NW CAPE CORAL/LEE COUNTY WATERSHED INITIATIVE

PHASE II
EVALUATION OF MANAGEMENT SCENARIO ALTERNATIVES

LEE COUNTY, FLORIDA

Prepared for:

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NW Cape Coral/Lee County Watershed Initiative
Phase II
Evaluation of Management Scenario Alternatives

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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

Lee County and the City of Cape Coral undertook a joint project called the Northwest Cape Coral/Lee County Watershed Initiative. This initiative was overseen under a joint Project Team consisting of representatives from Lee County, the City of Cape Coral, and expert consultants. Phase I of the project was completed in fall 2015. The overall goal of the Phase I work was to provide a detailed quantification of the existing (baseline) hydrodynamic and water quality conditions, identify key biological indicators and associated water quality targets, and develop a tool (hydrodynamic model) to allow assessment of changes in hydrodynamics due to future management activities. The goal of Phase II of the project is to assess the potential hydrodynamic responses of the system to specific defined management activities or scenarios and quantify the changes seen under each compared to baseline conditions.

The report presented herein presents a description of the overall project area, a brief review of the development of the hydrodynamic model, and analyses of output from the hydrodynamic model comparing baseline (existing) hydrodynamic conditions with the hydrodynamics under three defined management scenarios. The management scenarios include the following:

- Boat lift back in place within the system

- Reduction of flows from Gator Slough
- Increased connectivity between the Spreader Canal and the adjacent waters of 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 summary overview of the model development. Section 4 presents the analyses of the changes in the hydrodynamics between the baseline conditions and the three management scenarios listed in Section 1.2. Section 5 summarizes the findings of the study.

2.0 PROJECT AREA DESCRIPTION

Figure 2-1 provides an overview of the primary study area. In general, the system consists of four key areas;

- The North Spreader Canal (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).

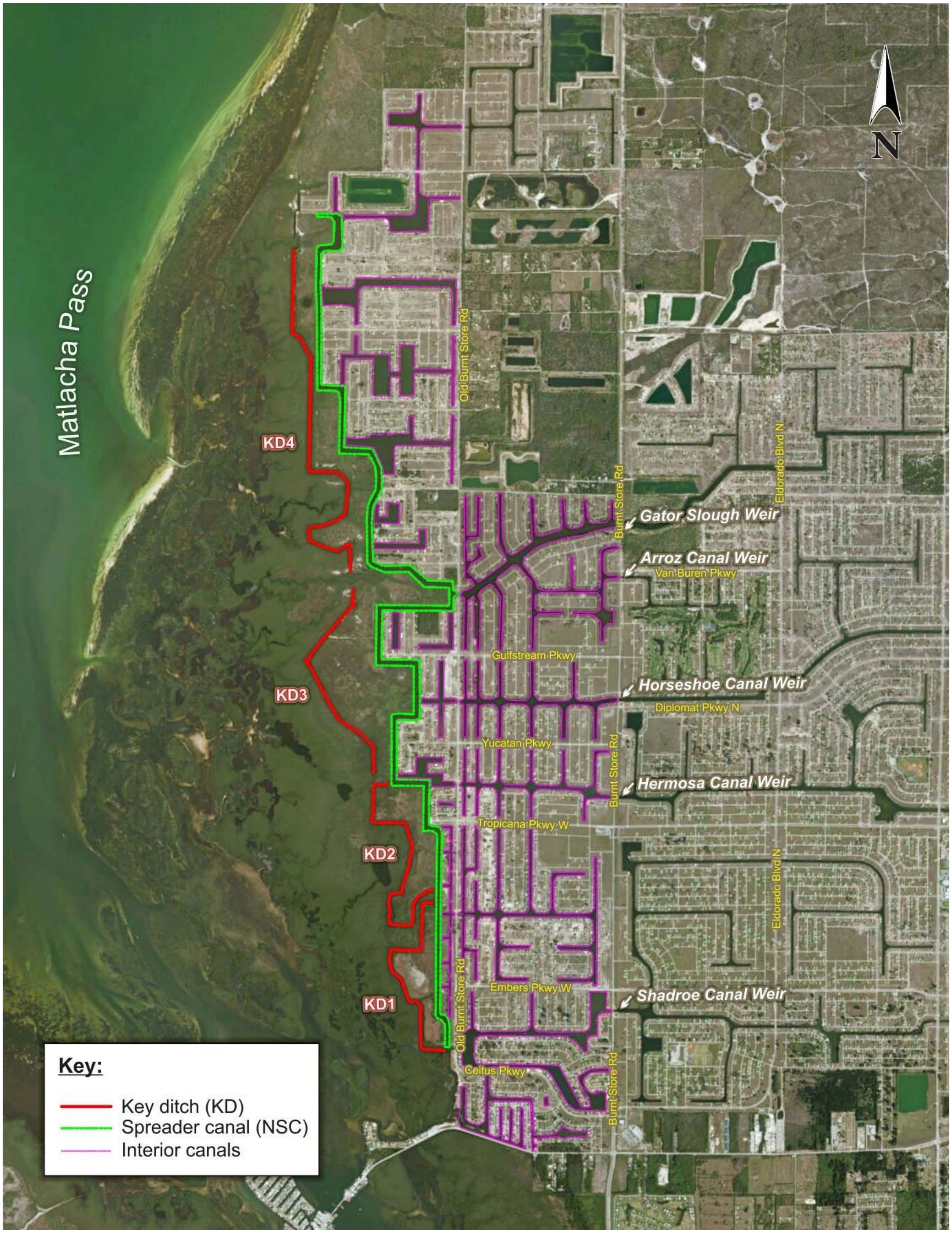


Figure 2-1. Project Area Map

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.

Under the Phase I work, 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 location identifications used for this study reflect where U.S. Geological Survey (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

The following paragraphs present descriptions of the current condition of each of these breaches.

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

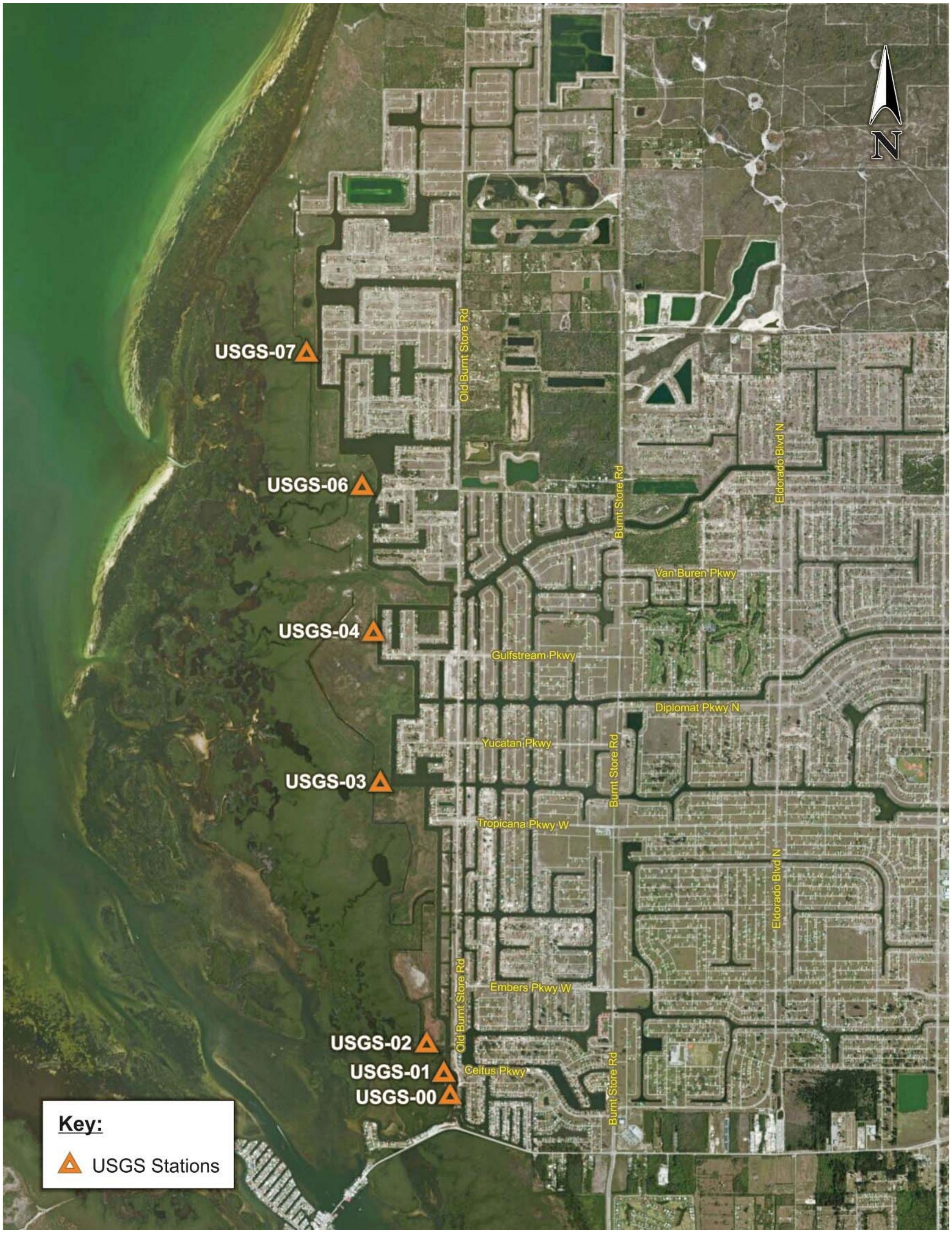


Figure 2-3. Location of USGS Monitoring Stations

Breach 1 connects to a small open water area 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 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.

Under Phase I, USGS established a primary flow and water level monitoring station in the main channel to the south of the former boat lift location to quantify the flow entering into the NSC through the southern channel. 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 in the following paragraphs.

Moving up through the NSC from south to north, the first monitored breach, USGS-01 (Breach 12), was 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 1,000 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 is 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 NSC 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
- 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 BASELINE HYDRODYNAMIC MODEL

Under Phase I of the project, a hydrodynamic model was developed and calibrated to existing conditions in the system. The following provides a summary of the development of the hydrodynamic model used for the scenario simulations presented in Section 4.0. A more detailed discussion of the development and calibration of the hydrodynamic model is provided in a report entitled *NW Cape Coral/Lee County Watershed Initiative Phase I, Hydrodynamic Model Development and Calibration* [Applied Technology and Management, Inc. (ATM), 2015a]. This report was provided as part of the Phase I deliverables.

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, FDEP and the water management districts (WMD) have used this model extensively throughout the state. Specific examples of applications of EFDC within Florida by FDEP and the WMD include Indian River Lagoon [St. Johns River Water Management District (SJRWMD)], tidal portions of the St. John's River (SJRWMD), Florida Bay [Suwannee River Water Management District (SRWMD)], tidal Caloosahatchee River (FDEP), and Pensacola and Escambia Bay (FDEP).

3.2 MODEL EXTENTS AND GEOMETRY

The hydrodynamic 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. Figure 3-1 presents the hydrodynamic model grid showing the areas that the model covers and the grid resolution.

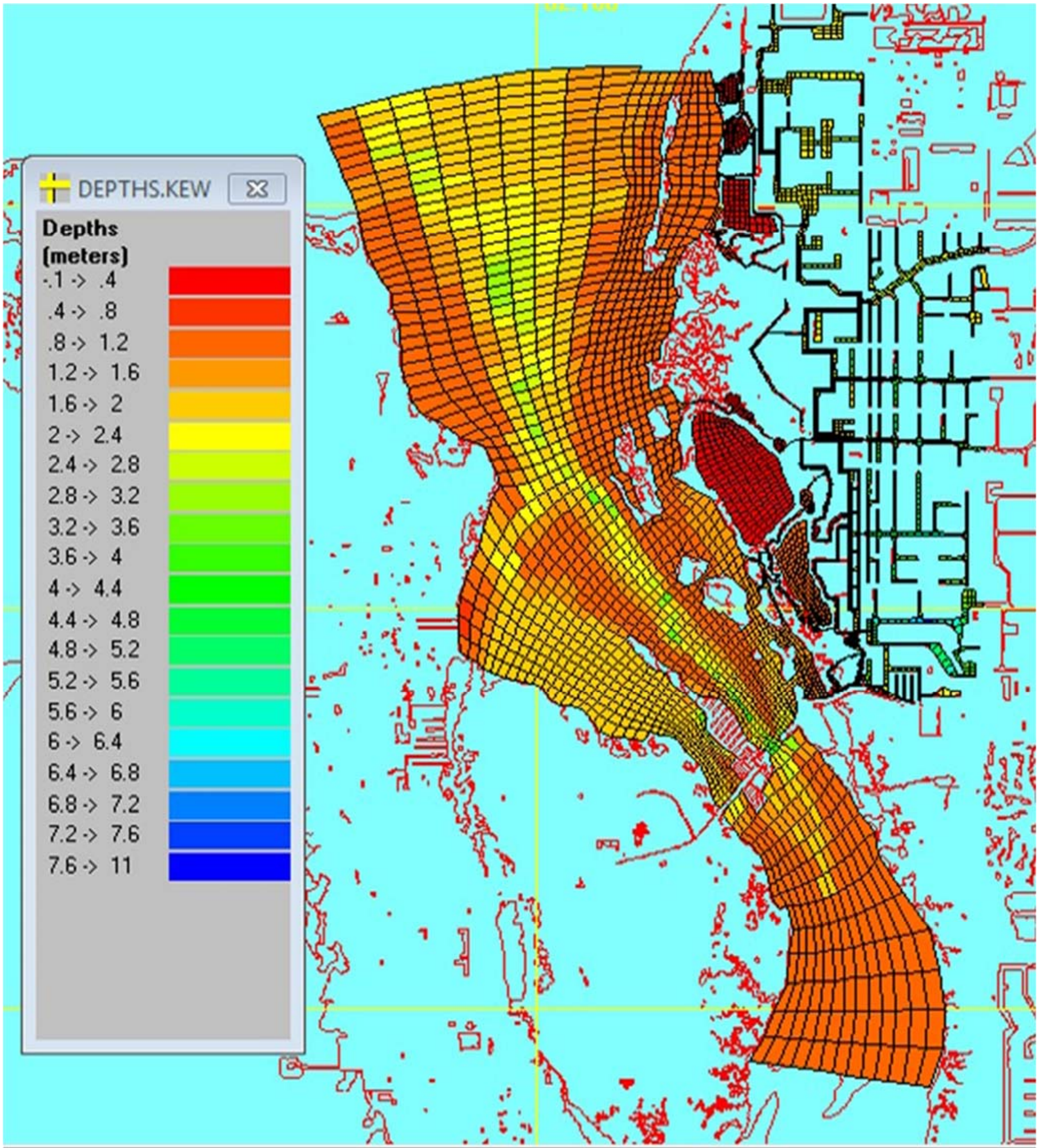


Figure 3-1. Model Grid and Bathymetry

The model was set up to represent the details of the interior canal system and the NSC, which govern the progression of tidal waves and the distribution of salt throughout the system under the existing conditions. Figure 3-1 also presents the bathymetric conditions used in the hydrodynamic model. The bathymetry data came from surveys conducted as part of the Phase I work and available bathymetric charts and other available surveys. All survey data, and water level boundary forcing data discussed in Section 3.3 were referenced to NAVD88, based on surveying of the instruments and available tidal conversions.

3.3 MODEL INPUTS AND PERIOD OF SIMULATION

For the hydrodynamic model simulations, boundary forcing conditions were prescribed for the following:

- 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
- Wind stress at the water surface

Measured data for the water levels and salinity were available within Matlacha Pass from October 2012 through December 2013. These data defined the period of simulation of the hydrodynamic model. For the simulations presented herein, the month of October was utilized as the model spin-up period, while the data from November 2012 through December 2013 were used for the scenario simulations. The baseline boundary forcings developed for the model calibration, were utilized for the scenario simulations, with modifications to the forcing files if prescribed by the specific scenario.

The water levels were derived from measured data taken within Matlacha Pass. These data were then time lagged to get the tides at the northern and southern boundaries. Figure 3-2 presents plots of the northern and southern boundary forcings over a 2-month period.

The salinities at the northern and southern boundaries were based upon available discrete measured data and continuous measurements at the northern end of the system. 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 and southern ends.

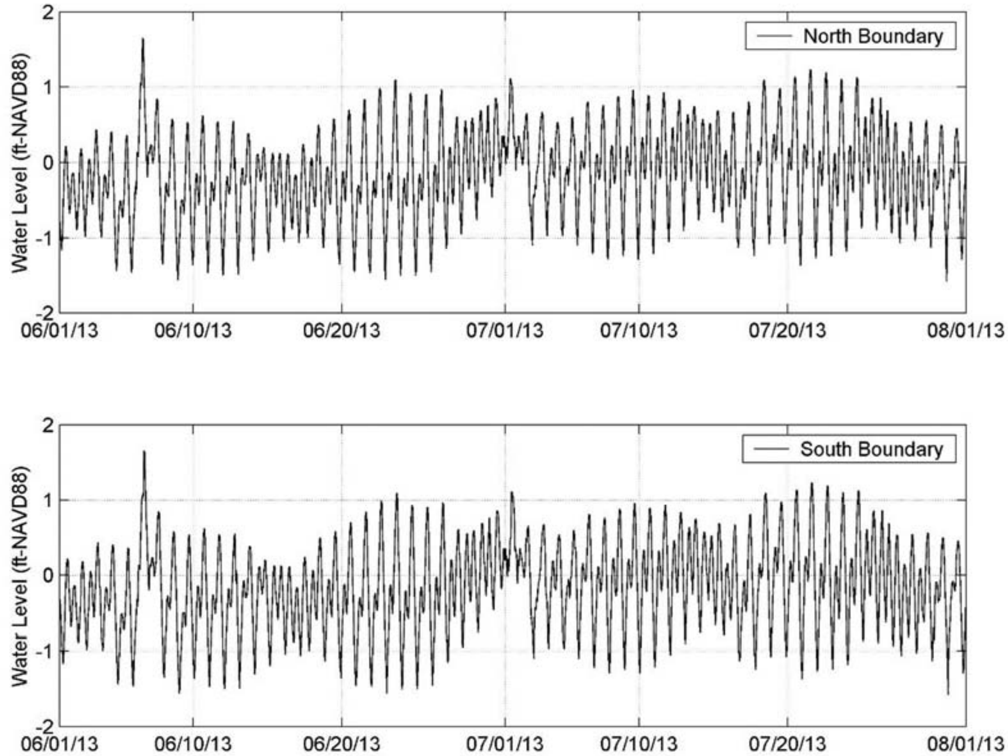


Figure 3-2. North and South Tidal Boundary Forcings

The flows over the weir structures were developed using measurements of water levels above the structures, data for the operation of the bladders at the weirs, and rating curves developed by USGS. The detailed methodology for the calculation of the weir flows was presented in a report entitled *NW Cape Coral/Lee County Watershed Initiative, Phase I, Hydrodynamic Data Characterization* (ATM, 2015b). Flows used in the model are presented in Figure 3-3.

The wind speed and direction for the hydrodynamic model were developed using data from the Big Carlos Pass station. While data were available from stations more proximal to the study area, this location was utilized because it represented the nearest nearshore station that includes the coastal influence on wind.

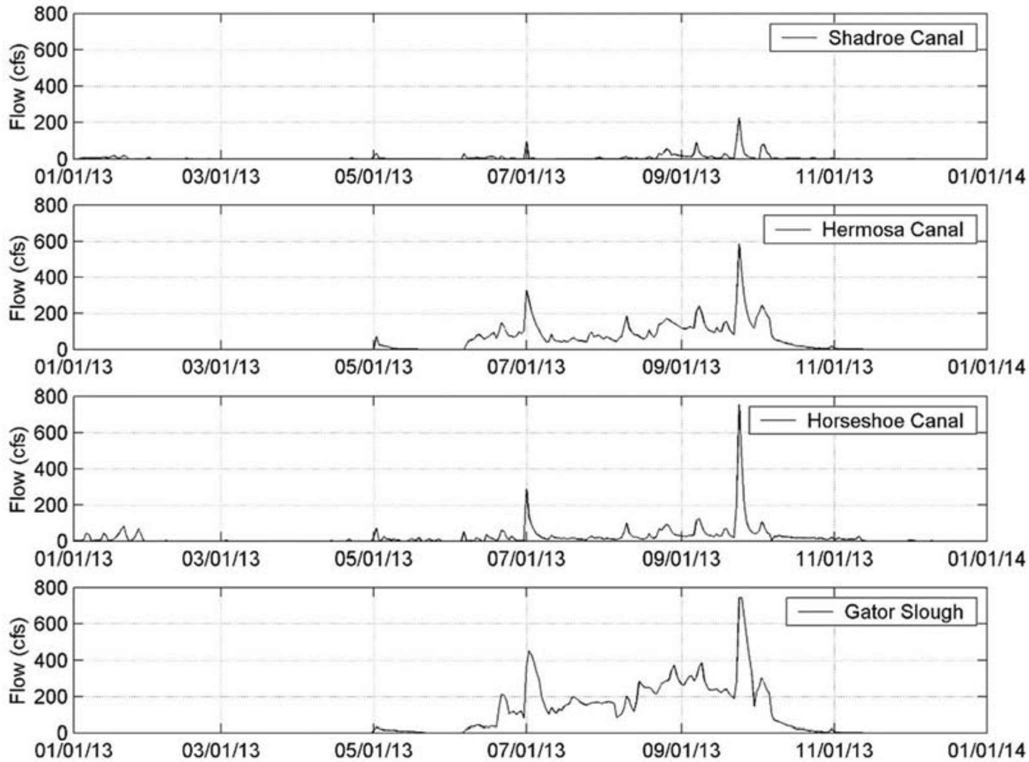


Figure 3-3. Freshwater Inflow over Weir Structures

4.0 BASELINE VERSUS MANAGEMENT SCENARIOS

This section presents the results from the three identified management scenarios against the existing (baseline) conditions. The specific management scenarios as stated previously include;

- Boat lift back in place within the system
- Reduction of flows from Gator Slough
- Increased connectivity between the NSC and Matlacha Pass

Section 4.1 presents the details of how the baseline model was modified for each of the management scenarios and the areas within the model domain identified for the analyses. Section 4.2 compares the changes in salinity between the baseline and the management scenarios. Section 4.3 compares the changes in residence time for each. Section 4.4 compares the changes in the velocities in the breaches.

4.1 MANAGEMENT SCENARIOS AND AREAS OF ANALYSES

The first management scenario is with the boat lift back in place. For this scenario, a barrier was placed in the model within the NSC. Figure 4-1 presents the location of the barrier.

The second management scenario was based upon the identification of potential reductions in the flow that may occur in the future for Gator Slough, based on potential future projects. As the flow reductions are anticipated to occur during higher flow conditions, only flows above a certain cutoff level were reduced. First a cutoff low flow value was defined, which was set at 35 cubic feet per second (cfs). Below this flow, no reductions occurred. When flow was above this point, the level of flow above 35 cfs was reduced by 50 percent. Figure 4-2 presents a plot of the baseline Gator Slough flow, along with the reduced flow time series for the period of the model simulations.

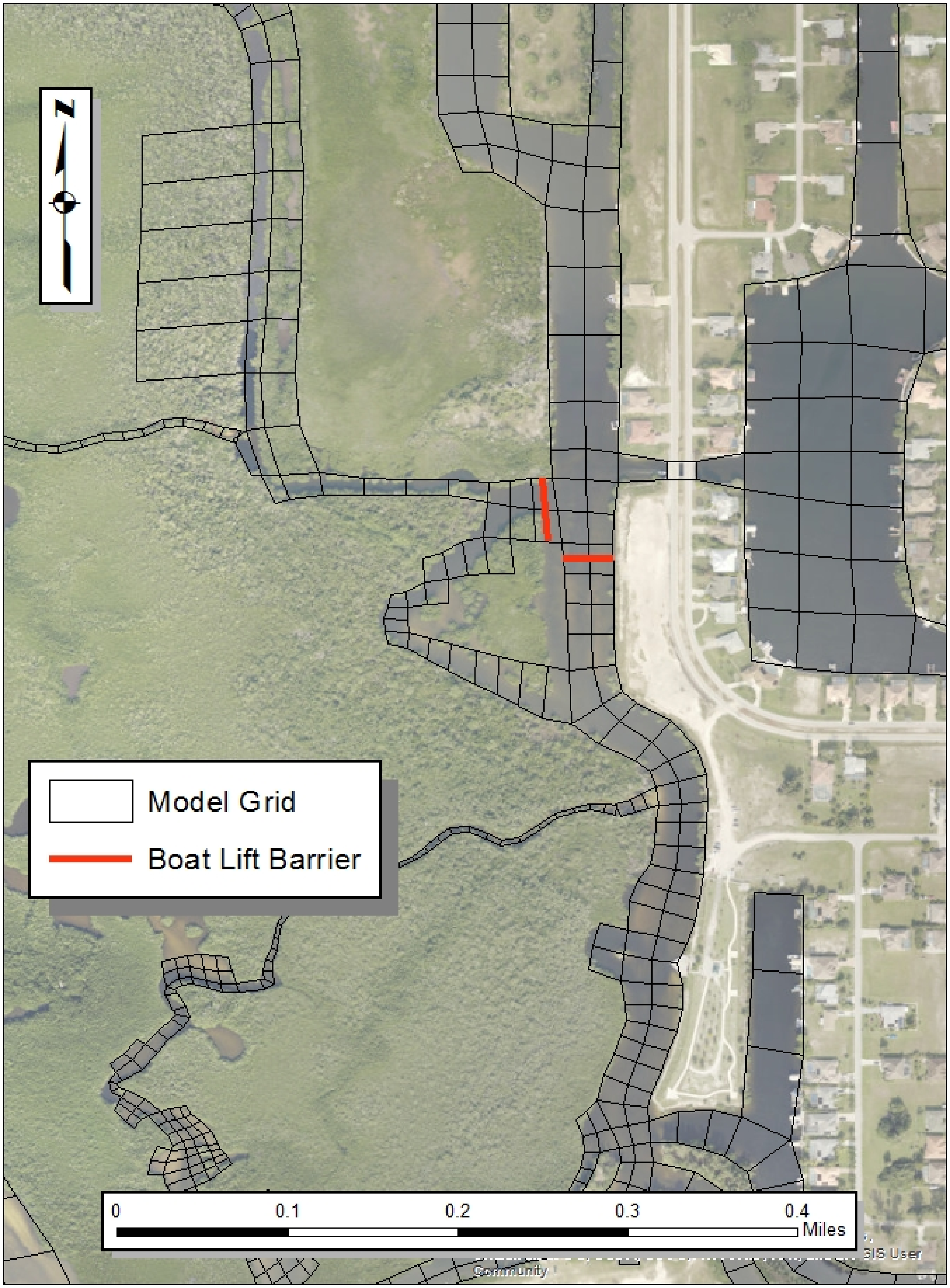


Figure 4-1. Boat Lift Barrier Location

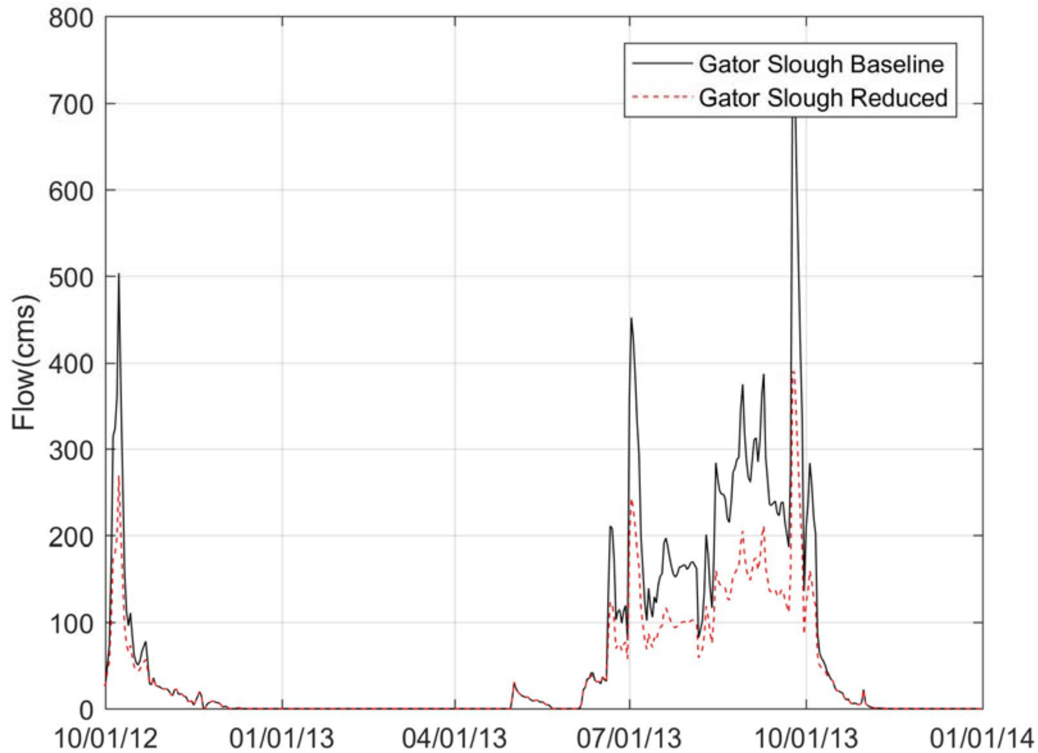


Figure 4-2. Flow Reductions in Gator Slough

The final scenario was the inclusion of a series of new connections between the Key Ditch and the NSC with Matlacha Pass. This scenario, in essence, examines what would happen if modifications were made to the system to increase the connectivity between the NSC and the Key Ditch and Matlacha Pass. The changes included additional channel connectivity, connections at points where limited physical alterations would be required to make the connection, and deepening of some of the presently existing shallow tidal channels that do not flow during lower tide conditions. Figure 4-3 shows the locations where the increased connectivity were made.

For the analyses of the management scenarios, specific key areas within the model domain were defined. The salinity and residence time analyses focus on these locations and present changes and statistics averaged over these areas. Figure 4-4 presents the four areas. These were defined based upon the metrics defined in the key indicators report (Janicki Environmental, Inc., 2015), prepared under Phase I, as well as recent discussions with Lee County staff.

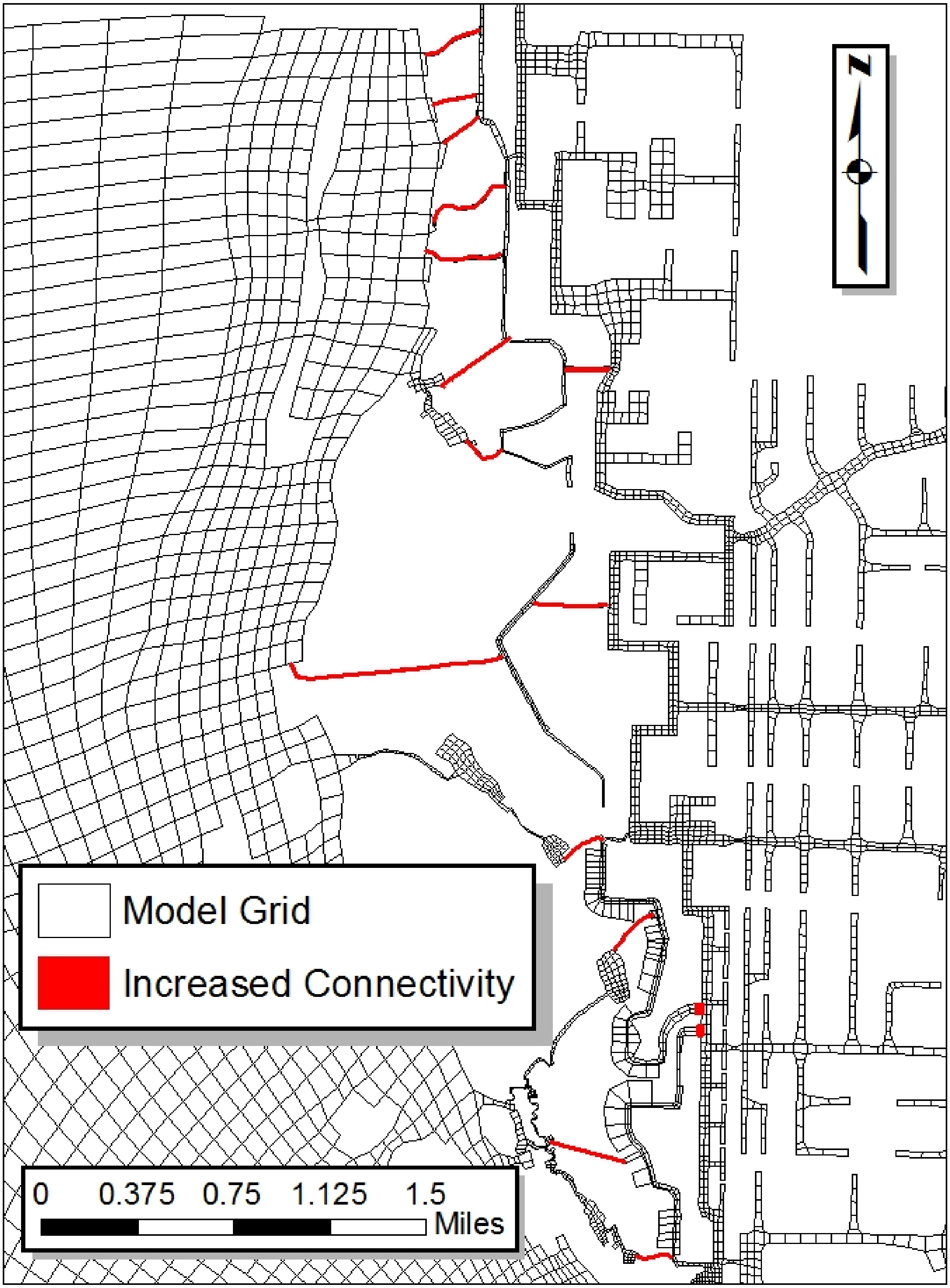


Figure 4-3. Grid Revisions for Increased Connectivity Run

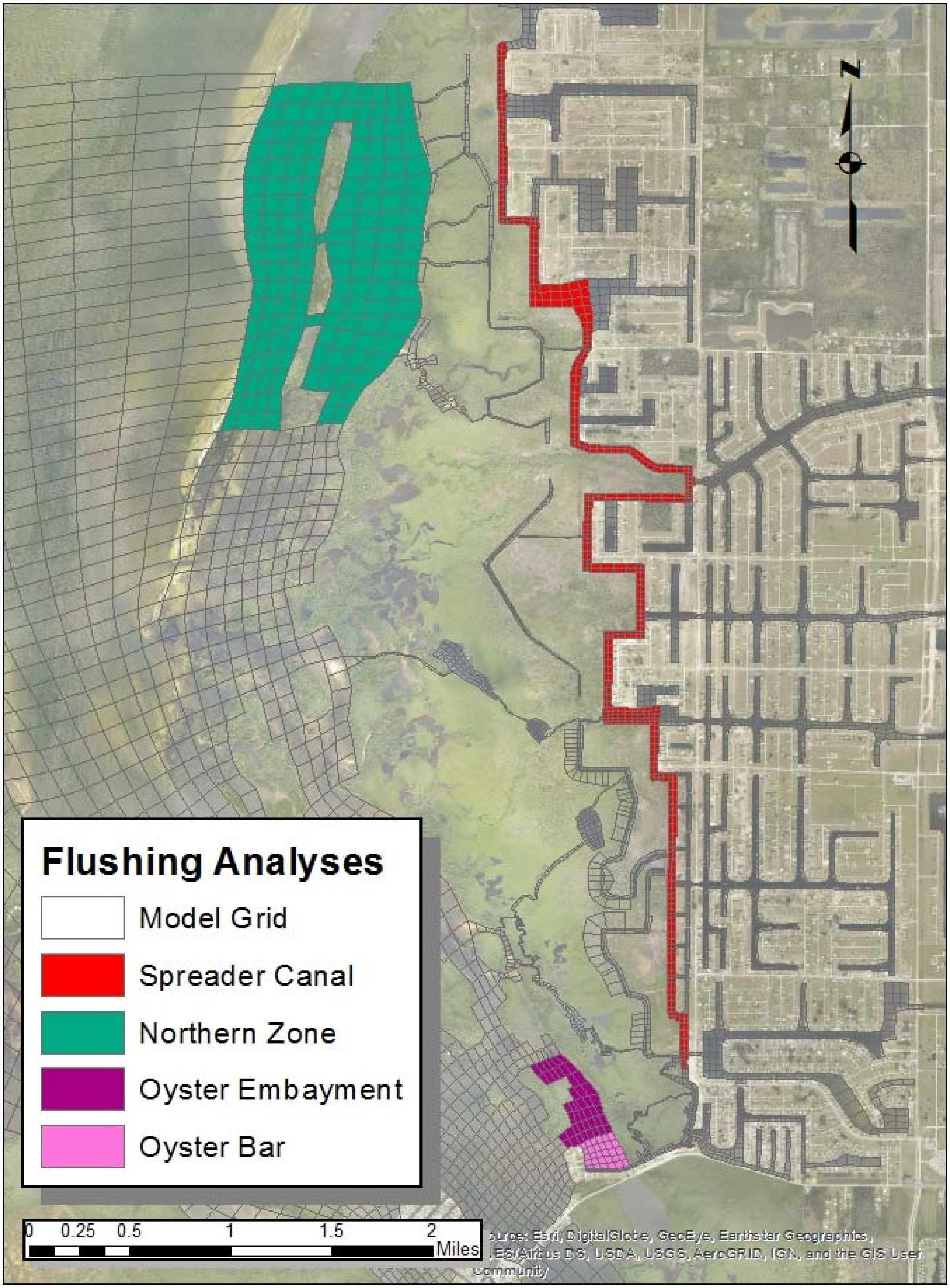


Figure 4-4. Areas of Analyses

The areas are titled as follows, the legend on Figure 4-4 shows each of these areas;

- Oyster Bar – area where oyster habitat has been identified near the southern entrance to the NCS
- Oyster Embayment – larger overall area surrounding the Oyster Bar
- Spreader Canal – the spreader canal, not including any of the interior canals. For the salinity analyses this area is further divided into an area north of where Gator Slough comes in and south of where Gator Slough comes in.
- Northern Zone – area where additional habitat has been identified for analyses.

4.2 SALINITY ANALYSES

Salinity is one of the key hydrodynamic parameters that the model was built to evaluate. The mean level, range of fluctuation, and the timing all have the potential to impact species of concern in the area.

For the salinity, three different analyses were utilized to compare the baseline conditions to the three scenarios. The first method is to plot the daily average time series for each over the period of the model simulations. The second method is to do a cumulative distribution function for each case using the data in the time series. Finally, a cumulative distribution was developed for the changes in the salinity over the critical salinity range identified in the key indicators report (10 ppt to 30 ppt) (Janicki, 2015).

Figures 4-5a through 4-5f present plots of the areawide average time series of salinity for the baseline compared to each of the management scenarios. Each of the plots represents the results for the areas listed in Section 4.1. Two additional plots are also presented that include the spreader canal divided into two areas, one north of where Gator Slough enters and one south.

For the Oyster Embayment (Figure 4-5a) and the Oyster Bar (Figure 4-5b) areas, the results are similar. The most significant differences from baseline comes from the Boat Lift in and Increased Interconnectivity Scenarios, which shows two primary differences. First, for the Boat Lift scenario, the overall range of long-term salinity is reduced from between greater than 30 parts per thousand (ppt) down to near 0 ppt for the baseline, to between 28 ppt down to near 10 ppt. Additionally, the Boat Lift in Scenario has much lower short-term variation, i.e., fluctuations over a short term on the order of 5 ppt to as large as 10 ppt in the baseline with little to no short-term variation in the boat lift case. For the Increased Connectivity scenario during the low flow periods the degrees of fluctuation are decreased and the overall salinity is reduced, as was seen in the boat lift. For the high flow periods the interconnectivity doesn't appear to have a significant impact on the Oyster Embayment or Area. For the Flow Reduction, the results are similar to the baseline, with some minor differences. The connection of Gator Slough reduces some of the short-term variability. The flow reduction during certain periods increases the overall salinity, but the variations are of the same order of magnitude as the baseline.

Looking next at the Spreader Canal, the comparisons show some marked differences. Figure 4-5c presents the results for the whole spreader canal. For the boat lift case, as expected, the spreader canal has a significant overall reduction in the salinity levels with levels below 10 ppt for the full period of the simulation and reduced short-term fluctuations. The baseline case shows ranges from near 0 ppt up to as high as 23 ppt on average. In contrast, the Increased Connectivity case creates an overall increase in the salinity levels during low flow periods, with the range increasing to as high as 30 ppt down to around 2 to 3 ppt. For high flows, overall the salinities are reduced but these are not significant changes. For the Flow Reduction scenario, there is some small increase in the salinities during the high flow period, which reflects the time frame of the reduced flows. Looking next at the conditions above and below where Gator Slough enters (Figures 4-5d and 4-5e), for the Boat Lift in Scenario, the results look similar both above and below. In contrast, the Gator Slough connection shows markedly different results above and below, with the majority of the salinity increases seen in the overall Spreader Canal coming above where Gator Slough enters the system.

Finally, looking at the Northern Zone (Figure 4-5f), the time series results show that there is little impact on this area for all the scenarios other than the Boat Lift in. Under the Boat Lift in place scenario, the overall range of salinities drops from around 8 ppt to 33 ppt, down to between 5 ppt and 30 ppt. Some periods show differences between the baseline and the Boat Lift scenarios on the order of 10 ppt. The Increased Connectivity scenario does show some level of reduction in salinities in this area, indicating that more of the freshwater inflow moves into this area, i.e. north, but the changes are not overly significant.

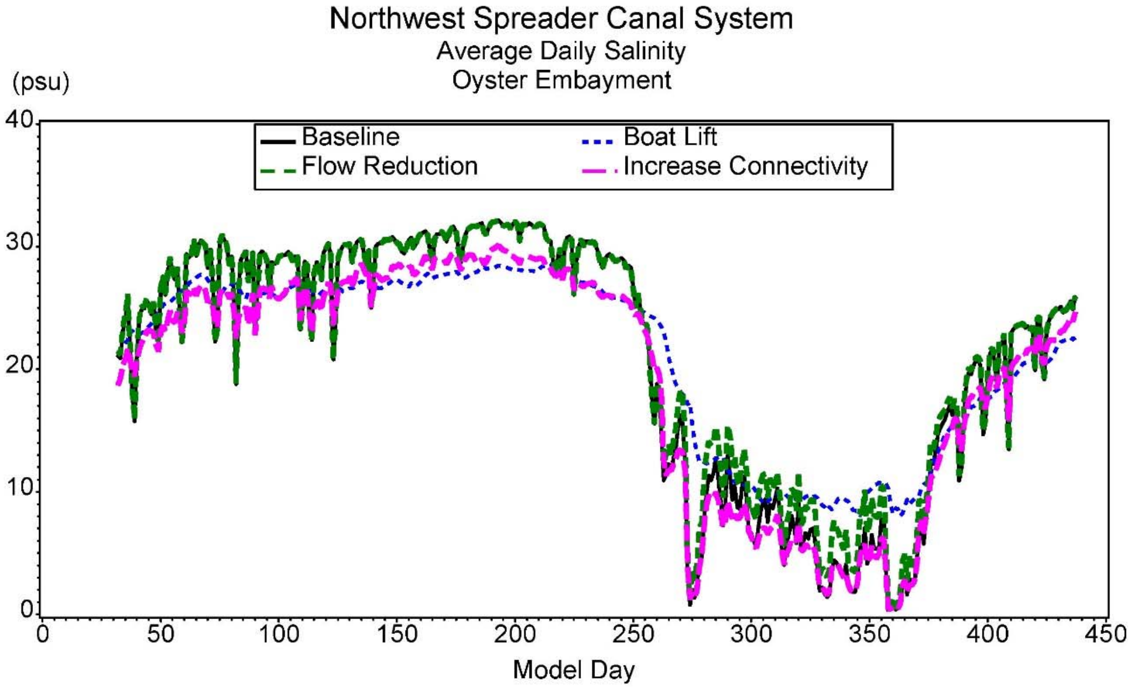


Figure 4-5a. Average Daily Salinity Time Series for the Oyster Embayment

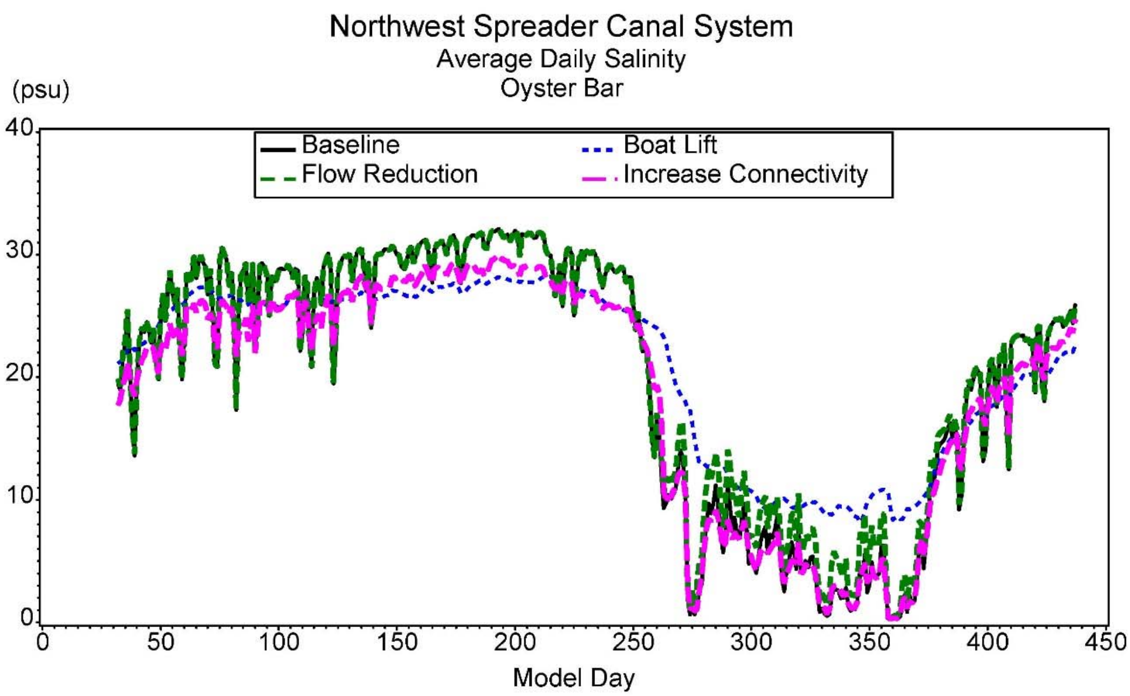


Figure 4-5b. Average Daily Salinity Time Series for the Oyster Bar

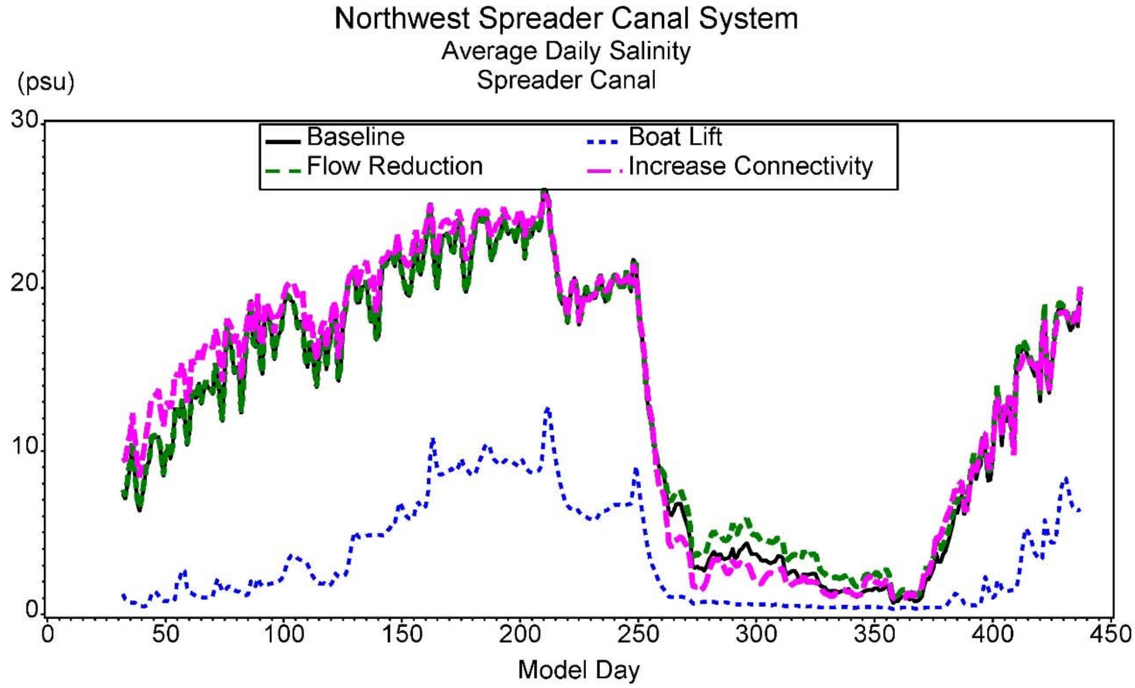


Figure 4-5c. Average Daily Salinity Time Series for the full NSC

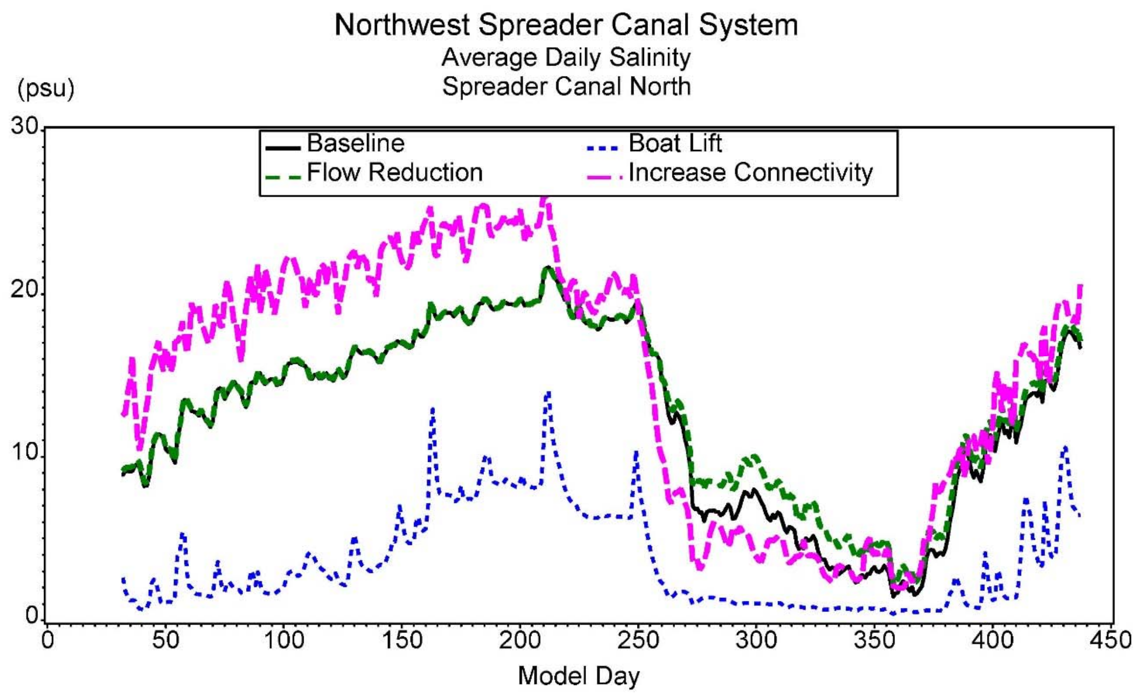


Figure 4-5d. Average Daily Salinity Time Series for the NSC North of Gator Slough

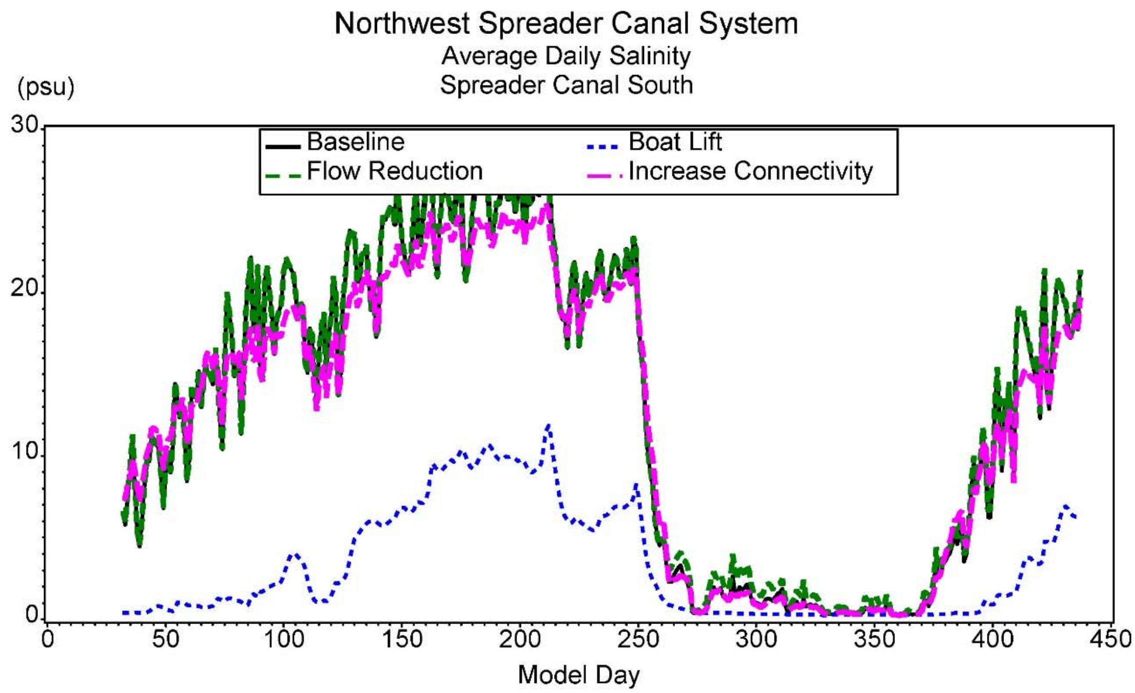


Figure 4-5e. *Average Daily Salinity Time Series for the NSC South of Gator Slough*

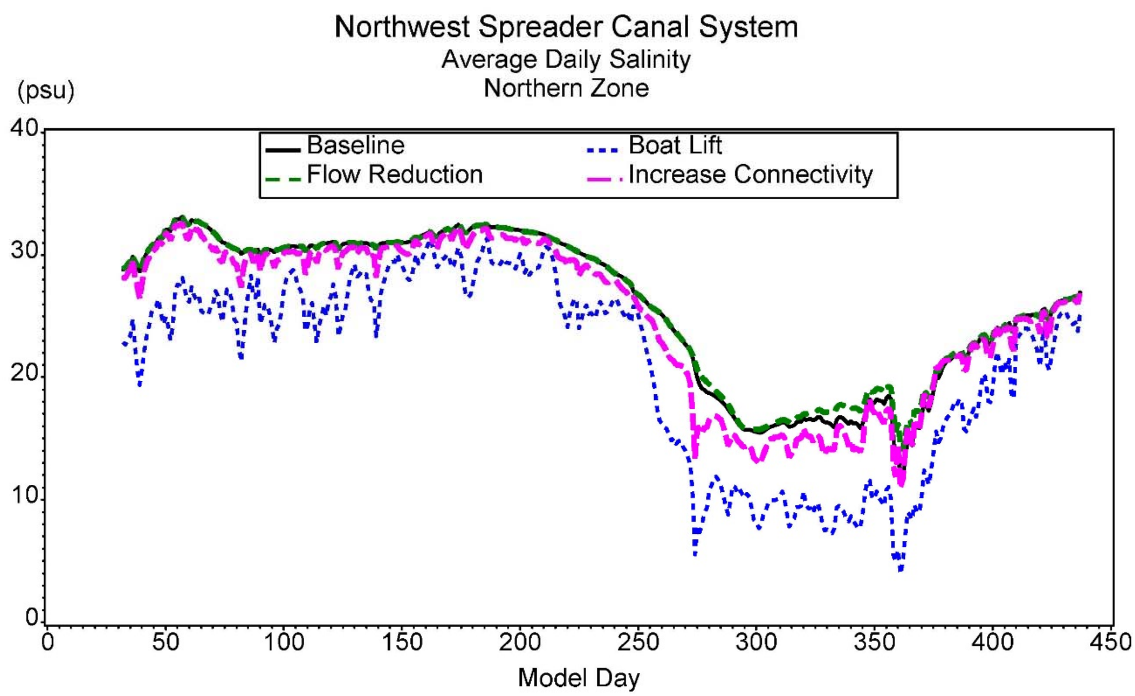


Figure 4-5f. *Average Daily Salinity Time Series for the Northern Zone*

Another way to look at the salinity results is to take the time series used to develop the daily average salinities presented in Figures 4-5a through 4-5f and do cumulative distribution function (CDF) plots. This allows a comparison of the percent of time that an area is at or less than a specified salinity level. The degree of difference between the CDF curves quantifies at what salinity ranges the greatest difference occurs. Additionally, as the hourly results are utilized, these graphs account for some of the shorter-term fluctuations in the system and their differences. Figures 4-6a through 4-6f present the CDFs for the full range of salinity conditions for each of the areas.

Looking first at the Oyster Embayment (Figure 4-6a) and the Oyster Bar (Figure 4-6b) areas, the results show that the biggest differences from baseline come from the Boat Lift scenario. These differences occur within the 0 ppt to 10 ppt range and the 25 ppt to more than 33 ppt range. The Boat Lift case does not exhibit the frequency of low or high ppt conditions seen with the other scenarios. Comparison of the Baseline with the Flow Reduction and Increased Connectivity scenarios shows a higher frequency of occurrence of low salinity (below 10 ppt) in the baseline.

For the Spreader Canal area (Figure 4-6c), introduction of the Boat Lift significantly reduces the frequency of occurrence of the higher salinity levels. For the Increased Connectivity there are some increases in the percent higher salinities, but these differences are not too significant. The Flow Reduction scenario shows some small increase in the lower salinity levels during the high flow period, but this difference is not significant. Looking at the Spreader Canal above and below where Gator Slough enters (Figures 4-6d and 4-6e), the changes in the frequency of occurrence of the lower salinity levels with the Boat Lift scenario are similar above and below. In contrast, the impacts of the Increased Connectivity scenario are much greater in the area of the Spreader Canal above rather than below.

Finally looking at the Northern Zone (Figure 4-6f) the frequency of occurrence of lower salinities is greatly increased under the Boat Lift in place scenario. The other scenarios do not see any appreciable changes in the frequency of occurrence, but there are some reductions in the higher salinity levels indicating some additional movement of freshwater to the north.

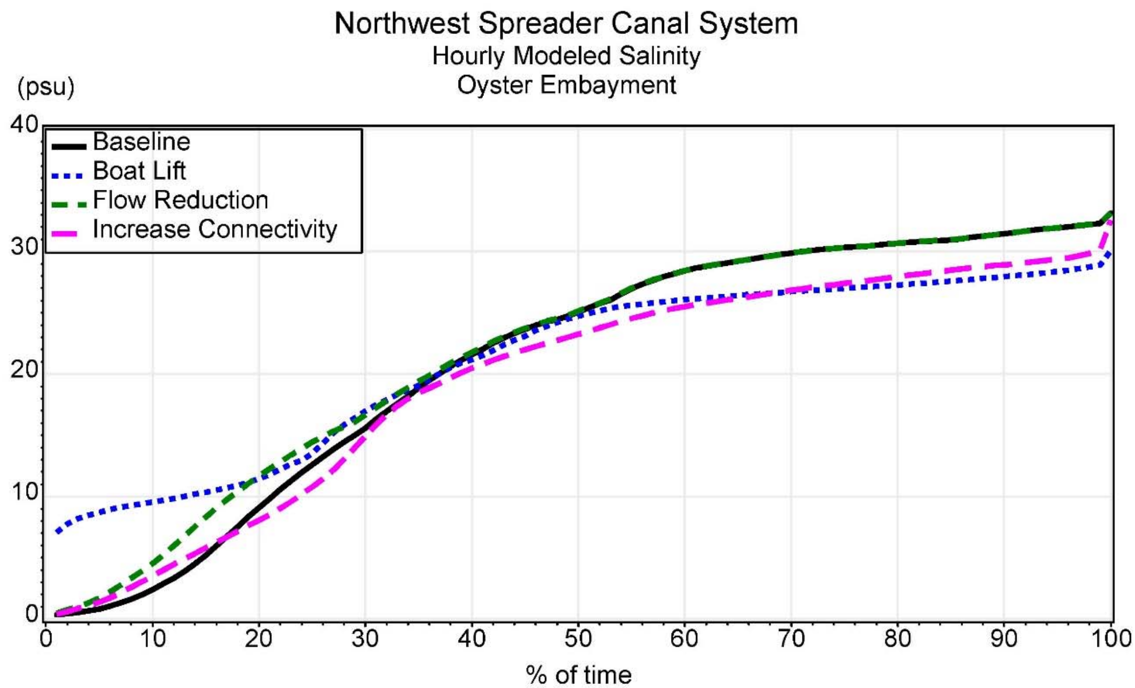


Figure 4-6a. Cumulative Distribution Function for Average Daily Salinity for the Oyster Embayment

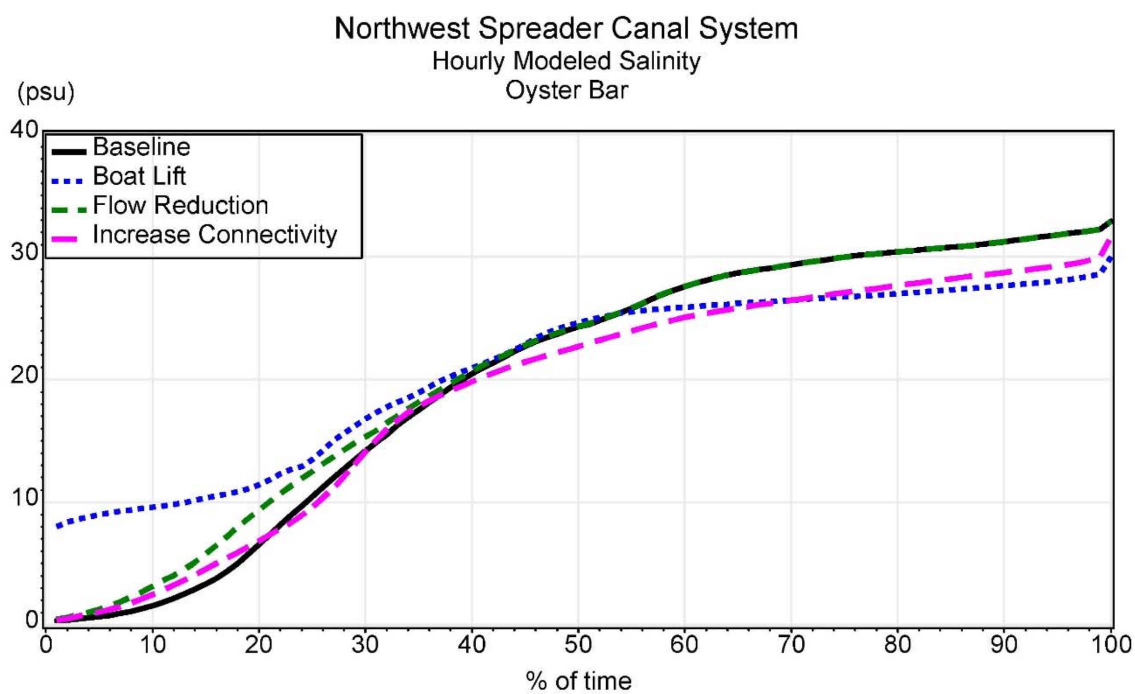


Figure 4-6b. Cumulative Distribution Function for Average Daily Salinity for the Oyster Bar

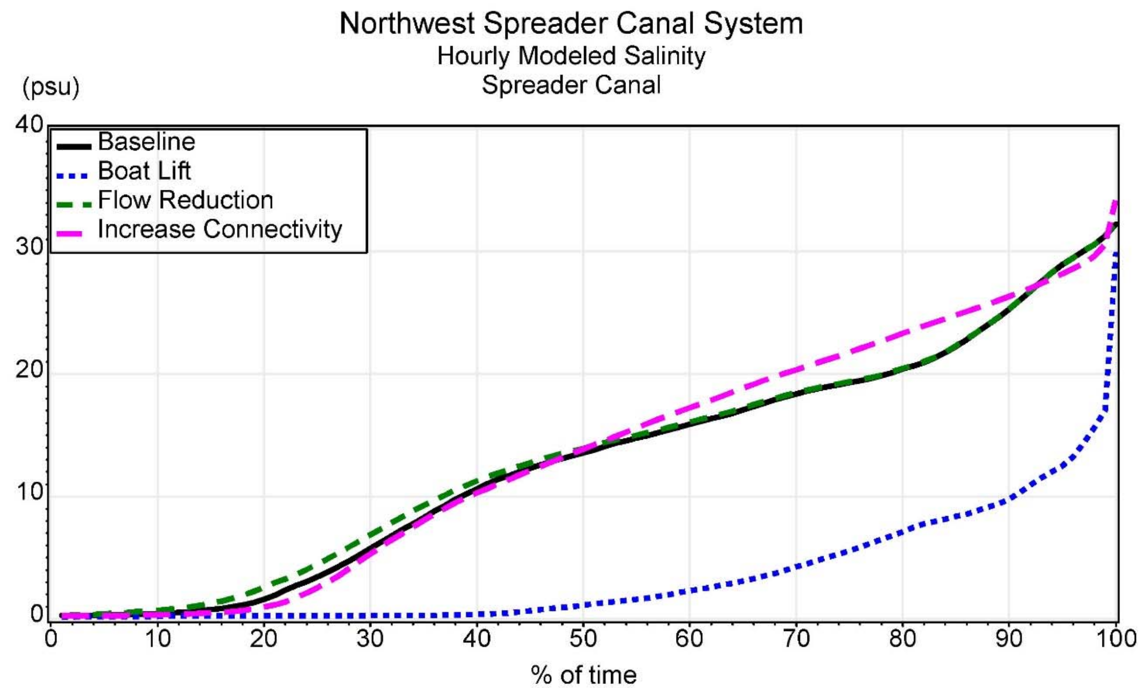


Figure 4-6c. Cumulative Distribution Function for Average Daily Salinity for the full NSC

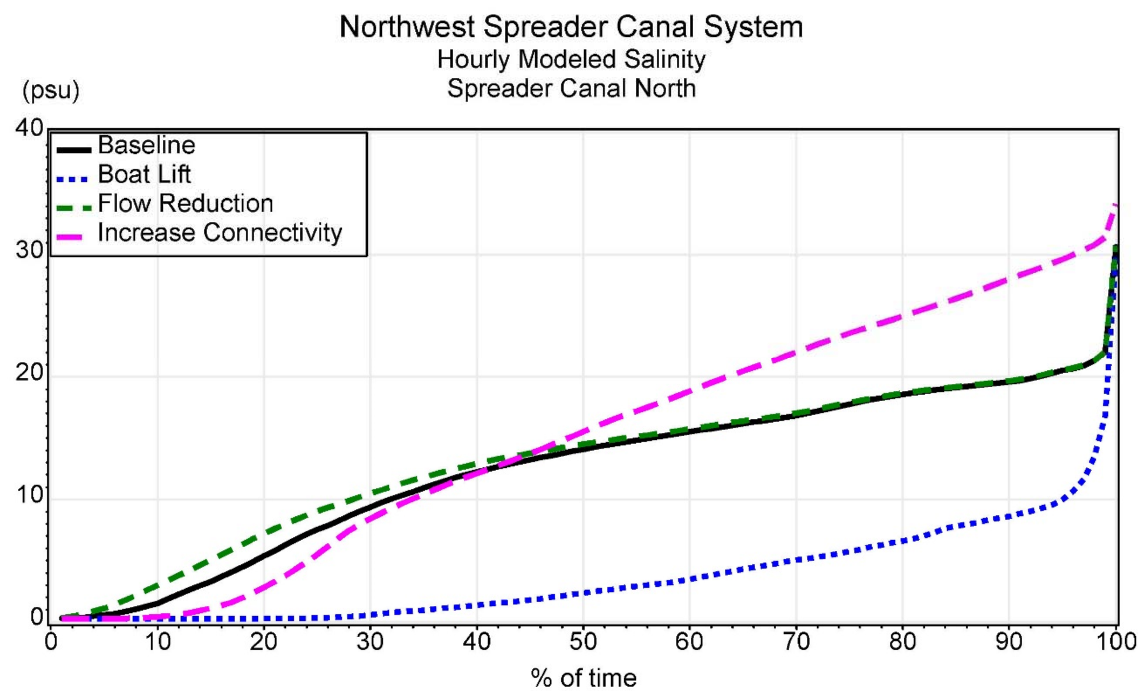


Figure 4-6d. Cumulative Distribution Function for Average Daily Salinity for the NSC North of Gator Slough

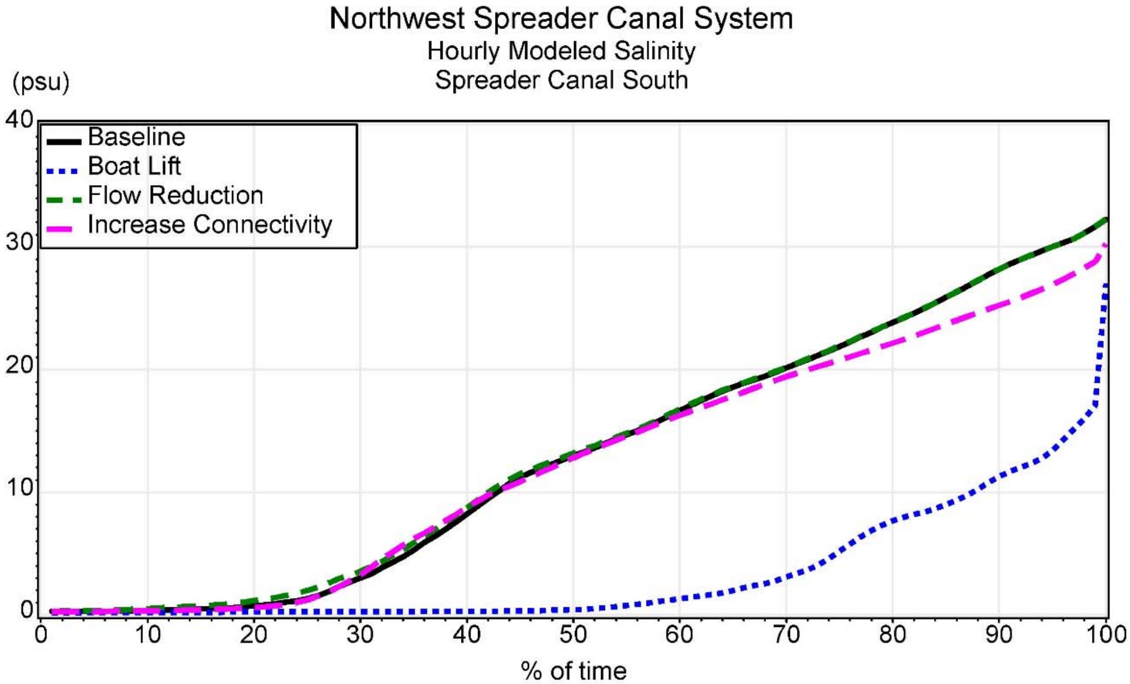


Figure 4-6e. Cumulative Distribution Function for Average Daily Salinity for the NSC South of Gator Slough

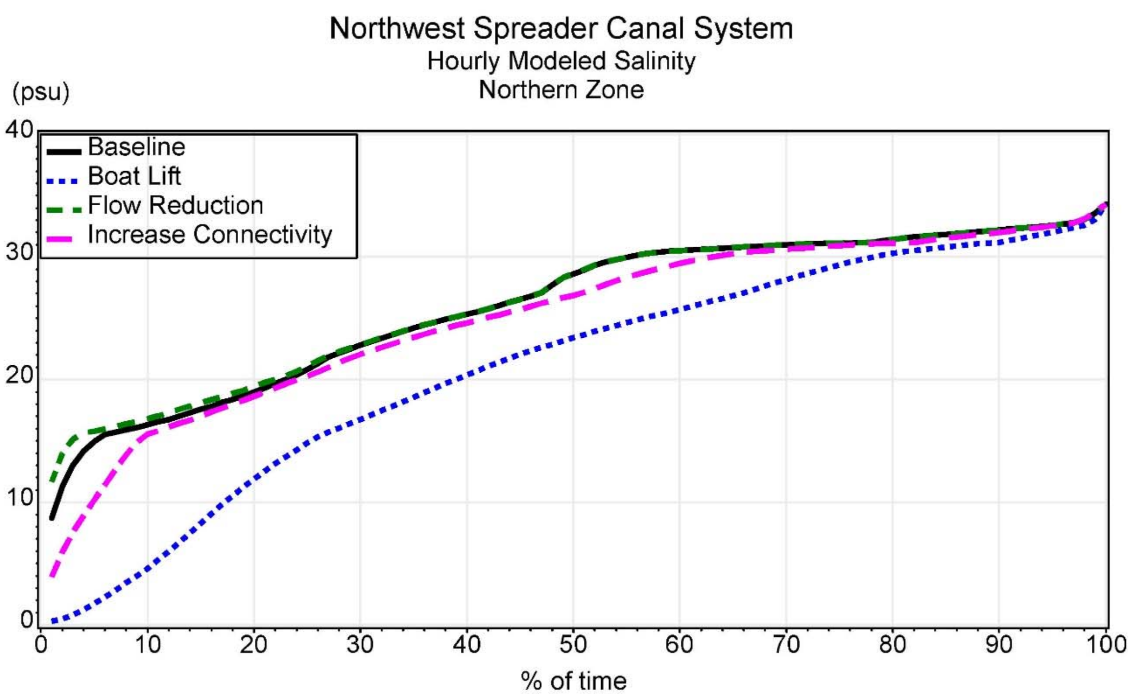


Figure 4-6f. Cumulative Distribution Function for Average Daily Salinity for the Northern Zone

As part of Phase I, in the NW Spreader Canal Water Quality and Biological Indicators report (Janicki, 2015), a critical salinity range for benthic organisms was identified from 10 ppt to 30 ppt. To assess the changes within this critical range, CDFs were determined for each of the four scenarios for the periods when salinities fell within this range. This eliminated the periods of high flow, when the system flushes out and goes fresh, and identifies how the scenarios impact the salinities outside of those high flow periods. Figures 4-7a through 4-7f present the CDF comparisons for each of the areas.

For the Oyster Embayment (Figure 4-7a) and Oyster Bar (Figure 4-7b) areas, while the Boat Lift scenario still shows differences, the magnitude of the differences in the CDF curves are less than was seen for the full range of salinities. The differences are generally less than 2 ppt. For portions of the curve, the probability of occurrence of higher salinity is greater and for portions, less. In general, for the critical salinity range, the impacts of the Boat Lift in place are less pronounced.

For the full Spreader Canal (Figure 4-7c), the impacts on salinities in the critical range are similar to what was found for the full range. The Boat Lift in place significantly reduces the probability of occurrence of higher salinities, while the Increased Connectivity significantly increases the probability. Similar patterns above and below Gator Slough (Figures 4-7d and 4-7e), described for the full range of salinities are seen for the critical salinity range.

As was seen for the Oyster areas, the Northern Zone (Figure 4-7f) shows significantly less differences in the CDF for the critical salinity range than was seen for the full range. The other scenarios show negligible difference. This identifies that for the non-high flow periods, the installation of the Boat Lift has a lesser impact on the timing and distribution of salinity in this area.

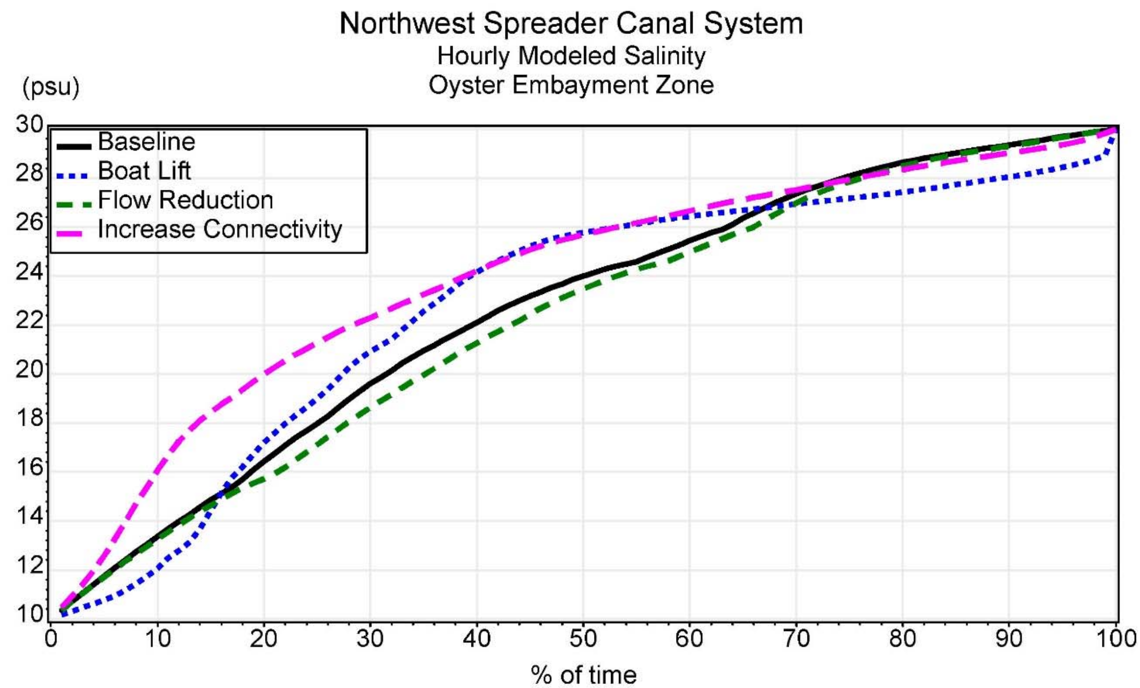


Figure 4-7a. Cumulative Distribution Function for Average Daily Salinity for the Oyster Embayment (Critical Range 10 to 30 ppt)

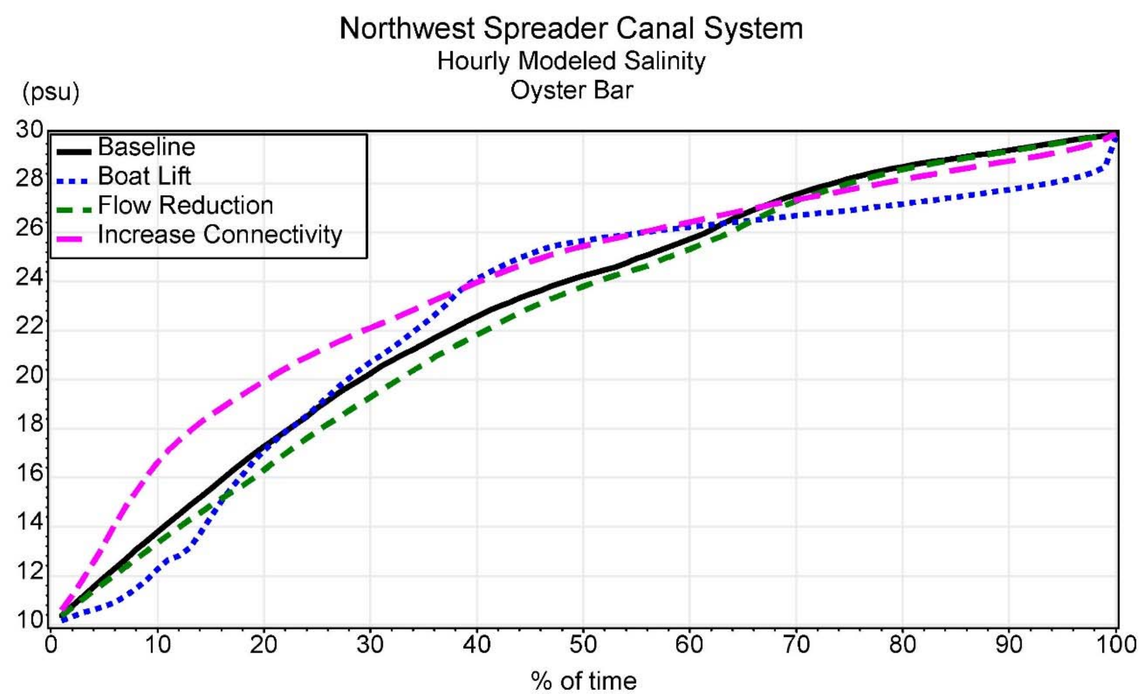


Figure 4-7b. Cumulative Distribution Function for Average Daily Salinity for the Oyster Bar (Critical Range 10 to 30 ppt)

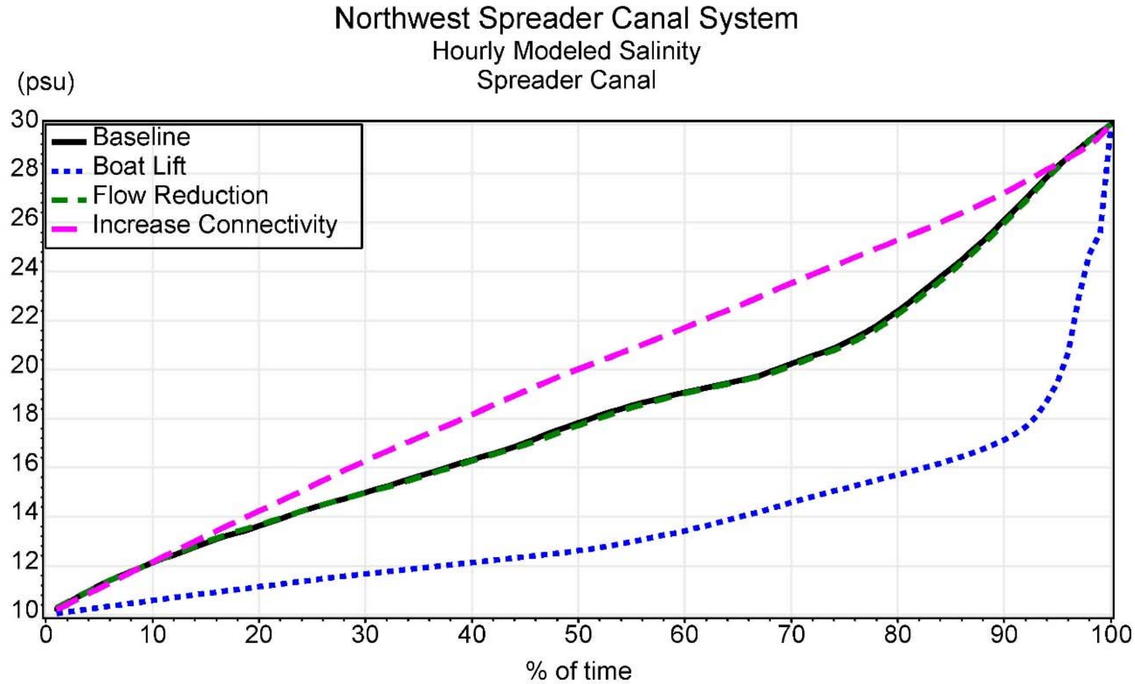


Figure 4-7c. Cumulative Distribution Function for Average Daily Salinity for the full NSC (Critical Range 10 to 30 ppt)

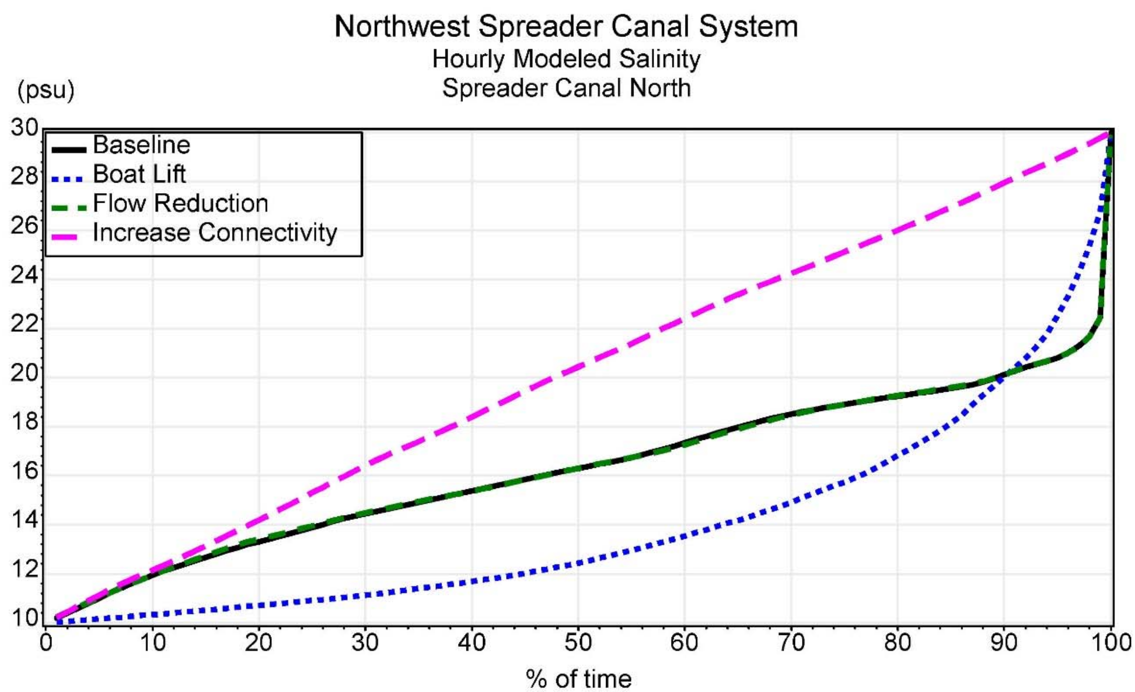


Figure 4-7d. Cumulative Distribution Function for Average Daily Salinity for the NSC North of Gator Slough (Critical Range 10 to 30 ppt)

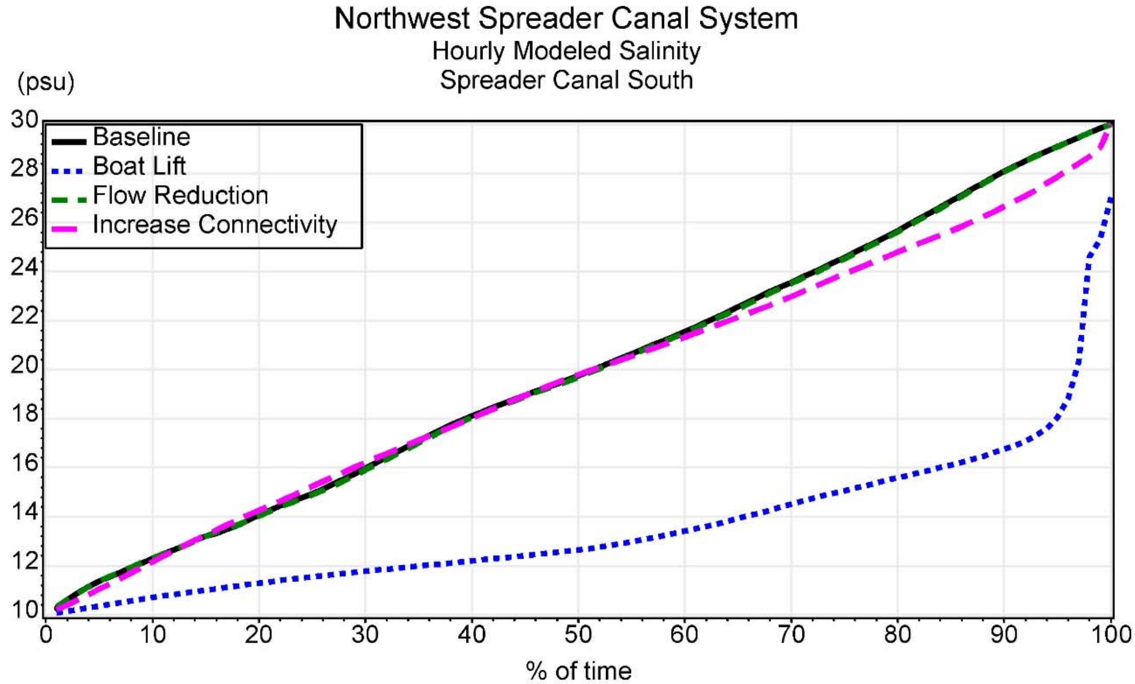


Figure 4-7e. Cumulative Distribution Function for Average Daily Salinity for the NSC South of Gator Slough (Critical Range 10 to 30 ppt)

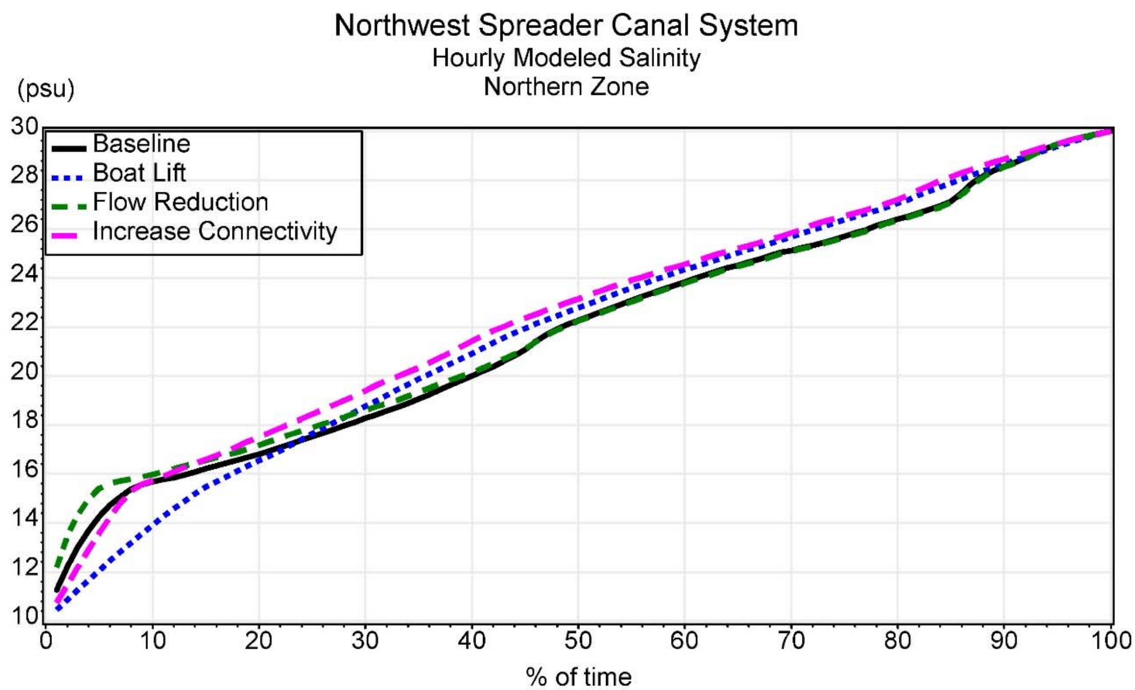


Figure 4-7f. Cumulative Distribution Function for Average Daily Salinity for the Northern Zone (Critical Range 10 to 30 ppt)

4.3 RESIDENCE TIME

Another key hydrodynamic parameter that will impact the overall water quality and, ultimately, the biological health of the system is residence time. Increased residence time can lead to degradation in water quality conditions and decreased residence time (or improved flushing) of the system can improve water quality conditions. For the residence time analyses, three of the four areas discussed in Section 4.1 were evaluated:

- Spreader Canal
- Oyster Embayment
- Oyster Bar

As the Northern Zone is generally an open water area, it is not anticipated that its residence time would be significantly altered by the proposed management scenarios and, therefore, it was not included.

To assess the residence times for the three areas listed above, dye tracer runs were performed where a mass of dye was put into the cells corresponding to the areas and then the time for that mass to move out of the area was determined and plotted over time. A parameter that has been used to define the residence time for other types of analyses is the point where the mass of dye in the area drops below 10 percent of its original value.

To assess how the system responds during high flow versus low flow, two flushing periods were evaluated. The first was for the high flow conditions, with a dye release date of August 22, 2013. The second was for a low flow condition, with a dye release date of February 3, 2013. Examination of the flow conditions in Figure 3-3 shows the flows during these periods. The high flow condition reflected average wet period levels of flow rather than the highest flow conditions. Low flow corresponded to a period of basically zero flow over the weirs.

Figures 4-8a and 4-8b present comparisons of the percent mass remaining within the Spreader Canal over time for the high flow and low flow cases, respectively. Looking at Figure 4-8a first (high flow condition) it is clear that the overall exchange time in the system under average wet season conditions is very short and driven primarily by the freshwater inflow. The residence times, based on the 10 percent remaining criteria, are all less than 5 days. With the Boat Lift in place, the system flushes even faster because there is no back pressure moving the dye back into the system (through the southern end). Flushing basically occurs due to exchange of the volume of the spreader with the freshwater entering the system over the weirs and some exchange through the limited tidal connections. The Increased Connectivity case significantly improves the overall flushing during the high flow periods by allowing more avenues for freshwater to escape.

For the low flow conditions, there are significant differences in the residence times under the various management scenarios. The residence times vary from around 8 days for the Increased Interconnectivity scenario to nearly 90 days for the Boat Lift scenario. The baseline and Flow Reduction scenarios have similar residence times, on the order of 35 days.

Figures 4-9a, 4-9b, 4-10a, and 4-10b present the residence time results for the Oyster Embayment and the Oyster Bar areas. For the high flow conditions (Figures 4-9a and 4-10a), the times are extremely short, on the order of 1 day. While the Boat Lift scenario has the longest times for both areas, these are still relatively short. The differences come from the removal of the freshwater outflow from the southern entrance, which then increases the exchange time. For the low flow conditions (Figures 4-9b and 4-10b), the residence times are still very short, on the order of 1 to 2 days, but as with the high flow, the Boat Lift in shows the most significant increase in the time over the baseline condition.

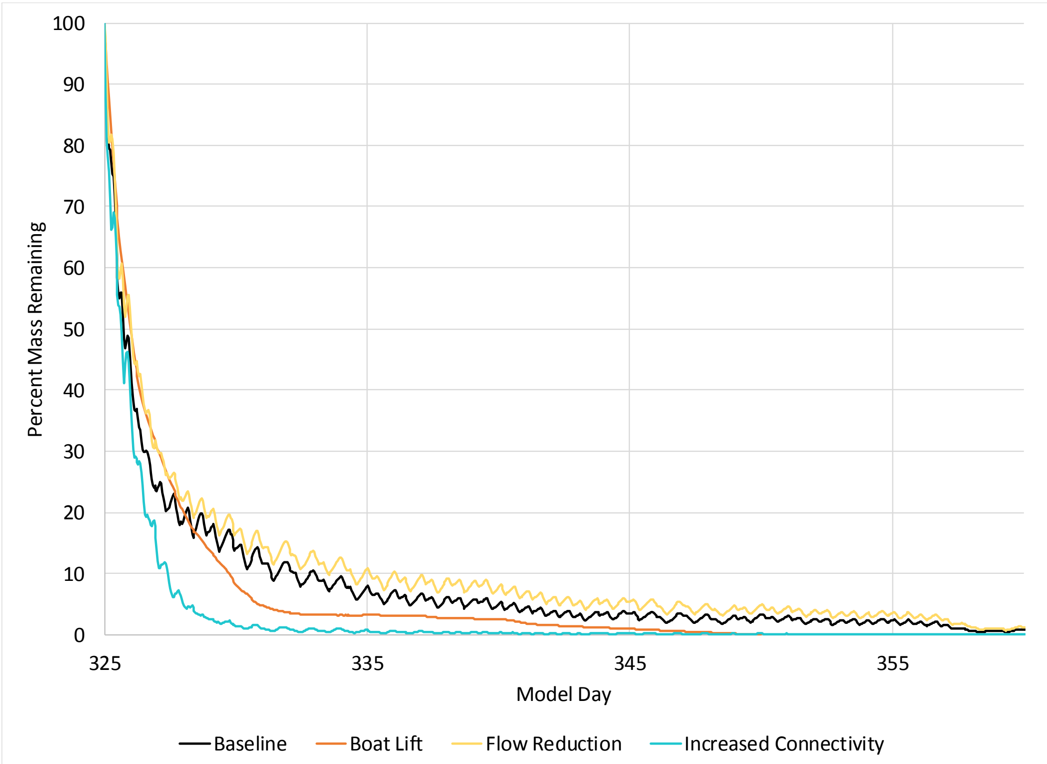


Figure 4-8a. Percent Mass Remaining in Spreader Canal (high flow condition)

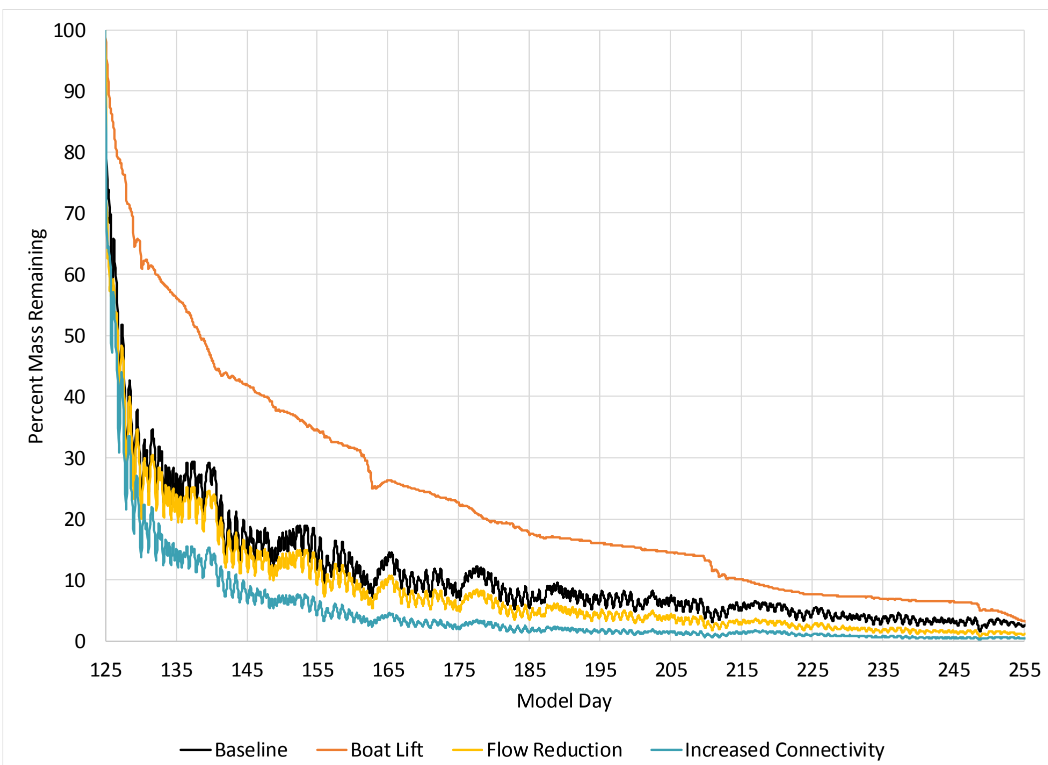


Figure 4-8b. Percent Mass Remaining in Spreader Canal (low flow condition)

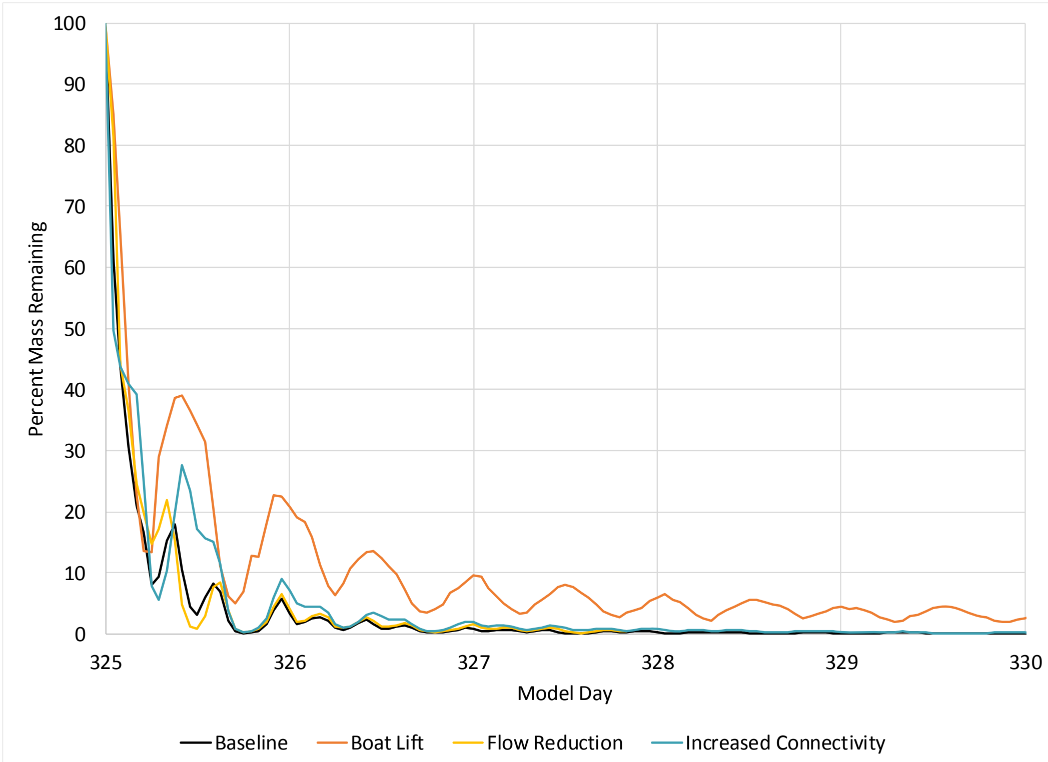


Figure 4-9a. Percent Mass Remaining in Oyster Embayment (high flow condition)

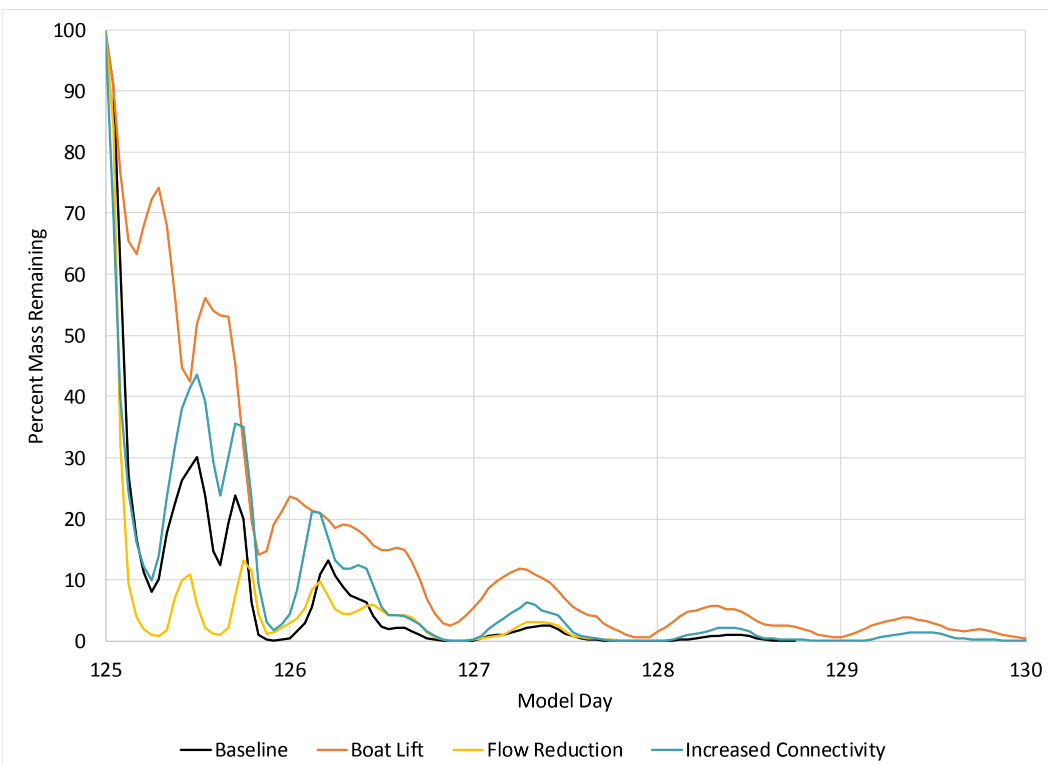


Figure 4-9b. Percent Mass Remaining in Oyster Embayment (low flow condition)

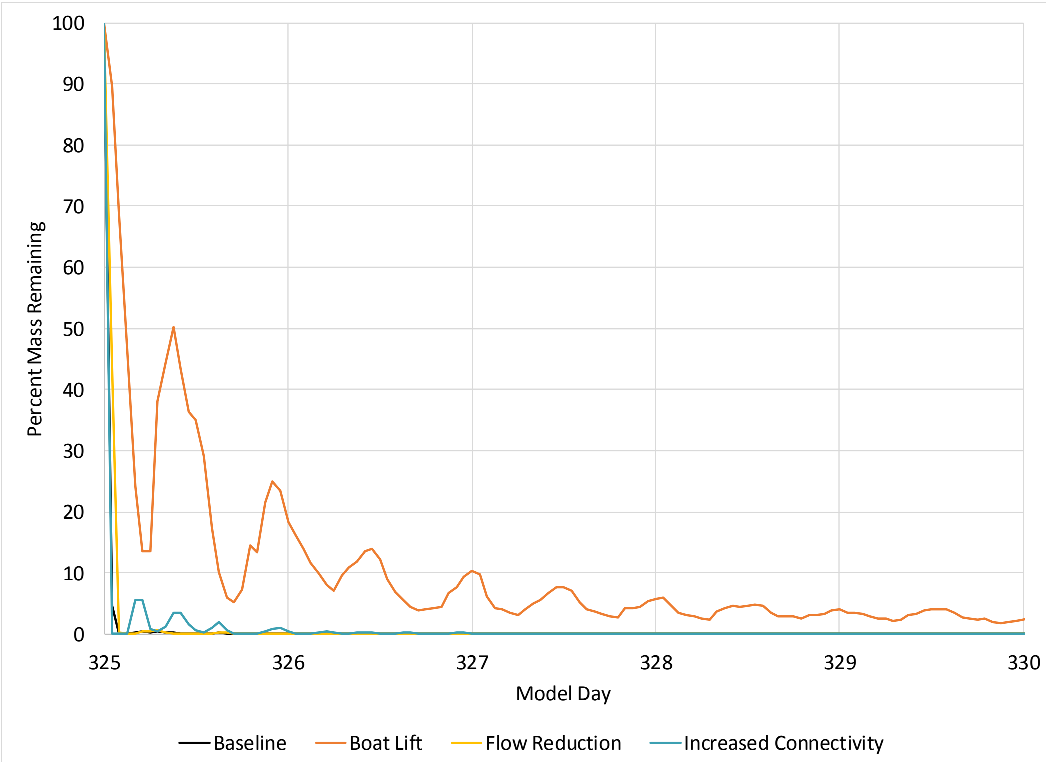


Figure 4-10a. Percent Mass Remaining in Oyster Bar (high flow condition)

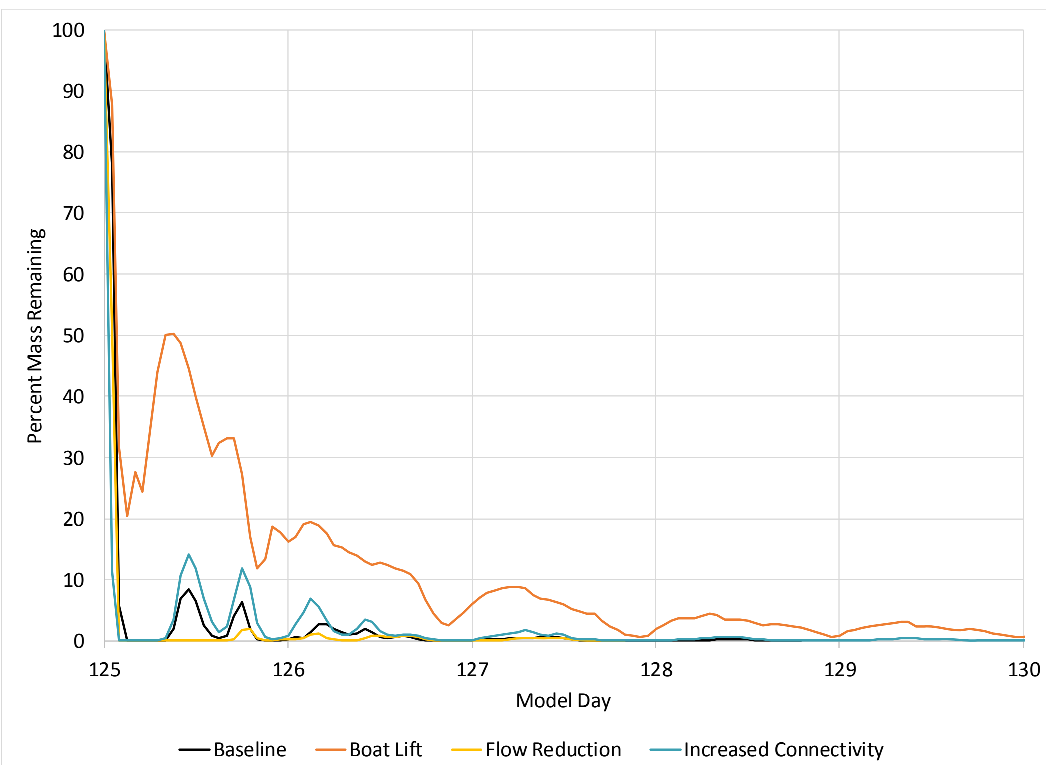


Figure 4-10b. Percent Mass Remaining in Oyster Bar (low flow condition)

4.4 BREACH VELOCITIES

Historical conditions in the Spreader Canal system resulted in changes in hydrodynamics that lead to the development of the breaches and significant erosion in certain areas. An important evaluation of the management scenarios is to determine if the changes associated with the alternative will place additional erosive stress in key areas. In order to do an initial assessment of the impacts of the proposed management alternatives, comparisons were made of the simulated velocities and their timing and distribution in the baseline case versus the three management scenarios. The analyses looked and identified where significant changes occurred that would increase the baseline erosive stress conditions.

For this analysis, nine locations were chosen. Figure 4-11 provides the locations where the velocities were taken from the model simulations. Points 1 through 5 reflect primary breach locations in the system connecting the Spreader Canal to the Key Ditch. Point 7 is in Ceitus Creek, which was an area of significant erosion when the boat lift was originally installed. Points 6, 8 and 9 reflect connections that presently pass flow between the Key Ditch and Matlacha Pass.

Given the highly time varying nature of the velocities, direct time series comparison is difficult to evaluate. Following the example from the salinity analyses, CDFs for the velocity magnitude were done for each of the scenarios at the locations in Figure 4-11. The CDFs represent the time varying nature of the velocity magnitudes over the full period of the simulation. Significant changes in the CDFs, i.e., showing higher frequency of occurrence of high velocities, would identify areas of potential increased erosive stress.

Figures 4-12a through 4-12i present comparisons of the CDFs for each scenario at the nine locations in Figure 4-11. For each of the plots, we are looking for where there is a significant shift in the curve from the baseline to increased velocity conditions (shift right). Additionally, we are looking for where the shift occurs in higher velocity conditions, i.e., generally greater than 0.5 to 1.0 meters per second (m/s). If the velocities are generally low even with a shift, these would not be considered changes that would induce future erosion.

Some significant shifts exist between the baseline, the Boat Lift scenario and the Increased Interconnectivity scenario. At Point 6, in the Boat Lift scenario, there is a significant shift from the baseline velocities, which are already high in this area. This is presently the primary connection between Matlacha Pass and the Spreader Canal, other than the southern entrance. Once the southern entrance is closed through the installation of the Boat Lift, this becomes the only avenue for tidal propagation into the system to the north. The velocity distribution for this location is such that flows may be topping out based upon friction in the system. Over time, this area (or other areas) would widen or open up to allow greater tidal flow into the system. Other significant shifts, primarily in the northern areas occur under the Increased Connectivity scenario. This is due to the fact that a number of new connections allow tidal velocities to pass between the NSC and Matlacha Pass have been opened and some previously shallow areas have been opened up, allowing a greater amount of flow. Only one of these increases to a range above 1 m/s and that is Point 1. This may mean that this scenario may cause some level of erosion at the primary breach connection to the northern Key Ditch.

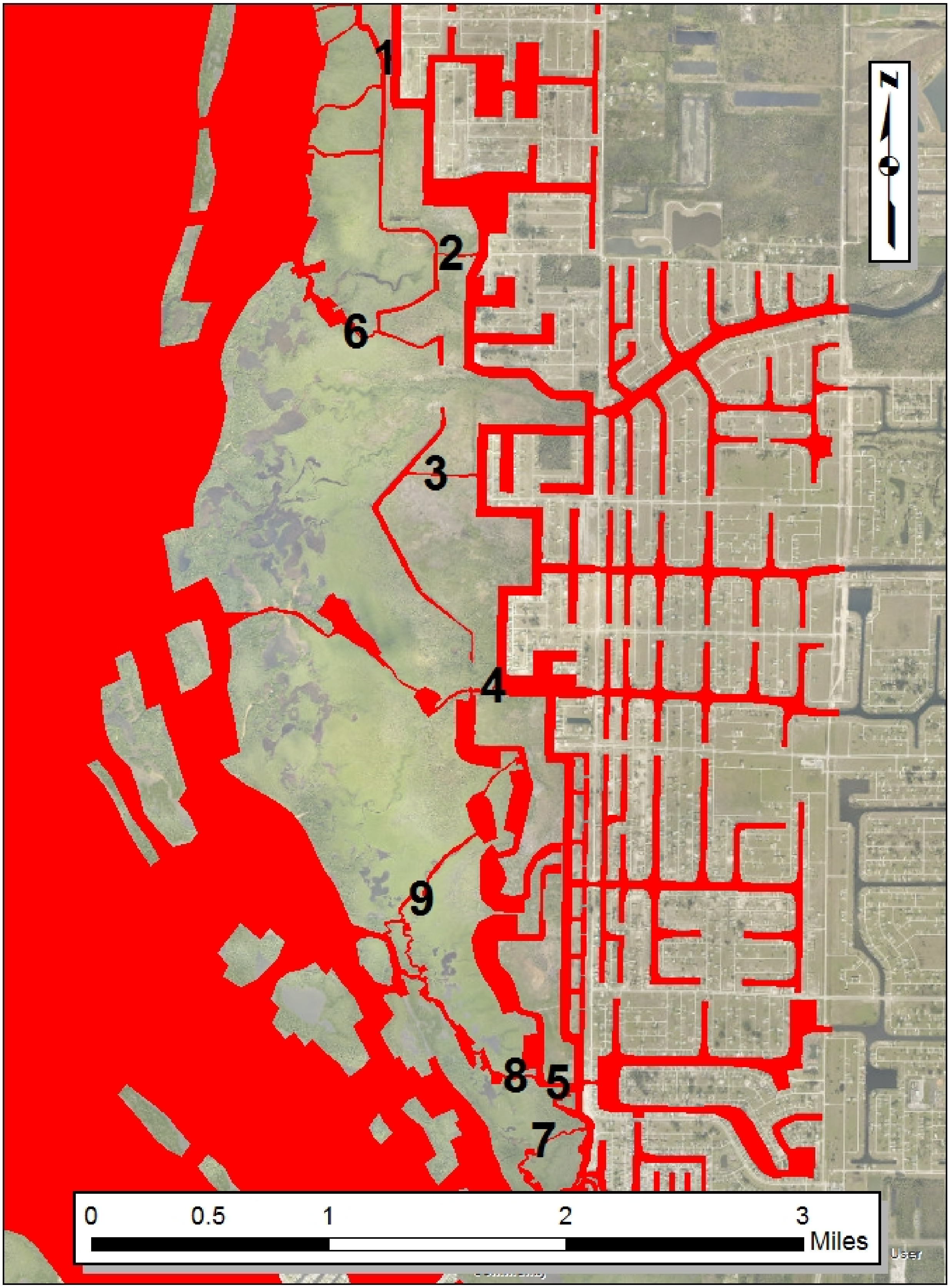


Figure 4-11. Locations of Velocity Analyses

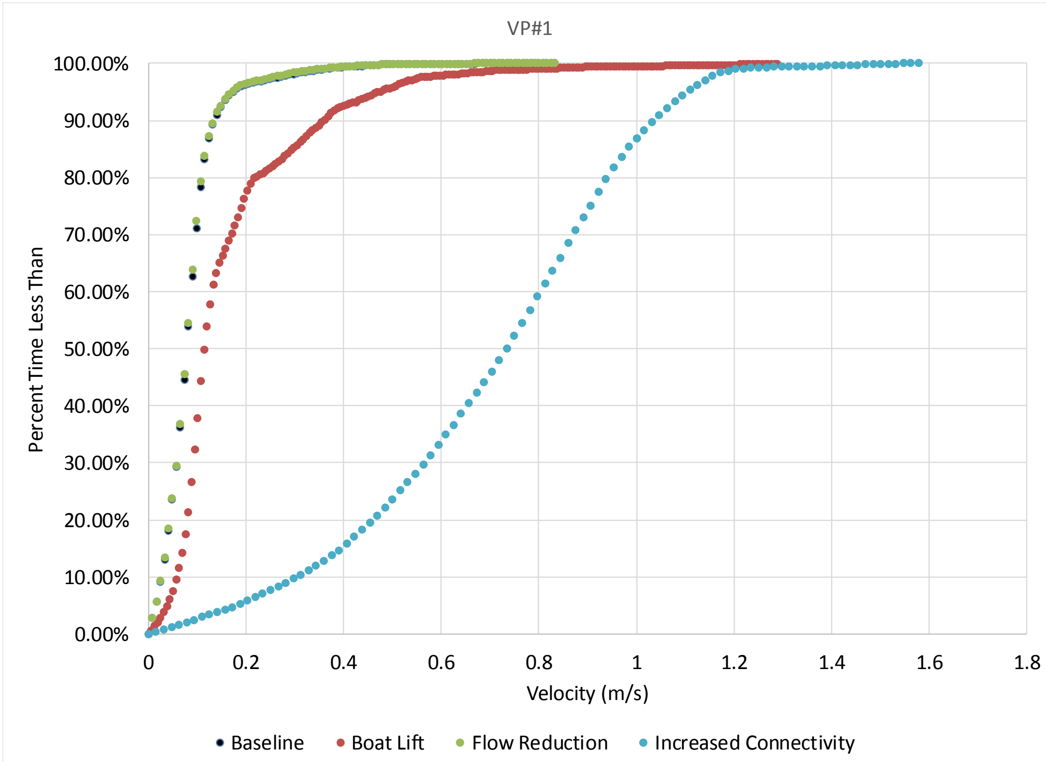


Figure 4-12a. CDF of Velocities at Point 1

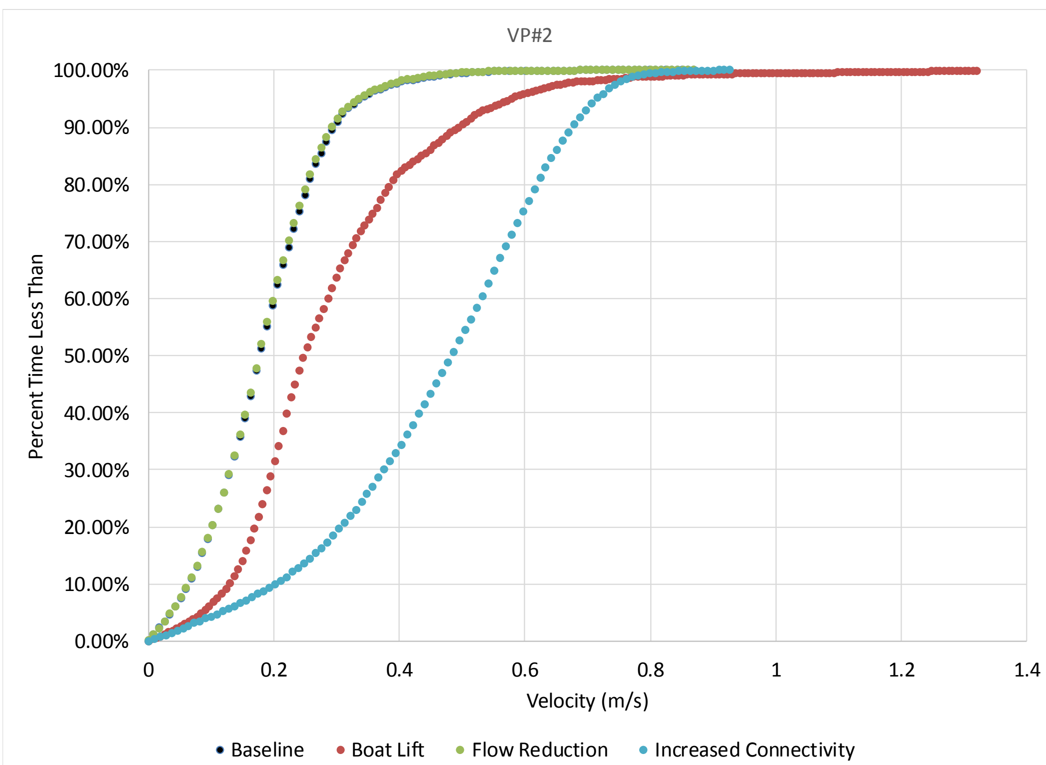


Figure 4-12b. CDF of Velocities at Point 2

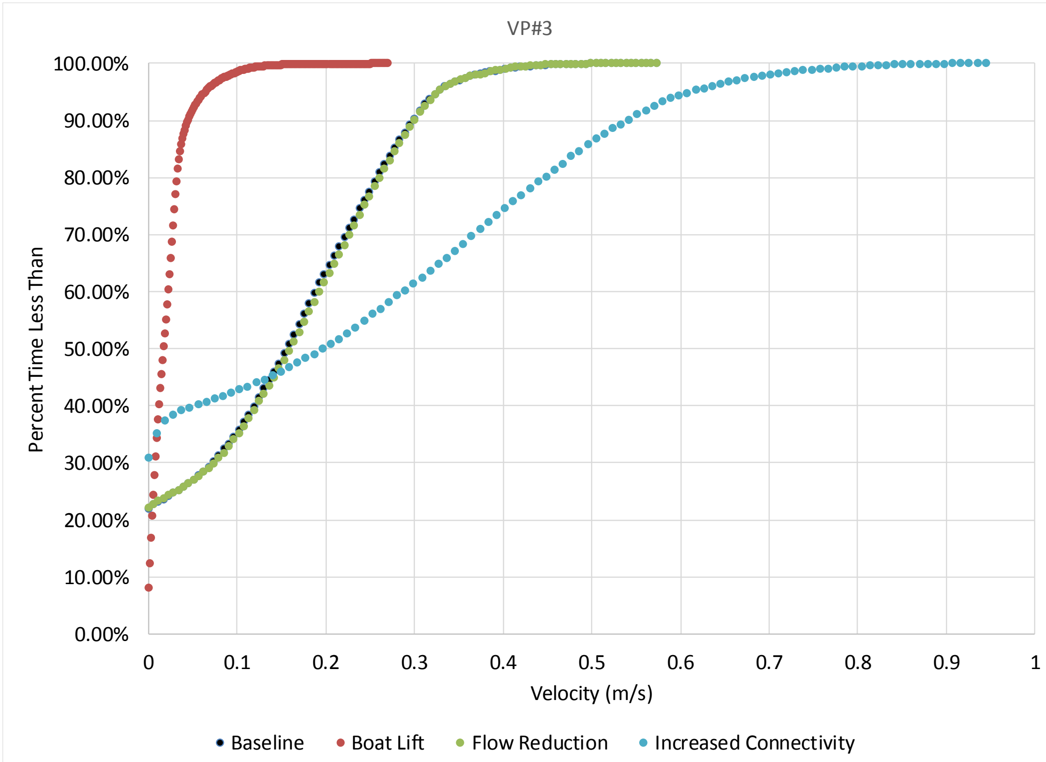


Figure 4-12c. CDF of Velocities at Point 3

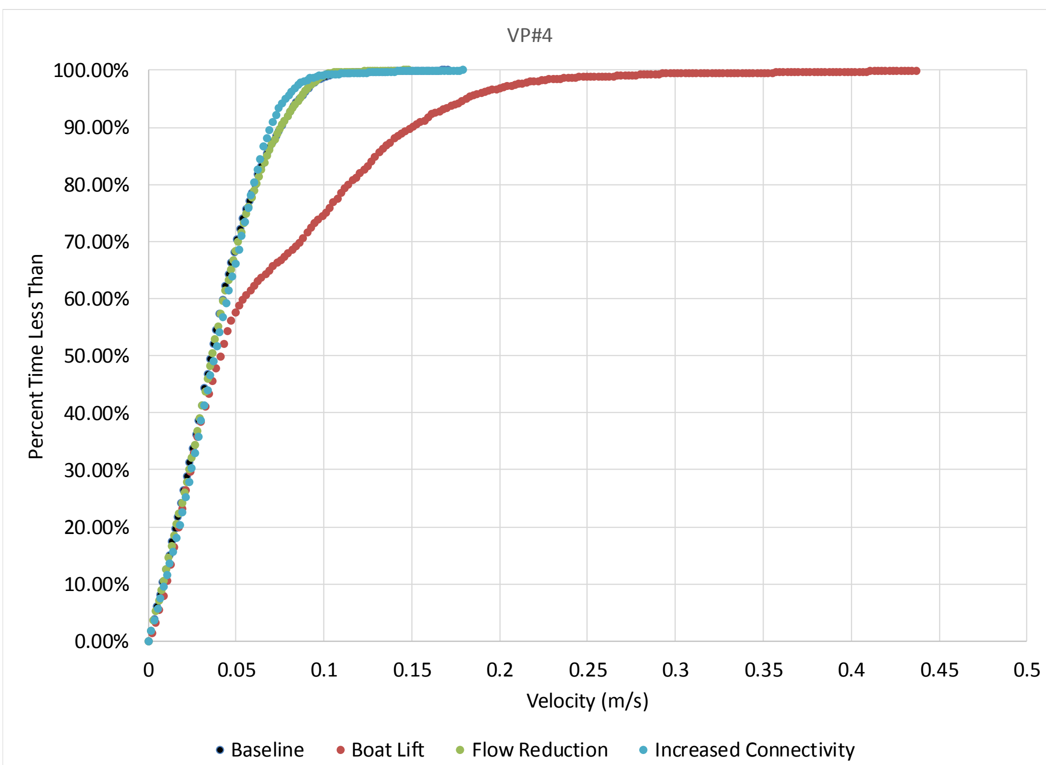


Figure 4-12d. CDF of Velocities at Point 4

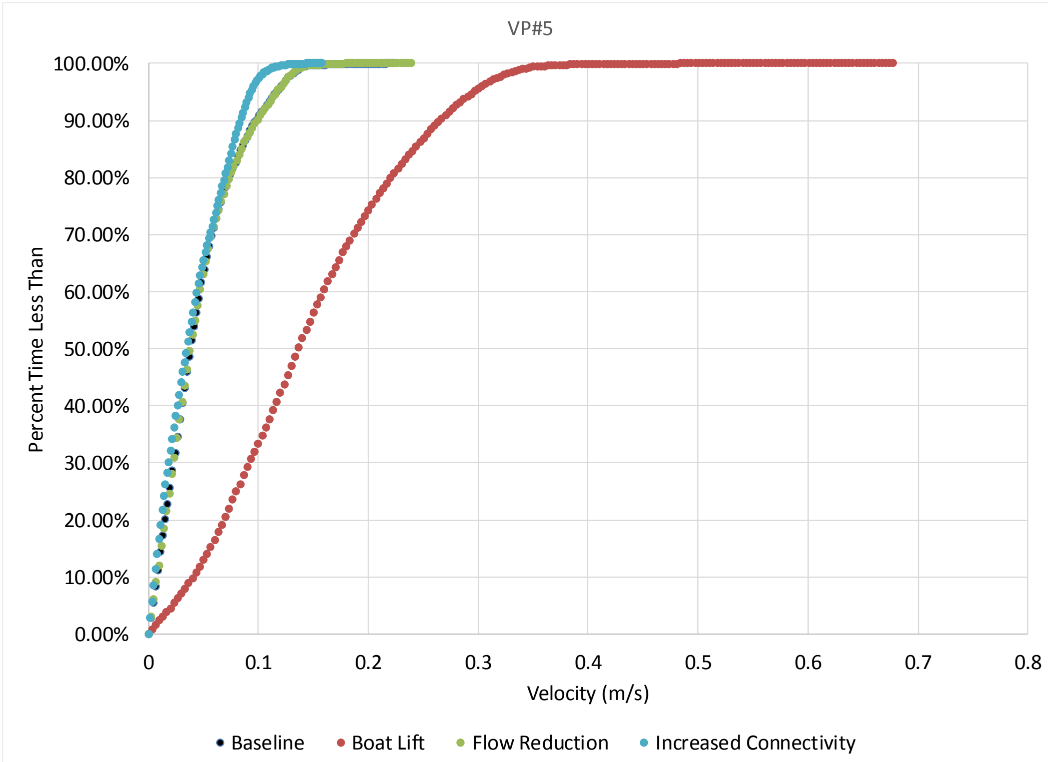


Figure 4-12e. CDF of Velocities at Point 5

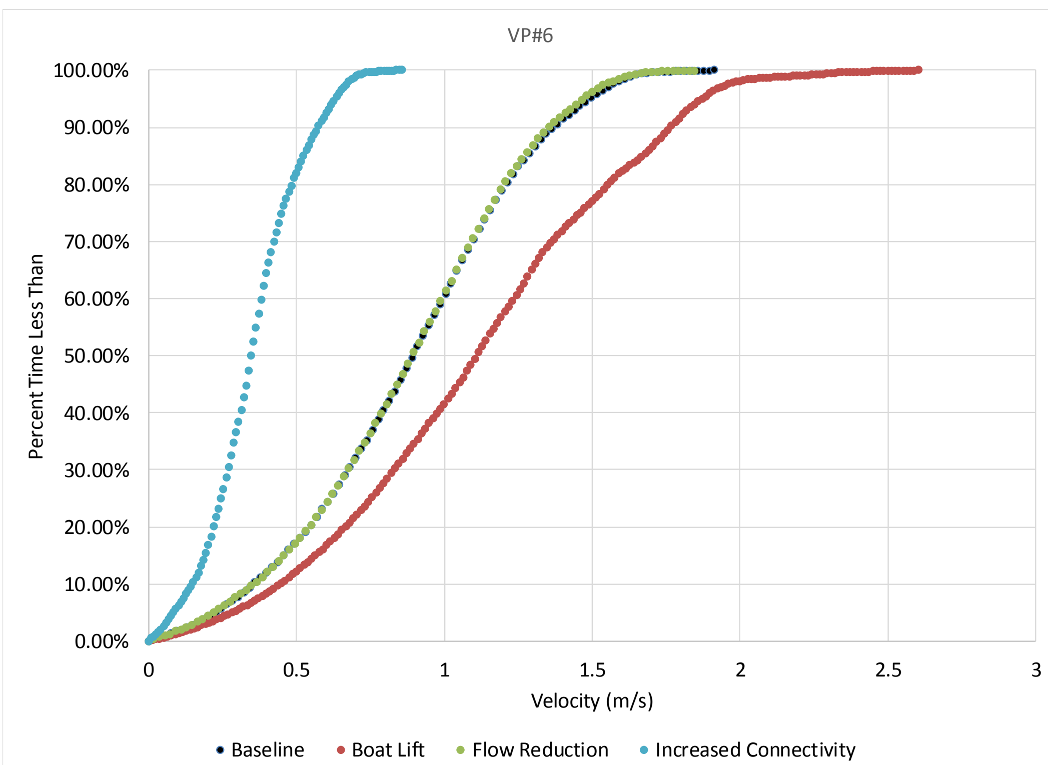


Figure 4-12f. CDF of Velocities at Point 6

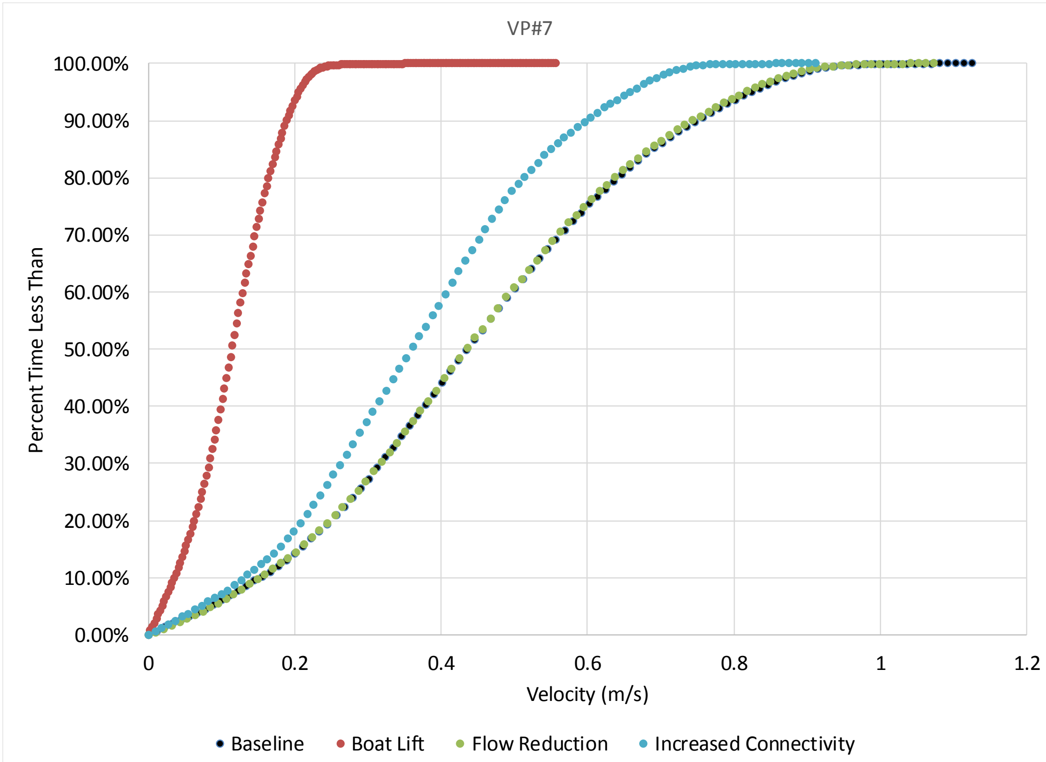


Figure 4-12g. CDF of Velocities at Point 7

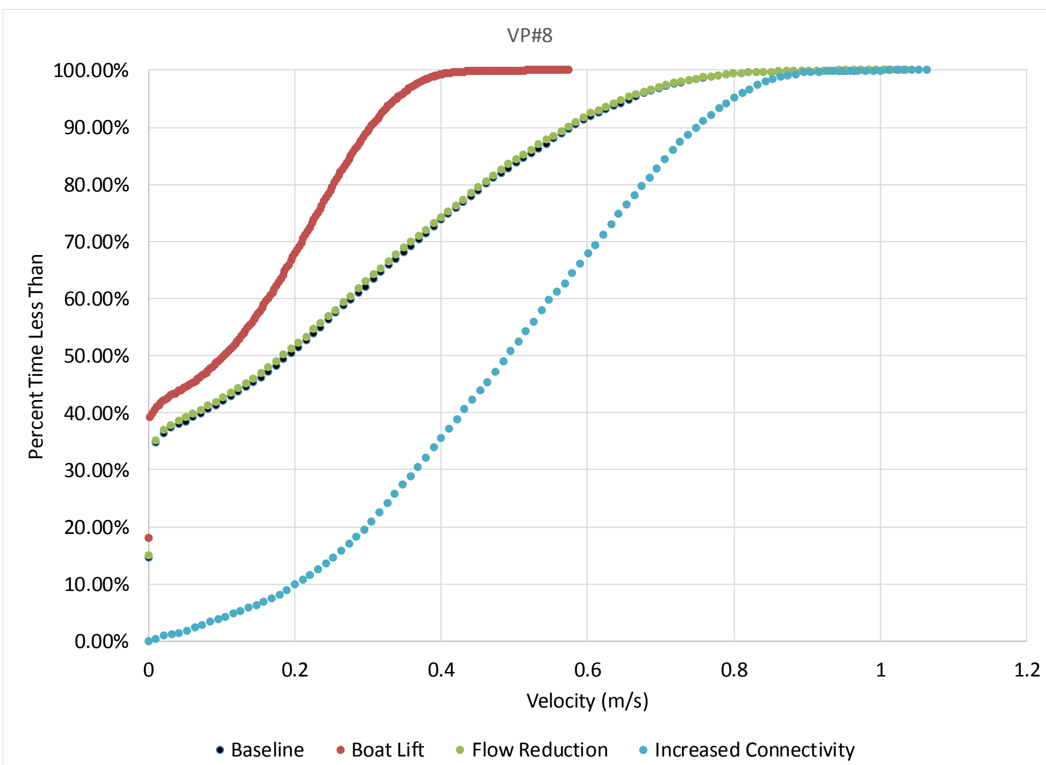


Figure 4-12h. CDF of Velocities at Point 8

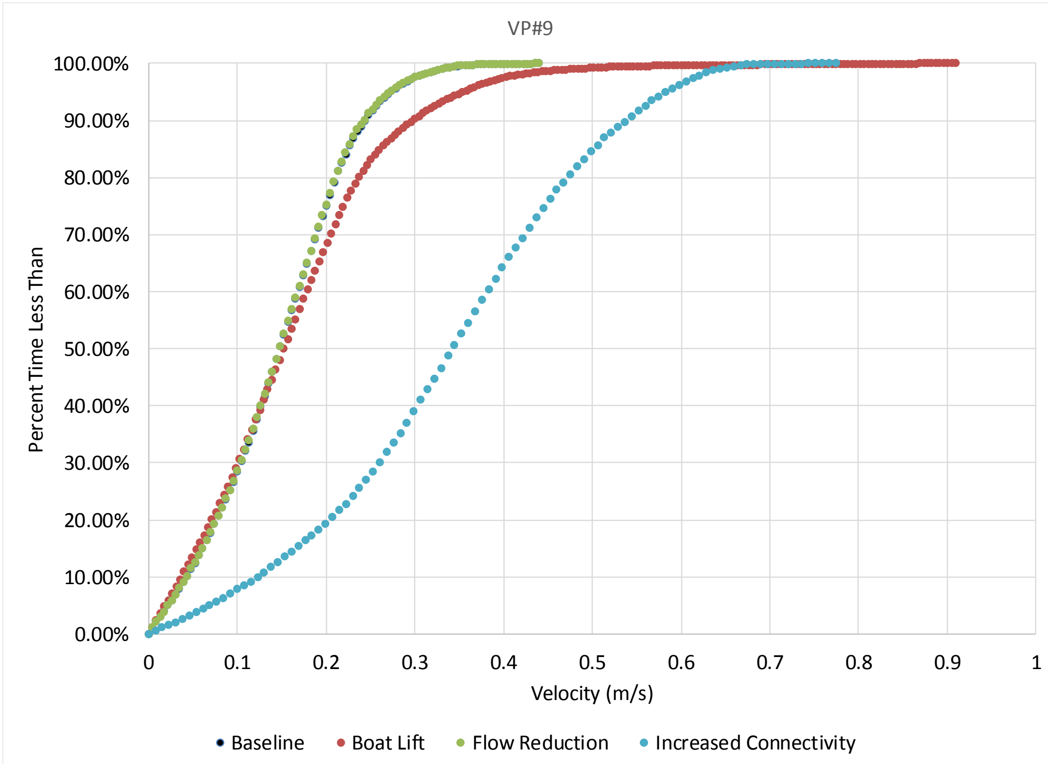


Figure 4-12i. *CDF of Velocities at Point 9*

5.0 SUMMARY AND CONCLUSIONS

Lee County and the City of Cape Coral have undertaken a joint project called the Northwest Cape Coral/Lee County Watershed Initiative. The initiative was divided into two phases. The overall goal of the Phase I work was to provide a detailed quantification of the existing (baseline) hydrodynamic and water quality conditions, identify key biological indicators and associated water quality targets, and develop a tool (hydrodynamic model) to allow assessment of changes in hydrodynamics due to future management activities. The goal of Phase II of the project was to assess the potential hydrodynamic responses of the system to specific defined management activities or scenarios and assess how those changes might impact hydrodynamic conditions.

This report provided analyses of the changes in the baseline (existing) salinity, residence times, and velocities for key areas within the Spreader Canal and adjacent waterways under three pre-defined management scenarios. The management scenarios reflected potential physical and hydrologic changes to the system defined by Lee County. The management scenarios were the following:

- Boat lift back in place within the system
- Reduction of flows from Gator Slough
- Increased connectivity between the NSC, Key Ditch, and Matlacha Pass

For the boat lift back in place scenario, barriers were placed in the model at locations provided by the City of Cape Coral. For the flow reductions in Gator Slough, the high flows (flows greater than 35 cfs) were reduced by 50 percent, assuming water withdrawal and rediversion. For the Increased Connectivity scenario, new connections were added between the NCS, KD and Matlacha Pass, and some presently partially blocked tidal channels to Matlacha Pass were deepened. The baseline and management scenarios were run with the same boundary forcing conditions (excluding the flow reductions) of tides, flows, and winds for the period from October 2012 to December 2013.

Four key areas were identified for the analyses of the salinity changes. The areas were the following:

- Oyster Embayment: a larger embayment area near the southern entrance to the Spreader Canal north of the causeway
- Oyster Bar: a sub-area of the Oyster Embayment immediately west of the southern entrance to the Spreader Canal
- Spreader Canal: the NSC above the area defined by the City of Cape Coral for the boat lift
- Northern Zone: an area in the northern end of Matlacha Pass within the transition zone between the mangroves to the east and the open waters of Matlacha Pass.

The analyses included comparisons of the daily average salinity over the defined area between baseline and the management scenarios as well as comparison of the CDFs of the simulated salinity. Key findings from the salinity analyses included the following:

- Within the Oyster Embayment and Oyster Bar, with the boat lift in place, there is a reduction in the range of salinities between the wet and dry periods, as well as a reduction in the short-term fluctuations in salinity. Only minor differences were seen in these areas under the Gator Slough flow reduction.
- Within the Spreader Canal, the most significant changes were seen with the boat lift back in place. With the boat lift back in place, the overall salinity levels in the spreader canal were significantly reduced.
- Within the Northern Zone, only the boat lift back in place showed significant changes in salinity, with the levels reduced as more freshwater is moved in this direction. The Increased Interconnectivity provided for a minor increase in the freshwater inflows moving to the north and this area showed some salinity reduction.
- When analyses were performed for a critical salinity range (10 to 30 ppt), the differences between the impacts under the three scenarios were reduced. This indicated that under lower flow to no flow conditions, the relative differences in salinity between the three scenarios and baseline conditions are smaller.
- Before any management action is taken, a thorough investigation should be conducted to assess the impacts on the Key Biological Indicators established in Phase I.

Using dye tracer simulations for three of the key areas (Oyster Embayment, Oyster Bar, and Spreader Canal) evaluations of residence times were performed under both high flow and low flow conditions. Key findings from these analyses showed the following:

- During high flow conditions, all areas have short residence times and there are relatively minor differences between the three scenarios.
- The residence times are short in all cases for the Oyster Embayment and Oyster Bar areas, but the longest times are seen when the boat lift is in place.
- The most significant change in the overall residence times occurs during the low flow period with the boat lift in place scenario, showing significant increases in the overall residence time in the Spreader Canal, from around 35 days up to 90 days.
- The Increased Connectivity provided for some significant decreases in the residence time during higher flow conditions, indicating more avenues for freshwater to leave the system. This scenario also showed significant reductions in the residence times during low flow conditions.

Finally, velocity evaluations were performed at key connections in the model between the Spreader Canal and KD and between KD and Matlacha Pass. The results were evaluated to determine if any of the scenarios showed the potential for significant increases in erosional stress in the system. The only connection that showed a significant increase was the existing channel that presently connects Matlacha Pass to the northern KD. This is the only present continuous connection between Matlacha Pass and KD. Once the southern entrance is closed through the installation of the boat lift, this becomes the only avenue for tidal propagation into the system to the north. The increases in the magnitude of velocities (when the boat lift was installed) indicated that under this scenario, there is a high potential for additional erosion of the connection or development of alternate flow pathways.

Another significant shift, primarily in the northern areas, occurred under the Increased Connectivity scenario. This indicated some potential erosion in the primary breach opening to the northern section of the KD.

6.0 LITERATURE

Applied Technology and Management, Inc. (ATM). 2015a. NW Cape Coral/Lee County Watershed Initiative, Phase I, Hydrodynamic Model Development and Calibration. Prepared for Lee County, Florida. Gainesville, FL.

Applied Technology and Management, Inc. (ATM). 2015b. NW Cape Coral/Lee County Watershed Initiative, Phase I, Hydrodynamic Data Characterization. Prepared for Lee County, Florida. Gainesville, FL.

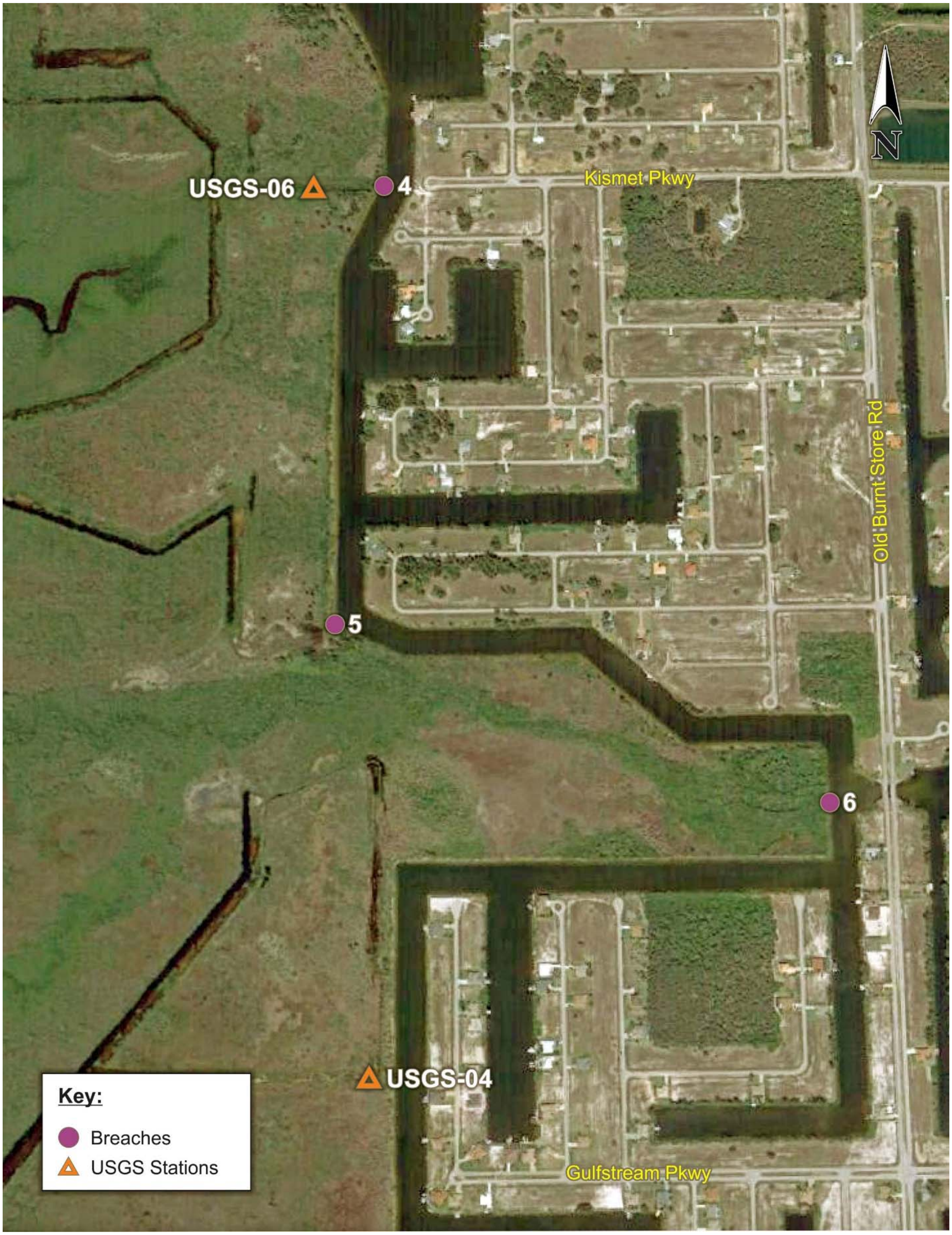
Havens & Emerson, Inc. 1993. Spreader Waterway Breach Area Improvements Design Report. Cape Coral, FL

Janicki Environmental, Inc. (Janicki). 2015. NW Cape Coral/Lee County Watershed Initiative, Phase I, Water Quality and Biological Indicators. Prepared for Lee County, Florida. St. Petersburg, 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



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

Aerial Photos of Breaches and USGS Monitoring Site Locations

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