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Coastal and Hydraulics Laboratory

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Hydrodynamic and Salinity Analysis of Conceptual Surge Barrier Designs in the Lake Pontchartrain Region

S. Keith Martin, Tate O. McAlpin, and Darla C. McVan

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Final report

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New Orleans District, Hurricane Protection Office
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Abstract: A three-dimensional hydrodynamic/salinity model of the Lake Pontchartrain system was developed for the purpose of analyzing the impacts of conceptual surge barrier designs on current velocities and salinity levels in the Lake Pontchartrain system. The model was validated against observed data and applied using boundary conditions developed from 2006 data.

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Preface

The model investigation presented in this report was authorized and funded by the U.S. Army Engineer Hurricane Protection Office (HPO), New Orleans. This floodgate analysis study of the Mississippi River Gulf Outlet and the Gulf Intracoastal Waterway was conducted by Keith Martin, Tate McAlpin, and Darla C. McVan.

This work was conducted at the Coastal and Hydraulics Laboratory (CHL) of the U. S. Army Engineer Research and Development Center (ERDC) during the period of July 2006 to December 2007 under the direction of Thomas W. Richardson, Director of the CHL; Dr. Rose Kress, Chief of the Navigation Division, CHL; Bruce Ebersole, Chief of the Flood and Storm Protection Division, CHL; Dennis W. Webb, Chief of the Navigation Branch, CHL; Dr. Robert McAdory, Chief of the Estuarine Engineering Branch, CHL.

COL Gary E. Johnston was Commander and Executive Director.
Dr. Jeffery P. Holland was Director of ERDC.

Executive Summary

Background

The U.S. Army Engineer Hurricane Protection Office (HPO) requested that the USACE Engineer Research and Development Center (ERDC) at Waterways Experiment Station perform a numerical modeling study of conceptual designs of a storm surge barrier(s) on the Gulf Intracoastal Waterway (GIWW) and the Mississippi River Gulf Outlet (MRGO). The purpose of the study was to develop conceptual barrier alternatives that reduced surge-related flooding in the study region but did not negatively impacting navigation and regional salinity values in the system.

The MRGO is a 66-mile-long deepwater channel that extends northwest from deep water in the Gulf of Mexico to New Orleans, LA. The MRGO merges with the GIWW and continues five miles further to the West where it joins the Inner Harbor Navigation Canal (IHNC). The IHNC proceeds approximately three more miles north from its intersection with the GIWW to connect with Lake Pontchartrain at Seabrook. The section of the GIWW that is of interest for this project extends southwest approximately 20 miles from its connection with Lake Borgne to its confluence with the MRGO.

Hydrodynamic Numerical Model

A three-dimensional hydrodynamic model was used to predict the effects of surge barrier alternatives on flow velocities and salinity in the study area. The model chosen for this study was TABS-MDS, which is a component of the TABS-MD modeling system. The TABS-MD modeling system is among the Corps of Engineers' standard modeling tools for three-dimensional, open-channel flow and sediment transport problems and uses the finite element formulation. The Surface Water Modeling System (SMS; see Brigham Young University, 1997) was used for model development and analysis.

Model Scenarios

The numerical modeling was conducted in two phases. In both phases, the model was run for the entire year of 2006 with three months of model spinup, Oct-Dec 2005. This time period was chosen in order to account for system changes due to Hurricane Katrina.

In Phase 1, HPO proposed four alternatives for testing:

System A

a) 150 foot by 16 foot (sill) one way sail thru structure on GIWW located just East of the Michoud Canal

b) 56 foot by 8 foot (sill) structure on Bayou Bienvenue (BB) located between MRGO and Lake Borgne

c) MRGO closed just south of Bayou Bienvenue

d) Barrier between structures a and b and between structure b and closure c. This barrier forms an arc between the GIWW structure and the MRGO closure. The wetland that this barrier traverses is not included in the model and therefore the performance of the barrier under non-flood conditions is not considered in the model.

System B

a) 150 foot by 16 foot (sill) one way sail thru structure on GIWW located just East of the Michoud Canal

b) 110 foot by 16 foot (sill) one way sail thru structure on MRGO with spillway (if required) located just south of Bayou Bienvenue

c) 110 foot by 16 foot (sill) open pass on MRGO located near la Loutre Ridge

System C

a) 350 foot by 40 foot (sill) one way sail thru structure on MRGO/GIWW with spillways (if required)

b) MRGO closed at la Loutre Ridge

System D

a) 350 foot by 40 foot (sill) one way sail thru structure on MRGO/GIWW with spillways (if required) located near Paris Rd

b) 110 foot by 16 foot (sill) open pass on MRGO located near la Loutre Ridge

The Base condition for Phase 1 was simply the existing conditions. Based upon the results in the first phase, HPO selected two systems, A and C, for further testing in Phase 2.

The Phase 2 Base condition was developed by adding a closure of the MRGO at la Loutre to the Phase 1 Base condition. The closure at la Loutre was made part of the Base condition in order to reflect the deauthorization of the MRGO. The scenarios for Phase 2 were developed by starting with the Base condition and incrementally adding the parts of the respective systems. In Phase 2, it should be noted that the parts of each of the systems, A and C, were not added in the order listed above for Phase 1. In both Systems A and C, the final scenarios, A4 and C2, resulted from adding a proposed structure on the IHNC near Seabrook.

Conclusions

The surface velocities in the MRGO and the GIWW did increase in the immediate vicinity of the sail through structures. However, the surface velocities and water levels decreased below pre-project values on the Lake Pontchartrain side of the structures at distances from the structure equal to approximately twice the width of the structure. Also, an examination of the surface velocities and water levels by ERDC navigation personnel did not indicate significant negative impacts to navigation due to implementation of any of the four proposed alternatives in Phase 1. Near-field effects were not considered as the structures in the model were only conceptual in nature. The actual design specifications of the structures would have to be represented in the model in order to simulate the near-field effects of the structures. Velocities in the structures themselves were significantly higher than the Base condition for both Systems A and C in Phase 1 and Systems A3, A4, C1, and C2 in Phase 2. As the Phase 1 modeling was used for vetting the four systems, only Phase 2 structure velocities will be in the table below. The factor is the factor by which the Base condition velocity magnitude is increased within each structure.

While the maximum velocity in the BB structure exceeded the 2.6 ft/sec threshold for fish movement, an exceedance analysis showed this velocity to be a low frequency event most probably associated with a frontal passage coupled with a strong spring tide.

System	Maximum Structure Velocities		
	GIWW (factor)	BB (factor)	Seabrook (factor)
A3	2.5 ft/sec (5)	5.9 ft/sec (12)	3.0 ft/sec (1)
A4	2.5 ft/sec (5)	5.9 ft/sec (12)	4.25 ft/sec (1.4)
C1	0.6 ft/sec (2)	NA	4.25 ft/sec (1.4)
C2	0.6 ft/sec (2)	NA	6.0 ft/sec (2)

An analysis of monthly averaged bottom salinity values was performed for both phases of modeling. The closures of the MRGO in the Phase 1 scenarios produced noticeable reductions, 1-5 ppt, in salinity values in the connecting channels, MRGO/GIWW/IHNC, especially during the dryer period (September 2006) of the year. However, Lakes Borgne and Pontchartrain experienced little to no change in bottom salinities. Sensitivity simulations were run during Phase 1 in which freshwater was released from the Bonnet Carre structure. Results from these simulations showed decreases in bottom salinity ranging from 0.5 to 2 ppt in all three major areas of the system: the connecting channels, Lake Pontchartrain, and Lake Borgne.

Phase 2 scenarios showed smaller changes in salinity compared to the scenarios of Phase 1 with salinity decreases in the 0.1-0.3 ppt range in the connecting channels with little to no change in bottom salinity for Lakes Borgne and Pontchartrain. The largest decreases occurred as a result of implementing the earthen dam on the MRGO at la Loutre for the Phase 2 Base condition. A comparison of the Base condition bottom salinity values from Phase 1 to Phase 2 illustrated that the earthen dam at la Loutre Ridge (Phase 2) had a significant effect on monthly average bottom salinity values not only in MRGO/GIWW/IHNC but also in the Lake Borgne area. Most areas showed decreases of 2-4 ppt with the MRGO showing the highest decrease in the region just north of the closure at ~10 ppt. Lake Pontchartrain showed little to no difference between the two Base conditions.

Unit Conversion Factors

Multiply	By	To Obtain
acres	4,046.873	square meters
acre-feet	1,233.5	cubic meters
cubic feet	0.02831685	cubic meters
cubic inches	1.6387064 E-05	cubic meters
cubic yards	0.7645549	cubic meters
degrees (angle)	0.01745329	radians
degrees Fahrenheit	(F-32)/1.8	degrees Celsius
fathoms	1.8288	meters
feet	0.3048	meters
foot-pounds force	1.355818	joules
inches	0.0254	meters
inch-pounds (force)	0.1129848	newton meters
knots	0.5144444	meters per second
microns	1.0 E-06	meters
miles (nautical)	1,852	meters
miles (U.S. statute)	1,609.347	meters
slugs	14.59390	kilograms
square feet	0.09290304	square meters
square yards	0.8361274	square meters
yards	0.9144	meters

1 Introduction

Background

The U.S. Army Engineer Hurricane Protection Office (HPO) requested that the USACE Engineer Research and Development Center (ERDC) at Waterways Experiment Station perform a numerical modeling study of conceptual designs of a storm surge barrier(s) on the Gulf Intracoastal Waterway (GIWW) and the Mississippi River Gulf Outlet (MRGO). The purpose of the study was to develop conceptual barrier alternatives that reduced surge-related flooding in the study region but did not negatively impacting navigation and regional salinity values in the system.

The MRGO is a 66-mile-long deepwater channel that extends northwest from deep water in the Gulf of Mexico to New Orleans, LA (Figure 1-1). The MRGO merges with the GIWW and continues 5 miles further to the West where it joins the Inner Harbor Navigation Canal (IHNC). The IHNC proceeds approximately 3 more miles north from its intersection with the GIWW to connect with Lake Pontchartrain at Seabrook. The IHNC also proceeds south from its intersection with GIWW to the IHNC lock connecting IHNC to the Mississippi River. The section of the GIWW that is of interest for this project extends southwest approximately 20 miles from its connection with Lake Borgne near the Mississippi/Louisiana border to its confluence with the MRGO.

Technical Approach

The TABS-MDS three-dimensional (3D) hydrodynamic numerical model developed in previous studies (Tate et al. 2002 and McAnally et al. 1997) was modified for use in this study. The model of the Lake Pontchartrain / Lake Borgne system is capable of representing the effects of salinity stratification in the system. The vertical mid-side nodes of the quadratic elements represent extra layers between the vertical corner nodes. Wind effects were incorporated into the model in a simplistic manner in order to account for the effects of frontal passage across the system. The previous model (Tate et al. 2002) was modified to improve shoreline accuracy, to reflect bathymetry changes to the system due to Hurricane Katrina, to improve resolution in the study area, and to accurately resolve the envisioned conceptual plan alternatives.

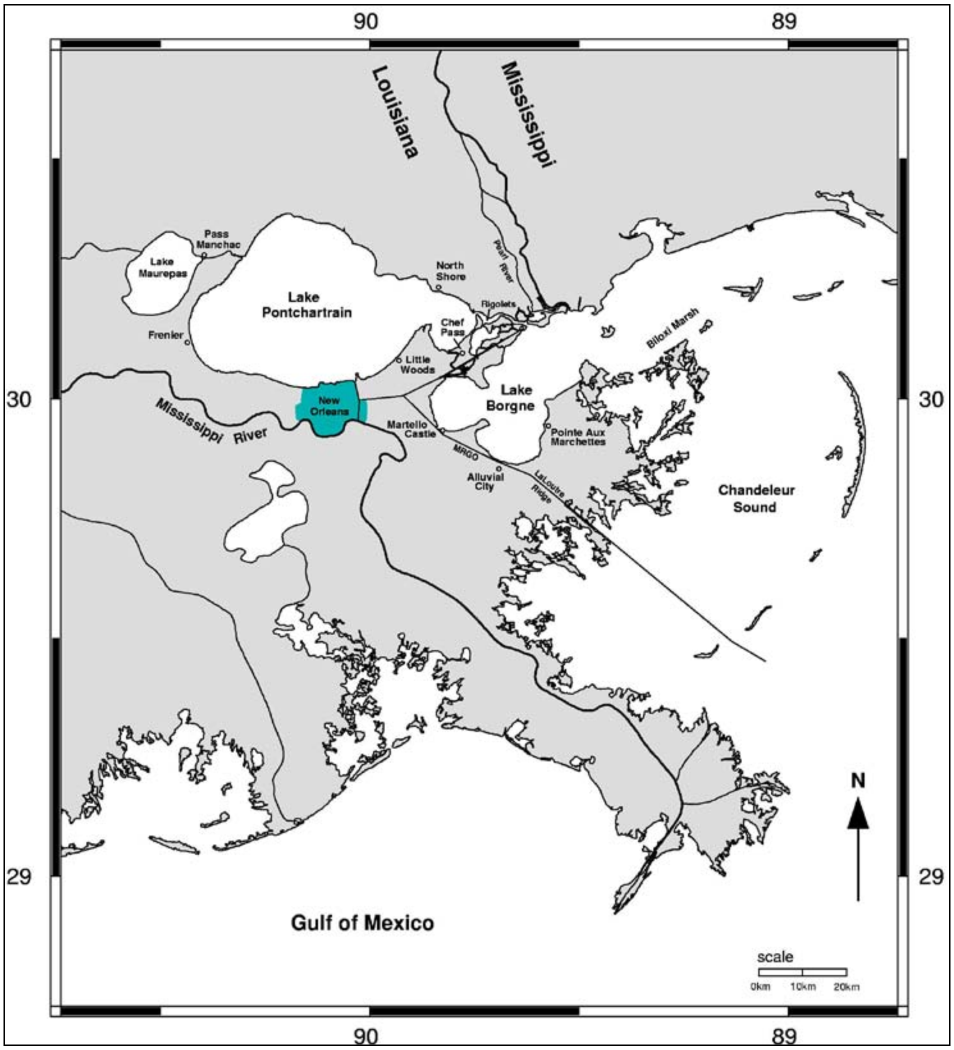

Figure 1-1. Vicinity Map.

The boundary conditions used were data from January through December 2006. These data included river inflows, tides, and winds.

Conceptual plan alternatives were developed by HPO. The alternatives were conceptual due to the fact that the actual design specifications of the structures had not yet been developed. The proposed structures were implemented in the model by narrowing the mesh at the structure locations. After the verification was completed, the model was run with and without the conceptual plan alternatives. The model results from the alternative runs were then analyzed and compared to the Base condition in order to evaluate the performance of the conceptual plan alternatives for water surface elevation, velocity and salinity in fulfillment of the study's purpose.

2 Model Development

Model Description

A 3D hydrodynamic model was used to predict the long term salinity effects in the study area. The model chosen for this study was TABS-MDS, which is a component of the TABS-MD modeling system. The TABS-MD modeling system is among the Corps of Engineers' standard modeling tools for three-dimensional, open-channel flow and sediment transport problems and uses the finite element formulation. The Surface Water Modeling System (SMS; see Brigham Young University, 1997) was used for model development and analysis.

The model solves the 3D shallow water form of the Navier-Stokes equations and includes advection, bottom friction, wind stress, and Coriolis forces. Turbulent mixing effects are handled with an eddy viscosity formulation. Vertical turbulence is estimated by a Mellor-Yamada 2 1/2 – order algebraic closure scheme. The model uses the hydrostatic assumption and the vertical velocities are computed from the local continuity equation.

Mesh Development

The mesh was developed using the Surface-water Modeling System (SMS), a graphical user interface developed by ERDC for increasing the modeling productivity for a variety of Corps numerical models, including the TABS-MD system. The entire mesh and the bathymetry for the model domain are shown in Figures 2-1 and 2-2, respectively, and an inset of the model bathymetry showing the study area is shown in Figure 2-3. Areas without elements (Figure 2-1) or without color contours (Figures 2-2 and 2-3) are not part of the mesh. The mesh was developed by modifying a previous MRGO study mesh (Tate et al. 2002). The modifications consisted of significantly increasing the resolution in the study area, checking the shoreline for accuracy, and updating the bathymetry to the post-Katrina conditions. The shoreline was re-evaluated using satellite imagery not previously available and updated to reflect existing conditions. Bathymetry was updated using data obtained from the SL-15 ADCIRC mesh used in the Louisiana Coastal Protection and Restoration study (USACE, 2006) and from MRGO survey data collected by the U.S. Army Engineer District, New Orleans in March 2007. The bathymetry in the vicinity of the structures was developed by setting the elevation in the structure to the sill elevation determined by HPO and tying back into the existing bathymetry using a 1 on 5 ratio of the change in elevation to the distance from structure sill. The Central Wetlands (CW), the red section in Figure 2-3, was only included as a storage component in order to simulate flow through its connection with the MRGO. The bathymetry in the CW is schematized. The Bayou Bienvenue (BB) marsh was not deemed important to the system response in this study and was not included in the mesh. This assertion was confirmed by the model's favorable agreement with field data shown in the verification section of this report.

The model used the slip bottom boundary condition as opposed to a no-slip where the velocities are held at zero. The slip boundary condition does not force the bottom velocities to zero, but uses user specified frictional parameters in calculating bottom velocities. The friction is specified in the model as a function of the water depth.

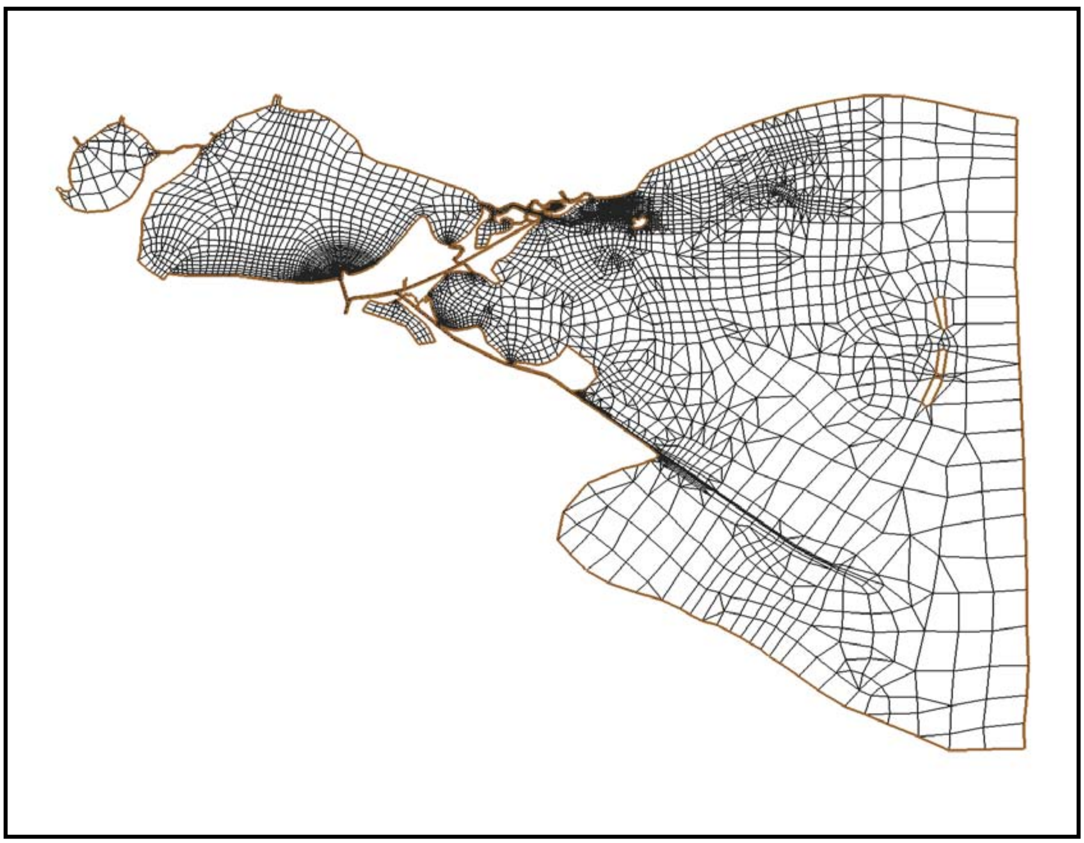

Figure 2-1. Model Domain.

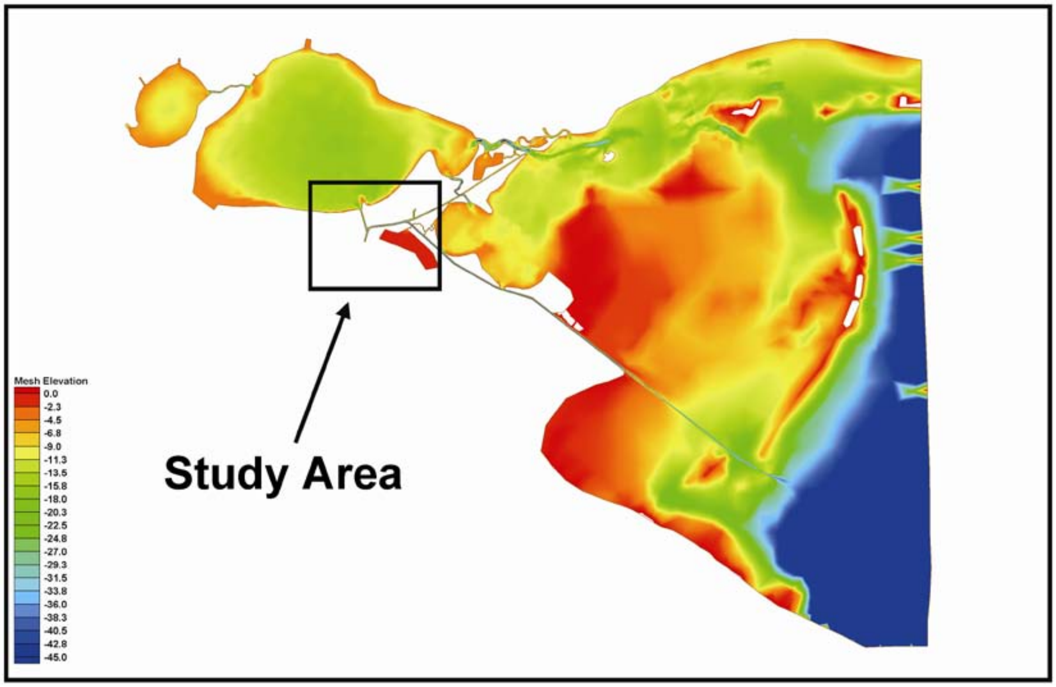

Figure 2-2. Model Contours.

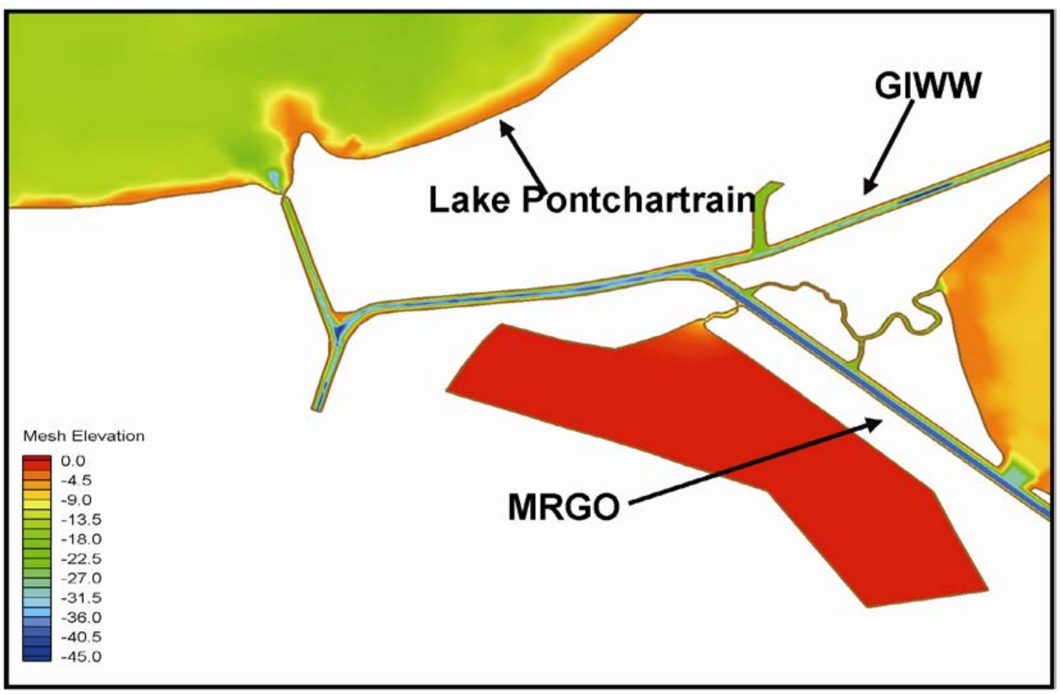

Figure 2-3. Study Area with Contours.

The vertical resolution of the model is shown in Figure 2-4. The yellow material type had a two element deep vertical resolution and the red material type had a three element deep vertical resolution. TABS-MDS uses a quadratic mesh which means that elements have mid-side nodes in the horizontal and the vertical. Due to the mid-side nodes in the vertical, the yellow and red areas represent vertical resolution of five and seven layers, respectively. The green areas are two-dimensional (2D) and model results in this area were depth-averaged.

Figure 2-4. Vertical Resolution.

Boundary Conditions

One set of boundary conditions was developed for the base condition and all alternatives. These boundary conditions included river inflows, tidal forcings, wind conditions, and salinity conditions. The river, tidal, and wind conditions were developed from 2006 data and the salinity conditions were obtained from a previous ERDC study performed for the Mobile District (unpublished work by ERDC for the Mobile District). 2006 was chosen in order to take into account post-Katrina conditions. Using data from pre-Katrina years would have introduced uncertainty. Also, water surface elevation verification would have not have been possible due to the tidal nature of the system as the historical data from pre-Katrina years were only daily values. While not from 2006, the salinity values chosen for this study were considered representative for the system.

The river inflows to the model domain were taken from the U.S. Geologic Survey streamflow database. Daily average values were applied to the model at six locations: the Pearl River, the Amite River, the Blind River, the Tchefuncte River, the Tickfaw River, and the Tangipahoa River. Ungaged flows were not factored into the model. The 2006 flows for each of the rivers are shown in Figure 2-5. The Blind River was not included on the plot; a small constant flow of 216 cfs was specified.

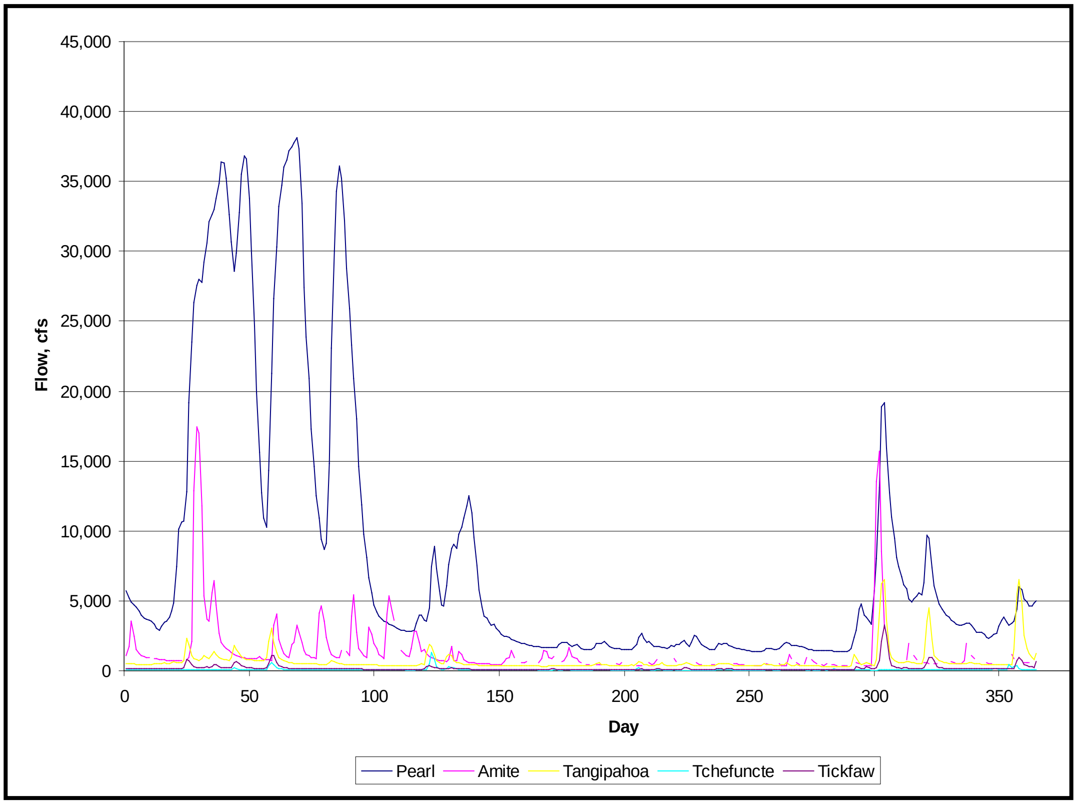

Figure 2-5. River Inflows.

The tidal forcings for the hydrodynamic model were generated using 2006 NOAA gage data located at the Waveland Yacht Club (gage #8747437) and Pilots Station East, SW Pass (gage #8760922). The time series of observed data for the endpoints of the tidal boundary are shown in Figures 2-6 and 2-7. The endpoints were linearly interpolated to generate a tidal forcing at each corner node along the tidal boundary. This linear interpolation used the distance from each of the gages as a weighting factor in the calculation.

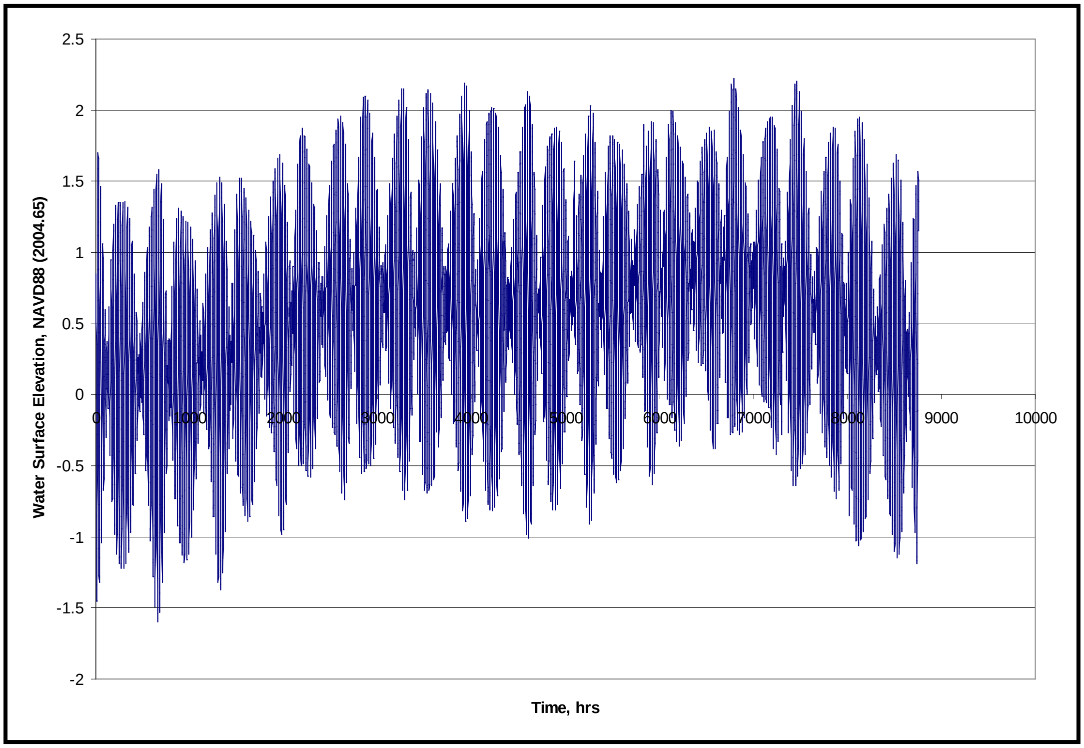

Figure 2-6. Waveland Yacht Club Gage (ft NAVD88).

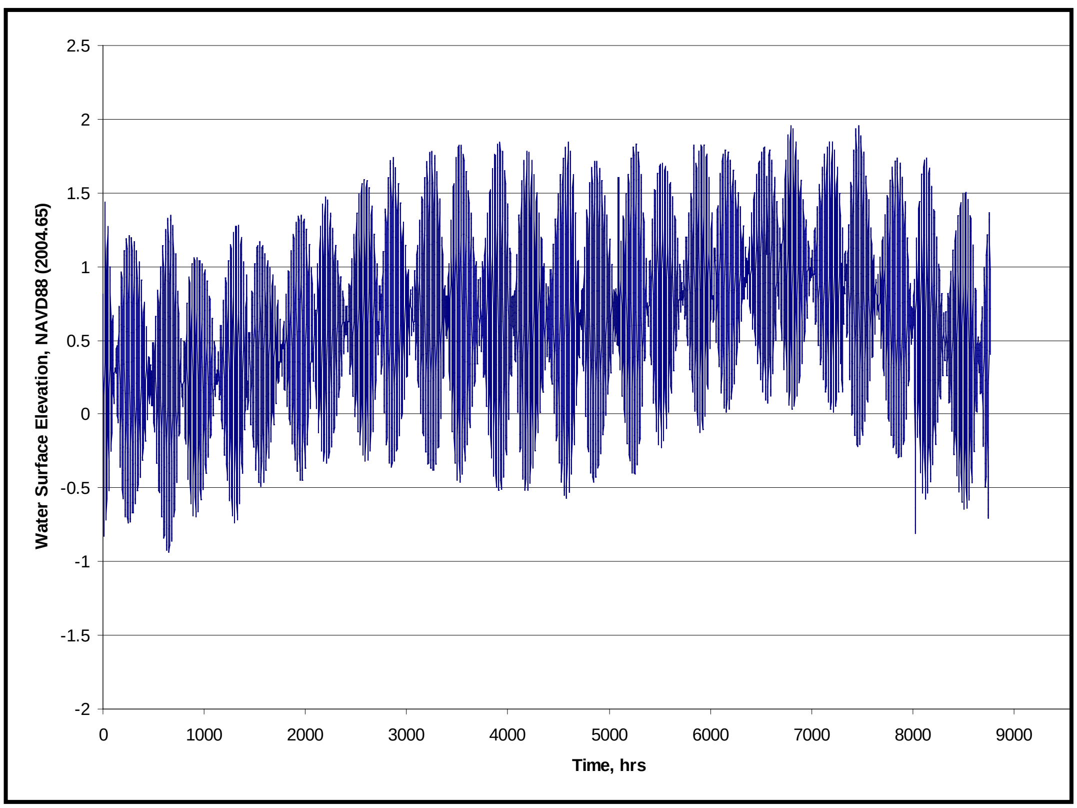

Figure 2-7. Pilots Station East, SW Pass (ft NAVD88).

The wind data used were obtained from the Joint Air Force and Army Weather Information Network and the Air Force Combat Climatology Center in Ashville, NC. These data are hourly surface winds at the New Orleans International Airport (Station 722310 – KMSY) for calendar year 2006 and were collected at a height of 10 m. This station was a land station and a land-sea correction was not performed on the data. This factor introduced some uncertainty to the wind shear stress calculations within the model due to wind speed differences over the land versus those over the water. No analyses were performed to compare the wind data from 2006 to prior years' wind data. One wind value per time increment was applied to the entire model domain.

The initial and boundary conditions for salinity were developed in a study of Gulfport Harbor (unpublished work by ERDC for the Mobile District) by setting a boundary well away from the area of interest and running with a constant salinity boundary condition of 35 ppt. The model simulation was run until equilibrium was reached. In the previous study, measurements were then compared to corresponding points in the model and found to be in agreement. The initial and boundary conditions for salinity for the HPO study were obtained by selecting salinity values from the previous model results that corresponded to node locations in the HPO mesh and along its boundary. This method is very similar to the method used in a previous study of salinity in Lake Pontchartrain (McAnally et al. 1997).

Model Verification

The model was previously verified in a salinity study of Lake Pontchartrain (McAnally et al. 1997) for hydrodynamics and salinity. Therefore only minimal verification was required for the present study. The model was spun up using the last three months of 2005, October thru December.

The hydrodynamic verification was performed by comparing base condition model results to USACE gages: Intracoastal Waterway Near Paris Road Bridge (gage# 76040) and Lake Pontchartrain at West End (gage# 85625) during March and April 2006. The tidal verification results are summarized in Figures 2-8 and 2-9. A comparison of average monthly discharge measurements through the IHNC which were made by the USGS in August 1997 (McCorquodale et al. 2007) to the model results for March and September 2006 showed reasonable agreement. The USGS measurements showed a discharge of 13,000 cfs (McCorquodale et al. 2007) compared to the model results at 12,240 and 12,750 for March and September, respectively. While a re-verification of the velocities was not performed due to a lack of field observations, the current model is based upon a previously verified model (McAnally et al. 1997). In the previous pre-Katrina verification in the GIWW near the Michoud Canal, the average prototype velocity for flood was 0.1 fps and the average velocity for ebb was 0.4 fps compared to model velocities of 0.2 (flood) and 0.3 (ebb). The prototype velocities were “the geometric mean of all the harmonic constituents plus residual from Outlaw (1982)” (McAnally et al. 1997). Base simulations for the current study produced 0.2 fps for both flood and ebb.

While the initial salinity field and boundary conditions generated for this study were considered to be reasonable and the model was built upon a previously verified model (McAnally et al. 1997), the salinity was not re-verified for this study due to a lack of salinity measurements for 2006. A qualitative comparison back to the salinity results from the previous study (McAnally et al. 1997) did show the salinity results from the current study to be reasonable. The model is thus judged adequate for assessing the changes expected to system hydrodynamics and salinity as a result of implementing the conceptual barrier alternatives.

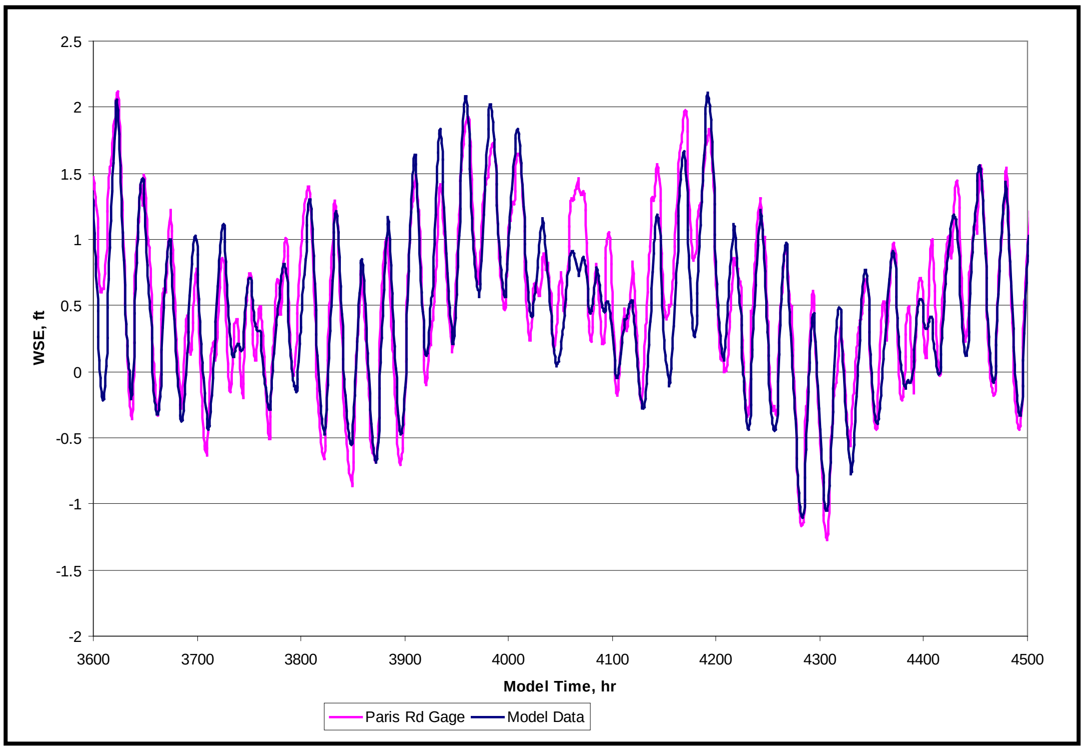

Figure 2-8. Verification at Paris Rd.

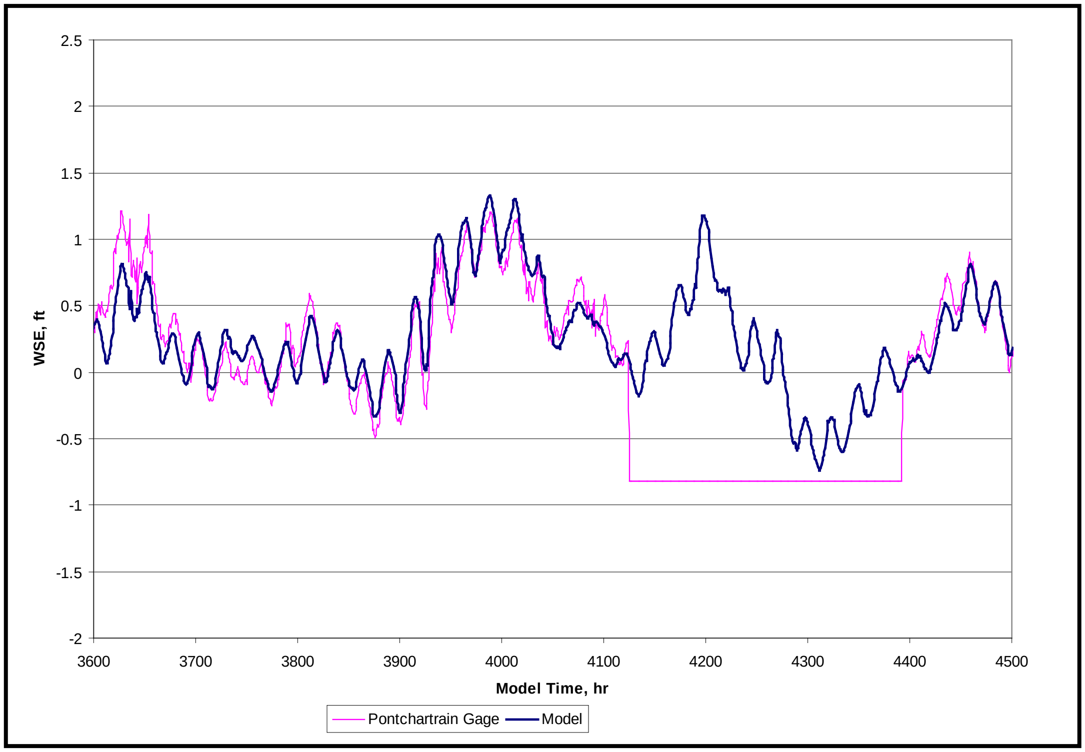

Figure 2-9. Verification at Lake Pontchartrain at West End.

3 Conceptual Plan Alternatives

The conceptual plan alternatives were developed with the aim at reducing flooding in the region due to storm passage while at the same time allowing for continued navigation of the system. The conceptual plan alternatives were developed in two phases.

Phase 1

Phase 1 was developed by HPO using the existing conditions in the system for 2006 as the Base condition. HPO proposed four alternatives for testing in Phase 1:

System A

a. 150 foot by 16 foot (sill) one way sail thru structure on GIWW located just East of the Michoud Canal at 30^0 00’ 52.32”N, 89^0 53’ 58.71”W

b. 56 foot by 8 foot (sill) structure on Bayou Bienvenue located at 30° 0'5.40"N, 89°54'15.17"W

c. MRGO closed south of Bayou Bienvenue at 29^0 59’ 50.59”N, 89^0 54’ 25.74”W

d. Barrier between structures a and b and between structure b and closure c. This barrier forms an arc between the GIWW structure and the MRGO closure. The wetland that this barrier traverses is not included in the model and therefore the performance of the barrier under non-flood conditions is not considered in the model.

System B

a. 150 foot by 16 foot (sill) one way sail thru structure on GIWW located just East of the Michoud Canal at 30^0 00’ 52.32”N, 89^0 53’ 58.71”W

b. 110 foot by 16 foot (sill) sail thru structure on MRGO with spillway (if required) located south of Bayou Bienvenue at 29^0 59’ 50.59”N, 89^0 54’ 25.74”W

c. 110 foot by 16 foot (sill) open pass on MRGO located at la Loutre Ridge at 29°49'26.62"N, 89°36'0.28"W

System C

a. 350 foot by 40 foot (sill) one way sail thru structure on MRGO/GIWW with spillways (if required) located at 30° 0'10.94"N, 89°56'30.03"W

b. MRGO closed at la Loutre Ridge at 29°49'26.62"N, 89°36'0.28"W

System D

a. 350 foot by 40 foot (sill) one way sail thru structure on MRGO/GIWW with spillways (if required) located at 30° 0'10.94"N, 89°56'30.03"W

b. 110 foot by 16 foot (sill) open pass on MRGO located at la Loutre Ridge at 29°49'26.62"N, 89°36'0.28"W

The alternatives were considered conceptual because the actual design specifications of the proposed structures had not yet been developed. As a result, the structures were represented in model by narrowing the mesh at the structure locations.

The conceptual plan alternatives were implemented by modifying the Base mesh (Figure 3-1) to reflect the proposed configurations (Figures 3-2 thru 3-8). The red line in Figure 3-4 indicates that, in addition to the original specifications of System B, BB was closed for System B simulations at the location specified by the red line.

The Base condition represented the system as it existed in 2006 with no closures or structures. The structures were implemented in the model by modifying the mesh to reflect the dimensions of the structure: length, width, and sill elevation. The bathymetry in the vicinity of the structures was developed by setting the elevation in the structure to the sill elevation determined by HPO and tying backing into the existing bathymetry using a 1 on 5 ratio of the change in elevation to the distance from structure sill.

Any references to closures mean that an infinitely high wall was placed in the model mesh at the closure location to close off all flow at that location.

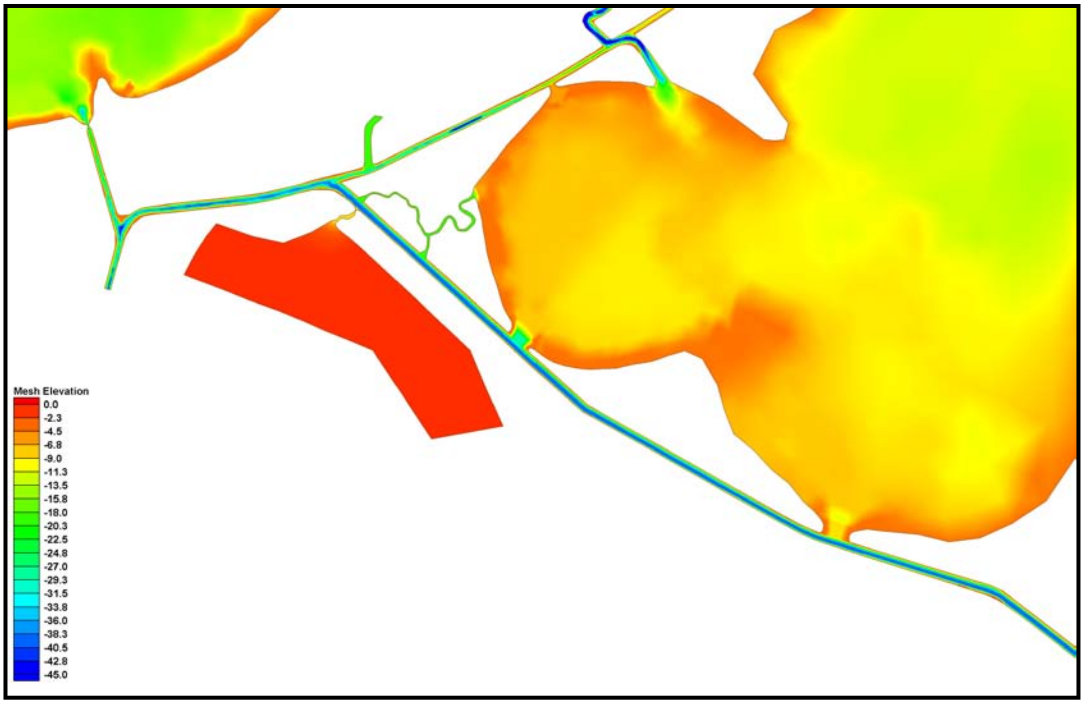

Figure 3-1. Phase 1 Base Condition (ft NAVD88).

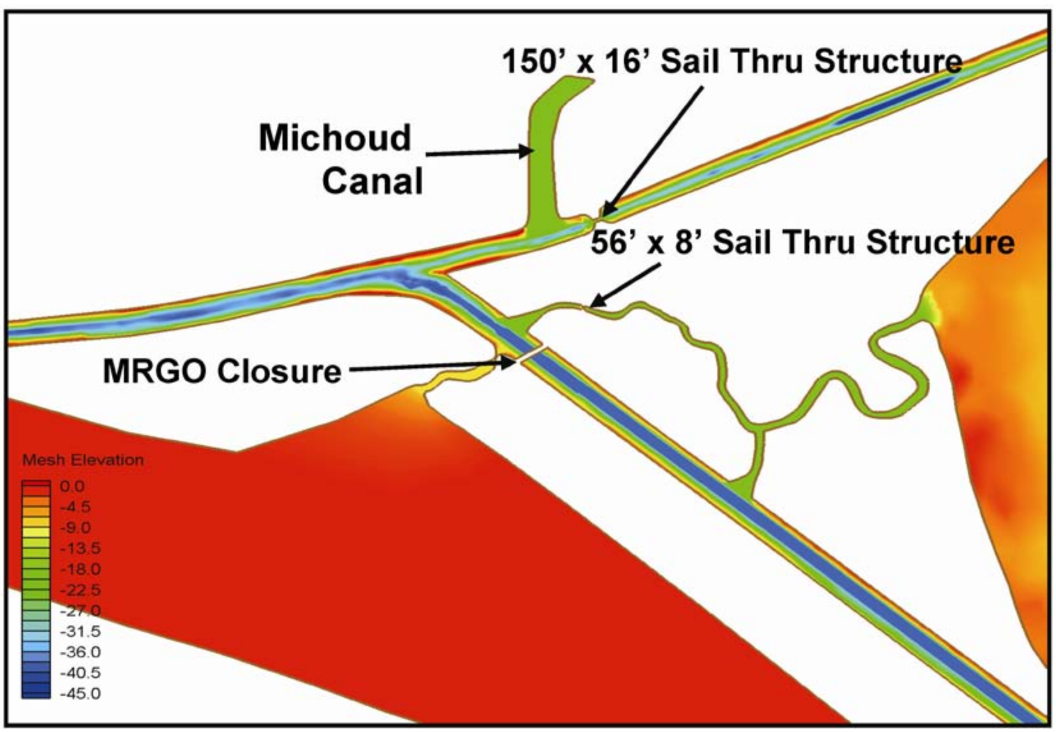

Figure 3-2. System A (ft NAVD88).

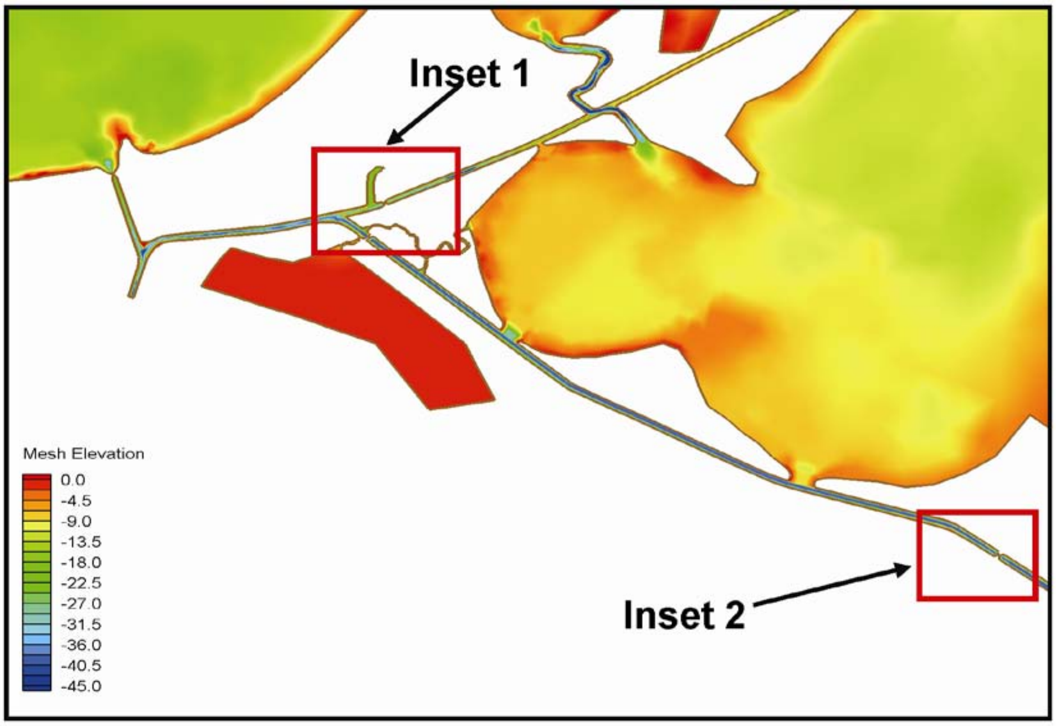

Figure 3-3. System B – wideshot (ft NAVD88).

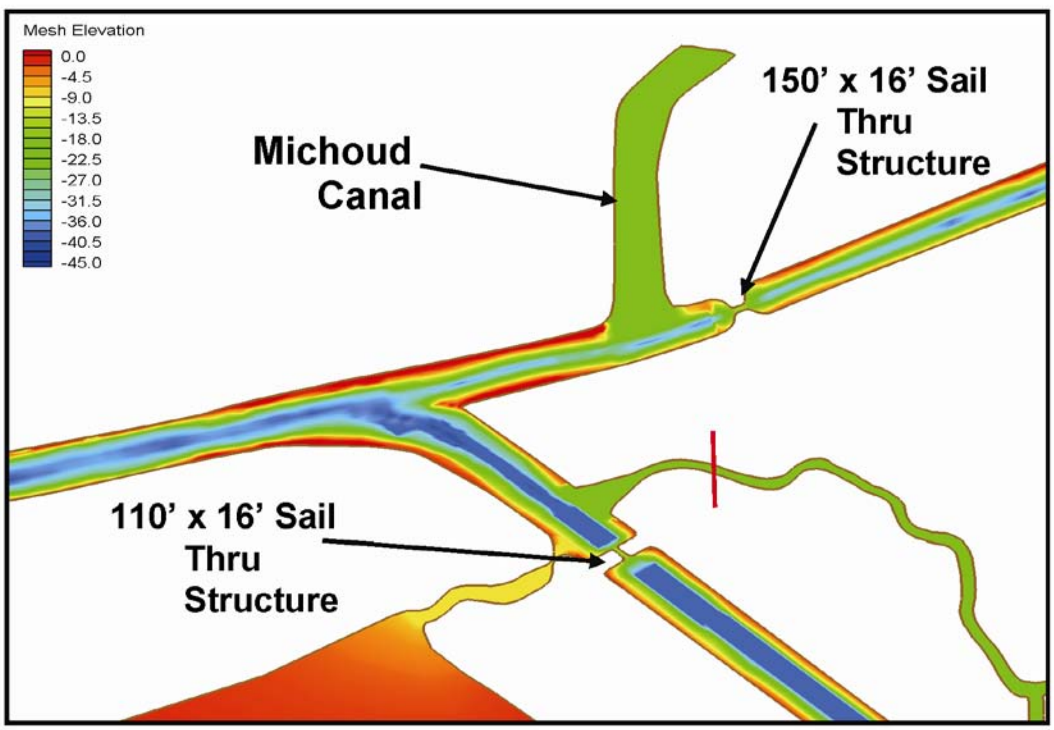

Figure 3-4. System B – Inset 1 (ft NAVD88).

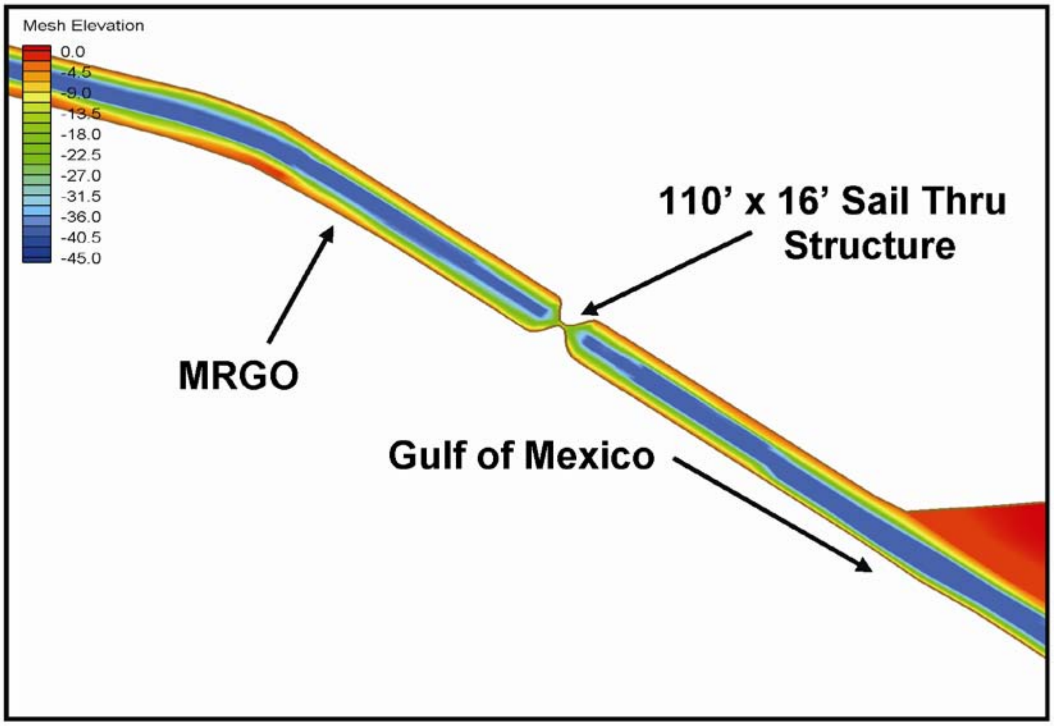

Figure 3-5. System B – Inset 2 (ft NAVD88).

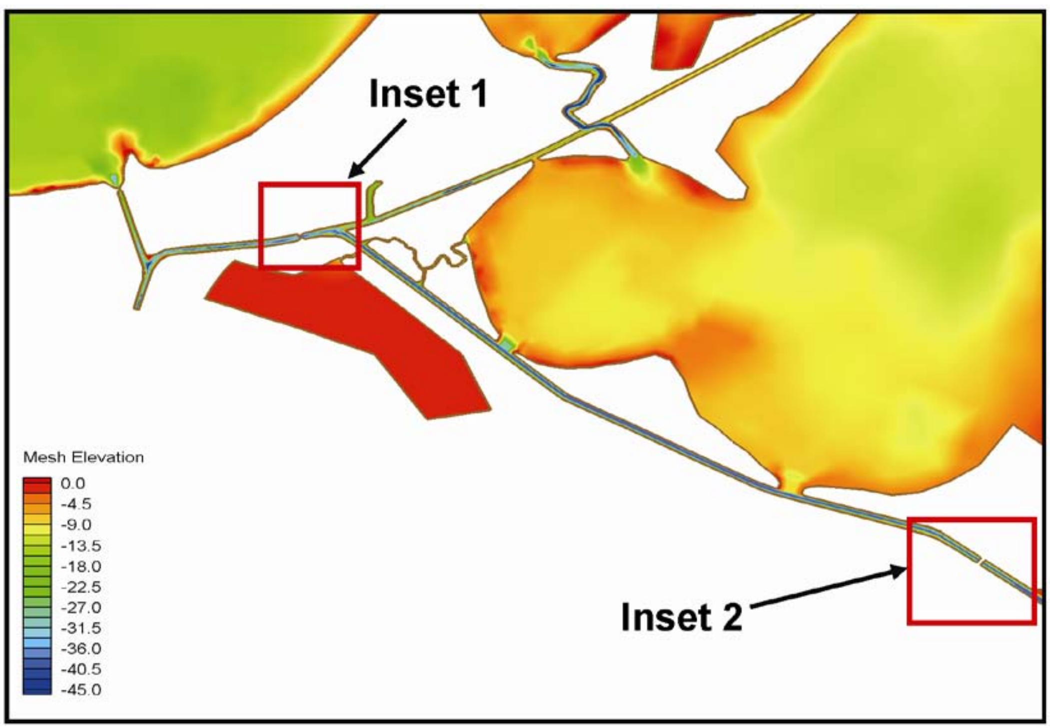

Figure 3-6. System C – wideshot (ft NAVD88).

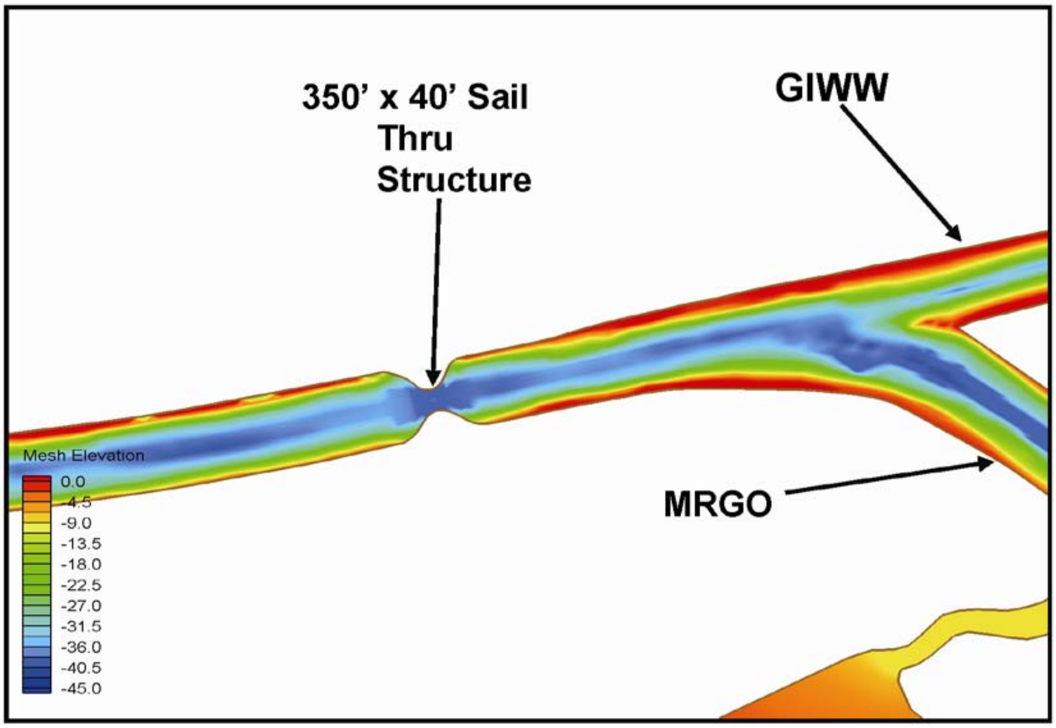

Figure 3-7. System C – Inset 1 (ft NAVD88).

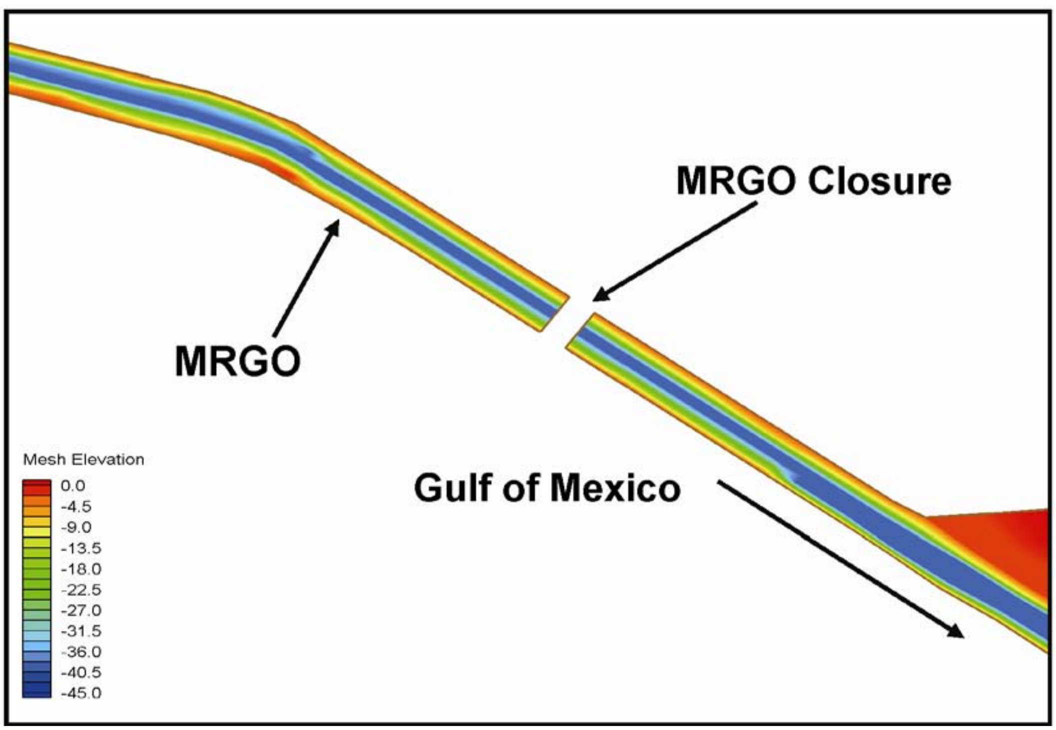

Figure 3-8. System C – Inset 2 (ft NAVD88).

TABS-MDS treats all model boundaries in this fashion. Therefore, the shorelines of the model should not be considered representative of the performance of existing or future levees.

Phase 2

Phase 2's Base condition (see Figure 3-9) was developed by adding a closure of the MRGO at la Loutre Ridge to the Phase 1 Base condition. The alternatives in Phase 2 were developed by incrementally adding aspects of Systems A and C to the Phase 2 Base condition.

Four alternatives, A1 – A4, were developed from Phase 1's System A features and two alternatives, C1 and C2, were developed from Phase 1's System C features. Note that the order of features in the Phase 1 systems do not reflect the order those features were added to the Phase 2 Base condition.

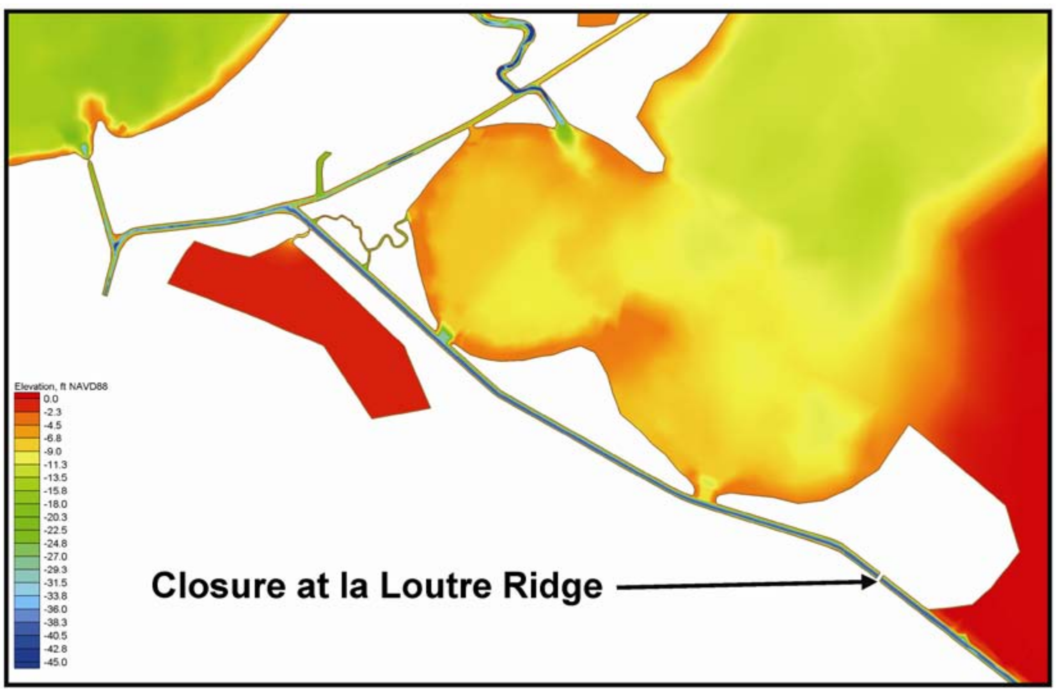

Figure 3-9. Phase 2 Base Condition (ft NAVD88).

System A1 – Add a closure of MRGO located south of Bayou Bienvenue at 29^0 59' 50.59"N, 89^0 54' 25.74"W to the Phase 2 Base condition (see Figure 3-10)

System A2 – Add a 56 foot by 8 foot (sill) structure on Bayou Bienvenue located at 30° 0'5.40"N, 89°54'15.17"W to System A1 (see Figure 3-11)

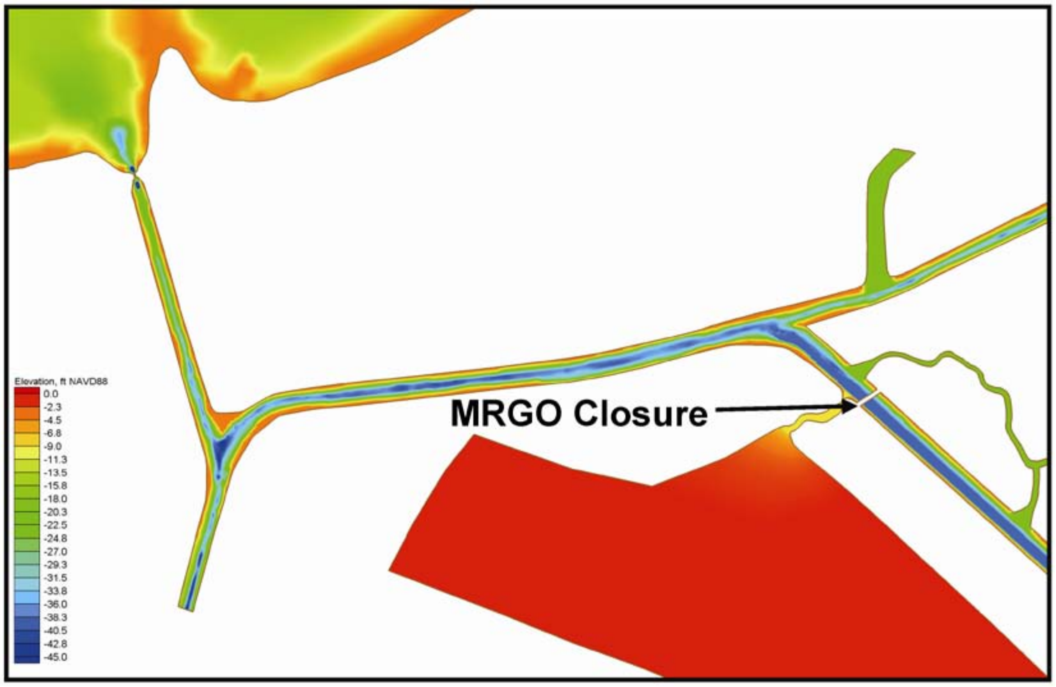

Figure 3-10. System A1 (Additions to Phase 2 Base).

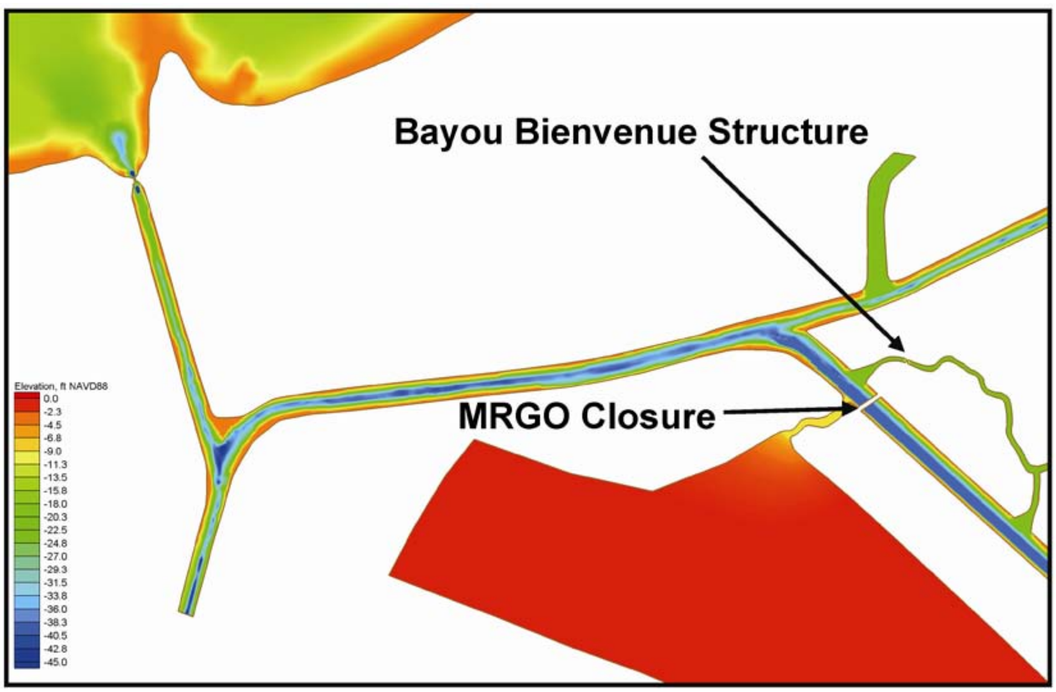

Figure 3-11. System A2 (Modifications to Phase 2 Base).

System A3 – Add a 150 foot by 16 foot (sill) one way sail thru structure on GIWW located just east of the Michoud Canal at 30⁰ 00’ 52.32”N, 89⁰ 53’ 58.71”W to System A2 (see Figure 3-12)

System A4 – Add a 95 foot by 16 foot (sill) one way sail thru structure on IHNC located at Seabrook at 30⁰ 01’ 50.98”N, 90⁰ 02’ 03.08”W (see Figure 3-13)

System C1 – Add a 350 foot by 40 foot (sill) one way sail thru structure on GIWW/MRGO at Paris Rd at 30° 0'10.94"N, 89°56'30.03"W to the Phase 2 Base condition (see Figure 3-14)

System C2 – Add a 95 foot by 16 foot (sill) one way sail thru structure on IHNC located at Seabrook at 30⁰ 01’ 50.98”N, 90⁰ 02’ 03.08”W to System C1 (see Figure 3-15)

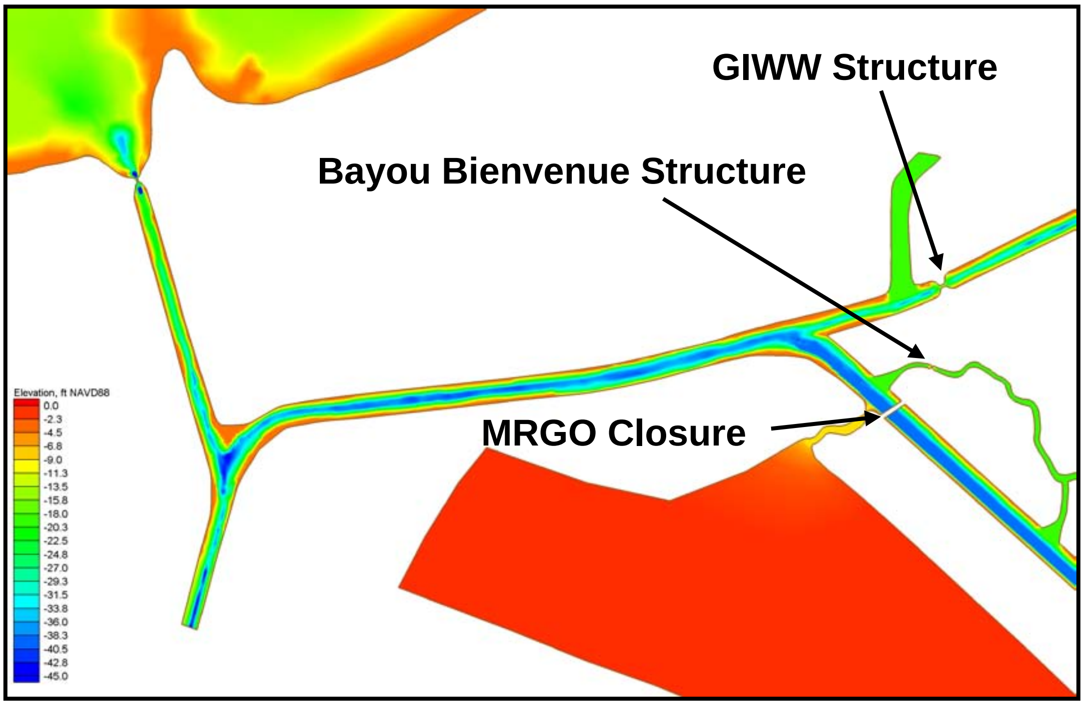

Figure 3-12. System A3 (Modifications to Phase 2 Base).

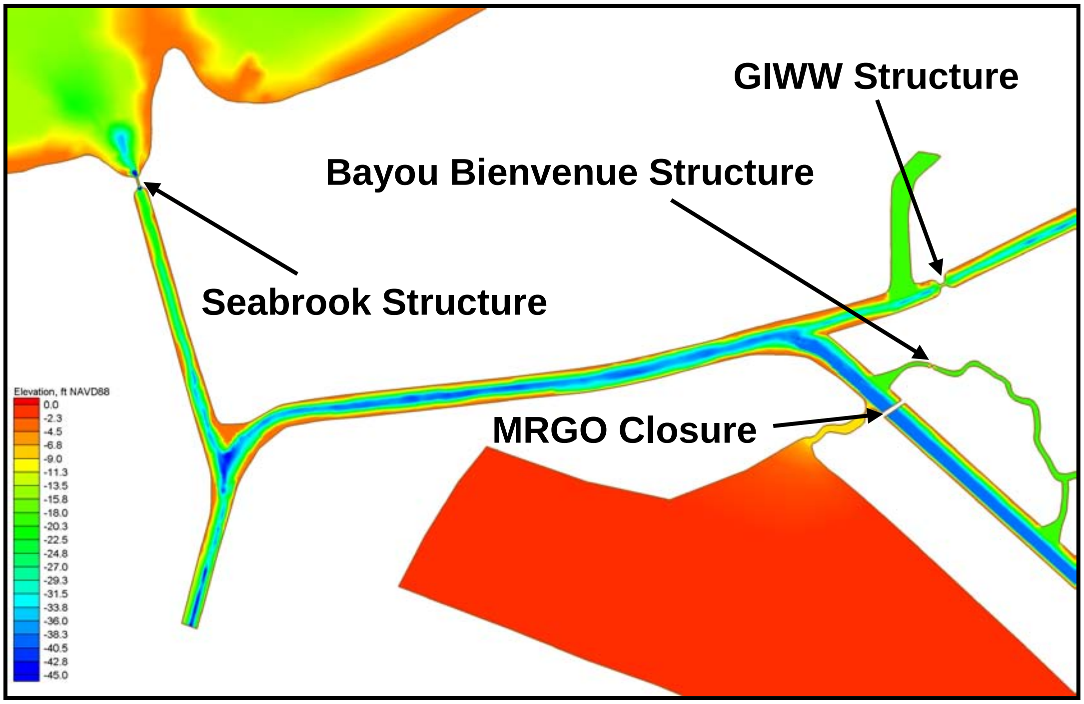

Figure 3-13. System A4 (Modifications to Phase 2 Base).

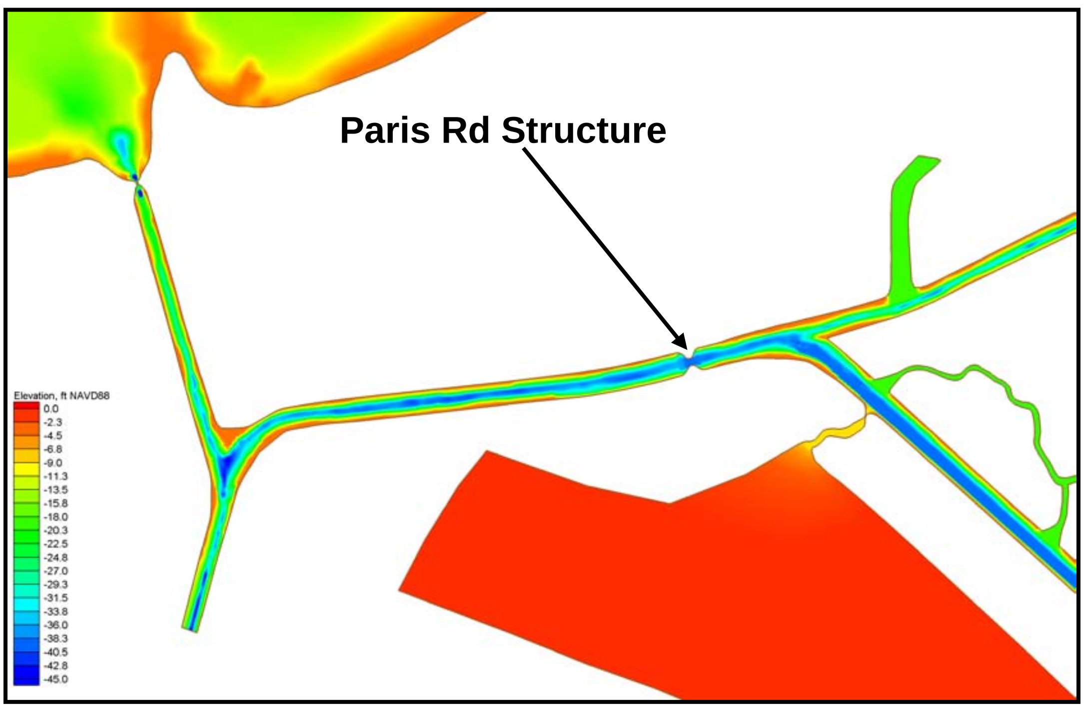

Figure 3-14. System C1 (Modifications to Phase 2 Base).

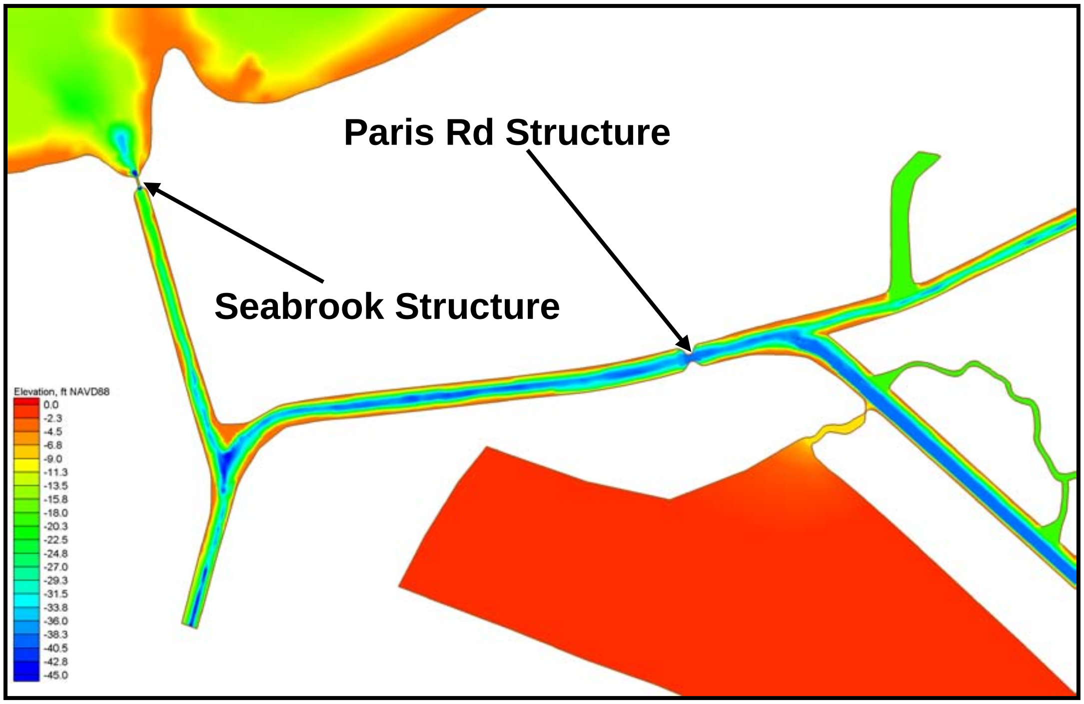

Figure 3-15. System C2 (Modifications to Phase 2 Base).

4 Results

Hydrodynamics

Phase 1

Velocity magnitudes and directions were analyzed for each of the four systems in Phase 1. Note that all velocities analyzed were surface velocities and that any reference to flow velocity in this report implies surface velocity. In most cases, the maximum surface velocities were of the most interest and were obtained by examining the velocities of the entire year-long simulations. There were two reasons for this focused approach. First, the surface velocities have the most impact on navigation. Second, analyzing the surface velocities produced conservative estimates of velocities for examination by environmental stakeholders. With respect to navigation, navigation personnel at ERDC examined these analyses and found no significant negative impacts to navigation in any of the four systems.

Implementation of Phase 1 alternatives had no measurable effect on current velocities in Lakes Borgne or Pontchartrain. Also, the effect on current velocities near the structures dissipated at a distance from the structure of twice the structure opening width. Therefore, what follows is a discussion of the impacts of Phase 1 alternatives on velocities within the structures themselves.

System A had a sail thru structure on GIWW just east of the Michoud Canal and a closure of the MRGO just south of Bayou Bienvenue. System A's simulation produced maximum flow velocities of approximately 0.6 ft/sec in the single sail thru structure on the GIWW (see Figures 4-1).

System B had two sail thru structures on MRGO in addition to the sail thru structure on GIWW from System A (see Figures 3-4 and 3-5). The southernmost structure on MRGO produced maximum flow velocities of approximately 0.5 ft/sec (see Figure 4-2) while the structure just below Bayou Bienvenue had maximum flow velocities of approximately 0.25 ft/sec (see Figure 4-3). The maximum flow velocities through the structure on the GIWW were approximately 0.3 ft/sec (see Figure 4-4).

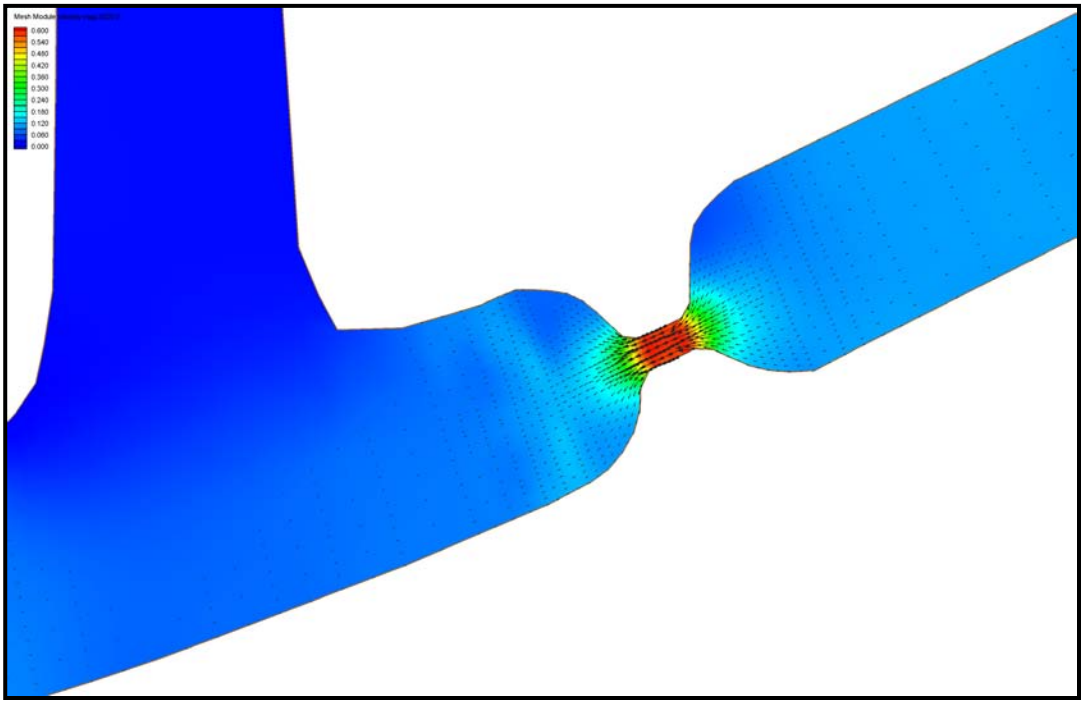

Figure 4-1. Maximum Surface Velocities in GIWW Structure (East of Michoud) – System A.

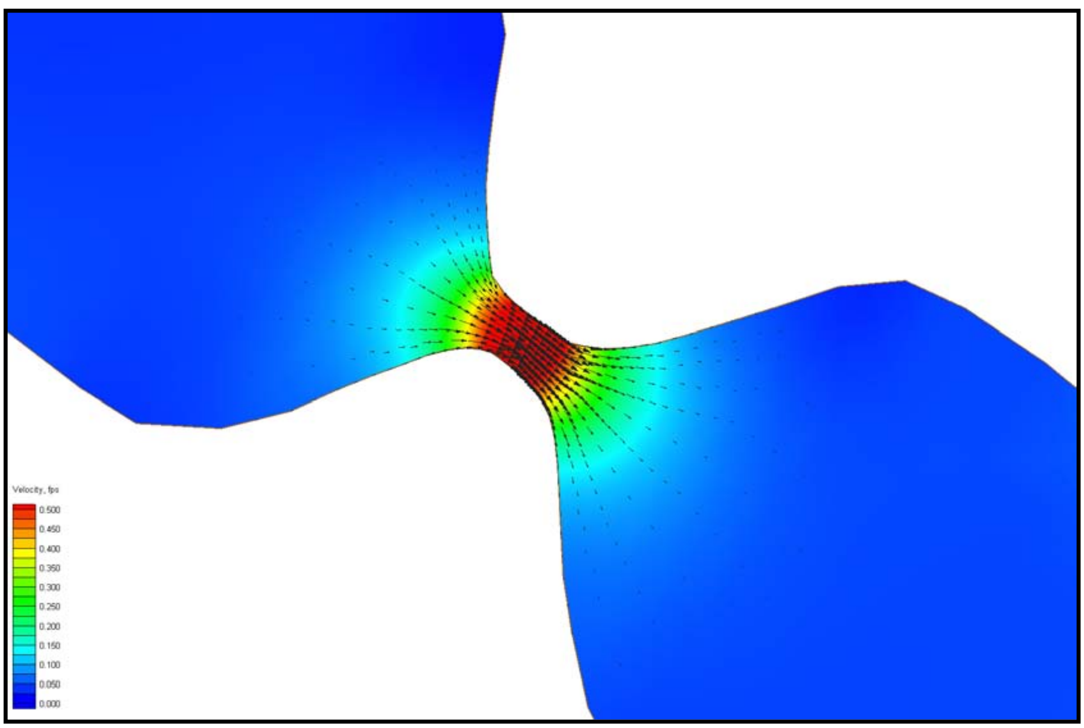

Figure 4-2. Surface Velocities in Southern Structure on MRGO – System B.

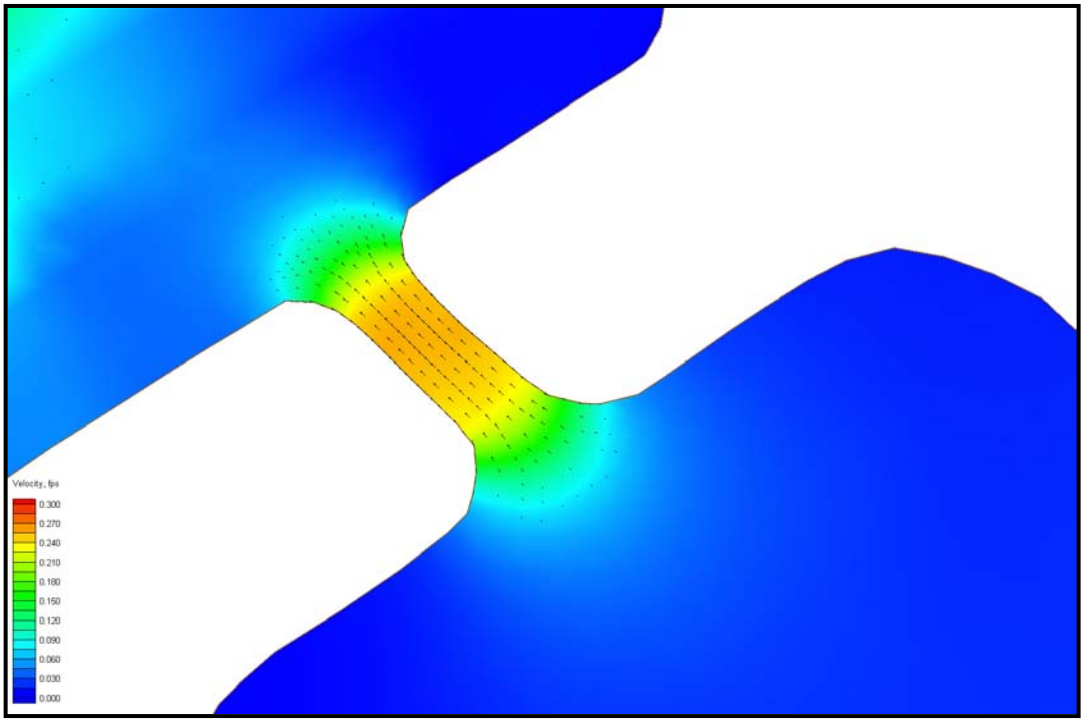

Figure 4-3. Surface Velocities in Northern MRGO Structure – System B.

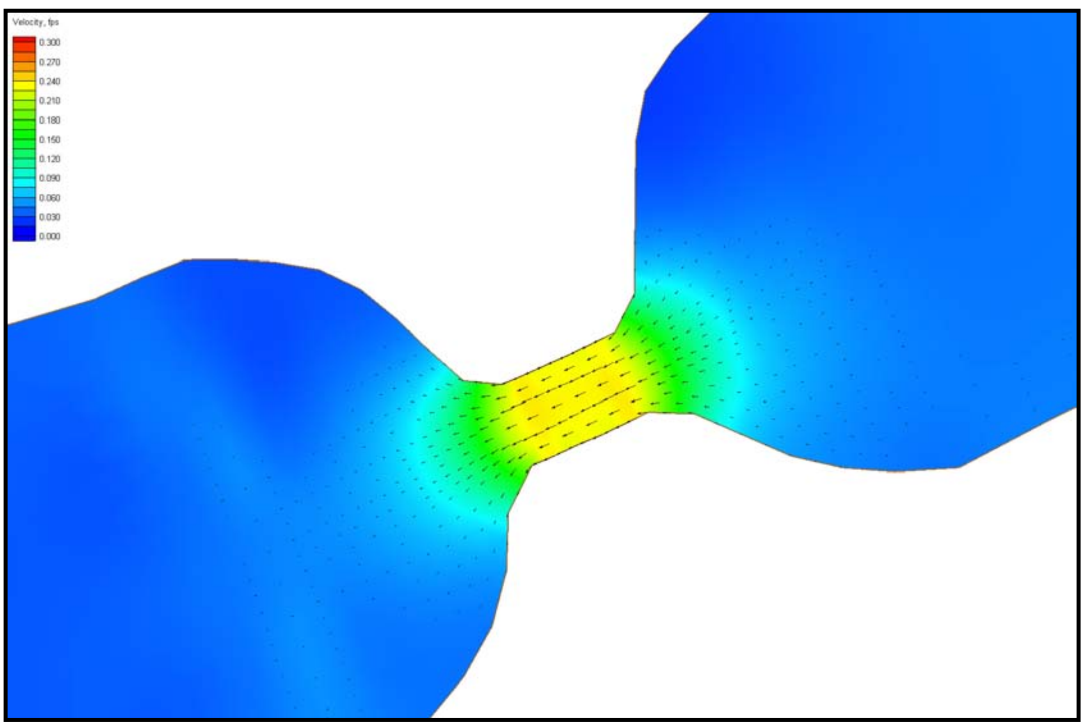

Figure 4-4. Surface Velocities in GIWW Structure – System B.

System C had only one sail thru structure located west of the MRGO/GIWW confluence in the vicinity of the Paris Rd bridge (see Figure 3-7). In addition, the MRGO was closed at approximately the same location as the southernmost structure in System B's configuration (see Figure 3-8). The maximum flow velocities produced in this constriction were approximately 1.0 ft/sec (see Figure 4-5). This increase in maximum flow velocity over System's A and B was to be expected as the structure at Paris Rd is now constricting the combined flow from MRGO and GIWW at a single location. This assertion would seem counter-intuitive as both Systems A and C have an MRGO closure. However, the placement of the closure in System C allows a significant amount of flow to enter the MRGO from its connections with Lake Borgne where the closure for System A does not.

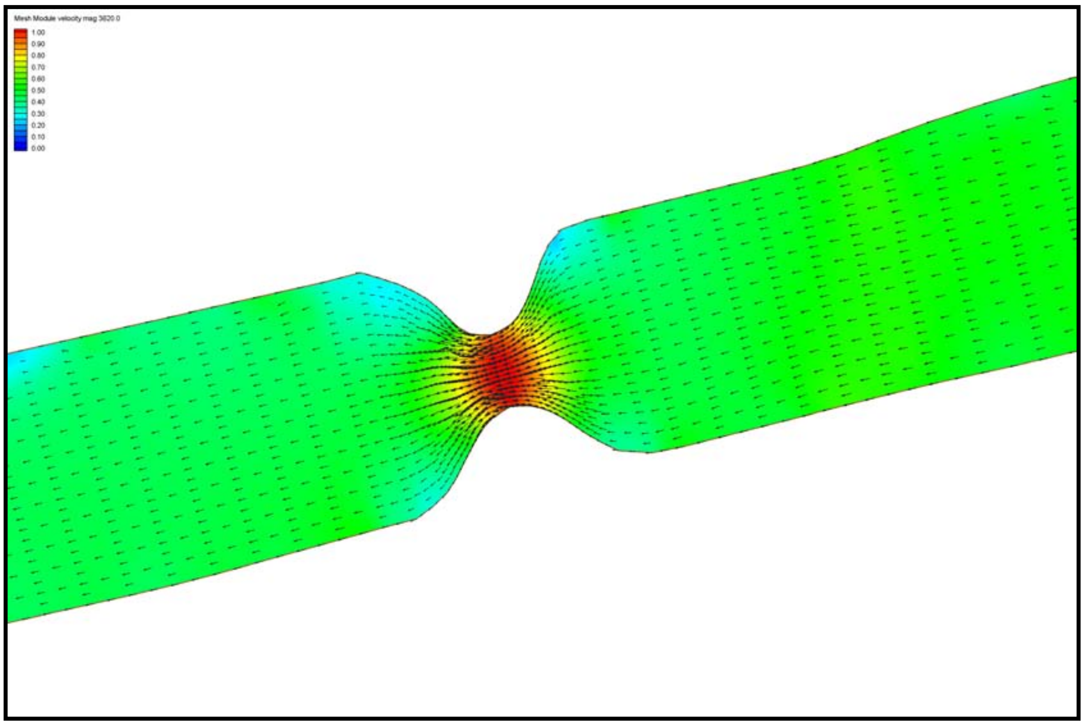

Figure 4-5. Surface Velocities in Paris Rd Structure – System C.

System D's two structures were taken from Systems B (MRGO) and C (GIWW). The MRGO structure is the same configuration and location as the southernmost MRGO structure in System B (see Figure 3-5). The GIWW structure is the same as the lone structure in System C's configuration (see Figure 3-7). The maximum flow velocity in both structures was approximately 1.0 ft/sec.

At first glance, this would seem to indicate that the majority of the flow that reaches the GIWW structure comes from the Lake Borgne connections and not from the MRGO's connection with the Gulf of Mexico. In actuality, flow enters the system predominantly through the MRGO and this flow splits at the confluence with GIWW with part of the flow going west toward IHNC and the remaining flow going east towards the Michoud Canal. An analysis of average discharges during flood tides in April 2006 and peak velocity vectors (see Figures 4-6 and 4-7) in the system proved that MRGO (not Lake Borgne) was indeed the majority contributor of flow through the GIWW study area.

For Example, Figures 4-6 and 4-7 represent the base conditions at peak flood during the maximum flood tide in April 2006. Figure 4-7 shows that flow is drawn off MRGO into the southernmost connection with Lake Borgne and the opposite is shown for the remaining direct connection. Examining both figures at the confluence of the MRGO and GIWW shows that flow from the MRGO splits and goes both East and West in the GIWW. Further examination of the velocities to the East of the Michoud Canal indicated an area of near zero velocity where the flow from the MRGO met the flow coming from Lake Borgne's direct connection to the GIWW.

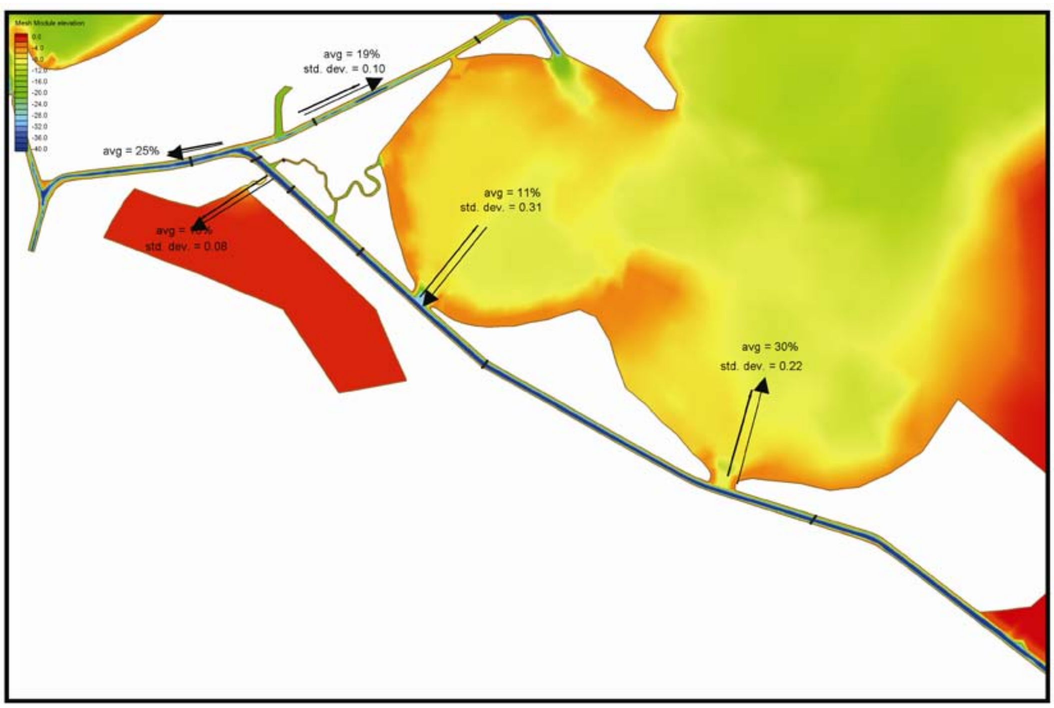

Figure 4-6. Discharge Analysis – Base.

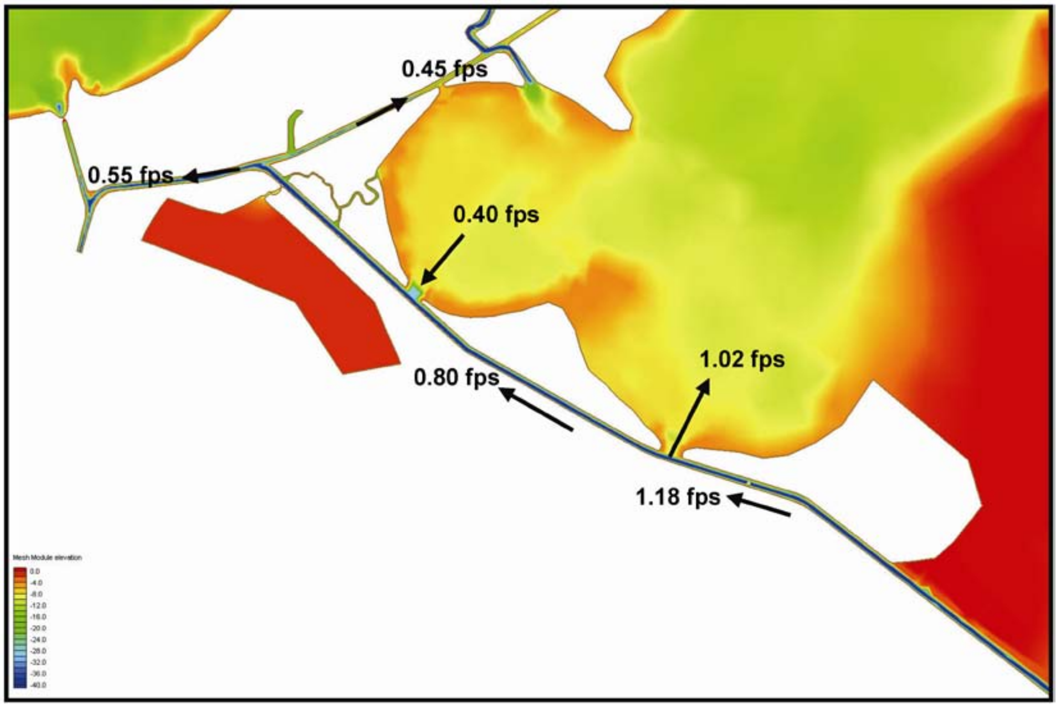

Figure 4-7. Surface Velocity Analysis – Base.

The discharge analysis is represented as discharges through the various connections to the MRGO. Discharges were analyzed by developing statistics, averages and standard deviations, using the maximum discharges at various locations during each of the maximum flood conditions of each tidal cycle occurring in April 2006. In the vector plot (see Figure 4-7), arrows pointing out of the MRGO indicated flow out of the MRGO and arrows pointing into the MRGO indicated flow into the MRGO. These discharges are reported as percentages (see Figure 4-6) of the incoming MRGO flow from the Gulf of Mexico during the flood tides in April 2006. The percentages are used as a reporting technique and will not sum to 100. Peak velocities were analyzed along the MRGO during the maximum flood tide of April 2006 to show how the velocity in the MRGO changed as a function of location (see Figure 4-7).

A second velocity analysis and water surface elevation analysis was performed on the most likely design scenarios to show how the velocities changed in GIWW (west of the confluence with the MRGO) as a result of the additions of sail through structures and closures (see Figures 4-8 thru 4-18). System B was not considered a likely scenario by HPO and therefore was not included in these analyses. These analyses were performed on model results from January 2006. This time period occurred immediately after the model spin-up period and contained a sufficient number of tidal cycles such that the analyses of the data would illustrate the general model response in this region. This region of the model was of particular concern during the early stages of this study as HPO considered implementing interim surge protection measures near this location.

Water surface elevation results (Figures 4-14 to 4-18) showed that the Paris Rd structures of Systems C and D damped the overall signal as well as altered the phase of the tidal signal. The velocity differences (Figures 4-9 to 4-13) in Systems C and D over the Base condition may be attributed to altering of the phase of the tidal signal due to the presence of the Paris Rd structure. The nearly identical magnitudes of velocity and water surface elevation for Systems C and D illustrate that the closure of the MRGO (System C) and the structure at the same location (System D) produce nearly the same system response.

System A experienced a damped tidal signal and significantly reduced velocities. However, the main factor contributing to these phenomena in system A was the closure of the MRGO just south of BB which closed off a major route for flow and thereby altered the phase and decreased the amplitude of the tidal signal and the amount of discharge reaching the western GIWW. While System C also had a closure of the MRGO, it was much further south and therefore a considerable amount of flow was allowed into the MRGO through its connections with Lake Borgne.

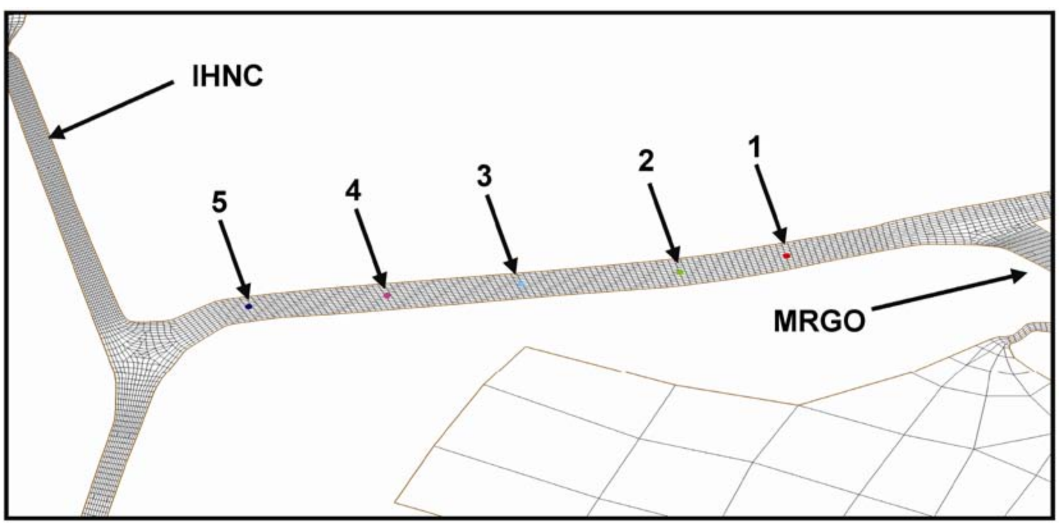

Figure 4-8. Point Locations for Surface Velocity and Water Surface Elevation Analysis.

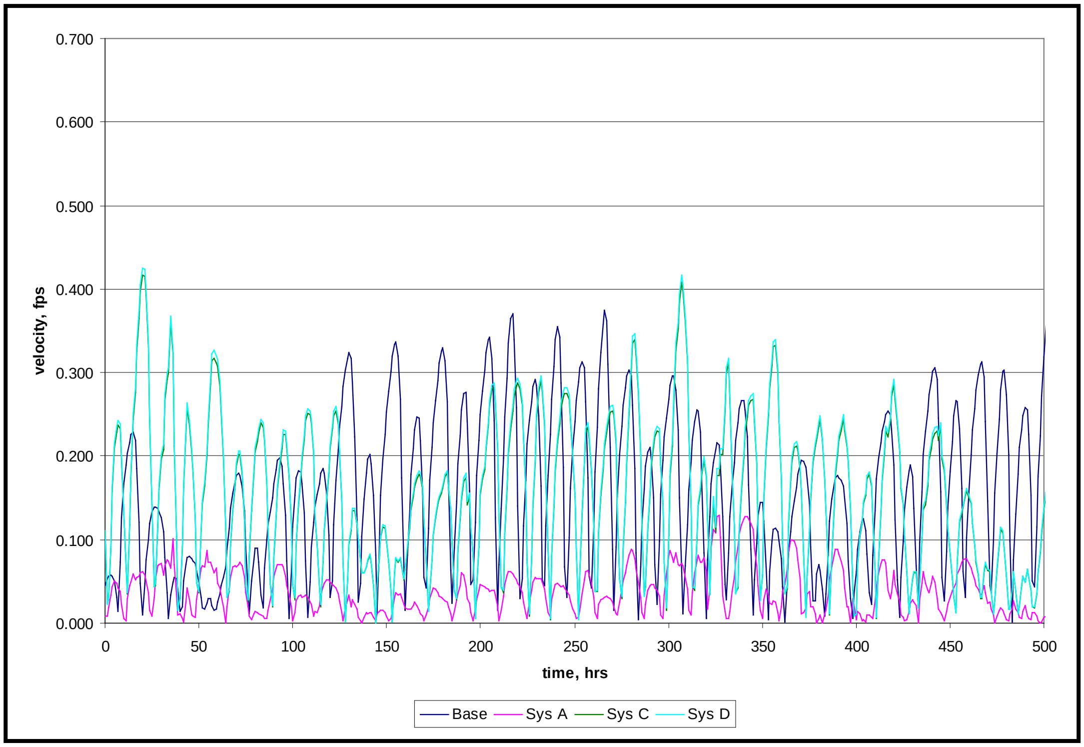

Figure 4-9. Surface Velocity Comparison – Point 1.

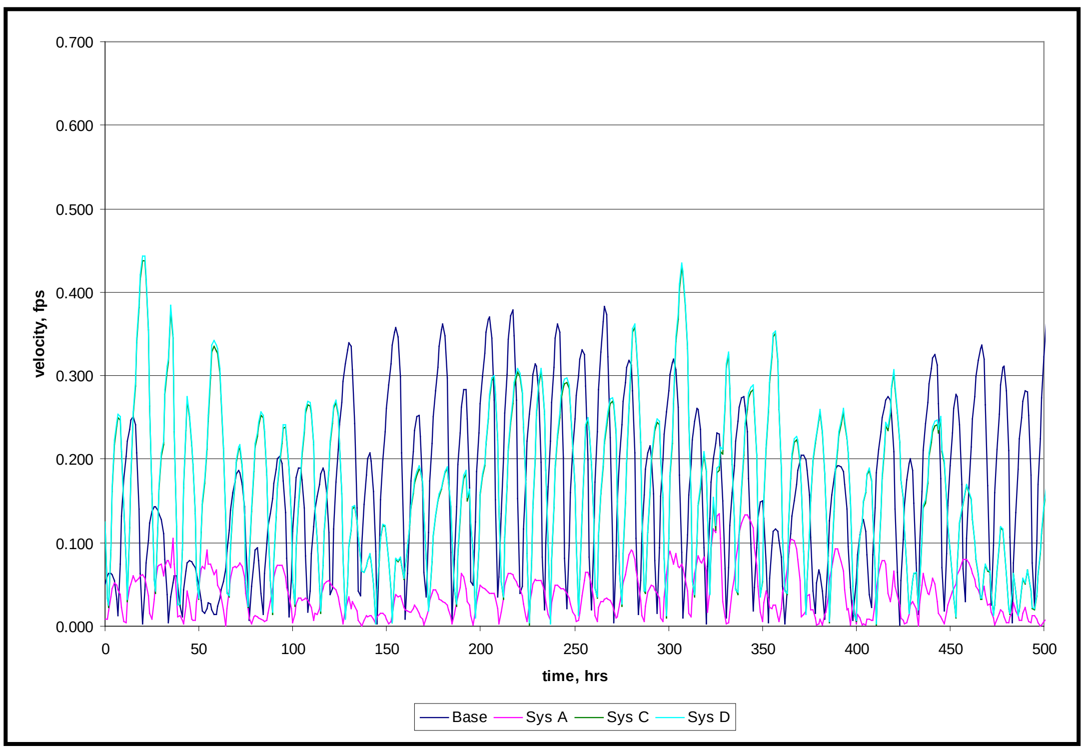

Figure 4-10. Surface Velocity Comparison – Point 2.

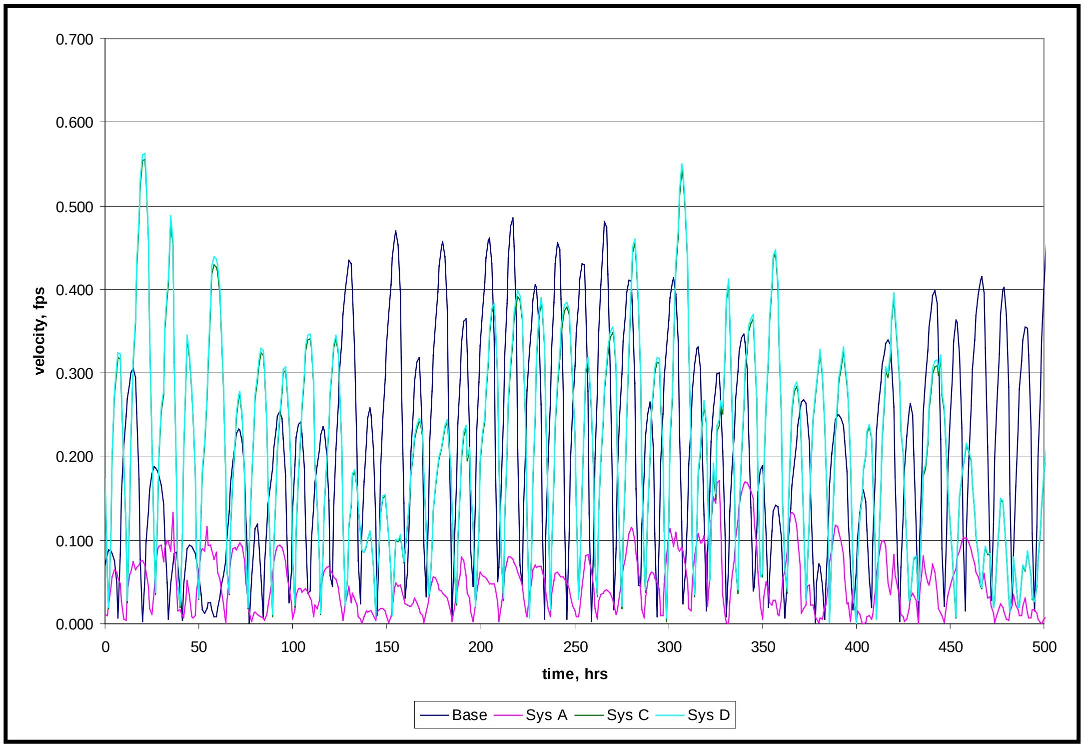

Figure 4-11. Surface Velocity Comparison – Point 3.

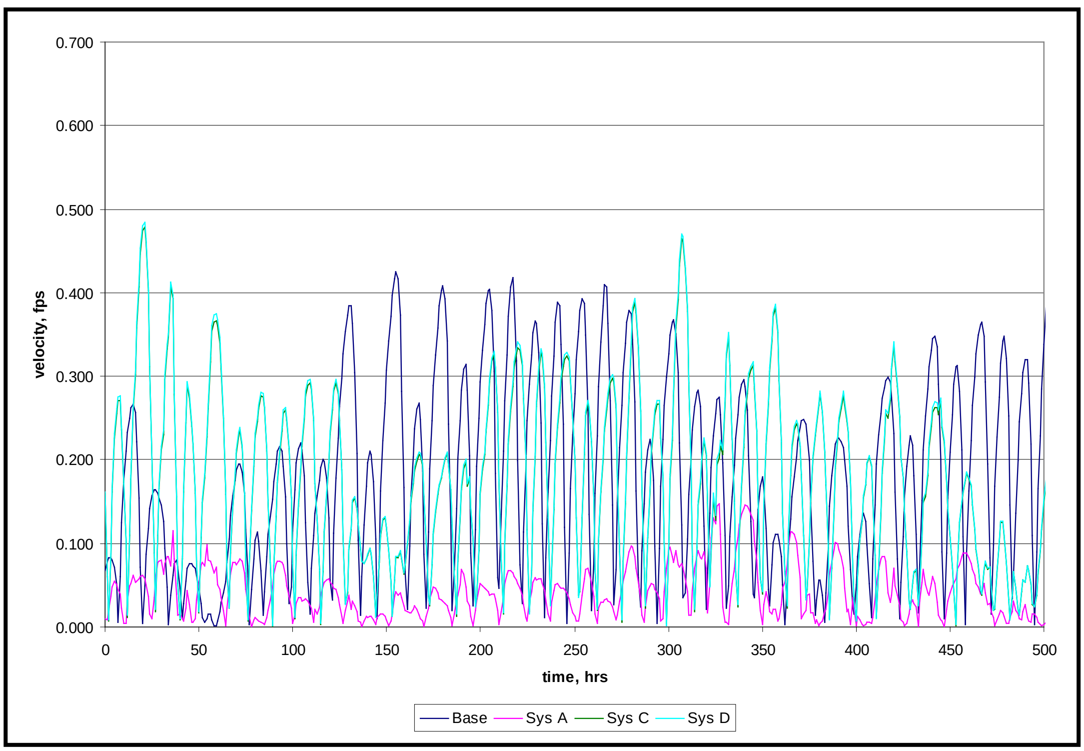

Figure 4-12. Surface Velocity Comparison – Point 4.

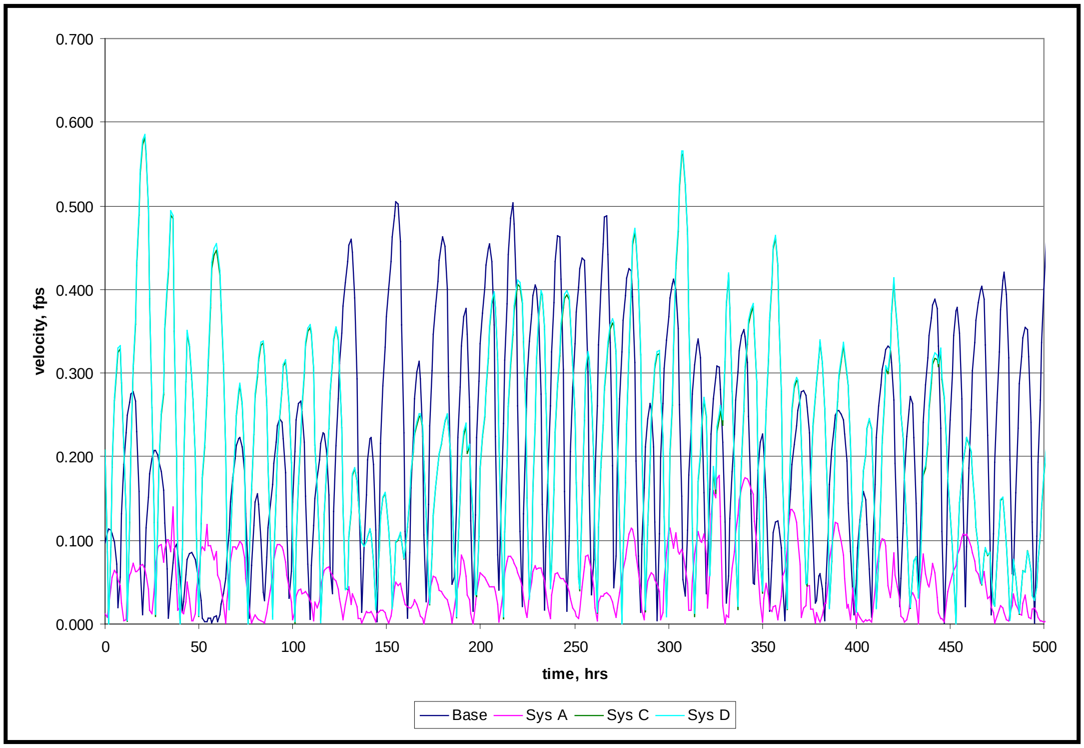

Figure 4-13. Surface Velocity Comparison – Point 5.

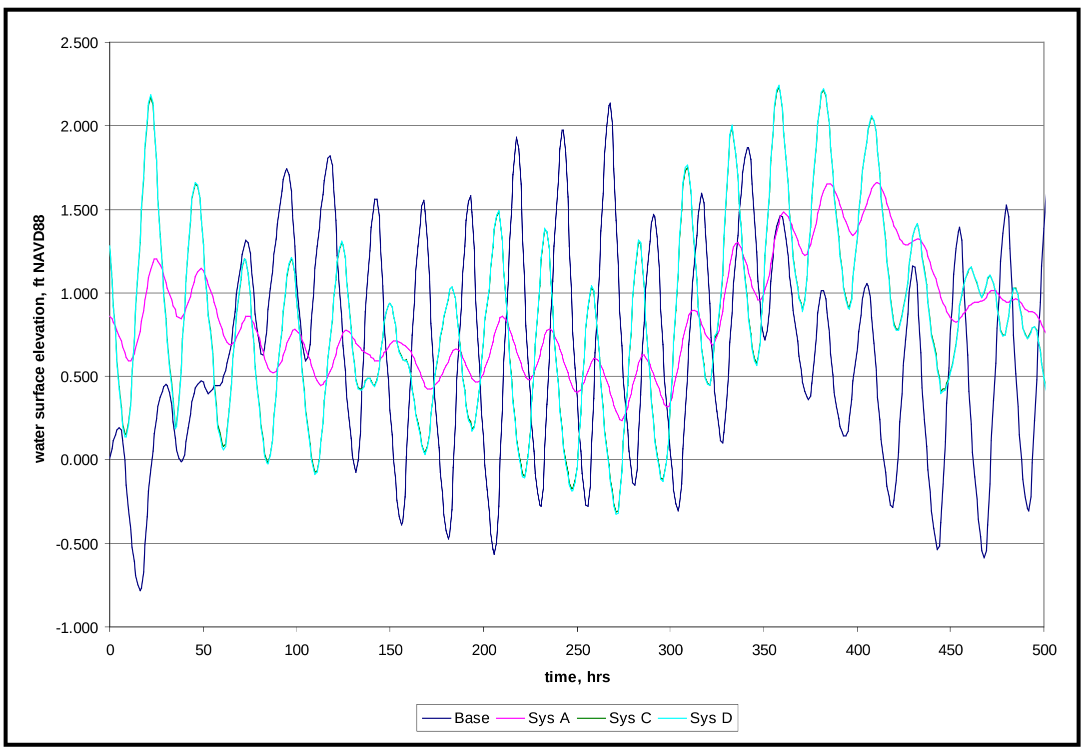

Figure 4-14. Water Surface Elevation Comparison – Point 1.

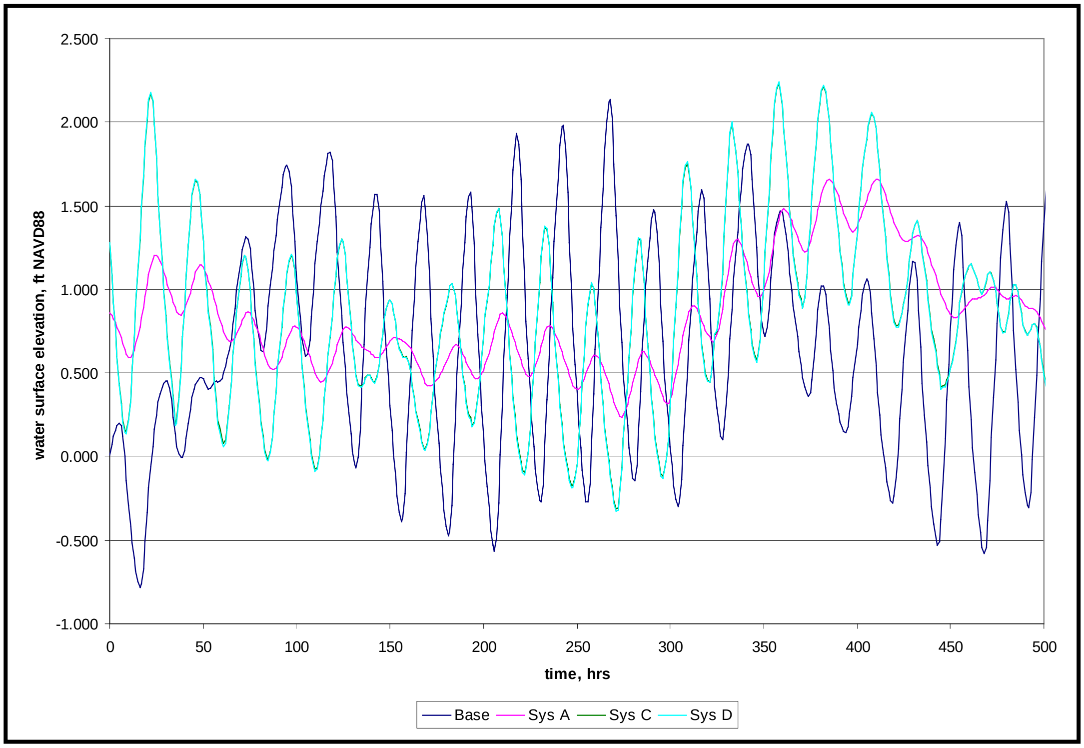

Figure 4-15. Water Surface Elevation Comparison – Point 2.

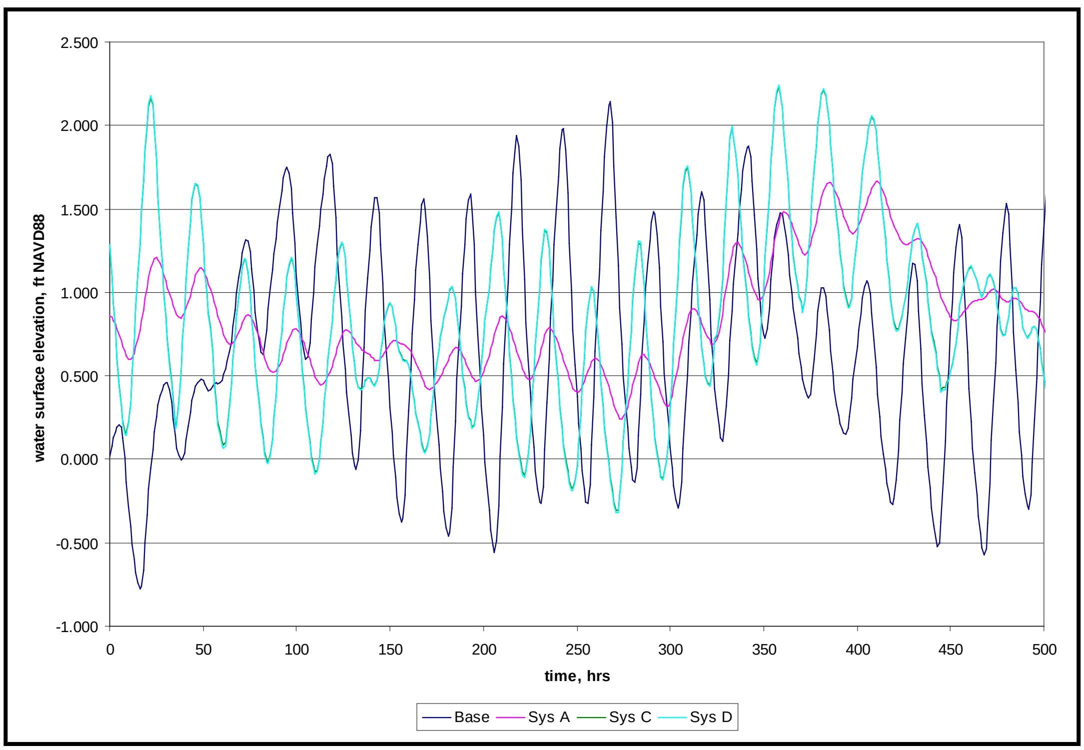

Figure 4-16. Water Surface Elevation Comparison – Point 3.

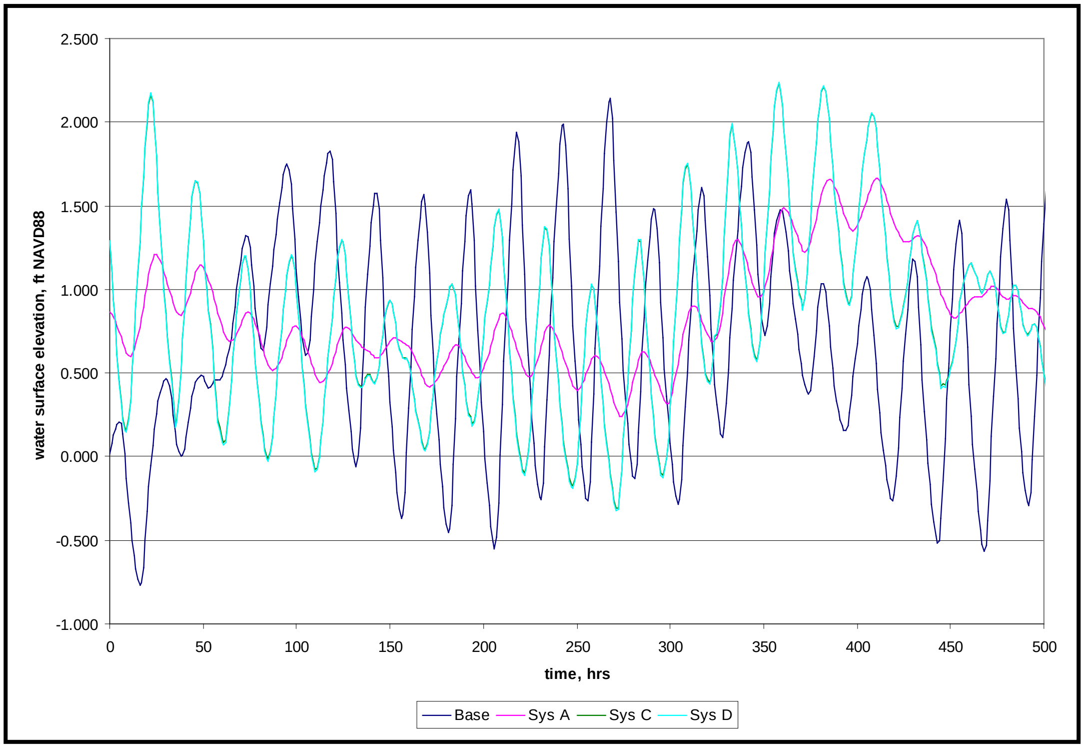

Figure 4-17. Water Surface Elevation Comparison – Point 4.

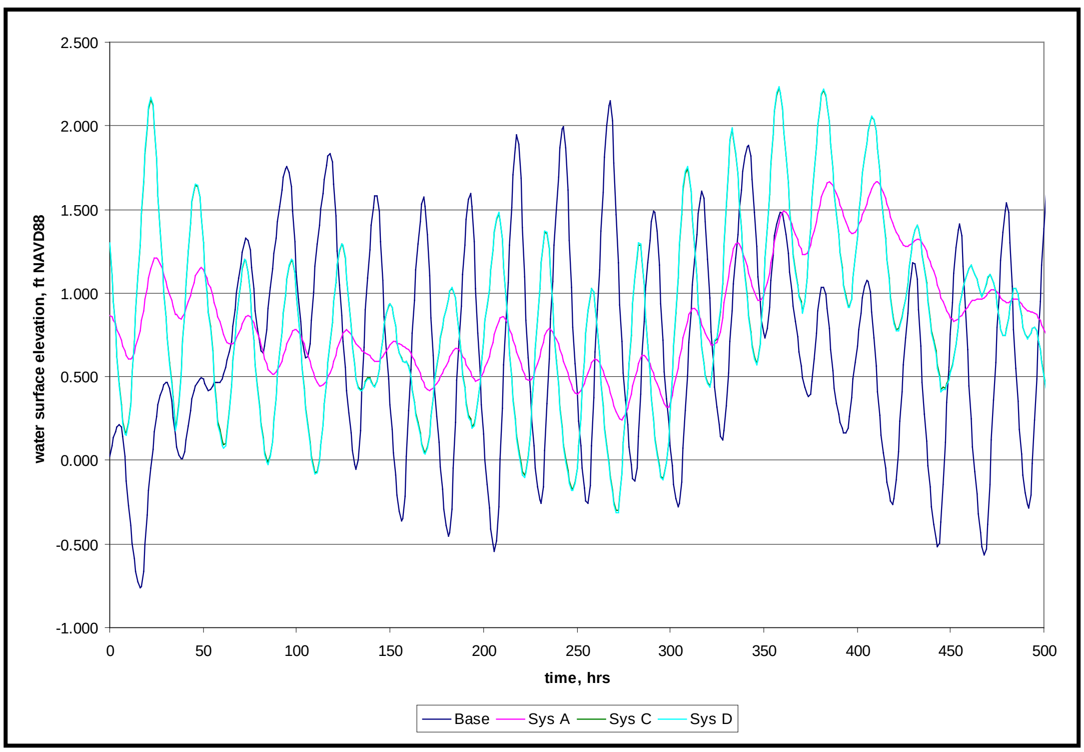

Figure 4-18. Water Surface Elevation Comparison – Point 5.

System A produced the most significant impacts on the western GIWW compared to the Base condition. System A produced velocity decreases for approximately 90% of the simulation and damped the water surface elevations for nearly 100% of the simulation. Systems C and D reduced velocities and damped water surface elevations for approximately 50% and 75% of the simulation time, respectively. As for the discharges, the water surface elevation decreases amount to a decrease in cross-section and coupled with the velocity decreases effectively result in a decrease in discharge through the GIWW west of its confluence with the MRGO.

Phase 2

Surface velocities were also analyzed in Phase 2 for the year-long simulations of each scenario. The first step was to compare the velocities of the Phase 1 Base condition to the Phase 2 Base condition. The Phase 2 Base condition differed from Phase 1 in that MRGO was completely closed off at la Loutre Ridge (see Figure 3-9). One velocity comparison was made at Seabrook (see Figures 4-19 and 4-20) and showed that by closing off MRGO at la Loutre Ridge, velocities are cut approximately in half. The Phase 2 Base condition had a maximum surface velocity of ~3.0 ft/sec at Seabrook (see figure 4-19) while the Phase 1 Base condition had a maximum velocity of ~5.0 ft/sec (see Figure 4-20). Velocity reductions on the order of 20-25% were also observed in the GIWW reach between MRGO and the IHNC and the reach immediately south of the MRGO/GIWW confluence. As in Phase 1, velocities in Lakes Borgne and Pontchartrain were not affected by implementation of the Phase 2 alternatives.

System A1 produced a maximum surface velocity of ~3.0 ft/sec (see Figure 4-21) which is the same value as that of the Base condition at Seabrook (see Figure 4-19). Examining the velocity vectors and contours of Figures 4-22 (Base) and 4-23 (System A1), it is observed that the second closure of the MRGO for System A1 increases flow through BB and Lake Borgne's connection with GIWW, but flow is decreased in the vicinity of the Michoud Canal and the MRGO/GIWW confluence. Therefore, while closing the MRGO in a second location would seem to further reduce flow into the system, the velocities at Seabrook indicate that enough water still enters the system to maintain the head difference across the Seabrook constriction and thereby the maximum velocities through the constriction.

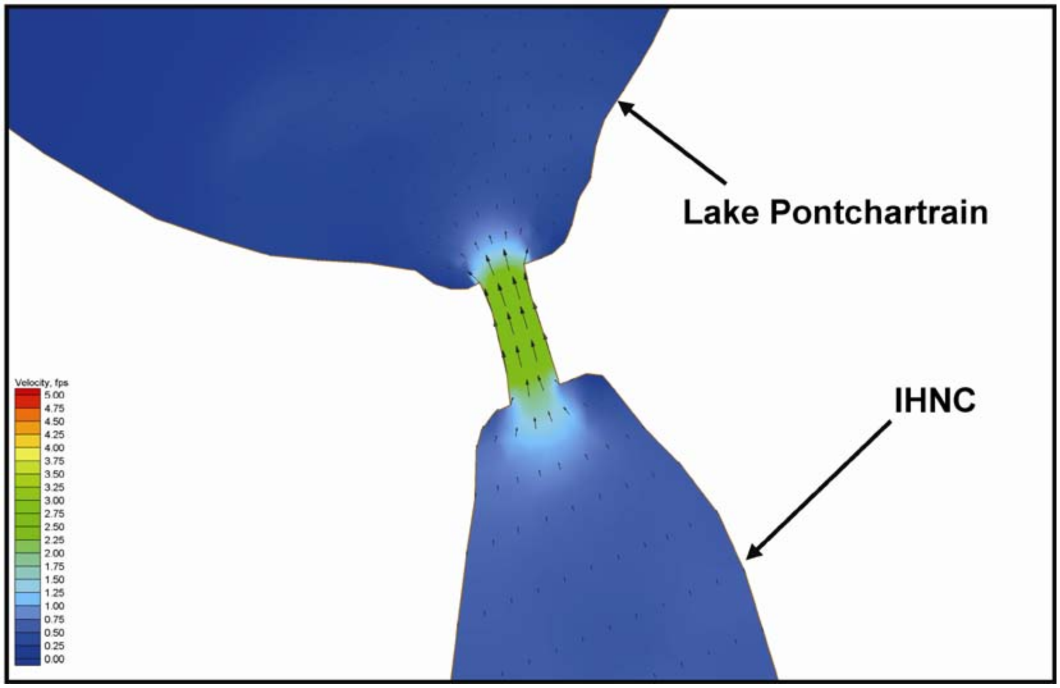

Figure 4-19. Surface Velocities at Seabrook – Phase 2 Base Condition.

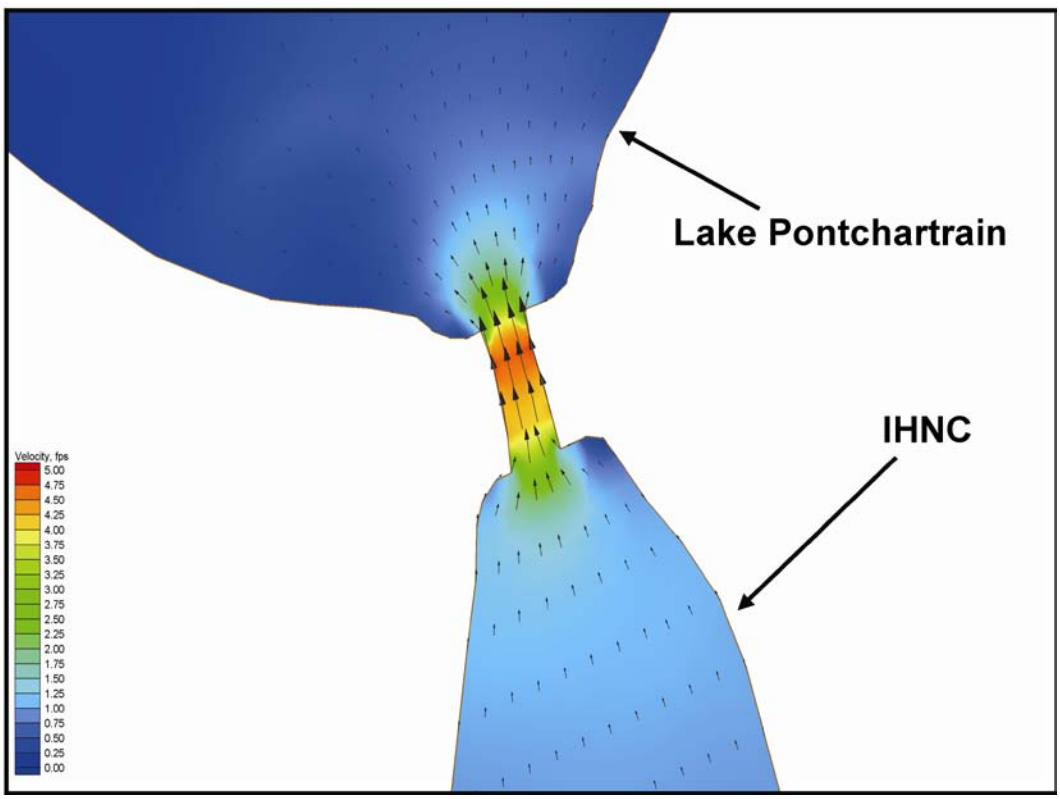

Figure 4-20. Surface Velocities at Seabrook – Phase 1 Base Condition.

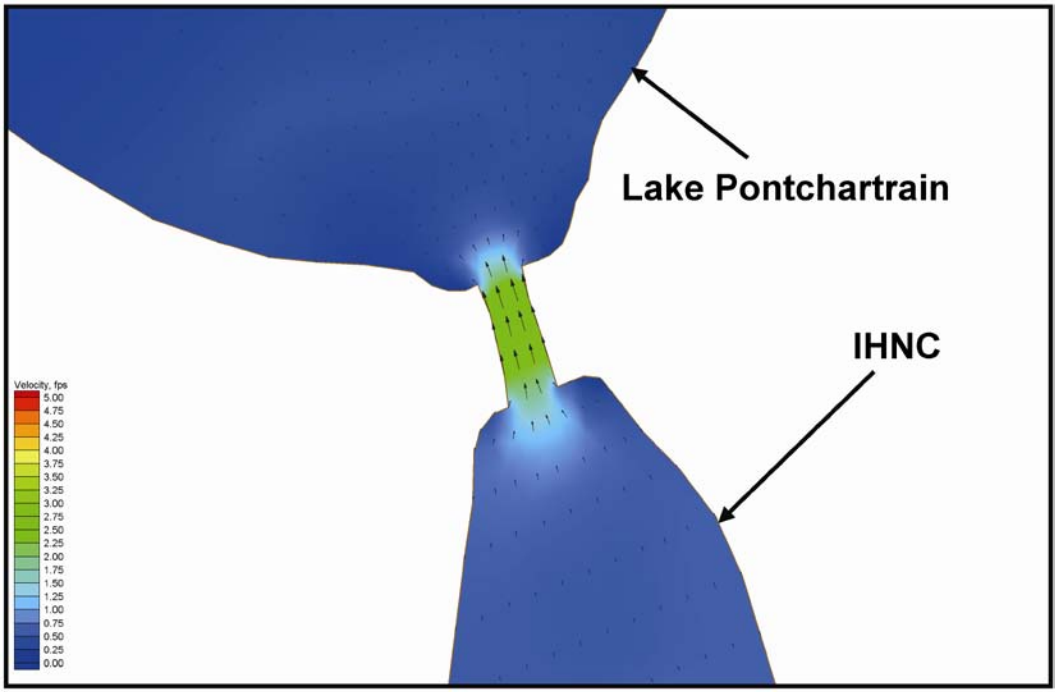

Figure 4-21. Surface Velocities at Seabrook – System A1.

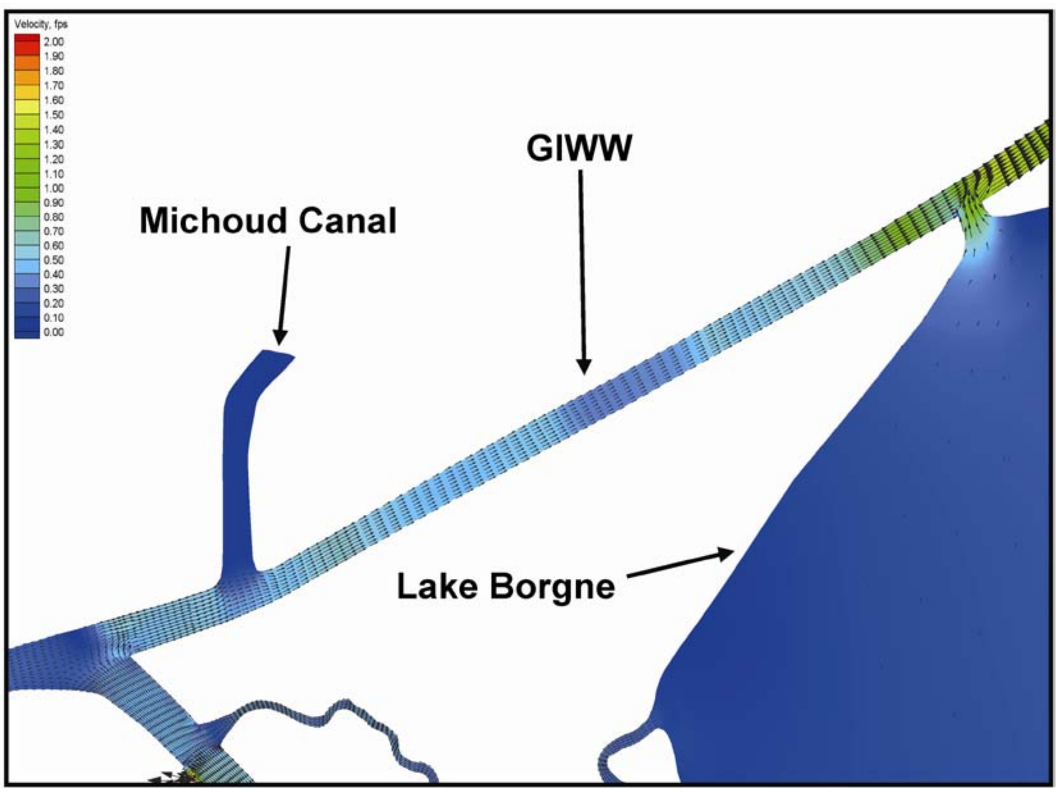

Figure 4-22. Surface Velocities from Lake Borgne – Base.

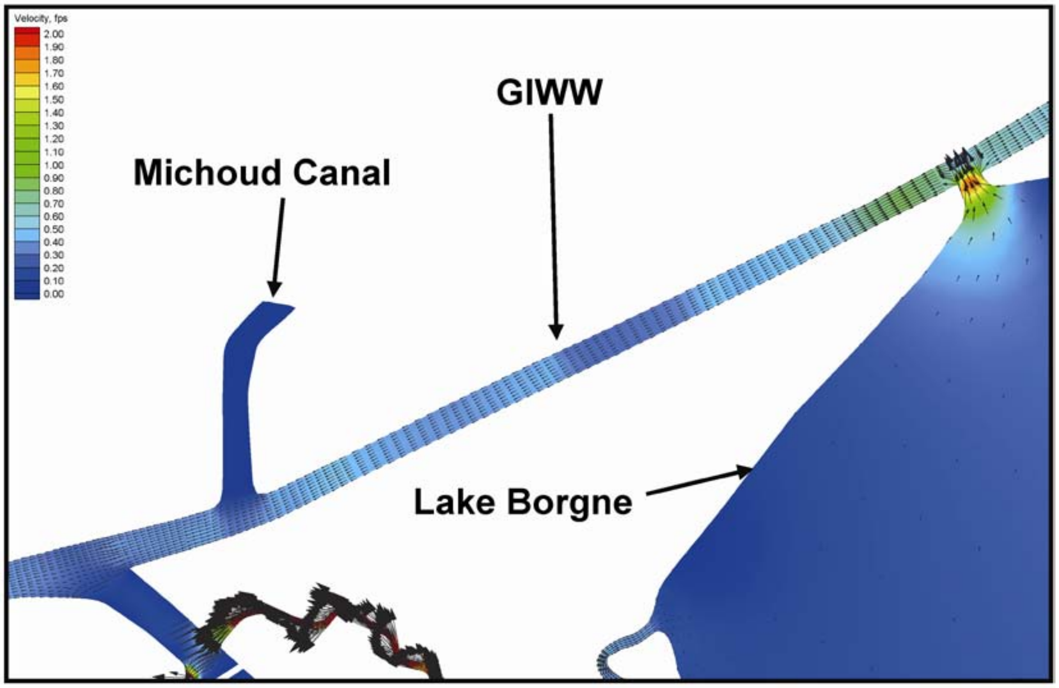

Figure 4-23. Surface Velocities from Lake Borgne – System A1.

System A2 added a structure on BB with a 56 foot width and a sill elevation of 8 feet. This configuration had maximum surface velocity of ~2.0 ft/sec at Seabrook (see Figure 4-24). Apparently, the constriction of the BB flow results in a drop of ~0.5 ft/sec over the Base condition at Seabrook. In the Bayou Bienvenue Structure, the velocity is ~1.6 ft/sec (see Figure 4-25).

Systems A3 and A4 have a structure placed in the GIWW east of the Michoud Canal. The resulting velocities at Seabrook are illustrated in Figures 4-26 and 4-27. System A3 has a maximum surface velocity of ~3.0 ft/sec (see Figure 4-26) while System A4 has maximum surface velocity of ~4.25 ft/sec (see Figure 4-27) at the same location. So while adding the structure on the GIWW did not appear to affect Seabrook velocities, System A4's additional structure at Seabrook increases the maximum velocities by ~1.25 ft/sec over the Base condition. This increase is attributable to the longer constriction length at Seabrook which increases the time needed for the flow to evacuate the constriction and thereby creates a larger head difference across the constriction. This larger head difference results in larger velocities at Seabrook.

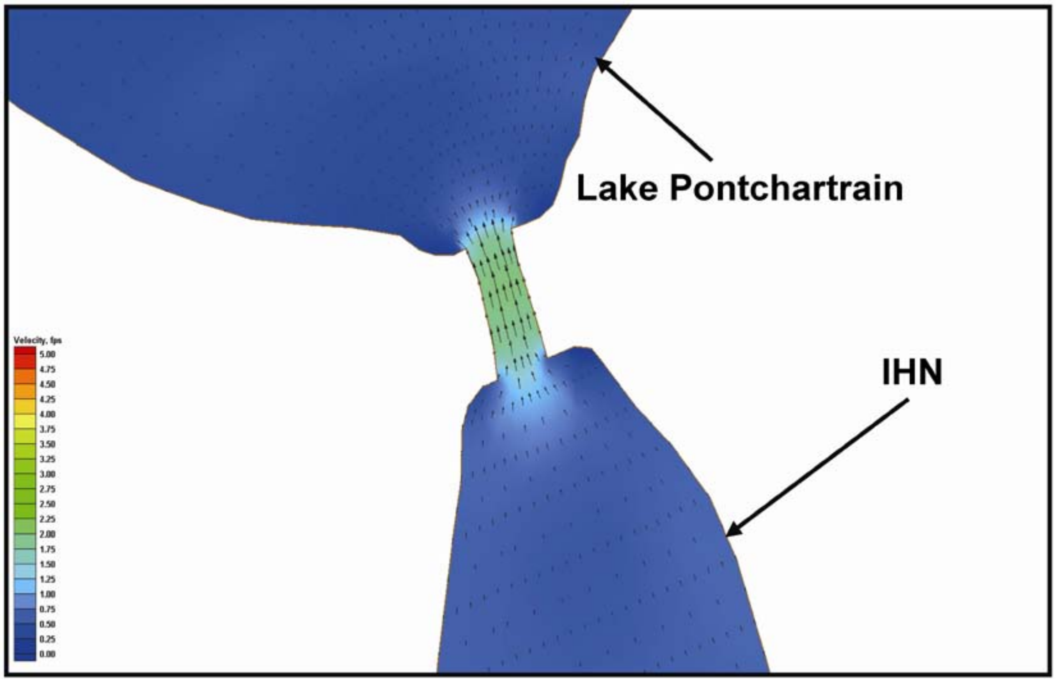

Figure 4-24. Surface Velocities at Seabrook – System A2.

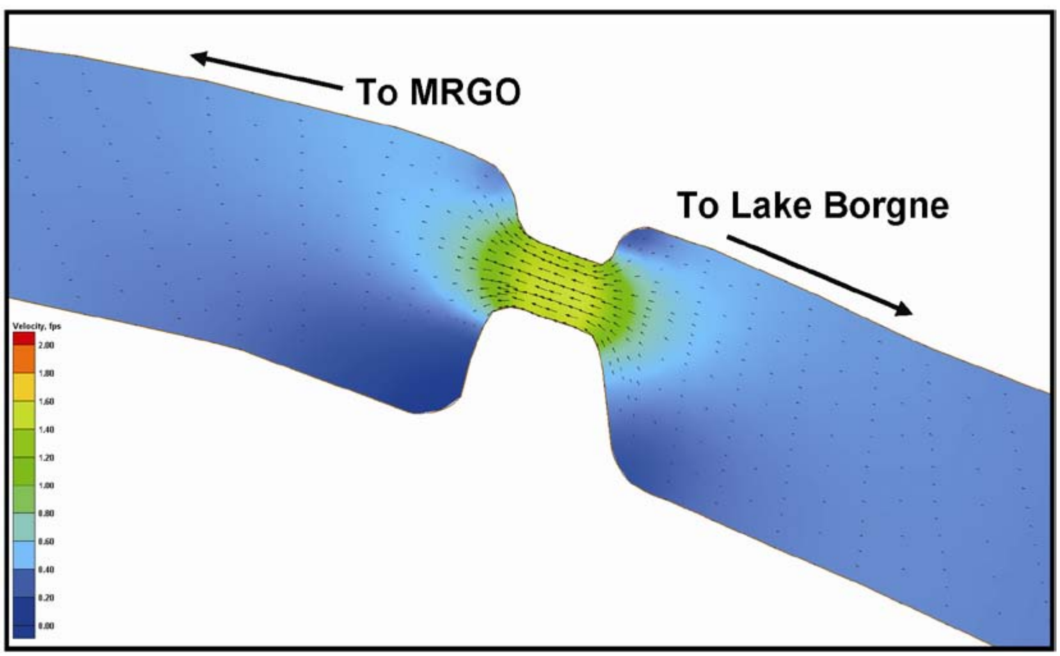

Figure 4-25. Surface Velocities at Bayou Bienvenue Structure – System A2.

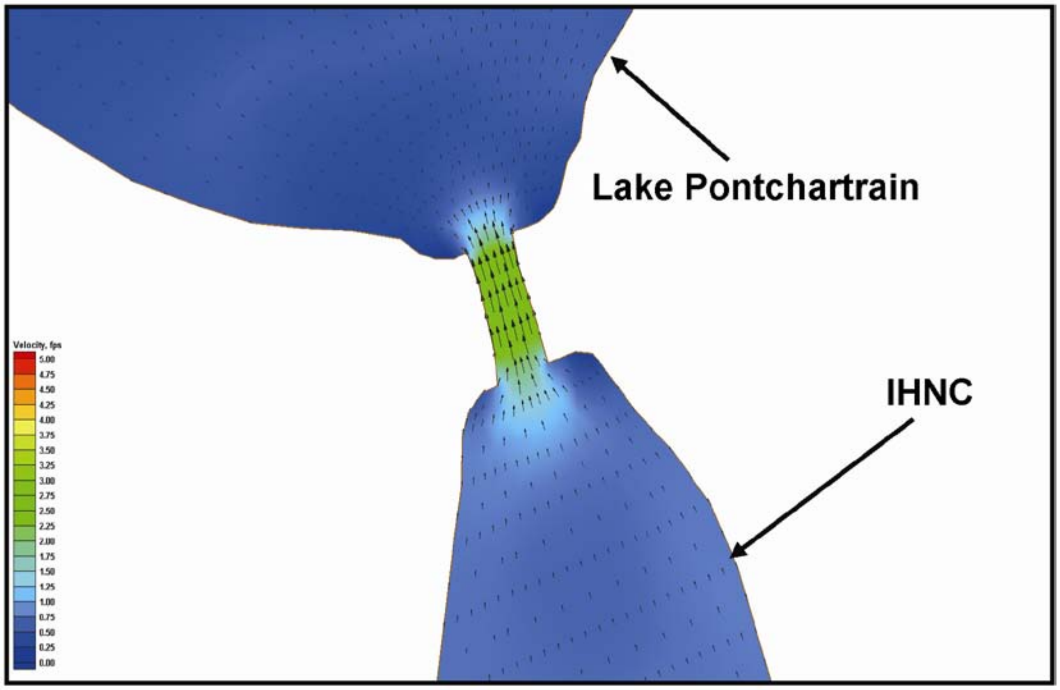

Figure 4-26. Surface Velocities at Seabrook – System A3.

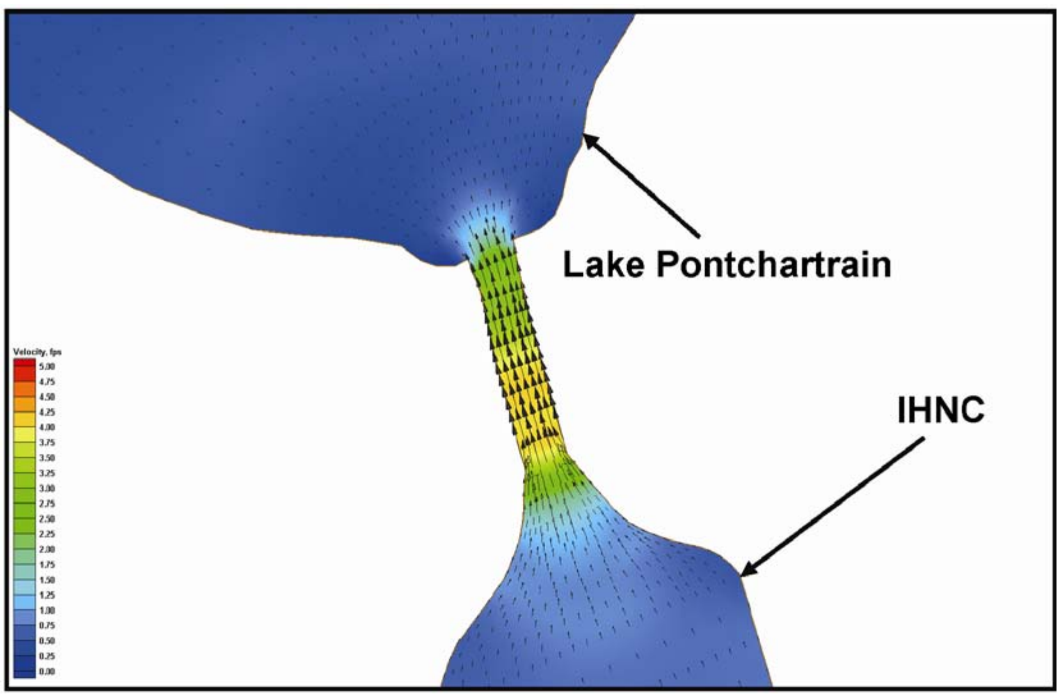

Figure 4-27. Surface Velocities at Seabrook – System A4.

The addition of the structure on GIWW for A3 and A4 had a significant effect on velocities in the Bayou Bienvenue structure. However, a contour plot of the maximum velocity would be misleading, showing a maximum velocity of ~5.9 ft/sec. The monthly averaged of peak velocity for March 2006 was only 2.2 ft/sec. The peak velocity of 5.9 ft/sec was of particular concern to environmental stakeholders as velocities over 2.6 ft/sec adversely affect fish movement. A more appropriate way of viewing these particular velocities was determined to be through a percent exceedance plot of March velocities (see Figure 4-29). This plot shows the higher velocities occurred for a low percentage of the total time period. Also, an examination of the March 2006 model velocities showed this 5.9 ft/sec velocity to be a spike in the velocities for March and most likely attributable to a frontal passage coupled with a strong spring tide. An examination of the wind data showed a spike in the wind values on March 8 which is day 67 in Figure 4-28. This spike in wind velocity appeared to be a part of larger wind event that started the day before the spike and continued on for approximately a week after the spike. This wind event did not appear to noticeably affect the velocities in the other structures for the System A3 alternative nor did it adversely affect the velocities for any of the other alternatives for Phase 2. Also, Seabrook velocities were already above the threshold for fish movement for the existing Phase 1 Base condition and implementation of surge protection measures actually decreased velocities at Seabrook.

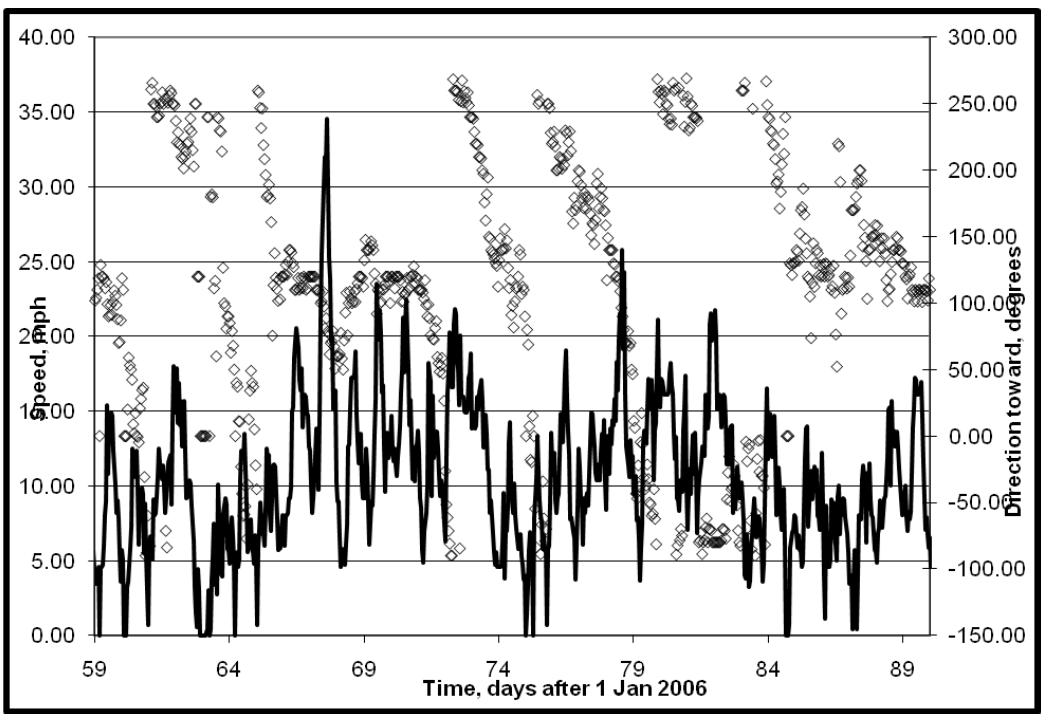

Figure 4-28. Wind Speeds and Directions for March 2006.

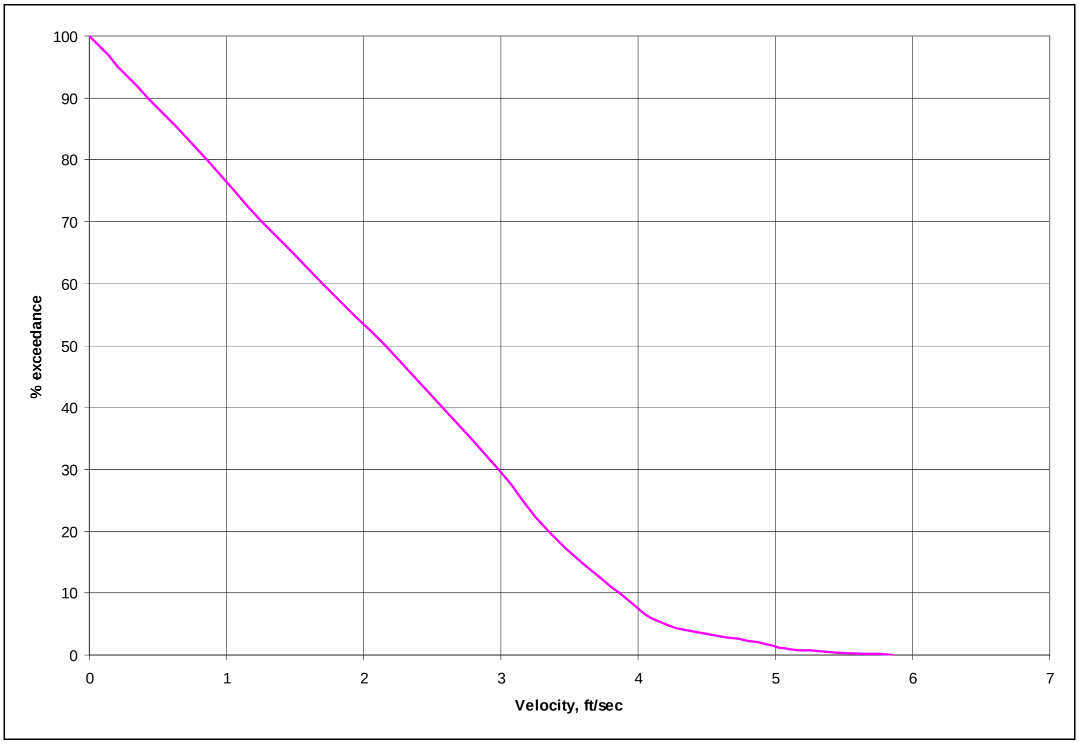

Figure 4-29. Surface Percent Exceedance Plot of Surface Velocities – System A3.

Velocities in the GIWW structure itself in Systems A3 and A4 were of similar magnitude, ~2.5 ft/sec (see Figure 4-30).

Velocities at Seabrook were ~4.25 ft/sec for System C1 (see Figure 4-31) and ~6.5 ft/sec for C2 (see Figure 4-32). The increase in velocity from C1 to C2 may be attributable to increased length of the constriction at Seabrook similar to the increase in velocity from System A3 to A4. C1's velocity increases over the Base condition may be attributable to the structure at Paris Rd hindering the ebb flow from the western GIWW and thereby storing water that would contribute to a greater head difference across the Seabrook constriction.

Systems C1 and C2 both had a 350 ft by 40 ft (sill) structure on GIWW at Paris Rd. At this structure, velocities were ~0.6 ft/sec in both System C1 (see Figure 4-33) and System C2 (see Figure 4-34). A summary of Phase 2 maximum velocities in the structures at Seabrook, the GIWW, and BB is shown below in Table 4-1.

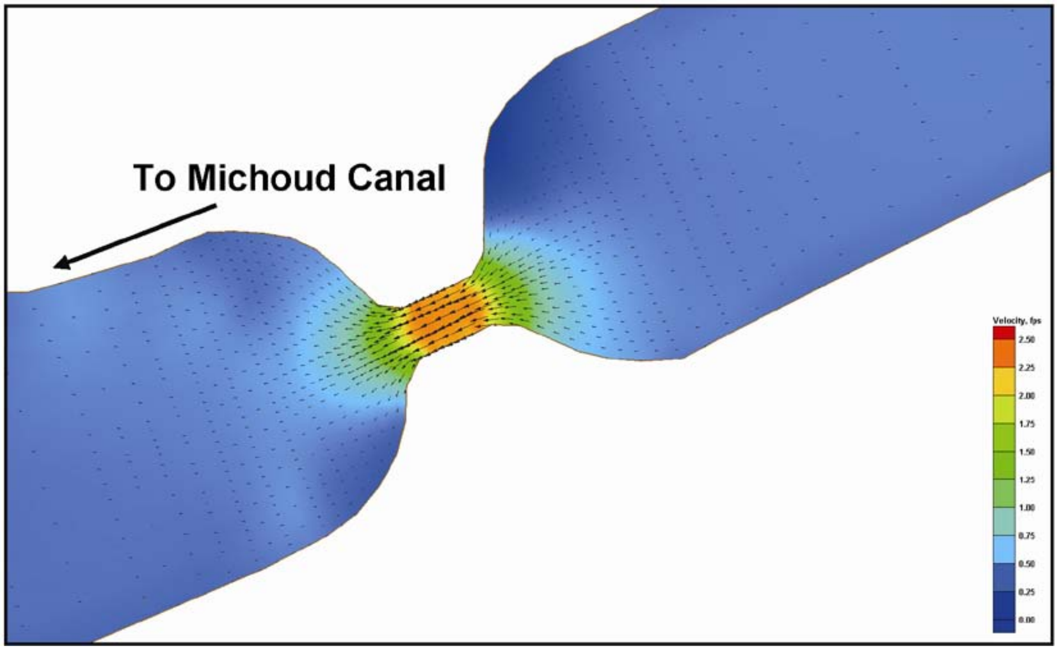

Figure 4-30. Surface Velocities at GIWW Structure – System A3.

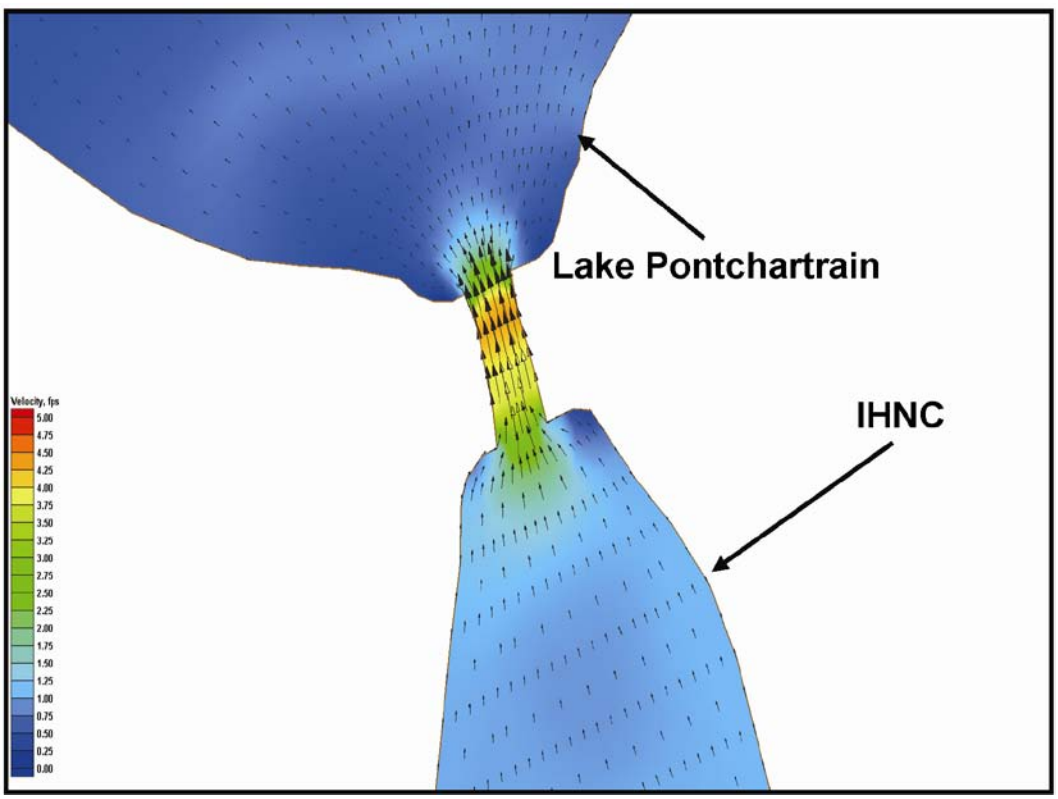

Figure 4-31. Surface Velocities at Seabrook – System C1.

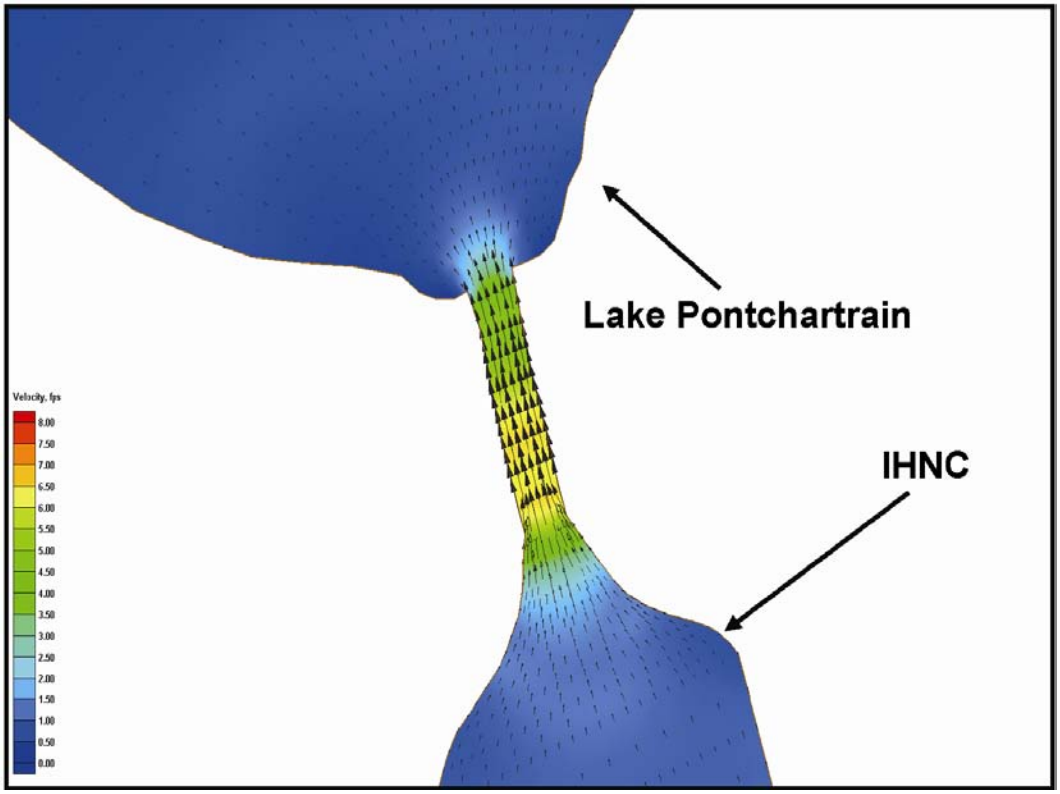

Figure 4-32. Surface Velocities at Seabrook – System C2.

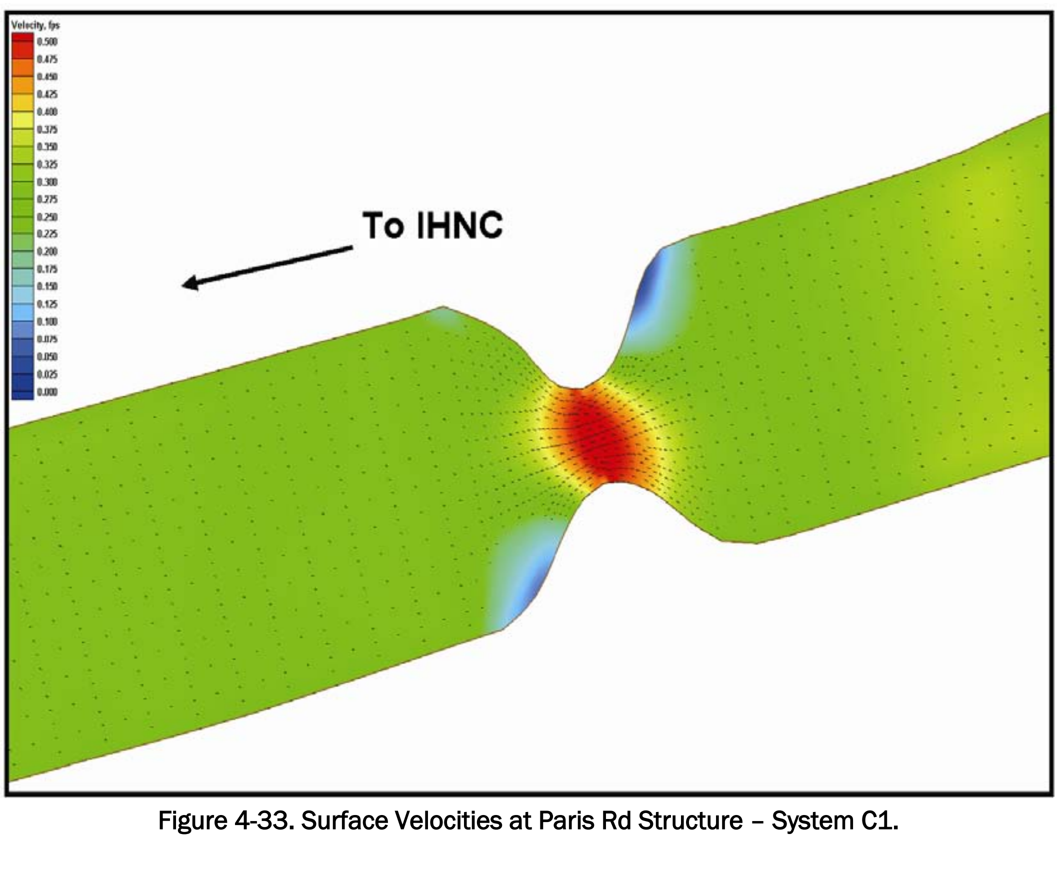

Figure 4-33. Surface Velocities at Paris Rd Structure – System C1.

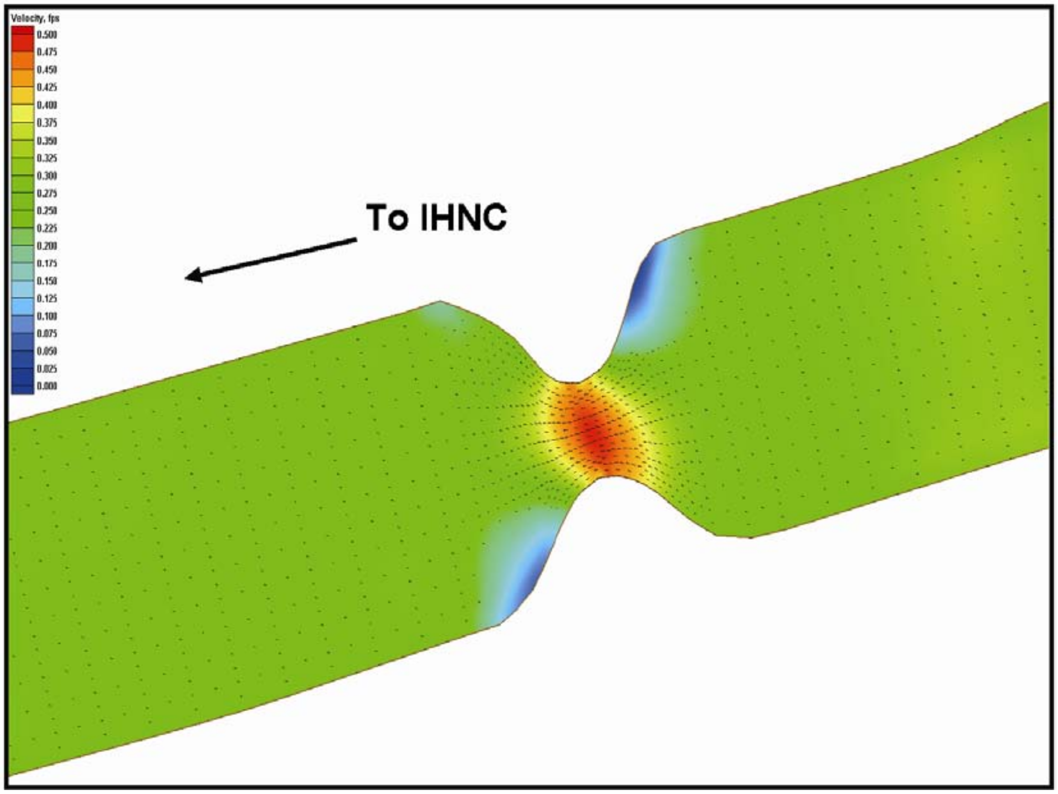

Figure 4-34. Surface Velocities at Paris Rd Structure – System C2.

Table 4-1. Maximum Velocities in Protection Structures

	Maximum Structure Velocities		
System	GIWW (factor)	BB (factor)	Seabrook (factor)
A3	2.5 ft/sec (5)	5.9 ft/sec (12)	3.0 ft/sec (1)
A4	2.5 ft/sec (5)	5.9 ft/sec (12)	4.25 ft/sec (1.4)
C1	0.6 ft/sec (2)	NA	4.25 ft/sec (1.4)
C2	0.6 ft/sec (2)	NA	6.0 ft/sec (2)

Salinity

Phase 1

Based on the results of the hydrodynamic portion of this study, HPO chose System A and System C for extended period salinity runs for Phase 1. These simulations had a three month spin-up period (Oct – Dec 2005) and were then run for the entire year of 2006.

Since a verification of salinity was not performed for this study, the results were analyzed as base-to-plan comparison. The comparisons were made between the base and plan monthly salinity average values for March 2006 and September 2006. The results are shown in Figures 4-35 through 4-39. The March 2006 comparisons represent a wet period of the year and a dry period is represented by the September 2006 comparisons. The wet period was a period of lower salinity while the dry period was a period of higher salinity. The isohalines for Systems A and C are displayed as a difference from the Base isohalines. A negative (-) isohaline indicates the Base salinities are higher than the plan salinities and a positive (+) isohaline indicates the plan salinities are higher than the Base. Bottom layer salinity values were used in the analyses where the model had vertical resolution (see Figure 2-4) and depth-averaged salinity values were used where the model only had two-dimensional resolution. The salinity values for three different regions will be discussed here: the connecting channels (MRGO/GIWW), Lake Borgne, and Lake Pontchartrain.

The March 2006 averaged Base isohalines for the wet period show salinities of 8-12 ppt in Lake Borgne, 4-8 ppt in Lake Pontchartrain, and 8-10 ppt in the connecting channels of the MRGO and the GIWW (see Figure 4-35). During the dry period, September 2006, the monthly average salinity values are 18-20 ppt in Lake Borgne, 6-14 ppt in Lake Pontchartrain, and 18-20 ppt in the connecting channels (see Figure 4-38). The Central Wetlands were not considered in this analysis as that section of the mesh was only added for storage purposes for the hydrodynamic simulations and was crudely represented in the model.

Monthly averaged salinity values were developed separately for the wet period and the dry period for System A and those two average salinity values were compared with the monthly average salinity values for the Base condition during the same time frames. The same process was followed for System C. The comparison showed that System A produces small increases in average salinity in the connecting channels on the order of 0-0.5 ppt. Lakes Borgne and Pontchartrain exhibited no measurable change in the monthly average salinity values in System A. In the September 2006 plot (see Figure 4-39), there was a noticeable 1-4 ppt drop in salinity in the connecting channels as a result of the closure of the MRGO in System A. As was the case for the wet period, Lakes Borgne and Pontchartrain showed no measurable change in monthly averaged salinity values for the dry period. The disparity between the salinity differences during the wet period and those of the dry period could be attributable to the larger amount of freshwater in the system during the wet period. This freshwater was attributed to larger freshwater inflows into the system during the wet period.

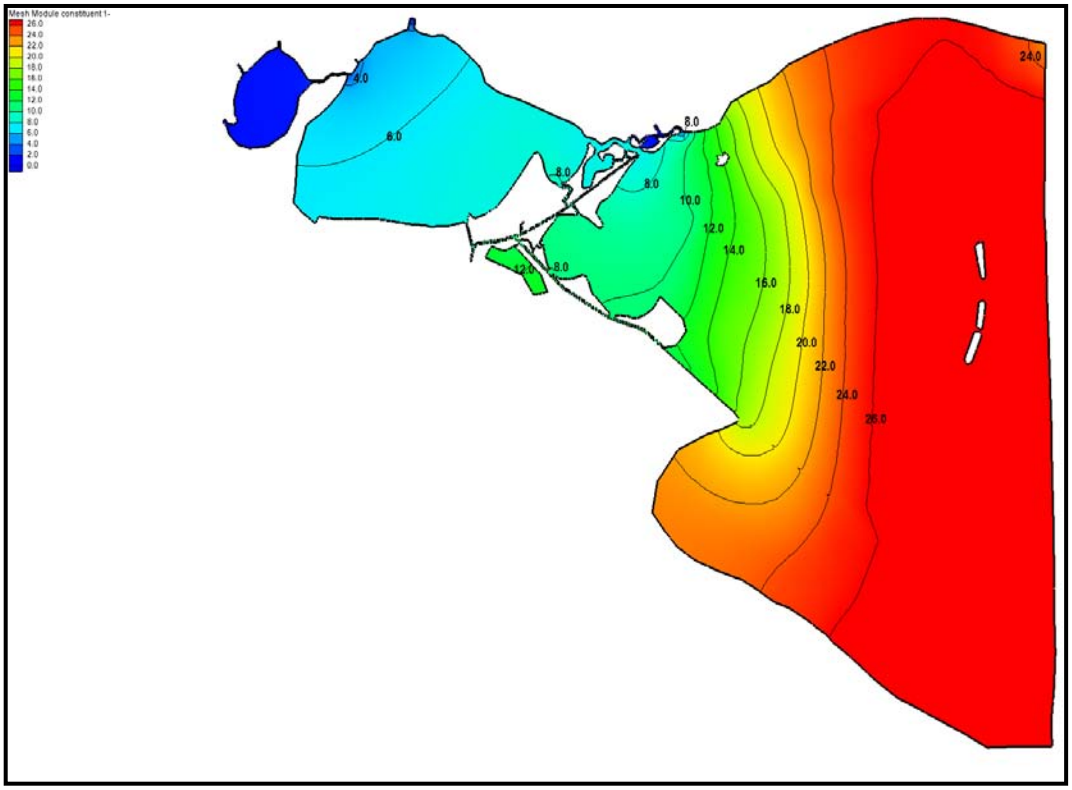

Figure 4-35. Base Isohalines – March 2006.

Figure 4-36. System A Isohalines (plan – base) – March 2006.

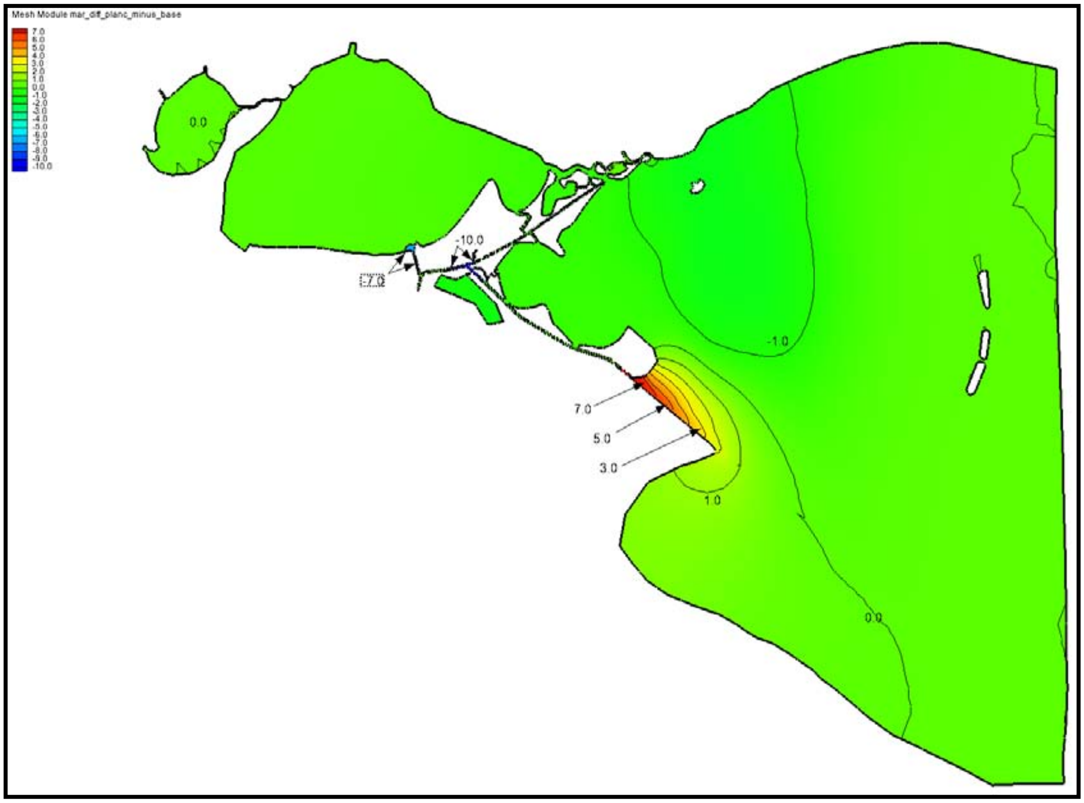

Figure 4-37. System C Isohalines (plan-base) – March 2006.

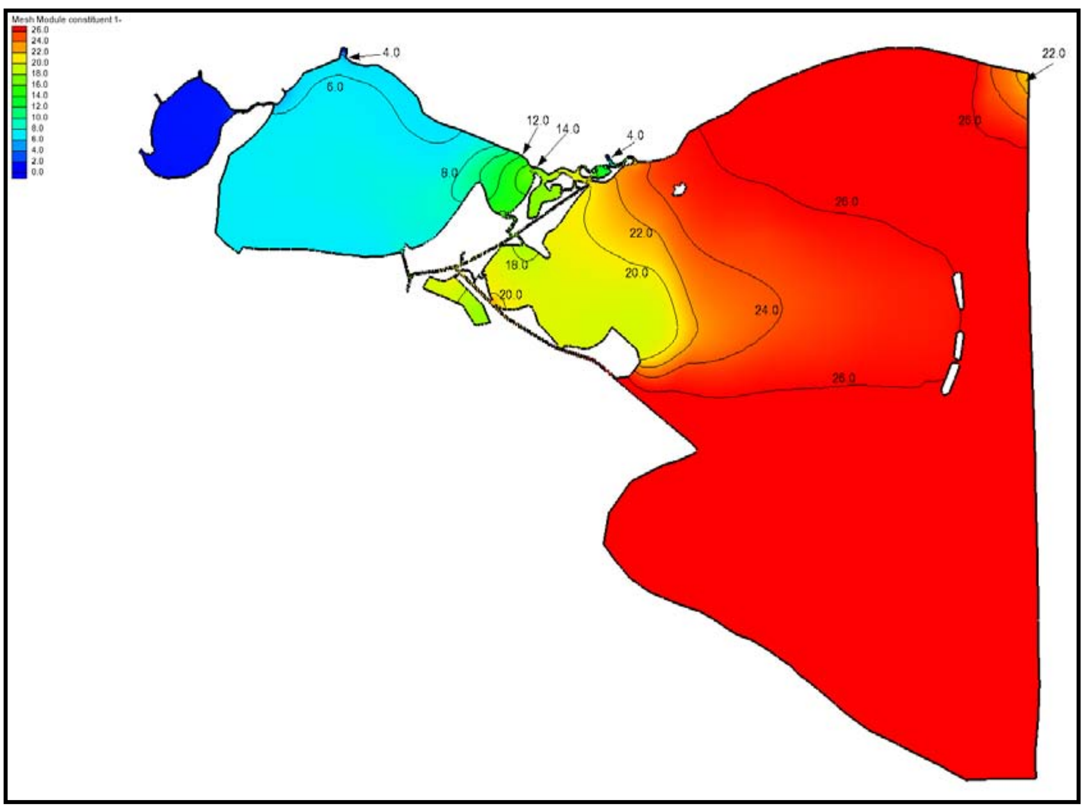

Figure 4-38. Base Isohalines – September 2006.

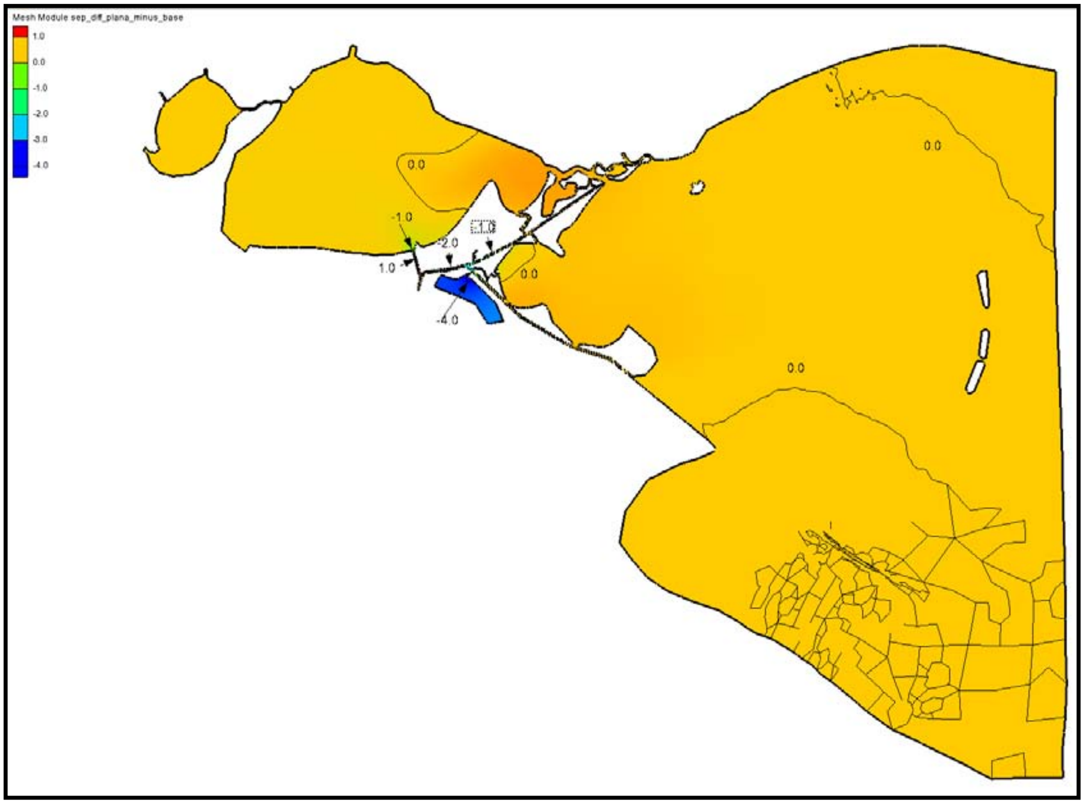

Figure 4-39. System A Isohalines (plan – base) – September 2006.

The average salinity for System C during March showed 7-10 ppt decreases from the Base condition in the connecting channels and no measurable changes in salinity in Lakes Borgne and Pontchartrain (see Figure 4-37). This larger decrease in average salinity for System C indicates that the location of the closure of MRGO is important to salinity values in the connecting channels. The location of the MRGO closure in System C also produced a salinity increase southeast of the closure. The average salinity during September in System C had a greater decrease from the Base condition in Lake Borgne and no increase southeast of the closure (see Figure 4-40) when compared to the March 2006 time period for System C.

Simulations were performed with a release of freshwater into Lake Pontchartrain from the Bonnet Carre structure (see Figures 4-41 thru 4-43). The release boundary condition was developed using data from an actual Bonnet Carre release event that began 19 March 1997 and ended on 20 April 1997. Therefore, only the March 2006 period was used in the analysis. The peak flow of ~240,000 cfs thru the structure was reached on 29 March and continued for nearly 22 hours. The MRGO closures in System A and System C reduced the amount of salinity entering Lake Pontchartrain and amplified the freshening effect of Bonnet Carre (Figures 4-42 and 4-43). The decreases in Lake Pontchartrain were on the order of 0.5-2.0 ppt for both systems while the connecting channels and Lake Borgne showed decreases of 0.5-1.0 ppt and 1.0-1.5 ppt for Systems A and C, respectively. While the magnitudes of the reductions in salinity were similar for both systems, the contour patterns were somewhat different which again indicates that the placement of the MRGO closure has an effect on salinity values in the system.

Phase 2

Phase 2 simulations were run for the same extended period as Phase 1: a 3 month spin-up period (Oct – Dec 2005) followed by the entire year of 2006. The results were also processed in a similar fashion by calculating monthly averages for the wet period of March and the dry period of September and differencing the plan simulations from the Base simulation. All salinity values in the figures were taken from the bottom layer of the model where there was vertical resolution (see Figure 2-4), but the salinity values were depth-averaged in the two-dimensional portions of the mesh.

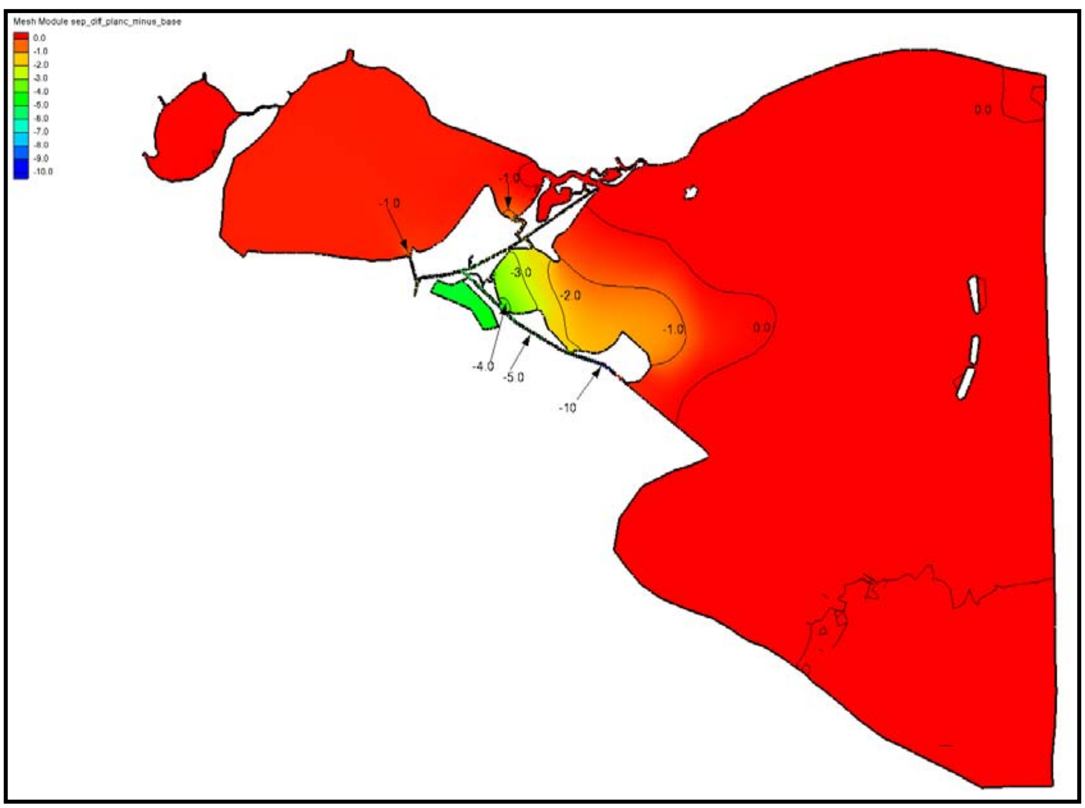

Figure 4-40. System C Isohalines (plan – base) – September 2006.

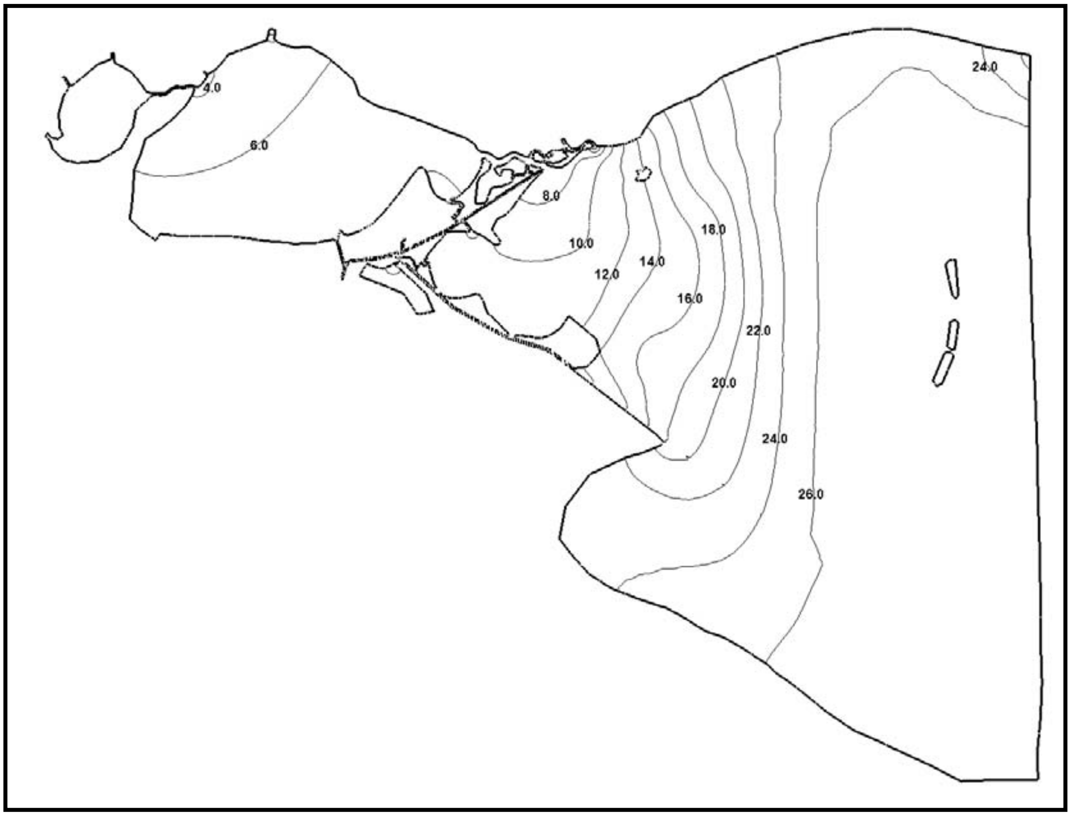

Figure 4-41. Base Isohalines, Bonnet Carre Open – March 2006.

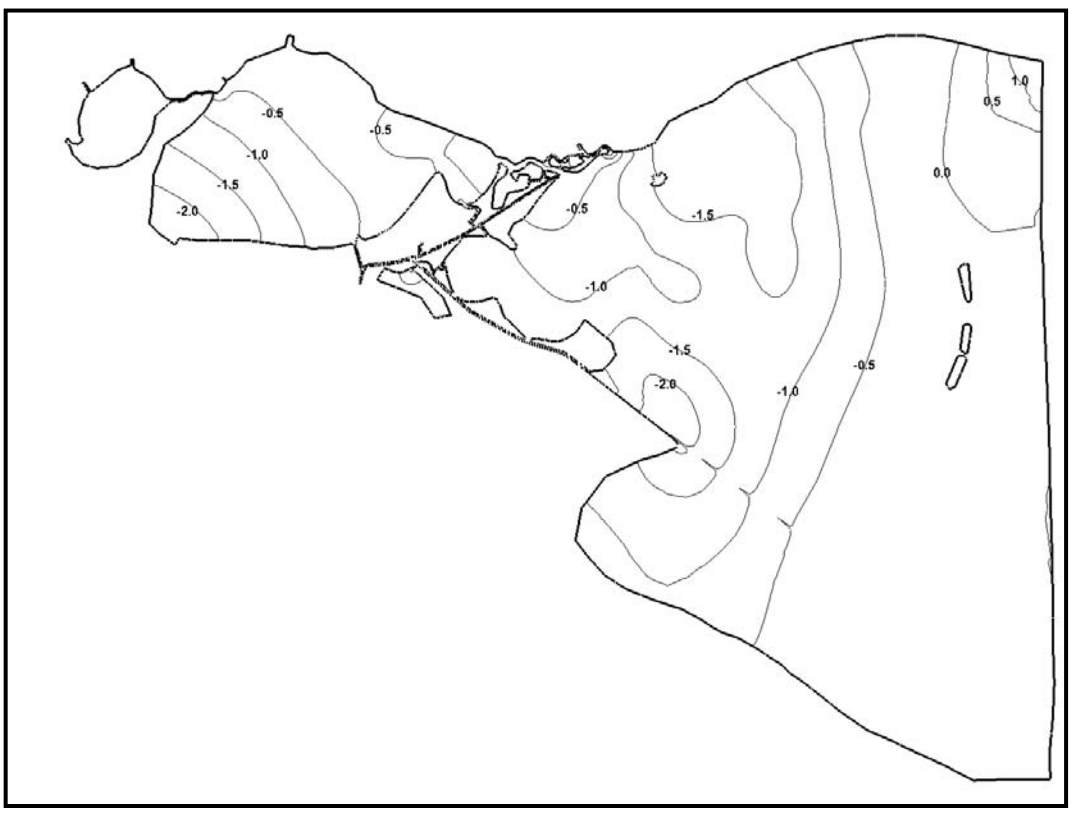

Figure 4-42. System A Isohalines (plan – base), Bonnet Carre Open – March 2006.

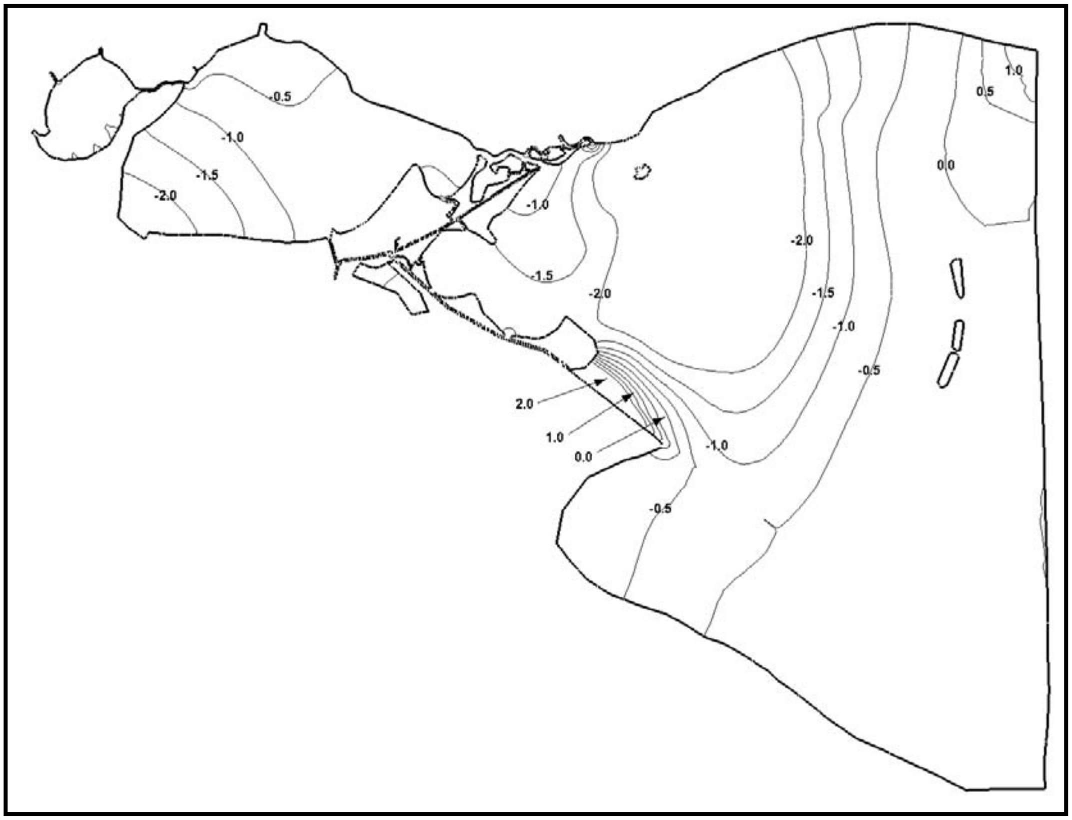

Figure 4-43. System C Isohalines (plan – base), Bonnet Carre Open – March 2006.

Systems A1-A4 produced small decreases in salinity in the connecting channels on the order of approximately 0.1-0.3 ppt (see Figures 4-44 thru 4-49) during the wet period. The decreases were most noticeable in the region of the model nearest the MRGO closure just south of BB and in the IHNC south of Seabrook. Lake Borgne exhibited 0.1 ppt increases for System A1 but only at the connection to BB and at the direct connection to the GIWW. Lake Pontchartrain showed no measurable change in salinity. As in Phase 1, the size of these decreases can be attributed to the fact that more freshwater is entering the system during the March period. The dry period (see Figures 4-52 thru 4-56) showed larger decreases of approximately 0.5-2.0 ppt between the Base and Systems A1-A4 in the connecting channels. The feature that produced the largest decrease was the closure of MRGO just south BB in System A1. This would indicate that GIWW does receive some salinity input from Lake Borgne once the closure at la Loutre Ridge has been implemented. Lakes Borgne and Pontchartrain exhibited no measurable change in salinity during the September 2006 period in Systems A1-A4.

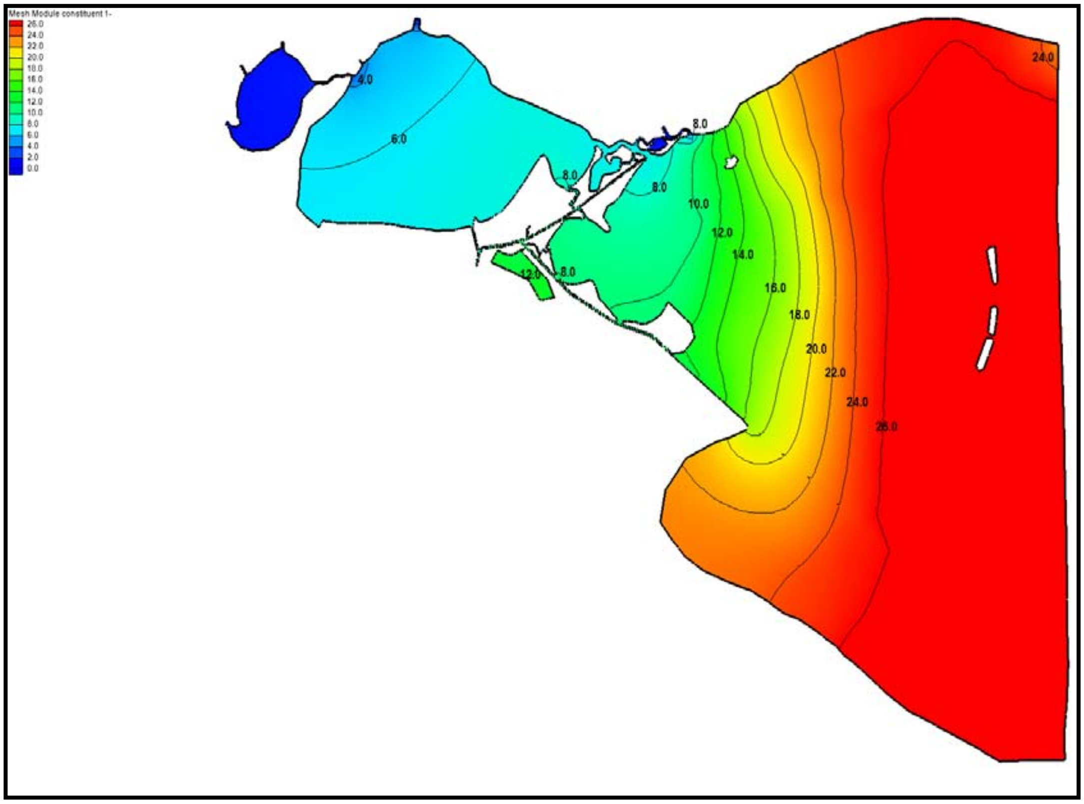

Figure 4-44. Phase 2 Base Isohalines – March 2006.

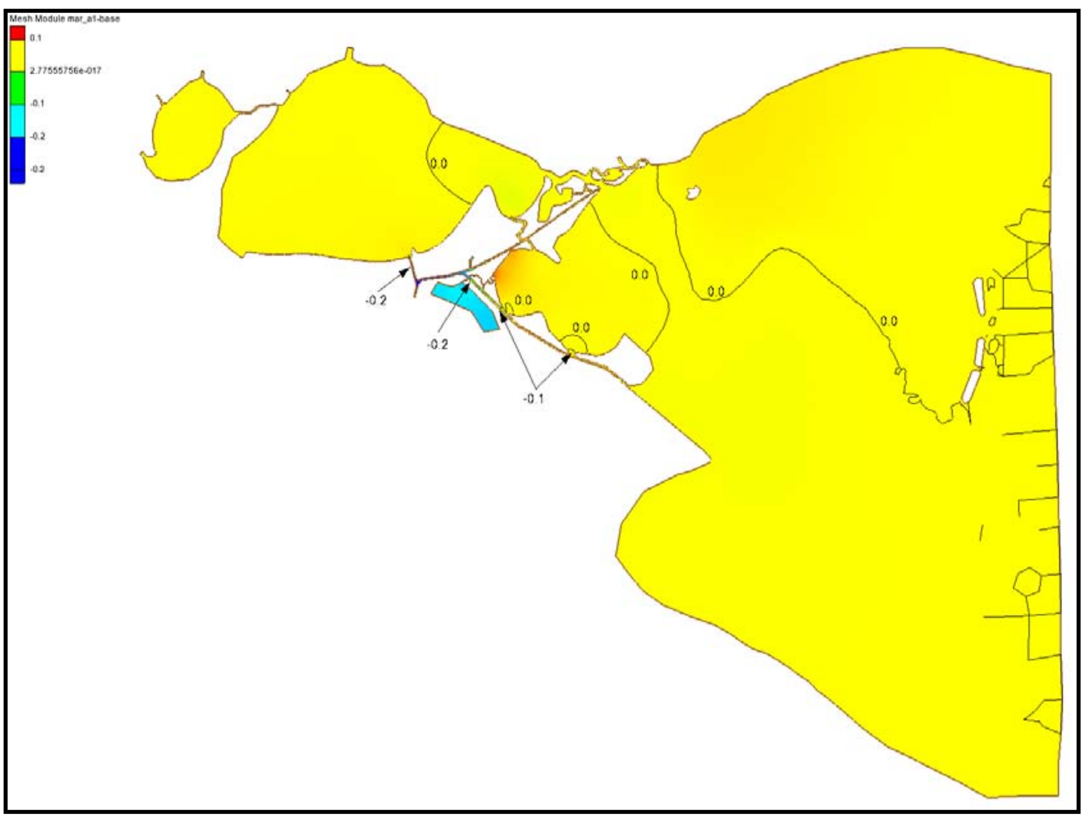

Figure 4-45. System A1 (plan - base) – March 2006.

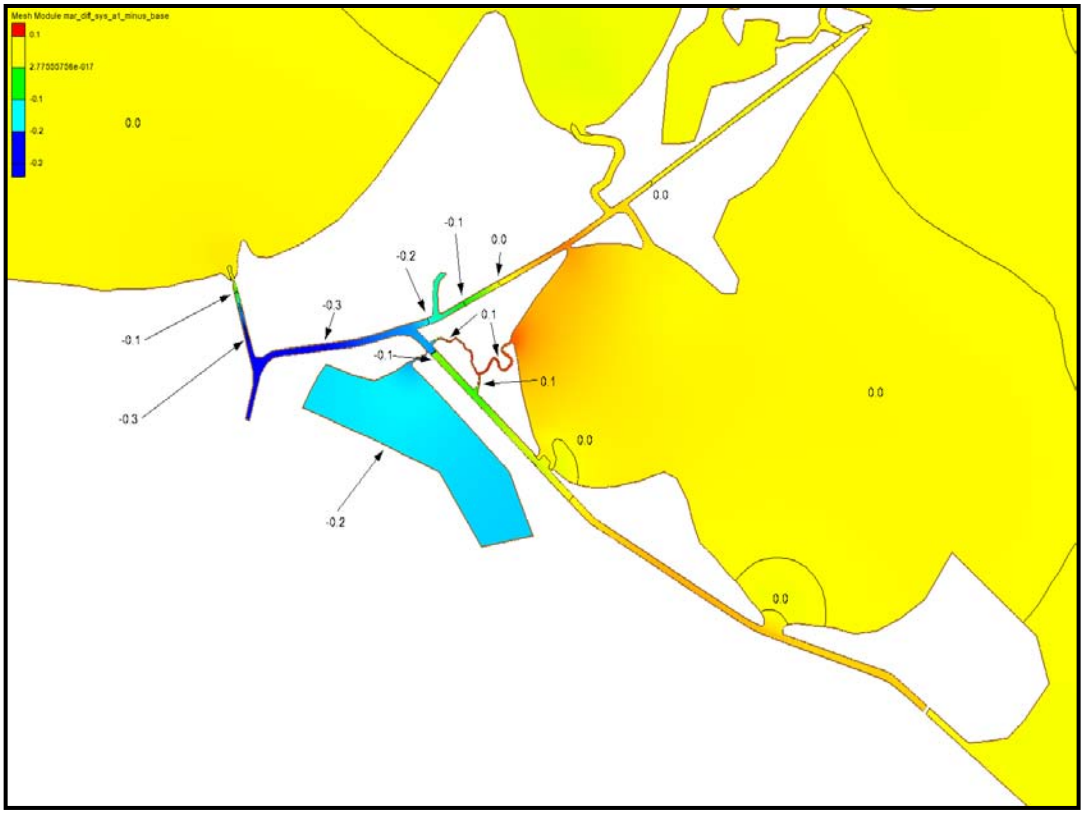

Figure 4-46. System A1 (plan - base) – March Inset.

Figure 4-47. System A2 (plan - base) – March Inset.

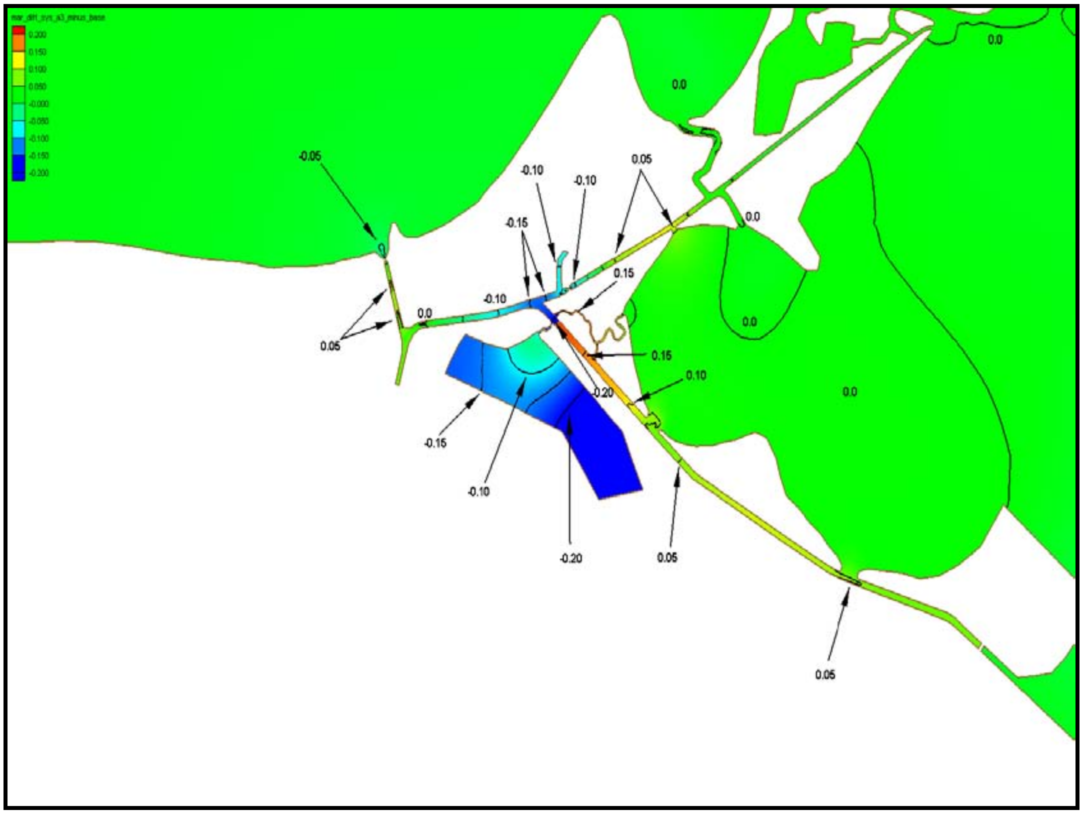

Figure 4-48. System A3 (plan - base) – March Inset.

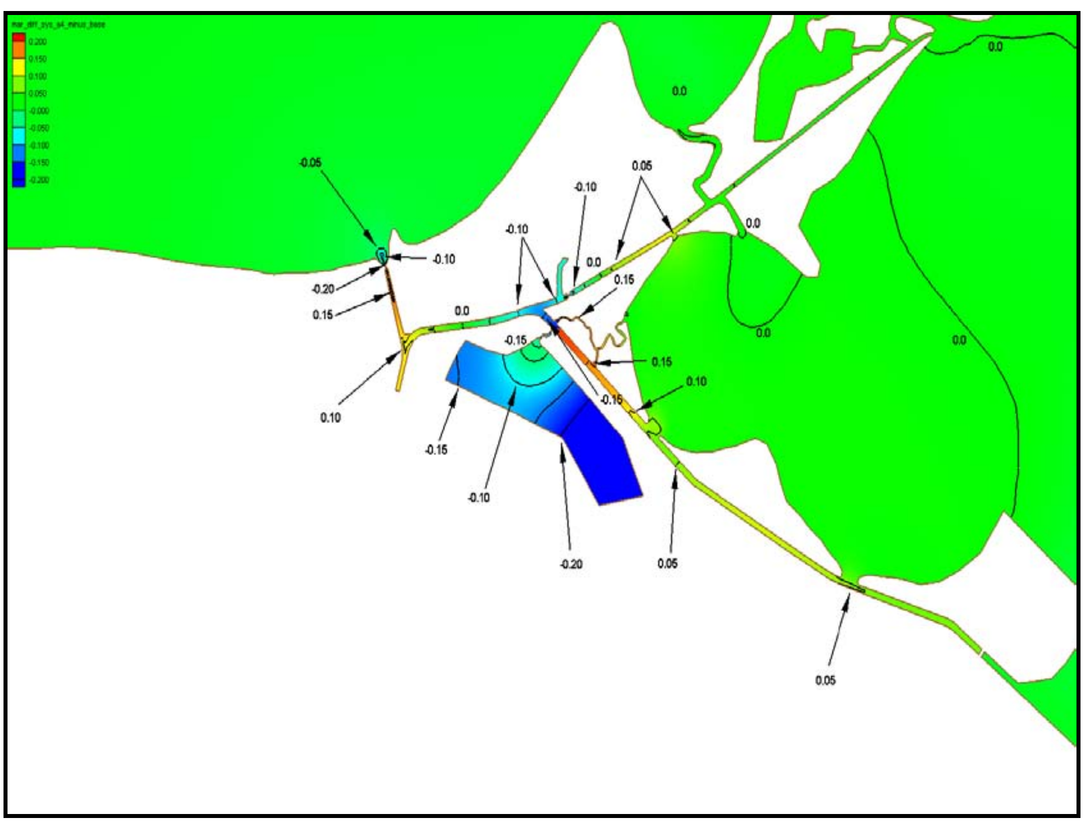

Figure 4-49. System A4 (plan - base) – March Inset.

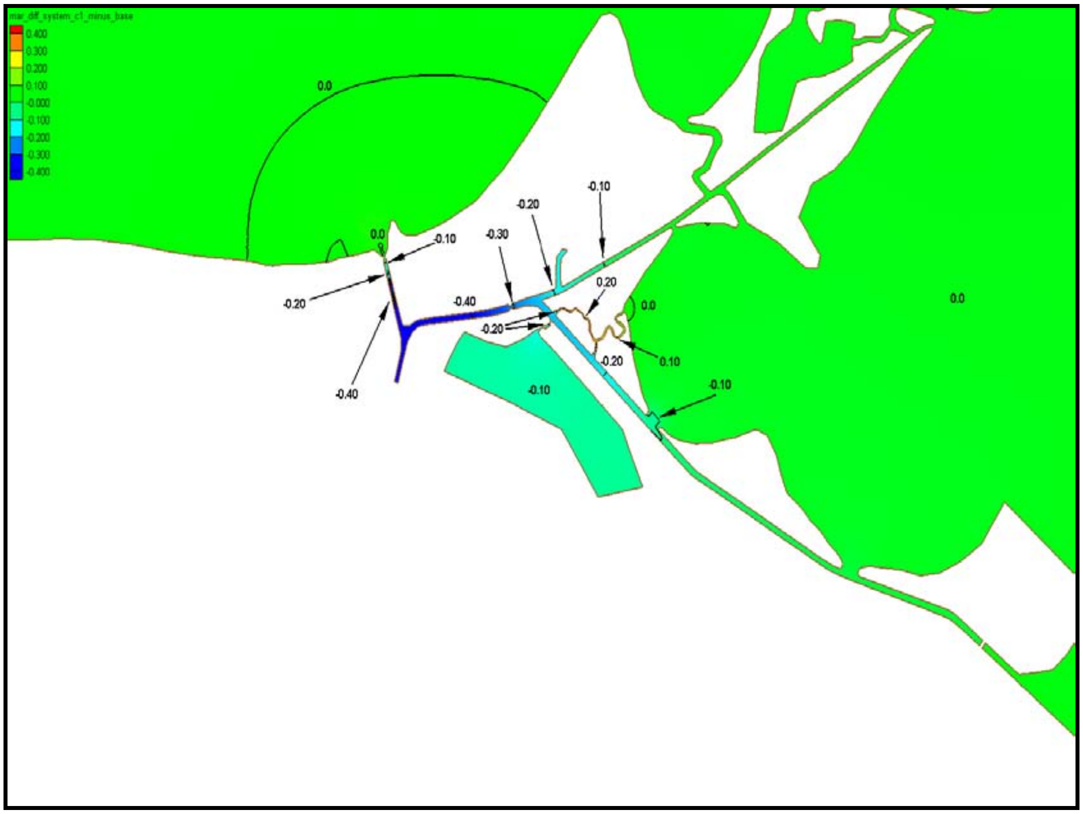

Figure 4-50. System C1 (plan - base) – March Inset.

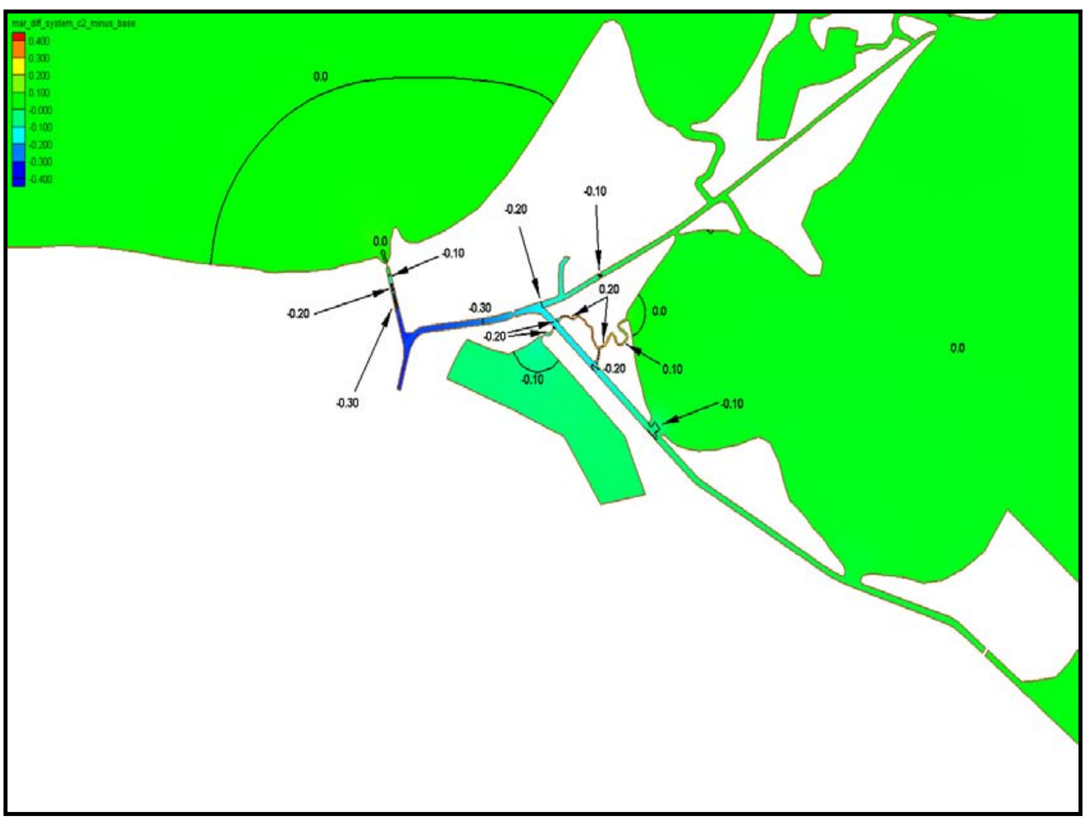

Figure 4-51. System C2 (plan - base) – March Inset.

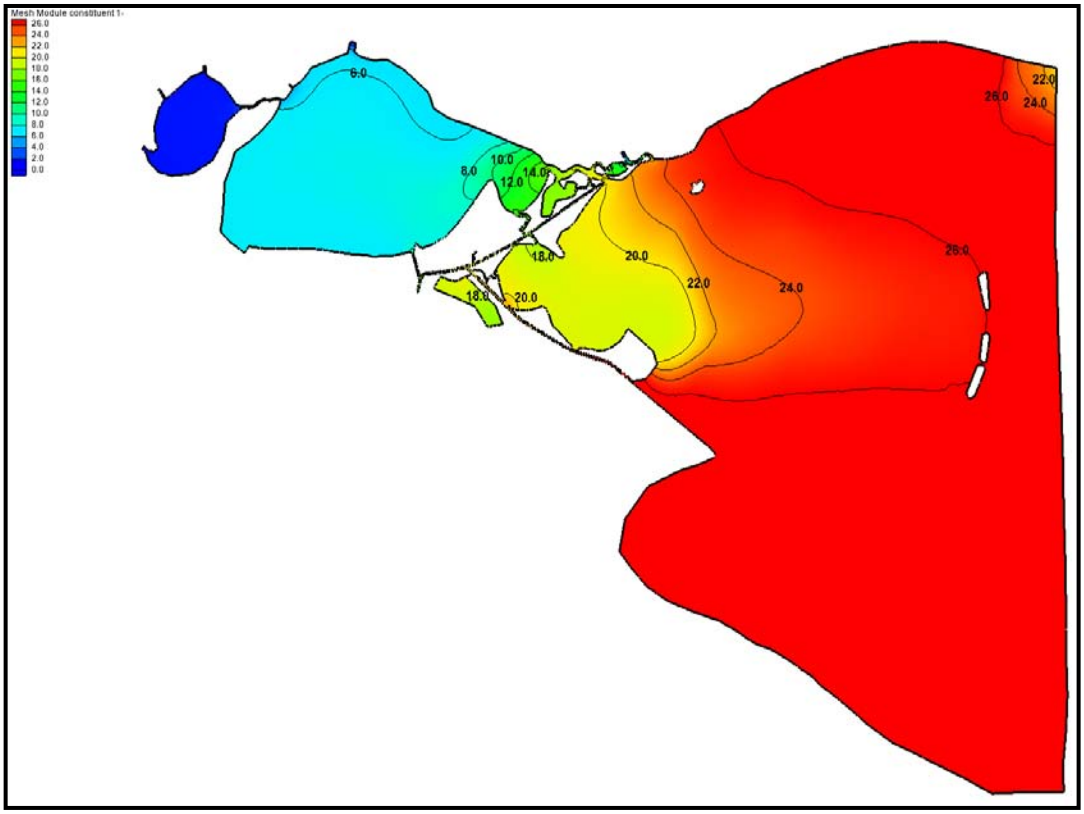

Figure 4-52. Phase 2 Base Isohalines – September 2006.

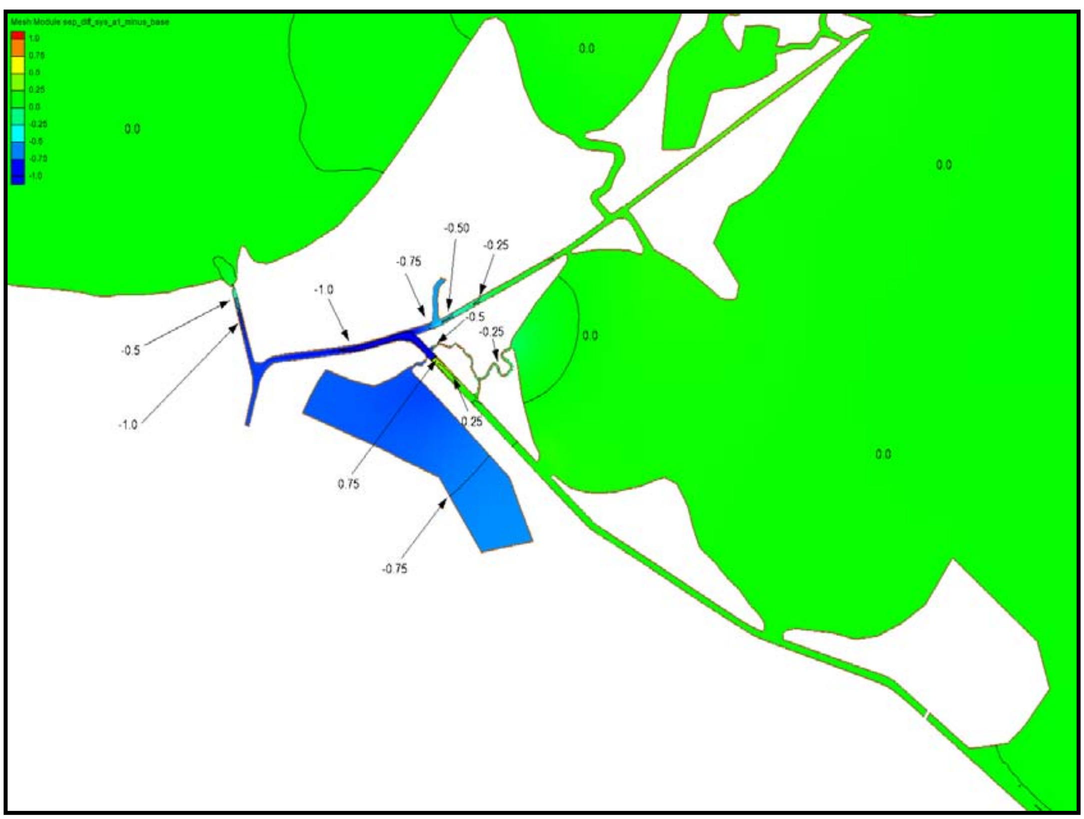

Figure 4-53. System A1 (plan - base) – September Inset.

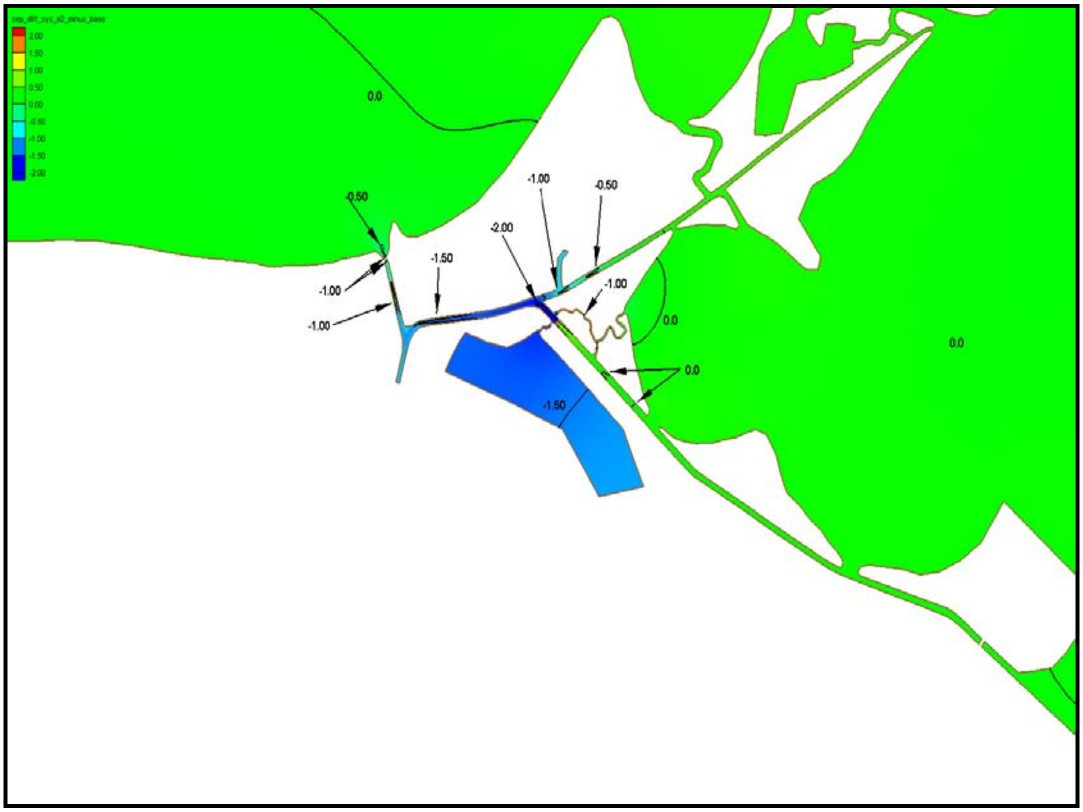

Figure 4-54. System A2 (plan - base) – September Inset.

Figure 4-55. System A3 (plan - base) – September Inset.

Figure 4-56. System A4 (plan - base) – September Inset.

Systems C1 and C2 produced small salinity decreases in the same areas as Systems A1-A4. The effects were slightly greater for C1 and C2 in the wet period (see Figures 4-50 and 4-51) and less than Systems A1-A4 for the dry period (see Figures 4-57 and 4-58). The differences between C1 and C2 during both periods may be attributable to tidal phasing effects created by the addition of the Seabrook structure.

For all systems, A1-A4 and C1-C2, and both periods, March and September 2006, there appear to be small salinity increases in BB. Increases also occur for the March 2006 period in the area of the eastern GIWW surrounding the direct connection to Lake Borgne for Systems A1-A4. The cause of these increases may be attributed to saline water not fully exiting these areas on the ebb tide and thereby increasing salinity in them with each successive tidal cycle. However, it is unclear as to why the GIWW increases occur only during the March 2006 period and not the September 2006 period.

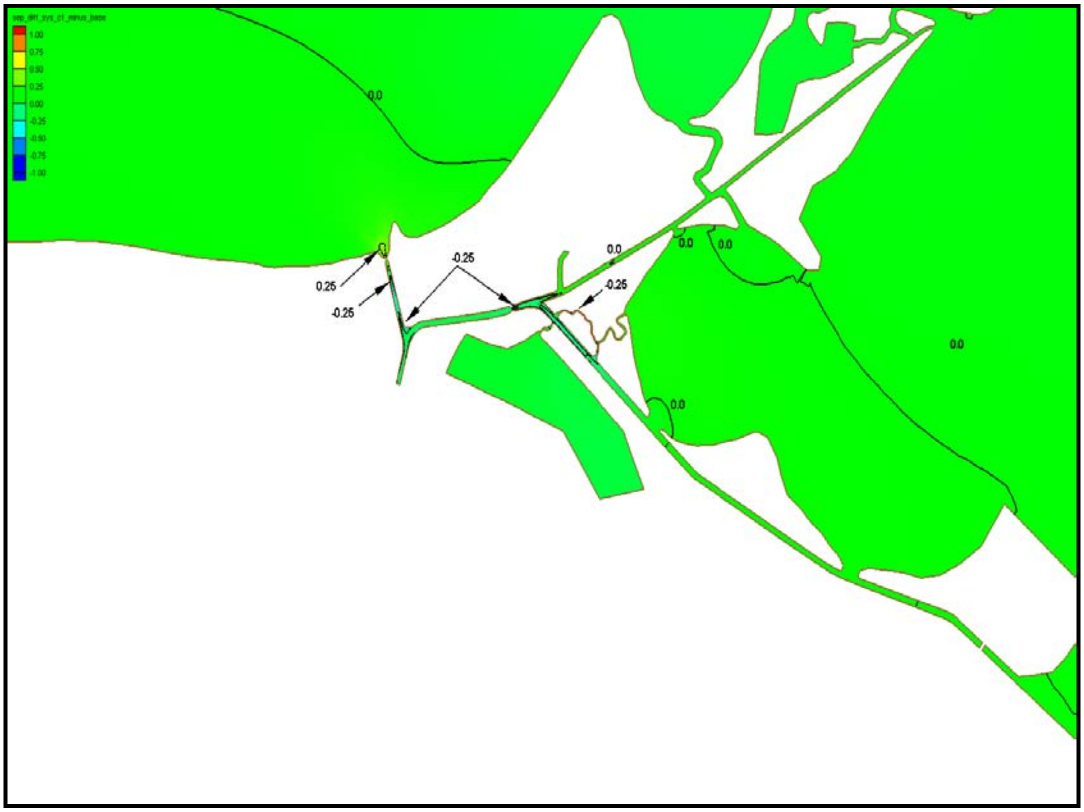

Figure 4-57. System C1 (plan - base) – September Inset.

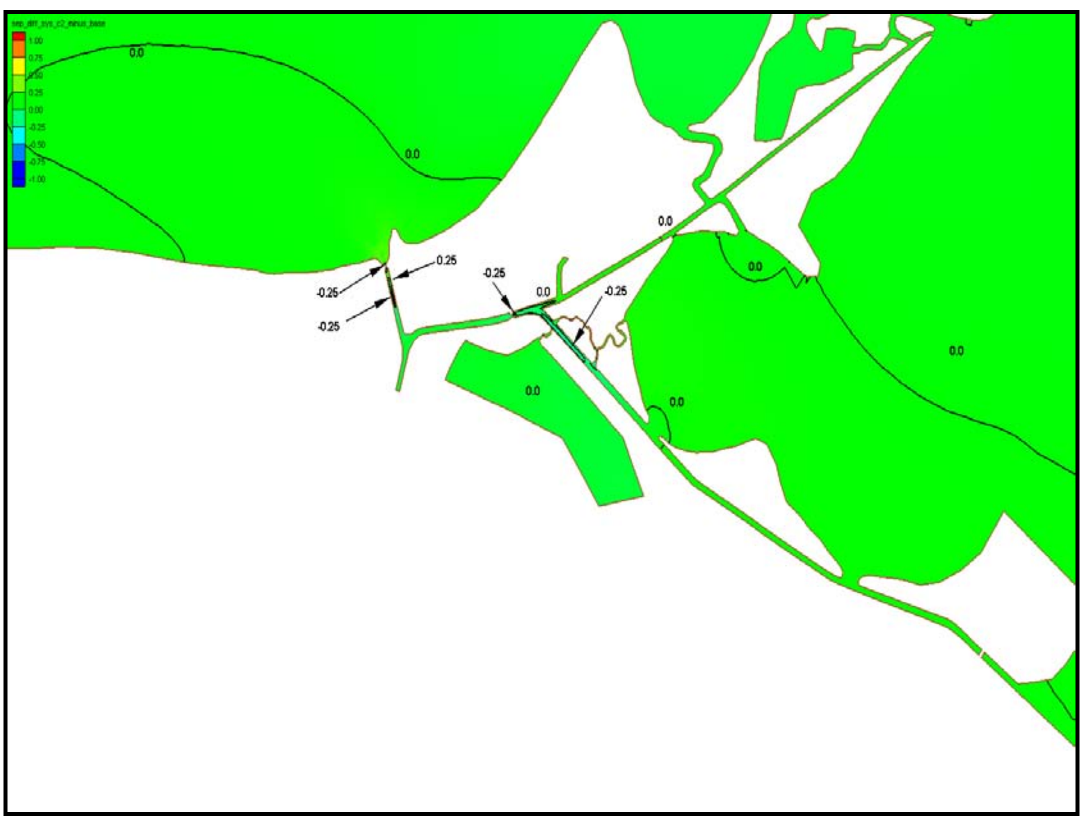

Figure 4-58. System C2 (plan - base) – September Inset.

A comparison of the two Base conditions (see Figures 4-59 and 4-60), Phase 1 and Phase 2, demonstrated that the closure at la Loutre (Phase 2) had the larger impact on salinity values in the system than the Phase 2 alternatives themselves. This indicates that the greatest contributor to salinity values in the system prior to the MRGO closure at la Loutre was the MRGO connection to the Gulf of Mexico.

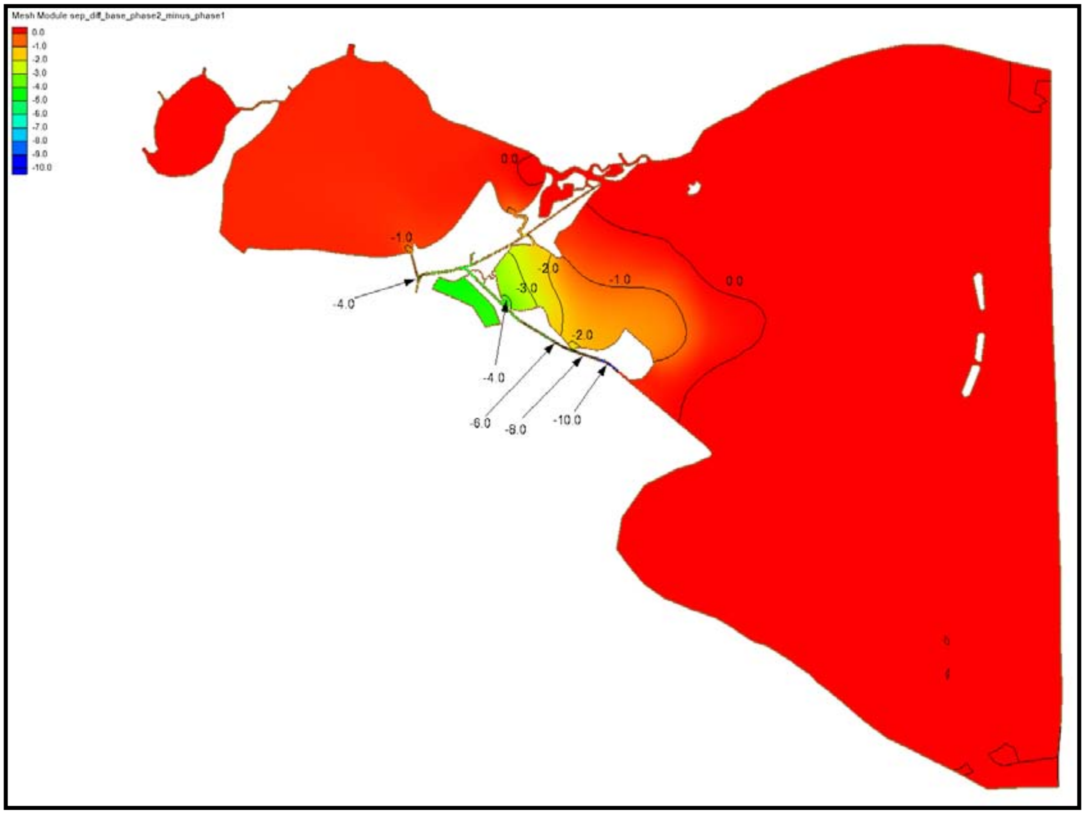

Figure 4-59. Phase 1 to Phase 2 Base Salinity Comparison (Phase 2 – Phase 1).

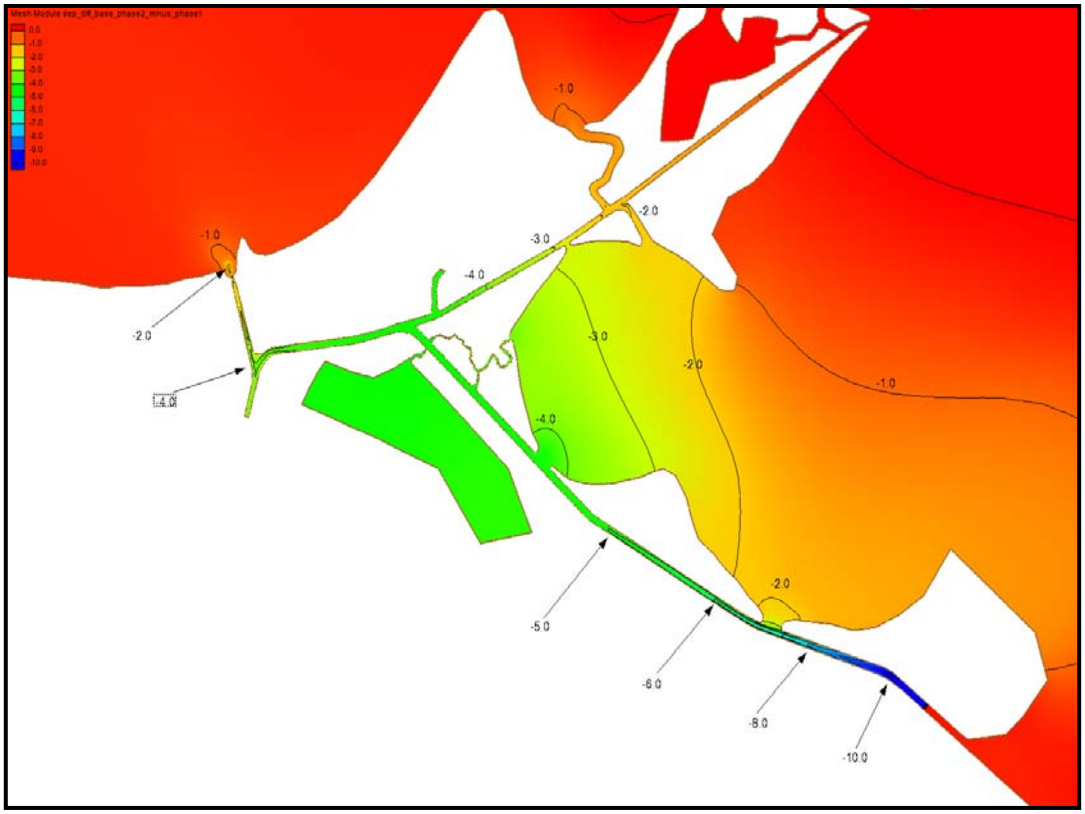

Figure 4-60. Phase 1 to Phase 2 Salinity Base Comparison (Phase 2 – Phase 1) – Inset.

5 Conclusions

The surface velocities in the MRGO and the GIWW did increase in the immediate vicinity of the sail through structures. However, the surface velocities and water levels decreased below pre-project values on the Lake Pontchartrain side of the structures at distances from the structure at approximately twice the width of the structure. Also, an examination of the surface velocities and water levels by ERDC navigation personnel did not indicate significant negative impacts to navigation due to the implement-tation of any of the four proposed alternatives in Phase 1. Near-field effects were not considered as the structures in the model were only conceptual in nature. The actual design specifications of the structures would have to be represented in the model in order to simulate the near-field effects of the structures. Velocities in the structures themselves were significantly higher than the Base condition for both Systems A and C in Phase 1 and Systems A3, A4, C1, and C2 in Phase 2. At BB, the maximum velocity in the structure exceeded the 2.6 ft/sec threshold for fish movement, but analyses showed this velocity to be a low frequency event most probably associated with a frontal passage coupled with a strong spring tide.

An analysis of monthly-averaged bottom salinity values was performed for both phases of modeling. The closures of the MRGO in the Phase 1 scenarios produced noticeable reductions, 1-5 ppt, in salinity values in the connecting channels, MRGO/GIWW/IHNC, especially during the dryer period of the year. However, Lakes Borgne and Pontchartrain experienced little to no change in bottom salinities. Sensitivity simulations were run during Phase 1 in which freshwater was released from the Bonnet Carre structure. Results from these simulations showed decreases in bottom salinity ranging from 0.5 to 2.0 ppt in all three major areas of the system: the connecting channels, Lake Borgne, and Lake Pontchartrain.

Phase 2 scenarios showed smaller changes in salinity compared to the scenarios of Phase 1 with salinity decreases in the 0.1-0.3 ppt range in the connecting channels with little to no change in bottom salinity for Lakes Borgne and Pontchartrain. The largest decreases occurred as a result of implementing the earthen dam on the MRGO at la Loutre for the Phase 2 Base condition. A comparison of the Base condition bottom salinity values from Phase 1 to Phase 2 illustrated that the earthen dam at la Loutre Ridge

(Phase 2) had a significant effect on monthly average bottom salinity values not only in MRGO/GIWW/IHNC but also in the Lake Borgne area. Most areas showed decreases of 2-4 ppt with MRGO showing the highest decrease in the region just north of the closure at ~10ppt. Lake Pontchartrain showed little to no difference between the two base conditions.

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14. ABSTRACT

A three-dimensional hydrodynamic/salinity model of the Lake Pontchartrain system was developed for the purpose of analyzing the impacts of conceptual surge barrier designs on current velocities and salinity levels in the Lake Pontchartrain system. The model was validated against observed data and applied using boundary conditions developed from 2006 data.

15. SUBJECT TERMS

Bayou Bienvenue	Inner Harbor Navigation Canal	Mississippi River-Gulf Outlet
Gulf Intracoastal Waterway	Lake Borgne	Surge barrier
	Lake Pontchartrain	TABS-MDS

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