plots Displaying the Distribution of Turbidity Concentrations among Cape Coral Fixed Water Quality Stations Located within the NSC

Time series plots indicate that annual average turbidity values tend to be under 5 NTU but can be as high as 9 NTU at Station 130 (Figure 2-28).

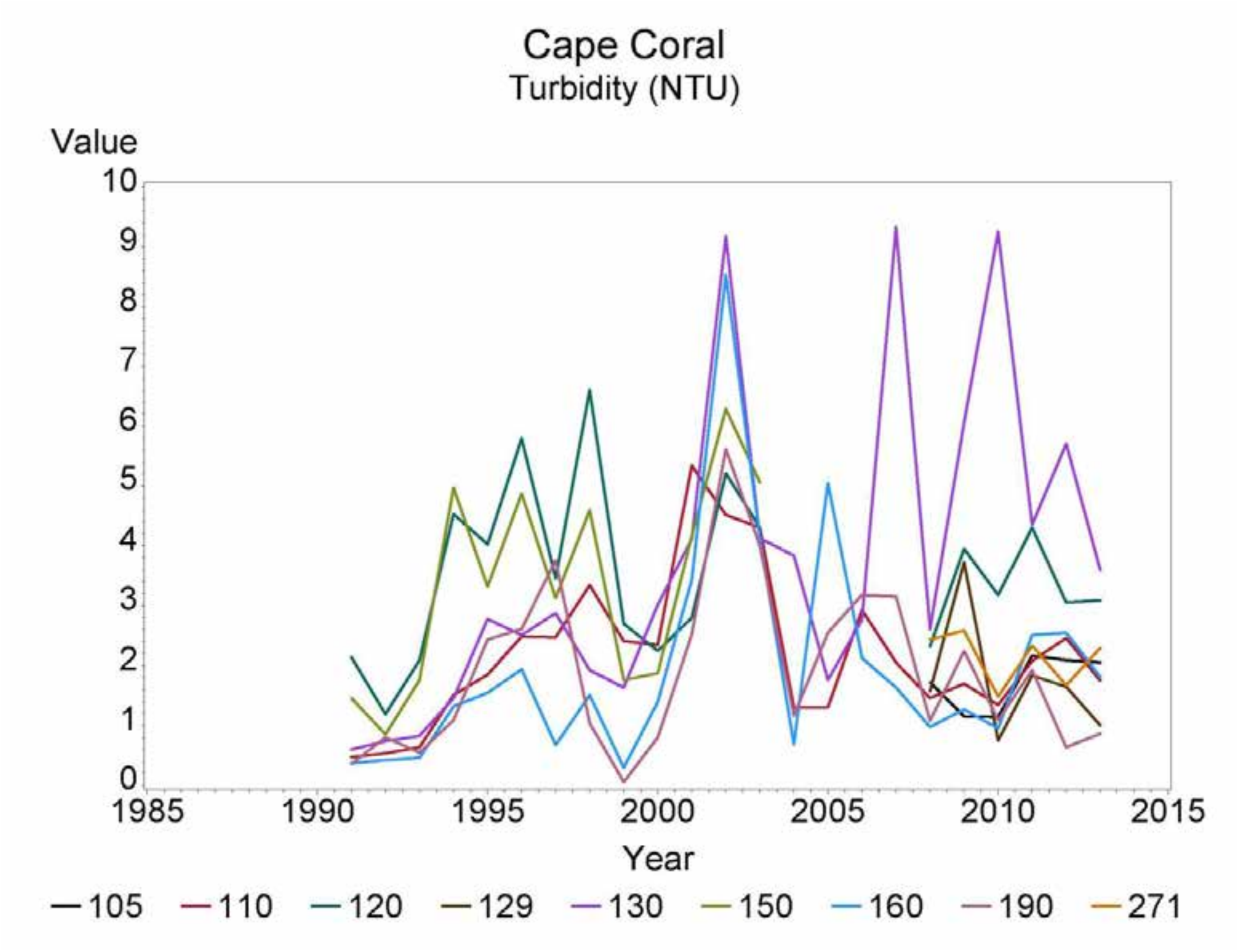


Figure 2-28. Time Series Plot of Turbidity for Cape Coral Water Quality Stations in the NSC

Trends for turbidity measurements for Cape Coral stations are displayed in Figure 2-29. Increasing trends were present in Stations 110, 130, and 150. No trends were examined on Stations 105 and 129 due to insufficient data (n <60 for turbidity observations).

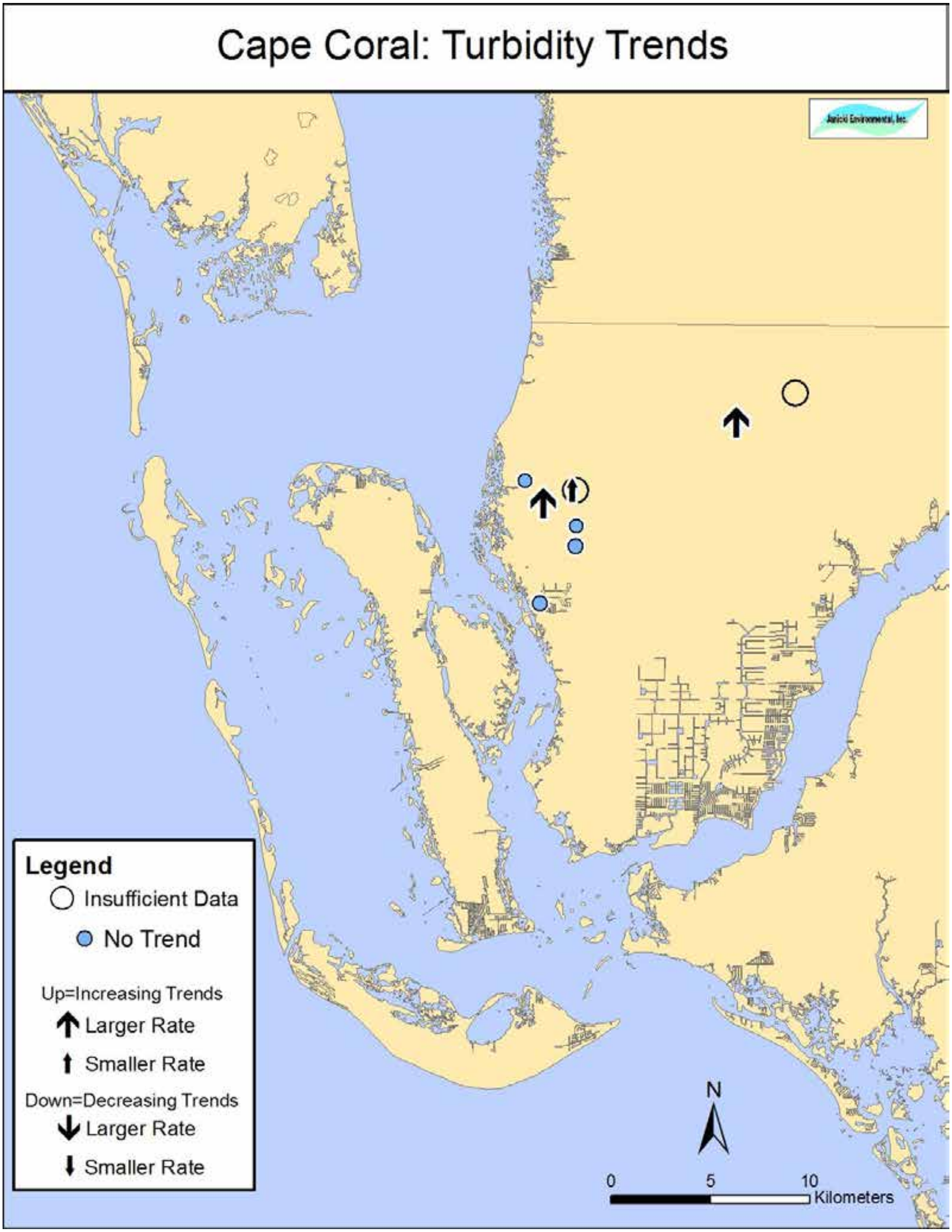


Figure 2-29. Turbidity Trends for Cape Coral Fixed Stations in the NSC

Cross correlation analysis suggested modest correlation among stations, with highest correlations between stations located above the weirs (129,160,190), while stations below the weirs were not as well correlated (Table 2-14).

Table 2-14. Spearman's Rank Correlation Coefficients for Turbidity for Cape Coral Fixed Stations in the NSC

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations									
	_110	_120	_130	_150	_160	_190	_105	_129	_271
_110	1.00000 252	0.18114 0.0124 190	0.28039 <.0001 245	0.26661 0.0016 137	0.37991 <.0001 247	0.30450 <.0001 249	0.53707 <.0001 57	0.25389 0.0639 54	0.42034 0.0016 54
_120	0.18114 0.0124 190	1.00000 202	0.39208 <.0001 198	0.53727 <.0001 144	0.29568 <.0001 198	0.35140 <.0001 200	0.41947 0.0014 55	0.42929 0.0008 58	0.33969 0.0079 60
_130	0.28039 <.0001 245	0.39208 <.0001 198	1.00000 256	0.40868 <.0001 141	0.45682 <.0001 253	0.41687 <.0001 254	0.34731 0.0081 57	0.42141 0.0010 58	0.44091 0.0004 60
_150	0.26661 0.0016 137	0.53727 <.0001 144	0.40868 <.0001 141	1.00000 145	0.52601 <.0001 141	0.52650 <.0001 143	. . 0	. . 0	1.00000 . 2
_160	0.37991 <.0001 247	0.29568 <.0001 198	0.45682 <.0001 253	0.52601 <.0001 141	1.00000 256	0.72216 <.0001 256	0.38123 0.0034 57	0.53909 <.0001 58	0.25779 0.0507 58
_190	0.30450 <.0001 249	0.35140 <.0001 200	0.41687 <.0001 254	0.52650 <.0001 143	0.72216 <.0001 256	1.00000 259	0.25389 0.0567 57	0.50456 <.0001 58	0.40539 0.0016 58
_105	0.53707 <.0001 57	0.41947 0.0014 55	0.34731 0.0081 57	. . 0	0.38123 0.0034 57	0.25389 0.0567 57	1.00000 58	0.21803 0.1098 55	0.34285 0.0104 55
_129	0.25389 0.0639 54	0.42929 0.0008 58	0.42141 0.0010 58	. . 0	0.53909 <.0001 58	0.50456 <.0001 58	0.21803 0.1098 55	1.00000 58	0.29246 0.0259 58
_271	0.42034 0.0016 54	0.33969 0.0079 60	0.44091 0.0004 60	1.00000 . 2	0.25779 0.0507 58	0.40539 0.0016 58	0.34285 0.0104 55	0.29246 0.0259 58	1.00000 60

2.1.7 TOTAL SUSPENDED SOLIDS

TSS is an indicator of water clarity, measuring the dry-weight of particles in a sample trapped by a filter and can be of organic or inorganic origin. TSS was sampled routinely by Cape Coral, and each station's frequency is displayed in Table 2-15.

Table 2-15. Total Suspended Solids Sampling Frequency by Station for Cape Coral Fixed Stations in the NSC

	Station									
Year	105	110	120	129	130	150	160	190	271	Total
1991	-	4	3	-	4	3	4	3	-	21
1992	-	12	12	-	12	12	12	12	-	72
1993	-	12	8	-	12	8	12	12	-	64
1994	-	11	-	-	11	-	11	11	-	44
1995	-	12	-	-	12	-	12	12	-	48
1996	-	12	-	-	12	-	12	12	-	48
1997	-	12	-	-	12	-	12	12	-	48
1998	-	12	-	-	9	-	9	9	-	39
1999	-	12	-	-	12	-	12	12	-	48
2000	-	11	-	-	11	-	11	11	-	44
2001	-	11	-	-	11	-	11	11	-	44
2002	-	12	-	-	10	-	10	10	-	42
2003	-	13	-	-	11	-	12	12	-	48
2004	-	12	-	-	11	-	12	12	-	47
2005	-	12	-	-	12	-	12	12	-	48
2006	-	12	-	-	12	-	11	12	-	47
2007	-	12	-	-	12	-	12	12	-	48
2008	5	12	3	3	12	-	12	12	3	62
2009	10	10	11	11	11	-	11	11	11	86
2010	12	12	12	12	12	-	12	12	12	96
2011	12	12	12	12	12	-	12	12	12	96
2012	9	9	12	9	12	-	9	9	12	81
2013	12	11	12	12	12	-	12	12	12	95
Total	60	260	85	59	257	23	255	255	62	1316

Annual arithmetic averages of total suspended solids values collected by Cape Coral from 2008-2013 are provided in Figure 2-30. Stations 120, 130, and 271 had the highest annual average of TSS values. For Cape Coral, the period of record is truncated to 2008-2013 since all stations (except Station 150) were collecting salinity data over this time period.

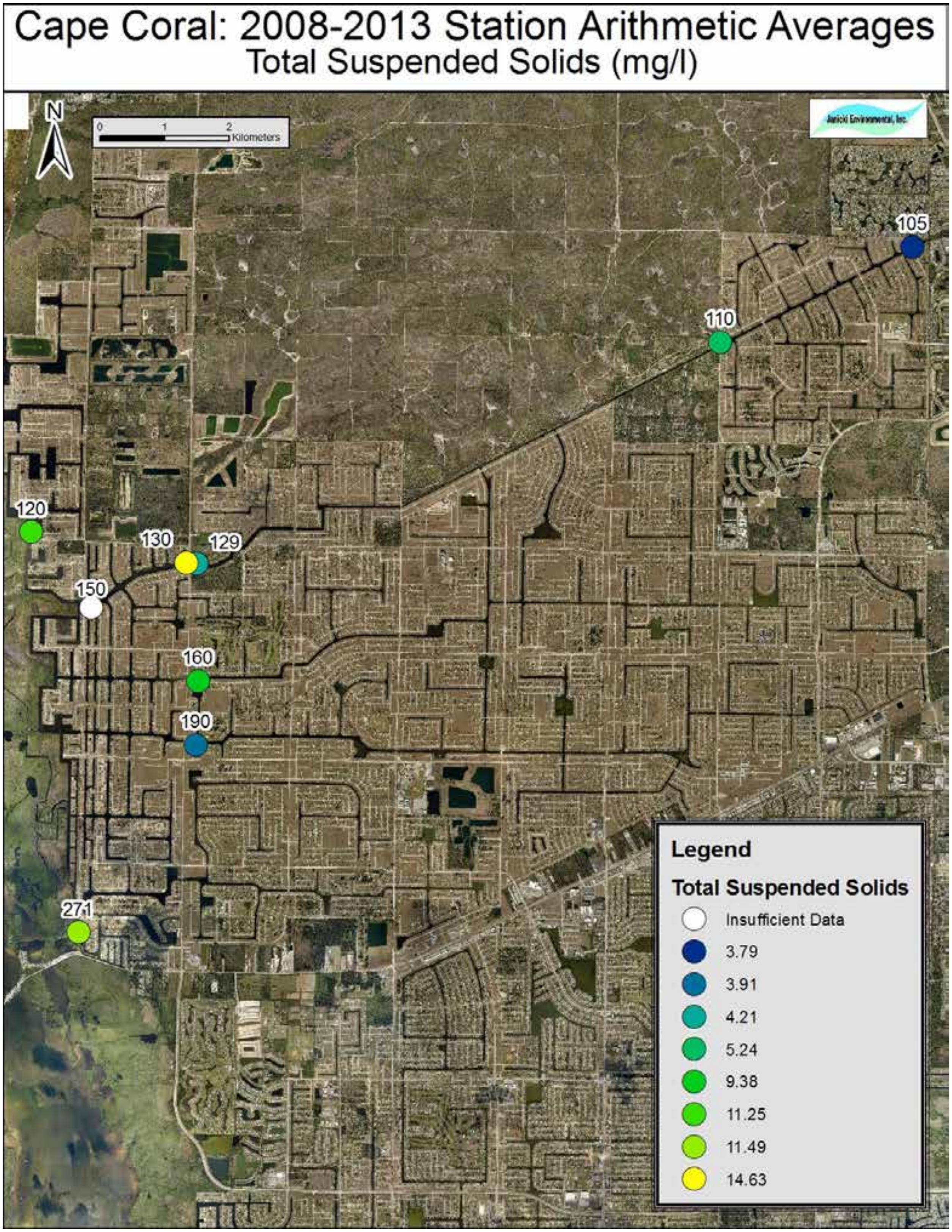


Figure 2-30. Arithmetic Averages for Total Suspended Solids for Cape Coral Station Samples Collected between 2008-2013 in the NSC

Between-station variability in TSS is presented in Figure 2-31. These plots represent the entire period of record for each station, which varied among stations. Note that TSS measurements were taken at Station 150 only in 1992 and 1994. Stations 120, 130 and 271 tended to be higher than the other stations sampled in Cape Coral and are more likley to have values above 7.5 mg/L. These plots are trimmed so that extremely high values are not displayed in the plots.

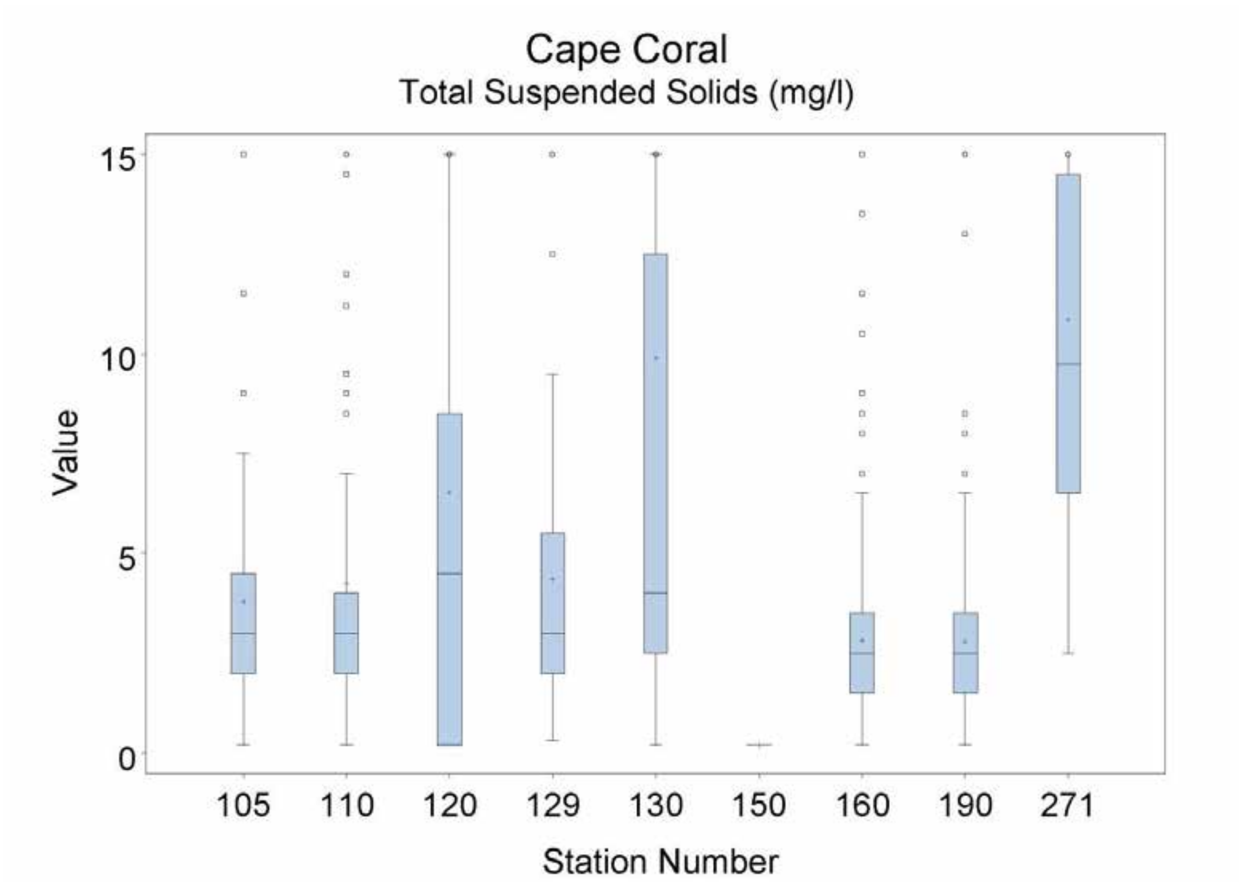


Figure 2-31. Box and Whisker Plots Displaying Total Suspended Solids Distribution among Cape Coral Fixed Water Quality Stations in the NSC

Time series plots of total suspended solids measurements taken by Cape Coral indicate average TSS values tend to be under 15 mg/L, with the exception of Station 130, which was as high as 45 mg/L in 2007 (Figure 2-32). Station 130 did not have good agreement with the other stations sampled during this time frame, in some cases showing increasing values where other stations showed decreasing values. The additional stations sampled beginning in 2008 (105, 120, 129, and 271) resulted in higher overall TSS values during that time period.

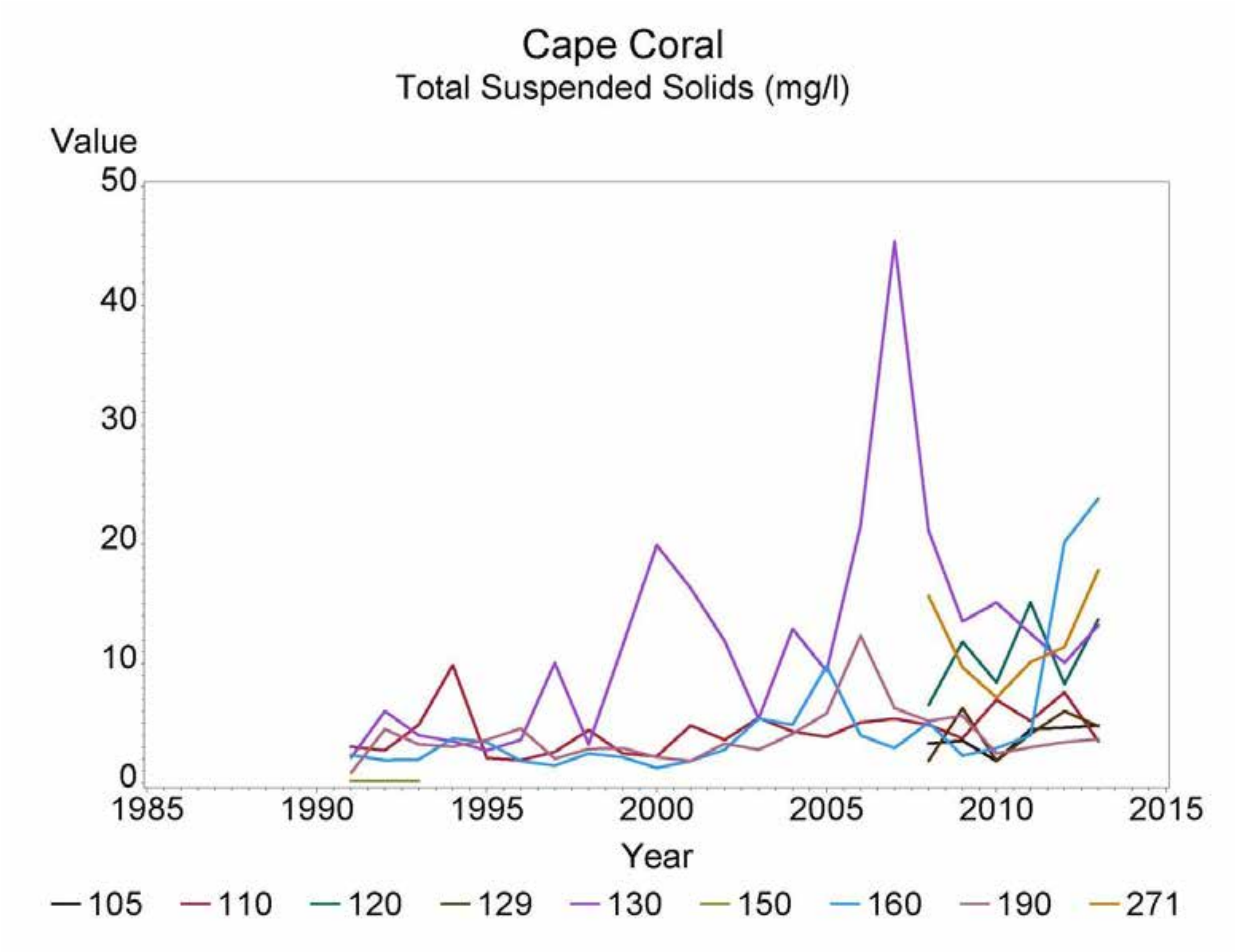


Figure 2-32. Time Series Plot of Total Suspended Solids for Cape Coral Water Quality Stations in the NSC

Trends for TSS measurements for Cape Coral stations are presented in Figure 2-33. No trends were examined for Station 129 due to insufficient data (n <60 for TSS observations). Most stations displayed a large increasing trend in TSS, with the exception of Station 105.

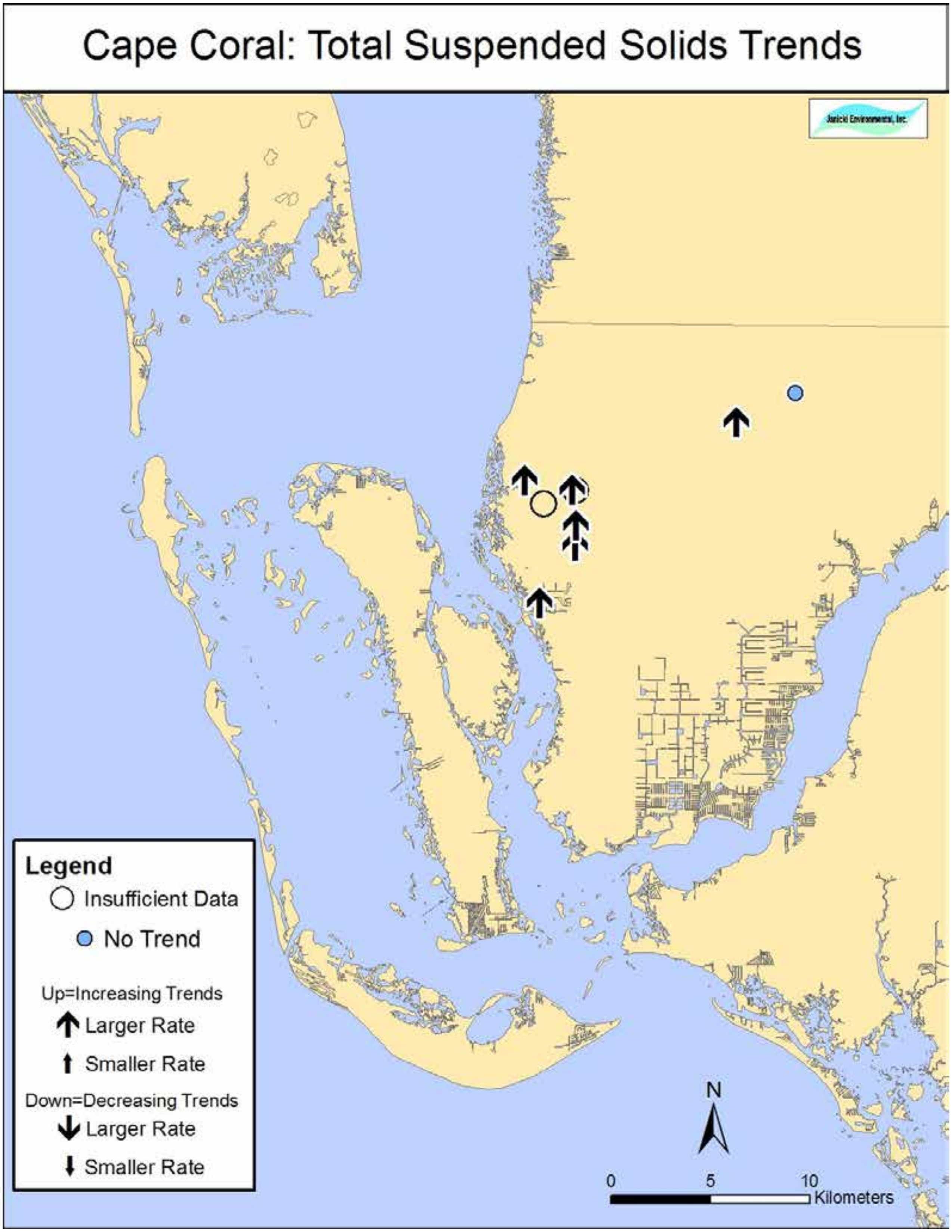


Figure 2-33. Total Suspended Solids Trends for Cape Coral Fixed Stations in the NSC

Cross correlation analysis suggested that TSS concentrations among stations for long-term stations were greatest between Stations 120 and 130 as well as 160 and 190. For the short-term correlation among stations with observations since 2008, no significant correlations were found (Table 2-16).

Table 2-16. Spearman Rank Correlation Coefficients for Total Suspended Solids for Cape Coral Fixed Stations in the NSC

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations	_110	_120	_130	_150	_160	_190	_105	_129	_271
_110	1.00000 257	0.30793 0.0061 78	0.17856 0.0048 248	. . 22	0.26568 <.0001 249	0.12228 0.0535 250	0.26796 0.0402 59	-0.04177 0.7598 56	0.11152 0.4132 56
_120	0.30793 0.0061 78	1.00000 83	0.69392 <.0001 82	. . 23	0.27098 0.0150 80	0.10504 0.3507 81	0.24425 0.0671 57	0.01020 0.9394 58	0.28750 0.0259 60
_130	0.17856 0.0048 248	0.69392 <.0001 82	1.00000 253	. . 22	0.24723 <.0001 250	0.19527 0.0019 251	0.52338 <.0001 59	0.25406 0.0543 58	0.43847 0.0005 60
_150	. . 22	. . 23	. . 22	. . 23	. . 22	. . 23	. . 0	. . 0	. . 0
_160	0.26568 <.0001 249	0.27098 0.0150 80	0.24723 <.0001 250	. . 22	1.00000 252	0.47787 <.0001 252	0.18563 0.1592 59	0.26159 0.0473 58	0.37892 0.0034 58
_190	0.12228 0.0535 250	0.10504 0.3507 81	0.19527 0.0019 251	. . 23	0.47787 <.0001 252	1.00000 254	0.16441 0.2134 59	0.28693 0.0290 58	0.04326 0.7471 58
_105	0.26796 0.0402 59	0.24425 0.0671 57	0.52338 <.0001 59	. . 0	0.18563 0.1592 59	0.16441 0.2134 59	1.00000 60	0.19218 0.1521 57	0.13605 0.3129 57
_129	-0.04177 0.7598 56	0.01020 0.9394 58	0.25406 0.0543 58	. . 0	0.26159 0.0473 58	0.28693 0.0290 58	0.19218 0.1521 57	1.00000 58	0.14639 0.2728 58
_271	0.11152 0.4132 56	0.28750 0.0259 60	0.43847 0.0005 60	. . 0	0.37892 0.0034 58	0.04326 0.7471 58	0.13605 0.3129 57	0.14639 0.2728 58	1.00000 60

2.1.8 SECCHI DISK

A secchi disk measurement is taken to measure the transparency of the water and is related to turbidity. Secchi disk measurements have been routinely taken by Cape Coral at Stations 110, 120, 130, 150, 160, and 190 since 1991, and at Stations 105, 129, and 271 since 2008 (Table 2-17).

Table 2-17. Secchi Disk Sampling Frequency by Station for Cape Coral Fixed Stations in the NSC

Year	Station									
	105	110	120	129	130	150	160	190	271	Total
1991	-	4	3	-	4	3	4	3	-	21
1992	-	12	12	-	12	12	12	12	-	72
1993	-	12	11	-	12	11	12	12	-	70
1994	-	12	11	-	12	11	12	12	-	70
1995	-	12	12	-	12	12	12	12	-	72
1996	-	12	11	-	12	12	12	12	-	71
1997	-	12	12	-	12	12	12	12	-	72
1998	-	11	12	-	12	12	12	12	-	71
1999	-	12	12	-	12	12	12	12	-	72
2000	-	10	11	-	11	11	11	11	-	65
2001	-	12	12	-	11	12	12	12	-	71
2002	-	11	11	-	11	12	11	12	-	68
2003	-	8	10	-	10	10	10	10	-	58
2004	-	11	12	-	11	12	12	12	-	70
2005	-	12	12	-	12	12	12	12	-	72
2006	-	10	11	-	10	11	9	11	-	62
2007	-	10	12	-	11	12	12	12	-	69
2008	5	10	12	3	12	12	12	12	3	81
2009	10	11	11	11	10	11	11	11	11	97
2010	12	12	12	12	12	12	12	12	12	108
2011	12	12	12	12	12	12	11	12	12	107
2012	9	9	12	9	12	11	9	9	11	91
2013	10	10	12	12	12	12	12	12	11	103
Total	58	247	258	59	257	259	256	259	60	1713

Annual arithmetic averages of secchi disk values collected by Cape Coral from 2008-2013 are presented in Figure 2-34. Stations 110, 160, and 190 had the highest annual average of secchi disk values, but these values should be interpreted carefully since secchi disk at shallow stations can reach the bottom and, therefore, be truncated by the station depth. For Cape Coral, the period of record is truncated to 2008-2013 since all stations were collecting secchi data over this time period.

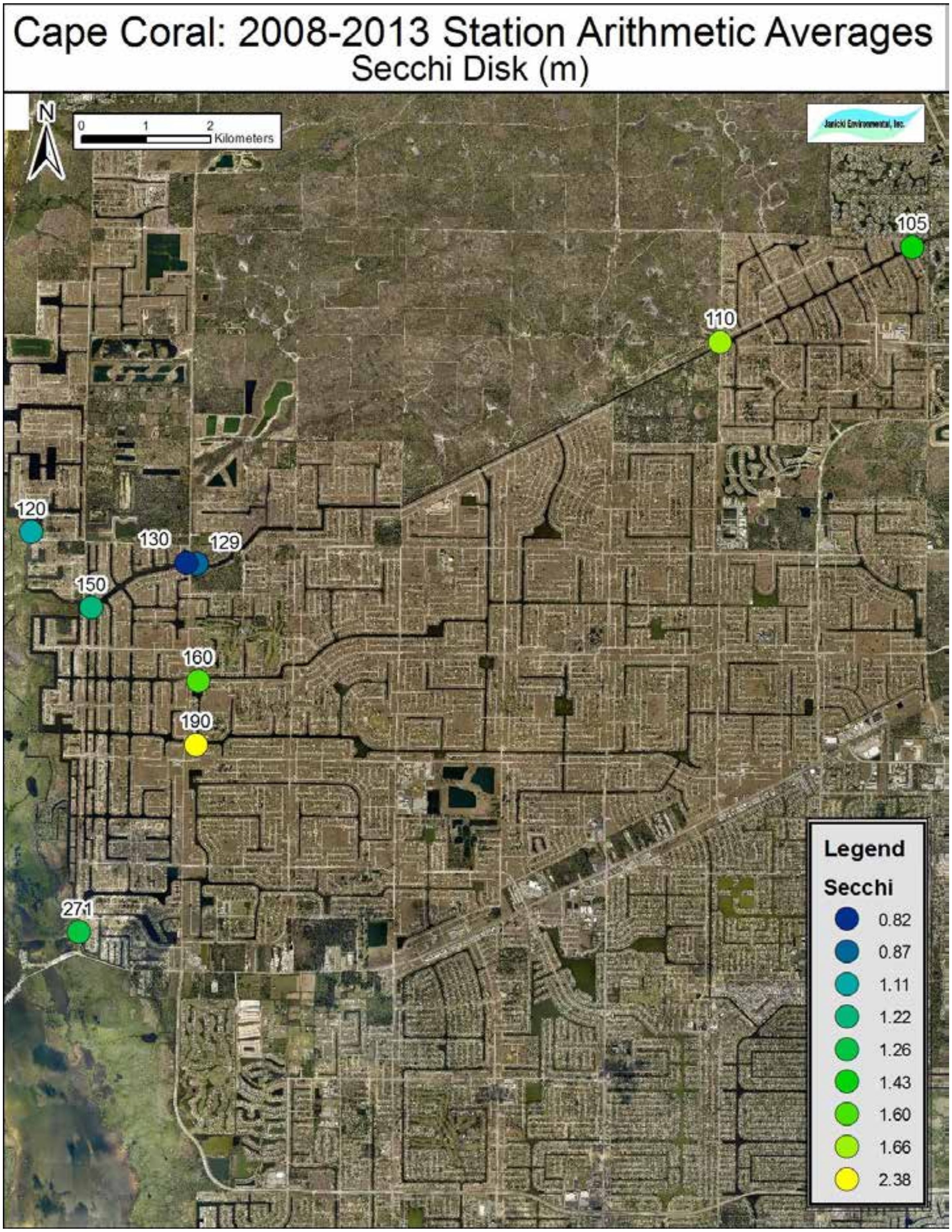


Figure 2-34. Arithmetic Average Secchi Disk Visibilities at Cape Coral Stations for Samples Collected between 2008 and 2013

The distribution of secchi disk visibilities are displayed in Figure 2-35. These plots represent the entire period of record for each station, which varies among stations. This plot shows some between-station variability but may be confounded by station depth.

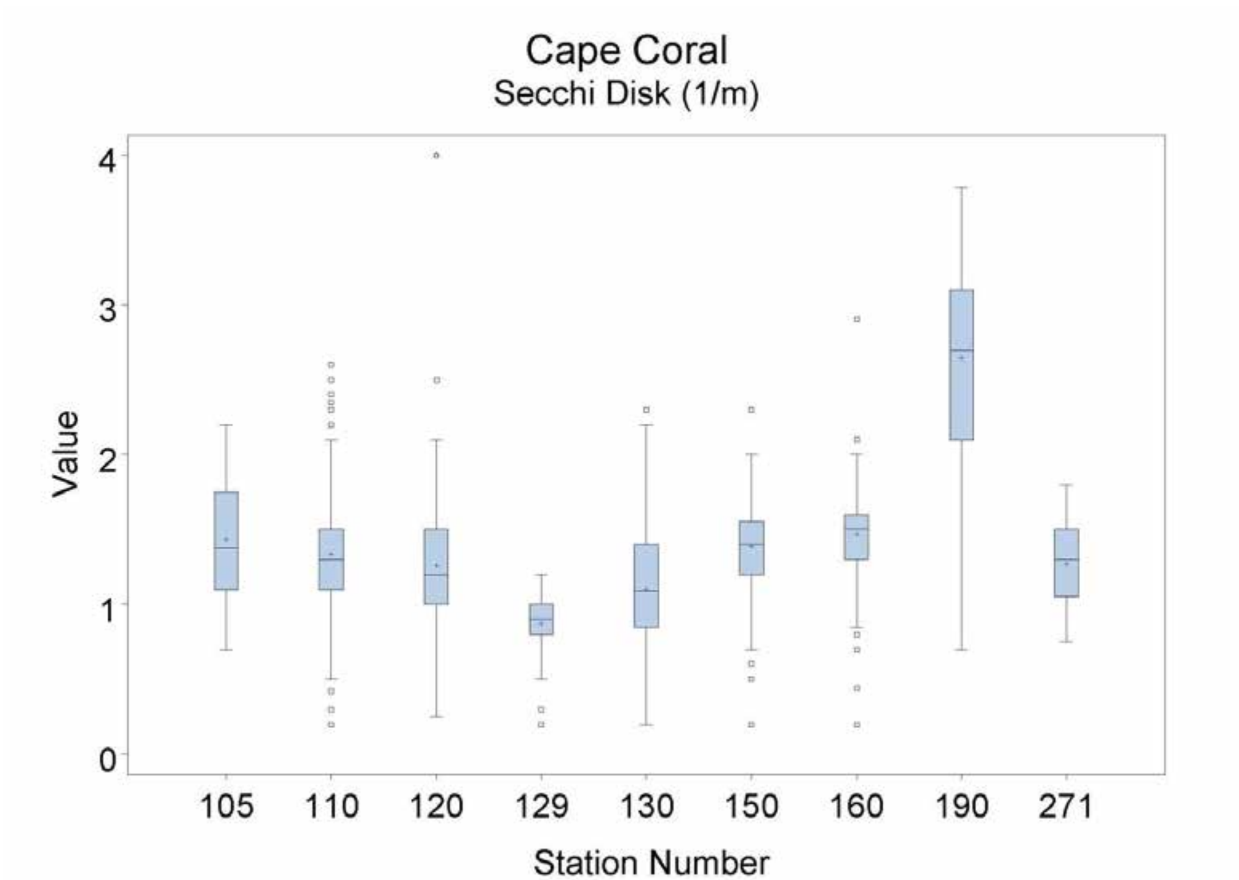


Figure 2-35. Box and Whisker Plots Displaying the Distribution of Secchi Disk Visibility Concentrations among Cape Coral Fixed Water Quality Stations Located within the NSC

Time series plots of annual secchi disk visibility measurements suggest good agreement among stations, except for Station 190 at Hermosa Canal, which was consistently deeper (Figure 2-36).

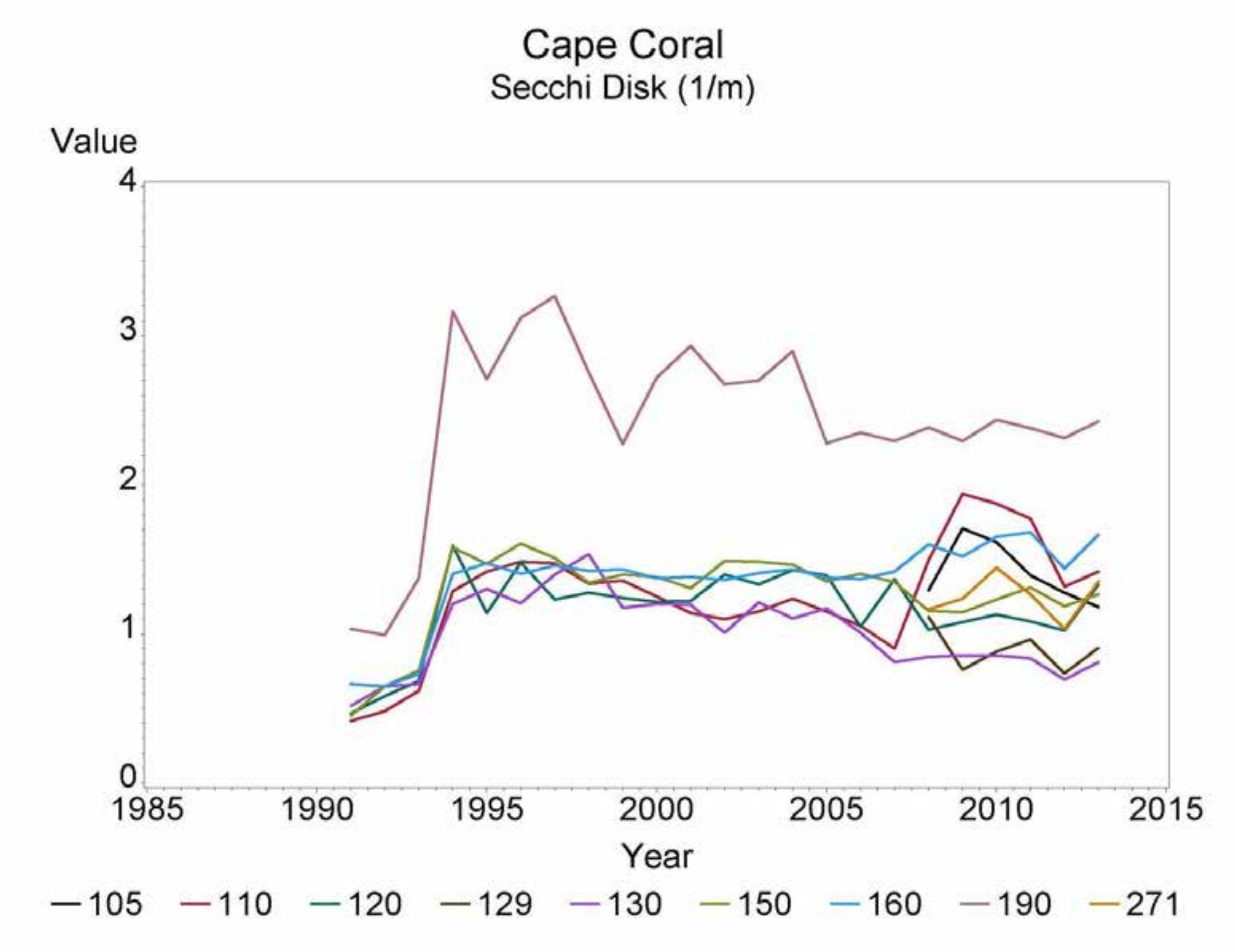


Figure 2-26. Time Series Plot of Secchi Disk Visibility for Cape Coral Water Quality Stations in the NSC

Trends for secchi disk measurements for Cape Coral stations are presented in Figure 2-37. Four stations had decreasing trends over time, while Station 160 had an increasing trend. Assuming that sampling was consistent over the period of record, depth would not confound this result. No trends were examined on Stations 105 and 129 due to insufficient data (n <60 for secchi observations).

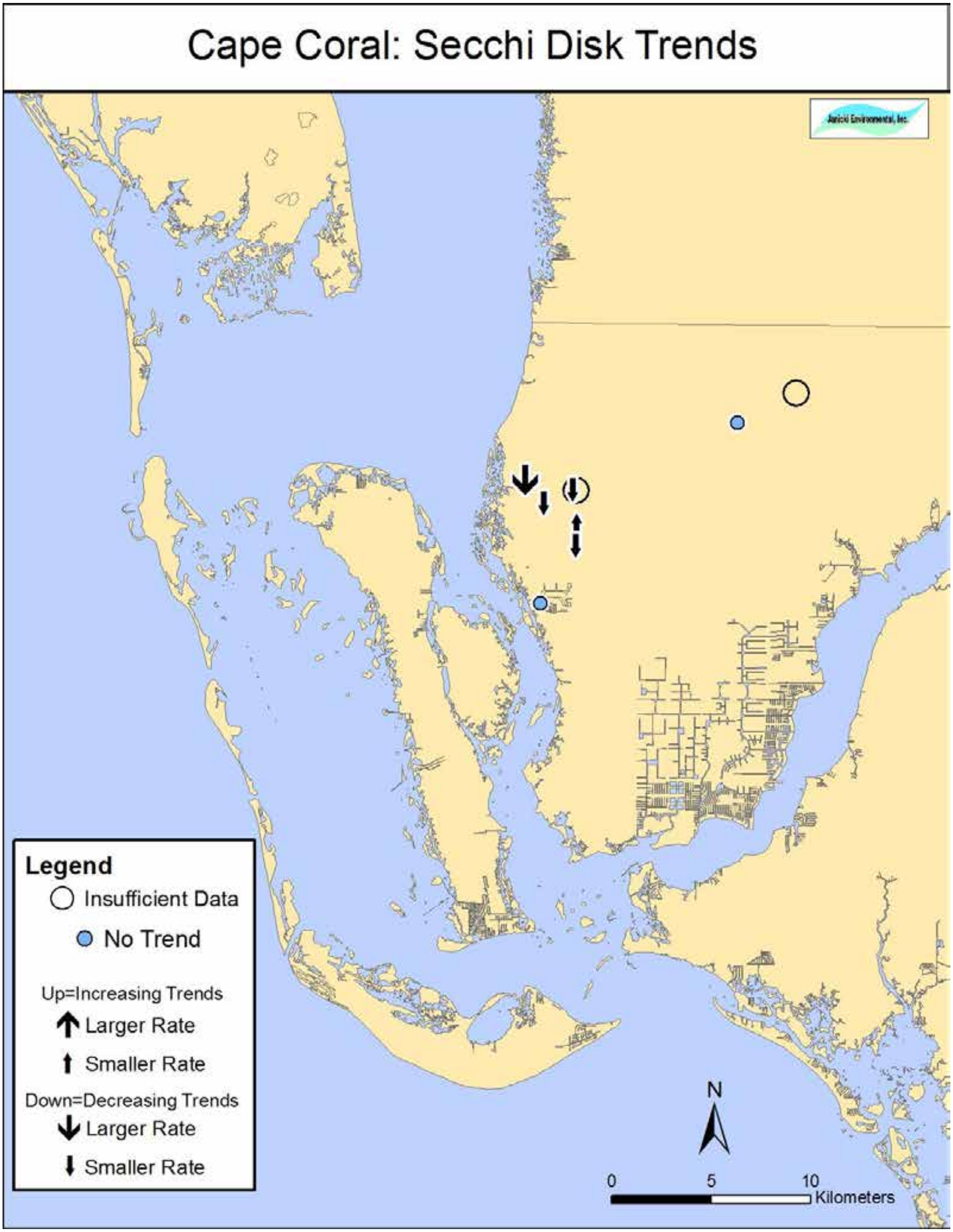


Figure 2-37. Secchi Disk Visibility Trends for Cape Coral Fixed Stations in the NSC

Cross correlation analysis suggested modest correlation among long- and short-term stations. For long-term stations, secchi disk correlations were greatest between Stations 120 and 150 as well as Stations 130 and 150. For the short-term correlation among stations with observations since 2008, correlations were greatest between Stations 129 and 271 (Table 2-18).

Table 2-18. Spearman Rank Correlation Coefficients for Secchi Disk Visibility for Cape Coral Fixed Stations in the NSC

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	_110	_120	_130	_150	_160	_190	_105	_129	_271
_110	1.00000 245	-0.10302 0.1122 239	-0.09354 0.1511 237	-0.10656 0.0996 240	0.24231 0.0002 239	0.00813 0.8997 243	0.53979 <.0001 57	-0.01649 0.9040 56	0.21807 0.1132 54
_120	-0.10302 0.1122 239	1.00000 256	0.25652 <.0001 249	0.51258 <.0001 255	-0.00005 0.9994 249	0.15472 0.0136 254	0.15771 0.2413 57	0.21861 0.0992 58	0.50522 <.0001 58
_130	-0.09354 0.1511 237	0.25652 <.0001 249	1.00000 253	0.47425 <.0001 250	-0.05467 0.3913 248	0.03561 0.5745 251	0.06114 0.6544 56	0.28699 0.0304 57	0.08838 0.5132 57
_150	-0.10656 0.0996 240	0.51258 <.0001 255	0.47425 <.0001 250	1.00000 257	-0.01118 0.8604 250	0.20283 0.0011 255	0.10561 0.4385 56	0.40160 0.0020 57	0.31805 0.0159 57
_160	0.24231 0.0002 239	-0.00005 0.9994 249	-0.05467 0.3913 248	-0.01118 0.8604 250	1.00000 253	-0.10635 0.0914 253	0.17112 0.2073 56	0.45952 0.0003 57	0.08801 0.5229 55
_190	0.00813 0.8997 243	0.15472 0.0136 254	0.03561 0.5745 251	0.20283 0.0011 255	-0.10635 0.0914 253	1.00000 258	0.25804 0.0526 57	0.19877 0.1347 58	0.20720 0.1255 56
_105	0.53979 <.0001 57	0.15771 0.2413 57	0.06114 0.6544 56	0.10561 0.4385 56	0.17112 0.2073 56	0.25804 0.0526 57	1.00000 58	-0.05652 0.6819 55	0.20081 0.1494 53
_129	-0.01649 0.9040 56	0.21861 0.0992 58	0.28699 0.0304 57	0.40160 0.0020 57	0.45952 0.0003 57	0.19877 0.1347 58	-0.05652 0.6819 55	1.00000 58	0.38275 0.0036 56
_271	0.21807 0.1132 54	0.50522 <.0001 58	0.08838 0.5132 57	0.31805 0.0159 57	0.08801 0.5229 55	0.20720 0.1255 56	0.20081 0.1494 53	0.38275 0.0036 56	1.00000 58

2.1.9 FECAL COLIFORM

Fecal coliform concentrations measure the concentration of bacteria indicative of human or animal waste, although coliform bacteria may have plant-based origins as well. Fecal coliforms are used as an indicator of pollution from human or animal sources but also occur naturally where large concentrations of migratory waterfowl congregate in shallow ponds and lakes. In Cape Coral, Stations 110, 130, 160, and 190 have been routinely sampled since 1991(Table 2-19). Stations 105, 129, and 271 have been routinely monitored since 2008. Stations 120 and 150 have had irregular sampling frequencies, as presented in Table 2-19.

Table 2-19. Fecal Coliform Sampling Frequency by Station for Cape Coral Fixed Stations in the NSC

	Station									
Year	105	110	120	129	130	150	160	190	271	Total
1991	-	4	3	-	4	3	4	3	-	21
1992	-	12	12	-	12	12	12	12	-	72
1993	-	11	8	-	11	8	11	11	-	60
1994	-	11	-	-	11	-	11	11	-	44
1995	-	12	1	-	12	3	12	12	-	52
1996	-	11	-	-	12	-	12	12	-	47
1997	-	8	-	-	7	-	7	7	-	29
1998	-	12	-	-	9	-	9	9	-	39
1999	-	11	-	-	10	-	10	10	-	41
2000	-	10	-	-	11	-	11	11	-	43
2001	-	12	-	-	9	-	10	10	-	41
2002	-	12	-	-	9	-	10	11	-	42
2003	-	12	-	-	11	-	12	12	-	47
2004	-	12	-	-	10	-	12	12	-	46
2005	-	12	-	-	12	-	12	12	-	48
2006	-	11	-	-	11	-	10	11	-	43
2007	-	12	-	-	11	-	12	12	-	47
2008	5	12	3	3	12	-	12	12	3	62
2009	10	10	11	11	10	-	11	11	11	85
2010	12	12	12	12	12	-	12	12	12	96
2011	12	12	12	12	12	-	12	12	12	96
2012	9	9	12	9	12	-	9	9	11	80
2013	12	11	12	12	12	-	12	12	11	94
Total	60	251	86	59	242	26	245	246	60	1275

Annual arithmetic averages of fecal coliform concentrations collected by Cape Coral are provided in Figure 2-38. Stations 105 and 110 had the highest annual average of fecal coliform, while Stations 271 had the lowest average concentrations.

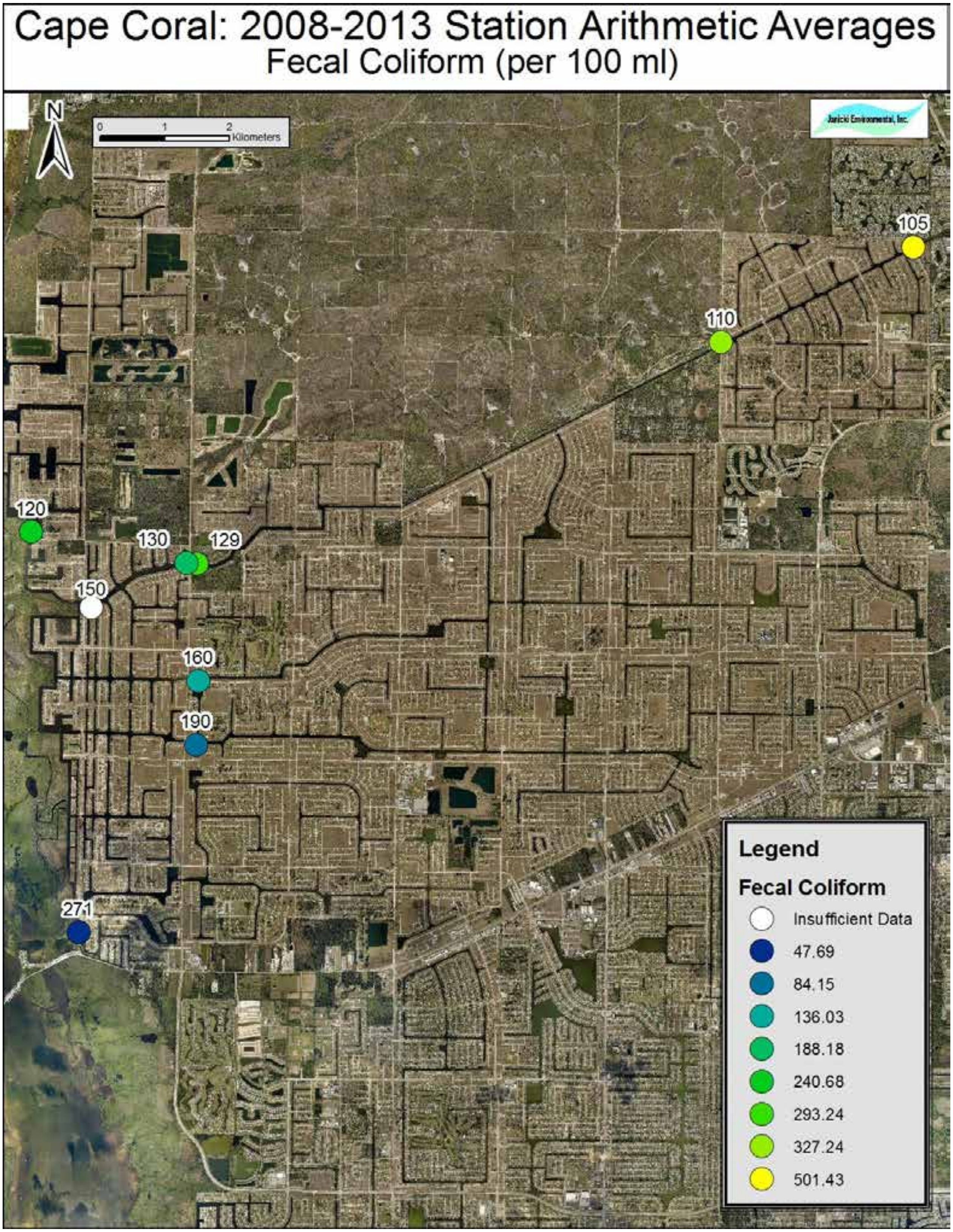


Figure 2-38. Arithmetic Average of Fecal Coliform at Cape Coral Stations for Samples Collected between 2008 and 2013 in the NSC

Between-station variability for fecal coliform concentrations are shown in Figure 2-39. These plots represent the entire period of record for each station, which varies among stations. Note that no fecal coliform measurements were taken at Station 150 after 1995. Stations 105 and 129 tended to have the highest distribution, approaching the instantaneous state threshold of 800 in more than 25 percent of the observations.

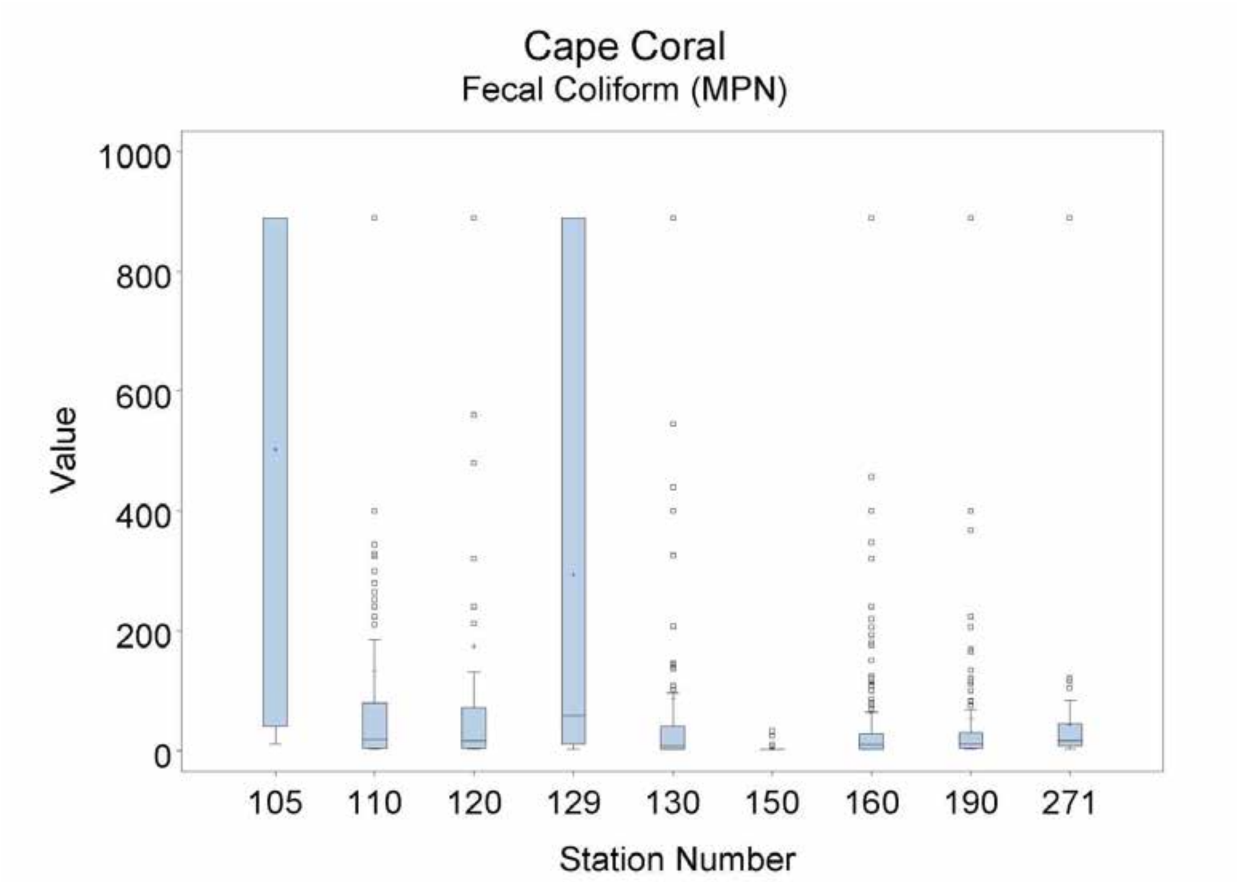


Figure 2-39. Box and Whisker Plots Displaying the Distribution of Fecal Coliform Concentrations among Cape Coral Fixed Water Quality Stations Located within the NSC

Time series plots of fecal coliform concentrations taken by Cape Coral indicate a fairly good agreement among stations up to 2009-2010 (Figure 2-40). A general increase in fecal coliform concentrations can be seen beginning in 2009-2010, at different magnitudes of increase, at all stations except for Stations 120, 129, and 271, which were more variable.

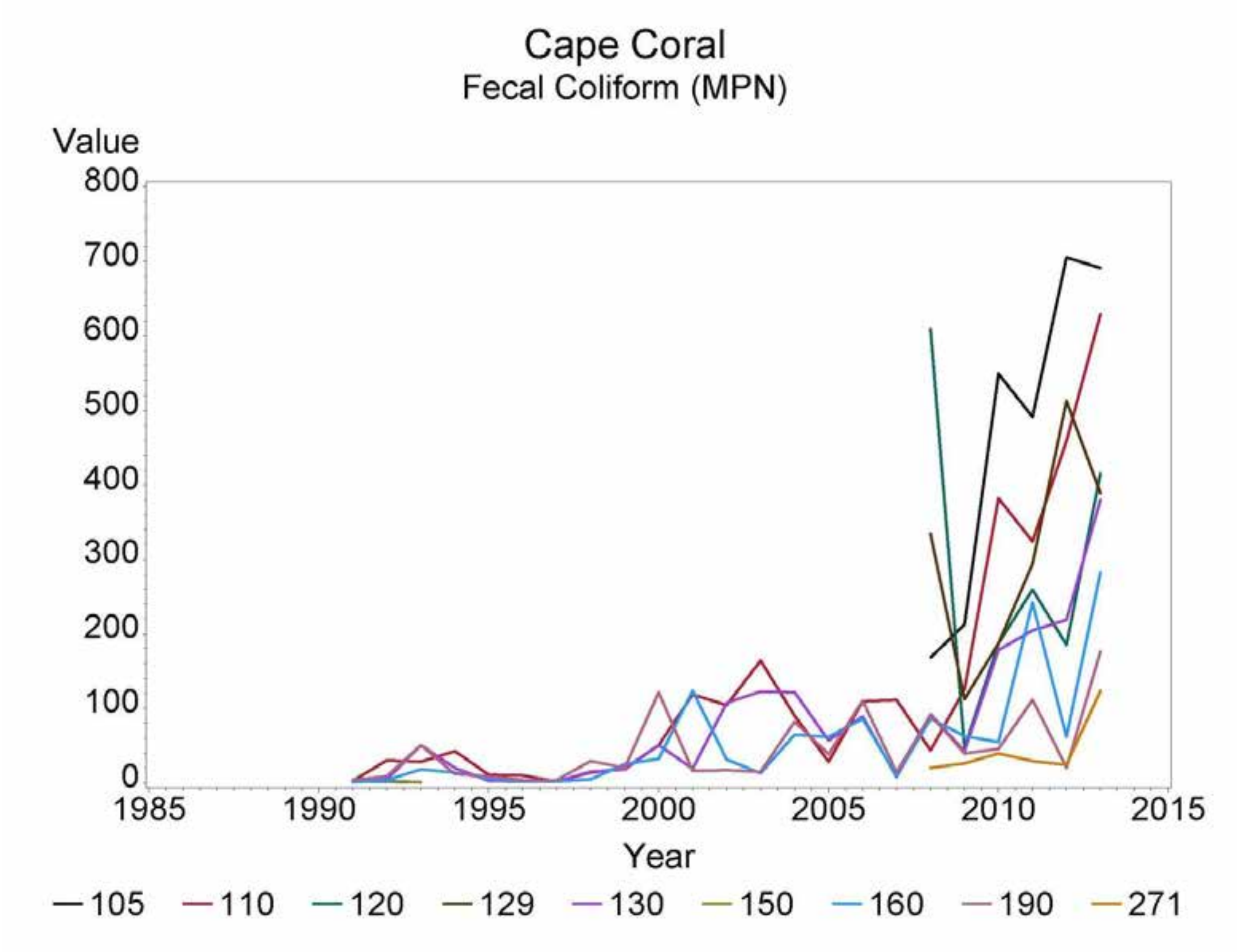


Figure 2-40. Time Series Plot of Fecal Coliform for Cape Coral Water Quality Stations in the NSC

Trends for fecal coliform concentrations for Cape Coral stations are provided in Figure 2-41. Most stations in Cape Coral show increasing trends, and several of these trends were of fairly large magnitude. No trends were examined on Stations 129 and 150 due to insufficient data (n <60 for fecal coliform observations).

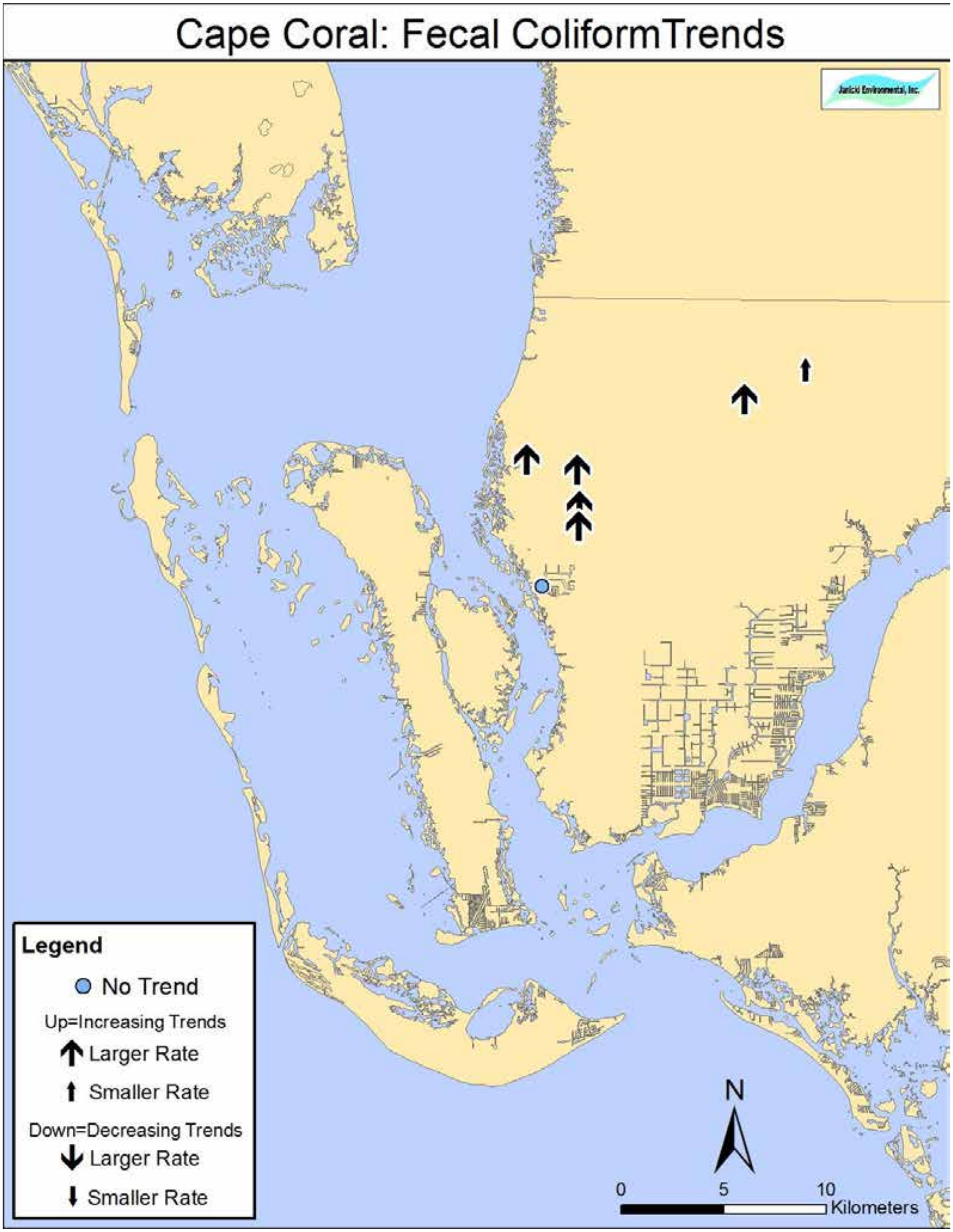


Figure 2-41. Fecal Coliform Trends for Cape Coral Samples Taken in the NSC

Cross correlation analysis suggested that fecal coliform concentrations among stations for long-term stations were greatest between Stations 110 and 130, 130 and 160, and 160 and 190, but all cross correlations for long-term stations were significant. For the short-term correlation among stations with observations since 2008, correlations were greatest between Stations 105 and 110, 129 and 130, 120 and 150, and 190 and 27 (Table 2-20).

Table 2-20. Spearman Rank Correlation Coefficients for Fecal Coliform for Cape Coral Water Quality Stations in the NSC

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations									
	_105	_110	_120	_129	_130	_150	_160	_190	_271
_105	1.00000 60	0.67593 <.0001 59	0.37358 0.0042 57	0.37199 0.0044 57	0.47841 0.0001 58	. . 0	0.37458 0.0035 59	0.26830 0.0399 59	0.32312 0.0161 55
_110	0.67593 <.0001 59	1.00000 249	0.42258 0.0001 79	0.29715 0.0261 56	0.47746 <.0001 232	-0.30181 0.1426 25	0.47797 <.0001 238	0.42904 <.0001 240	0.20794 0.1313 54
_120	0.37358 0.0042 57	0.42258 0.0001 79	1.00000 84	0.67784 <.0001 58	0.58097 <.0001 82	0.77437 <.0001 24	0.52426 <.0001 81	0.44450 <.0001 82	0.50673 <.0001 58
_129	0.37199 0.0044 57	0.29715 0.0261 56	0.67784 <.0001 58	1.00000 58	0.78092 <.0001 57	. . 0	0.55213 <.0001 58	0.35810 0.0058 58	0.28751 0.0317 56
_130	0.47841 0.0001 58	0.47746 <.0001 232	0.58097 <.0001 82	0.78092 <.0001 57	1.00000 238	-0.13284 0.5267 25	0.58996 <.0001 235	0.47103 <.0001 236	0.36959 0.0047 57
_150	. . 0	-0.30181 0.1426 25	0.77437 <.0001 24	. . 0	-0.13284 0.5267 25	1.00000 26	-0.28221 0.1717 25	0.08246 0.6888 26	. . 0
_160	0.37458 0.0035 59	0.47797 <.0001 238	0.52426 <.0001 81	0.55213 <.0001 58	0.58996 <.0001 235	-0.28221 0.1717 25	1.00000 242	0.54974 <.0001 242	0.37080 0.0049 56
_190	0.26830 0.0399 59	0.42904 <.0001 240	0.44450 <.0001 82	0.35810 0.0058 58	0.47103 <.0001 236	0.08246 0.6888 26	0.54974 <.0001 242	1.00000 245	0.77530 <.0001 56
_271	0.32312 0.0161 55	0.20794 0.1313 54	0.50673 <.0001 58	0.28751 0.0317 56	0.36959 0.0047 57	. . 0	0.37080 0.0049 56	0.77530 <.0001 56	1.00000 58

2.2 LEE COUNTY FIXED ESTUARY STATIONS

Lee County maintains a network of fixed water quality stations in the Charlotte Harbor Estuary. Four stations are within Matlacha Pass, and one station (PI-14) is located just inside Boca Grande Pass north of Cayo Costa State Park. The locations of these fixed sampling stations are shown in Figure 2-42.

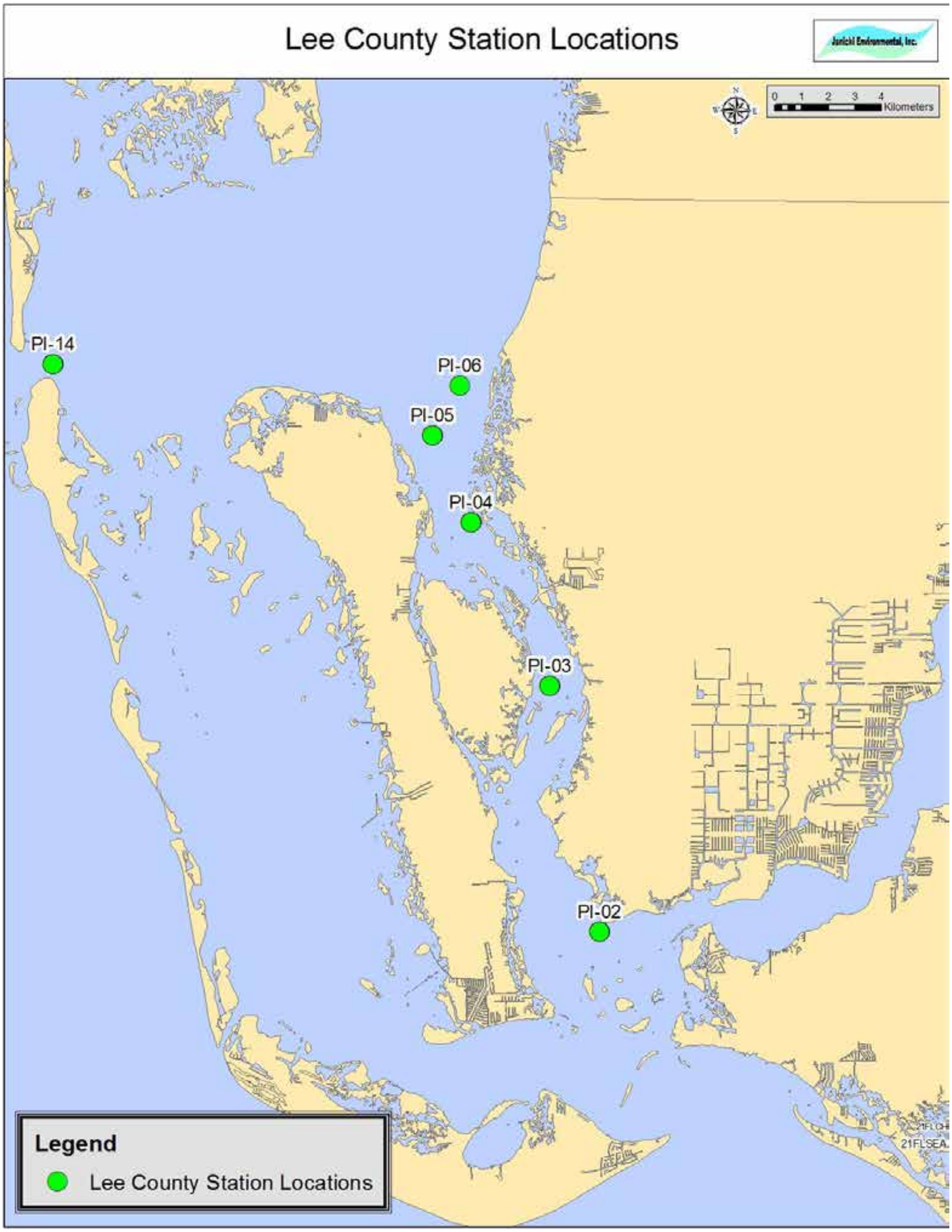


Figure 2-42.   Lee County Sampling Locations

Stations within Lee County's fixed-station sampling network have been routinely sampled since 1996. However, sampling at PI-06 was discontinued in 2003. Table 2-21 shows the period of record for each station sampled within Lee County's fixed-station sampling network.

Table 2-21. Lee County Station Period of Record

Station	Period of Record
PI-02	1996-2014
PI-03	1996-2014
PI-04	1996-2014
PI-05	1996-2014
PI-06	1996-2003
PI-14	1996-2014

A list of the periods of record for each parameter measured at each station is provided Table 2-22. The following subsections characterize the data collected by Lee County at these stations for the principal constituents of interest. Note that this table does not account for data gaps and only reports the minimum and maximum years for each parameter.

Table 2-22. Lee County Constituents Sampled and Period of Record

	Station					
Parameter	PI-02	PI-03	PI-04	PI-05	PI-06	PI-14
Chlorophyll *a* (Chlac_µgl)	1996-2013	1996-2013	1996-2013	1996-2013	1996-2003	1996-2013
Dissolved Oxygen (DO_mgl)	1996-2013	1996-2013	1996-2013	1996-2013	1996-2003	1996-2013
Fecal Coliform (FCOLI)	1996-2009	1996-2009	1996-2009	1996-2009	1996-2003	1996-2009
Salinity	1996-2013	1996-2013	1996-2013	1996-2013	1996-2003	1996-2013
Secchi Disk Visibility	2003-2006, 2008-2013	2003-2013	2003-2013	2003-2013	2003	2003-2013
Total Nitrogen (TN_mgl)	1996-2013	1996-2013	1996-2013	1996-2013	1996-2003	1996-2013
Total Phosphorus (TP_mgl)	1996-2013	1996-2013	1996-2013	1996-2013	1996-2003	1996-2013
Total Suspended Solids (TSS_mgl)	2003-2013	2003-2013	2003-2013	2003-2013	2003	2003-2013
Turbidity (TURB)	1996-2013	1996-2013	1996-2013	1996-2013	1996-2003	1996-2013

2.2.1 SALINITY

Salinity has been consistently sampled by Lee County since 1996 at all stations except PI-06, in which sampling stopped after 2003 (Table 2-23). The numbers in this table represents the sampling frequency at the surface level. Samples are generally taken at near surface and near bottom depths for salinity.

Table 2-23. Salinity Sampling Frequency by Station for Lee County Fixed Stations

	Station						
Year	PI-02	PI-03	PI-04	PI-05	PI-06	PI-14	Total
1996	2	2	2	2	2	2	12
1997	3	3	3	3	3	3	18
1998	4	4	4	4	4	4	24
1999	4	4	4	4	4	4	24
2000	4	4	4	4	4	4	24
2001	12	12	12	12	12	12	72
2002	12	12	12	12	12	12	72
2003	10	9	9	10	7	10	55
2004	9	9	9	9	-	8	44
2005	11	11	11	11	-	11	55
2006	9	11	10	10	-	10	50
2007	12	12	12	12	-	12	60
2008	12	12	12	12	-	12	60
2009	12	12	12	12	-	12	60
2010	12	12	12	12	-	12	60
2011	12	12	12	12	-	12	60
2012	12	12	12	12	-	11	59
2013	10	11	11	10	-	10	52
Total	162	164	163	163	48	161	861

The long-term overall arithmetic average salinity concentration between 1996-2013 for each station is presented in Figure 2-43. Stations PI-02 and PI-03 had the lowest average concentrations, while Station PI-14 had the highest average concentration. Note that Station PI-06 was discontinued after 2003.

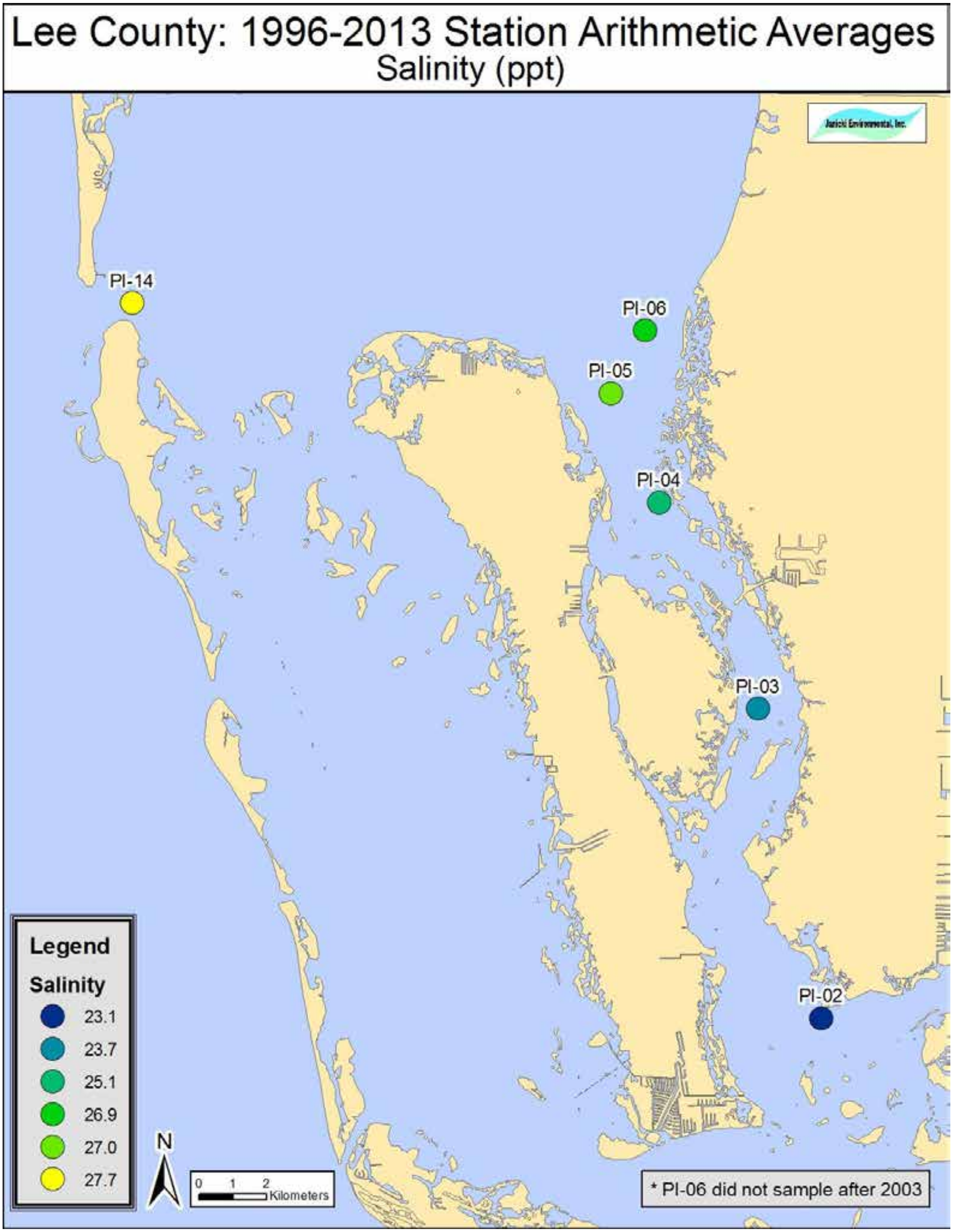


Figure 2-43. Arithmetic Average of Surface Salinities for Lee County Fixed Stations

Between-station variability in surface salinity is provided in Figure 2-44 and is very low. These plots represent the entire period of record for each station. Note that no salinity measurements were taken at Station PI-06 after 2003. As expected, all stations are tidally influenced, as demonstrated by typical values between 15 and 30 practical salinity units (PSU). All stations had median salinity values ranging from 23 to 29 PSU.

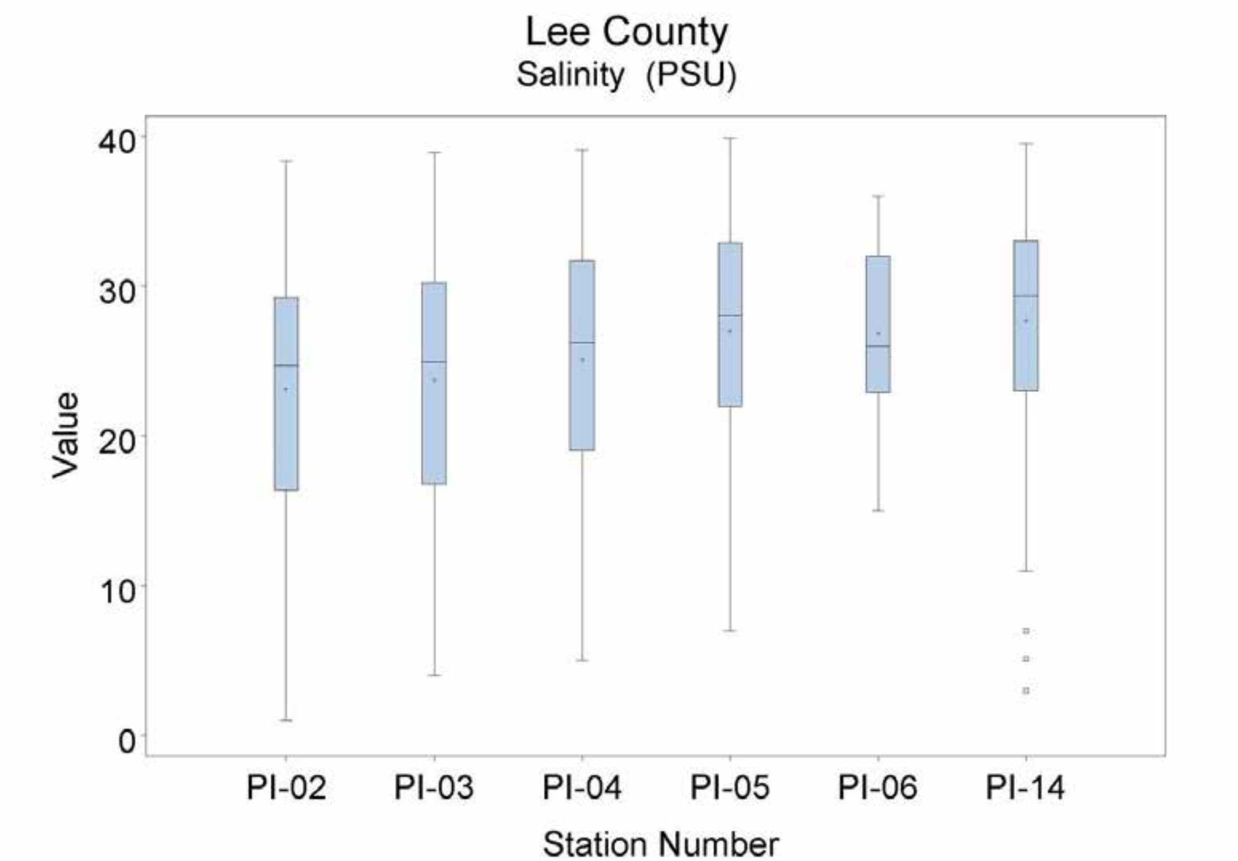


Figure 2-44. Box and Whisker Plots Displaying the Distribution of Surface Salinity Concentrations among Lee County Fixed Stations

Time series plots (Figure 2-45) indicate that there is a high temporal correlation among stations, though their long-term average values differ. A north-to-south decrease in average salinity was also evident, which may be related to the influence of the Caloosahatchee River. A substaintial increase is noted for all stations during the drought of 2007. Afterwards, stations return toward their long-term averages, although at different rates.

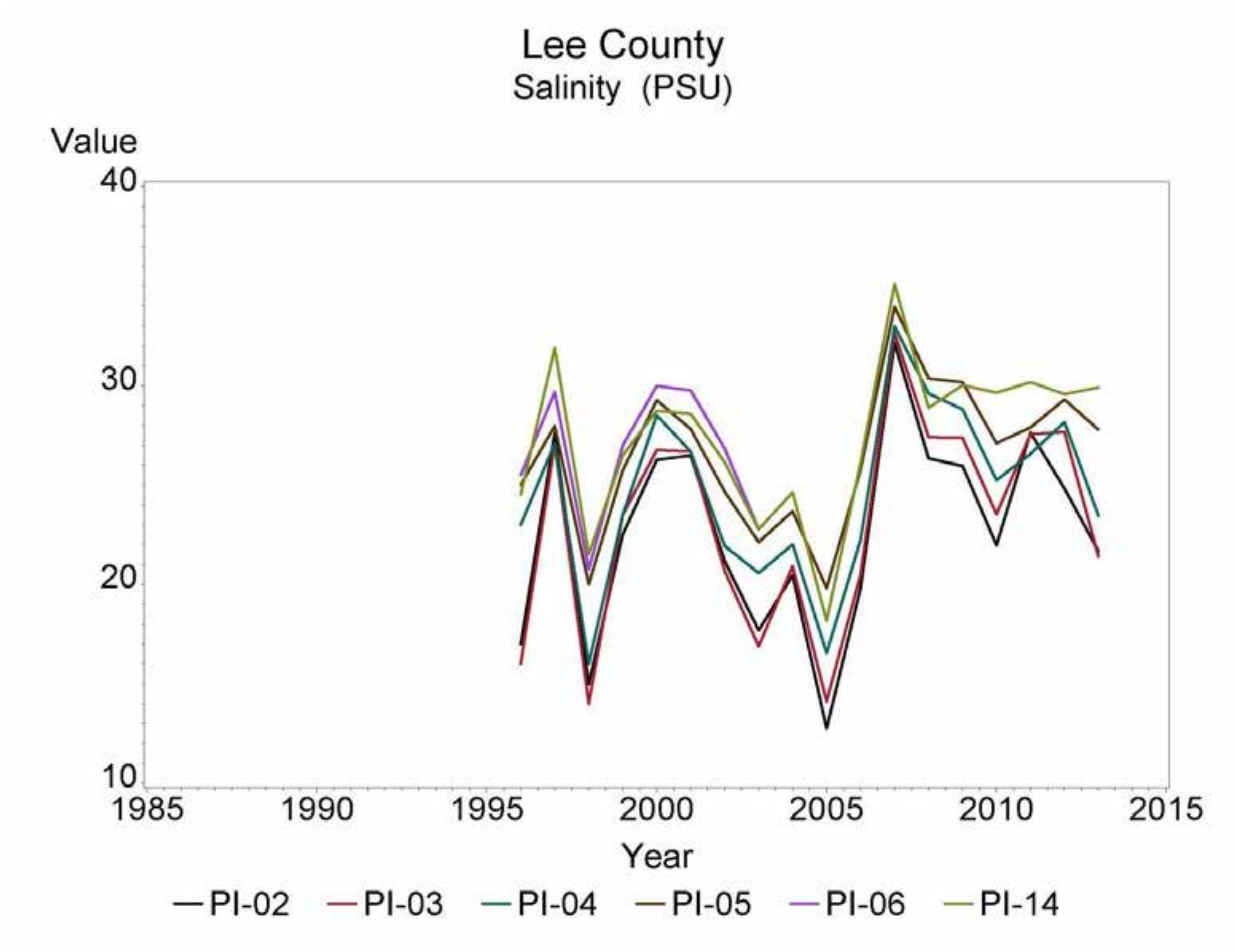


Figure 2-45. Time Series Plots of Surface Salinities for Lee County Fixed Stations

Surface salinity trends for Lee County stations are displayed in Figure 2-46. No monotonic (i.e., linearly increasing or decreasing) trends in surface salinity were identified from 1996 to 2013 for samples collected by Lee County. No trends were examined on Station PI-06 due to insufficient data (n <60 for salinity observations).

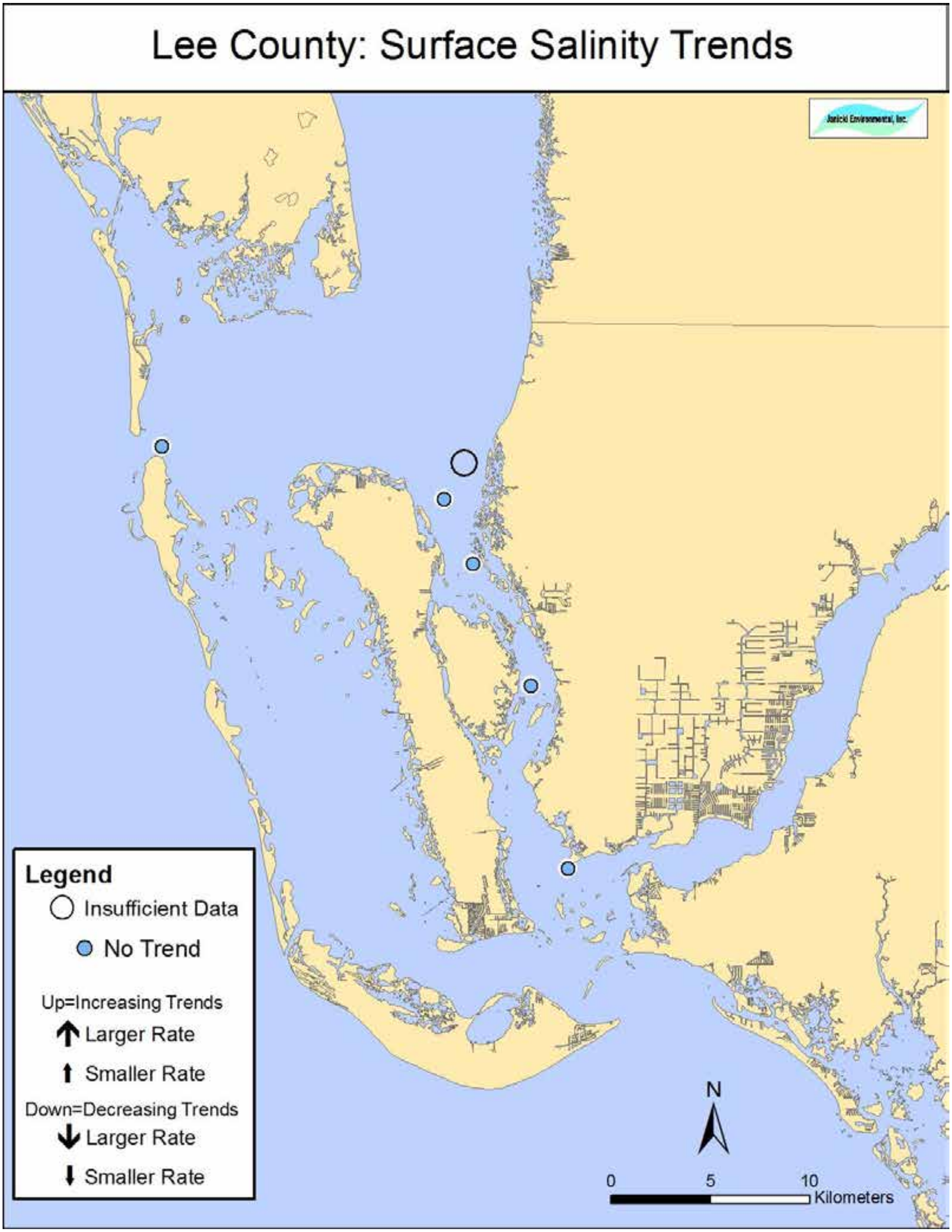


Figure 2-46. Surface Salinity Trends for Lee County Fixed Stations

Cross correlation analysis suggested that salinity concentrations among stations were greatest between Stations PI-04 and PI-05. All cross correlations were found to be highly statistically significant, positive correlations (Table 2-24).

Table 2-24. Spearman Rank Correlation Coefficients for Surface Salinity for Lee County Fixed Stations

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations						
	PI_02	PI_03	PI_04	PI_05	PI_06	PI_14
PI_02	1.00000 162	0.93385 <.0001 161	0.89939 <.0001 160	0.89809 <.0001 161	0.92951 <.0001 47	0.92101 <.0001 160
PI_03	0.93385 <.0001 161	1.00000 164	0.96814 <.0001 162	0.95481 <.0001 162	0.94867 <.0001 47	0.90719 <.0001 160
PI_04	0.89939 <.0001 160	0.96814 <.0001 162	1.00000 163	0.98366 <.0001 162	0.95373 <.0001 47	0.88524 <.0001 159
PI_05	0.89809 <.0001 161	0.95481 <.0001 162	0.98366 <.0001 162	1.00000 163	0.96567 <.0001 47	0.89489 <.0001 160
PI_06	0.92951 <.0001 47	0.94867 <.0001 47	0.95373 <.0001 47	0.96567 <.0001 47	1.00000 47	0.90306 <.0001 47
PI_14	0.92101 <.0001 160	0.90719 <.0001 160	0.88524 <.0001 159	0.89489 <.0001 160	0.90306 <.0001 47	1.00000 161

2.2.2 TOTAL NITROGEN

TN has been routinely sampled by Lee County since 1996 for all stations except Station PI-06, which stopped sampling after 2003 (Table 2-25).

Table 2-25. Total Nitrogen Sampling Frequency by Station for Lee County Fixed Stations

	Station						
Year	PI-02	PI-03	PI-04	PI-05	PI-06	PI-14	Total
1996	2	2	2	2	2	2	12
1997	3	3	3	3	3	3	18
1998	4	4	4	4	4	4	24
1999	4	4	4	4	4	4	24
2000	4	4	4	4	4	4	24
2001	12	12	12	12	12	12	72
2002	12	12	12	12	12	12	72
2003	10	9	9	10	7	10	55
2004	9	9	9	9	-	8	44
2005	11	11	11	11	-	11	55
2006	9	11	10	10	-	10	50
2007	12	12	12	12	-	12	60
2008	12	12	12	12	-	12	60
2009	12	12	12	12	-	12	60
2010	12	12	12	12	-	12	60
2011	12	12	12	12	-	12	60
2012	12	12	12	12	-	11	59
2013	10	11	11	10	-	10	52
Total	162	164	163	163	48	161	861

The overall arithmetic average TN concentration between 1996 and 2013 for each station is provided in Figure 2-47. Stations PI-06 and PI-05 had the lowest average concentrations, while Station PI-03 had the highest average concentration. Note that Station PI-06 stopped taking measurements after 2003.

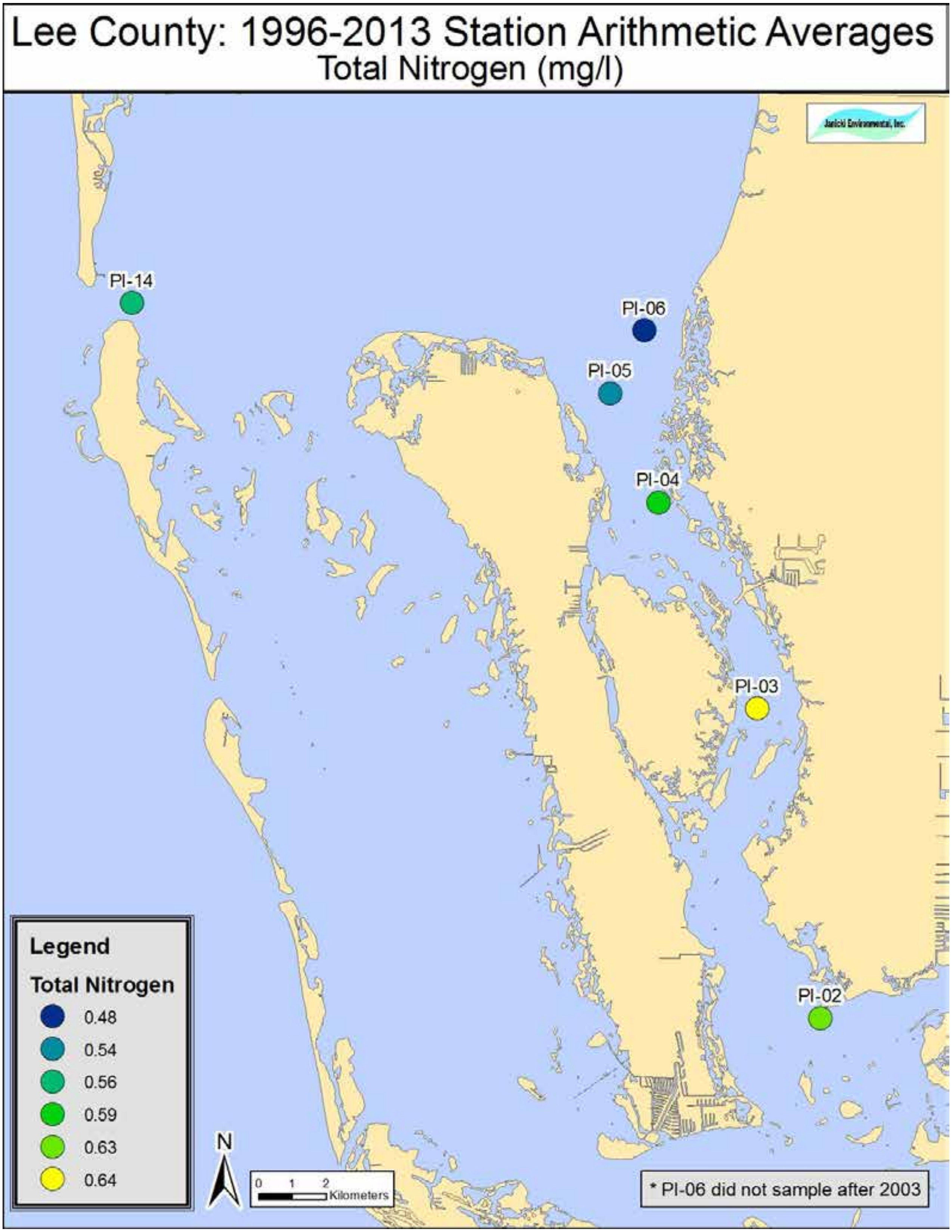


Figure 2-47. Arithmetic Averages for Total Nitrogen for Lee County Fixed Sampling Stations

Between-station variability in TN concentrations is portrayed in Figure 2-48. These plots represent the entire period of record for each station, which varies among stations. Note that no TN measurements were taken at Station PI-06 after 2003. While there are differences among stations, more than 75 percent of the values in all stations were below 1.0 mg/L, indicating that nitrogen concentrations are not unusually elevated at any location Lee County sampled. However, spikes in nitrogen concentrations did occur. These plots are trimmed such that extremely high values are not displayed in the plots.

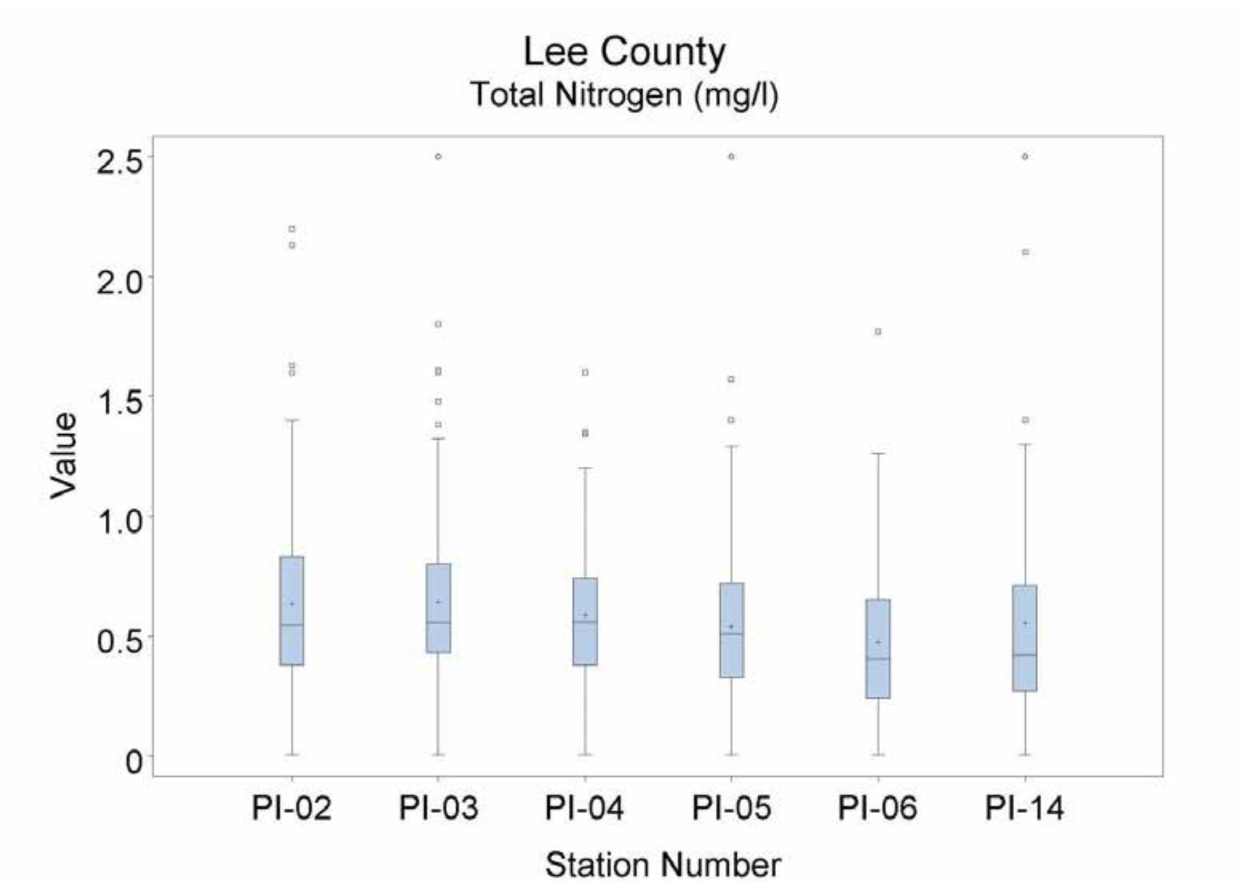


Figure 2-48. Box and Whisker Plots Displaying the Distribution of Total Nitrogen Concentrations among Lee County Fixed Sampling Stations

Time series plots of TN measurements taken by Cape Coral indicate excellent agreement among stations (Figure 2-49). However, PI-05 indicated a very high value (close to 5 mg/L) compared to the other stations when measurements first began in 1996 and only two samples were taken in that year.

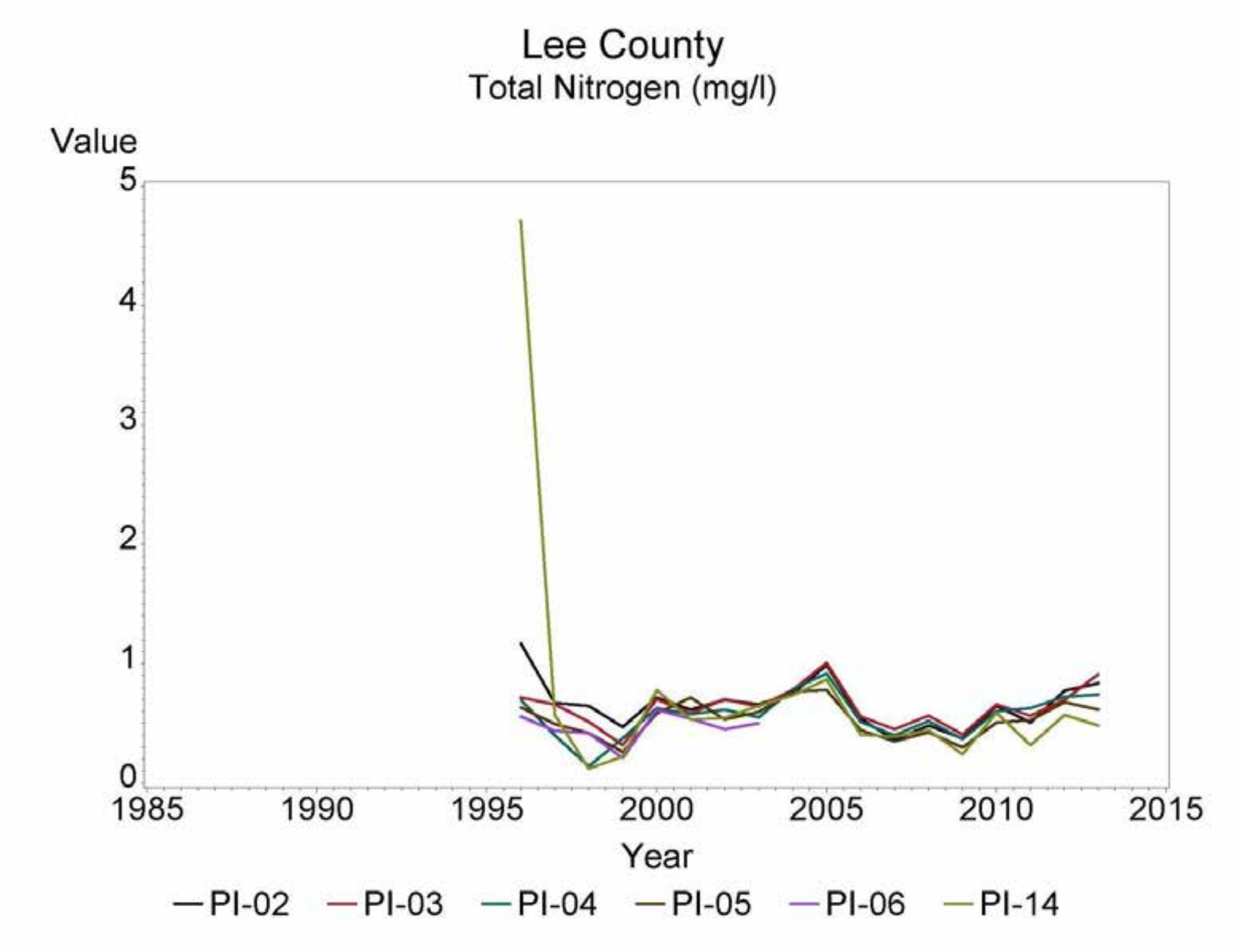


Figure 2-49. Time Series Plot of Total Nitrogen for Lee County Fixed Sampling Stations

TN trends for Lee County stations are displayed in Figure 2-50. No trends in TN were identified from 1996-2013 for samples Lee County collected. No trends were examined on Station PI-06 due to insufficient data (n <60 for TN observations).

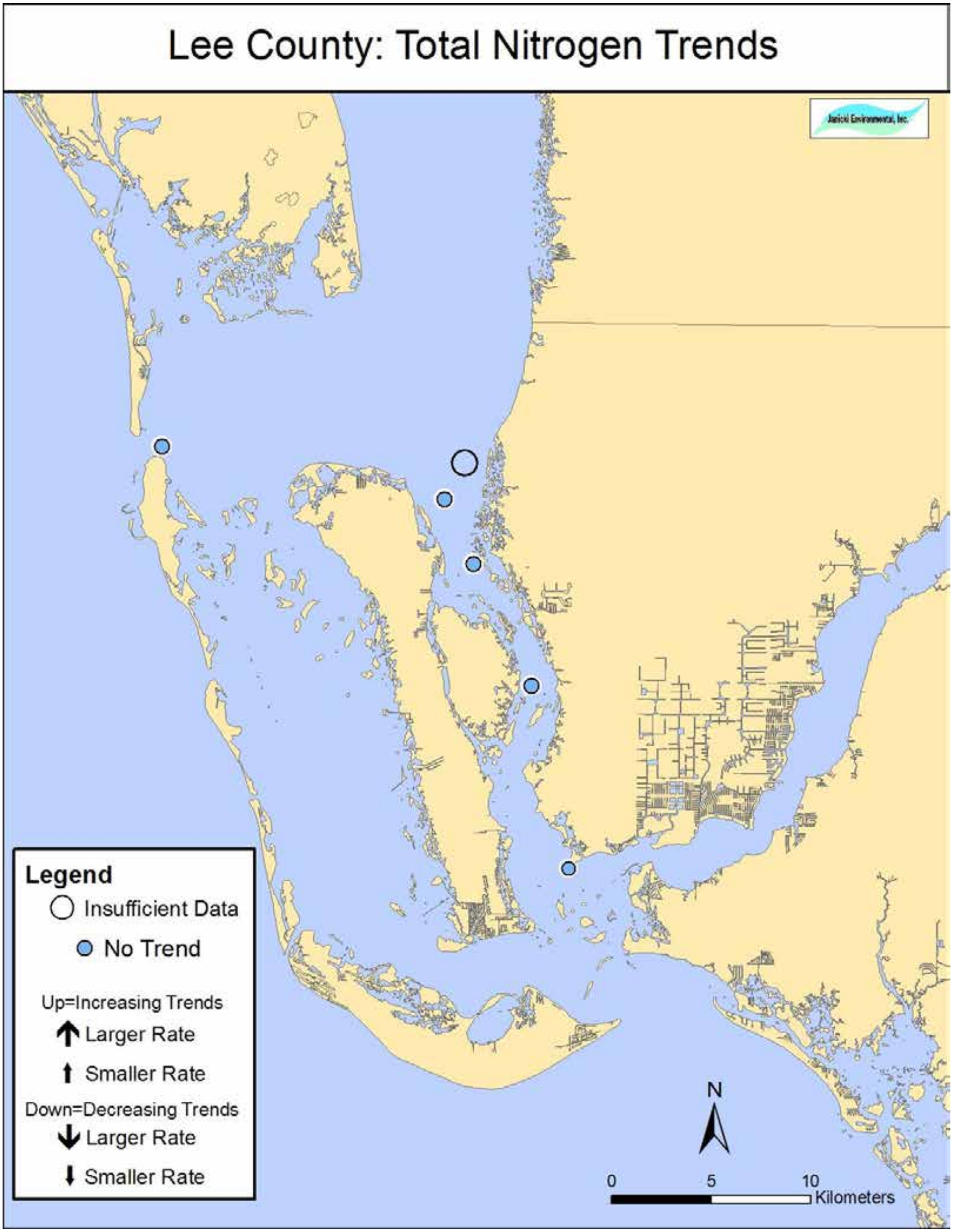


Figure 2-50. Total Nitrogen Trends for Lee County Fixed Sampling Stations

Cross correlation analysis suggested that TN concentrations among stations were all highly correlated, even between stations inside Matlacha Pass and Station PI-14 near the Boca Grande Pass (Table 2-26).

Table 2-26. Spearman Rank Correlation Coefficients for Total Nitrogen for Lee County Fixed Stations

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	PI_02	PI_03	PI_04	PI_05	PI_06	PI_14
PI_02	1.00000 162	0.78055 <.0001 161	0.71410 <.0001 160	0.77082 <.0001 161	0.88661 <.0001 47	0.73663 <.0001 160
PI_03	0.78055 <.0001 161	1.00000 164	0.79579 <.0001 162	0.74057 <.0001 162	0.89389 <.0001 47	0.69928 <.0001 160
PI_04	0.71410 <.0001 160	0.79579 <.0001 162	1.00000 163	0.81140 <.0001 162	0.73138 <.0001 47	0.69530 <.0001 159
PI_05	0.77082 <.0001 161	0.74057 <.0001 162	0.81140 <.0001 162	1.00000 163	0.92258 <.0001 47	0.69878 <.0001 160
PI_06	0.88661 <.0001 47	0.89389 <.0001 47	0.73138 <.0001 47	0.92258 <.0001 47	1.00000 47	0.71208 <.0001 47
PI_14	0.73663 <.0001 160	0.69928 <.0001 160	0.69530 <.0001 159	0.69878 <.0001 160	0.71208 <.0001 47	1.00000 161

2.2.3 TOTAL PHOSPHORUS

TP has been routinely sampled by Lee County since 1996 for all stations except Station PI-06, which stopped sampling after 2003 (Table 2-27).

Table 2-27. Total Phosphorus Sampling Frequency by Station for Lee County Fixed Stations

	Station						
Year	PI-02	PI-03	PI-04	PI-05	PI-06	PI-14	Total
1996	2	2	2	2	2	2	12
1997	3	3	3	3	3	3	18
1998	4	4	4	4	4	4	24
1999	4	4	4	4	4	4	24
2000	4	4	4	4	4	4	24
2001	12	12	12	12	12	12	72
2002	12	12	12	12	12	12	72
2003	10	9	9	9	7	10	54
2004	9	9	9	9	-	8	44
2005	11	11	11	11	-	11	55
2006	9	11	10	10	-	10	50
2007	12	12	12	12	-	12	60
2008	12	12	12	12	-	12	60
2009	12	12	12	12	-	12	60
2010	12	12	12	12	-	12	60
2011	12	12	12	12	-	12	60
2012	12	12	12	12	-	11	59
2013	10	11	11	10	-	10	52
Total	162	164	163	162	48	161	860

The overall arithmetic average TP concentration between 1996 and 2013 for each station is displayed in Figure 2-51. Stations PI-14 and PI-04 had the lowest average concentrations, while Station PI-06 had the highest average concentration. Note that Station PI-06 was discontinued after 2003.

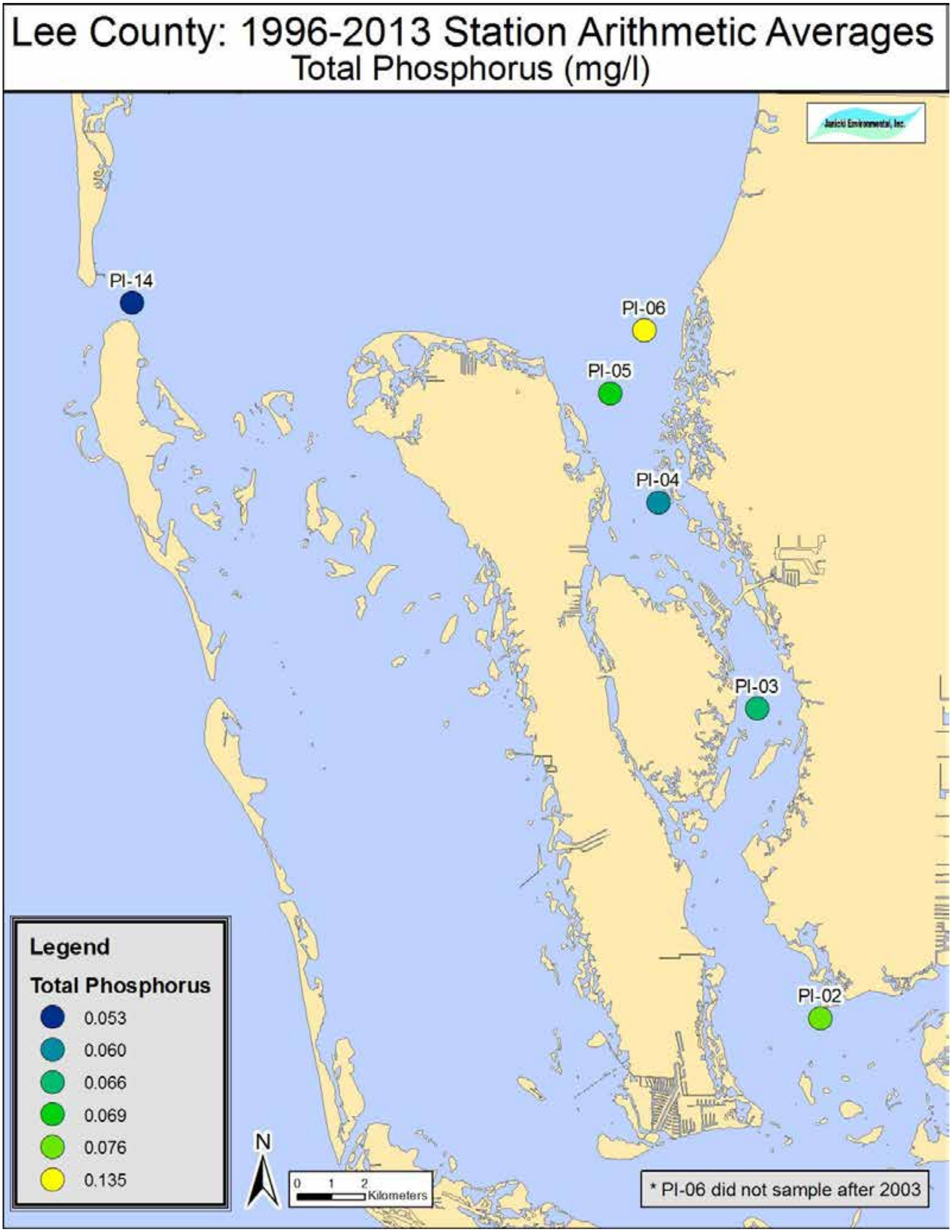


Figure 2-51. Arithmetic Averages for Total Phosphorus for Lee County Fixed Sampling Stations

Box and whisker plots of the TP distributions are shown in Figure 2-52. These plots suggest that 75 percent of the data collected in all stations except PI-06 had TP concentrations less than 0.10 mg/L.

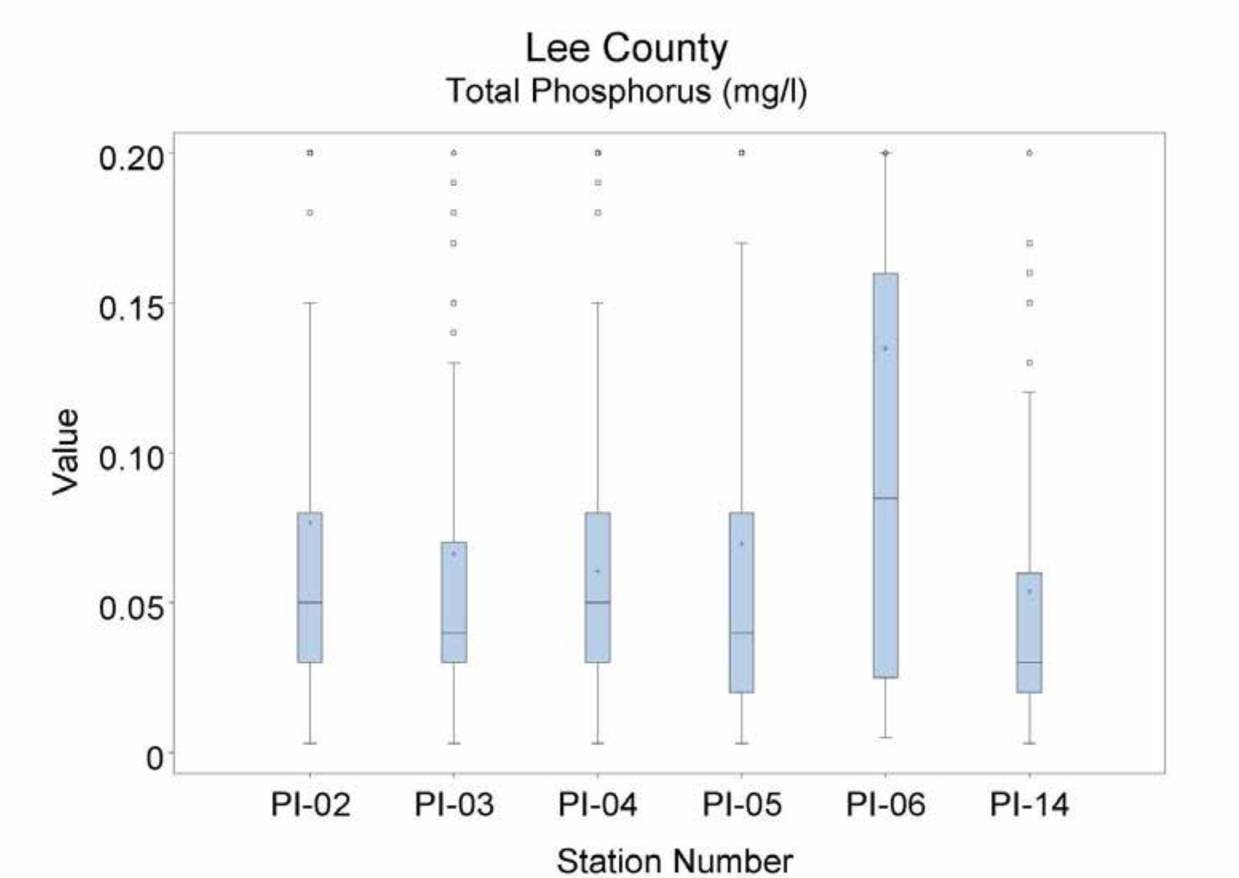


Figure 2-52. Box and Whisker Plots Displaying the Distribution of Total Phosphorus Concentrations among Lee County Fixed Stations

Time series plots of TP measurements taken by Lee County indicate that all stations (including PI-06) have substantial temporal agreement (Figure 2-53). The arithmetic average in 1996 was based on only two values and, therefore, is not representative of the true annual average.

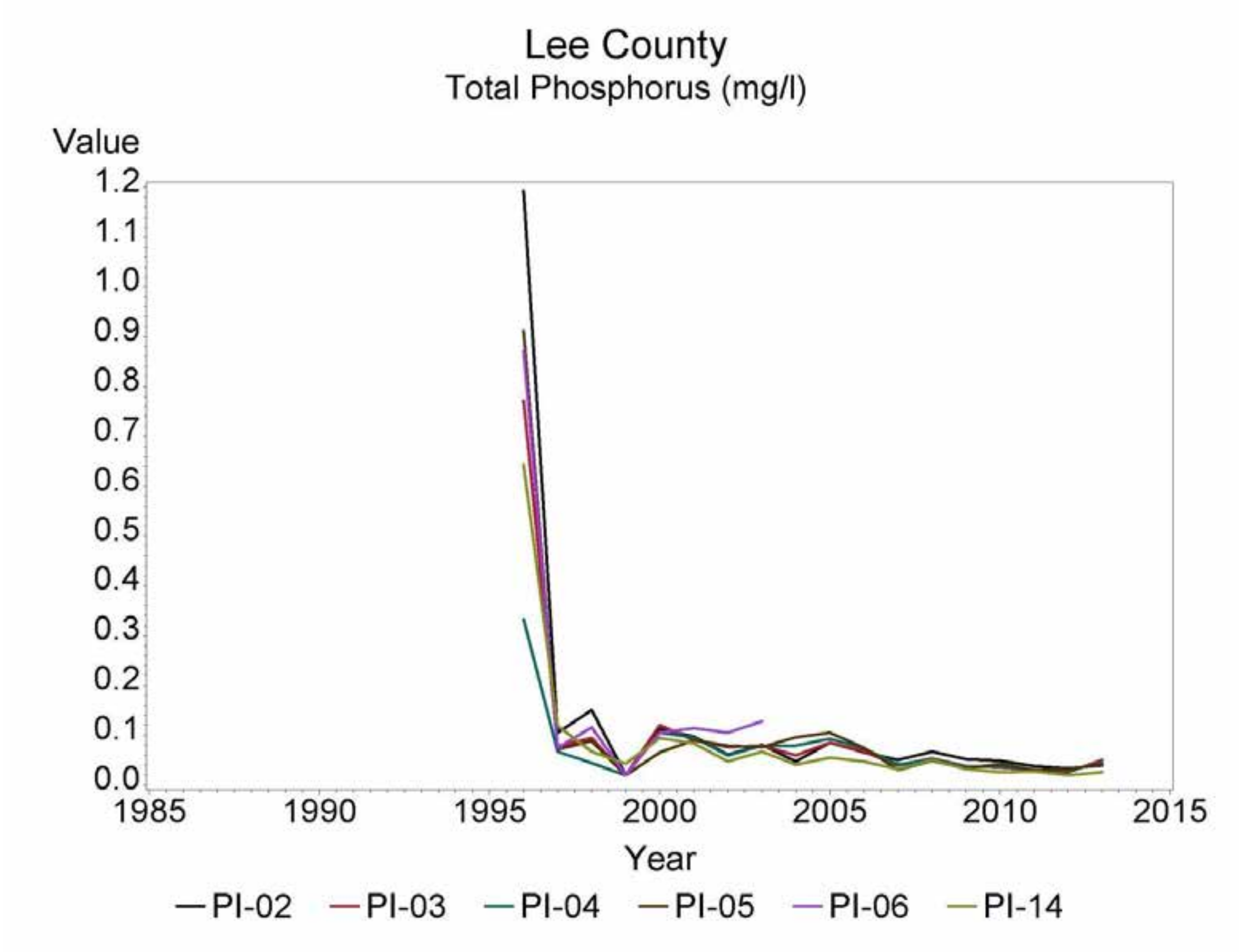


Figure 2-53. Time Series Plot of Total Phosphorus for Lee County Fixed Stations

TP trends for Lee County stations are displayed in Figure 2-54. Large and small decreasing trends were identified in all stations except Station PI-05, which was a stable trend between 1996 and 2013. No trends were examined on Station PI-06 due to insufficient data (n <60 for TP observations).

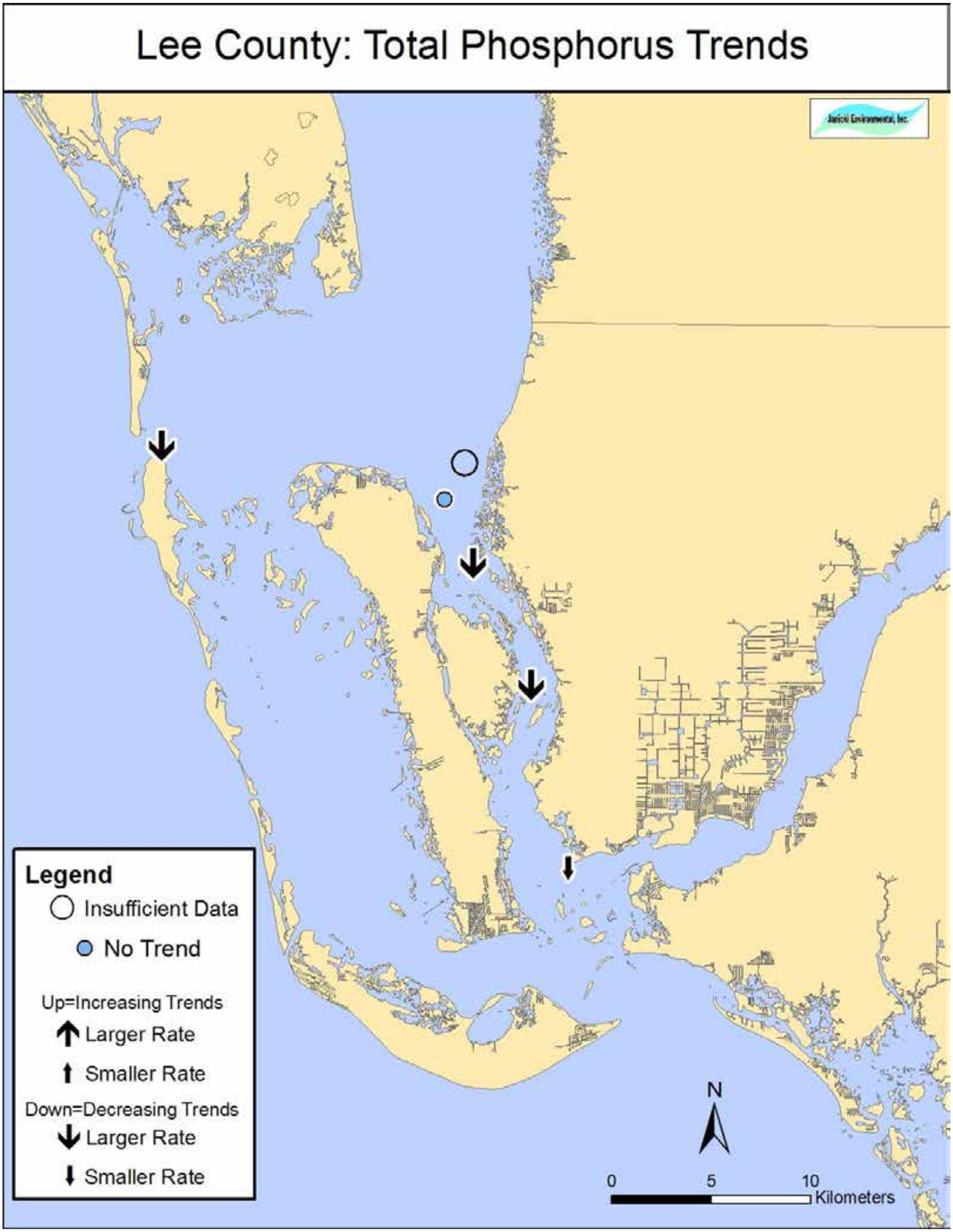


Figure 2-54. Total Phosphorus Trends for Lee County Fixed Stations

Cross correlation analysis suggested that TP concentrations among stations were greatest between Stations PI-03 and PI-04. All cross correlations were found to be highly statistically significant, positive correlations (Table 2-28).

Table 2-28. Spearman Rank Correlation Coefficients for Total Phosphorus for Lee County Fixed Stations

Spearman Correlation Coefficients
Prob > \|r\| under H0: Rho=0
Number of Observations

	PI_02	PI_03	PI_04	PI_05	PI_06	PI_14
PI_02	1.00000 162	0.74099 <.0001 161	0.68864 <.0001 160	0.67825 <.0001 160	0.85930 <.0001 47	0.75450 <.0001 160
PI_03	0.74099 <.0001 161	1.00000 164	0.90235 <.0001 162	0.78855 <.0001 161	0.81645 <.0001 47	0.68622 <.0001 160
PI_04	0.68864 <.0001 160	0.90235 <.0001 162	1.00000 163	0.81359 <.0001 161	0.81927 <.0001 47	0.67491 <.0001 159
PI_05	0.67825 <.0001 160	0.78855 <.0001 161	0.81359 <.0001 161	1.00000 162	0.88112 <.0001 46	0.65400 <.0001 159
PI_06	0.85930 <.0001 47	0.81645 <.0001 47	0.81927 <.0001 47	0.88112 <.0001 46	1.00000 47	0.74736 <.0001 47
PI_14	0.75450 <.0001 160	0.68622 <.0001 160	0.67491 <.0001 159	0.65400 <.0001 159	0.74736 <.0001 47	1.00000 161

2.2.4 DISSOLVED OXYGEN

Lee County has routinely sampled DO since 1996 for all stations except Station PI-06, which stopped sampling after 2003 (Table 2-29).

Table 2-29. Dissolved Oxygen Sampling Frequency by Station for Lee County Fixed Stations

	Station						
Year	PI-02	PI-03	PI-04	PI-05	PI-06	PI-14	Total
1996	2	2	2	2	2	2	12
1997	3	3	3	3	3	3	18
1998	4	4	4	4	4	4	24
1999	4	4	4	4	4	4	24
2000	4	4	4	4	4	4	24
2001	11	12	12	12	12	11	70
2002	12	12	12	12	12	12	72
2003	10	9	9	10	7	10	55
2004	9	9	9	9	-	8	44
2005	11	11	11	11	-	11	55
2006	9	11	10	10	-	10	50
2007	12	12	12	12	-	12	60
2008	12	12	12	12	-	11	59
2009	12	12	12	12	-	12	60
2010	12	12	12	12	-	12	60
2011	12	12	12	12	-	12	60
2012	12	12	12	12	-	11	59
2013	10	11	11	10	-	10	52
Total	161	164	163	163	48	159	858

The overall arithmetic average DO concentration between 1996 and 2013 for each station is displayed in Figure 2-55. Stations PI-02 and PI-04 had the lowest average concentrations, while Station PI-14 had the highest average concentration.

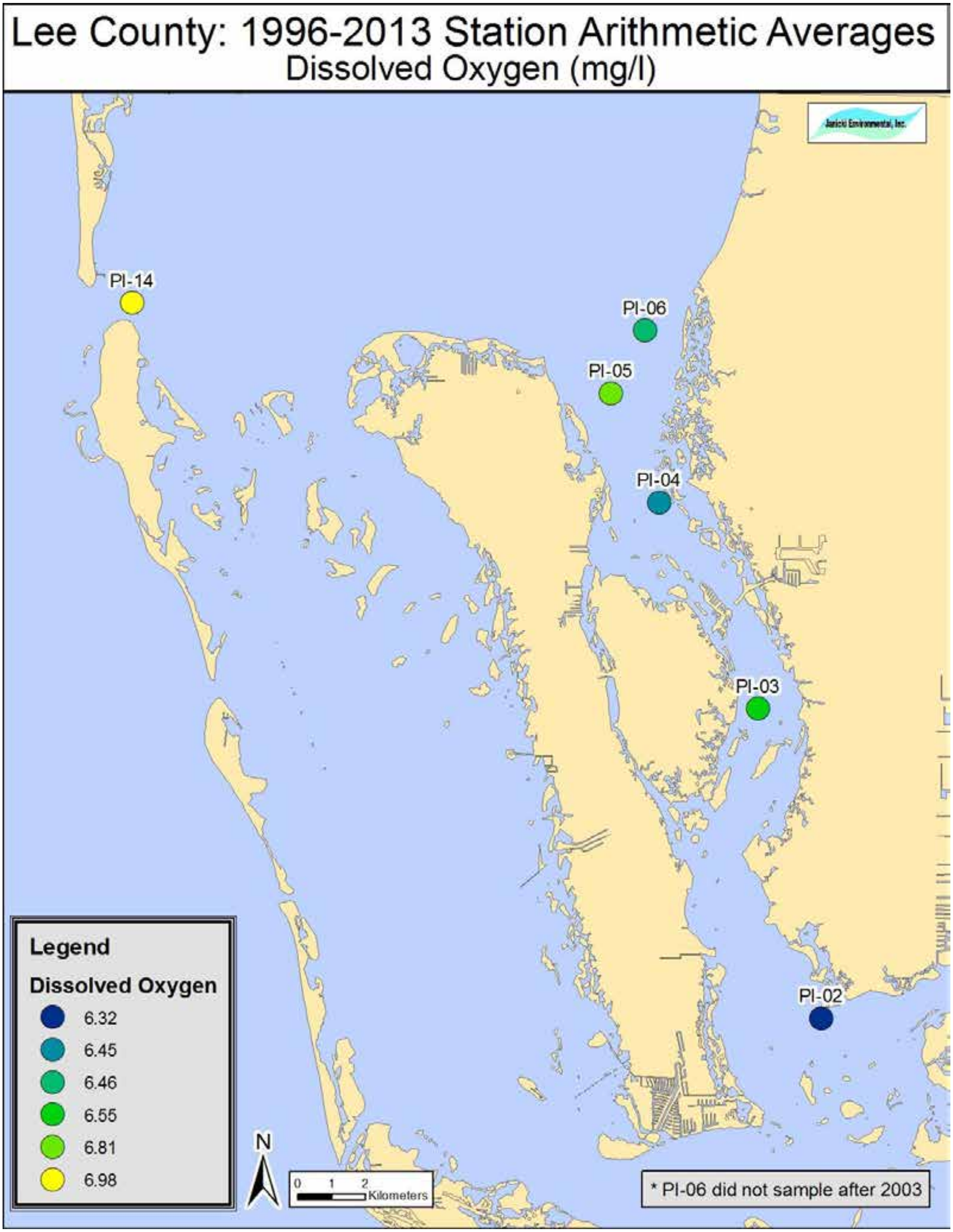


Figure 2-55. Arithmetic Average for Dissolved Oxygen for Lee County Fixed Stations

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 (Figure 2-56). The median values at each station are near or above 6.0 mg/L. These plots represent the entire period of record for each station, which varies among stations. Note that no DO measurements were taken at PI-06 after 2003.

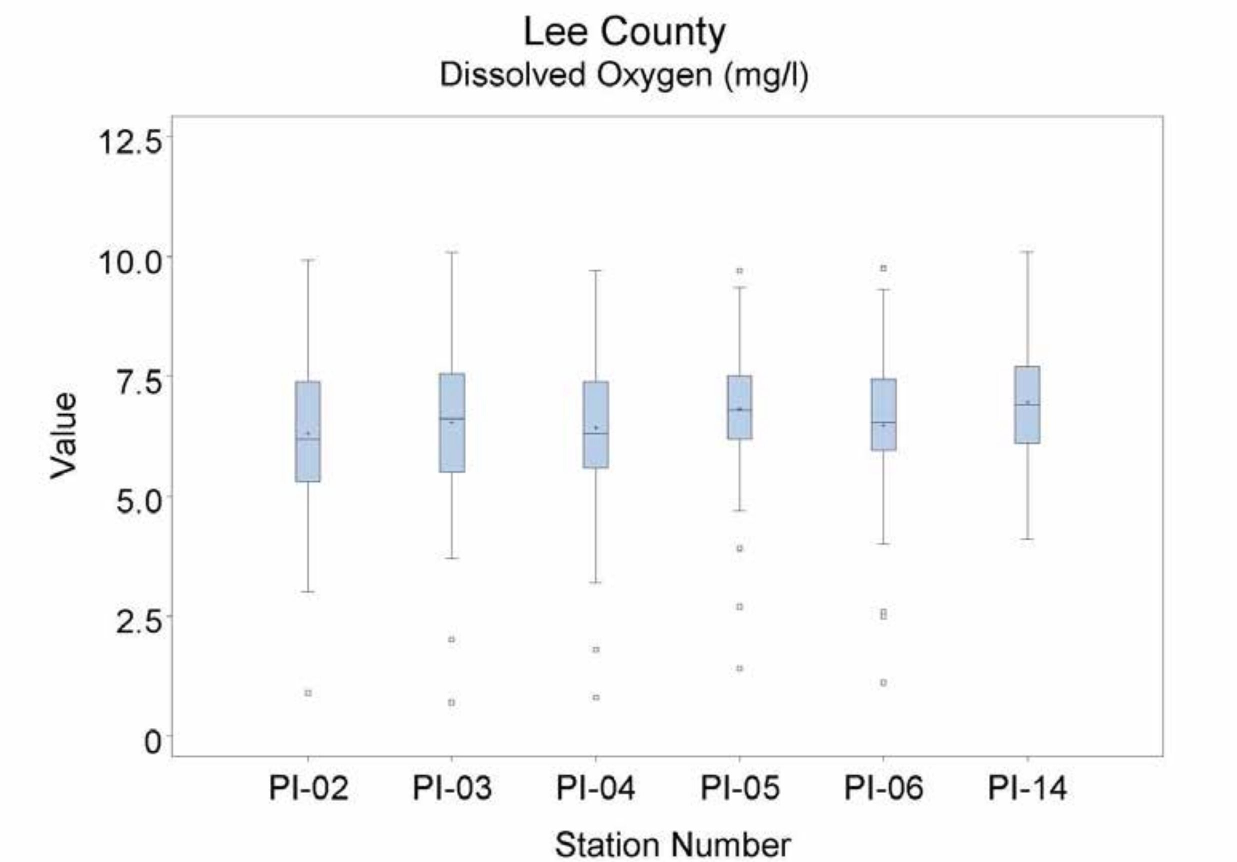


Figure 2-56. Box and Whisker Plots Displaying the Distribution of Dissolved Oxygen Concentrations among Lee County Fixed Stations

Time series plots of DO measurements taken by Lee County indicate good temporal agreement among stations (Figure 2-57). In 2000, all stations indicated a sharp decrease in DO, with PI-03 and PI-04, closest to the NSC, indicating the greatest decreases.

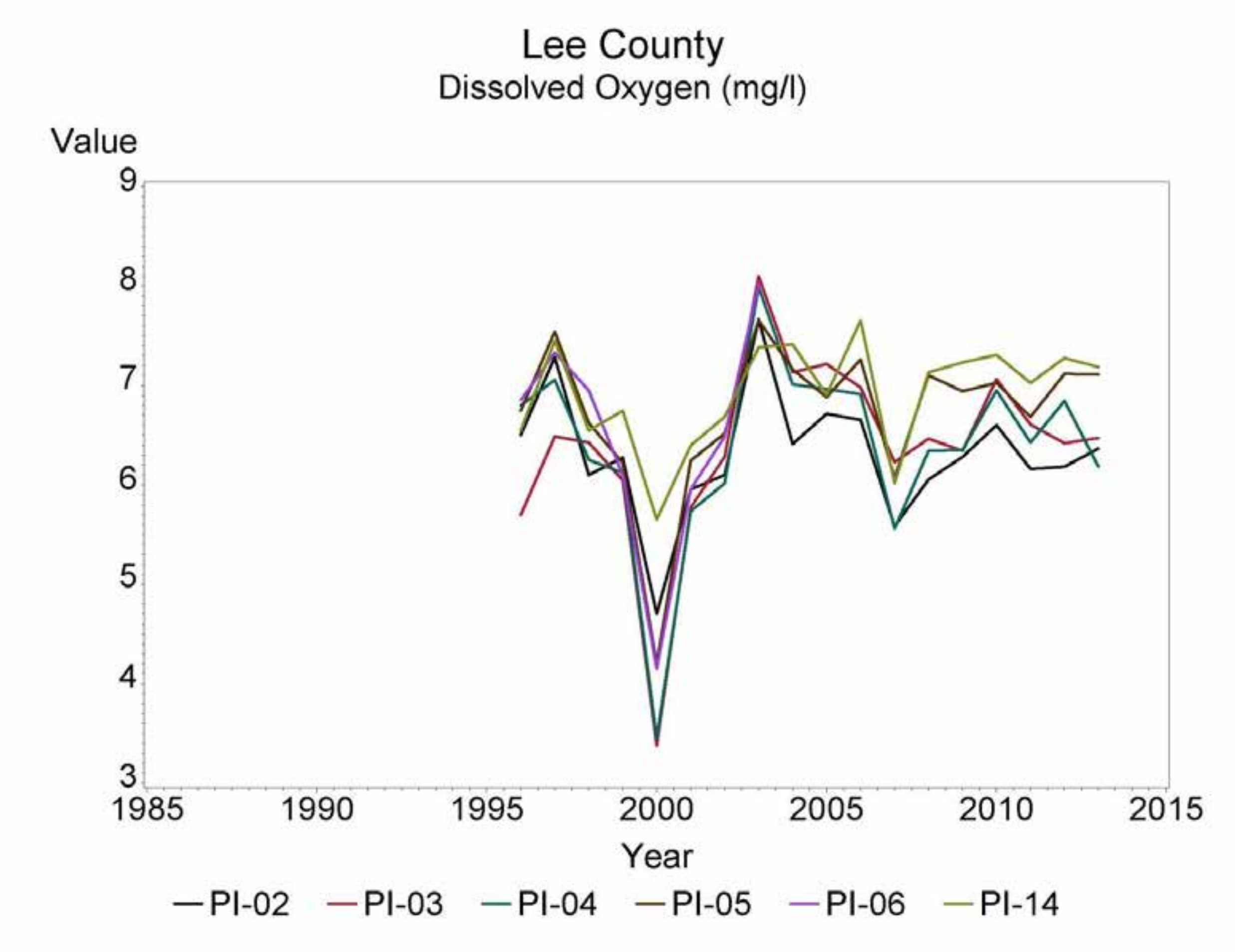


Figure 2-57. Time Series Plot of Dissolved Oxygen for Lee County Fixed Stations

DO trends for Lee County stations are displayed in Figure 2-58. No trends were identified in any stations except Station PI-14, which identified a small increasing trend from 1996 to 2013 for samples collected by Lee County. No trends were examined on Station PI-06 due to insufficient data (n <60 for DO observations).

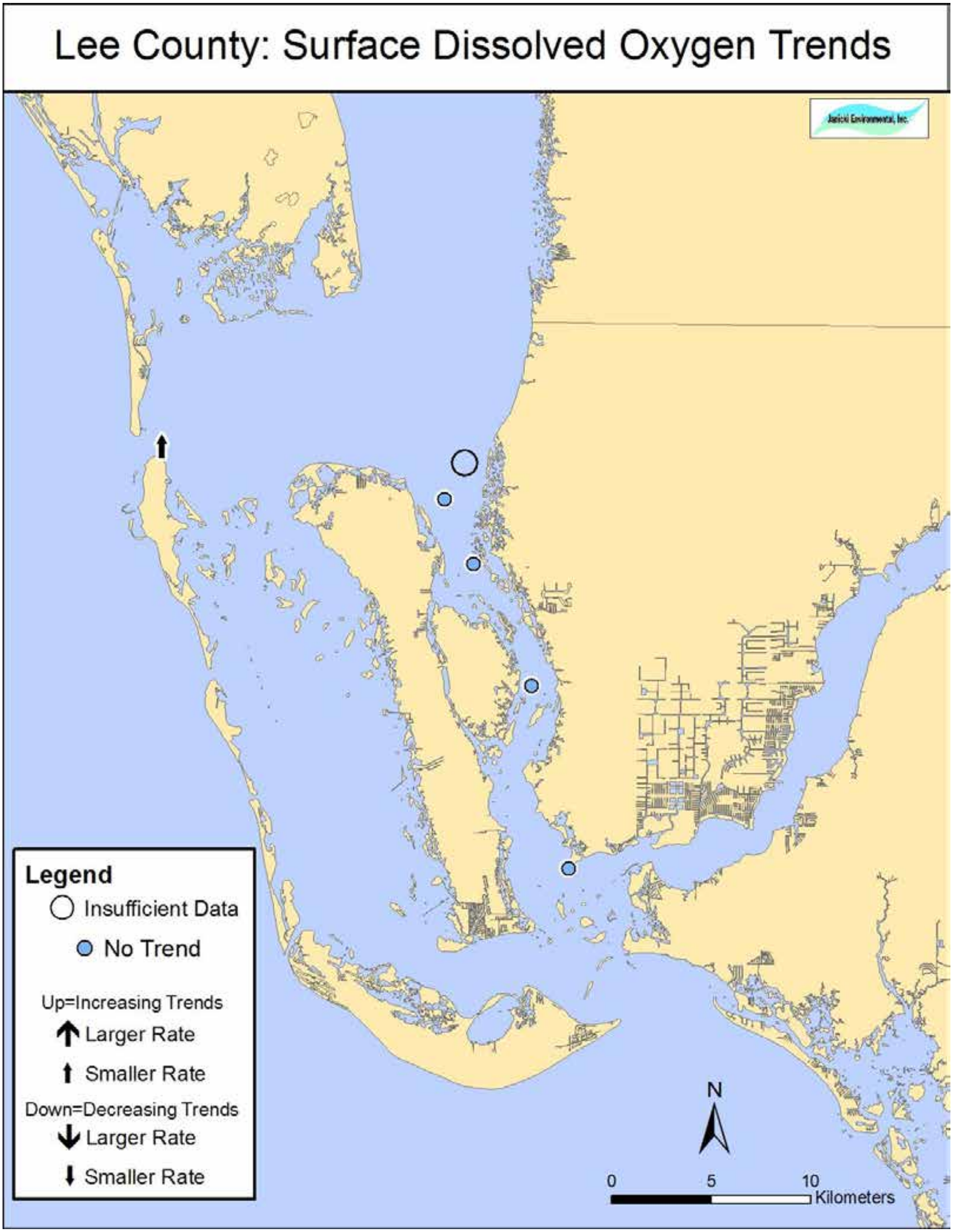


Figure 2-58. Dissolved Oxygen Trends for Lee County Fixed Stations

Cross correlation analysis suggested that DO concentrations among stations were greatest between Stations PI-05 and PI-06. However, no DO measurements were taken at PI-06 after 2003. The next most highly correlated stations were Stations PI-02 and PI-03. All cross correlations were found to be statistically significant, positive correlations (Table 2-30).

Table 2-30. Spearman Rank Correlation Coefficients for Dissolved Oxygen for Lee County Fixed Stations

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations						
	PI_02	**PI_03**	**PI_04**	**PI_05**	**PI_06**	**PI_14**
PI_02	1.00000 161	0.81462 <.0001 160	0.77036 <.0001 159	0.77959 <.0001 160	0.85743 <.0001 46	0.68389 <.0001 157
PI_03	0.81462 <.0001 160	1.00000 164	0.76801 <.0001 162	0.70575 <.0001 162	0.84257 <.0001 47	0.60502 <.0001 158
PI_04	0.77036 <.0001 159	0.76801 <.0001 162	1.00000 163	0.81119 <.0001 162	0.86926 <.0001 47	0.70021 <.0001 157
PI_05	0.77959 <.0001 160	0.70575 <.0001 162	0.81119 <.0001 162	1.00000 163	0.88457 <.0001 47	0.69268 <.0001 158
PI_06	0.85743 <.0001 46	0.84257 <.0001 47	0.86926 <.0001 47	0.88457 <.0001 47	1.00000 47	0.69426 <.0001 46
PI_14	0.68389 <.0001 157	0.60502 <.0001 158	0.70021 <.0001 157	0.69268 <.0001 158	0.69426 <.0001 46	1.00000 159

2.2.5 CHLOROPHYLL *A*

Chl *a* has been routinely sampled by Lee County since 1996 for all stations except Station PI-06, which was discontinued after 2003 (Table 2-31).

Table 2-31. Chlorophyll *a* Sampling Frequency by Station for Lee County Fixed Stations

	Station						
Year	PI-02	PI-03	PI-04	PI-05	PI-06	PI-14	Total
1996	2	2	2	2	2	2	12
1997	2	2	3	3	3	3	16
1998	4	4	4	4	4	4	24
1999	4	4	4	4	4	4	24
2000	4	4	4	4	4	4	24
2001	12	12	12	12	12	12	72
2002	12	12	12	12	12	12	72
2003	10	9	9	10	7	10	55
2004	9	9	9	9	-	8	44
2005	11	11	11	11	-	11	55
2006	9	11	10	10	-	10	50
2007	12	12	12	12	-	12	60
2008	12	12	12	12	-	12	60
2009	11	11	11	11	-	11	55
2010	12	12	12	12	-	12	60
2011	12	12	12	12	-	12	60
2012	12	12	12	12	-	11	59
2013	10	11	11	10	-	10	52
Total	160	162	162	162	48	160	854

The overall arithmetic average Chl *a* concentration between 1996 and 2013 for each station is presented in Figure 2-59. Stations PI-02 and PI-14 had the lowest average concentrations, while Station PI-06 had the highest average concentration. Note that Station PI-06 stopped taking measurements after 2003.

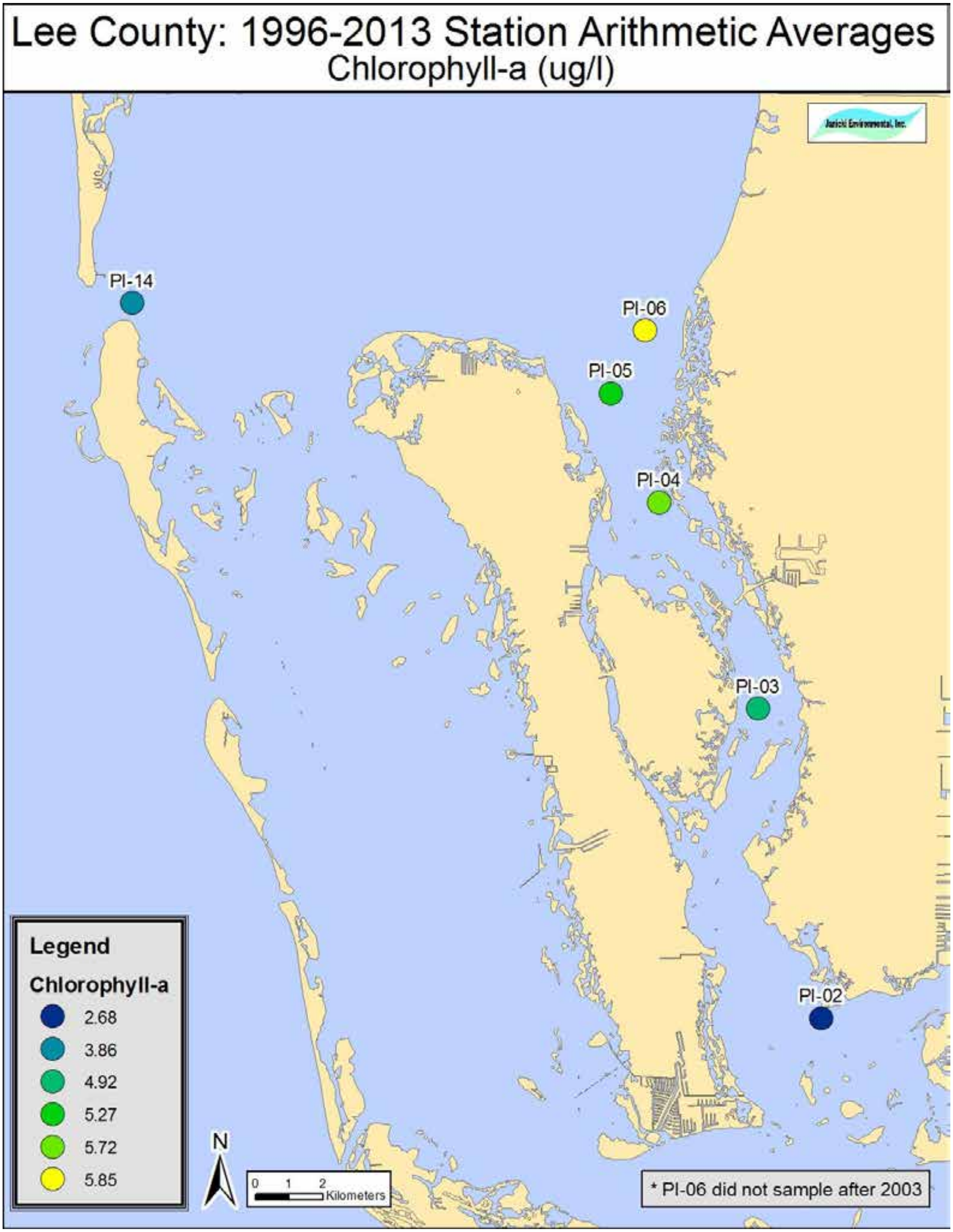


Figure 2-59. Arithmetic Average Chlorophyll a for Lee County Fixed Stations

Box and whisker plots of Chl *a* measurements taken by Lee County are displayed in Figure 2-60. At least 75 percent of the data collected were below 8 µg/L, indicating that typical chlorophyll values would not be considered bloom conditions. These plots represent the entire period of record for each station, which varies among stations. Note that no chlorophyll measurements were taken at PI-06 after 2003. These plots are trimmed such that extremely high values are not displayed in the plots.

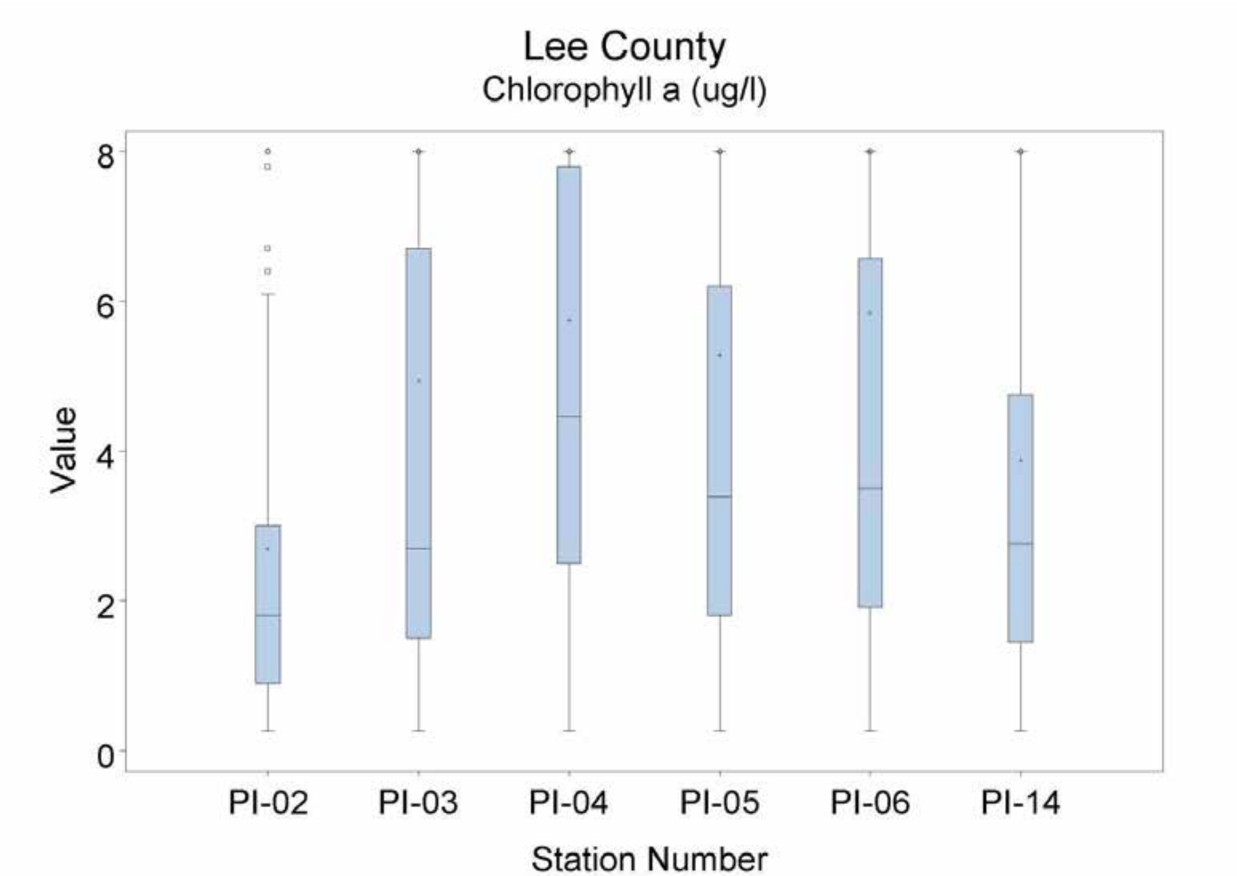


Figure 2-60. Box and Whisker Plots Displaying the Distribution of Chlorophyll a Concentrations among Lee County Fixed Stations

Time series plots of Chl *a* measurements taken by Lee County indicate that stations were not temporally well correlated, with annual average Chl *a* concentrations ranging across years between approximately 2 µg/L and 12 µg/L (Figure 2-61).

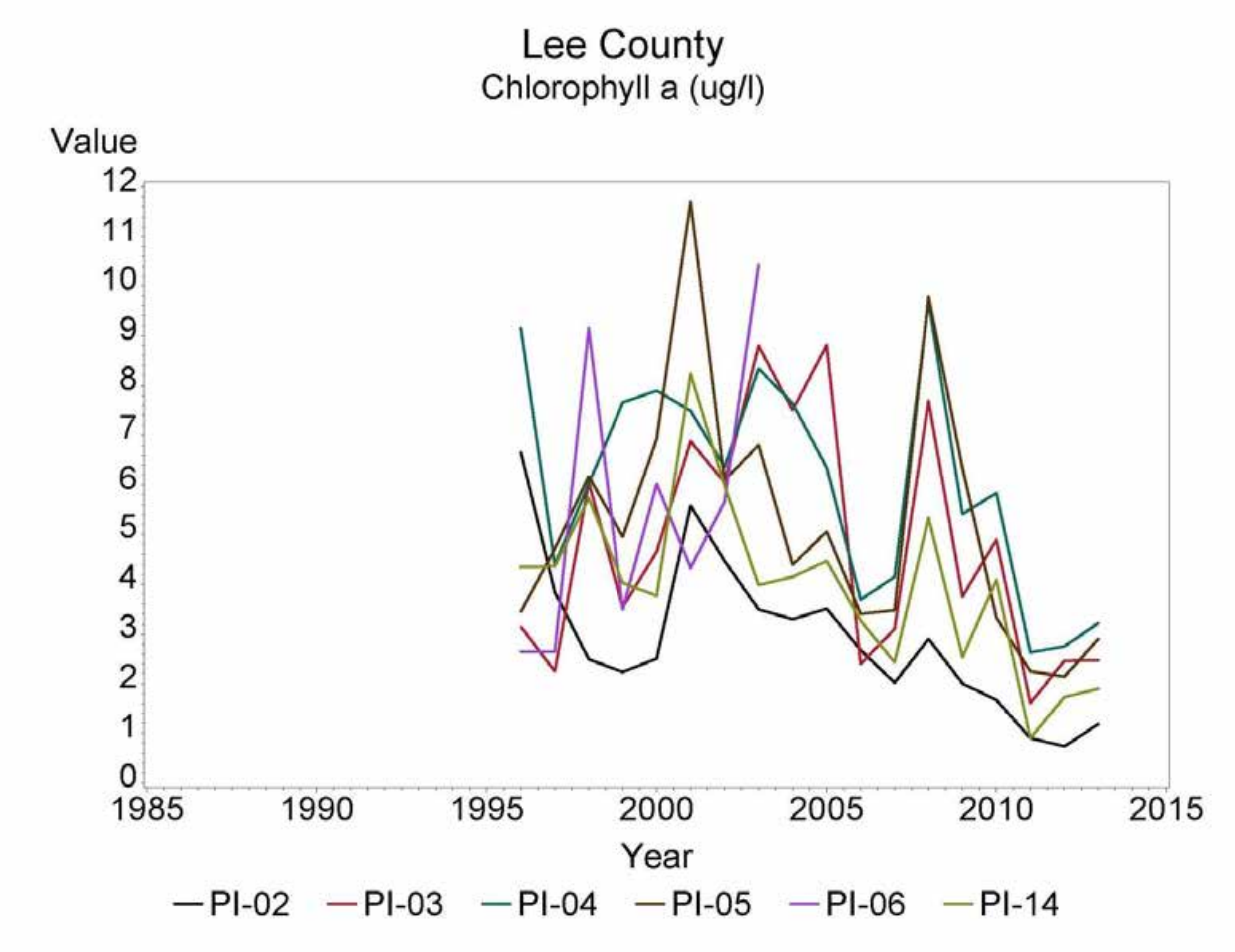


Figure 2-61. Time Series Plot of Chlorophyll a for Lee County Fixed Stations

Chl *a* trends for Lee County stations are presented in Figure 2-62. Large decreasing trends were identified in all stations from 1996 to 2013 for samples collected by Lee County. No trends were examined on Station PI-06 due to insufficient data (n <60 for Chl *a* observations).

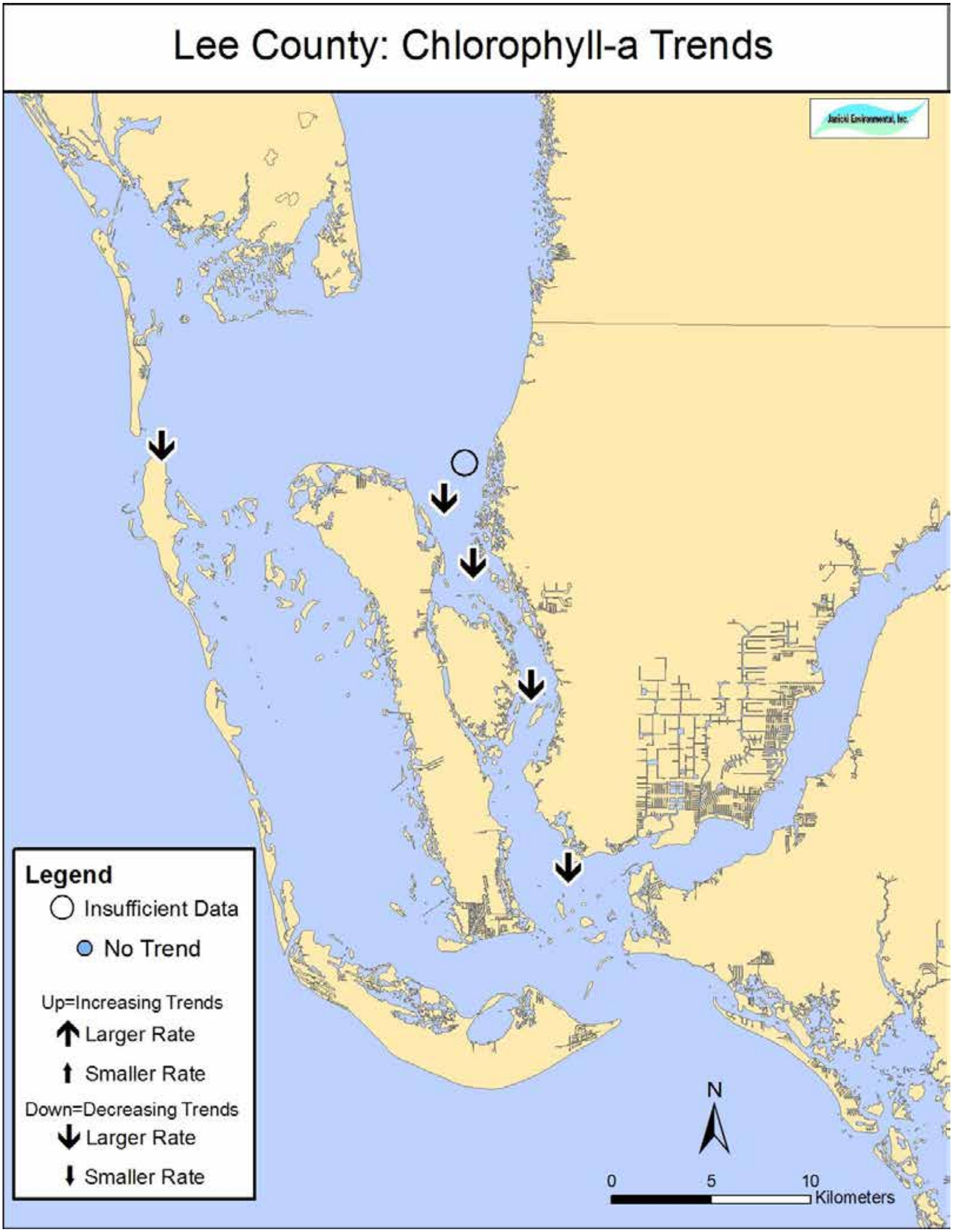


Figure 2-62. Chlorophyll a Trends for Lee County Fixed Stations

Cross correlation analysis suggested that Chl *a* concentrations among stations were greatest between Stations PI-05 and PI-06. Excluding Station PI-06, which has no data after 2003, the next most highly correlated stations were Stations PI-03 and PI-04. All cross correlations were found to be statistically significant, positive correlations (Table 2-32).

Table 2-32. Spearman Rank Correlation Coefficients for Chlorophyll *a* for Lee County Fixed Stations

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations						
	PI_02	PI_03	PI_04	PI_05	PI_06	PI_14
PI_02	1.00000 160	0.64749 <.0001 159	0.56204 <.0001 158	0.51810 <.0001 159	0.33437 0.0231 46	0.64340 <.0001 158
PI_03	0.64749 <.0001 159	1.00000 162	0.74241 <.0001 160	0.57077 <.0001 160	0.46043 0.0013 46	0.61848 <.0001 158
PI_04	0.56204 <.0001 158	0.74241 <.0001 160	1.00000 162	0.66677 <.0001 161	0.47346 0.0008 47	0.58351 <.0001 158
PI_05	0.51810 <.0001 159	0.57077 <.0001 160	0.66677 <.0001 161	1.00000 162	0.74551 <.0001 47	0.52375 <.0001 159
PI_06	0.33437 0.0231 46	0.46043 0.0013 46	0.47346 0.0008 47	0.74551 <.0001 47	1.00000 47	0.32154 0.0275 47
PI_14	0.64340 <.0001 158	0.61848 <.0001 158	0.58351 <.0001 158	0.52375 <.0001 159	0.32154 0.0275 47	1.00000 160

2.2.6 TURBIDITY

Turbidity has been routinely sampled by Lee County since 1996 for all stations except Station PI-06, which stopped sampling after 2003 (Table 2-33).

Table 2-33. Turbidity Sampling Frequency by Station for Lee County Fixed Stations

	Station						
Year	PI-02	PI-03	PI-04	PI-05	PI-06	PI-14	Total
1996	2	2	2	2	2	2	12
1997	3	3	3	3	3	3	18
1998	4	4	4	4	4	4	24
1999	4	4	4	4	4	4	24
2000	4	4	4	4	4	4	24
2001	12	12	12	12	12	12	72
2002	12	12	12	12	12	12	72
2003	10	9	9	10	7	10	55
2004	9	9	9	9	-	8	44
2005	10	10	10	10	-	10	50
2006	9	11	10	10	-	10	50
2007	11	11	11	11	-	11	55
2008	12	12	12	12	-	11	59
2009	11	11	11	11	-	11	55
2010	11	11	11	11	-	11	55
2011	8	8	8	8	-	8	40
2012	11	11	11	11	-	10	54
2013	9	10	10	9	-	9	47
Total	152	154	153	153	48	150	810

Turbidity values were generally low, with long-term averages between 1 and 2.03 NTU. The overall arithmetic average turbidity concentration between 1996 and 2013 for each station is provided in Figure 2-63. Stations PI-06 and PI-05 had the lowest average concentrations, while Station PI-14 had the highest average concentration. Note that Station PI-06 stopped taking measurements after 2003.

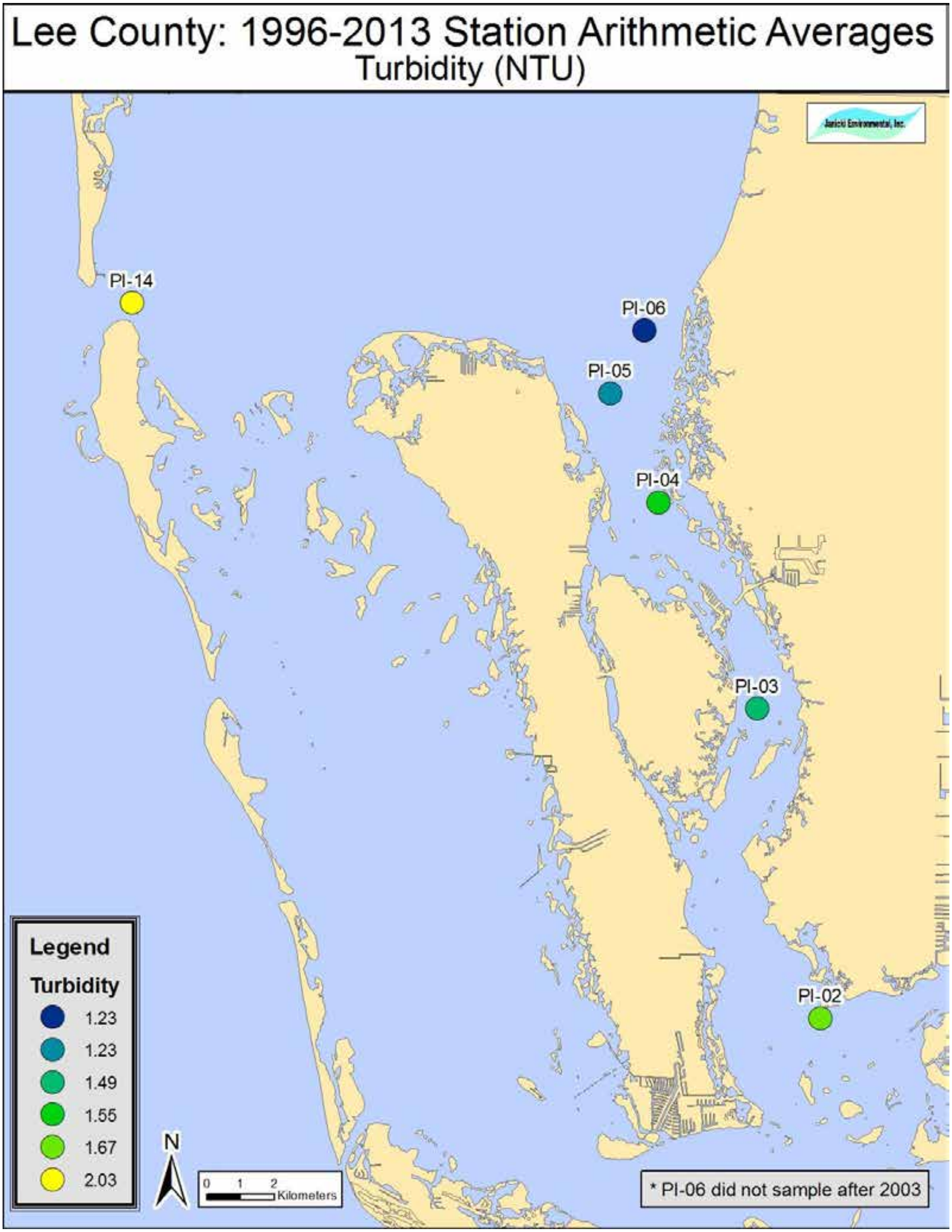


Figure 2-63. Arithmetic Averages for Turbidity for Lee County Fixed Stations

Between-station variability for turbidity measurements collected by Lee County are displayed in Figure 2-64 and indicate that 75 percent of the data collected fall below 2.5 NTU. These plots represent the entire period of record for each station, which varies among stations. Note that no turbidity measurements were taken at Station PI-06 after 2003. These plots are trimmed such that extremely high values are not displayed in the plots.

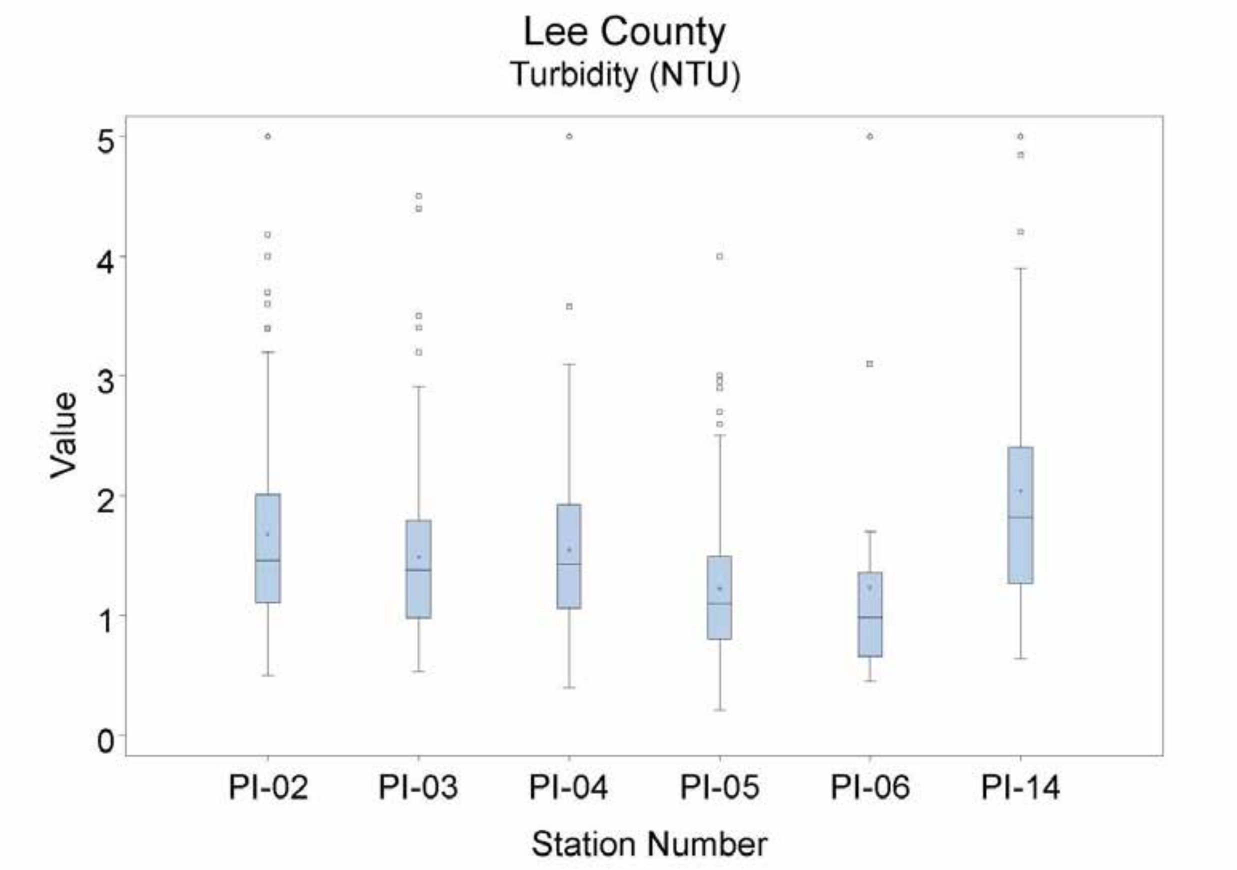


Figure 2-64. Box and Whisker Plots Displaying the Distribution of Turbidity Concentrations among Lee County Fixed Stations

Time series plots for turbidity measurements taken by Lee County indicate that the average turbidity values tend to be less than 2.5 NTU, but can be as high as 3.28 NTU, as Station PI-14 shows in 2001 (Figure 2-65).

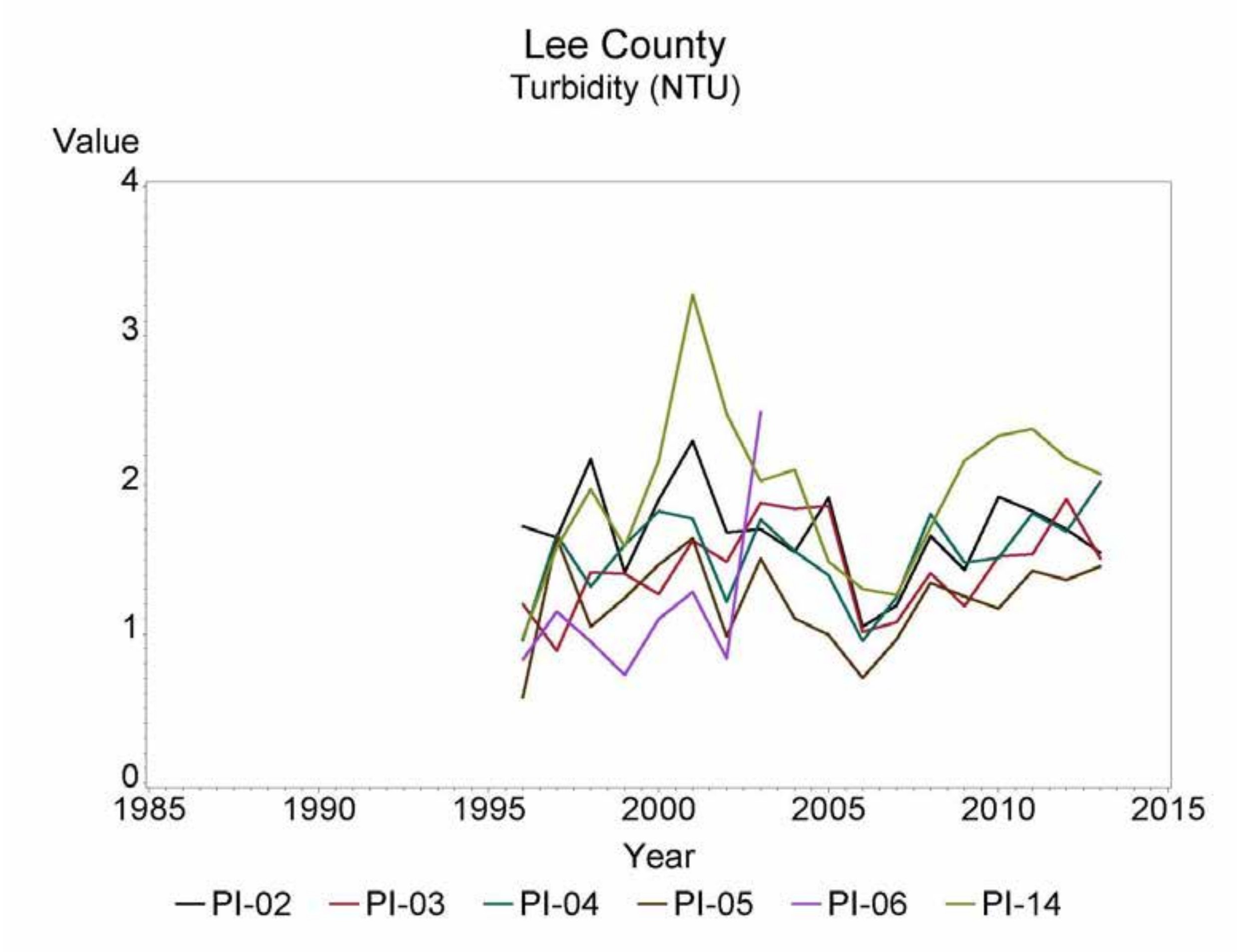


Figure 2-65. Time Series Plot of Turbidity for Lee County Fixed Stations

Turbidity trends for Lee County stations are presented in Figure 2-66. No trends were identified in any station from 1996 to 2013 for samples collected by Lee County. No trends were examined on Station PI-06 due to insufficient data (n <60 for turbidity observations).

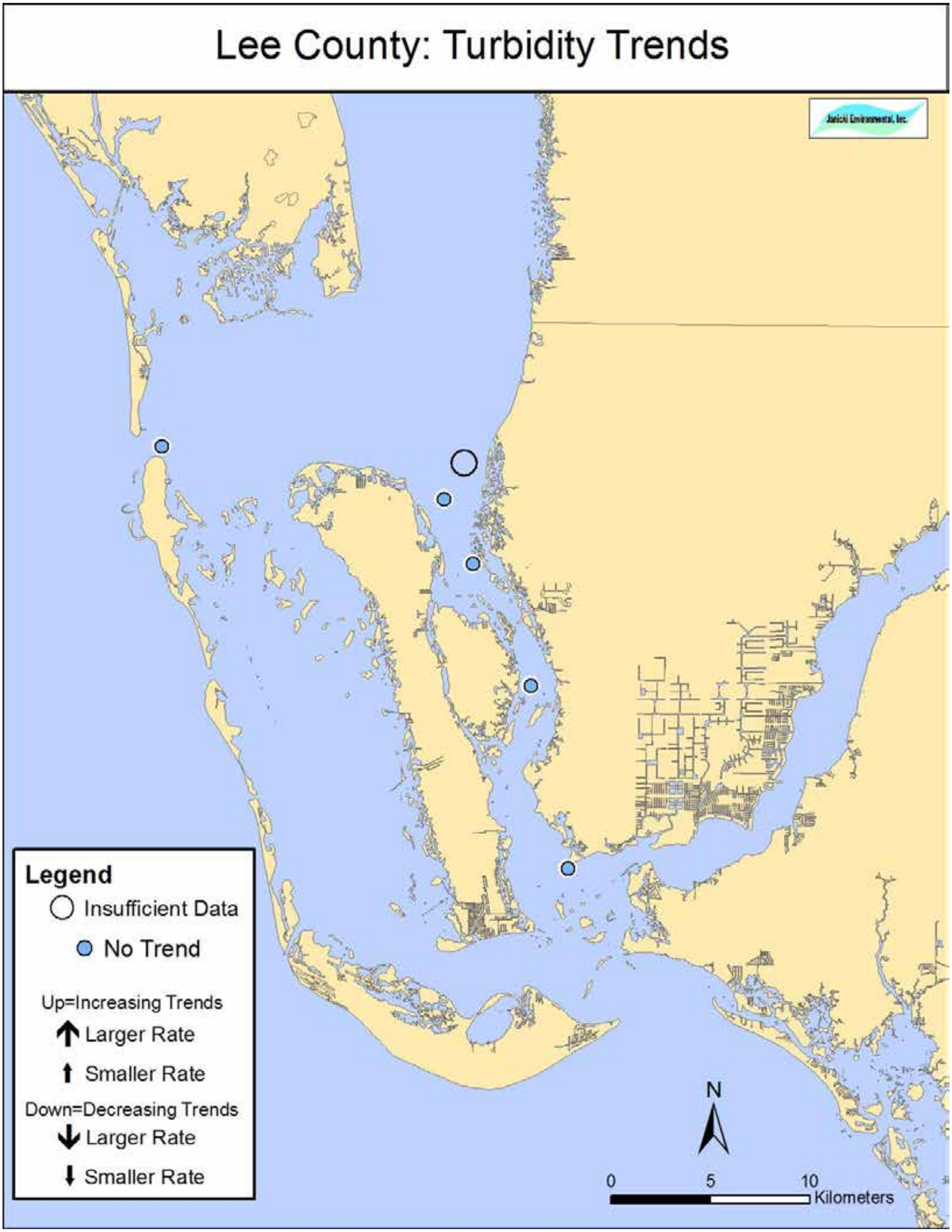


Figure 2-66. Turbidity Trends for Lee County Fixed Stations

Cross correlation analysis suggested that turbidity concentrations among stations were greatest between Stations PI-04 and PI-05. All cross correlations were found to be statistically significant, positive correlations except between Stations PI-03 and PI-06 (Table 2-34).

Table 2-34. Spearman Rank Correlation Coefficients for Turbidity for Lee County Fixed Stations

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations						
	PI_02	PI_03	PI_04	PI_05	PI_06	PI_14
PI_02	1.00000 152	0.52000 <.0001 151	0.50519 <.0001 150	0.45041 <.0001 151	0.55843 <.0001 47	0.57162 <.0001 149
PI_03	0.52000 <.0001 151	1.00000 154	0.57966 <.0001 152	0.37197 <.0001 152	0.25275 0.0865 47	0.32427 <.0001 149
PI_04	0.50519 <.0001 150	0.57966 <.0001 152	1.00000 153	0.75949 <.0001 152	0.51209 0.0002 47	0.36440 <.0001 148
PI_05	0.45041 <.0001 151	0.37197 <.0001 152	0.75949 <.0001 152	1.00000 153	0.71517 <.0001 47	0.41236 <.0001 149
PI_06	0.55843 <.0001 47	0.25275 0.0865 47	0.51209 0.0002 47	0.71517 <.0001 47	1.00000 47	0.37819 0.0088 47
PI_14	0.57162 <.0001 149	0.32427 <.0001 149	0.36440 <.0001 148	0.41236 <.0001 149	0.37819 0.0088 47	1.00000 150

2.2.7 TOTAL SUSPENDED SOLIDS

TSS has been routinely sampled by Lee County since 2003 for all stations except Station PI-06, which was only sampled in 2003 (Table 2-35).

Table 2-35. Total Suspended Solids Sampling Frequency by Station for Lee County Fixed Stations

	Station						
Year	PI-02	PI-03	PI-04	PI-05	PI-06	PI-14	Total
1996	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-
1998	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-
2002	-	-	-	-	-	-	-
2003	6	5	5	6	3	6	31
2004	9	9	9	9	-	8	44
2005	11	11	11	11	-	11	55
2006	9	11	10	10	-	10	50
2007	12	12	12	12	-	12	60
2008	12	12	12	12	-	12	60
2009	12	12	12	12	-	12	60
2010	12	12	12	12	-	12	60
2011	12	12	12	12	-	12	60
2012	12	12	12	12	-	11	59
2013	10	11	11	10	-	10	52
Total	117	119	118	118	3	116	591

The overall arithmetic average TSS concentration between 2003 and 2013 for each station is presented in Figure 2-67. Stations PI-06 and PI-02 had the lowest average concentrations, while Station PI-14 had the highest average concentration. For Lee County, the period of record is truncated to 2003-2013 since all stations (except PI-06) were collecting TSS data over this time period. Note that Station PI-06 recorded TSS measurements only in 2003.

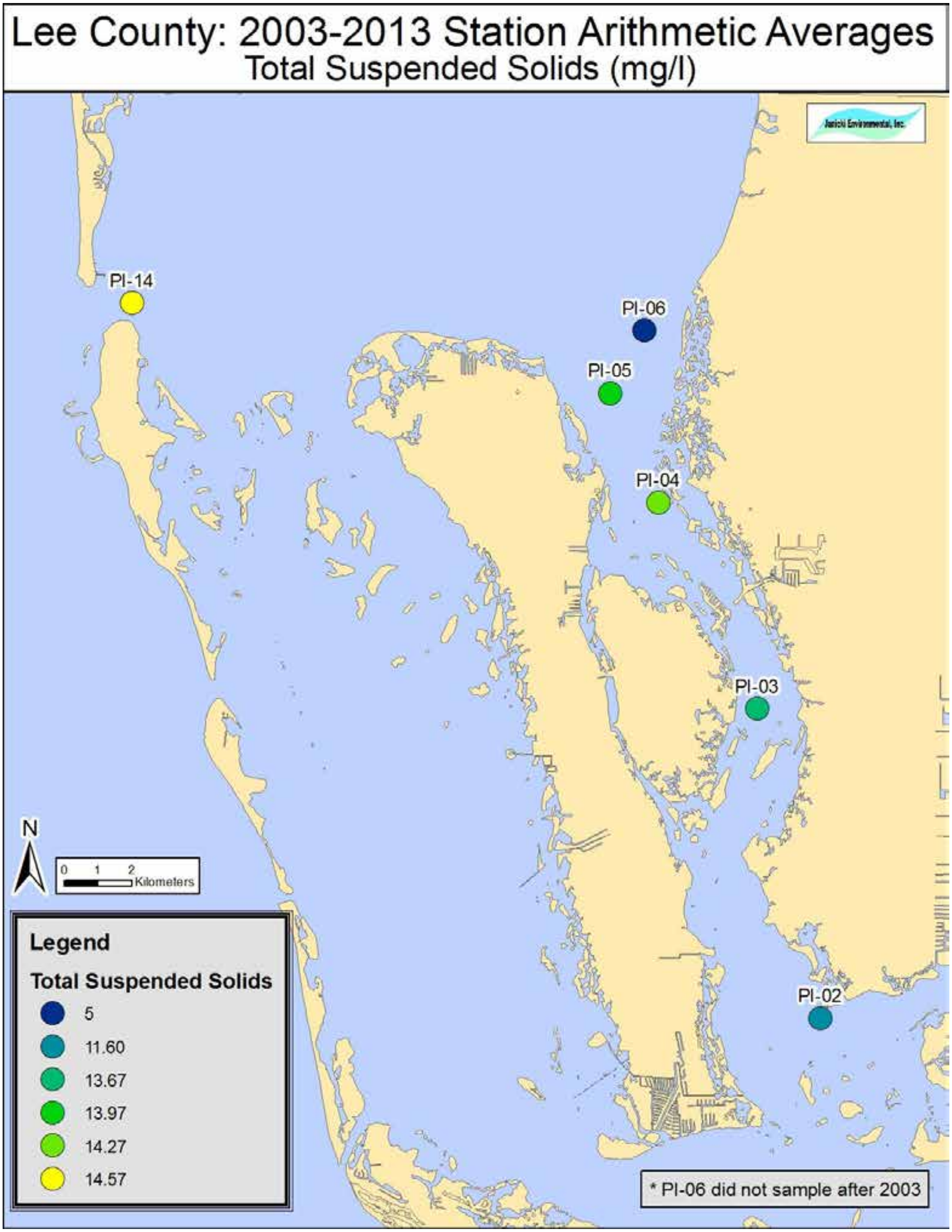


Figure 2-67. Arithmetic Averages for Total Suspended Solids for Lee County Fixed Stations

Box and whisker plots displaying the distribution of TSS collected by Lee County are shown in Figure 2-68. These plots indicate that 75 percent of the data collected fall at or below 20 mg/L. These plots represent the entire period of record for each station, which varies among stations. Note that TSS measurements were collected at Station PI-06 only in 2003.

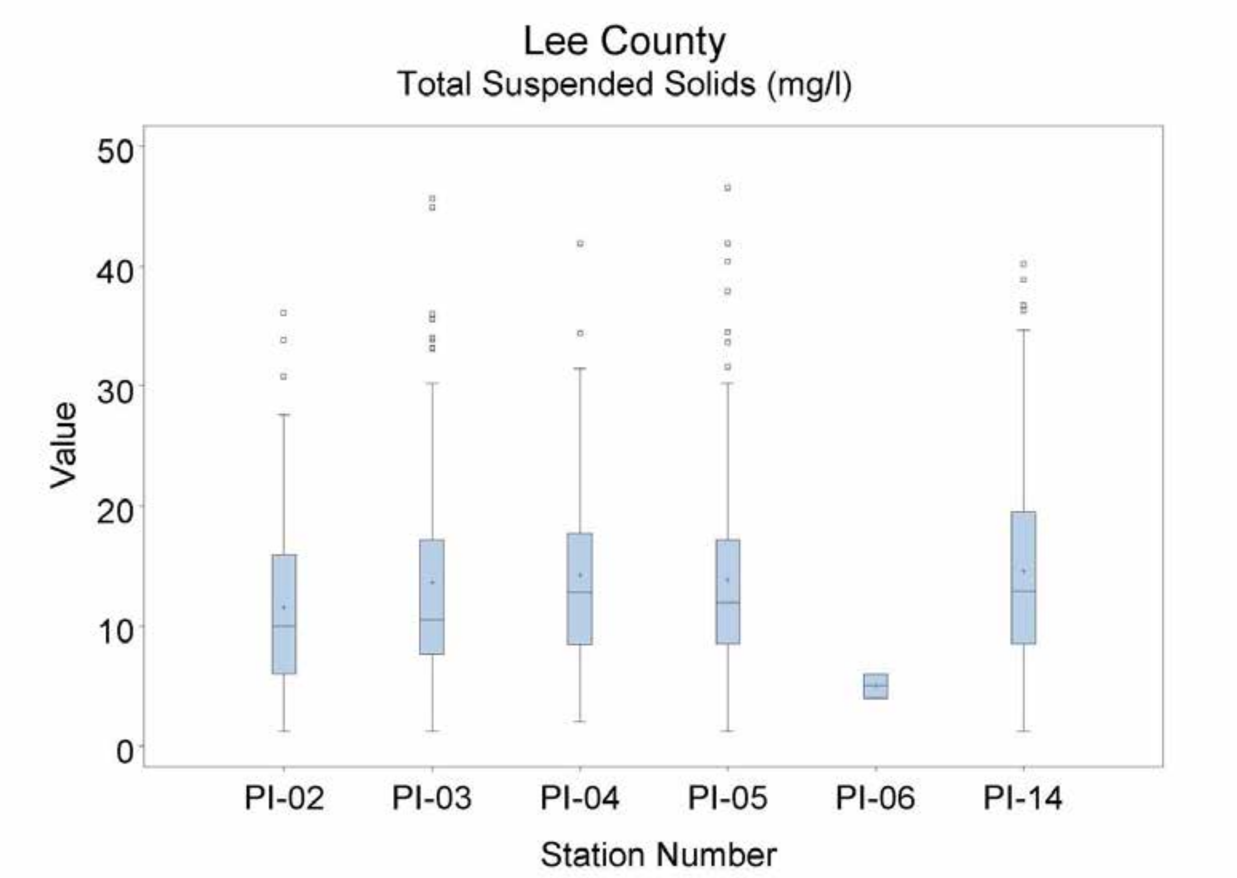


Figure 2-68. Box and Whisker Plots Displaying the Distribution of Total Suspended Solids Concentrations among Lee County Fixed Stations

Time series plots of TSS measurements taken by Lee County indicate good agreement among stations for all years, except in 2012, when Station PI-02 had decreasing TSS concentrations while the remaining stations increased, and in 2013 when Station PI-02 increased when most of the other stations noted a decrease (Figure 2-69).

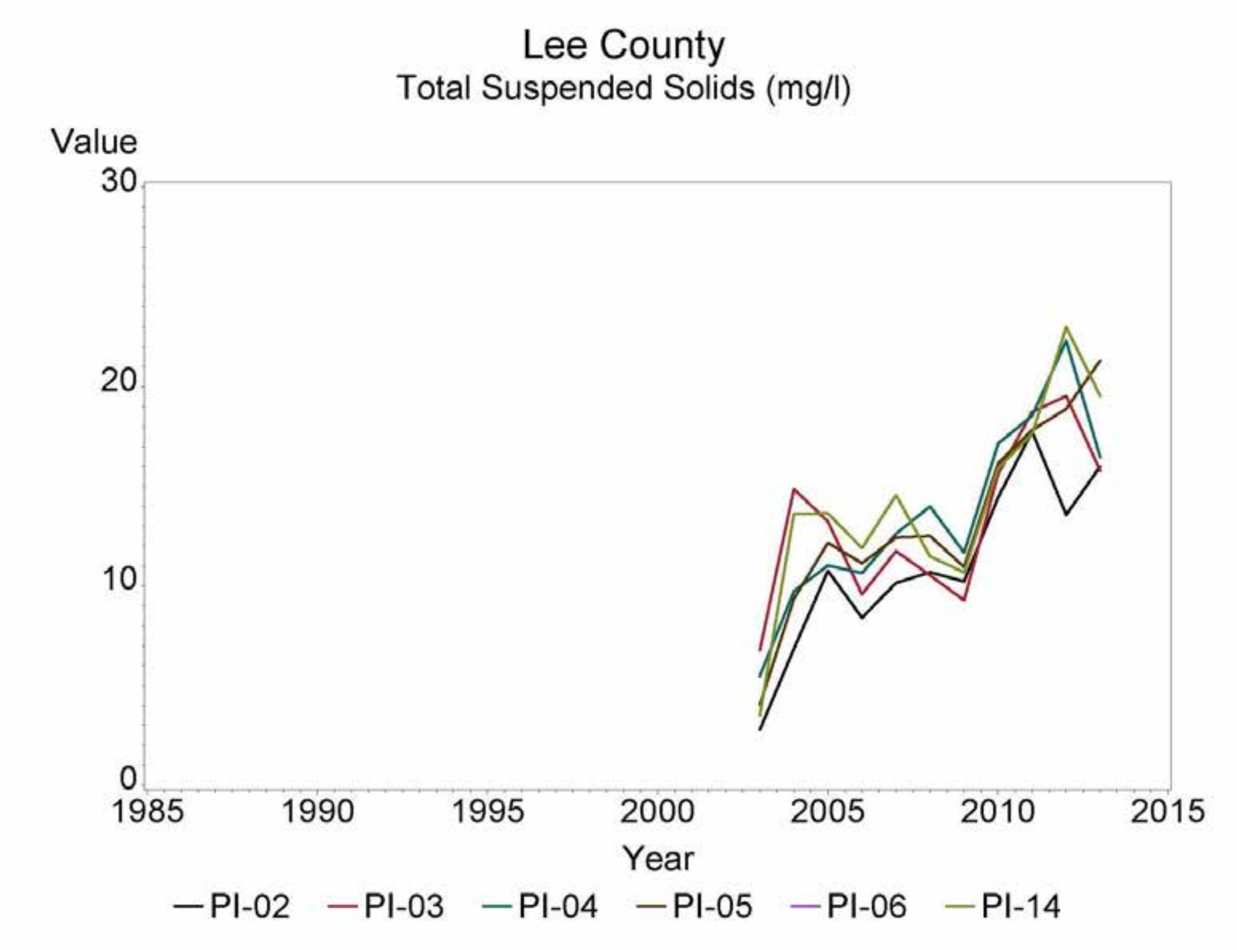


Figure 2-69. Time Series for Total Suspended Solids for Lee County Fixed Stations

Trends for TSS for Lee County stations are provided in Figure 2-70. Large increasing trends were identified in all stations except Station PI-03 (no trend) from 1996 to 2013 for samples collected by Lee County. No trends were examined on Station PI-06 due to insufficient data (n <60 for TSS observations).

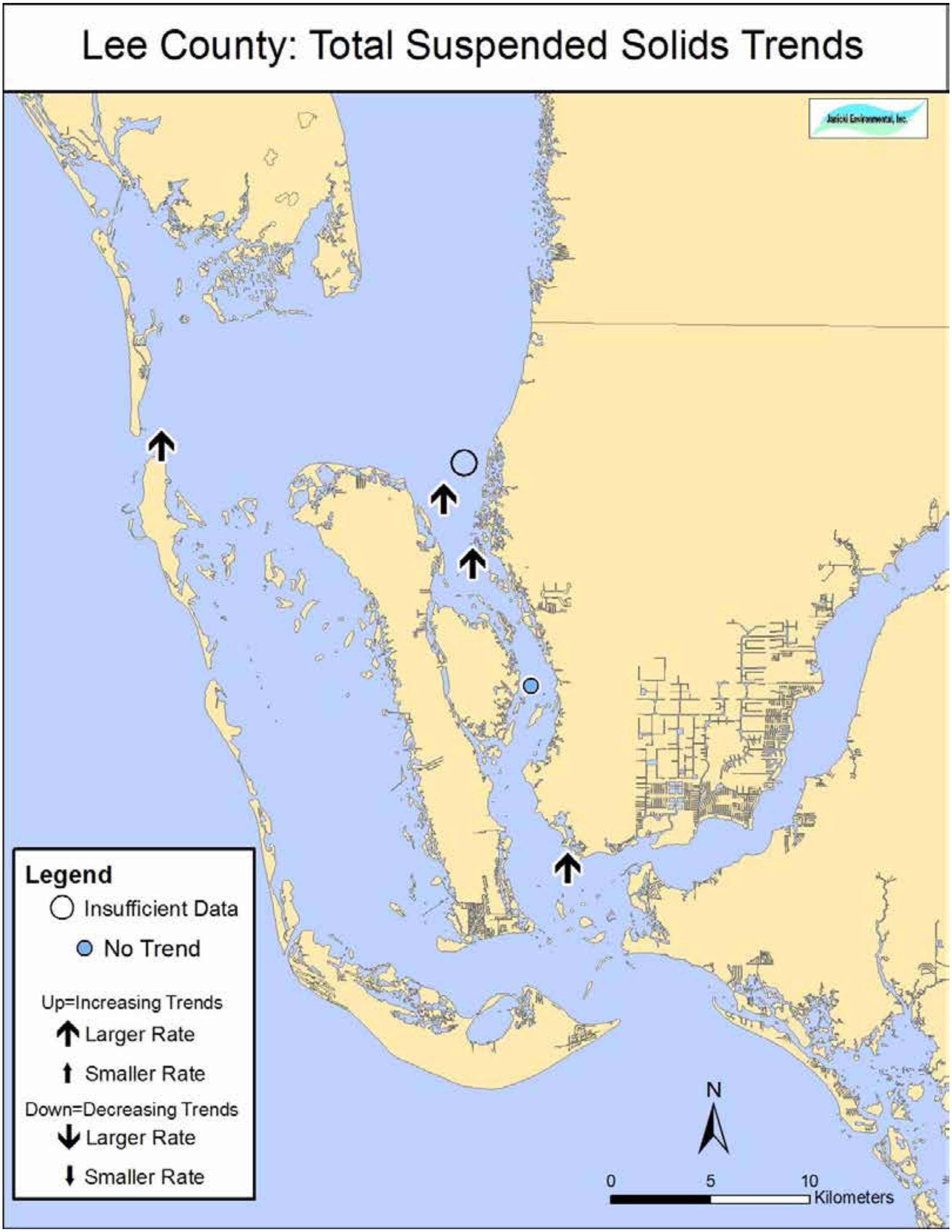


Figure 2-70. Total Suspended Solids Trends for Lee County Fixed Stations

Cross correlation analysis suggested that TSS concentrations among stations were greatest between Stations PI-06 and PI-14, but this is not considered significant. However, it should be noted that no TSS measurements were taken at PI-06 before or after 2003. The next highest correlation not including Station PI-06 was between Stations PI-04 and PI-05. All cross correlations were found to be statistically significant, positive correlations except between Stations PI-03 and PI-06 and between PI-06 and PI-14 (Table 2-36).

Table 2-36. Spearman Rank Correlation Coefficient for Total Suspended Solids for Lee County Fixed Stations

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations						
	PI_02	PI_03	PI_04	PI_05	PI_06	PI_14
PI_02	1.00000 118	0.48646 <.0001 117	0.60302 <.0001 116	0.54097 <.0001 117	1.00000 <.0001 3	0.42587 <.0001 116
PI_03	0.48646 <.0001 117	1.00000 120	0.56059 <.0001 118	0.56200 <.0001 118	-0.50000 0.6667 3	0.32987 0.0003 116
PI_04	0.60302 <.0001 116	0.56059 <.0001 118	1.00000 119	0.62920 <.0001 118	-1.00000 <.0001 3	0.54951 <.0001 115
PI_05	0.54097 <.0001 117	0.56200 <.0001 118	0.62920 <.0001 118	1.00000 119	0.50000 0.6667 3	0.44607 <.0001 116
PI_06	1.00000 <.0001 3	-0.50000 0.6667 3	-1.00000 <.0001 3	0.50000 0.6667 3	1.00000 3	0.86603 0.3333 3
PI_14	0.42587 <.0001 116	0.32987 0.0003 116	0.54951 <.0001 115	0.44607 <.0001 116	0.86603 0.3333 3	1.00000 117

2.2.8 SECCHI DISK

Secchi disk visibility has been routinely sampled by Lee County since 2003 for all stations except Station PI-06, which was only sampled in 2003 (Table 2-37).

Table 2-37. Secchi Disk Sampling Frequency by Station for Lee County Fixed Stations

	Station						
Year	PI-02	PI-03	PI-04	PI-05	PI-06	PI-14	Total
1996	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-
1998	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-
2002	-	-	-	-	-	-	-
2003	6	5	5	6	3	6	31
2004	9	9	9	9	-	8	44
2005	11	11	11	11	-	11	55
2006	3	4	6	7	-	10	30
2007	-	1	7	8	-	11	27
2008	4	3	8	7	-	9	31
2009	3	1	10	11	-	11	36
2010	6	7	9	11	-	11	44
2011	6	8	11	11	-	12	48
2012	8	11	11	11	-	11	52
2013	5	8	10	9	-	10	42
Total	61	68	97	101	3	110	440

The overall arithmetic average secchi disk visibility between 2003 and 2013 for each station is displayed in Figure 2-71. Stations PI-03 and PI-02 had the lowest average concentrations, while Station PI-05 had the highest average concentration. For Lee County, the period of record is truncated to 2003-2013 since all stations (except PI-06) were collecting secchi disk data over this time period. Note that Station PI-06 recorded secchi disk measurements only in 2003.

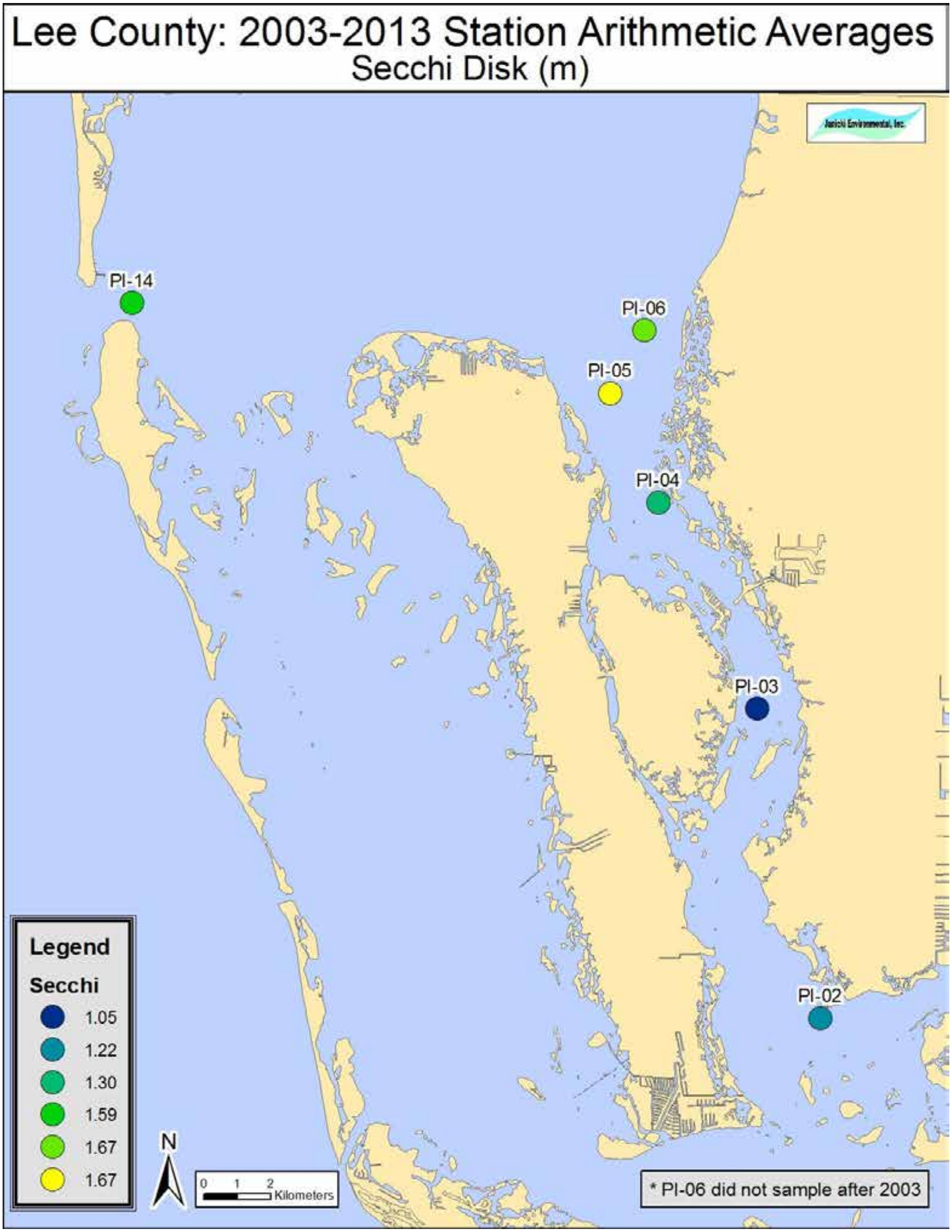


Figure 2-71. Arithmetic Average of Secchi Disk Visibility for Lee County Fixed Stations

Box and whisker plots for secchi disk measurements collected by Lee County are presented in Figure 2-72 and show that at least 75 percent of the data collected have a visibility greater than 1 meter (m). These plots represent the entire period of record for each station, which varies among stations. Note that secchi disk measurements were collected at Station PI-06 only in 2003.

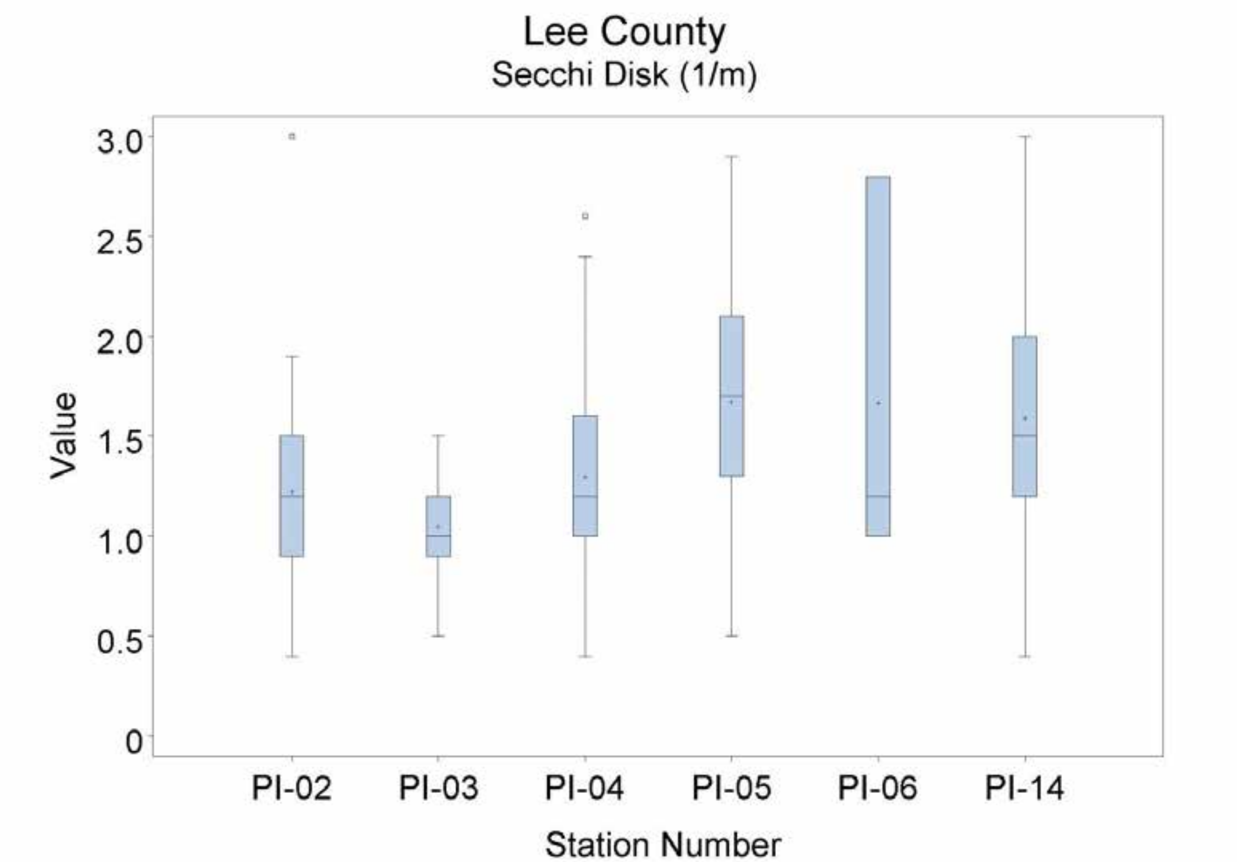


Figure 2-72. Box and Whisker Plots Displaying the Distribution of Secchi Disk Visibility for Lee County Fixed Stations

Time series plots of secchi disk visibility measurements taken by Lee County indicate that annual averages among stations seem to follow the same general temporal trend despite relatively large differences in the magnitude of the annual averages (Figure 2-73).

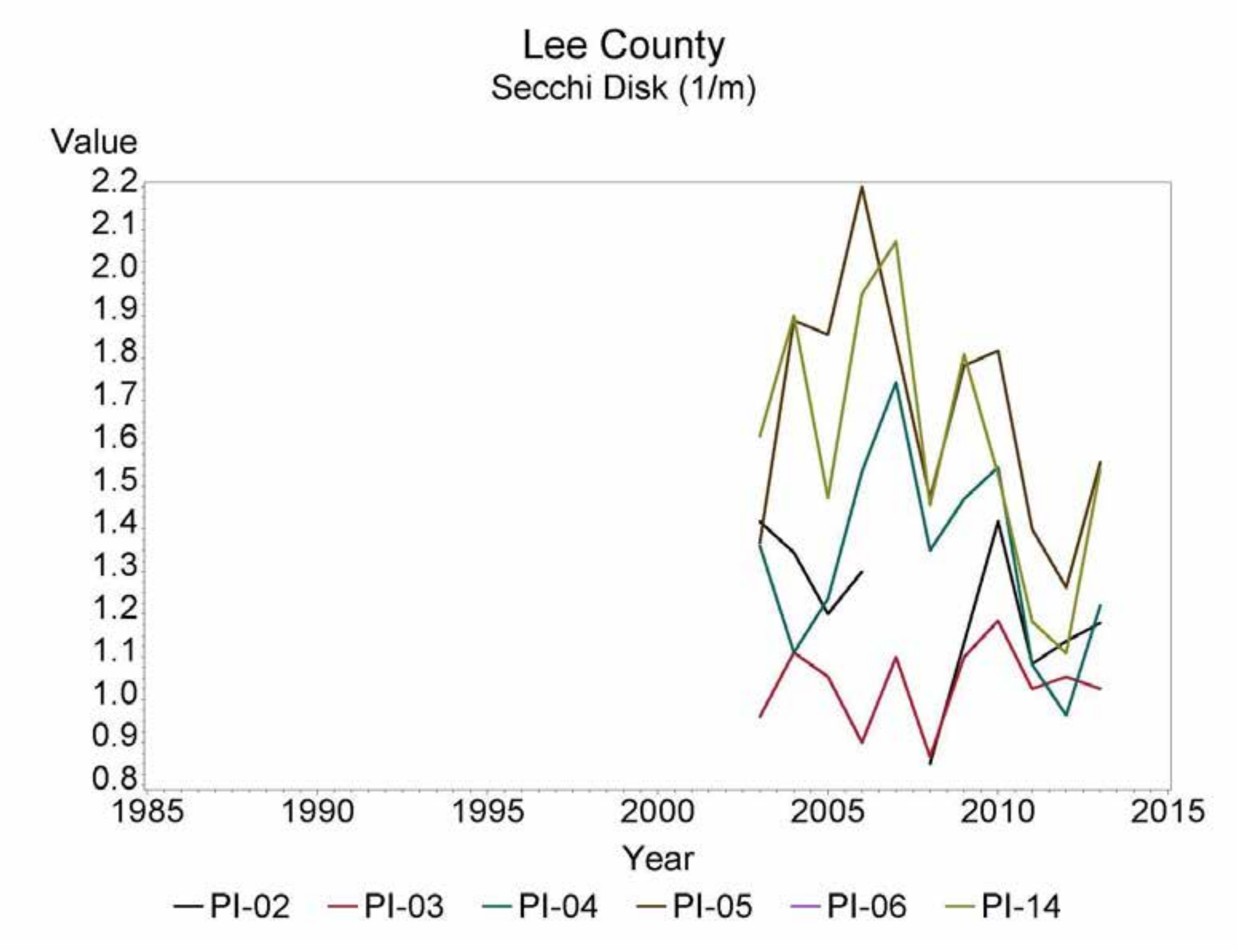


Figure 2-73. Time Series Plot of Secchi Disk Visibility for Lee County Fixed Stations

Trends for secchi disk visibility for Lee County stations are displayed in Figure 2-74. No trends were identified at any station except Station PI-05 and PI-14, which indicated large and small decreasing trends, respectively, from 1996 to 2013 for samples collected by Lee County. No trends were examined on Station PI-06 due to insufficient data (n <60 for secchi disk observations).

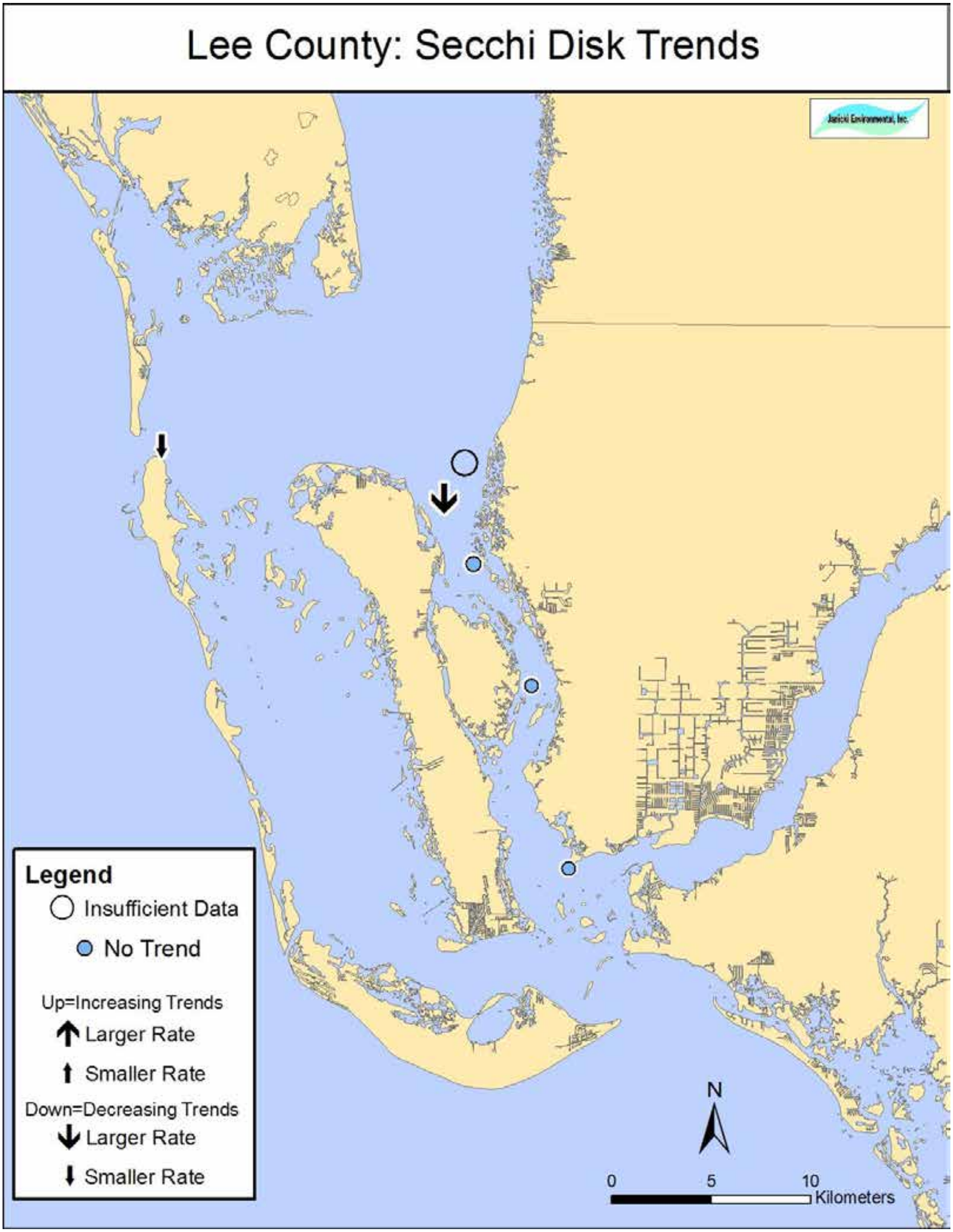


Figure 2-74. Secchi Disk Visibility Trends for Lee County Fixed Stations

Cross correlation analysis suggested that secchi disk concentrations among stations were greatest among Stations PI-02 and PI-03 as well as PI-02 and PI-14. All cross correlations among stations were considered significant except between Stations PI-06 and PI-14. However, it should be noted that no secchi disk measurements were taken at Station PI-06 before or after 2003 (Table 2-38).

Table 2-38. Spearman Rank Correlation Coefficients for Secchi Disk Visibility for Lee County Fixed Stations

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations						
	PI_02	**PI_03**	**PI_04**	**PI_05**	**PI_06**	**PI_14**
PI_02	1.00000 61	0.62073 <.0001 53	0.38038 0.0035 57	0.51218 <.0001 59	1.00000 <.0001 3	0.68984 <.0001 59
PI_03	0.62073 <.0001 53	1.00000 68	0.44237 0.0003 63	0.42910 0.0004 64	1.00000 <.0001 3	0.38770 0.0014 65
PI_04	0.38038 0.0035 57	0.44237 0.0003 63	1.00000 98	0.61162 <.0001 94	0.50000 0.6667 3	0.34489 0.0007 93
PI_05	0.51218 <.0001 59	0.42910 0.0004 64	0.61162 <.0001 94	1.00000 102	1.00000 <.0001 3	0.46681 <.0001 96
PI_06	1.00000 <.0001 3	1.00000 <.0001 3	0.50000 0.6667 3	1.00000 <.0001 3	1.00000 3	1.00000 <.0001 3
PI_14	0.68984 <.0001 59	0.38770 0.0014 65	0.34489 0.0007 93	0.46681 <.0001 96	1.00000 <.0001 3	1.00000 111

2.2.9 FECAL COLIFORM

Fecal coliform has been routinely sampled by Lee County since 1996 for all stations except Station PI-06, which stopped sampling after 2003 (Table 2-39).

Table 2-39. Fecal Coliform Sampling Frequency by Station for Lee County Fixed Stations

	Station						
Year	PI-02	PI-03	PI-04	PI-05	PI-06	PI-14	Total
1996	2	2	2	2	2	2	12
1997	3	3	3	3	3	3	18
1998	4	4	4	4	4	4	24
1999	4	4	4	4	4	4	24
2000	4	4	4	4	4	4	24
2001	12	12	12	12	12	12	72
2002	12	12	12	12	12	12	72
2003	10	9	9	10	7	10	55
2004	9	9	9	9	-	8	44
2005	11	11	11	11	-	11	55
2006	9	11	10	10	-	10	50
2007	12	12	12	12	-	12	60
2008	12	12	12	12	-	12	60
2009	1	1	1	1	-	1	5
2010	-	-	-	-	-	-	-
2011	-	-	-	-	-	-	-
2012	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-
Total	105	106	105	106	48	105	575

The overall arithmetic average fecal coliform concentration between 2003 and 2009 for each station is displayed in Figure 2-75. Stations PI-05 and PI-06 had the lowest average concentrations, while Station PI-14 had the highest average concentration. For Lee County, the period of record is truncated to 1996-2009 since all stations (except PI-06) were collecting fecal coliform data over this time period.

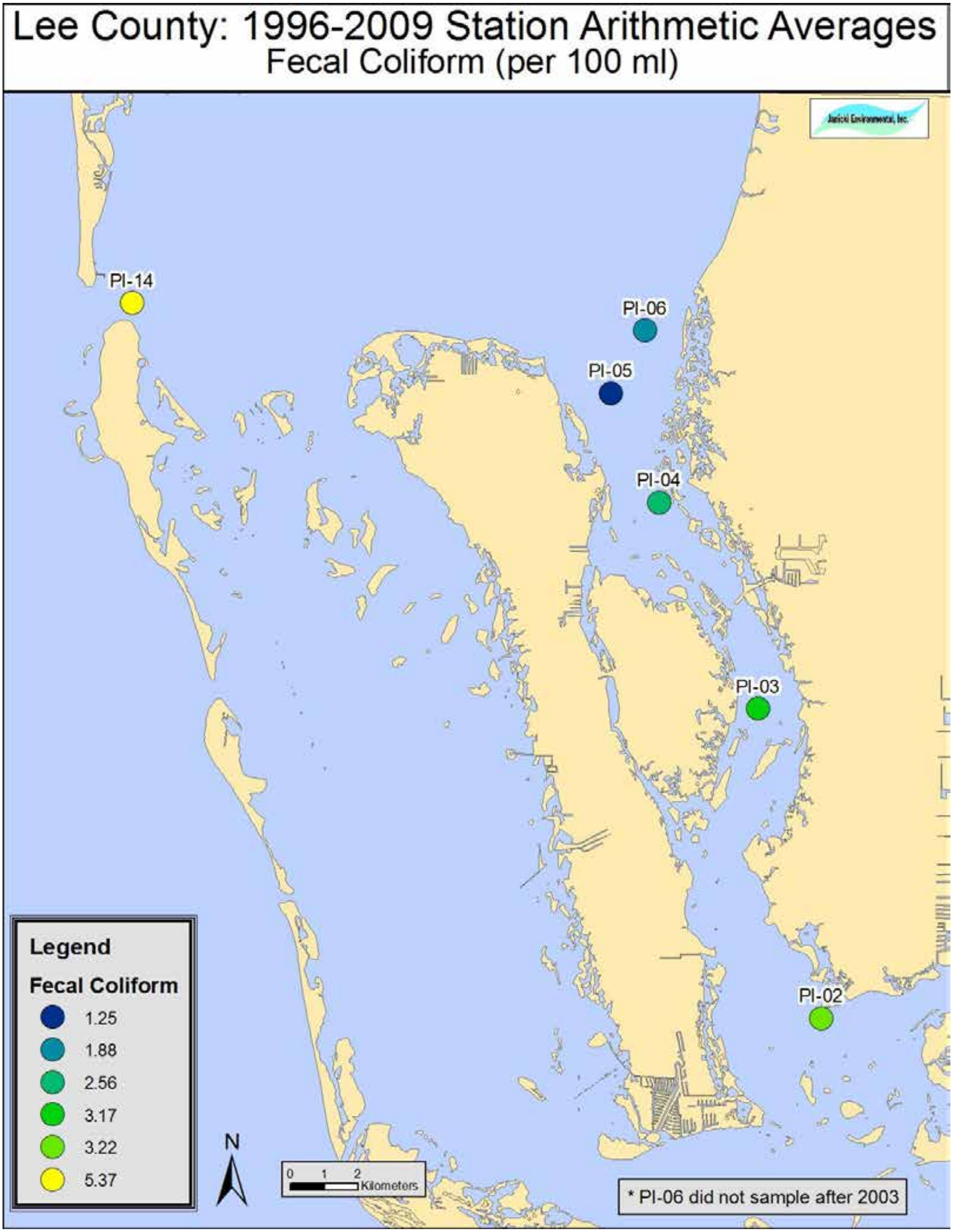


Figure 2-75. Arithmetic Average for Fecal Coliform for Lee County Fixed Stations

Box and whisker plots of fecal coliform concentrations collected by Lee County are displayed in Figure 2-76. Station PI-02, the southernmost station examined from Lee County in this project, had the highest distribution of fecal coliform concentrations. These plots represent the entire period of record for each station, which varies among stations. Note that no fecal coliform measurements were collected at Station PI-06 after 2003. These plots are trimmed such that extremely high values are not displayed in the plots.

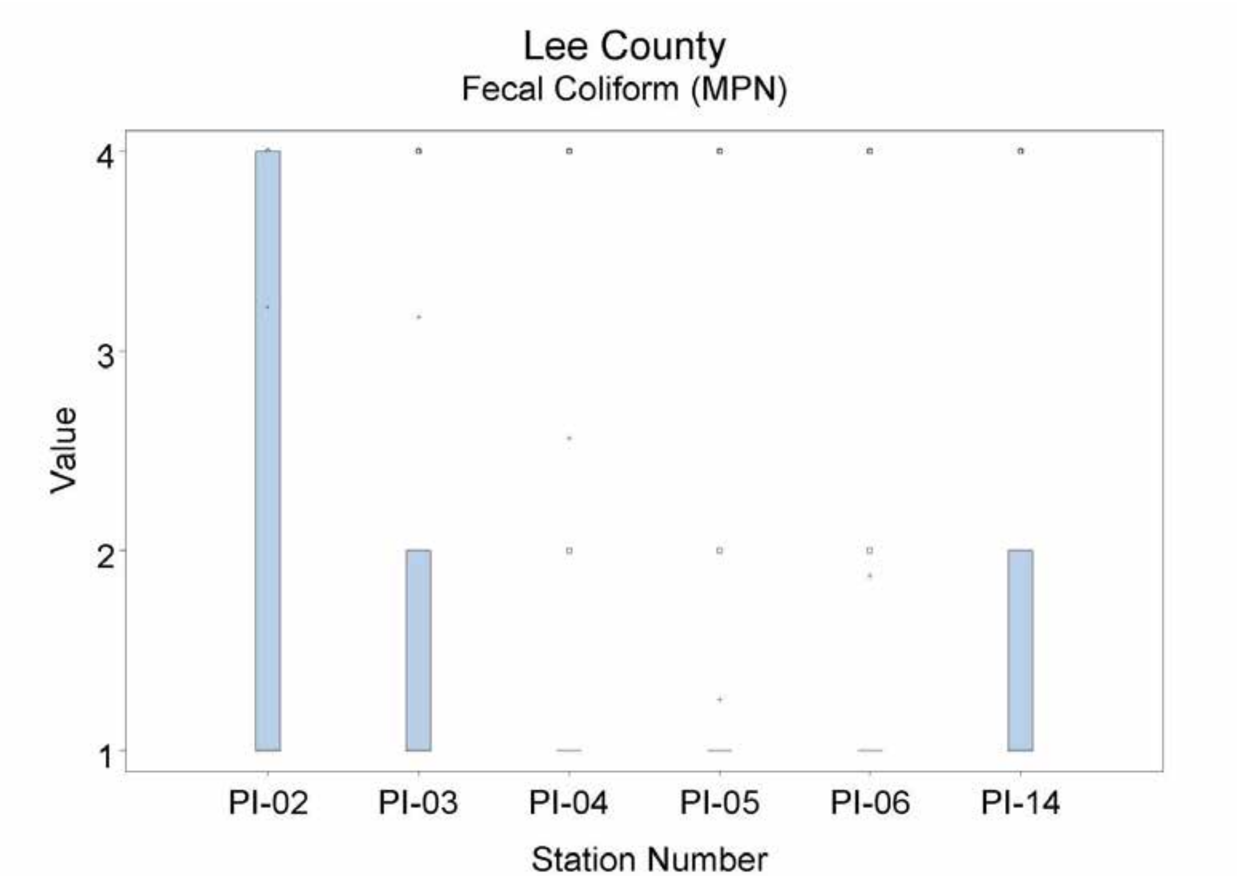


Figure 2-76. Box and Whisker Plots Displaying the Distribution of Fecal Coliform Concentrations among Lee County Fixed Stations

Time series plots of fecal coliform concentrations taken by Lee County indicate that all stations had arithmetic values near the detection limit and well below conditions considered to be indicative of effects of human or animal waste streams. Interestingly, Station PI-14 (Near Boca Grande Pass) experienced the highest fecal coliform concentrations in 2003 and 2008 (Figure 2-77), but were still well below concentrations indicative of fecal problems. All other stations were effectively near zero.

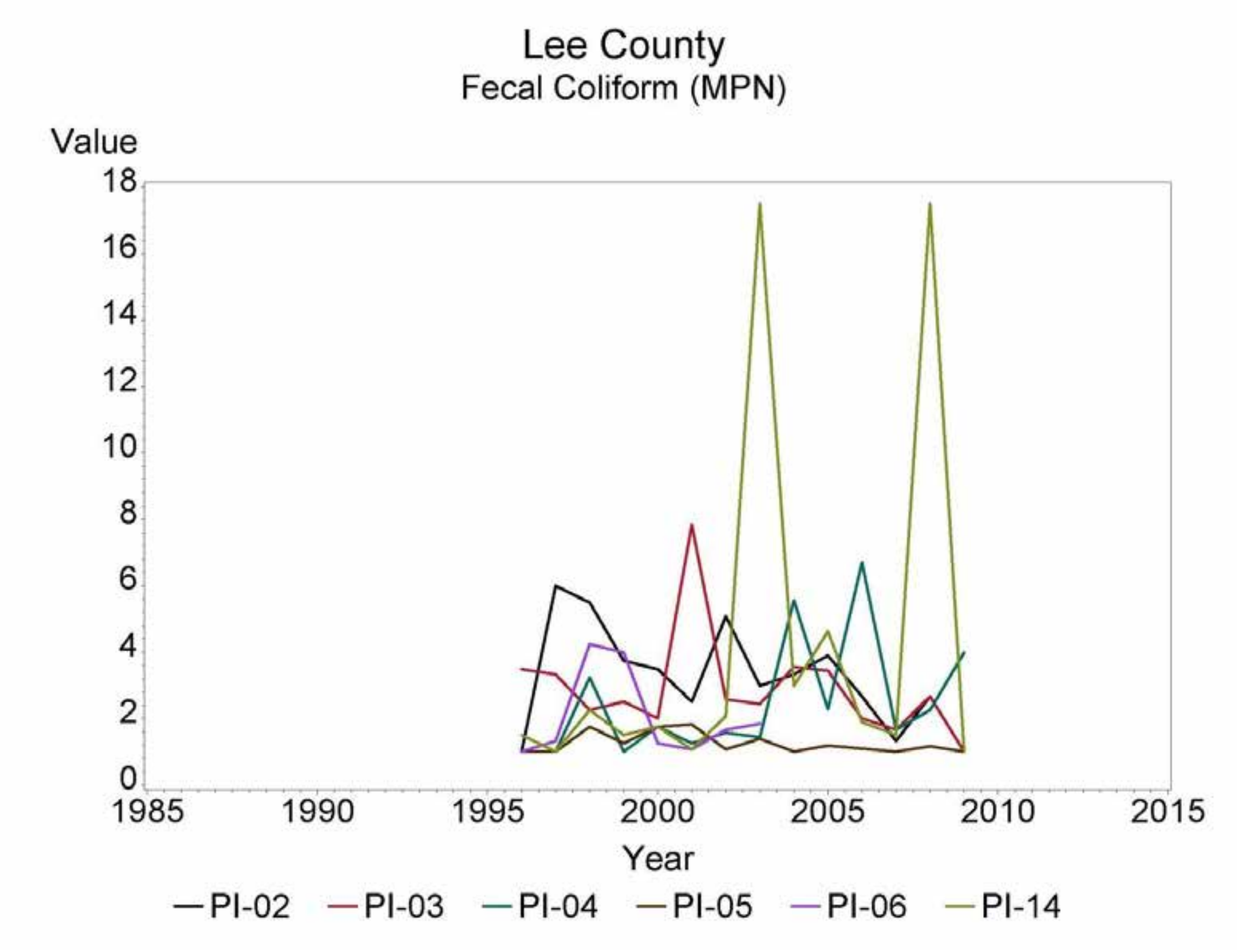


Figure 2-77. Time Series Plot of Fecal Coliform for Lee County Fixed Stations

Trends for fecal coliform concentrations for Lee County stations are provided in Figure 2-78. No trends were identified in any station from 1996 to 2013 for samples collected by Lee County. No trends were examined on Station PI-06 due to insufficient data (n <60 for fecal coliform observations).

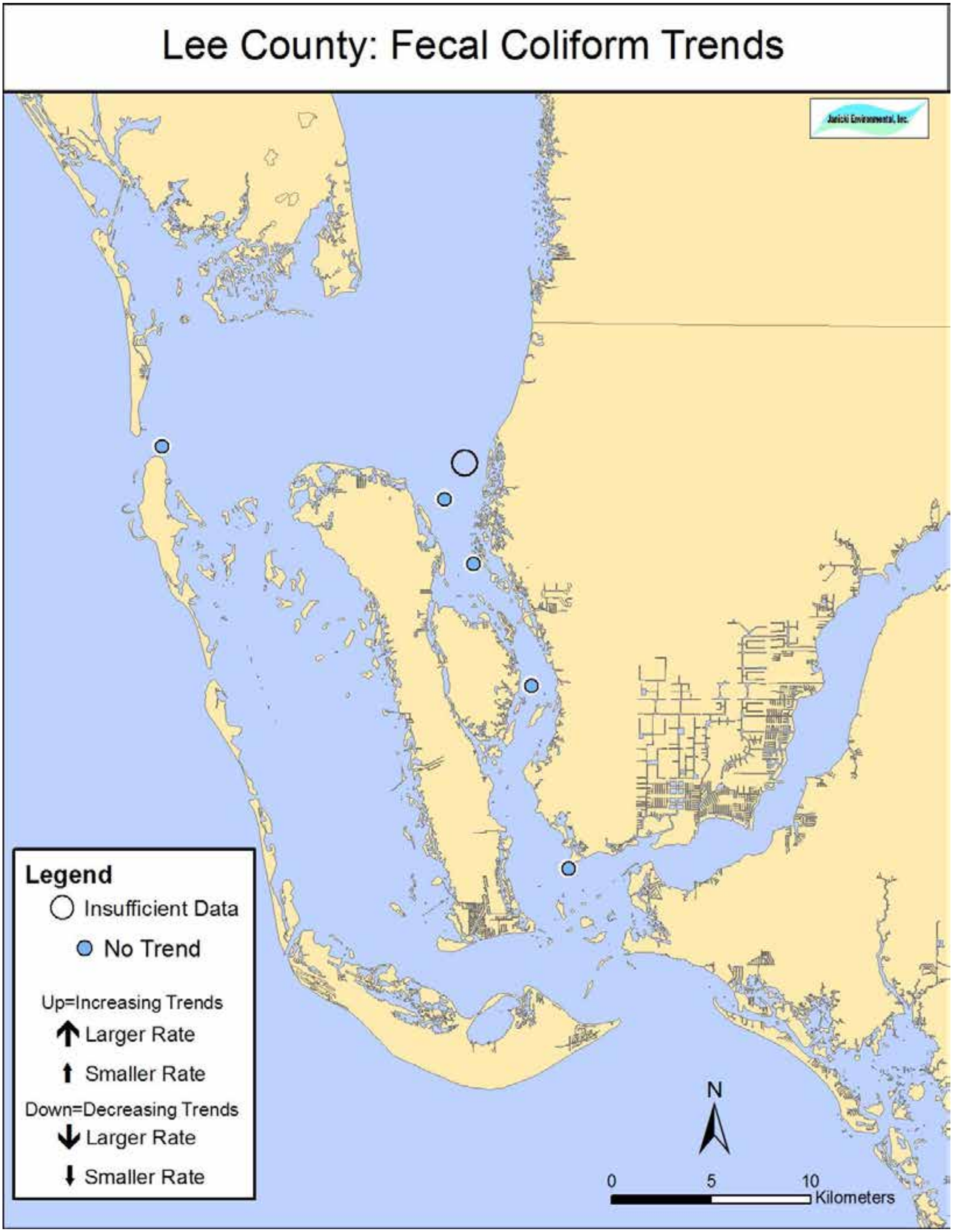


Figure 2-78. Fecal Coliform Trends for Lee County Stations

Cross correlation analysis suggested that correlation in fecal coliform concentrations were quite low and mostly not significant (Table 2-40).

Table 2-40. Spearman Rank Correlation Coefficients for Fecal Coliform Concentrations for Lee County Fixed Stations

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	PI_02	PI_03	PI_04	PI_05	PI_06	PI_14
PI_02	1.00000 104	0.26920 0.0060 103	0.17971 0.0707 102	0.17691 0.0738 103	0.23826 0.1068 47	0.27908 0.0043 103
PI_03	0.26920 0.0060 103	1.00000 105	0.17571 0.0758 103	0.10454 0.2909 104	0.34434 0.0178 47	0.41129 <.0001 103
PI_04	0.17971 0.0707 102	0.17571 0.0758 103	1.00000 104	0.24168 0.0135 104	0.19470 0.1897 47	0.10315 0.3022 102
PI_05	0.17691 0.0738 103	0.10454 0.2909 104	0.24168 0.0135 104	1.00000 105	-0.03565 0.8119 47	0.11052 0.2664 103
PI_06	0.23826 0.1068 47	0.34434 0.0178 47	0.19470 0.1897 47	-0.03565 0.8119 47	1.00000 47	-0.12905 0.3873 47
PI_14	0.27908 0.0043 103	0.41129 <.0001 103	0.10315 0.3022 102	0.11052 0.2664 103	-0.12905 0.3873 47	1.00000 104

2.3 LEE CEITUS

Lee County developed a special sampling program to collect more data within the NSC system in 2012 and 2013. The locations of Lee Ceitus sampling stations are shown in Figure 2-79.

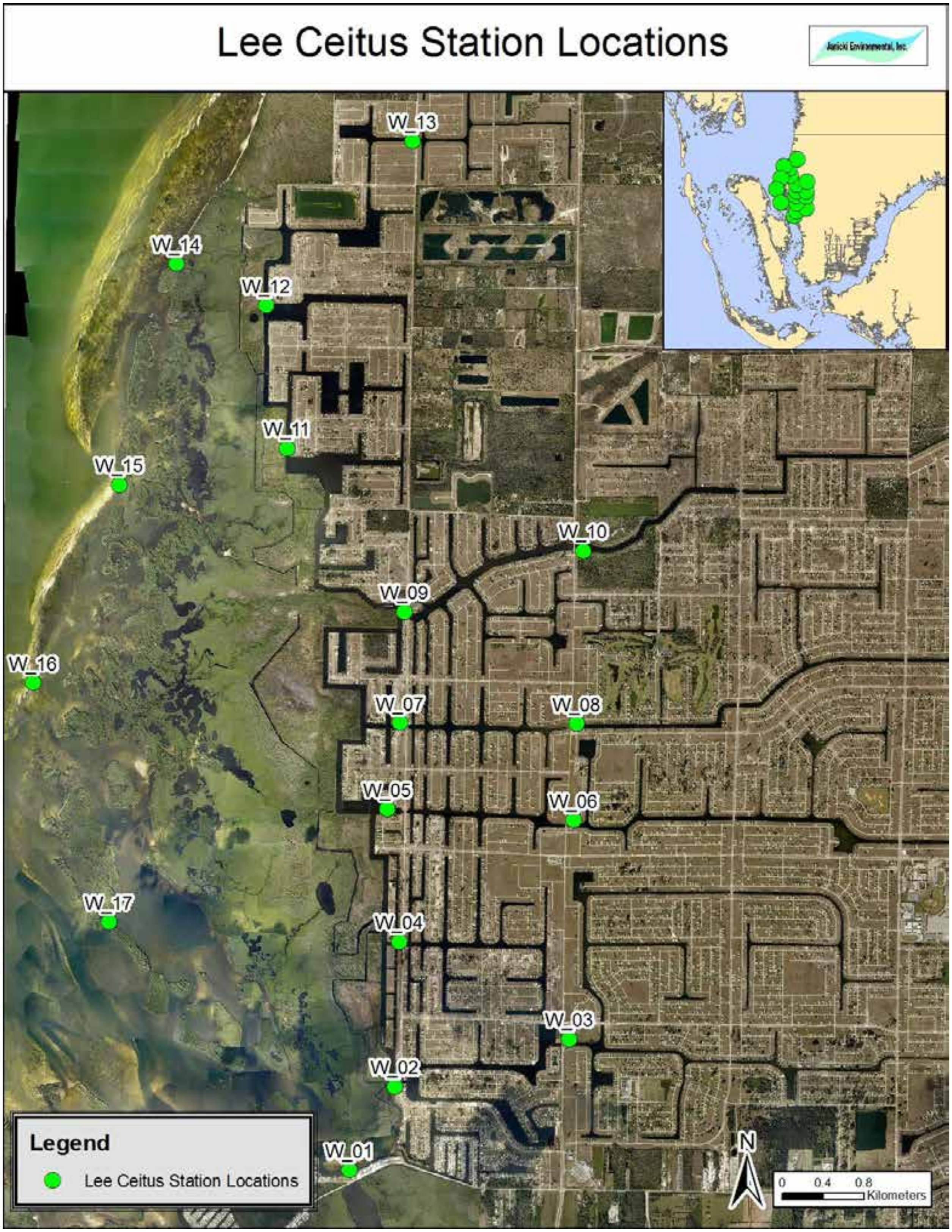


Figure 2-79. Lee Ceitus Sampling Locations

These stations routinely collected samples from 2012-2013. Specific station periods of record are provided in Table 2-41.

Table 2-41. Lee Ceitus Station Period of Record

Station	Period of Record
01	2012-2013
02	2012-2013
03	2012-2013
04	2012-2013
05	2012-2013
06	2012-2013
07	2012-2013
08	2012-2013
09	2012-2013
10	2012-2013
11	2012-2013
12	2012-2013
13	2012-2013
14	2012-2013
15	2012-2013
16	2012-2013
17	2012-2013

A list of the periods of record for each parameter measured at each station is provided in Table 2-42. The following subsections characterize the data collected at these stations for the principal constituents of interest. Note that this table does not account for data gaps and only reports the minimum and maximum years for each parameter.

Table 2-42. Lee Ceitus Constituents Sampled and Period of Record

	Station																
Parameter	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17
Chlorophyll *a* (chlac_ugl)	2013	-	2013	2013	2013	-	2013	-	-	-	-	2013	2013	2013	2013	2013	2013
Dissolved Oxygen (DO_mgl)	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013
Fecal Coliform (FCOLI)	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013
Salinity	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013
Secchi Disk Visibility	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Nitrogen (TN_mgl)	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013
Total Phosphorus (TP_mgl)	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013	2012-2013
Total Suspended Solids (TSS_mgl)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Turbidity (TURB)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

2.3.1 SALINITY

Salinity was sampled bimonthly between October 2012 and April 2013 and then monthly through the remainder of 2013 except at Stations 02, 06, 08, 09, 10, and 11, which were discontinued after April 2013 (Table 2-43). The numbers in this table represents the sampling frequency at the surface level. Samples are generally taken at near surface, mid water column and near bottom depths for salinity. No bottom salinity measurements were reported.

Table 2-43. Salinity Sampling Frequency by Station for Lee Ceitus Stations

		Station																
		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17
Year	**MONTH**																	
2012	**9**	1	1	1	1	1	1	1	1	1	1	1	1	1	.	.	.	.
	10	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	11	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	12	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
2013	**1**	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	3	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	4	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	5	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	6	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	7	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	8	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	9	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	10	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	11	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	12	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1

The overall station arithmetic average salinity concentration between 2012 and 2013 is displayed in Figure 2-80. Stations 08 and 10 had the lowest average concentrations, while Station 14 had the highest average concentration.

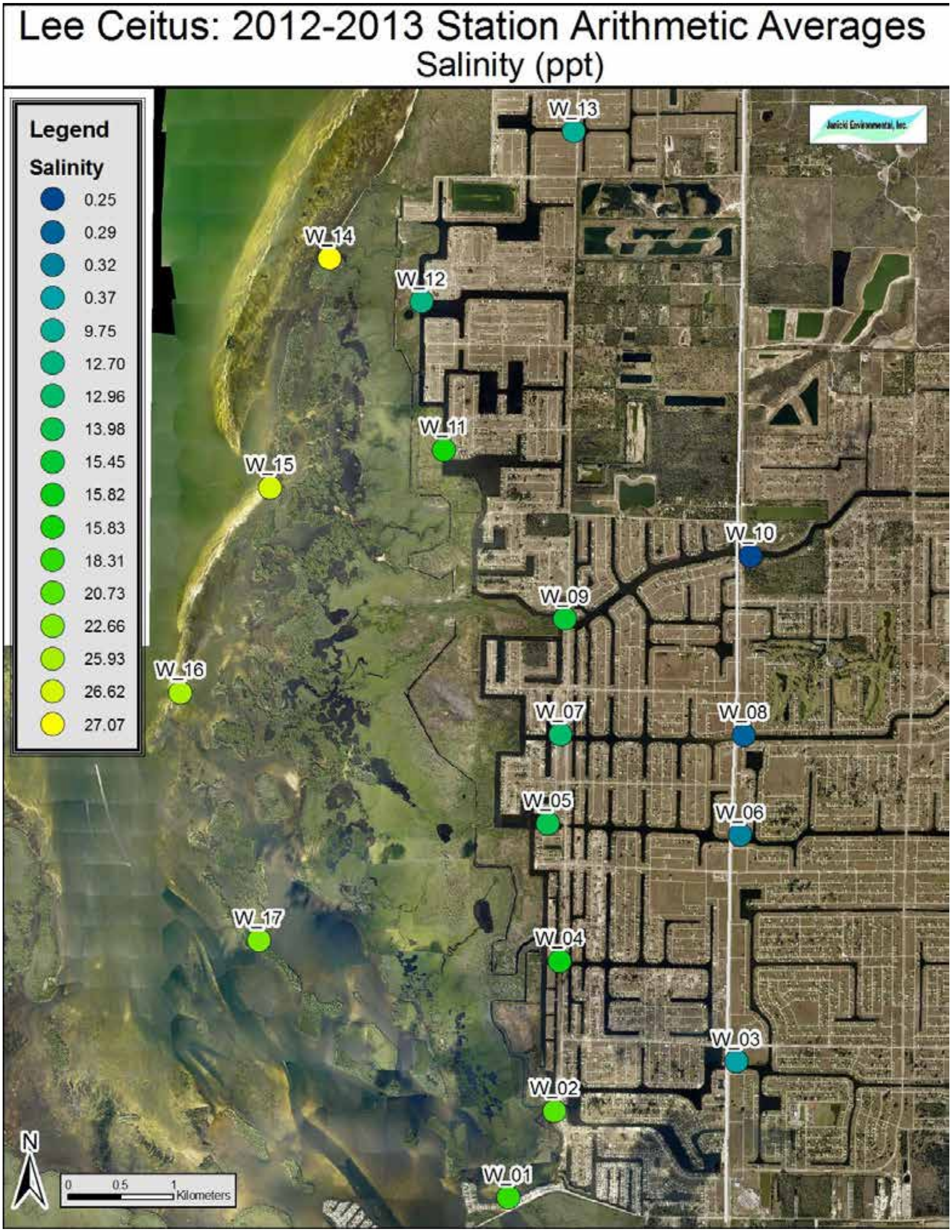


Figure 2-80. Arithmetic Averages of Salinity for Lee Ceitus Stations

Between-station variability in surface salinity is presented in Figure 2-81. As expected, Stations 14, 15, 16, and 17 have higher salinities as they are located within Matlacha Pass. Stations 04, 05, 07, 12, and 13 are tidally influenced since they are closer to Matlacha Pass, while Stations 03 (Shadroe Canal), 06 (Hermosa Canal), 08 (Horseshoe Canal), and 10 (Gator Slough) are located above the salinity barriers in the NSC. While the period of record varies among stations, it is clear that the stations within Matlacha Pass (e.g., 14, 15, 16, and 17) have higher average salinities than those stations above the salinity barriers. These plots represent the entire period of record for each station. Note that no salinity measurements were taken at Stations 02, 06, 08, 09, 10, and 11 after April 2013.

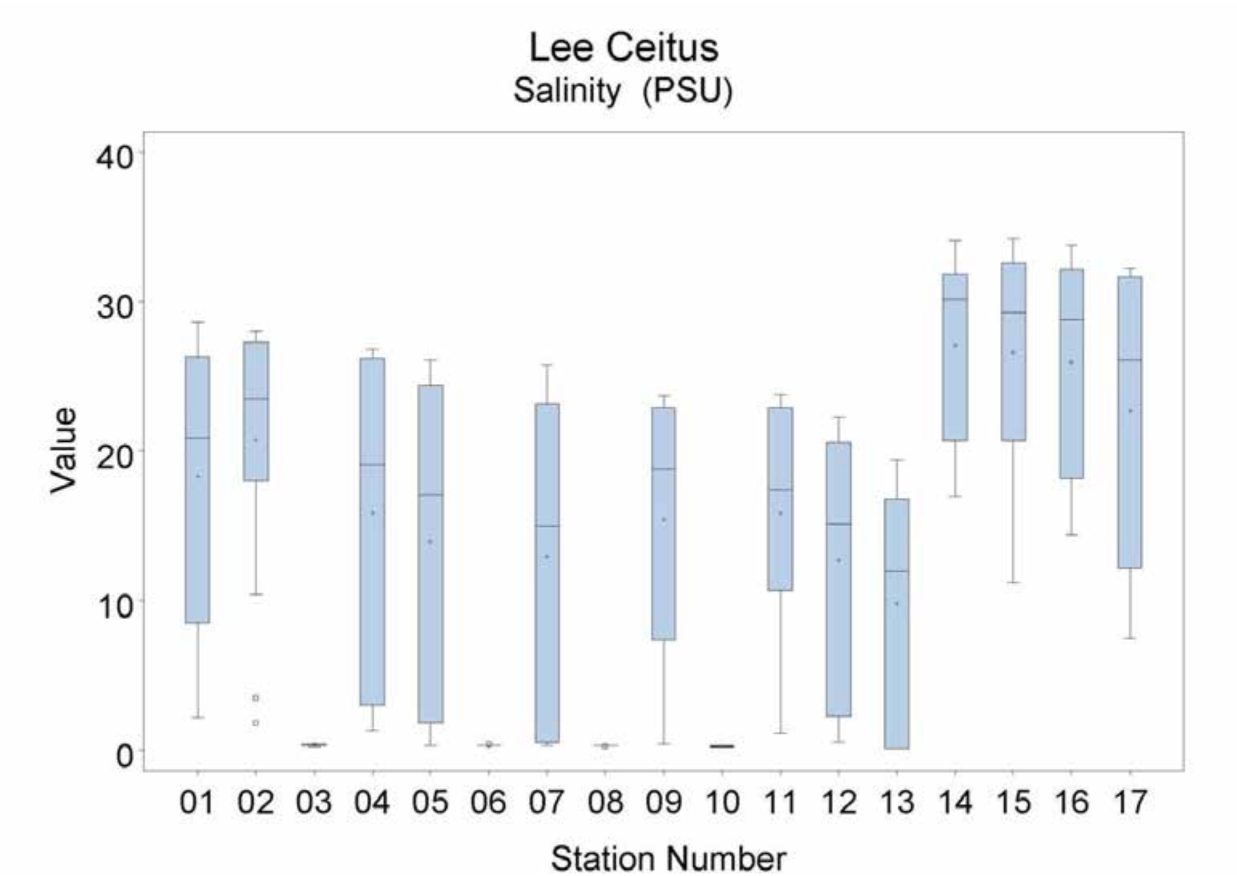


Figure 2-81. Box and Whisker Plots Displaying the Distribution of Salinity for Lee Ceitus Stations

Time series plots (Figure 2-82) indicate that there is a consistent temporal (i.e., seasonal) salinity pattern across stations, with offsets generally representing distance from the pass.

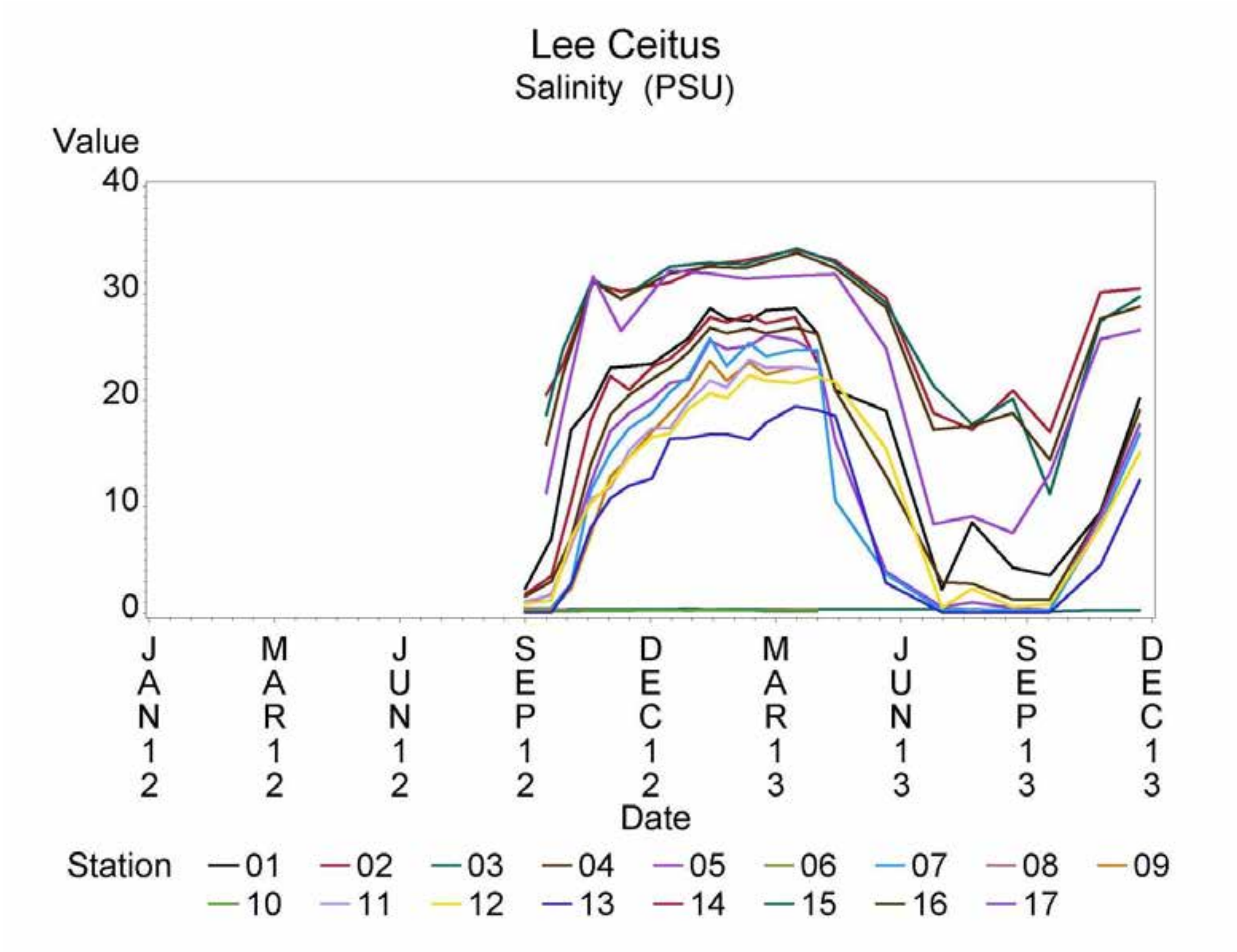


Figure 2-82. Time Series Plots of Surface Salinities for Lee Ceitus Stations

No trend examination was performed on salinity due to the limited time period examined.

Cross correlation analysis suggested that salinity concentrations among stations were greatest between Stations 05 and 07 (Table 2-44). All stations within Matlacha Pass (14, 15, 16, and 17) were significantly positively correlated.

Table 2-44. Spearman Rank Correlation Coefficients for Surface Salinity for Lee Ceitus Stations

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	_01	_02	_03	_04	_05	_06	_07	_08	_09	_10	_11	_12	_13	_14	_15	_16	_17
_01	1.00000 16	0.97619 <.0001 8	0.58964 0.0162 16	0.94845 <.0001 16	0.95000 <.0001 16	0.62738 0.0959 8	0.94986 <.0001 16	0.26498 0.5259 8	0.90476 0.0020 8	0.53675 0.1702 8	0.92857 0.0009 8	0.92568 <.0001 16	0.89861 <.0001 16	0.88909 <.0001 15	0.89723 <.0001 15	0.94549 <.0001 15	0.87500 <.0001 15
_02	0.97619 <.0001 8	1.00000 8	0.74834 0.0327 8	0.95810 0.0002 8	1.00000 <.0001 8	0.51827 0.1882 8	0.97619 <.0001 8	0.26498 0.5259 8	0.92857 0.0009 8	0.43916 0.2763 8	0.97619 <.0001 8	0.97619 <.0001 8	0.92857 0.0009 8	0.82886 0.0212 7	0.82143 0.0234 7	0.82143 0.0234 7	0.46429 0.2939 7
_03	0.58964 0.0162 16	0.74834 0.0327 8	1.00000 16	0.67188 0.0044 16	0.60821 0.0124 16	0.56671 0.1430 8	0.54016 0.0308 16	0.10794 0.7992 8	0.74834 0.0327 8	0.64984 0.0811 8	0.74834 0.0327 8	0.57226 0.0205 16	0.53881 0.0313 16	0.49223 0.0623 15	0.54854 0.0342 15	0.54854 0.0342 15	0.52915 0.0425 15
_04	0.94845 <.0001 16	0.95810 0.0002 8	0.67188 0.0044 16	1.00000 16	0.97349 <.0001 16	0.69975 0.0533 8	0.95864 <.0001 16	0.26657 0.5234 8	0.92217 0.0011 8	0.51542 0.1911 8	0.92217 0.0011 8	0.92631 <.0001 16	0.93282 <.0001 16	0.90771 <.0001 15	0.93465 <.0001 15	0.94449 <.0001 15	0.88551 <.0001 15
_05	0.95000 <.0001 16	1.00000 <.0001 8	0.60821 0.0124 16	0.97349 <.0001 16	1.00000 16	0.51827 0.1882 8	0.98526 <.0001 16	0.26498 0.5259 8	0.92857 0.0009 8	0.43916 0.2763 8	0.97619 <.0001 8	0.91685 <.0001 16	0.91951 <.0001 16	0.89446 <.0001 15	0.89187 <.0001 15	0.91510 <.0001 15	0.85000 <.0001 15
_06	0.62738 0.0959 8	0.51827 0.1882 8	0.56671 0.1430 8	0.69975 0.0533 8	0.51827 0.1882 8	1.00000 8	0.54554 0.1619 8	0.42857 0.2894 8	0.68193 0.0625 8	0.25156 0.5479 8	0.54554 0.1619 8	0.54554 0.1619 8	0.68193 0.0625 8	0.62625 0.1324 7	0.80781 0.0280 7	0.80781 0.0280 7	0.74870 0.0528 7
_07	0.94986 <.0001 16	0.97619 <.0001 8	0.54016 0.0308 16	0.95864 <.0001 16	0.98526 <.0001 16	0.54554 0.1619 8	1.00000 16	0.26498 0.5259 8	0.97619 <.0001 8	0.29277 0.4816 8	1.00000 <.0001 8	0.92251 <.0001 16	0.91623 <.0001 16	0.89408 <.0001 15	0.88431 <.0001 15	0.91660 <.0001 15	0.84947 <.0001 15
_08	0.26498 0.5259 8	0.26498 0.5259 8	0.10794 0.7992 8	0.26657 0.5234 8	0.26498 0.5259 8	0.42857 0.2894 8	0.26498 0.5259 8	1.00000 8	0.26498 0.5259 8	-0.23958 0.5677 8	0.26498 0.5259 8	0.26498 0.5259 8	0.26498 0.5259 8	0.35957 0.4283 7	0.44544 0.3165 7	0.44544 0.3165 7	0.26726 0.5623 7
_09	0.90476 0.0020 8	0.92857 0.0009 8	0.74834 0.0327 8	0.92217 0.0011 8	0.92857 0.0009 8	0.68193 0.0625 8	0.97619 <.0001 8	0.26498 0.5259 8	1.00000 8	0.24398 0.5604 8	0.97619 <.0001 8	0.97619 <.0001 8	1.00000 <.0001 8	0.93697 0.0019 7	0.92857 0.0025 7	0.92857 0.0025 7	0.50000 0.2532 7

Table 2-44. Spearman Rank Correlation Coefficients for Surface Salinity for Lee Ceitus Stations (Continued)

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	_01	_02	_03	_04	_05	_06	_07	_08	_09	_10	_11	_12	_13	_14	_15	_16	_17
_10	0.53675 0.1702 8	0.43916 0.2763 8	0.64984 0.0811 8	0.51542 0.1911 8	0.43916 0.2763 8	0.25156 0.5479 8	0.29277 0.4816 8	-0.23958 0.5677 8	0.24398 0.5604 8	1.00000 8	0.29277 0.4816 8	0.29277 0.4816 8	0.24398 0.5604 8	-0.07273 0.8769 7	0.10811 0.8175 7	0.10811 0.8175 7	0.57660 0.1754 7
_11	0.92857 0.0009 8	0.97619 <.0001 8	0.74834 0.0327 8	0.92217 0.0011 8	0.97619 <.0001 8	0.54554 0.1619 8	1.00000 <.0001 8	0.26498 0.5259 8	0.97619 <.0001 8	0.29277 0.4816 8	1.00000 8	1.00000 <.0001 8	0.97619 <.0001 8	0.90094 0.0056 7	0.85714 0.0137 7	0.85714 0.0137 7	0.42857 0.3374 7
_12	0.92568 <.0001 16	0.97619 <.0001 8	0.57226 0.0205 16	0.92631 <.0001 16	0.91685 <.0001 16	0.54554 0.1619 8	0.92251 <.0001 16	0.26498 0.5259 8	0.97619 <.0001 8	0.29277 0.4816 8	1.00000 <.0001 8	1.00000 16	0.95305 <.0001 16	0.91592 <.0001 15	0.91332 <.0001 15	0.93655 <.0001 15	0.85000 <.0001 15
_13	0.89861 <.0001 16	0.92857 0.0009 8	0.53881 0.0313 16	0.93282 <.0001 16	0.91951 <.0001 16	0.68193 0.0625 8	0.91623 <.0001 16	0.26498 0.5259 8	1.00000 <.0001 8	0.24398 0.5604 8	0.97619 <.0001 8	0.95305 <.0001 16	1.00000 16	0.97475 <.0001 15	0.97028 <.0001 15	0.96126 <.0001 15	0.90094 <.0001 15
_14	0.88909 <.0001 15	0.82886 0.0212 7	0.49223 0.0623 15	0.90771 <.0001 15	0.89446 <.0001 15	0.62625 0.1324 7	0.89408 <.0001 15	0.35957 0.4283 7	0.93697 0.0019 7	-0.07273 0.8769 7	0.90094 0.0056 7	0.91592 <.0001 15	0.97475 <.0001 15	1.00000 15	0.98389 <.0001 15	0.97762 <.0001 15	0.88193 <.0001 15
_15	0.89723 <.0001 15	0.82143 0.0234 7	0.54854 0.0342 15	0.93465 <.0001 15	0.89187 <.0001 15	0.80781 0.0280 7	0.88431 <.0001 15	0.44544 0.3165 7	0.92857 0.0025 7	0.10811 0.8175 7	0.85714 0.0137 7	0.91332 <.0001 15	0.97028 <.0001 15	0.98389 <.0001 15	1.00000 15	0.98301 <.0001 15	0.90974 <.0001 15
_16	0.94549 <.0001 15	0.82143 0.0234 7	0.54854 0.0342 15	0.94449 <.0001 15	0.91510 <.0001 15	0.80781 0.0280 7	0.91660 <.0001 15	0.44544 0.3165 7	0.92857 0.0025 7	0.10811 0.8175 7	0.85714 0.0137 7	0.93655 <.0001 15	0.96126 <.0001 15	0.97762 <.0001 15	0.98301 <.0001 15	1.00000 15	0.90259 <.0001 15
_17	0.87500 <.0001 15	0.46429 0.2939 7	0.52915 0.0425 15	0.88551 <.0001 15	0.85000 <.0001 15	0.74870 0.0528 7	0.84947 <.0001 15	0.26726 0.5623 7	0.50000 0.2532 7	0.57660 0.1754 7	0.42857 0.3374 7	0.85000 <.0001 15	0.90094 <.0001 15	0.88193 <.0001 15	0.90974 <.0001 15	0.90259 <.0001 15	1.00000 15

2.3.2 TOTAL NITROGEN

The sampling frequency for TN is provided in Table 2-45.

Table 2-45. Total Nitrogen Sampling Frequency by Station for Lee Ceitus Stations

		Station																
		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17
Year	MONTH																	
2012	9	1	1	1	1	1	1	1	1	1	1	1	1	1	.	.	.	.
	10	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	11	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	12	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
2013	1	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	3	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	4	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	5	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	6	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	7	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	8	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	9	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	10	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	11	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	12	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1

The overall station arithmetic average TN concentration between 2012 and 2013 is provided in Figure 2-83. Stations 15 and 16 had the lowest average concentrations, while Station 13 had the highest average concentration.

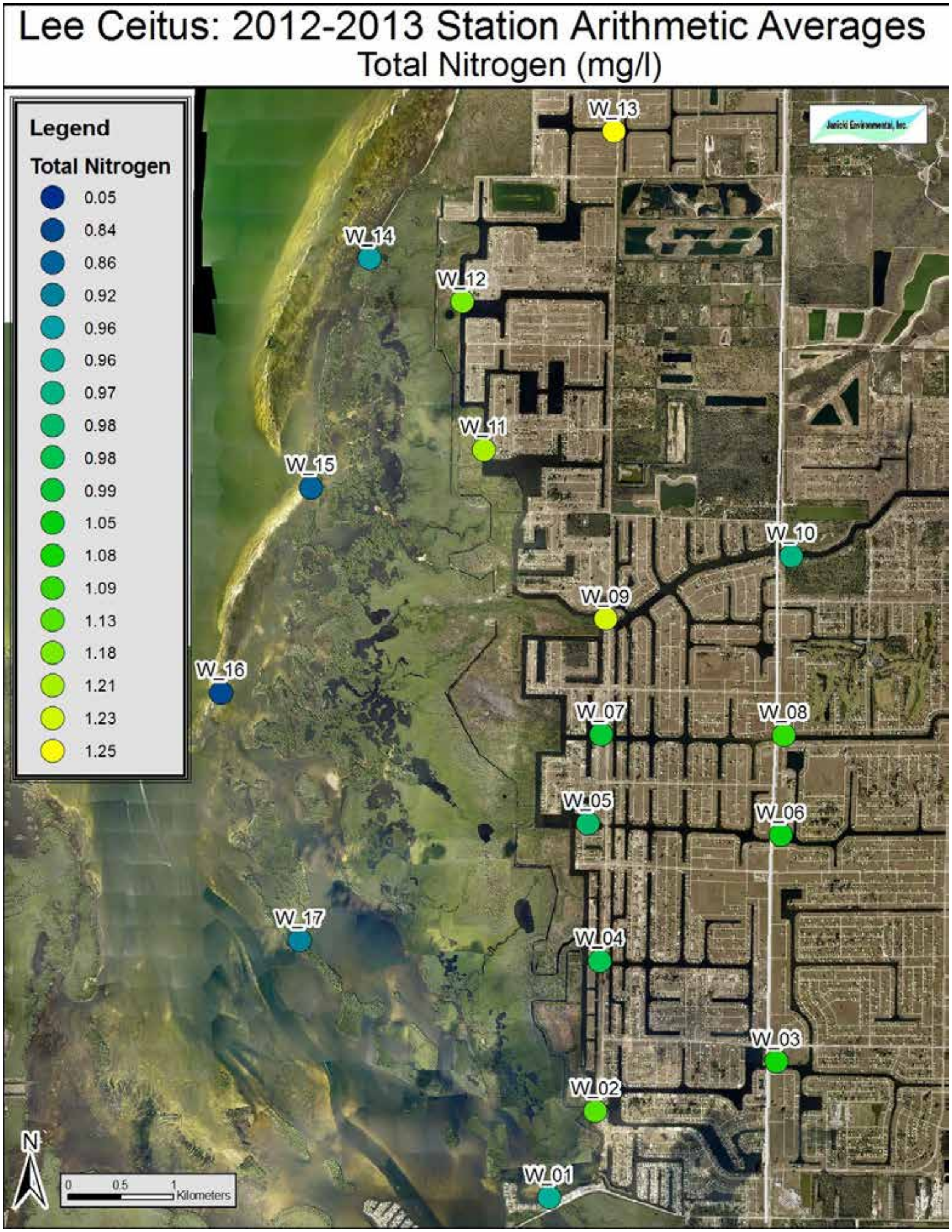


Figure 2-83. Arithmetic Average of Total Nitrogen for Lee Ceitus Stations

Between-station variability in TN is displayed in Figure 2-84. These plots represent the entire period of record for each station, which varies among stations. Note that no TN measurements were taken at Stations 02, 06, 08, 09, 10, and 11 after April 2013.

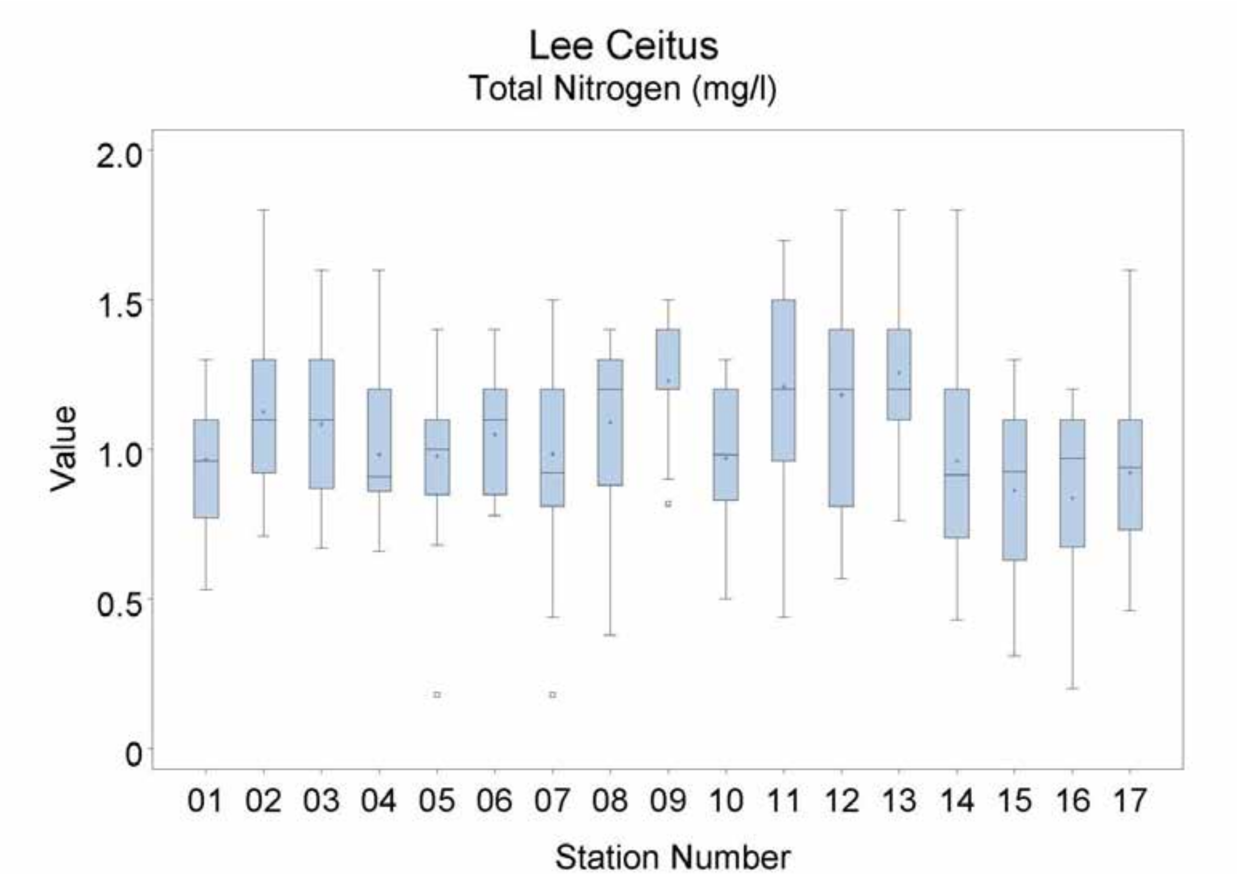


Figure 2-84. Box and Whisker Plots Displaying the Distribution of Total Nitrogen among Lee Ceitus Stations

Time series plots of TN measurements are shown in Figure 2-85.

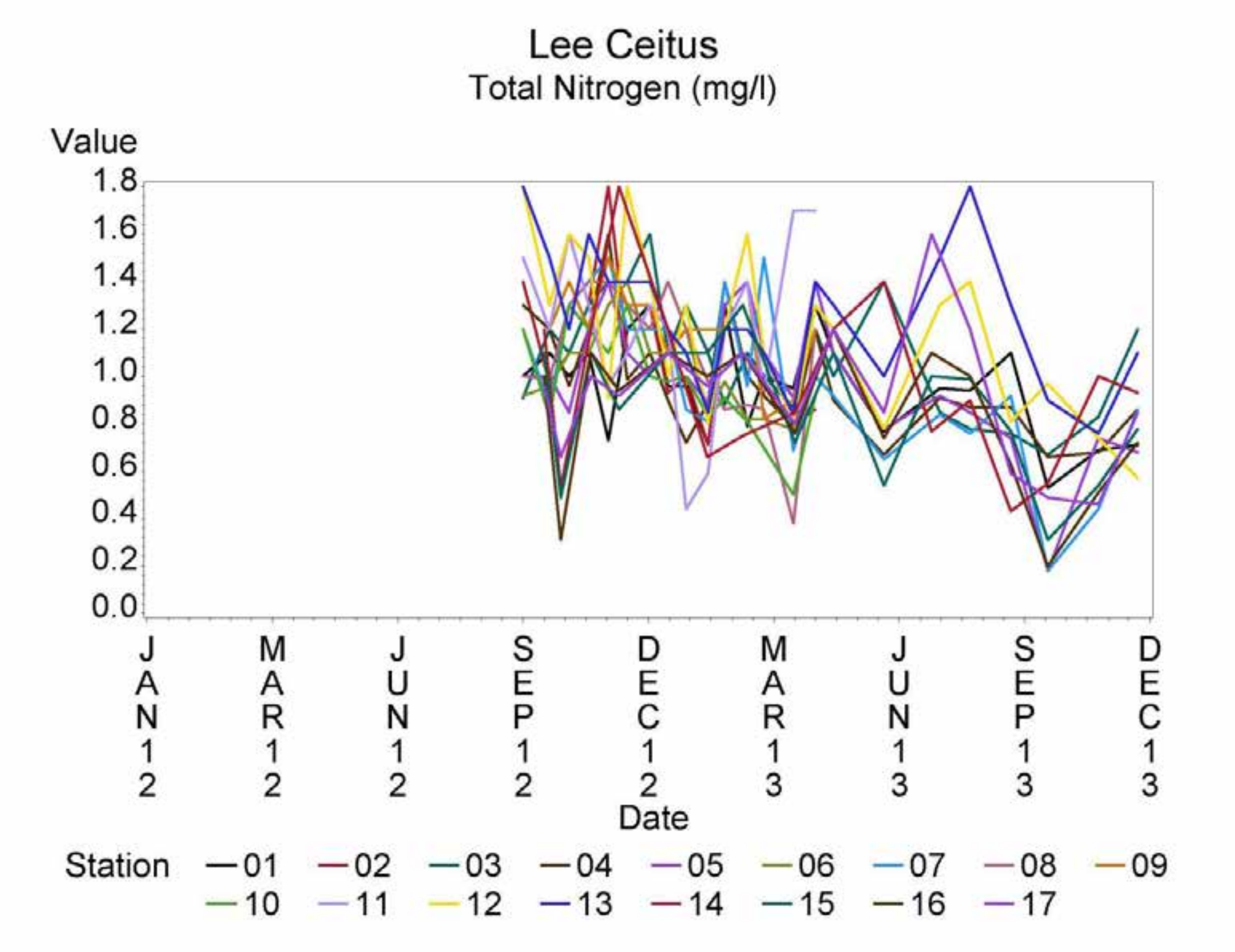


Figure 2-85. Time Series Plots of Total Nitrogen for Lee Ceitus Stations

No trend examination was performed on TN due to the limited time frame sampled.

Cross correlation analysis suggested that TN concentrations among stations were greatest between Stations 16 and 17. These two stations were also one of the few significant correlations. Stations 09 and 10, and 15 and 16 were also significantly positively correlated (Table 2-46).

Table 2-46. Spearman Rank Correlation Coefficients for Total Nitrogen for Lee Ceitus Stations

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	_01	_02	_03	_04	_05	_06	_07	_08	_09	_10	_11	_12	_13	_14	_15	_16	_17
_01	1.00000 16	-0.30952 0.4556 8	0.16483 0.5418 16	0.54860 0.0278 16	0.48527 0.0567 16	0.38095 0.3518 8	0.42889 0.0974 16	-0.16667 0.6932 8	0.00000 1.0000 8	0.02395 0.9551 8	0.50000 0.2070 8	0.45180 0.0789 16	0.43395 0.0931 16	0.06996 0.8043 15	0.27528 0.3207 15	0.29785 0.2809 15	0.18728 0.5039 15
_02	-0.30952 0.4556 8	1.00000 8	0.23810 0.5702 8	0.66667 0.0710 8	0.26190 0.5309 8	0.16667 0.6932 8	0.89822 0.0024 8	0.47619 0.2329 8	0.83333 0.0102 8	0.79043 0.0195 8	0.02381 0.9554 8	0.66667 0.0710 8	0.85031 0.0075 8	0.41443 0.3553 7	0.37062 0.4131 7	0.29650 0.5185 7	0.27028 0.5577 7
_03	0.16483 0.5418 16	0.23810 0.5702 8	1.00000 16	0.25460 0.3413 16	0.43267 0.0942 16	0.78571 0.0208 8	0.48306 0.0580 16	0.71429 0.0465 8	0.11905 0.7789 8	0.22755 0.5878 8	-0.33333 0.4198 8	0.13824 0.6097 16	0.03982 0.8836 16	0.74911 0.0013 15	0.25610 0.3569 15	0.31742 0.2490 15	0.18621 0.5064 15
_04	0.54860 0.0278 16	0.66667 0.0710 8	0.25460 0.3413 16	1.00000 16	0.74890 0.0008 16	0.04762 0.9108 8	0.80693 0.0002 16	0.26190 0.5309 8	0.78571 0.0208 8	0.62277 0.0991 8	0.14286 0.7358 8	0.65489 0.0059 16	0.59779 0.0145 16	-0.03049 0.9141 15	0.57042 0.0264 15	0.42691 0.1125 15	0.29660 0.2831 15
_05	0.48527 0.0567 16	0.26190 0.5309 8	0.43267 0.0942 16	0.74890 0.0008 16	1.00000 16	-0.04762 0.9108 8	0.73913 0.0011 16	-0.19048 0.6514 8	-0.16667 0.6932 8	-0.28743 0.4900 8	-0.07143 0.8665 8	0.52391 0.0372 16	0.35941 0.1716 16	0.20269 0.4688 15	0.72656 0.0022 15	0.74191 0.0015 15	0.48387 0.0676 15
_06	0.38095 0.3518 8	0.16667 0.6932 8	0.78571 0.0208 8	0.04762 0.9108 8	-0.04762 0.9108 8	1.00000 8	-0.03593 0.9327 8	0.69048 0.0580 8	0.28571 0.4927 8	0.39522 0.3325 8	-0.04762 0.9108 8	0.11905 0.7789 8	0.37126 0.3652 8	0.91896 0.0034 7	-0.33356 0.4647 7	0.00000 1.0000 7	-0.14415 0.7578 7
_07	0.42889 0.0974 16	0.89822 0.0024 8	0.48306 0.0580 16	0.80693 0.0002 16	0.73913 0.0011 16	-0.03593 0.9327 8	1.00000 16	0.31138 0.4528 8	0.55091 0.1570 8	0.47590 0.2333 8	-0.19162 0.6494 8	0.56848 0.0216 16	0.48080 0.0594 16	0.12377 0.6603 15	0.75003 0.0013 15	0.51627 0.0488 15	0.34140 0.2130 15
_08	-0.16667 0.6932 8	0.47619 0.2329 8	0.71429 0.0465 8	0.26190 0.5309 8	-0.19048 0.6514 8	0.69048 0.0580 8	0.31138 0.4528 8	1.00000 8	0.59524 0.1195 8	0.67067 0.0687 8	-0.50000 0.2070 8	0.23810 0.5702 8	0.56288 0.1463 8	0.73877 0.0579 7	0.22237 0.6317 7	0.40769 0.3639 7	0.39641 0.3786 7
_09	0.00000 1.0000 8	0.83333 0.0102 8	0.11905 0.7789 8	0.78571 0.0208 8	-0.16667 0.6932 8	0.28571 0.4927 8	0.55091 0.1570 8	0.59524 0.1195 8	1.00000 8	0.97008 <.0001 8	0.04762 0.9108 8	0.64286 0.0856 8	0.85031 0.0075 8	0.57660 0.1754 7	0.03706 0.9371 7	0.03706 0.9371 7	0.01802 0.9694 7

Table 2-46. Spearman Rank Correlation Coefficients for Total Nitrogen for Lee Ceitus Stations (Continued)

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations																	
	_01	_02	_03	_04	_05	_06	_07	_08	_09	_10	_11	_12	_13	_14	_15	_16	_17
_10	0.02395 0.9551 8	0.79043 0.0195 8	0.22755 0.5878 8	0.62277 0.0991 8	-0.28743 0.4900 8	0.39522 0.3325 8	0.47590 0.2333 8	0.67067 0.0687 8	0.97008 <.0001 8	1.00000 8	0.04791 0.9103 8	0.73055 0.0396 8	0.90361 0.0021 8	0.77273 0.0417 7	0.00000 1.0000 7	0.05610 0.9049 7	0.07273 0.8769 7
_11	0.50000 0.2070 8	0.02381 0.9554 8	-0.33333 0.4198 8	0.14286 0.7358 8	-0.07143 0.8665 8	-0.04762 0.9108 8	-0.19162 0.6494 8	-0.50000 0.2070 8	0.04762 0.9108 8	0.04791 0.9103 8	1.00000 8	0.42857 0.2894 8	0.25150 0.5479 8	0.00000 1.0000 7	-0.74125 0.0566 7	-0.77831 0.0393 7	-0.81084 0.0269 7
_12	0.45180 0.0789 16	0.66667 0.0710 8	0.13824 0.6097 16	0.65489 0.0059 16	0.52391 0.0372 16	0.11905 0.7789 8	0.56848 0.0216 16	0.23810 0.5702 8	0.64286 0.0856 8	0.73055 0.0396 8	0.42857 0.2894 8	1.00000 16	0.81564 0.0001 16	0.13979 0.6193 15	0.53745 0.0388 15	0.49416 0.0612 15	0.55148 0.0331 15
_13	0.43395 0.0931 16	0.85031 0.0075 8	0.03982 0.8836 16	0.59779 0.0145 16	0.35941 0.1716 16	0.37126 0.3652 8	0.48080 0.0594 16	0.56288 0.1463 8	0.85031 0.0075 8	0.90361 0.0021 8	0.25150 0.5479 8	0.81564 0.0001 16	1.00000 16	0.14016 0.6183 15	0.50725 0.0536 15	0.52623 0.0439 15	0.63645 0.0107 15
_14	0.06996 0.8043 15	0.41443 0.3553 7	0.74911 0.0013 15	-0.03049 0.9141 15	0.20269 0.4688 15	0.91896 0.0034 7	0.12377 0.6603 15	0.73877 0.0579 7	0.57660 0.1754 7	0.77273 0.0417 7	0.00000 1.0000 7	0.13979 0.6193 15	0.14016 0.6183 15	1.00000 15	0.08507 0.7631 15	0.29322 0.2888 15	0.22102 0.4286 15
_15	0.27528 0.3207 15	0.37062 0.4131 7	0.25610 0.3569 15	0.57042 0.0264 15	0.72656 0.0022 15	-0.33356 0.4647 7	0.75003 0.0013 15	0.22237 0.6317 7	0.03706 0.9371 7	0.00000 1.0000 7	-0.74125 0.0566 7	0.53745 0.0388 15	0.50725 0.0536 15	0.08507 0.7631 15	1.00000 15	0.88434 <.0001 15	0.80924 0.0003 15
_16	0.29785 0.2809 15	0.29650 0.5185 7	0.31742 0.2490 15	0.42691 0.1125 15	0.74191 0.0015 15	0.00000 1.0000 7	0.51627 0.0488 15	0.40769 0.3639 7	0.03706 0.9371 7	0.05610 0.9049 7	-0.77831 0.0393 7	0.49416 0.0612 15	0.52623 0.0439 15	0.29322 0.2888 15	0.88434 <.0001 15	1.00000 15	0.91413 <.0001 15
_17	0.18728 0.5039 15	0.27028 0.5577 7	0.18621 0.5064 15	0.29660 0.2831 15	0.48387 0.0676 15	-0.14415 0.7578 7	0.34140 0.2130 15	0.39641 0.3786 7	0.01802 0.9694 7	0.07273 0.8769 7	-0.81084 0.0269 7	0.55148 0.0331 15	0.63645 0.0107 15	0.22102 0.4286 15	0.80924 0.0003 15	0.91413 <.0001 15	1.00000 15

2.3.3 TOTAL PHOSPHORUS

The sampling frequency for TP is provided in Table 2-47.

Table 2-47. Total Phosphorus Sampling Frequency by Station for Lee Ceitus Stations

		Station																
		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17
Year	MONTH																	
2012	9	1	1	1	1	1	1	1	1	1	1	1	1	1	.	.	.	.
	10	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	11	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	12	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
2013	1	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	3	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	4	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	5	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	6	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	7	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	8	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	9	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	10	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	11	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	12	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1

The overall station arithmetic average TP concentration between 2012 and 2013 is displayed in Figure 2-86. Stations 08 and 10 had the lowest average concentrations, while Station 14 had the highest average concentration.

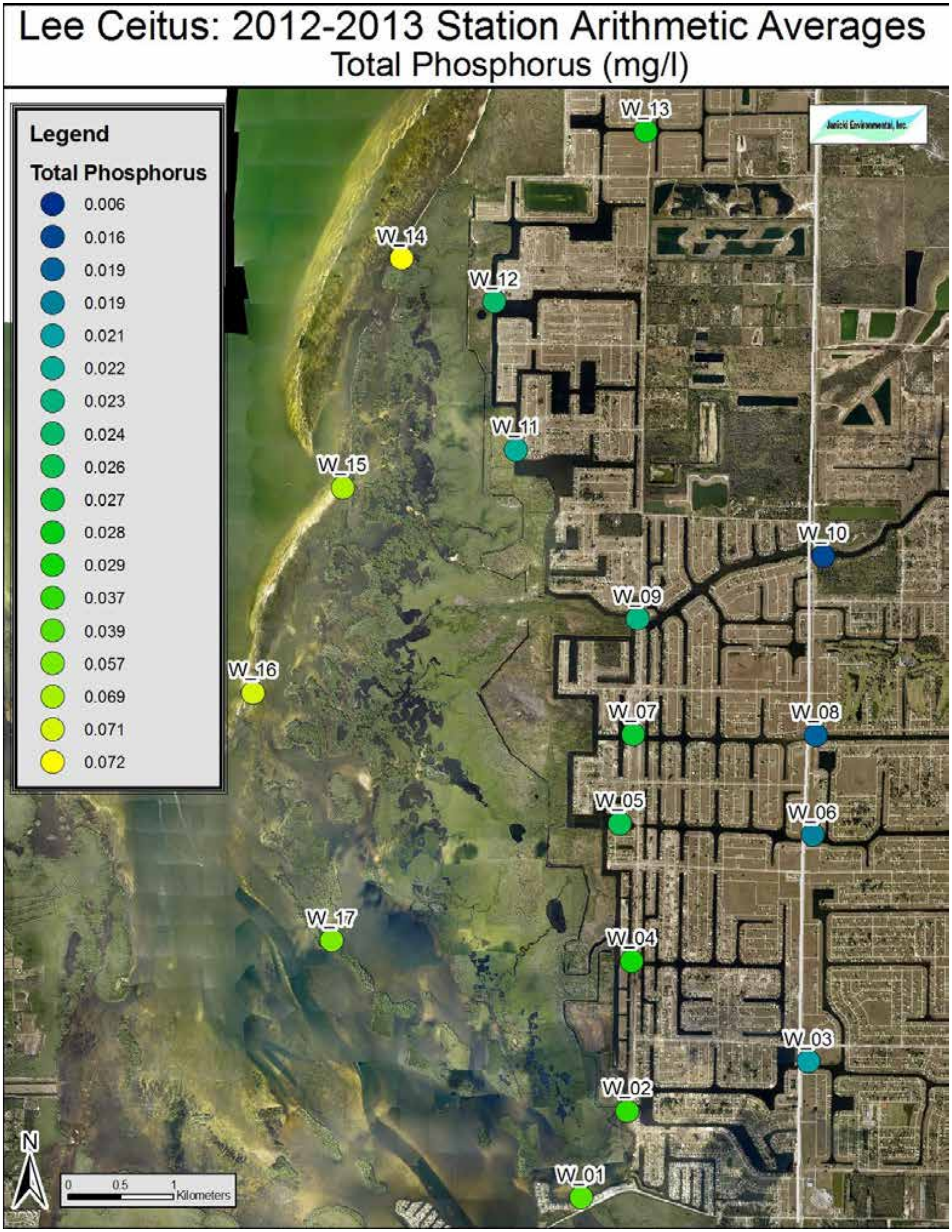


Figure 2-86. Arithmetic Average of Total Phosphorus for Lee Ceitus Stations

Between-station variability for TP measurements is shown in Figure 2-87. Stations 14, 15, 16 and 17 are located within Matlacha Pass and had higher TP distributions than the remaining stations. Note that no TP measurements were taken at Stations 02, 06, 08, 09, 10 and 11 after April 2013.

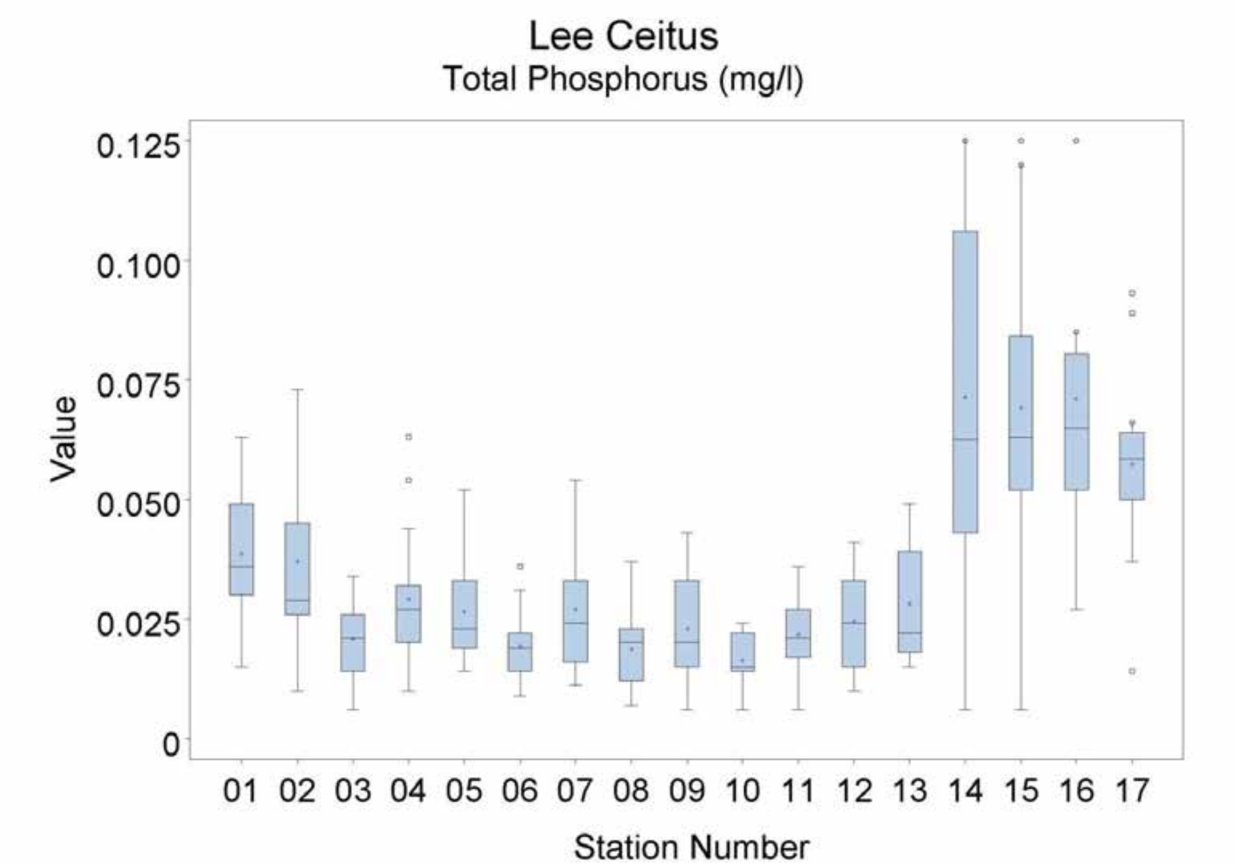


Figure 2-87. Box and Whisker Plots Displaying Total Phosphorus Distributions among Lee Ceitus Stations

Time series plots of TP (Figure 2-88) indicate that there is only modest correlation among stations and a substantial increase in TP after June 2013.

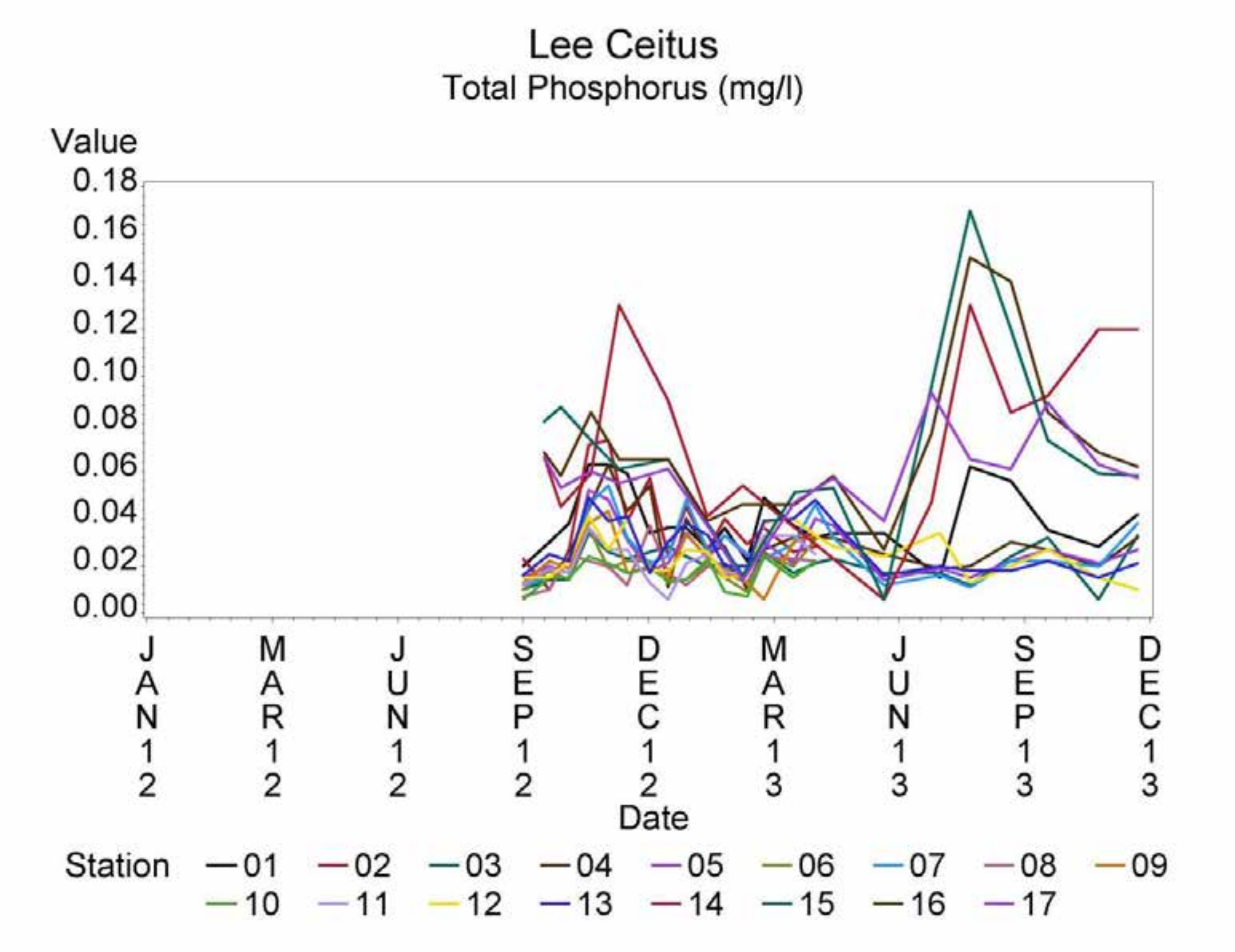


Figure 2-88. Time Series Plots of Total Phosphorus for Lee Ceitus Stations

No trend examination was performed on TP due to the limited time period sampled.

Cross correlation analysis suggested that TP concentrations among stations were greatest between Stations 02 and 03 (Table 2-48).

Table 2-48. Spearman Rank Correlation Coefficients for Total Phosphorus for Lee Ceitus Stations

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	_01	_02	_03	_04	_05	_06	_07	_08	_09	_10	_11	_12	_13	_14	_15	_16	_17
_01	1.00000 16	0.80952 0.0149 8	0.57417 0.0200 16	0.55852 0.0245 16	0.27683 0.2993 16	0.57143 0.1390 8	0.37075 0.1575 16	0.52381 0.1827 8	0.38095 0.3518 8	0.57143 0.1390 8	0.47619 0.2329 8	0.00739 0.9783 16	0.34146 0.1955 16	0.52603 0.0440 15	0.34978 0.2013 15	0.46900 0.0778 15	0.04129 0.8838 15
_02	0.80952 0.0149 8	1.00000 8	0.95238 0.0003 8	0.73810 0.0366 8	0.57143 0.1390 8	0.54762 0.1600 8	0.66667 0.0710 8	0.50000 0.2070 8	0.40476 0.3199 8	0.54762 0.1600 8	0.40476 0.3199 8	0.54762 0.1600 8	0.56288 0.1463 8	0.64286 0.1194 7	0.10714 0.8192 7	0.65465 0.1106 7	0.39286 0.3833 7
_03	0.57417 0.0200 16	0.95238 0.0003 8	1.00000 16	0.71250 0.0020 16	0.64845 0.0066 16	0.50000 0.2070 8	0.74355 0.0010 16	0.40476 0.3199 8	0.52381 0.1827 8	0.50000 0.2070 8	0.40476 0.3199 8	0.26917 0.3134 16	0.53171 0.0340 16	0.19517 0.4858 15	-0.02683 0.9244 15	0.08781 0.7557 15	-0.05372 0.8492 15
_04	0.55852 0.0245 16	0.73810 0.0366 8	0.71250 0.0020 16	1.00000 16	0.66938 0.0046 16	0.88095 0.0039 8	0.74778 0.0009 16	0.83333 0.0102 8	0.71429 0.0465 8	0.88095 0.0039 8	0.64286 0.0856 8	0.37158 0.1565 16	0.54552 0.0288 16	0.08993 0.7499 15	-0.08536 0.7623 15	0.02970 0.9163 15	-0.18345 0.5128 15
_05	0.27683 0.2993 16	0.57143 0.1390 8	0.64845 0.0066 16	0.66938 0.0046 16	1.00000 16	0.76190 0.0280 8	0.91870 <.0001 16	0.52381 0.1827 8	0.80952 0.0149 8	0.76190 0.0280 8	0.80952 0.0149 8	0.50074 0.0482 16	0.84763 <.0001 16	-0.21724 0.4367 15	-0.30493 0.2691 15	-0.18688 0.5048 15	-0.28007 0.3120 15
_06	0.57143 0.1390 8	0.54762 0.1600 8	0.50000 0.2070 8	0.88095 0.0039 8	0.76190 0.0280 8	1.00000 8	0.73810 0.0366 8	0.90476 0.0020 8	0.57143 0.1390 8	1.00000 <.0001 8	0.90476 0.0020 8	0.85714 0.0065 8	0.68265 0.0621 8	-0.17857 0.7017 7	-0.07143 0.8790 7	0.16366 0.7259 7	-0.14286 0.7599 7
_07	0.37075 0.1575 16	0.66667 0.0710 8	0.74355 0.0010 16	0.74778 0.0009 16	0.91870 <.0001 16	0.73810 0.0366 8	1.00000 16	0.54762 0.1600 8	0.88095 0.0039 8	0.73810 0.0366 8	0.69048 0.0580 8	0.39852 0.1263 16	0.77269 0.0004 16	-0.05551 0.8442 15	-0.30859 0.2631 15	-0.20520 0.4632 15	-0.31961 0.2456 15
_08	0.52381 0.1827 8	0.50000 0.2070 8	0.40476 0.3199 8	0.83333 0.0102 8	0.52381 0.1827 8	0.90476 0.0020 8	0.54762 0.1600 8	1.00000 8	0.33333 0.4198 8	0.90476 0.0020 8	0.71429 0.0465 8	0.80952 0.0149 8	0.51498 0.1915 8	-0.03571 0.9394 7	-0.21429 0.6445 7	0.05455 0.9075 7	-0.28571 0.5345 7
_09	0.38095 0.3518 8	0.40476 0.3199 8	0.52381 0.1827 8	0.71429 0.0465 8	0.80952 0.0149 8	0.57143 0.1390 8	0.88095 0.0039 8	0.33333 0.4198 8	1.00000 8	0.57143 0.1390 8	0.47619 0.2329 8	0.52381 0.1827 8	0.68265 0.0621 8	-0.14286 0.7599 7	0.39286 0.3833 7	0.32733 0.4736 7	0.53571 0.2152 7

Table 2-48. Spearman Rank Correlation Coefficients for Total Phosphorus for Lee Ceitus Stations (Continued)

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	_01	_02	_03	_04	_05	_06	_07	_08	_09	_10	_11	_12	_13	_14	_15	_16	_17
_10	0.57143 0.1390 8	0.54762 0.1600 8	0.50000 0.2070 8	0.88095 0.0039 8	0.76190 0.0280 8	1.00000 <.0001 8	0.73810 0.0366 8	0.90476 0.0020 8	0.57143 0.1390 8	1.00000 8	0.90476 0.0020 8	0.85714 0.0065 8	0.68265 0.0621 8	-0.17857 0.7017 7	-0.07143 0.8790 7	0.16366 0.7259 7	-0.14286 0.7599 7
_11	0.47619 0.2329 8	0.40476 0.3199 8	0.40476 0.3199 8	0.64286 0.0856 8	0.80952 0.0149 8	0.90476 0.0020 8	0.69048 0.0580 8	0.71429 0.0465 8	0.47619 0.2329 8	0.90476 0.0020 8	1.00000 8	0.80952 0.0149 8	0.73055 0.0396 8	-0.46429 0.2939 7	-0.28571 0.5345 7	-0.05455 0.9075 7	-0.35714 0.4316 7
_12	0.00739 0.9783 16	0.54762 0.1600 8	0.26917 0.3134 16	0.37158 0.1565 16	0.50074 0.0482 16	0.85714 0.0065 8	0.39852 0.1263 16	0.80952 0.0149 8	0.52381 0.1827 8	0.85714 0.0065 8	0.80952 0.0149 8	1.00000 16	0.65436 0.0060 16	-0.45878 0.0854 15	-0.17547 0.5316 15	-0.13543 0.6304 15	-0.14158 0.6148 15
_13	0.34146 0.1955 16	0.56288 0.1463 8	0.53171 0.0340 16	0.54552 0.0288 16	0.84763 <.0001 16	0.68265 0.0621 8	0.77269 0.0004 16	0.51498 0.1915 8	0.68265 0.0621 8	0.68265 0.0621 8	0.73055 0.0396 8	0.65436 0.0060 16	1.00000 16	-0.27867 0.3145 15	-0.23903 0.3909 15	-0.25650 0.3561 15	-0.37903 0.1635 15
_14	0.52603 0.0440 15	0.64286 0.1194 7	0.19517 0.4858 15	0.08993 0.7499 15	-0.21724 0.4367 15	-0.17857 0.7017 7	-0.05551 0.8442 15	-0.03571 0.9394 7	-0.14286 0.7599 7	-0.17857 0.7017 7	-0.46429 0.2939 7	-0.45878 0.0854 15	-0.27867 0.3145 15	1.00000 15	0.52820 0.0430 15	0.65919 0.0075 15	0.46864 0.0781 15
_15	0.34978 0.2013 15	0.10714 0.8192 7	-0.02683 0.9244 15	-0.08536 0.7623 15	-0.30493 0.2691 15	-0.07143 0.8790 7	-0.30859 0.2631 15	-0.21429 0.6445 7	0.39286 0.3833 7	-0.07143 0.8790 7	-0.28571 0.5345 7	-0.17547 0.5316 15	-0.23903 0.3909 15	0.52820 0.0430 15	1.00000 15	0.91040 <.0001 15	0.82901 0.0001 15
_16	0.46900 0.0778 15	0.65465 0.1106 7	0.08781 0.7557 15	0.02970 0.9163 15	-0.18688 0.5048 15	0.16366 0.7259 7	-0.20520 0.4632 15	0.05455 0.9075 7	0.32733 0.4736 7	0.16366 0.7259 7	-0.05455 0.9075 7	-0.13543 0.6304 15	-0.25650 0.3561 15	0.65919 0.0075 15	0.91040 <.0001 15	1.00000 15	0.85471 <.0001 15
_17	0.04129 0.8838 15	0.39286 0.3833 7	-0.05372 0.8492 15	-0.18345 0.5128 15	-0.28007 0.3120 15	-0.14286 0.7599 7	-0.31961 0.2456 15	-0.28571 0.5345 7	0.53571 0.2152 7	-0.14286 0.7599 7	-0.35714 0.4316 7	-0.14158 0.6148 15	-0.37903 0.1635 15	0.46864 0.0781 15	0.82901 0.0001 15	0.85471 <.0001 15	1.00000 15

2.3.4 DISSOLVED OXYGEN

The sampling frequency for DO is provided in Table 2-49.

Table 2-49. Dissolved Oxygen Sampling Frequency by Station for Lee Ceitus Stations

		Station																
		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17
Year	MONTH																	
2012	9	1	1	1	1	1	1	1	1	1	1	1	1	1	.	.	.	.
	10	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	11	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	12	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
2013	1	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	3	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	4	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	5	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	6	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	7	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	8	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	9	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	10	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	11	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	12	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1

The overall station arithmetic average DO concentration between 2012 and 2013 is displayed in Figure 2-89. Stations 13 and 14 had the lowest average concentrations, while Station 06 had the highest average concentration.

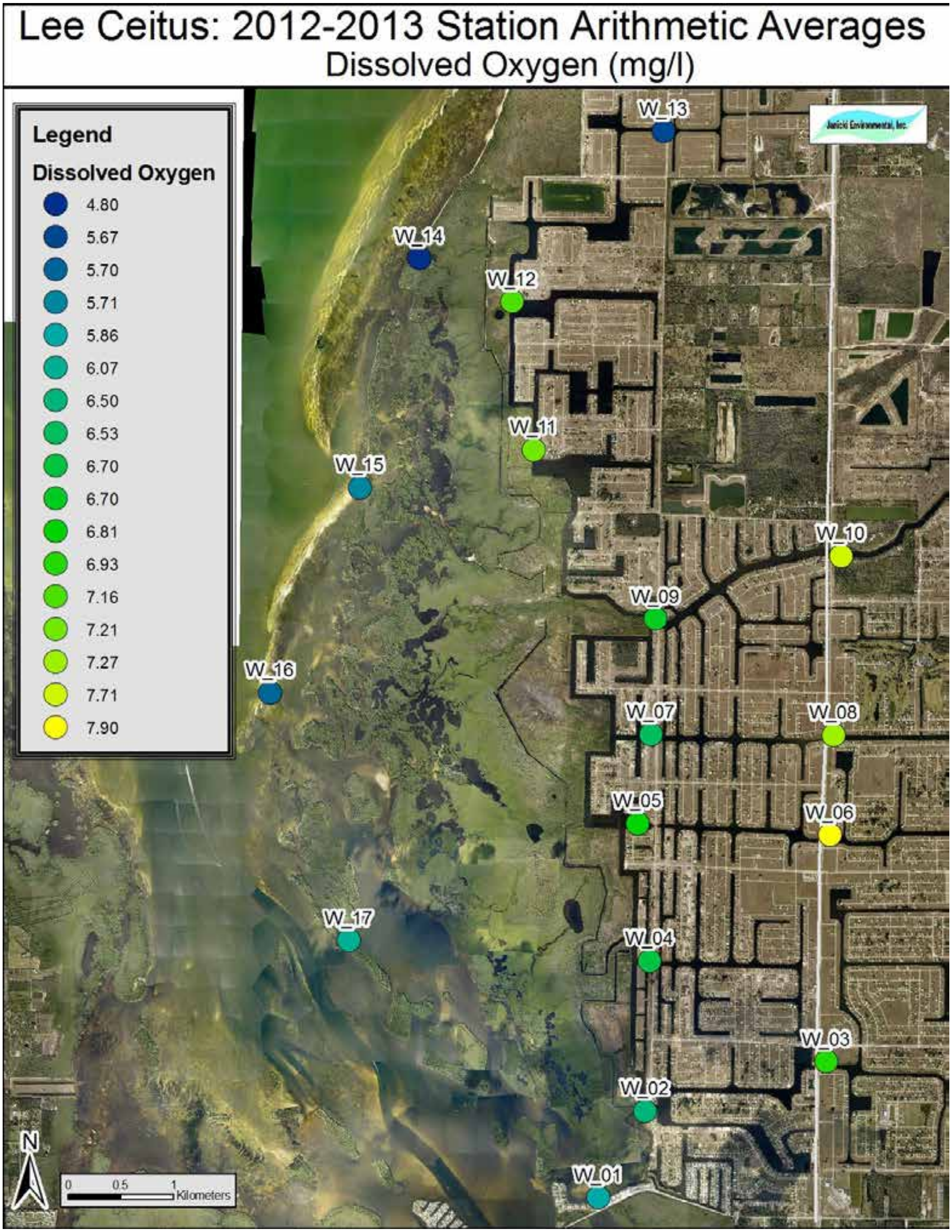


Figure 2-89. Arithmetic Average of Dissolved Oxygen for Lee Ceitus Stations

The distribution of DO concentration for each station is presented in Figure 2-90. Station 14 appeared to have lower average DO concentrations than the opther stations. Note that no DO measurements were taken at Stations 02, 06, 08, 09, 10, and 11 after April 2013.

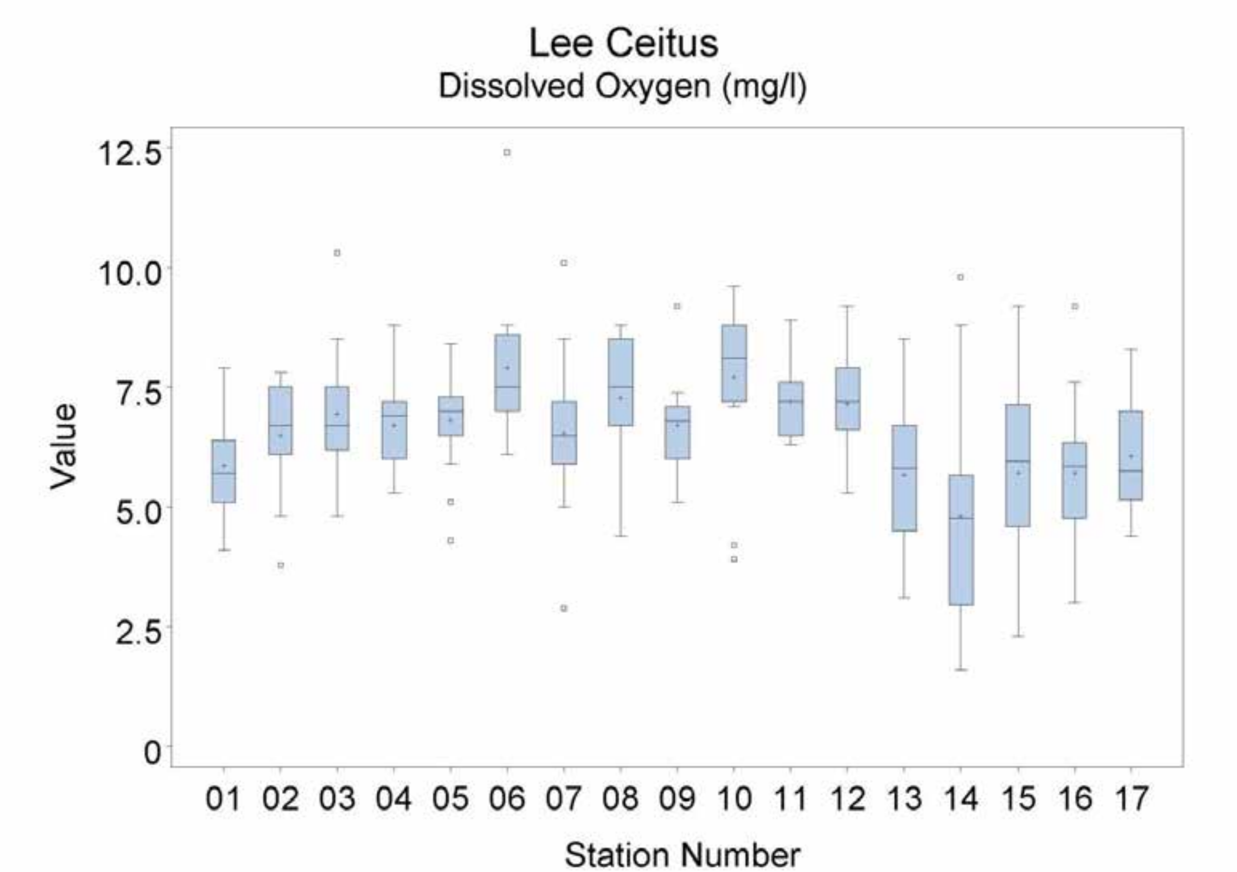


Figure 2-90. Box and Whisker Plots Displaying Dissolved Oxygen Distributions among Lee Ceitus Stations

Time series plots of DO are provided in Figure 2-91.

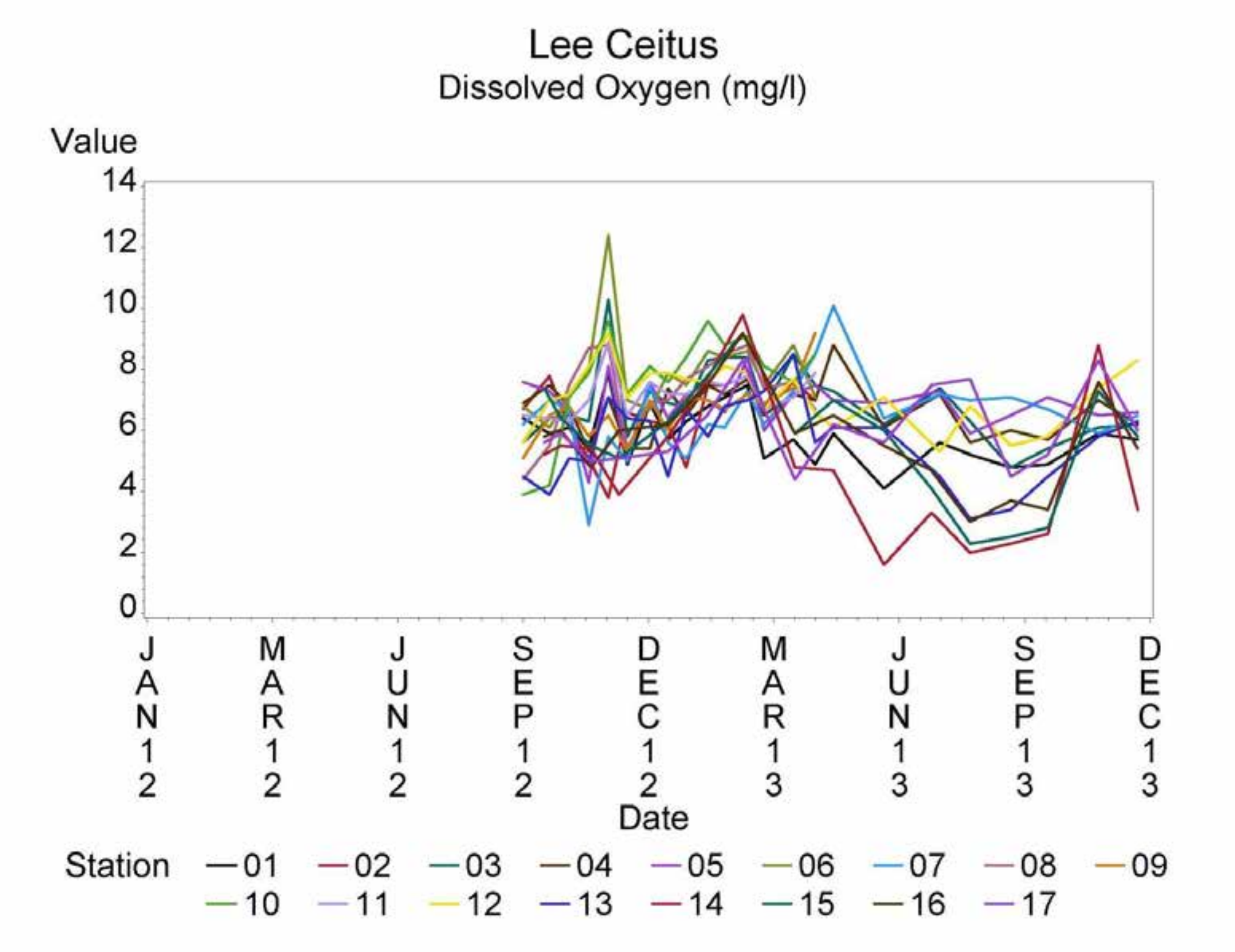


Figure 2-91. Time Series Plots of Surface Dissolved Oxygen for Lee Ceitus Stations

No trend examination was performed on DO due to the limited time period sampled.

Cross correlation analysis suggested that DO concentrations among stations were greatest between Stations 03 and 10, and 06 and 11, both of which were significant positive relationships (Table 2-50).

Table 2-50. Spearman Rank Correlation Coefficients for Dissolved Oxygen for Lee Ceitus Stations

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	_01	_02	_03	_04	_05	_06	_07	_08	_09	_10	_11	_12	_13	_14	_15	_16	_17
_01	1.00000 16	0.01198 0.9775 8	0.53471 0.0328 16	0.44904 0.0810 16	0.03397 0.9006 16	0.49103 0.2166 8	-0.52989 0.0348 16	0.52696 0.1796 8	-0.26506 0.5258 8	0.45510 0.2572 8	0.39522 0.3325 8	0.50591 0.0456 16	0.28668 0.2817 16	0.86817 <.0001 15	0.64395 0.0096 15	0.64543 0.0094 15	0.25494 0.3591 15
_02	0.01198 0.9775 8	1.00000 8	0.28571 0.4927 8	0.80241 0.0165 8	0.45238 0.2604 8	0.07143 0.8665 8	0.59524 0.1195 8	0.02381 0.9554 8	0.74253 0.0349 8	0.26190 0.5309 8	0.09524 0.8225 8	-0.28571 0.4927 8	0.39522 0.3325 8	0.21429 0.6445 7	0.57143 0.1802 7	0.46849 0.2890 7	0.35714 0.4316 7
_03	0.53471 0.0328 16	0.28571 0.4927 8	1.00000 16	0.54639 0.0285 16	0.07364 0.7864 16	0.92857 0.0009 8	-0.01913 0.9439 16	0.88095 0.0039 8	0.50300 0.2039 8	0.97619 <.0001 8	0.95238 0.0003 8	0.46465 0.0698 16	0.55978 0.0241 16	0.54156 0.0371 15	0.40751 0.1316 15	0.39893 0.1408 15	0.04830 0.8643 15
_04	0.44904 0.0810 16	0.80241 0.0165 8	0.54639 0.0285 16	1.00000 16	0.51841 0.0397 16	0.05988 0.8880 8	0.23694 0.3769 16	0.26348 0.5284 8	0.72289 0.0428 8	0.29941 0.4713 8	0.05988 0.8880 8	-0.00736 0.9784 16	0.26133 0.3282 16	0.53262 0.0409 15	0.68811 0.0046 15	0.55009 0.0336 15	0.38014 0.1622 15
_05	0.03397 0.9006 16	0.45238 0.2604 8	0.07364 0.7864 16	0.51841 0.0397 16	1.00000 16	-0.45238 0.2604 8	0.37675 0.1503 16	-0.52381 0.1827 8	0.25150 0.5479 8	-0.47619 0.2329 8	-0.42857 0.2894 8	-0.46834 0.0673 16	0.13512 0.6178 16	0.10545 0.7084 15	0.30563 0.2680 15	0.19678 0.4821 15	0.03131 0.9118 15
_06	0.49103 0.2166 8	0.07143 0.8665 8	0.92857 0.0009 8	0.05988 0.8880 8	-0.45238 0.2604 8	1.00000 8	-0.45238 0.2604 8	0.90476 0.0020 8	0.29941 0.4713 8	0.95238 0.0003 8	0.97619 <.0001 8	0.78571 0.0208 8	0.53893 0.1681 8	0.53571 0.2152 7	0.14286 0.7599 7	0.05406 0.9084 7	0.00000 1.0000 7
_07	-0.52989 0.0348 16	0.59524 0.1195 8	-0.01913 0.9439 16	0.23694 0.3769 16	0.37675 0.1503 16	-0.45238 0.2604 8	1.00000 16	-0.47619 0.2329 8	0.57486 0.1361 8	-0.33333 0.4198 8	-0.40476 0.3199 8	-0.64754 0.0067 16	-0.10386 0.7019 16	-0.40000 0.1396 15	-0.22500 0.4201 15	-0.25380 0.3614 15	0.01787 0.9496 15
_08	0.52696 0.1796 8	0.02381 0.9554 8	0.88095 0.0039 8	0.26348 0.5284 8	-0.52381 0.1827 8	0.90476 0.0020 8	-0.47619 0.2329 8	1.00000 8	0.35929 0.3821 8	0.92857 0.0009 8	0.85714 0.0065 8	0.80952 0.0149 8	0.33534 0.4168 8	0.71429 0.0713 7	0.32143 0.4821 7	0.09009 0.8477 7	0.17857 0.7017 7
_09	-0.26506 0.5258 8	0.74253 0.0349 8	0.50300 0.2039 8	0.72289 0.0428 8	0.25150 0.5479 8	0.29941 0.4713 8	0.57486 0.1361 8	0.35929 0.3821 8	1.00000 8	0.47905 0.2297 8	0.32336 0.4346 8	-0.01198 0.9775 8	0.62651 0.0965 8	0.30632 0.5040 7	0.63066 0.1289 7	0.36364 0.4227 7	0.23424 0.6132 7

Table 2-50. Spearman Rank Correlation Coefficients for Dissolved Oxygen for Lee Ceitus Stations (Continued)

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	_01	_02	_03	_04	_05	_06	_07	_08	_09	_10	_11	_12	_13	_14	_15	_16	_17
_10	0.45510 0.2572 8	0.26190 0.5309 8	0.97619 <.0001 8	0.29941 0.4713 8	-0.47619 0.2329 8	0.95238 0.0003 8	-0.33333 0.4198 8	0.92857 0.0009 8	0.47905 0.2297 8	1.00000 8	0.92857 0.0009 8	0.78571 0.0208 8	0.56288 0.1463 8	0.60714 0.1482 7	0.28571 0.5345 7	0.23424 0.6132 7	0.14286 0.7599 7
_11	0.39522 0.3325 8	0.09524 0.8225 8	0.95238 0.0003 8	0.05988 0.8880 8	-0.42857 0.2894 8	0.97619 <.0001 8	-0.40476 0.3199 8	0.85714 0.0065 8	0.32336 0.4346 8	0.92857 0.0009 8	1.00000 8	0.76190 0.0280 8	0.51498 0.1915 8	0.35714 0.4316 7	0.00000 1.0000 7	-0.10811 0.8175 7	-0.21429 0.6445 7
_12	0.50591 0.0456 16	-0.28571 0.4927 8	0.46465 0.0698 16	-0.00736 0.9784 16	-0.46834 0.0673 16	0.78571 0.0208 8	-0.64754 0.0067 16	0.80952 0.0149 8	-0.01198 0.9775 8	0.78571 0.0208 8	0.76190 0.0280 8	1.00000 16	0.60433 0.0132 16	0.58088 0.0232 15	0.40751 0.1316 15	0.43918 0.1015 15	-0.04651 0.8693 15
_13	0.28668 0.2817 16	0.39522 0.3325 8	0.55978 0.0241 16	0.26133 0.3282 16	0.13512 0.6178 16	0.53893 0.1681 8	-0.10386 0.7019 16	0.33534 0.4168 8	0.62651 0.0965 8	0.56288 0.1463 8	0.51498 0.1915 8	0.60433 0.0132 16	1.00000 16	0.45961 0.0848 15	0.57092 0.0262 15	0.65409 0.0082 15	-0.02336 0.9341 15
_14	0.86817 <.0001 15	0.21429 0.6445 7	0.54156 0.0371 15	0.53262 0.0409 15	0.10545 0.7084 15	0.53571 0.2152 7	-0.40000 0.1396 15	0.71429 0.0713 7	0.30632 0.5040 7	0.60714 0.1482 7	0.35714 0.4316 7	0.58088 0.0232 15	0.45961 0.0848 15	1.00000 15	0.78214 0.0006 15	0.80965 0.0003 15	0.28061 0.3110 15
_15	0.64395 0.0096 15	0.57143 0.1802 7	0.40751 0.1316 15	0.68811 0.0046 15	0.30563 0.2680 15	0.14286 0.7599 7	-0.22500 0.4201 15	0.32143 0.4821 7	0.63066 0.1289 7	0.28571 0.5345 7	0.00000 1.0000 7	0.40751 0.1316 15	0.57092 0.0262 15	0.78214 0.0006 15	1.00000 15	0.92404 <.0001 15	0.42895 0.1106 15
_16	0.64543 0.0094 15	0.46849 0.2890 7	0.39893 0.1408 15	0.55009 0.0336 15	0.19678 0.4821 15	0.05406 0.9084 7	-0.25380 0.3614 15	0.09009 0.8477 7	0.36364 0.4227 7	0.23424 0.6132 7	-0.10811 0.8175 7	0.43918 0.1015 15	0.65409 0.0082 15	0.80965 0.0003 15	0.92404 <.0001 15	1.00000 15	0.36136 0.1857 15
_17	0.25494 0.3591 15	0.35714 0.4316 7	0.04830 0.8643 15	0.38014 0.1622 15	0.03131 0.9118 15	0.00000 1.0000 7	0.01787 0.9496 15	0.17857 0.7017 7	0.23424 0.6132 7	0.14286 0.7599 7	-0.21429 0.6445 7	-0.04651 0.8693 15	-0.02336 0.9341 15	0.28061 0.3110 15	0.42895 0.1106 15	0.36136 0.1857 15	1.00000 15

2.3.5 CHLOROPHYLL A

Unlike other constituents, Chl *a* sampling began in May 2013 (Table 2-51).

Table 2-51. Chlorophyll *a* Sampling Frequency by Station for Lee Ceitus Stations

		Station																
		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17
Year	**MONTH**																	
2012	**9**	0	0	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	6	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	7	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	8	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	9	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	10	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	11	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	12	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1

The overall station arithmetic average Chl *a* concentration during 2013 for each station is provided in Figure 2-92. Stations 13 and 07 had the lowest average concentrations, while Station 14 had the highest average concentration based on the eight samples collected at these stations. Note that no Chl *a* measurements were taken at Stations 02, 06, 08, 09, 10 and 11.

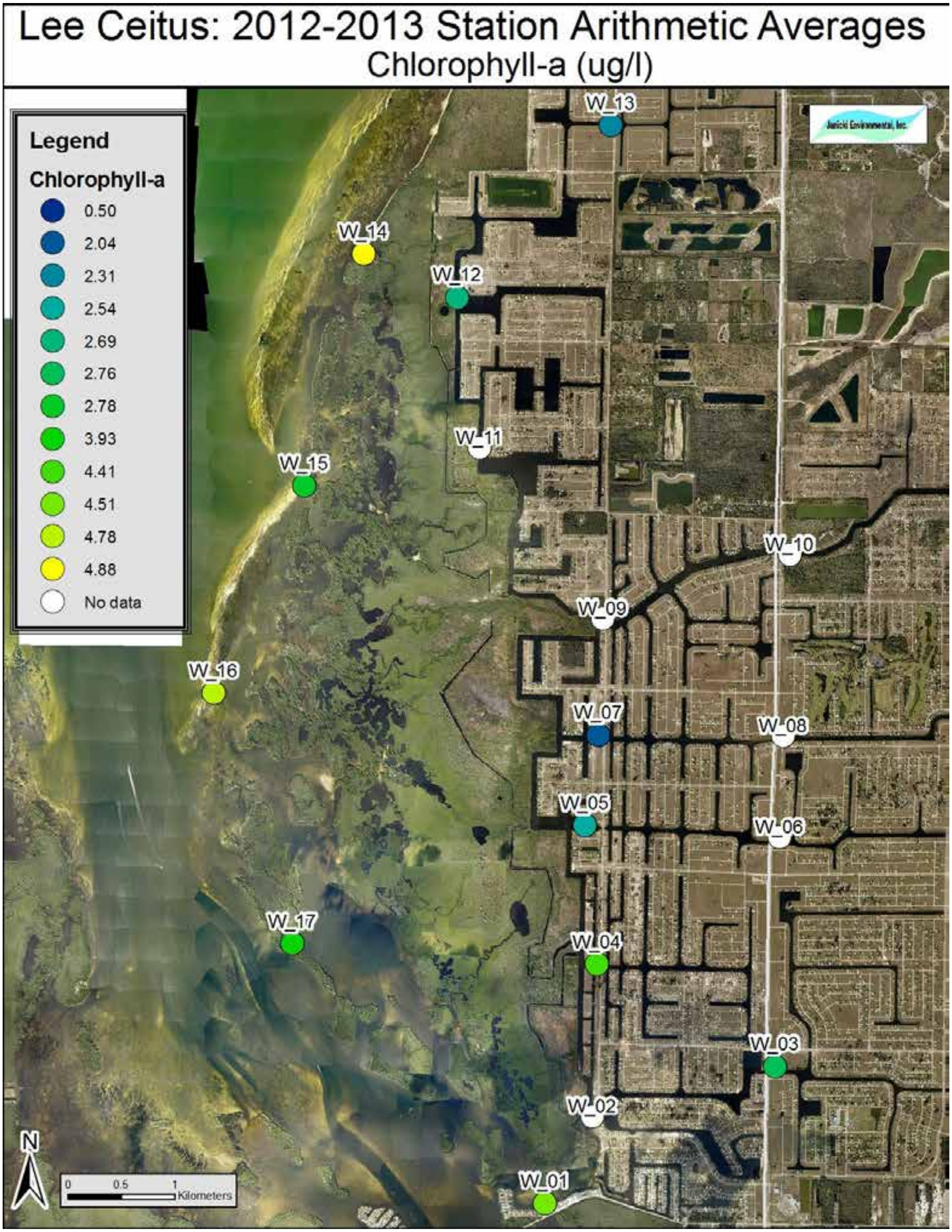


Figure 2-92. Arithmetic Average of Chlorophyll a for Lee Ceitus Stations

Box and whisker plots of Chl *a* measurements are provided in Figure 2-93. At least 75 percent of the data collected were below 8 µg/L, indicating that typical chlorophyll values would not be considered bloom conditions. These plots are trimmed such that extremely high values are not displayed in the plots.

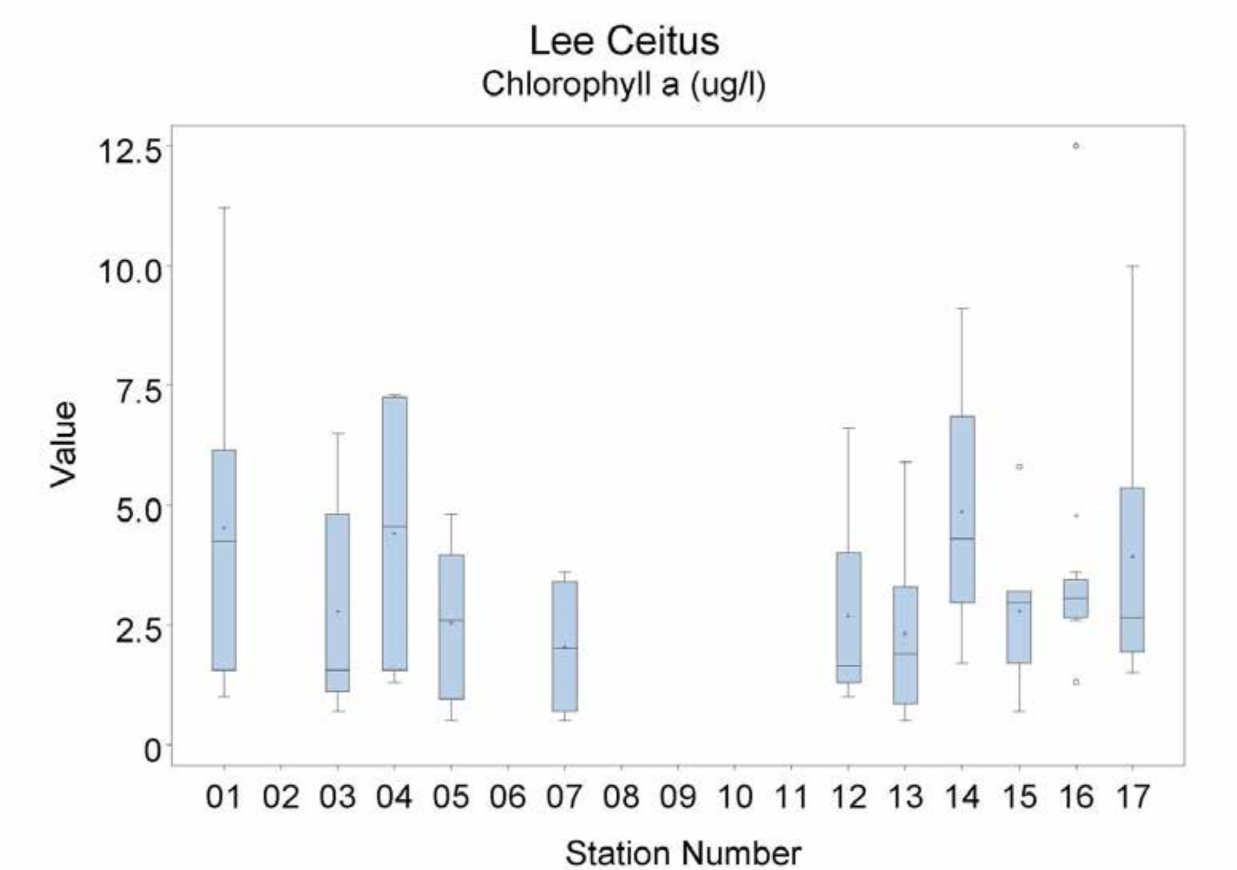


Figure 2-93. Box and Whisker Plots Displaying the Distribution of Chlorophyll a Concentrations among Lee Ceitus Stations

Time series plots of Chl *a* concentrations indicate that stations were not temporally well correlated, with Chl *a* concentrations ranging between approximately 2 µg/L and 18 µg/L (Figure 2-94).

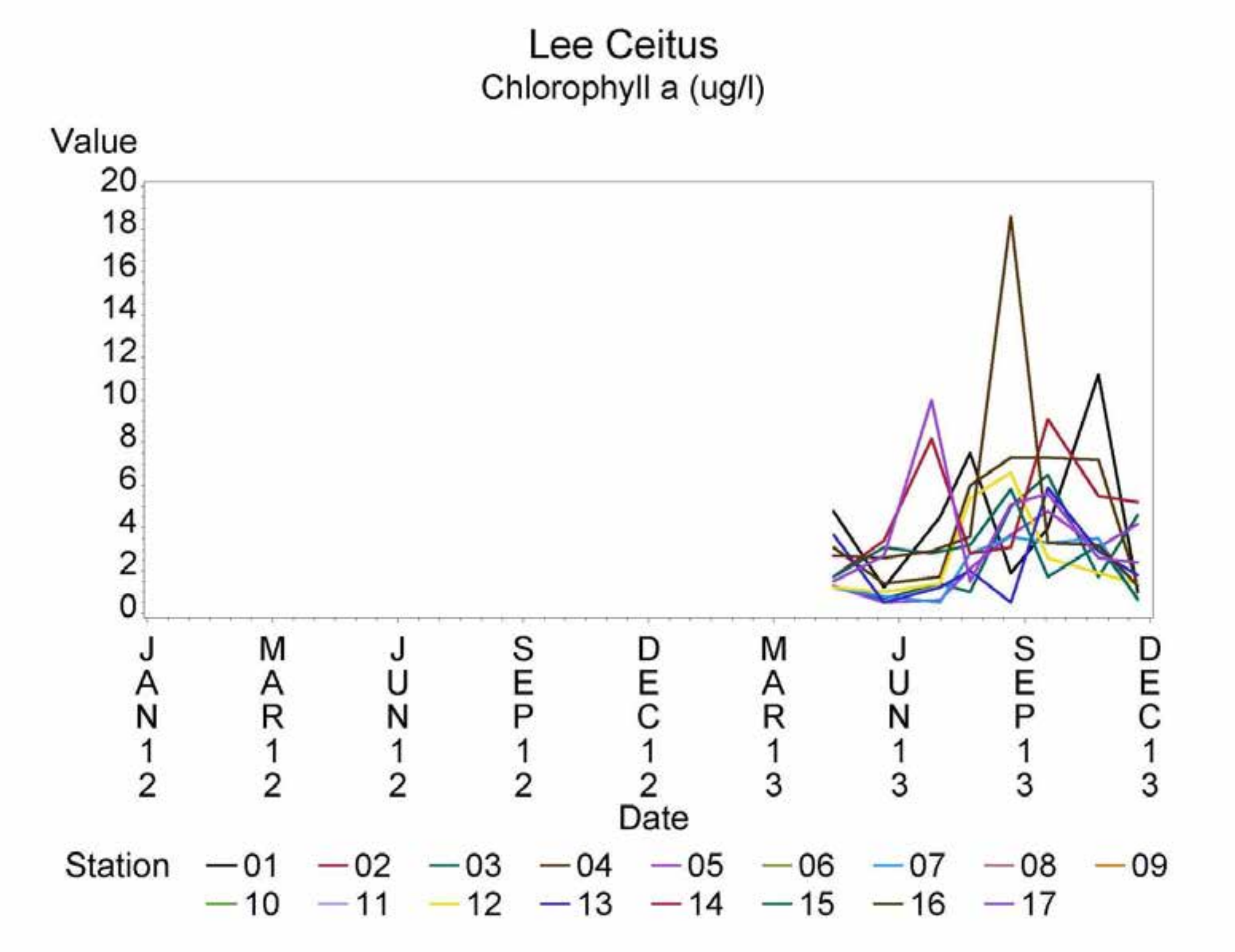


Figure 2-94. Time Series Plots of Chlorophyll a for Lee Ceitus Stations

No trend examination was performed on Chl *a* due to the limited time period sampled.

Cross correlation analysis is displayed in Table 2-52. Correlations were greatest between Stations 12 and 16.

Table 2-52. Spearman Rank Correlation Coefficients for Chlorophyll *a* for Lee Ceitus Stations

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	_01	_02	_03	_04	_05	_06	_07	_08	_09	_10	_11	_12	_13	_14	_15	_16	_17
_01	1.00000 8	. . 0	-0.21429 0.6103 8	0.41917 0.3013 8	-0.16667 0.6932 8	. . 0	0.33333 0.4198 8	. . 0	. . 0	. . 0	. . 0	0.23953 0.5678 8	0.51498 0.1915 8	-0.11905 0.7789 8	0.37352 0.3621 8	0.42857 0.2894 8	-0.27545 0.5091 8
_02	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0
_03	-0.21429 0.6103 8	. . 0	1.00000 8	0.53893 0.1681 8	0.88095 0.0039 8	. . 0	0.42857 0.2894 8	. . 0	. . 0	. . 0	. . 0	0.55091 0.1570 8	0.26348 0.5284 8	0.52381 0.1827 8	-0.14459 0.7327 8	0.33333 0.4198 8	0.44312 0.2715 8
_04	0.41917 0.3013 8	. . 0	0.53893 0.1681 8	1.00000 8	0.47905 0.2297 8	. . 0	0.88624 0.0034 8	. . 0	. . 0	. . 0	. . 0	0.77108 0.0251 8	0.34337 0.4050 8	0.10779 0.7995 8	0.51516 0.1914 8	0.88624 0.0034 8	0.24096 0.5654 8
_05	-0.16667 0.6932 8	. . 0	0.88095 0.0039 8	0.47905 0.2297 8	1.00000 8	. . 0	0.47619 0.2329 8	. . 0	. . 0	. . 0	. . 0	0.61079 0.1077 8	0.41917 0.3013 8	0.33333 0.4198 8	-0.19279 0.6474 8	0.30952 0.4556 8	0.05988 0.8880 8
_06	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0
_07	0.33333 0.4198 8	. . 0	0.42857 0.2894 8	0.88624 0.0034 8	0.47619 0.2329 8	. . 0	1.00000 8	. . 0	. . 0	. . 0	. . 0	0.70660 0.0501 8	0.20360 0.6287 8	-0.11905 0.7789 8	0.62655 0.0965 8	0.76190 0.0280 8	-0.03593 0.9327 8
_08	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0
_09	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0

Table 2-52. Spearman Rank Correlation Coefficients for Chlorophyll ***a*** for Lee Ceitus Stations (Continued)

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	_01	_02	_03	_04	_05	_06	_07	_08	_09	_10	_11	_12	_13	_14	_15	_16	_17
_10	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0
_11	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0	. . 0
_12	0.23953 0.5678 8	. . 0	0.55091 0.1570 8	0.77108 0.0251 8	0.61079 0.1077 8	. . 0	0.70660 0.0501 8	. . 0	. . 0	. . 0	. . 0	1.00000 8	0.07229 0.8649 8	0.04791 0.9103 8	0.54546 0.1620 8	0.89822 0.0024 8	0.12048 0.7763 8
_13	0.51498 0.1915 8	. . 0	0.26348 0.5284 8	0.34337 0.4050 8	0.41917 0.3013 8	. . 0	0.20360 0.6287 8	. . 0	. . 0	. . 0	. . 0	0.07229 0.8649 8	1.00000 8	0.15569 0.7128 8	-0.42425 0.2948 8	0.07186 0.8657 8	-0.27711 0.5064 8
_14	-0.11905 0.7789 8	. . 0	0.52381 0.1827 8	0.10779 0.7995 8	0.33333 0.4198 8	. . 0	-0.11905 0.7789 8	. . 0	. . 0	. . 0	. . 0	0.04791 0.9103 8	0.15569 0.7128 8	1.00000 8	-0.25303 0.5454 8	-0.04762 0.9108 8	0.75450 0.0305 8
_15	0.37352 0.3621 8	. . 0	-0.14459 0.7327 8	0.51516 0.1914 8	-0.19279 0.6474 8	. . 0	0.62655 0.0965 8	. . 0	. . 0	. . 0	. . 0	0.54546 0.1620 8	-0.42425 0.2948 8	-0.25303 0.5454 8	1.00000 8	0.71089 0.0481 8	0.07273 0.8641 8
_16	0.42857 0.2894 8	. . 0	0.33333 0.4198 8	0.88624 0.0034 8	0.30952 0.4556 8	. . 0	0.76190 0.0280 8	. . 0	. . 0	. . 0	. . 0	0.89822 0.0024 8	0.07186 0.8657 8	-0.04762 0.9108 8	0.71089 0.0481 8	1.00000 8	0.19162 0.6494 8
_17	-0.27545 0.5091 8	. . 0	0.44312 0.2715 8	0.24096 0.5654 8	0.05988 0.8880 8	. . 0	-0.03593 0.9327 8	. . 0	. . 0	. . 0	. . 0	0.12048 0.7763 8	-0.27711 0.5064 8	0.75450 0.0305 8	0.07273 0.8641 8	0.19162 0.6494 8	1.00000 8

2.3.6 FECAL COLIFORM

The sampling frequency for fecal coliform is provided in Table 2-53.

Table 2-53. Fecal Coliform Sampling Frequency by Station for Lee Ceitus Stations

		Station																
		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17
Year	**MONTH**																	
2012	**9**	1	1	1	1	1	1	1	1	1	1	1	1	1	.	.	.	.
	10	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	11	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	12	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
2013	**1**	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	3	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	4	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	5	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	6	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	7	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	8	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	9	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	10	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	11	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1
	12	1	.	1	1	1	.	1	.	.	.	.	1	1	1	1	1	1

The overall station arithmetic average fecal coliform concentration between 2012 and 2013 is displayed in Figure 2-95. Stations 16 and 17 had the lowest average concentrations, while Station W_11 had the highest average concentration.

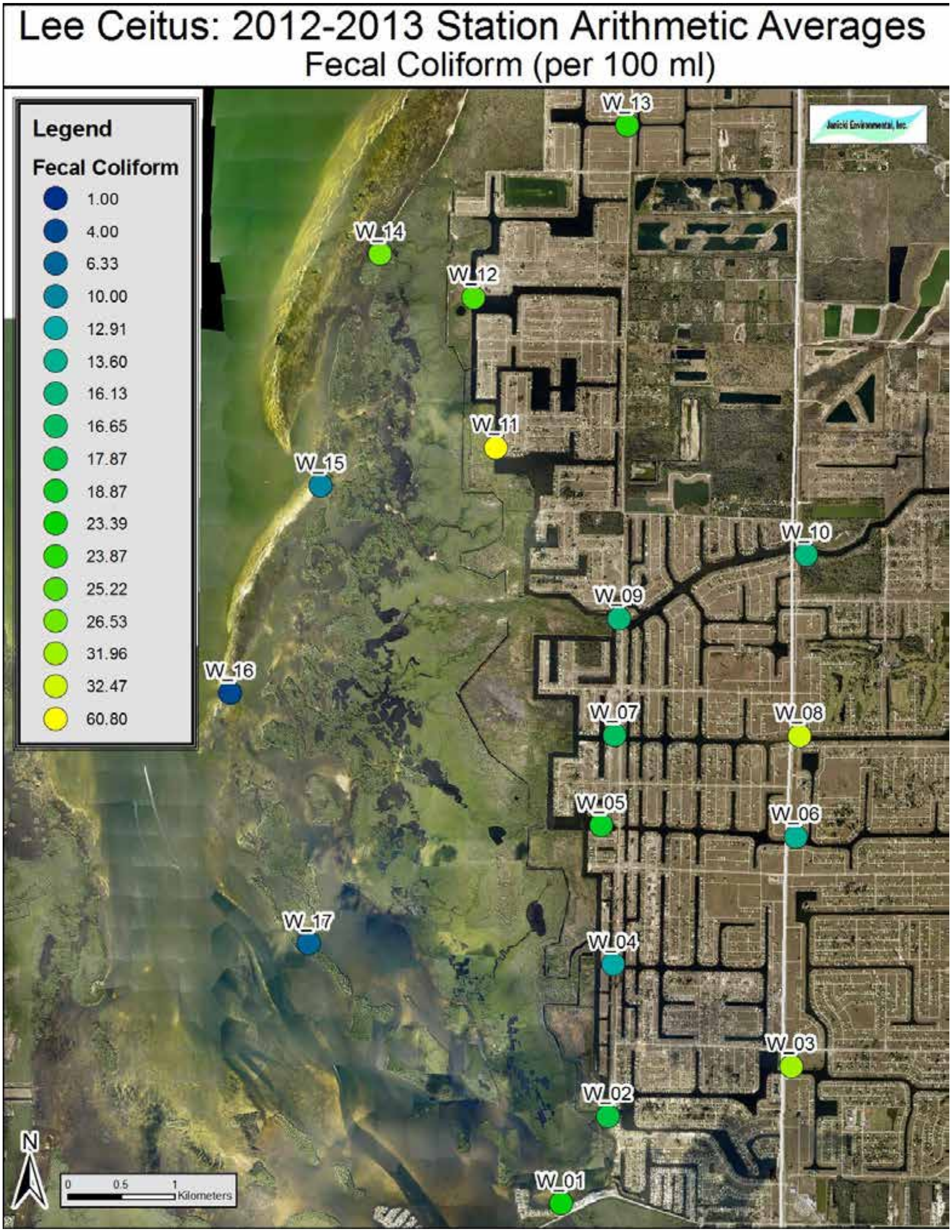


Figure 2-95. Arithmetic Averages of Fecal Coliform for Lee Ceitus Stations

Box and whisker plots of fecal coliform concentrations are provided in Figure 2-96. Stations 03 and 14 had the highest distributions of fecal coliform concentrations. These plots represent the entire period of record for each station, which varies among stations. Note that no fecal coliform measurements were collected at Stations 02, 06, 08, 09, 10 and 11 after April 2013. These plots are trimmed such that extremely high values are not displayed in the plots.

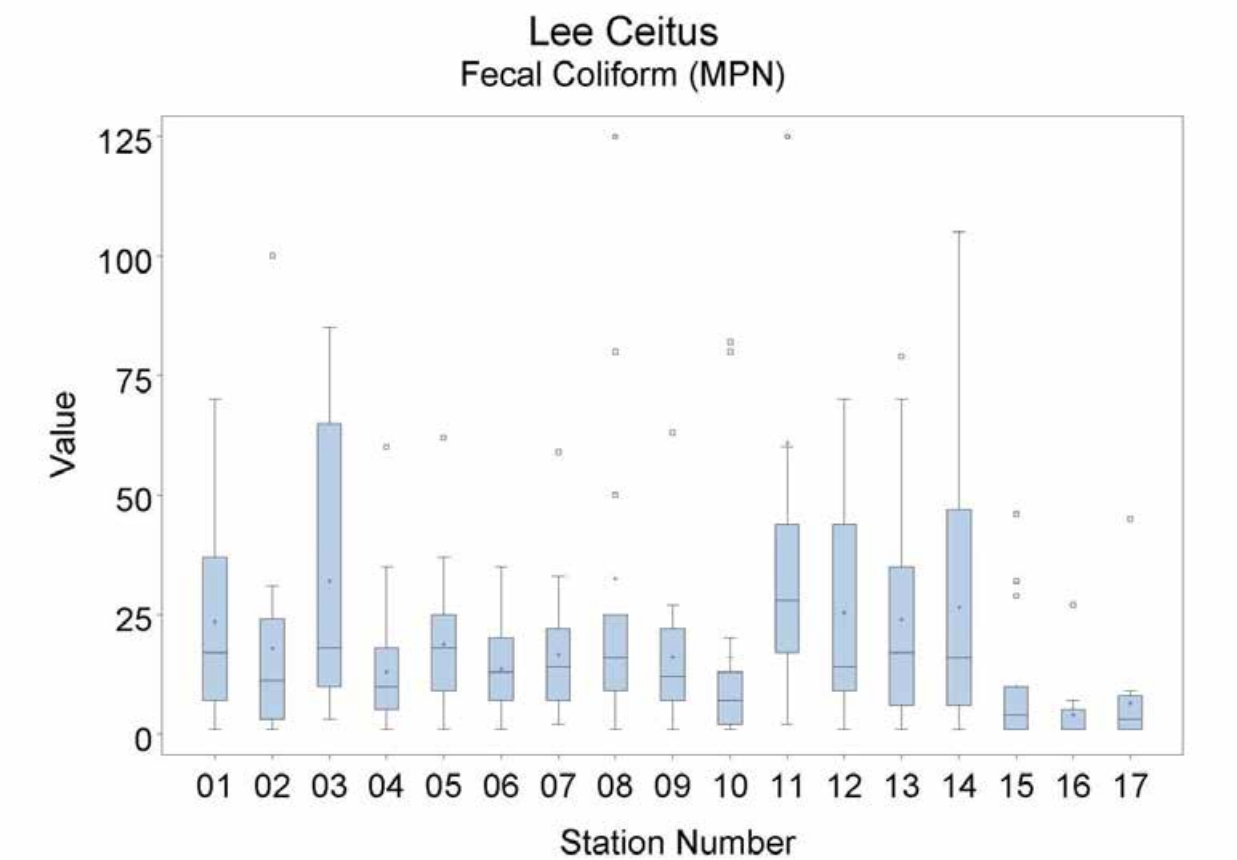


Figure 2-96. Box and Whisker Plots of Fecal Coliform Concentrations for Lee Ceitus Stations

Time series plots of fecal coliform concentrations indicate that stations can exhibit occasional spikes in concentration (Figure 2-97). Station 11 began with a high fecal coliform value in September 2012, but had reduced by nearly 500 most probable number (MPN) by October 2012. Station 08 experienced a peak in April 2013. These peaks were more than twice the fecal coliform values associated with all other stations from 2012-2013.

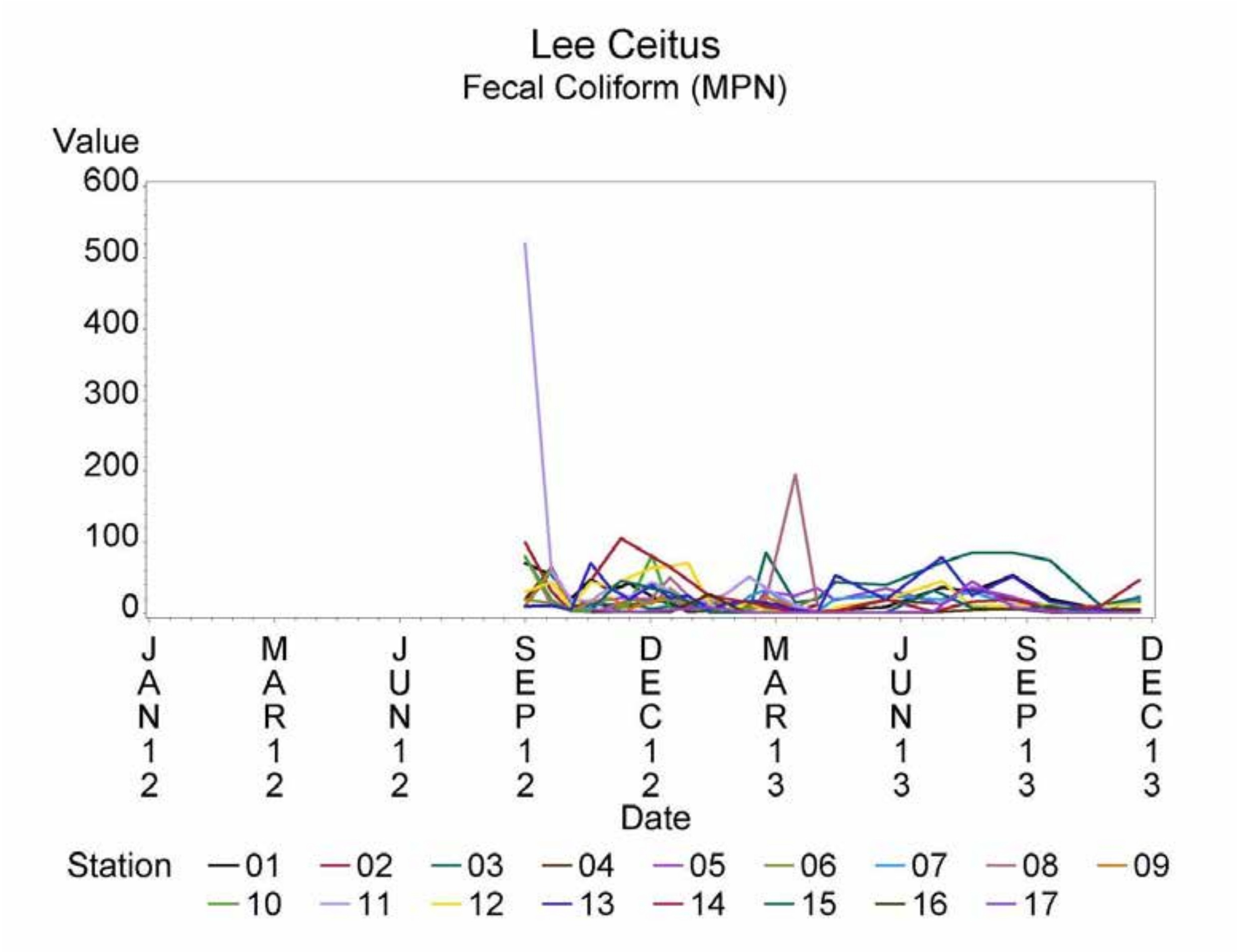


Figure 2-97. Time Series Plots of Fecal Coliform for Lee Ceitus Stations

No trend examination was performed on fecal coliform due to the limited time period sampled.

Cross correlation analysis suggested that fecal coliform concentrations among stations were greatest between Stations 10 and 11 (Table 2-54).

Table 2-54. Spearman Rank Correlation Coefficients for Fecal Coliform for Lee Ceitus Stations

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations	_01	_02	_03	_04	_05	_06	_07	_08	_09	_10	_11	_12	_13	_14	_15	_16	_17
_01	1.00000 16	0.44312 0.2715 8	0.23287 0.3854 16	0.77434 0.0004 16	0.19279 0.4744 16	0.00000 1.0000 8	0.20603 0.4439 16	-0.28571 0.4927 8	0.33333 0.4198 8	0.71429 0.0465 8	0.69048 0.0580 8	0.64901 0.0065 16	0.35762 0.1739 16	0.27167 0.3273 15	0.67454 0.0058 15	0.24981 0.3692 15	0.49037 0.0635 15
_02	0.44312 0.2715 8	1.00000 8	0.07229 0.8649 8	0.54217 0.1651 8	-0.03593 0.9327 8	0.57486 0.1361 8	0.11976 0.7776 8	0.50300 0.2039 8	-0.27545 0.5091 8	0.85031 0.0075 8	0.69462 0.0559 8	0.49103 0.2166 8	0.22755 0.5878 8	0.41443 0.3553 7	0.56097 0.1901 7	-0.23857 0.6064 7	-0.67316 0.0974 7
_03	0.23287 0.3854 16	0.07229 0.8649 8	1.00000 16	0.31707 0.2315 16	0.27139 0.3093 16	-0.49103 0.2166 8	0.45207 0.0787 16	-0.09581 0.8215 8	0.03593 0.9327 8	0.20360 0.6287 8	0.55091 0.1570 8	-0.26696 0.3175 16	0.30752 0.2466 16	-0.50000 0.0577 15	0.01134 0.9680 15	0.12524 0.6565 15	0.27989 0.3123 15
_04	0.77434 0.0004 16	0.54217 0.1651 8	0.31707 0.2315 16	1.00000 16	0.53801 0.0316 16	0.08383 0.8435 8	0.40222 0.1225 16	-0.22755 0.5878 8	0.37126 0.3652 8	0.82636 0.0114 8	0.70660 0.0501 8	0.53801 0.0316 16	0.24059 0.3694 16	0.23677 0.3955 15	0.53230 0.0411 15	0.23251 0.4043 15	0.47983 0.0703 15
_05	0.19279 0.4744 16	-0.03593 0.9327 8	0.27139 0.3093 16	0.53801 0.0316 16	1.00000 16	-0.14286 0.7358 8	0.50663 0.0452 16	-0.04762 0.9108 8	0.21429 0.6103 8	-0.02381 0.9554 8	-0.14286 0.7358 8	0.09867 0.7162 16	0.27393 0.3046 16	-0.02147 0.9395 15	0.13673 0.6270 15	0.08469 0.7641 15	0.22464 0.4209 15
_06	0.00000 1.0000 8	0.57486 0.1361 8	-0.49103 0.2166 8	0.08383 0.8435 8	-0.14286 0.7358 8	1.00000 8	-0.47619 0.2329 8	0.76190 0.0280 8	-0.47619 0.2329 8	0.28571 0.4927 8	-0.07143 0.8665 8	0.38095 0.3518 8	-0.07143 0.8665 8	0.35714 0.4316 7	0.40769 0.3639 7	0.05911 0.8998 7	-0.25944 0.5742 7
_07	0.20603 0.4439 16	0.11976 0.7776 8	0.45207 0.0787 16	0.40222 0.1225 16	0.50663 0.0452 16	-0.47619 0.2329 8	1.00000 16	-0.64286 0.0856 8	0.85714 0.0065 8	0.38095 0.3518 8	0.54762 0.1600 8	0.20103 0.4553 16	0.29161 0.2731 16	0.06261 0.8246 15	-0.01509 0.9574 15	0.06049 0.8304 15	0.11798 0.6754 15
_08	-0.28571 0.4927 8	0.50300 0.2039 8	-0.09581 0.8215 8	-0.22755 0.5878 8	-0.04762 0.9108 8	0.76190 0.0280 8	-0.64286 0.0856 8	1.00000 8	-0.80952 0.0149 8	0.04762 0.9108 8	-0.11905 0.7789 8	-0.09524 0.8225 8	-0.33333 0.4198 8	-0.03571 0.9394 7	0.00000 1.0000 7	-0.35465 0.4351 7	-0.66712 0.1016 7
_09	0.33333 0.4198 8	-0.27545 0.5091 8	0.03593 0.9327 8	0.37126 0.3652 8	0.21429 0.6103 8	-0.47619 0.2329 8	0.85714 0.0065 8	-0.80952 0.0149 8	1.00000 8	0.04762 0.9108 8	0.16667 0.6932 8	0.35714 0.3851 8	0.30952 0.4556 8	0.03571 0.9394 7	0.22237 0.6317 7	0.03941 0.9332 7	0.55594 0.1950 7

Table 2-54. Spearman Rank Correlation Coefficients for Fecal Coliform for Lee Ceitus Stations (Continued)

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	_01	_02	_03	_04	_05	_06	_07	_08	_09	_10	_11	_12	_13	_14	_15	_16	_17
_10	0.71429 0.0465 8	0.85031 0.0075 8	0.20360 0.6287 8	0.82636 0.0114 8	-0.02381 0.9554 8	0.28571 0.4927 8	0.38095 0.3518 8	0.04762 0.9108 8	0.04762 0.9108 8	1.00000 8	0.88095 0.0039 8	0.50000 0.2070 8	0.26190 0.5309 8	0.42857 0.3374 7	0.59300 0.1605 7	0.21673 0.6406 7	-0.18531 0.6908 7
_11	0.69048 0.0580 8	0.69462 0.0559 8	0.55091 0.1570 8	0.70660 0.0501 8	-0.14286 0.7358 8	-0.07143 0.8665 8	0.54762 0.1600 8	-0.11905 0.7789 8	0.16667 0.6932 8	0.88095 0.0039 8	1.00000 8	0.26190 0.5309 8	0.21429 0.6103 8	0.10714 0.8192 7	0.18531 0.6908 7	0.01970 0.9666 7	-0.14825 0.7511 7
_12	0.64901 0.0065 16	0.49103 0.2166 8	-0.26696 0.3175 16	0.53801 0.0316 16	0.09867 0.7162 16	0.38095 0.3518 8	0.20103 0.4553 16	-0.09524 0.8225 8	0.35714 0.3851 8	0.50000 0.2070 8	0.26190 0.5309 8	1.00000 16	0.36230 0.1679 16	0.50894 0.0527 15	0.75340 0.0012 15	-0.11292 0.6887 15	0.10855 0.7002 15
_13	0.35762 0.1739 16	0.22755 0.5878 8	0.30752 0.2466 16	0.24059 0.3694 16	0.27393 0.3046 16	-0.07143 0.8665 8	0.29161 0.2731 16	-0.33333 0.4198 8	0.30952 0.4556 8	0.26190 0.5309 8	0.21429 0.6103 8	0.36230 0.1679 16	1.00000 16	0.06351 0.8221 15	0.56387 0.0286 15	-0.18147 0.5175 15	0.24635 0.3761 15
_14	0.27167 0.3273 15	0.41443 0.3553 7	-0.50000 0.0577 15	0.23677 0.3955 15	-0.02147 0.9395 15	0.35714 0.4316 7	0.06261 0.8246 15	-0.03571 0.9394 7	0.03571 0.9394 7	0.42857 0.3374 7	0.10714 0.8192 7	0.50894 0.0527 15	0.06351 0.8221 15	1.00000 15	0.24611 0.3766 15	0.36496 0.1810 15	0.16046 0.5678 15
_15	0.67454 0.0058 15	0.56097 0.1901 7	0.01134 0.9680 15	0.53230 0.0411 15	0.13673 0.6270 15	0.40769 0.3639 7	-0.01509 0.9574 15	0.00000 1.0000 7	0.22237 0.6317 7	0.59300 0.1605 7	0.18531 0.6908 7	0.75340 0.0012 15	0.56387 0.0286 15	0.24611 0.3766 15	1.00000 15	-0.04464 0.8745 15	0.36418 0.1820 15
_16	0.24981 0.3692 15	-0.23857 0.6064 7	0.12524 0.6565 15	0.23251 0.4043 15	0.08469 0.7641 15	0.05911 0.8998 7	0.06049 0.8304 15	-0.35465 0.4351 7	0.03941 0.9332 7	0.21673 0.6406 7	0.01970 0.9666 7	-0.11292 0.6887 15	-0.18147 0.5175 15	0.36496 0.1810 15	-0.04464 0.8745 15	1.00000 15	0.53407 0.0403 15
_17	0.49037 0.0635 15	-0.67316 0.0974 7	0.27989 0.3123 15	0.47983 0.0703 15	0.22464 0.4209 15	-0.25944 0.5742 7	0.11798 0.6754 15	-0.66712 0.1016 7	0.55594 0.1950 7	-0.18531 0.6908 7	-0.14825 0.7511 7	0.10855 0.7002 15	0.24635 0.3761 15	0.16046 0.5678 15	0.36418 0.1820 15	0.53407 0.0403 15	1.00000 15

2.4 SHELLFISH ENVIRONMENTAL ASSESSMENT SECTION

SEAS, of the Florida Department of Agriculture and Consumer Services, Bureau of Aquaculture Environmental Services, maintains water quality samples from 39 areas throughout Florida. The 18 stations located in Matlacha Pass are of particular interest for this project. SEAS sampling locations examined for this project are shown in Figure 2-98.

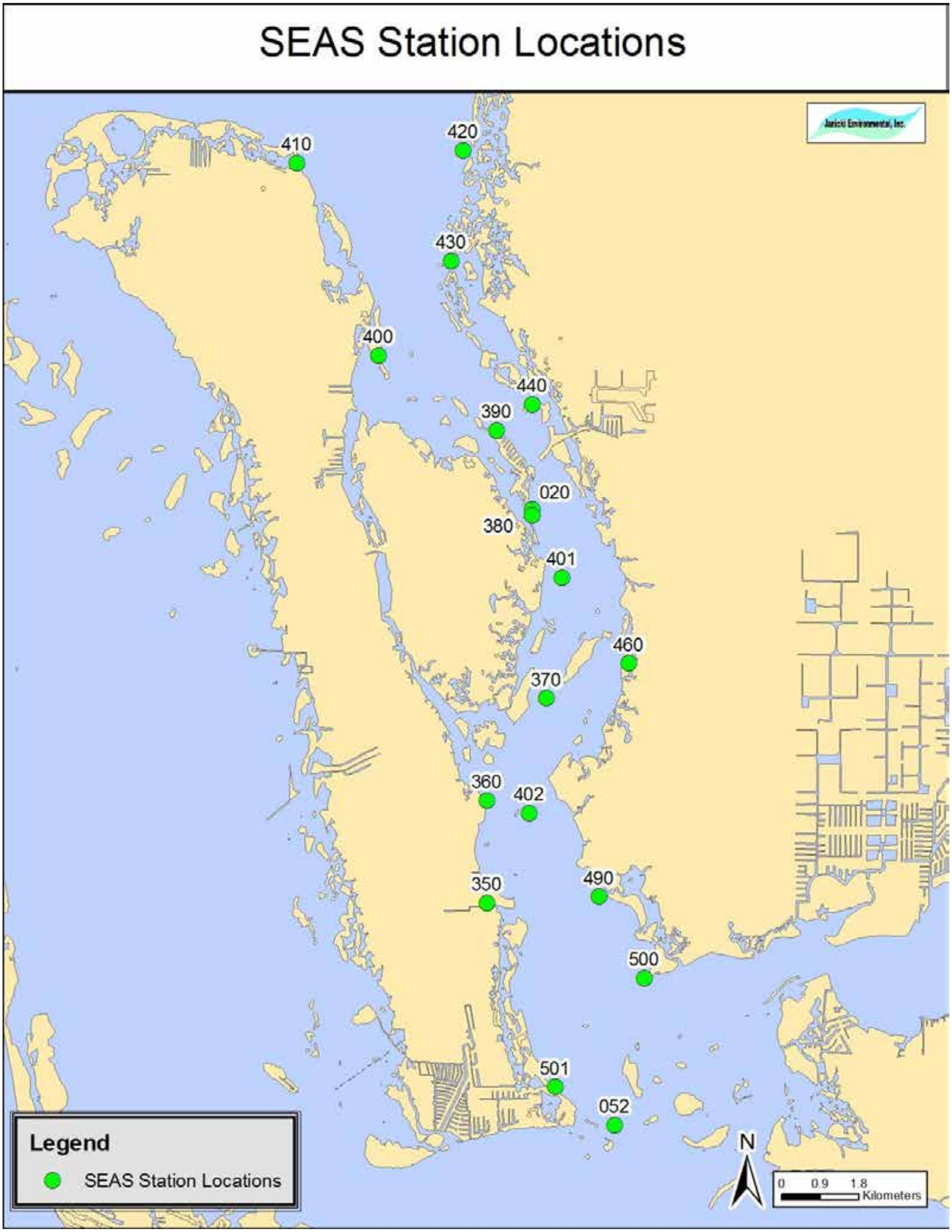


Figure 2-98. SEAS Sampling Locations

Stations in the SEAS sampling program were sampled from 1980 to 2013, with the exception of Stations 052, 401, 402, and 501 which began to be sampled at later dates. Specific station periods of record for SEAS stations can be found in Table 2-55.

Table 2-55. SEAS Station Period of Record

Station	Period of Record
020	1980-2013
052	1985-2013
350	1980-2013
360	1980-2013
370	1980-2013
380	1980-2013
390	1980-2013
400	1980-2012
401	1994-2013
402	1994-2013
410	1980-2013
420	1980-2013
430	1980-2013
440	1980-2013
460	1980-2013
490	1980-2013
500	1980-2013
501	1986-2013

A list of the periods of record for each parameter measured at each station is provided in Table 2-56. The following subsections characterize the data collected by SEAS at these stations for the principal constituents of interest. Note that this table does not account for data gaps and only reports the minimum and maximum years for each parameter. No nutrient or chlorophyll concentrations were collected as part of SEAS routine sampling efforts in Matlacha Pass.

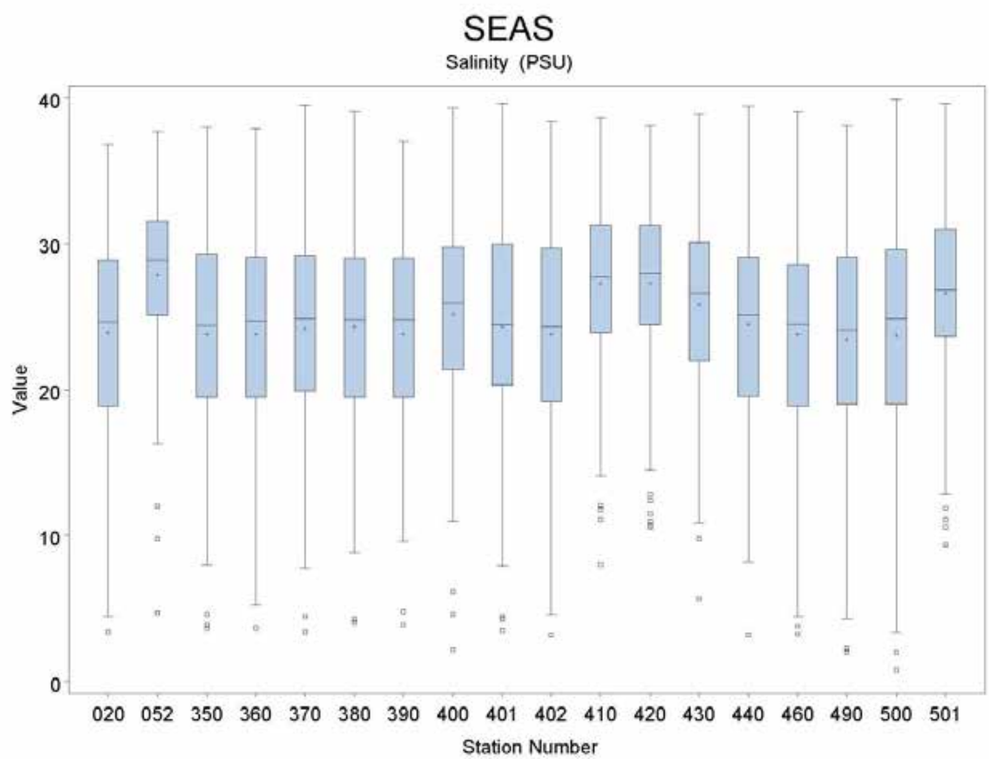
Table 2-56. SEAS Constituents Sampled and Period of Record

Parameter	Station																	
	020	052	350	360	370	380	390	400	401	402	410	420	430	440	460	490	500	501
Chlorophyll *a* (chlac_ugl)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Oxygen (DO_mgl)	1985-1986, 1988-2006, 2008-2012	1986, 1988-2006, 2008-2012	1985-2006, 2008-2013	1985-2006, 2008-2012	1985-2006, 2008-2013	1985-2006, 2008-2013	1985-2006, 2008-2013	1985-2006, 2008-2012	1994-2006, 2008-2012	1994-2006, 2008-2013	1985-2006, 2008-2013	1985-2006, 2008-2013	1985-1990, 1992-2006, 2008-2013	1985-2006, 2008-2013	1985-2006, 2008-2013	1985-2006, 2008-2013	1985-2006, 2008-2013	1986-2006, 2008-2013
Fecal Coliform (FCOLI)	1980-1986, 1988-2013	1985-2013	1980-2013	1980-2013	1980-2013	1980-2013	1980-2013	1980-2012	1994-2013	1994-2013	1980-2013	1980-2013	1980-2013	1980-2013	1980-2013	1980-2013	1980-2013	1986-2013
Salinity	1980-1986, 1988-2006, 2008-2012	1986-2006, 2008-2012	1980-2006, 2008-2012	1980-2006, 2008-2012	1980-2006, 2008-2012	1980-2006, 2008-2012	1980-2006, 2008-2012	1980-2006, 2008-2012	1994-2006, 2008-2012	1994-2006, 2008-2012	1980-2006, 2008-2012	1980-2006, 2008-2012	1980-2006, 2008-2012	1980-2006, 2008-2012	1980-2006, 2008-2012	1980-2006, 2008-2012	1980-2006, 2008-2012	1986-2006, 2008-2012
Secchi Disk Visibility	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Nitrogen (TN_mgl)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Phosphorus (TP_mgl)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Suspended Solids (TSS_mgl)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Turbidity (TURB)	1985-1986, 1988-2012	1986-2012	1985-2012	1985-2012	1985-2012	1985-2012	1985-2012	1985-2012	1994-2012	1994-2012	1985-2012	1985-2012	1985-2012	1985-2012	1985-2012	1985-2012	1985-2012	1986-2012

2.4.1 SALINITY

Salinity has been consistently sampled SEAS since 1980 at all stations except 052, 401, 402, and 501 in which sampling started at later dates (Table 2-57). Note that no stations collected salinity data in 2007 and 2013. The numbers in this table represents the sampling frequency at the surface level. Samples are generally taken at near surface and near bottom depths for salinity. Comparisons of salinity concentrations among sample levels suggest little variation as a function of depth for most stations.

A comparison between surface and bottom salinity measurements shows slight distribution differences (Figure 2-99). Between-station variability for surface and bottom salinity samples collected by SEAS was low, with bottom salinities varying between stations slightly more than surface salinities. Surface salinities also seem to have a larger range than bottom salinities. Data indicate that at least 75 percent of surface and bottom salinity measurements collected fell at or below 32 PSU. These plots represent the entire period of record for each station. Note that Station 052 and 501 began sampling salinity in 1986, Stations 401 and 402 began sampling salinity in 1994, and no station recorded salinity measurements in 2007 and 2013.



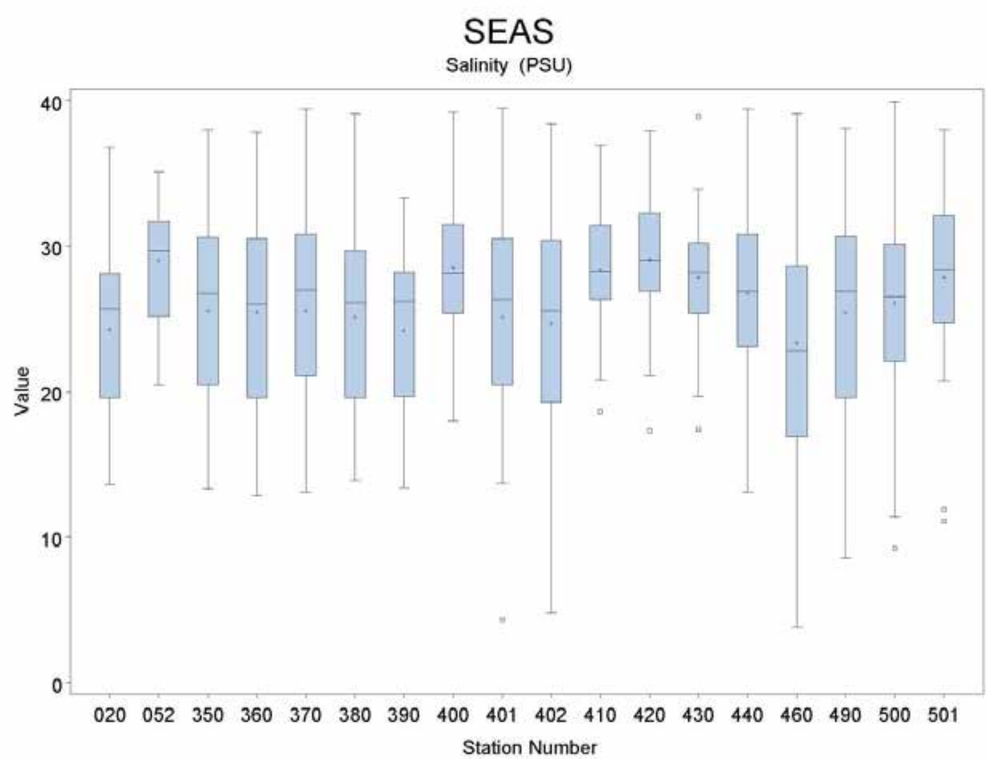


Figure 2-99. Box and Whisker Plots Displaying the Distribution of Surface (Top) and Bottom (Bottom) Salinities for SEAS Stations

Table 2-57. Salinity Sampling Frequency by Station for SEAS Stations

	Station																	
Year	020	052	350	360	370	380	390	400	401	402	410	420	430	440	460	490	500	501	Total
1980	6	-	6	6	6	6	6	6	-	-	6	6	6	6	5	6	6	-	83
1981	5	-	5	5	5	4	7	7	-	-	7	7	7	7	5	5	5	-	81
1982	6	-	6	6	6	6	5	4	-	-	5	4	5	5	4	6	6	-	74
1983	4	-	4	4	4	4	4	4	-	-	4	4	4	4	1	4	3	-	52
1984	3	-	3	3	3	3	3	3	-	-	3	3	3	3	1	3	3	-	40
1985	7	-	7	7	7	7	7	7	-	-	7	7	7	7	7	7	7	-	98
1986	4	4	4	4	4	4	4	4	-	-	4	4	4	4	3	4	4	4	63
1987	-	1	1	1	1	1	1	1	-	-	1	1	1	1	1	1	1	1	15
1988	5	5	5	5	5	5	5	4	-	-	5	5	5	5	4	5	5	5	78
1989	6	6	6	6	6	6	6	6	-	-	6	6	6	6	6	6	6	6	96
1990	5	4	5	5	5	5	5	5	-	-	5	5	5	5	5	5	5	5	79
1991	5	5	5	5	5	5	5	5	-	-	4	4	3	5	4	5	5	5	75
1992	7	7	7	7	7	7	7	6	-	-	6	4	6	7	7	7	7	7	106
1993	10	10	10	10	10	10	10	10	-	-	10	10	10	10	10	10	10	10	160
1994	11	10	11	11	11	11	9	11	5	5	11	11	11	10	11	10	10	10	179
1995	7	7	10	9	10	7	7	10	10	10	10	10	10	10	10	9	9	5	160
1996	9	8	10	10	10	9	8	10	10	10	10	10	10	10	9	10	10	8	171
1997	9	8	9	9	9	9	9	9	9	9	9	9	9	9	9	7	7	8	156
1998	6	6	7	7	7	6	6	7	7	7	7	7	7	6	7	7	7	6	120
1999	9	10	9	9	11	11	9	10	11	11	11	12	11	11	11	11	11	12	190
2000	12	11	12	12	13	13	12	12	13	13	13	13	13	13	13	13	13	14	228
2004	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	36
2005	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	126
2006	3	1	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	51
2007	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2008	3	2	2	2	4	4	3	4	4	4	5	5	5	5	4	4	4	4	68
2009	5	3	5	5	6	6	4	2	6	6	6	6	6	6	6	6	6	5	95

Table 2-57. Salinity Sampling Frequency by Station for SEAS Stations

	Station																		
Year	020	052	350	360	370	380	390	400	401	402	410	420	430	440	460	490	500	501	Total
2010	9	4	6	7	12	12	10	4	12	12	12	12	12	12	13	12	12	12	185
2011	6	3	5	1	7	7	4	3	7	7	6	7	7	7	7	7	7	7	105
2012	5	4	4	3	6	5	6	3	6	6	6	6	6	6	5	6	7	7	97
2013	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	176	128	176	171	192	185	174	168	112	112	191	190	191	192	180	188	188	153	3067

The overall arithmetic average salinity concentration between 1980 and 2012 for each station is displayed in Figure 2-100. Stations 490 and 500 had the lowest average concentrations, while Station 052 had the highest average concentration. Note that Stations 052 and 501 did not begin sampling until 1986, Stations 401 and 402 did not begin sampling until 1994, and no stations recorded data in 2007 and 2013.

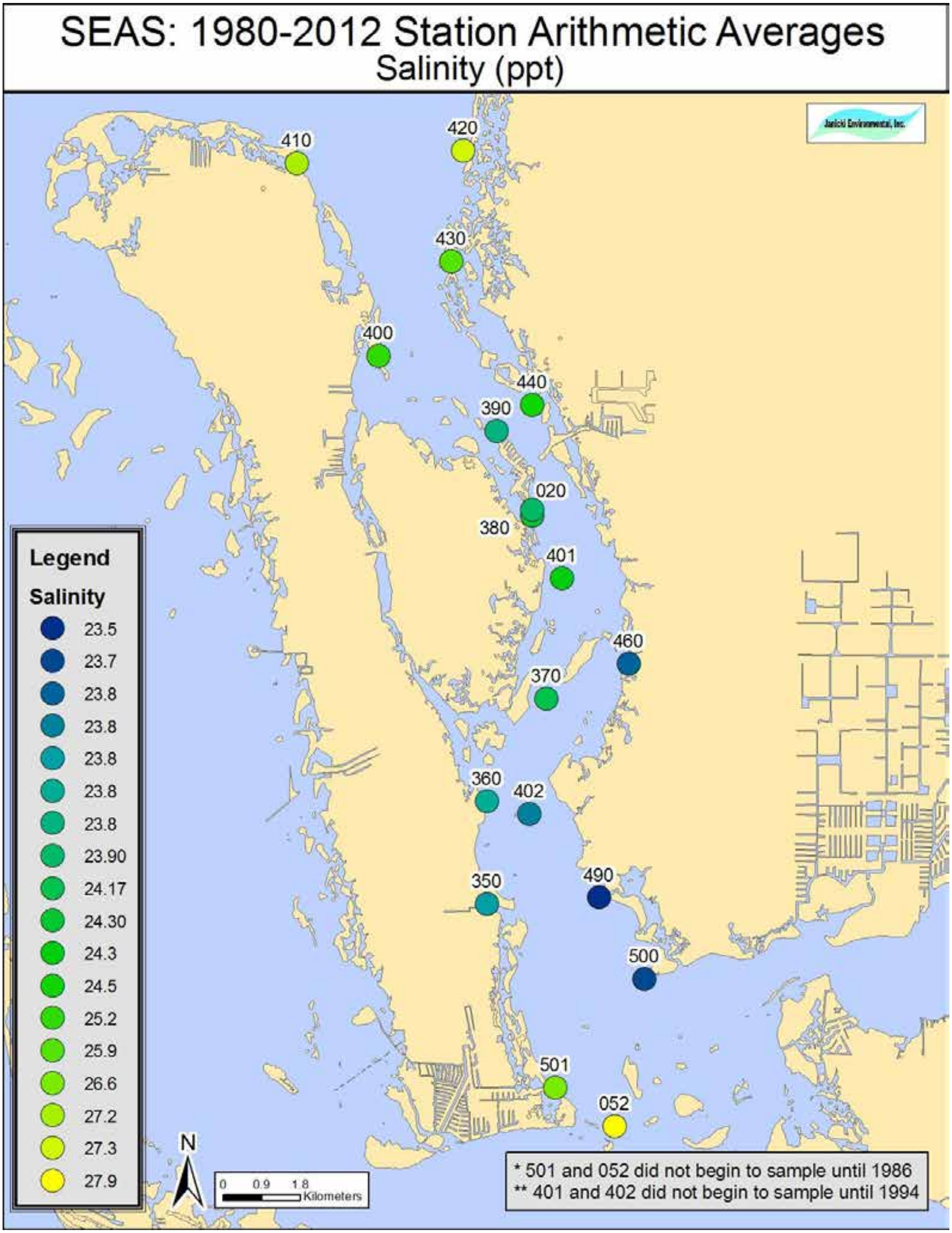


Figure 2-100. Arithmetic Average Surface Salinities at SEAS Stations

Time series plots of surface salinity measurements taken by SEAS indicate that all stations have the same general temporal trend in annual average salinity concentrations (Figure 2-101).

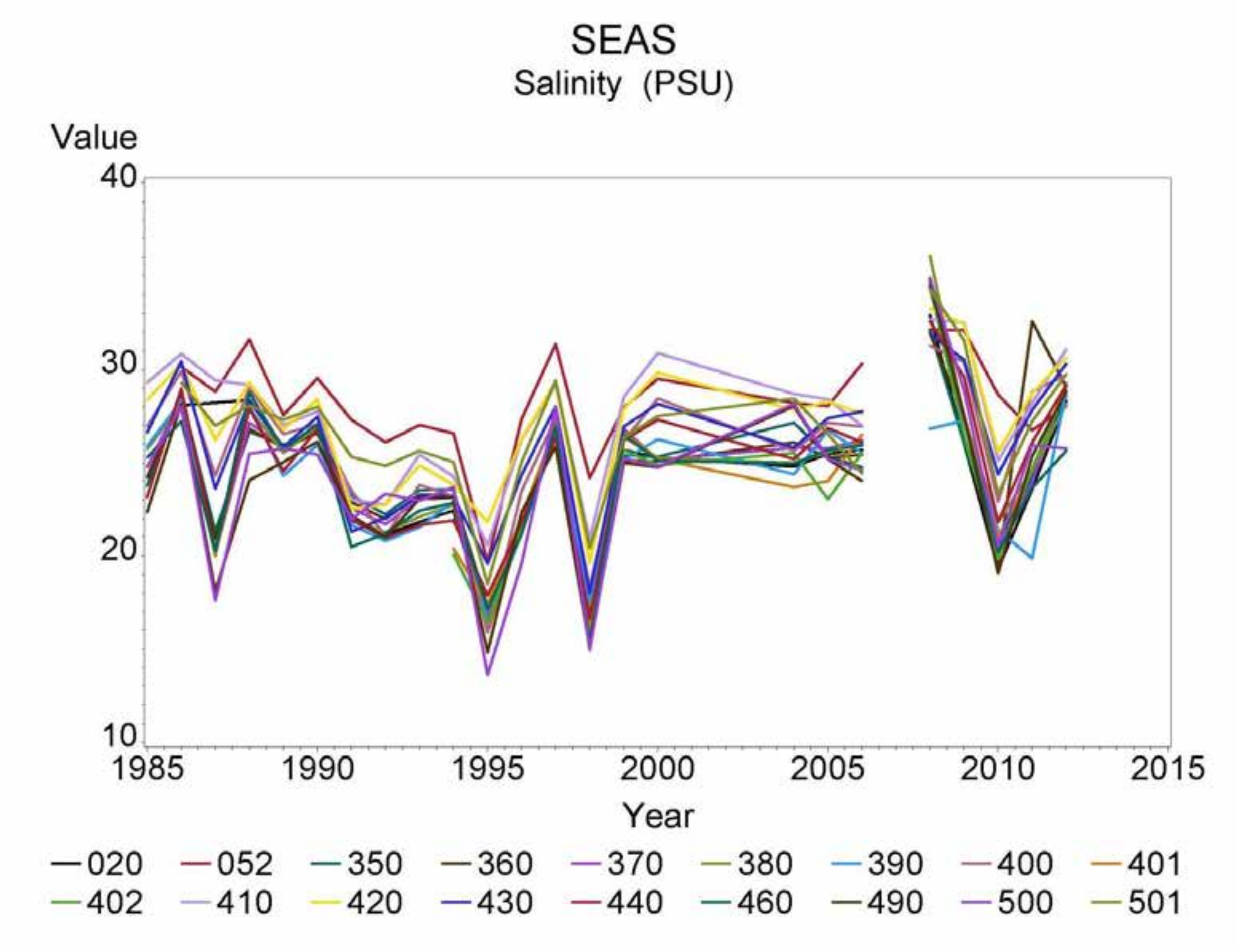


Figure 2-101. Time Series Plot of Surface Salinity for SEAS Stations

Trends for surface salinity measurements for SEAS stations are provided in Figure 2-102. No trends were identified in salinity measurements over the time period examined, indicating stable conditions of the period of record examined.

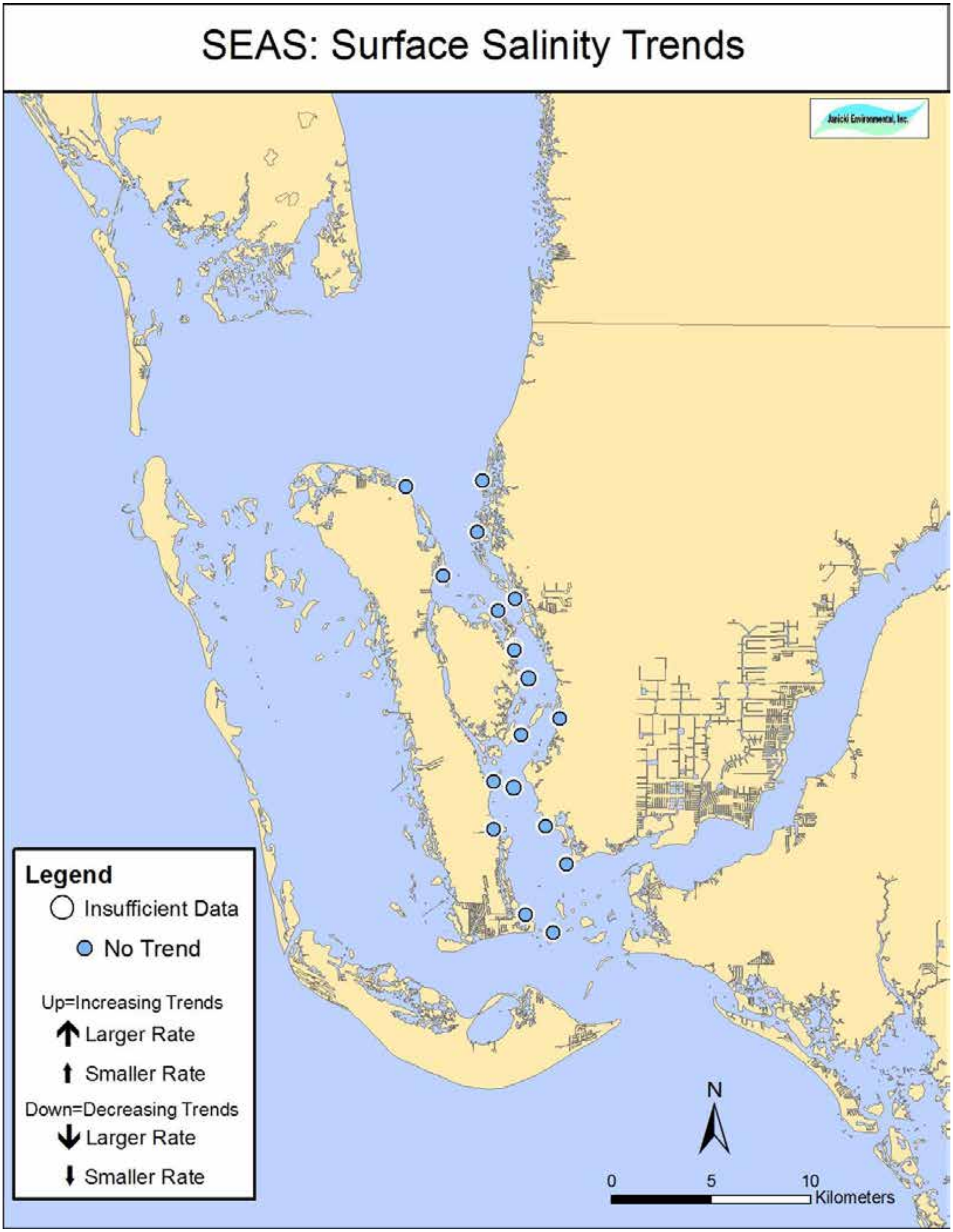


Figure 2-102. Surface Salinity Trends for SEAS Stations

Cross correlation analysis suggested that salinity concentrations among stations for long-term stations (since 1980) were greatest between Stations 350 and 360. For the short-term correlation among stations with observations since 2008, correlations were greatest between 401 and 402. Cross correlation between both short- and long-term stations showed that Stations 401 and 460 had the highest correlation. All cross correlations between stations were found to be statistically significant, positive correlations (Table 2-58).

Table 2-58. Spearman Rank Correlation Coefficient for Surface Salinity for SEAS Stations

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	_020	_350	_360	_370	_380	_390	_400	_410	_420	_430	_440	_460	_490	_500	_052	_501	_401	_402
_020	1.00000 154	0.91581 <.0001 152	0.93248 <.0001 145	0.95309 <.0001 154	0.97462 <.0001 153	0.95745 <.0001 146	0.92371 <.0001 140	0.85130 <.0001 150	0.83074 <.0001 148	0.89199 <.0001 150	0.92656 <.0001 151	0.96944 <.0001 144	0.85060 <.0001 151	0.84330 <.0001 150	0.84343 <.0001 108	0.90833 <.0001 119	0.96551 <.0001 78	0.93499 <.0001 78
_350	0.91581 <.0001 152	1.00000 158	0.98876 <.0001 151	0.97670 <.0001 158	0.93473 <.0001 153	0.90415 <.0001 146	0.88625 <.0001 146	0.80372 <.0001 154	0.79187 <.0001 152	0.83385 <.0001 154	0.88344 <.0001 155	0.94025 <.0001 147	0.93593 <.0001 155	0.94038 <.0001 154	0.87066 <.0001 110	0.95368 <.0001 119	0.95850 <.0001 81	0.98975 <.0001 81
_360	0.93248 <.0001 145	0.98876 <.0001 151	1.00000 153	0.98827 <.0001 153	0.94966 <.0001 148	0.92211 <.0001 142	0.90492 <.0001 143	0.81850 <.0001 150	0.80685 <.0001 147	0.84939 <.0001 149	0.90113 <.0001 150	0.95292 <.0001 142	0.92849 <.0001 150	0.93370 <.0001 149	0.86512 <.0001 108	0.95013 <.0001 114	0.96755 <.0001 76	0.99286 <.0001 76
_370	0.95309 <.0001 154	0.97670 <.0001 158	0.98827 <.0001 153	1.00000 165	0.97010 <.0001 159	0.94301 <.0001 149	0.91711 <.0001 147	0.84421 <.0001 161	0.82808 <.0001 159	0.87704 <.0001 161	0.92539 <.0001 162	0.97319 <.0001 153	0.91248 <.0001 162	0.91538 <.0001 161	0.85680 <.0001 111	0.94468 <.0001 126	0.98469 <.0001 88	0.98596 <.0001 88
_380	0.97462 <.0001 153	0.93473 <.0001 153	0.94966 <.0001 148	0.97010 <.0001 159	1.00000 159	0.96549 <.0001 147	0.94926 <.0001 142	0.86870 <.0001 155	0.84884 <.0001 153	0.90907 <.0001 155	0.94655 <.0001 156	0.98872 <.0001 149	0.88004 <.0001 156	0.87316 <.0001 155	0.84492 <.0001 111	0.92349 <.0001 125	0.98835 <.0001 83	0.94541 <.0001 83
_390	0.95745 <.0001 146	0.90415 <.0001 146	0.92211 <.0001 142	0.94301 <.0001 149	0.96549 <.0001 147	1.00000 152	0.95147 <.0001 141	0.88298 <.0001 150	0.84629 <.0001 147	0.92704 <.0001 149	0.95965 <.0001 151	0.96355 <.0001 139	0.85235 <.0001 147	0.83767 <.0001 146	0.80440 <.0001 108	0.90080 <.0001 117	0.95489 <.0001 74	0.92247 <.0001 74
_400	0.92371 <.0001 140	0.88625 <.0001 146	0.90492 <.0001 143	0.91711 <.0001 147	0.94926 <.0001 142	0.95147 <.0001 141	1.00000 150	0.95088 <.0001 149	0.90136 <.0001 146	0.95050 <.0001 148	0.94879 <.0001 148	0.93266 <.0001 137	0.84533 <.0001 144	0.82369 <.0001 143	0.81696 <.0001 107	0.90119 <.0001 111	0.91098 <.0001 74	0.88755 <.0001 74
_410	0.85130 <.0001 150	0.80372 <.0001 154	0.81850 <.0001 150	0.84421 <.0001 161	0.86870 <.0001 155	0.88298 <.0001 150	0.95088 <.0001 149	1.00000 164	0.94768 <.0001 161	0.93967 <.0001 163	0.91628 <.0001 162	0.86242 <.0001 151	0.77181 <.0001 158	0.75597 <.0001 157	0.78123 <.0001 109	0.86183 <.0001 123	0.88644 <.0001 87	0.84825 <.0001 87
_420	0.83074 <.0001 148	0.79187 <.0001 152	0.80685 <.0001 147	0.82808 <.0001 159	0.84884 <.0001 153	0.84629 <.0001 147	0.90136 <.0001 146	0.94768 <.0001 161	1.00000 163	0.92634 <.0001 161	0.88870 <.0001 160	0.84115 <.0001 149	0.74963 <.0001 156	0.75606 <.0001 155	0.81797 <.0001 108	0.86487 <.0001 123	0.89053 <.0001 88	0.85643 <.0001 88

Table 2-58. Spearman Rank Correlation Coefficient for Surface Salinity for SEAS Stations (Continued)

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	_020	_350	_360	_370	_380	_390	_400	_410	_420	_430	_440	_460	_490	_500	_052	_501	_401	_402
_430	0.89199 <.0001 150	0.83385 <.0001 154	0.84939 <.0001 149	0.87704 <.0001 161	0.90907 <.0001 155	0.92704 <.0001 149	0.95050 <.0001 148	0.93967 <.0001 163	0.92634 <.0001 161	1.00000 164	0.96410 <.0001 162	0.90226 <.0001 151	0.79851 <.0001 158	0.77838 <.0001 157	0.82233 <.0001 108	0.89126 <.0001 123	0.93683 <.0001 88	0.88540 <.0001 88
_440	0.92656 <.0001 151	0.88344 <.0001 155	0.90113 <.0001 150	0.92539 <.0001 162	0.94655 <.0001 156	0.95965 <.0001 151	0.94879 <.0001 148	0.91628 <.0001 162	0.88870 <.0001 160	0.96410 <.0001 162	1.00000 165	0.94270 <.0001 151	0.83732 <.0001 160	0.83404 <.0001 159	0.82308 <.0001 110	0.90432 <.0001 125	0.95700 <.0001 87	0.92204 <.0001 87
_460	0.96944 <.0001 144	0.94025 <.0001 147	0.95292 <.0001 142	0.97319 <.0001 153	0.98872 <.0001 149	0.96355 <.0001 139	0.93266 <.0001 137	0.86242 <.0001 151	0.84115 <.0001 149	0.90226 <.0001 151	0.94270 <.0001 151	1.00000 153	0.87838 <.0001 150	0.86622 <.0001 149	0.82618 <.0001 108	0.92085 <.0001 122	0.99307 <.0001 86	0.95508 <.0001 86
_490	0.85060 <.0001 151	0.93593 <.0001 155	0.92849 <.0001 150	0.91248 <.0001 162	0.88004 <.0001 156	0.85235 <.0001 147	0.84533 <.0001 144	0.77181 <.0001 158	0.74963 <.0001 156	0.79851 <.0001 158	0.83732 <.0001 160	0.87838 <.0001 150	1.00000 162	0.92390 <.0001 161	0.80930 <.0001 110	0.89674 <.0001 125	0.89854 <.0001 86	0.92529 <.0001 86
_500	0.84330 <.0001 150	0.94038 <.0001 154	0.93370 <.0001 149	0.91538 <.0001 161	0.87316 <.0001 155	0.83767 <.0001 146	0.82369 <.0001 143	0.75597 <.0001 157	0.75606 <.0001 155	0.77838 <.0001 157	0.83404 <.0001 159	0.86622 <.0001 149	0.92390 <.0001 161	1.00000 162	0.81730 <.0001 111	0.91058 <.0001 126	0.89955 <.0001 86	0.94650 <.0001 86
_052	0.84343 <.0001 108	0.87066 <.0001 110	0.86512 <.0001 108	0.85680 <.0001 111	0.84492 <.0001 111	0.80440 <.0001 108	0.81696 <.0001 107	0.78123 <.0001 109	0.81797 <.0001 108	0.82233 <.0001 108	0.82308 <.0001 110	0.82618 <.0001 108	0.80930 <.0001 110	0.81730 <.0001 111	1.00000 115	0.89888 <.0001 109	0.87611 <.0001 67	0.88800 <.0001 67
_501	0.90833 <.0001 119	0.95368 <.0001 119	0.95013 <.0001 114	0.94468 <.0001 126	0.92349 <.0001 125	0.90080 <.0001 117	0.90119 <.0001 111	0.86183 <.0001 123	0.86487 <.0001 123	0.89126 <.0001 123	0.90432 <.0001 125	0.92085 <.0001 122	0.89674 <.0001 125	0.91058 <.0001 126	0.89888 <.0001 109	1.00000 128	0.93978 <.0001 79	0.94537 <.0001 79
_401	0.96551 <.0001 78	0.95850 <.0001 81	0.96755 <.0001 76	0.98469 <.0001 88	0.98835 <.0001 83	0.95489 <.0001 74	0.91098 <.0001 74	0.88644 <.0001 87	0.89053 <.0001 88	0.93683 <.0001 88	0.95700 <.0001 87	0.99307 <.0001 86	0.89854 <.0001 86	0.89955 <.0001 86	0.87611 <.0001 67	0.93978 <.0001 79	1.00000 88	0.96169 <.0001 88
_402	0.93499 <.0001 78	0.98975 <.0001 81	0.99286 <.0001 76	0.98596 <.0001 88	0.94541 <.0001 83	0.92247 <.0001 74	0.88755 <.0001 74	0.84825 <.0001 87	0.85643 <.0001 88	0.88540 <.0001 88	0.92204 <.0001 87	0.95508 <.0001 86	0.92529 <.0001 86	0.94650 <.0001 86	0.88800 <.0001 67	0.94537 <.0001 79	0.96169 <.0001 88	1.00000 88

2.4.2 DISSOLVED OXYGEN

DO has been consistently sampled by SEAS since 1980 at all stations except 052, 401, 402, and 501, in which sampling started at later dates (Table 2-59). Note that no stations collected DO data in 2007, and no observations were reported for Stations 020, 052, 360, 400, and 401 in 2013. The numbers in this table represent the sampling frequency at the surface level. Samples are generally taken at near surface, and near bottom depths for dissolved oxygen. Comparisons of DO concentrations among sample levels suggest little variation as a function of depth for most stations.

Table 2-59. Surface Dissolved Oxygen Sampling Frequency by Station for SEAS Stations

	Station																		
Year	020	052	350	360	370	380	390	400	401	402	410	420	430	440	460	490	500	501	Total
1980	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1981	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1985	4	-	4	4	4	4	4	4	-	-	4	4	4	4	4	4	4	-	56
1986	2	2	2	2	2	3	2	2	-	-	2	2	2	2	2	2	2	2	31
1987	-	-	1	1	1	1	1	1	-	-	1	1	1	1	1	1	1	1	13
1988	1	1	1	1	1	1	1	1	-	-	1	1	1	1	1	1	1	1	15
1989	6	6	6	6	6	6	6	6	-	-	6	6	6	6	6	6	6	6	90
1990	5	4	5	5	5	5	5	5	-	-	5	5	5	5	5	5	5	5	74
1991	2	2	2	2	2	2	1	2	-	-	1	1	-	2	1	2	2	2	24
1992	7	7	7	7	7	7	7	6	-	-	6	4	6	7	7	7	7	7	99
1993	9	9	9	9	9	9	9	9	-	-	9	9	9	9	9	9	9	9	135
1994	9	8	9	9	9	9	8	9	5	5	9	9	9	9	9	9	9	8	143
1995	8	8	10	9	10	8	8	10	10	10	10	10	10	10	10	9	9	6	159
1996	9	8	10	10	10	9	8	10	10	10	10	10	10	10	9	10	10	8	163
1997	9	8	9	9	9	9	9	9	9	9	9	9	9	9	9	8	8	8	150
1998	6	6	7	7	7	6	6	7	7	7	7	6	7	6	7	7	7	6	113
1999	9	10	9	9	11	11	9	10	11	11	11	12	11	11	11	11	11	12	178
2000	12	11	12	12	13	13	12	12	13	13	13	13	13	13	13	13	13	14	214
2004	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	33
2005	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	119
2006	2	1	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	32
2007	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2008	2	1	1	1	1	3	2	2	2	2	3	2	2	3	2	2	2	1	33
2009	5	3	5	5	6	5	4	2	6	6	5	6	5	6	6	6	6	5	87

Table 2-59. Surface Dissolved Oxygen Sampling Frequency by Station for SEAS Stations

	Station																		
Year	020	052	350	360	370	380	390	400	401	402	410	420	430	440	460	490	500	501	Total
2010	9	4	6	7	12	12	10	4	12	12	12	12	12	12	13	12	12	12	173
2011	6	3	5	1	7	7	4	3	7	7	6	7	7	7	7	7	7	7	98
2012	5	4	4	3	6	5	6	3	6	6	6	6	6	6	5	6	7	7	90
2013	-	-	1	-	1	1	1	-	-	1	2	2	2	1	1	1	1	1	15
Total	136	115	136	130	150	147	134	126	109	110	149	148	148	151	149	149	150	139	2337

The overall arithmetic average DO concentration between 1985 and 2013 for each station is provided in Figure 2-103. Stations 020 and 380 had the lowest average concentrations, while Station 052 had the highest average concentration. Note that Stations 052 and 501 did not begin sampling until 1986, Stations 020 and 052 did not take samples in 1987, Stations 401 and 402 did not begin sampling until 1994, no stations recorded data in 2007, and Stations 020, 052, 360, 400, and 401 did not record data in 2013.

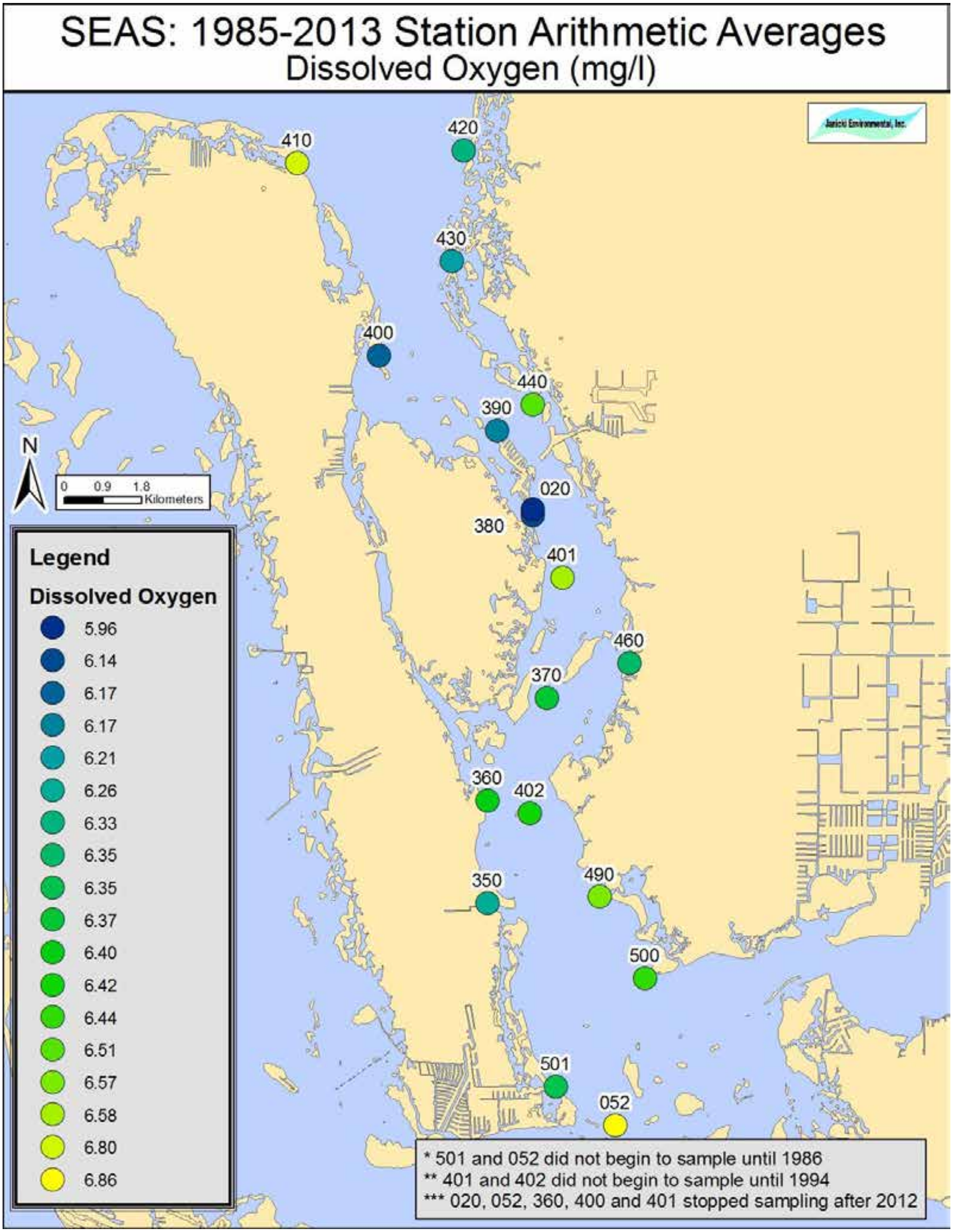
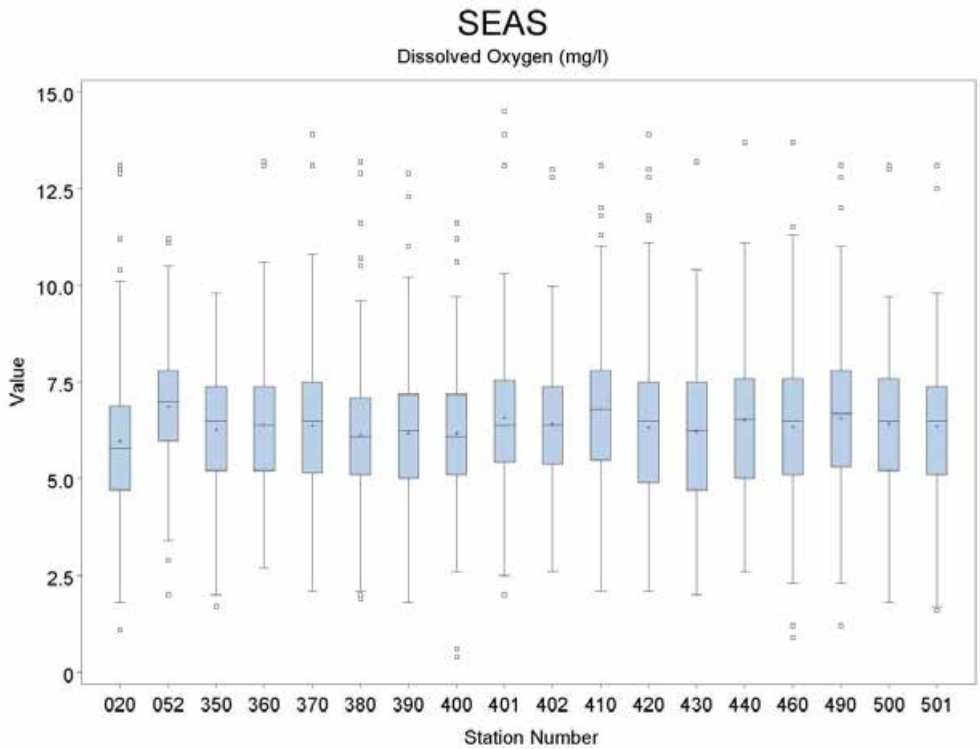


Figure 2-103. Arithmetic Average for Surface Dissolved Oxygen for SEAS Stations

Box and whisker plots of surface (top) and bottom (bottom) DO values collected by SEAS are shown in Figure 2-104. Most bottom DO distribution values have higher upper ranges, larger interquartile ranges, and higher between-station variability than surface measurements. Plots indicate that at least 75 percent of surface DO samples fell at or above 4.9 mg/L, where at least 75 percent of bottom DO samples fell at or above 3.7 mg/L. These plots represent the entire period of record for each station. Note that no DO measurements were taken at Stations 020, 052, 360, 400 and 401 after 2012, and Stations 401 and 402 did not begin recording DO until 1994.



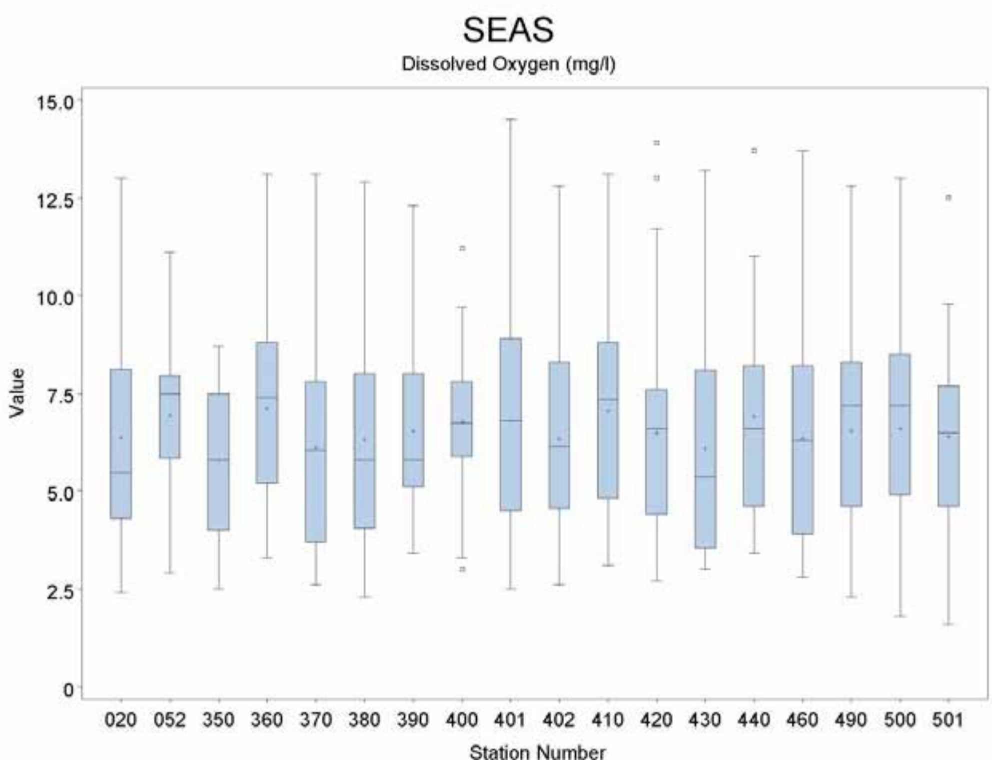


Figure 2-104. Box and Whisker Plots Displaying the Surface (Top) and Bottom (Bottom) Distribution of Dissolved Oxygen at SEAS Stations

Time series plots of DO measurements taken by SEAS indicate that stations are in a fairly good agreement (Figure 2-105). Most stations indicate annual averages above 3.5 mg/L.

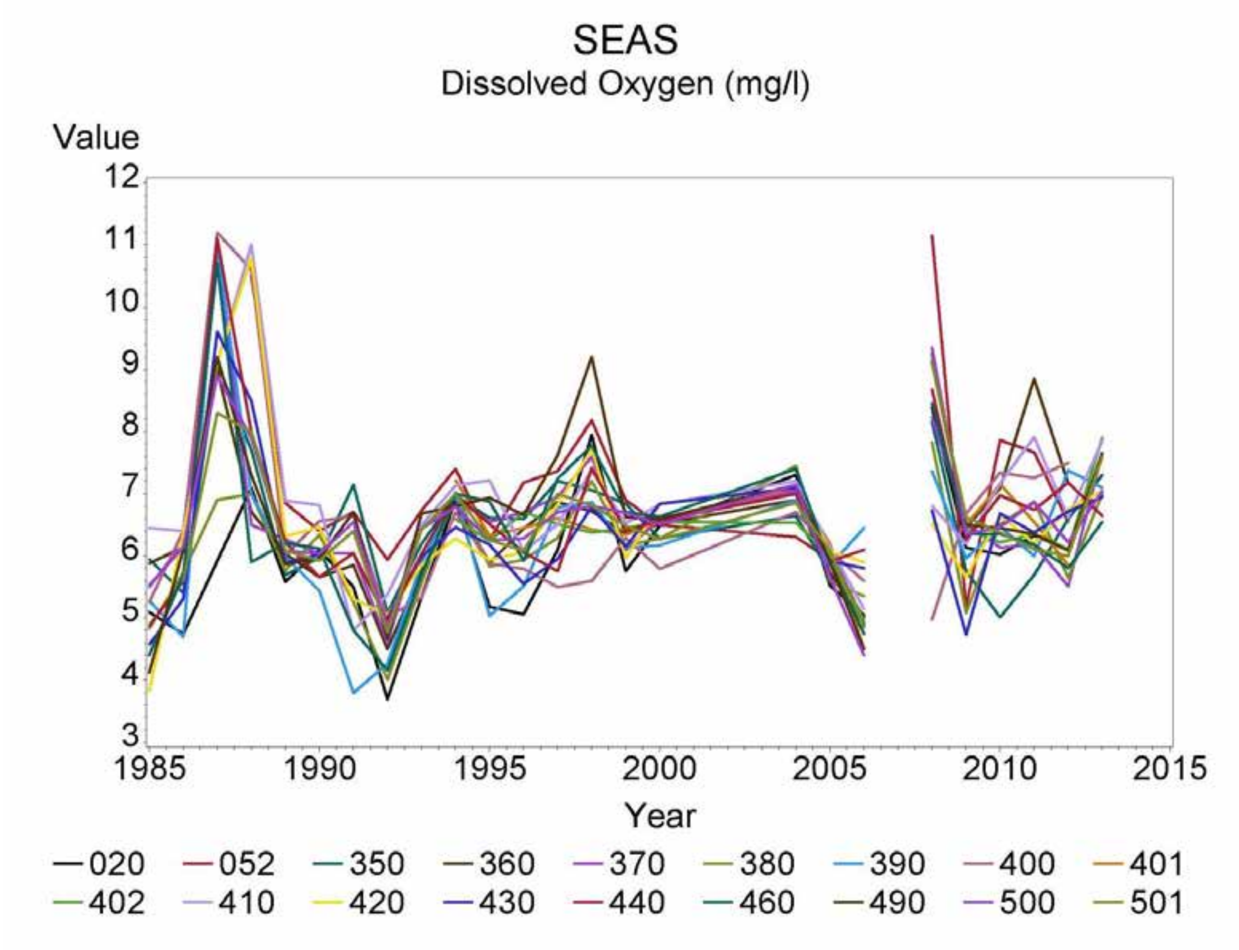


Figure 2-105. Time Series Plot of Surface Dissolved Oxygen at SEAS Stations

Trends for surface DO measurements for SEAS stations are displayed in Figure 2-106. No trends were identified in DO measurements over the time period examined.

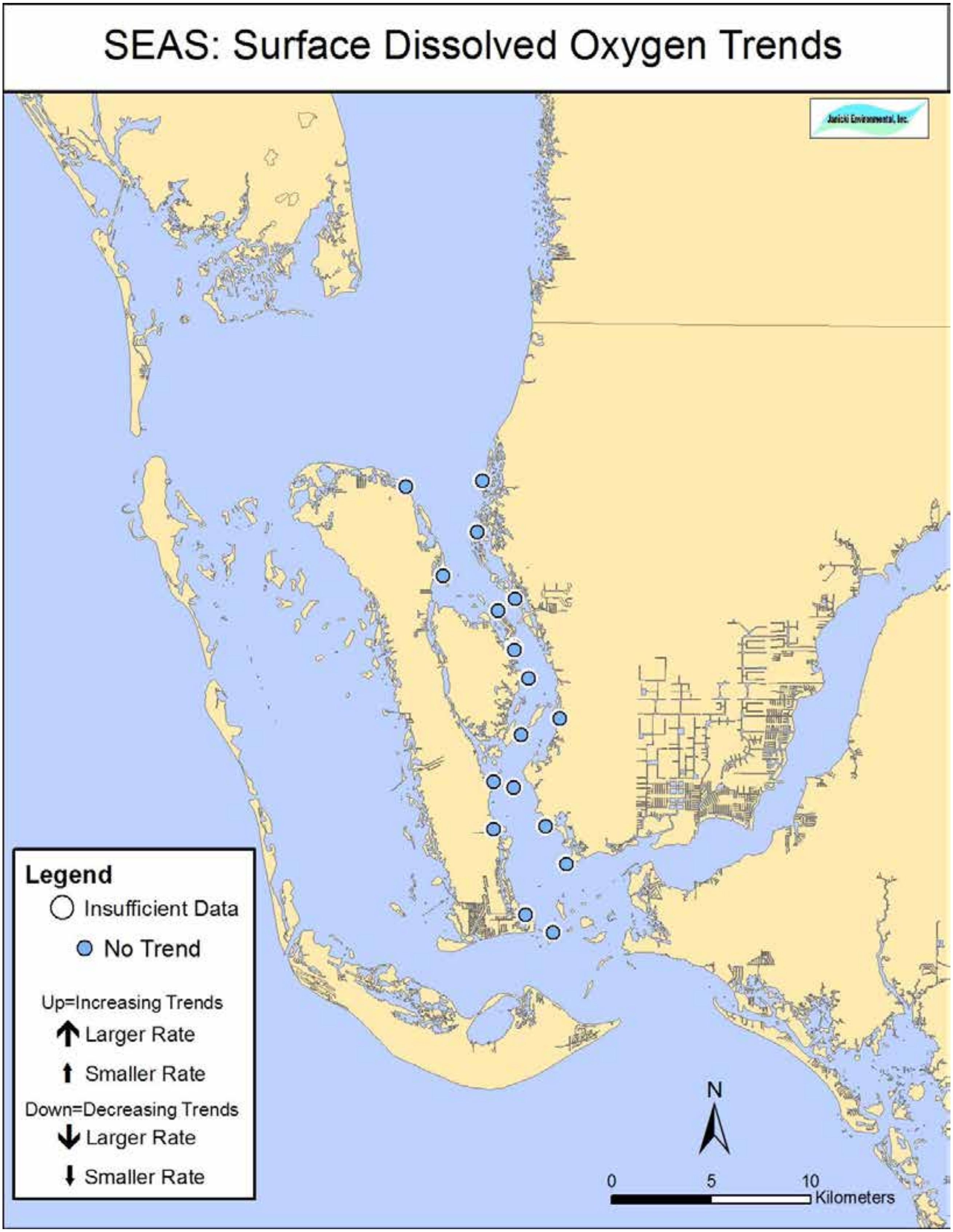


Figure 2-106. Surface Dissolved Oxygen Trends for SEAS Stations

Cross correlation analysis suggested that DO concentrations among stations for long-term stations were greatest between Stations 020 and 380. The only stations with shorter period of records were 401 and 402, beginning in 1994 instead of 1985. These stations did not have any correlations higher than that of 020 and 380. All cross correlations were found to be statistically significant positive (Table 2-60).

Table 2-60. Spearman Rank Correlation Coefficients for Surface Dissolved Oxygen for SEAS Stations

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations																		
	_020	_350	_360	_370	_380	_390	_400	_410	_420	_430	_440	_460	_490	_500	_052	_501	_401	_402
_020	1.00000 117	0.62690 <.0001 114	0.66421 <.0001 107	0.78041 <.0001 116	0.85690 <.0001 117	0.76507 <.0001 109	0.47417 <.0001 104	0.69752 <.0001 113	0.68728 <.0001 111	0.69424 <.0001 113	0.75861 <.0001 116	0.76981 <.0001 116	0.71314 <.0001 116	0.73367 <.0001 116	0.57042 <.0001 98	0.72536 <.0001 106	0.64230 <.0001 78	0.61964 <.0001 78
_350	0.62690 <.0001 114	1.00000 121	0.75259 <.0001 113	0.78153 <.0001 121	0.69740 <.0001 117	0.55914 <.0001 109	0.52828 <.0001 110	0.63189 <.0001 118	0.60522 <.0001 116	0.60697 <.0001 118	0.65065 <.0001 120	0.67074 <.0001 119	0.78363 <.0001 119	0.78803 <.0001 119	0.75703 <.0001 99	0.79024 <.0001 107	0.56158 <.0001 80	0.69177 <.0001 81
_360	0.66421 <.0001 107	0.75259 <.0001 113	1.00000 115	0.81491 <.0001 115	0.73839 <.0001 110	0.70798 <.0001 105	0.60274 <.0001 107	0.65355 <.0001 112	0.66902 <.0001 110	0.66476 <.0001 111	0.72270 <.0001 114	0.71984 <.0001 113	0.70333 <.0001 113	0.82405 <.0001 113	0.62963 <.0001 97	0.77736 <.0001 101	0.74566 <.0001 75	0.74686 <.0001 75
_370	0.78041 <.0001 116	0.78153 <.0001 121	0.81491 <.0001 115	1.00000 127	0.81000 <.0001 121	0.72611 <.0001 112	0.47514 <.0001 110	0.72864 <.0001 123	0.75649 <.0001 122	0.67582 <.0001 123	0.74413 <.0001 126	0.80980 <.0001 124	0.79438 <.0001 125	0.81333 <.0001 125	0.69699 <.0001 100	0.79040 <.0001 113	0.70162 <.0001 86	0.75479 <.0001 87
_380	0.85690 <.0001 117	0.69740 <.0001 117	0.73839 <.0001 110	0.81000 <.0001 121	1.00000 124	0.76062 <.0001 111	0.52648 <.0001 106	0.68733 <.0001 119	0.68270 <.0001 116	0.71862 <.0001 118	0.77744 <.0001 121	0.79373 <.0001 121	0.73526 <.0001 121	0.75361 <.0001 121	0.66453 <.0001 100	0.74971 <.0001 111	0.75747 <.0001 81	0.70105 <.0001 82
_390	0.76507 <.0001 109	0.55914 <.0001 109	0.70798 <.0001 105	0.72611 <.0001 112	0.76062 <.0001 111	1.00000 114	0.57742 <.0001 103	0.67034 <.0001 113	0.71128 <.0001 110	0.72399 <.0001 112	0.78031 <.0001 112	0.75014 <.0001 111	0.64487 <.0001 111	0.72786 <.0001 111	0.53808 <.0001 96	0.70637 <.0001 103	0.64008 <.0001 73	0.58307 <.0001 73
_400	0.47417 <.0001 104	0.52828 <.0001 110	0.60274 <.0001 107	0.47514 <.0001 110	0.52648 <.0001 106	0.57742 <.0001 103	1.00000 111	0.57735 <.0001 110	0.57460 <.0001 107	0.70858 <.0001 109	0.65584 <.0001 110	0.44739 <.0001 108	0.40888 <.0001 108	0.55260 <.0001 108	0.43989 <.0001 96	0.62385 <.0001 97	0.52562 <.0001 71	0.42375 0.0002 71
_410	0.69752 <.0001 113	0.63189 <.0001 118	0.65355 <.0001 112	0.72864 <.0001 123	0.68733 <.0001 119	0.67034 <.0001 113	0.57735 <.0001 110	1.00000 126	0.73149 <.0001 122	0.79362 <.0001 124	0.78840 <.0001 123	0.68014 <.0001 121	0.69079 <.0001 121	0.73501 <.0001 121	0.54320 <.0001 98	0.70244 <.0001 109	0.71349 <.0001 84	0.69043 <.0001 85
_420	0.68728 <.0001 111	0.60522 <.0001 116	0.66902 <.0001 110	0.75649 <.0001 122	0.68270 <.0001 116	0.71128 <.0001 110	0.57460 <.0001 107	0.73149 <.0001 122	1.00000 125	0.85373 <.0001 122	0.75837 <.0001 123	0.65631 <.0001 120	0.68127 <.0001 120	0.69684 <.0001 120	0.57383 <.0001 96	0.73297 <.0001 109	0.62335 <.0001 85	0.68723 <.0001 86

Table 2-60. Spearman Rank Correlation Coefficients for Surface Dissolved Oxygen for SEAS Stations (Continued)

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations	_020	_350	_360	_370	_380	_390	_400	_410	_420	_430	_440	_460	_490	_500	_052	_501	_401	_402
_430	0.69424 <.0001 113	0.60697 <.0001 118	0.66476 <.0001 111	0.67582 <.0001 123	0.71862 <.0001 118	0.72399 <.0001 112	0.70858 <.0001 109	0.79362 <.0001 124	0.85373 <.0001 122	1.00000 125	0.83127 <.0001 123	0.62481 <.0001 121	0.67236 <.0001 121	0.70228 <.0001 121	0.53844 <.0001 97	0.74827 <.0001 109	0.63171 <.0001 85	0.63558 <.0001 86
_440	0.75861 <.0001 116	0.65065 <.0001 120	0.72270 <.0001 114	0.74413 <.0001 126	0.77744 <.0001 121	0.78031 <.0001 112	0.65584 <.0001 110	0.78840 <.0001 123	0.75837 <.0001 123	0.83127 <.0001 123	1.00000 128	0.70926 <.0001 124	0.70048 <.0001 125	0.72003 <.0001 125	0.57297 <.0001 99	0.73561 <.0001 112	0.70697 <.0001 86	0.65521 <.0001 87
_460	0.76981 <.0001 116	0.67074 <.0001 119	0.71984 <.0001 113	0.80980 <.0001 124	0.79373 <.0001 121	0.75014 <.0001 111	0.44739 <.0001 108	0.68014 <.0001 121	0.65631 <.0001 120	0.62481 <.0001 121	0.70926 <.0001 124	1.00000 125	0.77776 <.0001 123	0.73653 <.0001 123	0.58315 <.0001 99	0.70265 <.0001 111	0.72540 <.0001 85	0.65313 <.0001 86
_490	0.71314 <.0001 116	0.78363 <.0001 119	0.70333 <.0001 113	0.79438 <.0001 125	0.73526 <.0001 121	0.64487 <.0001 111	0.40888 <.0001 108	0.69079 <.0001 121	0.68127 <.0001 120	0.67236 <.0001 121	0.70048 <.0001 125	0.77776 <.0001 123	1.00000 126	0.72504 <.0001 126	0.67542 <.0001 100	0.81058 <.0001 113	0.64168 <.0001 85	0.67001 <.0001 86
_500	0.73367 <.0001 116	0.78803 <.0001 119	0.82405 <.0001 113	0.81333 <.0001 125	0.75361 <.0001 121	0.72786 <.0001 111	0.55260 <.0001 108	0.73501 <.0001 121	0.69684 <.0001 120	0.70228 <.0001 121	0.72003 <.0001 125	0.73653 <.0001 123	0.72504 <.0001 126	1.00000 127	0.69948 <.0001 101	0.83704 <.0001 114	0.74857 <.0001 85	0.78485 <.0001 86
_052	0.57042 <.0001 98	0.75703 <.0001 99	0.62963 <.0001 97	0.69699 <.0001 100	0.66453 <.0001 100	0.53808 <.0001 96	0.43989 <.0001 96	0.54320 <.0001 98	0.57383 <.0001 96	0.53844 <.0001 97	0.57297 <.0001 99	0.58315 <.0001 99	0.67542 <.0001 100	0.69948 <.0001 101	1.00000 102	0.73885 <.0001 98	0.45548 0.0001 67	0.47516 <.0001 67
_501	0.72536 <.0001 106	0.79024 <.0001 107	0.77736 <.0001 101	0.79040 <.0001 113	0.74971 <.0001 111	0.70637 <.0001 103	0.62385 <.0001 97	0.70244 <.0001 109	0.73297 <.0001 109	0.74827 <.0001 109	0.73561 <.0001 112	0.70265 <.0001 111	0.81058 <.0001 113	0.83704 <.0001 114	0.73885 <.0001 98	1.00000 115	0.74972 <.0001 77	0.79698 <.0001 78
_401	0.64230 <.0001 78	0.56158 <.0001 80	0.74566 <.0001 75	0.70162 <.0001 86	0.75747 <.0001 81	0.64008 <.0001 73	0.52562 <.0001 71	0.71349 <.0001 84	0.62335 <.0001 85	0.63171 <.0001 85	0.70697 <.0001 86	0.72540 <.0001 85	0.64168 <.0001 85	0.74857 <.0001 85	0.45548 0.0001 67	0.74972 <.0001 77	1.00000 87	0.84473 <.0001 87
_402	0.61964 <.0001 78	0.69177 <.0001 81	0.74686 <.0001 75	0.75479 <.0001 87	0.70105 <.0001 82	0.58307 <.0001 73	0.42375 0.0002 71	0.69043 <.0001 85	0.68723 <.0001 86	0.63558 <.0001 86	0.65521 <.0001 87	0.65313 <.0001 86	0.67001 <.0001 86	0.78485 <.0001 86	0.47516 <.0001 67	0.79698 <.0001 78	0.84473 <.0001 87	1.00000 88

2.4.3 TURBIDITY

Turbidity has been consistently sampled by SEAS since 1980 at all stations except 052, 401, 402, and 501, in which sampling started at later dates (Table 2-61). Note that no observations were reported in 2013.

Table 2-61. Turbidity Sampling Frequency by Station for SEAS Stations

	Station																	
Year	020	052	350	360	370	380	390	400	401	402	410	420	430	440	460	490	500	501	Total
1985	5	-	5	5	5	5	5	5	-	-	4	5	5	5	5	5	5	-	69
1986	4	4	4	4	4	4	4	4	-	-	4	3	4	4	3	3	4	4	61
1987	-	1	1	1	1	1	1	1	-	-	1	1	1	1	1	1	1	1	15
1988	5	5	5	5	5	5	5	4	-	-	5	5	5	5	4	5	5	5	78
1989	6	6	6	6	6	6	6	6	-	-	6	6	6	6	6	6	6	6	96
1990	5	4	5	5	5	5	5	5	-	-	5	5	5	5	5	5	5	5	79
1991	5	5	5	5	5	5	5	5	-	-	4	4	3	5	5	5	5	5	76
1992	8	8	8	8	8	8	8	7	-	-	7	4	7	8	8	8	8	8	121
1993	9	9	9	9	9	9	9	9	-	-	9	9	9	9	9	9	9	9	144
1994	11	10	11	11	11	11	10	11	5	5	11	11	11	11	11	11	11	10	183
1995	8	8	11	10	11	8	8	11	11	11	11	11	11	11	11	10	10	6	178
1996	9	8	9	10	10	9	8	10	10	10	10	10	10	10	9	10	10	8	170
1997	9	8	9	9	9	9	9	9	9	9	9	9	9	9	9	8	8	8	158
1998	6	6	8	8	8	6	6	8	8	8	8	8	8	7	8	8	8	6	133
1999	10	10	10	10	14	14	10	11	14	14	13	14	14	14	14	14	14	14	228
2000	19	17	19	19	23	23	19	19	23	23	23	23	23	23	23	23	22	23	387
2004	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	71
2005	8	8	8	8	7	8	8	8	8	8	8	8	8	8	8	8	8	8	143
2006	4	2	4	4	4	4	4	3	4	4	3	4	4	4	4	4	4	4	68
2007	1	1	1	1	2	2	1	1	2	2	2	2	2	2	2	2	2	2	30
2008	4	4	3	3	9	9	6	6	9	9	10	10	10	10	9	9	9	9	138
2009	5	3	5	5	6	6	4	2	6	6	6	6	6	6	5	6	6	5	94
2010	9	4	6	7	12	12	10	4	11	12	12	12	12	12	13	12	12	12	184
2011	7	4	6	2	8	8	4	3	8	8	7	7	7	7	8	8	7	8	117
2012	5	3	4	3	5	5	5	3	5	5	5	5	5	5	4	5	4	5	81
2013	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	166	141	166	162	191	186	164	159	137	138	187	186	189	191	188	189	187	175	3102

Turbidity values were relatively low, with long-term averages between 1 and 2.68 NTU. The overall arithmetic average turbidity concentration between 1985 and 2012 for each station is displayed in Figure 2-107. Stations 410 and 420 had the lowest average concentrations, while Station 052 had the highest average concentration. Note that Stations 052 and 501 did not begin recording data until 1986, Station 020 did not record data in 1987, Stations 401 and 402 did not begin recording data until 1994, and no stations recorded data in 2013.

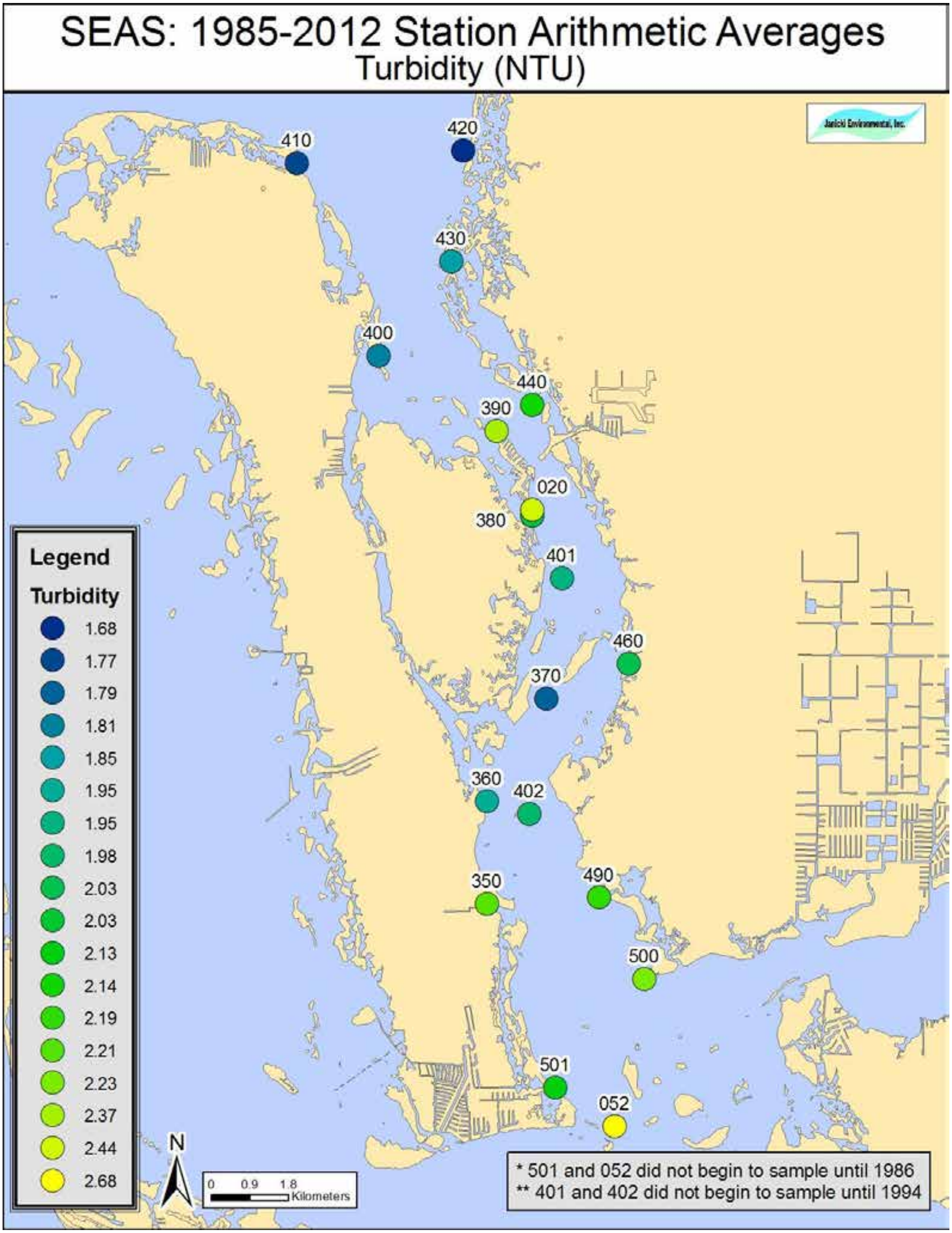


Figure 2-107. Arithmetic Average Turbidity at SEAS Stations

Box and whisker plots of turbidity sampled collected by SEAS are presented in Figure 2-108. Between-station variability is low. These plots represent the entire period of record for each station. Note that Station 052 and 501 began sampling turbidity in 1986, Stations 401 and 402 began sampling salinity in 1994, and no station recorded turbidity measurements in 2013. These plots are trimmed such that extremely high values are not displayed in the plots.

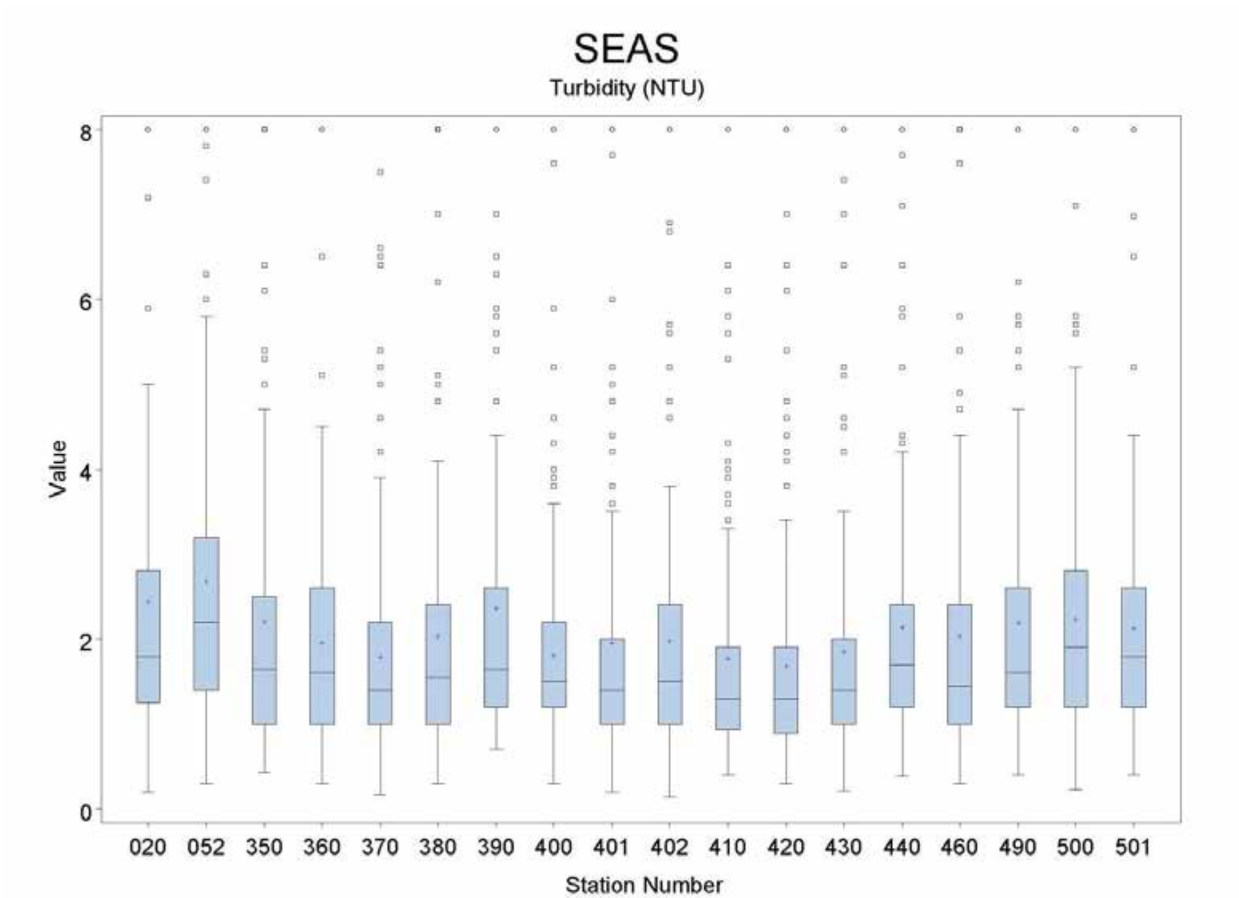


Figure 2-108. Box and Whisker Plot Displaying Turbidity Distributions for SEAS Stations

Time series plots of turbidity measurements taken by SEAS indicate that stations are in fairly good agreement (Figure 2-109). An increase in turbidity at most stations can be seen in 1998. After 2005, most stations become more closely correlated and indicated lower average turbidity values.

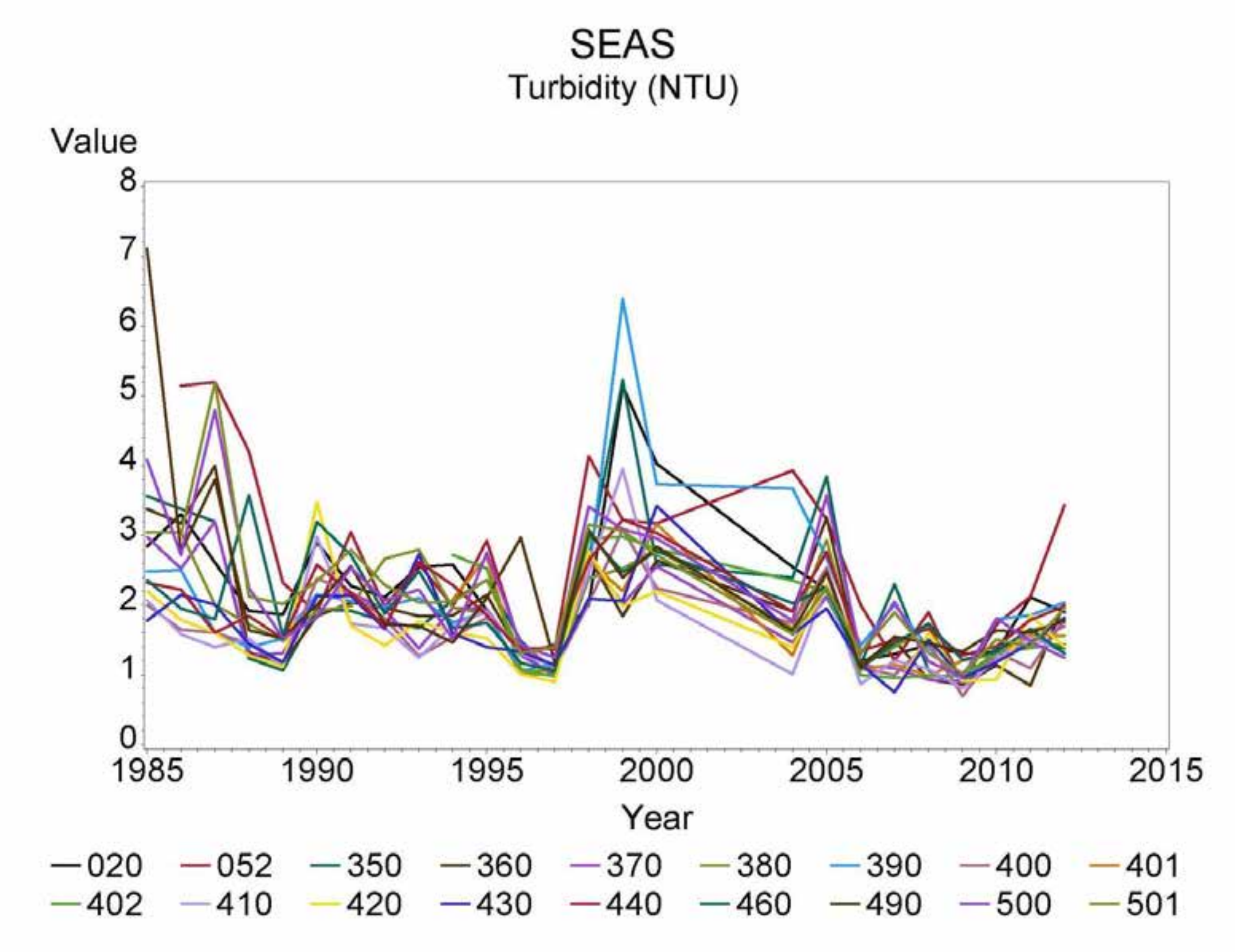


Figure 2-109. Time Series Plot of Turbidity for SEAS Stations

Trends for turbidity measurements for SEAS stations are provided in Figure 2-110. No trends were identified in turbidity measurements over the time period examined.

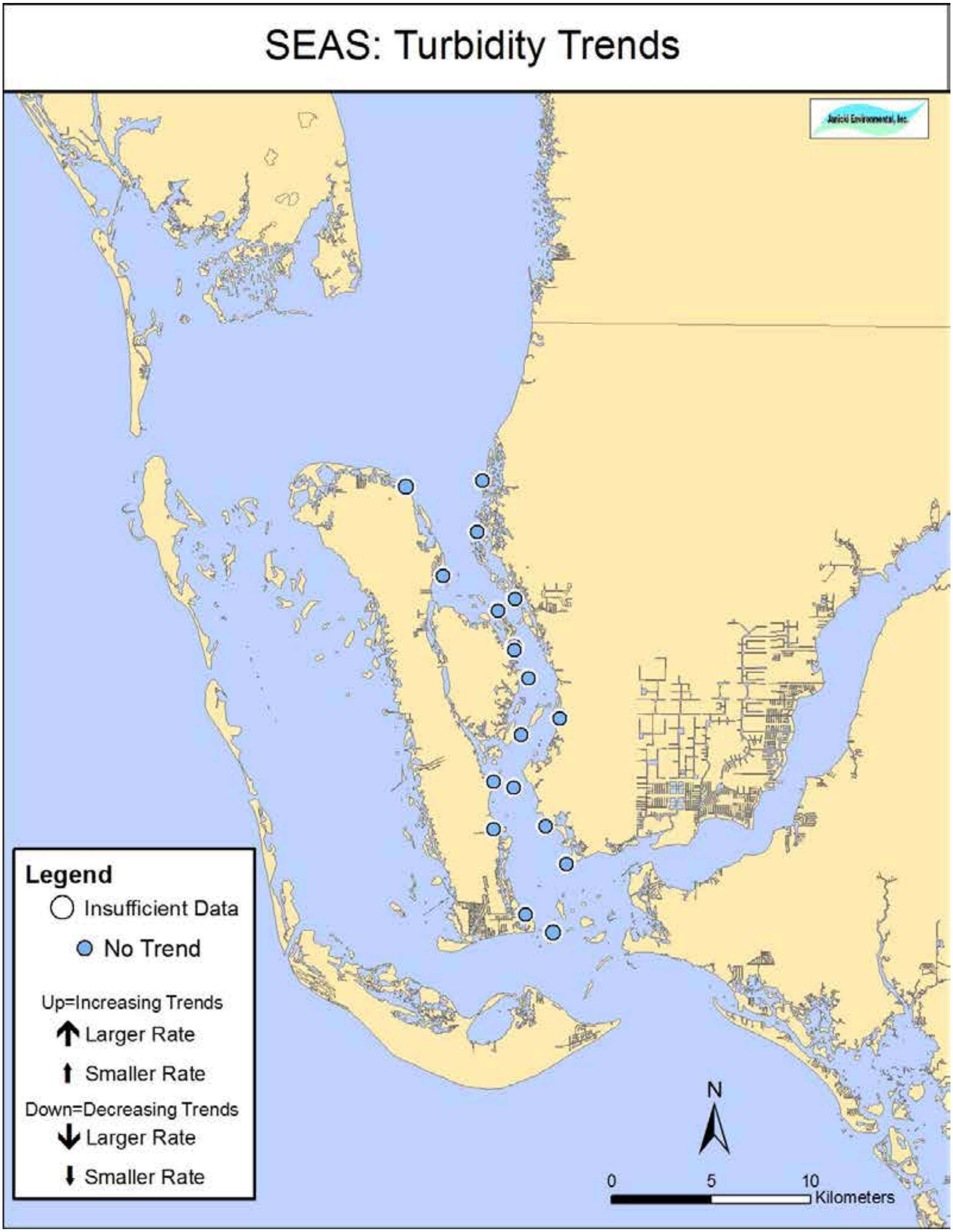


Figure 2-110. Turbidity Trends for SEAS Stations

Cross correlation analysis suggested that turbidity concentrations among stations for long-term stations were greatest between Stations 360 and 370, as well as Stations 350 and 360. The only stations with shorter period of records were 401 and 402, beginning in 1994 instead of 1985. These stations did not have any correlations higher than that of 360 and 370 or 350 and 360. All cross correlations were found to be statistically significantly positive correlations (Table 2-62).

Table 2-62. Spearman Rank Correlation Coefficients for Turbidity for SEAS Stations

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	_020	_350	_360	_370	_380	_390	_400	_410	_420	_430	_440	_460	_490	_500	_052	_501	_401	_402
_020	1.00000 139	0.57533 <.0001 137	0.62052 <.0001 130	0.62909 <.0001 138	0.73774 <.0001 139	0.71695 <.0001 132	0.66272 <.0001 126	0.54925 <.0001 134	0.61167 <.0001 132	0.68883 <.0001 135	0.66564 <.0001 137	0.75652 <.0001 137	0.50629 <.0001 137	0.49983 <.0001 137	0.45729 <.0001 117	0.57395 <.0001 129	0.70595 <.0001 88	0.60981 <.0001 88
_350	0.57533 <.0001 137	1.00000 143	0.84447 <.0001 136	0.76785 <.0001 142	0.70241 <.0001 139	0.61206 <.0001 132	0.43549 <.0001 132	0.46036 <.0001 138	0.47219 <.0001 136	0.49360 <.0001 139	0.49697 <.0001 141	0.54404 <.0001 141	0.67745 <.0001 141	0.71834 <.0001 141	0.39990 <.0001 119	0.60687 <.0001 129	0.61101 <.0001 91	0.71974 <.0001 91
_360	0.62052 <.0001 130	0.84447 <.0001 136	1.00000 139	0.85270 <.0001 138	0.74528 <.0001 134	0.60149 <.0001 128	0.49817 <.0001 130	0.49999 <.0001 134	0.51260 <.0001 132	0.53175 <.0001 135	0.59146 <.0001 137	0.62845 <.0001 136	0.70032 <.0001 137	0.73783 <.0001 138	0.48595 <.0001 117	0.70757 <.0001 124	0.71720 <.0001 86	0.75305 <.0001 87
_370	0.62909 <.0001 138	0.76785 <.0001 142	0.85270 <.0001 138	1.00000 155	0.77110 <.0001 150	0.63847 <.0001 135	0.48597 <.0001 134	0.54450 <.0001 150	0.50895 <.0001 148	0.57602 <.0001 151	0.59454 <.0001 153	0.67179 <.0001 152	0.74436 <.0001 153	0.76369 <.0001 153	0.48792 <.0001 120	0.70867 <.0001 140	0.81347 <.0001 102	0.82688 <.0001 103
_380	0.73774 <.0001 139	0.70241 <.0001 139	0.74528 <.0001 134	0.77110 <.0001 150	1.00000 151	0.71479 <.0001 136	0.57218 <.0001 130	0.55920 <.0001 146	0.57360 <.0001 144	0.60976 <.0001 147	0.69011 <.0001 149	0.75864 <.0001 149	0.62789 <.0001 149	0.68146 <.0001 149	0.45084 <.0001 121	0.61992 <.0001 141	0.80314 <.0001 98	0.72386 <.0001 99
_390	0.71695 <.0001 132	0.61206 <.0001 132	0.60149 <.0001 128	0.63847 <.0001 135	0.71479 <.0001 136	1.00000 137	0.57476 <.0001 127	0.50139 <.0001 133	0.57081 <.0001 131	0.64804 <.0001 134	0.71127 <.0001 136	0.73924 <.0001 134	0.52336 <.0001 134	0.56350 <.0001 134	0.54176 <.0001 117	0.54529 <.0001 127	0.66658 <.0001 83	0.55805 <.0001 84
_400	0.66272 <.0001 126	0.43549 <.0001 132	0.49817 <.0001 130	0.48597 <.0001 134	0.57218 <.0001 130	0.57476 <.0001 127	1.00000 136	0.69837 <.0001 133	0.61190 <.0001 131	0.65393 <.0001 134	0.62263 <.0001 135	0.65509 <.0001 132	0.38296 <.0001 133	0.48033 <.0001 133	0.40525 <.0001 116	0.53463 <.0001 121	0.53181 <.0001 85	0.52909 <.0001 85
_410	0.54925 <.0001 134	0.46036 <.0001 138	0.49999 <.0001 134	0.54450 <.0001 150	0.55920 <.0001 146	0.50139 <.0001 133	0.69837 <.0001 133	1.00000 152	0.66927 <.0001 148	0.63119 <.0001 151	0.56574 <.0001 151	0.57388 <.0001 148	0.42520 <.0001 149	0.49848 <.0001 149	0.33737 0.0002 116	0.53054 <.0001 136	0.57674 <.0001 100	0.56755 <.0001 101
_420	0.61167 <.0001 132	0.47219 <.0001 136	0.51260 <.0001 132	0.50895 <.0001 148	0.57360 <.0001 144	0.57081 <.0001 131	0.61190 <.0001 131	0.66927 <.0001 148	1.00000 150	0.71002 <.0001 149	0.57508 <.0001 149	0.59073 <.0001 146	0.43057 <.0001 148	0.46889 <.0001 147	0.45324 <.0001 115	0.52590 <.0001 134	0.57655 <.0001 102	0.58636 <.0001 103

Table 2-62. Spearman Rank Correlation Coefficients for Turbidity for SEAS Stations (Continued)

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations																		
	_020	**_350**	**_360**	**_370**	**_380**	**_390**	**_400**	**_410**	**_420**	**_430**	**_440**	**_460**	**_490**	**_500**	**_052**	**_501**	**_401**	**_402**
_430	0.68883 <.0001 135	0.49360 <.0001 139	0.53175 <.0001 135	0.57602 <.0001 151	0.60976 <.0001 147	0.64804 <.0001 134	0.65393 <.0001 134	0.63119 <.0001 151	0.71002 <.0001 149	1.00000 153	0.69263 <.0001 152	0.60614 <.0001 149	0.51138 <.0001 150	0.51387 <.0001 150	0.43987 <.0001 117	0.56058 <.0001 137	0.62344 <.0001 102	0.56906 <.0001 103
_440	0.66564 <.0001 137	0.49697 <.0001 141	0.59146 <.0001 137	0.59454 <.0001 153	0.69011 <.0001 149	0.71127 <.0001 136	0.62263 <.0001 135	0.56574 <.0001 151	0.57508 <.0001 149	0.69263 <.0001 152	1.00000 155	0.67931 <.0001 151	0.54631 <.0001 152	0.56818 <.0001 152	0.36445 <.0001 119	0.55516 <.0001 139	0.76530 <.0001 101	0.60430 <.0001 102
_460	0.75652 <.0001 137	0.54404 <.0001 141	0.62845 <.0001 136	0.67179 <.0001 152	0.75864 <.0001 149	0.73924 <.0001 134	0.65509 <.0001 132	0.57388 <.0001 148	0.59073 <.0001 146	0.60614 <.0001 149	0.67931 <.0001 151	1.00000 153	0.52545 <.0001 151	0.56885 <.0001 151	0.42926 <.0001 119	0.55545 <.0001 139	0.75294 <.0001 102	0.63420 <.0001 103
_490	0.50629 <.0001 137	0.67745 <.0001 141	0.70032 <.0001 137	0.74436 <.0001 153	0.62789 <.0001 149	0.52336 <.0001 134	0.38296 <.0001 133	0.42520 <.0001 149	0.43057 <.0001 148	0.51138 <.0001 150	0.54631 <.0001 152	0.52545 <.0001 151	1.00000 154	0.80078 <.0001 153	0.48461 <.0001 121	0.68044 <.0001 140	0.62140 <.0001 102	0.70306 <.0001 103
_500	0.49983 <.0001 137	0.71834 <.0001 141	0.73783 <.0001 138	0.76369 <.0001 153	0.68146 <.0001 149	0.56350 <.0001 134	0.48033 <.0001 133	0.49848 <.0001 149	0.46889 <.0001 147	0.51387 <.0001 150	0.56818 <.0001 152	0.56885 <.0001 151	0.80078 <.0001 153	1.00000 154	0.51100 <.0001 120	0.71638 <.0001 140	0.72099 <.0001 101	0.78826 <.0001 102
_052	0.45729 <.0001 117	0.39990 <.0001 119	0.48595 <.0001 117	0.48792 <.0001 120	0.45084 <.0001 121	0.54176 <.0001 117	0.40525 <.0001 116	0.33737 0.0002 116	0.45324 <.0001 115	0.43987 <.0001 117	0.36445 <.0001 119	0.42926 <.0001 119	0.48461 <.0001 121	0.51100 <.0001 120	1.00000 123	0.60211 <.0001 117	0.46942 <.0001 76	0.49241 <.0001 77
_501	0.57395 <.0001 129	0.60687 <.0001 129	0.70757 <.0001 124	0.70867 <.0001 140	0.61992 <.0001 141	0.54529 <.0001 127	0.53463 <.0001 121	0.53054 <.0001 136	0.52590 <.0001 134	0.56058 <.0001 137	0.55516 <.0001 139	0.55545 <.0001 139	0.68044 <.0001 140	0.71638 <.0001 140	0.60211 <.0001 117	1.00000 141	0.64928 <.0001 93	0.71653 <.0001 94
_401	0.70595 <.0001 88	0.61101 <.0001 91	0.71720 <.0001 86	0.81347 <.0001 102	0.80314 <.0001 98	0.66658 <.0001 83	0.53181 <.0001 85	0.57674 <.0001 100	0.57655 <.0001 102	0.62344 <.0001 102	0.76530 <.0001 101	0.75294 <.0001 102	0.62140 <.0001 102	0.72099 <.0001 101	0.46942 <.0001 76	0.64928 <.0001 93	1.00000 103	0.71677 <.0001 103
_402	0.60981 <.0001 88	0.71974 <.0001 91	0.75305 <.0001 87	0.82688 <.0001 103	0.72386 <.0001 99	0.55805 <.0001 84	0.52909 <.0001 85	0.56755 <.0001 101	0.58636 <.0001 103	0.56906 <.0001 103	0.60430 <.0001 102	0.63420 <.0001 103	0.70306 <.0001 103	0.78826 <.0001 102	0.49241 <.0001 77	0.71653 <.0001 94	0.71677 <.0001 103	1.00000 104

2.4.4 FECAL COLIFORM

Fecal coliform has been consistently sampled by SEAS since 1980, except Stations 401, 402, and 501 for which sampling started at later dates (Table 2-63)

Table 2-63. Fecal Coliform Sampling Frequency by Station for SEAS Stations

	Station																	
Year	020	052	350	360	370	380	390	400	401	402	410	420	430	440	460	490	500	501	Total
1980	6	-	6	6	6	6	6	6	-	-	6	6	6	6	5	6	6	-	83
1981	7	-	7	7	7	5	8	8	-	-	8	8	8	8	7	7	7	-	102
1982	6	-	6	6	6	6	5	4	-	-	5	4	5	5	4	6	6	-	74
1983	4	-	4	4	4	4	4	4	-	-	4	4	4	4	1	4	3	-	52
1984	3	-	3	3	3	3	3	3	-	-	3	3	3	3	1	3	3	-	40
1985	7	3	7	7	7	7	7	7	-	-	7	7	7	7	7	7	7	-	101
1986	4	4	4	4	4	4	4	4	-	-	4	4	4	4	3	4	4	4	63
1987	-	1	1	1	1	1	1	1	-	-	1	1	1	1	1	1	1	1	15
1988	5	5	5	5	5	5	5	4	-	-	5	5	5	5	4	5	5	5	78
1989	6	6	6	6	6	6	6	6	-	-	6	6	6	6	6	6	6	6	96
1990	5	4	5	5	5	5	5	5	-	-	5	5	5	5	5	5	5	5	79
1991	5	5	5	5	5	5	5	5	-	-	4	4	3	5	5	5	5	5	76
1992	8	8	8	8	8	8	8	7	-	-	7	5	7	8	8	8	8	8	122
1993	10	10	10	10	10	10	10	10	-	-	10	10	10	10	10	10	10	10	160
1994	11	10	11	11	11	11	10	11	5	5	11	11	11	11	11	11	11	10	183
1995	8	8	11	10	11	8	8	10	10	10	11	11	11	11	11	10	10	6	175
1996	9	8	9	10	10	9	8	10	10	10	10	10	10	10	9	10	10	8	170
1997	9	8	9	9	9	9	9	9	9	9	9	9	9	9	9	8	8	8	158
1998	6	6	8	8	8	6	6	8	8	8	8	8	8	7	8	8	8	6	133
1999	10	10	10	10	14	14	10	11	14	14	13	14	14	14	14	14	14	14	228
2000	19	18	19	19	23	23	19	19	23	23	23	23	23	23	23	23	22	23	388
2004	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	72
2005	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	126
2006	4	2	4	4	4	4	4	3	4	4	3	4	4	4	4	4	4	4	68
2007	1	1	1	1	2	2	1	1	2	2	2	2	2	2	2	2	2	2	30
2008	4	4	3	3	9	9	6	6	9	9	10	10	10	10	9	9	9	9	138
2009	5	3	5	5	6	6	4	2	6	6	6	6	6	6	5	6	6	5	94

Table 2-63. Fecal Coliform Sampling Frequency by Station for SEAS Stations

	Station																	
Year	020	052	350	360	370	380	390	400	401	402	410	420	430	440	460	490	500	501	Total
2010	9	4	6	7	12	12	10	4	11	12	12	12	12	12	13	12	12	12	184
2011	7	4	6	2	8	8	4	3	8	8	7	7	7	7	8	8	7	8	117
2012	6	5	5	3	8	8	7	3	8	8	8	8	8	8	6	8	8	9	124
2013	1	2	3	1	4	4	2	-	3	4	4	4	4	3	4	4	4	4	55
Total	196	150	198	191	227	219	196	185	141	143	223	222	224	225	214	225	222	183	3584

The overall station arithmetic average fecal coliform concentration between 1980 and 2013 is displayed in Figure 2-111. Stations 410 and 430 had the lowest average concentrations, while Station 350 had the highest average concentration. Note that Stations 052 and 501 did not begin recording data until 1985, Stations 401 and 402 did not begin recording data until 1994, and Station 020 did not record data in 1987.

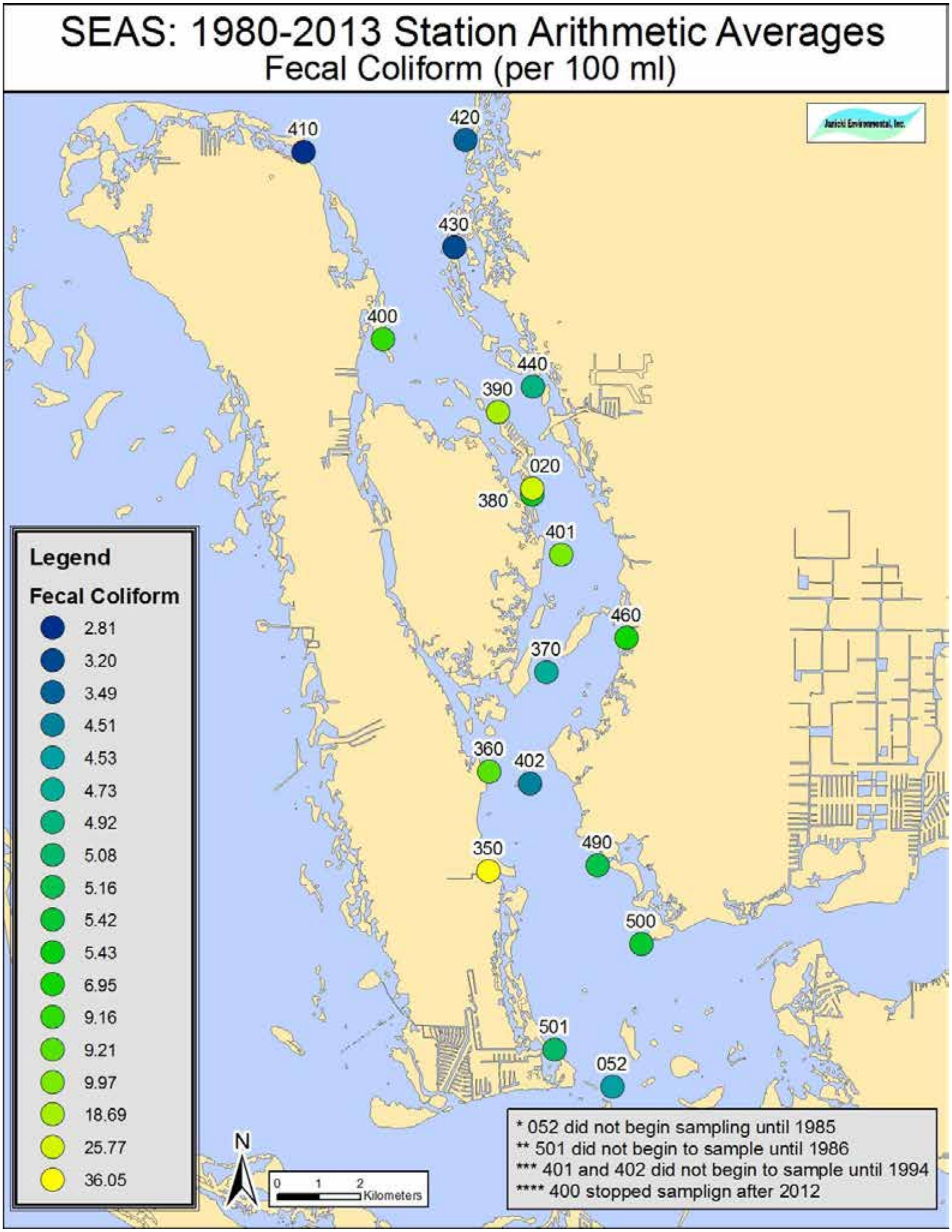


Figure 2-111. Arithmetic Average of Fecal Coliform Concentrations for SEAS Stations

Box and whisker plots of fecal coliform concentrations taken by SEAS are displayed in Figure 2-112. Importantly, the distributions of the concentrations suggest that fecal coliform concentrations are near detection limits and not indicative of poor water quality condition. However, occasional spikes in fecal coliforms concentrations are noted in the time series plots. Stations 350, 390 and 400 tend to have a higher distribution of values when compared to the other stations. Stations 063, 370, 401, 402, 410, 420, and 430 showed lower distribution values when compared to the other stations. These plots represent the entire period of record for each station. These plots are trimmed such that extremely high values are not displayed in the plots.

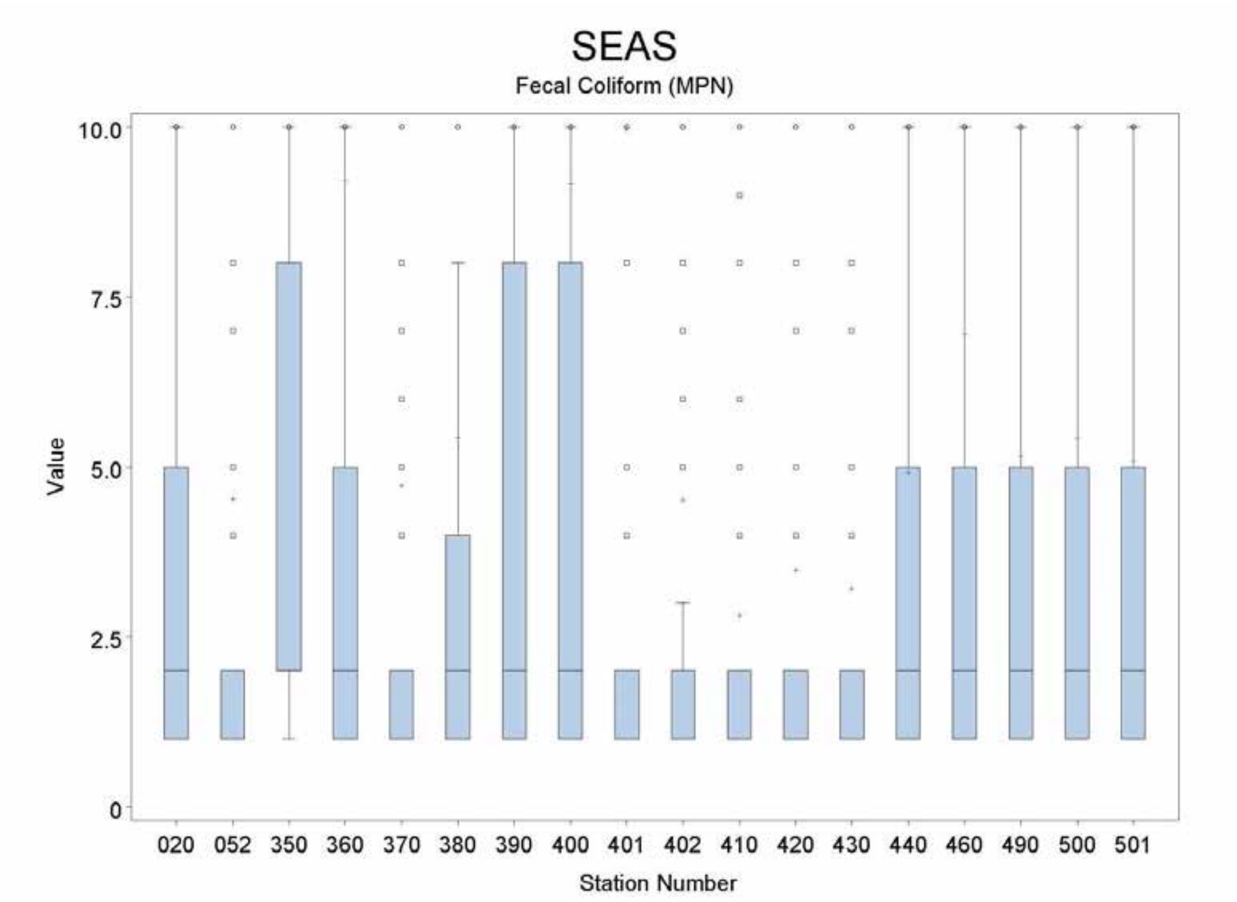


Figure 2-112. Box and Whisker Plots of Fecal Coliform for SEAS Stations

Time series plots of fecal coliform concentrations taken by SEAS indicate that stations can exhibit occasional spikes in concentration (Figure 2-113). Station 350 experienced peaks in fecal coliform in 1985 and 2005, Station 020 experienced peaks in 1993 and 1999, and Station 390 experienced a peak in 2005. All of these peaks were more than twice the fecal coliform values associated with all other SEAS stations from 1980-2013.

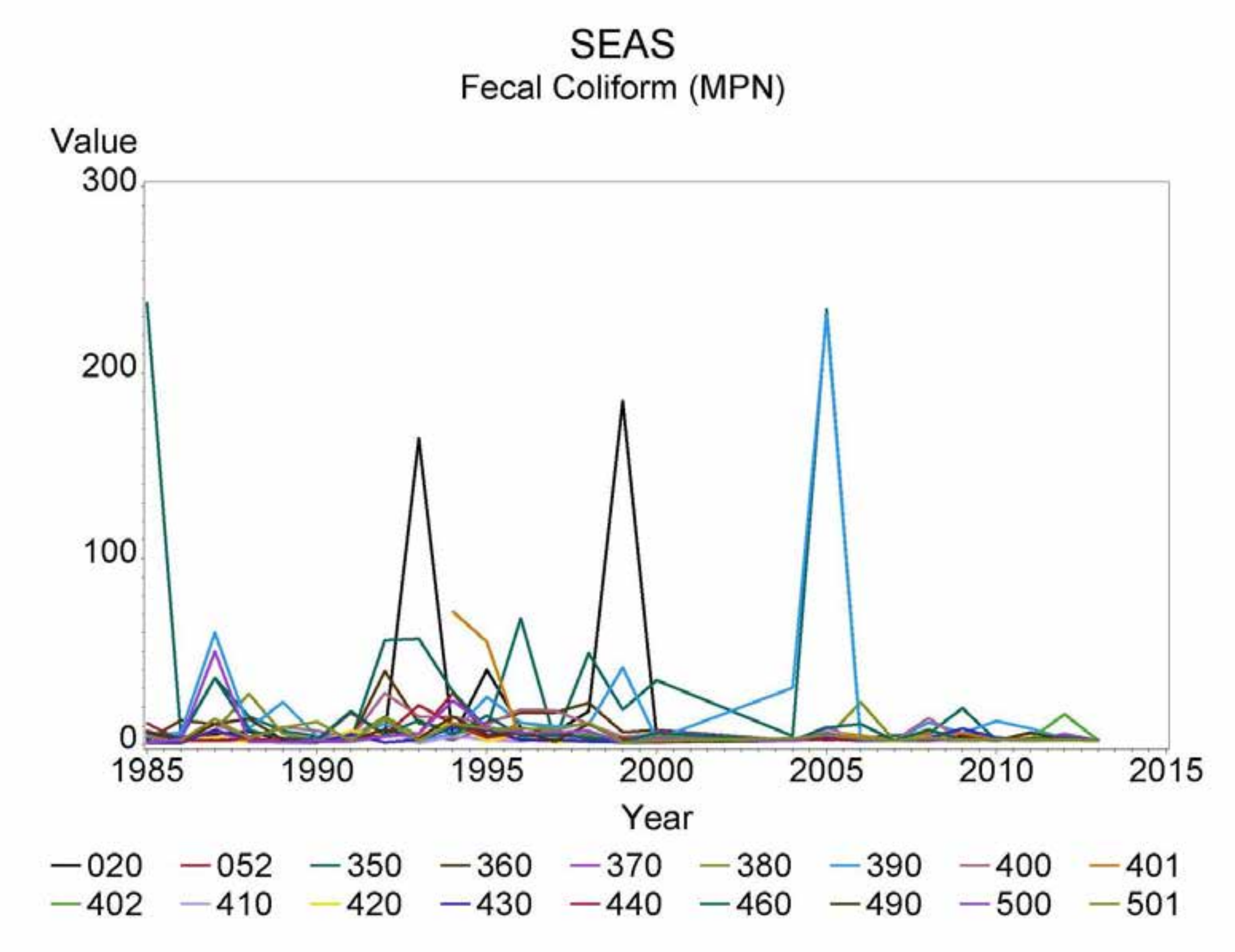


Figure 2-113. Time Series Plot of Fecal Coliform Concentrations Taken by SEAS

Trends for fecal coliform measurements for SEAS stations are displayed in Figure 2-114. No trends were identified in fecal coliform measurements over the time period examined.

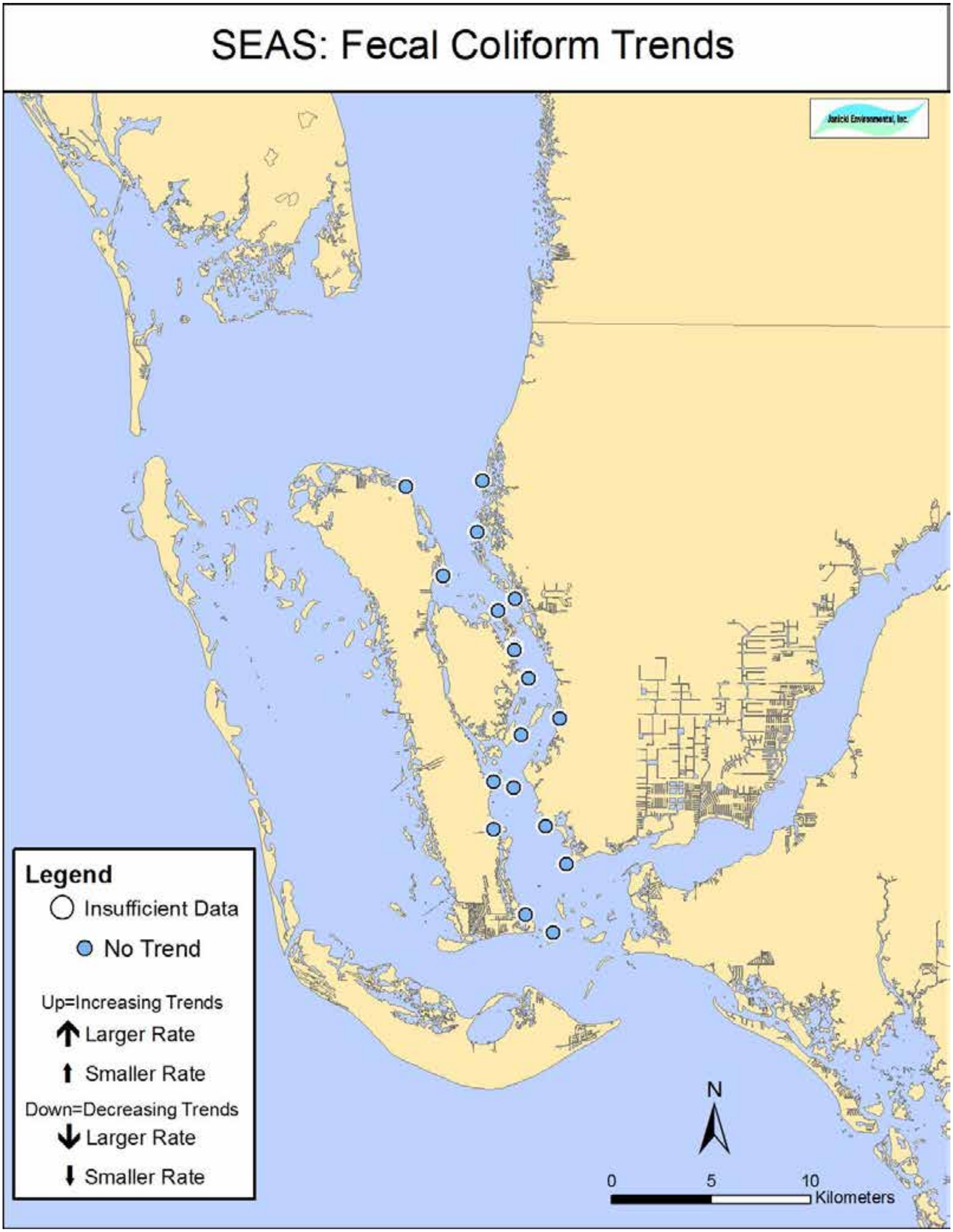


Figure 2-114. Fecal Coliform Trends for SEAS Stations

Cross correlation analysis suggested that fecal coliform concentrations among stations for long-term stations were greatest between Stations 052 and 490. Stations 402 and 490 had a higher correlation than 052 and 490, but note that 052 and 501 began sampling in 1984 and 1985, respectively, and Stations 401 and 402 began sampling in 1994 instead of 1980 (Table 2-64).

Table 2-64. Spearman Rank Correlation Coefficients for Fecal Coliform Concentrations for SEAS Stations

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations	_020	_350	_360	_370	_380	_390	_400	_410	_420	_430	_440	_460	_490	_500	_052	_501	_401	_402
_020	1.00000 169	0.39883 <.0001 166	0.30315 0.0001 159	0.27479 0.0003 169	0.24023 0.0018 167	0.29588 0.0001 161	0.27002 0.0008 152	0.02372 0.7638 163	0.17667 0.0245 162	0.27779 0.0003 164	0.25701 0.0008 166	0.39674 <.0001 159	0.39009 <.0001 168	0.26766 0.0005 166	0.36104 <.0001 120	0.33020 0.0001 132	0.27894 0.0078 90	0.30880 0.0031 90
_350	0.39883 <.0001 166	1.00000 174	0.55293 <.0001 165	0.38283 <.0001 174	0.22573 0.0033 168	0.19934 0.0110 162	0.33792 <.0001 158	0.20031 0.0092 168	0.36046 <.0001 167	0.32357 <.0001 169	0.26456 0.0005 171	0.37545 <.0001 165	0.50854 <.0001 173	0.24569 0.0012 171	0.34286 <.0001 124	0.36020 <.0001 133	0.28830 0.0048 94	0.48287 <.0001 94
_360	0.30315 0.0001 159	0.55293 <.0001 165	1.00000 168	0.49732 <.0001 168	0.34569 <.0001 161	0.33772 <.0001 156	0.39822 <.0001 156	0.22593 0.0038 162	0.30743 <.0001 161	0.34263 <.0001 163	0.31538 <.0001 165	0.34036 <.0001 158	0.53186 <.0001 167	0.34449 <.0001 166	0.40170 <.0001 120	0.40367 <.0001 126	0.37869 0.0003 87	0.43858 <.0001 88
_370	0.27479 0.0003 169	0.38283 <.0001 174	0.49732 <.0001 168	1.00000 189	0.34102 <.0001 182	0.26963 0.0004 167	0.35601 <.0001 161	0.13720 0.0640 183	0.43128 <.0001 182	0.45227 <.0001 184	0.16488 0.0245 186	0.43314 <.0001 178	0.56617 <.0001 188	0.37379 <.0001 186	0.53163 <.0001 127	0.35090 <.0001 147	0.53040 <.0001 108	0.64113 <.0001 109
_380	0.24023 0.0018 167	0.22573 0.0033 168	0.34569 <.0001 161	0.34102 <.0001 182	1.00000 182	0.26919 0.0005 165	0.31662 <.0001 154	0.25445 0.0007 176	0.38520 <.0001 175	0.36131 <.0001 177	0.37868 <.0001 179	0.29953 <.0001 172	0.53782 <.0001 181	0.34553 <.0001 179	0.46496 <.0001 127	0.40404 <.0001 147	0.45737 <.0001 103	0.42371 <.0001 104
_390	0.29588 0.0001 161	0.19934 0.0110 162	0.33772 <.0001 156	0.26963 0.0004 167	0.26919 0.0005 165	1.00000 169	0.31509 <.0001 154	0.18799 0.0156 165	0.19067 0.0145 164	0.30204 <.0001 166	0.21979 0.0042 168	0.25277 0.0014 158	0.36439 <.0001 166	0.35031 <.0001 164	0.25192 0.0051 122	0.40988 <.0001 132	0.28749 0.0069 87	0.41039 <.0001 88
_400	0.27002 0.0008 152	0.33792 <.0001 158	0.39822 <.0001 156	0.35601 <.0001 161	0.31662 <.0001 154	0.31509 <.0001 154	1.00000 163	0.07695 0.3335 160	0.26405 0.0008 159	0.29467 0.0001 161	0.26081 0.0008 162	0.08429 0.3019 152	0.36657 <.0001 160	0.38900 <.0001 158	0.36361 <.0001 119	0.47330 <.0001 122	0.22200 0.0411 85	0.33736 0.0016 85
_410	0.02372 0.7638 163	0.20031 0.0092 168	0.22593 0.0038 162	0.13720 0.0640 183	0.25445 0.0007 176	0.18799 0.0156 165	0.07695 0.3335 160	1.00000 185	0.44312 <.0001 182	0.30502 <.0001 184	0.11028 0.1362 184	0.19066 0.0120 173	0.23270 0.0016 182	0.34343 <.0001 180	0.28381 0.0015 122	0.36217 <.0001 142	0.25878 0.0077 105	0.28501 0.0031 106
_420	0.17667 0.0245 162	0.36046 <.0001 167	0.30743 <.0001 161	0.43128 <.0001 182	0.38520 <.0001 175	0.19067 0.0145 164	0.26405 0.0008 159	0.44312 <.0001 182	1.00000 184	0.45265 <.0001 183	0.31827 <.0001 183	0.29785 <.0001 172	0.51027 <.0001 181	0.33074 <.0001 179	0.52587 <.0001 122	0.48999 <.0001 142	0.27616 0.0040 107	0.44291 <.0001 108

Table 2-64. Spearman Rank Correlation Coefficients for Fecal Coliform Concentrations for SEAS Stations (Continued)

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations																		
	_020	_350	_360	_370	_380	_390	_400	_410	_420	_430	_440	_460	_490	_500	_052	_501	_401	_402
_430	0.27779 0.0003 164	0.32357 <.0001 169	0.34263 <.0001 163	0.45227 <.0001 184	0.36131 <.0001 177	0.30204 <.0001 166	0.29467 0.0001 161	0.30502 <.0001 184	0.45265 <.0001 183	1.00000 186	0.34063 <.0001 185	0.46164 <.0001 174	0.50468 <.0001 183	0.30821 <.0001 181	0.55376 <.0001 123	0.38987 <.0001 143	0.39415 <.0001 107	0.40808 <.0001 108
_440	0.25701 0.0008 166	0.26456 0.0005 171	0.31538 <.0001 165	0.16488 0.0245 186	0.37868 <.0001 179	0.21979 0.0042 168	0.26081 0.0008 162	0.11028 0.1362 184	0.31827 <.0001 183	0.34063 <.0001 185	1.00000 188	0.21433 0.0043 176	0.42597 <.0001 185	0.25420 0.0005 183	0.39540 <.0001 125	0.28651 0.0005 145	0.33888 0.0004 106	0.41617 <.0001 107
_460	0.39674 <.0001 159	0.37545 <.0001 165	0.34036 <.0001 158	0.43314 <.0001 178	0.29953 <.0001 172	0.25277 0.0014 158	0.08429 0.3019 152	0.19066 0.0120 173	0.29785 <.0001 172	0.46164 <.0001 174	0.21433 0.0043 176	1.00000 178	0.45600 <.0001 177	0.32819 <.0001 175	0.37419 <.0001 125	0.33583 <.0001 144	0.46299 <.0001 106	0.37118 <.0001 107
_490	0.39009 <.0001 168	0.50854 <.0001 173	0.53186 <.0001 167	0.56617 <.0001 188	0.53782 <.0001 181	0.36439 <.0001 166	0.36657 <.0001 160	0.23270 0.0016 182	0.51027 <.0001 181	0.50468 <.0001 183	0.42597 <.0001 185	0.45600 <.0001 177	1.00000 188	0.41585 <.0001 186	0.59129 <.0001 127	0.49883 <.0001 147	0.48587 <.0001 107	0.71778 <.0001 108
_500	0.26766 0.0005 166	0.24569 0.0012 171	0.34449 <.0001 166	0.37379 <.0001 186	0.34553 <.0001 179	0.35031 <.0001 164	0.38900 <.0001 158	0.34343 <.0001 180	0.33074 <.0001 179	0.30821 <.0001 181	0.25420 0.0005 183	0.32819 <.0001 175	0.41585 <.0001 186	1.00000 186	0.38432 <.0001 126	0.48692 <.0001 146	0.36284 0.0001 106	0.34066 0.0003 107
_052	0.36104 <.0001 120	0.34286 <.0001 124	0.40170 <.0001 120	0.53163 <.0001 127	0.46496 <.0001 127	0.25192 0.0051 122	0.36361 <.0001 119	0.28381 0.0015 122	0.52587 <.0001 122	0.55376 <.0001 123	0.39540 <.0001 125	0.37419 <.0001 125	0.59129 <.0001 127	0.38432 <.0001 126	1.00000 129	0.44204 <.0001 122	0.29631 0.0076 80	0.41507 0.0001 81
_501	0.33020 0.0001 132	0.36020 <.0001 133	0.40367 <.0001 126	0.35090 <.0001 147	0.40404 <.0001 147	0.40988 <.0001 132	0.47330 <.0001 122	0.36217 <.0001 142	0.48999 <.0001 142	0.38987 <.0001 143	0.28651 0.0005 145	0.33583 <.0001 144	0.49883 <.0001 147	0.48692 <.0001 146	0.44204 <.0001 122	1.00000 147	0.42612 <.0001 98	0.34805 0.0004 99
_401	0.27894 0.0078 90	0.28830 0.0048 94	0.37869 0.0003 87	0.53040 <.0001 108	0.45737 <.0001 103	0.28749 0.0069 87	0.22200 0.0411 85	0.25878 0.0077 105	0.27616 0.0040 107	0.39415 <.0001 107	0.33888 0.0004 106	0.46299 <.0001 106	0.48587 <.0001 107	0.36284 0.0001 106	0.29631 0.0076 80	0.42612 <.0001 98	1.00000 108	0.51607 <.0001 108
_402	0.30880 0.0031 90	0.48287 <.0001 94	0.43858 <.0001 88	0.64113 <.0001 109	0.42371 <.0001 104	0.41039 <.0001 88	0.33736 0.0016 85	0.28501 0.0031 106	0.44291 <.0001 108	0.40808 <.0001 108	0.41617 <.0001 107	0.37118 <.0001 107	0.71778 <.0001 108	0.34066 0.0003 107	0.41507 0.0001 81	0.34805 0.0004 99	0.51607 <.0001 108	1.00000 109

2.5 COASTAL CHARLOTTE HARBOR MONITORING NETWORK

The Coastal Charlotte Harbor Monitoring Network (CCHMN) has conducted monthly sampling in Matlacha Pass since 2002 using a probabilistic sampling scheme. The CCHMN is a collaborative effort among cities and counties and is administered by the Charlotte Harbor National Estuary Program (CHNEP). The sampling grid, along with the locations of each sample collected since 2002 is presented in Figure 2-115. Each month, five grid cells are randomly chosen for water quality sampling.

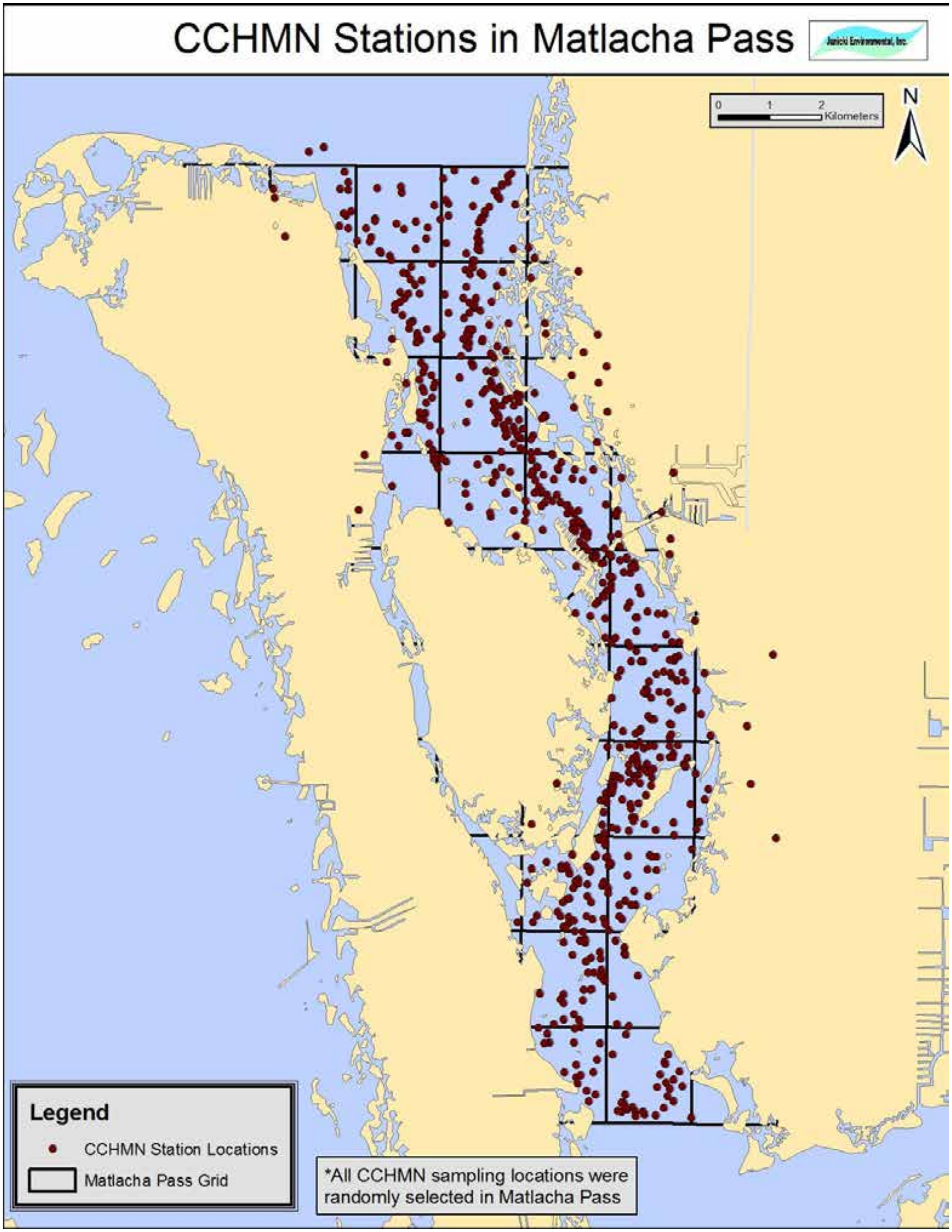


Figure 2-115. CCHMN Sampling Station Locations

Table 2-65 displays the period of record for the CCHMN randomly selected stations.

Table 2-65. CCHMN Station Period of Record

Station	Period of Record
CCHMN	2002-2013

A list of the periods of record for each parameter measured is provided in Table 2-66. The following subsections characterize the data collected by CCHMN for the principal constituents of interest.

Table 2-66. CCHMN Constituents Sampled and Period of Record

Parameter	Station CCHMN
Chlorophyll *a* (chlac_ugl)	2002-2013
Dissolved Oxygen (DO_mgl)	2002-2013
Salinity	2002-2013
Total Nitrogen (TN_mgl)	2002-2013
Total Phosphorus (TP_mgl)	2002-2013
Total Suspended Solids (TSS_mgl)	2002-2013
Turbidity (TURB)	2002-2013

2.5.1 SALINITY

Salinity has been consistently sampled by CCHMN since 2002 at randomly selected stations in Matlacha Pass (Table 2-67). The numbers in this table represent the sampling frequency at the surface level. Samples are generally taken at near surface and near bottom depths for salinity. Comparisons of salinity concentrations among sample levels suggest little variation as a function of depth for most stations sampled.

Table 2-67. Salinity Sampling Frequency by Station for CCHMN Randomly Selected Stations in Matlacha Pass

Year	Station CCHMN
2002	43
2003	54
2004	51
2005	60
2006	60
2007	59
2008	60
2009	60
2010	60
2011	55
2012	60
2013	52
Total	674

Box and whisker plots of surface (top) and bottom (bottom) salinities for all randomly selected CCHMN samples collected are displayed in Figure 2-116. Salinity variation between sample levels is low, and 75 percent of both surface and bottom salinity samples were below 32 PSU. These plots represent the entire period of record (2002-2013).

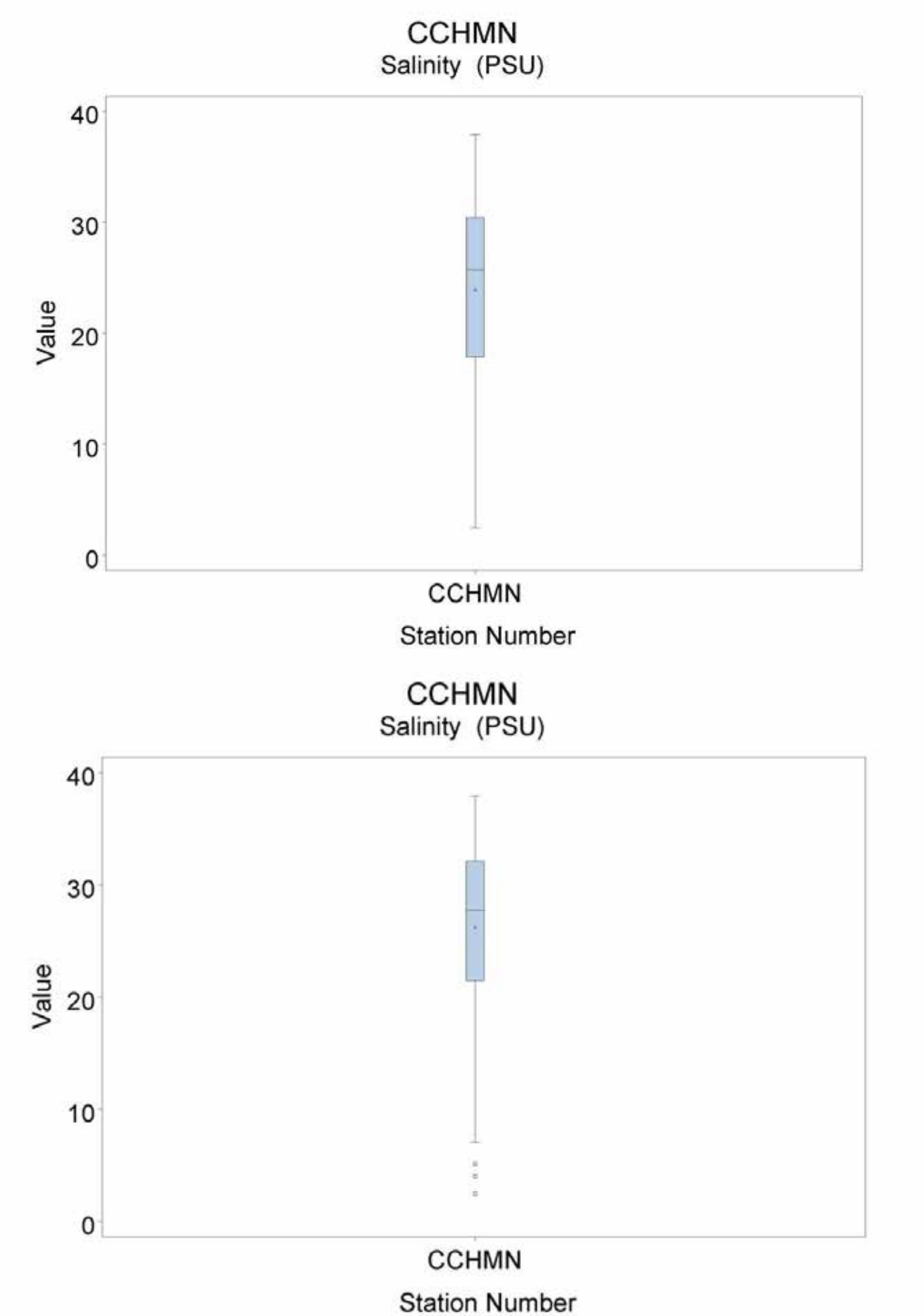


Figure 2-116. Box and Whisker Plots Displaying Surface (Top) and Bottom (Bottom) Salinity Distributions for CCHMN Randomly Selected Stations in Matlacha Pass

Time series plots of annual average surface salinity indicate increased salinity rather dramatic variation in salinity between the wet years of 2003-2005 and the dry years of 2007-2008 **(**Figure 2-117).

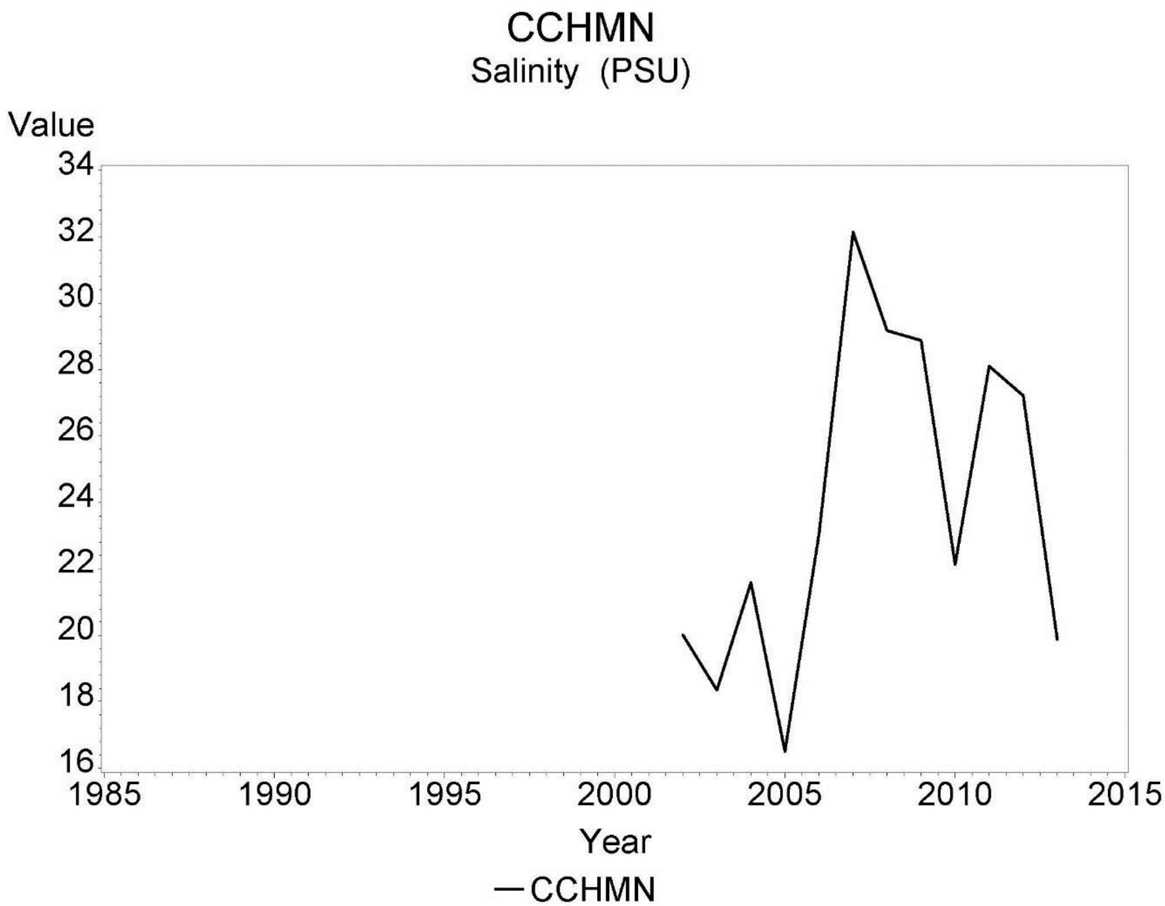


Figure 2-117. Time Series of Surface Salinity for CCHMN Randomly Selected Stations in Matlacha Pass

Trends for surface salinity measurements for CCHMN stations are displayed in Figure 2-118 and trends for bottom salinity measurements are displayed in Figure 2-119. No trends were identified in surface or bottom salinity measurements from 2002 to 2013. Note that these data are averaged across all samples within the stratum on a monthly basis. The station location is depicted as a single point to represent the trend result.

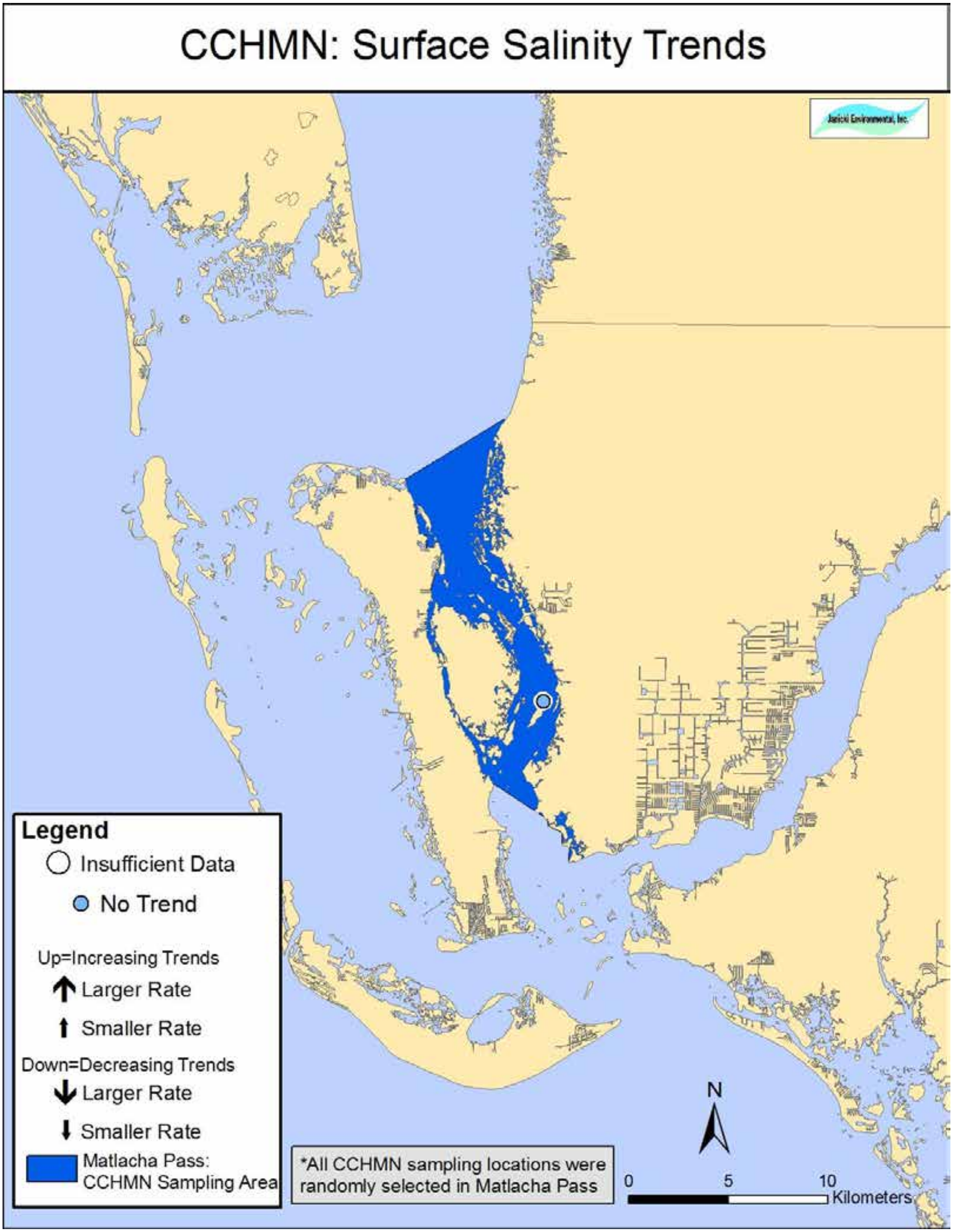


Figure 2-118. Surface Salinity Trends for CCHMN Randomly Selected Stations in Matlacha Pass

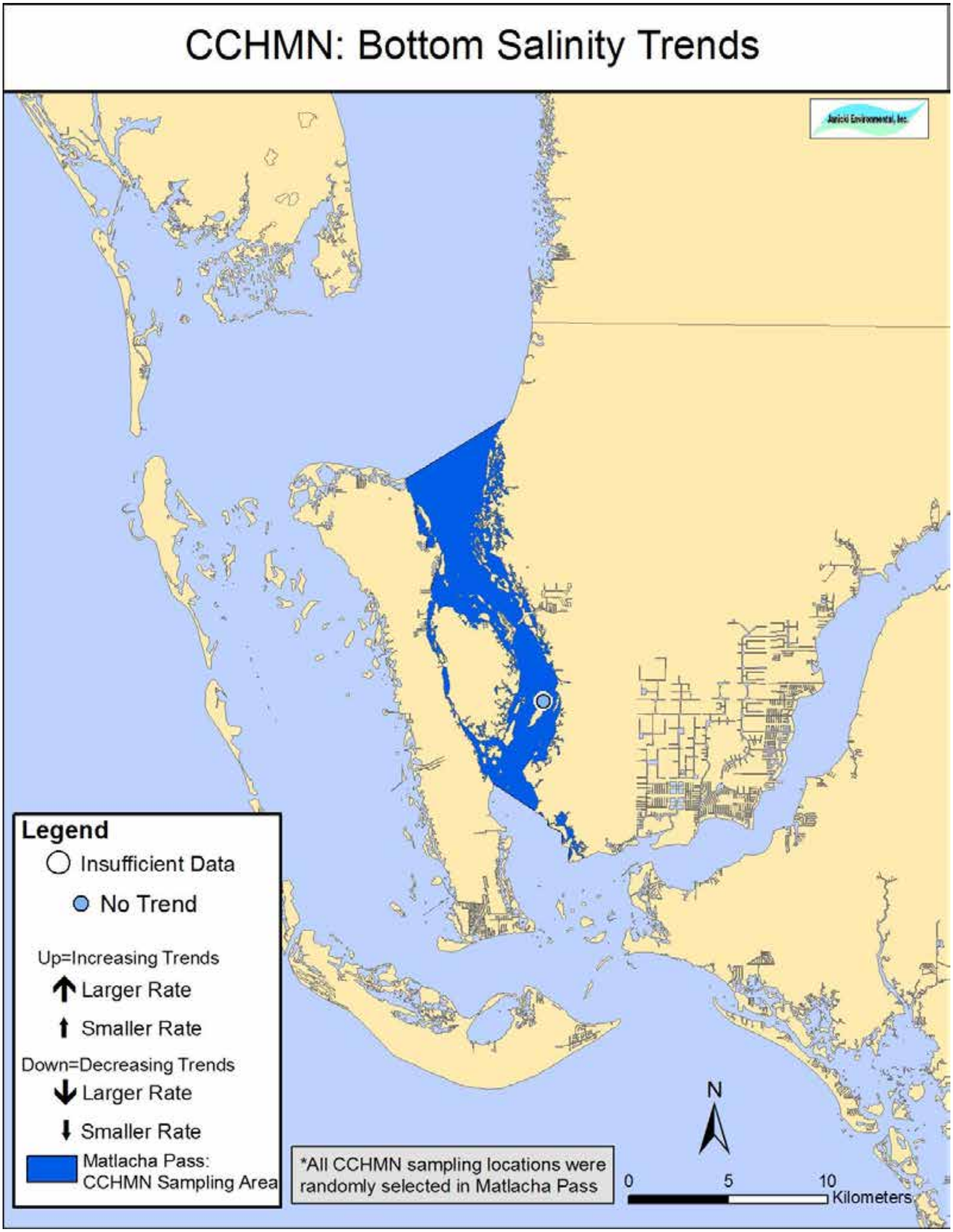


Figure 2-119. Bottom Salinity Trends for CCHMN Randomly Selected Stations in Matlacha Pass

2.5.2 TOTAL NITROGEN

TN has been routinely sampled by CCHMN since 2002 at randomly selected stations in Matlacha Pass (Table 2-68).

Table 2-68. Total Nitrogen Sampling Frequency by Station for CCHMN Randomly Selected Station in Matlacha Pass

Year	Station CCHMN
2002	38
2003	49
2004	44
2005	46
2006	36
2007	34
2008	56
2009	49
2010	51
2011	52
2012	50
2013	55
Total	560

A box and whisker plot of TN values collected by CCHMN is shown in Figure 2-120. Note that over 75 percent of the values were below 1.0 mg/L. This plot represents the entire period of record examined (2002-2013).

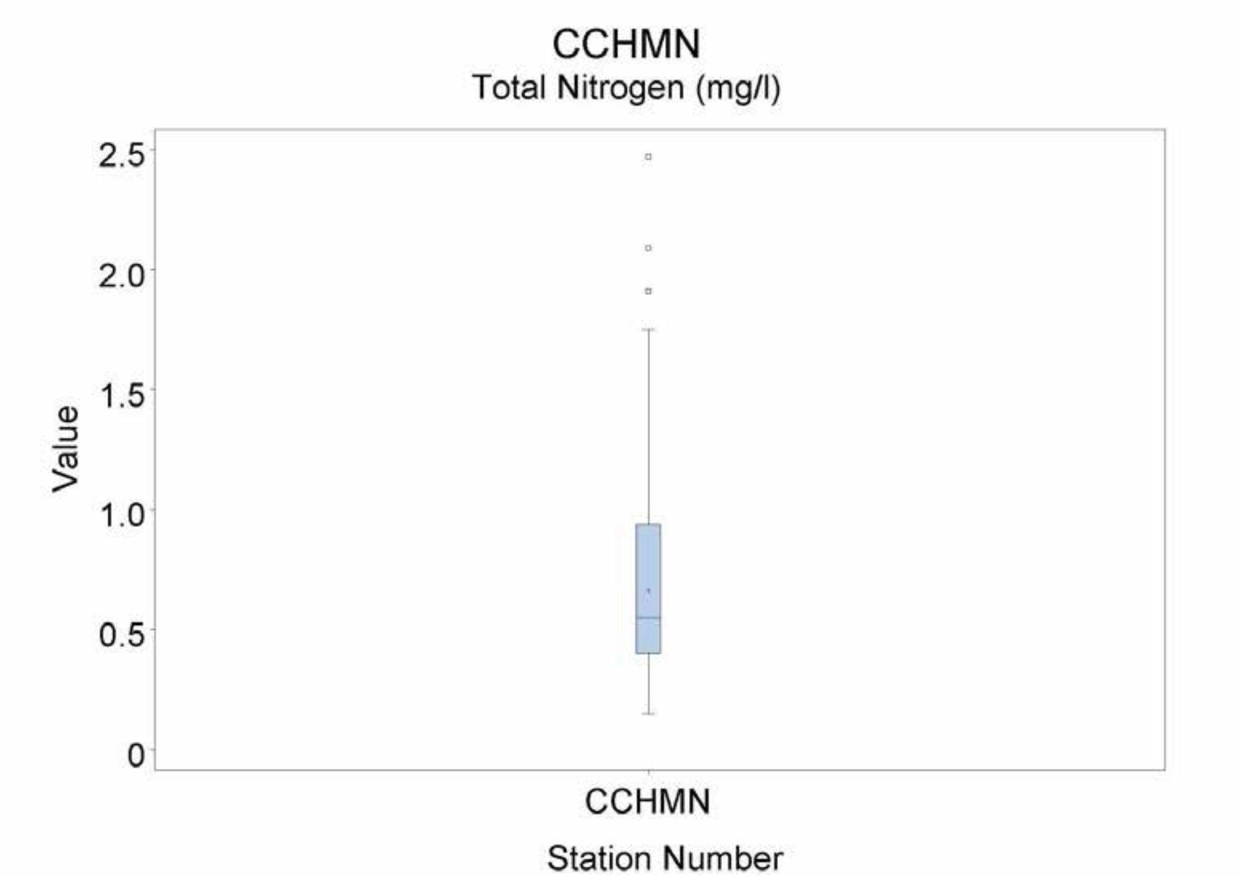


Figure 2-120. Box and Whisker Plots Displaying Total Nitrogen Distributions for CCHMN Randomly Selected Stations in Matlacha Pass

Time series of TN values indicate differences from year to year with increased annual average values after 2009 (Figure 2-121).

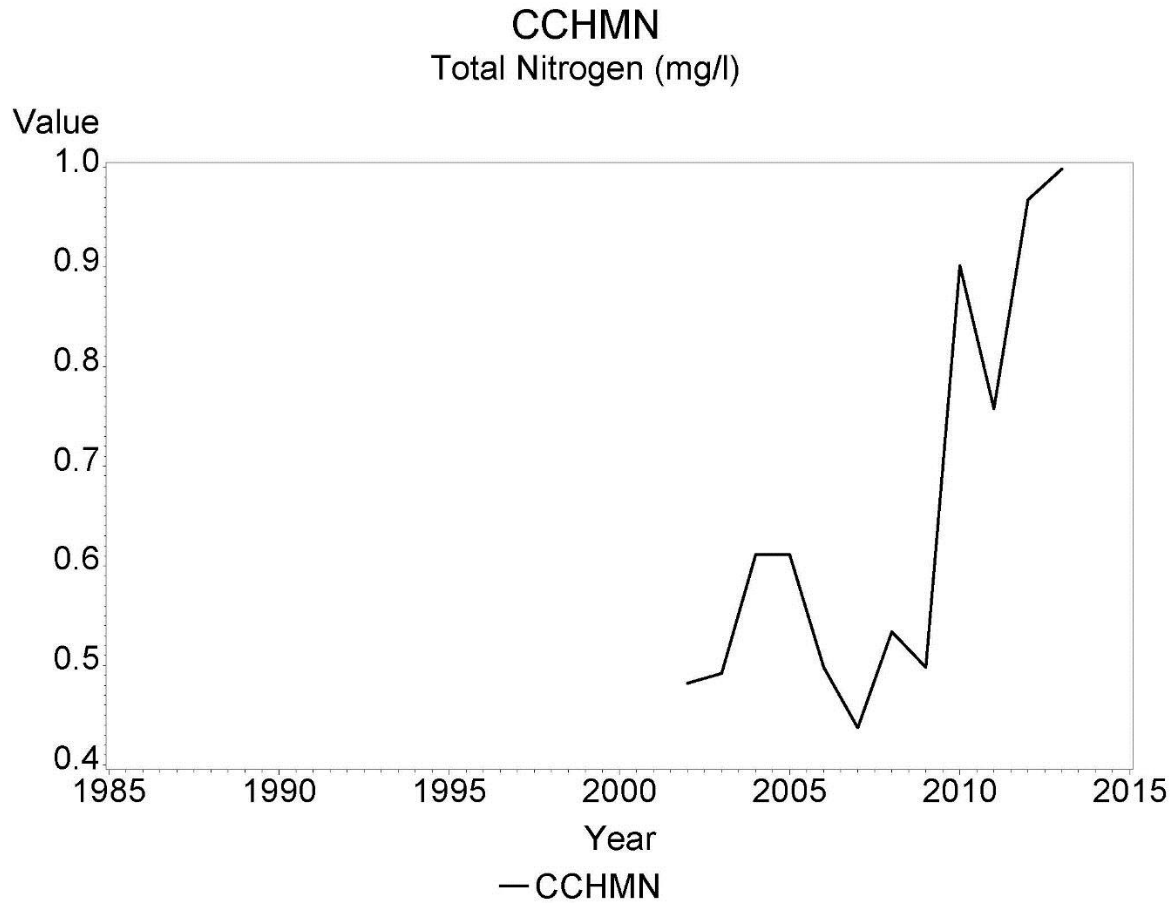


Figure 2-121. Time Series of Total Nitrogen for CCHMN Randomly Selected Stations in Matlacha Pass

Trends for TN measurements for CCHMN stations are displayed in Figure 2-122. A large increasing trend in TN was identified from 2002-2013. Note that the station location depicted in the map is representative of all randomly selected stations in Matlacha Pass (shaded blue).

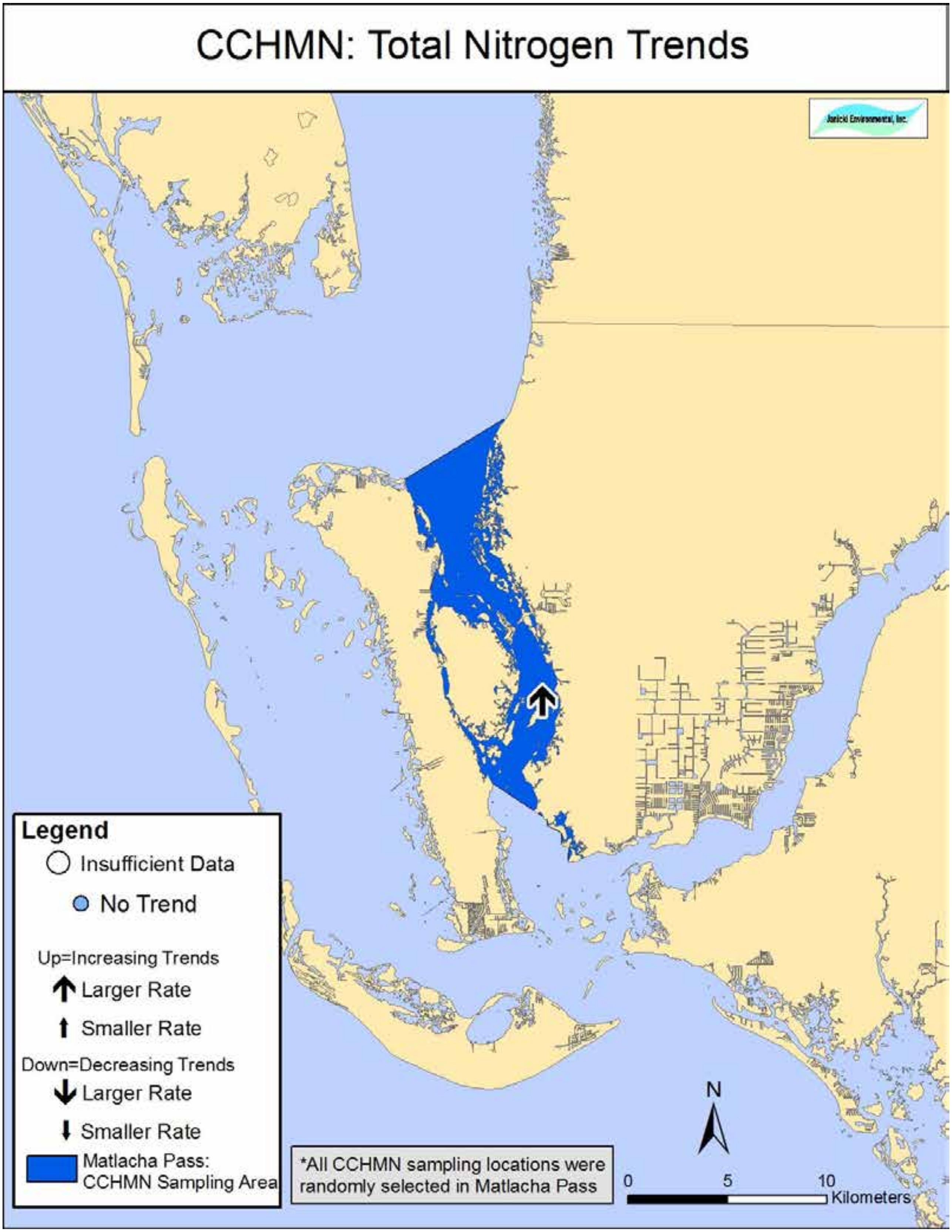


Figure 2-122. Total Nitrogen Trends for CCHMN Randomly Selected Stations in Matlacha Pass

2.5.3 TOTAL PHOSPHORUS

TP has been routinely sampled by CCHMN since 2002 at randomly selected stations in Matlacha Pass (Table 2-69).

Table 2-69. Total Phosphorus Sampling Frequency by Station for CCHMN Randomly Selected Stations in Matlacha Pass

Year	Station CCHMN
2002	39
2003	49
2004	34
2005	28
2006	10
2007	1
2008	29
2009	35
2010	48
2011	52
2012	60
2013	54
Total	439

A box and whisker plot of TP values collected by CCHMN is displayed in Figure 2-123. This plot represents the entire period of record examined (2002-2013). This plot is trimmed such that extremely high values are not displayed in the plots.

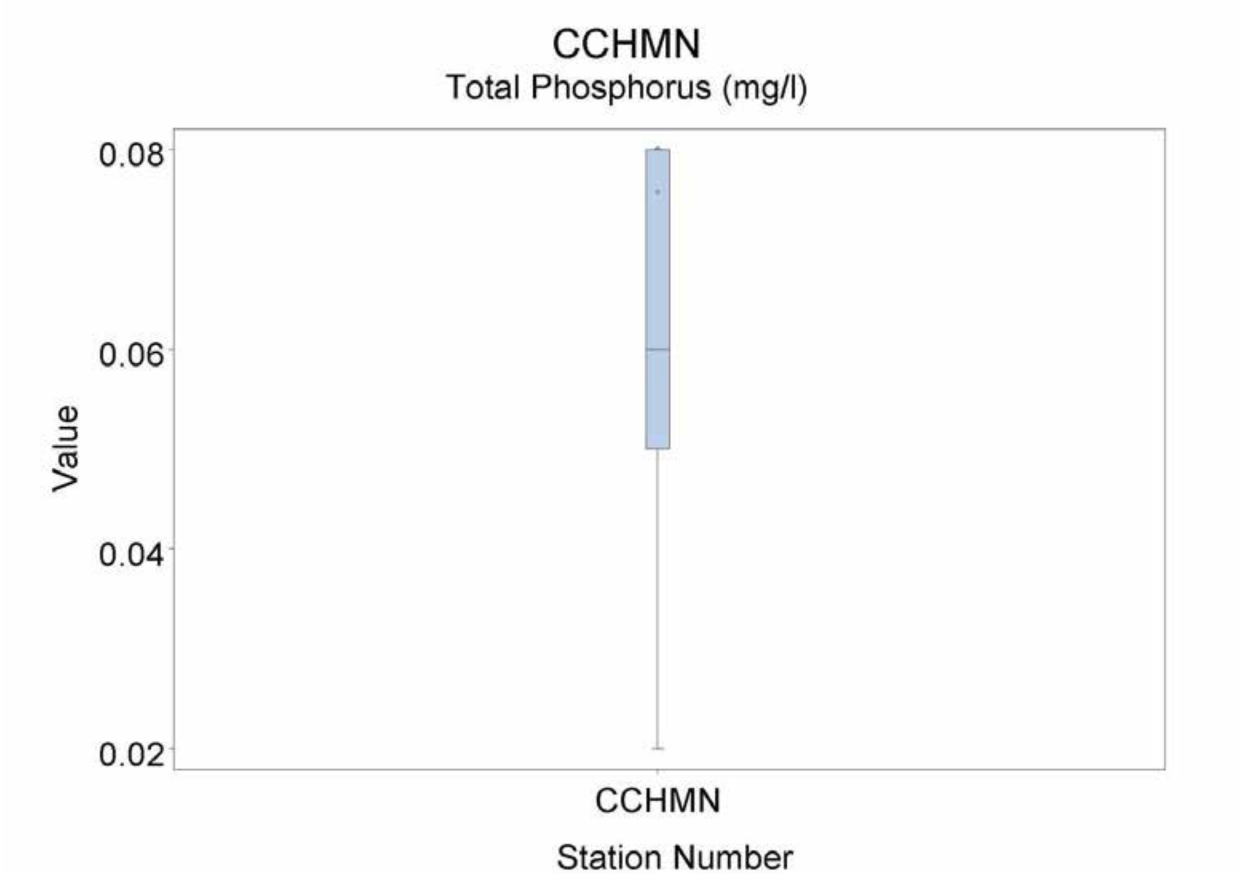


Figure 2-123. Box and Whisker Plots Displaying Total Phosphorus Distributions for CCHMN Randomly Selected Stations in Matlacha Pass

Time series of TP measurements taken by CCHMN indicate that there is a decrease in TP concentrations beginning in 2002 (Figure 2-124).

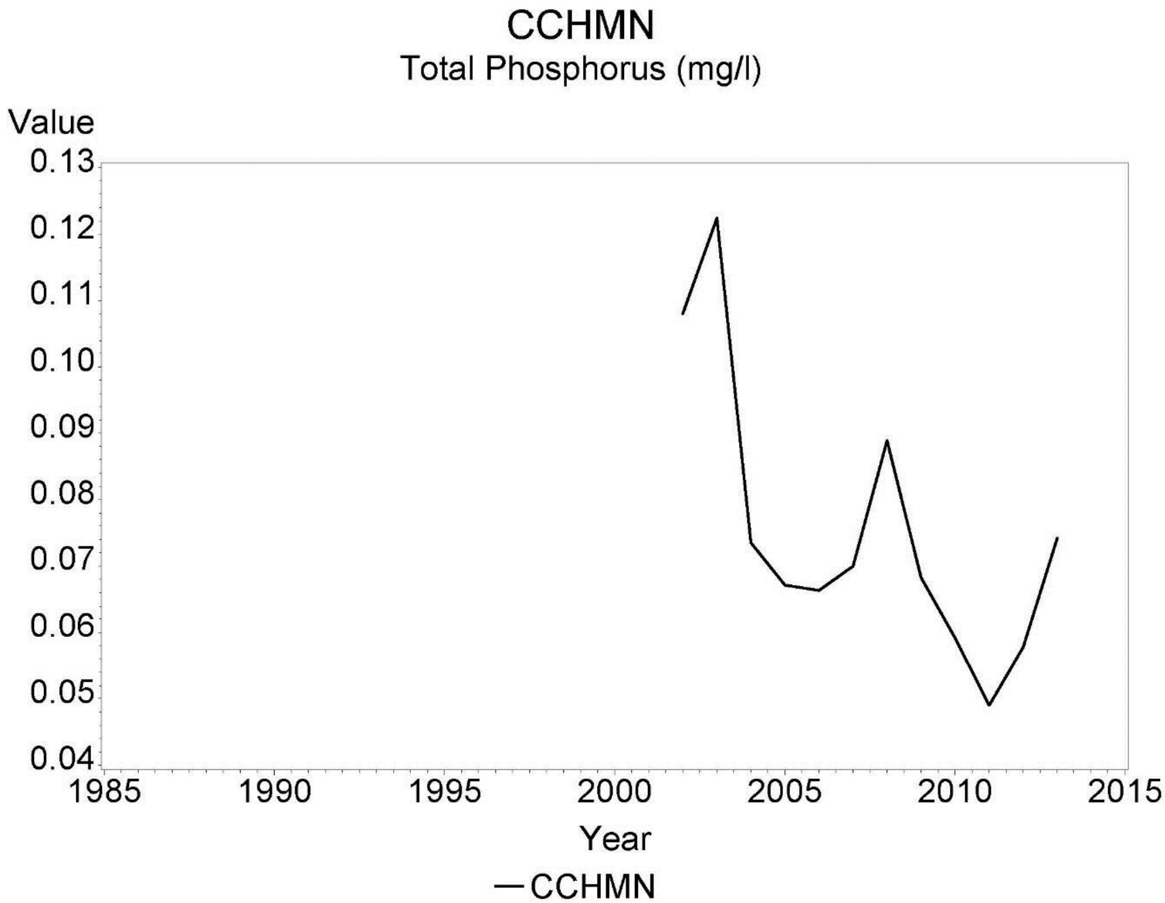


Figure 2-124. Time Series Plot of Total Phosphorus for CCHMN Randomly Selected Stations in Matlacha Pass

Trends for TP measurements for CCHMN stations are presented in Figure 2-125. A small decreasing trend in TP was identified in measurements from 2002 to 2013. Note that these data are averaged across all samples within the stratum on a monthly basis. The station location is depicted as a single point to represent the trend result.

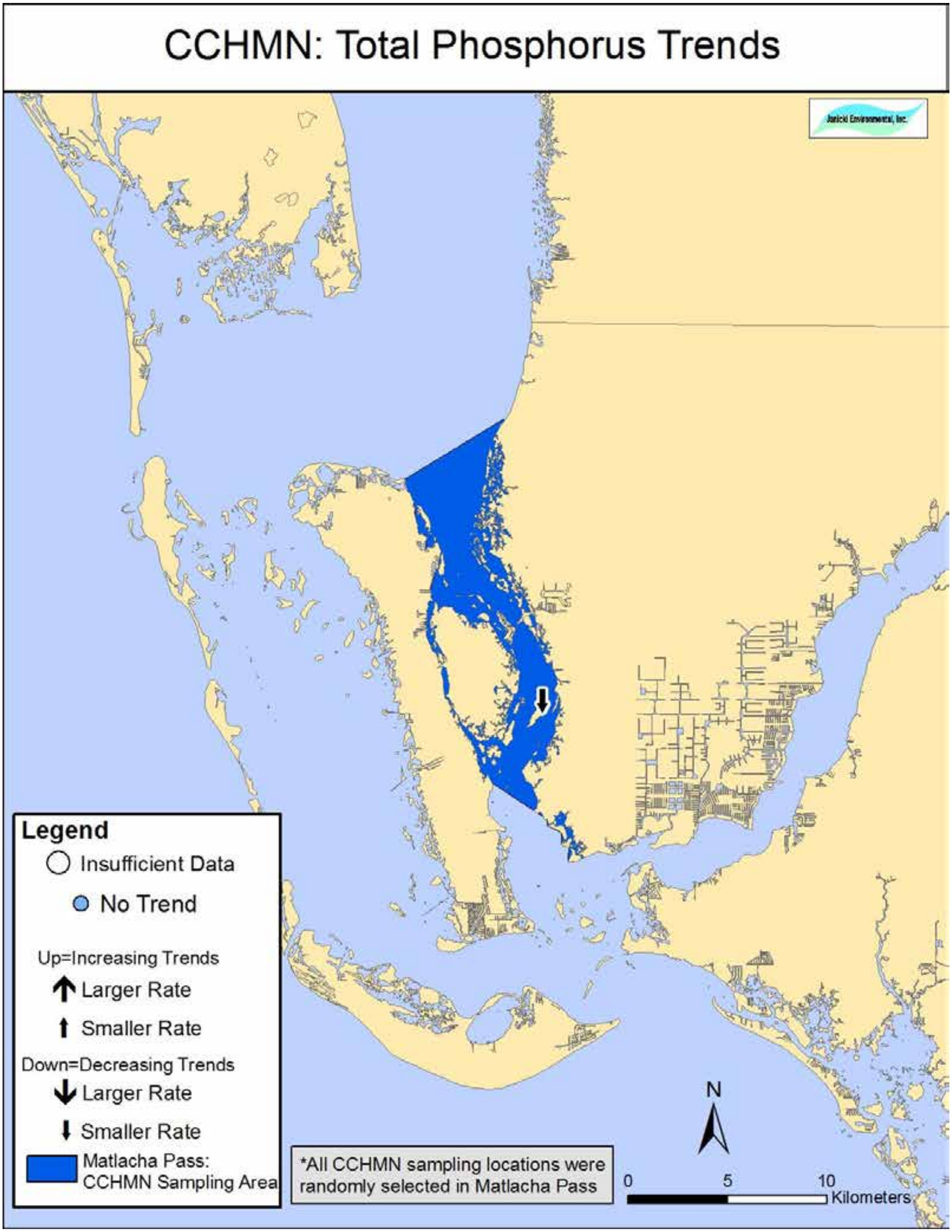


Figure 2-125. Total Phosphorus Trends for CCHMN Randomly Selected Stations in Matlacha Pass

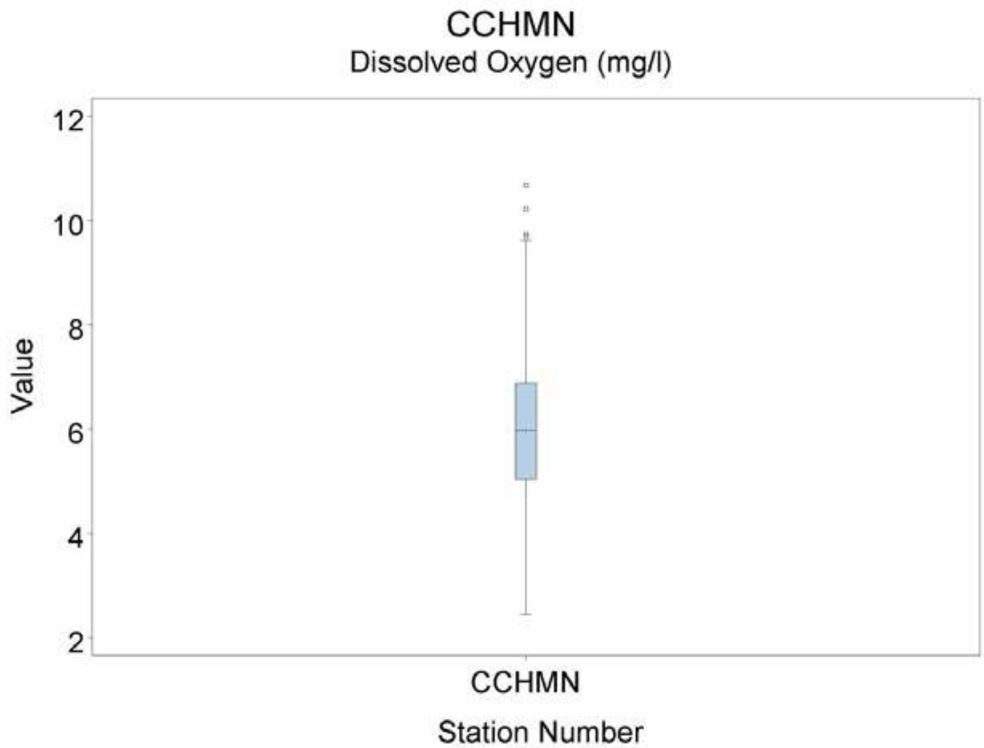
2.5.4 DISSOLVED OXYGEN

DO has been consistently sampled by CCHMN since 2002 in Matlacha Pass (Table 2-70). The numbers in this table represents the sampling frequency at the surface level. Samples are generally taken at near surface and near bottom depths for DO. Comparisons of DO concentrations among sample levels suggest little variation as a function of depth for most samples.

Table 2-70. Dissolved Oxygen Sampling Frequency by Station for CCHMN Randomly Selected Stations in Matlacha Pass

Year	Station CCHMN
2002	45
2003	55
2004	49
2005	60
2006	60
2007	59
2008	60
2009	60
2010	60
2011	55
2012	60
2013	47
Total	670

A comparison of surface (top) and bottom) (bottom) DO values collected by CCHMN is provided in Figure 2-126. Data indicate that 75 percent of both surface and bottom DO values collected were at or above 5.0 mg/L, and there appears to be little difference between surface and bottom concentrations. This plot represents the entire period of record examined (2002-2013).



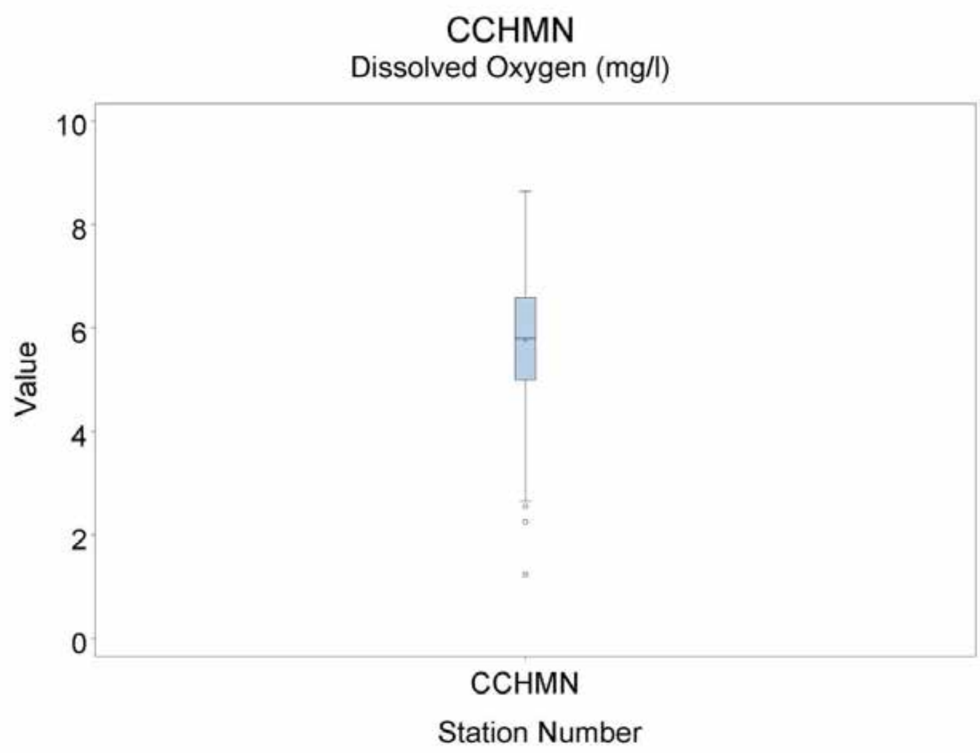


Figure 2-126. Box and Whisker Plots Displaying Surface (Top) and Bottom (Bottom) Dissolved Oxygen Distributions for CCHMN Randomly Selected Stations in Matlacha Pass

Time series plots of annual average surface DO concentrations indicate concentrations between 5.5 and 6.5 mg/L (Figure 2-127).

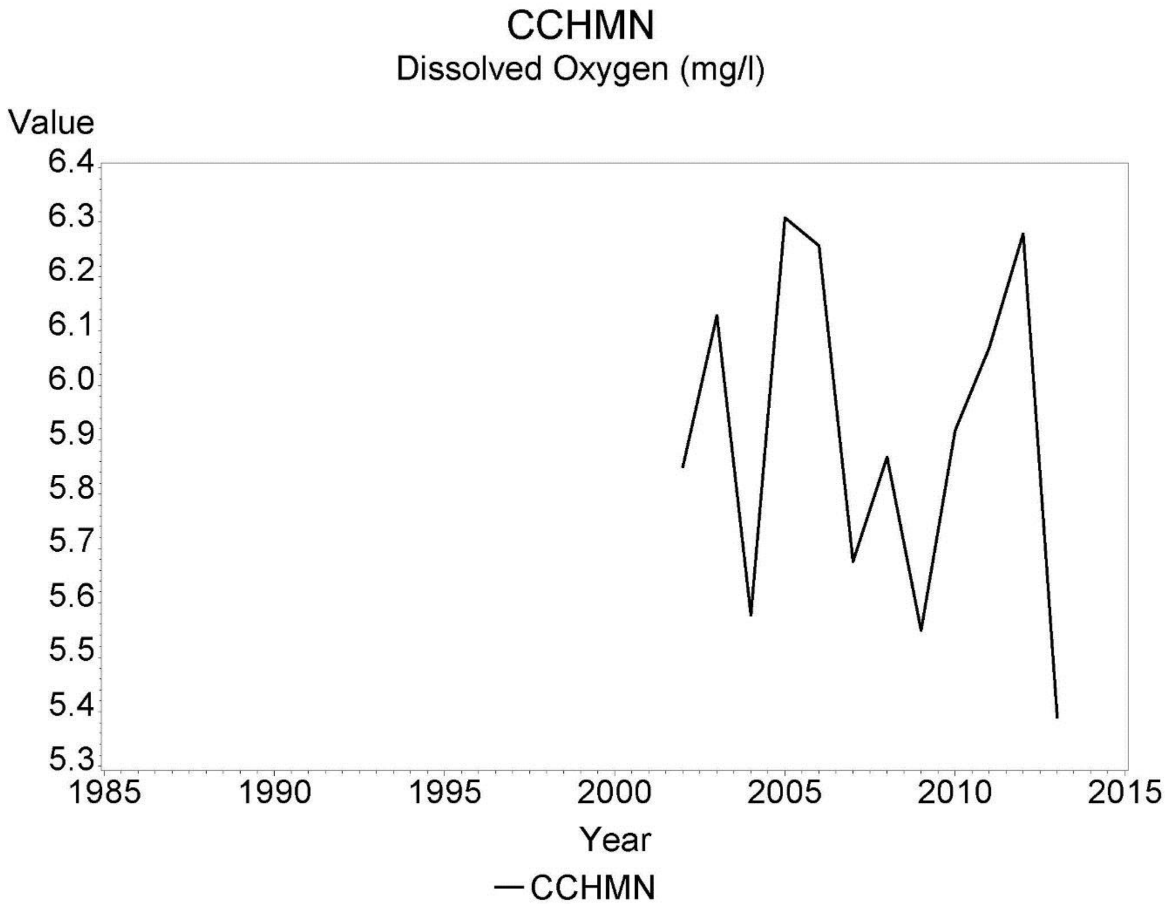


Figure 2-127. Time Series Plot of Dissolved Oxygen at CCHMN Randomly Selected Stations in Matlacha Pass

Trends for surface DO measurements for CCHMN stations are presented in Figure 2-128, and bottom DO trends are displayed in Figure 2-129. No trends in surface or bottom DO were identified in measurements from 2002 to 2013. Note that these data are averaged across all samples within the stratum on a monthly basis. The station location is depicted as a single point to represent the trend result.

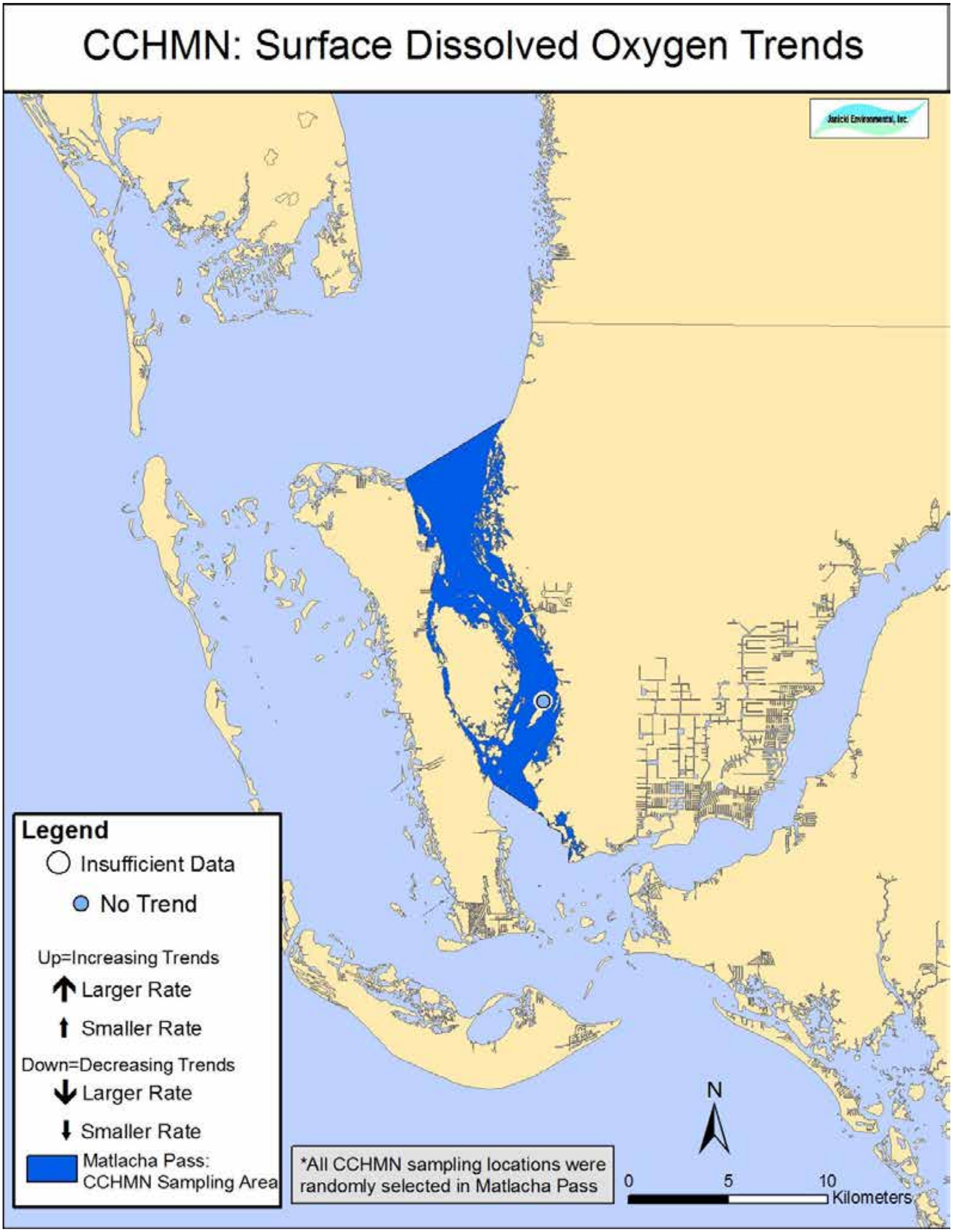


Figure 2-128. Surface Dissolved Oxygen Trends for CCHMN Randomly Selected Stations in Matlacha Pass

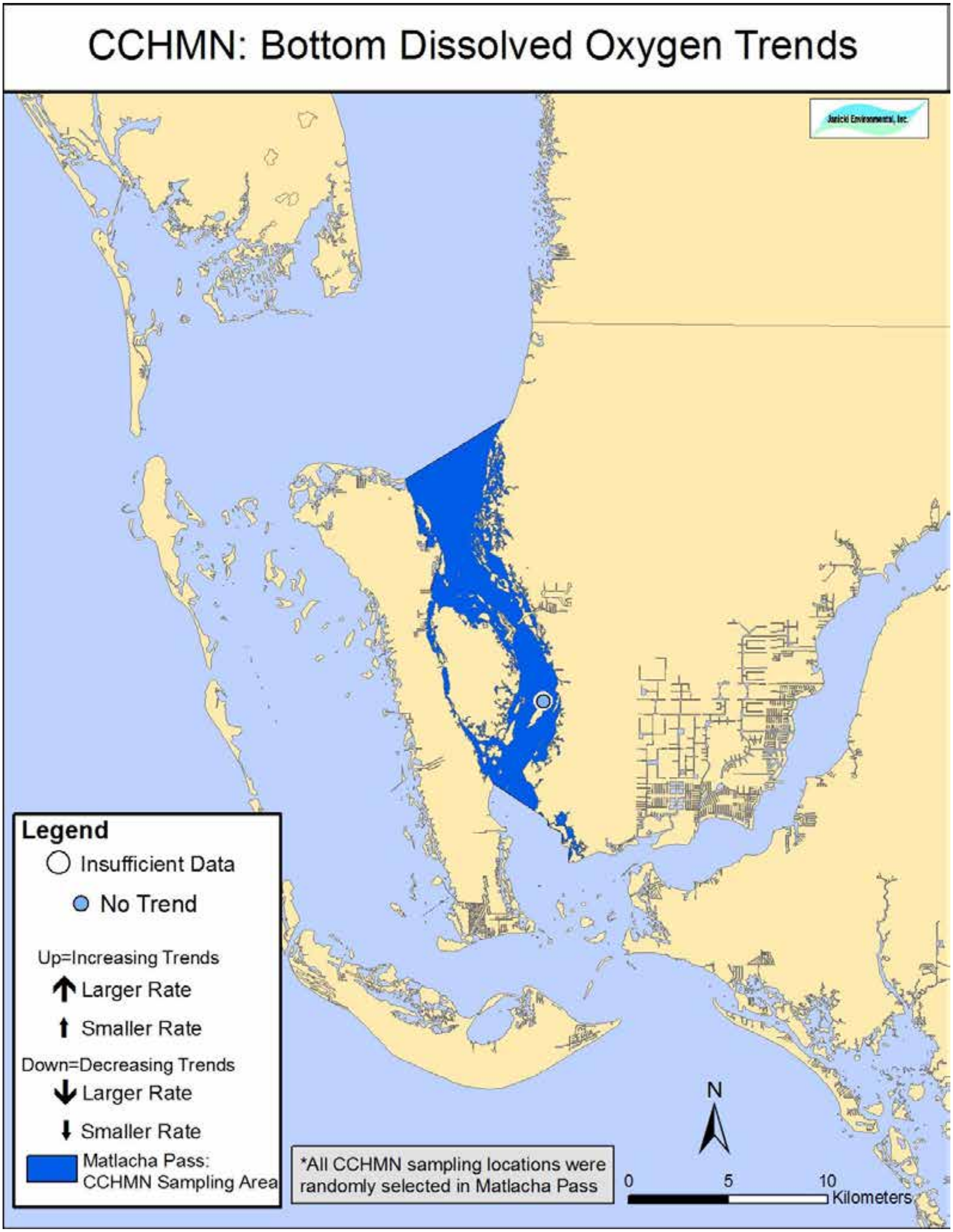


Figure 2-129. Bottom Dissolved Oxygen Trends for CCHMN for Randomly Selected Stations in Matlacha Pass

2.5.5 CHLOROPHYLL *A*

Chl *a* has been routinely sampled by CCHMN since 2002 in Matlacha Pass (Table 2-71).

Table 2-71. Chlorophyll *a* Sampling Frequency by Station for CCHMN Randomly Selected Stations in Matlacha Pass

Year	Station CCHMN
2002	6
2003	7
2004	37
2005	55
2006	60
2007	60
2008	54
2009	45
2010	58
2011	48
2012	52
2013	49
Total	531

A box and whisker plot of Chl *a* values is presented in Figure 2-130. This plot represents the entire period of record examined (2002-2013). At least 75 percent of the values in each randomly selected station were below 6 µg/L, indicating that typical chlorophyll values would not be considered bloom conditions. This plot is trimmed such that extremely high values are not displayed in the plots.

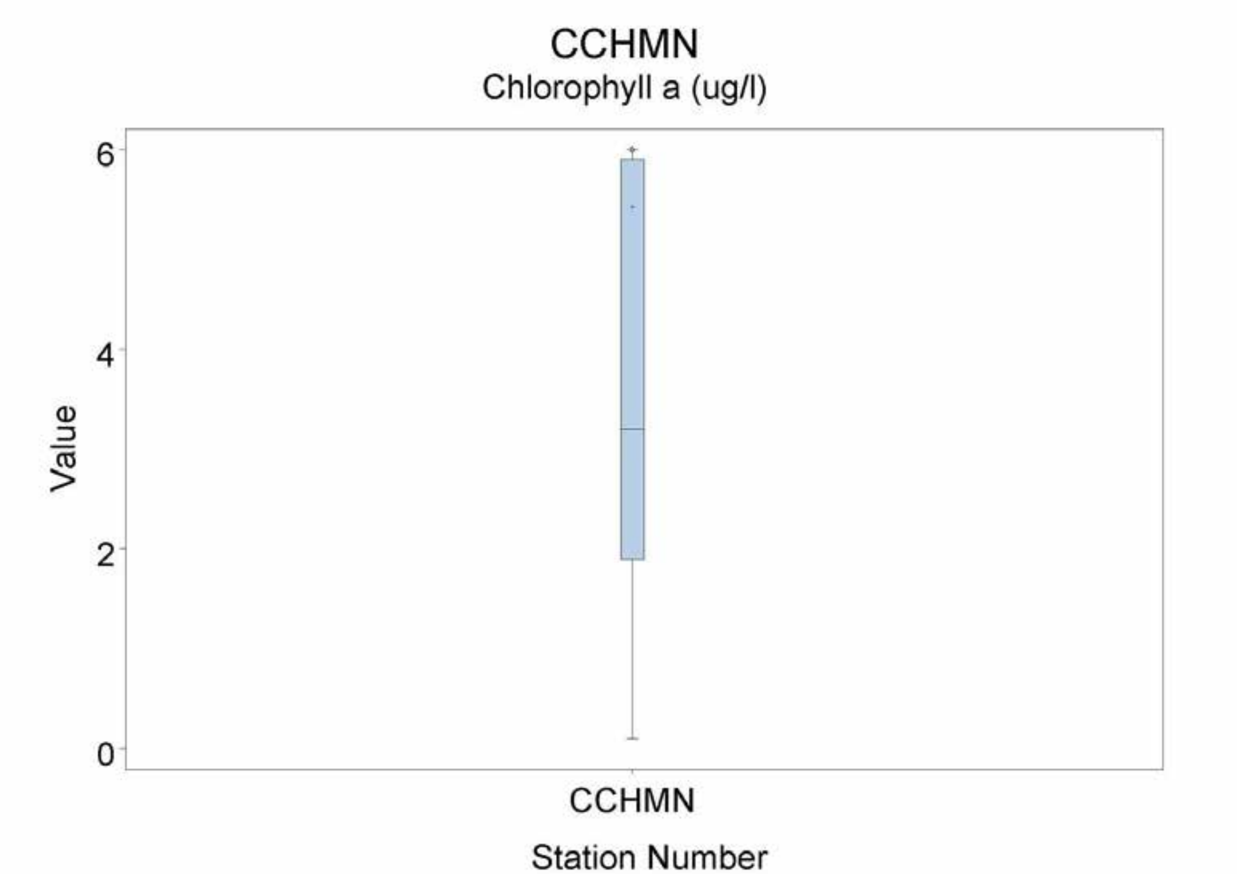


Figure 2-130. Box and Whisker Plots Displaying Chlorophyll a Distributions for CCHMN Randomly Selected Stations in Matlacha Pass

Time series plots of Chl *a* concentrations indicate considerable variability in annual average chlorophyll concentrations (Figure 2-131).

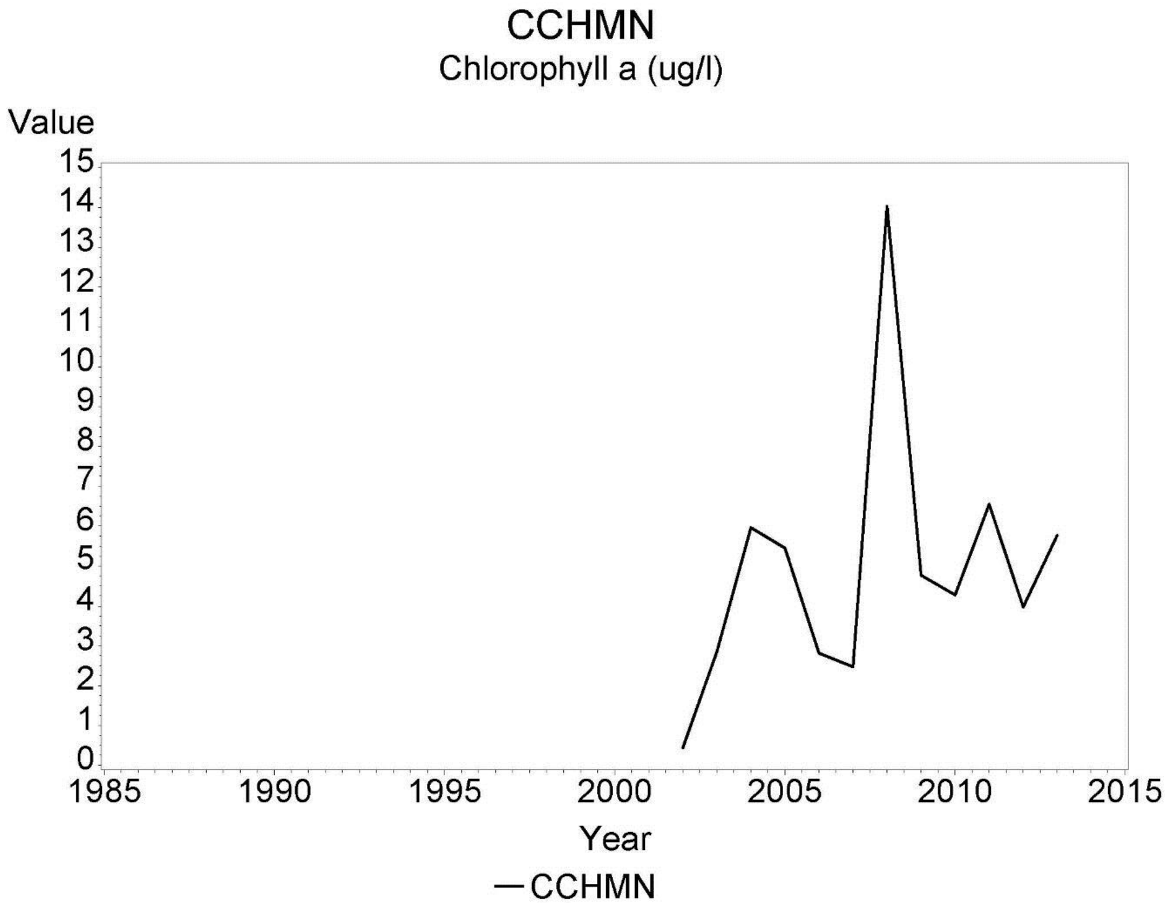


Figure 2-131. Time Series Plot of Chlorophyll a for CCHMN Randomly Selected Stations in Matlacha Pass

Trends for Chl *a* measurements for CCHMN stations are displayed in Figure 2-132. Statistical analysis suggest that there was no time series trend in Chl *a* concentrations for the period between 2002 and 2013. Note that these data are averaged across all samples within the stratum on a monthly basis. The station location is depicted as a single point to represent the trend result.

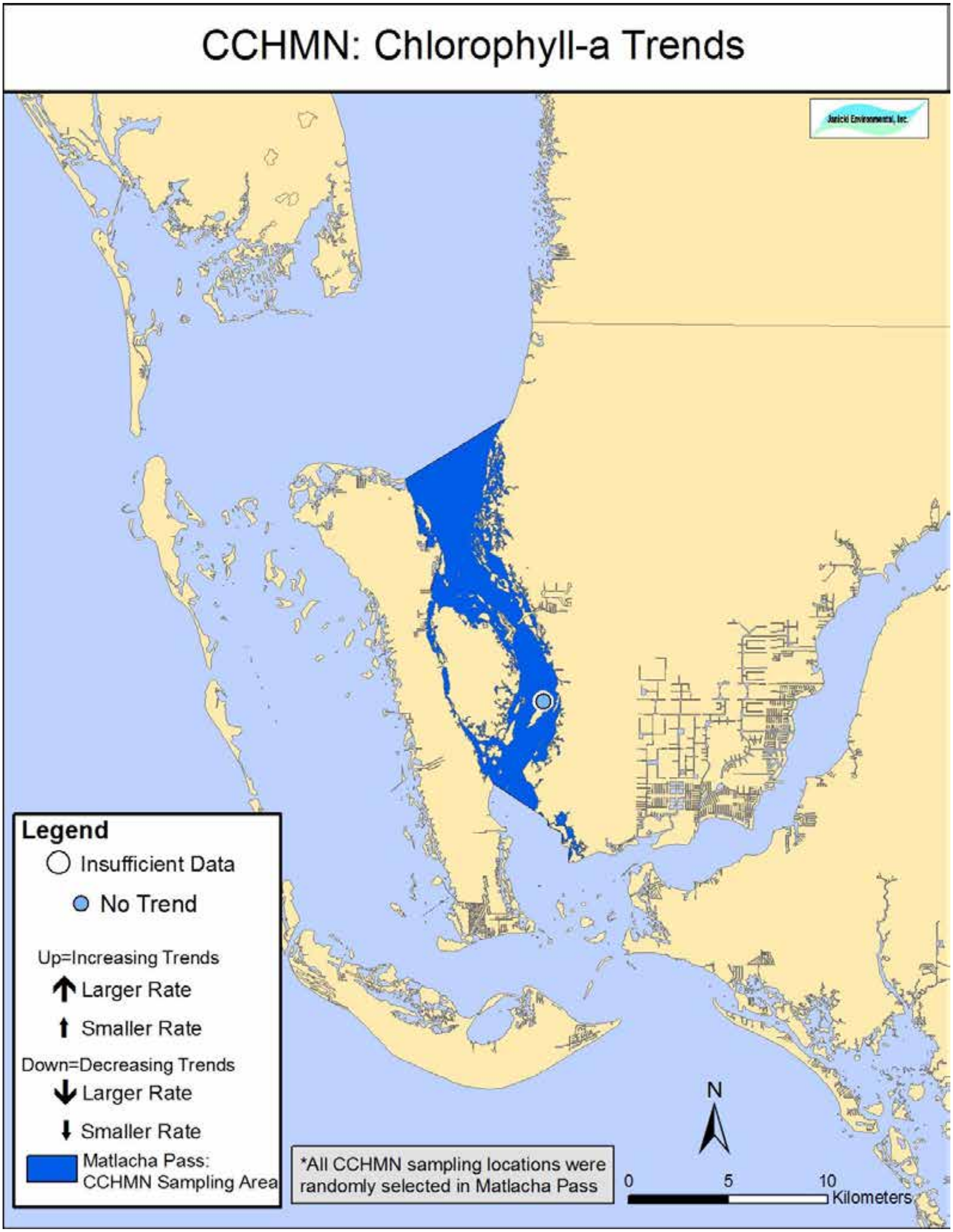


Figure 2-132. Chlorophyll a Trends for CCHMN Randomly Selected Stations in Matlacha Pass

2.5.6 TURBIDITY

Turbidity has been routinely sampled by CCHMN since 2002 at randomly selected stations in Matlacha Pass (Table 2-72).

Table 2-72. Turbidity Sampling Frequency by Station for CCHMN Randomly Selected Stations in Matlacha Pass

Year	Station CCHMN
2002	45
2003	55
2004	47
2005	56
2006	54
2007	60
2008	57
2009	54
2010	60
2011	55
2012	60
2013	55
Total	658

A box and whisker plot of turbidity values is displayed in Figure 2-133. This plot represents the entire period of record examined (2002-2013). At least 75 percent of the values were below 2.3 NTU.

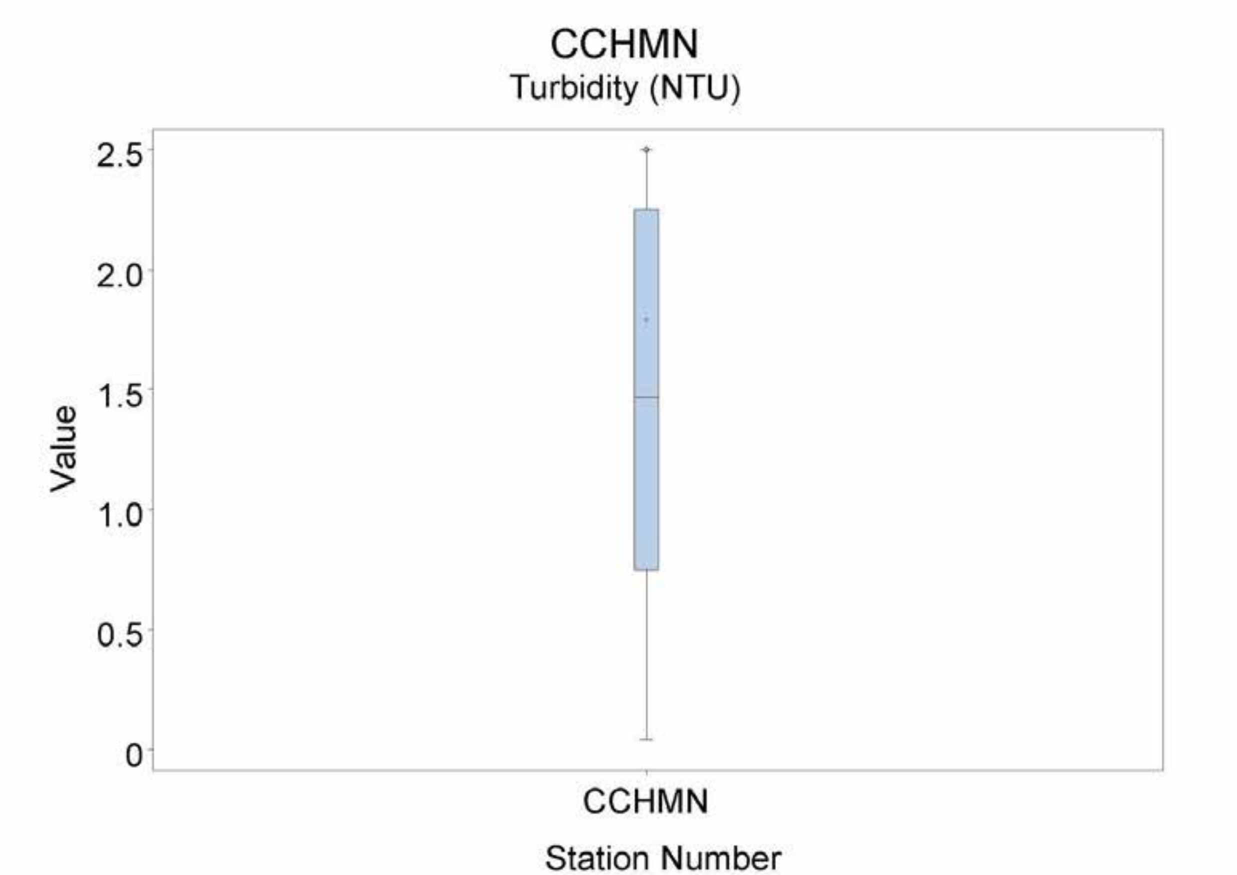


Figure 2-133. Box and Whisker Plots Displaying Turbidity Distributions for CCHMN Randomly Selected Stations in Matlacha Pass

Time series plots of annual average turbidity concentrations indicate that averages seem to be increasing in a long-term trend (Figure 2-134), however, the magnitude of the values are small overall and are not generally indicative of water quality problems.

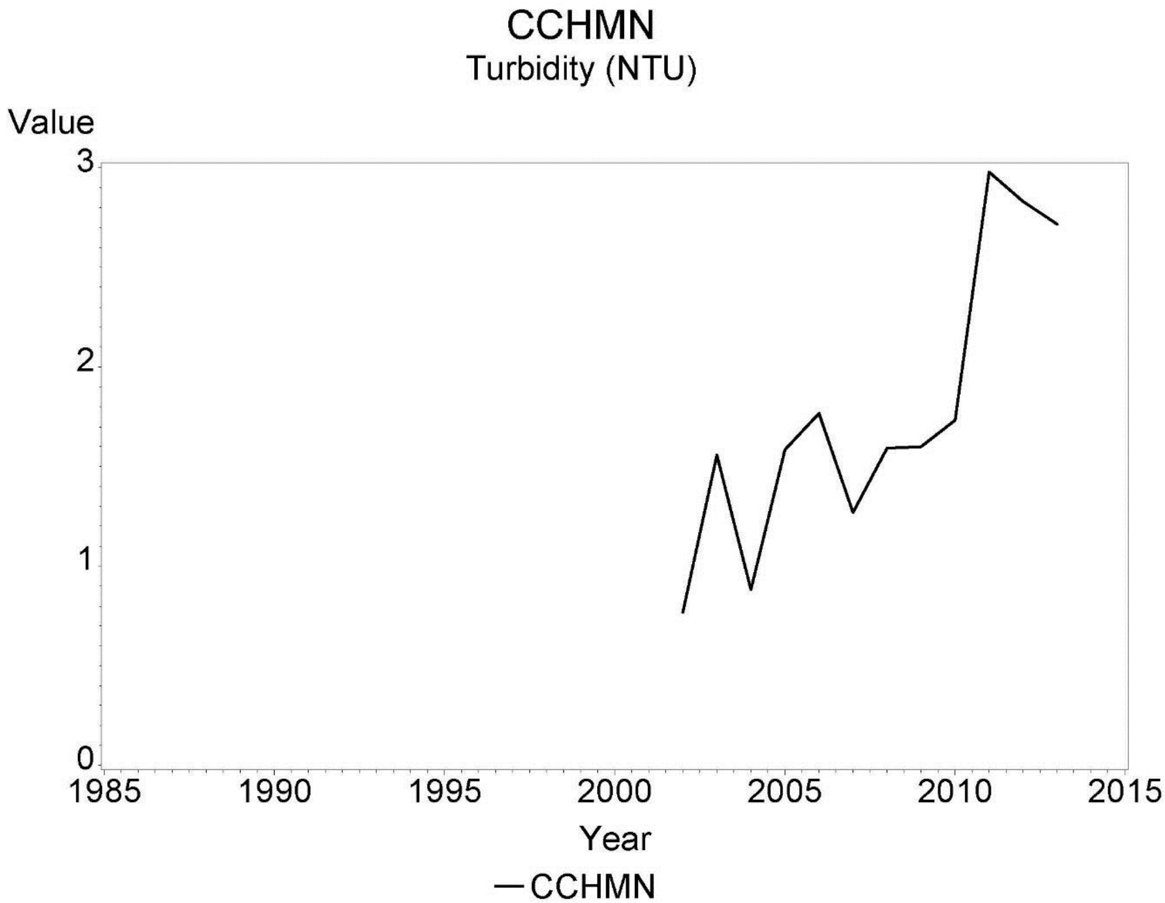


Figure 2-134. Time Series Plot of Annual Average Turbidity for CCHMN in Matlacha Pass

The time series trend for turbidity concentrations for CCHMN stations are presented in Figure 2-135. A significant increasing trend in turbidity was identified between 2002 and 2013. Note that these data are averaged across all samples within the stratum on a monthly basis. The station location is depicted as a single point to represent the trend result.

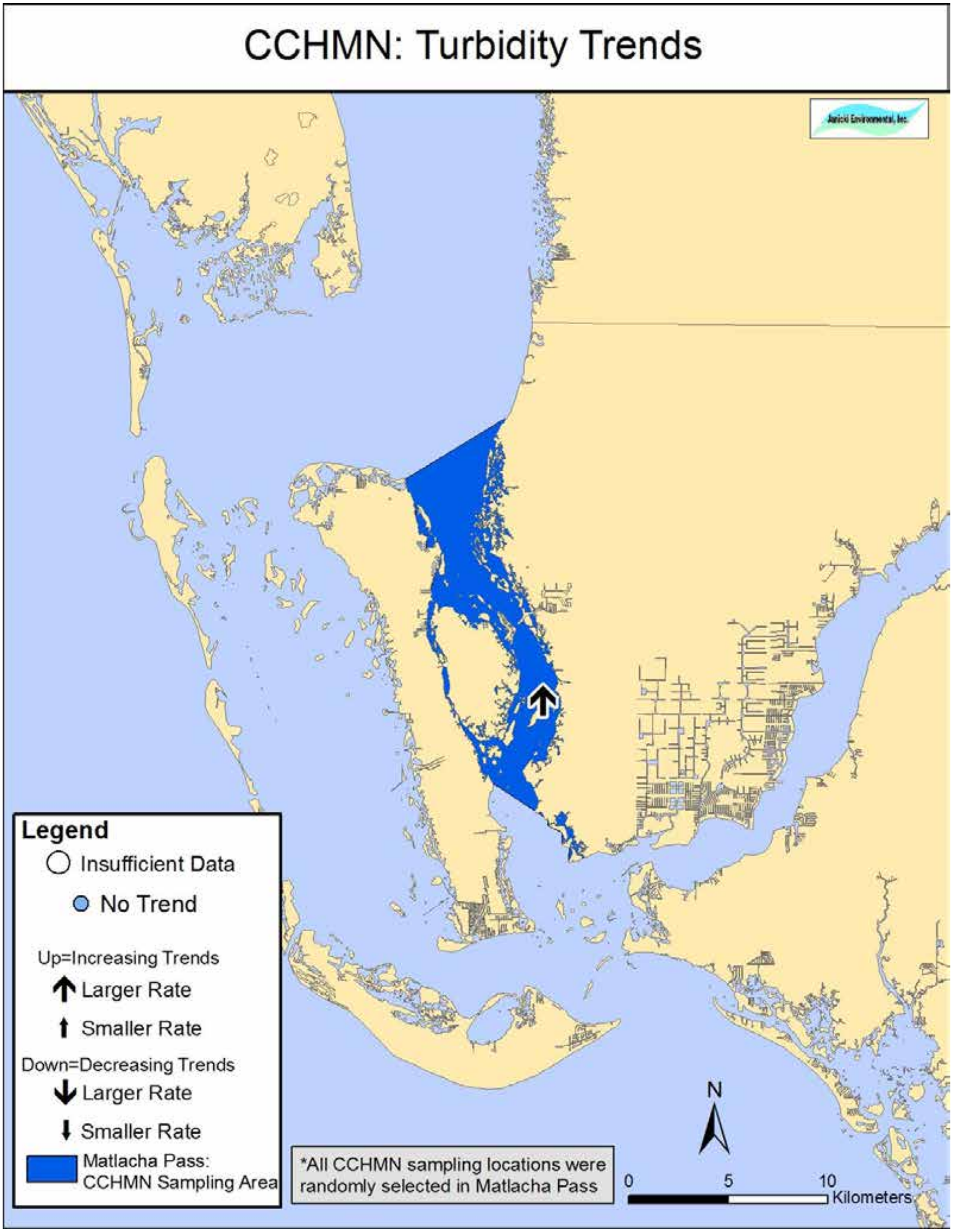


Figure 2-135. Turbidity Trends for CCHMN Randomly Selected Stations in Matlacha Pass

2.5.7 TOTAL SUSPENDED SOLIDS

TSS have been routinely sampled by CCHMN since 2002 in Matlacha Pass (Table 2-73).

Table 2-73. Total Suspended Solids Sampling Frequency by Station for CCHMN Randomly Selected Stations in Matlacha Pass

Year	Station CCHMN
2002	35
2003	55
2004	50
2005	55
2006	59
2007	59
2008	56
2009	55
2010	60
2011	55
2012	60
2013	55
Total	654

A box and whisker plot of TSS concentrations is displayed in Figure 2-136. This plot represents the entire period of record examined (2002-2013). At least 75 percent of the values in each randomly selected station were below 15 mg/L. This plot is trimmed such that extremely high values are not displayed.

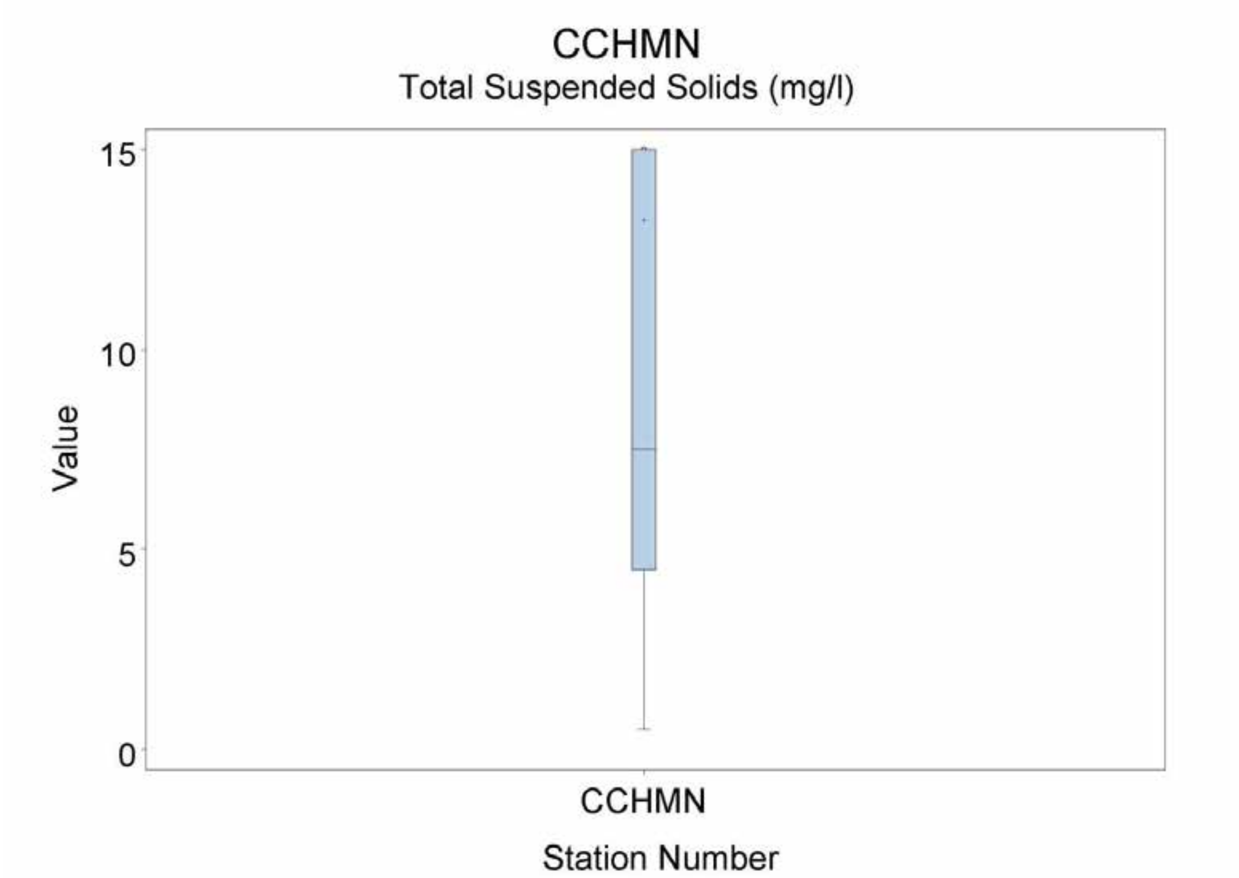


Figure 2-136. Box and Whisker Plots Displaying Total Suspended Solids Distributions for CCHMN Randomly Selected Stations in Matlacha Pass

Time series plots of TSS concentrations are displayed in Figure 2-137.

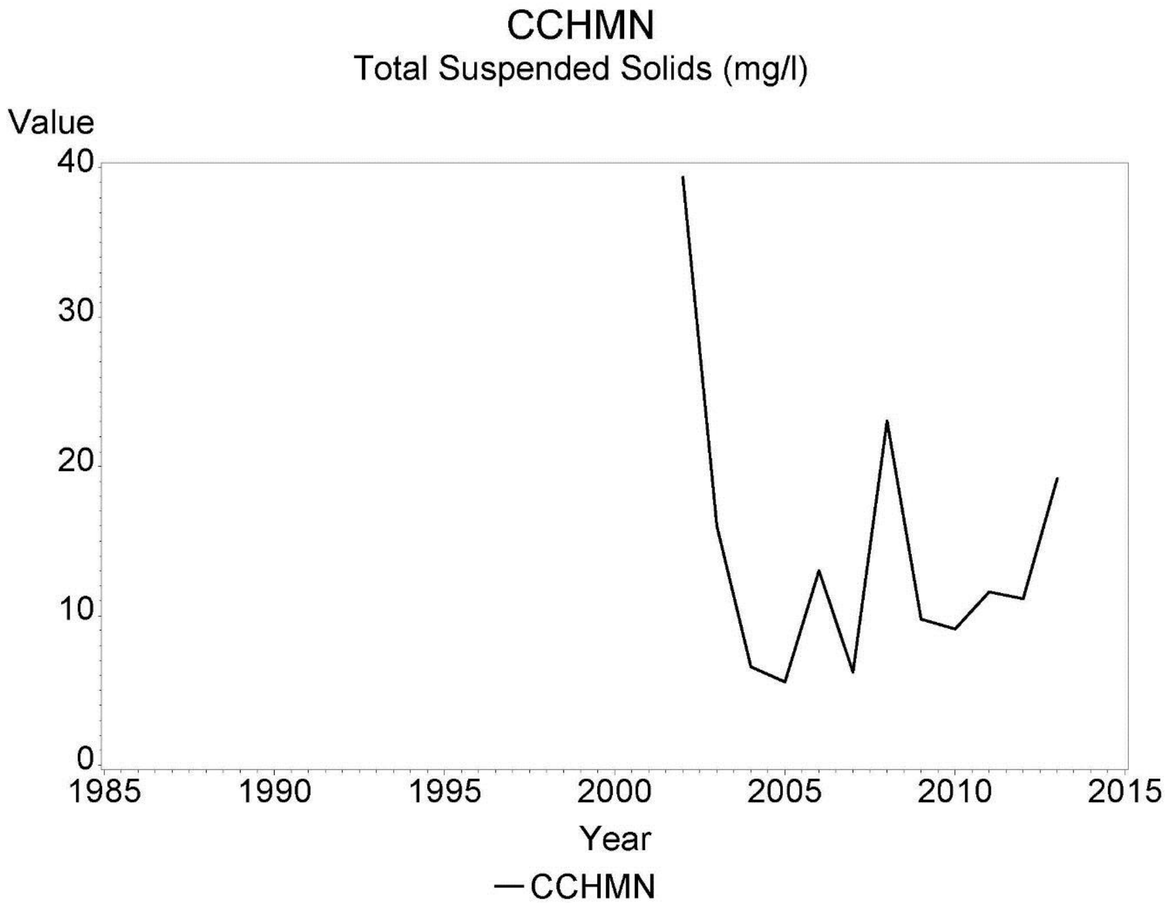


Figure 2-137. Time Series Plot of Total Suspended Solids for CCHMN Randomly Selected Stations in Matlacha Pass

Trends for TSS concentrations for CCHMN stations are displayed in Figure 2-138. A significant increasing trend in TSS was identified in measurements from 2002-2013. Note that these data are averaged across all samples within the stratum on a monthly basis. The station location is depicted as a single point to represent the trend result.

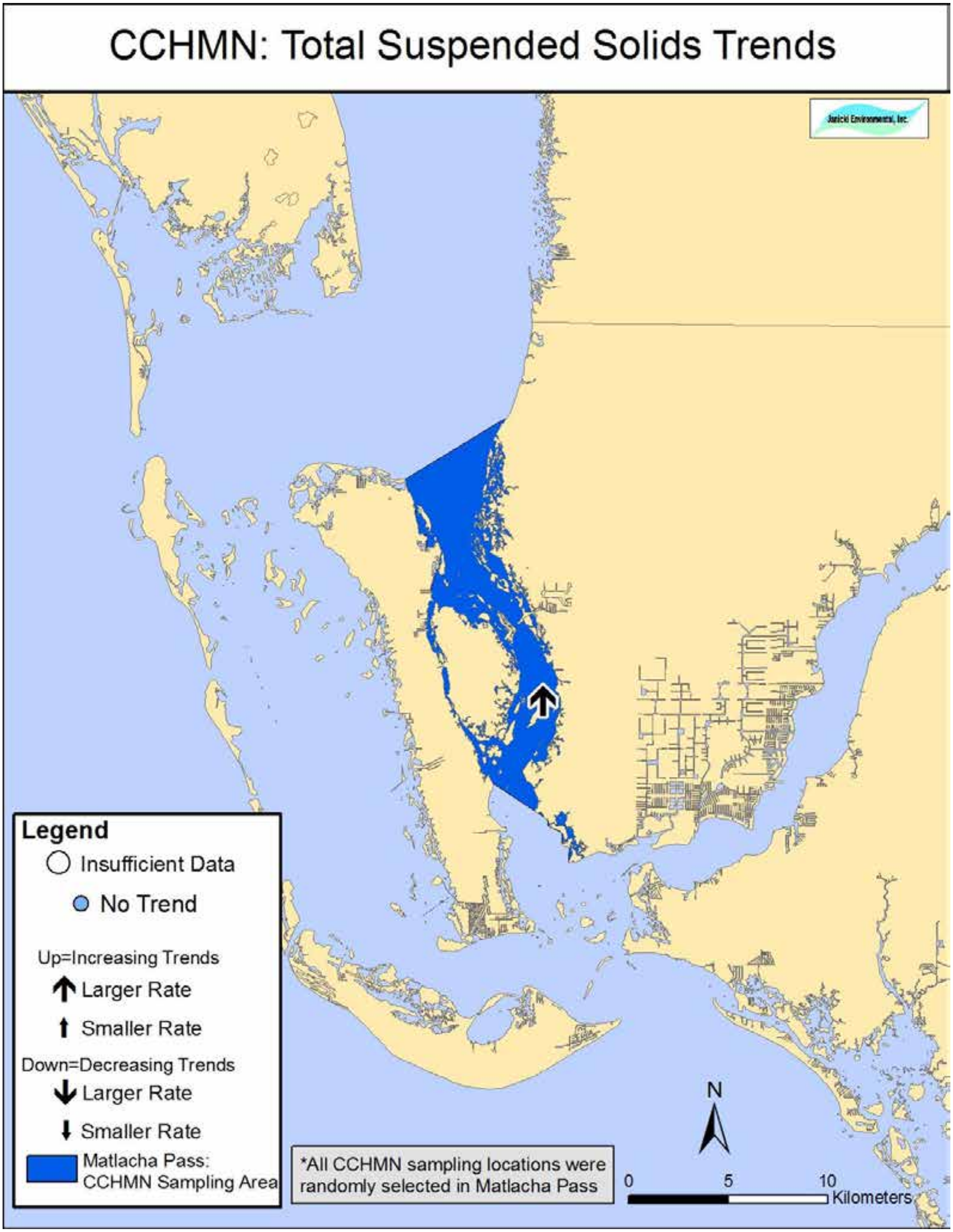


Figure 2-138. Total Suspended Solids Trends for CCHMN Randomly Selected Stations in Matlacha Pass

3.0 CAPE CORAL FLOWS AND LOADS

The U.S. Geological Survey (USGS) has maintained four flow and gage height stations at the weir structures which discharge into the NSC system including, from north to south: Gator Slough (USGS 02293264); Horseshoe Canal (02293346); Hermosa Canal (02293347), and Shadroe Canal (02293345) (Figure 3-1).

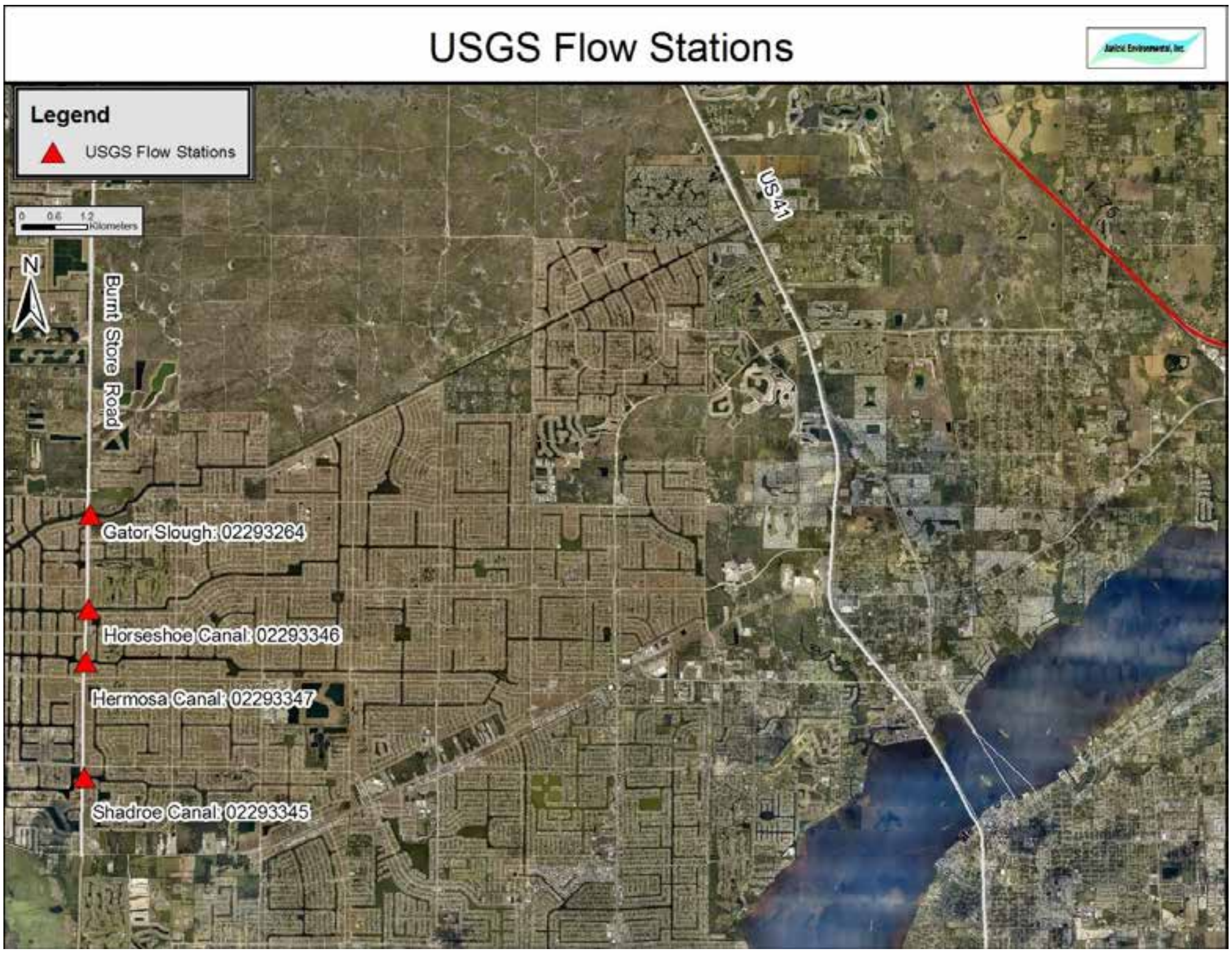


Figure 3-1. USGS Flow Stations

The following paragraph describing the Gator Slough Watershed was taken from the Lee County website.

> The Gator Slough Watershed includes portions of Charlotte and Lee Counties. This watershed covers an area of approximately fifty-five square miles with much of the watershed's upstream area within the Webb Wildlife Management Area in

Charlotte County. Surface water in Gator Slough Watershed in the vicinity of I-75, the Lee/Charlotte County line and the abandoned railroad grade intermingles with Powell Creek (a tributary to the Caloosahatchee River) surface water. The co-mingled waters then part again one and one-half miles to two miles south of Lee County's northern boundary. Water flowing west remains in the Gator Slough Watershed, and water flowing south is conveyed into Powell Creek. Within the Gator Slough watershed as it enters the eastern portion of the Spreader Canal, there are several branches that convey water south from Gator Slough into the network of canals. Thereby, flows recorded in Horseshoe and Hermosa Canals are likely influenced by flows coming down Gator Slough. Shadroe Canal seems to be less directly connected to Gator Slough and appear to convey water trapped on the north side of Pine Island Road.

3.1 FLOWS

Gator Slough has the longest period of record of daily flow data, beginning in 1984. Flows over that period of record have ranged from 0 to 1,400 cubic feet per second (cfs) (Figure 3-2). Note that a data gap exists in the period of record between October 1, 1997 and June 14, 2000. No flows over the structure occurred on 10 percent of the days when measurements were taken and 50 percent of the data were at or below 14 cfs. Only 10 percent of the values were above 138 cfs, and 1 percent of the values were above 438 cfs.

Horseshoe Canal is located in the first major canal running east-west, south of Gator Slough. Flows at Horseshoe Canal have been measured since 1987, although a data gap exists between October 1, 2004 and September 30, 2006 (Figure 3-3). Flows from Horseshoe Canal ranged from 0 to 1,060 cfs. Flows from Horseshoe Canal were zero 10 percent of the time and less than 6.3 cfs 50 percent of the time. Only 5 percent of the discharge values were above 91 cfs and above 200, less than 1 percent of the time.

Hermosa Canal is located south of Horseshoe Canal. Flows have been measured continuously at Hermosa Canal since 1987 with no data gaps. Flows from Hermosa Canal ranged from 0 to 1,040 cfs (Figure 3-4). Flows from Hermosa Canal were zero 10 percent of the time and less than 7.0 cfs 50 percent of the time. Only 5 percent of the discharge values were above 85 cfs and above 200, less than 1 percent of the time.

Shadroe Canal is the southernmost of the major canals within the NSC network. Flows have been measured continuously at Shadroe Canal since 1987, with a 1-month data gap between June 17 and July 21, 2008. Flows from Shadroe Canal ranged from 0 to 1040 cfs (Figure 3-5). Flows from Hermosa Canal were zero 10 percent of the time and less than 4.0 cfs 50 percent of the time. Only 5 percent of the discharge values were above 35 cfs and above 122 cfs, less than 1 percent of the time.

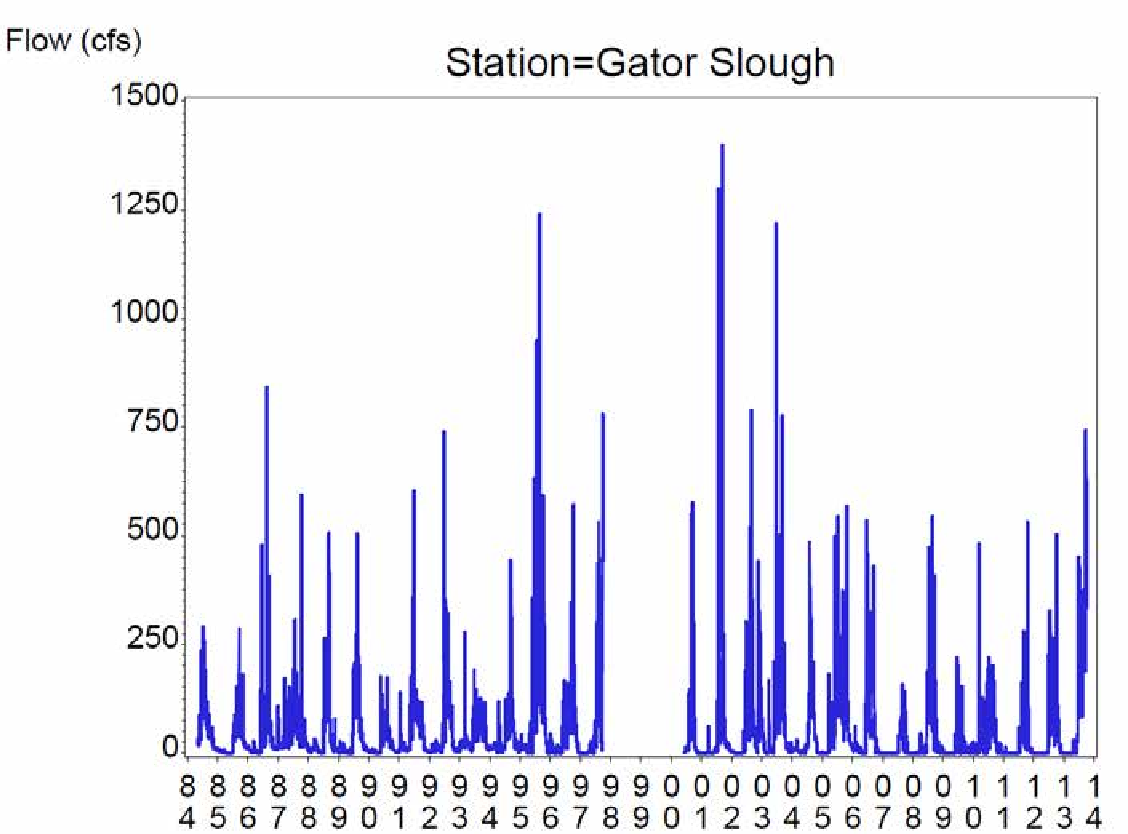


Figure 3-2. Gator Slough Flows

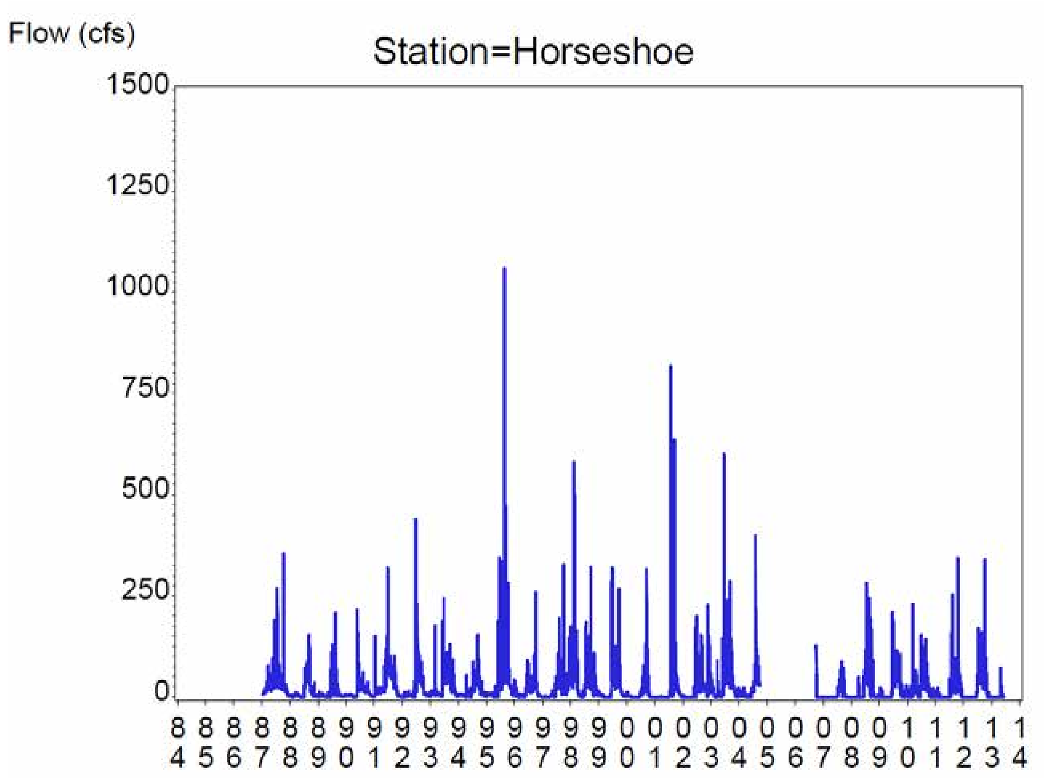


Figure 3-3. Horseshoe Canal Flows

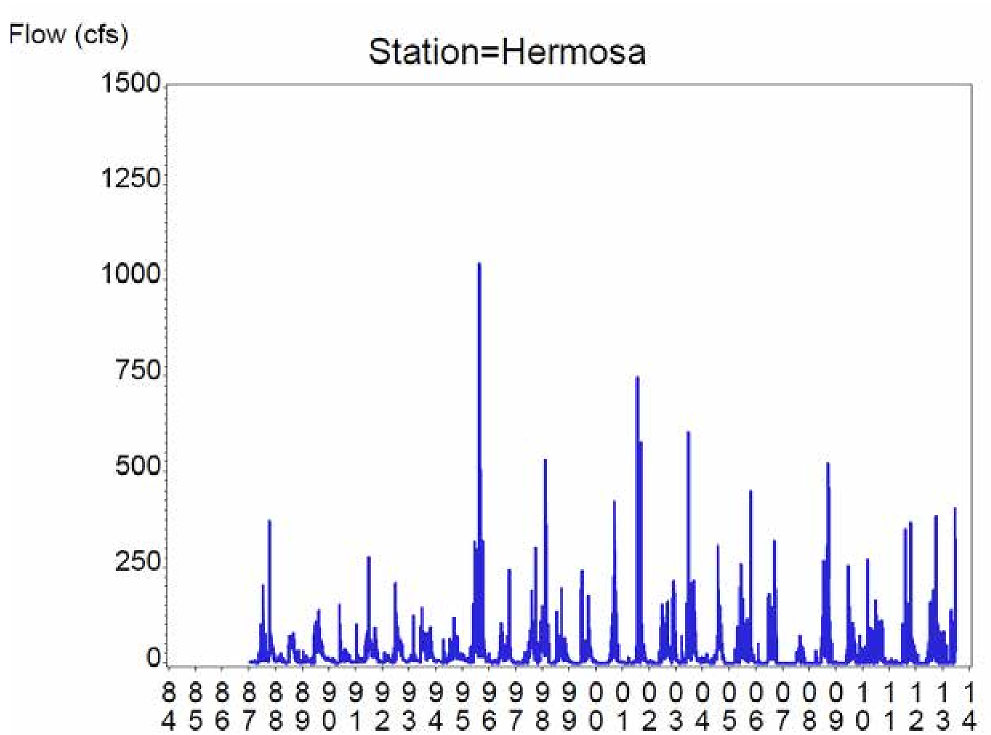


Figure 3-4. Hermosa Canal Flows

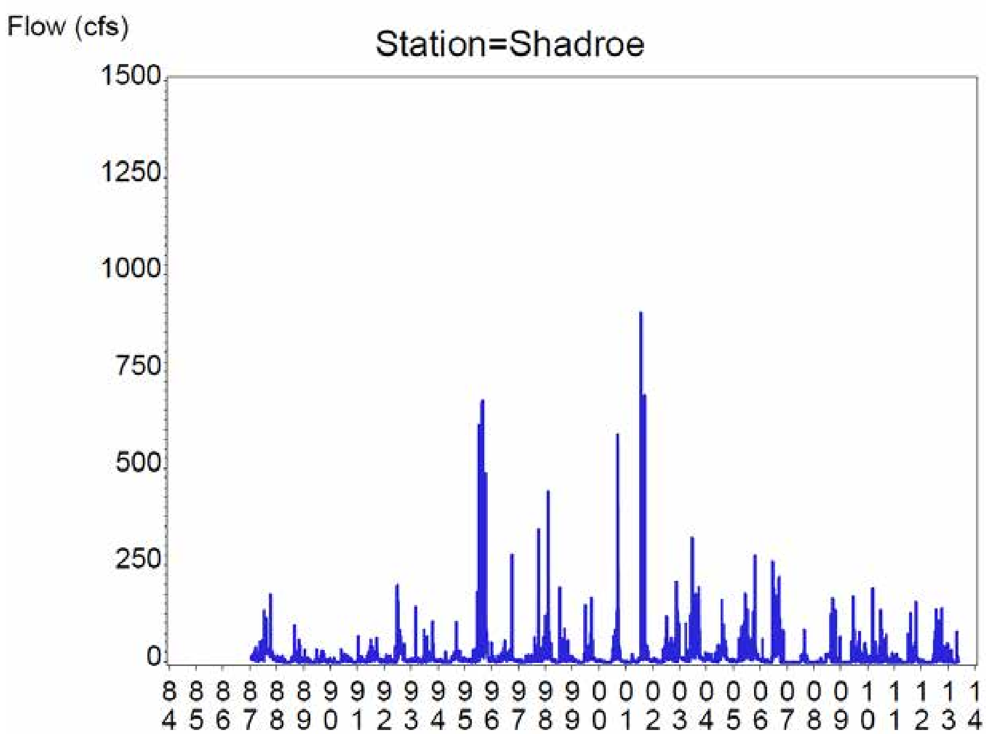


Figure 3-5. Shadroe Canal Flows

3.2 LOADS

Utilizing the monthly averages of measured flows, along with available measured concentrations above the weir structures, estimates of the loads for nutrients (TN and TP) were calculated for the period of record of flow. The measured concentrations represent monthly sampling above the weirs so that the loads are estimates, with the assumption that the overall concentrations do not change significantly and the measured monthly values are representative of the averages for that month. Where no concentration data were available for any month, no load was calculated. For the period of record, there were no long-term stations located above the weir structure at Shadroe Canal, therefore no loads were calculated over this weir for any portion of the flow period of record.

Figures 3-6 through 3-11 present the TN and TP loads respectively for Gator Slough, Horseshoe Canal, and Hermosa Canal. The plots show that overall Gator Slough represents the bulk of the nutrient load coming into the system. For both TN and TP Gator Slough on average carries upwards of 50% of the load coming into the system.

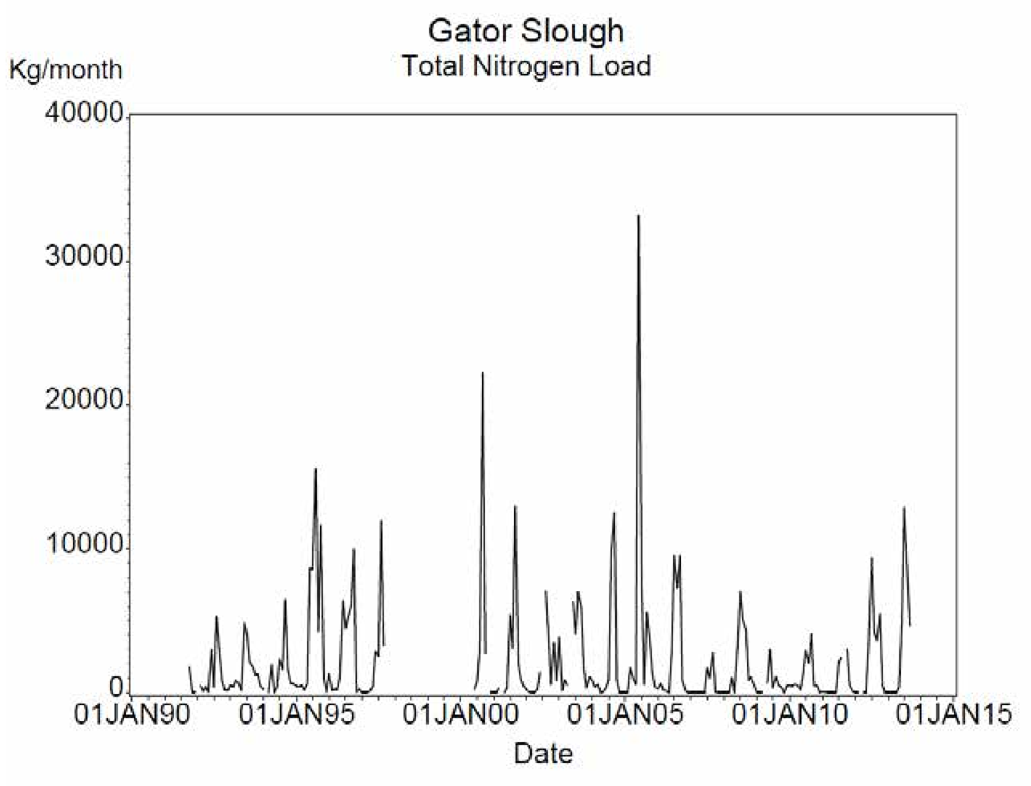


Figure 3-6. Estimated TN Load from Gator Slough

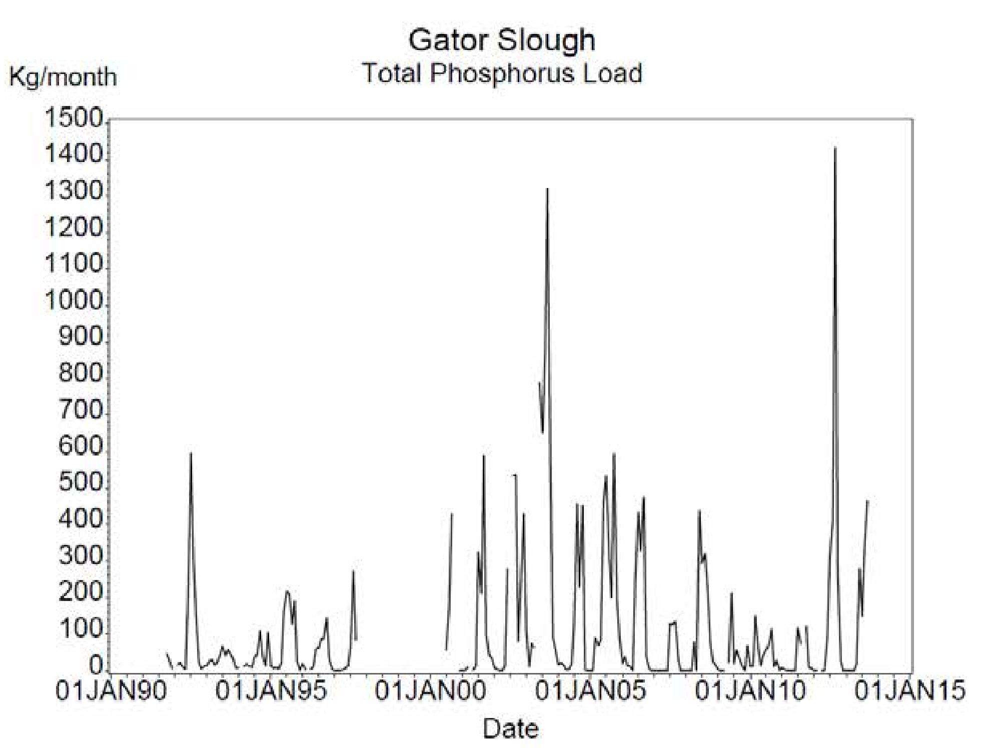


Figure 3-7. Estimated TP Load from Gator Slough

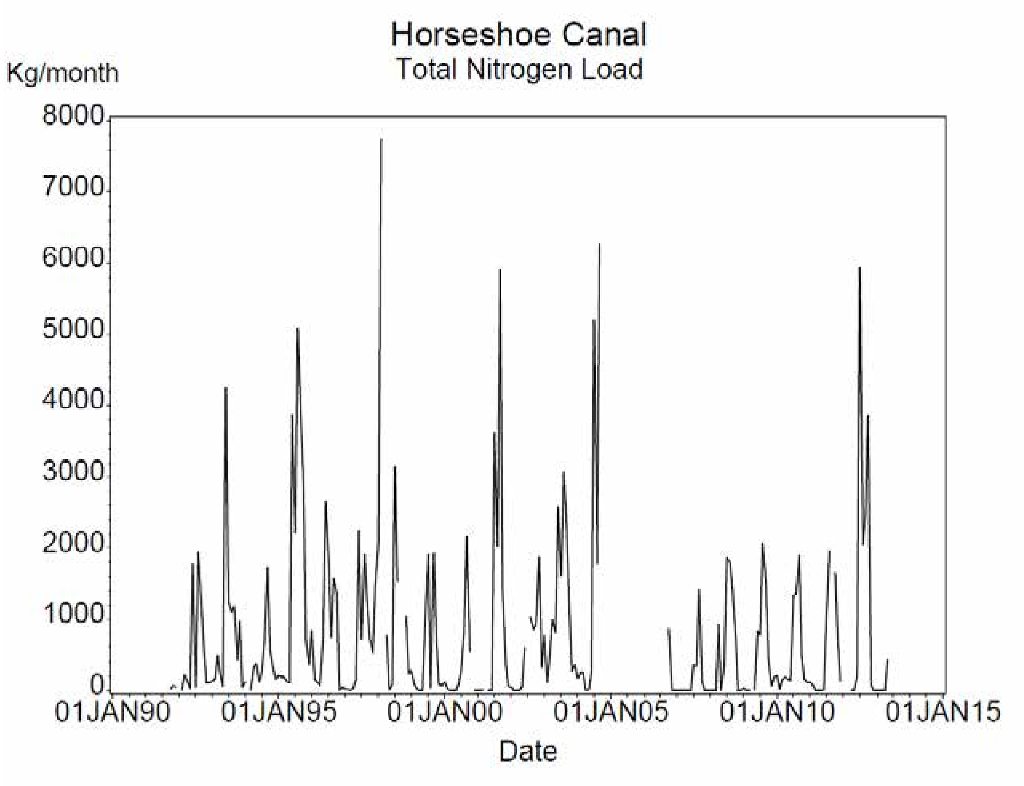


Figure 3-8. Estimated TN Load from Horseshoe Canal

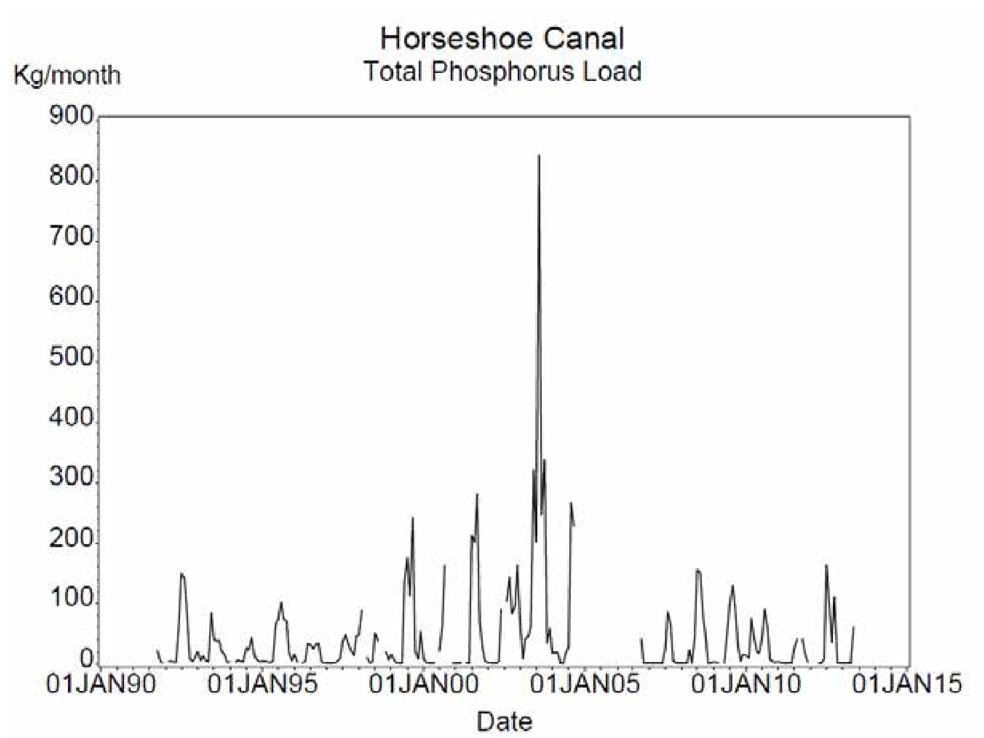


Figure 3-9. Estimated TP Load from Horseshoe Canal

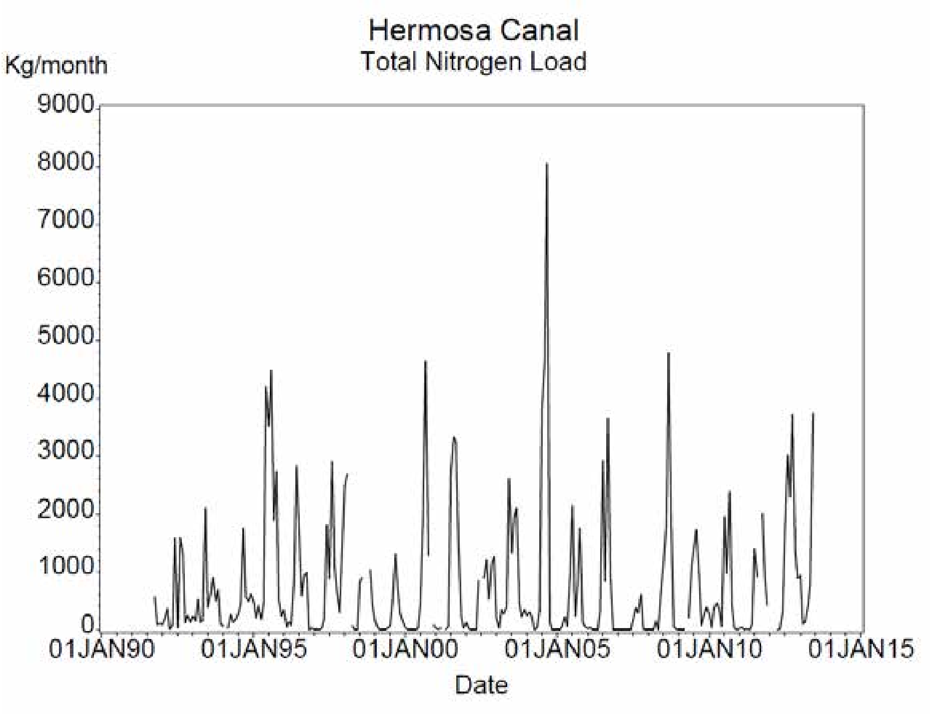


Figure 3-10. Estimated TN Load from Hermosa Canal

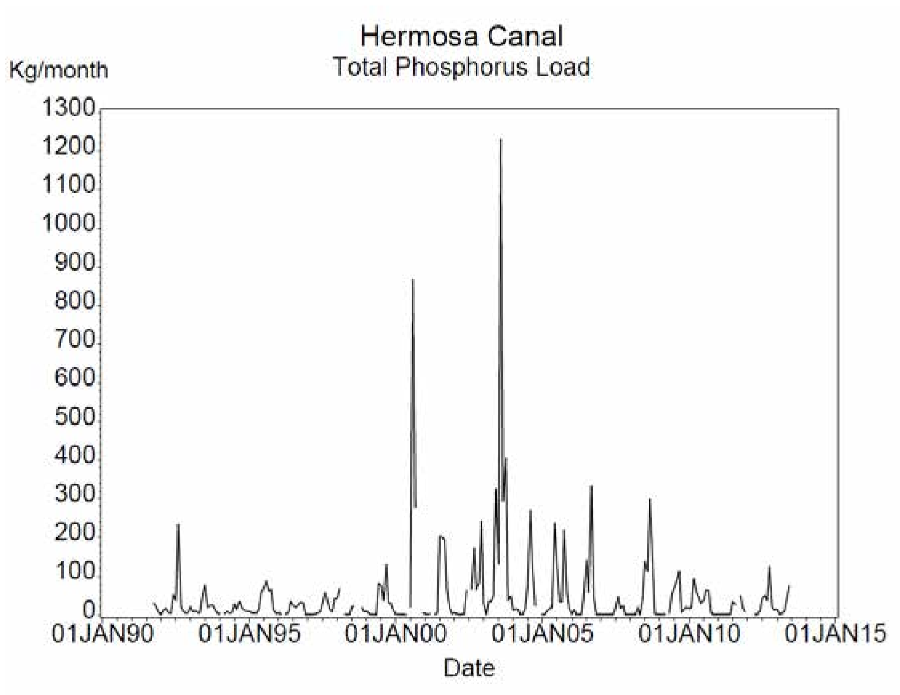


Figure 3-11. Estimated TP Load from Hermosa Canal

4.0 SUMMARY

This report provides a detailed spatial and temporal description of existing water quality data collected within the Cape Coral NSC and Matlacha Pass. This 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 a follow on report, the relationships between water quality in the NSC upstream of the weirs and water quality in the downstream receiving waterbodies will be evaluated to identify potential stressor response relationships and identify key water quality indicators that may be used to evaluate the effects of the NSC on downstream water quality. Additionally, the available water quality data will be assessed against presently adopted criteria for key parameters.

NW Cape Coral/Lee County Watershed Initiative
Phase I
Water Quality and Biological Indicators

Lee County, Florida

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June 2015

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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 four 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

The report presented herein has the following goals:

- 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.

1.3 REPORT OUTLINE

Following this introduction, the report is broken down into four sections. Section 2 presents the key water quality indicators and targets. Section 3 presents comparisons of ambient water quality against the proposed targets. Section 4 presents the key biological indicators and targets.

2.0 KEY WATER QUALITY INDICATORS AND TARGETS

The assessment of the ecological conditions within the NSC and Matlacha Pass and the potential effects of returning the Ceitus boat lift will include an evaluation of the current status of key water quality indicators. To achieve this objective, those key water quality indicators will include the following:

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

These water quality parameters 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.

3.0 COMPARISON OF AMBIENT WATER QUALITY TO WATER QUALITY STANDARDS

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

- Freshwater
    - 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/Estuarine
    - 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

These criteria serve as the proposed targets for this project. The targets for salinity and water clarity will be based on the key biological indicators selected and their habitat requirements with regard to salinity and water clarity, as appropriate.

Table 3-1 presents the years (1991-2013) that the fresh waters within the City of Cape Coral have either passed or failed the freshwater criteria. These data were obtained from the Impaired Waters Rule (IWR) database maintained by the Florida Department of Environmental Protection (FDEP). 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.

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 fresh waters 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, the U.S. Environmental Protection Agency (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.

Table 3-1. 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%

The analyses presented in Table 3-2, where measured values in the estuarine portion of the NSC are compared to the Matlacha Pass NNC, should be understood as not representing a true evaluation against criteria, but as a preliminary assessment of the conditions. Once tidal creek NNCs are adopted, the analyses can be revisited with the appropriate criteria.

Table 3-2 presents the years (1996-2013) that the estuarine waters within the NSC have either passed or failed the Matlacha Pass NNC and the marine DO criteria. The criteria applied in this table were established specifically for Matlacha Pass. The annual average Chl *a* concentrations exceeded this criterion during 3 years of the 1996-2013 period. Non-compliance with the criterion occurs if the criterion is exceeded more than 1 year in 3. The DO standard was exceeded more than 10 percent of the time from 2007 through 2012. The TN criterion established for Matlacha Pass and applied to the NSC data was exceeded for most years from 2002 through 2013. The annual average TP concentrations from all years from 2002 through 2013 complied with the TP criterion established for Matlacha Pass.

Table 3-2. Average Annual Concentrations for Estuarine Waters within the NSC and Pass/Fail Relative to Water Quality Criteria

Year	N	Annual Averages			Pass/Fail			
		Chlorophyll	TN	TP	Chlorophyll	TN	TP	DO %Fail
1996	35	1.88	0.67	0.01	P	F	P	0%
1997	36	4.50	0.73	0.01	P	F	P	0%
1998	36	2.20	0.66	0.01	P	F	P	0%
1999	36	5.37	0.61	0.04	P	F	P	5%
2000	34	3.40	1.30	0.04	P	F	P	6%
2001	36	5.64	0.65	0.03	P	F	P	0%
2002	36	3.06	0.50	0.05	P	P	P	2%
2003	36	5.40	0.61	0.07	P	F	P	2%
2004	36	4.67	0.85	0.05	P	F	P	14%
2005	36	2.54	0.55	0.04	P	P	P	0%
2006	36	4.34	0.53	0.03	P	P	P	8%
2007	36	4.98	0.53	0.03	P	P	P	11%
2008	39	9.49	0.68	0.04	F	F	P	10%
2009	44	5.86	0.62	0.04	P	F	P	15%
2010	48	5.29	0.70	0.03	P	F	P	16%
2011	48	8.74	0.72	0.03	F	F	P	16%
2012	83	8.51	1.13	0.04	F	F	P	14%
2013	112	4.83	0.86	0.03	P	F	P	8%

Table 3-3 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 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 percent 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.

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 fresh waters nor strictly estuarine (Janicki Environmental, 2011). Therefore, applying the current 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. The current NNC should therefore be viewed as targets until tidal creek NNCs are adopted.

Table 3-3. 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%

4.0 KEY BIOLOGICAL INDICATORS AND TARGETS

FDEP conducted a survey of biological conditions in the NSC in 2011 (Appendix A). The existing conditions at seven locations within and near the NSC were described, including bottom types, benthic invertebrates, seagrasses, mangroves, and macroalgae. The general conclusion was that these areas supported a relatively diverse biota typical of estuarine conditions in southwest Florida.

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.

4.1 SEAGRASSES

Seagrass targets have been established for Matlacha Pass by the Charlotte Harbor National Estuary Program (CHNEP) (Janicki et al., 2009). Establishment of seagrass targets provides a necessary basis for management decisions regarding water quality and other issues that can influence the distribution and persistence of this valuable submerged habitat. 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. Historical photographs of the area were taken around 1950. Since many alterations have occurred to the shoreline and water bottom in the study area, the target setting took these changes into account as non-restorable areas. Additionally, trends in seagrass coverage were identified throughout the CHNEP, based on recent aerial surveys. These analyses were not an assessment of the quality of seagrasses currently or historically present in Charlotte Harbor, nor were they intended to identify causal explanations for the observed changes in seagrass distribution over time.

Figure 4-1 presents the historical distribution of seagrasses in Matlacha Pass. Figure 4-2 presents the areal seagrass coverage during the historical (ca. 1950) and recent years (2009, 2003, 2004, and 2006). Figure 4-3 presents the recent persistence (1999, 2003, 2004, and 2006) of seagrass cover in Matlacha Pass.

Matlacha Pass
1950 Seagrass

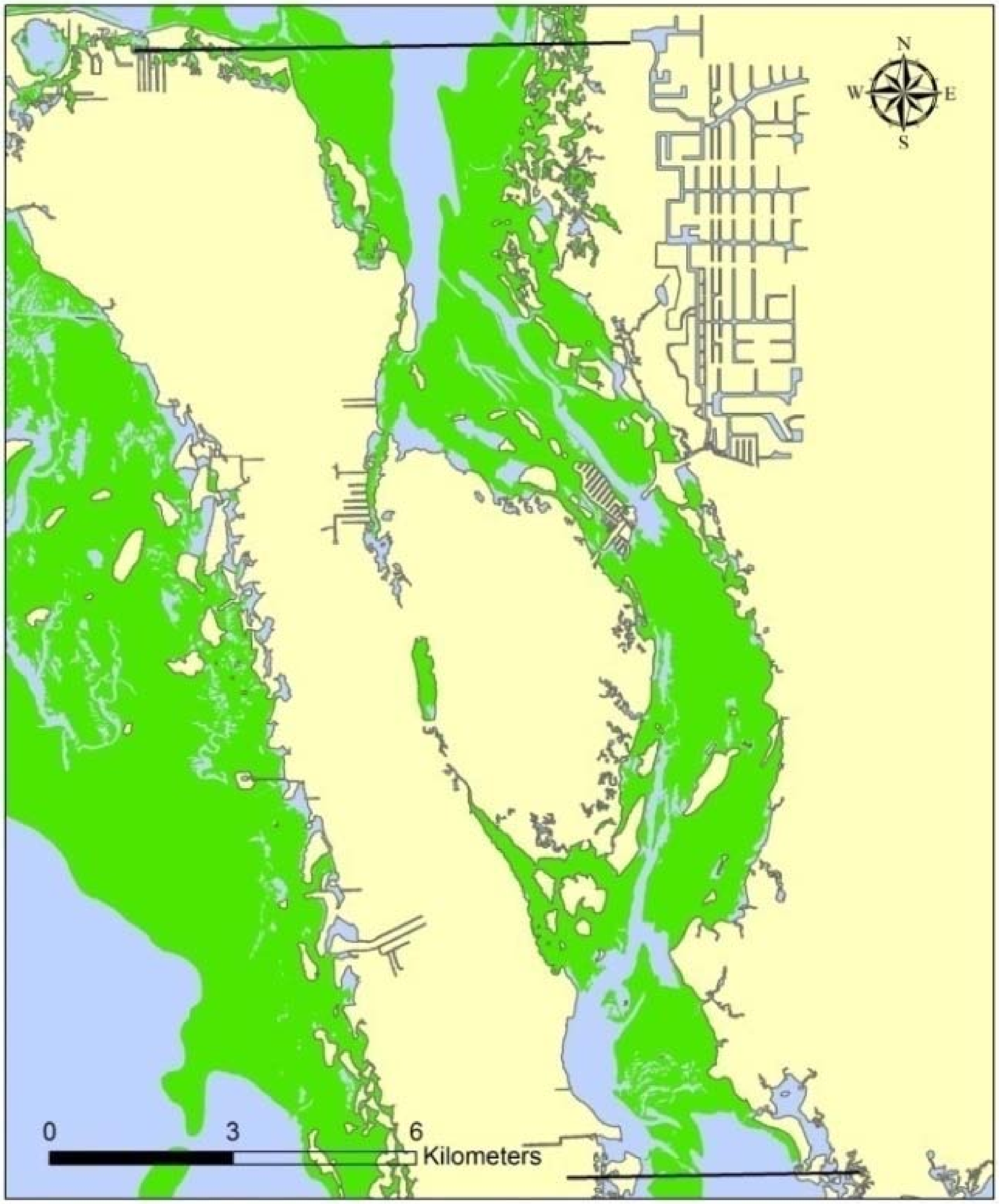

Figure 4-1. Historical Seagrass Coverage in Matlacha Pass

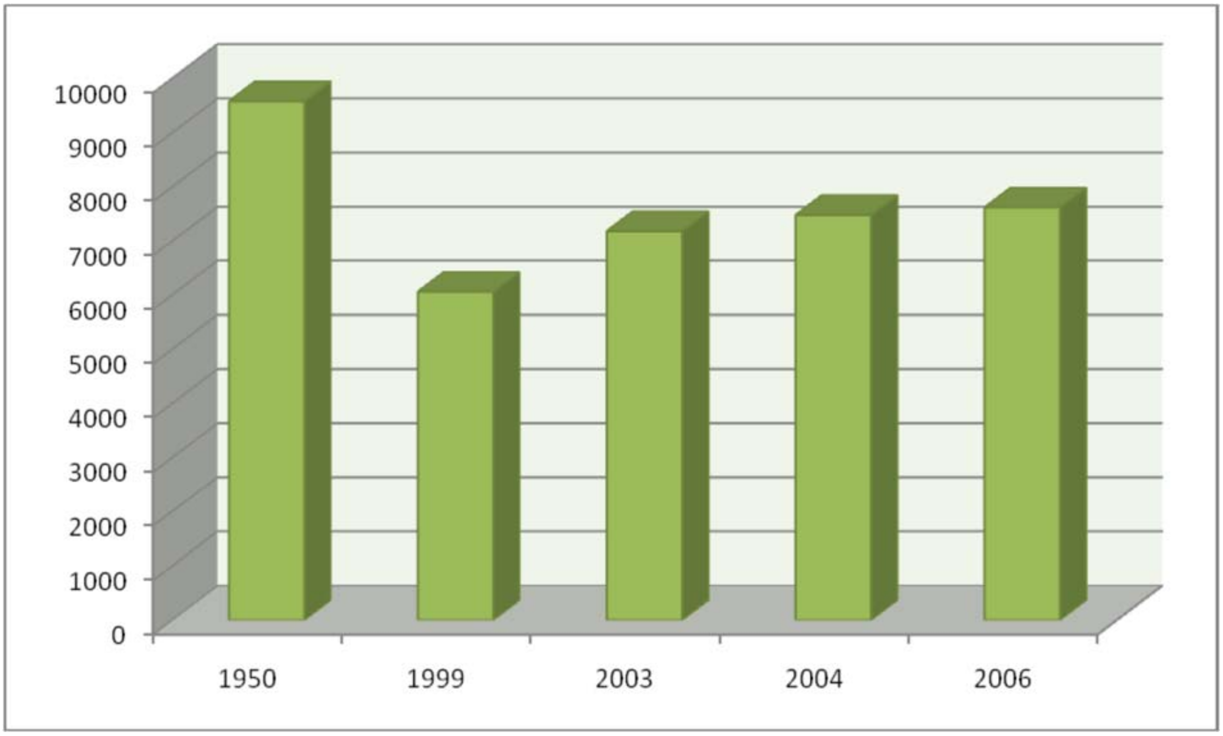

Figure 4-2. Seagrass Coverage in Matlacha Pass

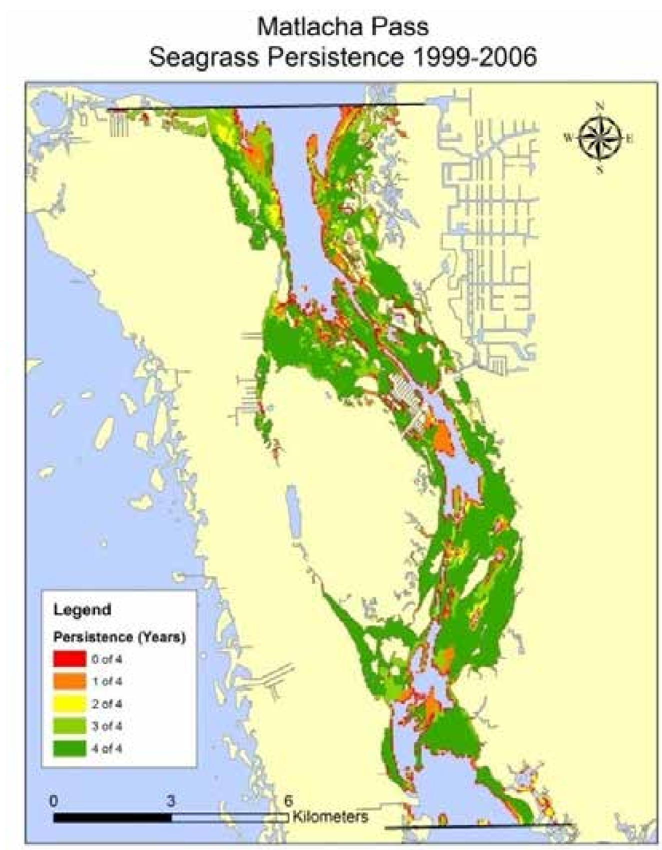

Figure 4-3. Recent Persistence of Seagrass Coverage in Matlacha Pass

The CHNEP seagrass targets for Matlacha Pass are:

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

The seagrasses in Matlacha Pass and the immediate vicinity of the NSC were mapped in 2008 (Figure 4-4). This most recent (2008) seagrass coverage is proposed as the seagrass target for the project. To achieve this target, two key water quality indicators must be within the ranges adequate for the typical seagrasses in this area – *Halodule wrightii* and *Thallassia testudinum. Thallassia* is generally considered as being stenohaline, with optimal salinity ranging from 24 to 35 parts per thousand (ppt) (Mazzotti et al., 2007). The optimal salinity for *Halodule* is greater than 20 ppt (Mazzotti et al., 2007). Table 4-1 presents other reported salinity tolerances and optimal salinities for *Halodule* and *Thallassia.*

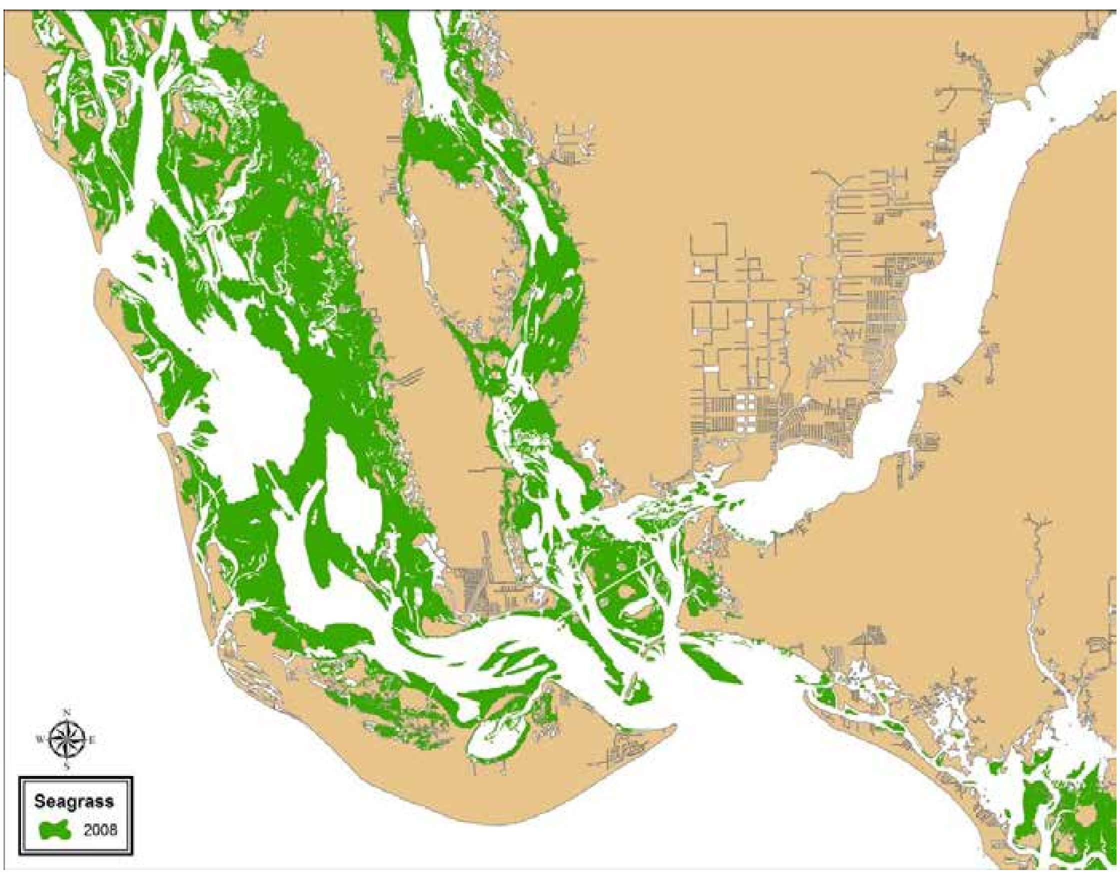

Figure 4-4. 2008 Seagrass Coverage in Matlacha Pass

Table 4-1. Salinity Tolerances and Salinity Optima for *Halodule* and *Thallassia*

Scientific Name	Salinity Tolerance (ppt)	Optimal Salinity (ppt)	Sources: Salinity Tolerance and Optimal Salinity
Halodule wrightii	21 – 35 25 – 50 <5 - 80	22 - 31 30 – 36 23 – 37	Pulich, 1985 McMillan, 1974 Childress et al., 1975 White et al., 1989; TPWD, 1990a(3)
Thalassia testudinum	10 - 50 50 -55 (upper limit)	33 – 38	Phillips, 1960 McMillan, 1974 SFWMD website, 2002

It can be seen that both of these seagrasses have relatively wide salinity tolerances, which is not surprising given their typical habitat conditions. The seagrasses have shown the ability to withstand salinity variations since their primary mode of growth is by expansion of their root systems that are not exposed to the same variation in salinity as the above-ground plant parts. Given this information, the proposed salinity target for seagrasses is an annual average salinity that ranges from 20 to 35 ppt.

Dixon and Wessel (2014) recently reported segment-specific diffuse attenuation coefficient K_{dPAR} ranges for CHNEP. For Matlacha Pass, this range is 0.62 (30th percentile) and 0.92 (70th percentile). Therefore, the proposed light target to support seagrasses is based on the Dixon and Wessel Water Quality Estimating Tool.

4.1.1 SEAGRASS CONCLUSIONS

- The CHNEP seagrass targets for Matlacha Pass proposed for this project are as follows:
  - Protection Target – 7,582 acres
  - Restoration Target – 1,733 acres
  - Total Target – 9,315 acres
- The proposed salinity target for seagrasses is an annual average salinity that ranges from 20 to 35 ppt.
- 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).

4.2 OYSTERS AND OTHER BENTHIC INVERTEBRATES

Oysters compose a significant component of the estuarine ecosystem in and around the NSC. They have often been used as indicator organisms, given their sessile nature and propensity to bio-accumulate toxic substances. They are also recognized for their economic value. 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.

4.2.1 DISTRIBUTION OF OYSTERS IN NSC

Oysters can be found throughout the mangrove fringe along the NSC and much of Matlacha Pass (Figures 4-6). 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 can be proposed.

Figure 4-6. Oyster Distribution in and near the NSC (Lee County DNR)

Oyster habitat suitability has been the subject of many past research projects. Barnes et al., (2007) presented a habitat suitability index model for the Eastern oyster (*Crassostrea virginica*) for the nearby Caloosahatchee River. They conducted a literature review to obtain information regarding salinity tolerances and preferences for the Eastern oyster and reported the following:

- Oyster larvae
    - Salinity limits – 5 ppt to 35 ppt
    - Optimal salinity- 10 ppt to 30 ppt;
    - Peak – 20 ppt to 22 ppt
    - Settlement peak - 25 ppt to 29 ppt
    - In Caloosahatchee – most favorable 15 ppt to 25 ppt
- Oyster adult
    - Optimal salinity – 10 ppt to 20 ppt
    - Normal range – 10 ppt to 30 ppt.

Oysters can withstand a wide range of salinity conditions and their 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.

Oyster habitat commonly shifts depending on conditions from year to year, due to natural variations in salinity and temperature, as well as disease and predator abundance. For example, the hydrozoan *Eutima* sp. is an inquiline symbiont known to infest the gills of *Crassostrea virginica* (Tolley, et al., 2010). This research suggest that freshwater inflow may not only limit the distribution and abundance of *Eutima* polyps inhabiting oysters by reducing salinities but may also impact the initial settlement of planulae onto reefs.

The oyster parasite *Perkinsus marinus* is considered to be a major cause of mortality in Gulf Coast waters (Craig et al., 1989, Soniat, 1996). LaPeyre et al. (2003) collected data that appear to support the hypothesis that repetitive and well-timed freshet events can prevent infection of oysters with *P. marinus* or at least maintain these infections at non-lethal intensities in oyster populations. The researchers concluded that use of an adaptive management approach involving control of freshwater inflows could be invaluable to the oyster industry in areas close to freshwater diversion projects.

The salinity tolerances of some of the predominant oyster predators can also be reflected in the ability of oysters to withstand relatively wide salinity conditions. The crown conch is a predator typically found along the Gulf Coast that consumes oysters by inserting its proboscis between the oyster's valves. Conchs thrive in higher salinity water and can overrun a drought-stricken oyster reef. They are known to survive for long periods in salinities of 8 ppt

It is recommended that the target salinity range be outside of the optimal salinity range for growth and reproduction to lessen the negative effects of disease and high salinity predators. 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, salinity variation can be an important factor that reduces the presence of both disease-causing organisms and oyster predators (Volety et al., 2009). Therefore, the management of salinity should focus on limiting lengthy excursions in salinity either below or above this range. Performance measures that should be considered in the assessment of oyster health are the following:

- Density of living oysters (per square meter)
- Condition index
- Reproductive activity (gonadal condition)
- Larval recruitment
- Disease prevalence and intensity of P. marinus
- Growth and survival

4.2.2 OTHER MACROINVERTEBRATES

This section presents the macroinvertebrates (all samples taken with single sweeps of a dipnet) that FDEP found during its 2011 survey:

- Bivalves (*Geukensia demissa*, *Crassostrea virginica*),
- Xanthid crabs
- Hermit crabs,
- Several mysids

- Amphipods,
- Cumaceans
- Gastropods (*Nassarius* sp.)
- Worms (3 taxa)
- “Moon snail”
- Nemerteans
- Isopods
- Tellin clams
- Polychaetes
- Flatworms
- Tanaids

Given this diverse benthic community, it can be expected that the relative abundance will vary both seasonally and spatially, often in response to variation in salinity conditions. Therefore, no one salinity will support this diverse community. Rather, maintenance of a range of salinity conditions will best serve to protect this critical ecosystem component. Given the salinity tolerances for oysters, the recommended salinity range is 10 ppt to 30 ppt for the long-term average. This range will support macroinvertebrates with salinity tolerances that range from oligohaline to polyhaline.

5.0 REFERENCES

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Appendix A

Field Reconnaissance of Biological Conditions in the North Spreader Waterway, Cape Coral

<u>3/21/2011–Ford Walton, Chris Nappi–DEP South District</u>

Canal west of NW 36^{th} St. dead-ends into saltern

Dead end canal south of NW 36^{th} Street has storm water drainage pipe at end

Stormwater drainage pipes empty directly into spreader canal at end of most east/west roads

No flow apparent

Sand banks

Mangrove roots have oysters and barnacles

Small cove- no visible connection to key ditch

Canal access south of NW 31^{st} St

- N 26.70942 W 82.07008
- Clear water with algae mats
- Depth approx. 0.75m
- Width approx. 7m
- Slow flow north in south branch, no flow seen in north branch
- Inflow from spreader (possibly wind driven)

N 26.69753 W 82.06406 - Small creek opposite Kismet Pkwy

- At 1245- very slow flow east into spreader/ Low Tide- approx. ≤ 0.1m/sec
- Sparse *Typha sp.* and thin bladed seagrass
- Connects to key ditch and Matlacha Pass
- Approx. 2m wide

In main Spreader very slow flow South @ 1242

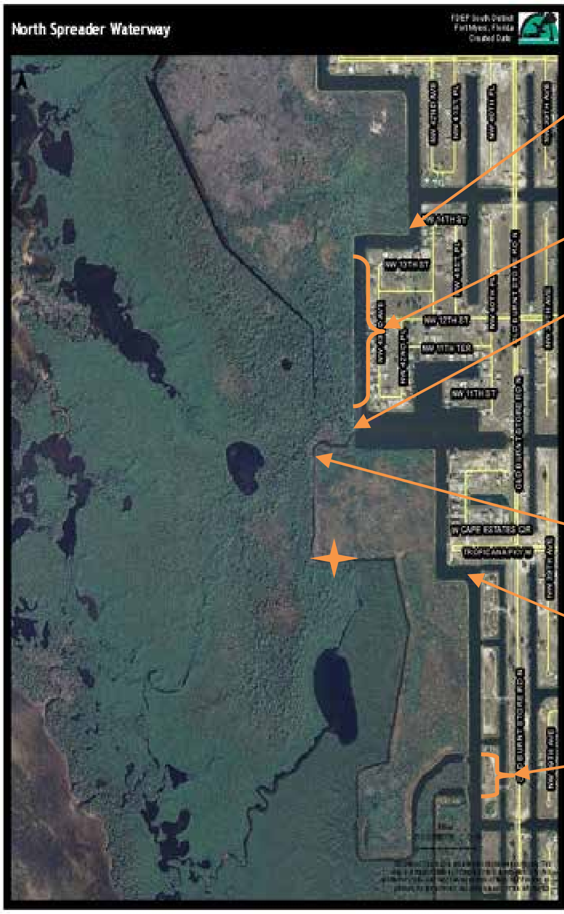
Opposite NW 22^{nd} St- More mangroves on west shore, no *Typha sp.*, abundant live oysters

South corner opposite Gator Slough South flow at 1222, North flow at 1424

- At 1423- slow flow into Gator Slough (surface wind flow out)
- Seawall on opposite bank with two pipes, land much higher elevation, slash pines

Small Creek just North of Gulfstream opposite bank had no flow at 1211, very shallow ($\leq$0.1m), same water height at 1436

Seawalls with oysters, abundant *Typha sp.*, mangroves sparse, abundant *Melaleuca sp.* and Australian pine (*Casuarina equisetifolia)*



Piling at canal turn
- At 1150 obvious south flow
- At 1444 obvious north flow

Typha sp. and sparse mangroves along banks

N 26.67081 W 82.06351
- At 1127- slow flow east toward spreader
- At 1452- slow flow west into creek, height appears to be the same as earlier
- Approx. 3+m wide at mouth, approx. 7-10m wide further inside
- Areas of exposed mud, mangroves line banks, oysters scattered- more common near mouth of creek
- White mangroves (*Languncularia racemosa)* with exposed roots

At 1501- obvious north flow ≥ 0.2m/sec

Both creeks closed to main spreader – approx. 1 foot of elevation between – trail over northern barrier

motored to this point

At 1512- definite northern flow

Banks of spreader sandy with mangroves

East shore with high unstable sand banks

No connection to spreader at east end or ditch @ west end, lined with Australian pines

At 1520- Stronger northern flow- approx 0.2m/sec

Back to Ceitus canal at 1520. Surface water blowing west, unclear if it was tidal or wind

<u>3/22/2011</u>

N 26.64719 W 82.05960; at 1056- No flow, low tide, dead wood around with sand, mud, and scattered oysters, approx. 5-10m wide- varies
- Mouth of two creeks/canals approx. 30m wide
- At 1107- no flow

Areas of sand, exposed & submerged mud, scattered oysters on mangrove root, algae mats

At 1110- South flow in main canal approx. 0.15m/sec

At 1110- good flow west into creek– approx. 0.15m / sec
At 1339- incoming well ≥ 0.2m/sec

- Approx. 5m wide and 0.5-1.0m deep
- Area of sand deposit @ mouth
- Concrete barrier across mouth, washout around concrete barrier approx. 1m deep, oysters growing on concrete
- Areas of living and dead mangroves with oysters on roots

Heavy washout of sand banks

Shell bottom with live oysters along banks

Currently a large sand deposit is here along bank

Entire Southern Bank along businesses lined with shell/live oysters

At 1118 outgoing flow

- Oyster bed, sandy, algae (drift), mangroves with oysters on roots
- Approx. 20 m wide with sandy shallow spots
- Under cut
- Green filamentous algae mats

6- N 26.64153 W 82.06034- Sampled sand and leaf, approx. 0.2 m deep

- gastropods (*Nassarius* sp.), amphipods (*Cerapus* sp.) and others, hermit crabs, mysids, 2 species of cumaceans

Oyster bed- no access on 3/22/2011- shallow (≤0.2m)

Areas of sand deposit- shallow- exposed at low tide

Oyster bed- looks fairly healthy

Sand currently extends to this point

Red and Black Mangroves- intertidal zone has drift algae & oysters

Sandy with scattered/patchy *Halodule wrightii* and drift algae, many crab traps in this area

Deposits of heavy drift algae

All samples taken with dipnet (single sweeps).

1- N 26.63882 W 82. 06195- sampled oysters and sand just downstream, approx 0.5m deep
- oyster: bivalves (*Geukensia demissa*, *Crassostrea virginica*), xanthid crabs, hermit crabs, several amphipods
- sand: mysids, amphipods, 2 cumaceans, small bivalves, gastropods

2- N 26. 63959 W 82.06308- sampled sand and drift algae (green and red macroalgae), approx 0.2m deep
- sand: mysids, bivalves, 3 worms, amphipods, "moon snail", nemertean, 2 cumaceans
- drift algae: mysids, xanthid crabs, several amphipods, gastropods (*Nassarius* sp.), isopods

3- N 26.64095 W 82.06428- sampled sand with *Halodule wrightii*, approx 0.5m
- sand: mysids, several ampipods, *Erichsonella* sp., flatworm, gastropods, 2 cumaceans, bivalves, polychaetes

4- N 26.63987 W 82.06642- sampled sand with *H. wrightii*- approx 0.4m deep
- sand: mysids, 2 cumaceans, *Erichsonella* sp., several amphipods, several gastropods, tellin clams, xanthid crabs

5- N 26.26.64031 W 82.06232- sampled sand- approx 0.3m deep
- sand: cumaceans, tanaids, several amphipods, mysids, polychaetes, gastropods

Appendix B

FGCU Data

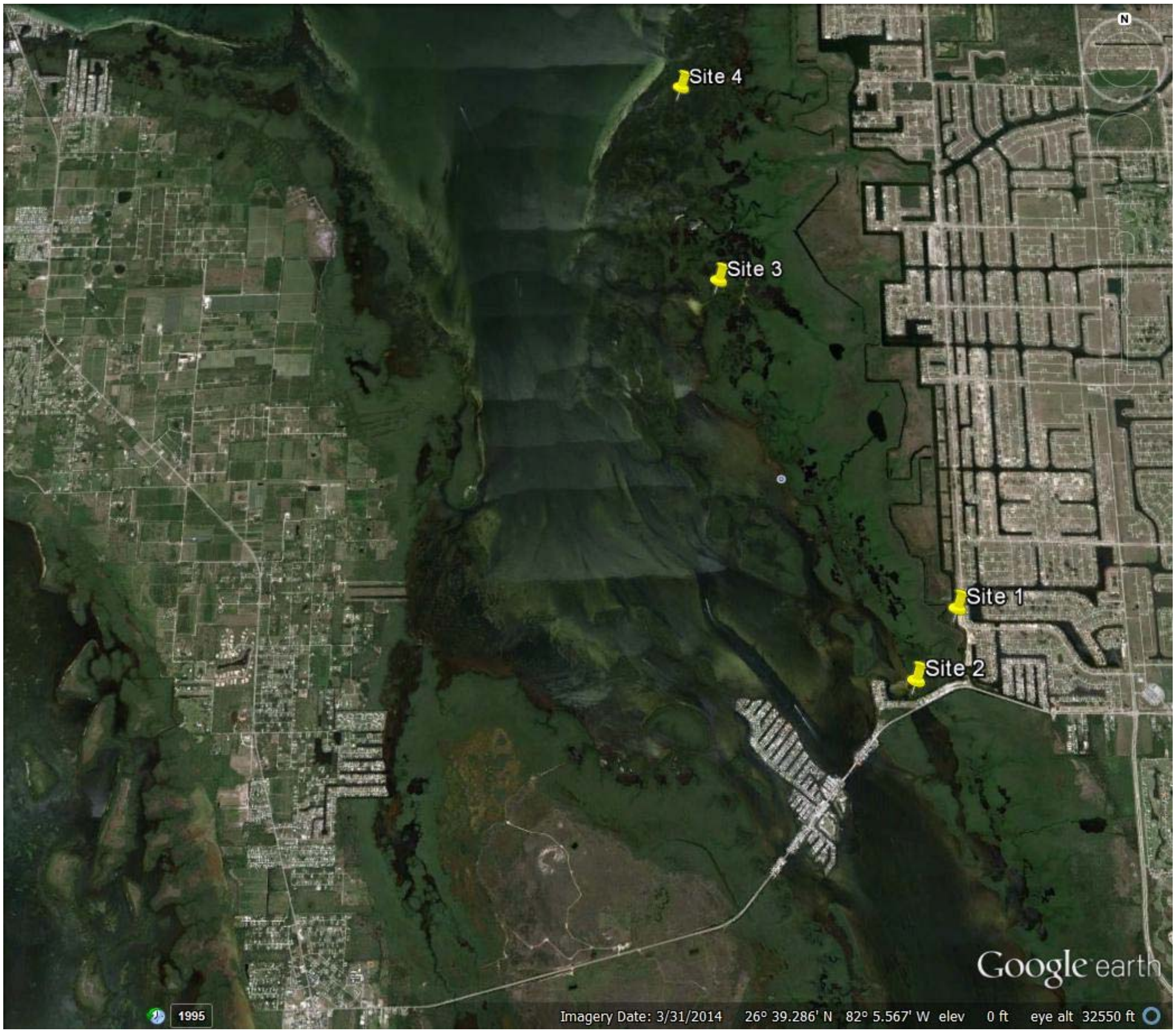


Figure B-1 Map of FGCU sampling locations

Salinity at each of the sampling stations visited by FGCU.				
Date	**NSC1**	**NSC2**	**NSC3**	**NSC4**
Jun-14	25	25	31	33
Jul-14	15.52	18.39	31.78	32.34
Aug-14	5.59	6.66	22.01	25.47
Sep-14	14.93	14.50	22.07	24.34
Oct-14	3.32	6.41	17.72	17.43
Nov-14	15.15	18.65	27.51	26.92
Dec-14	13.41	16.95	25.80	26.31
Jan-15	21.84	23.76	31.75	31.48
Feb-15	25.27	23.43	29.86	29.44

Temperature at each of the sampling stations visited by FGCU.				
Date	**NSC1**	**NSC2**	**NSC3**	**NSC4**
Jun-14	30.97	31.04	30.82	30.47
Jul-14	31.80	32.21	30.97	30.54
Aug-14	30.57	30.38	30.14	30.37
Sep-14	27.91	27.14	25.18	24.99
Oct-14	23.11	22.64	21.56	20.74
Nov-14	22.38	21.76	22.15	20.82
Dec-14	23.39	22.56	21.42	19.52
Jan-15	18.88	19.70	17.59	16.87
Feb-15	30.97	31.04	30.82	30.47

Oyster gonadal condition at each sampling station (FGCU).						
Station	**Jun '14**	**Jul '14**	**Aug '14**	**Sept '14**	**Oct '14**	**Nov '14**
NSC 1	3.2	2.1	3.3	4.1	3.0	2.8
NSC 2	3.1	3.2	2.1	3.9	4.3	2.3
NSC 3	3.1	2.3	3.7	3.3	2.9	2.6
NSC 4	3.2	2.3	3.0	3.5	2.3	1.8

Average size (mm) of oysters in closed bags at each sampling station.

Station	DATE								
	6/13/2014	7/14/2014	8/6/2014	9/8/2014	10/8/2014	11/12/2014	12/8/2014	1/7/2015	2/4/2015
NSC1	29.7	38.1	42.8	52.3	53.9	59.2	61.9	68.7	71.4
NSC2	27.2	33.1	39.6	49.4	51.8	61.1	64.0	66.6	71.7
NSC3	28.6	31.7	33.1	34.3	32.5	37.4	38.2	44.3	46.9
NSC4	28.6	31.3	35.8	36.5	36.9	38.7	41.3	44.1	44.3

Average size (mm) of oysters in open bags at each sampling station.

Station	DATE								
	6/13/2014	7/14/2014	8/6/2014	9/8/2014	10/8/2014	11/12/2014	12/8/2014	1/7/2015	2/4/2015
NSC1	30.5	37.8	42.8	48.9	51.7	57.3	61.3	68.3	30.5
NSC2	28.8	35.6	38.8	51.7					28.8
NSC3	30.3	32.5	33.4	34.0	31.5				30.3
NSC4	28.9	31.8	35.0	36.6	37.6	36.3			28.9

Average size (mm) of oysters in closed bags at each sampling station.

Station	DATE								
	6/13/2014	7/14/2014	8/6/2014	9/8/2014	10/8/2014	11/12/2014	12/8/2014	1/7/2015	2/4/2015
NSC1	29.7	38.1	42.8	52.3	53.9	59.2	61.9	68.7	71.4
NSC2	27.2	33.1	39.6	49.4	51.8	61.1	64.0	66.6	71.7
NSC3	28.6	31.7	33.1	34.3	32.5	37.4	38.2	44.3	46.9
NSC4	28.6	31.3	35.8	36.5	36.9	38.7	41.3	44.1	44.3

Number of surviving oysters in closed bags at each sampling station.

Station	DATE								
	6/13/2014	7/14/2014	8/6/2014	9/8/2014	10/8/2014	11/12/2014	12/8/2014	1/7/2015	2/4/2015
NSC1	96.3	83.0	80.7	74.7	73.0	62.0	43.3	39.7	37.7
NSC2	92.0	66.7	61.7	53.3	46.0	39.7	35.0	30.0	33.7
NSC3	93.7	70.7	57.7	56.3	52.0	43.7	42.7	39.3	38.7
NSC4	96.3	81.0	76.3	73.3	72.0	65.3	62.7	58.3	55.7